CENTENNIAL

CENTENNIAL COAL
AIRLY MINE
ANNUAL REVIEW

March 2022

Table 1: Annual Review Title Block

Name of Operation	AIRLY MINE
Name of Operator	CENTENNIAL AIRLY PTY LIMITED
Development Consent/ Project Approval #	SSD_5581 (as Modified)
Name of holder of Development Consent/ Project Approval	CENTENNIAL AIRLY PTY LIMITED
Mining Lease #	ML1331 ML1814
Name of Holder of Mining Lease	CENTENNIAL AIRLY PTY LIMITED
Water License #	WAL 24386 and WAL 36565
Name of Holder of Water License	CENTENNIAL AIRLY PTY LIMITED
MOP/RMP Start Date	10/01/2018 (MOP/RMP Amendment A approved 09/04/2020)
MOP/RMP End Date	31/12/2024
Annual Review Start Date	01/01/2021
Annual Review End Date	31/12/2021

I, MICHAEL CLARK certify that this audit report is a true and accurate record of the compliance status of Centennial Airly Mine for the period 1 January to 31 December 2021 and that I am authorised to make this statement on behalf of Centennial Coal Pty Limited.

Note:

- *The Annual Review is an 'environmental audit' for the purposes of s122B(2) of the Environmental Planning and Assessment Act 1979. Section 122E provides that a person must not include false or misleading information (or provide information for inclusion) in an audit report produced to the Minister in connection with an environmental audit if the person knows that the information is false or misleading in a material respect. The maximum penalty is, in the case of a corporation, $1 million and for an individual, $250,000.*
- *The Crimes Act 1900 contains other offences relating to false and misleading information: section 192G (intention to defraud by false or misleading statement – maximum penalty 5 years imprisonment); sections 307A, 307B and 307C (False or misleading applications/information/documents –maximum penalty 2 years imprisonment or $22,000, or both).*

Name of Authorised Reporting Officer	MICHAEL CLARK
Title of Authorised Reporting Officer	Director
Signature of Authorised Reporting Officer	M. Clark
Date	31-3-22

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PLAN 2	AIRLY MINE - ENVIORNMENTAL MONITORING PLAN
PLAN 3	AIRLY – MINING CONSENT ZONES & 2021 WORKINGS

Appendices

Appendix No.	Appendix Name
1	2021 WATER MONITORING REPORT
2	2021 STYGO FAUNA MONITORING REPORT
3	2021 AQUATIC ECOLOGY REPORT
4	2021 ECOLOGICAL MONITORING REPORT
5	2021 SUBSIDENCE MONITORING REPORT
6	2021 NOISE MONITORING REPORT
7	2021 IEA ACTION UPDATE

Abbreviation Table

AEMP	Aquatic Ecology Monitoring Program
AEMR	Annual Environmental Management Report
AQMP	Air Quality Management Plan
AR	Annual Review
AWS	Automatic Weather Station
BC Act	Biodiversity Conservation Act 2016
BOM	Bureau of Meteorology
CCL	Consolidated Coal Leases
DDG	Depositional Dust Gauges

DPE	Former Department of Planning & Environment
DPIE	Department of Planning, Industry and Environment
DRNSW-MEG	Department of Regional NSW – Mining, Exploration & Geosciences
EC	Electrical Conductivity
EPA	Environmental Protection Authority
EP&A Act	Environmental Planning and Assessment Act 1979
EPL	Environmental Protection Licence
HCS	Habitat Complexity Scores
HVAS	High volume air sampler
LDP	Licenced Discharge Points
LFA	Landscape Function Analysis
ML	Mining Lease
MOP	Mining Operations Plan
NMP	Noise Management Plan
NPI	National Pollutant Inventory
PA	Project Approval
PPMZ	Panel and Pillar Mining Zones
RAP	Registered Aboriginal Parties
SMP	Subsidence Management Plan
SSA	Soil Surface Assessment
SSD	State Significant Development
TSP	Total Suspended Particulates
TSS	Total Suspended Solids
WAL	Water Access Licence
WAP	Weed Action Plan
WMP	Water Management Plan
WRACHMP	Western Region Aboriginal Cultural Heritage Management Plan
WRHHMP	Western Region Historic Heritage Management Plan

1 STATEMENT OF COMPLIANCE

Table 1: Statement of Compliance

Were all conditions of the relevant approval(s) complied with?	
Development consent SSD_5581	No
Mining Lease 1331	Yes
Authorisation 232 (A232)	Yes
EPL 12374	Yes
WAL24386 (Production Bore)	Yes
WAL36565 (Mine Dewatering)	Yes
EPBC Approval (EPBC 2013/7606)	Yes
SMP / Extraction Plan Approvals	Yes
Onsite Sewage Management Approval (Ref No: 105413)	Yes
/Development Approval – DA033/19 (Airly Solar Farm)	Yes
NPWS – Licence for Minor Works (dated July 2021): *Pt Hatteras Subsidence Monitoring Equipment Installations*	No

Table 2: 2021 Non-Compliances Summary

Relevant Approval	Condition #	Condition summary	Compliance Status	Comment	Where Addressed in Annual Review
SSD_5581	Schedule 3, Condition 2	Subsidence Impact Performance Measures – No greater subsidence impacts or environmental consequences than predicted in the EIS	Non-Compliant	18 February 2021 – Subsidence Performance Criteria Exceedance resulting in surface cracking over and adjacent to MW6 area on Mt Airly.	**Table 31**

Relevant Approval	Condition #	Condition summary	Compliance Status	Comment	Where Addressed in Annual Review
SSD_5581	Schedule 3, Condition 2	Subsidence Impact Performance Measures – No greater subsidence impacts or environmental consequences than predicted in the EIS	Non-Compliant	04 June 2021 – Subsidence Performance Criteria Exceedance resulting in surface cracking above MW10, sub-parallel with MW9 goaf edge.	**Table 32**
SSD_5581	Schedule 3, Condition 2	Subsidence Impact Performance Measures – No greater subsidence impacts or environmental consequences than predicted in the EIS	Non-Compliant	01 September 2021 – *(Addendum Report to 4 June 2021 Incident Notification)* Subsidence Performance Criteria Exceedance resulting in an additional surface crack above MW10 between 4 & 5 cut-through.	**Table 33**
SSD_5581	Schedule 3, Condition 2	Subsidence Impact Performance Measures – No greater subsidence impacts or environmental consequences than predicted in the EIS	Non-Compliant	16 September 2021 – *(Addendum Report to 18 February 2021 Incident Notification)* Subsidence Performance Criteria Exceedance resulting in an additional surface cracking above MW6 chain pillar (between 5 & 6 cut-through).	**Table 34**
SSD_5581	Schedule 3, Condition 2	Subsidence Impact Performance Measures – No greater subsidence impacts or environmental consequences than predicted in the EIS	Non-Compliant	23 December 2021 – *(Addendum Report to 02 December 2020 Incident Notification)* Subsidence Performance Criteria Exceedance resulting in the widening of a natural joint to the North of MW3 (Fracture 02 Continuation – minor sink hole).	**Table 35**

Relevant Approval	Condition #	Condition summary	Compliance Status	Comment	Where Addressed in Annual Review
NPWS – Licence for Minor Works (dated July 2021): *Pt Hatteras Subsidence Monitoring Equipment Installations*	Schedule 5, Condition 6	Works to be carried out in accordance with the description of the activity and environmental safeguards or mitigation measures listed in the REF	Non-Compliant	6 October 2021 – Airly Mine undertook activities that were not clearly described within the approved REF. These activities included: - Installation of Photo Control Points; - Use of several small rocks to support the base of 1 x GNS Station (Station 2).	**Table 36**

Note: Compliance Status Key for

Risk Level	Colour Code	Description
High	Non-Compliant	Non-compliance with potential for significant environmental consequences, regardless of the likelihood of occurrence
Medium	Non-Compliant	Non-compliance with: • Potential for serious environmental consequences, but is unlikely to occur; or • Potential for moderate environmental consequences, but is likely to occur
Low	Non-Compliant	Non-compliance with: • Potential for moderate environmental consequences, but is unlikely to occur; or • Potential for low environmental consequences, but is likely to occur
Administrative	Non-Compliant	Only to be applied where the non-compliance does not result in any risk of environmental harm (e.g. submitting a report to government later than required under approval conditions)

2 INTRODUCTION

Airly Mine is an underground coal mine located in the Western Coalfields (refer **Figure 1**), within the Sydney Basin, approximately 40 kilometres (km) north-northwest of Lithgow and approximately 171 km northwest of Sydney. The Mine's current consent allows extraction of 1.8 million tonnes of coal per annum for supply to both domestic and international markets by rail. Centennial Airly Pty Limited (Centennial Airly) is the operator of Airly Mine and is a wholly owned subsidiary of Centennial Coal Company Pty Limited.

Development consent (DA 162/91) was granted to Airly Mine on 14 April 1993 pursuant to Section 101 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). DA 162/91 authorised the extraction of up to 1.8 Mtpa of run-of-mine (ROM) coal within the existing mining lease area, ML 1331 (PLAN 1). DA 162/91 allowed for a limited scale trial mine for a period of 12 months with transport of 300,000 tonnes of ROM coal by road to the Mount Piper Power Station.

Two subsequent modifications to DA 162/91 were approved and allowed an increased amount of trial mining coal throughput of up to 500,000 tonnes per annum for 2 years to be transported to Mount Piper Power Station by road (MOD 1), and for the construction and operation of a 66 kV power line to the pit top (MOD 2).

Airly Mine moved to a care and maintenance phase in January 2013 and remained in care and maintenance until March 2014. During this phase extraction activities ceased, however environmental management of the mine was ongoing including ongoing environmental monitoring. Coal production at Airly Mine resumed in March 2014.

Following re-opening of the mine, another three modifications to DA 162/91 were approved. These modifications were all in relation to extending the expiry date of DA 162/91 while the Airly Mine Extension Project application was being assessed. In October 2014 the development consent for Airly Mine was extended until 31 October 2015 (MOD 3). In August 2015 the development consent for Airly Mine was extended until 30 April 2016 (MOD 4); in March 2016 the consent was extended until 31 October 2016 (MOD 5) and in September 2016 the consent was extended until 31 January 2017 (MOD 6).

The Airly Mine Extension Project (SSD_5581) was approved in December 2016 and allows mining operations for a period of 20 years within the Project Area **(PLAN 1)**. Airly commenced operations under SSD_5581 on 31 January 2017.

SSD_5581 was modified (Mod 1) in August 2018 to include additional clarification relating to angle of draw restrictions for secondary workings. A further modification of SSD_5581(Mod 2) was approved in July 2019 and permits the importation of water via rail from Charbon Colliery.

In November 2019, Airly Mine submitted a modification application (Mod 3) relating to the increase in production approval limits from 1.8 million tonnes per year to 3.0 million tonnes per year. Following subsidence performance criteria exceedances, Airly Mine voluntarily withdrew the Mod 3 application on 8 December 2020.

As of March 2022, there are currently no modification applications of SSD_5581 that are under assessment or in preparation.

The Mine's disturbance footprint is limited to the pit top and surface infrastructure areas including water management systems, car park, administration building, workshop, conveyors, coal handling plant and mine ventilation infrastructure. The current disturbance footprint of Airly Mine is 54.4 Ha, the primary disturbance domains are shown in **Figure 2**.

Airly Mine does not have any offset areas.

2.1 Scope

This Annual Review (AR) details the compliance, environmental management and community engagement activities associated with the Airly Mine over the Period 1 January 2021 to 31 December 2021. The AR has been prepared in accordance with the *Annual Review Guideline* (DPIE 2015), and satisfies:

- Schedule 6, Condition 11 of SSD_5581;
- Reporting requirements of mining and exploration tenements (including rehabilitation report); and
- Reporting requirements of Environmental Management Plans, Extraction Plans / Subsidence Management Plans.

2.2 Mine Contacts

The contact details for the personnel responsible for environmental management and community relations at Airly Mine are provided in **Table 3.**

Table 3: Centennial Site Environmental Contact Details

Name	Position	Phone
Bob Miller	Mine Manager	T: (02) 63592101
		E: Bob.Miller@centennialcoal.com.au
Sam Price	Environment & Community Coordinator	T: (02) 63592108; 0427647657
		E: Sam.Price@centennialcoal.com.au

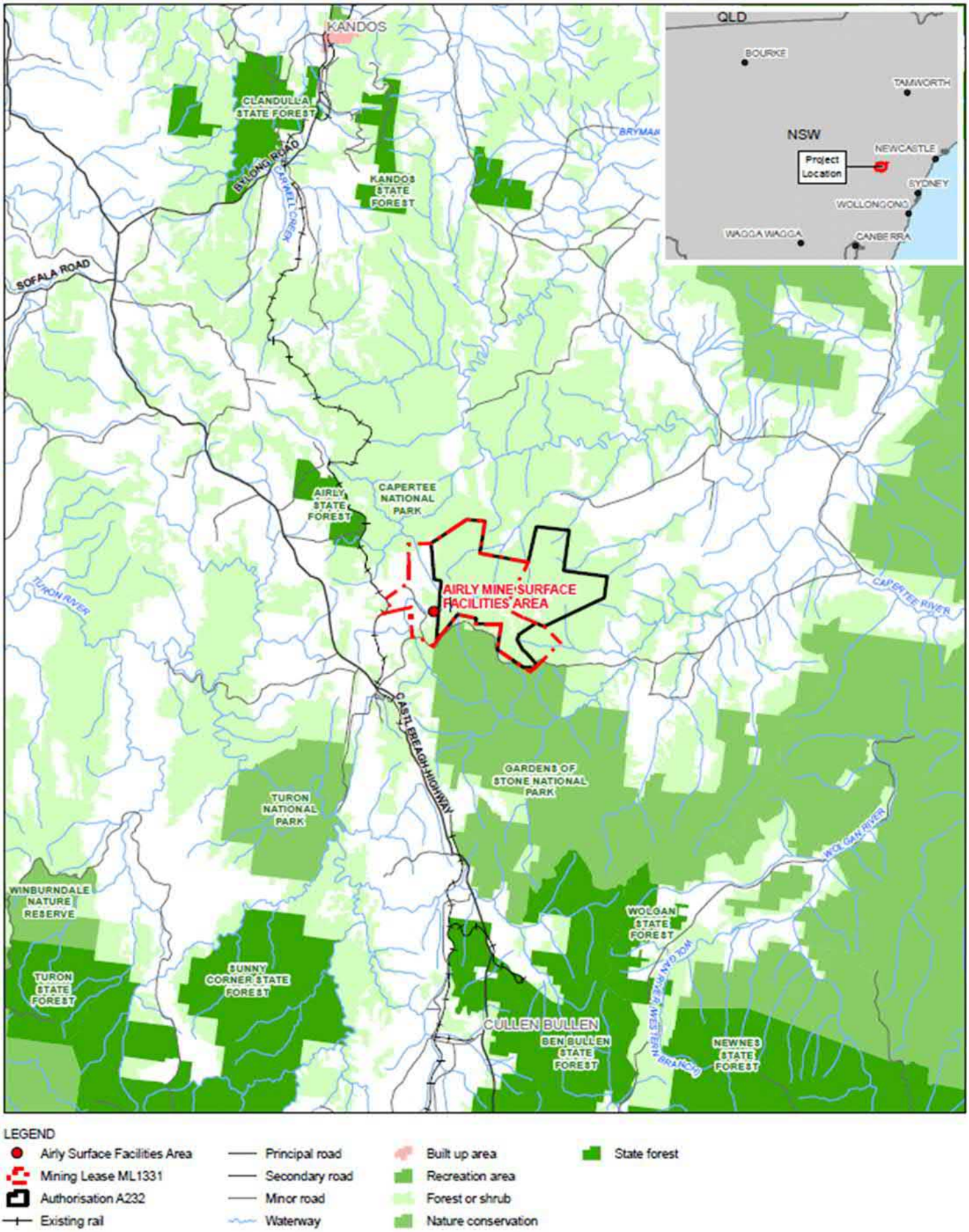


Figure 1: Regional Context



Figure 2: Surface Disturbance Footprint and Domain Plan

3 APPROVALS

A summary of Project Approvals, Mining Leases, and other Licences relevant to Airly Mine is provided in Table 4. Current Project Approvals, EPBC Approvals, Exploration Licences, and Mining Leases are available at: https://www.centennialcoal.com.au/operations/airly/

Table 4: Airly Mine Leases; Licenses and Consent.

Approval	Description	Expiry Date	Change to Approval during Reporting Period
Project Approval – NSW Department to Planning, Industry and Environment			
Development Consent SSD_5581	Underground mine development to extract up to 1.8 million tonnes per annum	31/01/2037	Nil
Extraction Plans – NSW Department to Planning, Industry and Environment			
SMP / Extraction Plan Approval: *Cliff Line Zone of First Workings Extraction Plan.*	Cliff Line Zone of First Workings Extraction Plan.	Reviewed annually	Nil
SMP / Extraction Plan Approval: *Splitting & Quartering Extraction Plan.*	Splitting & Quartering Extraction Plan.	When 207 and 206 extraction is completed	Nil
SMP / Extraction Plan Approval: *Mt Airly Panel & Pillar Mining Zone Extraction Plan.*	Mt Airly Panel & Pillar Mining Zone Extraction Plan.	When Panel and Pillar Extraction Mining is completed under Mt Airly	Nil
SMP / Extraction Plan Approval: *Pt Hatteras Panel & Pillar Mining Zone Extraction Plan (MW13-16).*	Pt Hatteras Panel & Pillar Mining Zone Extraction Plan (MW13-16).	When MW's 13-16 are complete	Approved on 13 December 2021. Mining not commenced under EP during the reporting period.
Environmental Protection Licence – NSW Environment Protection Agency			
Environmental Protection Licence 12374 (EPL 12374)	3 licenced discharge points Production of coal >500,000T to 2,000,000T per annum	Renewed Annually	Nil
Mining Tenements – Resources Regulator			

Approval	Description	Expiry Date	Change to Approval during Reporting Period
Mining Lease 1331 (ML1331)	Mining lease area of approximately 2,745 hectares	20 October 2035	Nil
Mining Lease 1814 (ML1814)	Mining lease area of approximately 1,258 hectares	22 July 2042	Granted 22 July 2021
Authorisation 232 (A 232)	Exploration Area of approximately 3,054 hectares	A232 renewal is currently awaiting approval from Resources Regulator.	Nil
EPBC Approval – Commonwealth Department of Agriculture, Water and the Environment			
EPBC Approval (EPBC 2013/7606)	Permission to carry out mining operations in accordance with SSD_5581 with conditions relating to the protection of matters of national environmental significance.	31/03/2047	Nil
Water Licences – DPIE Water			
Water Access Licence (WAL) 24386 (Production Bore)	Extract up to 158ML per annum	Perpetuity	Nil
Water Access Licence (WAL) 36565 (Mine Dewatering)	Extract up to 120ML per annum	Perpetuity	Nil
10BL604518	ARP01	Perpetuity	Nil
10BL604520	ARP02A & ARP03A	Perpetuity	Nil
10BL604521	ARP04 &ARP05	Perpetuity	Nil
10BL605352	ARP06, ARP07, ARP08 & ARP09	Perpetuity	Nil
10BL605794	ARP11	Perpetuity	Nil

Approval	Description	Expiry Date	Change to Approval during Reporting Period
10BL605793	ARP12, ARP13, ARP13SP, ARP14, ARP15 & ARP15SP	Perpetuity	Nil
Additional Approvals - Lithgow City Council			
Approval to Operate Onsite Sewage Management System at Airy Mine (Ref: 101937)	Approval to Operate Onsite Sewage Management System (Ecomax) at Airly Mine	14/07/2023	Nil
Development Approval – DA033/19	Airly Solar Farm	31/05/2024	Nil

4 OPERATIONS SUMMARY

Details of production and associated waste generated by the site for the report period and next reporting is provided in **Table 5**.

Table 5: Production Summary & Forecast

Material	Approved Limit (and source)	Previous Reporting Period (2020 Actual)	This Reporting Period (2021 Actual)	Next Reporting Period (Forecast)
Waste Rock/ Overburden	N/A	Nil	Nil	Nil
ROM Coal	1.8 MTPA	1,476,209 (t)	1,308,170 (t)	1,300,000 (t)
Coarse reject	N/A	Nil	Nil	Nil
Fine reject (Tailings)	N/A	Nil	Nil	Nil
Saleable product	1.8 MTPA	1,476,209 (t)	1,308,170 (t)	1,300,000 (t)

4.1 OTHER OPERATIONS

Details of other operations relevant to Airly Mine are provided in **Table 6**.

Table 6: Operations Summary

Limits	Approved Limit	Previous Reporting Period (2020 Actual)	This Reporting Period (2021 Actual)	Comment
Hours of operation	24/7	24/7	24/7	Compliant
Transport (rail)	N/A	Total: 1,451,330 (t) Average: 1.167 Trains/day Max: 5 Trains/day	Total: 1,311,166 (t) Average: 1.079 Trains/day Max: 3 Trains/day	Compliant. No exceedance of daily or annual transport limits
Transport (road)	No transport of coal by road. (SSD_5581)	Nil	Nil	All coal transported by rail
ROM Stockpile Size	200,000 T (Airly Mine Extension Project EIS, 2014)	Fluctuated throughout the year but always <200,000 (t)	Fluctuated throughout the year but always <200,000 (t)	Compliant. The stockpile design does not physically allow the storage of greater than 200,000
Employee Numbers	Up to 155 Full time equivalent employees	126 Personnel as of 31 Dec 2020	124 Personnel as of 31 Dec 2021	Compliant. Employee numbers below the

Limits	Approved Limit	Previous Reporting Period (2020 Actual)	This Reporting Period (2021 Actual)	Comment
	(Airly Mine Extension Project EIS, 2014)			maximum approved 155 full time equivalent employees.

There were no inconsistencies between the approved limit and actual production for the reporting period.

4.2 EXPLORATION

No exploration was undertaken during the reporting period.

4.3 LAND DISTURBANCE

There was no additional land disturbance during the 2021 reporting period.

4.4 CONSTRUCTION

No construction was undertaken during the reporting period.

4.5 NEXT REPORTING PERIOD

The primary objective for Airly Mine is business sustainability achieved through the initiative of a strategic plan and timeline which links the key elements of health and safety, environment, organisational health, community and shareholder value.

Key Operational Milestones for 2022

- Annual Budget:
  1. 1.3Mt ROM production
  2. 20km of roadway development
- Completion of the initial Herringbone development mining to determine the system capability.

5 ACTIONS REQUIRED FROM PREVIOUS ANNUAL REVIEW

There were no specific actions or requirements from the previous Annual Review to be included in the 2021 Annual Review other than details of all incidents and non-compliances during the reporting period (addressed in **Section 11**).

Table 7: Actions from Previous Annual Review

Action Required	Requested By	Action Taken	Where addressed in Annual Review
Nil	N/A	N/A	N/A

6 ENVIRONMENTAL PERFORMANCE

Airly Mine implements an Environmental Management Strategy, including management plans, procedures and monitoring programs that provide a framework for managing environment and community risks and impacts. To measure compliance with site approvals and licences, Airly Mine undertake a comprehensive monitoring program.

This section provides a summary of environmental performance in the reporting period, including:

- Section 6.1 – Meteorological Summary
- Section 6.2 – Noise
- Section 6.3 – Blasting
- Section 6.4 – Air Quality
- Section 6.5 – Biodiversity
- Section 6.6 – Heritage
- Section 6.7 – Waste
- Section 6.8 – Greenhouse Gas
- Section 6.9 – Subsidence

The environmental performance for water, rehabilitation and community aspects are reported in Sections 7, 8 and 9 respectively.

Table 8 Summarises the Airly Mine monitoring requirements and where they have been reported in this AR.

Table 8: Summary of Environmental Monitoring Requirements

Monitoring Type	Overview of Monitoring Requirements	Requirement of Approval / Management Plan	Performance during the reporting period	Annual Review Section
Air quality	4 x DGs – Monthly HVAS – 6 day cycle	Air Quality & Greenhouse Gas Management Plan EPL 12374	Compliant and consistent with EIS predictions.	Section 6.4
Biodiversity	Annual Spring/Summer Monitoring Program in consultation with NPWS	Biodiversity Management Plan EPBC Approval	No impact. Compliant and consistent with EIS predictions.	Section 6.5; APPENDIX 4.
Blasting Monitoring	Not Applicable – No Blasting	Not Applicable – No Blasting	No Blasting	Section 6.3
Heritage	As required	Historic Heritage Management Plan	No impact	Section 6.6
Meteorological Monitoring	1 weather station - Continuous	SSD_5581 EPL 12374	Compliant	Section 6.1
Noise	Annual Attended Noise Monitoring	Noise Management Plan	Compliant	Section 6.2
Rehabilitation	Not yet required.	Mining Operations Plan / Rehabilitation Plan	Not applicable. Rehabilitation works will be conducted in conjunction with mine closure.	Section 8

Monitoring Type	Overview of Monitoring Requirements	Requirement of Approval / Management Plan	Performance during the reporting period	Annual Review Section
Subsidence: ***MOD 3 Extraction Plan (As Varied)***	Cliffs, minor cliffs, pagodas and general land – inspection for damage. Underground workings - survey of as built pillars compliance with design parameters. Statutory inspections of workings Surface inspections of tracks Inspection of heritage sites undermined during 2019 Stone Cottage in Airly Gap Telstra copper line in Airly Gap to remain fully functional.	ML1331 MOD 3 Extraction Plan (as varied)	Compliant. No extraction workings in the MOD3 (DA162/91) in 2021. All subsidence monitoring has previously been completed. Ongoing monitoring is incorporated with the Cliff Zone of First Workings 3D photogrammetery. No cracking or damage present. No further monitoring required with cessation of extraction workings for >24 months. Dilapidation survey of Stone Cottage completed before first workings in 2017. First workings under Stone Cottage resulted in no damage. Telstra copper line remained functional. No second workings in Airly Gap during 2021.	Section 6.9 APPENDIX 5.
Subsidence: ***Cliff Line Zone Extraction Plan***	Cliffs, minor cliffs, pagodas and general land - LIDAR and Photogrammetry every 6 months - monitor for change. Underground Workings/ Pillar Stress monitoring. Underground workings - survey of as built pillars. Pillars built as per parameters in Master TARP Statutory inspections of workings Surface inspections of tracks Inspection of heritage sites undermined during 2019	SSD_5581 ML1331 Cliff Line Zone Extraction Plan	Compliant. Pillars were formed at least 1/10th depth from surface. Height <3.0m average. Roadways were mined at 5.5m wide. Pillars were >2.11 FOS (i.e., long term stable) Vertical and oblique 3D photogrammetry surveys conducted in May 2021 and post mining of MW12 in February 2022. No mining related changes found in current data. Pillar systems complied with parameters laid out in the Cliff Zone ML1331 Extraction Plan. No evidence of pillar instability found in 2021 during statutory inspections No damage to unsealed tracks noted during monthly environmental inspections. No heritage sites undermined in the Cliff Zone of First Workings in 2021.	Section 6.9 APPENDIX 5.
Subsidence:	Cliffs, minor cliffs, pagodas and	SSD_5581	Non - Compliant.	Section 6.9

Monitoring Type	Overview of Monitoring Requirements	Requirement of Approval / Management Plan	Performance during the reporting period	Annual Review Section
Mt Airly Panel and Pillar Mining Zone Extraction Plan	general land – visual inspection for damage/ LiDAR photogrammetry survey, conventional subsidence lines, GNSS real time monitoring Underground workings - survey of as built pillars compliance with design parameters. No extraction within 26.5° angle of draw from crest of cliffs CLZ extraction panels Statutory inspections of workings Surface inspections of tracks Inspection of heritage sites as required Ground water and surface water monitoring	ML1331 Splitting & Quartering Extraction Plan IEP recommendations for underground monitoring	MW2-12 panel extracted within approved area. Compliant pillar dimensions for extraction. LIDAR and photogrammetry surveys conducted in May 2021. LIDAR/Photogrammetry completed in February 2022 (Post mining of MW 12 in December 2022) awaiting data. Conventional subsidence monitoring conducted in accordance with Subsidence Monitoring Plan. Panels extracted in period • MW 8 exceeded 125mm • MW 9 exceeded 125mm • MW 10 exceeded 125mm Following increase in barrier size • MW 11 no exceedance • MW 12 no exceedance Where subsidence exceeded 125mm the incident was notified to DPIE as per Master TARP and adaptive management process engaged. Exceedance of subsidence related performance criteria. Surface cracking identified in general land surface as previously reported. Non-compliance notified to DPIE. Pillar systems complied with parameters laid out in the Extraction Plan Mater TARP. No indications of pillar failure were evident. Statutory inspections of accessible areas found no pillar instability in 2021. No heritage sites undermined in 2021. Previously undermined site has remained stable and unaffected. Mt Airly surface unsealed track undermined in 2021. No impacts. Ground water and surface water impacts within predictions.	APPENDIX 5.
Subsidence: ***Pt Hatteras Panel & Pillar Mining Zone Extraction***	Cliffs, minor cliffs, pagodas and general land – visual inspection for damage/ LiDAR photogrammetry survey, conventional	ML1331 & ML1814 Pt Hatteras Panel & Pillar Mining Zone Extraction Plan (MW13-16).	Approved on 13 December 2021. Mining not commenced under EP during the reporting period.	Section 6.9 APPENDIX 5.

Monitoring Type	Overview of Monitoring Requirements	Requirement of Approval / Management Plan	Performance during the reporting period	Annual Review Section
Plan (MW13-16).	subsidence lines, GNSS real time monitoring Underground workings - survey of as built pillars compliance with design parameters. No extraction within 26.5° angle of draw from crest of cliffs CLZ extraction panels Statutory inspections of workings Surface inspections of tracks Inspection of heritage sites as required Ground water and surface water monitoring			
Water	Surface Water Volume & Quality Monthly + Various Groundwater Depth & Quality Monthly + Various	Water Management Plan EPL 12374	Extensive water monitoring program continued during 2021 with the results and analysis being consistent with EIS predictions. Airly Mine was compliant with all conditions of the WMP, EPL12374 and SSD_5581 during the reporting period.	Section 7 APPENDIX 1

6.1 METEROLOGICAL SUMMARY

6.1.1 Environmental Management

During the reporting period, meteorological monitoring at Airly Mine was:

- Compliant with Schedule 4, Condition 8 of SSD_5581; and
- Compliant with EPL 12374.

Rainfall

Airly Mine has a site-based meteorological station which was established in April 2010. The weather station undergoes regular inspections and calibration to ensure that the equipment is operating in accordance with the Australian Standard AS3580.14:2014. Rainfall and temperature data for 2021 is shown in **Figure 3**. Comparative rainfall and temperature data for 2020 has also been provided in **Figure 4.**

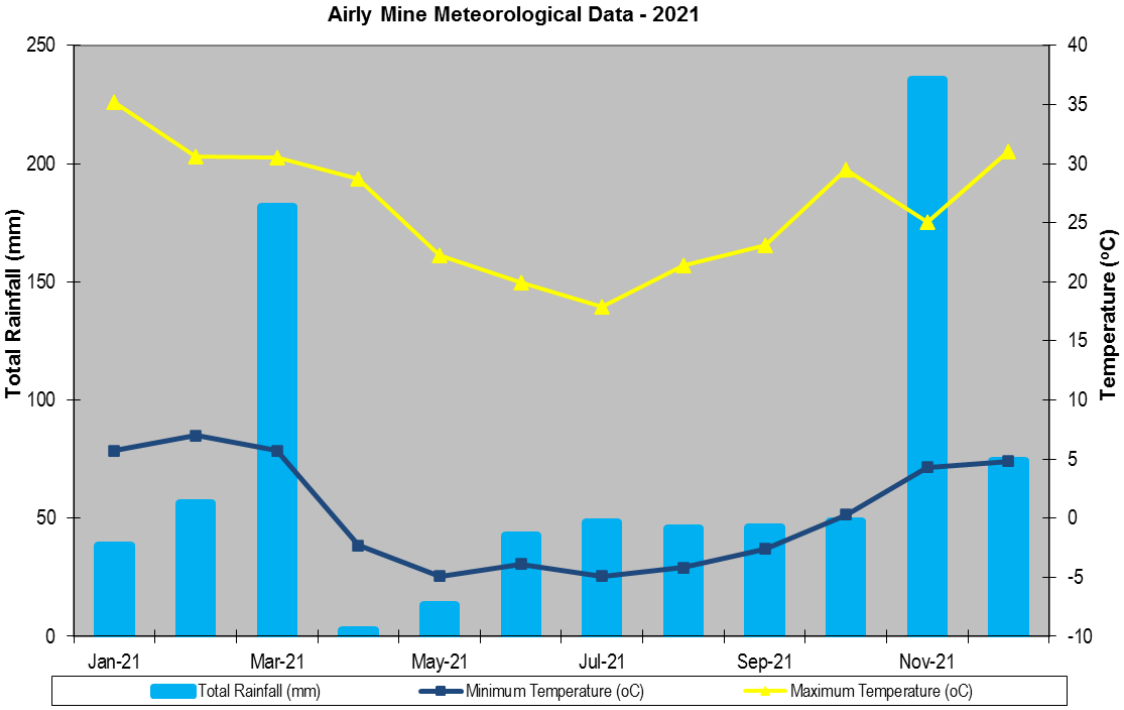


Figure 3: Airly Mine – 2021 Weather Data

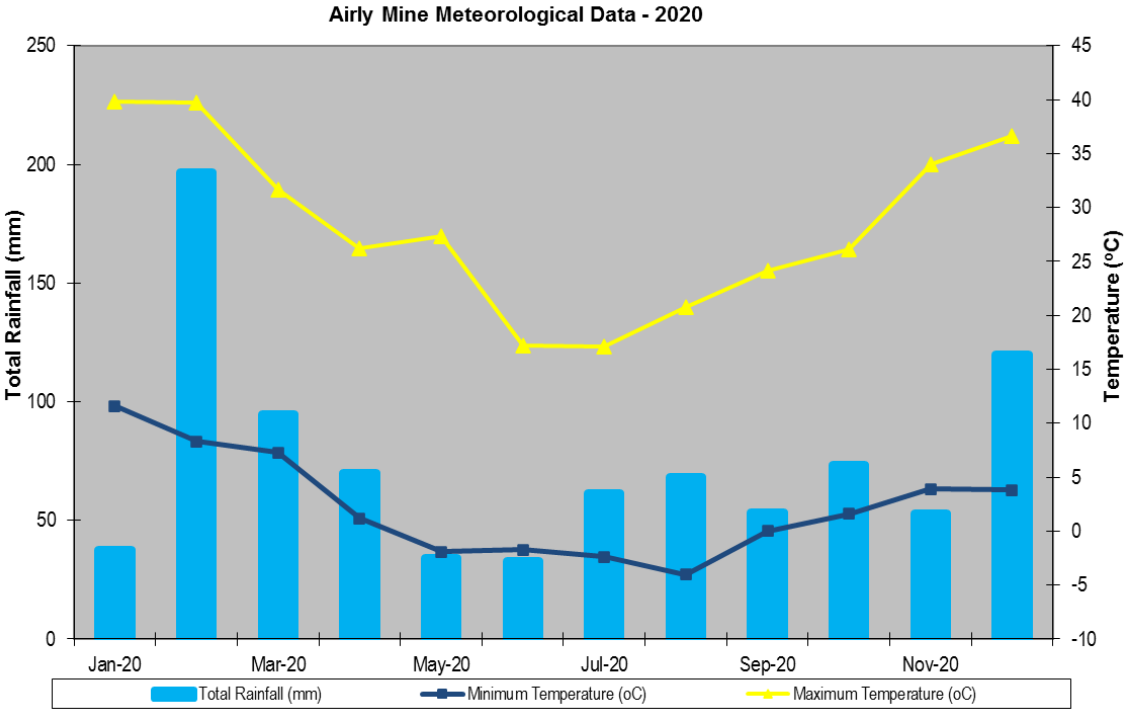


Figure 4: Airly Mine – 2020 Weather Data

Total rainfall at Airly Mine for 2021 was 834mm, which is less than the previous year's rainfall total of 895.4mm. The maximum temperature was recorded in January with a value of measurement of 35.2˚C, the minimum temperature -4.9°C was recorded in both May and July.

Comparisons of rainfall and temperature data from 2017, 2018, 2019, 2020, and 2021 have been provided in **Table 9**.

Table 9: Airly Mine – Comparison of previous Weather Data

	2017	2018	2019	2020	2021
Total Rainfall (mm)	474.6	575	398.4	895.4	834
Average Rainfall (mm)	680	680	680	680	680
Maximum Temperature (°C)	41.4	38.7	39.6	39.8	35.2
Minimum Temperature (°C)	-5.5	-8.4	-6.9	-2.4	-4.9

Historic and trended rainfall data has been obtained from the BOM Ilford (Warrangunyah) weather station, which is located approximately 29km north-west of Airly Mine. The period of rainfall data extends from 1901 to 2021 and is summarised as annual totals in **Figure 5.**

The statistics for this rainfall dataset are:

1. Minimum annual rainfall – 280mm (1982);
2. Average annual rainfall – 680mm; and
3. Maximum annual rainfall – 1,527mm (1950).

Monthly and annual rainfall trends from the Airly Mine Weather Station are provided in **Figure** 6 and **Figure 7** below**.**

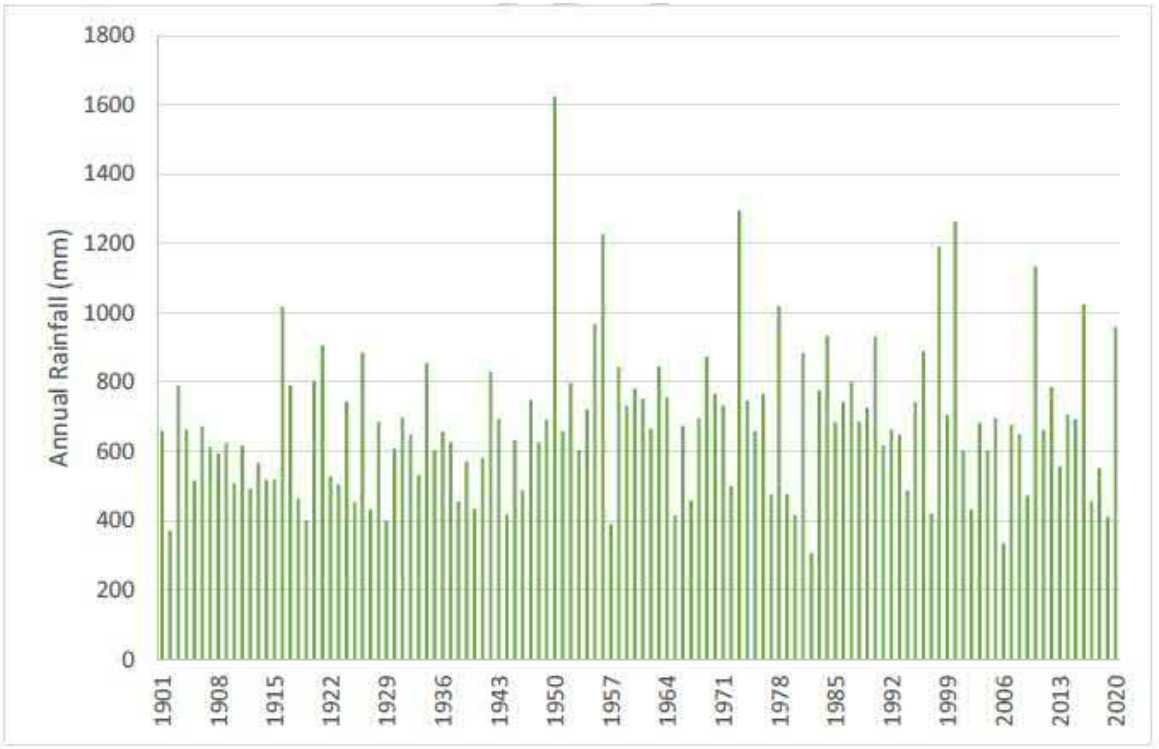


Figure 5: Historic Rainfall Trends from Ilford (Warrangunyah) Weather Station

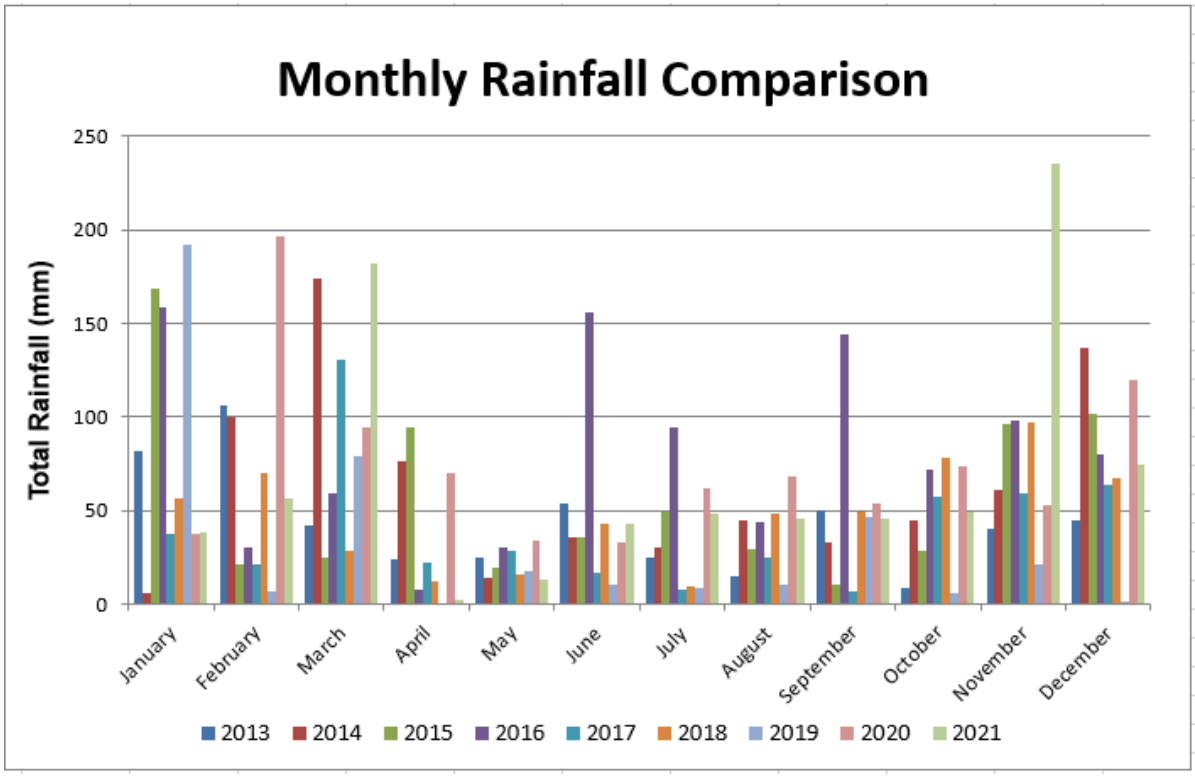


Figure 6: Monthly Rainfall Trends from Airly Mine Weather Station

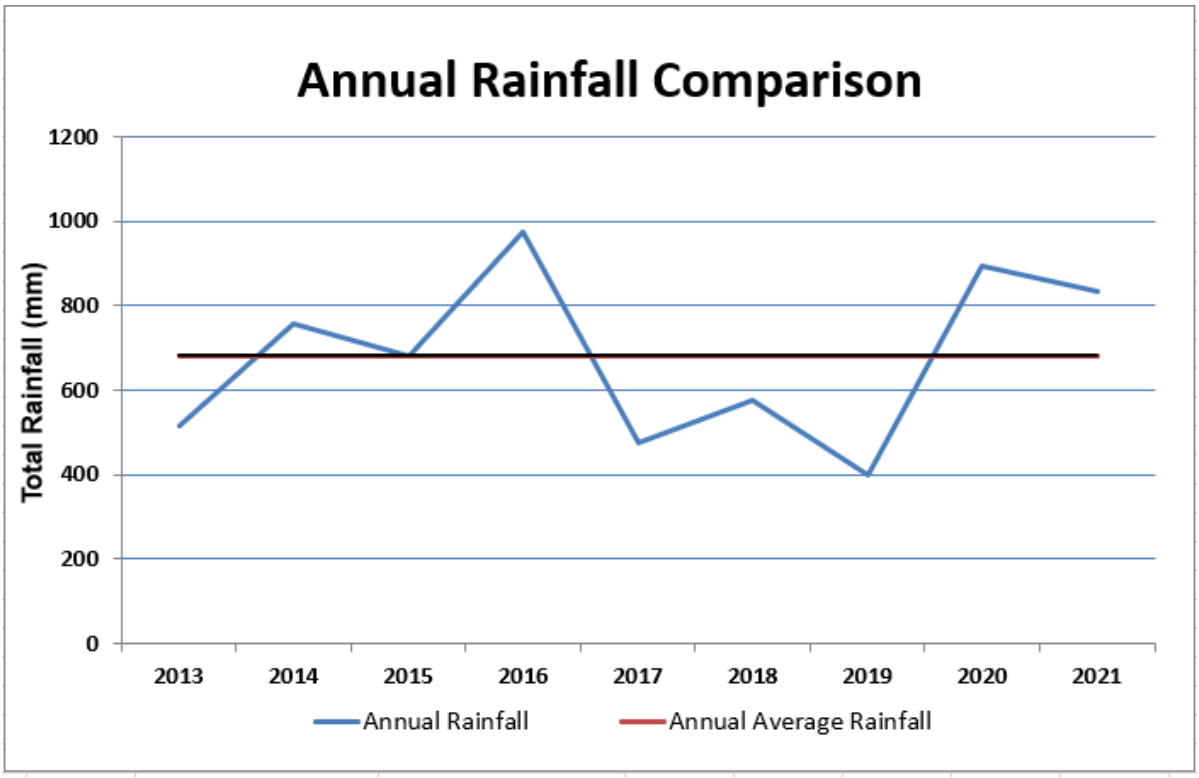


Figure 7: Annual Rainfall Trends from Airly Mine Weather Station

6.2 NOISE

6.2.1 Environmental Management

Attended monitoring is conducted at Airly Mine in accordance with the NSW Environmental Protection Agency (EPA) 'Noise Policy for Industry' (NPfI) and Australian Standard AS1055-1997 'Acoustics, Description and Measurement of Environmental Noise'. The duration of each measurement is 15 minutes and weather conditions are recorded for each noise level measurement using the Airly Mine Weather Station (AMWS).

Airly Mine has no specific noise monitoring requirements or noise criteria in the EPL. However, Schedule 4, Condition 2 of SSD_5581 provides noise limits for sensitive receivers. The noise criteria for locations around Airly Mine are described in **Table 10**. **Figure 11** shows the approved noise monitoring locations.

Location ANM1 demonstrates compliance for receptors A2 – A5 (inclusive). Location ANM2 demonstrates compliance for A7 and A8. Location AMN3 directly measures compliance at the Camp Ground in Mugii Murum-ban State Conservation Area.

There were no non-compliances or exceedances of operational noise or low frequency noise criteria during the 2021 reporting period.

Table 10: Airly Mine Noise Criteria and Compliance Status

Descriptor	Day/Evening/Night Criteria LAeq,15minute (dB)	Night Criteria LA1,1minute (dB)	Compliance Status
R1 – R8 inclusive	35	52	Compliant
Muggi Murum-ban State Conservation Area	50 (when in use)	N/A	Compliant
R17 (Campground)	50 (when in use)	N/A	Compliant
R18 (Nissan Hut)	50 (when in use)	N/A	Compliant

Operator attended noise measurements were conducted during the day, evening and night-time periods on Tuesday 21 December 21.

Weather conditions during the surveys were relatively warm with temperatures up to 33°C during the day and down to 13°C during the night. Winds were generally 1-3 m/s during the daytime period and were relatively calm during the evening and night-time monitoring periods.

A summary of the operator attended measurements in relation to SSD_5581 Approval criteria is contained within **Table 11.**

Table 11: Airly Mine Noise Monitoring Summary - 2021

Noise Monitoring Location	Time Period	Approval criteria $L_{Aeq,15min}$	EIS / EA Predictions	Airly Mine performance during the reporting period (2021)	Trend compared to previous years
Location ANM1	Day	35	N/A	<30	Consistent with previous years. No increase in noise levels.
	Evening	35	N/A	<30	
	Night	35	N/A	30	
Location ANM2	Day	50	N/A	IA	Consistent with previous years. No increase in noise levels.
	Evening	50	N/A	IA	
	Night	50	N/A	IA	
Location ANM3	Day	35	N/A	IA	Consistent with previous years. No increase in noise levels.
	Evening	35	N/A	IA	
	Night	35	N/A	IA	

IA = Inaudible

Historic noise monitoring data from 2015 to 2020 has been correlated for each time period (day, evening and night) and is shown in **Figure 8**, **Figure 9** and **Figure 10**, respectively.

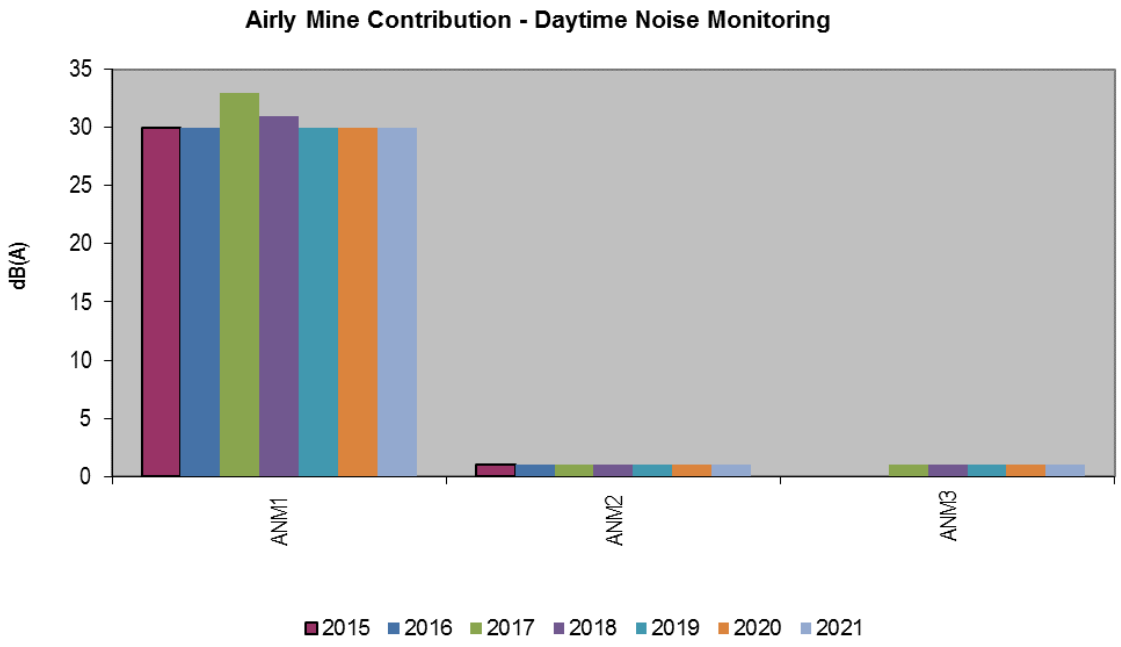


Figure 8: Airly Mine – Daytime Noise Monitoring Results 2015 – 2021

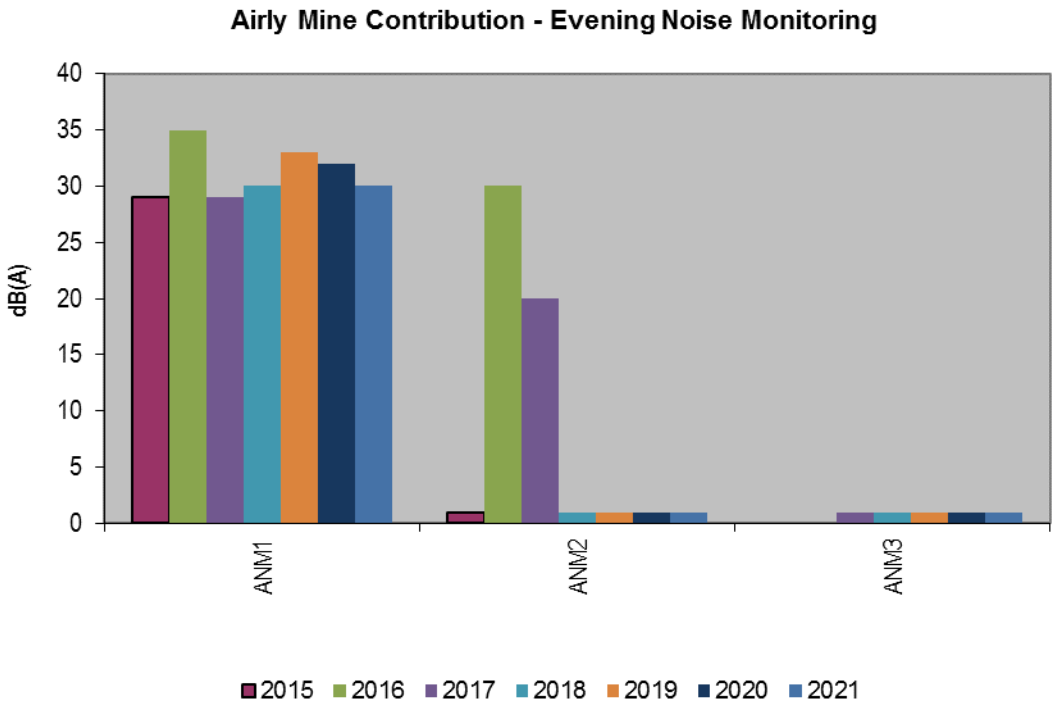


Figure 9: Airly Mine – Evening Noise Monitoring Results 2015 – 2021

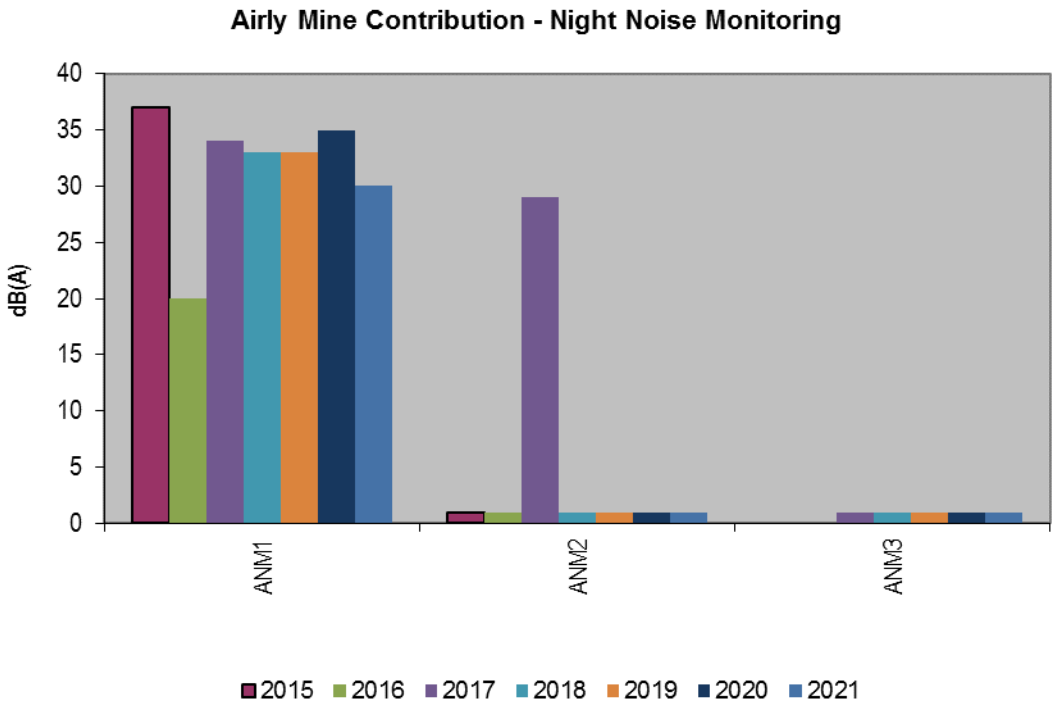


Figure 10: Airly Mine – Night-time Noise Monitoring Results 2015 – 2021

Referring to **Table 11** and **Figure 8**, **Figure 9** and **Figure 10**, there have been no non-compliances in relation to noise during the 2021 period. The 2021 results have been consistent and comparable to previous years.

It is clear from the historic trends that Airly Mine is a low noise generating site and for the last 7 years has maintained full noise monitoring compliance.

Airly Mine will continue to utilise this historic trended data to optimize and revise the noise monitoring and management program.

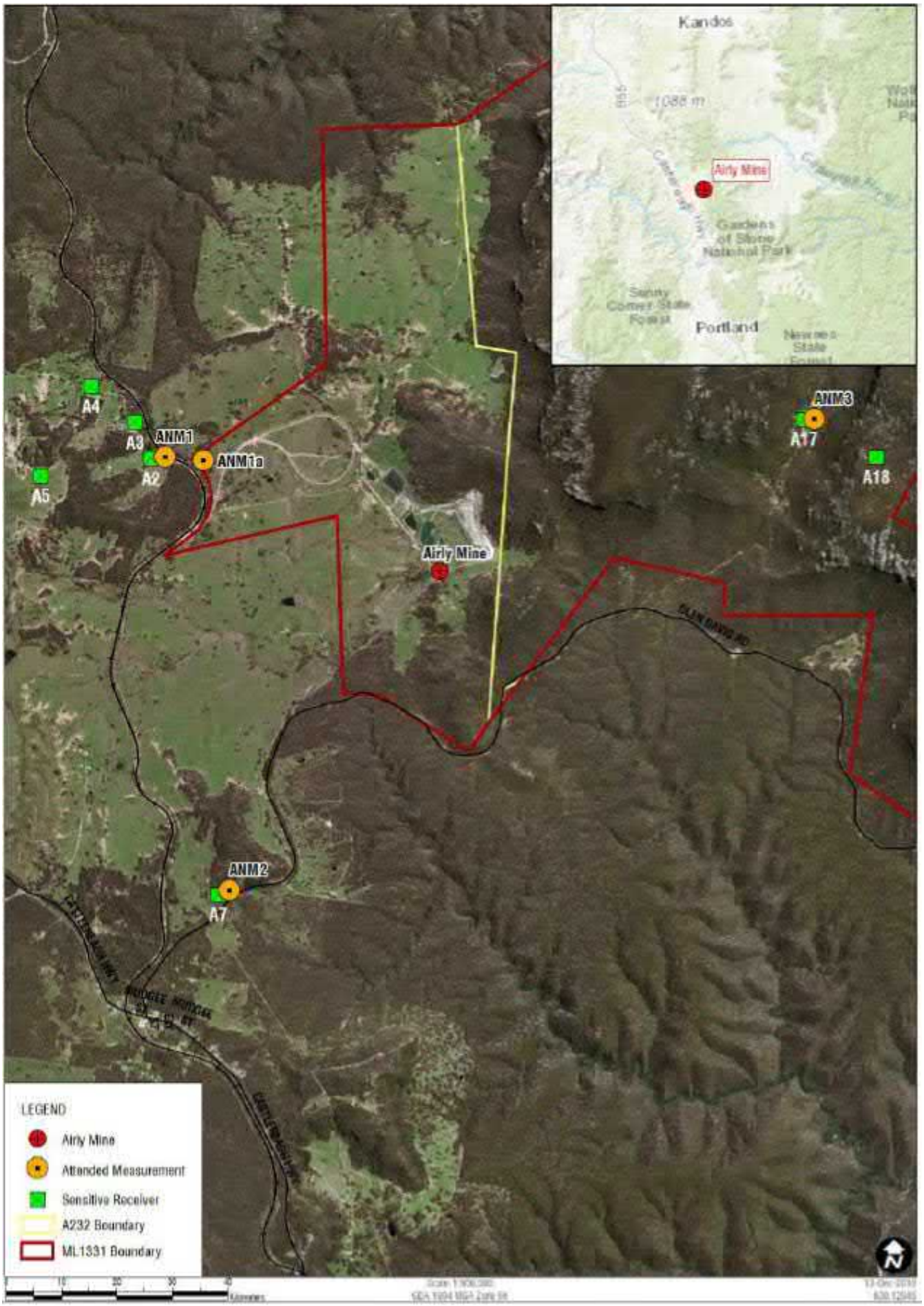


Figure 11: Airly Mine – Noise Monitoring Locations

6.3 BLASTING

Airly Mine does not have any need or approval for blasting works. There have been no blasting operations undertaken at Airly Mine to-date and there are no planned blasting operations in future activities.

6.4 AIR QUALITY

Air quality at Airly Mine is managed and monitored in accordance with Schedule 4, Condition 5 of SSD_5581, which requires that the air pollution generated by the development does not exceed the criteria listed in

Table 12**.**

Table 12: Air Quality Criteria

Table 5: Air quality criteria

Pollutant	Averaging Period	Criterion	
Particulate matter < 10 µm (PM_{10})	Annual	[a,d] 25 µg/m³	
Particulate matter < 10 µm (PM_{10})	24 hour	[a] 50 µg/m³	
Total suspended particulates (TSP)	Annual	[a,d] 90 µg/m³	
[c] Deposited dust	Annual	[b] 2 g/m²/month	[a,d] 4 g/m²/month

Notes to Table 5:
a Cumulative impact (ie increase in concentrations due to the development plus background concentrations due to all other sources).
[b] Incremental impact (ie increase in concentrations due to the development alone, with zero allowable exceedances of the criteria over the life of the development.
[c] Deposited dust is to be assessed as insoluble solids as defined by Standards Australia, AS/NZS 3580.10.1:2003: Methods for Sampling and Analysis of Ambient Air - Determination of Particulate Matter - Deposited Matter - Gravimetric Method.
[d] Excludes extraordinary events such as bushfires, prescribed burning, dust storms, fire incidents or any other activity agreed by the Secretary.
e "Reasonable and feasible avoidance measures" includes, but is not limited to, the operational requirements in conditions 6 and 7 to develop and implement an air quality management system that ensures operational responses to the risks of exceedance of the criteria.

6.4.1 Environmental Management

Management and monitoring of air quality is undertaken in accordance with the Western Region Air Quality and Greenhouse Gas Management Plan (WRAQGMP).

The air quality monitoring program at Airly Mine consists of the following:

- Four depositional dust gauges;
- One on-site Automatic Weather Station (AWS); and
- One HVAS (measuring Total Suspended Particulate [TSP] matter and Particulate Matter <10µm [PM_{10}]).

The measures summarised in **Table 13** below are currently being implemented at Airly Mine to minimise to the greatest extent practicable emissions to air.

Table 13: Airly Mine Air Quality Management/Mitigation Measures

Emission source	Emission type	Control measure
Unsealed roads	Dust	Use of water carts to dampen trafficable areas. Vehicle speeds restrictions.
Coal stockpiles	Dust	Use of water cannons/water sprays on coal stockpile, as required.
Train loading	Dust	The use of a train loader which produces a low and even profile of coal on the surface of the wagon and reduces spillages. Transporting coal with a high inherent moisture content.
Mobile Equipment	Exhaust emissions Dust	Regular maintenance of plant and equipment in accordance with the manufacturer's specifications to ensure optimal operating conditions.
Ventilation fans	Exhaust emissions	Use of low sulfur diesel and diesel engines that conform to the standards for exhaust emissions. Implementation of an underground dust suppression system involving the use of water sprays on coal cutting machinery and rubber conveyor belts.
Disturbance areas	Dust	Timely rehabilitation of disturbed areas wherever practical

Airly Mine operates a dust monitoring program which consists of four dust deposition gauges that are strategically located around mining operations and are analysed monthly. A review of this dust monitoring network was undertaken following issue of the Draft Conditions of Approval (SSD_5581) for the Airly Mine Extension Project in 2015. The aim of this review was to identify methods to improve the efficiency and value provided from the dust monitoring network. The review considered:

- Changes in the regulatory requirements since the previous Consent and EPL;
- Changes in operations and predicted dust impacts from supporting environmental assessments;
- Long term trends in monitoring data from Annual Reviews and monthly monitoring reports; and
- Complaints relating to air quality.

Consent SSD_5581 does not specify dust monitoring locations. The current monitoring programs consists of four depositional dust gauges and are described in **Table 14**, locations of the depositional dust monitors can be seen in **Figure 20**.

Table 14: Description and Summary of Air Quality Monitoring at Airly Mine

Monitor Point Reference	Description / Location
DG1	Dust gauge DG1 is located south of the operations and nearby a sensitive receiver location designated as A7 (isolated rural residence). This site was predicted to have very low impacts at this location and has not received complaints relating to dust.
DG2	Dust gauge DG2 was located near sensitive receiver A1. This receiver has been proven not to be adversely impacted by dust generation from mining operations. As such and in accordance with the approved WRAQGMP. A depositional dust monitoring gauge has remained in place at A1 and will continue to be sampled monthly until such time as EPL12474 variation is approved. There were nil air quality compliance issues at A1 during the 2021 reporting period. In accordance with the Long-Term Monitoring Program as described within the WRAQGMP, DG2 was relocated during the 2020 reporting period to be representative of A2.
DG3	Dust gauge DG3 is not at a sensitive receiver but is close to mine operations along Torbane Rd. If compliance is met at DG3, extrapolated compliance can be inferred for all sites to the west of the operation.
DG4	Dust gauge DG4 is located on mine-owned land to the southwest of the surface facilities. This location is upwind of the prevailing south-westerly winds and is utilised to determine impacts in the south westerly direction.
HVAS	As described within the WRAQGMP a HVAS (or equivalent) has been installed as part of the 'long term monitoring program'. The HVAS was installed and commissioned during 2020. Formal HVAS sampling and reporting of PM_{10} and TSP commenced on 1 January 2021. HVAS results can be seen within the monthly environmental monitoring reports which are available on the Centennial website.

6.4.2 Environmental Performance

6.4.2.1 Depositional Dust Summary – 2021

A summary of dust monitoring results from 2021 have been presented in **Table 15**.

Table 15: Air Quality Environmental Performance

Dust Monitor	Approval criteria	EIS / EA Predictions	Performance during the reporting period	Trend compared to previous years
DG1	2 g/m^2/month Max Annual Average Increase	<2 g/m^2/month annual average increase from the previous year.	Compliant. Annual average of DG1 for 2021 was 0.8 g/m^2/month which is the same result for the 2020 reporting period.	Consistent with previous years monitoring results and lower than EIS predictions.
	4 g/m^2/month Total Annual Average	<1.3 g/m^2/month cumulative impact at all Sensitive Receptors.	Compliant. Annual average of DG1 for 2021 was 0.8 g/m^2/month.	Consistent with previous years monitoring results and within EIS predictions
DG2	2 g/m^2/month Max Annual Average Increase	<2 g/m^2/month annual average increase from the previous year.	Compliant. Annual average of DG2 for 2021 was 0.4 g/m^2/month which is 0.2 g/m^2/month lower than 2020.	Consistent with previous years monitoring results and lower than EIS predictions.
	4 g/m^2/month Total Annual Average	<1.3 g/m^2/month cumulative impact at all Sensitive Receptors.	Compliant. Annual average of DG2 for 2021 was 0.4 g/m^2/month.	Consistent with previous years monitoring results and within EIS predictions.
DG3	2 g/m^2/month Max Annual Average Increase	<2 g/m^2/month annual average increase from the previous year.	Compliant. Annual average of DG3 for 2021 was 0.7 g/m^2/month which is 0.1 g/m^2/month higher than 2020.	Consistent with previous years monitoring results and within EIS predictions
	4 g/m^2/month Total Annual Average	<1.3 g/m^2/month cumulative impact at all Sensitive Receptors.	Compliant. Annual average of DG3 for 2021 was 0.7 g/m^2/month.	Consistent with previous years monitoring results and within EIS predictions
DG4	2 g/m^2/month Max Annual Average Increase	<2 g/m^2/month annual average increase from the previous year.	Compliant. Annual average of DG4 for 2021 was 0.6 g/m^2/month which is 0.2 g/m^2/month lower than 2020.	Consistent with previous years monitoring results and within EIS predictions
	4 g/m^2/month Total Annual Average	<1.3 g/m^2/month cumulative impact at all Sensitive Receptors.	Compliant. Annual average of DG4 for 2021 was 0.6 g/m^2/month.	Consistent with previous years monitoring results and within EIS predictions
HVAS PM_{10}	25 µg/m^3 Annual Average	Model predictions for current operations (Scenario 1a) show an Annual Average PM10 prediction of 9.7 µg/m^3 at	As per the approved Air Quality & Greenhouse Gas Management Plan, Airly Mine, the HVAS was installed and	Not applicable

Dust Monitor	Approval criteria	EIS / EA Predictions	Performance during the reporting period	Trend compared to previous years
		the most affected receptor (R2).	commissioned during 2020. Annual average of PM_{10} for 2021 was 8 µg/m^3	
	50 µg/m^3 24Hr Average	Model predictions for current operations (Scenario 1a) show a maximum cumulative 24Hr PM10 concentration of <43.4 µg/m^3 at all identified sensitive receiver locations.	As per the approved Air Quality & Greenhouse Gas Management Plan, Airly Mine, the HVAS was installed and commissioned during 2020. 24 hour average of PM_{10} for 2021 was 25 µg/m^3	Not applicable
HVAS TSP	90 µg/m^3 Annual Average	Model predictions for current operations (Scenario 1a) shows a predicted annual TSP concentration level of 19.7 µg/m^3 at the most affected receptor (R2).	As per the approved Air Quality & Greenhouse Gas Management Plan, Airly Mine, the HVAS was installed and commissioned during 2020. Annual average of TSP for 2021 was 12.94 µg/m^3	Not applicable

Depositional dust (g/m^2/mth) results (total insoluble solids) for 2021 are summarised in **Table 16** and monthly depositional dust (g/m2 /mth) results for 2021 are shown graphically in **Figure 12.** Depositional dust gauge (DDG) monitoring data indicates that dust deposition results for 2021 ranged from 2.0 g/m2/mth to 0.1 g/m2/mth. These are within set conditions included in Schedule 4, Condition 5 of the Airly Mine Development Consent SSD_5581.

There were no exceedances for depositional dust during the 2021 reporting period.

Table 16: Airly Mine – 2021 Depositional Dust Results

Data Published:		14/01/2022				Licensee:		Airly					
Data Sampled:		03/12/21 – 04/01/22				Address:		Glen Davis Road, Capertee NSW 2846					
Data Obtained:		14/01/2022				EPL No.		12374					
	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21	Annual Average
DM1	0.6	0.7	1.5	0.1	1.7	2.0	0.5	0.3	0.6	0.6	0.5	1.0	0.8
DM2	5.8*	0.6	0.4	0.2	0.2	0.2	0.4	0.2	0.4	0.7	0.6	0.5	0.4
DM3	0.5	0.3	0.4	0.2	0.2	0.1	1.0	0.9	1.0	0.6	0.8	1.9	0.7
DM4	0.5	0.3	1.3	0.4	0.3	0.2	0.4	0.2	0.6	0.8	1.5	0.7	0.6
Criteria	Annual Average Limit (4g/m^2/mth)												

* Sample contaminated by external factors such as bird droppings and insects. Sample result excluded from annual average.

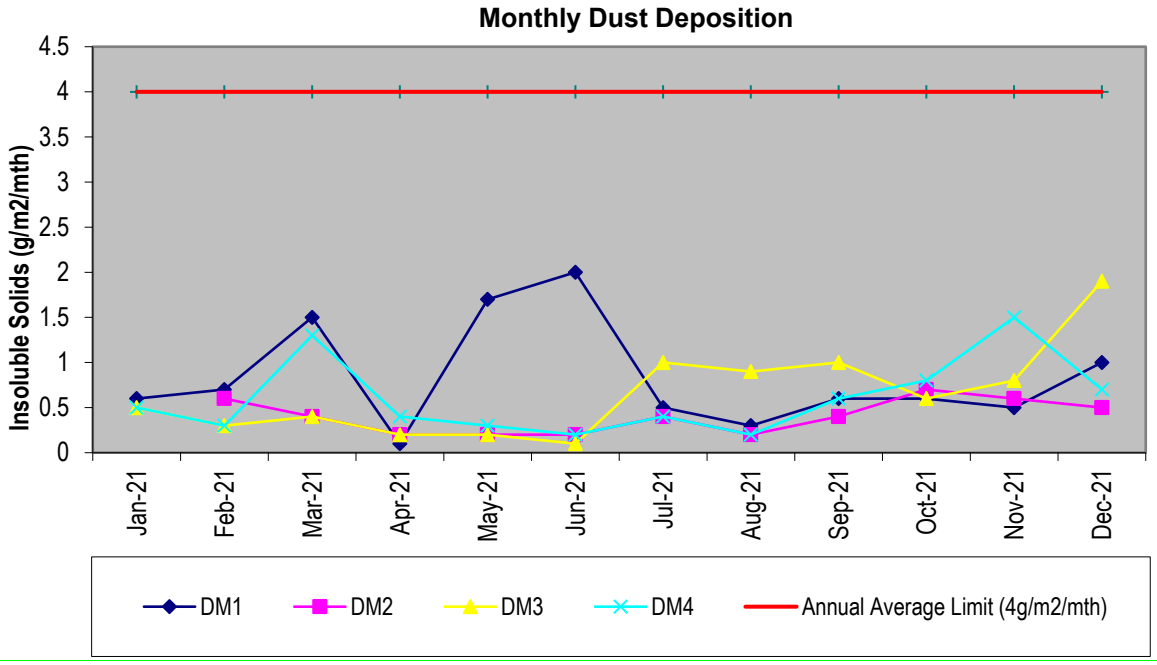


Figure 12: Monthly Depositional Dust Results for 2021

Historic trends in depositional dust data is graphically represented below in **Figure 13**, **Figure 14**, **Figure 15** and **Figure 16**. Dust monitoring results from 2015 – 2020 have been provided to demonstrate trends in of monthly results for each depositional dust monitoring location. **Figure 17** provides a comparison of the annual average of depositional dust trends over the past 5 years.

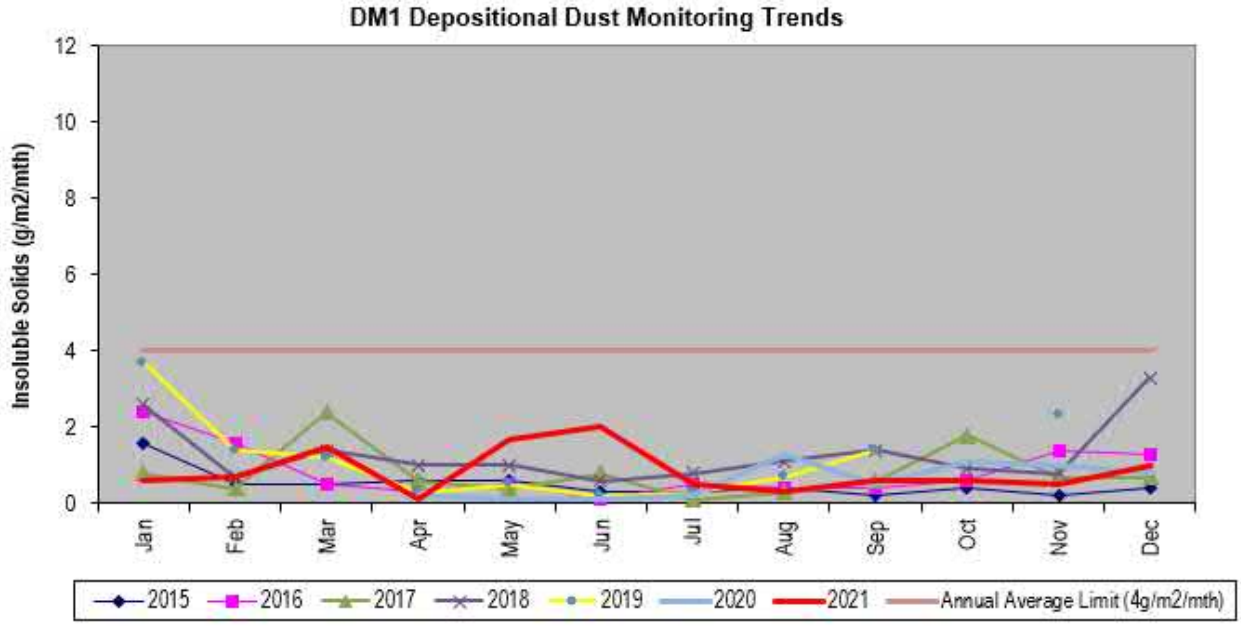


Figure 13: Airly Mine – Historic Trends in Depositional Dust – DM1

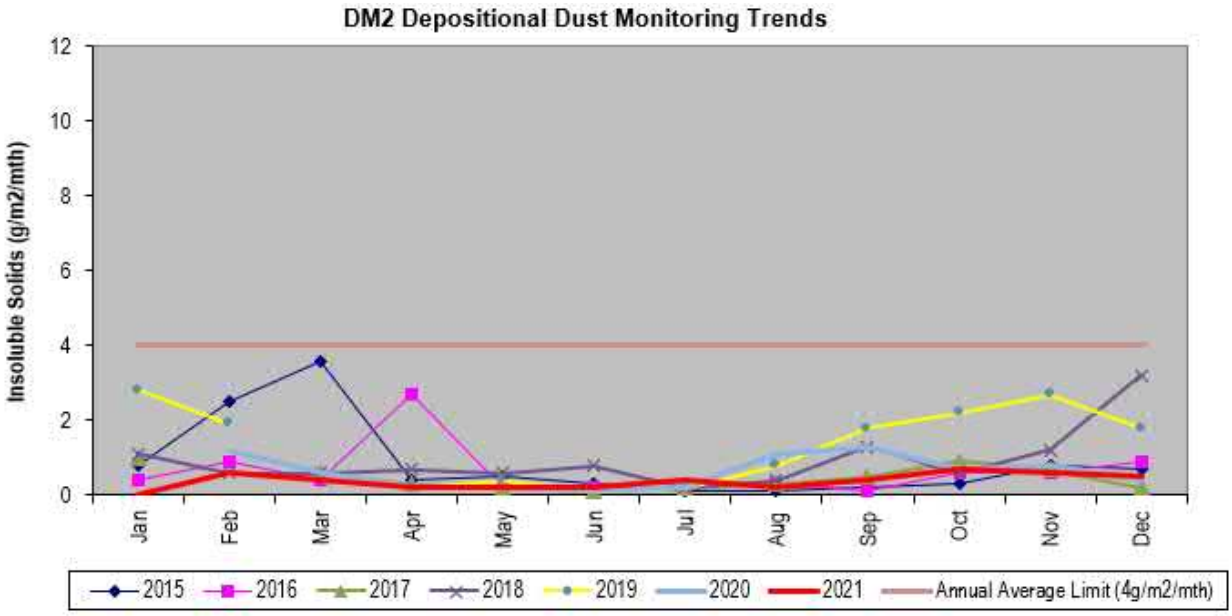


Figure 14: Airly Mine – Historic Trends in Depositional Dust – DM2

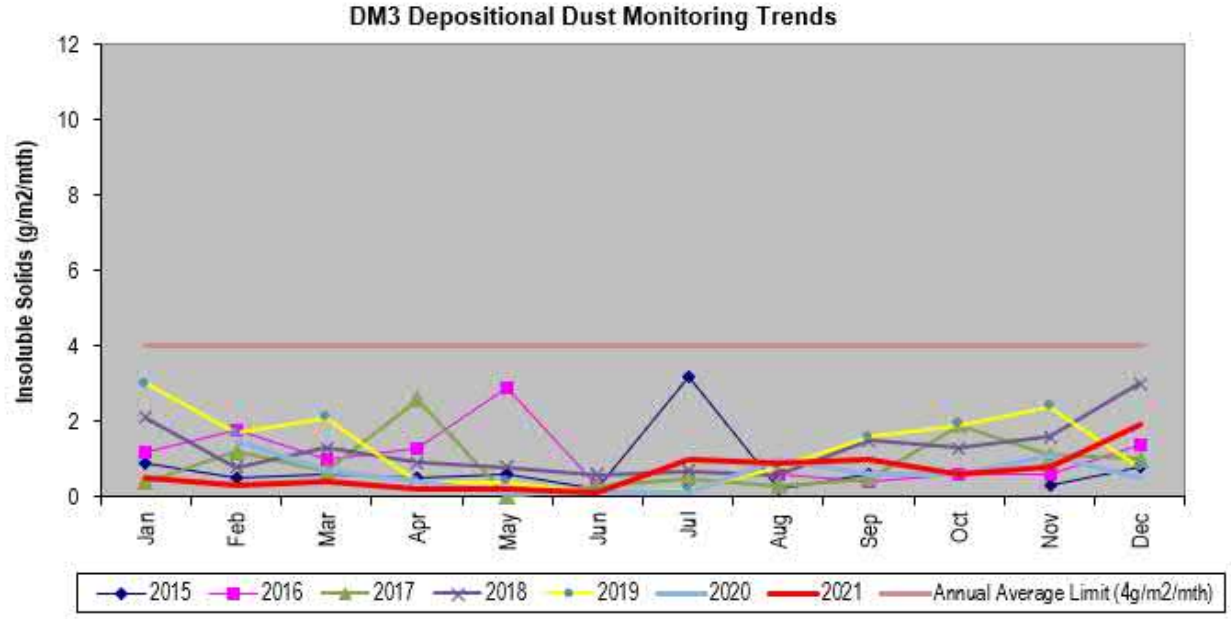


Figure 15: Airly Mine – Historic Trends in Depositional Dust – DM3

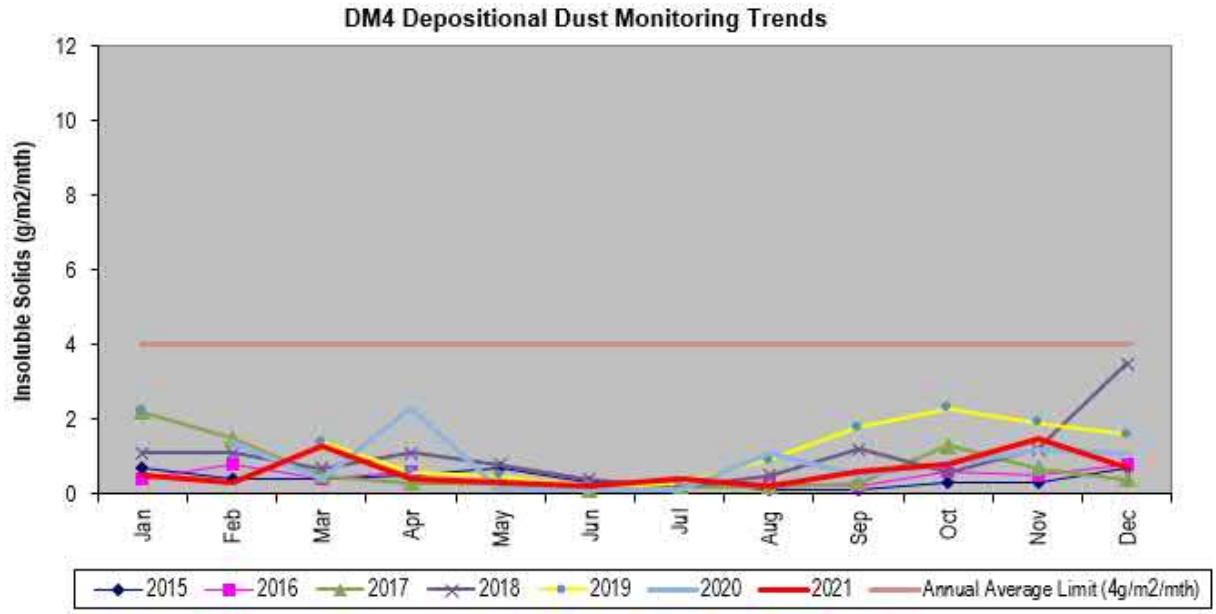


Figure 16: Airly Mine – Historic Trends in Depositional Dust – DM4

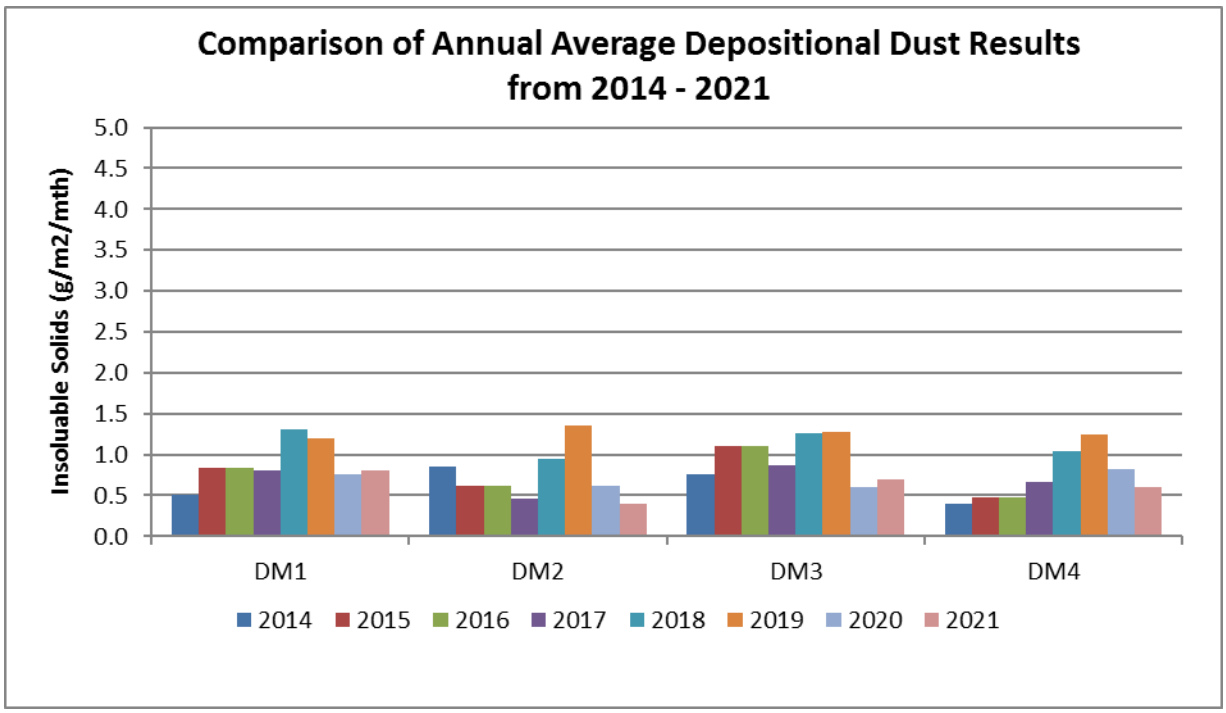


Figure 17: Annual Depositional Dust Averages – 2014 to 2021

6.4.3 HVAS Monitoring Results – 2021

HVAS monitored particulate concentrations (less than 10 micrometres in size [PM_{10}] and Total Suspended Particulates [TSP]) during the reporting period. A summary of monitoring results for 2021 is provided below in **Table 17** and **Table 18**. A graphical summary of the monitoring results for the 2021 reporting period is provided in **Figure 18** and **Figure 19.**

Table 17: Airly Mine HVAS TSP Monitoring Results – 2021

Gauge	Annual Average (µg/m3) (excluding extraordinary events)
	TSP (µg/m³)
Consent Criteria	**90**
HVAS	12.94

Table 18: Airly Mine HVAS PM_{10} Monitoring Results - 2021

Gauge	Annual Average	Maximum 24-hour Average PM10 (µg/m³)
	PM10 (µg/m³)[1]	PM10 (µg/m³)[1]
Consent Criteria	**25**	**50**
HVAS	8.0	25

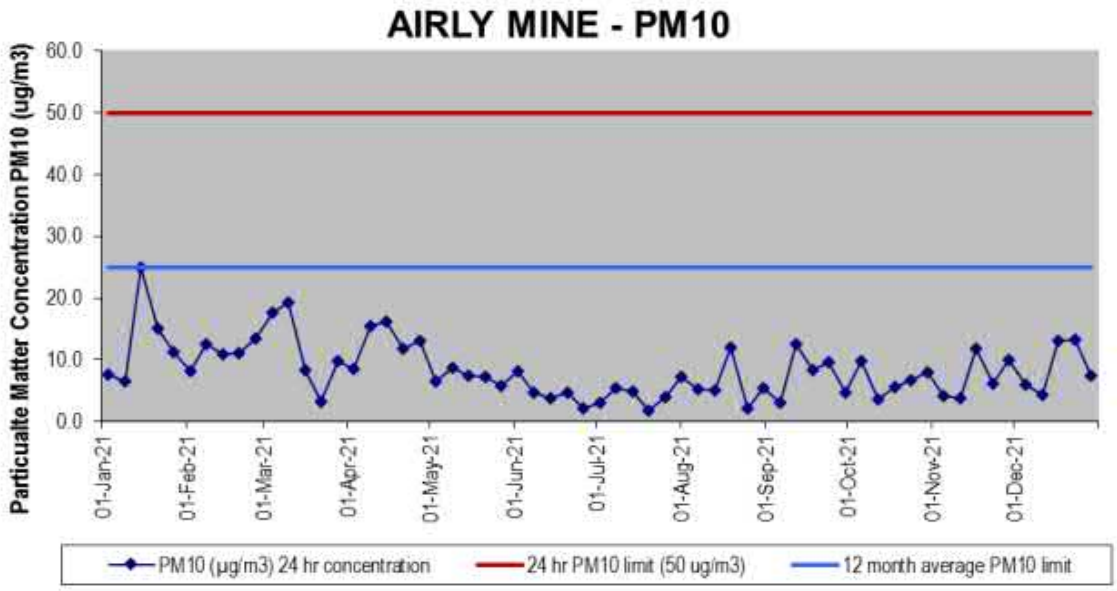


Figure 18: PM_{10} Monitoring Results – 2021

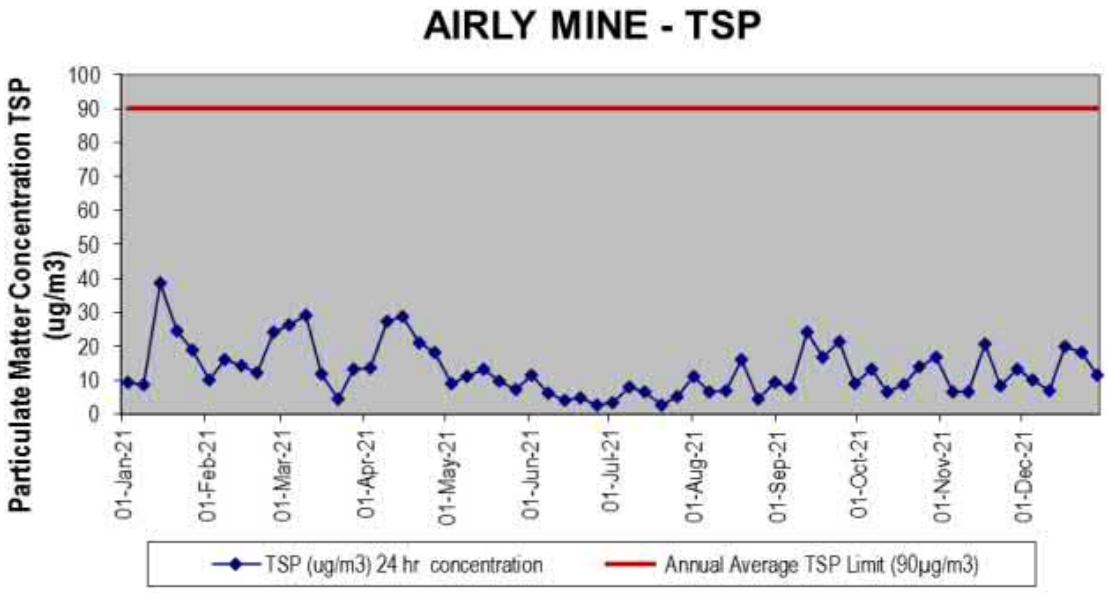


Figure 19: TSP Monitoring Results - 2021

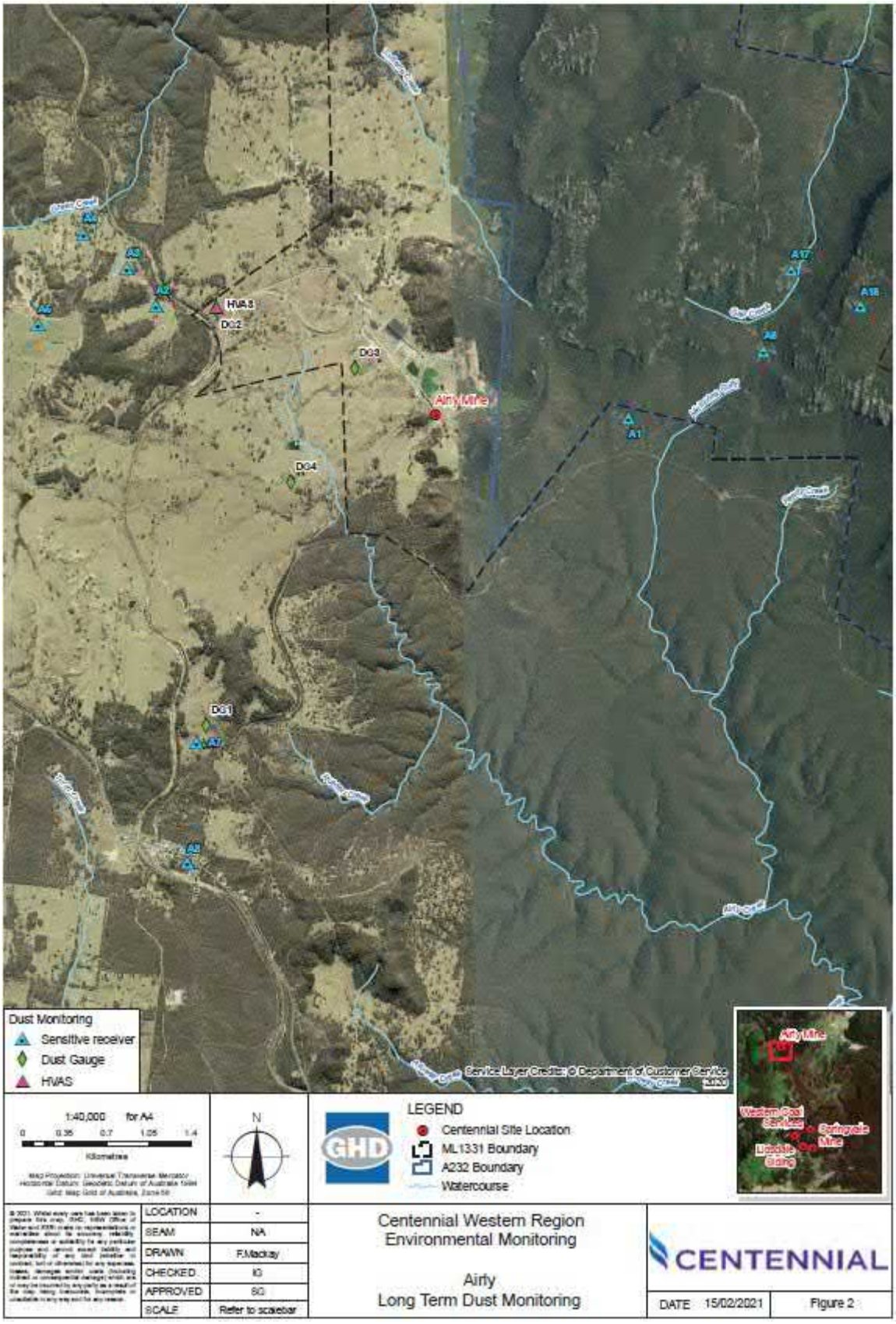


Figure 20: Airly Mine – Dust Monitoring Locations

6.4.4 Comparison against Predictions

There are no identifiable trends in historic data in relation to Airly Mine operations. Instead, the graphical data from 2014 to 2021 (as shown in **Figure 17**), suggests a direct correlation between depositional dust results and seasonal variability. As Airly Mine is a relatively low dust emission source, the depositional dust monitoring results are largely representative of the background air quality. This is supported by the fact the dust monitoring sites closer to the Airly operations often record lower results than the designated background site at DM1.

The slight increase in depositional dust monitoring results for all DDG's for 2018 & 2019 appear to be directly correlated with prolonged drought conditions, regional dust storms and long periods of elevated bushfire smoke. The reduction in the depositional dust monitoring results for the 2021 period can largely be attributed to the improvement in the background air quality brought about by a return to average seasonal rainfall.

6.5 BIODIVERSITY

6.5.1 Environmental Management

Biodiversity monitoring throughout the Development Consent Area for SSD_5581 is currently being undertaken in compliance with the Airly Biodiversity Management Plan (BMP) required by Schedule 4, Condition 17 of SSD-5581.

Ongoing seasonal ecological monitoring has been conducted since 2012 to examine the potential effects, if any, of underground mining on threatened species and communities of flora and fauna that are present onsite. The monitoring methodology has been refined and adjusted to specifically target threatened species, populations and communities and to identify potential changes to these overtime as a result of mining activities on site. All ecological monitoring locations are shown in **Appendix 4**. Compliance with biodiversity related conditions of Development consent SSD_5581 are outlined in **Table 19**.

Table 19: Compliance with Biodiversity related Conditions of Development Consent SSD_5581

Schedule/ Condition	Action	Compliant
Schedule 3 Condition 2	Negligible environmental consequences to threatened species, threatened populations, EEC and groundwater dependant ecosystems	Yes
Schedule 4 Condition 17	Prior to carrying out any development under this consent that would cause surface disturbance, the Applicant must prepare a Biodiversity Management Plan for the development to the satisfaction of the Secretary. This Plan Must:	
	• Be prepared in consultation with OEH and DoE;	Yes – As per Airly Site Specific BMP
	• Established baseline data for existing remnant vegetation and habitat on site, including mapping of the location of Pultenaea sp. Genowlan Point;	Yes – Baseline data has been established and outlined in the 'Baseline Data – Terrestrial Ecology' section of the Airly Site Specific BMP. Mapping of *Pultenaea sp.* Genowlan Point has been conducted independently by NSW National Parks and Wildlife Services (NPWS).
	• Describe the short, medium and long term measures that would be implemented to manage the remnant vegetation and habitat on site, including but not limited to; - *Prostanthera stricta* (Mt. Vincent Mintbush);	Yes – Management measures for *Prostanthera stricta* and *Eucalyptus cannonii* are managed via monitoring programs outlined in this report. Management measures for Pultenaea sp. Genowlan Point and Genowlan Point *Allocasuarina nana* Heathland will be undertaken and described by NSW NPWS.

Schedule/ Condition	Action	Compliant
	- *Eucalyptus cannonii* (Capertee Stringybark); - *Pultenaea sp. Genowlan Point*; and - Genowlan Point *Allocasuarina nana* Heathland.	
	• Include a detailed description of the measures that would be implemented to: • Minimise the impacts to fauna of site, including undertaking pre-clearance surveys; • Avoid and mitigate the spread of *Phytopthora cinnamon* (*P. cinnamomi*); • Control weeds and Feral pests including, but not limited to goats, rabbits, European Red Fox, cats and pigs; • Manage salinity; • Control erosion; • Control Access; and • Manage bushfire risk	Yes; 1. Western Region BMP Section 4.3 Surface disturbance activities describes the procedure for all surface disturbance activities, including the completion of the Centennial Coal Land Disturbance Protocol. 2. Measures to avoid and mitigate the spread of *P. cinnamomi* are addressed in the Management section of the Airly Site Specific BMP 3. Management in State Conservation Area undertaken by NPWS. The incursion and spread of weeds and feral animals is monitored opportunistically as part of the annual Airly monitoring program 4. Addressed in Airly Water Management Plan 5. Addressed in Airly Water Management Plan 6. Control access is currently being implemented via the use of gates and signage throughout the Airly lease 7. Implemented as per Airly Site Specific BMP
	• Include a program to monitor and report on the effectiveness of these measures and progress against the detailed performance and completion criteria;	Yes – Management Section of the Airly Site Specific BMP describes the monitoring program to demonstrate the effectiveness of management measures. The requirements for reporting against the BMP are included in the Western Region BMP Section 5.4.
	• Include details of who would be responsible for monitoring, reviewing and implementing the plan	Yes – Identification of responsible persons for monitoring, reviewing and implementing the Western Region BMP are included in Section 5.1 of that BMP.
Schedule 6 Condition 11	• describe the development (including any rehabilitation) that was carried out in the previous calendar year, and the development that is proposed to be carried out over the current calendar year;	Yes - Addressed within the Airly Mine Annual Review document
	• Include a comprehensive review of the monitoring results and complaints record of the development over the previous calendar year, which includes a comparison of these results against: • the relevant statutory requirements, limits or performance measures/criteria; • the monitoring results of the previous years; and • the relevant predictions in the documents listed under condition 2(a) and the IPRP's Report;	Yes - Addressed within Sections 2, 3, 4 and 5 of Appendix 4. Note: IPRP's report does not have any specific recommendations relating to ecological monitoring
	• Identify any non-compliance over the last year, and describe what actions	Yes – No non-compliance issues have arisen in relation to biodiversity monitoring for 2020.

Schedule/ Condition	Action	Compliant
	were (or are being) taken to ensure compliance;	
	• Identify any trends in the monitoring data over the life of the development;	Yes - Addressed in Sections 3 and 4 of Appendix 4.
	• Identify any discrepancies between the predicted and actual impacts of the development, and analyse the potential cause of any significant discrepancies; and	Yes - There have been no discrepancies between the predicted and actual impacts of Airly Mine operations on any ecological parameters. See Section 3 and 4 of Appendix 4.
	• describe what measures will be implemented over the next year to improve the environmental performance of the development.	Recommended improvement opportunities are provided in Section 4 of Appendix 4.

Airly 2021 Flora Surveys Included:

- Point transects and floristic density plots for known locations of Prostanthera stricta;
- Tree health assessment for eighteen individual Eucalyptus cannonii to measure condition, crown extent, growth changes and associated species in relation to prior monitoring; and
- Biodiversity Assessment Method (BAM) plots to assess vegetation condition and species richness within Capertee Rough-barked Apple – Redgum – Yellow Box Grassy Woodland (MU20) Endangered Ecological Community (EEC).

Airly 2021 Fauna Surveys Included:

- Six site assessments within suitable habitat dominated by *Allocasurina littoralis* to assess the presence and age of chewed orts, which is a primary food-source for the Glossy Black- Cockatoo (*Calyptorhynchus lathami*);
- Call playback and spotlighting for large forest owls in addition to visiting known roosts to ascertain the level of continued activity in the area;
- 30-minute surveys across permanent transects and opportunistic surveys in suitable habitat to target threatened bird species known to occur across the site and in the local area;
- Targeted surveys via echolocation recording apparatus (Anabat) at foraging, roosting sites and flyways of cave-dwelling microbats;
- Targeted trapping surveys and remote cameras in gully habitats and lower lying rocky habitats within the Airly Mine consent boundary to develop a vertebrate census; and
- Opportunistic surveys of all terrestrial vertebrates.

For further details regarding methodology see **Appendix 4**.

Key Results:

The following key results were obtained from the 2021 monitoring activities:

Mount Vincent Mintbush (*Prostanthera stricta*): No mining related change was detected. The controlled burn that was conducted on Mount Airly in May 2018 resulted in the reduction of large areas of *P. Stricta* in the 2020 monitoring period, It was recorded that all the plots in 2021 exhibited a significant increase in percent

cover of *P. Stricta* when compared with the 2020 survey period, particularly in Transects 1, 2, 3 and 4.

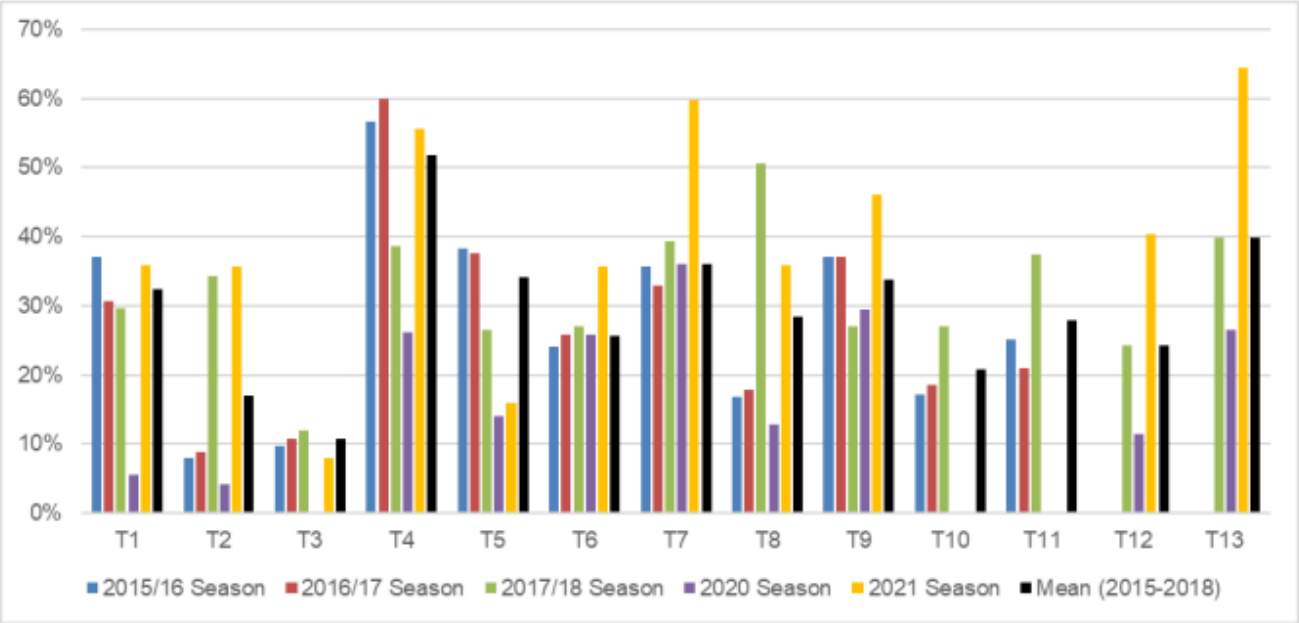


Figure 21: Percentage cover of Prostanthera stricta

- **Capertee Stringybark (*Eucalyptus cannonii*):** No change detected

- **Capertee Rough-Barked Apple – Redgum – Yellow Bow Grassy Woodland (MU20):** No mining related change detected. 2021 vegetation surveys within MU20 demonstrated the highest plant species richness to date. There was a substantial increase in native species richness in quadrats 1 and 2 in the 2021 survey period with Plot 1 having the highest species richness (n=88). The primary contributing factor to this result is likely due to comparatively higher rainfall recorded in 2021 (with BAM data collected in February 2021).

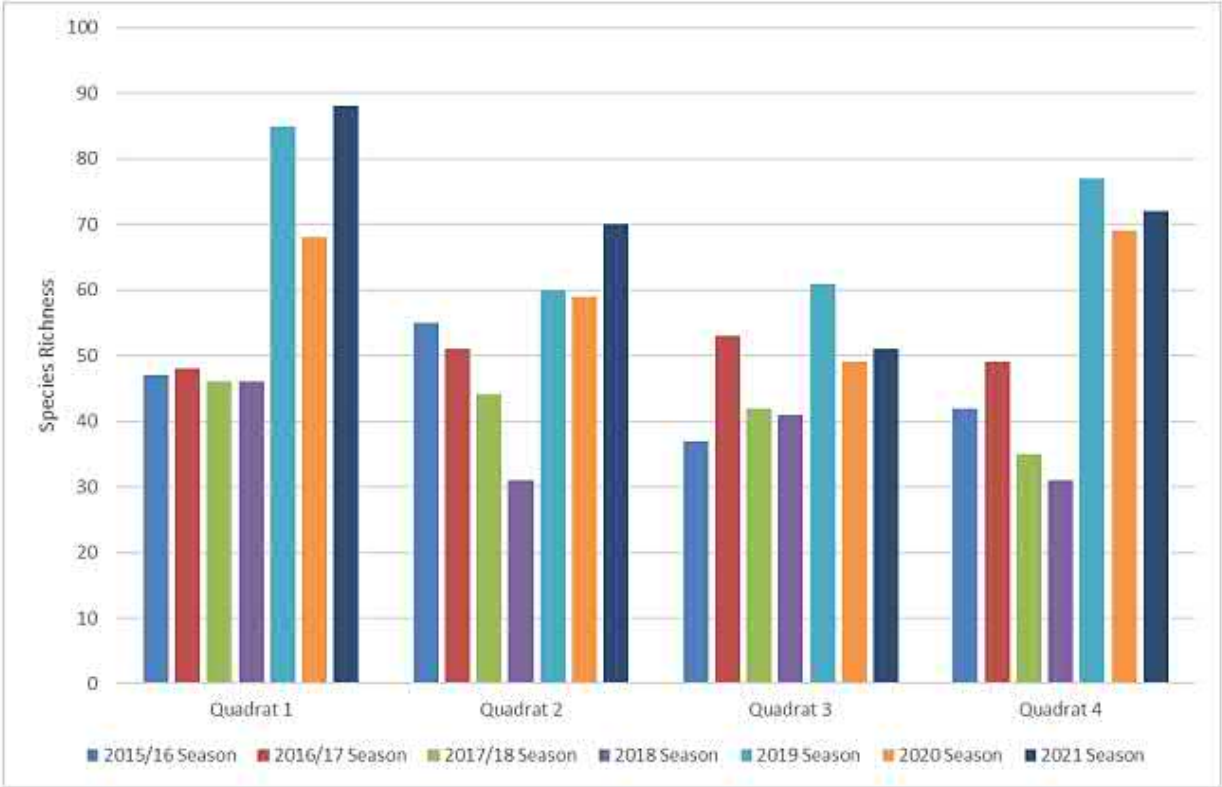


Figure 22: MU20 Plot Species Diversity

- **Glossy Black-Cockatoo:** The continued presence of Glossy Black-Cockatoos within the Airly mining lease boundary was confirmed through sightings and the presence of 'Orts' at six separate monitoring locations.
- **Sooty and Powerful Owl:** Three of four locations where Powerful and Sooty Owls have previously been observed were surveyed in February and November 2021. Site 2 was inaccessible due to a landslide at the base of Mount Airly. Searches were conducted for owl pellets and whitewash. No roost sites displayed indirect evidence of use; However, a Sooty Owl was observed on Mount Airly during spotlighting near roost site 3 in November 2021.
- **Cave Dwelling Microbats:** Two of the three target microbat species were detected during both spring and summer surveys, being the Eastern Horseshoe-bat (Rhinolophus megaphyllus) and the Large-eared Pied-bat (Chalinolobus dwyeri). The Eastern Bentwing-bat (Miniopterus schreibersii oceanensis) was possibly detected at Anabat 8, given the high number of calls, and location at a known bat roost, it is likely that the Eastern Bentwing-bat (Miniopterus schreibersii oceanensis) is roosting there. Fifteen microbat species were recorded in total, One threatened microbat species, the Large-eared Pied Bat (Chalinolobus dwyeri) was confidently detected in the 2021 monitoring period.
- **Bird Census:** A total of 52 species were recorded across these sites in both February and November (excluding opportunistic bird observations during all surveys). This result displayed a slight decrease on the previous year's results. A number of threatened bird species were recorded, including the Brown Treecreeper, Gang-gang Cockatoo and Glossy Black-Cockatoo. The Varied Sitella was observed during the 2020 monitoring period, however was not observed during this reporting period. The results are depicted in **Figure 23**.

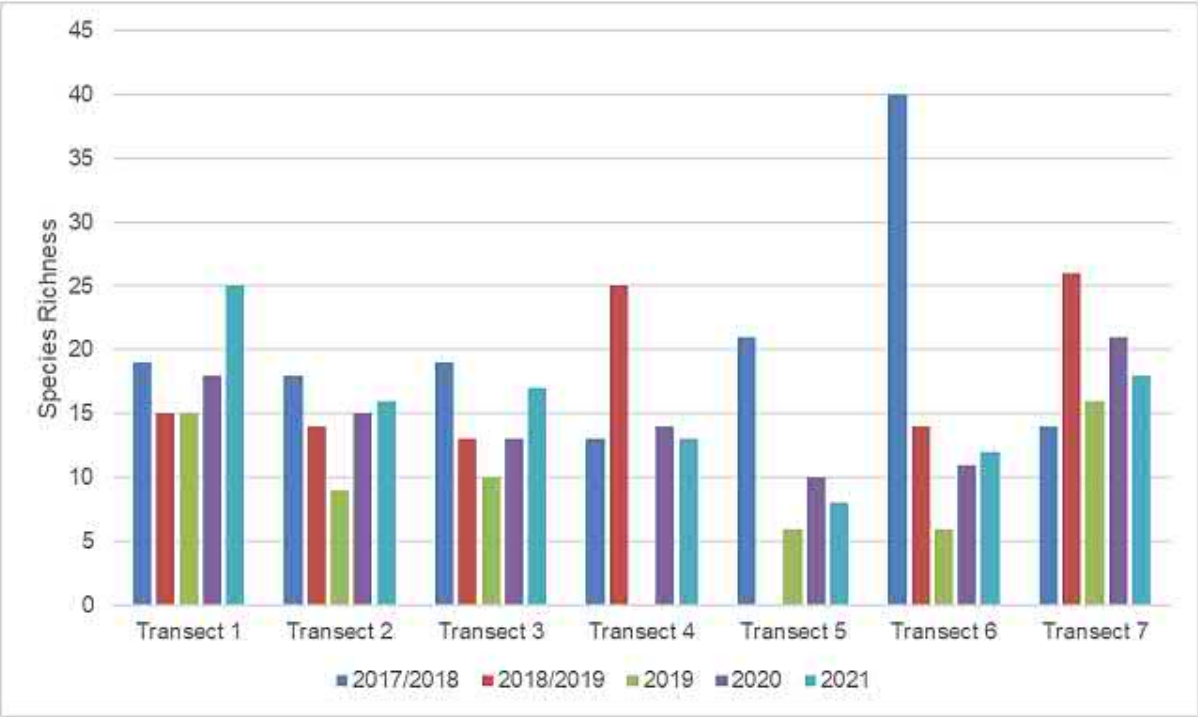


Figure 23: Diurnal Bird Transect Species Diversity

- **Targeted threatened fauna search:** No Spotted-tailed Quolls Broad-headed Snakes were identified within the site during 2021 surveys. The Rosenberg's Goanna (*Varanus rosenbergi*: Vulnerable under the BC Act) was observed at Point Hatteras for the second year in a row.

- The total number of vertebrate species recorded on site during 2021 annual monitoring was 35. Of the species recorded, three species are listed under the BC Act and/or EPBC Act, including:

- Koala (*Phascolarctos cinereus*) (Vulnerable under the BC Act and Endangered under the EPBC Act);

- Greater Glider (*Petauroides volans*) (Vulnerable under EPBC Act);

- Rosenberg's Goanna (*Varanus rosenbergi*) (Vulnerable under the BC Act);

Conclusion:

Monitoring in 2021 revealed the overall presence and condition of threatened flora and fauna as comparable to previous monitoring seasons.

Annual monitoring shows that conditions of consent have been adequately addressed and performance criteria have been met.

The full 2021 Annual Ecological Monitoring Report is provided in **Appendix 4**

6.6 HERITAGE

6.6.1 Environmental Management

There were no non-compliances relating to heritage matters during the 2021 reporting period. The Western Aboriginal Cultural Heritage Committee Meetings were held on the 12 May and the 17 November 2021. The presentations included operational updates, compliance reporting, sites undermined and environment and community updates.

As per mine schedule and with reference to **Figure 24**, no registered Aboriginal heritage sites were undermined during 2021.

In accordance with the ACHMP, the monitoring program for all undermined sites consists of pre and post mining inspections. This is done to ensure that no mining induced impacts to the site have occurred. As such, the monitoring program has been split into three phases:

- Phase 1: Baseline recording (prior to site being undermined);
- Phase 2: Post mining initial condition; and
- Phase 3: Post mining secondary inspection (greater than 8 months after mining).

Monitoring phases 1 and 2 were completed on site 45-1-2748 during 2017 and as expected, no mining induced impacts being observed. The final phase 3 inspection of the site was completed in December 2020.

Additionally, following higher than predicted subsidence levels on Mt Airly, a periodic in field assessment of all cultural heritage sites within the Project Area was completed in August 2020. No mining related impacts were observed at any of the registered sites.

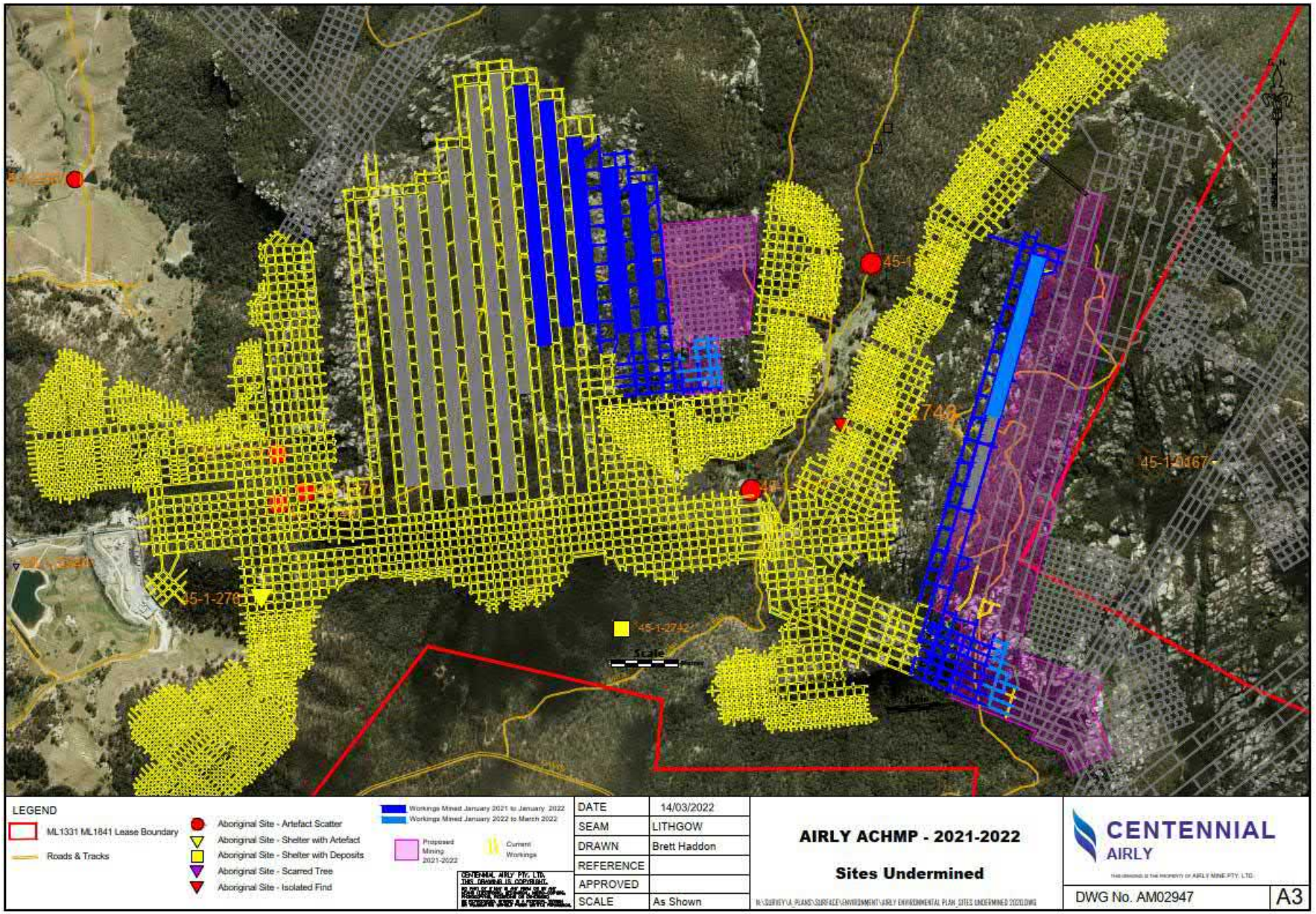


Figure 24: Airly Mine 2021 Working and Proposed 2022 Working in Relation to Registered Aboriginal Sit

6.7 WASTE MANAGEMENT

The major waste streams generated by the mine include water, packing materials, paper, cardboard, wood, waste oil, oil filters, air filters, oil drums, scrap metal, hoses, sewage effluent, as well as general putrescible rubbish. A summary of Airly's disposed and recycled waste for 2021 is presented in **Table 20** and graphically in **Figure 25**, **Figure 26**, **Figure 27** and **Figure 28**.

During 2021, Airly Mine continued to operate a waste sorting system to improve site waste management and recycling efficiencies. The system works by placing all pit top and underground solid waste on a large concrete pad. The waste is then sorted once per week by a qualified waste technician into the correct waste or recycling bins. The system has proven to be very successful in improving recycling efficiencies and Airly will continue to utilise and refine the system in the next reporting period.

Figure 25 below shows the concrete waste sorting pad, general waste bin and scrap metal bin; other recycling bins are located beyond the extent of the photograph.

Figure 26 below shows the waste oil system, consisting of two waste oil bins sitting under cover on a bunded concrete slab.

Whilst waste recycling percentages was lower in 2021 compared to previous years, this can be attributed to reduced scrap steel removal volumes. During 2021 Airly Mine was more efficient in the reduction and re-use of scrap steel items on site which resulted in only 25.7 tonnes of scrap steel being removed from site compared to nearly 44.65 tonnes for the previous year/s.

There were no non-compliances at Airly Mine in relation to waste or sewage management during the 2021 reporting period.



Figure 25: Airly Mine – Waste Sorting Area



Figure 26: Airly Mine – Waste Oil Area

Table 20: Airly Mine – 2021 Disposed and Recycled Waste Summary

Date	Hazardous Disposed (Tonnes)	Non-Hazardous Disposed (Tonnes)	Hazardous Recycled (Tonnes)	Non-Hazardous Recycled (Tonnes)	Contained On-site (Tonnes)	Recycled (%)
Jan – 2021	0	17.445	0	0.345	0	**1.94**
Feb – 2021	0	24.260	0.188	9.050	0	**27.58**
Mar – 2021	0.868	23.670	4.200	0.465	0	**15.97**
Apr – 2021	0	8.780	1.4	5.823	0	**45.14**
May – 2021	0	33.140	0	4.675	0	**12.36**
Jun – 2021	0.194	26.820	0.9	4.155	0	**15.76**

Date	Hazardous Disposed (Tonnes)	Non-Hazardous Disposed (Tonnes)	Hazardous Recycled (Tonnes)	Non-Hazardous Recycled (Tonnes)	Contained On-site (Tonnes)	Recycled (%)
Jul – 2021	0	22.340	0	0.660	0	**2.87**
Aug – 2021	0.218	23.515	1.3	0.485	0	**7.00**
Sep – 2021	0.018	21.650	0.032	5.525	0	**20.41**
Oct – 2021	0	22.755	1.25	0.535	0	**7.27**
Nov – 2021	0	27.330	0	0.370	0	**1.34**
Dec - 2021	2.356	42.590	0.7	0.460	0	**2.52**
TOTAL:	**3.654**	**294.295**	**9.970**	**32.548**	**0**	**13.34**

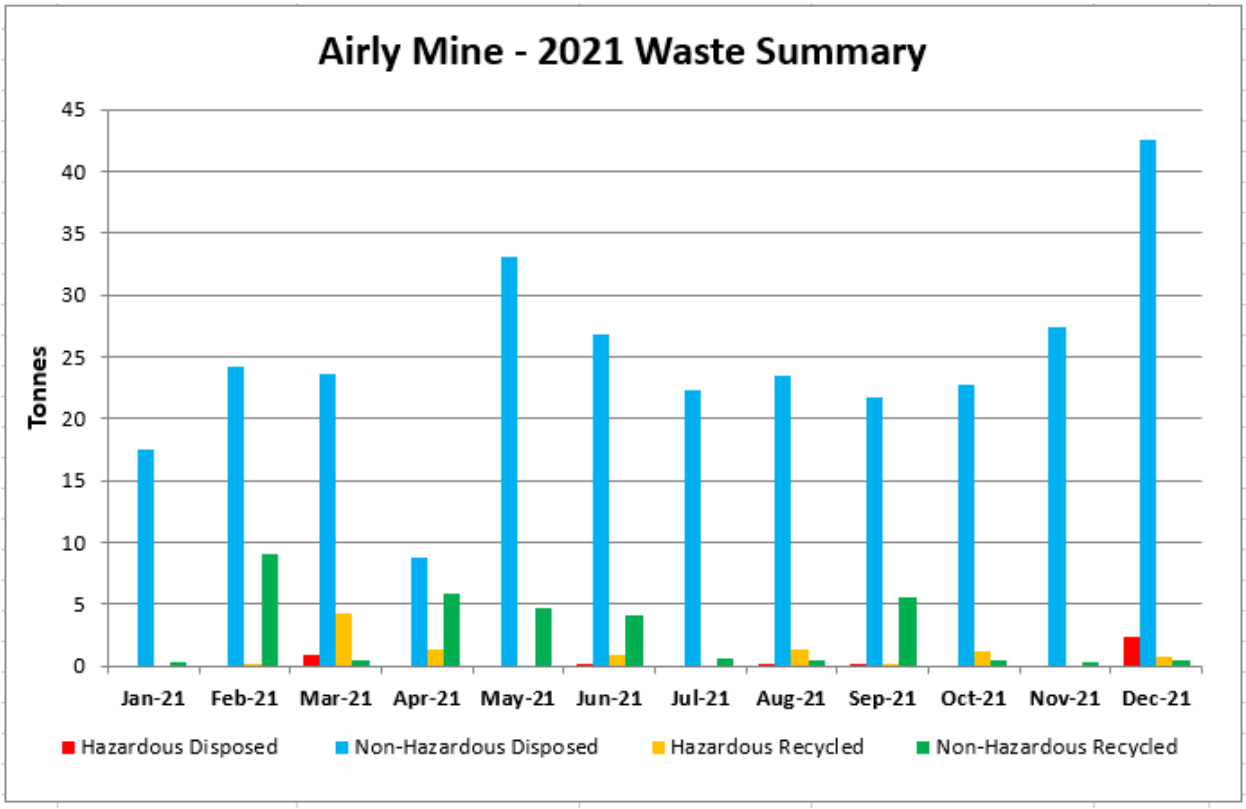


Figure 27: Airly Mine – 2021 Waste Summary

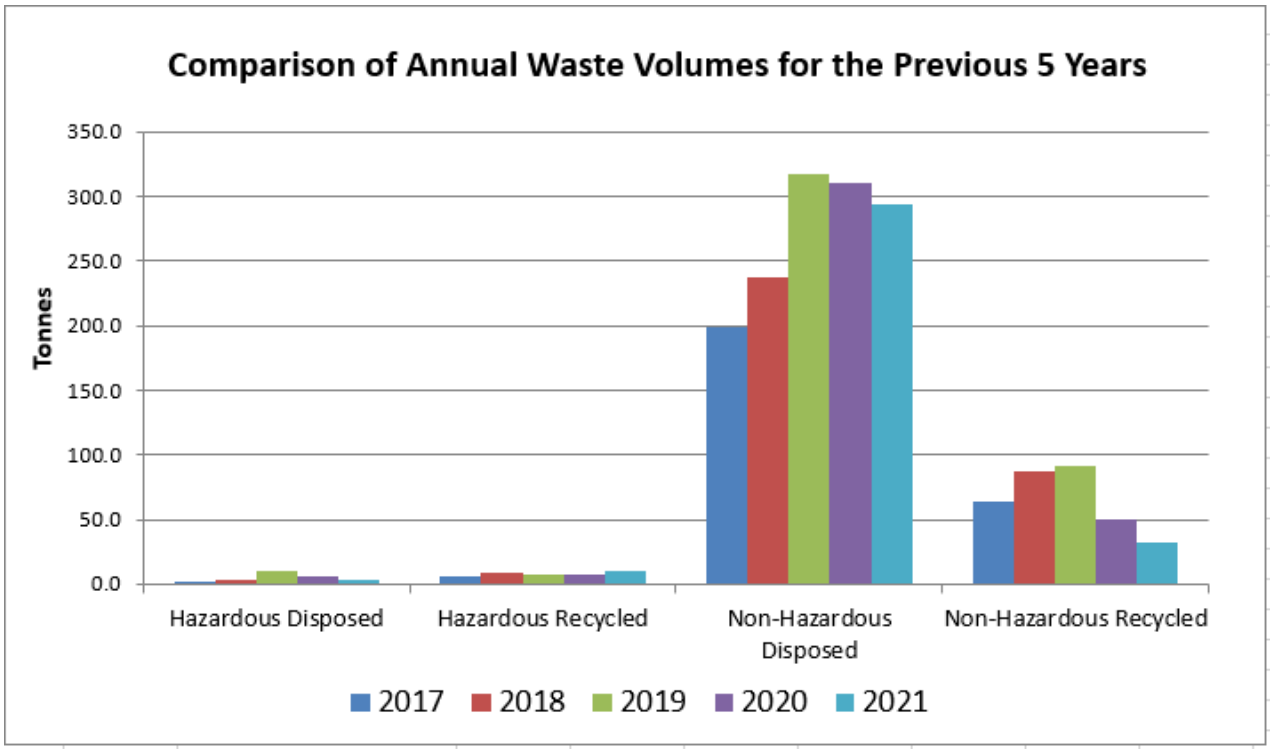


Figure 28: Airly Mine – Waste Summary Comparison

6.8 GREENHOUSE GAS

6.8.1 Environmental Management

Airly Mine currently implements an Energy and Greenhouse Gas Management System that monitors and reports energy usage. Key performance indicators are tracked and include energy demand and greenhouse gas (GHG) emissions per tonne of ROM coal produced. In accordance with Centennial Coal's standard for GHG reporting, the 2021 financial year (FY 1 July 2020 to 30 June 2021) emissions in CO2 equivalent tonnes (CO2-et) as defined in the National Greenhouse and Energy Reporting Act 2007 are provided in **Table 21** and presented in **Figure 29.**

Total GHG emissions from Airly Mine for the 2021 FY period were 15,135 CO2-et; this is an 3% increase on the 14,762 CO2-et GHG emissions for 2020. The increased total emission for 2021 can be attributed to a 52% increase in coal production from the previous reporting period. Furthermore, the 52% increase in fugitive CO2 is due to the increased coal extraction during FY 2021. The 20% reduction in emissions from electricity can be attributed to the influence of electricity supplied from the solar farm installed in 2020.

Table 21: Total GHG Emissions from Airly Mine

Scope	Emission Source	Estimated Emissions (CO_2-et)		Variance from Previous Reporting Period
		FY20	FY21	
1	Diesel combustion	1,466	1,400	-5%
1	Oil/Grease consumption	218	170	-22%
1	SF_6	5	11	120%
1	Fugitives - CH_4	0	127	NA*
1	Fugitives - CO_2	3,627	5,872	62%
Total Scope 1		**5,316**	**7,580**	**43%**
2	Electricity consumption	9,446	7,555	-20%
Total Scope 2		**9,446**	**7,555**	**-20%**
Scope 1 and 2 Emissions		**14,762**	**15,135**	**3%**

*CH4 data was not available for FY2020

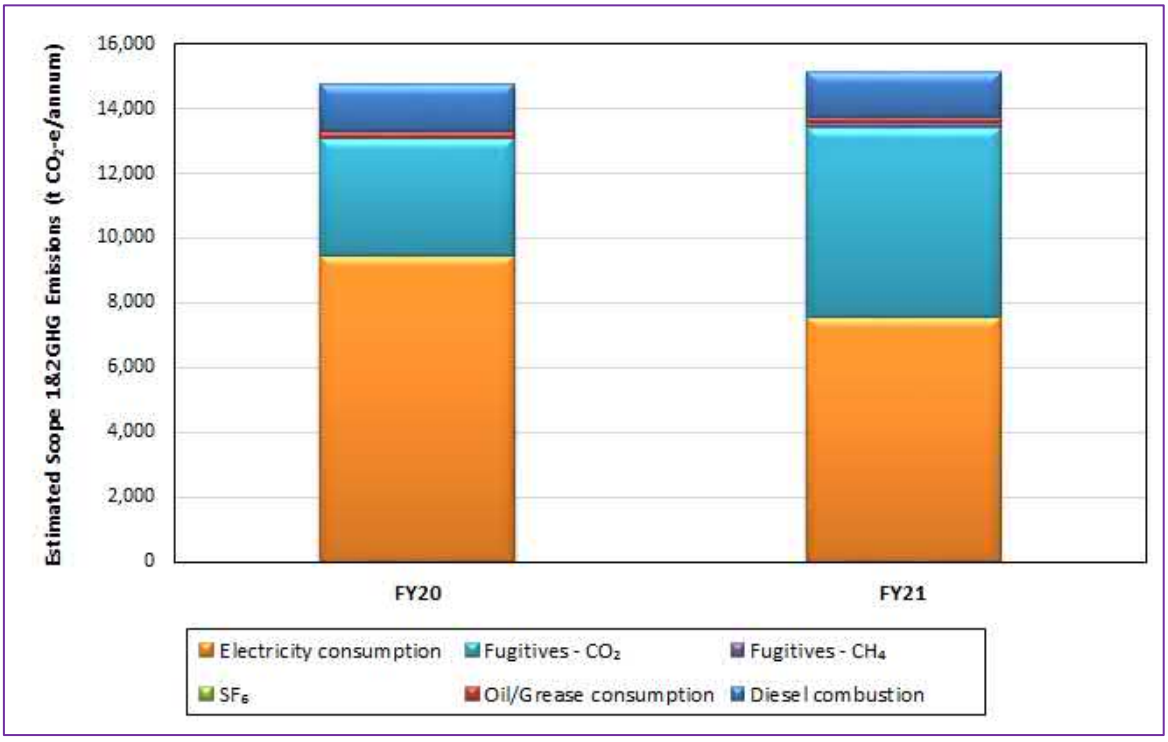


Figure 29: Scope 1 and Scope 2 GHG Emissions from Airly Mine

Airly Mine has relatively low GHG emission levels and implements a number of GHG emission reduction measures on site, including:

- Engineered mine and infrastructure design to improve energy efficiency;
- Regular maintenance of plant and equipment to minimise fuel consumption; and
- Consideration of energy efficiency in plant and equipment selection.

There were no non-compliances relating to GHG emissions or management measures during the reporting period. Airly will continue to monitor and implement GHG management and reduction measures during the next reporting period.

6.9 MINE SUBSIDENCE

On 15 December 2016, Airly Mine received State Significant Development (SSD_5581) consent to operate an underground coal mine using partial extraction techniques. Since SSD_5581 was granted, the consent has been modified twice. Mod 1 allows:

- Constraints on proximity of panel and pillar mining adjacent to cliffs.
- Constraints on pillar splitting and quartering operations in areas downslope of cliffs in the Partial Pillar Extraction Zone.
- No second workings within the 26.5-degree angle of draw plus 50 metres from the limit of the New Hartley Shale historic workings.

The second modification allows Airly to receive up to 170 megalitres of water per year, via rail from Charbon Colliery.

Predicted impacts

The 2014 Airly EIS report predicted the maximum subsidence over the Panel and Pillar Mining Zone (PPMZ) areas of the mine, after the extraction of a 2.8m thick seam, 61m wide mini wall panel widths and 30m chain pillars, would be less than 125mm, tilts would be less than 2.5mm/m and strains would be less than 2mm/m. It was assessed that, at these low subsidence values, no surface cracking, rock falls or cliff impacts were expected.

Observed Impacts

Surveyed subsidence levels exceeded the maximum predicted value of 125mm after the extraction of MW4 (3rd panel extracted). In January 2020, vertical subsidence was recorded up to 185 millimetres in some areas. A surface inspection was carried out in the week commencing 10 February 2020. No mining related impacts were identified during the preliminary visual surface inspection.

The surface of the extracted area was inspected with a particular focus on minor cliffs, pagodas steep slopes and rock shelves above and immediately adjacent to the extraction area. The inspection was conducted by walking the area and was over two days.

A presentation was provided to DPIE and the Airly Mine Independent Expert Panel (IEP) members on 19 February 2020. At that meeting the suitability of the current approved subsidence monitoring program was discussed and it was considered adequate for the management of the increased subsidence levels.

The first surface fracture was identified on 7 July 2020. The New South Wales DPIE has since been notified of additional surface fractures in February 2021, June 2021 and September 2021. The maximum recorded vertical subsidence on Mount Airly was 713 millimetres. There were five non-compliances with the subsidence impact performance measures identified during the 2021 reporting period. These non-compliances are detailed further in Section 11.

Immediate Response

Centennial engaged Mine Subsidence Engineering Consultants (MSEC) in accordance with requirements of the approved Extraction Plan. Centennial Airly engaged MSEC to:

- Undertake an independent review of the available mine subsidence monitoring data over the Airly Mine; and
- Conduct a visual inspection over the surface areas of the Mount Airly mesa to investigate and assess whether there have been subsidence impacts above and near where the first three miniwall panels extracted.

The visual inspection by MSEC was undertaken on 4 March 2021. MSEC assessed whether there have been subsidence impacts near the first three previously extracted miniwall (MW) panels.

Centennial engaged Strata Control Technology (SCT) to review the existing subsidence model, assess the causes of deviations from previous forecasts and update predictions for future mining at Airly based on a numerical modelling approach.

These assessments determined that increased subsidence at Airly is caused by the fracturing and compression of strata above the chain pillars. This is primarily a function of weak strata, abutment load, reduced confinement due to the adjacent goaf voids, and pillar width.

Updated Modelling

The University of NSW (UNSW) were engaged through MSEC to build a new UDEC 2D and ultimately 3D subsidence model for Airly. The model was developed in consultation with MSEC and included the following approach:

- A suitable section across Mount Airly was chosen for modelling and monitoring.
- The model included available strata data from Airly.
- The numerical model was built and run initially for 1 panel then subsequent mining of additional panels.
- Faulting overburden jointing and stress was included.

In addition to the above, the Airly Independent Expert Panel suggested that SCT be engaged to construct a 2D FLAC model to explore the mechanism of higher than expected subsidence and predict the expected maximum subsidence on Mt Airly. A FLAC model has subsequently been prepared for Airly Mine, which has been calibrated to measured subsidence data. The outcomes of the modelling detailed above have determined that:

- The higher than predicted subsidence is due to failure of the strata above the chain pillars between the extraction voids.
- The relatively low strength material above the Lithgow Seam (up to 25m into the roof) was the major contributor to the strata failure and increased subsidence.

Further mathematical modelling work was undertaken by SCT using FLAC that was based on the available subsidence monitoring up to 2021. The MSEC1243 Airly Annual Subsidence Review 2021 (See Appendix 5) dated January 2021, documents the detail findings of the modelling.

Adaptive Management

In response to the increased subsidence, Centennial has reviewed Airly's mine design. Actions taken to limit subsidence to 125 millimetres at MW11 and MW12 included:

- Developing a 60-metre wide maingate pillar in MW10.
- Developing a 40-metre wide maingate pillar between MW11 and MW12.

Following extraction of MW11 and MW12, measured subsidence above these panels was under 125 millimetres, in line with SCT's predictions and within the Development Consent limit.

Point Hatteras

Centennial has modelled various pillar sizes and pillar size combinations for its extraction plan to mine below Point Hatteras. This modelling assessment indicated that a consistent pillar width of 70 metres and extraction height of 2.8 metres was the most appropriate mining geometry for the 61-metre-wide panels at Point Hatteras. The numerical modelling approach used for mine design was consistent with that successfully used for MW11 and MW12. The Point Hatteras Extraction Plan was prepared in consultation with the Airly Independent Expert Panel and approved by DPIE in December 2021.

Mining under Point Hatteras has proceeded based on increased pillar sizes (to 70 metres). This enables Centennial to control the fracturing in the strata above the pillars, therefore

maintaining the surface subsidence at Mount Genowlan to within the 125-millimetre limit and mitigate the risk of cracking. This conservative mine design means the subsidence performance criteria is likely to be complied with. Surface subsidence monitoring will validate the mine design and adaptive management will allow for mining to be stopped before subsidence exceeds the maximum allowable limit, as per the approved Extraction Plan.

Controls

Centennial will mine MW13, MW14, MW15A, MW15B and MW16 under Point Hatteras. Mine subsidence and impacts will be assessed on an ongoing basis and will be dependent on subsidence being maintained at under 125 millimetres. Additional subsidence monitoring will be undertaken to provide an appropriate early warning for potential exceedance of subsidence thresholds. Furthermore, extraction of the southern portion of MW15A and the length of MW15B is contingent on Airly demonstrating that subsidence levels and trends are within predictions.

6.9.1 Environmental Performance

6.9.1.1 Subsidence Analysis

The following analysis is drawn from the 2021 Annual Subsidence Monitoring Report (Appendix 5). All figure references quoted can be found in that report.

Subsidence results associated with MW02-MW12 have been presented in **Table 22**, including relevant results from 2019 and 2020. After extracting the first three mini walls on Mount Airly, i.e., MW02, MW03 & MW04, Airly advised that the observed subsidence had exceeded the maximum predicted subsidence of 125 mm.

After Airly extracted MW05 in April 2020, the maximum observed subsidence had increased to 297 mm and, after MW06 was extracted in September 2020, the maximum observed subsidence had increased to 548 mm.

The maximum observed subsidence that was observed in 2020 over MWs 02 to 07 was 612mm. Despite the increased levels of subsidence, no surface cracking or cliff falls were found on the Mount Airly mesa after the extraction of MW04, despite the maximum subsidence being measured at that time of 297mm.

It can be noted that MWs 08, 09 and 10 resulted in lower incremental subsidence than MW06 and 07. However they still show increased levels of subsidence occurring over the earlier panels, which indicated that the strata over the chain pillars was still failing. The extraction of MW06 still provided the highest maximum incremental subsidence profiles.

The maximum observed subsidence in 2021 over MWs 02 to 12 was 713mm, which is located over MW05 with extraction completed in May 2020 (refer to **Table 22** and **Figure 30**).

Following the implementation of the revised mine design, the levels of incremental subsidence over MWs 11 and 12 have been less than 125mm. No mining induced cliff falls have occurred. The report, SCT AIRLY5240, dated January 2021, predicted, using the FLAC model, that the extra subsidence caused by extracting MW11 and 12 would not exceed 125mm over MWs11 &12. The observed incremental subsidence for MW11 and MW12 is consistent with the predictions of SCT.

Table 22: Maximum total and incremental subsidence over the MW panels

Panel	Survey Date	Panel Extraction End Date	Maximum Subsidence (mm)	Incremental Subsidence (mm)
MW2	7-Aug-2019	19-Aug-2019	38	38
MW3	25-Oct-2019	5-Nov-2019	95	63
MW4	31-Jan-2020	11-Feb-2020	186	104
MW5	23-Apr-2020	8-May-2020	297	144
MW6	22-Sep-2020	11-Sep-2020	548	289
MW7	26-Nov-2020	1-Dec-2020	612	177
MW8	23-Feb-2021	5-Mar-2021	655	123
MW9	17-May-2021	12-May-2021	670	164
MW10	27-Aug-2021	23-Aug-2021	680	131
MW11	12-Oct-2021	12-Oct-2021	690	44
MW12	10-Dec-2021	8-Dec-2021	713	44

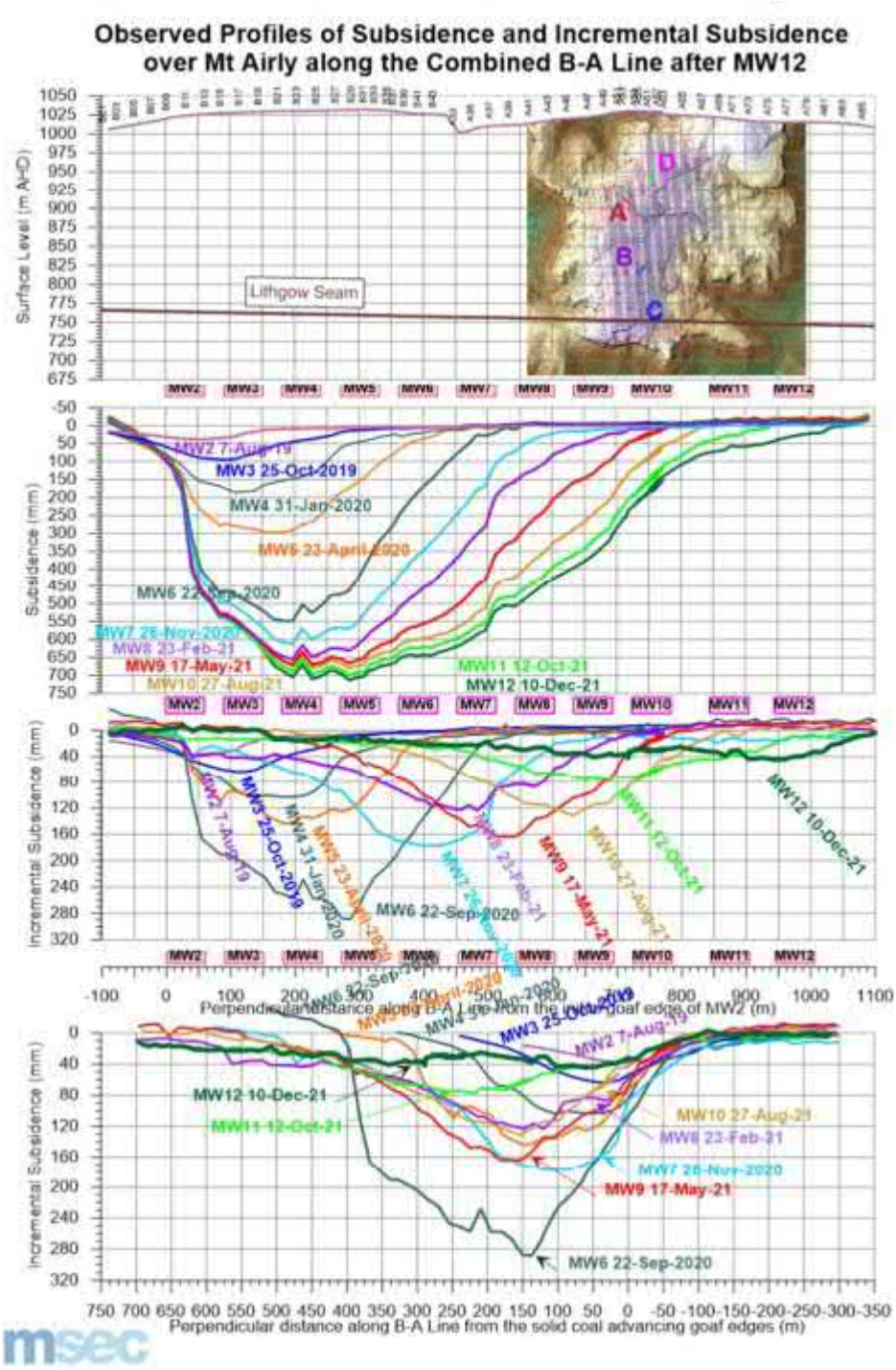


Figure 30: Observed total and incremental subsidence profiles after MWs 02 to 12.

7 WATER

7.1 WATER MANAGEMENT

7.1.1 Water Licences

Airly Mine currently holds two water access licences (WALs) under the *Water Management Act 2000* for the extraction of groundwater. A total of 278 ML is licenced for extraction from the Sydney Basin North groundwater source as part of the Water Sharing Plan (WSP) for the Greater Metropolitan Region Groundwater Sources, made up of WAL 24386 (158 ML/year) and WAL 36565 (120 ML/year). WAL 24386 licences the take of water from the production bore (water supply works approval 10WA112537), which is used to supplement water for use in mining activities. WAL 36565 licences the extraction of water from the underground workings to the Dirty Water Dam.

No water was transferred from the underground workings to the surface during the 2021 reporting period.

Table 23 identifies the water take under the water licences for the water year (1 July 2020 to 30 June 2021), not the calendar year.

Table 23: Water Take

License #	Water Sharing Plan, source and management zone (as applicable)	Entitlement (ML)	Passive take / inflows	Active pumping (ML)	TOTAL (ML)
WAL 2438 (Production Bore)	Greater Metropolitan Region Groundwater Sources, Sydney Basin North groundwater source	158	Negligible	0.0483	0.0483
WAL 36565 (Mine Inflows)	Greater Metropolitan Region Groundwater Sources, Sydney Basin North groundwater source	120	Negligible	nil	nil

Volume is reported in annual megalitres (ML)

7.1.2 Water Balance

A site water balance model was previously developed for Airly Mine as part of the Airly Mine Extension Project (GHD 2014) to quantify transfers within the site under future operational conditions using various rainfall patterns. The site water balance was updated to reflect the current mine plan and operational conditions (GHD 2019b). The site water balance for the 2021 calendar year is presented in **Table 24**.

Table 24: Site Water Balance

Water flow	Volume (ML/year)
INPUTS	
Direct rainfall onto storages and catchment runoff	57
External potable water supply	1
Groundwater inflows into underground workings	10
Extraction from production bore	38
In situ coal moisture	23
TOTAL INPUTS	**129**
OUTPUTS	
Evaporation	49
Dust suppression	5
Sewage to Ecomax effluent treatment system	2
Discharge through LDP001	0
Discharge through LDP002	0
Discharge through LDP003	0
Product coal moisture	78
TOTAL OUTPUTS	**134**
CHANGE IN STORAGE	
Surface water storages	-5
Underground workings	0
TOTAL CHANGE IN STORAGE	**-5**
BALANCE	
Inputs – outputs – change in storage	0

7.2 SURFACE WATER

7.2.1 Environmental Management

There is an established surface water quality monitoring program for Airly Mine that includes both continuous surface water flow monitoring and monthly surface water quality monitoring.

The monitoring locations are described in **Table 25** and shown in **Appendix 1**.

Table 25: Surface Water Monitoring Locations

Monitoring Point	Description
LDP001	Correlates to EPL Monitoring Location 1, discharge from Discharge Dam into Airly Creek and includes continuous flow monitoring.
LDP002	Correlates to EPL Monitoring Location 7, discharge from 7ML Stockpile Dam into Airly Creek.
LDP003	Correlates to EPL Monitoring Location 8, discharge from Train Loader Dam into Airly Creek. EPL Monitoring Location 8.
Airly Creek	Water quality monitoring location situated on Airly Creek downstream of LDP001.

Monitoring Point	Description
Airly Creek Upstream	Water quality monitoring location situated on a tributary of Airly Creek, upstream to the west of site Airly Creek site. This location is utilised as a 'background' representation.
Airly Tributary	Water quality monitoring location situated on a tributary of Airly Creek upstream of site Airly Creeksite.
Gap Creek	Water quality monitoring location and continuous flow monitoring.
The Grotto	Water quality monitoring location located on Genowlan Creek.
Genowlan Creek	Water quality and continuous flow monitoring location located on Genowlan Creek.
Genowlan Creek 2	Water quality monitoring location and continuous flow monitoring situated on Genowlan Creek.
Various on site dams[1]	Located in pit top.

1 Includes 35 ML discharge dam, Dirty water dam, Train loader dam, Settling dam and Office tank.

Surface Flows:

Continuous flow monitoring is undertaken at Gap Creek, Genowlan Creek and LDP001.

Flow was recorded in Genowlan Creek for some of 2021, averaging 490.7 kL/day for those periods. High daily flows occurred on 24 March and 7 November at 7,318.9 kL/day and 4,047.5 kL/day respectively. No flow was recorded between:

- 14 February and 13 March.
- 16 May and 6 November.
- 22 and 31 December.

Flow was recorded in Gap Creek for most of 2021, averaging 174.5 kL/day. The highest daily flow for 2021 occurred on 12 November at 4,392.9 kL/day. No flow was recorded between:

- 1 January and 21 March.
- 10 August and 23 August.
- 19 September and 29 September.
- 7 October and 12 October.
- 20 October and 4 November.

A v-notch weir was installed at Genowlan Creek 2 during the second quarter of 2019. Flow was recorded in Genowlan Creek 2 for most of 2021, averaging 563.0 kL/day. Peak flows occurred on:

- 2 January at 2,330.9 kL/day.
- 27 March at 3,796.7 kL/day.
- 15 November at 3,600.3 kL/day.
- 29 November at 4,142.0 kL/day.
- 10 December at 4,686.2 kL/day.

No flow occurred between 23 and 26 March, 10 and 14 November and 26 and 28 November 2021.

7.2.2 Environmental Performance

7.2.2.1 Surface Water Quality

The water quality sampling for the monitoring period has been presented in **Table 26**.

Table 26: Water Quality Sampling Period

Location	Sampling comments
Airly Creek	Sampled in all months
Airly Creek Upstream	No flow in February, March or November
Airly Tributary	No flow in February, March or November
Gap Creek	Dry in January and February
Genowlan Creek (The Grotto)	Sampled in all months
Genowlan Creek 2	Sampled in all months
LDP001	Discharge in November only
LDP002	Discharge in March only
LDP003	No discharge
Production Dam	Sampled in all months except August
Stockpile Dam	Sampled in all months except August
Train Loader Dam	Sampled in all months except August
Dirty Water Dam	Sampled in all months except August

Time series plots of historical water quality at these sites, including results from 2021, are included in **Appendix 1**.

Airly Creek

Airly Creek contained water in all months, while Airly Creek Upstream and Airly Creek Tributary were able to be sampled in January, April to October and December only due to dry conditions.

In Airly Creek, pH remained within the SSGVs ranging 6.8 to 7.7 pH units. EC was gauged below the SSGV in all months except for June (2,960 µS/cm) and July (2,840 µS/cm) and below historical values in December (1270 µS/cm). Water type is magnesium/calcium-sulphate.

In Airly Creek Upstream, pH remained within the SSGVs and within historical ranges (7.2 to 8.0 pH units), except for October (8.1 pH units). EC exceeded SSGV levels in June (3,200 µS/cm) and July (2,930 µS/cm). Water type is consistent with Airly Creek and is magnesium/calcium-sulphate.

Airly Tributary pH remained within the SSGVs and within historical ranges (7 to 7.4 pH units). EC exceeded the SSGV in June (3,160 µS/cm) and July (2,770 µS/cm). Water type is consistent with Airly Creek and Airly Creek Upstream and is magnesium/calcium-sulphate.

Repeated exceedances of dissolved nickel in Airly Tributary have been noted, however are consistent with historical concentrations since December 2012. Attention to this will continue throughout the 2022 monitoring program.

Genowlan Creek

Surface water at The Grotto is acidic and fresh. pH exceeded the lower SSGV in all months (ranging 4.84 to 6.69 pH units) except for September and November. Review of time series indicates increasing trends throughout 2021. EC ranged between 41.8 µS/cm and 121.4 µS/cm, exceeding the SSGV in June, August and October (62.3 µS/cm, 121.4 µS/cm and 70.5 µS/cm, respectively). The Grotto is of sodium-chloride type, similar to the Genowlan Creek Alluvium.

Gap Creek pH ranged slightly acidic to alkaline, exceeding the SSGV in March (6.04 pH units), May (7.93 pH units), September (8.29 pH units), October (7.64 pH units), and November (8.11 pH units), consistent with historical data. EC ranged between 83.6 µS/cm and 231.6 µS/cm, exceeding the SSGV in August (231.6 µS/cm). Gap Creek is of mixed type, with a slight sodium/potassium cation dominance and no dominant anion, similar to Gap Creek Alluvial groundwater but considerably different to the Airly Creek Catchment.

Surface water quality at Genowlan Creek 2 was slightly acidic to fresh, consistent with 2019 and 2020 data.

Genowlan Creek 2 is consistent with The Grotto and is of sodium-chloride type.

Licenced Discharge Points

During high rainfall events, overflows from the Stockpile Dam are monitored as a discharge point to Airly Creek (LDP002). The water level is maintained by pumping water to the 109 ML Dirty Water Dam. Until 2021, no discharges had been recorded. One non-routine discharge from LDP002 to Airly Creek occurred on 23 March 2021 due to increased rainfall. This discharge was compliant under condition L2.5 of EPL12374.

Overflows from the Production Dam are monitored continuously via LDP001. Prior to 2013, 6 discharges had occurred. In 2021, a controlled discharge was recorded between 27 November and 30 November inclusive, due to increased rainfall. This discharge was compliant under condition both L2.4 and L2.5 of EPL12374.

7.2.2.2 Surface Water Discharges

There were no discharges from LDP003 (overflow from the Train Loader Dam) during 2021. One discharge was recorded in March 2021 at LDP002 and a controlled release from LDP001 was carried out over 4 consecutive days in November 2021.

There were no non-compliances in relation to water discharges from Airly Mine during the 2021 reporting period.

7.2.2.3 Surface Water Monitoring – Data Interpretation

Visual inspection of the time series plots in **Appendix 1** indicates that surface water quality in 2021 is similar to pre-2021 surface water quality. Therefore, there has been no observable impact on surface water quality in 2021 attributable to mining operations.

Surface water quality changes can likely be attributed to the continued above average rainfall received during 2020 and 2021, which was preceded by a three-year period of below average rainfall.

Exceedances of SSGVs for The Grotto and Gap Creek were variable but occurred primarily in the fourth quarter, following similar trends to rainfall. Several dissolved metals exceedances occurring in December at the Grotto may be attributable to increased sediment in runoff following the November and December rainfall events.

7.3 GROUNDWATER

7.3.1 Environmental Management

The monitoring program for 2021 comprised:

- Monitoring of deep aquifer water pressures via vibrating wire piezometers (VWPs) at eight locations (excluding ARP01 which served it's purpose and was intentionally mined through in 2018).

- Monitoring of water levels in alluvial, Narrabeen Sandstone and Permian aquifers from ten standpipe piezometers (excluding ARP07 which has been dry since July 2013 and ARP16, which has been dry since installation in December 2021).
- Monitoring water quality of alluvial, Narrabeen Sandstone and Permian aquifers via nine standpipe piezometers (excluding ARP07 and ARP16) and three private production bores for water quality assessment.
- Monitoring of groundwater seepage flows at Village Spring and in mine workings.

The VWPs (ARP01, APR02, ARP03, ARP04, ARP06, ARP07, ARP08, ARP13 and ARP15) monitor Triassic, Permian and Devonian strata in both mined and unmined areas. The standpipes (ARP05, ARP07, ARP07, ARP09, ARP11, ARP12, ARP14, ARP13SP and ARP15SP) target alluvium, Triassic and Permian strata, also in both mined and unmined areas. Groundwater levels at the production bore AM2B-1 have been recorded since May 2017.

Monitoring locations ARP11, ARP12, ARP13, ARP13SP, ARP14, ARP15 and ARP15SP were installed in December 2016 and January 2017. With the exception of ARP11, these monitoring locations are currently outside of the mining area and are collecting baseline groundwater level and quality data.

Groundwater Levels:

All levels recorded for ARP02, ARP03, ARP04, and ARP06 during 2021 were within their respective trigger values. However, ARP13 (un-mined area on Mt Genowlan, establishing baseline data) recorded levels below the trigger value in the first three quarters of 2021.

Piezometric pressure is generally low and stable at the existing VWP monitoring locations, generally ranging from 0 m to 10 m above the measuring point elevation, with little observable response to rainfall. The low piezometric pressure is considered to reflect the extensive groundwater seepage areas across the slopes of Mount Airly and Genowlan Mountain.

Pressures reported in 2021 are generally similar to those reported between 2013 and 2020, with the exception of ARP04 within the Marrangaroo Formation. Minor decreasing trends were observed in 2014 through 2017 in the Middle River Seam at ARP07 and in the Marrangaroo Sandstone at ARP02A. These minor decreasing trends ceased in late 2017. Pressures remained stable from 2018 to the end of 2021 at ARP07 and remained stable at ARP02A until 2019 when the data logger malfunctioned. A drop in pressure of approximately 0.5 m occurred at ARP04 between September and December 2015 in the Lithgow Seam and the Marrangaroo Formation. The depressurisation may be attributable to activities at Airly Mine since the mine workings came within 200 m of this monitoring site in 2015. A minor decreasing trend was observed throughout 2016. Pressures stabilised in 2017 and remained stable from 2018 through to the end of 2020. In 2021, pressure in the Marrangaroo Formation increased by 0.5 m, while pressures in the Lithgow Seam decreased by 0.1 m. Pressures varied within the Shoalhaven Group between 2012 and April 2017. A steady increasing trend has been observed since. In 2021, between January and October a pressure increase of 0.9 m was recorded.

7.3.2 Environmental Performance

7.3.2.1 Groundwater Quality

Newly recovered groundwater at ARP05 (Gap Creek Alluvium) is fresh and ranging acidic to neutral. pH was slightly less acidic and more neutral in 2021 than before the bore went dry in 2017. EC concentrations were comparable to those recorded in 2017. Groundwater at ARP05 within the Gap Creek Alluvium is of calcium-bicarbonate type and is consistent with Gap Creek surface water. In April 2021 following water level recovery, dissolved metals were increased

compared to available monitoring data in 2017, specifically manganese, iron and copper. Concentrations of these dissolved metals decreased throughout 2021, to 2017 concentrations.

Groundwater at ARP08 (Lithgow Seam) is alkaline and brackish. EC concentrations in 2021 are significantly elevated compared to those recorded in 2019 (1,615 µS/cm to 6,867 µS/cm). Dissolved metals concentrations were consistent with those recorded in 2020, except for copper which decreased throughout 2021.

Groundwater at ARP09 (Genowlan Creek Alluvium) is acidic and fresh. Physicochemical characteristics and dissolved metal concentrations are comparable to historical values. Groundwater at ARP09 is of sodium-chloride type and is similar to the Genowlan Creek surface water.

Groundwater at ARP11 (Permian strata) has historically been slightly brackish and slightly alkaline. In 2021 groundwater was slightly brackish and slightly acidic. There were no exceedances of SSGVs except for dissolved zinc in November and December. Groundwater is of mixed type, though with a dominant sodium cation and bicarbonate/chloride dominant anions.

Groundwater at ARP12 (Genowlan Creek Alluvium) is slightly acidic to neutral and fresh. Groundwater type is of mixed/ sodium-chloride type. Dissolved metal concentrations are low and without trend of concern, with the exception of zinc, which was elevated in November and December 2021.

Groundwater at ARP13SP (Lithgow Seam) is slightly brackish and slightly less acidic than 2020, ranging from below the lower trigger value threshold to above the upper trigger value threshold of pH. Groundwater at ARP13SP is of calcium-bicarbonate type. Metal concentrations are generally low without any trends of concern. Dissolved zinc exceeded the threshold in late 2021. No other exceedances occurred.

Groundwater at ARP14 (alluvial aquifer) is fresh and neutral and of mixed type with a slight dominant sodium cation. EC concentrations were consistent with the previous year, with one exceedance of the maximum trigger value. Dissolved metal concentrations were generally low and below trigger values except for copper which exceeded the threshold in December only and both iron and manganese in November and December.

Groundwater at ARP15SP (Narrabeen Sandstone) is generally fresh and slightly acidic. pH increased in 2021 ARP15SP but remained below the lower trigger value in all months excepting April, October and December.

Groundwater within the Narrabeen Sandstone is of sodium-chloride type. Metal concentrations were reported to be below trigger values except for nickel in November and zinc in December.

Groundwater at AM2B-1 was slightly acidic to fresh and fresh to brackish throughout 2021, continuing from 2020. EC was highly variable ranged from 729 µS/cm to 4,770 µS/cm. Metal concentrations were mostly stable and without any trends of concern. Compared to Airly Mine monitoring bores installed in the Permian Coal Measures and the alluvium, Shoalhaven Group groundwater at AM2B-1 has elevated concentrations of dissolved metals including, copper, iron, manganese, magnesium, nickel and zinc.

Groundwater at the landholder bores is generally slightly alkaline and slightly brackish. In the absence of defined trigger values, groundwater from private bores is compared to DGVs. Although these criteria recognised to be inappropriate given naturally occurring conditions.

Seepage of groundwater at the Village Spring is generally fresh and slightly alkaline. Monitoring data collected in 2021 has been compared to groundwater quality trigger values in the WMP (GHD, 2021). Trigger value exceedances occurred for pH (lower trigger value in January, April, May and June, upper trigger value in November), TSS (February, May and November) and dissolved nickel (May, June, July, August, October, November and December). These exceedances are consistent with historical variations. The Village Spring groundwater seepage is of calcium-bicarbonate type. In comparison to Groundwater within the

Permian Strata at ARP11, Groundwater at Village Spring may be more influenced by rock interactions.

8 REHABILITATION

Airly Mine did not complete any rehabilitation within the 2021 reporting period. Airly will conduct rehabilitation works in accordance with the approved Mining Operations Plan/Rehabilitation Management Plan (MOP/RMP) at the completion of life-of-mine operations. Due to the nature of Airly Mine, there is limited opportunity for any progressive rehabilitation to occur prior to the cessation of life-of-mine operations.

Airly's disturbance footprint remained at 54.4ha during the reporting period.

Airly Mine's Rehabilitation Cost Estimate (RCE) was approved by the Resources Regulator on 16 April 2020. Accordingly, the Airly Mine security deposit, as required by ML 1331, was amended to reflect the revised value. A new RCE will be submitted prior to 2 July 2022 to satisfy requirements of the NSW Rehabilitation Reforms.

8.1 Summary – Next Reporting Period

There are no areas of land available to be rehabilitated as all areas of the active disturbance footprint are currently being utilised for mining operations. As such, there is no rehabilitation activities planned for the next reporting period; this is unlikely to change until Airly moves into closure preparation.

Table 27: Rehabilitation Status

Mine Area Type	Previous Reporting Period (Actual)	This Reporting Period (Actual)	Next Reporting Period (Forecast)
	Year 2020 (ha)	Year 2021 (ha)	Year 2022 (ha)
• **Total mine footprint**[1]	54.4	54.4	54.4
• **Total active disturbance**[2]	54.4	54.4	54.4
• **Land being prepared for rehabilitation**[3]	0	0	0
• **Land under active rehabilitation**[4]	0	0	0
• **Completed rehabilitation**[5]	0	0	0

[1] **Total Mine Footprint:** includes all areas within a mining lease that either have at some point in time or continue to pose a rehabilitation liability due to mining and associated activities. As such it is the sum of total active disturbance, decommissioning, landform establishment, growth medium development, ecosystem establishment, ecosystem development and relinquished lands (as defined in the DRE MOP/RMP Guidelines). Please note that subsidence remediation areas are excluded.

[2] **Total Active Disturbance:** includes all areas requiring rehabilitation

[3] **Land being prepared for rehabilitation:** includes the sum of mine disturbed land that is under the following rehabilitation phases – decommissioning, landform establishment and growth medium development (as defined in DRE MOP/RMP Guidelines)

[4] **Land under active rehabilitation:** includes areas under rehabilitation and being managed to achieve relinquishment – includes 'ecosystem and land use establishment' and 'ecosystem and land use sustainability (as defined under the DRE MOP/RMP Guidelines)

[5] **Completed rehabilitation**: requires formal sign off from DRE that the area has successfully net the rehabilitation land use objectives or completion criteria

9 COMMUNITY CONSULTATION

Airly Mine has established and operates a Community Consultative Committee (CCC) in accordance with the *Community Consultative Committee Guidelines for State Significant Projects* (Department of Planning & Environment, 2016) as required by Condition 8, Schedule 6 of SSD_5581.

The Airly Mine Community Consultative Committee is chaired by an independent Chairperson, and includes representatives from the community, Capertee Valley Land Care Group, Lithgow City Council, Colo Committee and National Parks and Wildlife Service.

During the reporting period, the Committee held 3 CCC meetings: on 17 March, 10 August, and 30 November 2021. Topics discussed during the year at the CCC Meetings include Airly Operations, Environmental Management, Subsidence Management, Environmental Monitoring, Proposed Modifications to SSD_5581 and Community Relations.

Minutes of all Community meetings are available on the Centennial Coal website, www.centennialcoal.com.au.

Airly Mine will continue to maintain and improve an open dialogue with community stakeholders and the CCC during the next reporting period.

9.1 COMMUNITY SPONSORSHIP

Financial and in-kind contributions were made by Airly Mine to the following non-profit organisations and community groups during the 2021 reporting period:

- Capertee School
- Capertee Hall / Capertee Progress Association
- Capertee Progress Association (CPA)
- Capertee Wild Dog Group
- Mudgee Charity Golf Day
- NSW Rural Fire Service
- Kandos High School Presentation Day

In addition, Airly also provides in kind donations as well as volunteering employee time to help organise and run community events and fund raisers. Airly will continue to offer the same community service and contributions in the next reporting period.

9.2 COMMUNITY COMPLAINTS

There was zero community complaints made to Airly Mine during 2021 reporting period. Details of these complaints are listed on the Complaints Register on the Centennial Coal – Airly website.

Table 28: Summarises analysis of annual complaints across eight years.

Table 28: Record of annual community complaints for 2013 to 2021

Community Complaints						
Year	Air	Water	Noise	Waste	Other	Total
2021	0	0	0	0	0	0
2020	0	0	0	0	1	1
2019	0	0	0	0	0	0
2018	0	0	0	0	0	0
2017	0	0	0	0	2	2
2016	0	0	0	0	0	0
2015	0	0	0	0	1	1
2014	0	0	0	0	0	0
2013	0	0	0	0	0	0

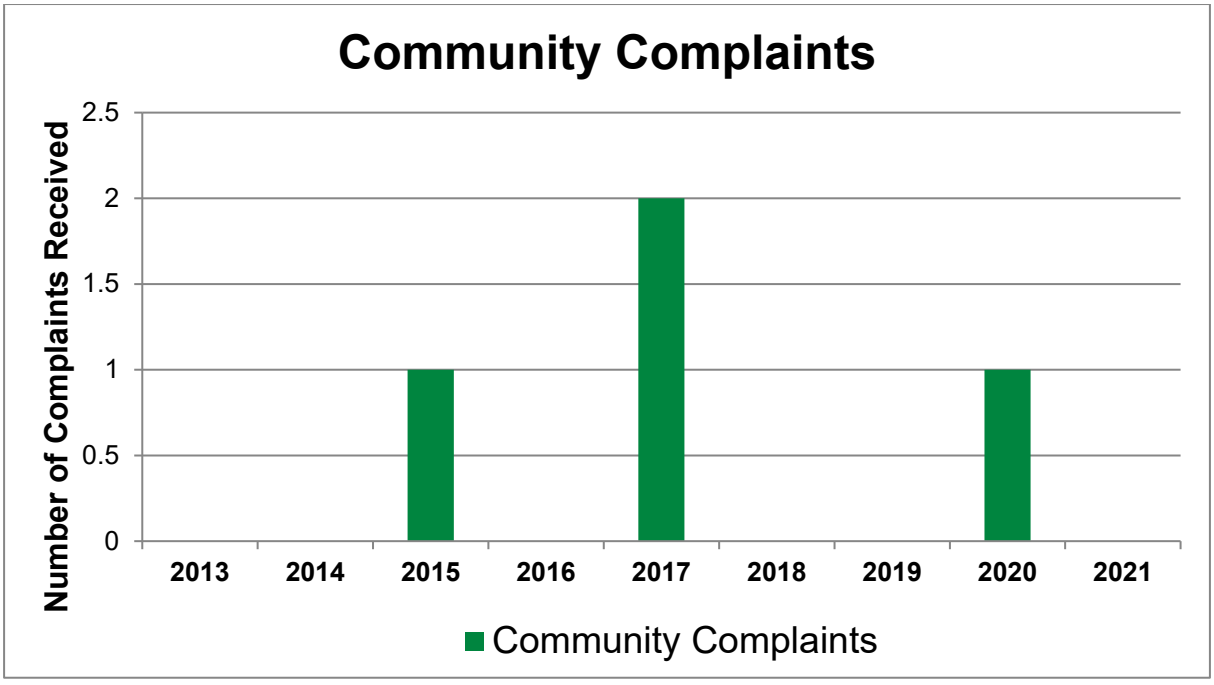


Figure 31: Airly Mine – Community Complaint Frequency Comparison from 2013 to 2021

Referring to **Table 28** and corresponding **Figure 31**, there is no evidence of an identifiable trend in the frequency of community complaints being received by Airly Mine. The total complaints for the site are relatively low with only 4 complaints being received in the past eight years; one of which turned out to be completely unrelated to the mine and the other two were offsite traffic related.

10 INDEPENDENT ENVIRONMENTAL AUDIT

An Independent Environmental Audit (IEA) of Airly Mine's development consent was undertaken in 2021.

In January 2021, Airly Mine formally commissioned the endorsed auditors, *MCW Environmental Consulting Pty Limited* (MCW Environmental) to undertake an Independent Environmental Audit (IEA) of Airly Mine in accordance with Schedule 6, Condition 12 of the Airly Mine Development Consent (SSD_5581), which states:

"*Within one year of the date of commencement and every 3 years thereafter, unless the Secretary directs otherwise, the Applicant shall commission and pay the full cost of an Independent Environmental Audit of the development. This audit must:*

- *be conducted by a suitably qualified, experienced and independent team of experts whose appointment has been endorsed by the Secretary;*
- *include consultation with the relevant agencies;*
- *assess the environmental performance of the development and assess whether it is complying with the requirements in this consent and any relevant approvals, relevant EPL/s or Mining Lease/s (including any assessment, plan or program required under these approvals);*
- *review the adequacy of strategies, plans or programs required under the abovementioned approvals; and*
- *recommend appropriate measures or actions to improve the environmental performance of the development, and/or any strategy, plan or program required under these approvals; and*
- *be conducted and reported to the satisfaction of the Secretary."*

Additionally, as part of the IEA process, Airly Mine has also commissioned Mr. Noel Merrick of SLR Consulting to conduct an Independent Expert Review (IER) of Airly's Groundwater Management Plan & Groundwater Model in accordance with Schedule 4, Condition 16 of SSD_5581, which states:

"As part of any Independent Environmental Audit of the development (see condition 12 of schedule 6), the Applicant must commission an independent expert whose appointment has been endorsed by the Secretary, to carry out a review of the Groundwater Management Plan for the development, including the groundwater model. This review must include a:

- *review of all available monitoring data;*
- *comparison of predicted and actual groundwater impacts; and*
- *review of the effectiveness of the Groundwater Management Plan for the development, including the groundwater model."*

The following tables (**Table 29** and **Table 30)** are representative of Airly Mine's Response to the Auditor's Recommendations (RAR) identified within the May 2021 Independent Environmental Audit (IEA) Report. This document was originally prepared to satisfy Schedule 6, Condition 13 of the Airly Mine Development Consent (SSD_5581).

The 2021 IEA Report, inclusive of Airly Mine's RAR, was accepted by the Department of Planning, Industry and Environment (DPIE) on 1 June 2021. A status update column has been added to the below tables for the sole purpose of providing a transparent update as part of the 2021 Annual Review.

Table 29: Airly Mine Response to the IEA Recommendations listed within Table 30 of the 2021 IEA Report

SSD 5581 Condition ID	IEA - Recommendation	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of March 2022)
Schedule 2 Condition 1 **Obligation to minimise harm to the Environment** In addition to meeting the specific performance measures and criteria established under this consent, the Applicant must implement all reasonable and feasible measures to prevent and/or minimise any harm to the environment that may result from the construction, operation, or rehabilitation of the development.	NV1 AIR IEA 2021 As the exceedance of SSD_5581 Schedule 3 Condition 2 subsidence impact performance measure is currently under investigation by DPIE, no further recommendations have been made.	It is Centennial's position that Airly is Compliant with Schedule 2, Condition 1. The following points are made: • it is noted that harm to the environment has been minimised by implementing a conservative mine design in different areas of the lease to minimise impacts. • all extraction has been undertaken in accordance with the mine design parameters approved by the EIS and subsequent Extraction Plans. • Centennial has adopted a more	N/A	N/A Still under investigation by DPIE.

SSD 5581 Condition ID	IEA - Recommendation	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of March 2022)
		conservative mine design to further reduce to the potential impacts to cliffs as a result of mining, operating with a 26.5 degree angle of draw set back from the tops of cliffs within the cliff line zone around all miniwall panels (not just the first four as required by consent and significantly greater than the approved 8 degree angle of draw). • A range of adaptive management measures have been implemented, further demonstrating Centennial's commitment to minimise harm and operate in accordance with the mining schedule and EIS. • The consent allows for impacts to occur and in many respects,		

SSD 5581 Condition ID	IEA - Recommendation	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of March 2022)
		impacts have been less than predicted. Although subsidence cracking was not expected (and therefore not allowed), it is not indicative of the work that Centennial has done to minimise impacts to the environment. • The proactive minimisation of impacts has come at a significant loss of resource and cost to the Company. Centennial will actively engage with DPIE during its investigation in regard to these matters		
Schedule 2 Condition 2 **Terms of Consent** The Applicant must carry out the development (a) generally in accordance with the EIS and the Mining schedule (see Figure 3 in Appendix 2)	NV2 AIR IEA 2021 As the exceedance of SSD_5581 Schedule 3 Condition 2 subsidence impact performance measure is currently under investigation by DPIE, no further recommendations have been made.	It is Centennial's position that Airly is Compliant with Schedule 2, Condition 2. The following points are made: A conceptual Trigger Action Response Plan (TARP) was included in the EIS which identified the measures that would be undertaken should the	N/A	**N/A** Still under investigation by DPIE.

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		mine experience greater then predicted subsidence. A refined TARP was included as part of the Mt Airly Panel and Pillar Extraction Plan which was approved by the Department of Planning, Industry and Environment on 31 May 2021. Centennial is of the position that Airly has operated in accordance with the approved TARP following the identification of subsidence exceeding the 125 mm. In this regard, Airly has carry out the development generally in accordance with the EIS..		
Schedule 3 Condition 2 **Performance Measures – Natural and Heritage Features, etc** The Applicant must ensure that the development does not cause any exceedances of the performance measures (Table 1): All other land not covered by a performance measure above: No greater subsidence impacts or environmental consequences than predicted	NC3 AIR IEA 2021 As the exceedance of SSD_5581 Schedule 3 Condition 2 subsidence impact performance measure is currently under investigation by DPIE, no further recommendations have been made.	Airly acknowledged an exceedance of this performance criteria in Notification submitted 24 November 2020.	N/A	**N/A**

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in the EIS				
Schedule 4 Condition 15 **Biodiversity Management Plan** Prior to carrying out any development under this consent that would cause surface disturbance, the Applicant must prepare a Biodiversity Management Plan for the development to the satisfaction of the Secretary. This plan must: (d) include a detailed description of the measures that would be implemented to: control weeds and feral pests including, but not limited to goats, rabbits, European Red Fox, cats and pigs;	R1 AIR IEA 2021 Develop a regular weed inspection and treatment regime; and raise awareness of Centennial Airly's weed control obligations under SSD_5581, by informing lessees of Centennial Airly's aim to continue to progress the control and suppression of weeds and minimise potential weed impacts on the adjacent Mugii Murum-ban State Conservation Area.	A1 AIR IEA 2021: Centennial will develop a weed inspection and control program for Airly operational mine owned land. Additionally, Centennial will provide a letter to all neighbouring lessees detailing Airly Mine's current and planned weed control program. This letter will emphasise the overall aim to continue to progress the control and suppression of weeds and minimise potential weed impacts on the adjacent Mugii Murum-ban State Conservation Area.	July 2021	**Action Completed.** Airly Mine weed inspection and control program developed on 11 June 2021. Letter sent to neighbouring lessees (3) on 9 July 2021.
Schedule 4 Condition 15 **Biodiversity Management Plan** Prior to carrying out any development under this consent that would cause surface disturbance, the Applicant must prepare a Biodiversity Management Plan for the development to the satisfaction of the Secretary. This plan must: (d) include a detailed description of the measures that would be implemented to: control weeds and feral pests including,	R2 AIR IEA 2021 Correct weed management reference numbering in the Western Region Biodiversity Management Plan Appendix B Airly e.g. the Airly site-specific Biodiversity Management Plan references Section 4.4.2 in the RBMP for weed management. There is no Section 4.4.2, alternatively Section 6.6.2 includes weed management treatment and timing.	A2 AIR IEA 2021: Centennial will correct the reference numbering of the Western Region Biodiversity Management Plan during the next revision.	September 2021	**Action Completed.** Reference numbering of the Western Region Biodiversity Management Plan (WRBMP) was corrected during a revision of the document on 2 June 2021. Subsequently, in response to the resubmission of the revised WRBMP, the Department of Planning & Environment requested a full revision of the document including full consultation

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but not limited to goats, rabbits, European Red Fox, cats and pigs;				with stakeholders. In March 2022, Centennial Western sites (Inclusive of Airly Mine) commenced the consultation process and full revision of the WRBMP. It is anticipated that the document will be submitted for approval by May 2022.
Schedule 6 Condition 2 **Management Plan Requirements** The Applicant must ensure that the management plans required under this consent are prepared in accordance with any relevant guidelines, and include: (b) a description of: • the relevant statutory requirements (including any relevant approval, licence or lease conditions); (e) a contingency plan to manage any unpredicted impacts and their consequences; (f) a program to investigate and implement ways to improve the environmental performance of the development over time; (g) a protocol for managing and reporting any:	R3 AIR IEA 2021 Consult with DPIE regarding the approval status of new and/or revised environmental management plans, programs and strategies.	A3 AIR IEA 2021: Resubmit any management plans previously submitted and not approved through the Departments online portal system to formally recommence the assessment and approval of any management plans and track progress.	September 2021	**Action Completed.** This action was addressed as part of the submission of the Pt Hatteras Extraction Plan on 8 September 2021. Consultation with the Department has prompted additional revisions and consultation in relation to the Western Region Biodiversity Management Plan (WRBMP) and the Airly Water Management Plan (WMP). Airly Mine is currently in the process or revision and updating these documents to satisfy the Departments requests. It is anticipated that the WRBMP and the Airly WMP will be submitted for approval in May 2022.

SSD 5581 Condition ID	IEA - Recommendation	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of March 2022)
i) incidents; ii) complaints; iii) non-compliances with statutory requirements; and iv) exceedances of the impact assessment criteria and/or performance criteria; and (h) a protocol for periodic review of the plan.				
Schedule 6 Condition 8 **Community Consultative Committee** The Applicant must operate a Community Consultative Committee for the development to the satisfaction of the Secretary. This CCC must be operated in accordance with the Guidelines for Establishing and Operating Community Consultative Committees for Mining Projects (Department of Planning, 2007) or its latest version.	R4 AIR IEA 2021 CCC Chair to provide an Annual Report to DPIE (in accordance with Community Consultative Committee Guidelines, State Significant Projects (DPIE, November 2016).	A4 AIR IEA 2021: Submit a letter to the Airly CCC Chair reminding them of the Chair's obligations to provide an Annual Report to DPIE in accordance with the CCC Guidelines.	July 2021	**Action Completed.** Letter sent to Airly CCC Chair on 15 June 2021.
Schedule 3 Condition 3 **Performance Measure – Built Features** The Applicant must ensure that the development does not cause any exceedances of the performance measures in Table 2 to the satisfaction of the Secretary.	R5 AIR IEA 2021 Consult with NPWS to agree on a program for maintenance of Mugii Murum-ban State Conservation Area access and trail management and meet SSD_5581 Schedule 3 Condition 3 performance measures for *'Other built*	A4 AIR IEA 2021: Submit a letter to the NPWS proposing an access maintenance program for the Muggii Murum-ban State Conservation Area and seek their endorsement of the program.	July 2021	**Action Completed.** Following consultation with NPWS, endorsement of the proposed access track maintenance program for Mt Airly and Mt Genowlan received from NPWS on 4 June 2021.

SSD 5581 Condition ID		IEA - Recommendation	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of March 2022)
Other built features and improvements including Airly Camp Ground, walking and 4WD tracks, fences and gates	Use should be maintained wherever practicable in consultation with BCD	*features and improvements including Airly Camp Ground, walking and 4WD tracks, fences and gates'.*			
Schedule 4 Condition 8 **Meteorological Monitoring** Prior to commencement of development under this consent and for the life of the development, the Applicant must ensure that there is a meteorological station in the vicinity of the site that: (a) complies with the requirements in the Approved Methods for Sampling of Air Pollutants in New South Wales guideline and the NSW Industrial Noise Policy; and (b) is capable of continuous real-time measurement of atmospheric stability category determined by the sigma theta method in accordance with the NSW Industrial Noise Policy.		R6 AIR IEA 2021 Include on the 6-month and 12-month weather station verification report, that the weather station has been assessed against the Approved Methods for Sampling of Air Pollutants in New South Wales guideline and the NSW Industrial Noise Policy and is capable of continuous real-time measurement of atmospheric stability category determined by the sigma theta method in accordance with the NSW Industrial Noise Policy.	A6 AIR IEA 2021: This action is currently being undertaken however, Airly Mine will ensure that the next verification report includes specific written confirmation that the Meteorological Station complies with the relevant guidelines and the requirements of Schedule 4 Condition 8 of SSD_5581.	December 2021	**Action Completed.** Verification reports from ALS now includes specific written confirmation that the Meteorological Station complies with the relevant guidelines and the requirements of Schedule 4 Condition 8 of SSD_5581. Updated verification report received October 2021.

SSD 5581 Condition ID	IEA - Recommendation	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of March 2022)
Schedule 4 Condition 10 **Water Pollution** Unless an EPL authorises otherwise, the Applicant must comply with Section 120 of the POEO Act.	R7 AIR IEA 2021 Reduce the sediment load and potential for surface water contamination in the area adjacent to the train loading bay sump to prevent loss of containment to the Airly Creek catchment area and potential breach of Section 120 POEO Act; and assess the impact of reed growth on the capacity of the 35 ML Discharge Dam and conduct corrective actions if required.	A7 AIR IEA 2021: Install sediment control structures in area adjacent to the train loading bay sump; Confirm the volume of reeds growing in the Discharge Dam and produce an action plan to correct if the capacity of the dam is reduced by more than 2ML.	December 2021	**Action Completed** Sediment control structures installed adjacent to train loading sump on 14/9/2021. Reed volume calculation in the Discharge Dam was completed on 24 May 2021. Reed volume estimated to be 0.491ML. Therefore, no action is required at this stage.
Schedule 4 Condition 12 **Water Management Performance Measures** The Applicant must comply with the performance measures in Table 6 to the satisfaction of the Secretary. Chemical and petroleum storage: Chemical and hydrocarbon products to be stored in bunded areas in accordance with relevant Australian Standards	R8 AIR IEA 2021 Monitor the effectiveness of recent improvements in hydrocarbon and chemical storage in the pit top area against Australian Standards and take corrective action where required; progress improvements to the storage of waste oils in the workshop; and provide capacity in bunds to contain leaks and spills and prevent bund overflow.	A8 AIR IEA 2021: Centennial will: A. Complete a review of the effectiveness of the recent improvements in hydrocarbon and chemical storage areas; B. Install a new filter drainage bin in the workshop; and C. Include a check within the weekly environmental inspection report to monitor the Pit Top diesel bund sump capacity.	December 2021	**Action Completed.** All 3 required actions were completed in November 2021. a) Improvements to the Hydrocarbon and Chemical Storage area are working well. b) New filter drainage bin, inclusive of new plumbing to a new self bunded waste oil container was completed in November 2021;

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				c) Weekly inspection report has been updated to include an inspection of the Pit Top diesel bund sump capacity.
Schedule 4 Condition 14 **Independent Expert Review** As part of any Independent Environmental Audit of the development (see condition 12 of schedule 6), the Applicant must commission an independent expert whose appointment has been endorsed by the Secretary, to carry out a review of the Groundwater Management Plan for the development, including the groundwater model. This review must include a: (a) review of all available monitoring data; (b) comparison of predicted and actual groundwater impacts; and (c) review of the effectiveness of the Groundwater Management Plan for the development, including the groundwater model.	R9 AIR IEA 2021 Confirm acceptability of the independent expert review process, to meet the requirements of SSD_5581 Schedule 4 Condition 12, with DPIE.	A9 AIR IEA 2021: Submit a letter to DPIE seeking confirmation of endorsement of Mr Noel Merrick of SLR.	May 2021	**Action Completed.** Endorsement request letter sent to DPIE on 6 May 2021. DPIE provided confirmation of endorsement of Mr Noel Merrick of SLR on 19 May 2021.
Schedule 6 Condition 1 **Environmental Management Strategy** Prior to carrying out any development under this consent, the Applicant must	R10 AIR IEA 2021 Consult with DPIE to confirm if the current approach is acceptable where the	No action proposed. The EMS was approved by DPIE in 2017.	N/A	**N/A**

SSD 5581 Condition ID	IEA - Recommendation	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of March 2022)
prepare an Environmental Management Strategy for the development to the satisfaction of the Secretary. This strategy must: (f) include: a clear plan depicting all the monitoring to be carried out in relation to the development.	Environmental Management Strategy references management plans required by SSD_5581, and that these separate management plans include the monitoring requirements to meet SSD_5581 Schedule 4, Condition 1 (f).			
EPL12374 P1.3 LDPs are identified in EPL12374 for the purposes of the monitoring and/or the setting of limits for pollutants to water from the point.	R11 AIR IEA 2021 Clearly label EPL 12374 licensed discharge monitoring points.	A10 AIR IEA 2021: Install signs at LDPs	December 2021	**Action Completed.** LDP signs installed in October 2021.
EPL12374 M5.2	R12 AIR IEA 2021 Clearly indicate the public complaints line on the Centennial Airly website.	A11 AIR IEA 2021: Update the Centennial Airly website to clearly identify the public complaints number (02 6359 2100).	July 2021	**Action Completed.** Centennial Airly website was updated to clearly identify the complaints telephone number on 15 May 2021.
ML1331 – 3(f) The lease holder must prepare a Rehabilitation Report to the satisfaction of the Minister. The report must: iii. be prepared in accordance with any relevant annual reporting guidelines published on the Department's website at www.resources.nsw.gov.au/environment	R13 AIR IEA 2021 Engage with DPIE and the Resources Regulator to agree on the format of the Annual Review on how to meet the requirements of the Annual Review Guideline (DPIE, 2015) and the Form and Way Annual Rehabilitation Report and Forward Program for Small and Large Mines (Resources Regulator, September 2020).	A12 AIR IEA 2021: Centennial seek endorsement from the Department and Resources Regulator of a revised Annual Review Template to confirm it adequately addresses the requirements of the Annual Review Guideline and the Annual Rehabilitation Reporting requirements.	March 2022	**Action Completed.** Consultation has been undertaken with DPIE. Suggested revisions have been made to the Centennial Annual Review Template. 2021 Annual Review will be submitted by 31 March 2022.

SSD 5581 Condition ID	IEA - Recommendation	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of March 2022)
	R14 AIR IEA 2021 DPIE and Centennial Airly to consider directing the IEP to conduct independent third-party reviews of the subsidence findings in the Annual Review, in particular assessment of whether Airly are meeting the requirements for the performance measures as defined in the Development Consent.	No action proposed. Centennial understands that the IEP is engaged by DPIE as required.	N/A	**N/A**

Table 30: Airly Mine Response to the 'Opportunities for Improvement' listed IER of the Groundwater Management Plan (GWMP) Report

IER of GWMP – Opportunities for Improvement	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of September 2021)
The groundwater monitoring requirements of the current WMP (GHD, 2019) are generally considered to be appropriate based on project risks to groundwater values. However, a number of opportunities for improvement are suggested:	N/A	N/A	**N/A**
• The WMP groundwater level triggers should be reviewed and updated for unsaturated / non-operational VWP sensors.	Noted. The VWP's that are not working do not have trigger values. A review of the groundwater level triggers in relation to VWP's will be undertaken during the next revision of the Water Management Plan.	September 2021	**Action Completed.** Groundwater trigger levels in relation to VWP's were reviewed and the revised Water Management Plan was submitted on 24 August 2021.

IER of GWMP – Opportunities for Improvement	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of September 2021)
• As mining progresses, additional monitoring locations should be considered in the northeast towards Genowlan Point prior to mining progression into the area.	Noted. Additional monitoring bores in the northeast towards Genowlan Point will be reviewed and considered during the next revision of the Water Management Plan.	September 2021	**Action Completed.** The are no accessible drilling locations for additional groundwater monitoring bores to the northeast towards Genowlan Point. Revised water Management Plan was submitted on 24 August 2021.
• Review monitoring locations for Gap Creek and Genowlan Creek alluvial standpipes and consider the replacement of dry bores ARP05 and ARP09 with standpipes in deeper sections of the alluvium to allow continued monitoring of alluvial groundwater levels and quality.	Noted. The replacement/relocation of dry bores ARP05 and ARP09 will be reviewed and considered within the next revision of the Water Management Plan.	September 2021	**Action Completed.** Review was undertaken in August 2021. Both bores have since recovered and are functioning. Installation of additional locations not feasible due to access and environmental constraints.

IER of GWMP – Opportunities for Improvement	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of September 2021)
• Whilst the groundwater quality analytical suite has been significantly improved by the removal of a large number of parameters that had no practical use within the monitoring program, a number of parameters remain for which there are no water quality guideline values, and which are unlikely to result from mining activity. Some further rationalisation of the suite could be undertaken without significant impact on the groundwater quality monitoring objectives.	Noted. The groundwater quality analytical suite will be revised during the next revision of the Water Management Plan.	September 2021	**Action Completed.** The analytical suite has been reduced in the WMP (August 2021). Implementation of the changes is pending regulatory approval.
• Consider including a requirement to review predicted drawdowns against groundwater level observations in the annual monitoring report.	Noted. The requirement for annual reporting of predicted drawdowns against the groundwater level observations will be included in the next Water Management Plan revision.	September 2021	**Action Completed.** Predicted drawdowns form the basis of trigger values. Groundwater levels are assessed in relation to trigger values in the Annual report.
• Consider stipulations relating to the presentation of data in the annual monitoring report as suggested below.	Noted. Stipulation relating to the presentation of data as per the below suggestions will be considered during the next revision of the Water Management Plan.	September 2021	**Action Completed.** Annual Report data presentation has been amended where required.
Following review of the 2020 Annual Water Monitoring Report (GHD, 2021), a number of improvements to the presentation of annual water monitoring data are recommended, some of which could be specified in the WMP to aid data	N/A	N/A	N/A

IER of GWMP – Opportunities for Improvement	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of September 2021)
interpretation, the identification of trends and demonstrate compliance with the WMP:			
• VWP hydrographs: ○ Should be plotted on appropriate vertical and horizontal scales to allow more detailed interpretation and evaluation of pressure responses.	Noted. Will be revised within the next Annual Water Monitoring Report.	March 2022	**Action Completed.** Hydrographs have been updated with display of historical data to allow for comparison of trends. Vertical scales retained to show initial pressures. Particularly relevant for VWPs without trigger levels.
○ Should be annotated where VWPs have become unsaturated.	Noted. Will be revised within the next Annual Water Monitoring Report.	March 2022	**Action Completed.** VWP charts are annotated with logger functionality. Boreholes/standpipes annotated with saturation status.
○ Should include trigger levels (TLs should also be included on standpipe hydrographs).	Noted. This has been completed in past and will be reinstated within the next Annual Water Monitoring Report.	March 2022	**Action Completed.** TLs included on graphs with trigger levels.
○ Should include plots of rainfall excess / deficit (also should be included on standpipe hydrographs).	Noted. A rainfall graph is already included in the annual report. This action will be reviewed during the draft phase of the next Annual Water	March 2022	**Action Completed.** Rainfall included in separate graphic only. Excess/deficit included on standpipe graphs.

IER of GWMP – Opportunities for Improvement	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of September 2021)
	Monitoring Report. If the inclusion of rainfall correlation on all graphs doesn't overcrowd and confuse the data, this recommendation will be adopted.		
• WQ time series data should be thoroughly checked for anomalies / errors and allow easy differentiation of the time series for each individual bore when data for all bores is plotted on the same chart.	Noted. Graphics are currently being reviewed and will be amended where needed, specifically, plots for arsenic and beryllium as identified.	March 2022	**Action Completed.** All charts have been reviewed and updated.
• The flow monitoring data for Gap Creek and Genowlan Creek should be plotted with a logarithmic vertical scale to provide detail for periods of low flow / baseflow conditions.	Noted. Will be included in next Annual Water Monitoring Report.	March 2022	**Action Completed.** **- Not implemented due to indiscernible data.** Logarithmic scales produced indiscernible data. The existing plots were maintained for visual clarity.

IER of GWMP – Opportunities for Improvement	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of September 2021)
• The monitoring report would benefit from clear concise tabulation of monitoring requirements, compliance with requirements, and trigger level breaches. Such a table would allow easy identification of whether each monitoring location had been monitored in accordance with the WMP for the specified parameters (quality, levels, flow etc) at the specified frequency, with explanations provided for where this was not possible e.g. bore dry, VWP no longer functioning etc.	Such information is tabulated in a series of tables throughout the report. These will be combined into a single additional overarching summary table within the next Annual Water Monitoring Report.	March 2022	**Action Completed.** A summary table is included in the annual report.
• Explanation should be provided for any monitoring parameters or locations specified in the WMP which are not presented in the annual monitoring report and the lack of dynamic response in model predictions.	Each Annual Water Monitoring Report states discrepancies to the Water Management Plan requirements. A review of water pressures in comparison to model predictions will be included in the next Annual Water Monitoring Report.	March 2022	**Action Completed.** All parameters and locations are presented in the Annual Report. Predicted drawdowns form the basis of trigger values. Groundwater levels are assessed in relation to trigger values in the Annual report.

11 INCIDENTS AND NON-COMPLIANCES DURING THE REPORTING PERIOD

Table 31: Non-Compliance 1 – Surface Cracking over MW6 Area

Overview of incident/non-compliance	Incident Notification: 18 February 2021. On 29 January 2021, during an inspection with representatives from Centennial, Department of Planning & Environment (DPE) and the Independent Expert Panel (IEP), minor horizontal cracking was identified above the MW6 mining area.
Description of Incident/non-compliance	Several small cracks (1-3m long horizontal cracks generally less than 5mm wide) were noted in several rock features in an area over and adjacent to MW6 mining area. The performance criteria for this land is “no greater subsidence impacts or environmental consequences than predicted in the EIS”. The EIS states that in relation to subsidence predictions for the Panel and Pillar Mining Zone that surface cracking is not expected.
Actions	In accordance with Schedule 6, Condition 9 of SSD_5581, an Incident Notification was provided to all relevant regulatory departments on 18 February 2021. A detailed Incident Investigation Report was subsequently provided to all relevant stakeholders on 26 February 2021. Details of the non-compliance along with the management actions was provided to the Community Consultative Committee during an onsite meeting on 17 March 2021. **Summary of Adaptive Management Actions:** - On 24 February 2021, Centennial voluntarily made the decision to cease the extraction of coal in MW08 and MW09 at their current approved lengths (to prevent further subsidence related impacts on Mt Airly); - Increased the gateroad chain pillar widths from MW10 and for the remainder of mining under Mt Airly (to arrest subsidence impacts and to bring subsidence performance results back below 125mm); - Engaged multiple external experts and commenced detailed review of subsidence exceedance causal analysis and strategies to bring subsidence back under the approved limits of 125mm; - Review and consideration of potential subsidence crack remediation strategies (in consultation with NPWS and BCSD).
Summary of enforcement actions and responses	On-going consultation with DPE in relation to the subsidence performance criteria exceedances throughout 2020 and 2021. In relation to this particular non-compliance, the Department noted that the matter is part of an on-going broader investigation and as such did not require any additional information at the time.

	On 22 October 2021, Centennial Airly was issued with a Show Cause Notice in relation to the subsidence performance criteria exceedances and associated surface cracking non-compliances on Mt Airly. In response to the Show Cause, Airly Mine in consultation with NPWS and BCSD, submitted a draft Enforceable Undertaking on 31 November 2021. Following multiple remediation risk assessments and on-going consultation with NPWS and BCSD the Enforceable Undertaking is scheduled to be finalised in April/May 2022.
Current Status of Actions	All extraction mining has been completed on Mt Airly. Conservative revised mine design (significant increase to barrier pillar size) has been implemented to ensure recurrence of the non-compliance does not occur. Subsidence crack remediation program currently being developed.

Table 32: Non-Compliance 2 – Surface Cracking over MW9-10 Area

Overview of incident/non-compliance	Incident Notification: 4 June 2021. A surface crack was observed above the MW9-MW10 mining area during a targeted subsidence monitoring on Mt Airly.
Description of Incident/non-compliance	A surface crack was identified above the MW10 chain pillar, sub-parallel with the MW09 goaf edge. The crack is approximately 10mm wide and continues with varying surface visibility (areas covered by soil/vegetation) for a total distance of approximately 250m. The performance criteria for this land is “no greater subsidence impacts or environmental consequences than predicted in the EIS”. The EIS states that in relation to subsidence predictions for the Panel and Pillar Mining Zone that surface cracking is not expected.
Actions	In accordance with Schedule 6, Condition 9 of SSD_5581, an Incident Notification was provided to all relevant regulatory departments on 4 June 2021. Details of the non-compliance along with the management actions was provided to the Community Consultative Committee during an onsite meeting on 10 August 2021. **Summary of Adaptive Management Actions:** - On 24 February 2021, Centennial voluntarily made the decision to cease the extraction of coal in MW08 and MW09 at their current approved lengths (to prevent further subsidence related impacts on Mt Airly); - Increased the gateroad chain pillar widths from MW10 and for the remainder of mining under Mt Airly (to arrest subsidence impacts and to bring subsidence performance results back below 125mm); - Engaged multiple external experts and commenced detailed review of subsidence exceedance causal analysis and

	strategies to bring subsidence back under the approved limits of 125mm; - Review and consideration of potential subsidence crack remediation strategies (in consultation with NPWS and BCSD).
Summary of enforcement actions and responses	On-going consultation with DPE in relation to the subsidence performance criteria exceedances throughout 2020 and 2021. In relation to this particular non-compliance, the Department noted that the matter is part of an on-going broader investigation and as such did not require any additional information at the time. On 22 October 2021, Centennial Airly was issued with a Show Cause Notice in relation to the subsidence performance criteria exceedances and associated surface cracking non-compliances on Mt Airly. In response to the Show Cause, Airly Mine in consultation with NPWS and BCSD, submitted a draft Enforceable Undertaking on 31 November 2021. Following multiple remediation risk assessments and on-going consultation with NPWS and BCSD the Enforceable Undertaking is scheduled to be finalised in April/May 2022.
Current Status of Actions	All extraction mining has been completed on Mt Airly. Conservative revised mine design (significant increase to barrier pillar size) has been implemented to ensure recurrence of the non-compliance does not occur. Subsidence crack remediation program currently being developed.

Table 33: Non-Compliance 3 – Addendum Notification – Additional Surface Cracking observed above MW10 Area

Overview of incident/non-compliance	Incident Notification (Addendum): 1 September 2021. An additional surface crack was observed above the MW10 mining area during a targeted subsidence monitoring on Mt Airly.
Description of Incident/non-compliance	A surface crack was identified above the MW10 between 4 and 5 cut-through. The crack is approximately 5-15mm wide and continues with varying surface visibility (areas covered by soil/vegetation) for a total distance of approximately 146m. This cracking here is aligned over the stronger (increased width) MW10-11 barrier. The wider barrier pillar, whilst arresting the subsidence, has also concentrated tensile strain above the pillar and this bridging effect resulted in surface cracking. The performance criteria for this land is “no greater subsidence impacts or environmental consequences than predicted in the EIS”. The EIS states that in relation to subsidence predictions for the Panel and Pillar Mining Zone that surface cracking is not expected.

Actions	In accordance with Schedule 6, Condition 9 of SSD_5581, an Incident Notification was provided to all relevant regulatory departments on 1 September 2021. Details of the non-compliance along with the management actions was provided to the Community Consultative Committee (CCC) during an onsite meeting on 30 November 2021. An independent expert also provided a comprehensive subsidence cracking causal analysis and associated management response to the CCC during this meeting. **Summary of Adaptive Management Actions:** - On 24 February 2021, Centennial voluntarily made the decision to cease the extraction of coal in MW08 and MW09 at their current approved lengths (to prevent further subsidence related impacts on Mt Airly); - Increased the gateroad chain pillar widths from MW10 and for the remainder of mining under Mt Airly (to arrest subsidence impacts and to bring subsidence performance results back below 125mm); - Engaged multiple external experts and commenced detailed review of subsidence exceedance causal analysis and strategies to bring subsidence back under the approved limits of 125mm; - Review and consideration of potential subsidence crack remediation strategies (in consultation with NPWS and BCSD).
Summary of enforcement actions and responses	On-going consultation with DPE in relation to the subsidence performance criteria exceedances throughout 2020 and 2021. In relation to this particular non-compliance, the Department noted that the matter is part of an on-going broader investigation and as such did not require any additional information at the time. On 22 October 2021, Centennial Airly was issued with a Show Cause Notice in relation to the subsidence performance criteria exceedances and associated surface cracking non-compliances on Mt Airly. In response to the Show Cause, Airly Mine in consultation with NPWS and BCSD, submitted a draft Enforceable Undertaking on 31 November 2021. Following multiple remediation risk assessments and on-going consultation with NPWS and BCSD the Enforceable Undertaking is scheduled to be finalised in April/May 2022.
Current Status of Actions	All extraction mining has been completed on Mt Airly. Conservative revised mine design (significant increase to barrier pillar size) has been implemented to ensure recurrence of the non-compliance does not occur. Subsidence crack remediation program currently being developed.

Table 34: Non-Compliance 4 – Addendum Notification – Additional Surface Cracking observed above MW6 Area

Overview of incident/non-compliance	Incident Notification (Addendum): 16 September 2021. Additional surface cracking was observed above the MW6 mining area during a targeted subsidence monitoring on Mt Airly.
Description of Incident/non-compliance	On the 13 September 2021, an additional surface crack was identified above MW6 between 5 and 6 cut-through. The crack is approximately 5-60mm wide and continues with varying surface visibility (areas covered by soil/vegetation) for a total distance of approximately 50m. The performance criteria for this land is "no greater subsidence impacts or environmental consequences than predicted in the EIS". The EIS states that in relation to subsidence predictions for the Panel and Pillar Mining Zone that surface cracking is not expected.
Actions	In accordance with Schedule 6, Condition 9 of SSD_5581, an Incident Notification was provided to all relevant regulatory departments on 16 September 2021. Details of the non-compliance along with the management actions was provided to the Community Consultative Committee (CCC) during an onsite meeting on 30 November 2021. An independent expert also provided a comprehensive subsidence cracking causal analysis and associated management response to the CCC during this meeting. **Summary of Adaptive Management Actions:** - On 24 February 2021, Centennial voluntarily made the decision to cease the extraction of coal in MW08 and MW09 at their current approved lengths (to prevent further subsidence related impacts on Mt Airly); - Increased the gateroad chain pillar widths from MW10 and for the remainder of mining under Mt Airly (to arrest subsidence impacts and to bring subsidence performance results back below 125mm); - Engaged multiple external experts and commenced detailed review of subsidence exceedance causal analysis and strategies to bring subsidence back under the approved limits of 125mm; - Review and consideration of potential subsidence crack remediation strategies (in consultation with NPWS and BCSD).
Summary of enforcement actions and responses	On-going consultation with DPE in relation to the subsidence performance criteria exceedances throughout 2020 and 2021. In relation to this particular non-compliance, the Department noted that the matter is part of an on-going broader investigation and as such did not require any additional information at the time. On 22 October 2021, Centennial Airly was issued with a Show Cause Notice in relation to the subsidence performance criteria exceedances and associated surface cracking non-compliances on Mt Airly. In response to the Show Cause, Airly Mine in

	consultation with NPWS and BCSD, submitted a draft Enforceable Undertaking on 31 November 2021. Following multiple remediation risk assessments and on-going consultation with NPWS and BCSD the Enforceable Undertaking is scheduled to be finalised in April/May 2022.
Current Status of Actions	All extraction mining has been completed on Mt Airly. Conservative revised mine design (significant increase to barrier pillar size) has been implemented to ensure recurrence of the non-compliance does not occur. Subsidence crack remediation program currently being developed.

Table 35: Non-Compliance 5 – Addendum Notification – Widening of Natural Joint to the North of MW3 (Continuation of Fracture 02 – Minor Sink Hole)

Overview of incident/non-compliance	Incident Notification (Addendum): 23 December 2021. On the 22 December 2021 following an inspection, minor pothole subsidence was identified along an extension of Fracture 2 (approximately 60 metres North of MW03 start line).
Description of Incident/non-compliance	Fracture 02 (originally reported 02 December 2020) runs into an area of naturally jointing. Potentially correlated with the high rainfall events in 2021, it appears that surface soils to flowed into the joint creating several depressions or sink holes of approximately 400mm and 3m long. Maximum depth of the sink hole is estimated at 2.5m. The performance criteria for this land is “no greater subsidence impacts or environmental consequences than predicted in the EIS”. The EIS states that in relation to subsidence predictions for the Panel and Pillar Mining Zone that surface cracking (including sink holes) is not expected.
Actions	Immediate notification to NPWS and Resources Regulator in relation to proposed temporary barrier fencing to mitigate any public safety concerns. Temporary fencing erected on the morning of 23 December 2021. NPWS representatives inspected the area on 23 December 2021 and were satisfied with the installation barrier fences. Inspection report provided to Resources Regulator on 23 December 2021 and weekly there after in relation to the condition of the site (no further deterioration of the area has occurred as of March 2022). In accordance with Schedule 6, Condition 9 of SSD_5581, an Incident Notification was provided to all relevant regulatory departments on 23 December 2021. **Summary of Adaptive Management Actions:** - On 24 February 2021, Centennial voluntarily made the decision to cease the extraction of coal in MW08 and MW09

	at their current approved lengths (to prevent further subsidence related impacts on Mt Airly); - Increased the gateroad chain pillar widths from MW10 and for the remainder of mining under Mt Airly (to arrest subsidence impacts and to bring subsidence performance results back below 125mm); - Engaged multiple external experts and commenced detailed review of subsidence exceedance causal analysis and strategies to bring subsidence back under the approved limits of 125mm; - Review and consideration of potential subsidence crack remediation strategies (in consultation with NPWS and BCSD). - Airly Mine has committed to remediating the sink holes in accordance with the approved remediation program (currently being developed).
Summary of enforcement actions and responses	On-going consultation with DPE in relation to the subsidence performance criteria exceedances throughout 2020 and 2021. In relation to this particular non-compliance, the Department noted that the matter is part of an on-going broader investigation and as such did not require any additional information at the time. On 22 October 2021, Centennial Airly was issued with a Show Cause Notice in relation to the subsidence performance criteria exceedances and associated surface cracking non-compliances on Mt Airly. In response to the Show Cause, Airly Mine in consultation with NPWS and BCSD, submitted a draft Enforceable Undertaking on 31 November 2021. Following multiple remediation risk assessments and on-going consultation with NPWS and BCSD the Enforceable Undertaking is scheduled to be finalised in April/May 2022.
Current Status of Actions	All extraction mining has been completed on Mt Airly. Conservative revised mine design (significant increase to barrier pillar size) has been implemented to ensure recurrence of the non-compliance does not occur. Subsidence crack remediation program currently being developed.

Table 36: Non-Compliance 6 – NPWS Licence for Minor Works – Pt Hatteras

Overview of incident/non-compliance	Non-compliance with NPWS Licence for Minor Works (dated July 2021): *Pt Hatteras Subsidence Monitoring Equipment Installations*
Description of Incident/non-compliance	Correspondence received from NPWS on 6 October 2021. Airly Mine undertook activities that were not clearly described within the approved REF. These activities included: - Installation of Photo Control Points; - Use of several small rocks to support the base of 1 x GNS Station (Station 2).

	Schedule 5, Condition 6 of the Licence for Minor Works states that “works to be carried out in accordance with the description of the activity and environmental safeguards or mitigation measures listed in the REF”. The disturbance footprint related to the installation of the photo control points was approximately 6mm (1 x small anchor bolt) at each site. The disturbance footprint related to the rocks around the base of a post was contained to only 1 GNS Station (Station 2).
Actions	The program was completed under supervision of a qualified Ecologist. A photo inspection report of all GNSS locations was provided to NPWS for review along with an REF Addendum that includes the Photo Control Points. Details of the non-compliance has been communicated with contractor to ensure that a recurrence of a similar non-compliance does not occur.
Summary of enforcement actions and responses	NPWS satisfied with Airly’s response. No further action required.
Current Status of Actions	N/A.

12 ACTIVITES TO BE COMPLETED IN THE NEXT REPORTING PERIOD

The key activities for Airly Mine during the 2022 reporting period are summarised below:

- Continue to improve surface pollution control management structures such as: hydrocarbon storage area, diesel refuelling area, workshop waste oil drainage area and oil-water separator.

- Continue the feral animal control program on mine owned lands to target feral cats and wild dogs. This program has been designed in consultation with Local Land Services, National Parks & Wildlife Service and RPS Consultancy. The program is designed to reduced impacts of feral animal predation to native fauna.

- Continue to improve onsite water management system to prevent unlicensed discharge events. The focus will be on making the existing system more robust and automated;

- Continue to monitor privately owned bores to the east of the Project in an attempt to improve monitoring transparency and trust with the community;

- Continue the extensive environmental monitoring and reporting program;

PLANS

MGA GRID
ZONE 56

N

Scale
Metres
0 50 100 150 200 250

NOTE: The workings and scale shown on this plan are **indicative only**
Current mine workings - refer to digital mine working plan
Any queries on the workings - refer to the survey department at Airly Mine

LEGEND

- EXISTING WORKINGS
- TORBANE COLLIERY OLD WORKINGS
- NEW HARTLEY SHALE MINE OLD WORKINGS
- NEW HARTLEY SHALE MINE POTENTIAL INTERACTION ZONE (PIZ)
- ADDITIONAL 50m SETBACK / FIRST WORKINGS ONLY AREA
- 2018 Mine Workings
- 2019 Mine Workings
- 2020 Mine Workings
- CONSENT AREA FOR SSD_5581
- ML1331 (Offset for Clarity)
- MINING LIMIT(26.5°Offset from Cliff Base (as defined by RPS,110 DOC or 30m from base of Cliff)
- CLIFF LINE ZONE (CLZ) - EXTRACTION PLAN AREA (EP Area)
- REMAINDER OF CLIFF LINE ZONE AS APPROVED BY SSD_5581 WITHIN A232
- SPLITTING AND QUARTERING AREA
- PARTIAL PILLAR ZONE
- PANEL AND PILLAR MINING ZONE
- SHALLOW MINING ZONE

DATE	22/03/2021
REFERENCE	
SCALE	As Shown

Airly Consent Mining Zones Workings 2018,2019 &2020 30/12/2020 Mine Workings

CENTENNIAL AIRLY

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DRG. No. AM02568

M:\Survey\LMGA2020\PLANS\SURFACE\Environment\Environmental Review Plans\2018-2020_Workings_ConsentZones1.dwg

MGA GRID
ZONE 56

N

b 13

b 18

25

Scale

0 0.5 1
KILOMETRES

NOTE: The workings and scale shown on this plan are **indicative only**
Current mine workings - refer to digital mine working plan
Any queries on the workings - refer to the survey department at Airly Mine

LEGEND

- EXISTING WORKINGS
- TORBANE COLLIERY OLD WORKINGS
- NEW HARTLEY SHALE MINE OLD WORKINGS
- NEW HARTLEY SHALE MINE POTENTIAL INTERACTION ZONE (PIZ)
- ADDITIONAL 50m SETBACK / FIRST WORKINGS ONLY AREA
- 2019 Mine Workings
- 2020 Mine Workings
- 2021 Mine Workings
- CONSENT AREA FOR SSD_5581
- ML1331 (Offset for Clarity)
- MINING LIMIT(26.5°Offset from Cliff Base (as defined by RPS,110 DOC or 30m from base of Cliff)
- CLIFF LINE ZONE (CLZ) - EXTRACTION PLAN AREA (EP Area)
- REMAINDER OF CLIFF LINE ZONE AS APPROVED BY SSD_5581 WITHIN A232
- SPLITTING AND QUARTERING AREA
- PARTIAL PILLAR ZONE
- PANEL AND PILLAR MINING ZONE
- SHALLOW MINING ZONE

DATE	29/03/2022
REFERENCE	
N:\Survey\1.MGA2020\PLANS\SURFACE\Environment\Environmental Review Plans\2018-2020_Workings_ConsentZones.dwg	
SCALE	AS SHOWN

Airly Consent Mining Zones
Workings 2019,2020 & 2021
30/12/2021 Mine Workings

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MGA GRID ZONE 56

N

E 220 000

E 225 000

E 230 000

N 6 335 000

N 6 330 000

SCALE 0 1.0 2.0KM

CAPERTEE NATIONAL PARK

GARDENS OF STONE NATIONAL PARK

MOUNT AIRLY

GENOWLAN MOUNTAIN

VILLAGE SPRING

GAP CREEK

ARP01

ARP02

ARP03

ARP04

ARP05

ARP06

ARP07

ARP08

ARP09

ARP11

ARP12

ARP13

ARP14

ARP15

V-Notch Weir

GENOWLAN CREEK 2

GENOWLAN CREEK

THE GROTTO

AMN2

DM2

HVAS

TRAIN LOADER DAM

7ML DAM

MP8=LDP3

PRODUCTION BORE

MP7=LDP2

MP1=LDP1

DM3

109 ML DAM

SETTLING DAM

Railway

Wallerawang Gwabegar

AIRLY DAM

"Airly"

DM4

AIRLY CREEK TRIBUTARY

UPSTREAM AIRLY CREEK

AIRLY CREEK

Glen Davis Road

"Carinya"

AMN2

DM1

NOTE: The workings and scale shown on this plan are **indicative only**
Current mine workings - refer to digital mine working plan
Any queries on the workings - refer to the survey department at Airly Mine

AIRLY MINE EPL
LICENCE No. 12374
MONITORING POINTS

EPA ID No.	NAME	TYPE
MP1	LDP1	WATER
MP3	DM1	DUST
MP4	DM2	DUST
MP5	DM3	DUST
MP6	DM4	DUST
MP7	LDP2	WATER
MP8	LDP3	WATER

LEGEND

- ML1331 Lease Boundary
- A232 Authorisation Boundary
- National Park
- Cadastral Boundary
- Mugii Murum-Ban SCA
- Ground Water Monitoring
- Noise Monitoring
- Dust Monitoring
- Water Monitoring
- HVAS

DATE	29 March 2022
REFERENCE	N:\Survey\1.MGA2020\DWG\Transform\Airly Environmental Monitoring Plan 2019.dwg
SCALE	As Shown

Environmental Monitoring Plan

CENTENNIAL AIRLY

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DRG. No. AM02970

APPENDICES

Appendix 1: 2021 Water Monitoring Report

Airly Mine Water Monitoring

2021 Annual Report

Centennial Airly Pty Ltd

8 March 2022

→ **The Power of Commitment**



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Document status

Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S3	0	A Harvey	A Barron		S. Gray		08/03/22

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Executive summary

Centennial Airly Ltd engaged GHD Pty Ltd to compile a groundwater and surface water report for the 2021 monitoring period. The purpose of this report is to satisfy the conditions of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the Airly Mine Extension Project (EPBC 2013/7076, SSD - 5581) and the 2021 Airly Mine Water Management Plan (GHD, 2021). The information presented herein demonstrates compliance with these conditions has been met throughout 2021.

Groundwater monitoring

Groundwater monitoring was undertaken in accordance with the groundwater monitoring program as set out in the WMP (GHD, 2021) and includes vibrating wire piezometers (VWPs), sampling of groundwater bores (levels and quality) and flow monitoring of groundwater seepage. Groundwater pressures and levels are assessed in comparison with triggers developed for functional VWPs ARP04, ARP06, ARP13 and standpipes ARP14 and ARP15SP. Groundwater levels throughout 2021 were within the respective trigger values except for ARP13, which is currently 0.9 m below the trigger level, consistent with 2020.

Groundwater pressures and levels were generally consistent with 2020, with the exception of ARP04, which demonstrated a pressure increase in the Marrangaroo Formation and decrease in the Lithgow Seam.

Site Specific groundwater quality triggers have been developed based on 80th percentile historical groundwater monitoring data. Site Specific groundwater quality triggers (Site Specific Guideline Values - SSGV) have been developed for ARP05, Village Spring, ARP11, ARP13SP, ARP14 and ARP15. Groundwater quality monitoring was undertaken in 2021 at all sites except for ARP14, which was dry throughout the year.

Quality triggers were exceeded at ARP05, which experienced water level recovery throughout 2021, since being dry from 2017. Concentrations of dissolved metals were elevated coinciding with water level recovery in April and decreased throughout the year, similar to historical concentrations. Exceedances of quality triggers at ARP11 occurred for dissolved zinc in November and December. No other exceedances were recorded at this location. At ARP13SP pH was variable exceeding the upper and lower thresholds. Dissolved zinc was recorded above the SSGV in late 2021. At ARP14, one exceedance of EC for the maximum trigger value occurred in 2021. Dissolved metal concentrations were generally low and below trigger values except for copper which exceeded the threshold in December only and both iron and manganese in November and December. At ARP15SP, metal concentrations were reported to be below trigger values except for nickel in November and zinc in December. Village spring recorded SSGV exceedances the on multiple occasions throughout 2021 including pH, TSS and dissolved nickel, though concentrations were within historical ranges.

All other groundwater sites are compared to the ANZECC (2000) Default Guideline Values (DGV). Groundwater sites recording DGV exceedances in 2021 were consistent with historical records and without trends of concern, except at ARP08. ARP08 has experienced rising pH, EC and alkalinity. Investigation of trends found a blockage in the standpipe annulus, which may have been associated with the degradation of grout. Groundwater migration was also found to be limited and the elevated pH was found to be localised to the bore. These investigations were confirmed through sampling of mine water, which contrasts the water type at ARP08.

Seepage flow

Groundwater seepage from the Permian strata is monitored continuously at Village Spring. Continuous flow was observed throughout 2021, consistent with observed above-average rainfall. Groundwater inflow into the underground workings was reportedly negligible throughout 2021.

Surface water quality monitoring

Surface water quality triggers have been developed for the Airly Creek and Genowlan Creek Surface water monitoring sites.

During 2021, surface water quality within the Airly Creek catchment ranged circumneutral to alkaline and was slightly brackish. Dissolved metal exceedances were limited and occurred primarily within April 2021. Nickel exceedances were reported in Airly Tributary throughout 2021, consistent with historical records.

Surface water quality within the Genowlan Creek catchment ranged slightly acidic to slightly alkaline and was fresh. Dissolved metal exceedances were limited and occurred predominantly within the final quarter of 2021, corresponding to periods of high flow. The SSGV exceedances were within historical ranges.

This report is subject to, and must be read in conjunction with, the limitations set out in Section 1 and the assumptions and qualifications contained throughout the report.

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1. Introduction

Airly Mine is an underground coal mine owned and operated by Centennial Airly Pty Limited (Centennial Airly). It is located near Capertee village, approximately 40 km north-west of Lithgow on the Castlereagh Highway in the Western Coalfield of NSW, as shown in Figure 1.1.

Centennial Airly Pty Ltd (Centennial Airly) commissioned GHD to compile surface water and groundwater data pertaining the site and its monitoring network into a consolidated annual report for the purpose of completeness and compliance monitoring requirements. This report presents an assessment of surface water and groundwater related to Airly Mine for the period of 2021 in relation to trigger values specified in the Airly Mine Water Management Plan (WMP) (GHD, 2021) and historical trends. The information provided herein will be relied upon for inclusion in overarching reports for the Airly Mine Annual Review.

1.1 Background

Airly Mine was granted Development Consent DA162/91 for the development of an underground coal mine on 14 April 1993 by the then Minister for Planning following a Commission of Inquiry held in 1993. The development consent allows Airly Mine to extract up to 1.8 million tonnes per annum (Mtpa) of run of mine (ROM) coal within the mining lease ML1331. Mining is undertaken by bord and pillar methods within the Lithgow Seam.

The mine underwent a period of care and maintenance from January 2013 to March 2014. The Airly Mine Extension Project (SSD_5581) was approved in December 2016 and allowed mining for a period of 20 years within the boundaries of ML1331 and Authorisation 232 (A232). Six modifications have been approved subsequent to the initial development consent (MOD 1 through MOD6).

1.2 Objectives of this report

The objective of this report is to present the status of surface water and groundwater in the vicinity of the Airly underground mine with respect to:

– Mining related activity, identifying any potential impact/s, if occurring.
– Conditions of the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) Airly Mine Extension Project (EPBC 2013/7076, SSD - 5581).
– The 2021 Airly Mine Water Management Plan (GHD, 2021).

1.3 Limitations

This report: has been prepared by GHD for Centennial Airly Pty Ltd and may only be used and relied on by Centennial Airly Pty Ltd for the purpose agreed between GHD and Centennial Airly Pty Ltd as set out in section 1 of this report.

GHD otherwise disclaims responsibility to any person other than Centennial Airly Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

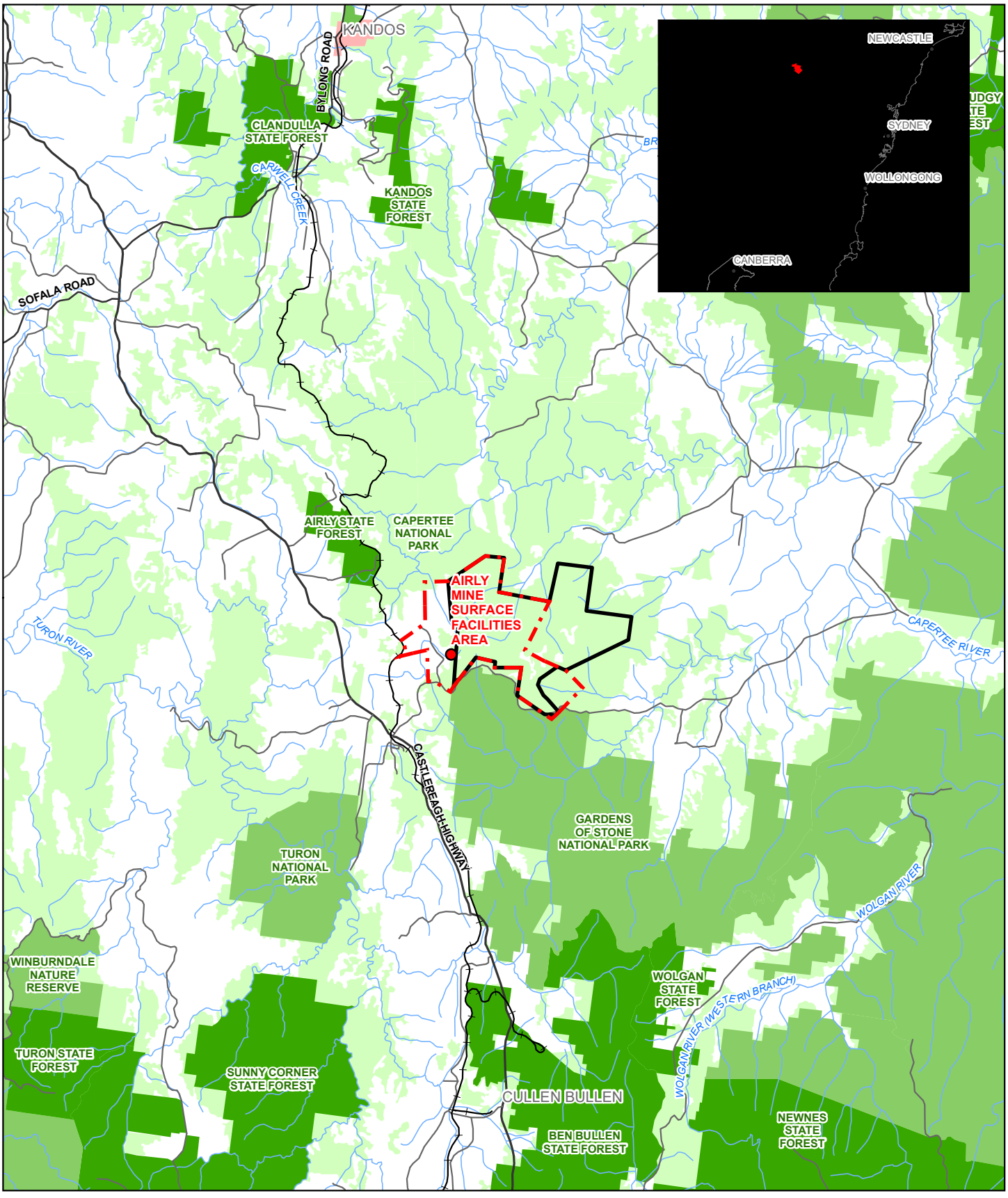
The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Centennial Airly Pty Ltd and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Site conditions may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.



LEGEND

- Airly Surface Facilities Area
- Mining Lease ML1331
- Authorisation A232
- Existing rail
- Dual carriageway
- Principal road
- Secondary road
- Minor road
- Waterway
- Built up area
- Recreation area
- Forest or shrub
- Nature conservation
- State forest

Paper Size A4

0 1,000 2,000 4,000 6,000 8,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Airly Mine
Airly Mine Annual Reporting
2021 Annual Water Monitoring Report

Locality plan

Job Number	12526161
Revision	A
Date	10/02/2022

Figure 1-1

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

G:\22\0105001\GIS\Maps\Deliverables\Western\Airly\2212526161\AnnualReview2021\12526161_AEMR001_Locality_A.mxd

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Data source: @ Commonwealth of Australia (Geoscience Australia): 250K Topographic Data Series 3 2006; Centennial: Boundaries. Created by: smacdonald

2. Approvals and licence requirements

2.1 Development consent

The WMP addresses specific water components of the conditions of development consent SSD-5581, which was granted by the Planning Assessment Commission of NSW on 15 December 2016 for the Airly Mine Extension Project. The relevant requirements of the consent are outlined in Table 2.1. This is noted to be a comprehensive list and not all conditions are relevant to this annual report. The sections of this document where relevant conditions have been addressed are also detailed in Table 2.1, otherwise direction to another source has been made.

Table 2.1 Development consent SSD-5581 conditions

Condition		Compliant	Relevant section of this document
Schedule 4 13.	Prior to carrying out any development under this consent, unless the Secretary agrees otherwise, the Applicant must prepare a Water Management Plan for the development to the satisfaction of the Secretary. This plan must:	Yes	NA (refer to WMP, GHD (2021))
Schedule 4 13. (a)	Be prepared in consultation with the DoE, EPA and DPI Water, by suitably qualified and experienced person/s whose appointment has been approved by the Secretary.	Yes	NA (refer to WMP)
Schedule 4 13. (b)	Include detailed performance criteria and describe measures to ensure that the Applicant complies with the Water Management Performance Measures (see Table 6).	Yes	NA (refer to WMP)
Site water balance			
Schedule 4 13. (c) (i)	Details of sources and security of water supply, including contingency supply for future reporting periods.	Yes	NA (refer to Sections 3.2 to and 3.5 of the WMP)
	Details of water use and management on site.	Yes	Section 3.1 Also refer to Section 3.2 to 3.4 of the WMP
	Details of any off-site water discharges.	Yes	Section 5.2.3 Also refer to Section 3.5.2 of the WMP
	Reporting procedures, including the preparation of a site water balance for each calendar year.	Yes	Section 6.1.6 Also refer to Section 7.4 of the WMP
	Investigates and implements all reasonable and feasible measures to minimise water use on site.	Yes	NA (refer to Section 3.5.1 of the WMP)
Surface water management plan			
Schedule 4 13. (c) (ii)	Detailed baseline data on water flows and quality in the watercourses that could potentially be affected by the development, including, but not limited to Gap, Genowlan and Airly Creeks.	Yes	Section 5 Also refer to Section 5.1 of the WMP
	Continuous flow monitoring at Airly Village Spring and the Grotto.	Yes	Section 4.5.1 and Section 5 Also refer to Section 4.2.2 of the WMP
	Provisions for the recalculation of site-specific trigger values in relation to water discharges to Airly Creek once a minimum of two years data is obtained from the Airly Creek 'U/S' monitoring location in accordance with ANZECC guidelines.	Yes	NA (refer GHD 2018a and Section 6.1.1 of the WMP)

Condition		Compliant	Relevant section of this document
	The provision and implementation of adaptive management measures to ensure that subsequent water discharges to Airly Creek comply with the recalculated site-specific trigger values derived from the Airly Creek 'U/S' monitoring location.	Yes	NA (refer to TARPS in Appendix E of the WMP)
	A detailed description of the water management system, including the: – Clean water diversion systems. – Erosion and sediment controls (mine water system). – Mine water management systems.	Yes	NA (refer to Section 3.2 of the WMP)
	Detailed objectives and performance criteria, including trigger levels for investigating any potentially adverse impacts associated with the development for:	Yes	
	Downstream surface water quality.		Section 5.2 Also refer to Section 6 of the WMP
	Downstream water users, including with respect to any subsidence-related flow reductions in Gap and Genowlan Creeks.		NA (refer GHD 2018a and Section 6 of the WMP)
	Stream and riparian vegetation health in Gap, Genowlan and Airly Creeks within and immediately outside of the site.		NA Refer to Section 6.2 of the WMP Riparian vegetation assessment outlined in Airly Site Specific Biodiversity Management Plan (BMP)
	A program to monitor and report on: Effectiveness of the mine water management system. Surface water flows, quality and geomorphology of the watercourses potentially affected by the development within and immediately outside of the site. The performance measures listed in Table 6 including, but not limited to event-based monitoring of the hydrology, quality, ecotoxicology and chemical composition of water in Airly Creek under discharge conditions at points 5 and 6, or as otherwise determined in consultation with the EPA, to ensure that protection is provided to 99% of all species in the Gardens of Stone National Park and Greater Blue Mountains World Heritage Area in accordance with ANZECC guidelines.	Yes	Section 5 Also refer to Section 4 and 7 of the WMP Also refer to Section 1.3.2 of GHD (2018b)
	Reporting procedures for the results of the monitoring program.	Yes	NA (refer to WMP)
	A plan to respond to any exceedances of performance measures, and repair, mitigate and/or offset any adverse surface water impacts of the development, including measures to provide compensatory water supply to any affected downstream water user.	Yes	NA (refer to WMP)
Groundwater Management Plan			
Schedule 4 13. (c) (iii)	Detailed baseline data of groundwater levels, yield and quality in the region that could be affected by the development, including licensed privately-owned groundwater bores and a detailed survey/schedule of groundwater dependent ecosystems (including springs and their discharge quantity and quality).	Yes	Section 4

Condition		Compliant	Relevant section of this document
	Consultation with DPI Water on the installation of all new monitoring bores, the scheduled sampling and quality determination of parameters for monitoring bores.	Yes	NA (refer to Section 4.4 of the WMP)
	Groundwater assessment criteria including trigger levels for investigating any potentially adverse groundwater impacts.	Yes	Section 4.3 and 4.4
	A program to monitor and report on: – Springs and their discharge quantity and quality. – Groundwater inflows transferred to the surface water management system. – The seepage/leachate from water storages and emplacements. Impacts of the development on: – Regional and local (including alluvial) aquifers. – Groundwater supply of potentially affected landowners. – Groundwater dependent ecosystems (including rules for the management of groundwater level impacts to protect groundwater dependent ecosystems), and riparian vegetation.	Yes	Section 4.1 Also refer to Sections 4.4 and 4.5 of the WMP.
	A program to monitor and report on stygofauna and hyporheic fauna.	Yes	NA (refer to Sections 4.4.3 and 7.1 of the WMP and the Western Region Stygofauna Monitoring Assessment Plan.
	A program to review and validate the groundwater model for the development, including independent expert review.	Yes	NA (refer to Section 7.5 of the WMP)
	A plan to respond to any exceedances of the performance measures.	Yes	NA (refer to Appendix E of the WMP)

NA – not applicable to this report

2.1.1 Airly Mine extension project statement of commitments

In addition to the conditions of development consent, Centennial Airly also committed to the management strategies and monitoring activities outlined in Table 2.2 as part of the Airly Mine Extension Project.

Table 2.2 Statement of commitments

Commitment	Compliant	Where addressed
Additional groundwater monitoring bores will be installed during the pre-mining phase within Gap Creek and Genowlan Creek alluvium in the areas of predicted groundwater drawdown and monitored for groundwater levels and quality (where accessible).	Yes	NA (refer GHD 2017c)
Daily groundwater volumes transferred to the surface facilities area will be monitored.	Yes	Section 4.5.2
The WMP will establish critical threshold levels for groundwater levels and groundwater quality to trigger additional assessment and management, and will define the mechanism for identifying and reporting exceedances. Action will be taken if the Level 1 minimal impact considerations (or other critical threshold levels) are found to be exceeded.	Yes	NA (refer to Section 6.1.3 of the WMP)
Groundwater monitoring data will be audited on an annual basis and compared to hydrogeological modelling predictions. The WMP will define the mechanism for identifying and reporting variations from predictions.	Yes	Section 4.3

Commitment	Compliant	Where addressed
Should more than 278 ML/year of groundwater flow into the underground workings (i.e. more than the existing water access licences) due to greater than predicted storage within the Permian strata (particularly within the old shale workings), it will be necessary for Centennial Airly to purchase an additional water access licence to cover the excess groundwater volume.	Yes	NA (refer to Sections 1.2.5 and 6.1.3 of the WMP)
Additional groundwater monitoring points to be installed during the pre-mining phase within Gap Creek and Genowlan Creek alluvium in the areas of predicted groundwater drawdown. The groundwater monitoring points will monitor the following parameters: – Piezometric height. – Groundwater quality. – Groundwater flow. – Geomorphic conditions of third order streams. The monitoring of the above noted parameters will be undertaken on a quarterly basis except for the monitoring of geomorphic condition of third order streams which will be undertaken every two years.	Yes	NA (refer GHD 2017c)
Monitoring groundwater bores on adjacent private properties will be undertaken to provide understanding of regional groundwater systems. Parameters to be monitored will be: Piezometric height. Groundwater quality.	Yes	Monitoring program outlined in Section 4.4.1 of the WMP. Section 4.5.2
Monitor macroinvertebrate ecology in Airly Creek at appropriate upstream and downstream locations biannually (spring and autumn).	Yes	NA (refer to Section 3.5 of GHD 2018b)

NA – not applicable to this report

2.2 Environment protection licence

Airly Mine currently holds environment protection licence (EPL) 12374, with water currently licensed to be discharged from the site through the following licensed discharge points (LDPs):

– LDP001 – Discharge to Airly Creek via the Production Dam
– LDP002 – Discharge to Airly Creek via the Stockpile Dam
– LDP003 – Discharge to Airly Creek via the Train Loader Dam

Water quality concentration limits for LDP001, LDP002 and LDP003 specified by EPL 12374 are summarised in Table 2.3 and Table 2.4.

Table 2.3 LDP001 water quality concentration limits

Parameter	Units	Concentration limit	
		90 percentile concentration limit	100 percentile concentration limit
Ammonia	mg/L	-	0.32
Arsenic (dissolved)	mg/L	-	0.024
Electrical conductivity (EC)	µS/cm	2244	-
Copper (dissolved)	mg/L	-	0.013
Nickel (dissolved)	mg/L	-	0.1
Nitrogen (total)	mg/L	2	-
Oil and grease	mg/L	-	10
pH	pH units	-	6.5-9.0

Parameter	Units	Concentration limit	
		90 percentile concentration limit	100 percentile concentration limit
Phosphorus (total)	mg/L	0.5	-
Total suspended solids (TSS)	mg/L	-	50
Turbidity	NTU	-	40
Zinc (dissolved)	mg/L	-	0.072

Table 2.4 LDP002 and LDP003 water quality concentration limits

Parameter	Units	100 percentile concentration limit
Oil and grease	mg/L	10
pH	pH units	6.5–9.0
Total suspended solids (TSS)	mg/L	50
Turbidity	NTU	40

The water quality limits presented in Table 2.3 and Table 2.4 do not apply when the discharge occurs solely as a result of significant rainfall, measured as that which exceeds 44 mm over any consecutive five-day period at the site.

2.3 Water licences

Airly Mine currently holds two water access licences (WALs) under the *Water Management Act 2000* for the extraction of groundwater. A total of 278 ML is licensed for extraction from the Sydney Basin North groundwater source as part of the Water Sharing Plan (WSP) for the Greater Metropolitan Region Groundwater Sources, made up of WAL 24386 (158 ML/year) and WAL 36565 (120 ML/year). WAL 24386 licenses the take of water from the production bore (water supply works approval 10WA112537), which is used to supplement water for use in mining activities. WAL 36565 licenses the extraction of water from the underground workings to the 109 ML Dirty Water Dam.

A number of licences are held by Airly Mine under the *Water Act 1912* for groundwater monitoring bores.

3. Site environment

The site environment, including descriptions of the topography, hydrology, geology and hydrogeology, is provided in the WMP (GHD, 2021). A review of current water management infrastructure and climatic data updated for inclusion of 2021 records is presented below.

3.1 Water management infrastructure

Water management infrastructure for surface catchment and management of clean and dirty water at Airly Mine comprise:

- A discharge dam (Production Dam) for the storage of clean water for use or discharge via licensed discharge point 1 (LDP001) into a drainage channel which flows through the site and ultimately discharges to Airly Creek.
- A system of small primary settling dams for trapping coarse sediment, including the Train Loader Dam and Filter Ponds upstream of the 109 ML Dirty Water Dam.
- Overflows from the Train Loader Dam are discharged to Airly Creek via licensed discharge point 2 (LDP003).
- A large secondary dam (109 ML Dirty Water Dam) and a smaller dam (Stockpile Dam) into which overflow from the small settling dams and the coal stockpile discharge, respectively, and allow settlement of fine sediments.
- Overflows from the Stockpile Dam are discharged to Airly Creek via licensed discharge point 2 (LDP002).
- A Production bore (AM2B-1).

Water management infrastructure are shown in Figure 3.1.

3.1.1 Production bore

Centennial Airly has a licensed production bore (AM2B-1, bore licence no. 10WA112537; Water Access Licence (WAL) 24386), located adjacent to the existing rail loop. AM2B-1 was installed in 2009 within sandstone and siltstone of the Shoalhaven Group and was licensed to extract up to 158 ML/year of groundwater at a maximum rate of 5 L/s. AM2B-1 is a potential water supply for mining operations at Airly Mine. Approximately 0.0483 ML was extracted from the production bore in 2021 for the purpose of groundwater purging for quality monitoring.

AM2B-1 is sampled for water quality via the installed pump. Water levels are gauged in the adjacent ‘old production bore’.



LEGEND

- Licensed discharge point
- Infrastructure
- Pollution control structure
- Waterway
- Rail loop

Paper Size A4

0 40 80 160 240 320

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

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Airly Mine
Airly Mine Annual Reporting
2022 Annual Water Monitoring Report

Job Number	12526161
Revision	A
Date	10/02/2022

Surface facilities area features

Figure 3-1

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

G:\22\0105001\GIS\Maps\Deliverables\Western\Airly\2212526161\AnnualReview2020\12526161_AEMR002_SurfaceFacilityFeatures_A_.mxd

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Data source: LPI: DTDB 2012; Centennial: Imagery, monitoring, boundaries, survey. Created by: smacdonald

3.2 Climate

3.2.1 Rainfall

Daily rainfall data was obtained from the Scientific Information for Land Owners (SILO) database operated by the Queensland Government - Department of Science, Information Technology and Innovation (DSITI, 2020). SILO Patched Point Data is based on historical data from a particular Bureau of Meteorology (BoM) station with missing data 'patched in' by interpolating with data from nearby stations.

For this assessment, SILO data was obtained from the BoM Ilford (Warrangunyah) Station (station number 62031), which is located approximately 29 km north-west of Airly Mine. This station was chosen based on the length and quality of the data record and proximity to the site.

The period of rainfall data used for this assessment dates from January 1901 to December 2021 and is summarised as annual totals in Figure 3.2.

The statistics for this rainfall dataset are:

– Minimum annual rainfall – 299.8 mm in 1982
– Average annual rainfall – 682.3 mm
– Median annual rainfall – 662.0 mm
– Maximum annual rainfall – 1544 mm in 1950
– Total rainfall for 2021 – 951.6 mm (91st percentile)

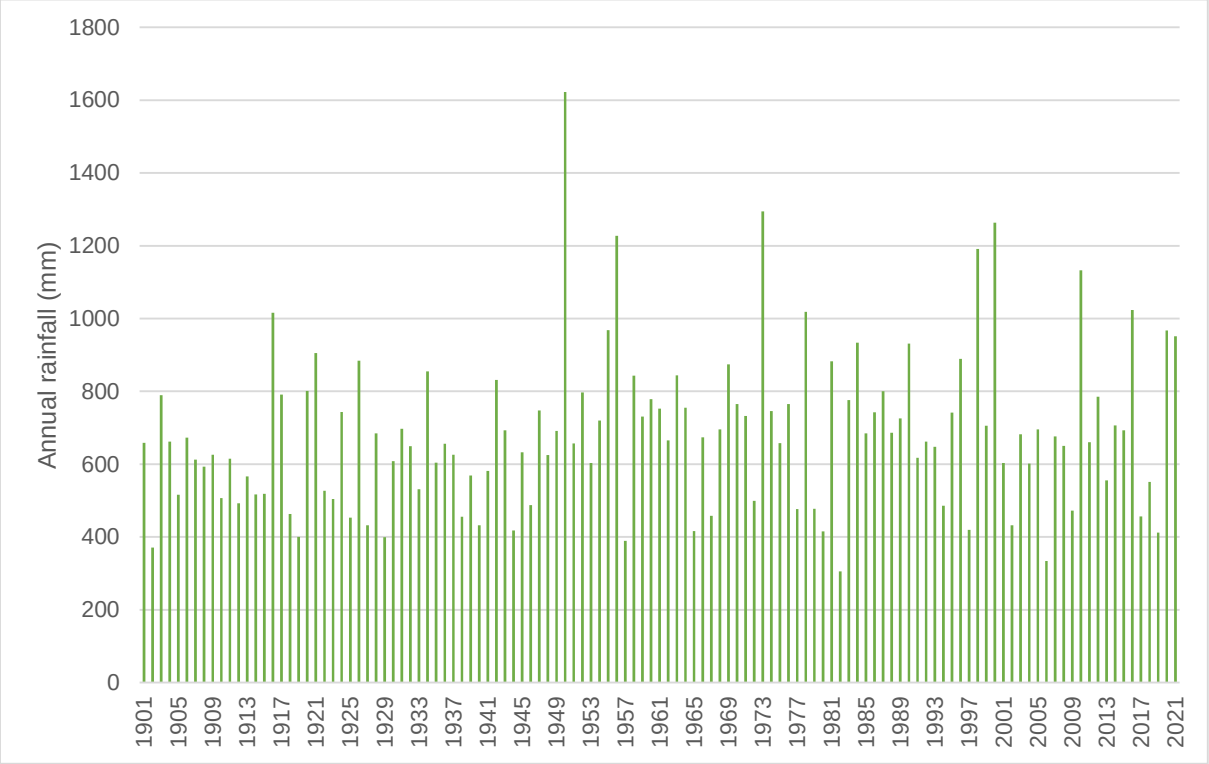


Figure 3.2 Annual rainfall recorded at Illford (Warrangunyah) Station, 1901 to 2021

Total rainfall in 2021 was above the historical average (951.6 mm versus 682.3 mm). Monthly rainfall varied from 3.6 mm in April to 200.4 mm in November. The monthly rainfall for March, June and July 2021 was double the long-term monthly averages, while rainfall in November was triple the long-term monthly average. Higher than average rainfall was also recorded in February and August 2021.

3.2.2 Cumulative rainfall departure

A cumulative rainfall departure (CRD) curve presents the cumulative difference between the observed monthly rainfall and long-term average monthly rainfall. The CRD curve only deviates from zero due to atypical (above and below average) rainfall. Increase in the CRD reflects above average rainfall while a decrease reflects below average rainfall. Historical CRD inclusive of results from 2021 is shown in Figure 3.3. An increasing trend is observed during 2021 (Figure 3.4).

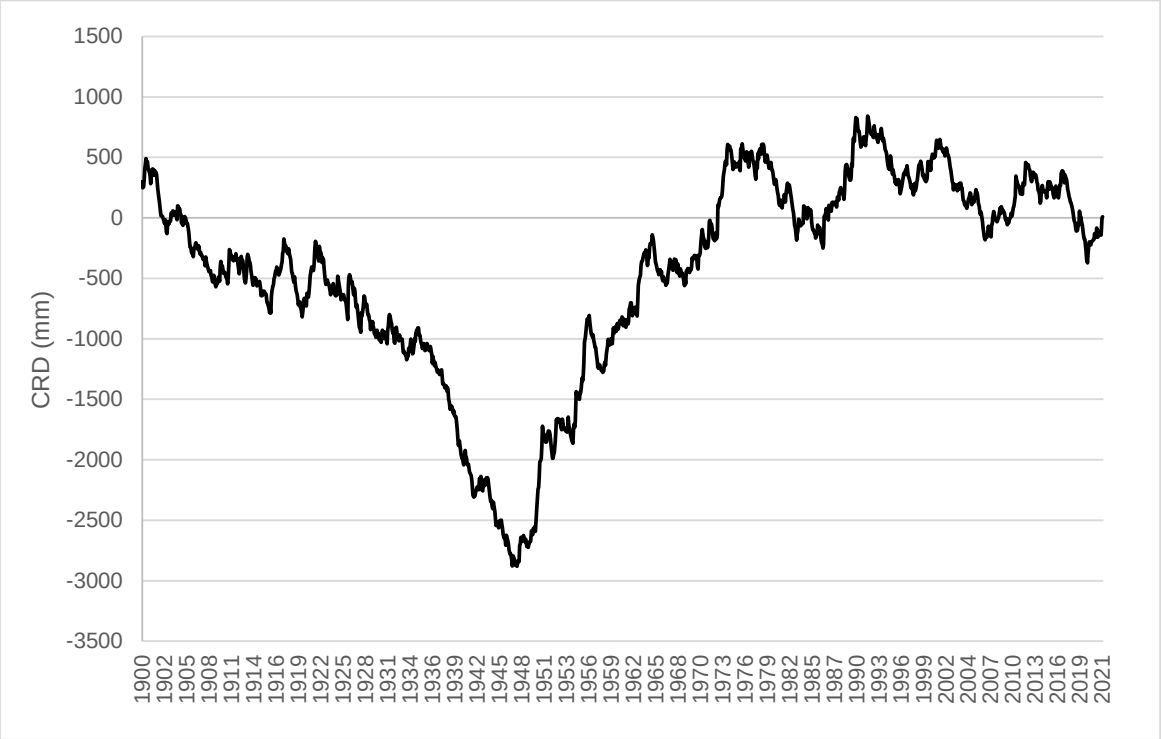


Figure 3.3 Cumulative rainfall departure curve, 1901 to 2022

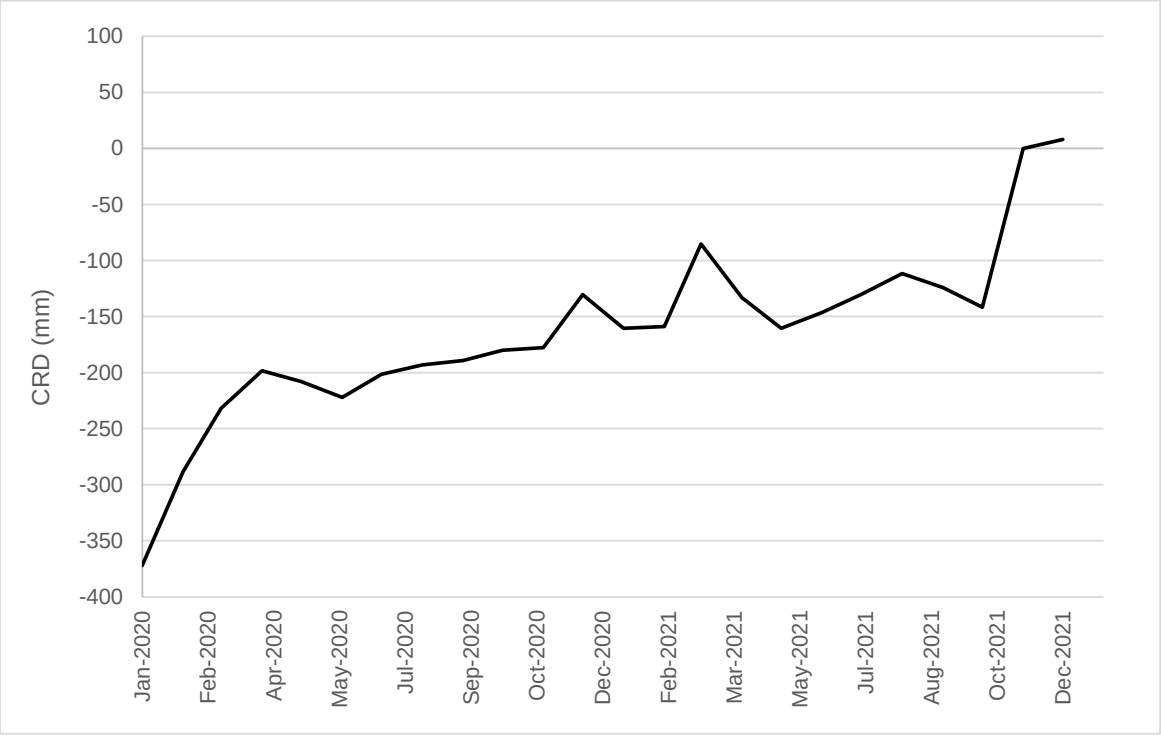


Figure 3.4 Cumulative rainfall departure, 2020 / 2021

3.2.3 Evaporation

Evaporation data was also obtained from the BoM Ilford (Warrangunyah) Station (station number 62031), as the nearest station with historical evaporation records. The long-term average annual evaporation total is 1351.9 mm, compared to the long-term annual average rainfall of 682.3 mm. This gives an annual deficit of approximately 669.6 mm. Monthly evaporation varied between 27.4 mm in June and 163.9 mm in December. In 2021, the evaporation totals for all months were below the historical average, with no significant deviation.

The monthly evaporation rates for 2021 are presented in Figure 3.5.

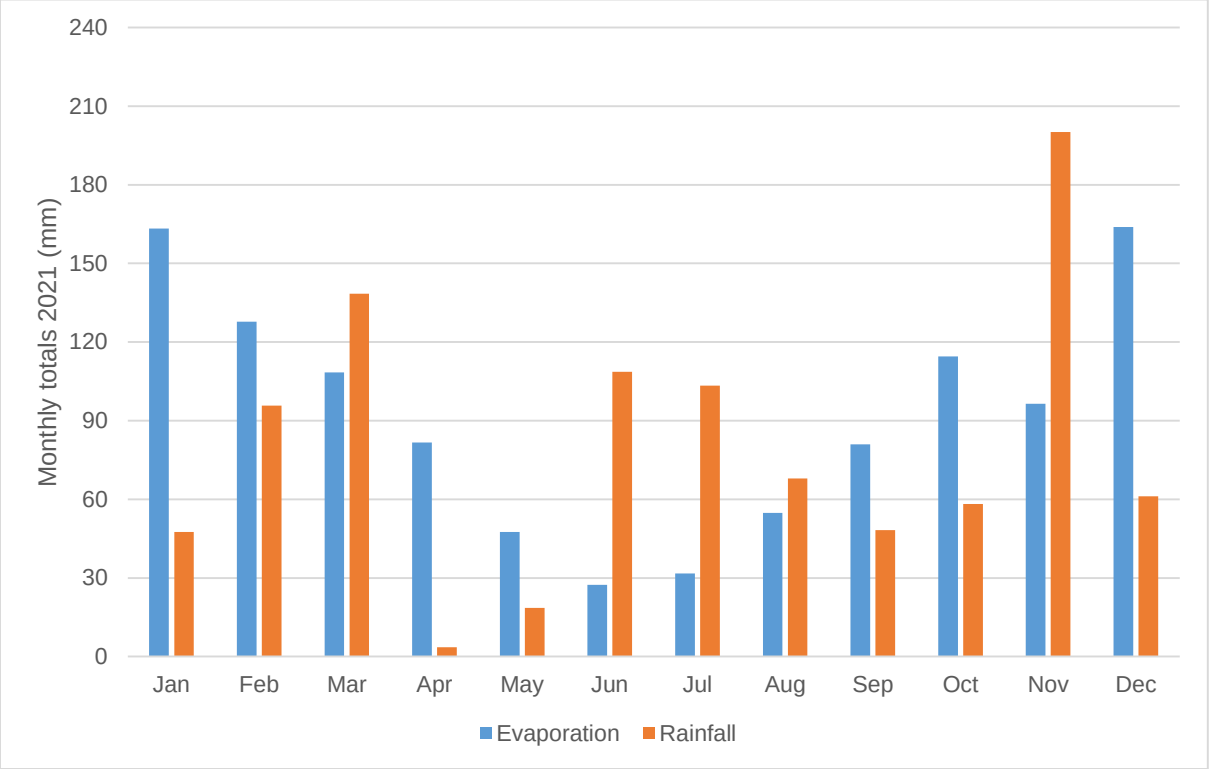


Figure 3.5 Monthly evaporation and rainfall recorded at BoM Illford (Warrangunyah) Station (station 62031), 2021

4. Groundwater monitoring

4.1 Monitoring Network

The monitoring program for 2021 comprised:

– Monitoring of deep aquifer water pressures via vibrating wire piezometers (VWPs) at eight locations (excluding ARP01 which has been completely dysfunctional since 2018).
– Monitoring of water levels in alluvial, Narrabeen Sandstone and Permian aquifers from ten standpipe piezometers (excluding ARP07 which has been dry since July 2013 and ARP16, which has been dry since installation in December 2021).
– Monitoring water quality of alluvial, Narrabeen Sandstone and Permian aquifers via nine standpipe piezometers (excluding ARP07 and ARP16) and three private production bores for water quality assessment.
– Monitoring of groundwater seepage flows at Village Spring and in mine workings.

Details of the monitoring network are presented in Table 4.1 and shown in Figure 4.1.

Table 4.1 Groundwater monitoring network details

Type	Location	Monitoring Period	Lithology	Status
VWPs	ARP01	June 2012–2018 All loggers dysfunctional since 2018.	Narrabeen Sandstone (74 m bgl)	Dysfunctional (2015)
			Irondale Seam (238.5 m bgl)	Dysfunctional (2018)
			Lithgow Seam (260 m bgl)	Dysfunctional (2018)
			Marrangaroo Formation (263 m bgl)	Dysfunctional (2018)
	ARP02A	May 2012–present Marrangaroo Formation, Irondale and Lithgow Seam dysfunctional since 2020.	Narrabeen Sandstone (65 m bgl)	Working
			Irondale Seam (243 m bgl)	Dysfunctional (2020)
			Lithgow Seam (266 m bgl)	Dysfunctional (2020)
			Marrangaroo Formation (270 m bgl)	Dysfunctional (2020)
	ARP03A	July 2012–present	Narrabeen Sandstone (136 m bgl)	Dysfunctional (2020)
			Middle River Seam (165 m bgl)	Working
			Lithgow Seam (252 m bgl)	Dysfunctional (2019)
			Marrangaroo Formation (257 m bgl)	Dysfunctional (2019)
	ARP04	April 2012–present	Lithgow Seam (25 m bgl)	Working
			Marrangaroo Formation (28.5 m bgl)	Working
			Shoalhaven Siltstone (210.3 m bgl)	Working

Type	Location	Monitoring Period	Lithology	Status
	ARP06	June 2013–present	Narrabeen Sandstone (230 m bgl)	Working
			Irondale Seam (252 m bgl)	Working
			Lithgow Seam (288 m bgl)	Working
			Marrangaroo Formation (295 m bgl)	Working
	ARP07	July 2013–present (dry)	Middle River Seam (168 m bgl)	Working
			Lithgow Seam (252 m bgl)	Working
	ARP08	September 2013– present	Narrabeen Sandstone (183 m bgl)	Working
			Irondale Seam (282.5 m bgl)	Working
	ARP13	December 2016– present	Shoalhaven Group (120 m bgl)	Dysfunctional (2021)
			Devonian strata (280 m bgl)	Dysfunctional (2021)
	ARP15[1]	January 2017– present	Lithgow Seam (125 m bgl)	Working
			Shoalhaven Group (200 m bgl)	Working
			Devonian strata (365 m bgl)	Working
Standpipes	AM2B-1	2009–present	Shoalhaven Group (38–87 m bgl)	Working (quality only)
	Old Production Bore	May 2017- present	Shoalhaven group (37-69 m bgl)	Working (Levels only)
	ARP05	August 2012–present	Gap Creek alluvium (8–11 m bgl)	Working
	ARP07	July 2013–present	Narrabeen Sandstone (110–119 m bgl)	Working – dry since July 2013
	ARP08	September 2013– present	Lithgow Seam (301–305 m bgl)	Working
	ARP09	June 2013–present	Genowlan Creek alluvium (3–4 m bgl)	Working – mostly dry, responds after rainfall
	ARP11	January 2017– present	Permian strata (1.25–15.3 m bgl)	Working – rising trend since Sept 2021
	ARP12	January 2017– present	Genowlan Creek alluvium (0.5–2.6 m bgl)	Working – mostly dry, responds after rainfall
	ARP13SP	January 2017– present	Lithgow Seam (67.5–70.5 m bgl)	Working

[1] Logger box damaged by tree fall January 2021

Type	Location	Monitoring Period	Lithology	Status
	ARP14	January 2017– present	Genowlan Creek alluvium (0.5–2.3 m bgl)	Working
	ARP15SP	January 2017– present	Narrabeen sandstone (10–16 m bgl)	Working
	ARP16 (Nissan Hut)	December 2021 – present	Unknown	Working (Dry since install)
Landholder bores	Nioka	January 2017 – present	Devonian strata	Working (quality only)
	Kingdom	November 2019– present	Devonian strata	Working (quality only)
	GW80876	December 2021 - present	Unknown	Working – dry (quality only)
Seepage	Village Spring	February 2011–present	Permian Siltstone	Regular flow – accessed when passable by foot
	Mine workings	December 2009–present	Lithgow Seam	Negligible volumes reported to date

4.2 Monitoring program

4.2.1 Water levels

Water pressure is gauged automatically at each VWP and recorded by data loggers every 12 hours. Numerous loggers have become dysfunctional since installation, as presented in Table 4.1.

Water pressure is gauged automatically via pressure transducers in standpipes ARP07, ARP08, ARP09, ARP13SP, ARP11, ARP12, ARP14 and ARP15SP and recorded by data loggers every one to six hours. The transducer located at ARP05 failed in 2019 and was removed in 2020. It was not replaced given the well was been dry between September 2017 and April 2021. The logger has since been replaced and will be monitored throughout 2022. The logger within ARP08 was removed in December 2021 due to activities undertaken by contractors within the bore.

Data loggers were downloaded every one to three months throughout 2021. Manual water level gauging of each standpipe also occurred monthly. Groundwater levels are not able to be measured at production bores AM2B-1, Nioka, Kingdom and GW800787 due to installed head works. Groundwater levels at the old production bore (adjacent to AM2B-1) have been recorded since May 2017.

4.2.2 Water quality

Water quality is assessed from standpipes, the production bore (AM2B-1) and Village Spring (when possible) on a monthly basis, and the privately registered bores GW103410 (Nioka), Kingdom and GW800787 quarterly. No samples were collected from ARP07 during 2021 due to persistent dry conditions within the bore.

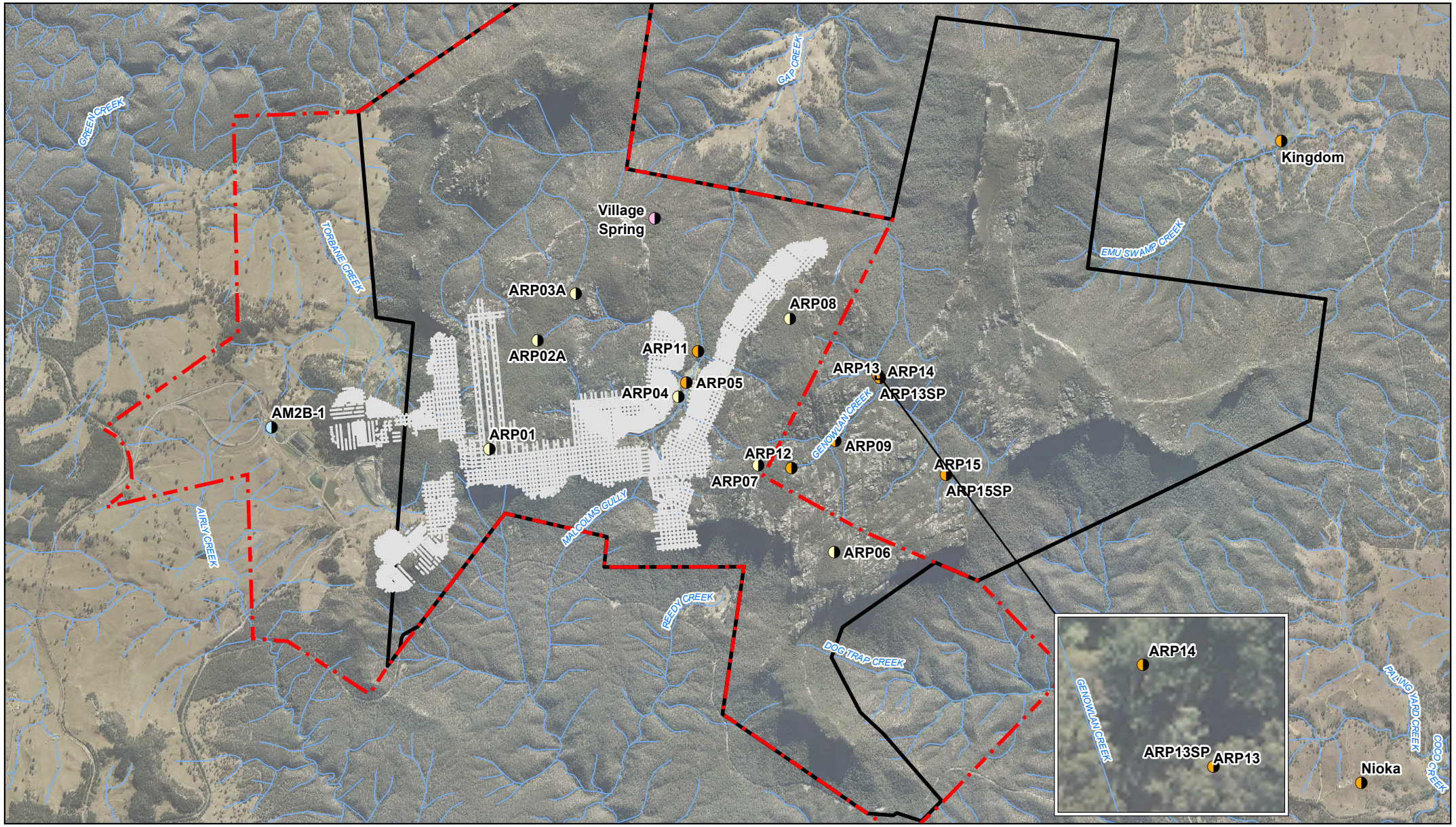
4.2.3 Seepage flow

The flow rate at Village Spring is monitored continuously using a tipping bucket flow gauge and data logger. Data is uploaded to an online database via remote telemetry.

Seepage into the existing Lithgow Seam workings is reportedly negligible. No mine dewatering occurred in 2021.

4.2.4 Access

Access to most monitoring locations is considered adequate during dry weather and low fire risk conditions. The track to ARP06 and Village Spring has degraded and become impassable requiring access by foot. Access to ARP13, ARP14 and ARP15 is also limited to foot given site rehabilitation activities. Continued access to these locations may be impeded by vegetation growth.



Paper Size A4

0 200 400 800 1,200 1,600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Groundwater seepage
- Production bore
- Standpipe monitoring bore
- Vibrating wire piezometer
- Existing workings
- Mining Lease ML1331
- Authorisation A232
- Waterway

Airly Mine
Airly Mine Annual Reporting
2021 Annual Water Monitoring Report

Job Number 12526161
Revision A
Date 10/02/2022

Groundwater monitoring locations

Figure 4-1

G:\22\0105001\GIS\Maps\Deliverables\Western\Airly\2212526161\AnnualReview2020\12526161_AEMR003_GWMonitoringBores_A.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

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Data source: LPI: DTDB 2012; Centennial: Imagery, monitoring, boundaries, survey. Created by: smacdonald

4.3 Groundwater levels

4.3.1 Vibrating wire piezometers

Time series plots for all VWPs are presented in 0. All levels recorded for ARP02, ARP03, ARP04, and ARP06 during 2021 were within their respective trigger values. However, ARP13 recorded levels below the trigger value in the first three quarters of 2021. In the fourth quarter no data was available due to data download failure, however the pressure is assumed to remain below the trigger value throughout the quarter (Table 4.2).

As detailed in Table 4.2, pressure data is not available at ARP01 and is incomplete at ARP02, ARP03 and ARP08. The data loggers at ARP01 malfunctioned in 2018. The Marrangaroo Formation data logger at ARP02 failed in April 2020, followed by the Lithgow and Irondale seam data loggers in June 2020.

At ARP03, data loggers have failed in the Narrabeen Sandstone since April 2020, in the Lithgow Seam and Marangaroo Formation since January 2020 and the Middle River Seam since March 2021. However, manual readings have occasionally been successful via the VWP unit, for the Lithgow Seam (January to August 2021), Marrangaroo Formation (February to June 2021) and the Middle River Seam (April to December 2021).

The data logger in the Irondale Seam at ARP08 malfunctioned between April and October 2020 but has remained functional since.

Piezometric pressure is generally low and stable at the existing VWP monitoring locations, generally ranging from 0 m to 10 m above the measuring point elevation, with little observable response to rainfall. The low piezometric pressure is considered to reflect the extensive groundwater seepage areas across the slopes of Mount Airly and Genowlan Mountain.

Pressures reported in 2021 are generally similar to those reported between 2013 and 2020, with the exception of ARP04 within the Marrangaroo Formation. Minor decreasing trends were observed in 2014 through 2017 in the Middle River Seam at ARP07 and in the Marrangaroo Sandstone at ARP02A. These minor decreasing trends ceased in late 2017. Pressures remained stable from 2018 to the end of 2021 at ARP07 and remained stable at ARP02A until 2019 when the data logger malfunctioned.

A drop in pressure of approximately 0.5 m occurred at ARP04 between September and December 2015 in the Lithgow Seam and the Marrangaroo Formation. The depressurisation may be attributable to activities at Airly Mine since the mine workings came within 200 m of this monitoring site in 2015. A minor decreasing trend was observed throughout 2016. Pressures stabilised in 2017 and remained stable from 2018 through to the end of 2020. In 2021, pressure in the Marrangaroo Formation increased by 0.5 m, while pressures in the Lithgow Seam decreased by 0.1 m. Pressures varied within the Shoalhaven Group between 2012 and April 2017. A steady increasing trend has been observed since. In 2021, between January and October a pressure increase of 0.9 m was recorded.

There is a downward hydraulic gradient from the Narrabeen Sandstone to the Illawarra Coal Measures. It is noted that at some locations (ARP02A, ARP03A and ARP04), the piezometric pressure of the Marrangaroo Formation underlying the Lithgow Seam is similar to or higher than the pressure within the Lithgow Seam.

A decreasing trend is recorded in the Shoalhaven Group at ARP13 from 2018. In 2018 through 2019 pressure decreased by approximately 11.5 m. This trend has continued at a lesser rate, decreasing by approximately 2.4 m in 2020 and 0.4 m in 2021. A decreasing trend has also been observed in the Devonian Strata, since 2017. In 2019 the total pressure decrease was 1.4 m. In 2020, this trend continued to decrease by a further 0.9 m, falling below the trigger value since the first quarter of 2020. In 2021, pressures continued to decrease, falling a further 0.2 m. The decreasing trend in these lower formations has not been observed in the standpipe ARP13SP installed in the Lithgow Seam which has remained stable since June 2017. The reducing pressures may therefore reflect the removal of overlying matrix material (mined product) rather than loss of water volume.

Pressures in ARP15 settled in the Lithgow seam within a month of installation and have remained relatively stable since. A declining trend of approximately 60 m was recorded for both the Shoalhaven and Devonian at ARP15 during 2017. Since June 2017, pressures within the Shoalhaven have been stable and this has continued through 2021. Within the Devonian, groundwater pressures were:

– Declining from January and September 2017. Drawdown started prior to mining in the region (within 1.5 km).
– Stable or slightly increasing from September 2017 to January 2018.
– Decreasing from January 2018 throughout 2019, 2020 and 2021, a total decrease of 37 metres and mining progressing to within 1.7 km.

Table 4.2 Minimum observed water levels

Monitoring location	Strata	Trigger Value (WMP, GHD (2019)) (m AHD)	Jan - Mar (m AHD)	Apr – Jun (m AHD)	Jul - Sept (m AHD)	Oct – Dec (m AHD)
Vibrating Wire Piezometers						
ARP01	Narrabeen Sandstone	-	ND	ND	ND	ND
	Irondale Seam	-	ND	ND	ND	ND
	Lithgow Seam	-	ND	ND	ND	ND
	Marrangaroo Formation	-	ND	ND	ND	ND
ARP02	Narrabeen Sandstone	-	957.2	957.2	957.2	957.2
	Irondale Seam	-	ND	ND	ND	ND
	Lithgow Seam	-	ND	ND	ND	ND
	Marrangaroo Formation	753	ND	ND	ND	ND
ARP03	Narrabeen Sandstone	867	ND	ND	ND	ND
	Middle River Seam	-	835.9	Dry	Dry (836.8)	Dry (836.7)
	Lithgow Seam	-	ND	Dry	Dry (749.09)	ND
	Marrangaroo Formation	745	ND	746.6	ND	ND
ARP04	Lithgow Seam	-	737.4	737.4	735.7	737.4
	Marrangaroo Formation	734	734.9	735.0	735.0	735.5
	Shoalhaven Siltstone	669	673.2	673.2	674.1	674.3
ARP06	Narrabeen Sandstone	866	868.0	868.1	868.1	867.9
	Irondale Seam	–	768.1	768.2	768.2	768.5
	Lithgow Seam	–	738.8	738.7	738.7	737.9
	Marrangaroo Formation	–	730.4	731.4	731.8	730.8
ARP07	Middle River Seam	–	813.1	812.9	813.1	812.9
	Lithgow Seam	–	734.1	734.4	734.5	734.5

Monitoring location	Strata	Trigger Value (WMP, GHD (2019)) (m AHD)	Jan - Mar (m AHD)	Apr – Jun (m AHD)	Jul - Sept (m AHD)	Oct – Dec (m AHD)
ARP08	Narrabeen Sandstone	–	843.8	843.8	843.8	843.7
	Irondale Seam	–	755.7	754.9	754.7	754.6
ARP13	Shoalhaven Group	-	688.9	688.9	688.9	ND
	Devonian strata	573	**571.8**	**571.8**	**571.8**	ND
ARP15	Lithgow Seam	-	729.5	729.3	729.0	728.9
	Shoalhaven Group	-	641.9	641.5	641.2	640.9
	Devonian strata	–	581.5	580.6	579.4	576.7
Standpipes						
ARP05	Gap Creek alluvium	–	Dry (746.5)	755.09	755.2	754.6
ARP07SP	Narrabeen Sandstone	–	Dry	Dry	Dry	Dry (872.6)
ARP08SP	Lithgow Seam	–	779.1	781.86	780.7	761.62
ARP09	Genowlan Creek Alluvium	–	853.9	Dry	Dry	Dry (853.6)
ARP11	Permian strata	–	Dry	Dry	Dry (735.4)	736.1
ARP12	Genowlan Creek Alluvium	–	892.0	892.07	892.2	891.8
ARP13SP	Lithgow Seam	–	720.2	720.27	720.3	720.2
ARP14	Genowlan Creek Alluvium	Dry (781.0)	782.7	782.69	782.6	782.6
ARP15SP	Narrabeen Sandstone	829.1	834.0	835.41	833.9	833.7
ARP16 (Nissan Hut)	Unknown	-	-	-	-	Dry (Depth of bore: 14.78 m)

Notes:

ND - No available data due to malfunctioning VWP data logger

Bold - trigger value exceedance

4.3.2 Standpipes

Hydrographs for alluvial groundwater at ARP05, ARP09, ARP11, ARP12 and ARP14; and fractured and porous rock groundwater at ARP07, ARP08, ARP13SP and ARP15SP are shown in 0. The following is a summary of 2021 records:

- ARP05 exhibited water level recovery in April 2021, having been dry since September 2017. Historically, this location has only recorded a water level post above average rainfall. In 2021, the water level at ARP05 was consistent ranging 754.6 m AHD to 755.5 m AHD, coinciding with above average rainfall throughout 2020 and 2021 (CRD).
- ARP07 has been dry since installation and remained dry throughout 2021.
- Groundwater levels at ARP08 were steady throughout most of 2021 ranging 779.6 m AHD in January to 778.5 m AHD in November. The water level dropped significantly in December (761.2 m AHD) following airlifting by Centennial as part of water quality investigations.
- ARP09 was predominantly dry between May and November 2021, showing response to rainfall in January to March and December within historical ranges.
- ARP11 was dry from January to September 2021 showing no response to rainfall although being installed in alluvium. Water level recovery was observed from late September through December 2021 ranging 735.4 m AHD to 736.0 m AHD, potentially responding to cumulative above average rainfall received throughout 2021 and higher rainfall in October and December.
- ARP12 varied throughout 2021 in response to rainfall, consistent with 2020 ranges.
- Groundwater levels remained stable at ARP13SP throughout 2021, unresponsive to rainfall and consistent with levels since June 2017.
- Groundwater levels at ARP14 remained consistent and above the trigger value throughout 2021. A spike in groundwater levels occurred in March 2021, associated with an increase in rainfall received in late February to early March.
- Groundwater levels at ARP15SP remained above the trigger value throughout 2021. Water levels show rainfall response, responding above historical levels.
- ARP16 was dry at install depth of 14.78 metres, recorded in December.

4.4 Groundwater quality

Groundwater quality results for 2021 are plotted with historical records in Appendix A. Plots pertain to ARP05, ARP08, ARP09, ARP11, ARP13SP, ARP14, ARP15SP, production bore (AM2B-1), Village Spring, Kingdom and private bore GW103410 (Nioka) as well as historical data for monitoring bore ARP07.

Groundwater quality data for ARP05, ARP11, ARP13SP, ARP14 and ARP15SP have been presented with corresponding trigger values as defined in the WMP. ARP08 and ARP09 have been presented with ANZECC (2000) default guideline values (DGVs), in the absence of defined trigger values.

4.4.1 Standpipe monitoring bores

Newly recovered groundwater at ARP05 (Gap Creek Alluvium) is fresh and ranging acidic to neutral. pH was slightly less acidic and more neutral in 2021 than before the bore went dry in 2017. EC concentrations were comparable to those recorded in 2017. Groundwater at ARP05 within the Gap Creek Alluvium is of calcium-bicarbonate type and is consistent with Gap Creek surface water. In April 2021 following water level recovery, dissolved metals were increased compared to available monitoring data in 2017, specifically manganese, iron and copper. Concentrations of these dissolved metals decreased throughout 2021, to 2017 concentrations.

Groundwater at ARP08 (Lithgow Seam) is alkaline and brackish. EC concentrations in 2021 are significantly elevated compared to those recorded in 2019 (1615 µS/cm to 6867 µS/cm). Groundwater type is further discussed in Section 6.1. Dissolved metals concentrations were consistent with those recorded in 2020, except for copper which decreased throughout 2021.

Groundwater at ARP09 (Genowlan Creek Alluvium) is acidic and fresh. Physicochemical characteristics and dissolved metal concentrations are comparable to historical values. Groundwater at ARP09 is of sodium-chloride type and is similar to the Genowlan Creek surface water as shown on the piper diagram in Appendix C.

Groundwater at ARP11 (Permian strata) has historically been slightly brackish and slightly alkaline. In 2021 groundwater was slightly brackish and slightly acidic. There were no exceedances of SSGVs except for dissolved zinc in November and December. The piper diagram contained in Appendix C indicates that groundwater is of mixed type, though with a dominant sodium cation and bicarbonate/chloride dominant anions.

Groundwater at ARP12 (Genowlan Creek Alluvium) is slightly acidic to neutral and fresh. Groundwater type is of mixed/ sodium-chloride type. Dissolved metal concentrations are low and without trend of concern, with the exception of zinc, which was elevated in November and December 2021.

Groundwater at ARP13SP (Lithgow Seam) is slightly brackish and slightly less acidic than 2020, ranging from below the lower trigger value threshold to above the upper trigger value threshold of pH. Groundwater at ARP13SP is of calcium-bicarbonate type. Metal concentrations are generally low without any trends of concern. Dissolved zinc exceeded the threshold in late 2021. No other exceedances occurred.

Groundwater at ARP14 (alluvial aquifer) is fresh and neutral and of mixed type with a slight dominant sodium cation, shown in on the piper diagram in Appendix C. EC concentrations were consistent with the previous year, with one exceedance of the maximum trigger value. Dissolved metal concentrations were generally low and below trigger values except for copper which exceeded the threshold in December only and both iron and manganese in November and December.

Groundwater at ARP15SP (Narrabeen Sandstone) is generally fresh and slightly acidic. pH increased in 2021 ARP15SP but remained below the lower trigger value in all months excepting April, October and December. Groundwater within the Narrabeen Sandstone is of sodium-chloride type shown on the piper diagram in Appendix C. Metal concentrations were reported to be below trigger values except for nickel in November and zinc in December.

4.4.2 Shoalhaven Group groundwater – Production Bore (AM2B-1)

Groundwater at AM2B-1 was slightly acidic to fresh and fresh to brackish throughout 2021, continuing from 2020. EC was highly variable ranged from 729 µS/cm to 4770 µS/cm. Metal concentrations were mostly stable and without any trends of concern. Compared to Airly Mine monitoring bores installed in the Permian Coal Measures and the alluvium, Shoalhaven Group groundwater at AM2B-1 has elevated concentrations of dissolved metals including, copper, iron, manganese, magnesium, nickel and zinc.

4.4.3 Devonian groundwater – Nioka and Kingdom

Groundwater at the landholder bores is generally slightly alkaline and slightly brackish. In the absence of defined trigger values, groundwater from private bores is compared to DGVs. Although these criteria recognised to be inappropriate given naturally occurring conditions.

At Nioka, concentrations for EC and dissolved copper, iron and zinc exceeded DGVs in 2021, comparable to previous years. Metal concentrations are generally low and there are no trends of concern.

At Kingdom concentrations of EC exceeded the DGV in 2021, decreasing from 2020 and 2019. Dissolved metals were generally low with no trends of concern except for dissolved copper and zinc which were consistently above the DGV.

Groundwater at Kingdom is slightly more calcium and bicarbonate dominant than at Nioka which is influenced by calcium and sulfate, shown on the piper diagram in Appendix C.

4.4.4 GW800787

Groundwater at the landholder bore GW800787 (installed in 1996) was first sampled as part of the groundwater monitoring program in December 2021. Groundwater was circumneutral (7.5 pH units) and slightly brackish (EC gauged above the DGV). Elevated dissolved metals included copper and zinc, exceeding the DGVs. Groundwater at GW800787 is of the same water type in the Devonian groundwater aquifer at Nioka and is of calcium-bicarbonate type.

4.4.5 Permian groundwater – Village Spring seepage

Seepage of groundwater at the Village Spring is generally fresh and slightly alkaline. Monitoring data collected in 2021 has been compared to groundwater quality trigger values in the WMP (GHD, 2021). Trigger value exceedances occurred for pH (lower trigger value in January, April, May and June, upper trigger value in November), TSS (February, May and November) and dissolved nickel (May, June, July, August, October, November and December). These exceedances are consistent with historical variations. As shown in the piper diagram in Appendix C, the Village Spring groundwater seepage is of calcium-bicarbonate type. In comparison to Groundwater within the Permian Strata at ARP11, Groundwater at Village Spring may be more influenced by rock interactions.

4.5 Groundwater flow

4.5.1 Village Spring

The rate of seepage of groundwater from the Permian strata at Village Spring has been monitored since February 2011. A plot of daily groundwater seepage rates is shown in Figure 4.2. Continuous flow was recorded throughout 2021. The average seepage rate recorded between 1 January and 31 December 2021 was 5.997 kL/day, with the minimum being 2.665 kL on 2 March 2021 and the maximum being 10.933 kL on 12 November 2021. A similar flow was also recorded on 23 March 2021 at 10.787 kL.

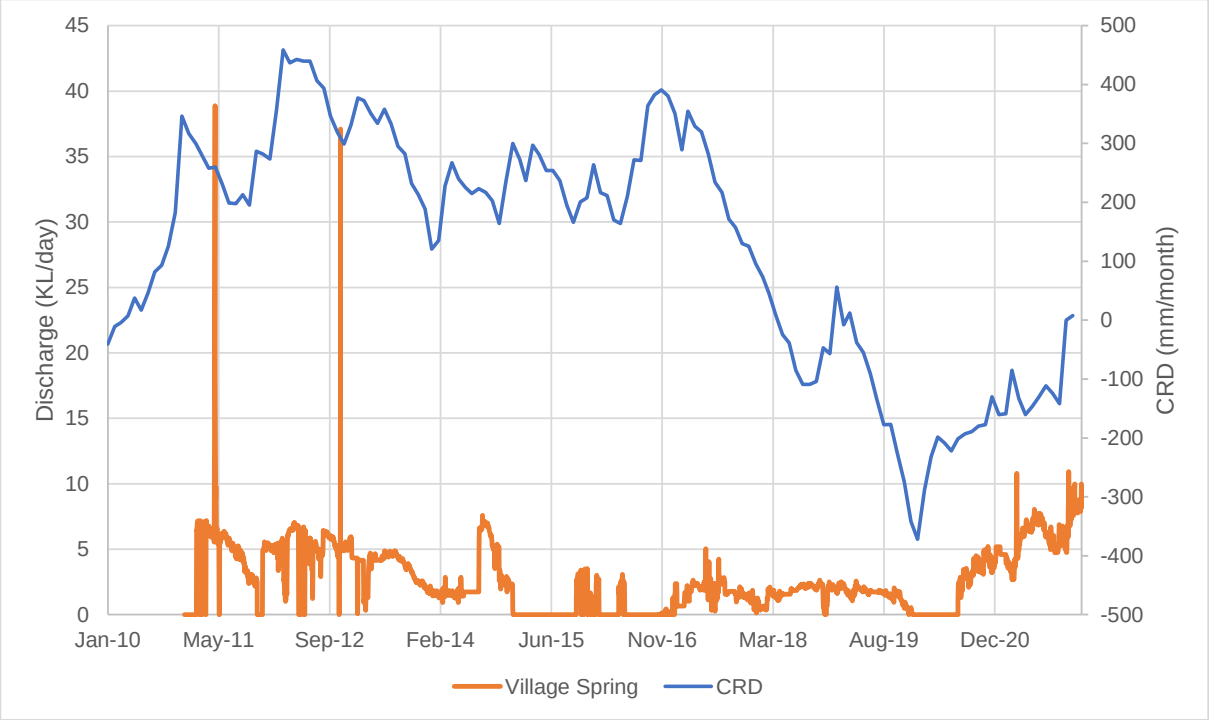


Figure 4.2 Recorded flows at Village Spring

4.5.2 Underground workings

Groundwater inflow to mine workings has historically been reported as low and of negligible volume. To this end, water from Production Dam (abstracted from the production bore) has been relied on for use in underground mining activities.

No water was transferred from the underground workings to the surface.

5. Surface water monitoring program

The surface water monitoring program undertaken throughout 2021 at Airly Mine included both water flow and water quality monitoring. All existing surface water monitoring locations are shown in Figure 5.1.

5.1 Surface water flow

Continuous flow monitoring is undertaken at Gap Creek, Genowlan Creek and LDP001.

Recorded flows for the Genowlan Creek catchment sites are presented in Figure 5.2 (2017 to 2021), while LDP001 recorded flows are presented in Figure 5.3.

Flow was recorded in Genowlan Creek for some of 2021, averaging 490.7 kL/day for those periods. High daily flows occurred on 24 March and 7 November at 7318.9 kL/day and 4047.5 kL/day respectively. No flow was recorded between:

– 14 February and 13 March
– 16 May and 6 November
– 22 and 31 December

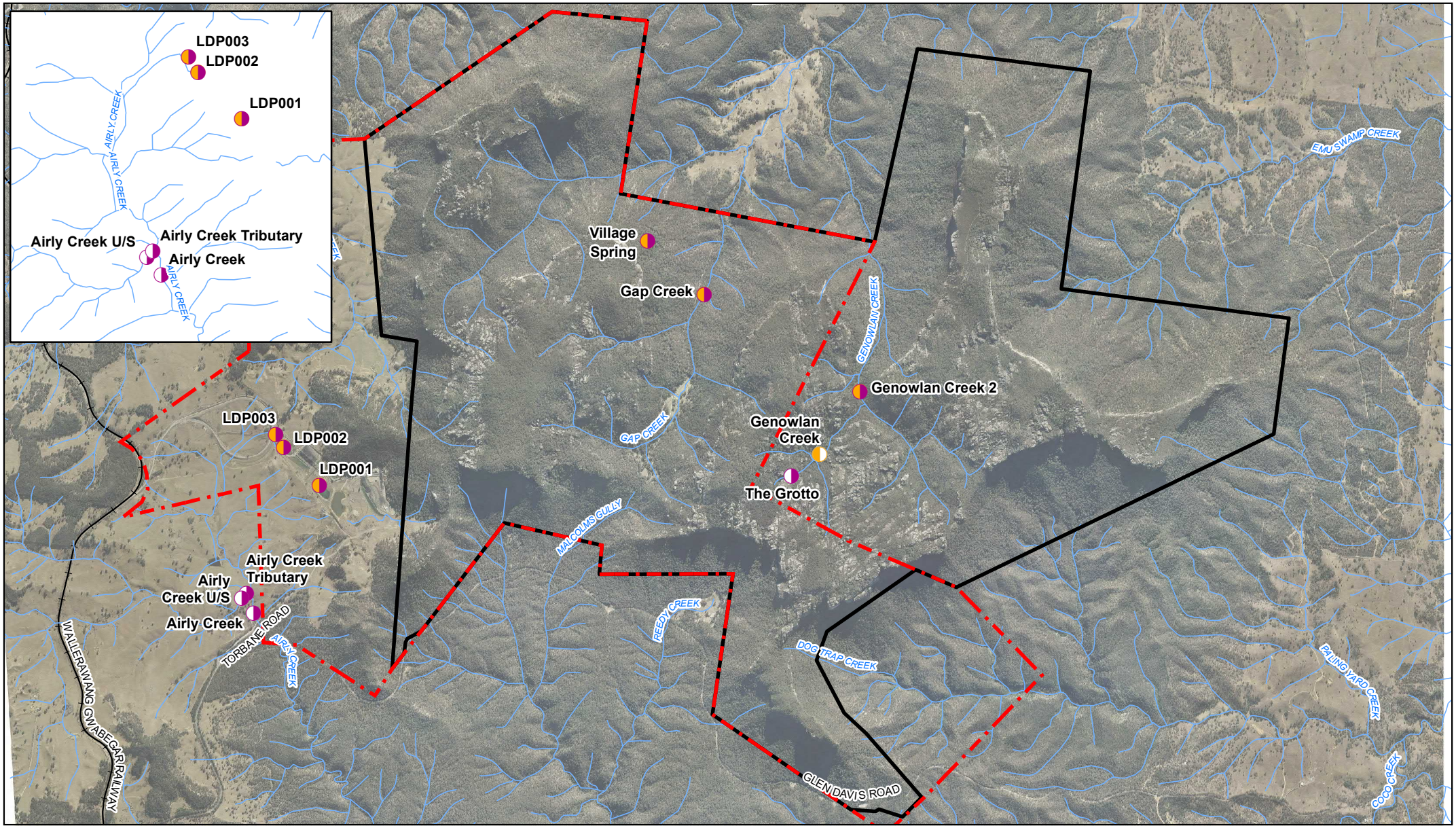
Flow was recorded in Gap Creek for most of 2021, averaging 174.5 kL/day. The highest daily flow for 2021 occurred on 12 November at 4392.9 kL/day. No flow was recorded between:

– 1 January and 21 March
– 10 August and 23 August
– 19 September and 29 September
– 7 October and 12 October
– 20 October and 4 November

A v-notch weir was installed at Genowlan Creek 2 during the second quarter of 2019. Flow was recorded in Genowlan Creek 2 for most of 2021, averaging 563.0 kL/day. Peak flows occurred on:

– 2 January at 2330.9 kL/day
– 27 March at 3796.7 kL/day
– 15 November at 3600.3 kL/day
– 29 November at 4142.0 kL/day
– 10 December at 4686.2 kL/day

No flow occurred between 23 and 26 March, 10 and 14 November and 26 and 28 November.



Paper Size A4

0 200 400 800 1,200 1,600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Mining Lease ML1331
- Authorisation A232
- Waterway
- Existing railway
- Flow monitoring
- Flow and water quality monitoring
- Water quality monitoring

Airly Mine
Airly Mine Annual Reporting
2021 Annual Water Monitoring Report

Job Number 12526161
Revision A
Date 10/02/2022

Surface water monitoring locations

Figure 5-1

G:\22\0105001\GIS\Maps\Deliverables\Western\Airly\2212526161\AnnualReview2021\12526161_AEMR005_WaterMonitoringLocations_A.mxd

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

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Data source: LPI: DTDB 2012; Centennial: Imagery, monitoring, boundaries, survey. Created by: smacdonald

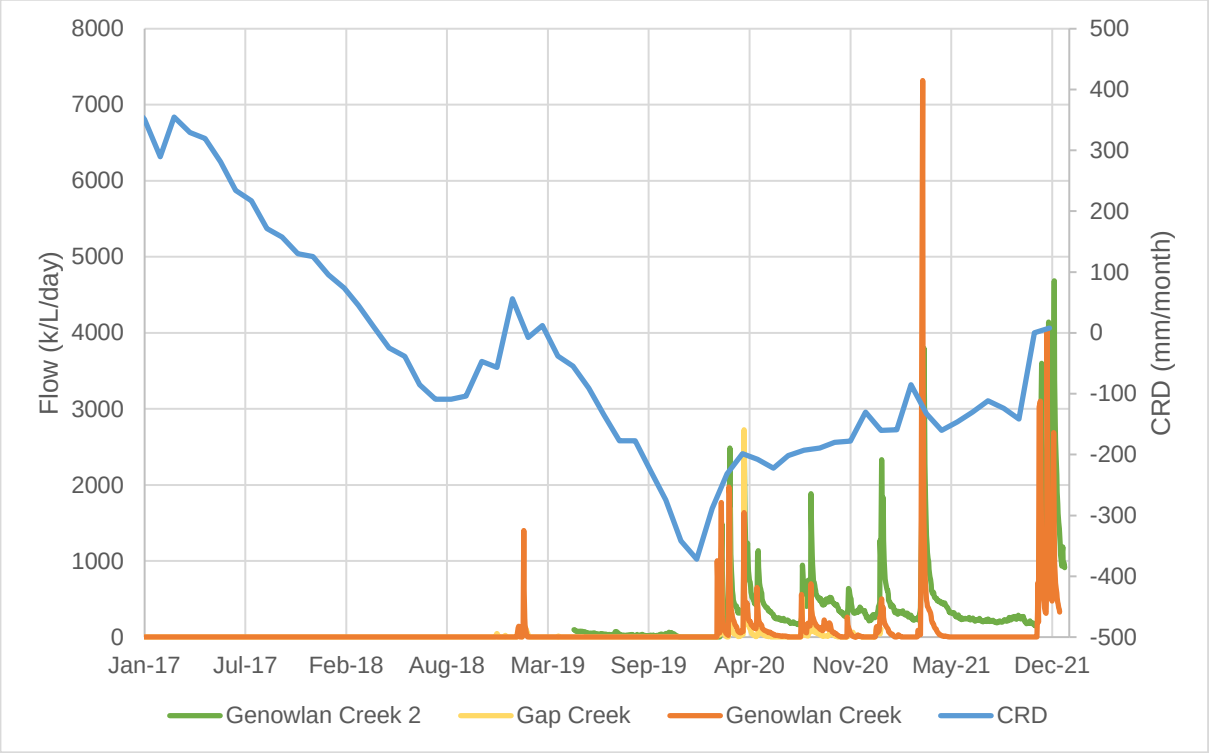


Figure 5.2 Recorded flows at Gap Creek, Genowlan Creek and Genowlan Creek 2 2017 – 2021

5.2 Surface water quality

Surface water quality monitoring locations were sampled monthly with the exception of dry locations as listed in Table 5.1.

Table 5.1 Sampling locations exceptions

Location	Sampling comments
Airly Creek	Sampled in all months
Airly Creek Upstream	No flow in February, March or November
Airly Tributary	No flow in February, March or November
Gap Creek	Dry in January and February
Genowlan Creek (The Grotto)	Sampled in all months
Genowlan Creek 2	Sampled in all months
LDP001	Discharge in November only
LDP002	Discharge in March only
LDP003	No discharge
Production Dam	Sampled in all months except August
Stockpile Dam	Sampled in all months except August
Train Loader Dam	Sampled in all months except August
Dirty Water Dam	Sampled in all months except August

Time series plots of surface water quality are shown in Appendix C. Water quality data have been compared to site specific guideline values (SSGVs) or trigger values reported in the WMP (GHD, 2021).

5.2.1 Airly Creek

Airly Creek contained water in all months, while Airly Creek Upstream and Airly Creek Tributary were able to be sampled in January, April to October and December only due to reportedly dry conditions.

In Airly Creek, pH remained within the SSGVs ranging 6.8 to 7.7 pH units. EC was gauged below the SSGV in all months except for June (2960 µS/cm) and July (2840 µS/cm) and below historical values in December (1270 µS/cm). Water type is magnesium/calcium-sulphate as shown in the piper diagram in Appendix C. Dissolved metal SSGV exceedances included:

– Barium in May (0.019 mg/L) and June (0.022 mg/L).
– Boron in April (0.12 mg/L)
– Cobalt in April (0.002 mg/L)
– Nickel in April (0.013 mg/L) and December (0.01 mg/L)
– Zinc in April (0.019 mg/L)

In Airly Creek Upstream, pH remained within the SSGVs and within historical ranges (7.2 to 8.0 pH units), except for October (8.1 pH units). EC exceeded SSGV levels in June (3200 µS/cm) and July (2930 µS/cm). Water type is consistent with Airly Creek and is magnesium/calcium-sulphate as shown in the piper diagram in Appendix C. Dissolved metal exceedances included:

– Barium in April (0.019 mg/L), May (0.020 mg/L) and June (0.018 mg/L)
– Nickel in December (0.009 mg/L)

Airly Tributary pH remained within the SSGVs and within historical ranges (7 to 7.4 pH units). EC exceeded the SSGV in June (3160 µS/cm) and July (2770 µS/cm). Water type is consistent with Airly Creek and Airly Creek Upstream and is magnesium/calcium-sulphate as shown in the piper diagram in Appendix C. Dissolved metal exceedances included:

– Nickel in January (0.009 mg/L), April (0.009 mg/L), May (0.012 mg/L), June (0.012 mg/L), July (0.009 mg/L) and December (0.013 mg/L)
– Zinc in April (0.009 mg/L), May (0.011 mg/L) and June (0.011 mg/L)

Repeated exceedances of dissolved nickel in Airly Tributary have been noted, however are consistent with historical concentrations since December 2012. Attention to this will continue throughout the 2022 monitoring program.

5.2.2 Genowlan Creek

The Grotto, Gap Creek and Genowlan Creek 2 are located within the Genowlan Creek catchment. These sites are monitored for potential subsidence impacts.

Surface water at The Grotto is acidic and fresh. pH exceeded the lower SSGV in all months (ranging 4.84 to 6.69 pH units) except for September and November. Review of time series indicates increasing trends throughout 2021. EC ranged between 41.8 µS/cm and 121.4 µS/cm, exceeding the SSGV in June, August and October (62.3 µS/cm, 121.4 µS/cm and 70.5 µS/cm, respectively). The Grotto is of sodium-chloride type, similar to the Genowlan Creek Alluvium as shown in the piper diagram in Appendix C. Dissolved metal exceedances included arsenic in December (0.004 mg/L), copper in December (0.006 mg/L) and zinc in August (0.024 mg/L).

Gap Creek pH ranged slightly acidic to alkaline, exceeding the SSGV in March (6.04 pH units), May (7.93 pH units), September (8.29 pH units), October (7.64 pH units), and November (8.11 pH units), consistent with historical data. EC ranged between 83.6 µS/cm and 231.6 µS/cm, exceeding the SSGV in August (231.6 µS/cm). As shown in the piper diagrams in Appendix C, Gap Creek is of mixed type, with a slight sodium/potassium cation dominance and no dominant anion, similar to Gap Creek Alluvial groundwater but considerably different to the Airly Creek Catchment. Most dissolved metals were below SSGVs, with the exception of manganese in November (0.084 mg/L), consistent with historical data.

Surface water quality at Genowlan Creek 2 was slightly acidic to fresh, consistent with 2019 and 2020 data. Genowlan Creek 2 is consistent with The Grotto and is of sodium-chloride type as shown in the piper diagram in Appendix C. Exceedances of SSGVs included:

– pH in April (6.82 pH units), October (7.6 pH units) and December (7.57 mg/L)
– EC in all months except December, with exceedances ranging 52.1 µS/cm to 128 µS/cm
– Dissolved nickel in October (0.004 mg/L)
– Dissolved zinc in October (0.013 mg/L)

5.2.3 Licenced discharge points

Surface water storages were monitored for water quality and discharge volumes throughout 2021. Dam storage water quality time series are presented in Appendix C. Dam storages are of magnesium/calcium-sulphate as shown in the piper diagram in Appendix C.

There were no discharges from LDP003 (overflow from the Train Loader Dam) during 2021. One discharge was recorded in March 2021 at LDP002 (overflow from the Stockpile Dam) while in November 2021 four consecutive discharges were recorded at LDP001 (overflow from the Production Dam) (Figure 5.3). According to the Environmental Protection Licence (no. 12374), 100 percentile concentration limits apply to discharges from LDP001 and LDP002, except when rainfall exceeds 44 mm in a consecutive 5-day period.

During high rainfall events, overflows from the Stockpile Dam are monitored as a discharge point to Airly Creek (LDP002). The water level is maintained by pumping water to the 109 ML Dirty Water Dam. Until 2021, no discharges had been recorded. One non-routine discharge from LDP002 to Airly Creek occurred on 23 March 2021 due to increased rainfall. Between 19 March and 23 March, 64.3 mm of rain was received. Only one exceedance was recorded in the discharge for turbidity (67.2 NTU). Airly Creek was subsequently monitored with no exceedances of EPL 100 percentile concentration limits or Airly Creek WMP (2021) trigger values.

Overflows from the Production Dam are monitored continuously via LDP001. Prior to 2013, 6 discharges had occurred. In 2021, four consecutive non-routine discharges were recorded between 27 November and 30 November inclusive, due to increased rainfall. Five days prior to the final discharge, on 26 November, 45 mm of rainfall was received.

Water quality within the Production Dam was within concentration limits for LDP001 specified by EPL 12374 throughout 2021 with the exception of TSS and turbidity. TSS exceeded the concentration limits in June 2021 (66 mg/L). Turbidity exceeded the concentration limits in June and December (73.3 mg/L and 57.3 mg/L, respectively).

Water quality within the Production Dam also met the SSGVs for Airly Creek throughout 2021, with exception of the following:

– pH exceeded the upper SSGV in all months except April, October and November ranging 8.1 to 8.3 pH units, consistent with lower ranging historical data.
– Dissolved aluminium exceeded the SSGV (008 mg/L) in August.
– Dissolved barium exceeded the SSGV (0.017 mg/L) throughout the year except for October and November, ranging 0.02 mg/L (September) to 0.031 mg/L (March).
– Dissolved boron exceeded the SSGV in August (0.3 mg/L)

Time series graphs of water quality data from the Production Dam are shown in Appendix C.

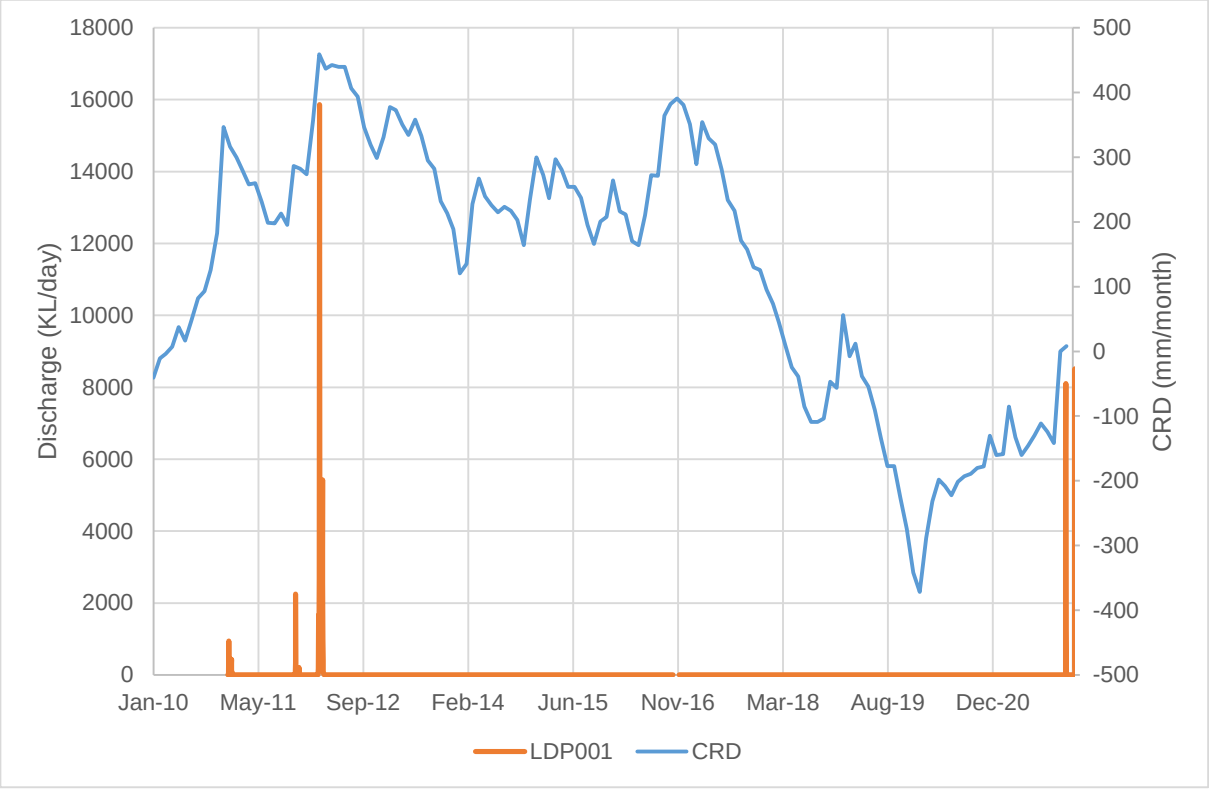


Figure 5.3 LDP001 discharge to Airly Creek

6. Impact assessment

6.1 2021 operations

6.1.1 Groundwater inflow

Mining methods prior to 2019 at Airly Mine have been bord and pillar only within the Lithgow Seam. Since 2015 bord and pillar mining has generally extended to the east from the surface facilities area. In addition to bord and pillar methods, panel and pillar mining commenced in 2019, occurring to the east of ARP01 and the south-west of ARP03A. Bord and pillar operations also occurred south and south-west of ARP06 during 2020. In 2021, operations included continuation of first workings directly east of the existing workings, east of ARP05 and including panel and pillar extraction near ARP08. Bord and pillar mining occurred to the south-east of ARP06.

There were no reported groundwater inflows into the mine in 2021. The hydrogeological model for Airly Mine (GHD, 2021) estimated the rate of groundwater inflow in 2021. Based on the workings undertaken, the hydrogeological model predicted groundwater inflows into the mine of approximately 22.2 ML/year during 2021. These inflows would not be measurable and would have mostly been realised in increased coal moisture and would not have required transfer to the surface facilities area. These inflows are predicted to occur predominantly from the overlying Permian strata and from the coal seam itself, with a smaller amount originating from the underlying Marrangaroo Formation.

6.1.2 Groundwater level and quality

Pressures reported in 2021 are generally similar to those reported between 2013 and 2020 (and reported in the EIS).

Groundwater pressures were generally stable within the deeper fractured and porous rock aquifer between 2013 and 2020. A continuation of previous trends occurred, with the exception of ARP04. At ARP04 in 2021, some slight increases in groundwater pressure were observed within the Shoalhaven Group and Marrangaroo Formation, while in the Lithgow Seam some slight depressurisation occurred. Mining occurred previously in 2015 within the vicinity of ARP04 (up to 200 metres). In 2021, mining came within approximately 500 metres to both the west and east of ARP04. Minor pressure decreases observed within the Shoalhaven and Devonian strata, with mining coming within 900 m of the site in 2021. Pressure decreases were also observed at ARP15 in the Devonian Strata. Throughout 2021 mining has generally come within 1.7 km of ARP15.

As discussed in Section 4.3, the alluvial groundwater level recovery at ARP05 in 2021 is attributable to the cumulative above average rainfall received in 2020 and 2021. The lack of a response in groundwater levels at ARP05 between 2018 and 2020 following rainfall events in early 2020 was thought to be attributed to insufficient groundwater recovery from previous drought years. Historically elevated dissolved metals exceedances in April 2021 may have been due to the sorption of metals into the alluvium being dissolved following groundwater recovery.

At ARP09, groundwater levels fluctuated in the first half of the year, likely in response to fluctuations in rainfall. Following June 2021, the bore was predominantly dry, with small water level spikes (less than 0.5 metres) in August and October, corresponding with reduced rainfall during those months. Water levels recorded in December were more elevated, increasing by approximately 2.9 metres, coinciding with a significant increase in above average rainfall between October and December. During this period in Genowlan Creek 2, pH became more neutral and EC increased slightly, likely due to increased rainfall. Mining came within 700 m of the site in 2021, with proposed activities for 2022 to come within 300 m.

Monitoring of ARP11 commenced in December 2016. Between 2016 and 2019 groundwater levels at ARP11 were generally decreasing in accordance with the below average rainfall conditions, by approximately 4 metres. By October 2019, the bore was dry. Groundwater levels at ARP11 did not respond to the periods of above average rainfall in 2020. Between September and December 2021 alluvial groundwater levels increased by 1.5 metres. It is likely that the extended period of above average rainfall throughout 2020 and 2021 has resulted recharging of the alluvial aquifer observable in the monitoring bore from late 2021.

ARP12 groundwater levels were variable throughout 2021, corresponding to monthly fluctuations in rainfall. A decreasing trend of 1.9 metres was observed between March and September 2021. The rapid increase in rainfall between October and December 2021 coincided with an increase in groundwater levels of approximately 2 metres. These fluctuations are consistent with variations in groundwater behaviour in 2020. There were no quality trends of concern at ARP12, indicating that groundwater fluctuations do not reflect influence of mining.

At ARP14, groundwater levels decreased between December 2019 and mid-February 2020, with limited rainfall available to recharge the alluvium. Rainfall in late February 2020 recharged the standpipe by approximately 1 metre, maintaining this level throughout the year. In 2021 these levels were maintained, aside from a spike in groundwater elevation in March 2021 by about half a metre. Following this groundwater levels have been consistent, falling by less than 0.1 metres in September.

Based on the visual assessment of groundwater quality time series plots and groundwater levels plot, with the exception of ARP08, groundwater quality and levels in 2021 have been similar to pre-2021 groundwater quality and levels and therefore is not observed to be impacted by mining related activities.

6.1.2.1 ARP08

Groundwater levels at ARP08 remained high from the previous year. pH has been increasing steadily from May 2020 to December 2021. Electrical conductivity displayed an increasing trend during 2020, however has decreased throughout 2021. EC is one to two orders of magnitude above Gap Creek. The standpipe ARP08 is installed in the Lithgow Seam. Bord and pillar mining was undertaken in the vicinity of ARP08 during 2020. The increasing trends were previously thought to be due to water accumulating from adjacent mine workings, used for the purpose of dust suppression which includes salting of roads and spraying with residual production water.

To confirm these trends, mine water sampling was undertaken proximal to ARP08 in September 2021, in two separate locations[2]. In 2019, groundwater at ARP08 was of similar type to mine water, though more calcium dominant, less magnesium. Throughout 2020 and 2021, groundwater type has fluctuated slightly, moving away from calcium-carbonate type becoming more calcium-chloride dominant suggesting rainfall infiltration (Figure 5.3). Hydroxides are highly elevated in ARP08 and may indicate breakdown of the grout within the bore annulus (Table 6.1).

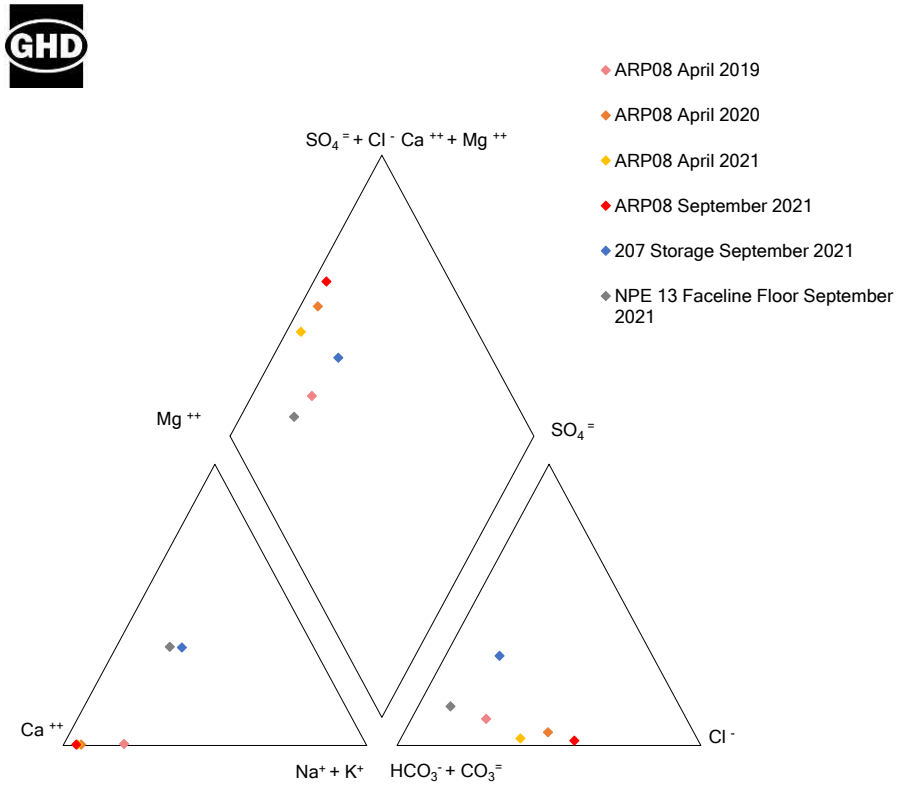


Figure 6.1 Major ions signatures of ARP08 over time

[2] Exact locations unknown to GHD.

An investigation of the high pH and EC was carried out by Centennial in December 2021 (Centennial, 2021). An obstruction to the bore casing was identified at 29 meters above the installation depth. This obstruction has not hindered sample collection. Air-development techniques were used to purge the well. After 15 minutes, the pH reduced from pH 12 to pH 8 indicating that the high pH water was localised to within the bore. The well was purged dry and left to recharge overnight. The bore did not recover within this time. Subsequent sampling confirmed a return to high pH and EC conditions. The cause of the high pH and EC is unconfirmed though the damage to the casing may support suspection that it is resulting from the degradation of grout in the ARP08 annulus due to infiltrating rain waters.

In 2021, mining came within 100 m of ARP08. ARP08 will be lost in the progression of mine workings in 2022 (screened in the Lithgow Seam).

Table 6.1 September 2021 monitoring data

Parameter		ARP08	207 Storage	NPE 13 Faceline floor
Physicochemical	EC (µS/cm)	5330	827	832
	pH (pH units)	12.4	8.1	7.3
Alkalinity	Bicarbonate (as CaCO3)	<1	202	357
	Carbonate (as CaCO3)	24	<1	<1
	Hydroxide Alkalinity (as CaCO3)	1570	<1	<1
Major ions (mg/L)	Calcium	557	72	80
	Magnesium	<1	35	36
	Potassium	12	19	19
	Sodium	21	30	23
	Chloride	25	56	35
	Sulfate	<1	136	62
Dissolved metals (mg/L)	Arsenic	<0.001	<0.001	<0.001
	Copper	0.024	<0.001	<0.001
	Lead	0.003	<0.001	<0.001
	Zinc	0.026	<0.005	0.006

6.1.3 Surface water

Visual inspection of the time series plots in Appendix C indicates that surface water quality in 2021 is similar to pre-2021 surface water quality. Therefore, there has been no observable impact on surface water quality in 2021 attributable to mining operations.

Flow gauge data in Gap Creek and Genowlan Creek has been discussed in Section 5.1. Flows in Gap Creek and Genowlan Creek were responsive to the rainfall events throughout 2021. The flows were significantly increased on 2020 and previous years of data, as shown in Figure 5.2.

Surface water quality changes can likely be attributed to the continued above average rainfall received during 2020 and 2021, which was preceded by a three-year period of below average rainfall, as shown in the CRD curve (Figure 3.3).

Exceedances of SSGVs for The Grotto and Gap Creek were variable but occurred primarily in the fourth quarter, following similar trends to rainfall. Several dissolved metals exceedances occurring in December at the Grotto may be attributable to increased sediment in runoff following the November and December rainfall events.

6.1.4 Production bore AM2B-1

Approximately 48.3 kL of groundwater was extracted from the production bore during 2021, for the purpose of groundwater purging for water monitoring. This is within the annual extraction limit of 158 ML/year. All monitoring data for AM2B-1 are shown in Appendix B.

6.1.5 Old production bore

Old production bore water levels were recorded at 8.6 m depth prior to October 2020. A decreasing pressure trend developed from October to December 2020 with levels dropping to 15.3 m depth. During 2021, water levels continued to decrease to 20.3 m depth. Water level monitoring data for the old production bore are presented in Appendix A.

6.1.6 Site water balance

A site water balance model was previously developed for Airly Mine as part of the Airly Mine Extension Project (GHD 2014) to quantify transfers within the site under future operational conditions using various rainfall patterns. The site water balance was updated to reflect the current mine plan and operational conditions (GHD 2019b). The site water balance for the 2018 calendar year is presented in Table 6.2.

Table 6.2 Annual water balance – existing conditions (2018)

Water flow	Volume (ML/year)
INPUTS	
Direct rainfall onto storages and catchment runoff	57
External potable water supply	1
Groundwater inflows into underground workings	10
Extraction from production bore	38
In situ coal moisture	23
TOTAL INPUTS	**129**
OUTPUTS	
Evaporation	49
Dust suppression	5
Sewage to Ecomax effluent treatment system	2
Discharge through LDP001	0
Discharge through LDP002	0
Discharge through LDP003	0
Product coal moisture	78
TOTAL OUTPUTS	**134**
CHANGE IN STORAGE	
Surface water storages	-5
Underground workings	0
TOTAL CHANGE IN STORAGE	**-5**
BALANCE	
Inputs – outputs – change in storage	0

The observed water flows during 2021 at Airly Mine were reviewed qualitatively:

– Groundwater inflows intercepted by the underground workings would not be measurable and would have mostly been realised in increased coal moisture and would not have required transfer to the surface facilities area (refer to Section 6.1.1).
– Extraction from the production bore remained low compared to the licensed extraction limit (refer to Section 1).
– One off-site discharge was reported from the site water management system (refer to Section 6.1.3).

Coal moisture fluxes likely remained proportional to the ROM coal production at Airly Mine, and rainfall, runoff and evaporation aligned with site rainfall conditions (refer to Section 3.2). Approximately 1.69 ML of potable water was imported and 0.551 ML of rainfall was captured for site reuse. Approximately 68.476 ML of production water was used from the production dam to tanks.

Existing conditions at Airly Mine during 2021 are therefore considered to be generally aligned with the 2018 annual water balance.

6.2 2022 operations

The proposed mining activities for 2022 include continuation of first workings to the east of the existing workings; east of ARP05 and including panel and pillar extraction in the vicinity of ARP08 and ARP12. Bord and pillar mining is also proposed south-west of ARP06. The depth of cover (i.e., thickness of overlying strata) throughout these areas ranges from approximately 100 m to 180 m. Depth of cover above proposed first workings varies from approximately 200 m to 300 m.

6.2.1 Groundwater

The hydrogeological model for Airly Mine (GHD, 2021b) was updated and rerun to reflect the proposed workings for 2022. The updated model simulates groundwater inflows of approximately 26.9 ML/year into mined voids. Groundwater inflows are simulated to occur predominantly from the overlying Permian strata and from the coal seam itself, with a smaller amount originating from the underlying Marrangaroo Formation.

No changes to groundwater quality along Gap Creek are simulated.

6.2.2 Surface water

Since the proposed workings will not undermine the Oasis or the Grotto, subsidence related impacts on these surface waterways are not expected. The proposed mine plan has been designed to be stable and self-supporting for the long-term and is not expected to result in any surface measurable subsidence. As such, there are no adverse impacts predicted for these hydrological or hydraulic conditions of catchments or waterways. The upper reaches of Gap and Genowlan Creeks are undermined by existing mine workings. Existing mine workings are generally within 100 m of Gap Creek. 2022 panel and pillar mine workings will come within 100 m to 300 m of Genowlan Creek.

Changes to the site water balance and mine water discharges from surface facilities area are not expected. Water levels within the Production Dam are managed to maintain sufficient freeboard in case of significant rain events. However, based on available water quality data for Production Dam, it is unlikely that a discharge would impact Airly Creek.

7. Summary

Table 7.1 consolidates the monitoring locations and monitoring status for 2021 into a single table as requested by Centennial Airly.

Table 7.1 Summary of monitoring

	ID	Lithology	Level/ Flow Monitored	Quality Monitored	Level/Flow Triggered	Quality Triggered
Groundwater						
VWPs	ARP01	Narrabeen Sandstone	No, logger failure	NA	NA	NA
		Irondale Coal Seam			NA	
		Lithgow coal seam			NA	
		Marrangaroo Formation			NA	
	ARP02A	Narrabeen Sandstone	Yes		NA	
		Irondale Coal Seam	No, logger failure		NA	
		Lithgow Seam			NA	
		Marrangaroo Formation			753 m AHD	
	ARP03A	Upper sandstone	No, logger failure		867 m AHD	
		Middle River Coal Seam	Yes		NA	
		Lithgow Seam	No, logger failure		NA	
		Marrangaroo Formation			745 m AHD	
	ARP04	Lithgow Seam	Yes		NA	
		Marrangaroo Formation			734 m AHD	
		Shoalhaven			669 m AHD	
	ARP06	Narrabeen Sandstone	Yes		866 m AHD	
		Irondale Coal Seam			NA	
		Lithgow coal seam			NA	
		Marrangaroo Formation			NA	
	ARP07	Middle River coal seam	Yes		NA	
		Lithgow coal seam			NA	
	ARP08	Narrabeen sandstone	Yes		NA	
		Lower Irondale			NA	

	ID	Lithology	Level/ Flow Monitored	Quality Monitored	Level/Flow Triggered	Quality Triggered
	ARP13	Shoalhaven	No, logger failure		NA	
		Devonian formation			573 m AHD	
	ARP15[3]	Lithgow Coal Seam	Yes		NA	
		Shoalhaven			NA	
		Devonian formation			NA	
Standpipes	AM2B-1		NA	2009–present	NA	WMP 2021 SSGV
	Old Production Bore		Yes	May 2017-present	NA	No
	ARP05	Gap Creek Alluvium	Yes	August 2012–present	NA	WMP 2021 SSGV
	ARP07	Narrabeen Sandstone	Yes	July 2013–present	NA	WMP 2021 SSGV
	ARP08	Lithgow Seam	Yes	September 2013–present	NA	ANZECC DGV
	ARP09	Genowlan Creek Alluvium		June 2013–present	NA	ANZECC DGV
	ARP11	Permian Strata	Yes	January 2017–present	NA	ANZECC DGV
	ARP12	Genowlan Creek Alluvium	Yes	January 2017–present	NA	ANZECC DGV
	ARP13SP	Lithgow Seam	Yes	January 2017–present	NA	WMP 2021 SSGV
	ARP14	Genowlan Creek Alluvium	Yes	January 2017–present	781 m AHD	WMP 2021 SSGV
	ARP15SP	Narrabeen Sandstone	Yes	January 2017–present	829.1 m AHD	WMP 2021 SSGV
	ARP16 (Nissan Hut)	NA	Yes	December 2021 – present	NA	ANZECC DGV
Landholder bores	Nioka	Devonian Strata	NA	January 2017 – present	NA	ANZECC DGV
	Kingdom	Devonian Strata	NA	November 2019–present	NA	ANZECC DGV
	GW80876	NA	NA	December 2021 - present	NA	ANZECC DGV

[3] Logger box damaged by tree fall January 2021

	ID	Lithology	Level/ Flow Monitored	Quality Monitored	Level/Flow Triggered	Quality Triggered
Seepage	Village Spring	Permian Strata	Yes	February 2011–present	NA	WMP 2021 SSGV
	Mine workings		Yes	December 2009–present	NA	NA
Surface Water						
Creeks	Airly Creek		NA	Yes	NA	Yes
	Airly Upstream		NA	Yes	NA	Yes
	Airly Tributary		NA	Yes	NA	Yes
	Genowlan Creek 2		Yes	Yes	NA	Yes
	Gap Creek		Yes	Yes	NA	Yes
	The Grotto		NA	Yes	NA	Yes
Discharge Points	LDP001		Yes	Yes	Yes	Yes
	LDP002		NA continuous monitoring not available	Yes	Yes	Yes
	LDP003		Yes	Yes	Yes	Yes

8. References

ANZECC (2000), *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

Centennial (2021) *Memorandum: Recovery of ARP08.* Letter prepared by Centennial 17 December 2021.

GHD (2014) Airly Mine Extension Project: Water and Salt Balance Assessment, prepared by GHD Pty Ltd for Centennial Airly Pty Limited.

GHD (2016), *Gap Creek and Genowlan Creek Flow Investigation.*

GHD (2017a) *Hydrogeological Model Recalibration*: Letter prepared for Centennial 24 July 2017.

GHD (2017b) Airly Mine - Additional Water and Salt Balance Modelling.

GHD (2017c) *Airly Mine – 2016 Annual Water Monitoring Report.*

GHD (2018a) *SSGV Update and EPL Review*: Letter prepared for Centennial 14 February 2018.

GHD (2018b) *Airly aquatic ecology 2017.*

GHD (2021) *Airly Mine Water Management Plan.*

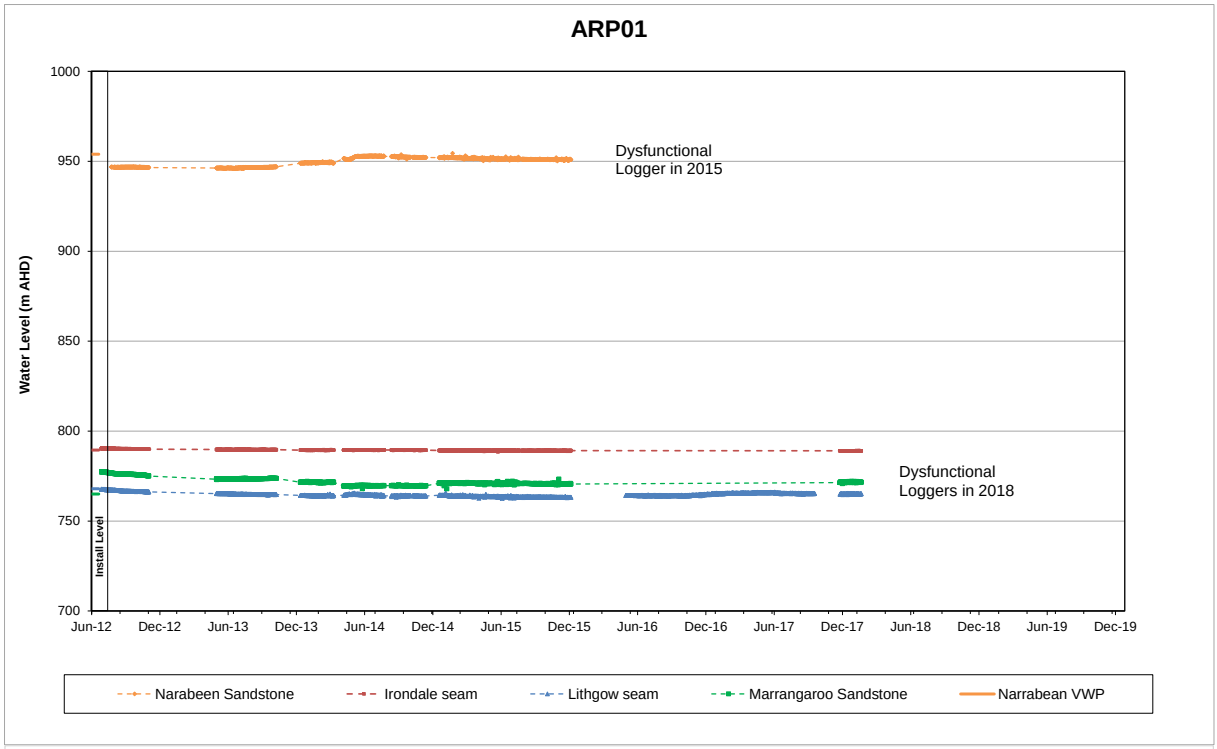
GHD (2019a) *Airly Mine Mod 3: Hydrogeological Model Report.*

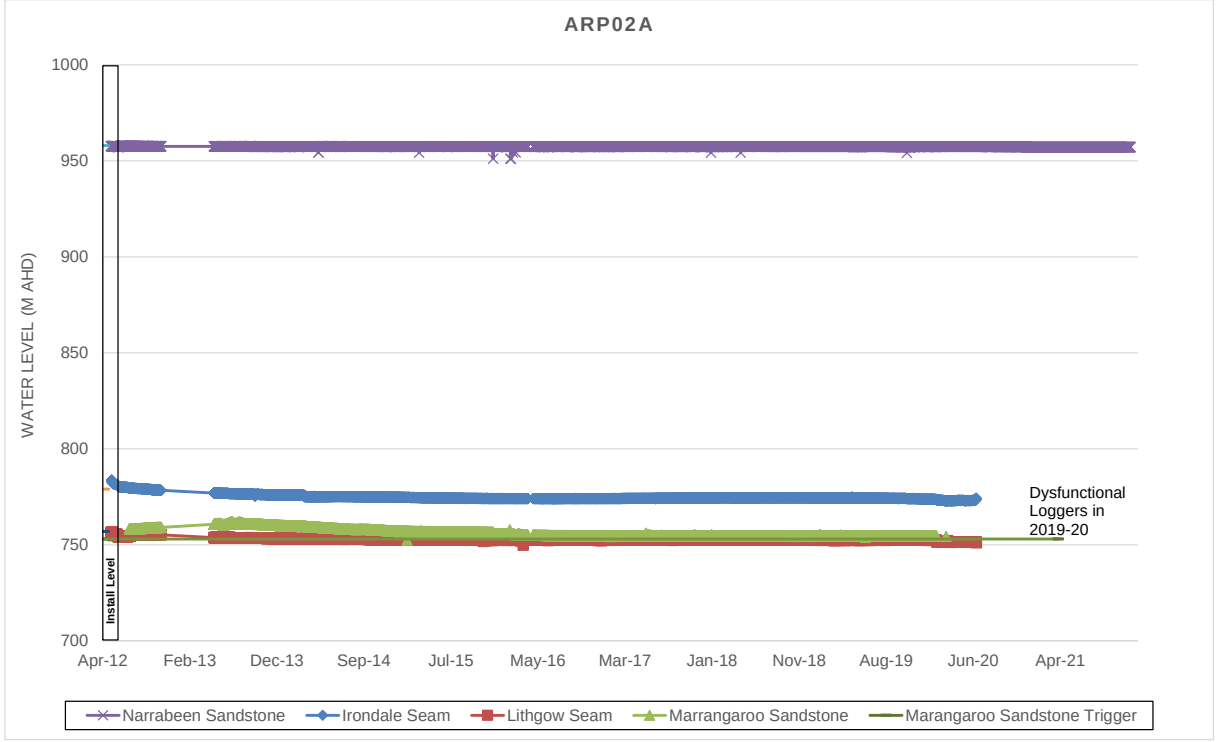
GHD (2019b) *Airly Mine Extension Project Modification 2: Surface Water Impact Assessment*, prepared by GHD Pty Ltd for Centennial Airly Pty Limited.

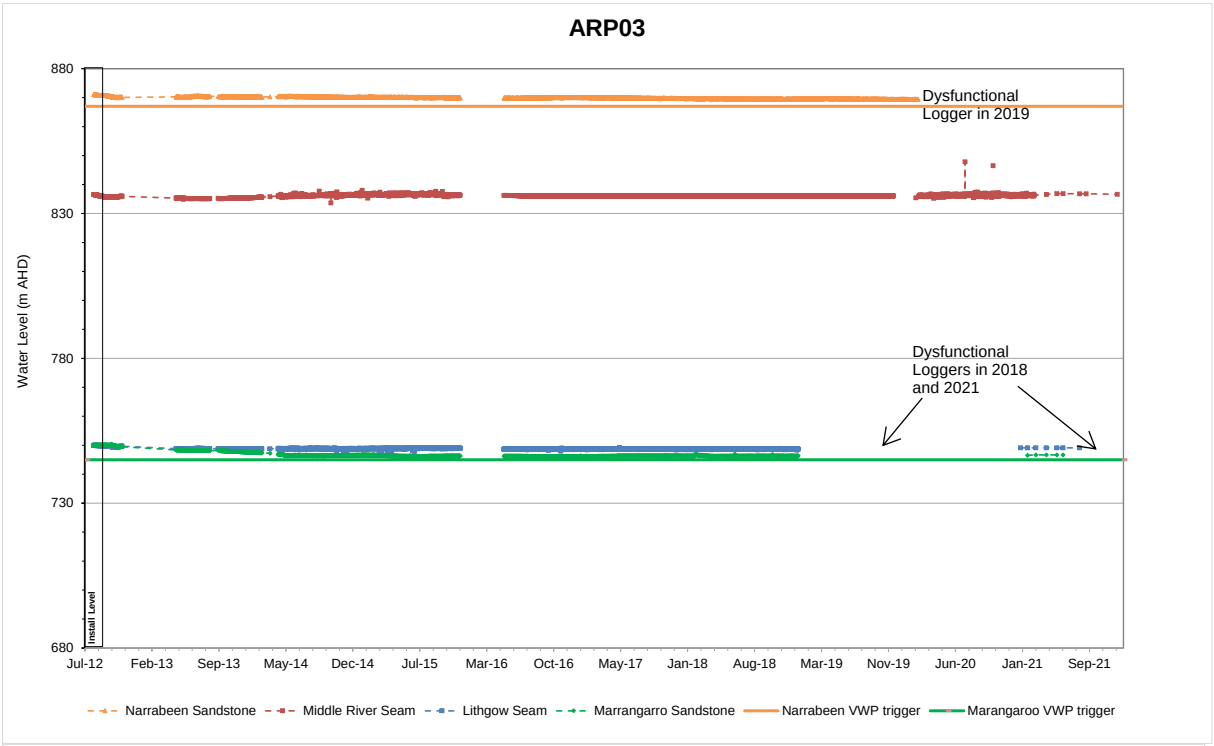
Appendices

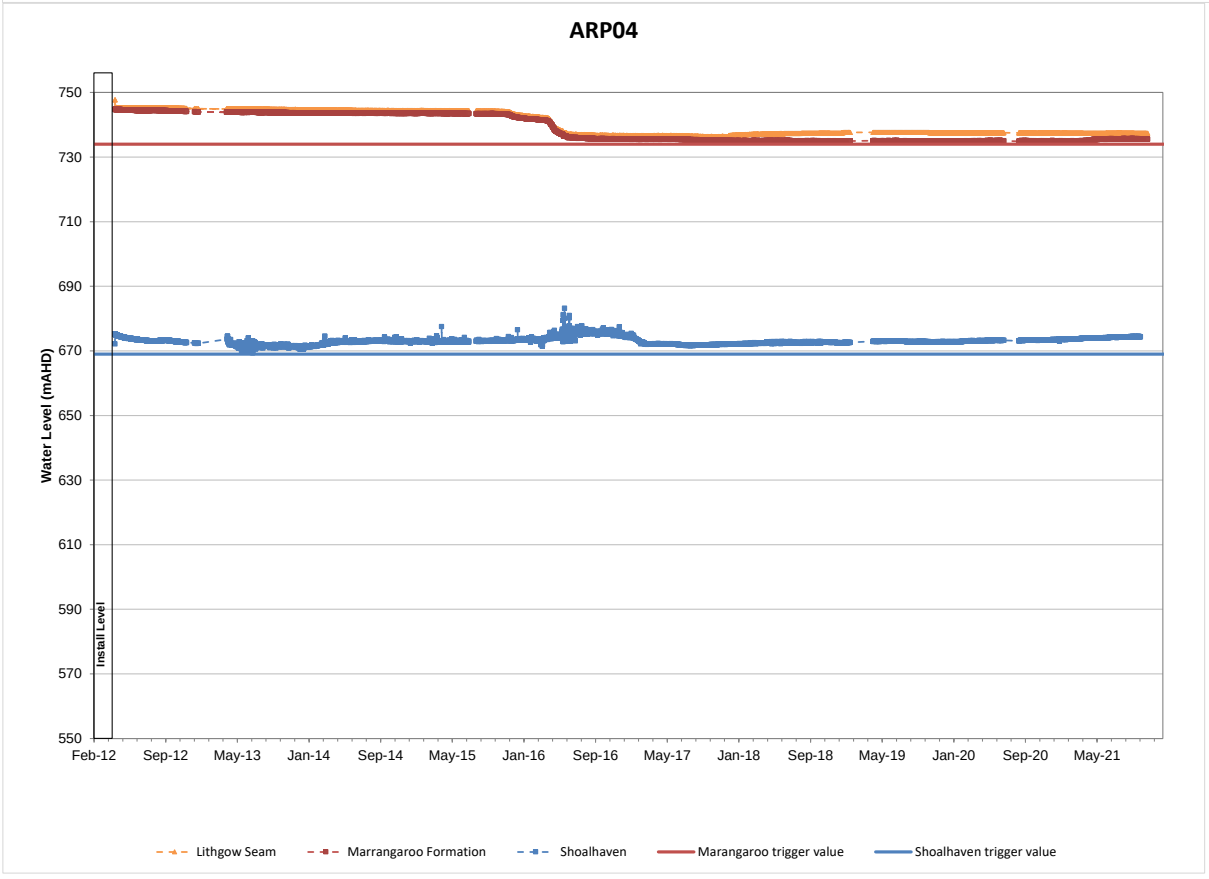
Appendix A

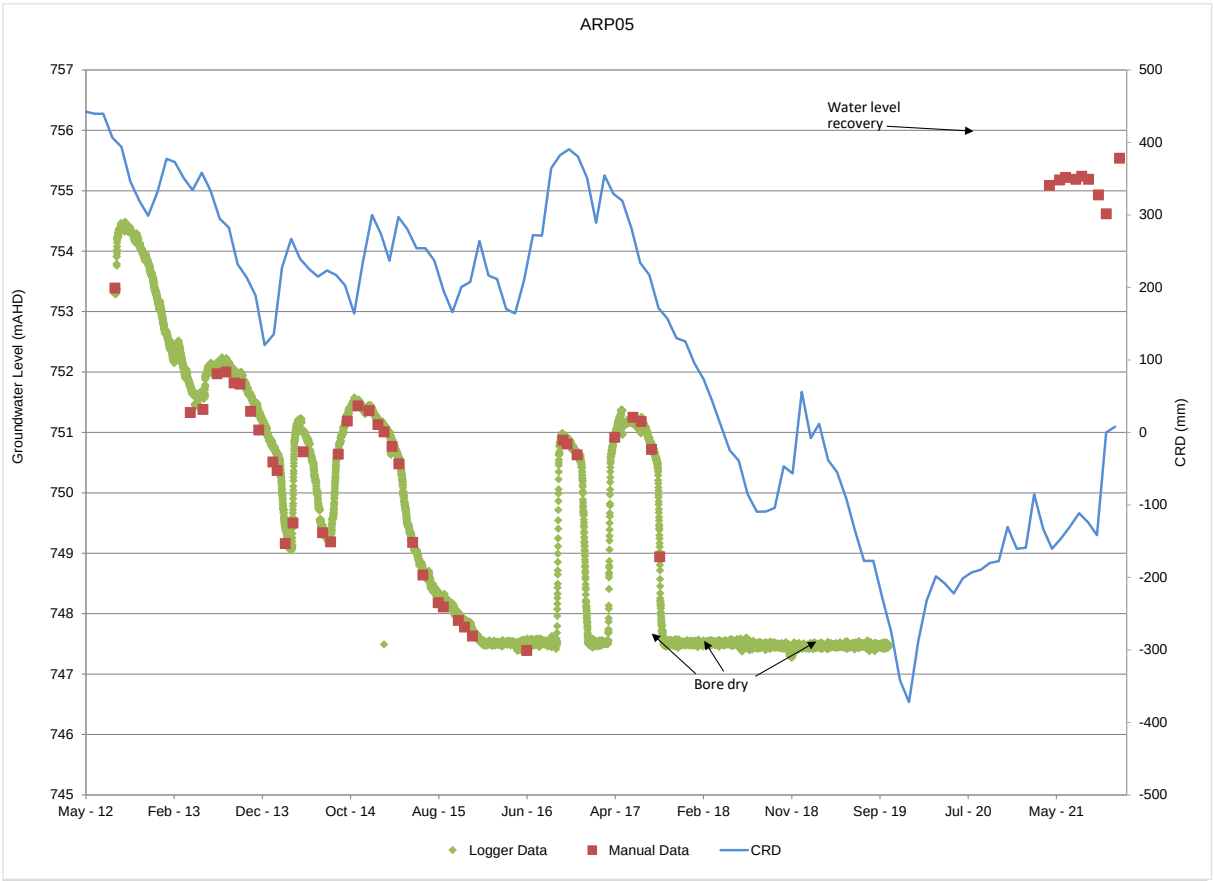
Groundwater hydrographs

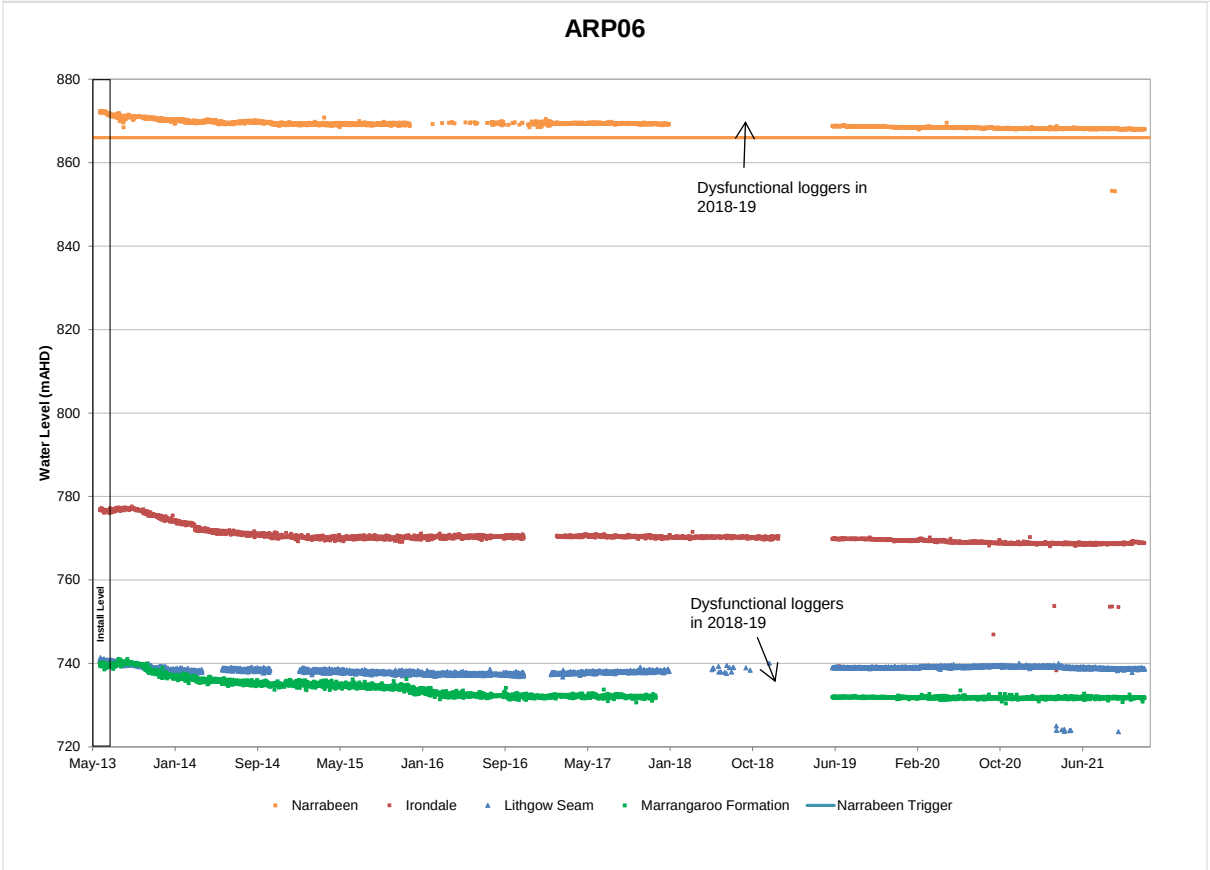

ARP01
Water Level (m AHD)
1000
950
900
850
800
750
700
Install Level
Dysfunctional Logger in 2015
Dysfunctional Loggers in 2018
Jun-12
Dec-12
Jun-13
Dec-13
Jun-14
Dec-14
Jun-15
Dec-15
Jun-16
Dec-16
Jun-17
Dec-17
Jun-18
Dec-18
Jun-19
Dec-19
Narabeen Sandstone
Irondale seam
Lithgow seam
Marrangaroo Sandstone
Narrabean VWP

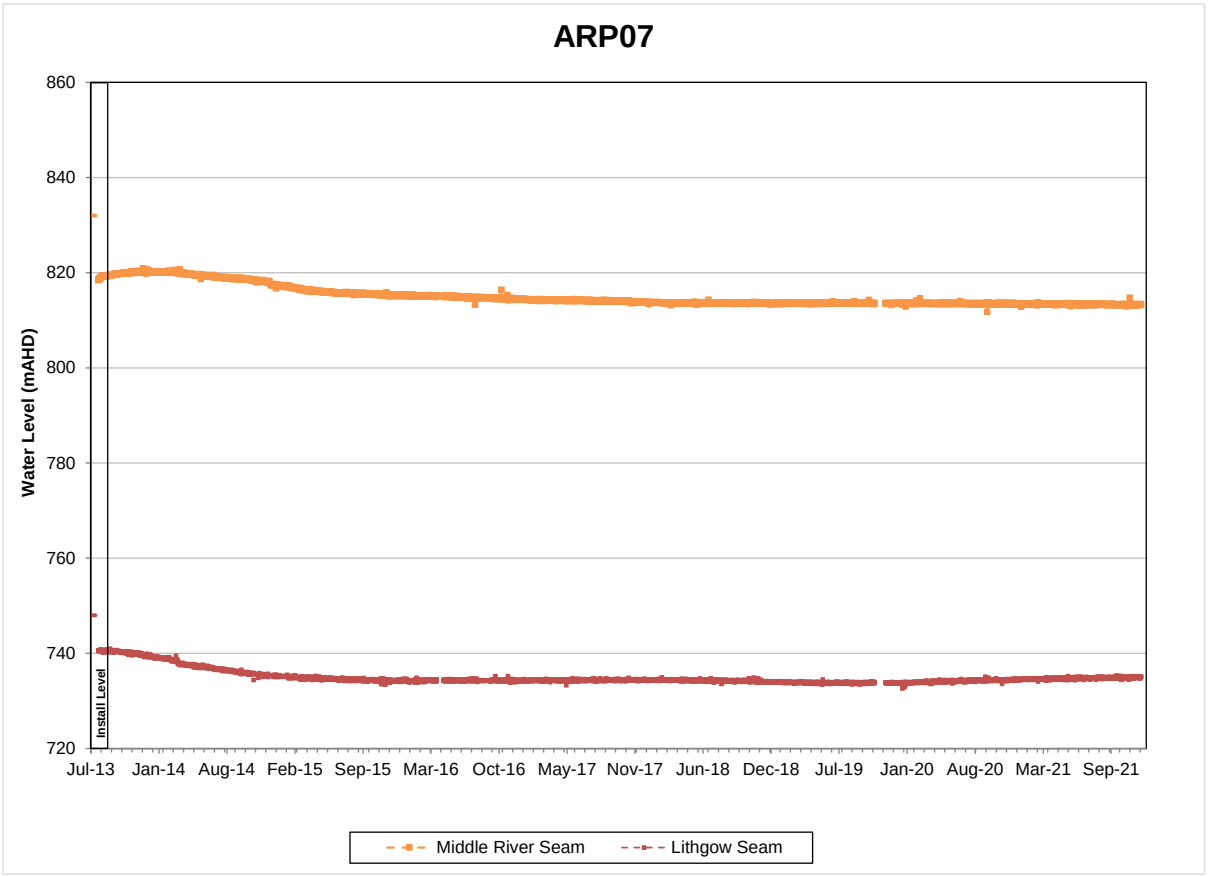

ARP02A
WATER LEVEL (M AHD)
1000
950
900
850
800
750
700
Install Level
Dysfunctional Loggers in 2019-20
Apr-12
Feb-13
Dec-13
Sep-14
Jul-15
May-16
Mar-17
Jan-18
Nov-18
Aug-19
Jun-20
Apr-21
Narrabeen Sandstone
Irondale Seam
Lithgow Seam
Marrangaroo Sandstone
Marangaroo Sandstone Trigger

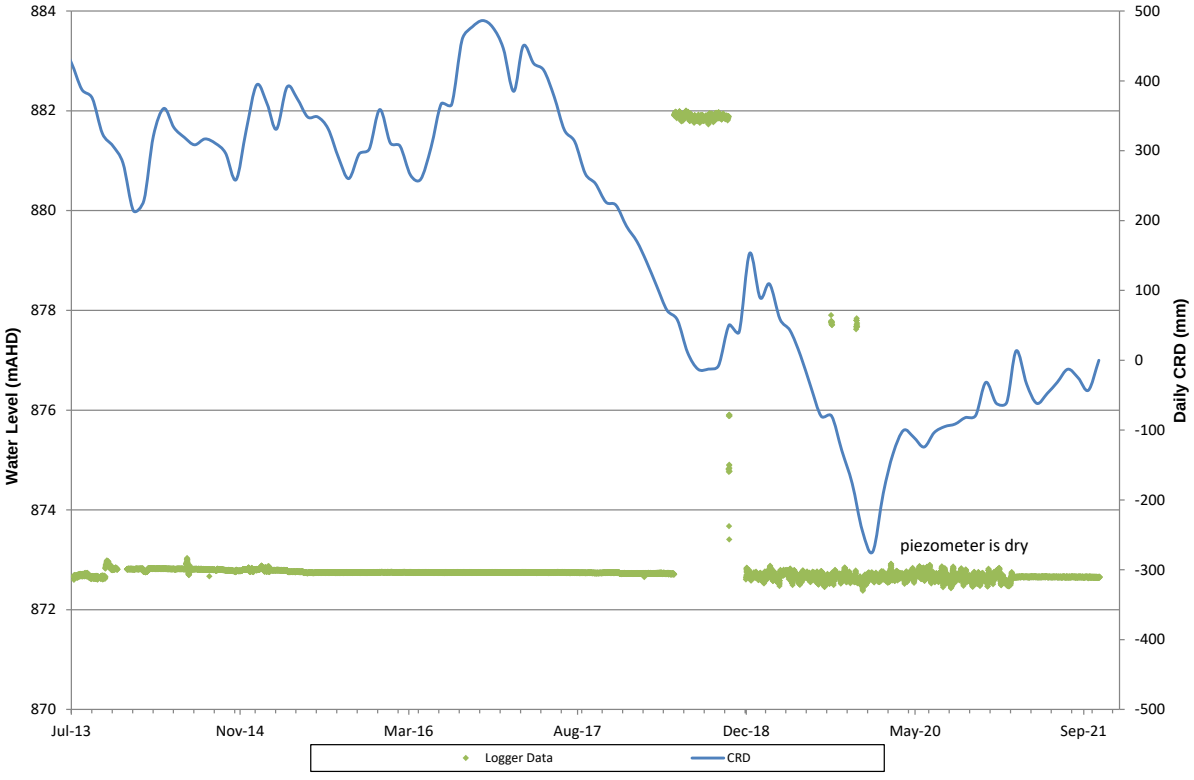

ARP03
Water Level (m AHD)
880
830
780
730
680
Install Level
Dysfunctional Logger in 2019
Dysfunctional Loggers in 2018 and 2021
Jul-12
Feb-13
Sep-13
May-14
Dec-14
Jul-15
Mar-16
Oct-16
May-17
Jan-18
Aug-18
Mar-19
Nov-19
Jun-20
Jan-21
Sep-21
Narrabeen Sandstone
Middle River Seam
Lithgow Seam
Marrangarro Sandstone
Narrabeen VWP trigger
Marangaroo VWP trigger

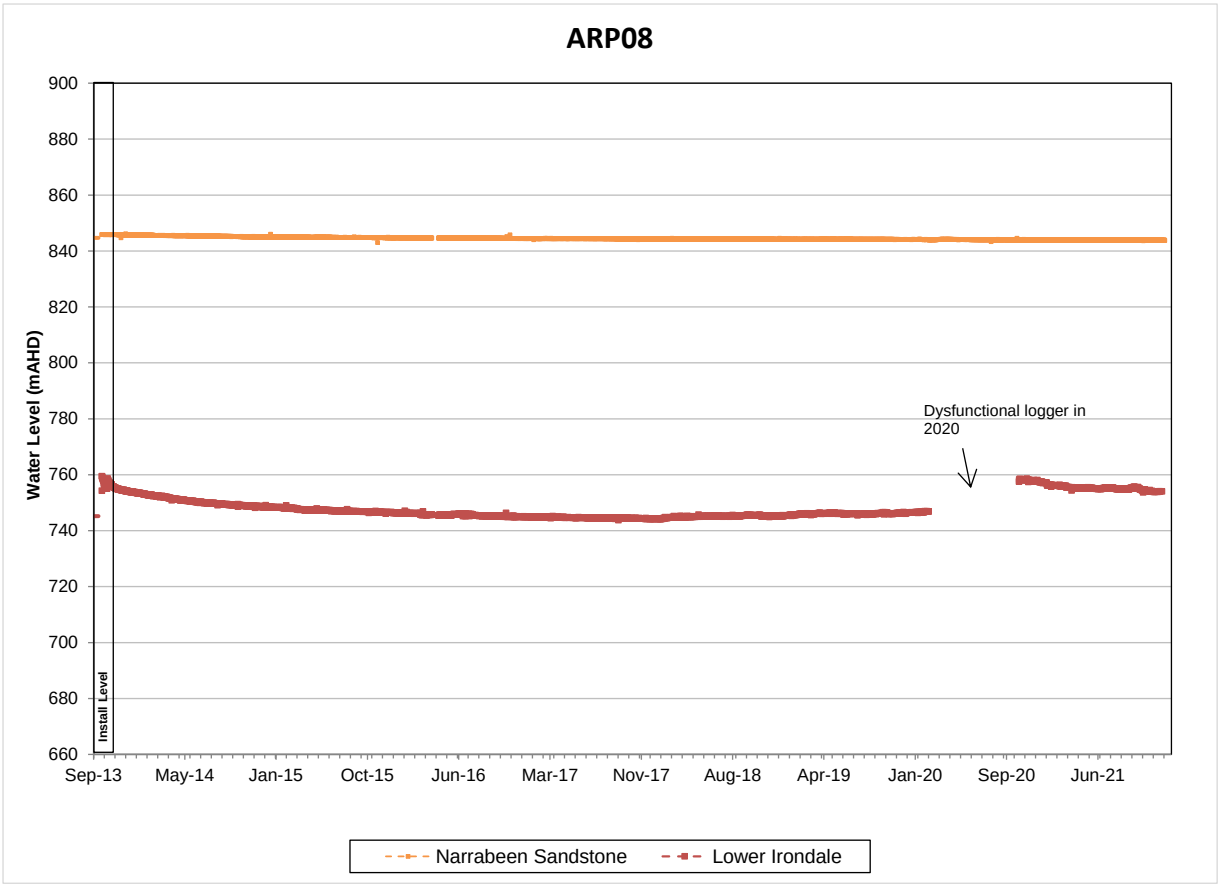

ARP04
Water Level (mAHD)
750
730
710
690
670
650
630
610
590
570
550
Install Level
Feb-12
Sep-12
May-13
Jan-14
Sep-14
May-15
Jan-16
Sep-16
May-17
Jan-18
Sep-18
May-19
Jan-20
Sep-20
May-21
Lithgow Seam
Marrangaroo Formation
Shoalhaven
Marangaroo trigger value
Shoalhaven trigger value

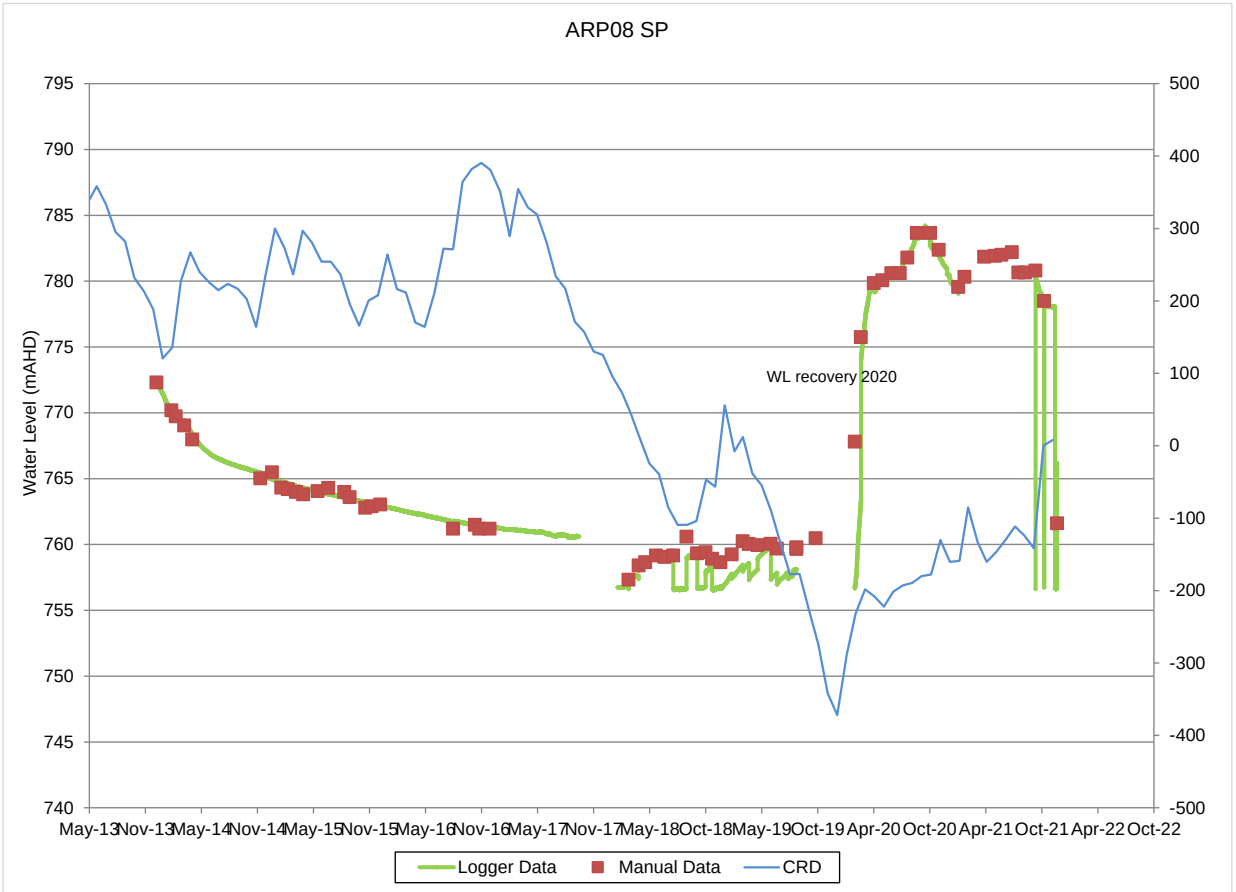

ARP05
Groundwater Level (mAHD)
CRD (mm)
Water level recovery
Bore dry
757
756
755
754
753
752
751
750
749
748
747
746
745
500
400
300
200
100
0
-100
-200
-300
-400
-500
May - 12
Feb - 13
Dec - 13
Oct - 14
Aug - 15
Jun - 16
Apr - 17
Feb - 18
Nov - 18
Sep - 19
Jul - 20
May - 21
Logger Data
Manual Data
CRD

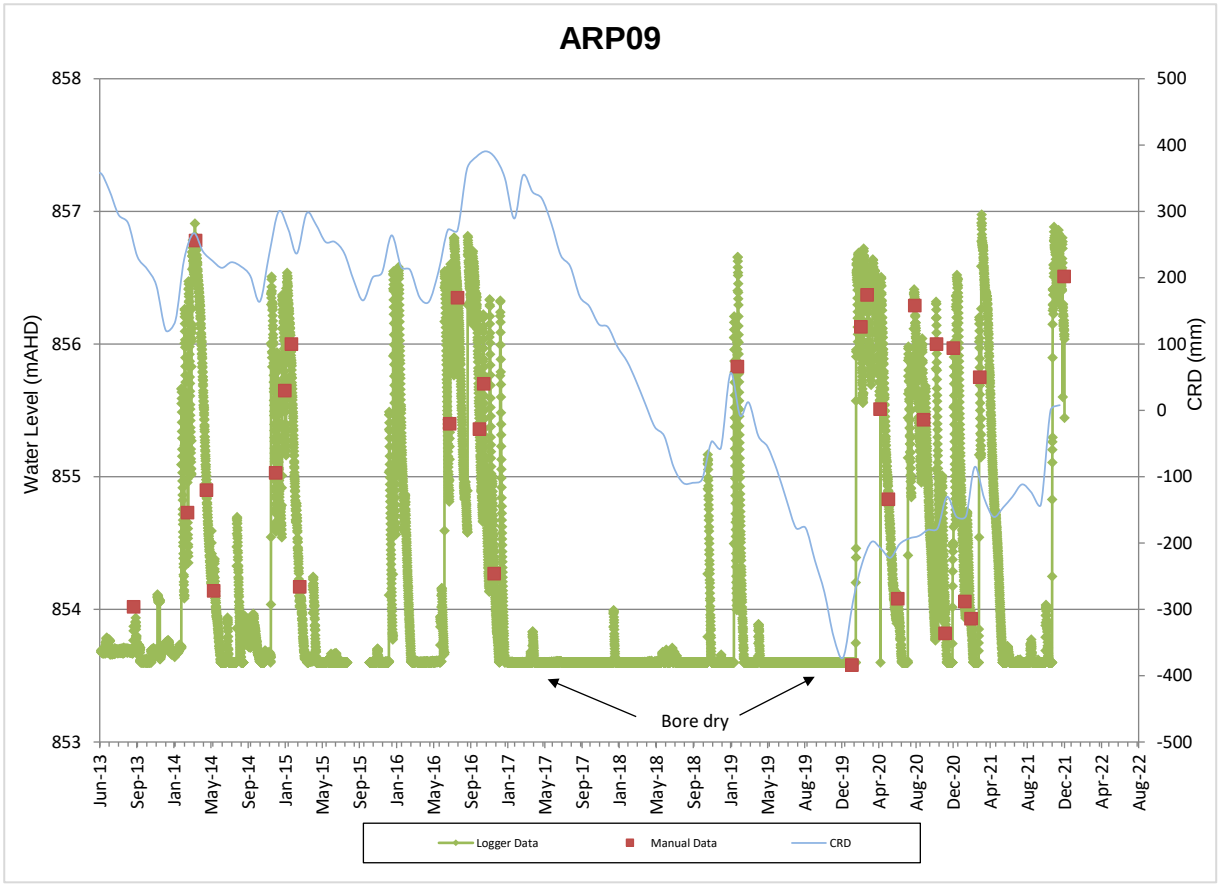

ARP06
Water Level (mAHD)
Dysfunctional loggers in 2018-19
Dysfunctional loggers in 2018-19
Install Level
880
860
840
820
800
780
760
740
720
May-13
Jan-14
Sep-14
May-15
Jan-16
Sep-16
May-17
Jan-18
Oct-18
Jun-19
Feb-20
Oct-20
Jun-21
Narrabeen
Irondale
Lithgow Seam
Marrangaroo Formation
Narrabeen Trigger

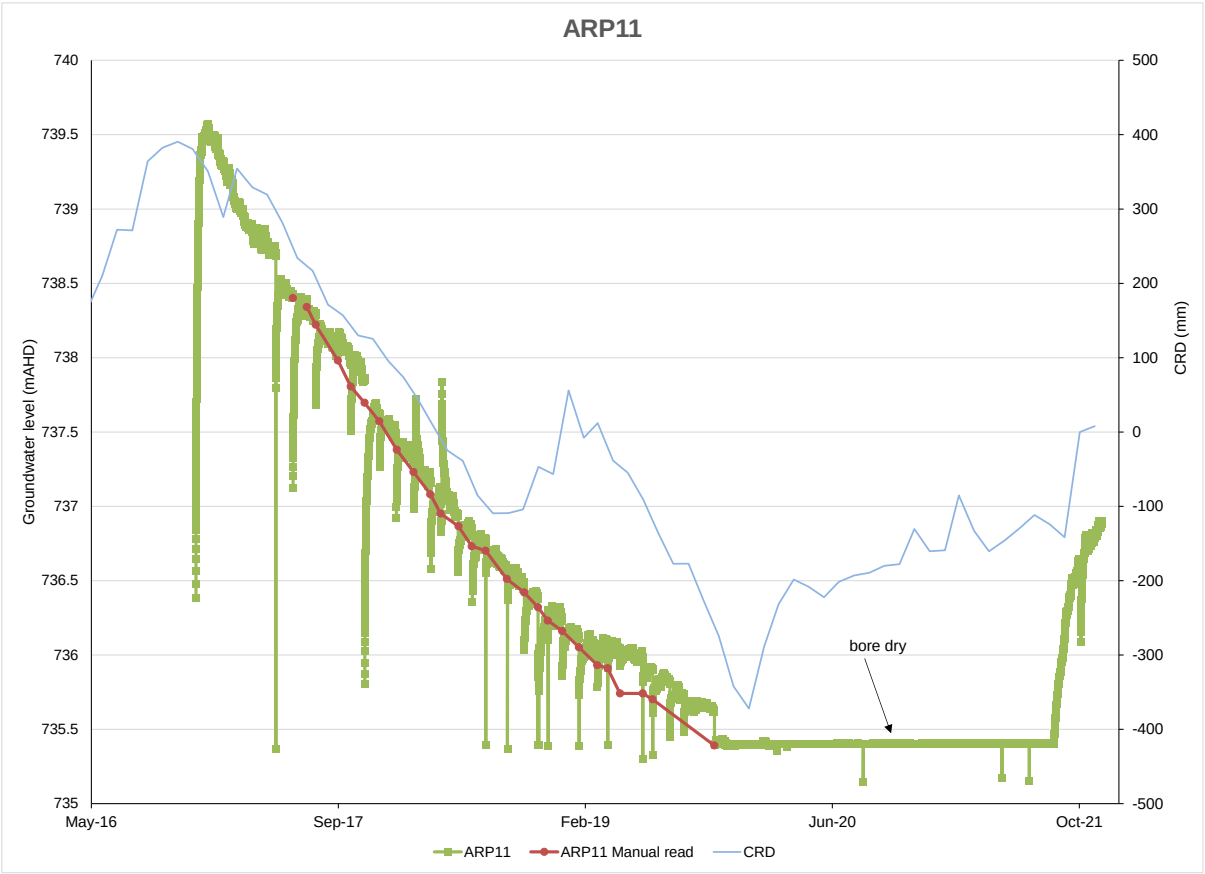

ARP07
Water Level (mAHD)
860
840
820
800
780
760
740
720
Install Level
Jul-13
Jan-14
Aug-14
Feb-15
Sep-15
Mar-16
Oct-16
May-17
Nov-17
Jun-18
Dec-18
Jul-19
Jan-20
Aug-20
Mar-21
Sep-21
Middle River Seam
Lithgow Seam

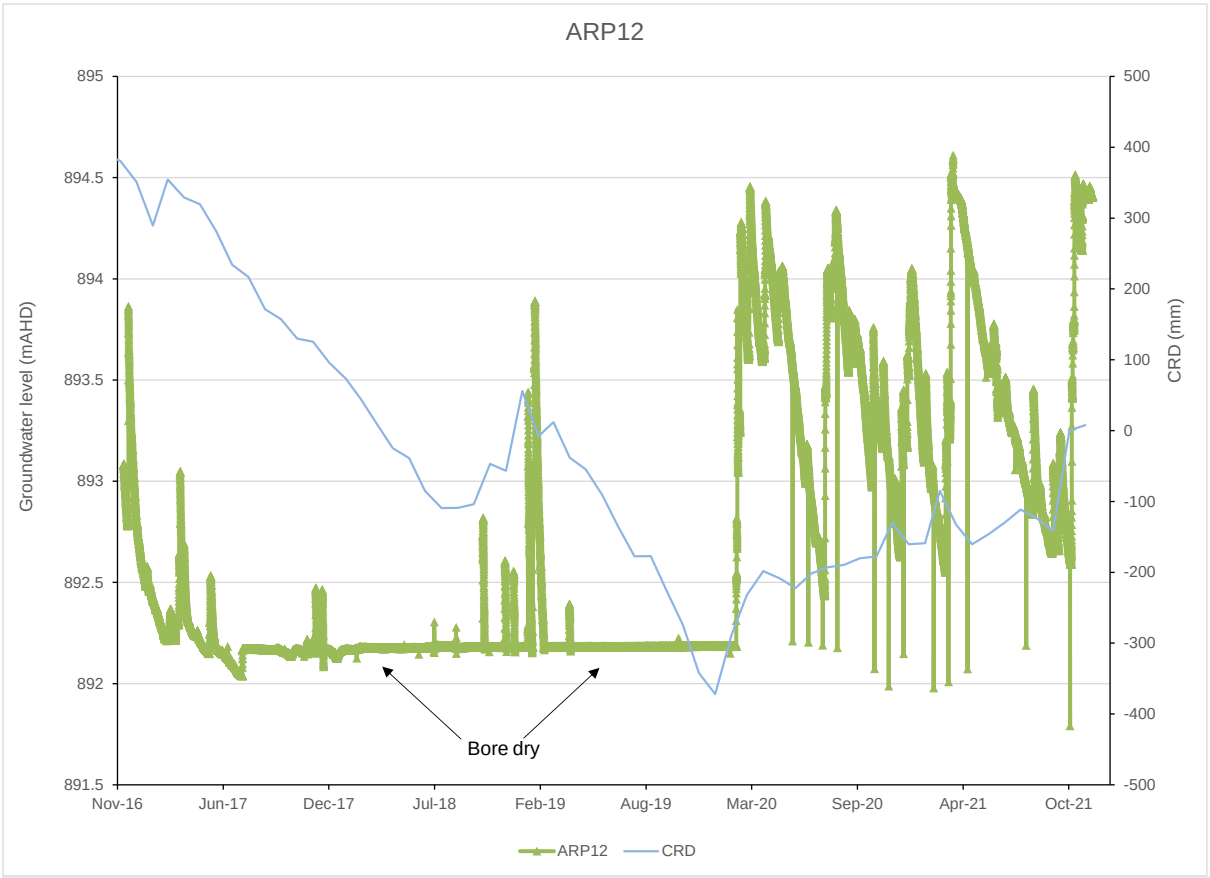

Water Level (mAHD)
884
882
880
878
876
874
872
870
Daily CRD (mm)
500
400
300
200
100
0
-100
-200
-300
-400
-500
Jul-13
Nov-14
Mar-16
Aug-17
Dec-18
May-20
Sep-21
piezometer is dry
Logger Data
CRD

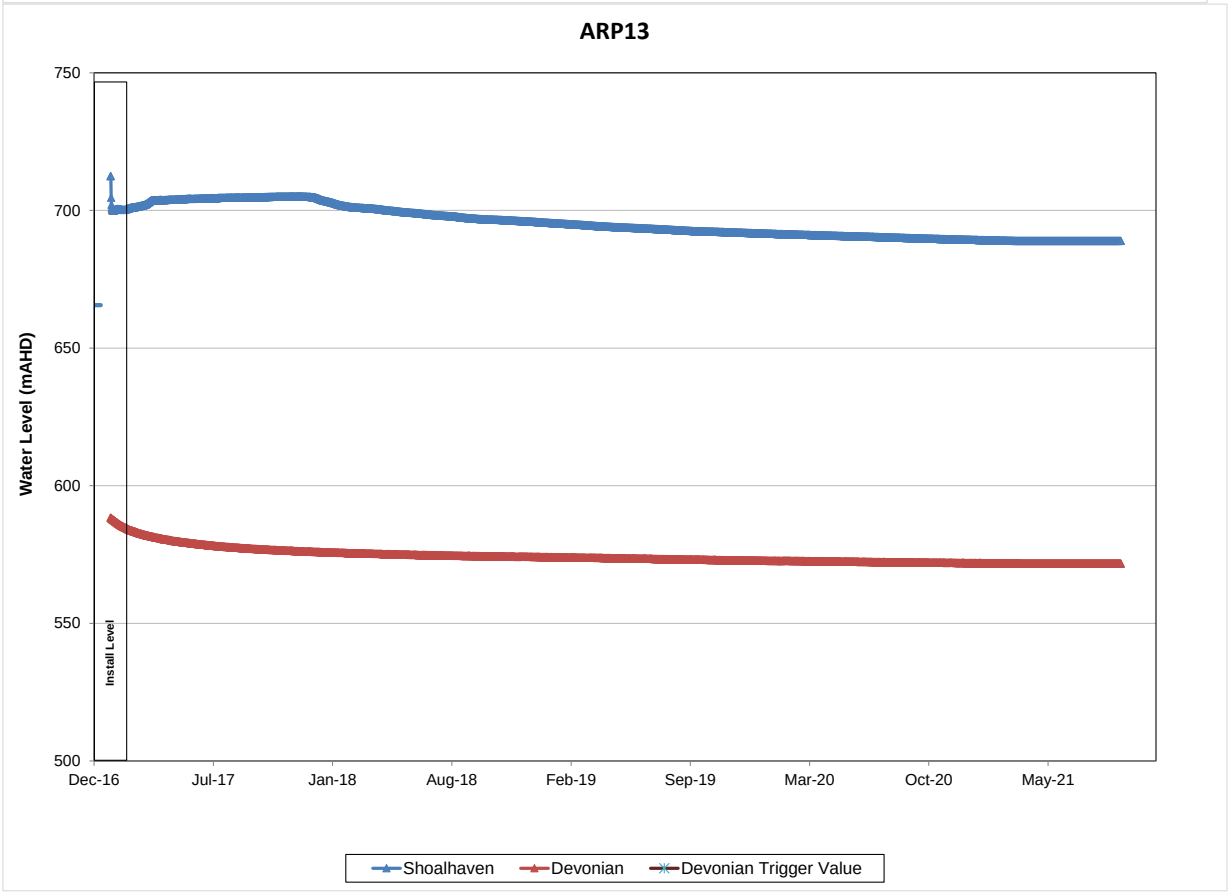

ARP08
Water Level (mAHD)
900
880
860
840
820
800
780
760
740
720
700
680
660
Install Level
Dysfunctional logger in 2020
Sep-13
May-14
Jan-15
Oct-15
Jun-16
Mar-17
Nov-17
Aug-18
Apr-19
Jan-20
Sep-20
Jun-21
Narrabeen Sandstone
Lower Irondale

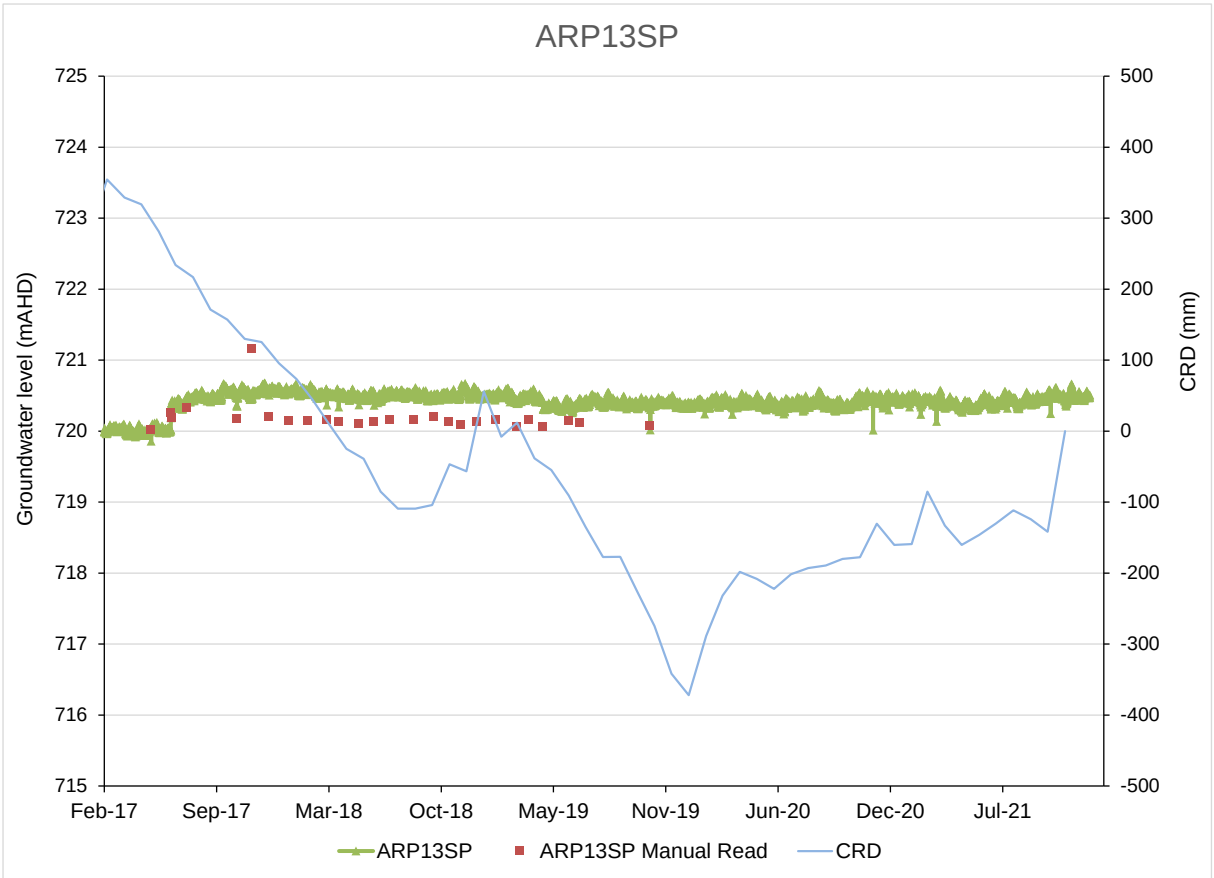

ARP08 SP
Water Level (mAHD)
795
790
785
780
775
770
765
760
755
750
745
740
500
400
300
200
100
0
-100
-200
-300
-400
-500
WL recovery 2020
May-13
Nov-13
May-14
Nov-14
May-15
Nov-15
May-16
Nov-16
May-17
Nov-17
May-18
Oct-18
May-19
Oct-19
Apr-20
Oct-20
Apr-21
Oct-21
Apr-22
Oct-22
Logger Data
Manual Data
CRD


ARP09
Water Level (mAHD)
CRD (mm)
858
857
856
855
854
853
500
400
300
200
100
0
-100
-200
-300
-400
-500
Jun-13
Sep-13
Jan-14
May-14
Sep-14
Jan-15
May-15
Sep-15
Jan-16
May-16
Sep-16
Jan-17
May-17
Sep-17
Jan-18
May-18
Sep-18
Jan-19
May-19
Aug-19
Dec-19
Apr-20
Aug-20
Dec-20
Apr-21
Aug-21
Dec-21
Apr-22
Aug-22
Bore dry
Logger Data
Manual Data
CRD

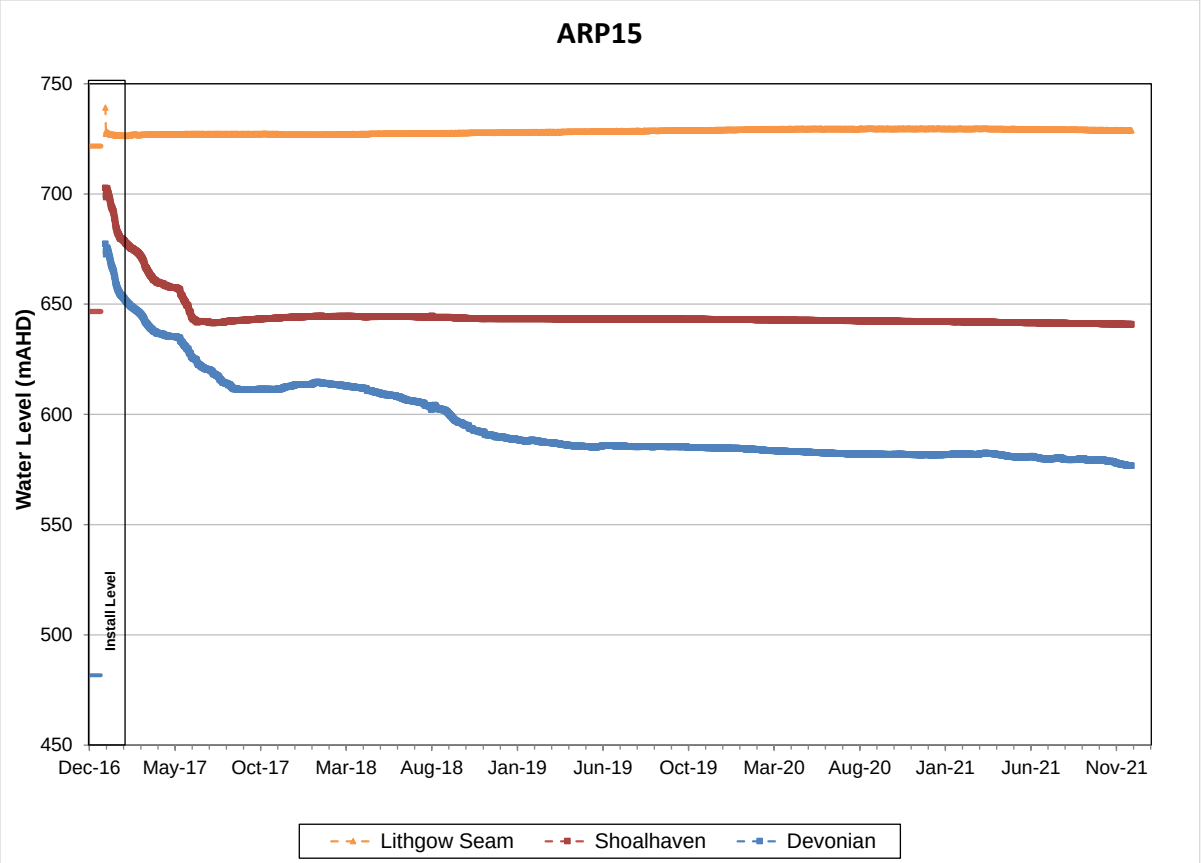

ARP11
Groundwater level (mAHD)
CRD (mm)
740
739.5
739
738.5
738
737.5
737
736.5
736
735.5
735
500
400
300
200
100
0
-100
-200
-300
-400
-500
May-16
Sep-17
Feb-19
Jun-20
Oct-21
bore dry
ARP11
ARP11 Manual read
CRD

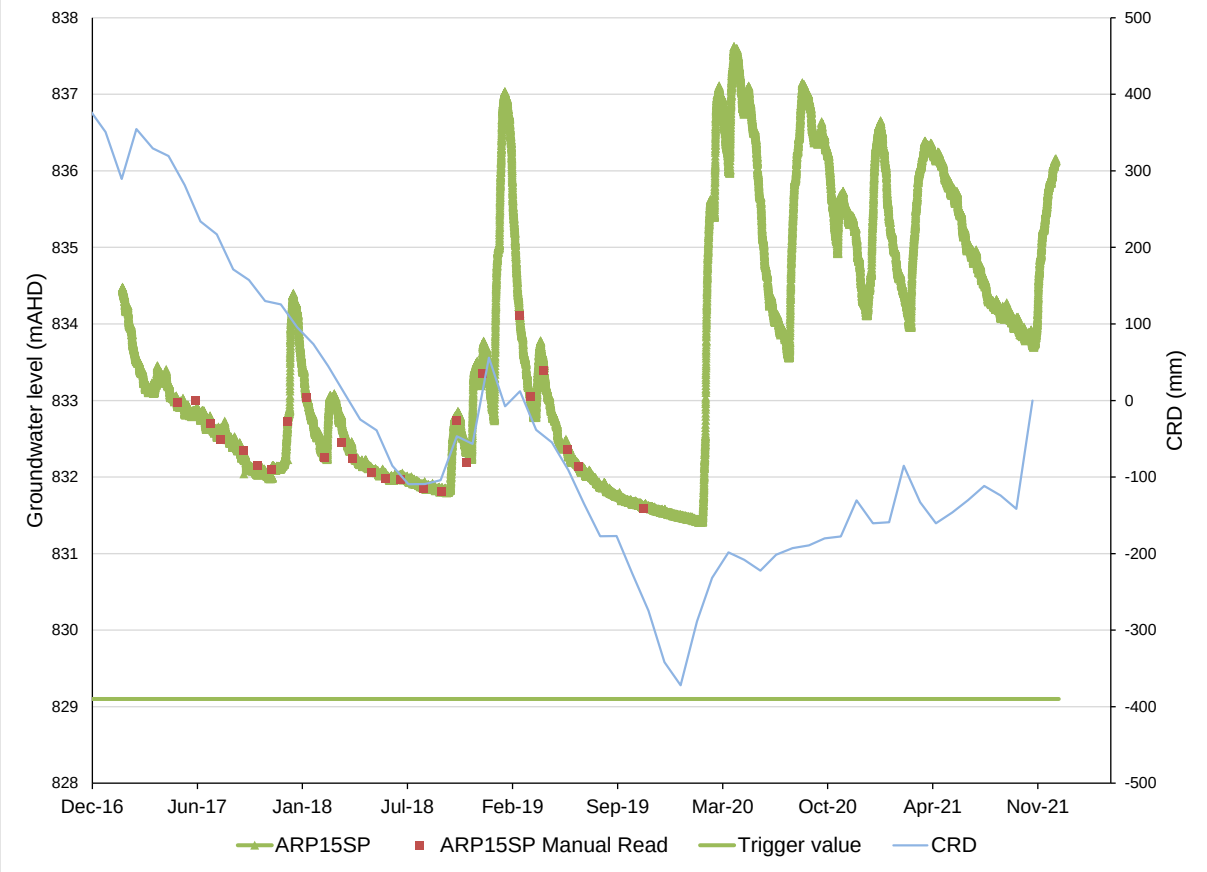

ARP12
Groundwater level (mAHD)
CRD (mm)
895
894.5
894
893.5
893
892.5
892
891.5
500
400
300
200
100
0
-100
-200
-300
-400
-500
Nov-16
Jun-17
Dec-17
Jul-18
Feb-19
Aug-19
Mar-20
Sep-20
Apr-21
Oct-21
Bore dry
ARP12
CRD

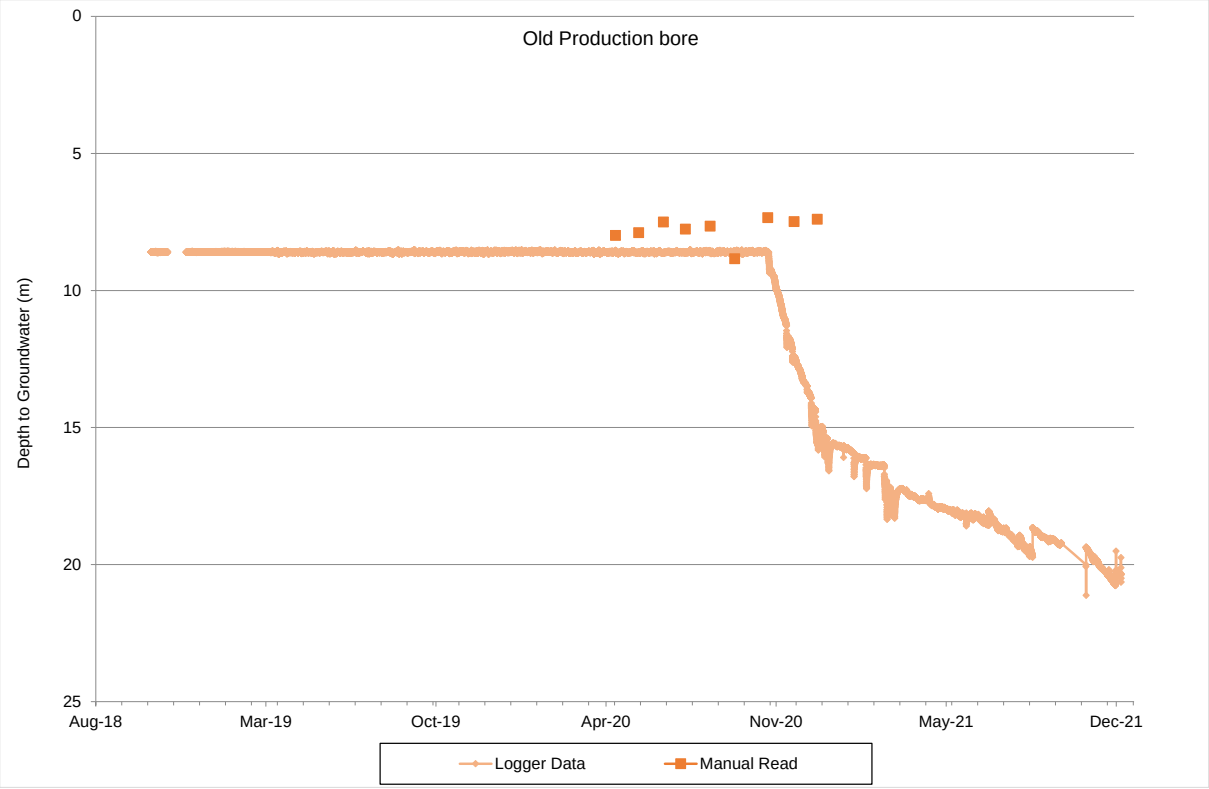

ARP13
Water Level (mAHD)
750
700
650
600
550
500
Install Level
Dec-16
Jul-17
Jan-18
Aug-18
Feb-19
Sep-19
Mar-20
Oct-20
May-21
Shoalhaven
Devonian
Devonian Trigger Value


ARP13SP
Groundwater level (mAHD)
CRD (mm)
725
724
723
722
721
720
719
718
717
716
715
500
400
300
200
100
0
-100
-200
-300
-400
-500
Feb-17
Sep-17
Mar-18
Oct-18
May-19
Nov-19
Jun-20
Dec-20
Jul-21
ARP13SP
ARP13SP Manual Read
CRD


Groundwater level (mAHD)
CRD (mm)
785
784.5
784
783.5
783
782.5
782
781.5
781
780.5
780
500
400
300
200
100
0
-100
-200
-300
-400
-500
Dec-16
May-17
Oct-17
Mar-18
Jul-18
Dec-18
May-19
Oct-19
Mar-20
Aug-20
Jan-21
Jun-21
Nov-21
ARP14
ARP14 Manual Read


ARP15
Water Level (mAHD)
750
700
650
600
550
500
450
Install Level
Dec-16
May-17
Oct-17
Mar-18
Aug-18
Jan-19
Jun-19
Oct-19
Mar-20
Aug-20
Jan-21
Jun-21
Nov-21
Lithgow Seam
Shoalhaven
Devonian

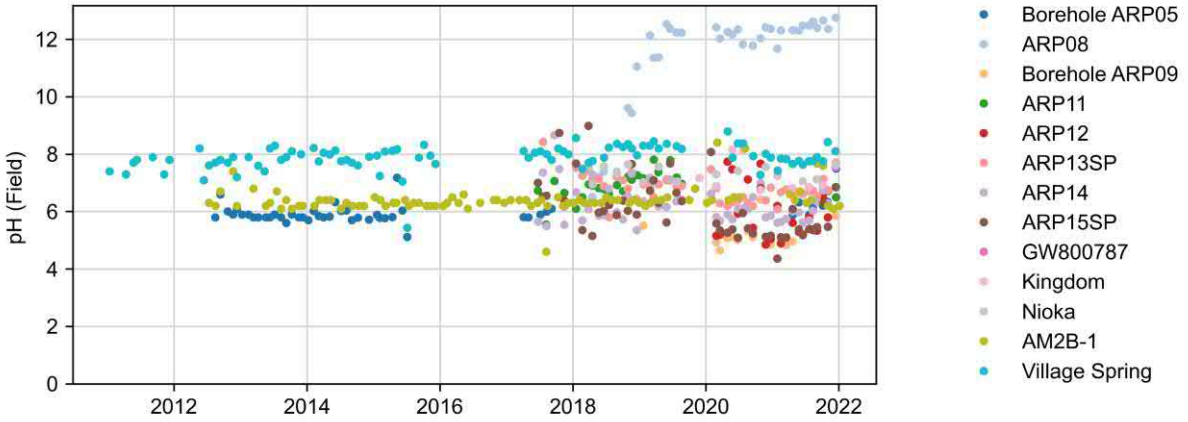

Groundwater level (mAHD)
838
837
836
835
834
833
832
831
830
829
828
CRD (mm)
500
400
300
200
100
0
-100
-200
-300
-400
-500
Dec-16
Jun-17
Jan-18
Jul-18
Feb-19
Sep-19
Mar-20
Oct-20
Apr-21
Nov-21
ARP15SP
ARP15SP Manual Read
Trigger value
CRD

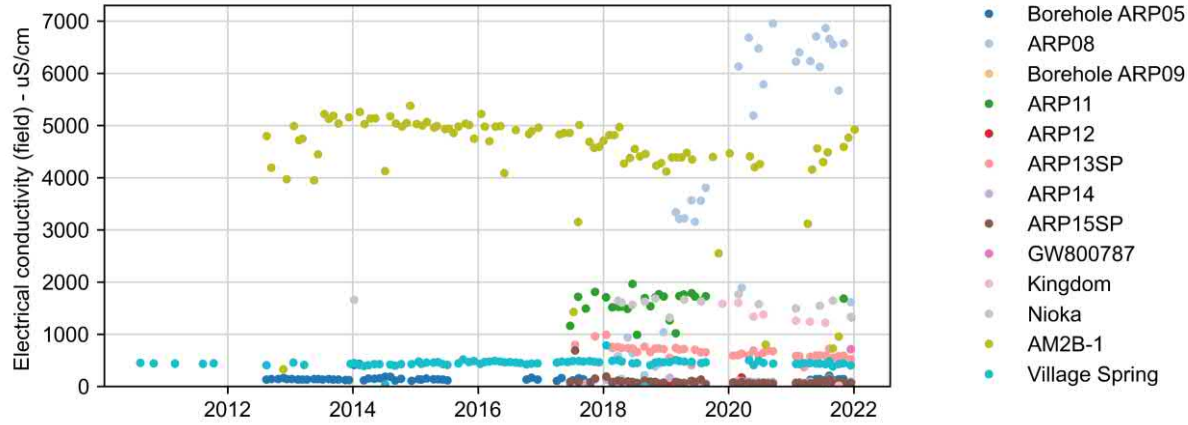

Old Production bore
Depth to Groundwater (m)
0
5
10
15
20
25
Aug-18
Mar-19
Oct-19
Apr-20
Nov-20
May-21
Dec-21
Logger Data
Manual Read

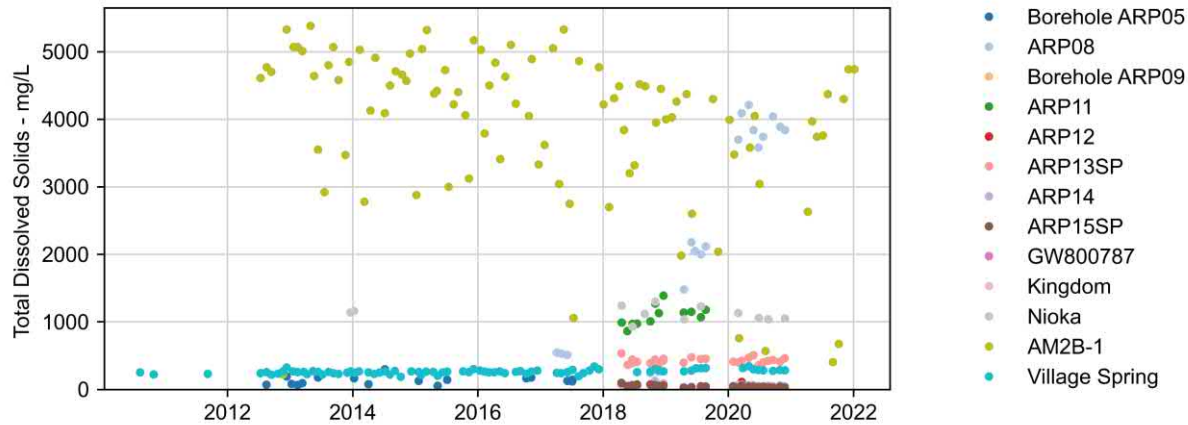
Appendix B

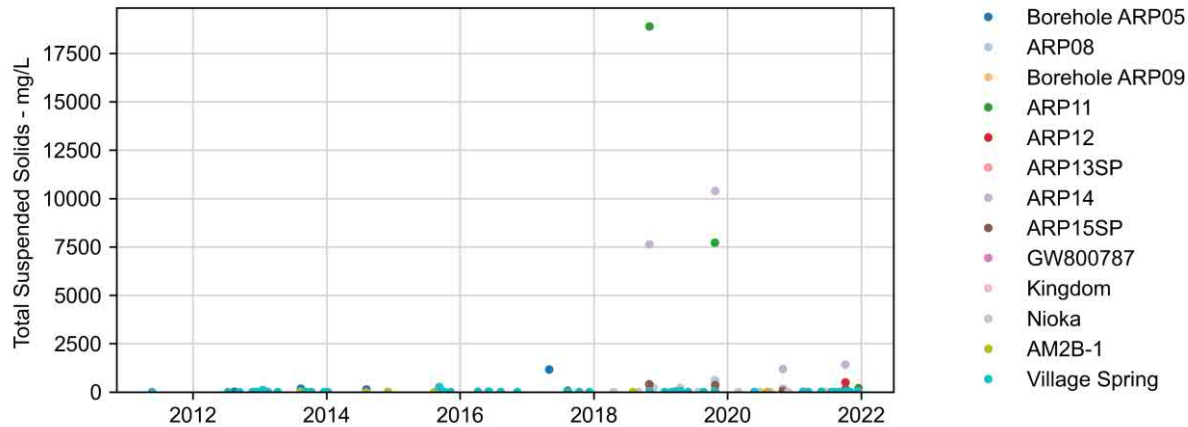
Groundwater quality

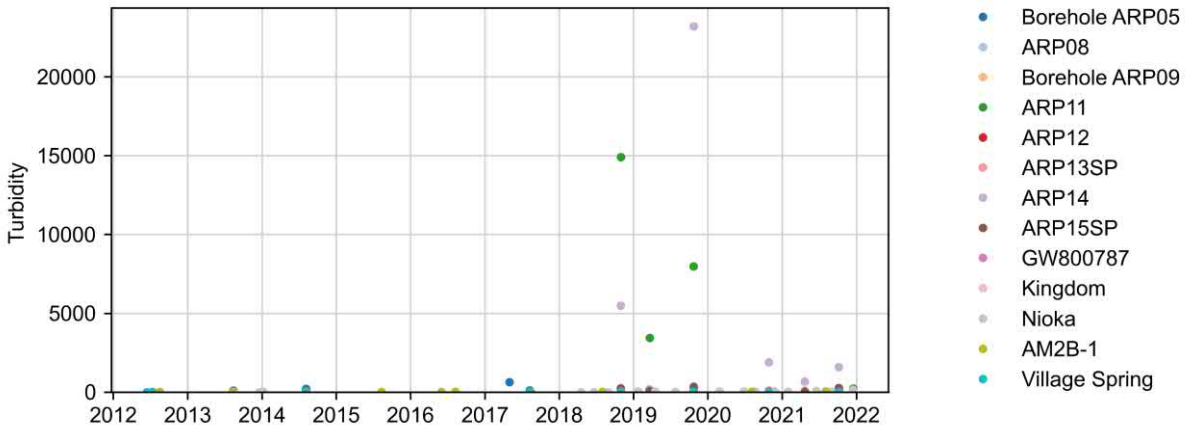
Physicochemical parameters

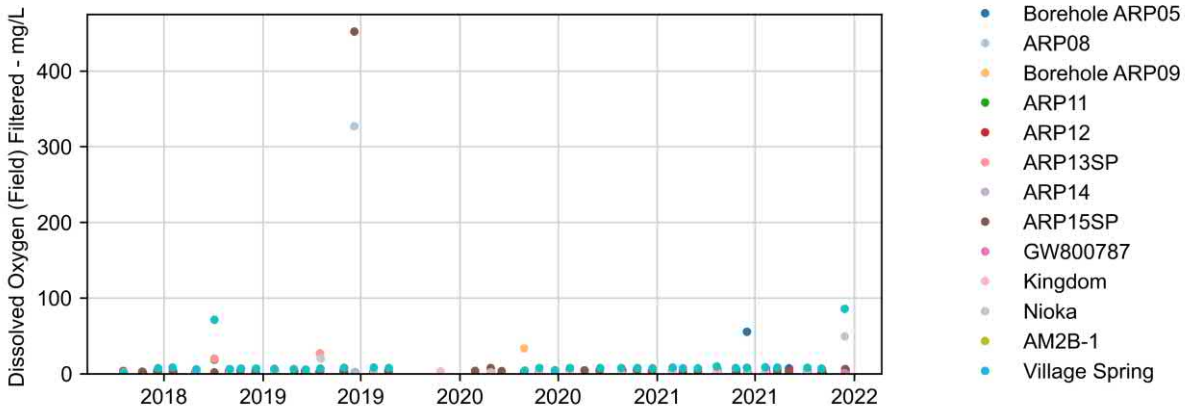




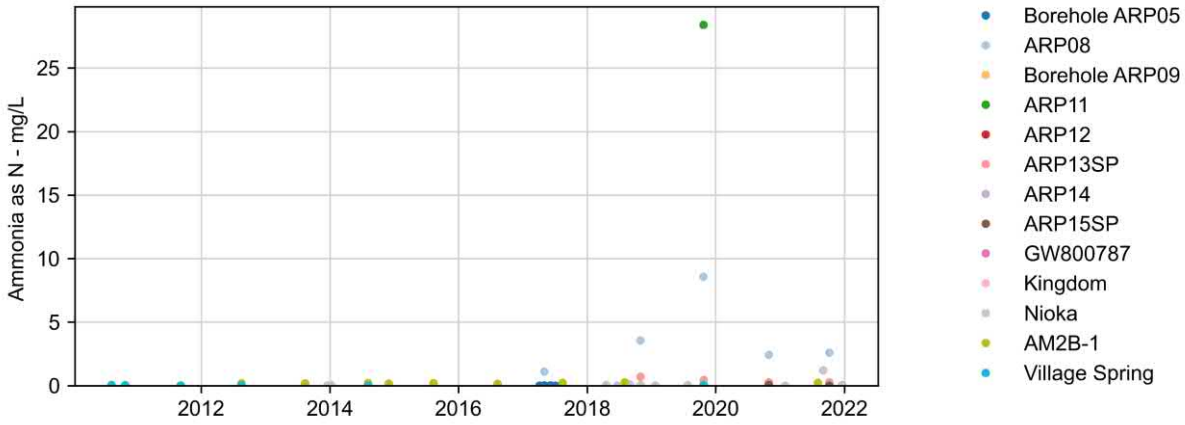


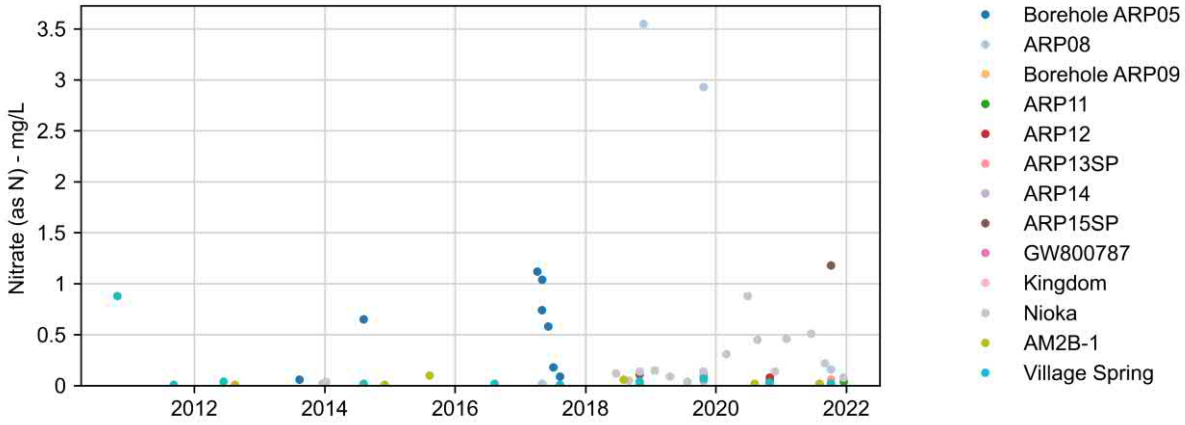


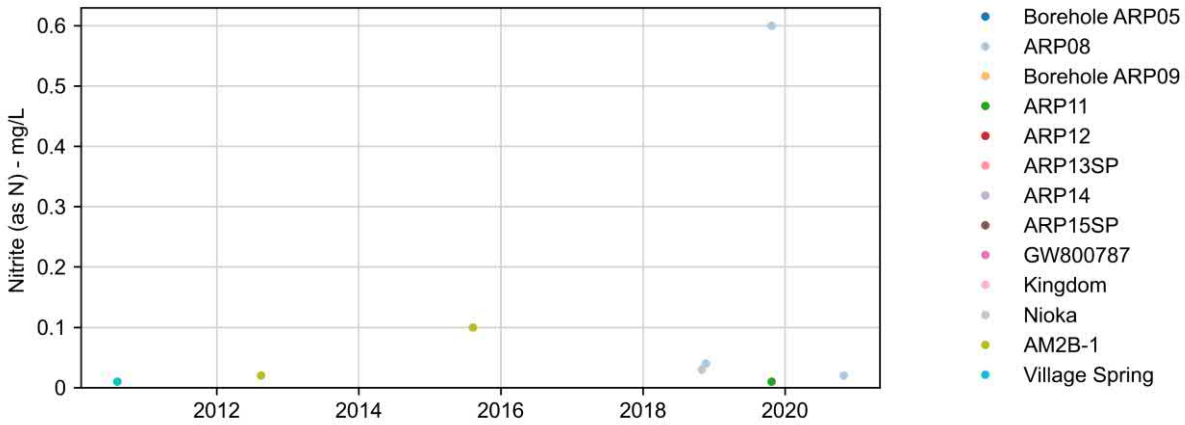

Turbidity
20000
15000
10000
5000
0
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

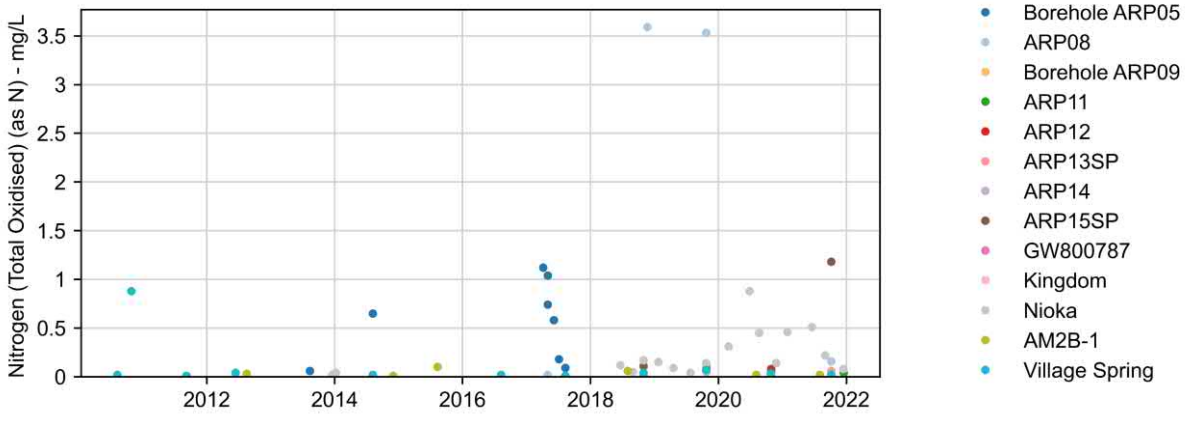

Dissolved Oxygen (Field) Filtered - mg/L
400
300
200
100
0
2018
2019
2019
2020
2020
2021
2021
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

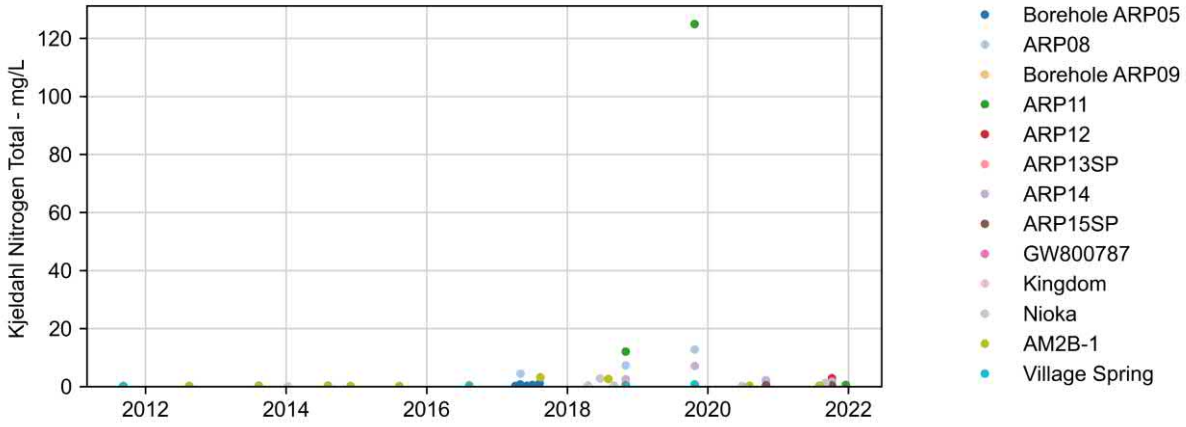
Nutrients

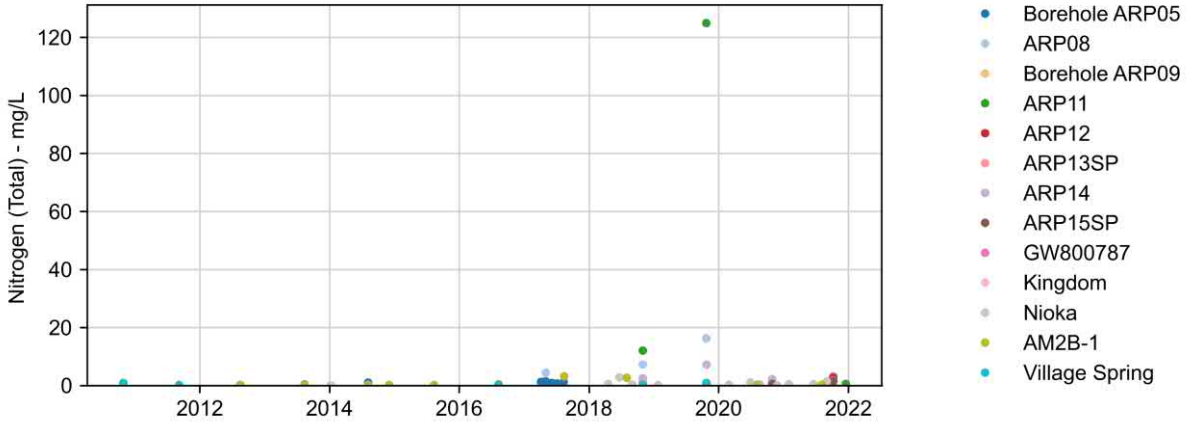

Ammonia as N - mg/L
0
5
10
15
20
25
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

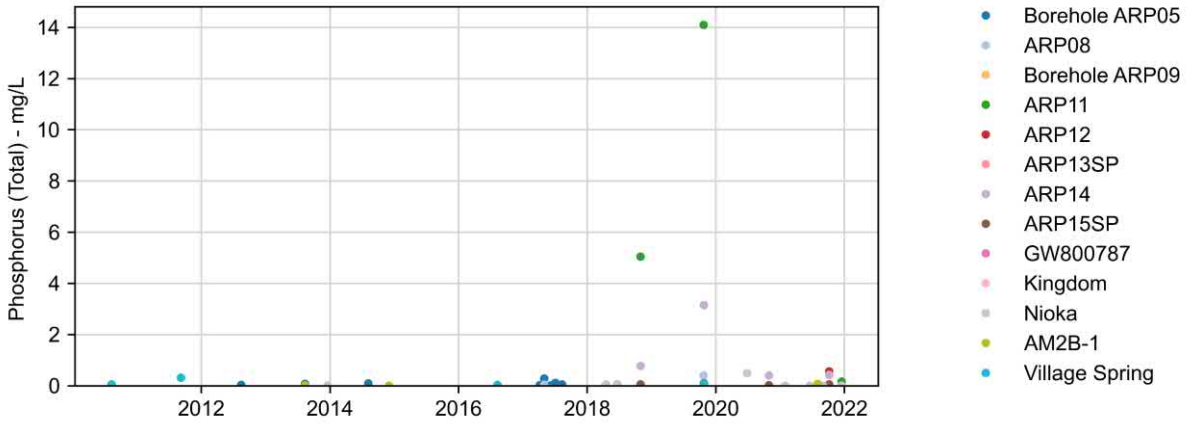

Nitrate (as N) - mg/L
0
0.5
1
1.5
2
2.5
3
3.5
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring


Nitrite (as N) - mg/L
0
0.1
0.2
0.3
0.4
0.5
0.6
2012
2014
2016
2018
2020
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

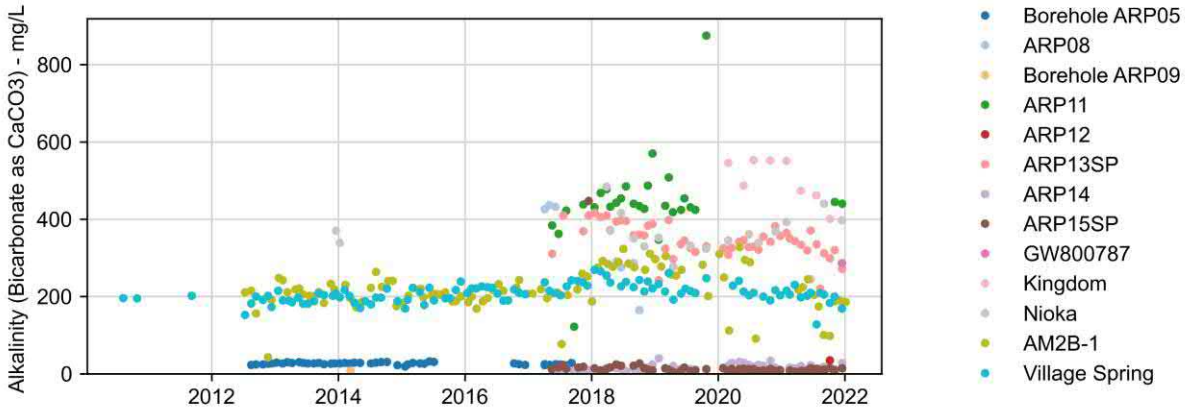

Nitrogen (Total Oxidised) (as N) - mg/L
0
0.5
1
1.5
2
2.5
3
3.5
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

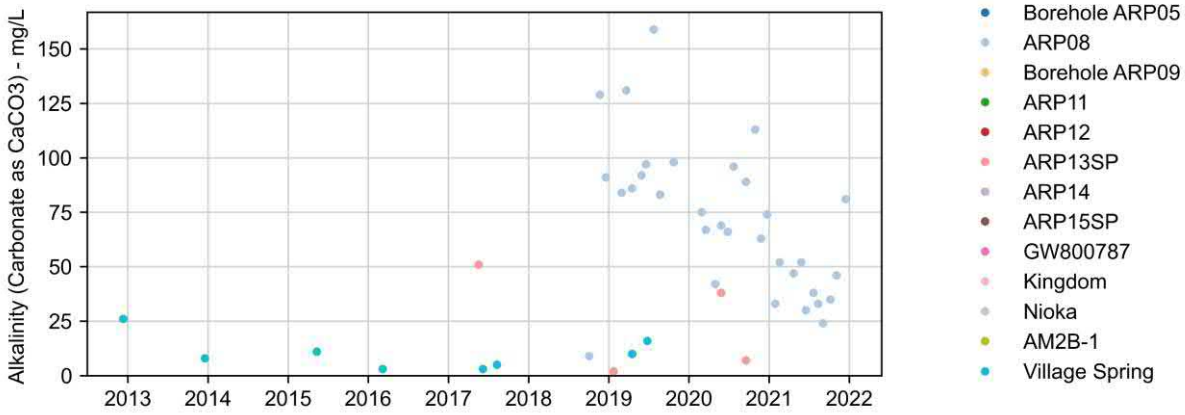

Kjeldahl Nitrogen Total - mg/L
0
20
40
60
80
100
120
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

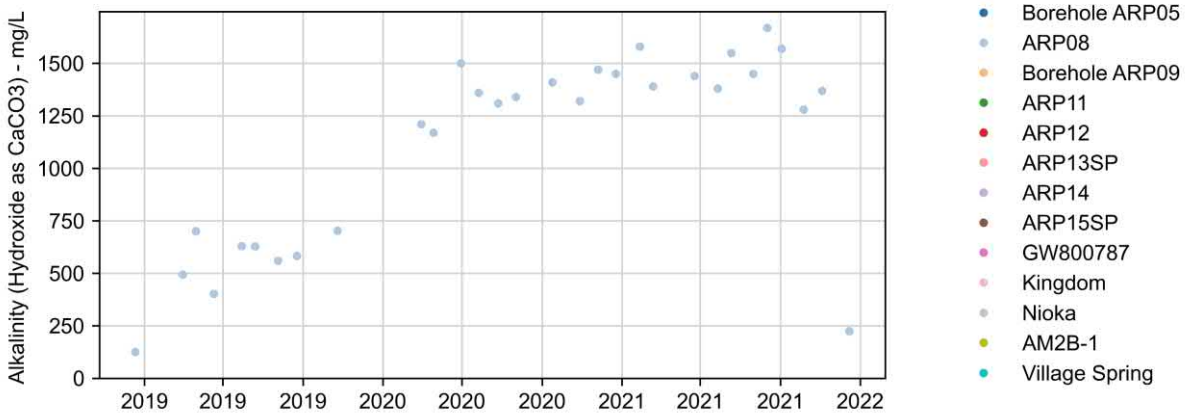

Nitrogen (Total) - mg/L
0
20
40
60
80
100
120
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

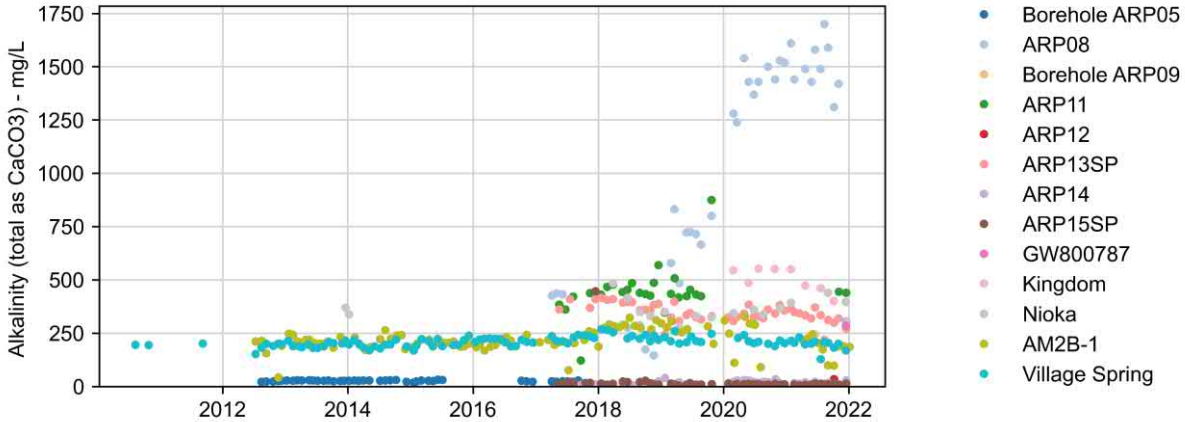

Phosphorus (Total) - mg/L
0
2
4
6
8
10
12
14
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

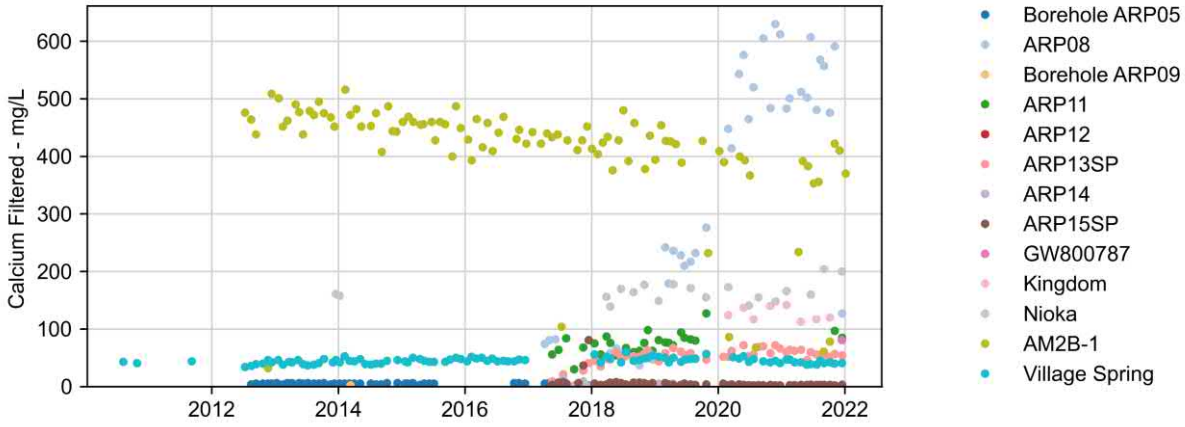
Major Ions

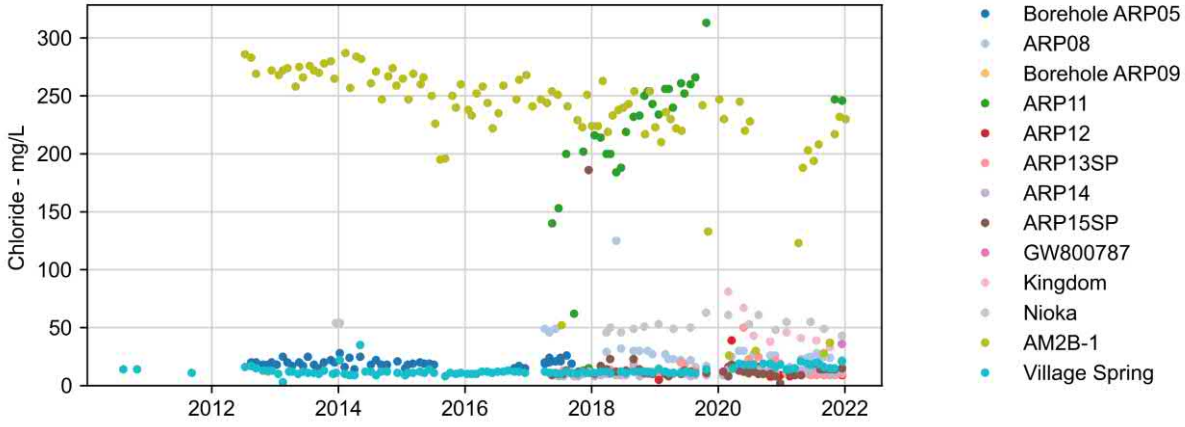

Alkalinity (Bicarbonate as CaCO3) - mg/L
0
200
400
600
800
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

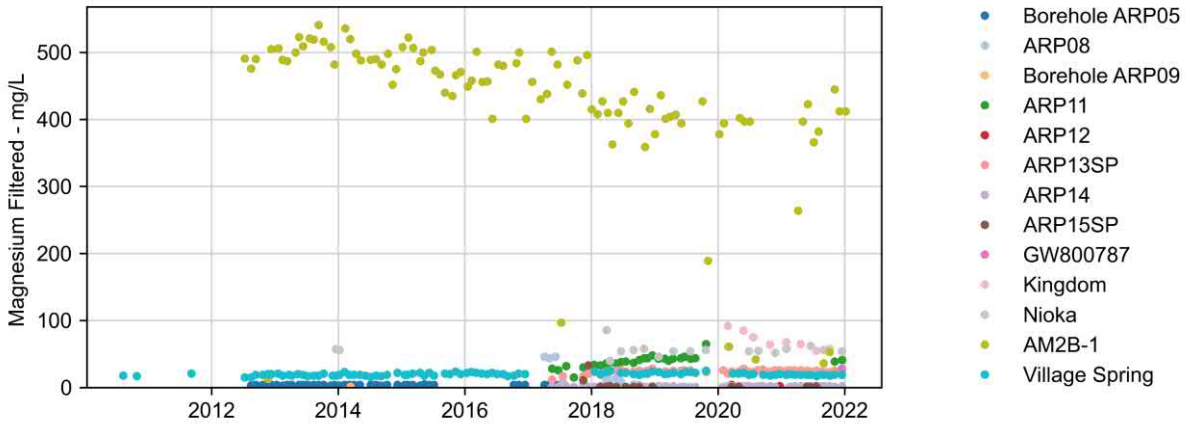

Alkalinity (Carbonate as CaCO3) - mg/L
0
25
50
75
100
125
150
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

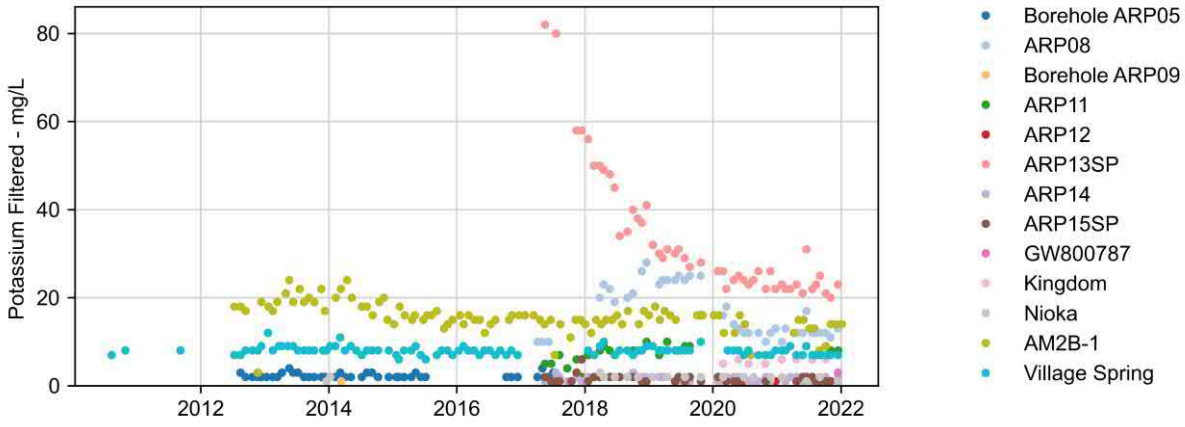

Alkalinity (Hydroxide as CaCO3) - mg/L
0
250
500
750
1000
1250
1500
2019
2019
2019
2020
2020
2020
2021
2021
2021
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

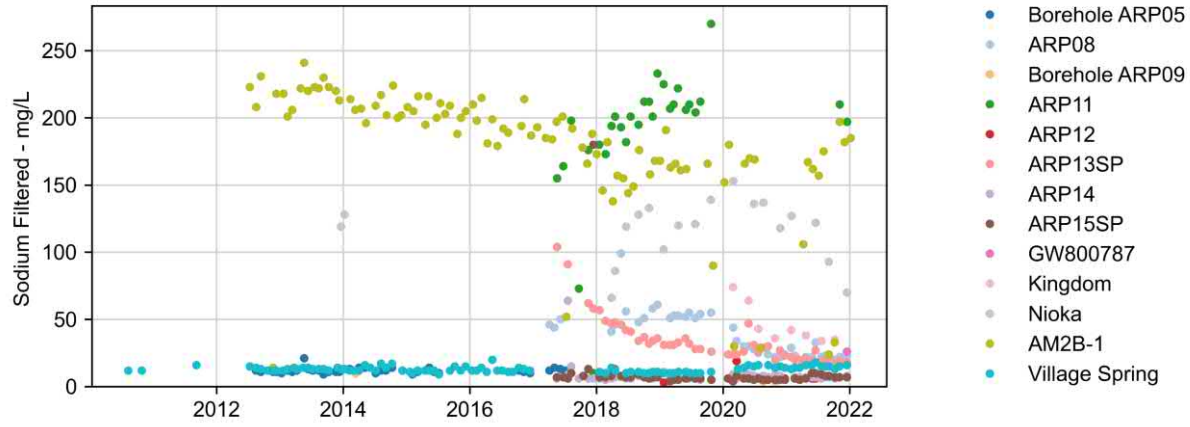

Alkalinity (total as CaCO3) - mg/L
0
250
500
750
1000
1250
1500
1750
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

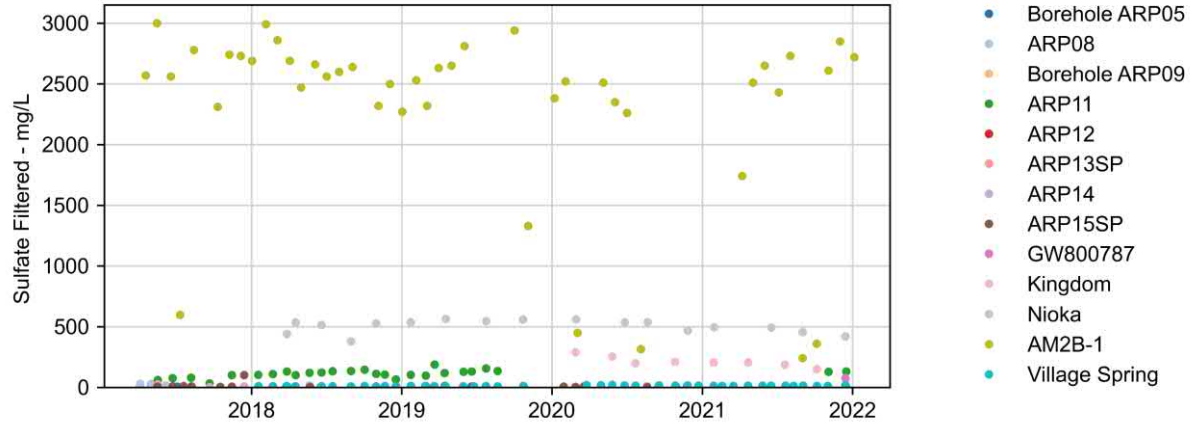

Calcium Filtered - mg/L
0
100
200
300
400
500
600
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

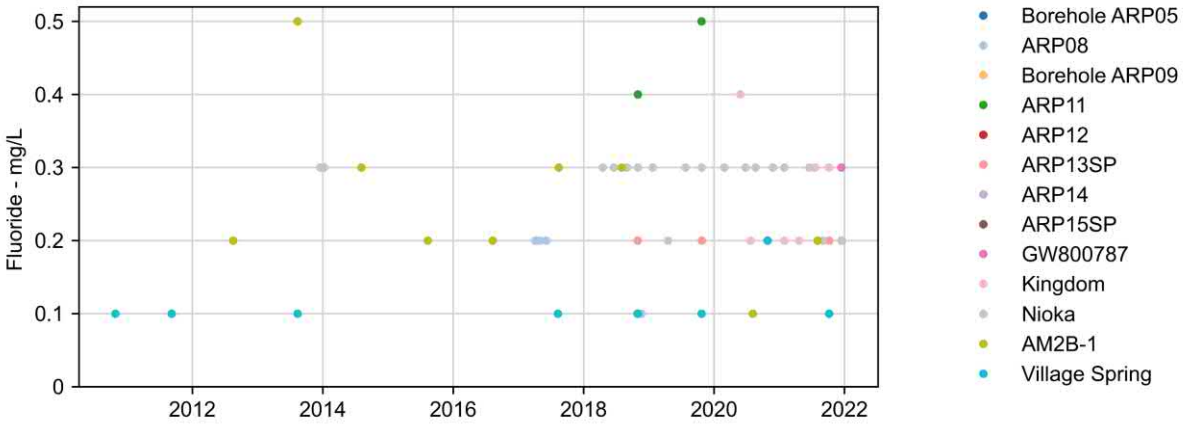

Chloride - mg/L
0
50
100
150
200
250
300
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring


Magnesium Filtered - mg/L
0
100
200
300
400
500
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

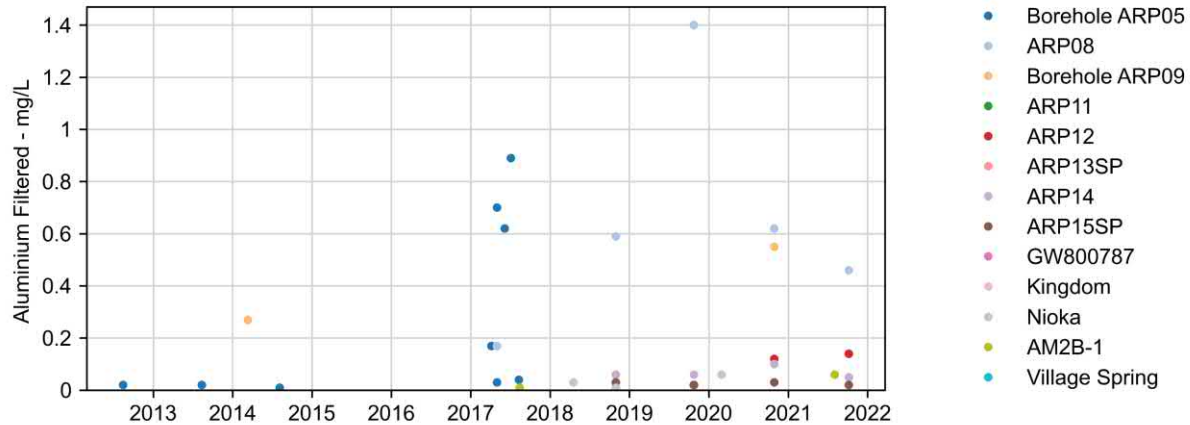

Potassium Filtered - mg/L
0
20
40
60
80
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

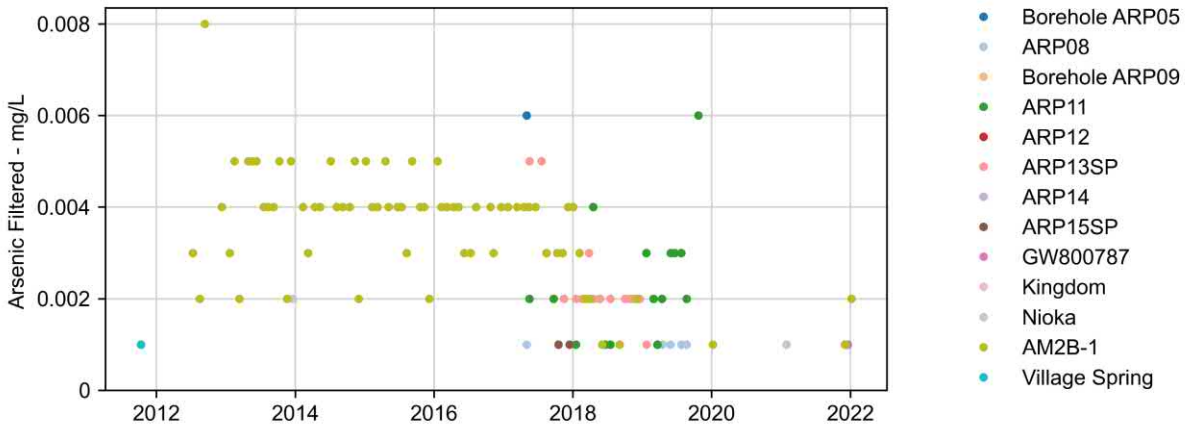


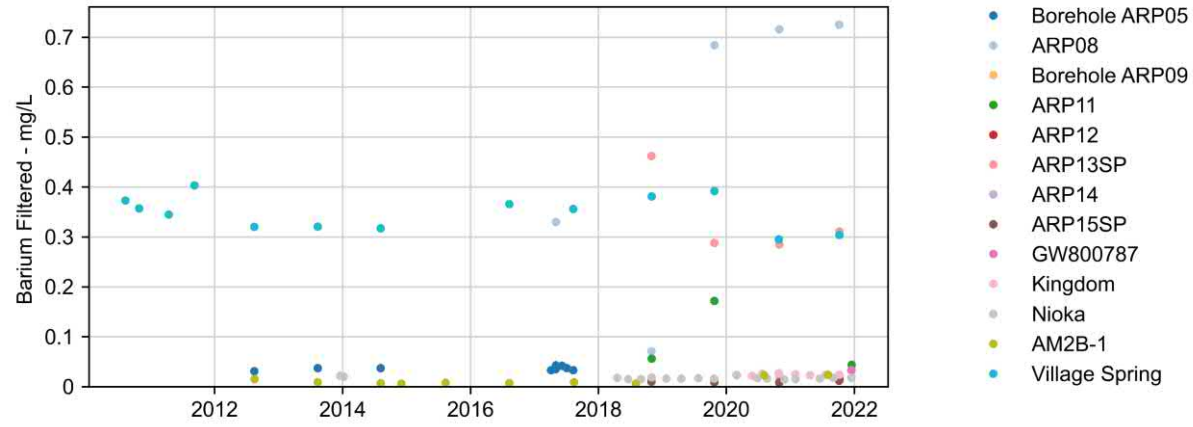


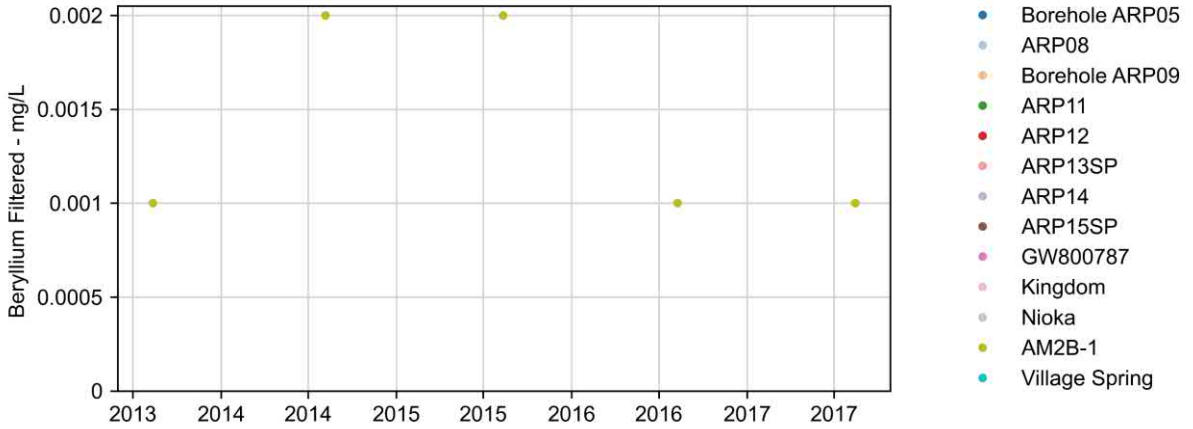


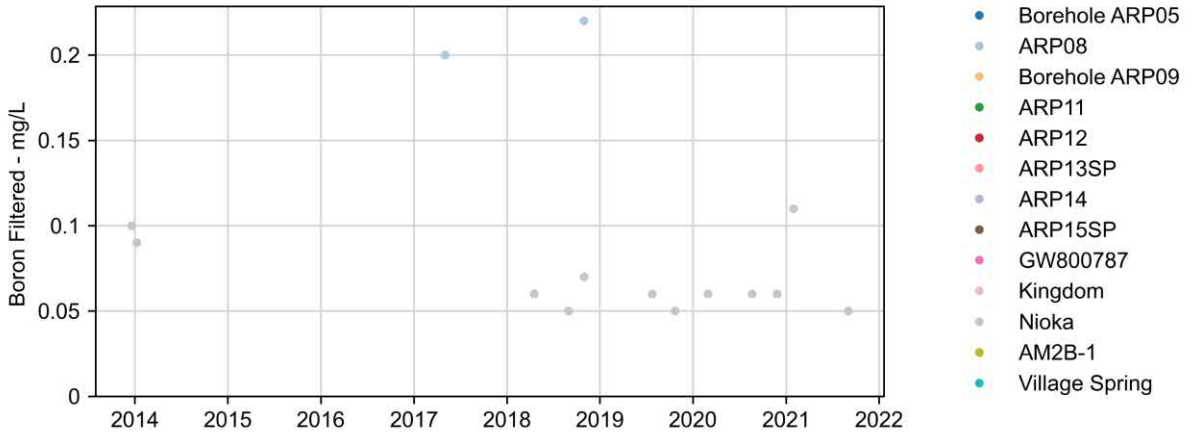
Metals (dissolved)

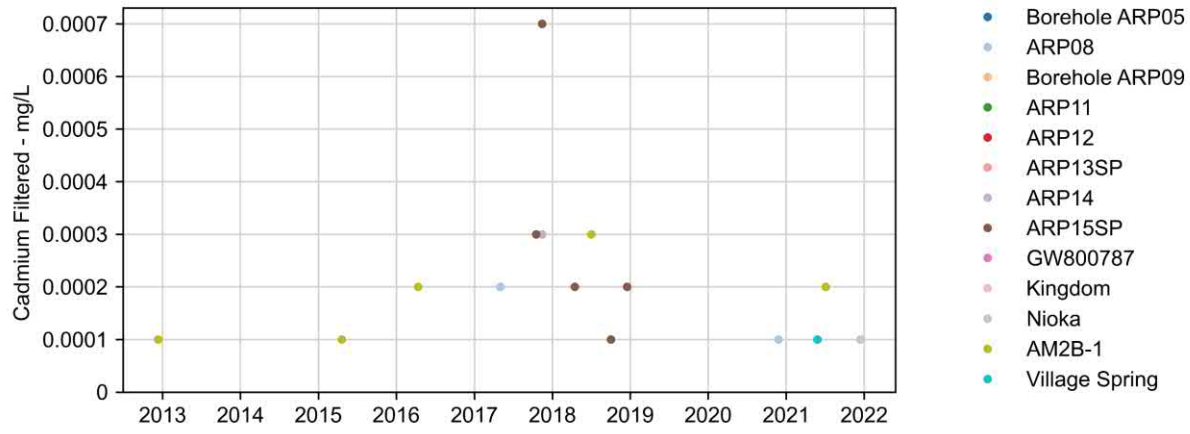


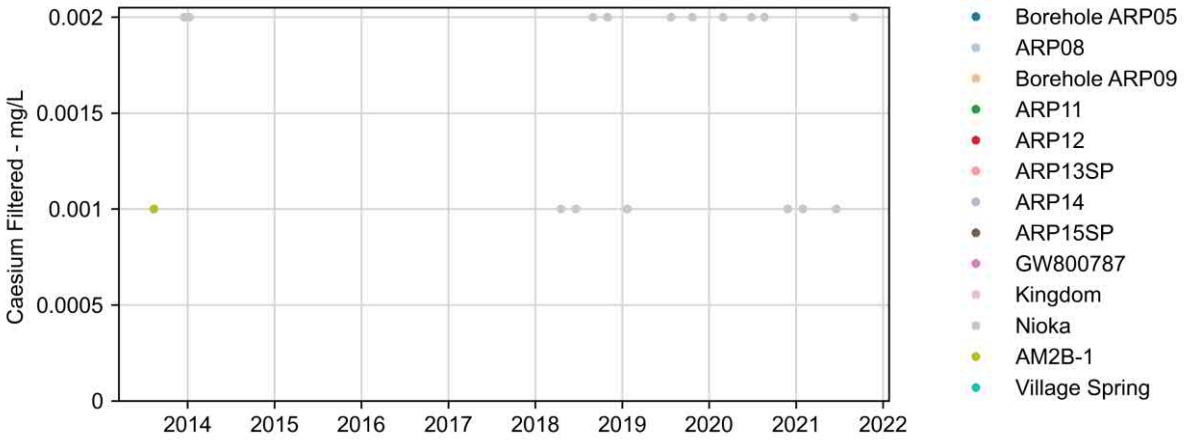

Arsenic Filtered - mg/L
0.008
0.006
0.004
0.002
0
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

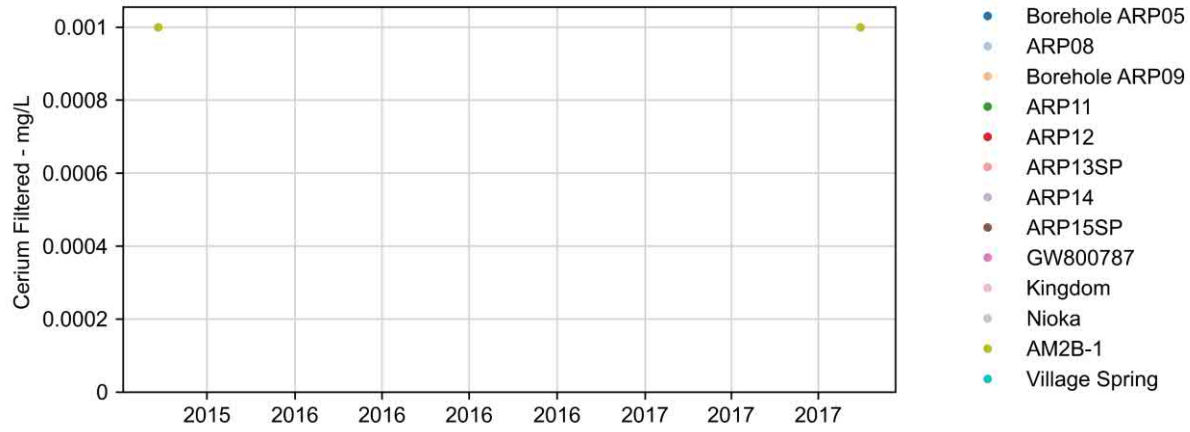

Barium Filtered - mg/L
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

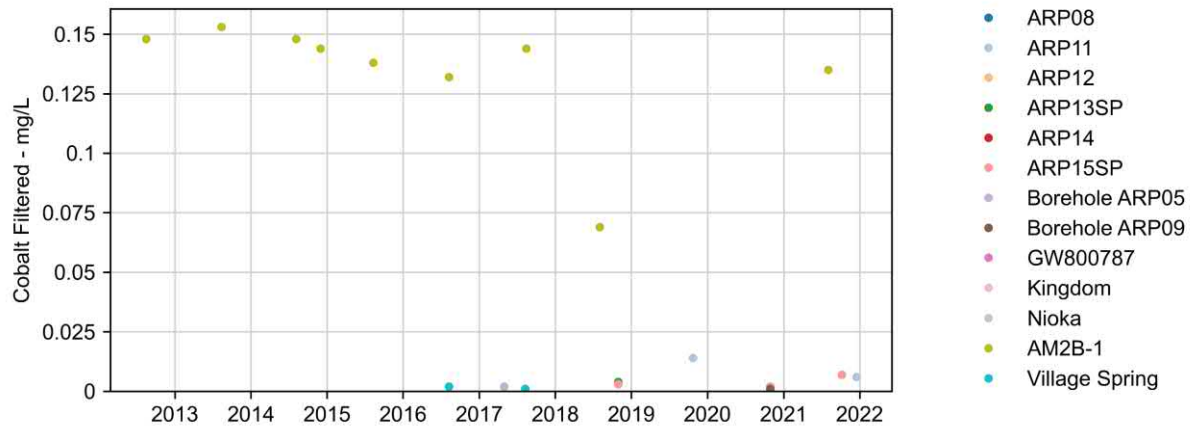

Beryllium Filtered - mg/L
0.002
0.0015
0.001
0.0005
0
2013
2014
2014
2015
2015
2016
2016
2017
2017
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

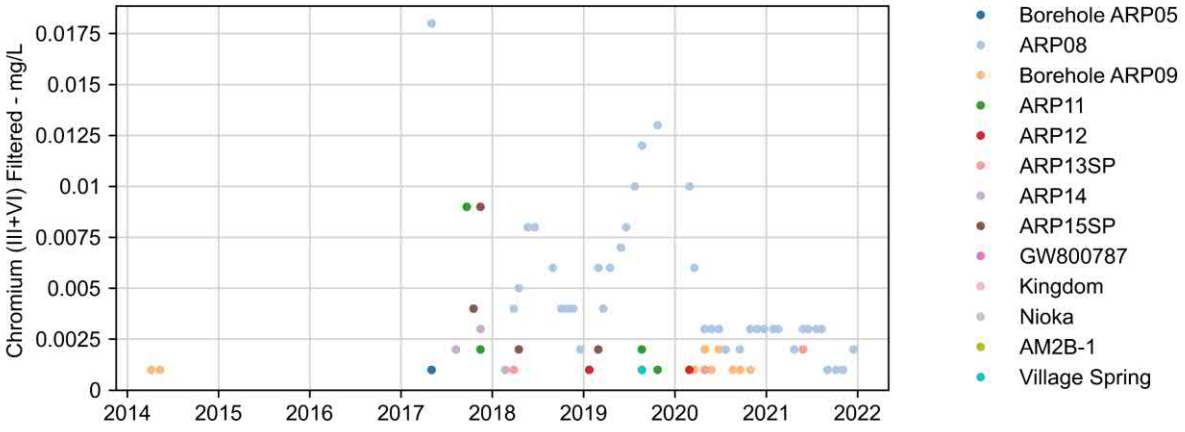

Boron Filtered - mg/L
0.2
0.15
0.1
0.05
0
2014
2015
2016
2017
2018
2019
2020
2021
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

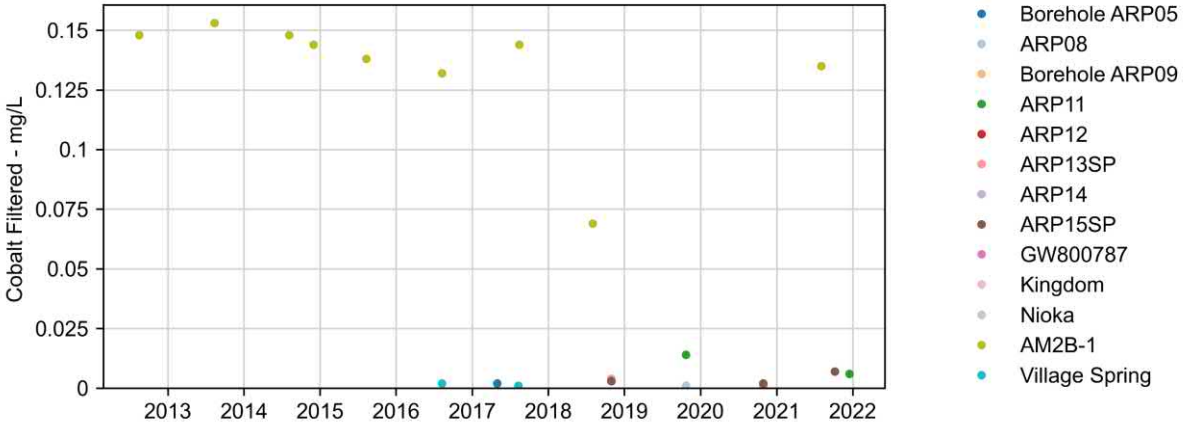

Cadmium Filtered - mg/L
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

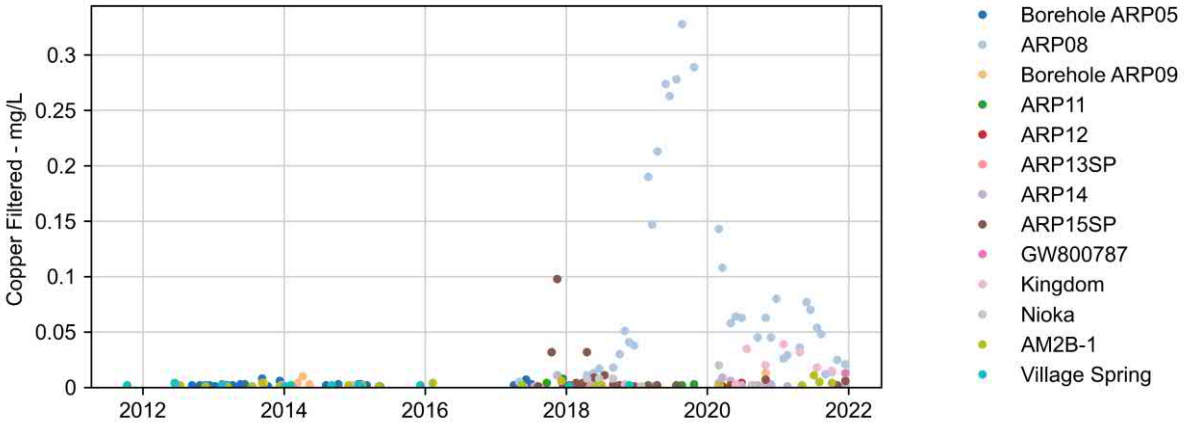

Caesium Filtered - mg/L
0.002
0.0015
0.001
0.0005
0
2014
2015
2016
2017
2018
2019
2020
2021
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

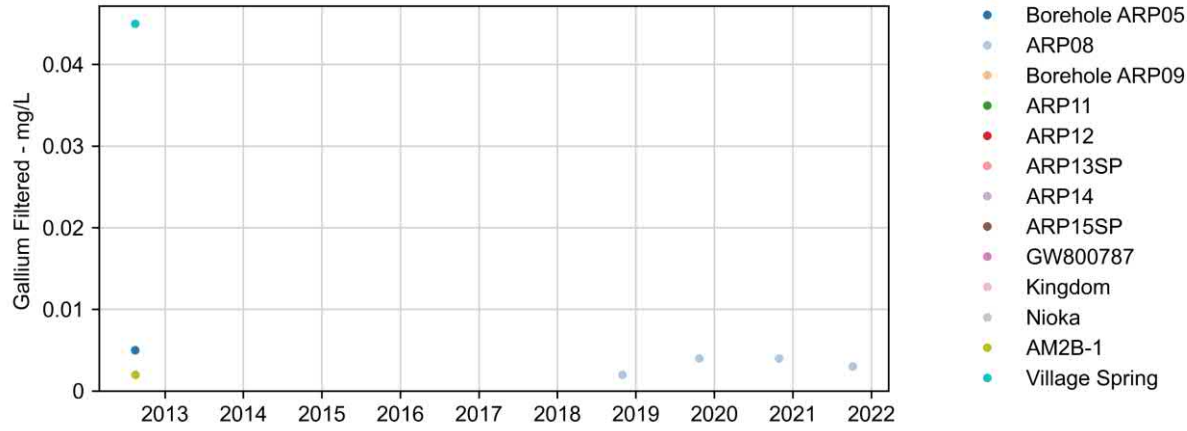

Cerium Filtered - mg/L
0.001
0.0008
0.0006
0.0004
0.0002
0
2015
2016
2016
2016
2016
2017
2017
2017
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

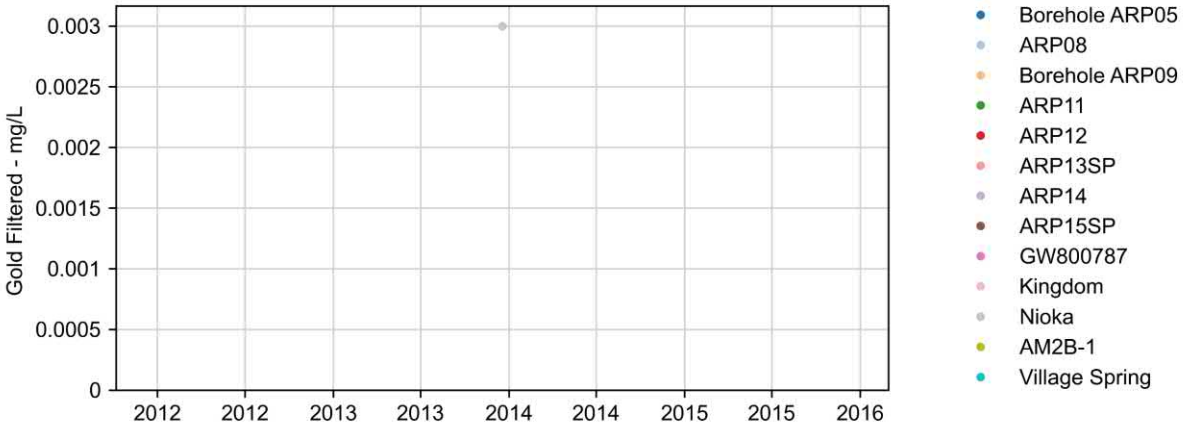

Cobalt Filtered - mg/L
0.15
0.125
0.1
0.075
0.05
0.025
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
ARP08
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
Borehole ARP05
Borehole ARP09
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

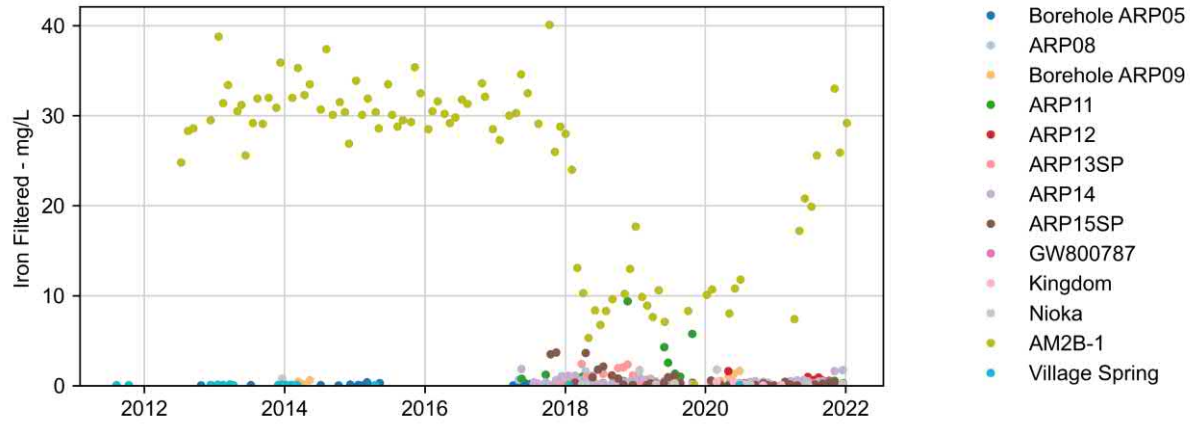

Chromium (III+VI) Filtered - mg/L
0.0175
0.015
0.0125
0.01
0.0075
0.005
0.0025
0
2014
2015
2016
2017
2018
2019
2020
2021
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

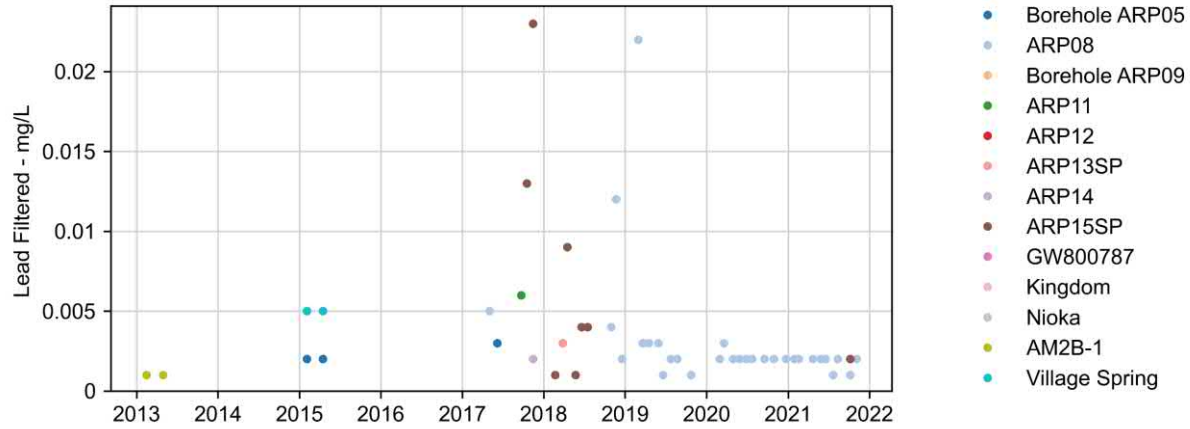

Cobalt Filtered - mg/L
0.15
0.125
0.1
0.075
0.05
0.025
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

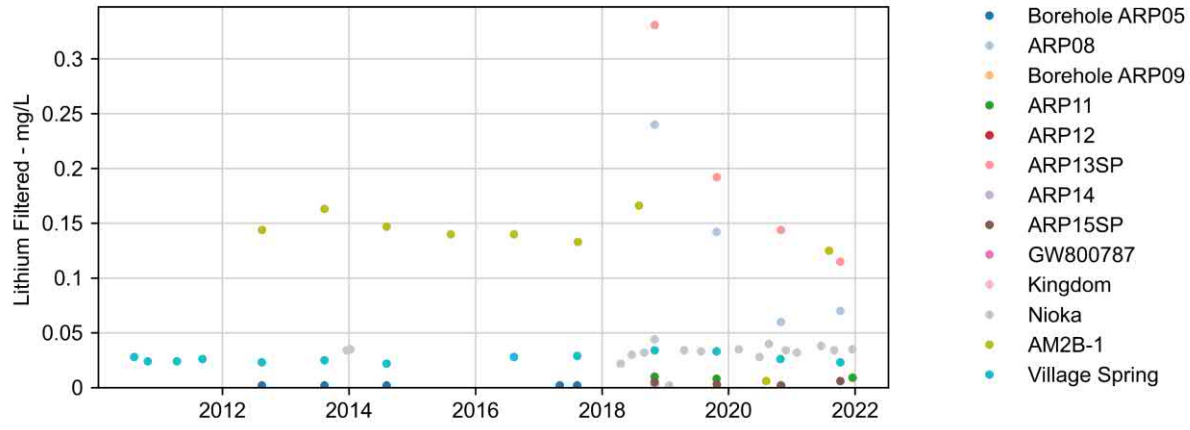

Copper Filtered - mg/L
0.3
0.25
0.2
0.15
0.1
0.05
0
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

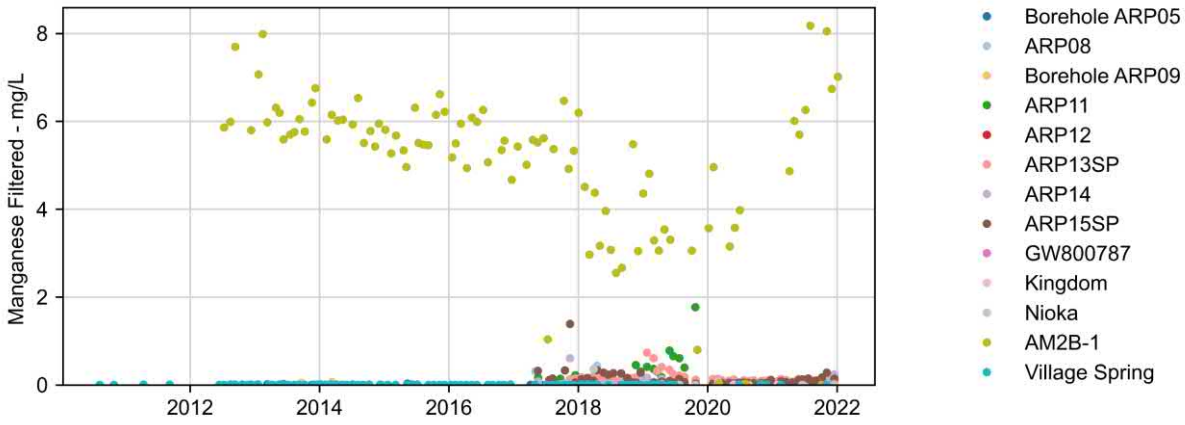

Gallium Filtered - mg/L
0.04
0.03
0.02
0.01
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

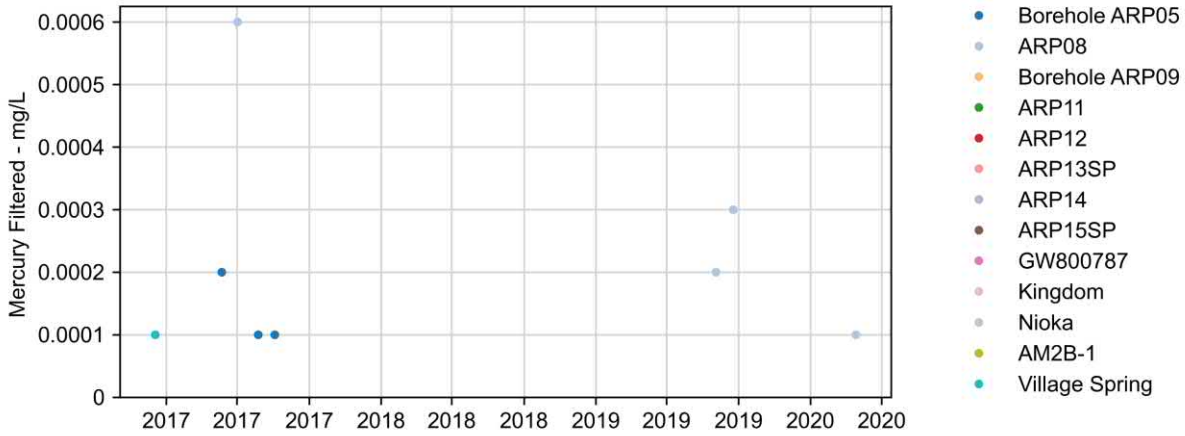

Gold Filtered - mg/L
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
2012
2012
2013
2013
2014
2014
2015
2015
2016
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

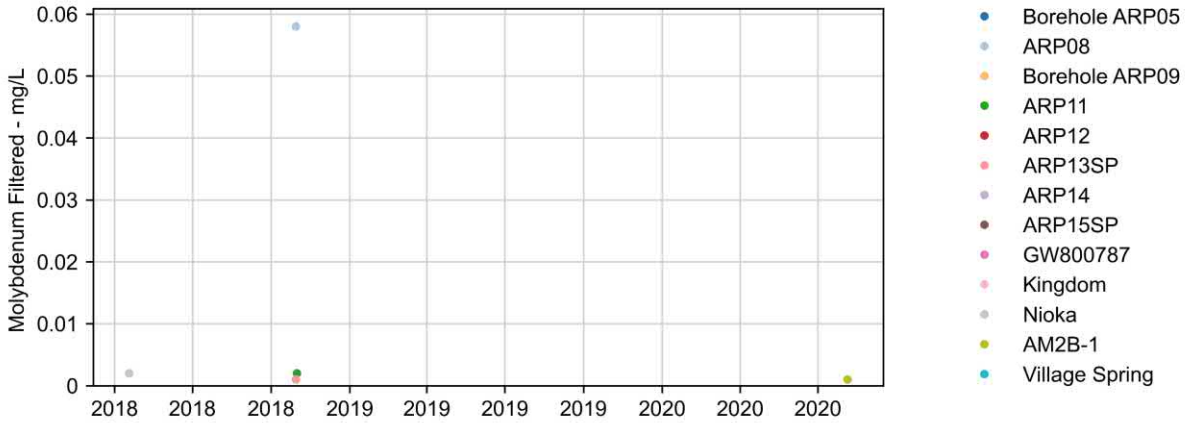

Iron Filtered - mg/L
40
30
20
10
0
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

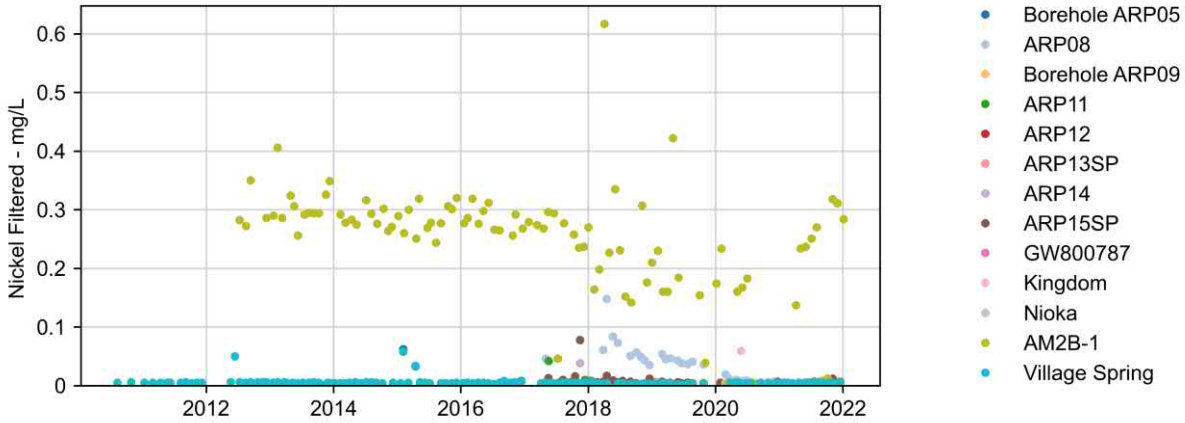

Lead Filtered - mg/L
0.02
0.015
0.01
0.005
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

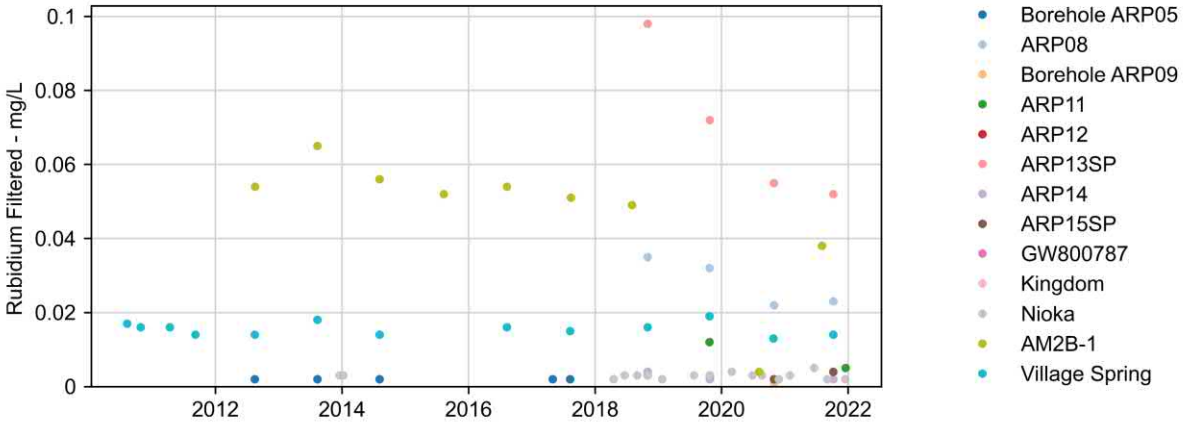

Lithium Filtered - mg/L
0.3
0.25
0.2
0.15
0.1
0.05
0
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

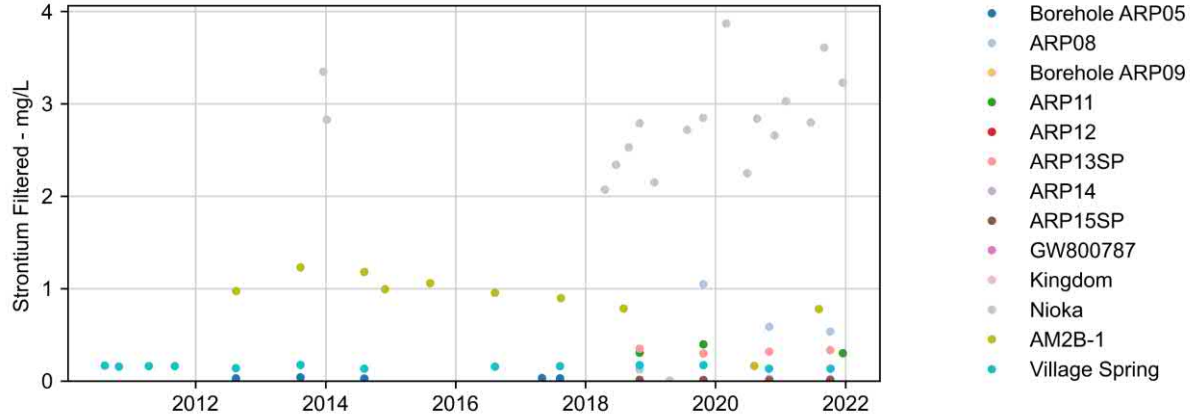

Manganese Filtered - mg/L
0
2
4
6
8
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

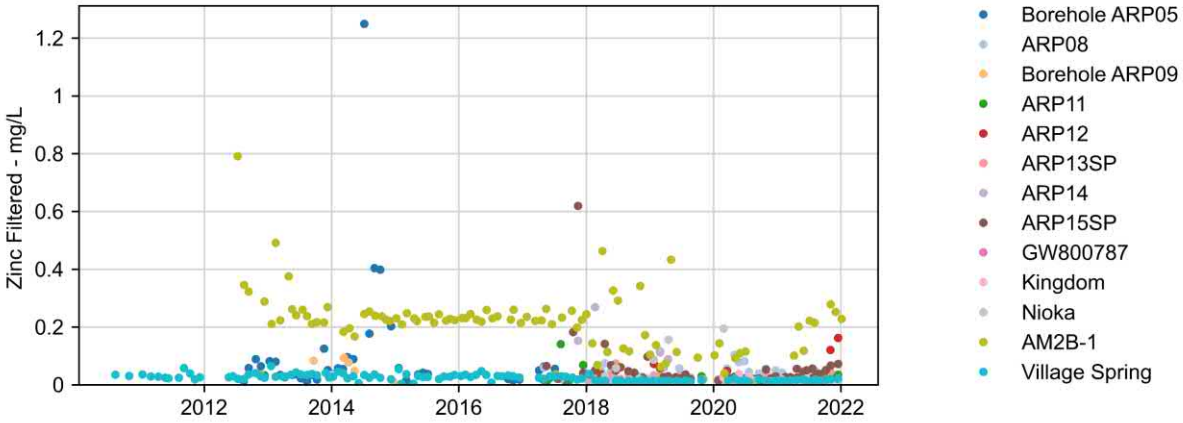

Mercury Filtered - mg/L
0
0.0001
0.0002
0.0003
0.0004
0.0005
0.0006
2017
2017
2017
2018
2018
2018
2019
2019
2019
2020
2020
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

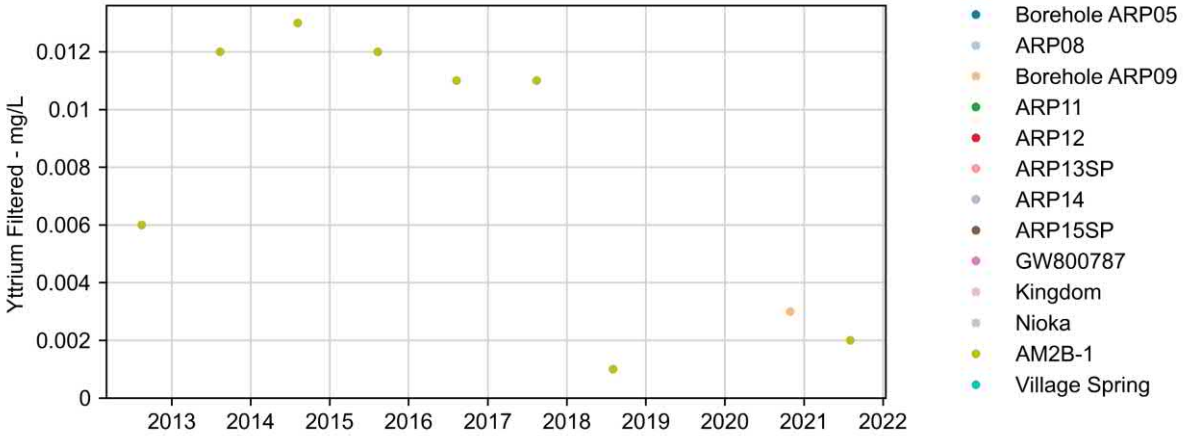

Molybdenum Filtered - mg/L
0
0.01
0.02
0.03
0.04
0.05
0.06
2018
2018
2018
2019
2019
2019
2019
2020
2020
2020
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

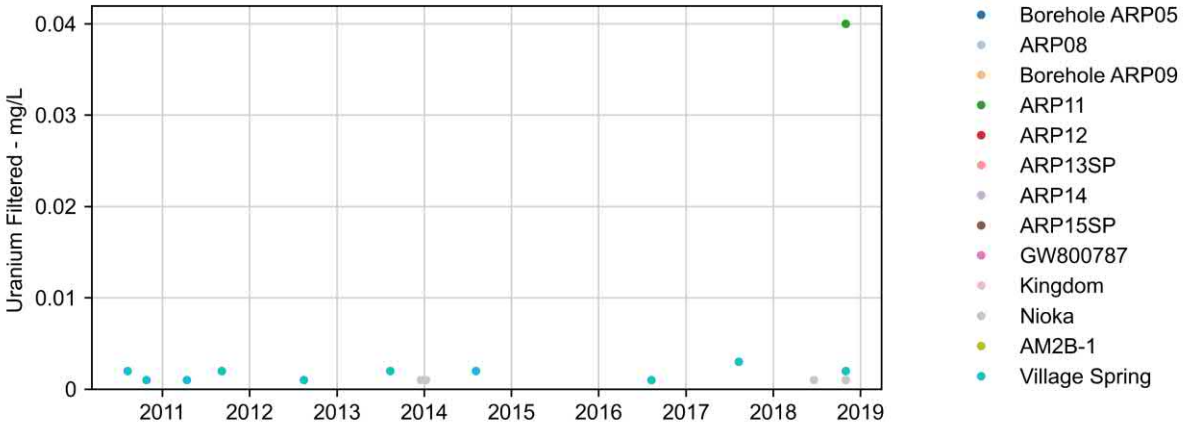

Nickel Filtered - mg/L
0
0.1
0.2
0.3
0.4
0.5
0.6
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

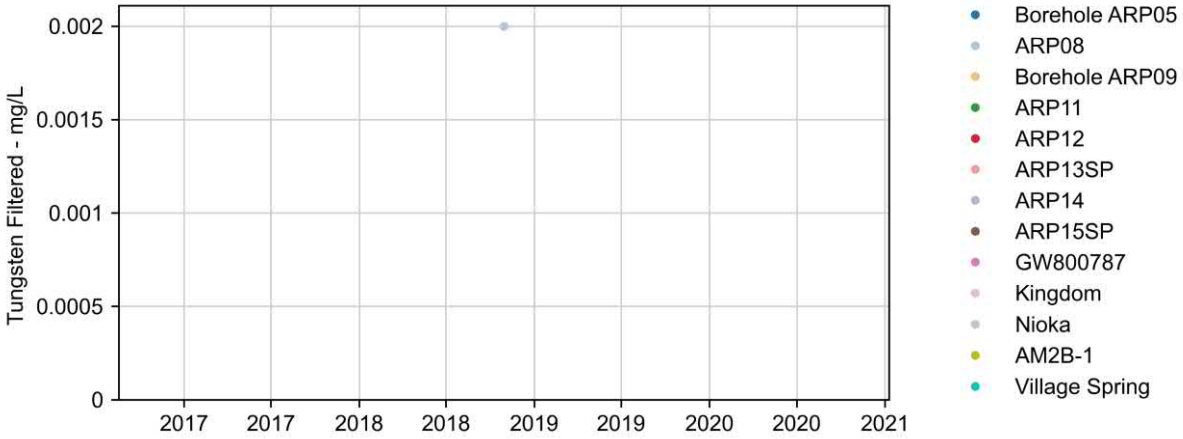

Rubidium Filtered - mg/L
0.1
0.08
0.06
0.04
0.02
0
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

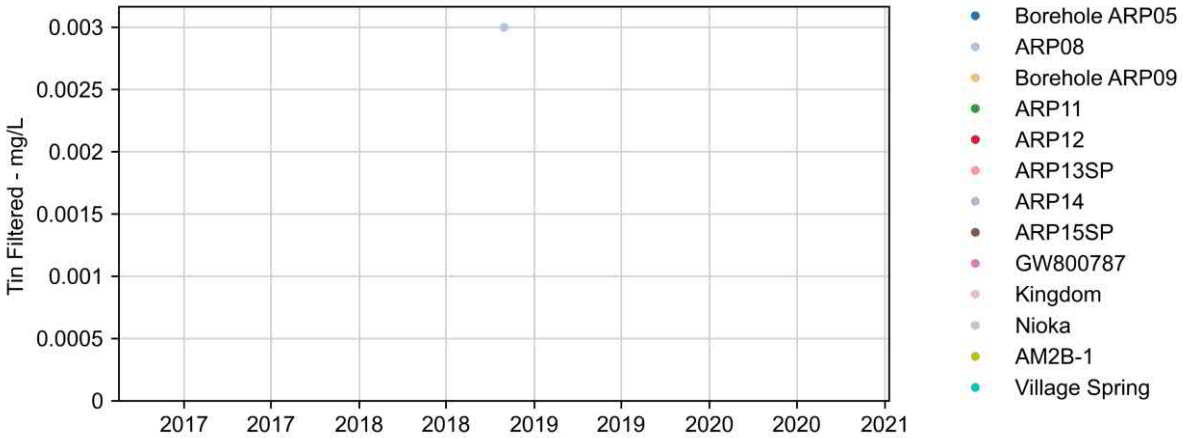

Strontium Filtered - mg/L
4
3
2
1
0
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

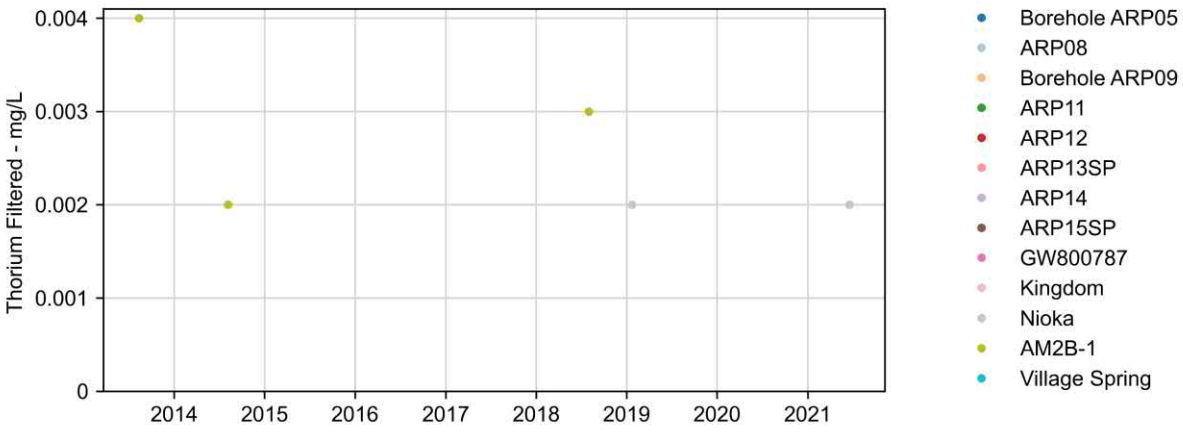

Zinc Filtered - mg/L
1.2
1
0.8
0.6
0.4
0.2
0
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring


Yttrium Filtered - mg/L
0.012
0.01
0.008
0.006
0.004
0.002
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

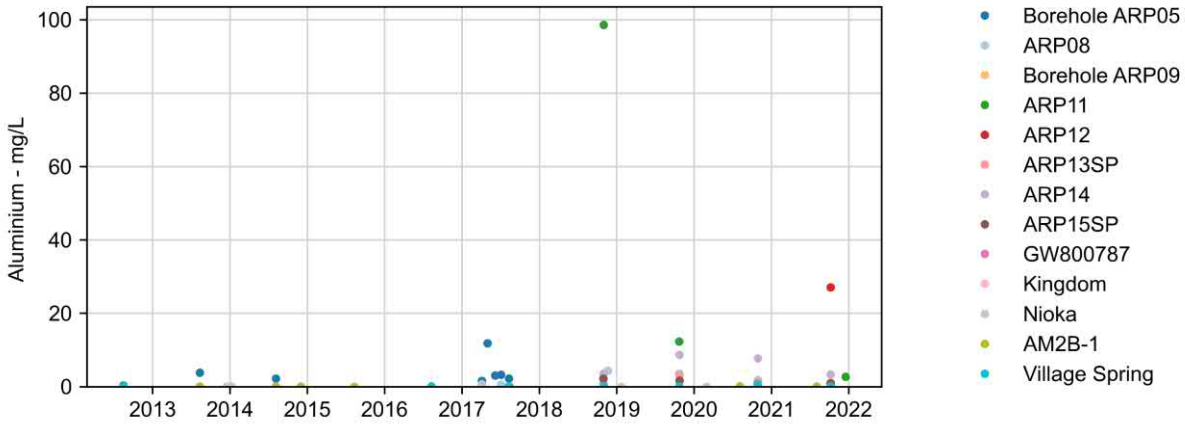

Uranium Filtered - mg/L
0.04
0.03
0.02
0.01
0
2011
2012
2013
2014
2015
2016
2017
2018
2019
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

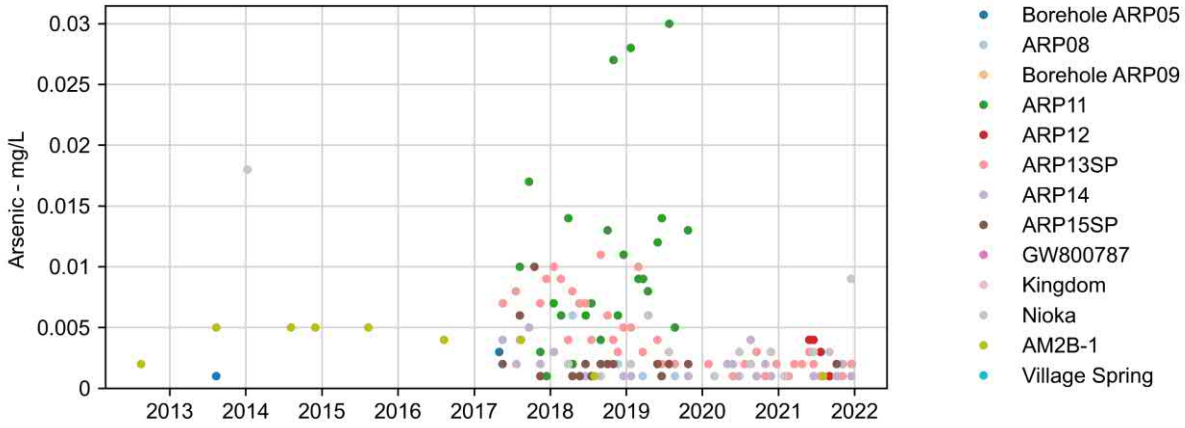

Tungsten Filtered - mg/L
0.002
0.0015
0.001
0.0005
0
2017
2017
2018
2018
2019
2019
2020
2020
2021
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

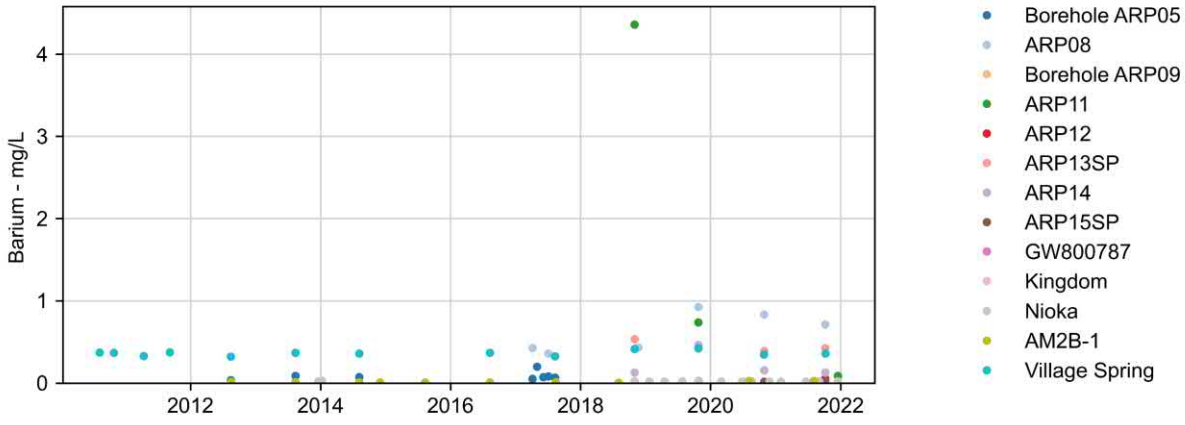

Tin Filtered - mg/L
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
2017
2017
2018
2018
2019
2019
2020
2020
2021
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

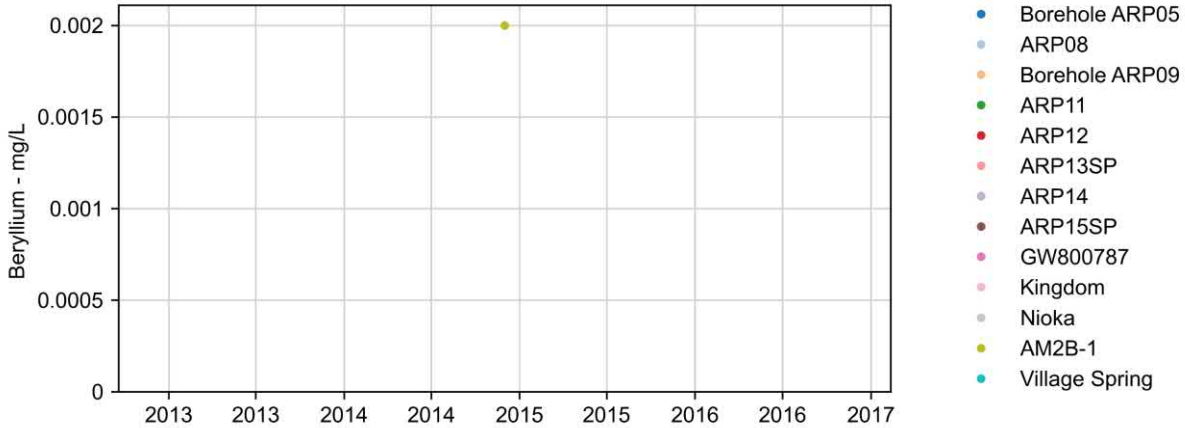

Thorium Filtered - mg/L
0.004
0.003
0.002
0.001
0
2014
2015
2016
2017
2018
2019
2020
2021
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

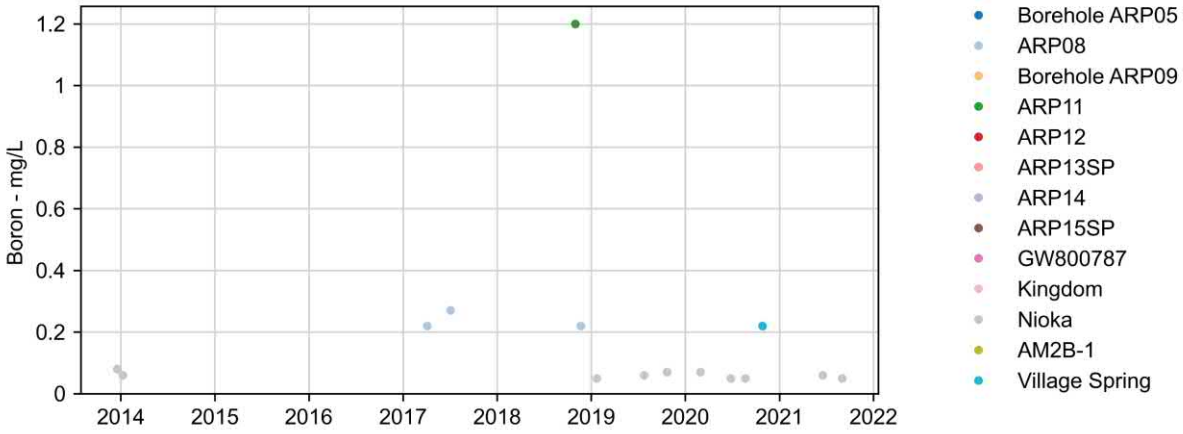
Metals (total)

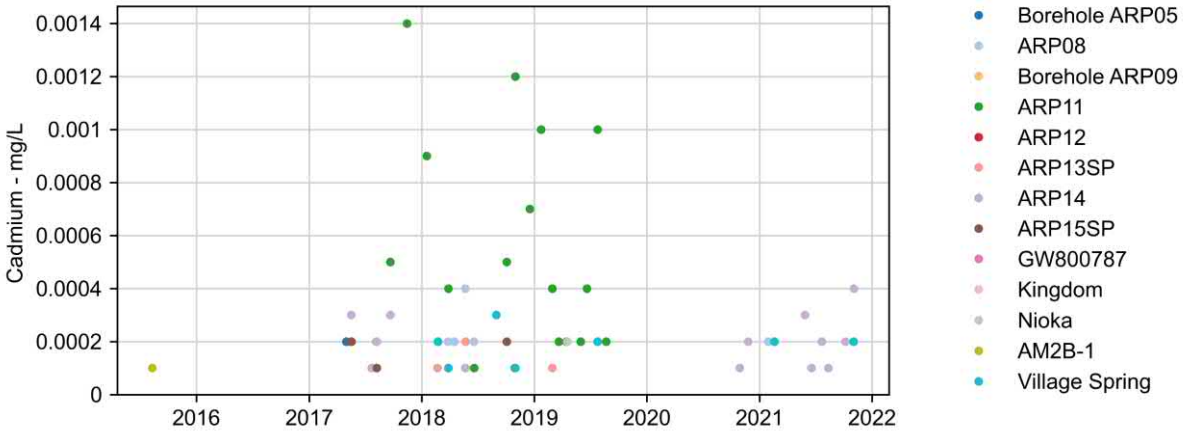


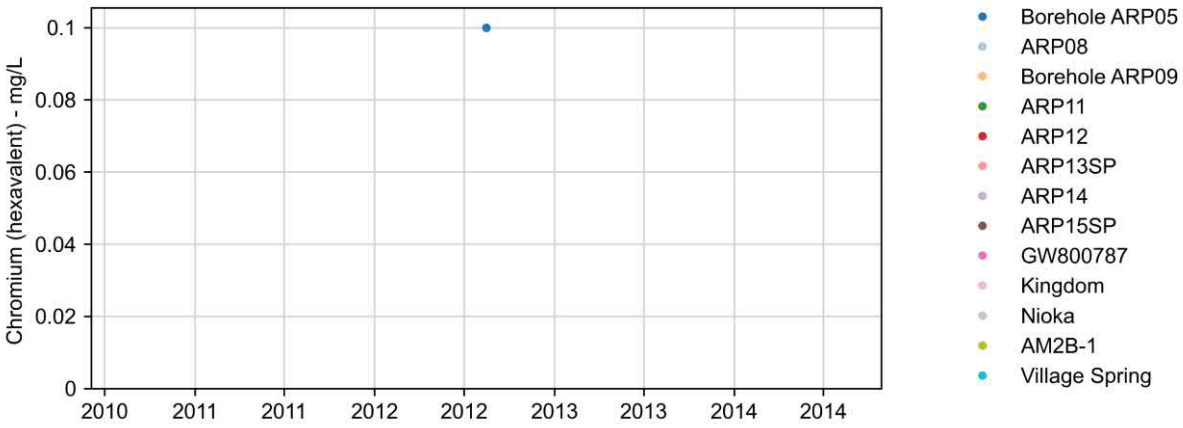


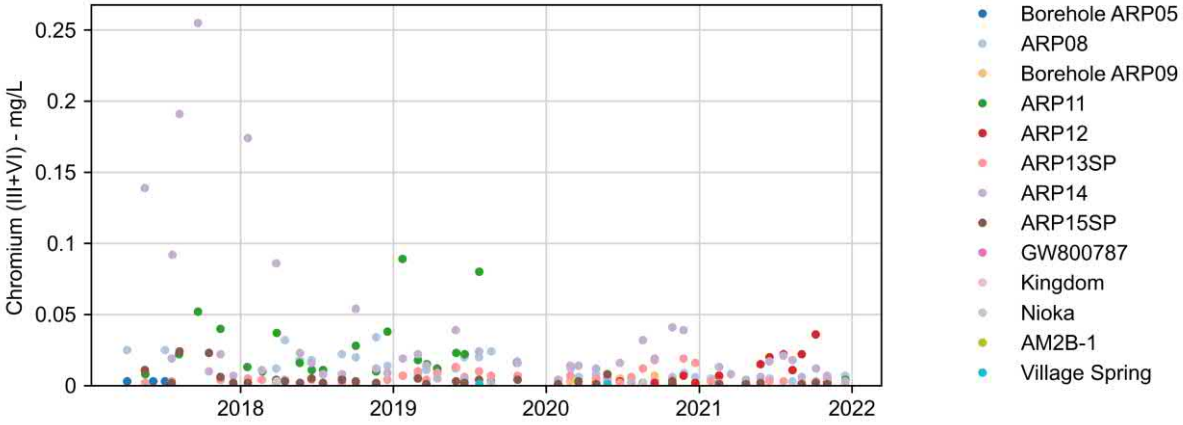


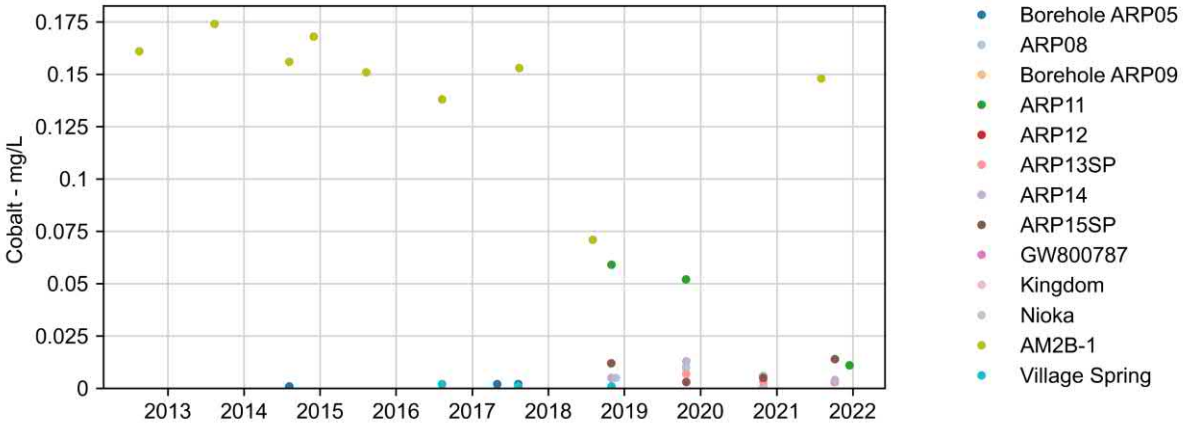


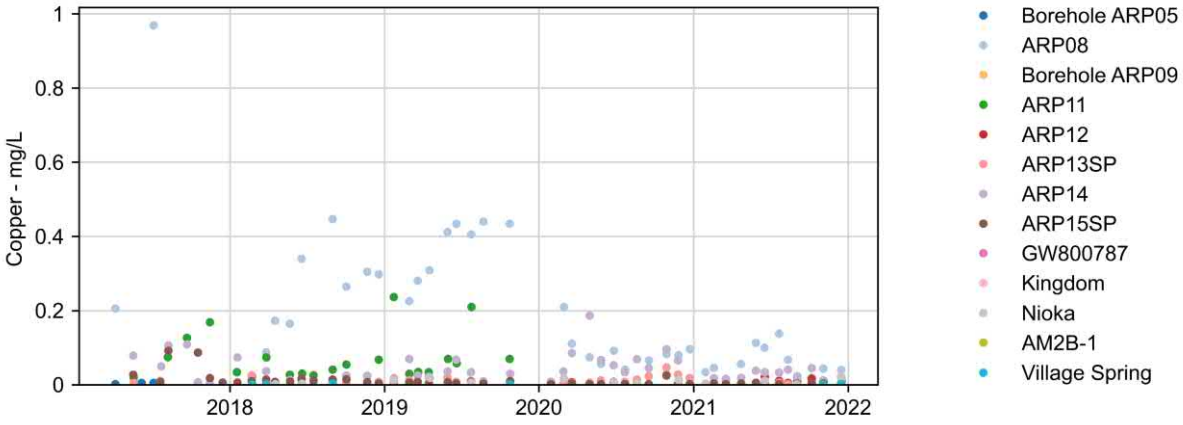

Boron - mg/L
1.2
1
0.8
0.6
0.4
0.2
0
2014
2015
2016
2017
2018
2019
2020
2021
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

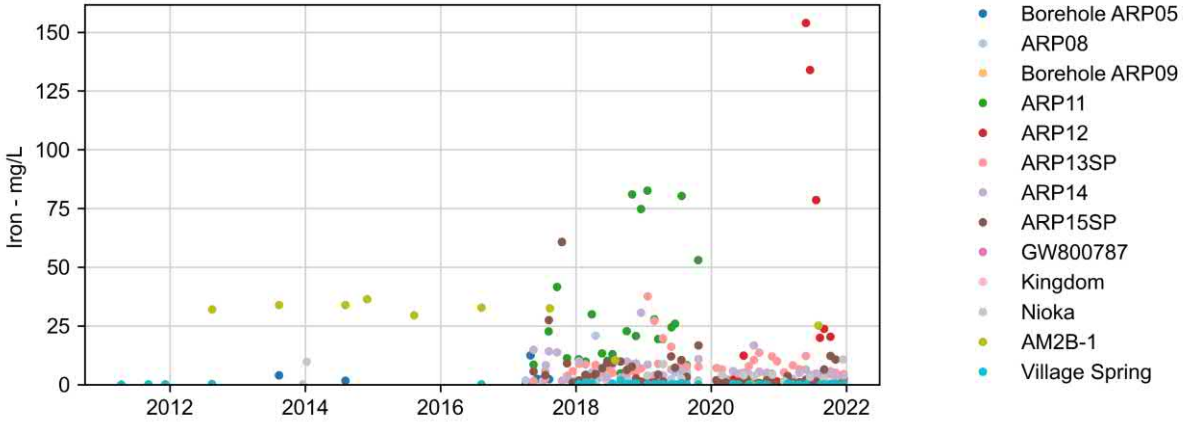

Cadmium - mg/L
0.0014
0.0012
0.001
0.0008
0.0006
0.0004
0.0002
0
2016
2017
2018
2019
2020
2021
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

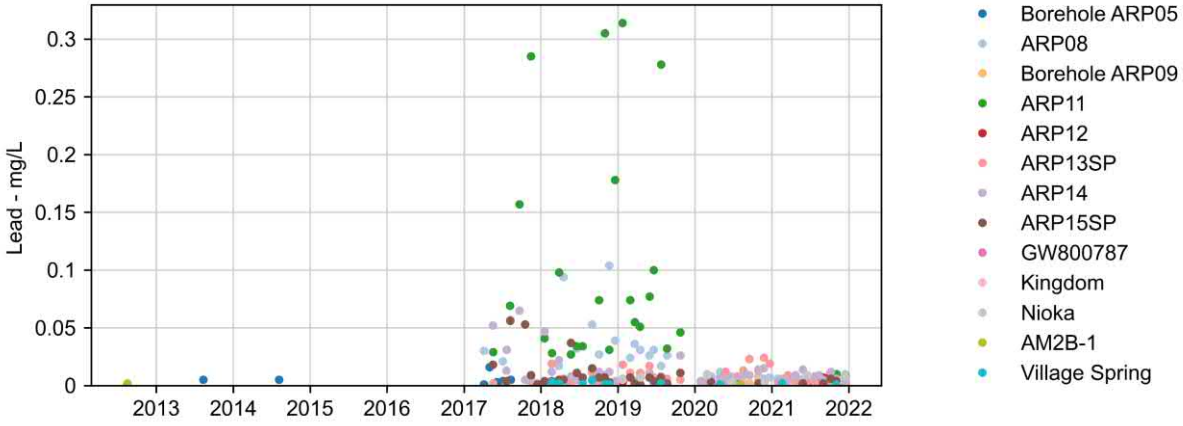

Chromium (hexavalent) - mg/L
0.1
0.08
0.06
0.04
0.02
0
2010
2011
2011
2012
2012
2013
2013
2014
2014
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

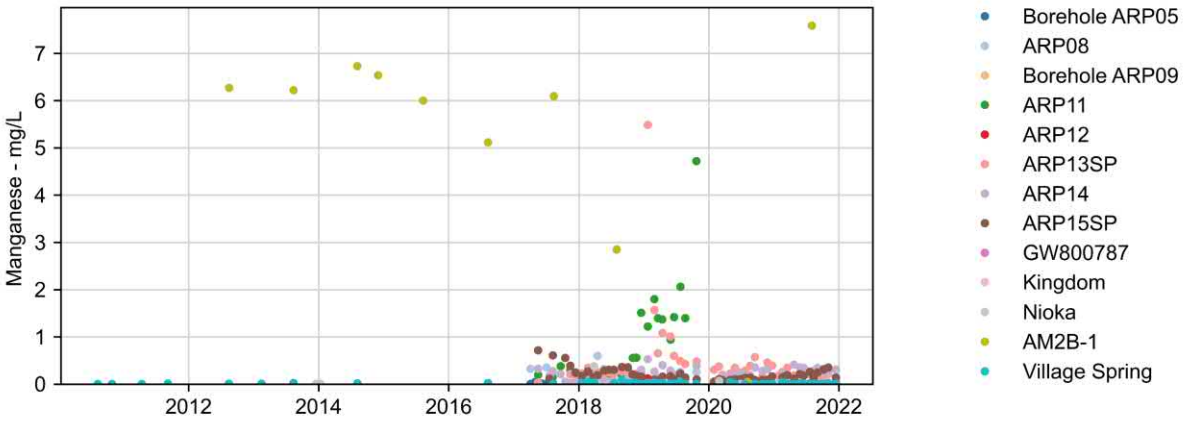

Chromium (III+VI) - mg/L
0.25
0.2
0.15
0.1
0.05
0
2018
2019
2020
2021
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

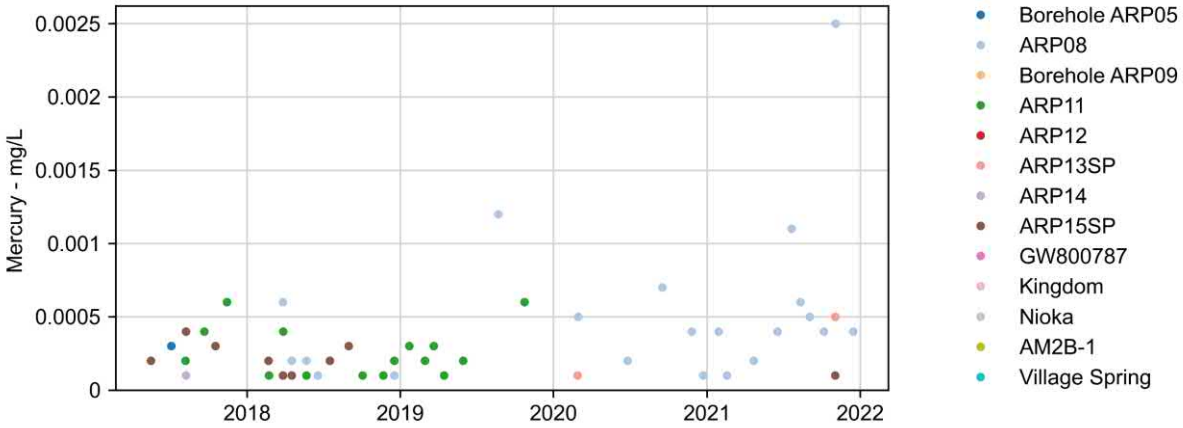

Cobalt - mg/L
0.175
0.15
0.125
0.1
0.075
0.05
0.025
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

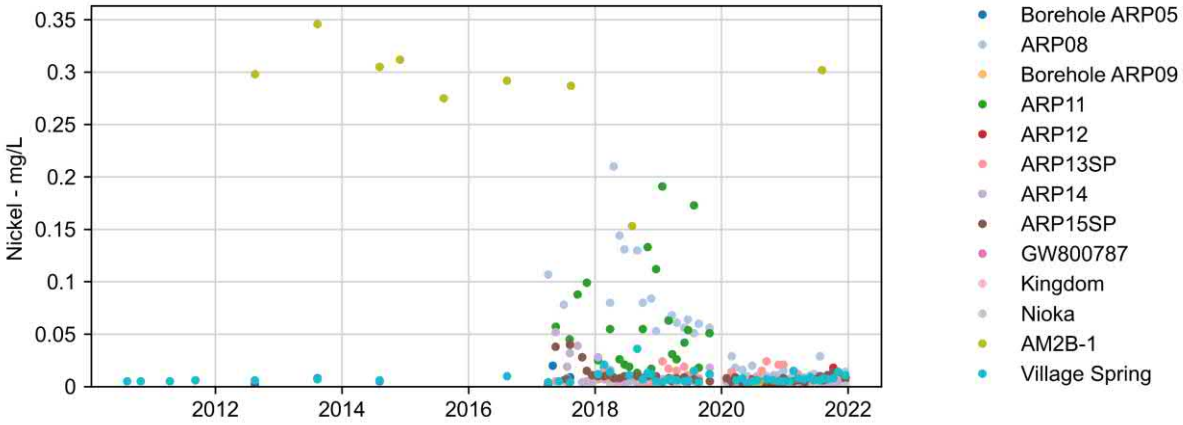

Copper - mg/L
1
0.8
0.6
0.4
0.2
0
2018
2019
2020
2021
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

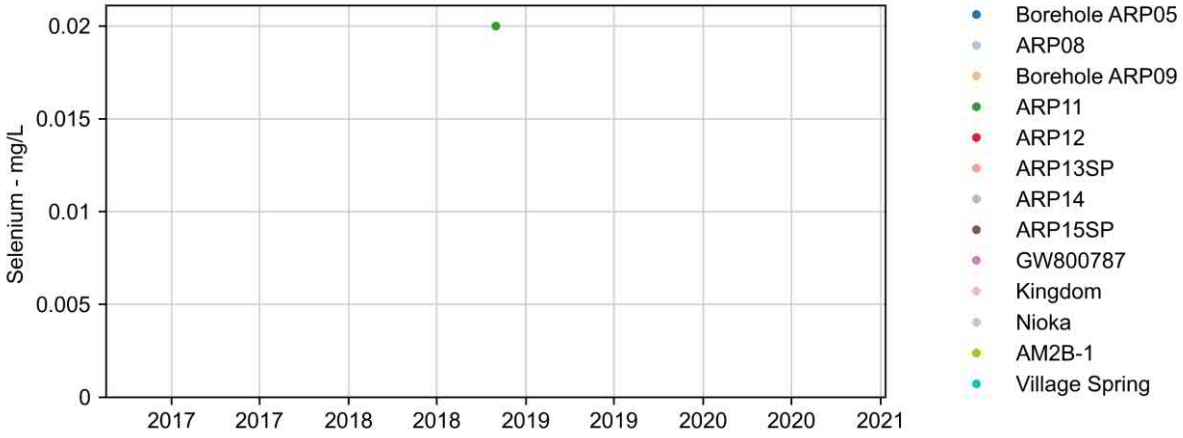

Iron - mg/L
150
125
100
75
50
25
0
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

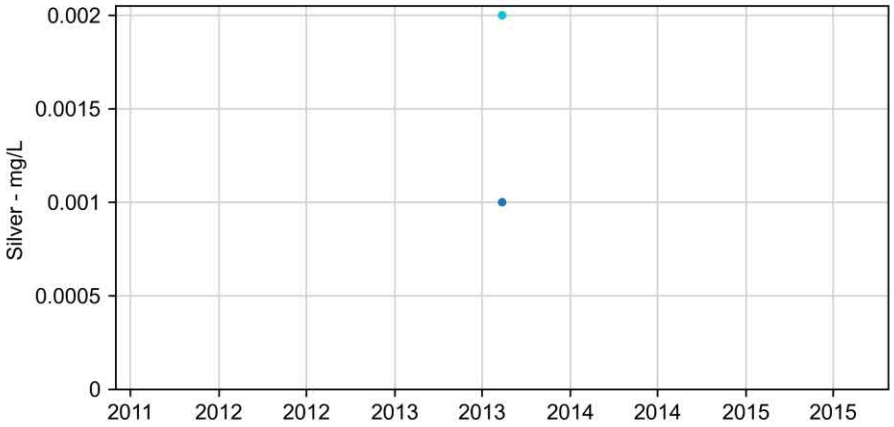

Lead - mg/L
0.3
0.25
0.2
0.15
0.1
0.05
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

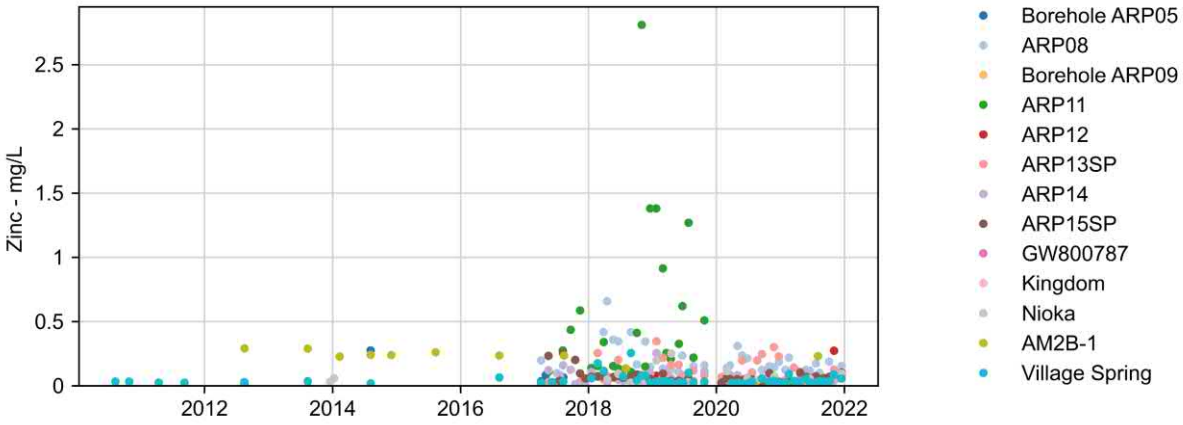

Manganese - mg/L
0
1
2
3
4
5
6
7
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring


Mercury - mg/L
0
0.0005
0.001
0.0015
0.002
0.0025
2018
2019
2020
2021
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

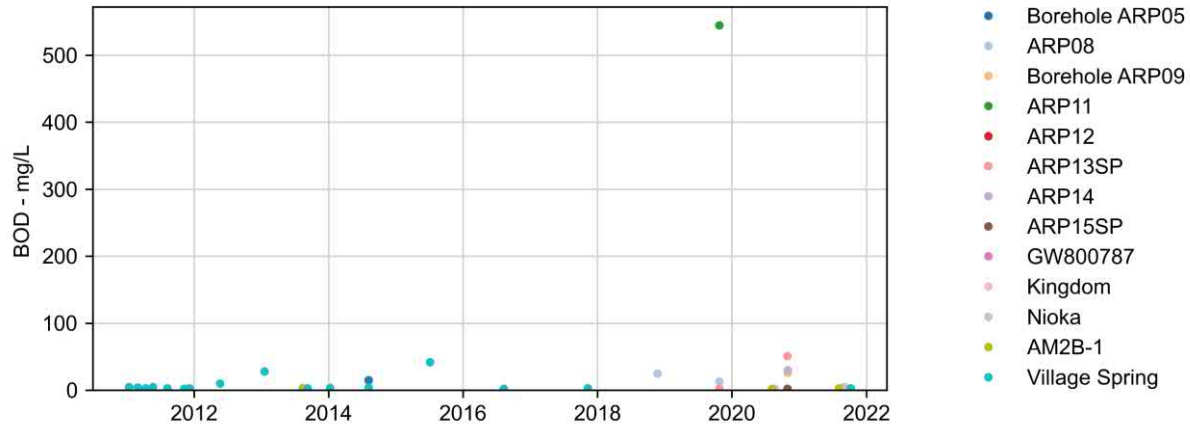

Nickel - mg/L
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

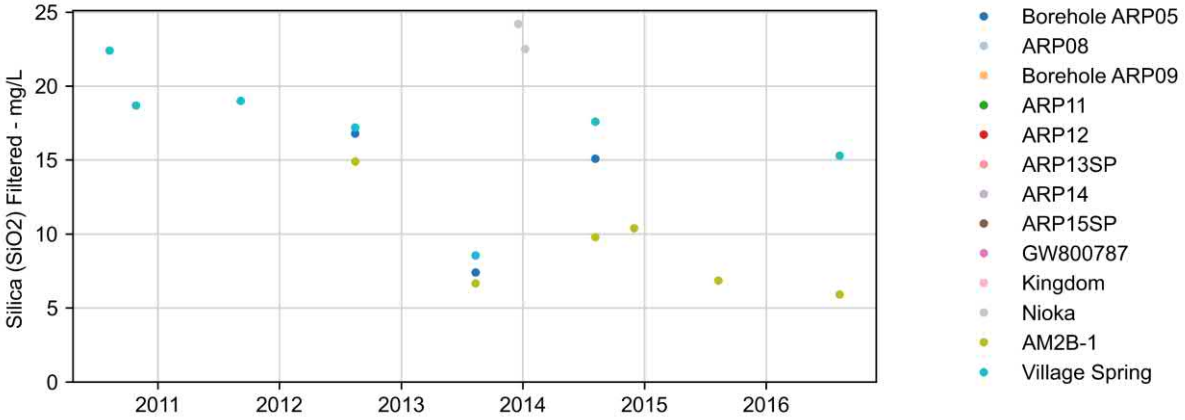

Selenium - mg/L
0
0.005
0.01
0.015
0.02
2017
2017
2018
2018
2019
2019
2020
2020
2021
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

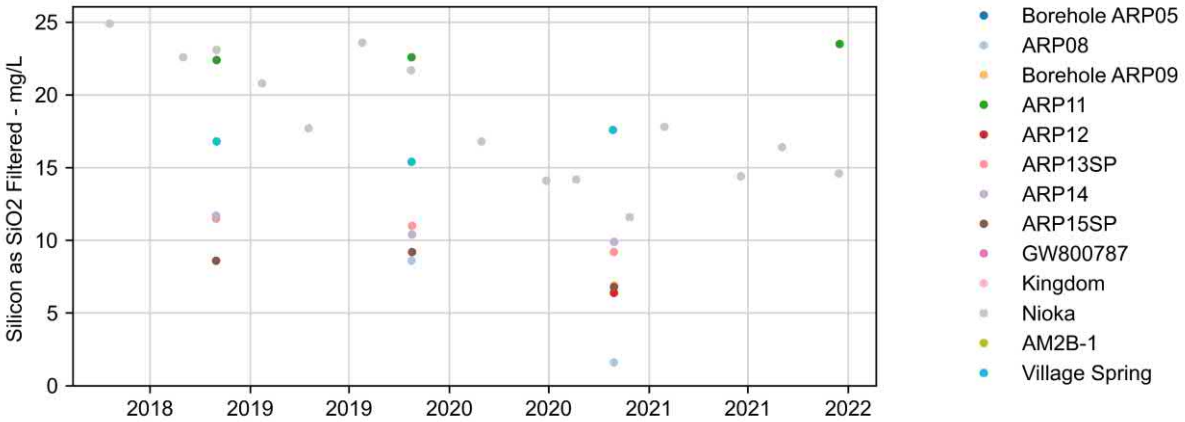

Silver - mg/L
0.002
0.0015
0.001
0.0005
0
2011
2012
2012
2013
2013
2014
2014
2015
2015
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

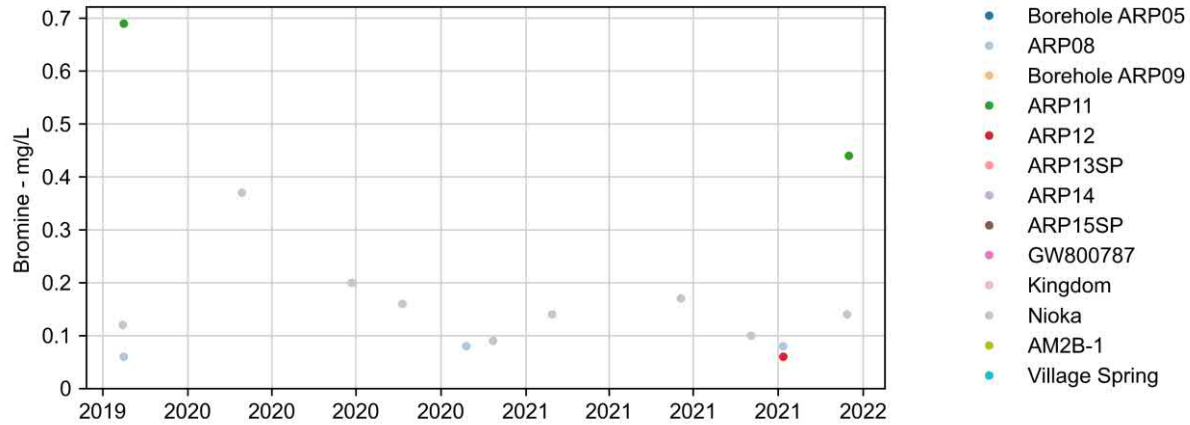

Zinc - mg/L
2.5
2
1.5
1
0.5
0
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

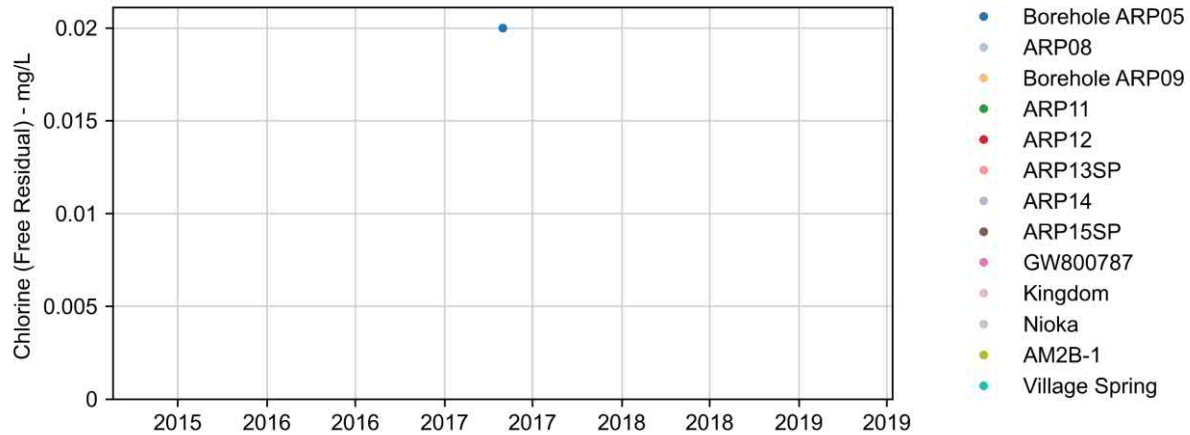
Other

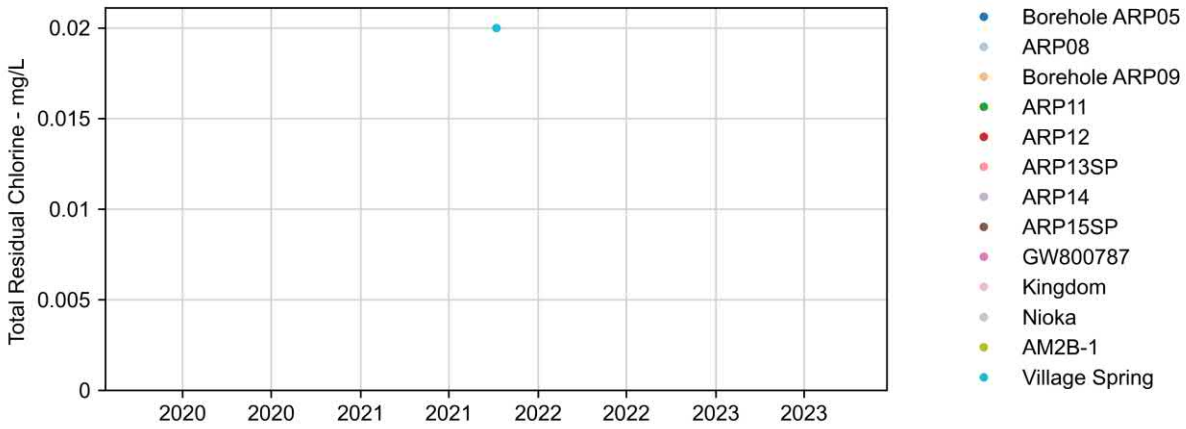

BOD - mg/L
500
400
300
200
100
0
2012
2014
2016
2018
2020
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring


Silica (SiO2) Filtered - mg/L
25
20
15
10
5
0
2011
2012
2013
2014
2015
2016
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring


Silicon as SiO2 Filtered - mg/L
25
20
15
10
5
0
2018
2019
2019
2020
2020
2021
2021
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring


Bromine - mg/L
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2019
2020
2020
2020
2020
2021
2021
2021
2021
2022
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

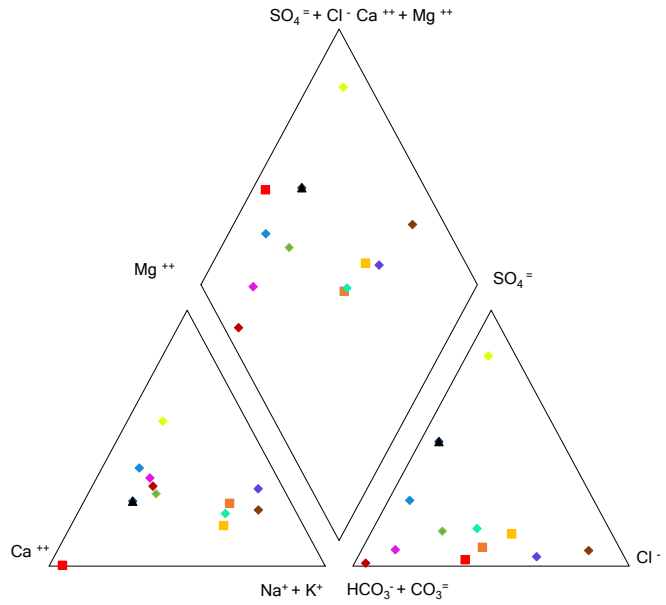

Chlorine (Free Residual) - mg/L
0.02
0.015
0.01
0.005
0
2015
2016
2016
2017
2017
2018
2018
2019
2019
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring


Total Residual Chlorine - mg/L
0.02
0.015
0.01
0.005
0
2020
2020
2021
2021
2022
2022
2023
2023
Borehole ARP05
ARP08
Borehole ARP09
ARP11
ARP12
ARP13SP
ARP14
ARP15SP
GW800787
Kingdom
Nioka
AM2B-1
Village Spring

Appendix C

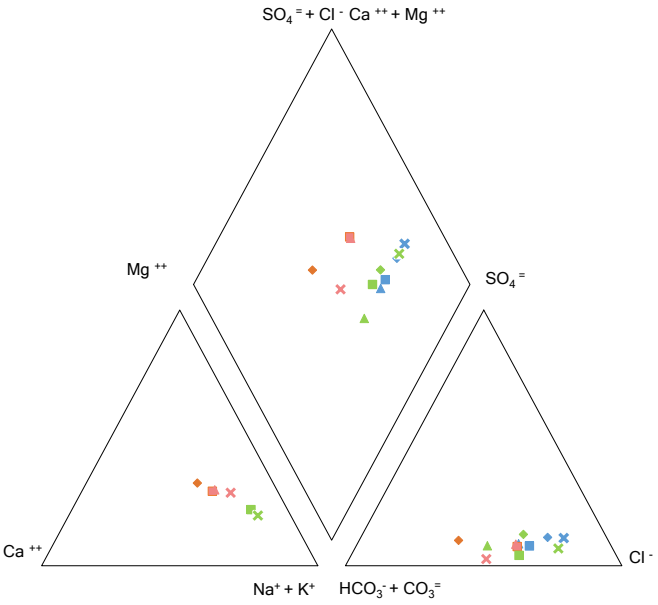
Piper charts

Groundwater



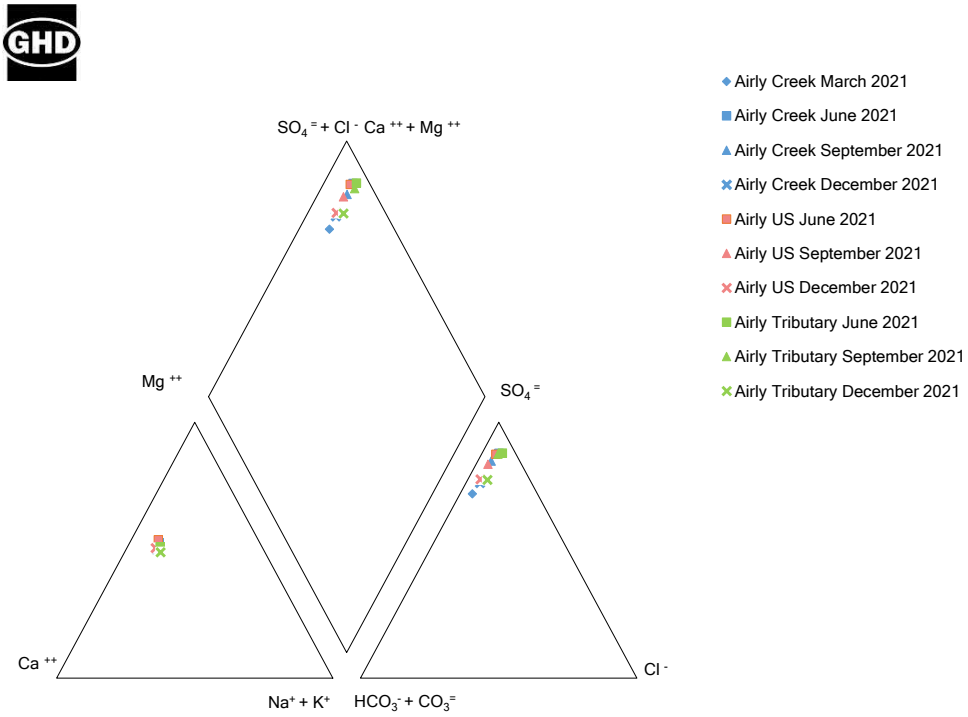
- Permian Strata - Village Spring April 2021
- Lithgow Seam - ARP13SP April 2021
- Narrabeen Sandstone - ARP15SP April 2021
- Genowlan Creek Alluvium - ARP14 April 2021
- Permian Strata - ARP11 December 2021
- Lithgow Seam - ARP08 April 2021
- Gap Creek Alluvium - ARP05 April 2021
- Shoalhaven Group - Production Bore April 2021
- Genowlan Creek Alluvium - ARP09 April 2021
- Genowlan Creek Alluvium - ARP12 April 2021
- Devonian Groundwater - Kingdom October 2021
- GW800787 - December 2021
- Devonian Groundwater - Nioka December 2021

Genowlan Creek

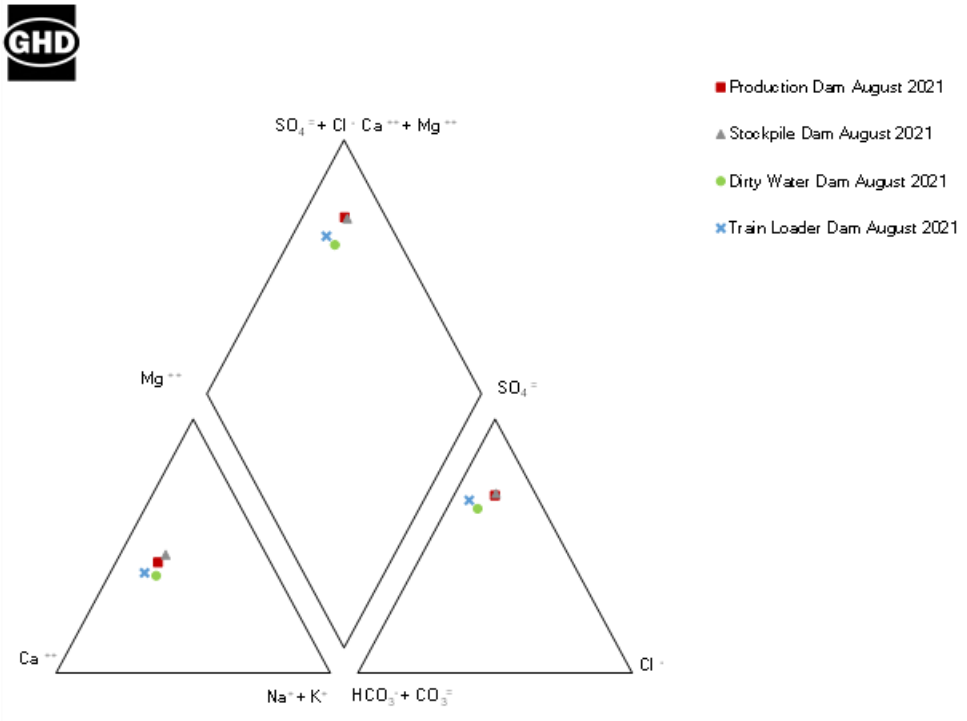


- Genowlan Creek 2 March 2021
- Genowlan Creek 2 June 2021
- Genowlan Creek 2 September 2021
- Genowlan Creek 2 December 2021
- Gap Creek March 2021
- Gap Creek June 2021
- Gap Creek September 2021
- Gap Creek December 2021
- The Grotto March 2021
- The Grotto June 2021
- The Grotto September 2021
- The Grotto December 2021

Airly Creek



Surface dam storages

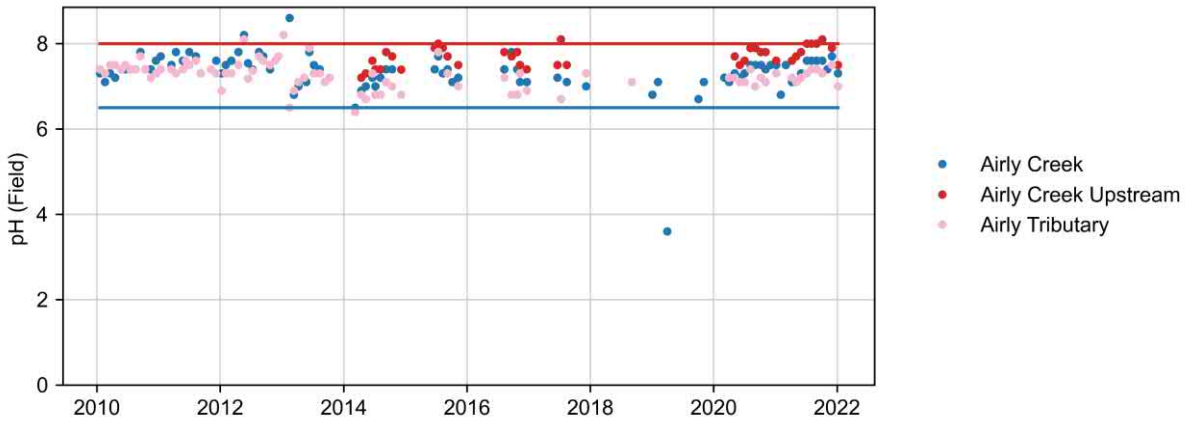


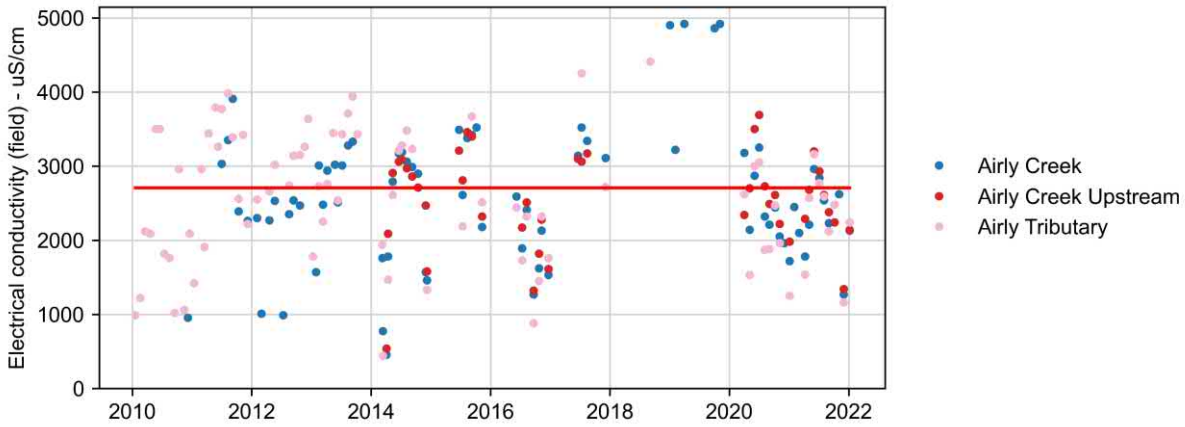
Appendix D

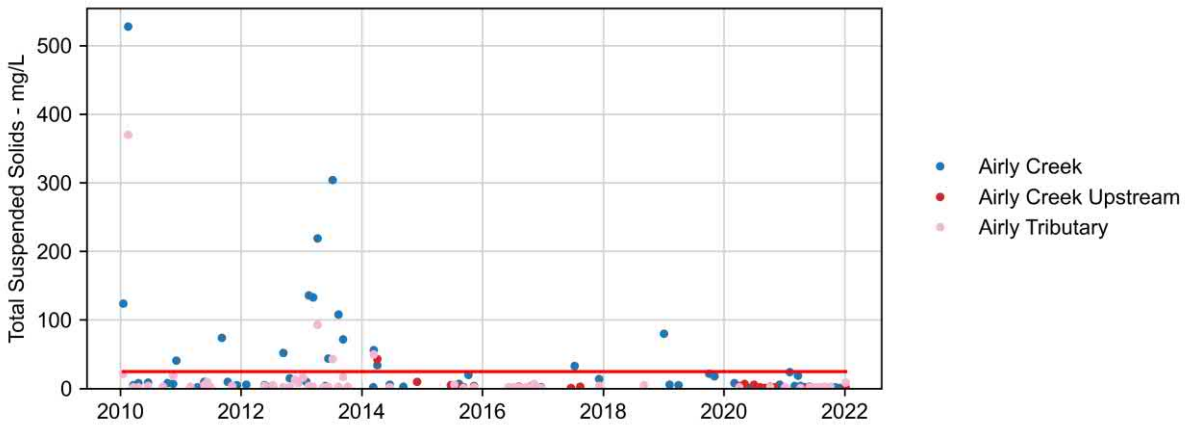
Surface water quality

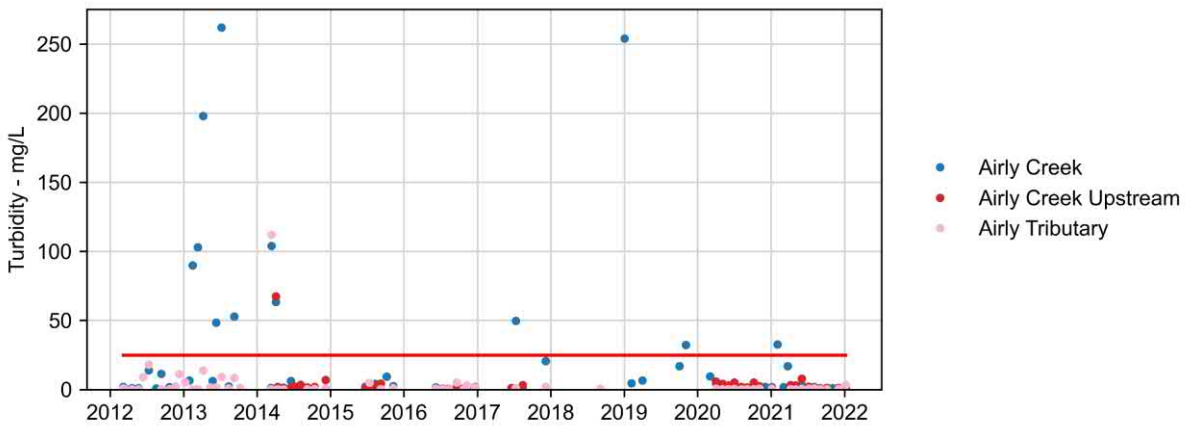
Airly Creek

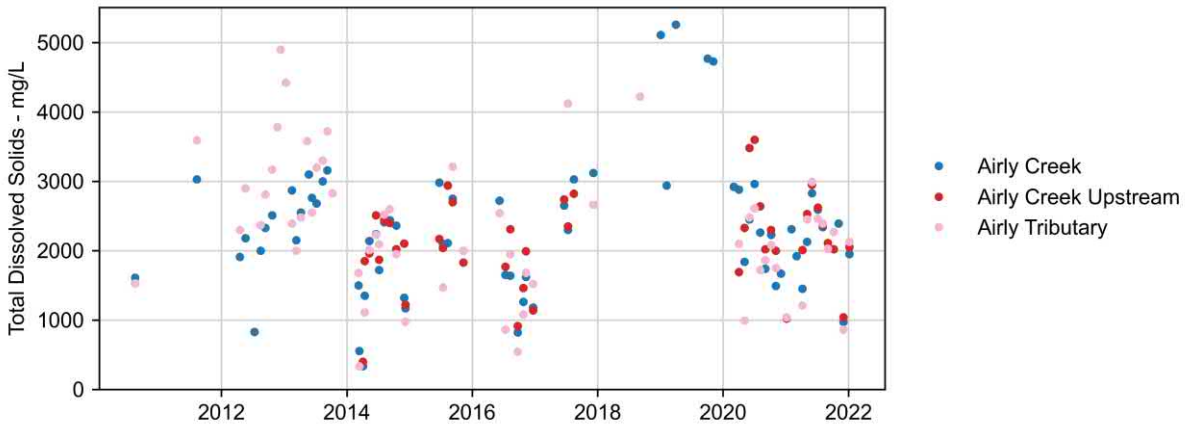
Physicochemical parameters

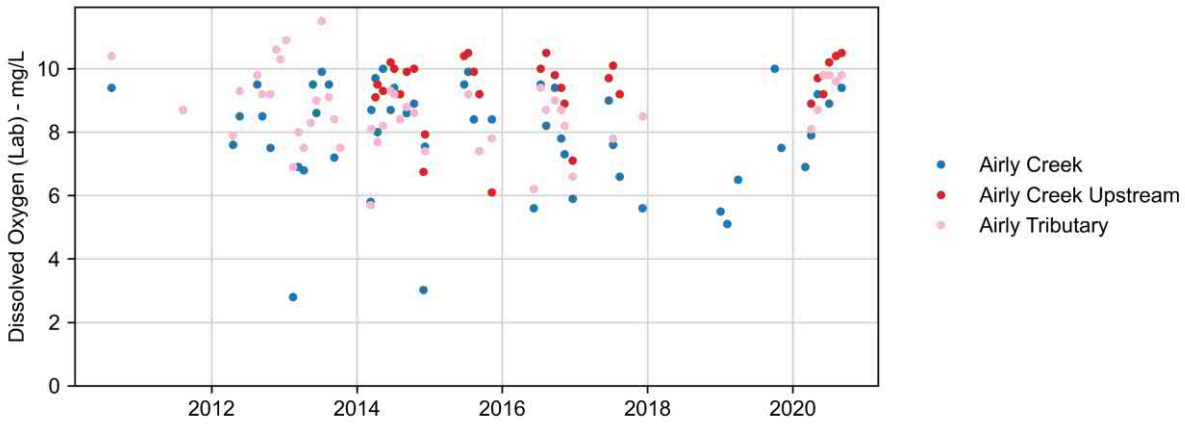




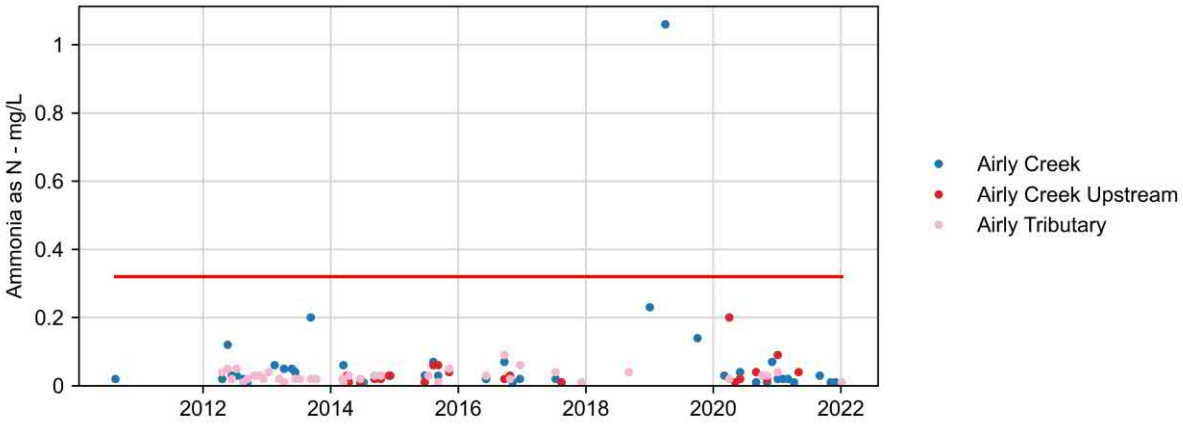


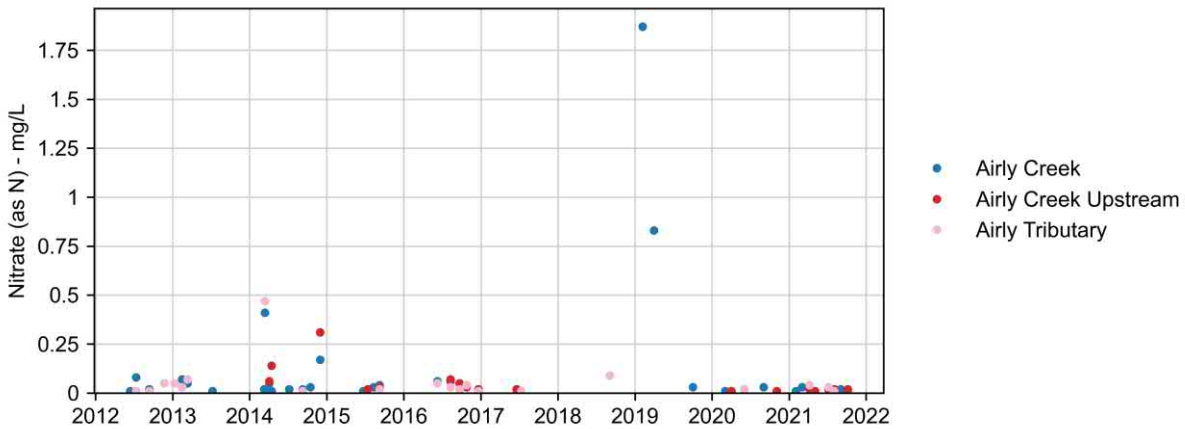


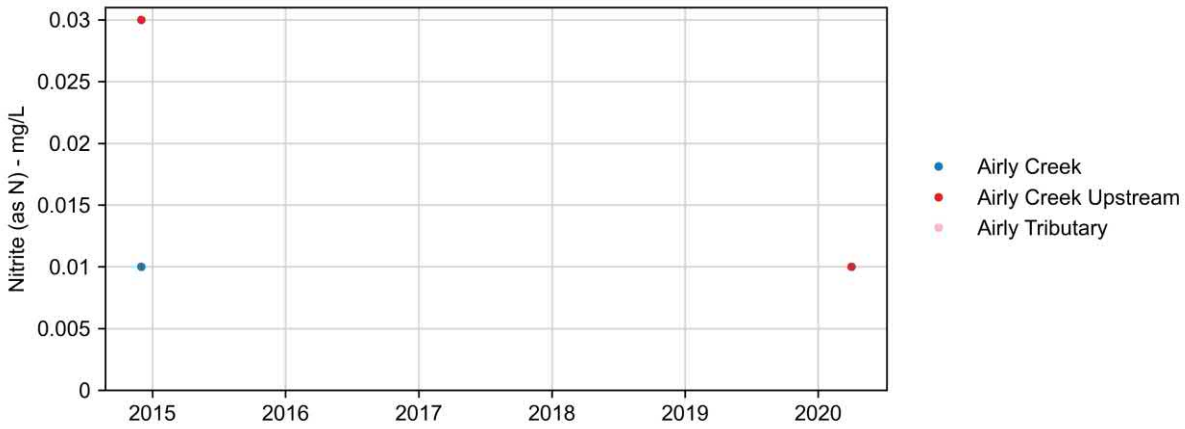

Total Dissolved Solids - mg/L
5000
4000
3000
2000
1000
0
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary

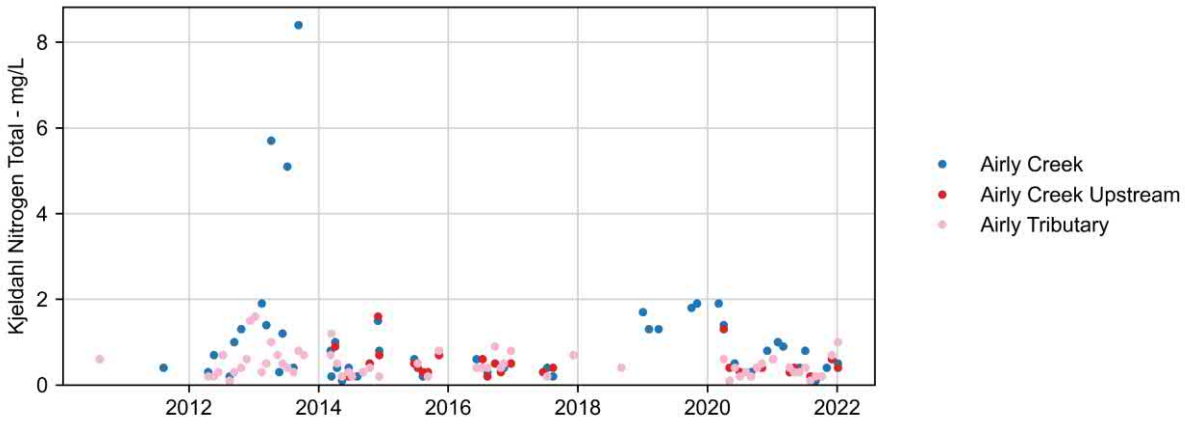

Dissolved Oxygen (Lab) - mg/L
10
8
6
4
2
0
2012
2014
2016
2018
2020
Airly Creek
Airly Creek Upstream
Airly Tributary

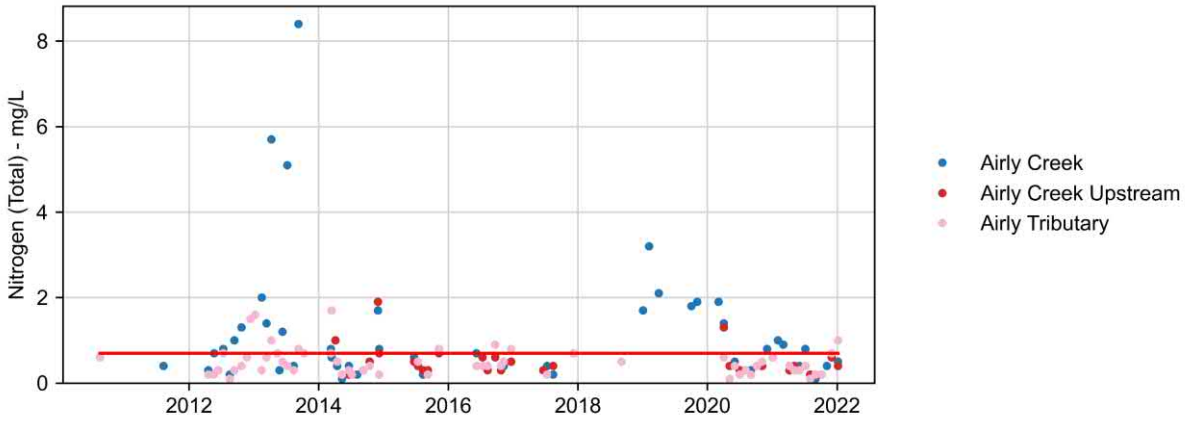
Nutrients

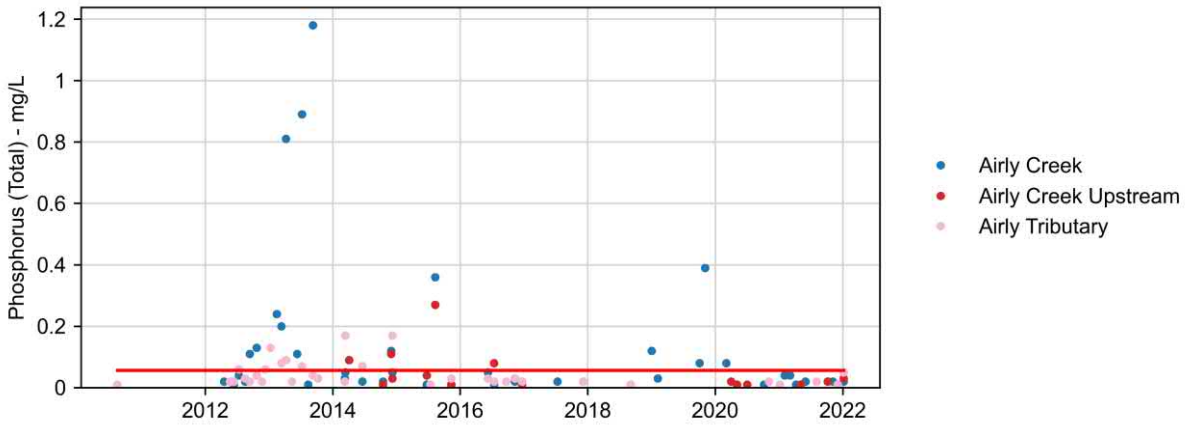

Ammonia as N - mg/L
1
0.8
0.6
0.4
0.2
0
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary


Nitrate (as N) - mg/L
1.75
1.5
1.25
1
0.75
0.5
0.25
0
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Airly Creek
Airly Creek Upstream
Airly Tributary


Nitrite (as N) - mg/L
0.03
0.025
0.02
0.015
0.01
0.005
0
2015
2016
2017
2018
2019
2020
Airly Creek
Airly Creek Upstream
Airly Tributary

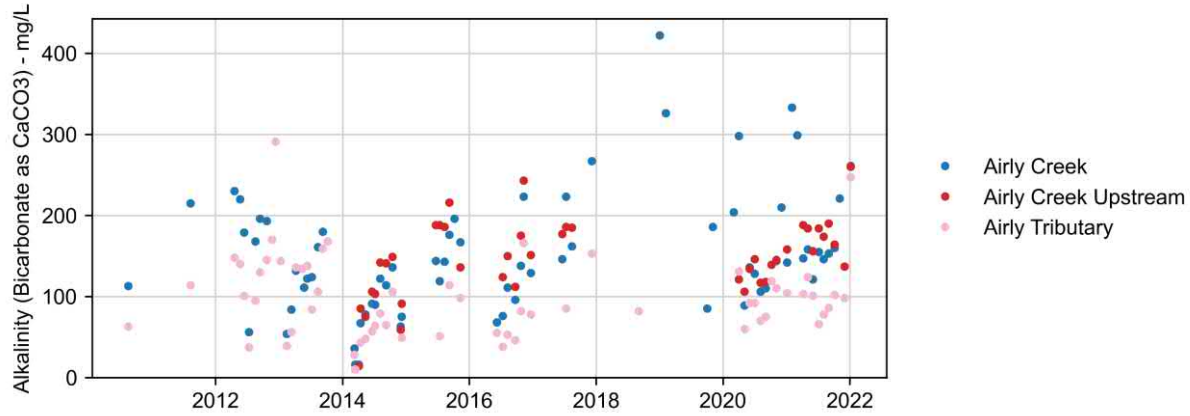

Kjeldahl Nitrogen Total - mg/L
8
6
4
2
0
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary

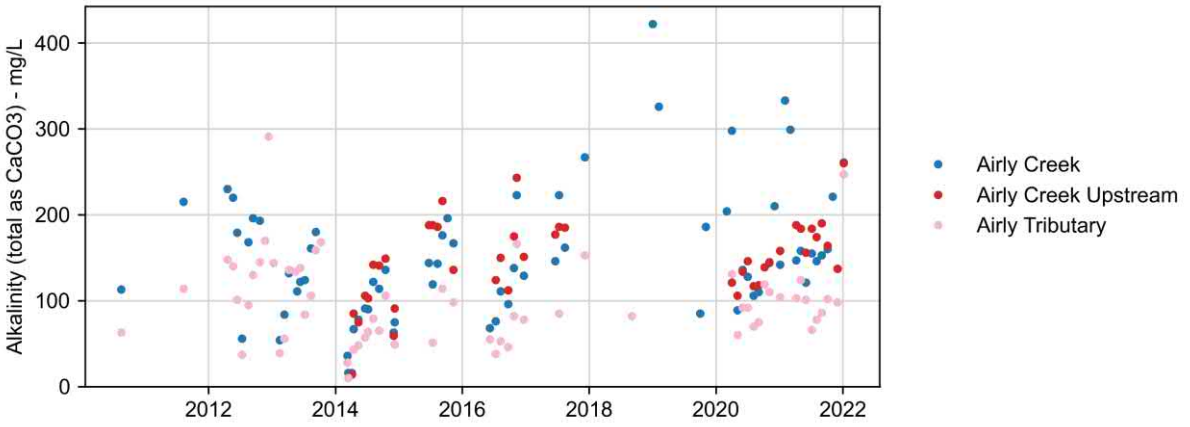

Nitrogen (Total) - mg/L
8
6
4
2
0
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary

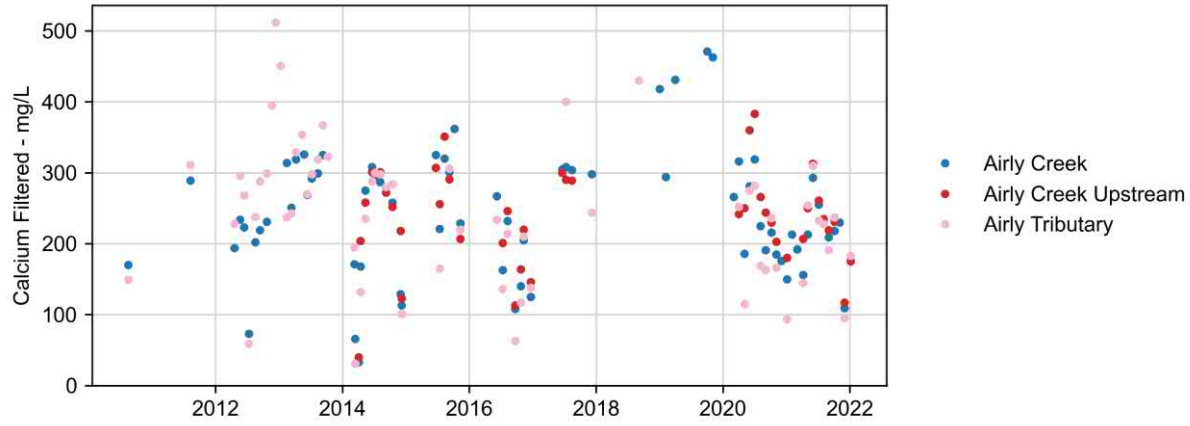

Phosphorus (Total) - mg/L
1.2
1
0.8
0.6
0.4
0.2
0
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary

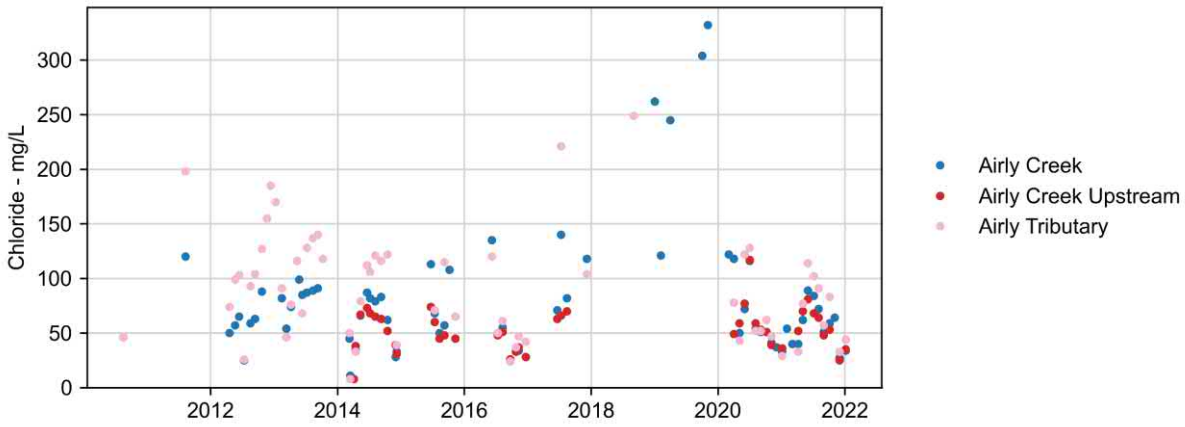
Major ions

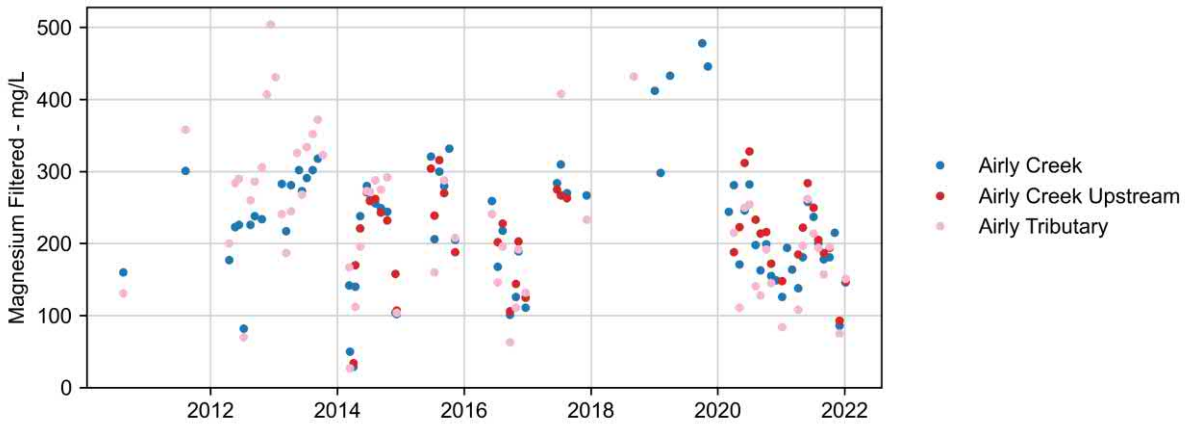
Note graphs for hydroxide alkalinity and carbonate alkalinity are not presented as all values are less than the LOR.

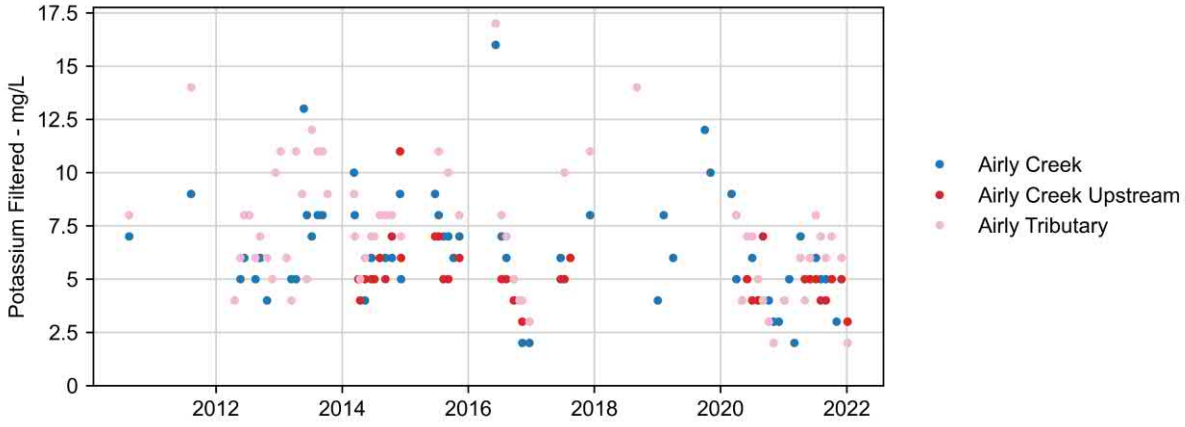


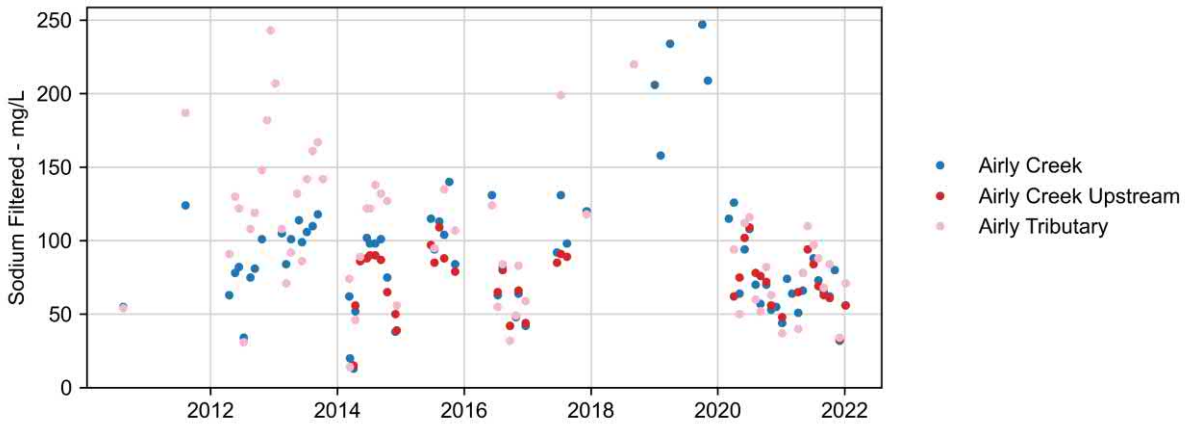


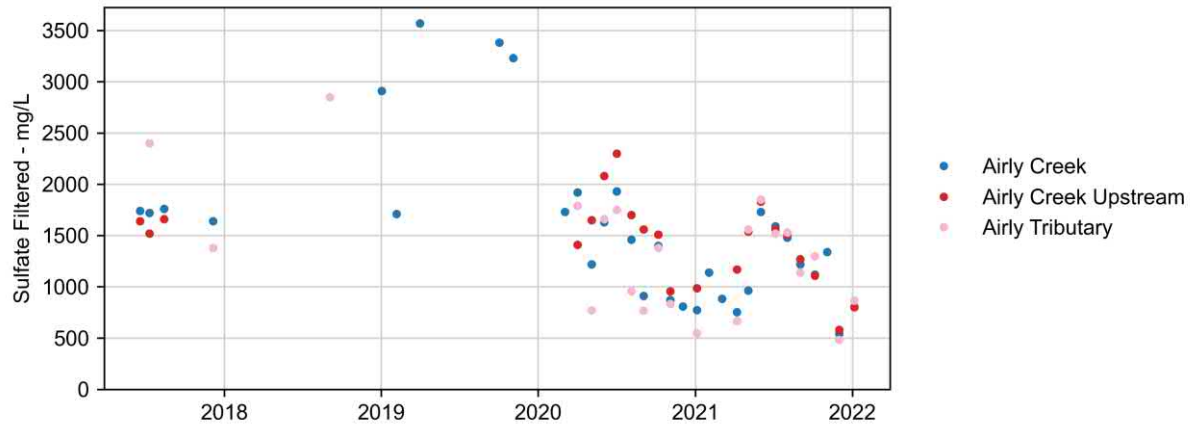


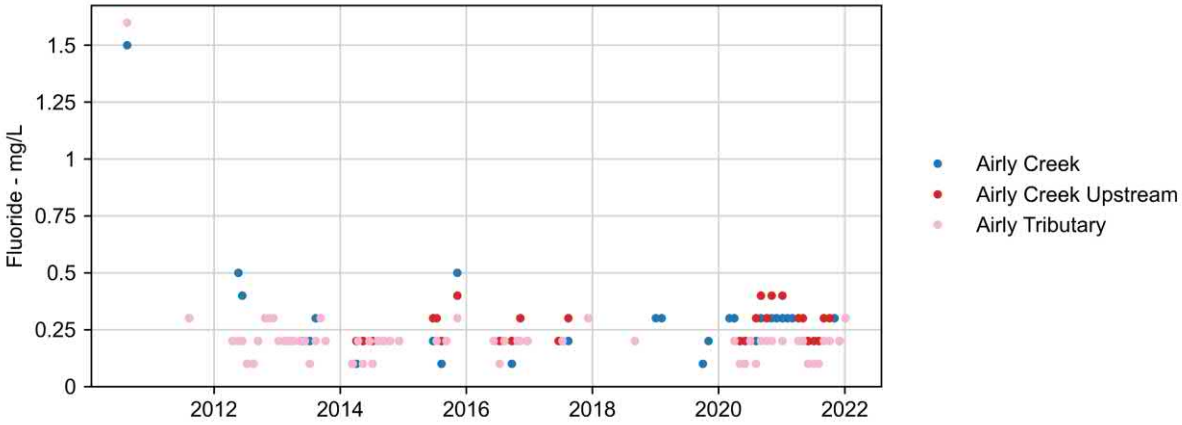

Chloride - mg/L
0
50
100
150
200
250
300
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary


Magnesium Filtered - mg/L
0
100
200
300
400
500
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary

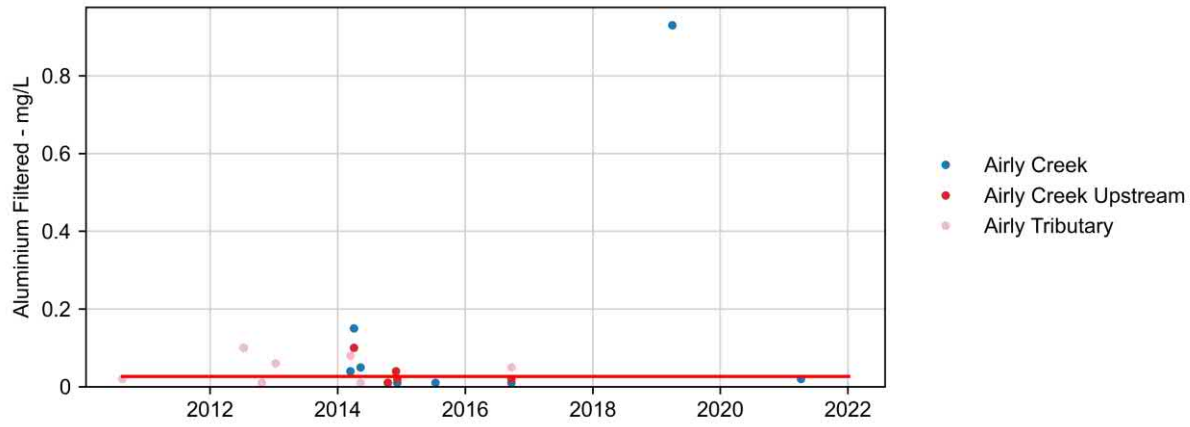

Potassium Filtered - mg/L
0
2.5
5
7.5
10
12.5
15
17.5
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary

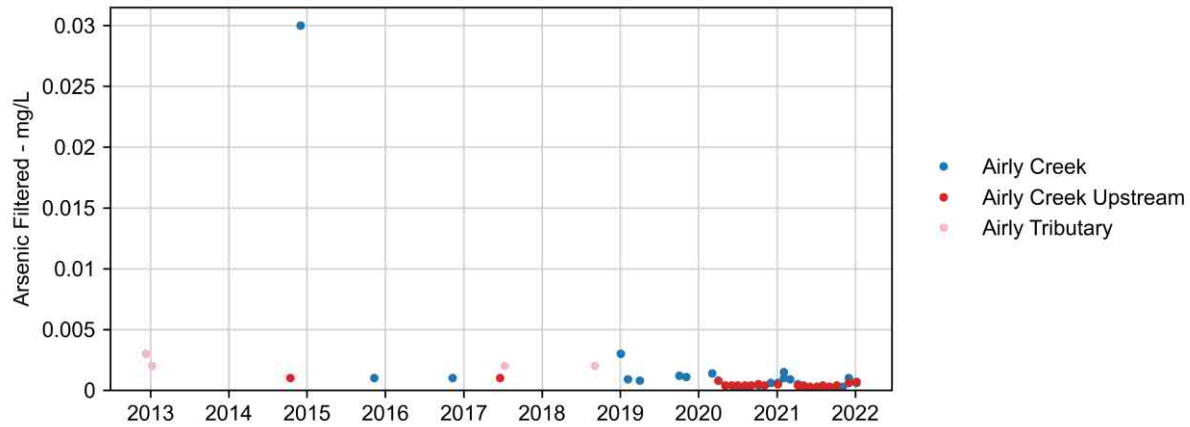

Sodium Filtered - mg/L
0
50
100
150
200
250
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary

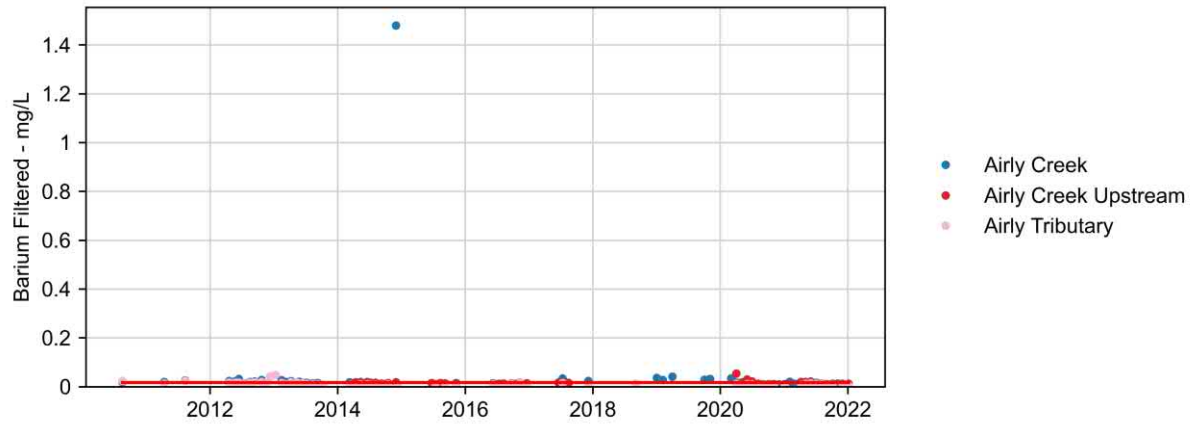


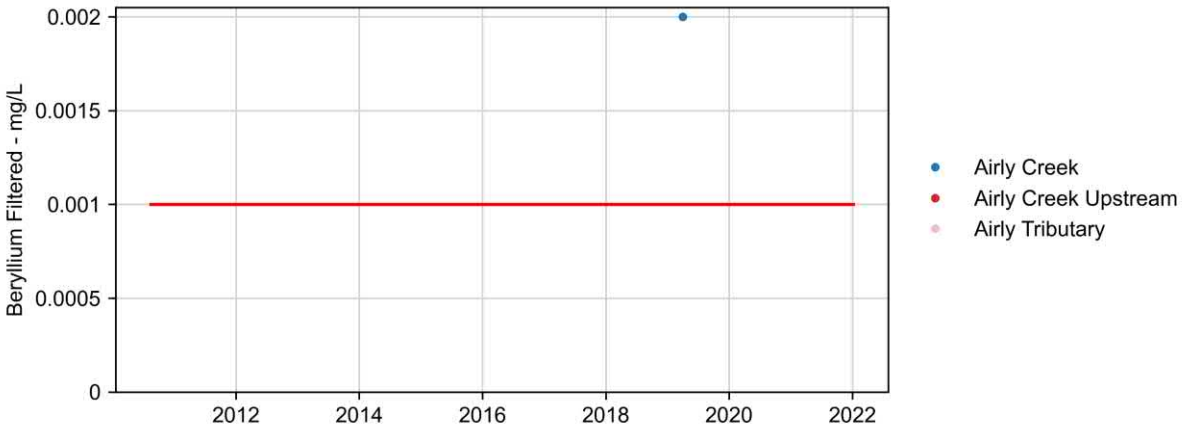


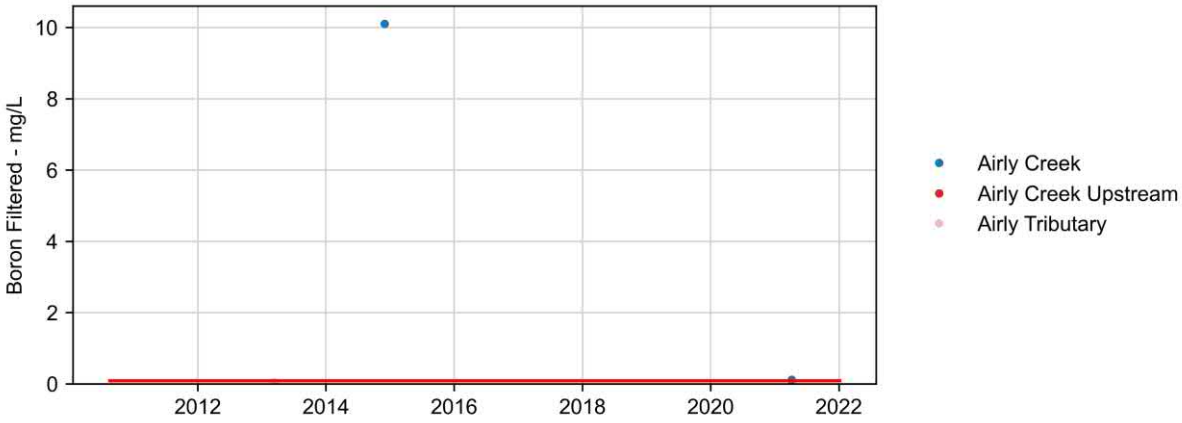
Metals (dissolved)

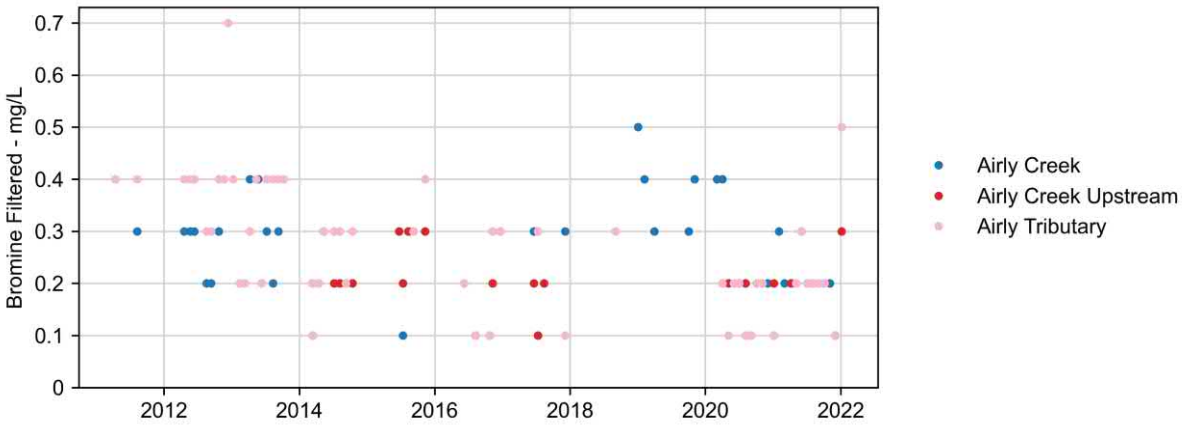


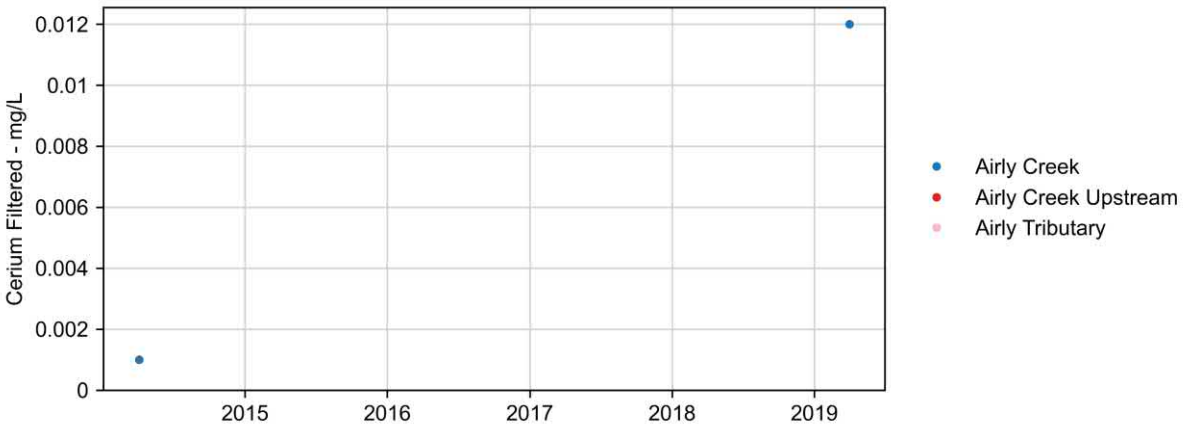


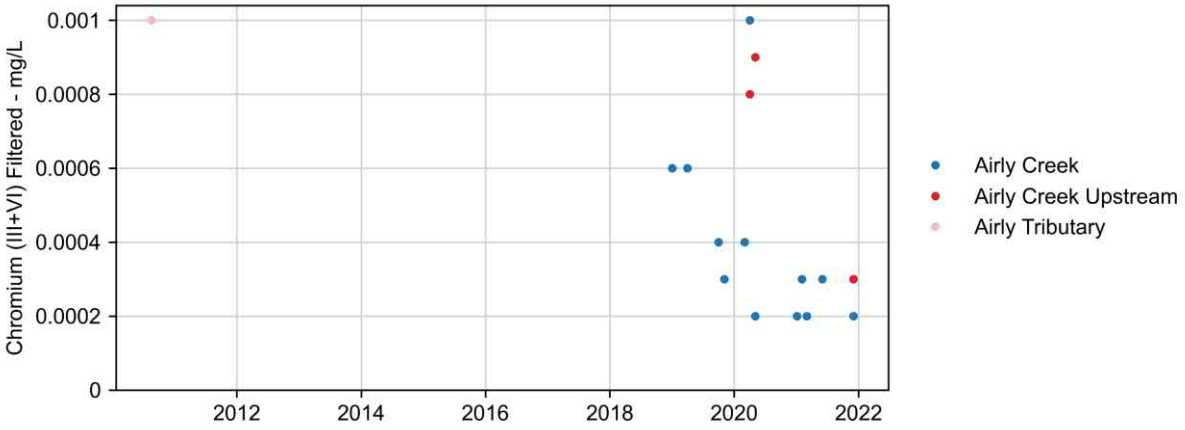

Barium Filtered - mg/L
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary

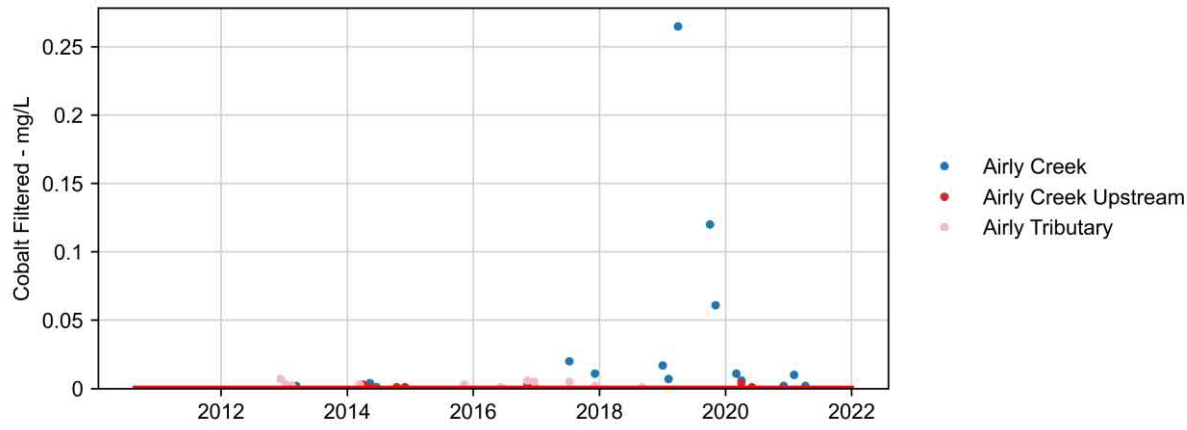

Beryllium Filtered - mg/L
0.002
0.0015
0.001
0.0005
0
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary

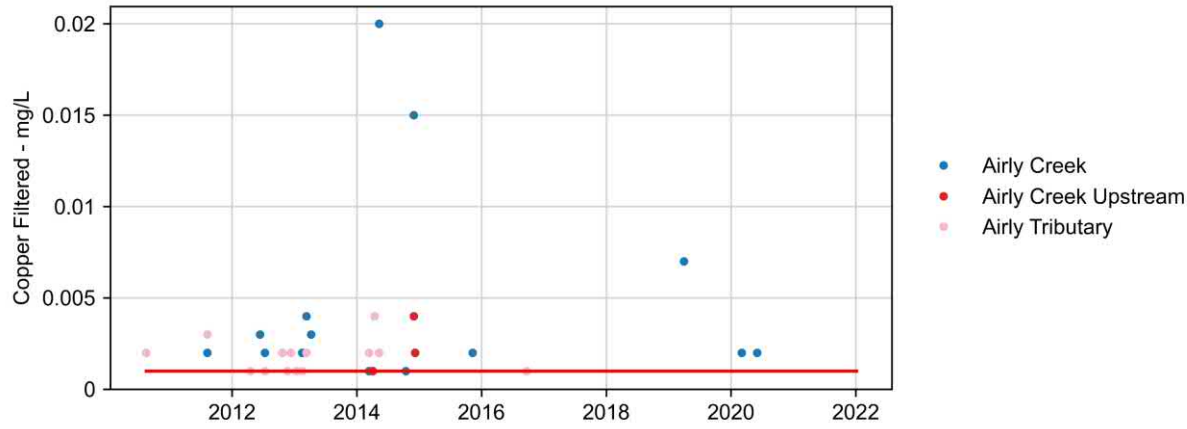

Boron Filtered - mg/L
10
8
6
4
2
0
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary

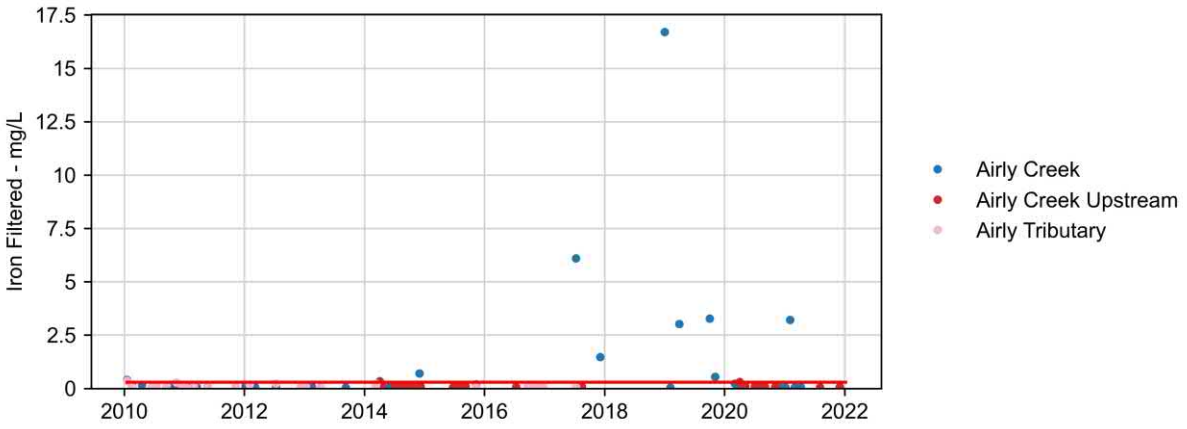

Bromine Filtered - mg/L
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary

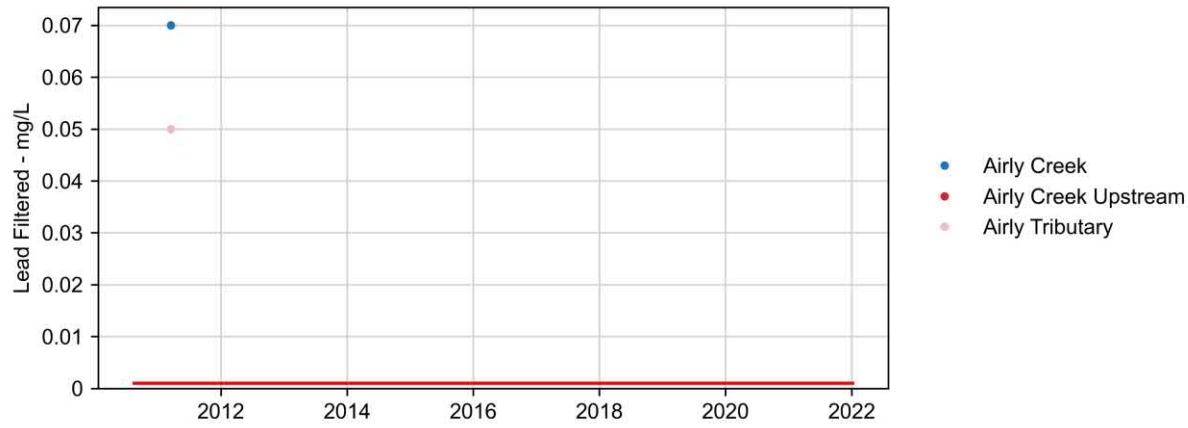

Cerium Filtered - mg/L
0.012
0.01
0.008
0.006
0.004
0.002
0
2015
2016
2017
2018
2019
Airly Creek
Airly Creek Upstream
Airly Tributary

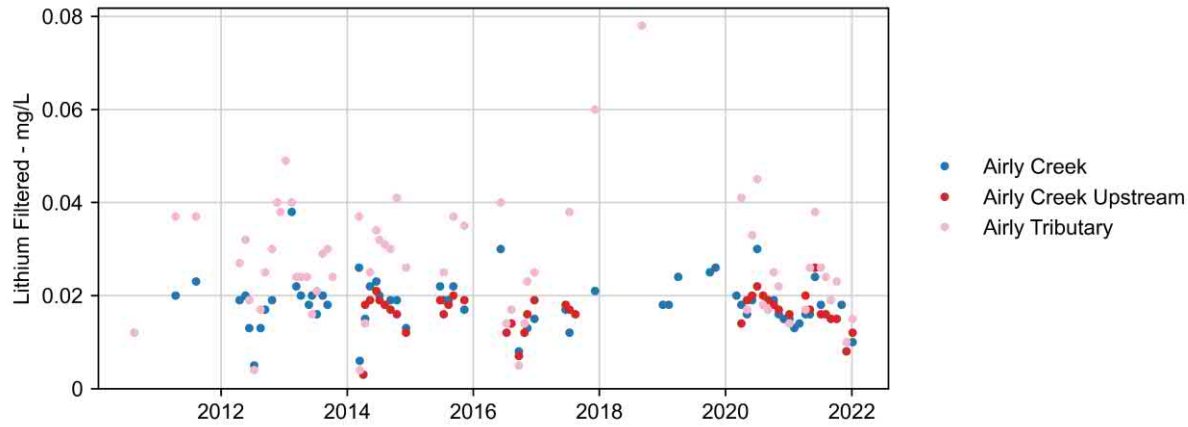

Chromium (III+VI) Filtered - mg/L
0.001
0.0008
0.0006
0.0004
0.0002
0
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary

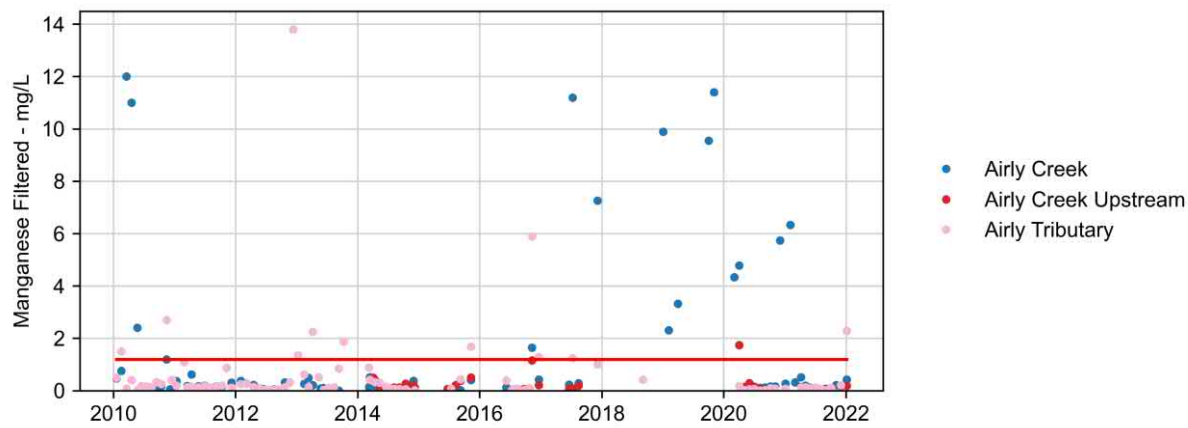

Cobalt Filtered - mg/L
0.25
0.2
0.15
0.1
0.05
0
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary

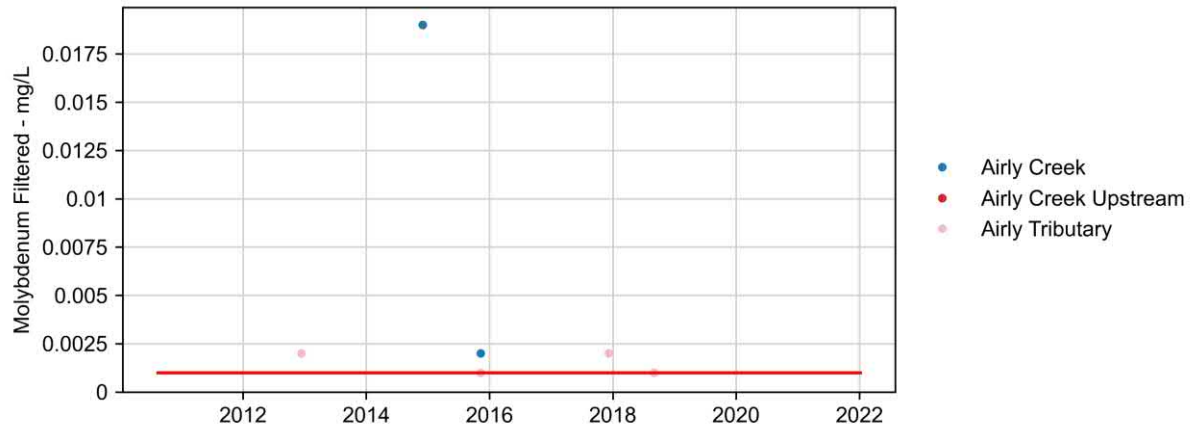

Copper Filtered - mg/L
0.02
0.015
0.01
0.005
0
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary

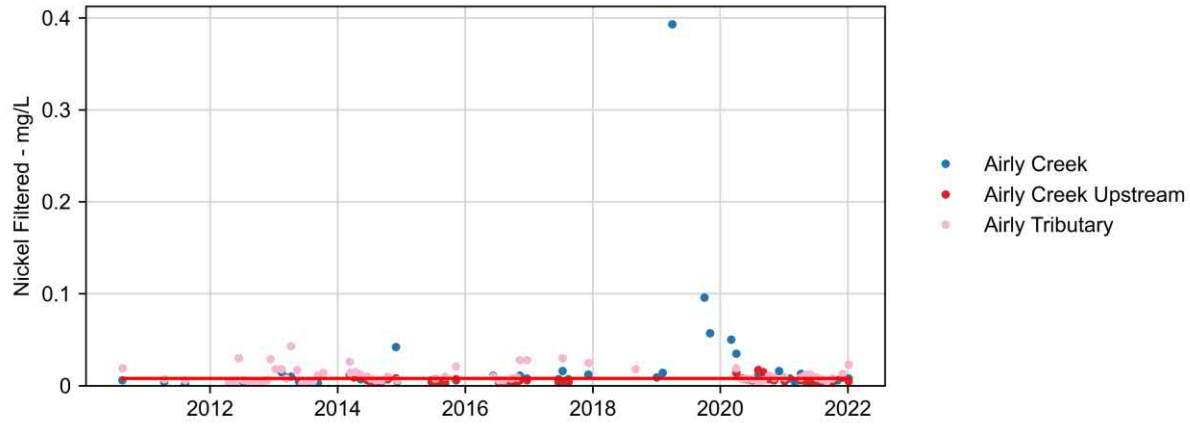

Iron Filtered - mg/L
17.5
15
12.5
10
7.5
5
2.5
0
2010
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary

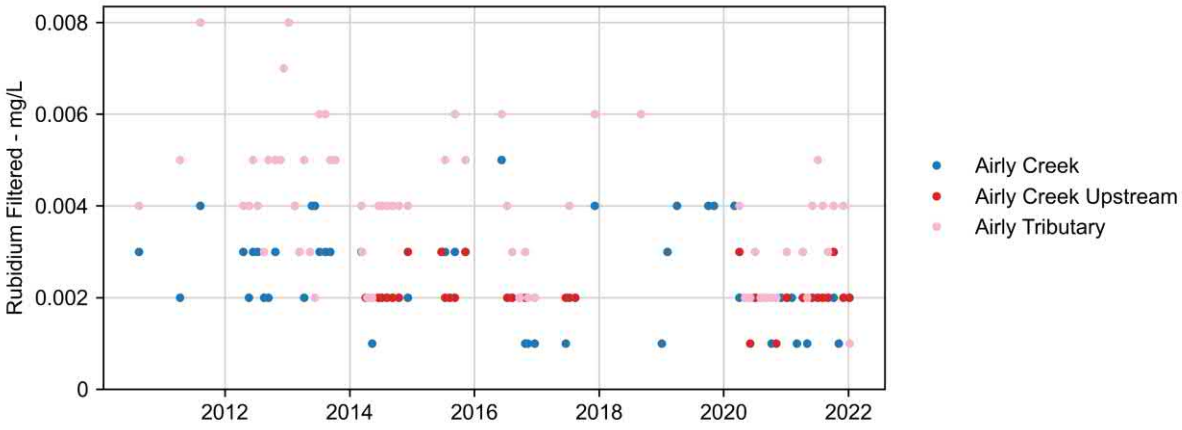

Lead Filtered - mg/L
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary

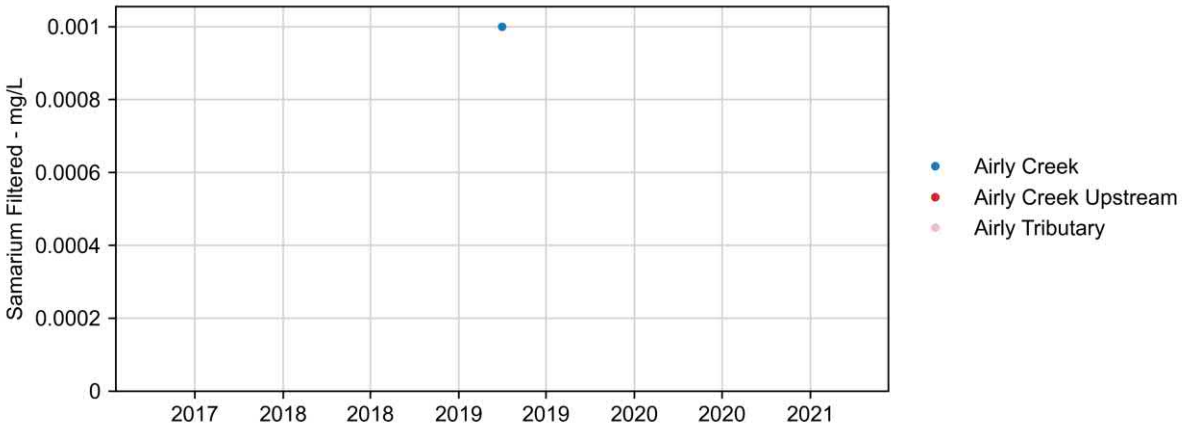

Lithium Filtered - mg/L
0.08
0.06
0.04
0.02
0
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary

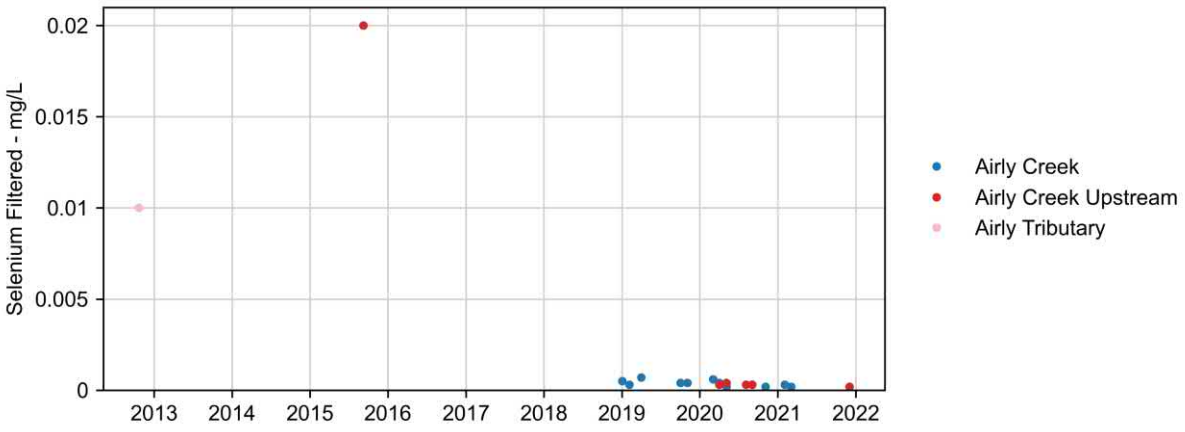

Manganese Filtered - mg/L
14
12
10
8
6
4
2
0
2010
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary

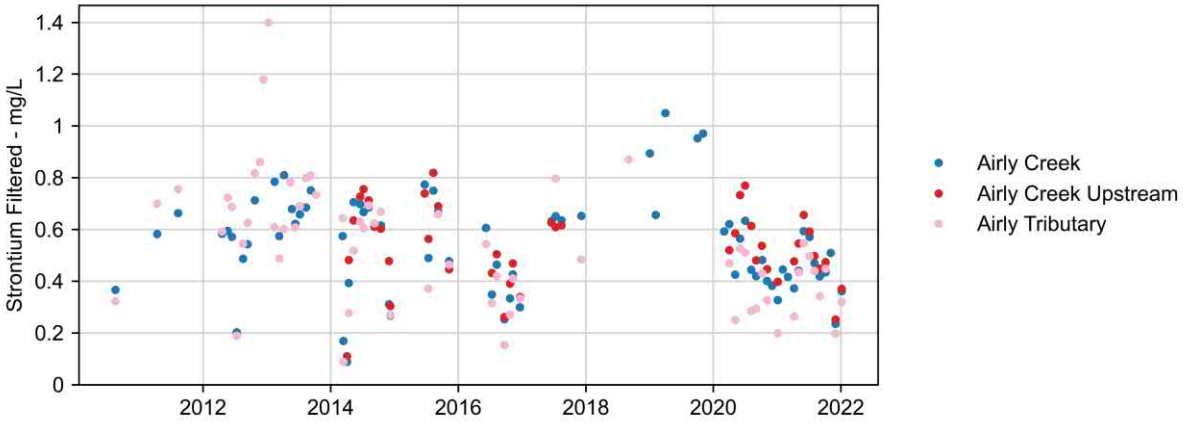

Molybdenum Filtered - mg/L
0.0175
0.015
0.0125
0.01
0.0075
0.005
0.0025
0
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary

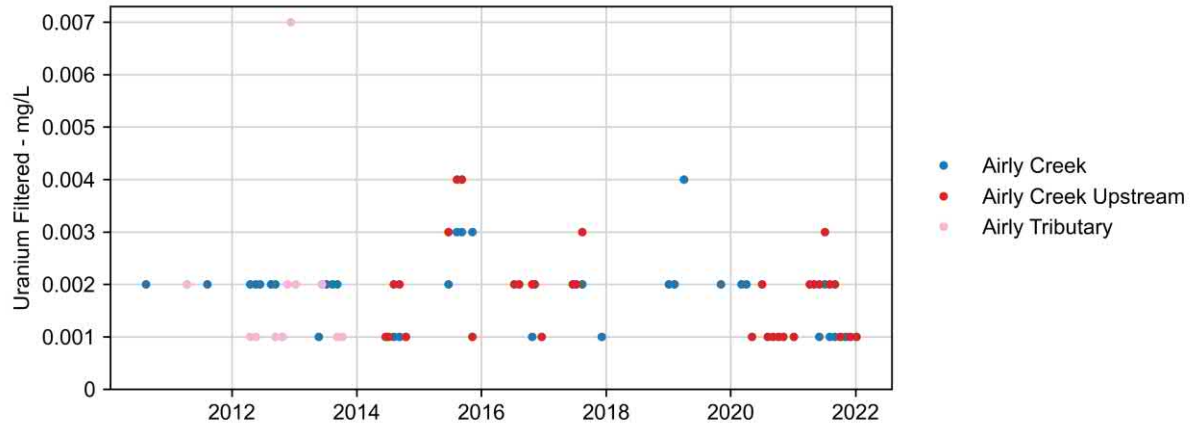

Nickel Filtered - mg/L
0.4
0.3
0.2
0.1
0
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary

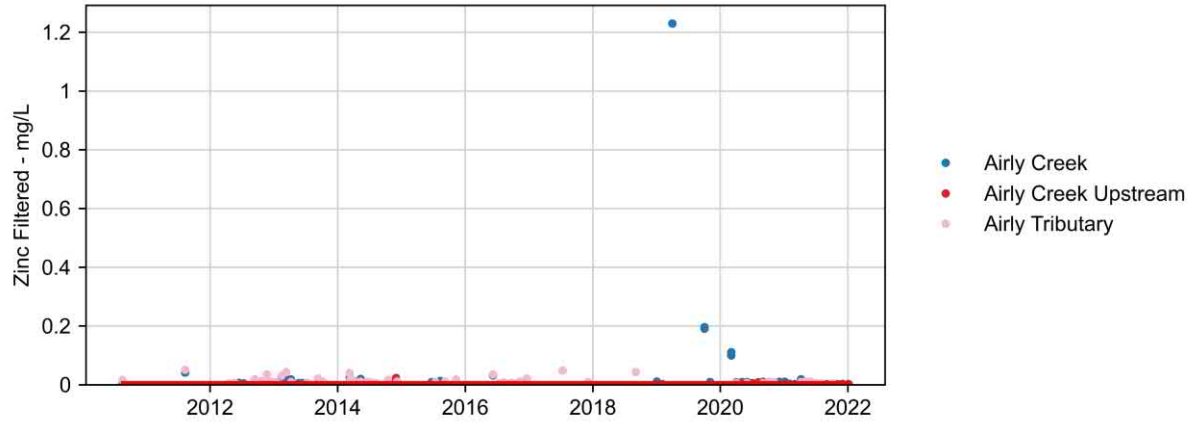

Rubidium Filtered - mg/L
0.008
0.006
0.004
0.002
0
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary


Samarium Filtered - mg/L
0.001
0.0008
0.0006
0.0004
0.0002
0
2017
2018
2018
2019
2019
2020
2020
2021
Airly Creek
Airly Creek Upstream
Airly Tributary

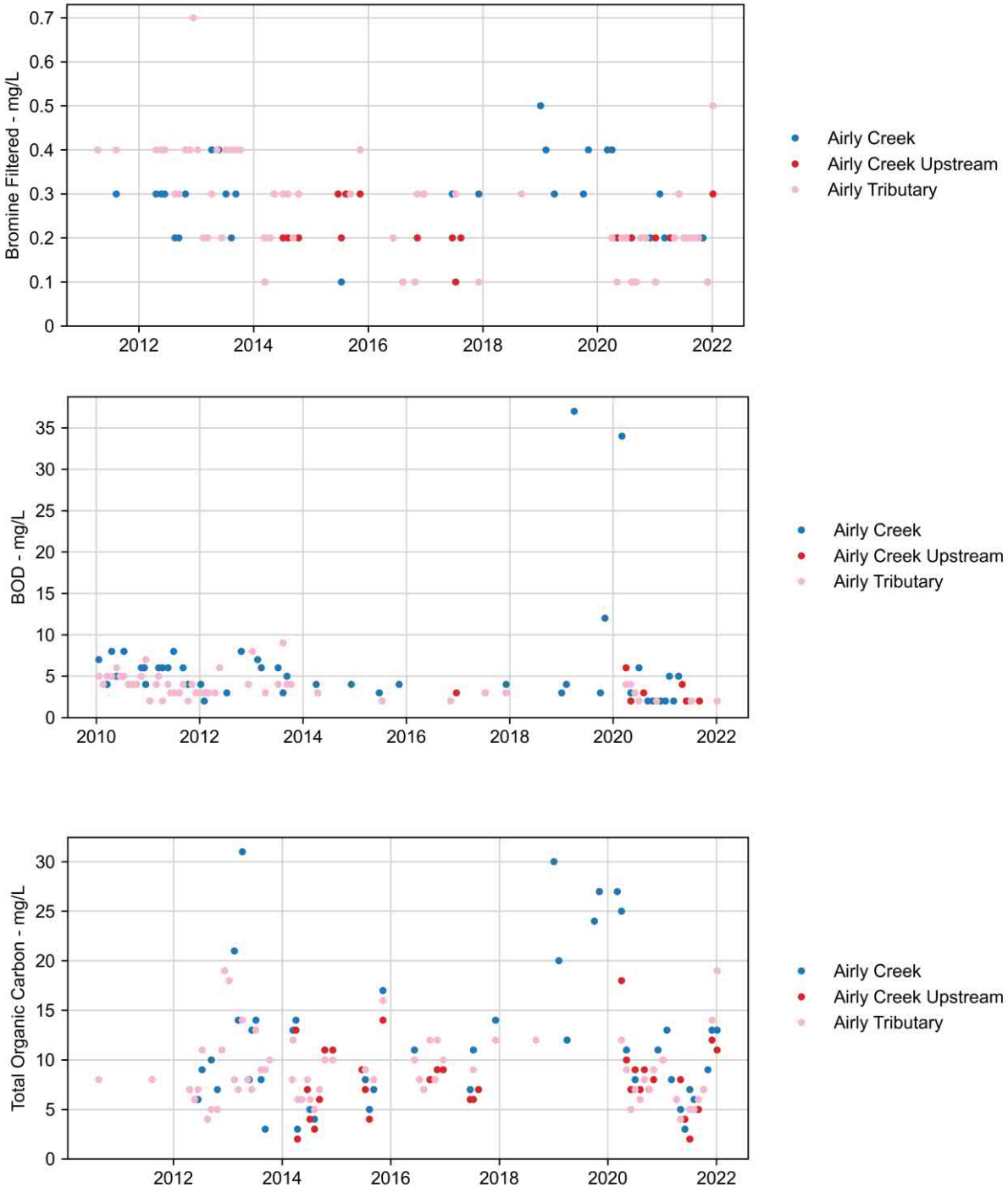

Selenium Filtered - mg/L
0.02
0.015
0.01
0.005
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Airly Creek
Airly Creek Upstream
Airly Tributary


Strontium Filtered - mg/L
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary


Uranium Filtered - mg/L
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary

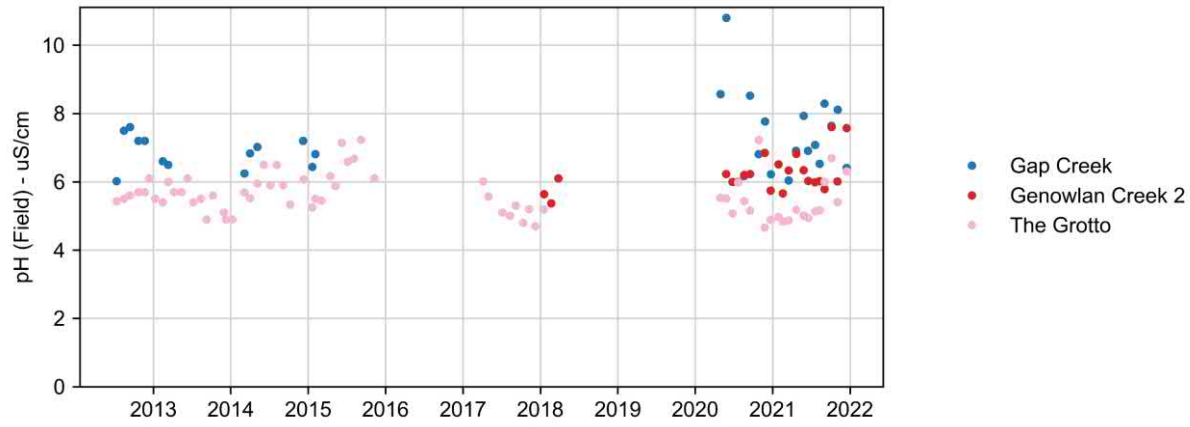

Zinc Filtered - mg/L
1.2
1
0.8
0.6
0.4
0.2
0
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary

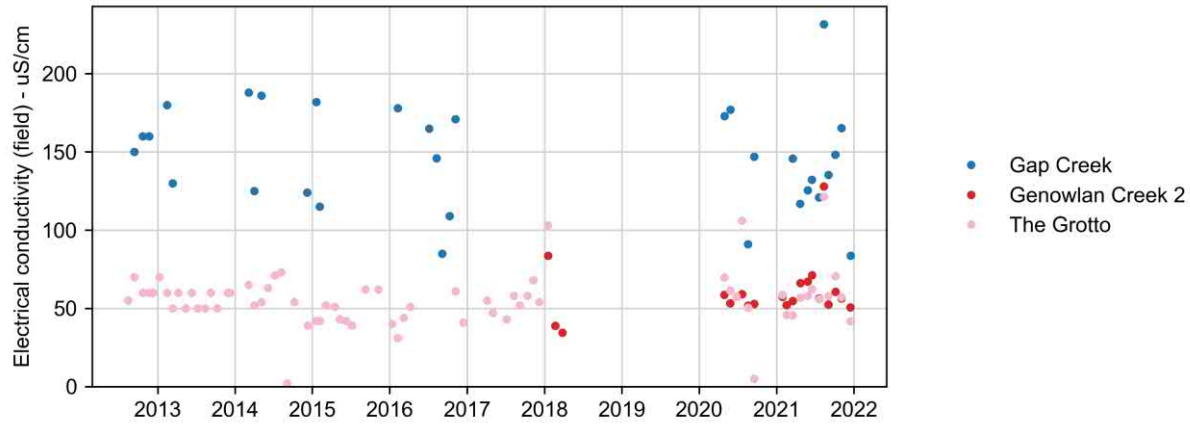
Other

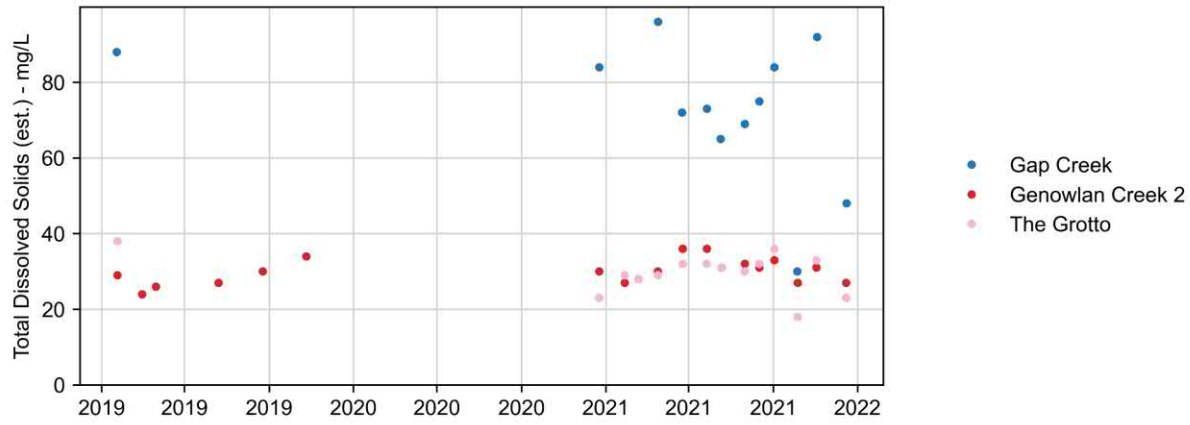

Bromine Filtered - mg/L
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary
BOD - mg/L
0
5
10
15
20
25
30
35
2010
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary
Total Organic Carbon - mg/L
0
5
10
15
20
25
30
2012
2014
2016
2018
2020
2022
Airly Creek
Airly Creek Upstream
Airly Tributary

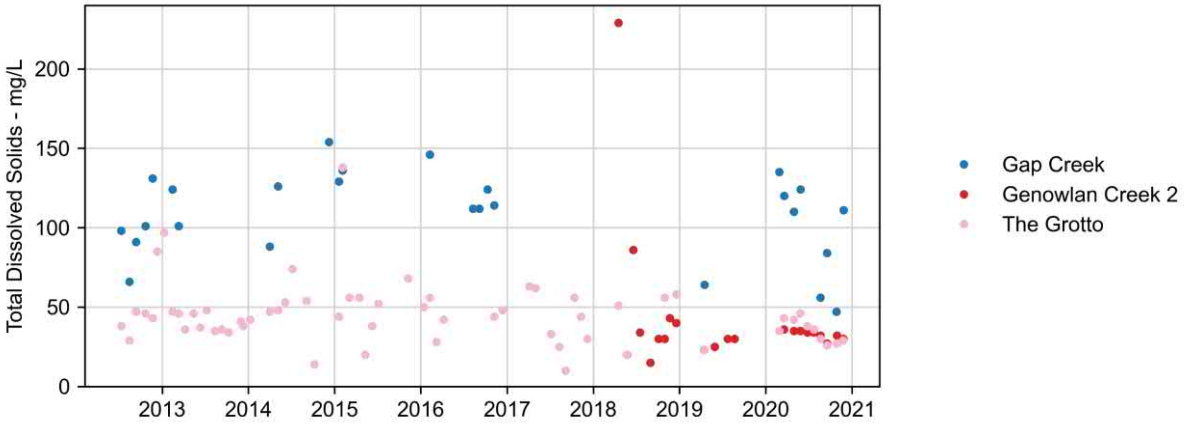
Genowlan Creek

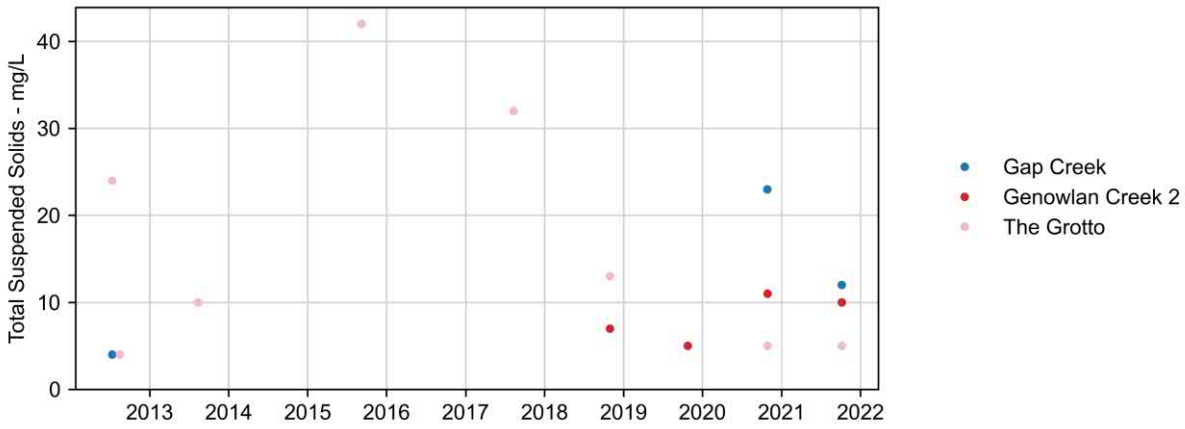
Physiochemical parameters

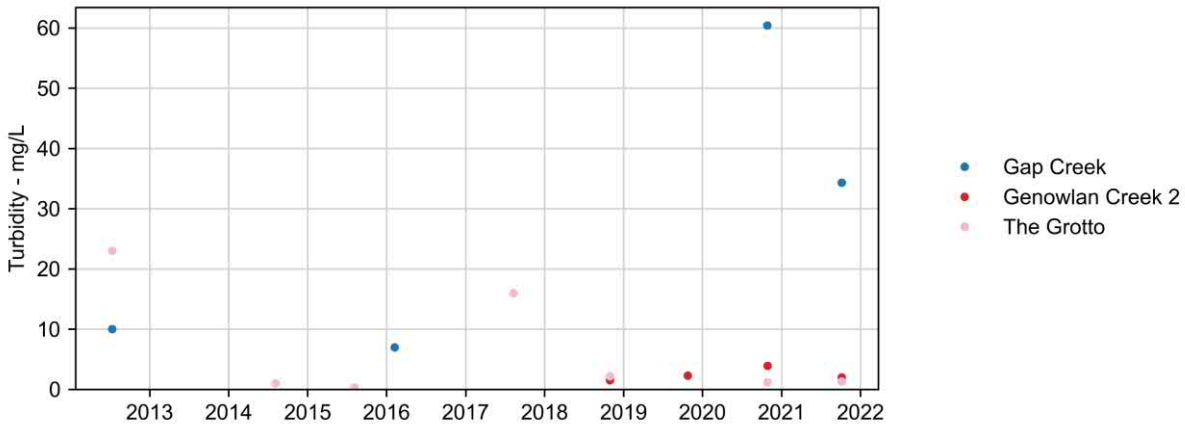




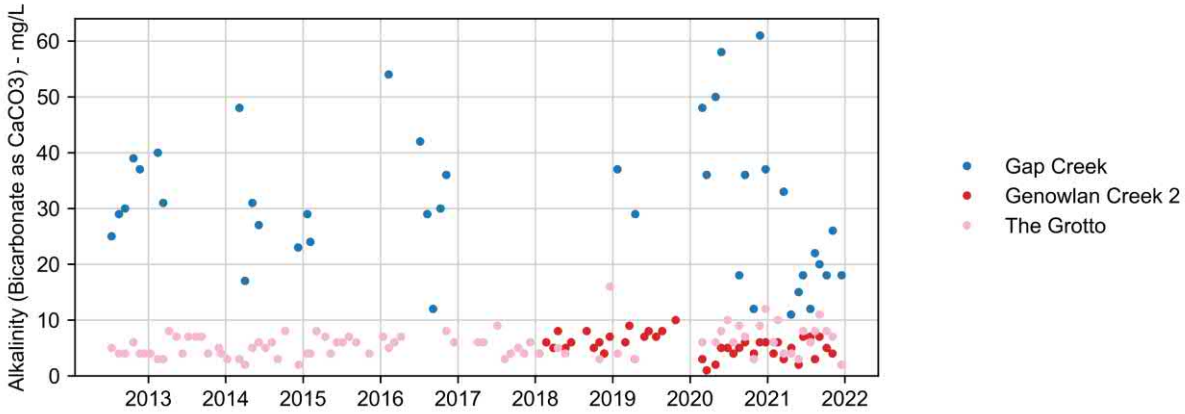


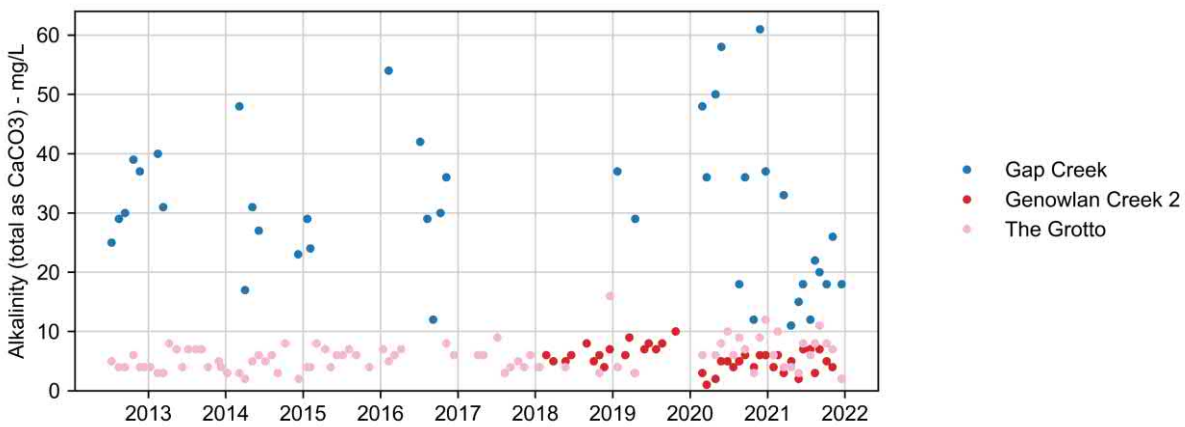


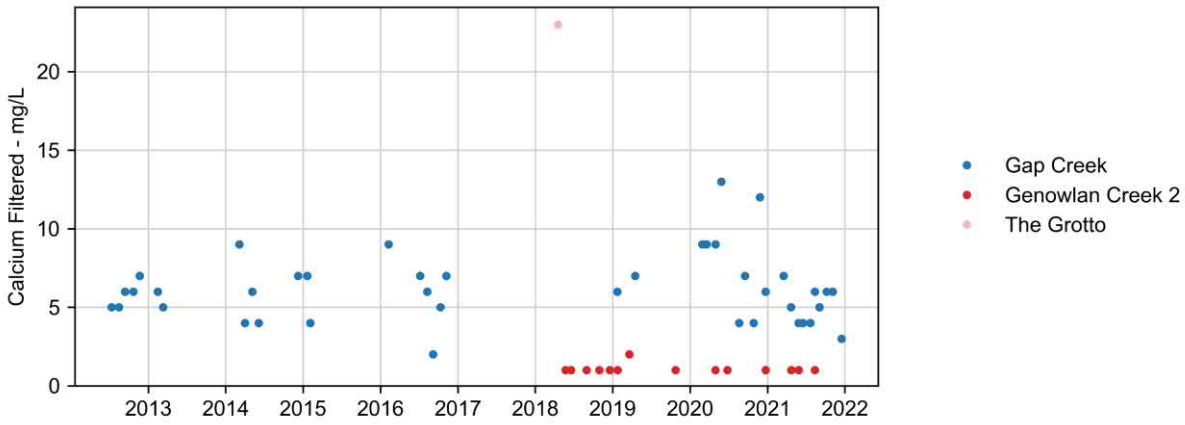

Total Suspended Solids - mg/L
0
10
20
30
40
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Gap Creek
Genowlan Creek 2
The Grotto

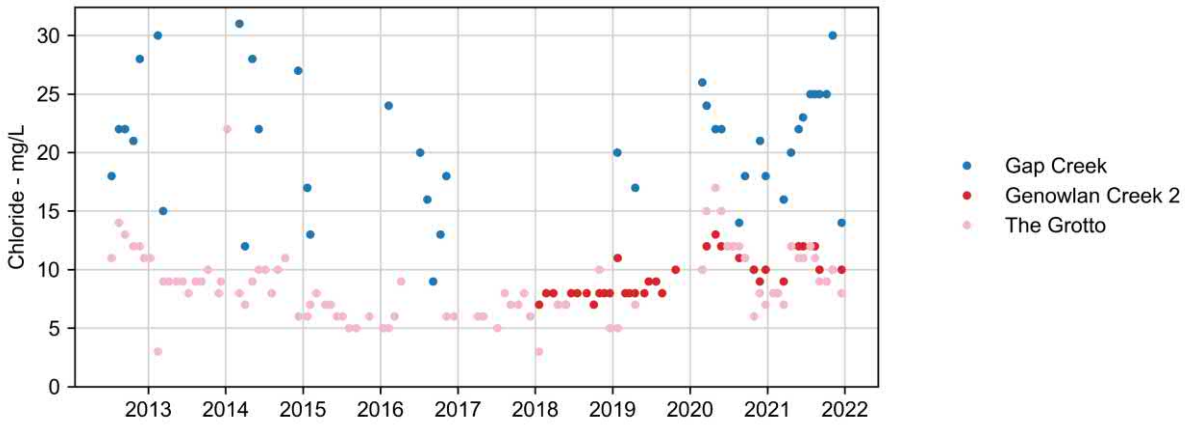

Turbidity - mg/L
0
10
20
30
40
50
60
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Gap Creek
Genowlan Creek 2
The Grotto

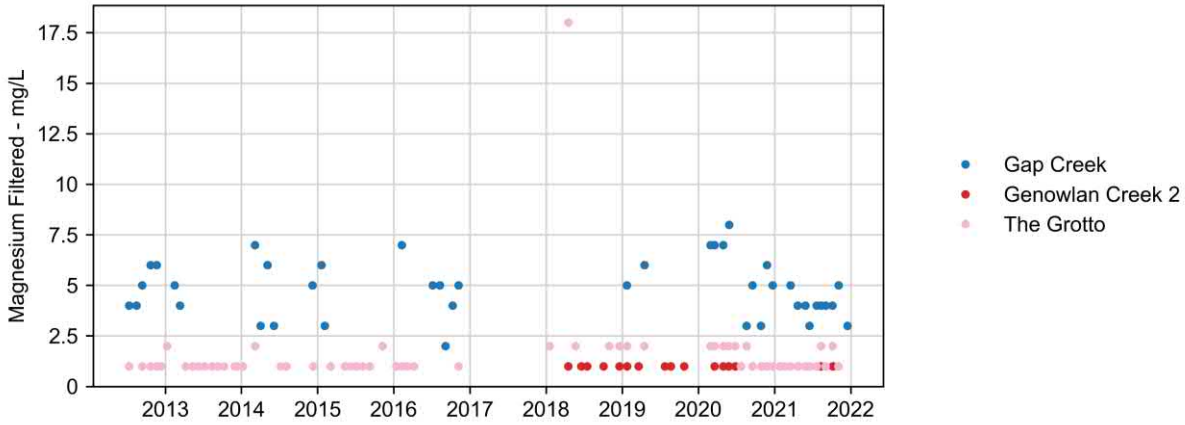
Major Ions

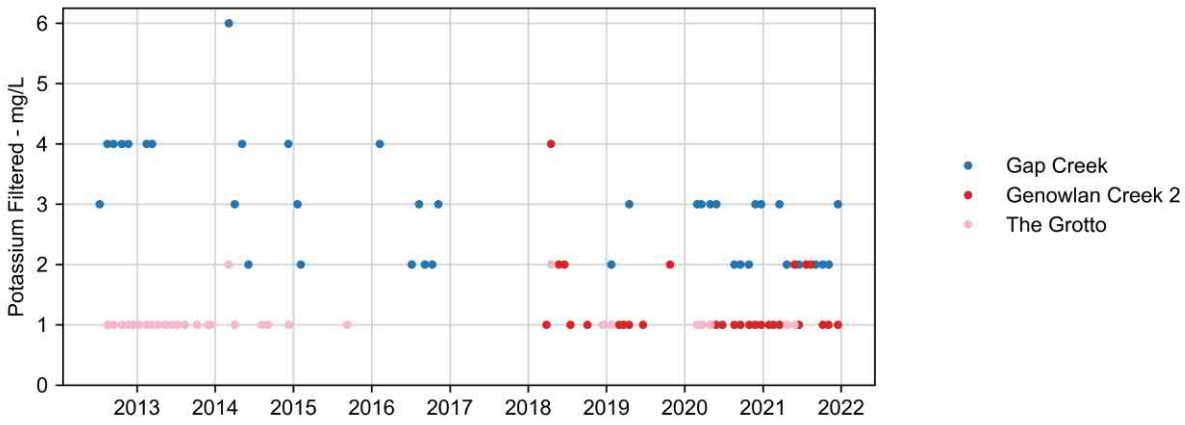

Alkalinity (Bicarbonate as CaCO3) - mg/L
0
10
20
30
40
50
60
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Gap Creek
Genowlan Creek 2
The Grotto

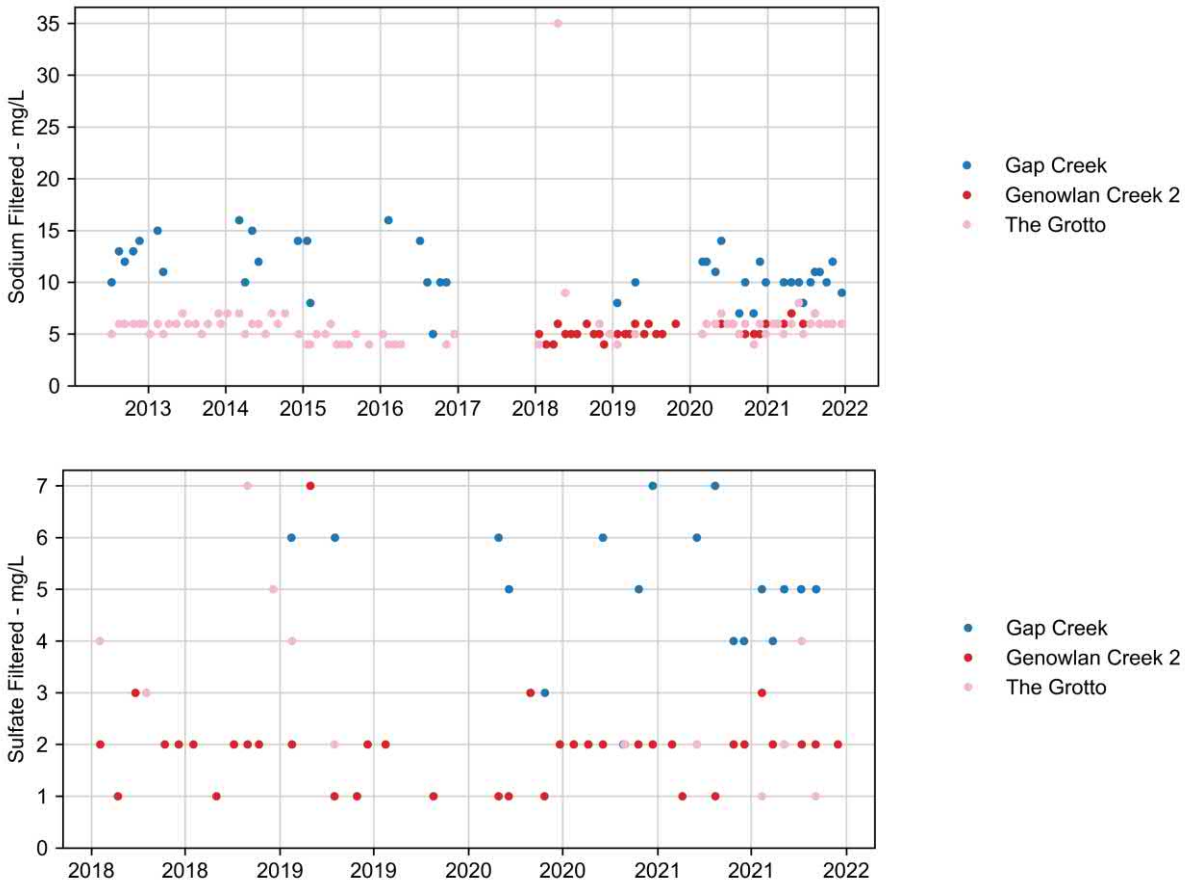

Alkalinity (total as CaCO3) - mg/L
0
10
20
30
40
50
60
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Gap Creek
Genowlan Creek 2
The Grotto


Calcium Filtered - mg/L
0
5
10
15
20
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Gap Creek
Genowlan Creek 2
The Grotto


Chloride - mg/L
0
5
10
15
20
25
30
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Gap Creek
Genowlan Creek 2
The Grotto

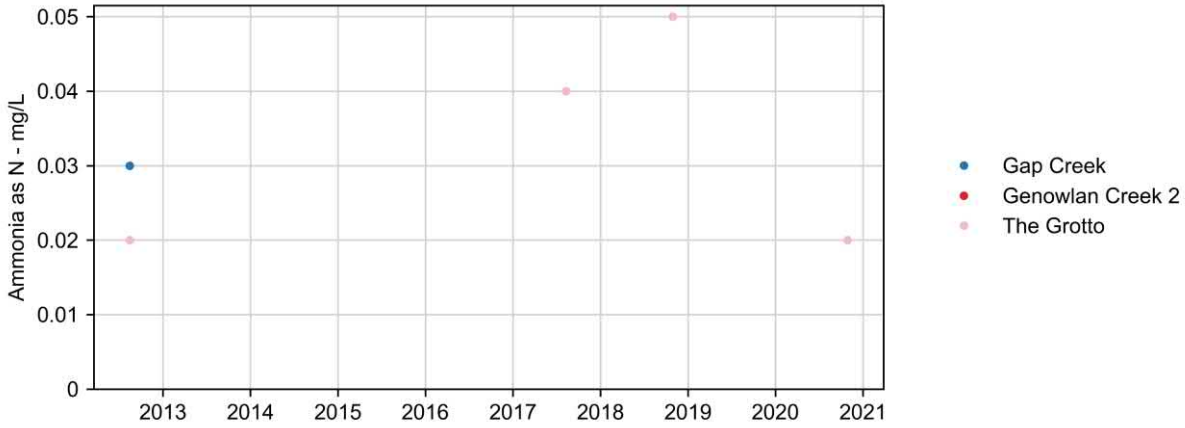

Magnesium Filtered - mg/L
0
2.5
5
7.5
10
12.5
15
17.5
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Gap Creek
Genowlan Creek 2
The Grotto

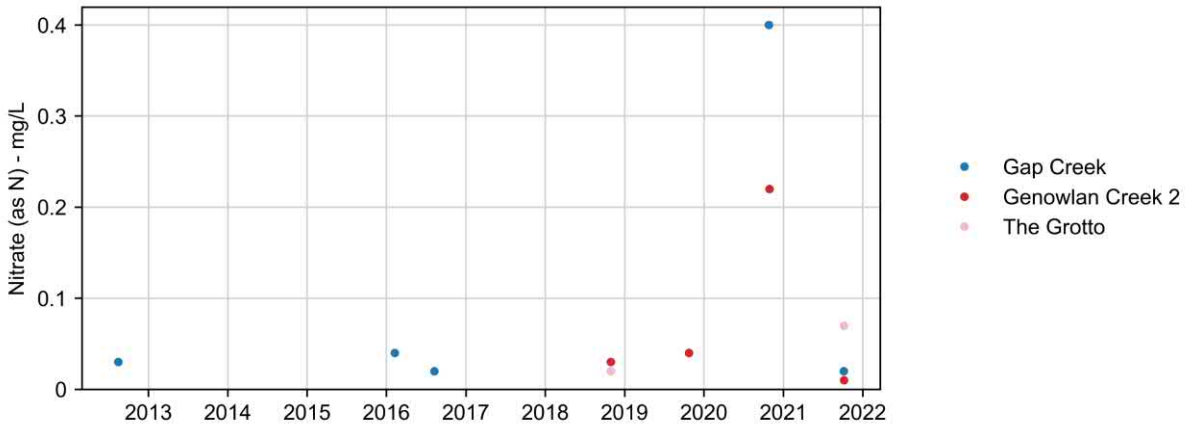

Potassium Filtered - mg/L
0
1
2
3
4
5
6
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Gap Creek
Genowlan Creek 2
The Grotto

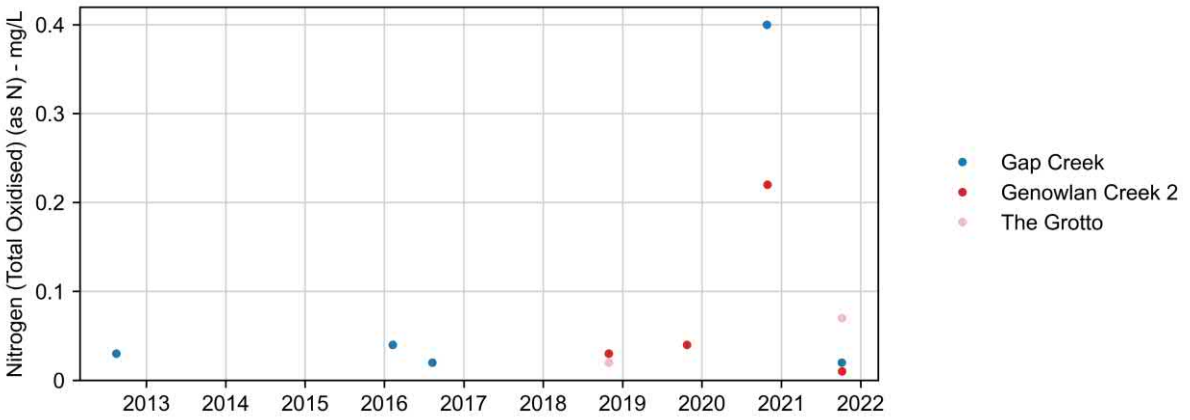

Sodium Filtered - mg/L
0
5
10
15
20
25
30
35
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Gap Creek
Genowlan Creek 2
The Grotto

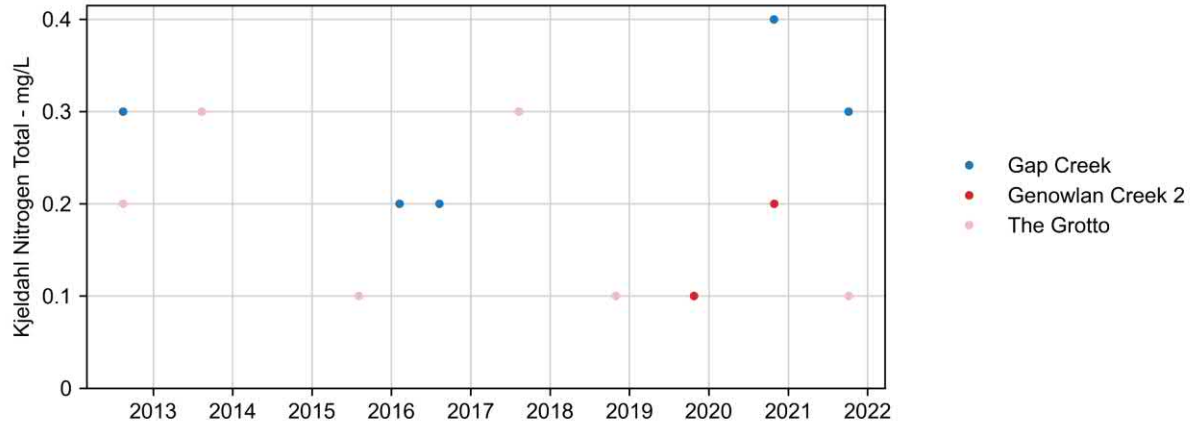
Sulfate Filtered - mg/L
0
1
2
3
4
5
6
7
2018
2018
2019
2019
2020
2020
2021
2021
2022
Gap Creek
Genowlan Creek 2
The Grotto

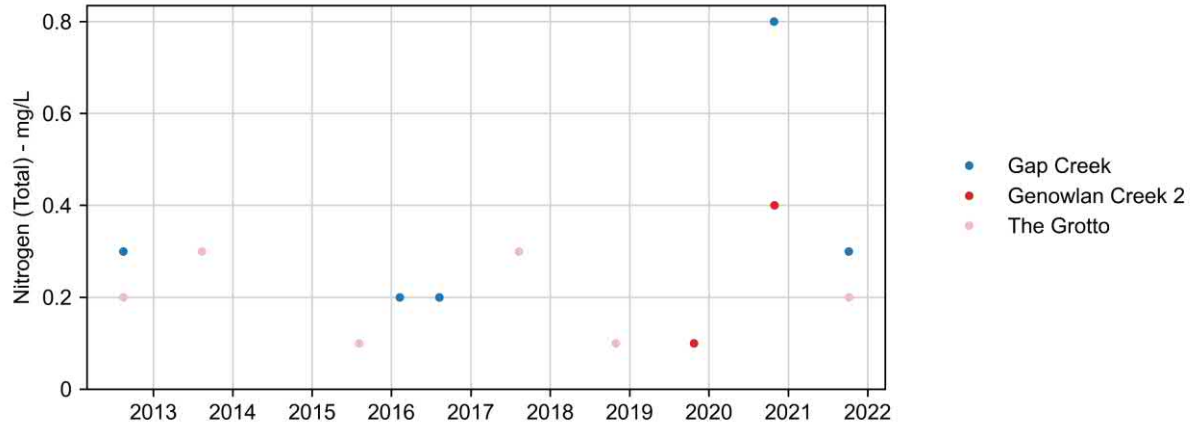
Nutrients

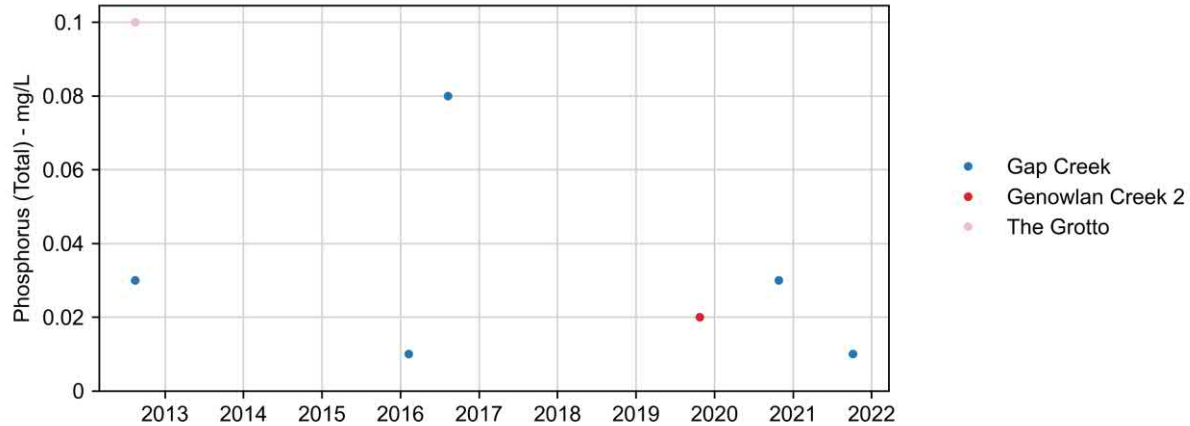

Ammonia as N - mg/L
0
0.01
0.02
0.03
0.04
0.05
2013
2014
2015
2016
2017
2018
2019
2020
2021
Gap Creek
Genowlan Creek 2
The Grotto


Nitrate (as N) - mg/L
0
0.1
0.2
0.3
0.4
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Gap Creek
Genowlan Creek 2
The Grotto


Nitrogen (Total Oxidised) (as N) - mg/L
0.4
0.3
0.2
0.1
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Gap Creek
Genowlan Creek 2
The Grotto

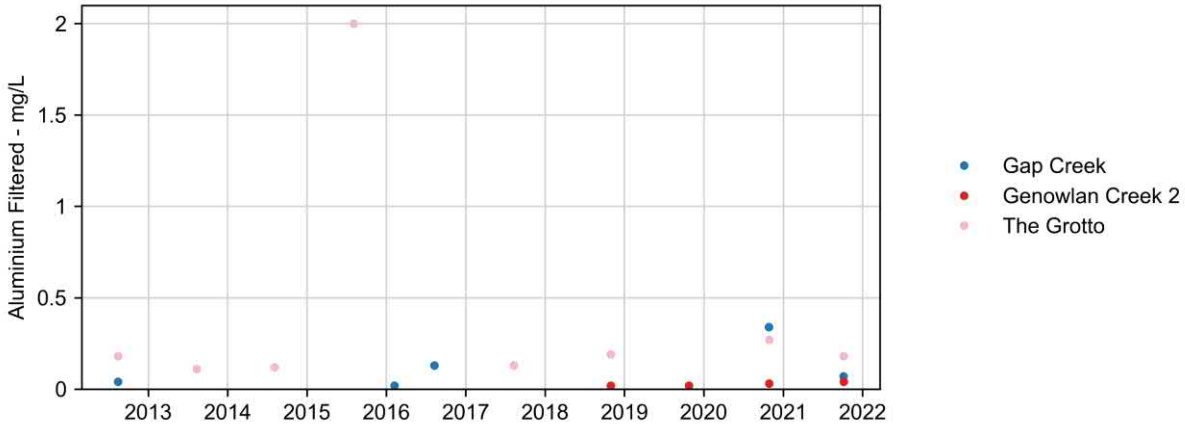

Kjeldahl Nitrogen Total - mg/L
0.4
0.3
0.2
0.1
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Gap Creek
Genowlan Creek 2
The Grotto

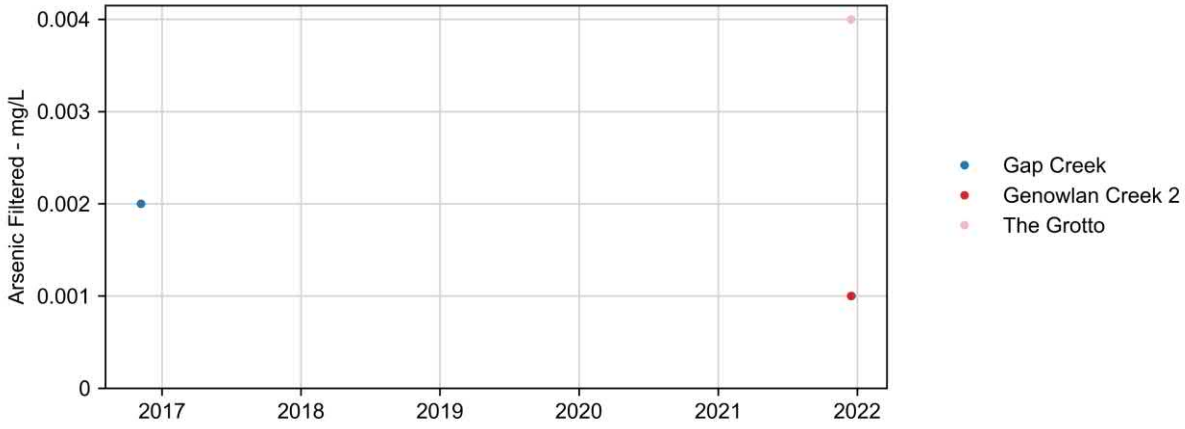

Nitrogen (Total) - mg/L
0.8
0.6
0.4
0.2
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Gap Creek
Genowlan Creek 2
The Grotto

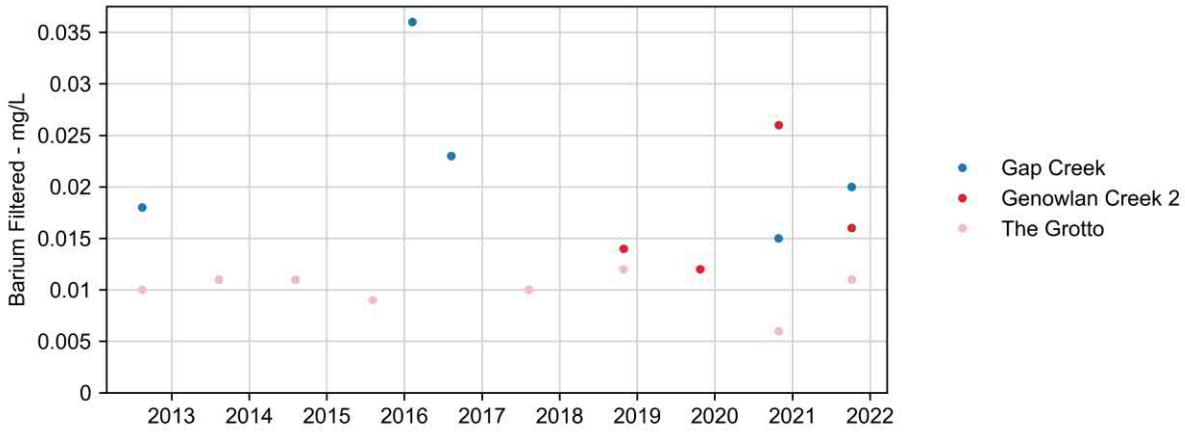

Phosphorus (Total) - mg/L
0.1
0.08
0.06
0.04
0.02
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Gap Creek
Genowlan Creek 2
The Grotto

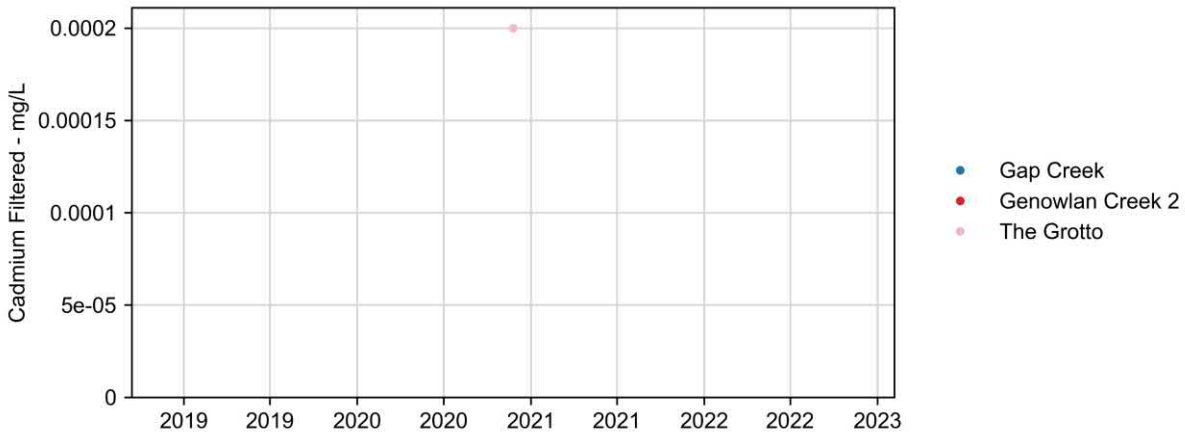
Metals (dissolved)

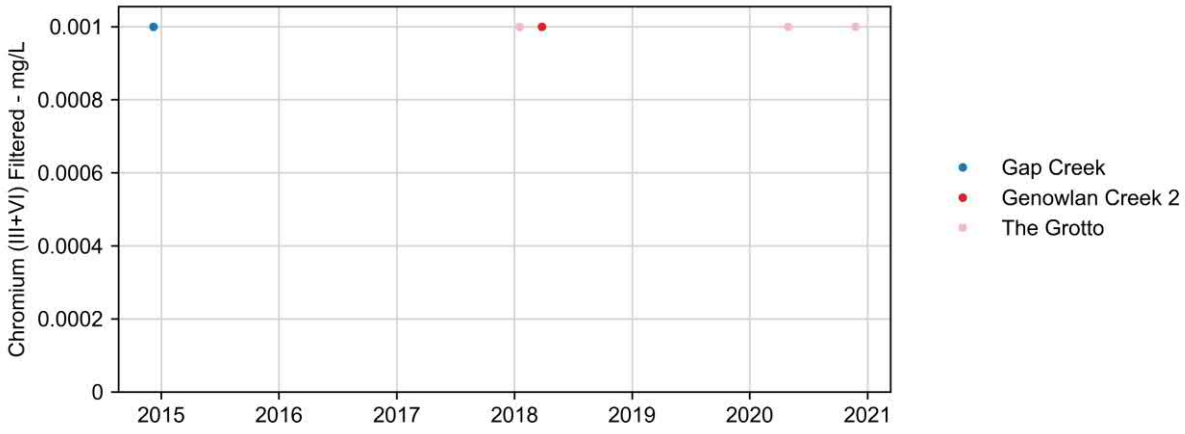
Graphs for dissolved lead, selenium, silver and mercury are not presented as all values are less than the LOR.

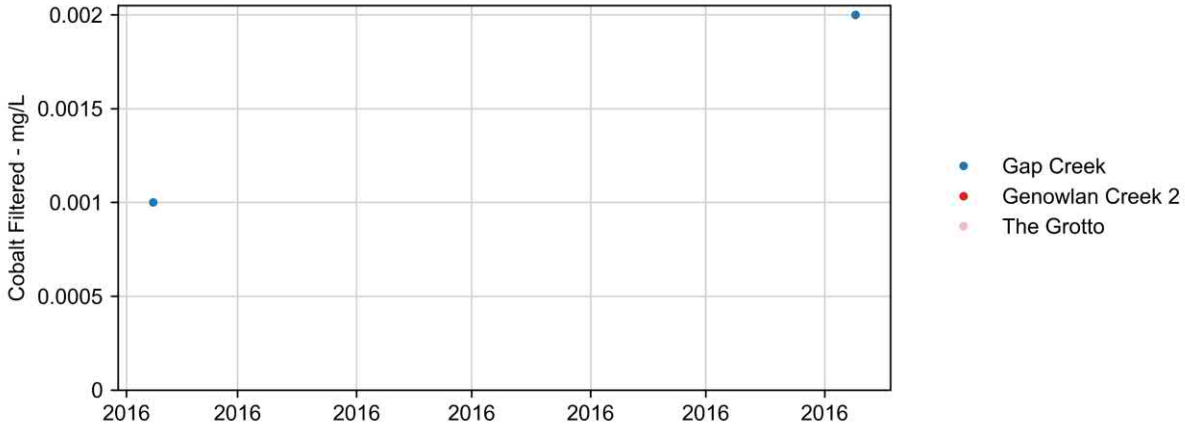


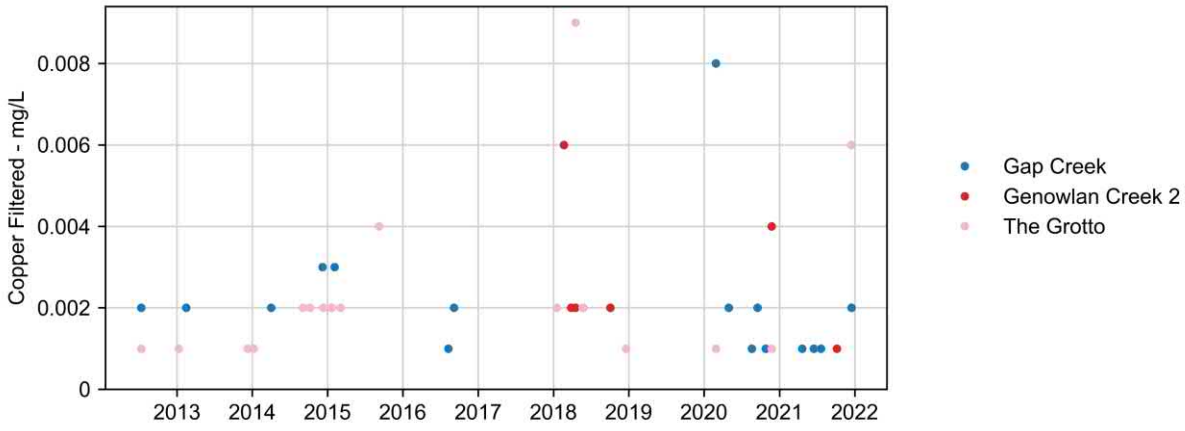


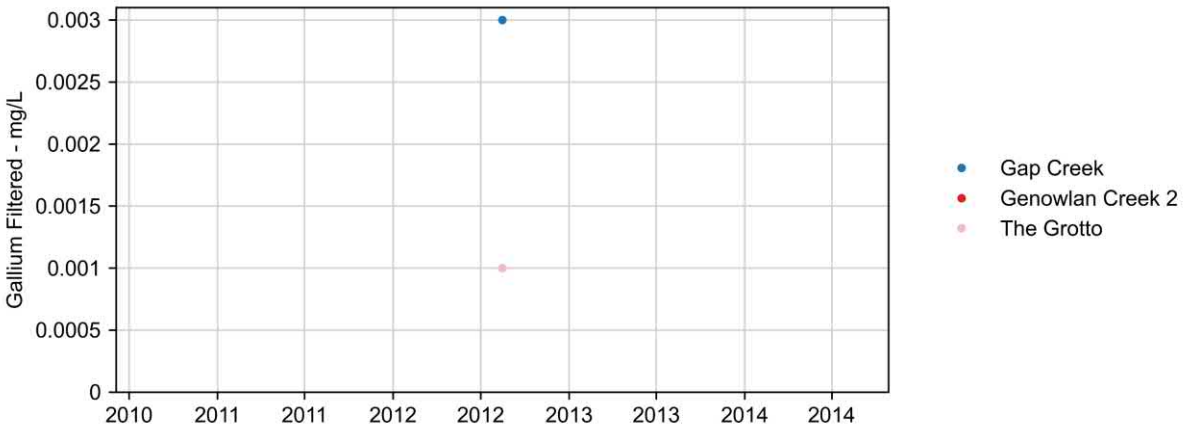


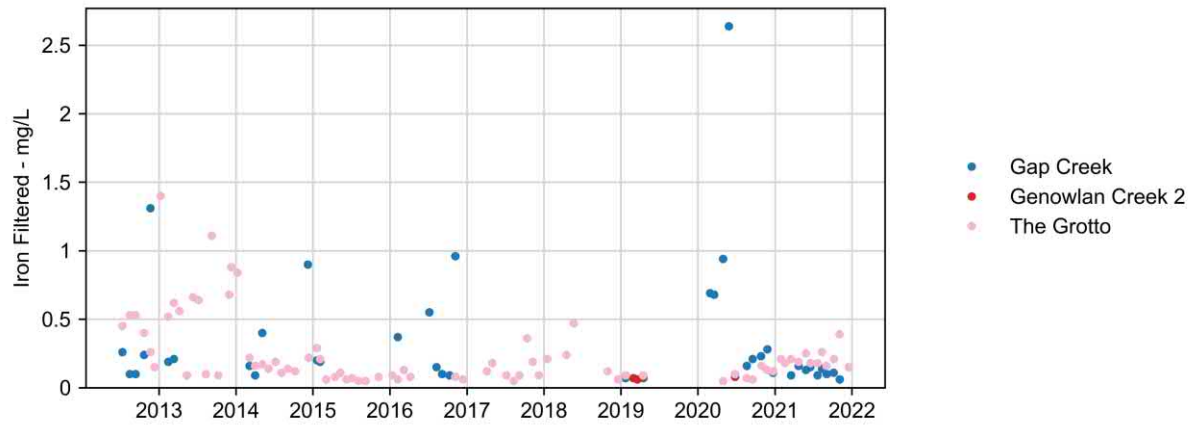

Cadmium Filtered - mg/L
0.0002
0.00015
0.0001
5e-05
0
2019
2019
2020
2020
2021
2021
2022
2022
2023
Gap Creek
Genowlan Creek 2
The Grotto

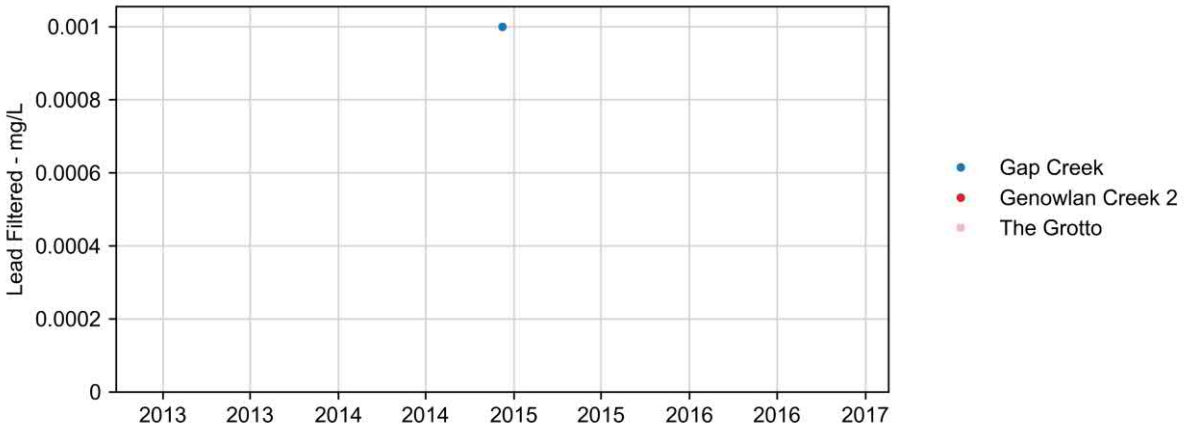

Chromium (III+VI) Filtered - mg/L
0.001
0.0008
0.0006
0.0004
0.0002
0
2015
2016
2017
2018
2019
2020
2021
Gap Creek
Genowlan Creek 2
The Grotto

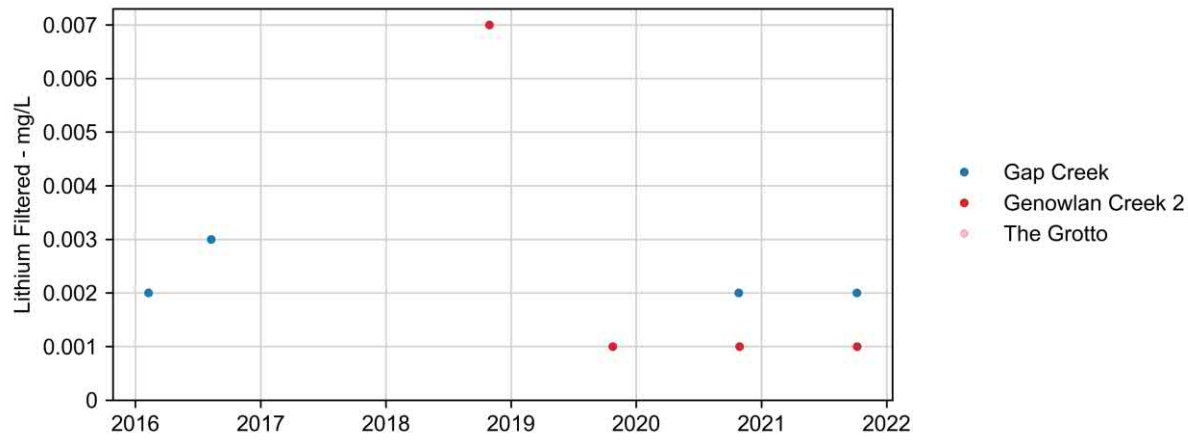

Cobalt Filtered - mg/L
0.002
0.0015
0.001
0.0005
0
2016
2016
2016
2016
2016
2016
2016
Gap Creek
Genowlan Creek 2
The Grotto

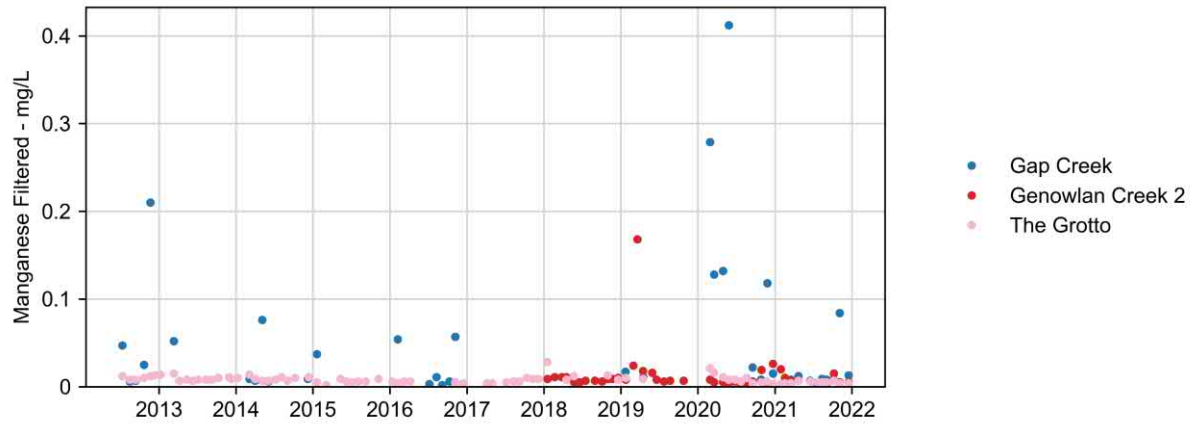

Copper Filtered - mg/L
0.008
0.006
0.004
0.002
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Gap Creek
Genowlan Creek 2
The Grotto

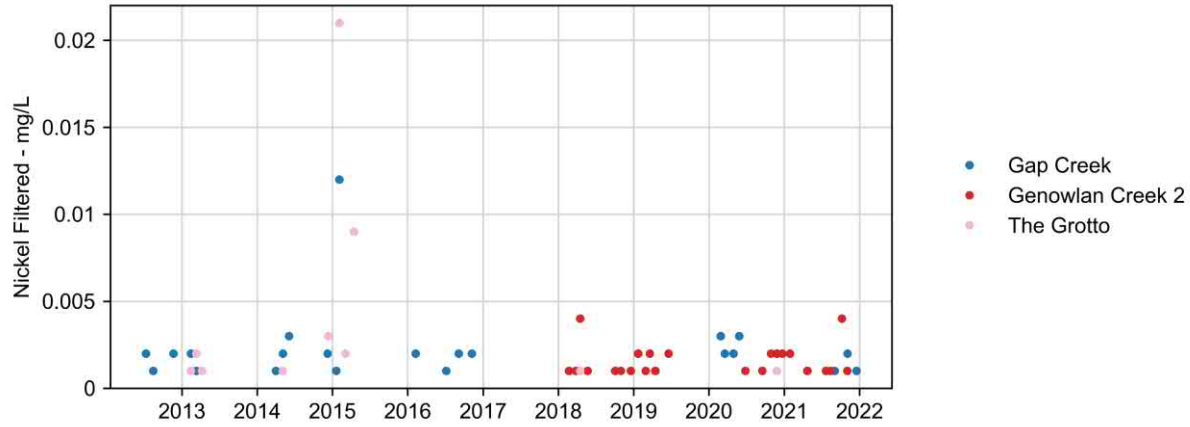

Gallium Filtered - mg/L
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
2010
2011
2011
2012
2012
2013
2013
2014
2014
Gap Creek
Genowlan Creek 2
The Grotto

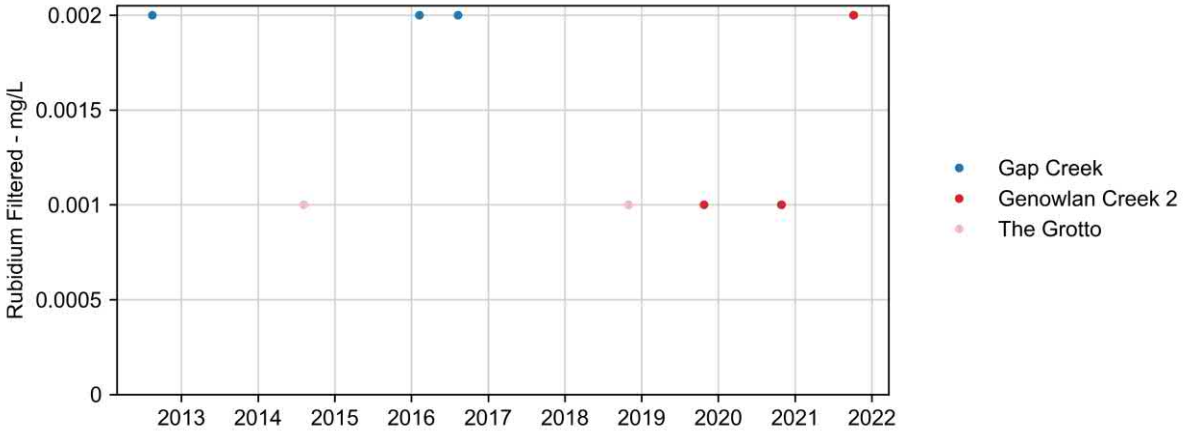

Iron Filtered - mg/L
2.5
2
1.5
1
0.5
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Gap Creek
Genowlan Creek 2
The Grotto

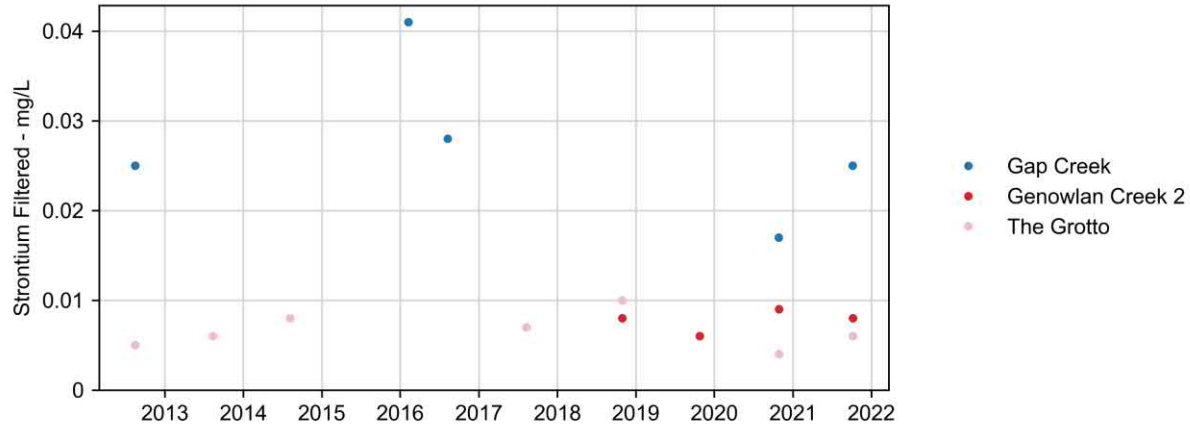

Lead Filtered - mg/L
0.001
0.0008
0.0006
0.0004
0.0002
0
2013
2013
2014
2014
2015
2015
2016
2016
2017
Gap Creek
Genowlan Creek 2
The Grotto

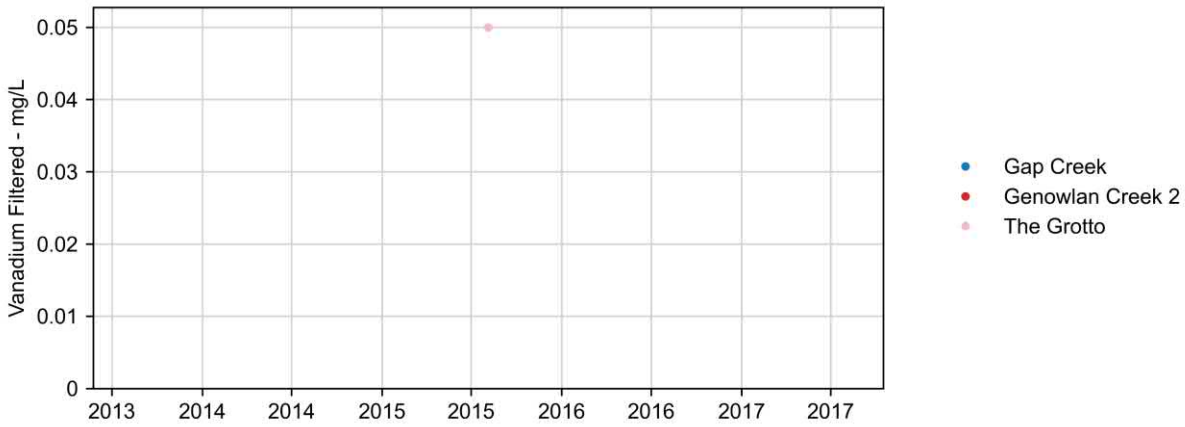

Lithium Filtered - mg/L
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
2016
2017
2018
2019
2020
2021
2022
Gap Creek
Genowlan Creek 2
The Grotto

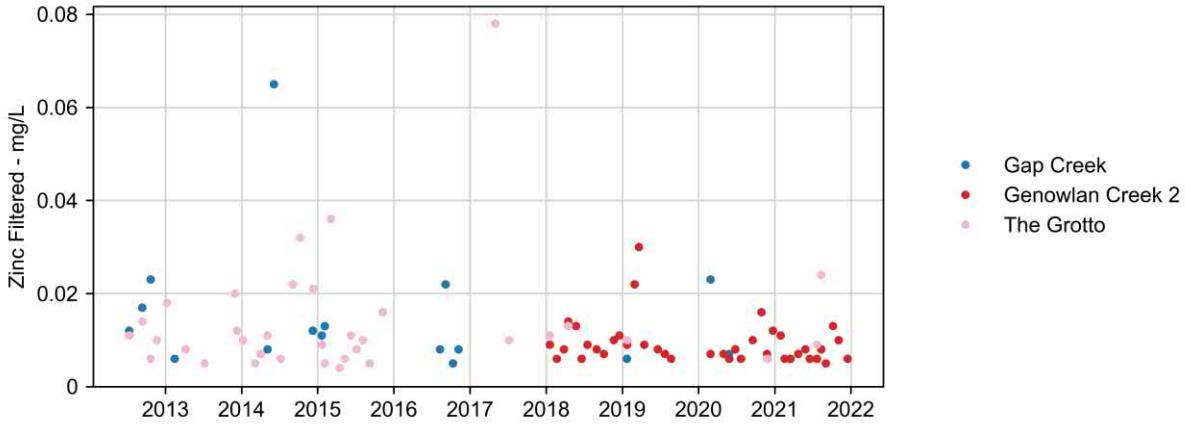

Manganese Filtered - mg/L
0.4
0.3
0.2
0.1
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Gap Creek
Genowlan Creek 2
The Grotto


Nickel Filtered - mg/L
0.02
0.015
0.01
0.005
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Gap Creek
Genowlan Creek 2
The Grotto

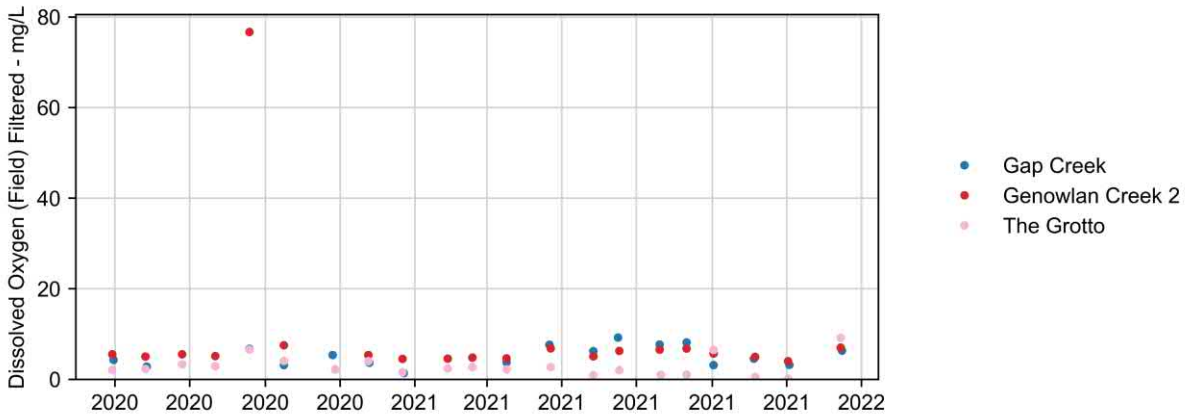

Rubidium Filtered - mg/L
0.002
0.0015
0.001
0.0005
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Gap Creek
Genowlan Creek 2
The Grotto

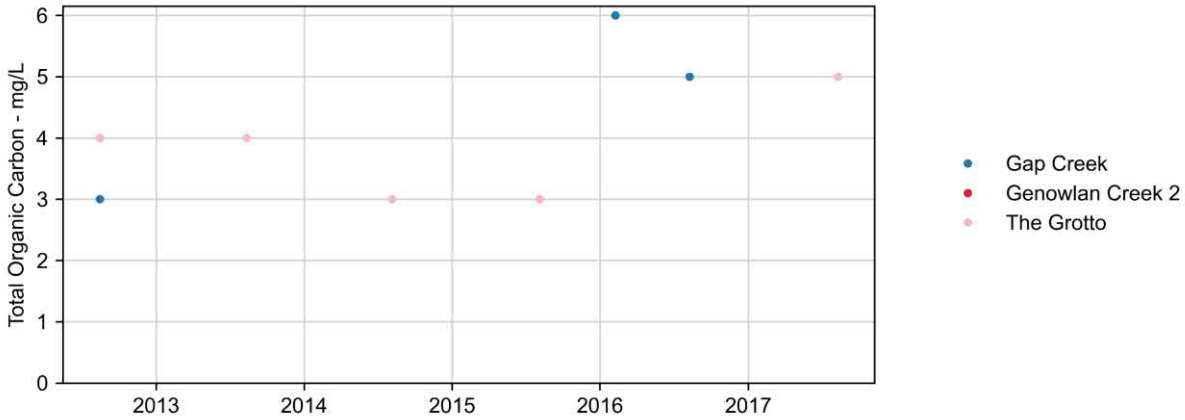

Strontium Filtered - mg/L
0.04
0.03
0.02
0.01
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Gap Creek
Genowlan Creek 2
The Grotto

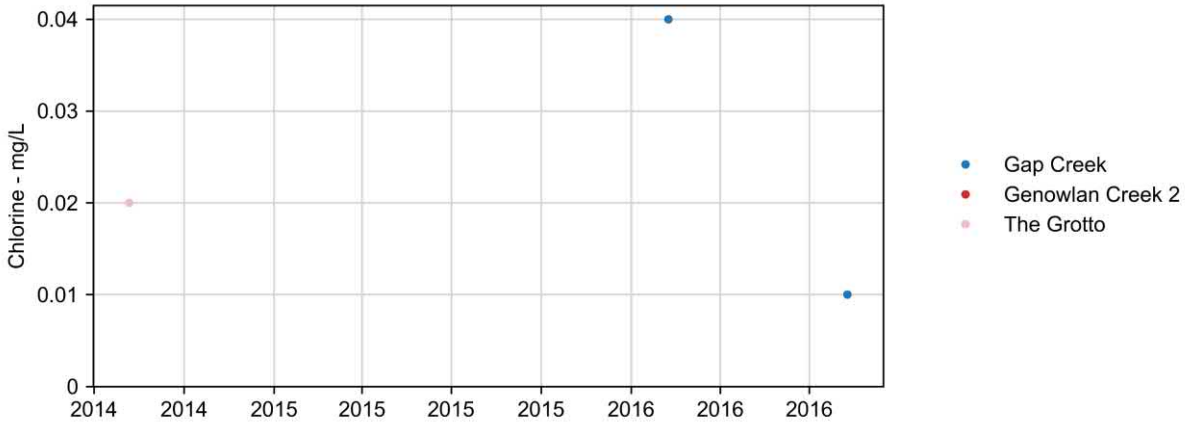

Vanadium Filtered - mg/L
0.05
0.04
0.03
0.02
0.01
0
2013
2014
2014
2015
2015
2016
2016
2017
2017
Gap Creek
Genowlan Creek 2
The Grotto

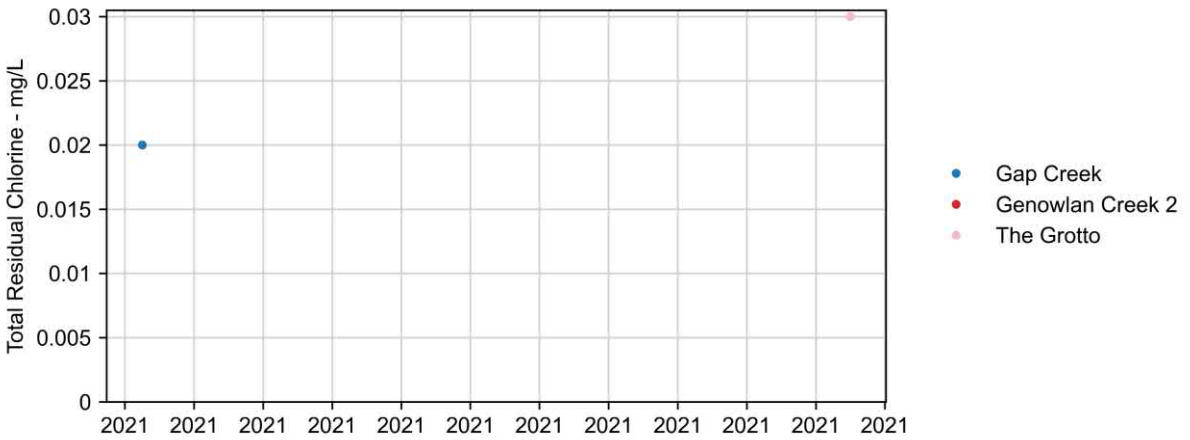

Zinc Filtered - mg/L
0.08
0.06
0.04
0.02
0
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Gap Creek
Genowlan Creek 2
The Grotto

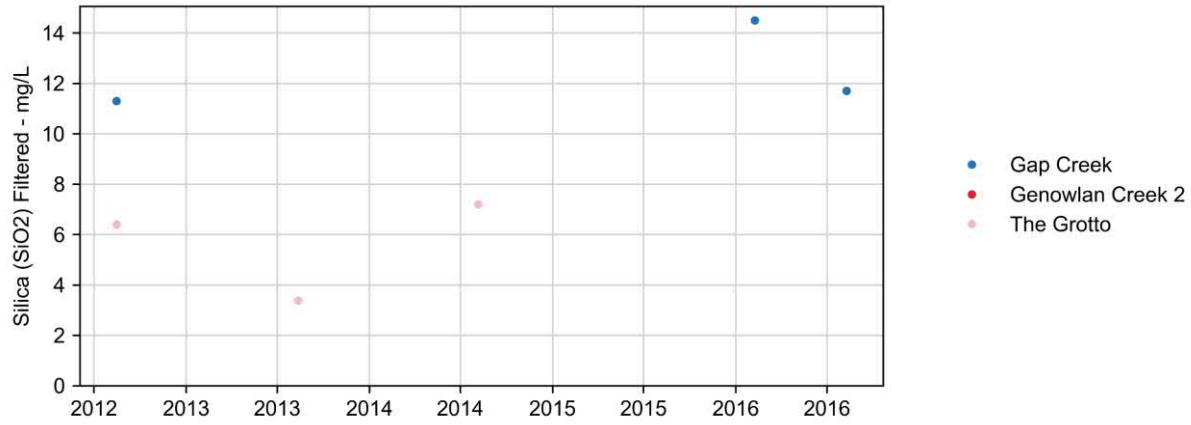
Other

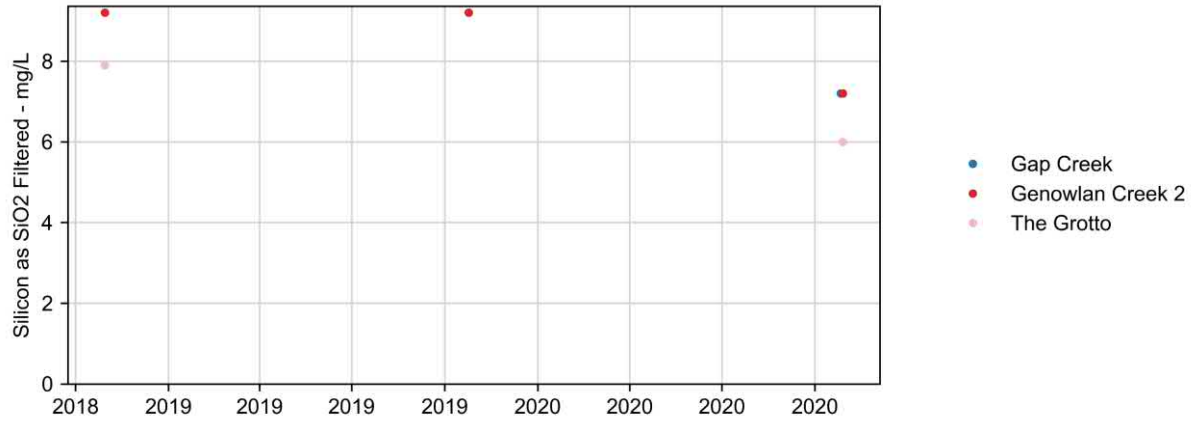

Dissolved Oxygen (Field) Filtered - mg/L
80
60
40
20
0
2020
2020
2020
2020
2021
2021
2021
2021
2021
2021
2022
Gap Creek
Genowlan Creek 2
The Grotto

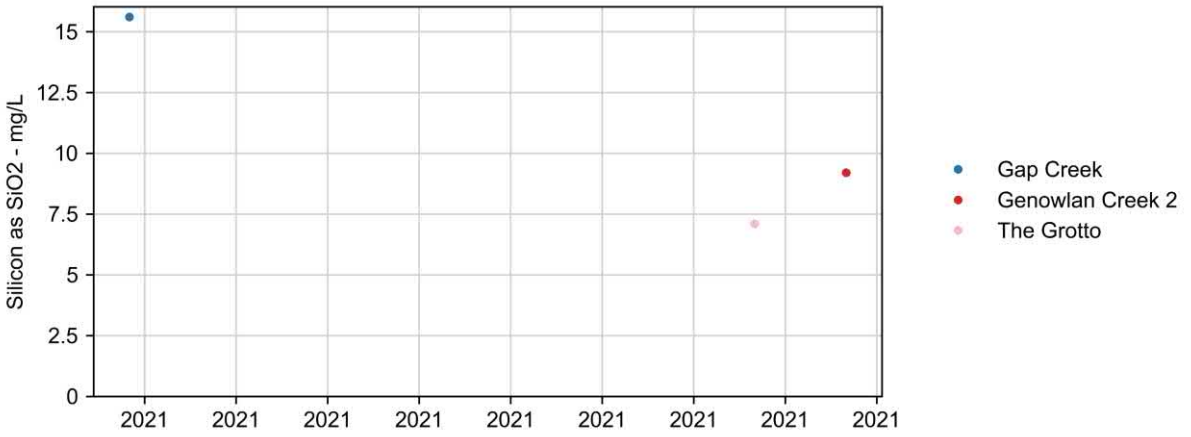

Total Organic Carbon - mg/L
6
5
4
3
2
1
0
2013
2014
2015
2016
2017
Gap Creek
Genowlan Creek 2
The Grotto


Chlorine - mg/L
0.04
0.03
0.02
0.01
0
2014
2014
2015
2015
2015
2015
2016
2016
2016
Gap Creek
Genowlan Creek 2
The Grotto


Total Residual Chlorine - mg/L
0.03
0.025
0.02
0.015
0.01
0.005
0
2021
2021
2021
2021
2021
2021
2021
2021
2021
2021
2021
Gap Creek
Genowlan Creek 2
The Grotto

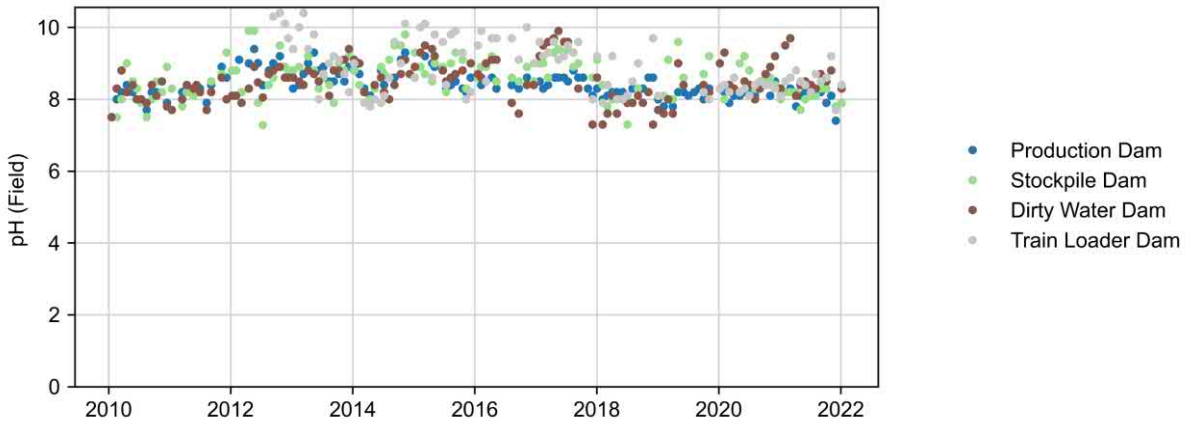

Silica (SiO2) Filtered - mg/L
0
2
4
6
8
10
12
14
2012
2013
2013
2014
2014
2015
2015
2016
2016
Gap Creek
Genowlan Creek 2
The Grotto

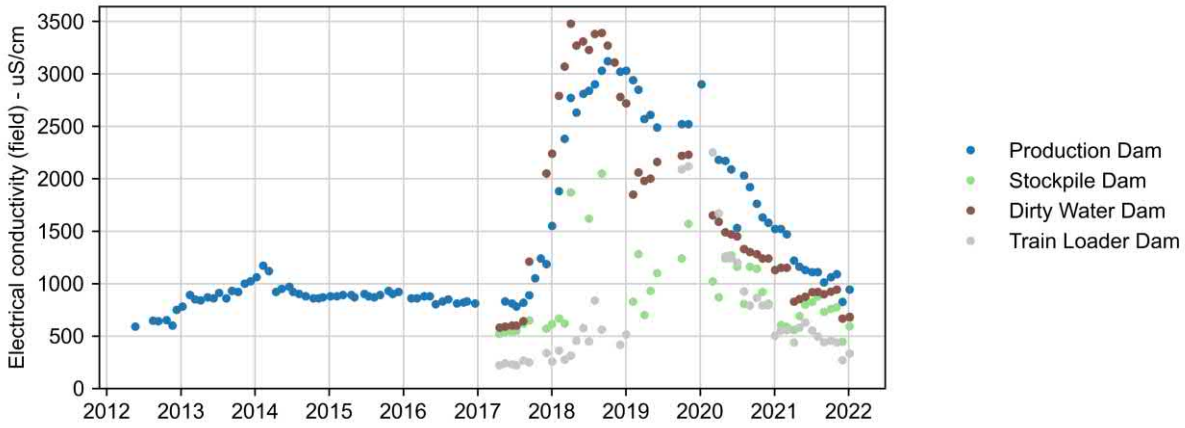

Silicon as SiO2 Filtered - mg/L
0
2
4
6
8
2018
2019
2019
2019
2019
2020
2020
2020
2020
Gap Creek
Genowlan Creek 2
The Grotto

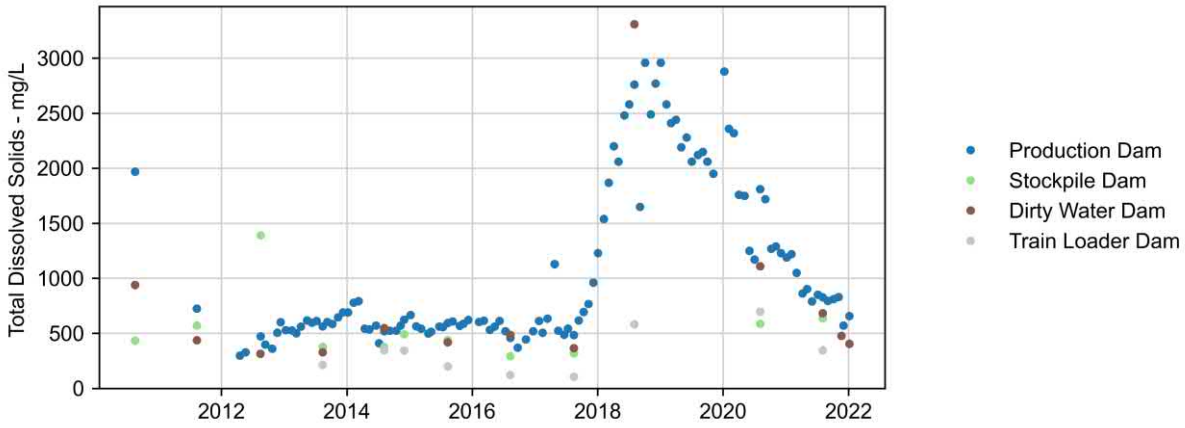

Silicon as SiO2 - mg/L
0
2.5
5
7.5
10
12.5
15
2021
2021
2021
2021
2021
2021
2021
2021
2021
Gap Creek
Genowlan Creek 2
The Grotto

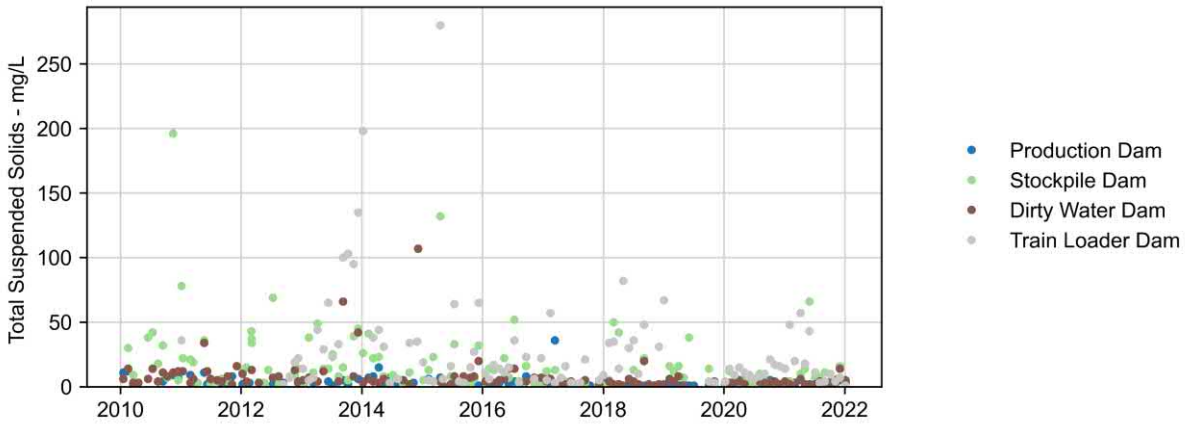
Dam water quality

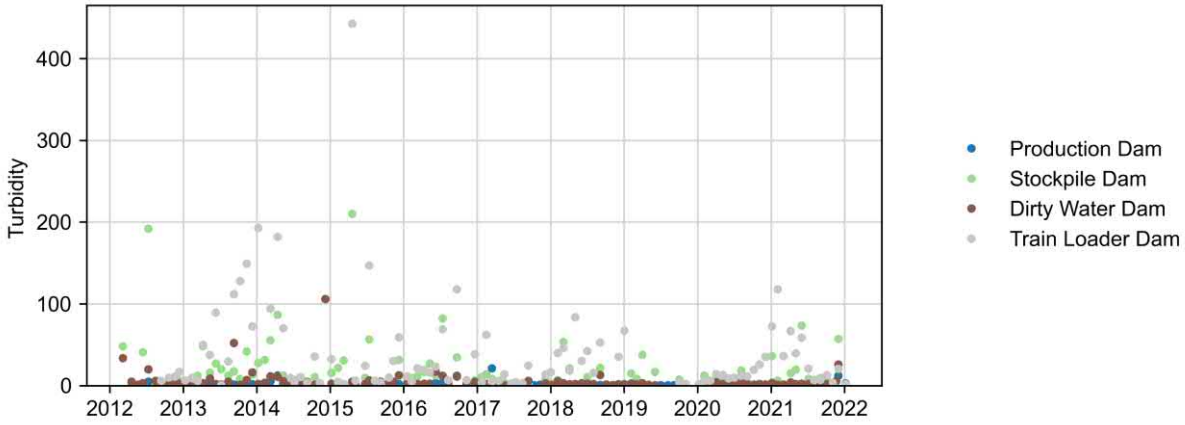
Physiochemical parameters



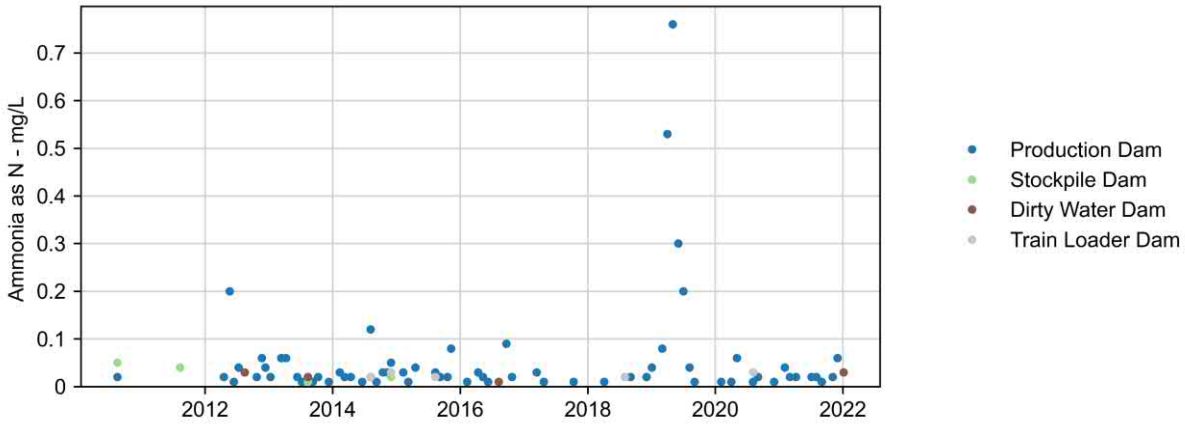


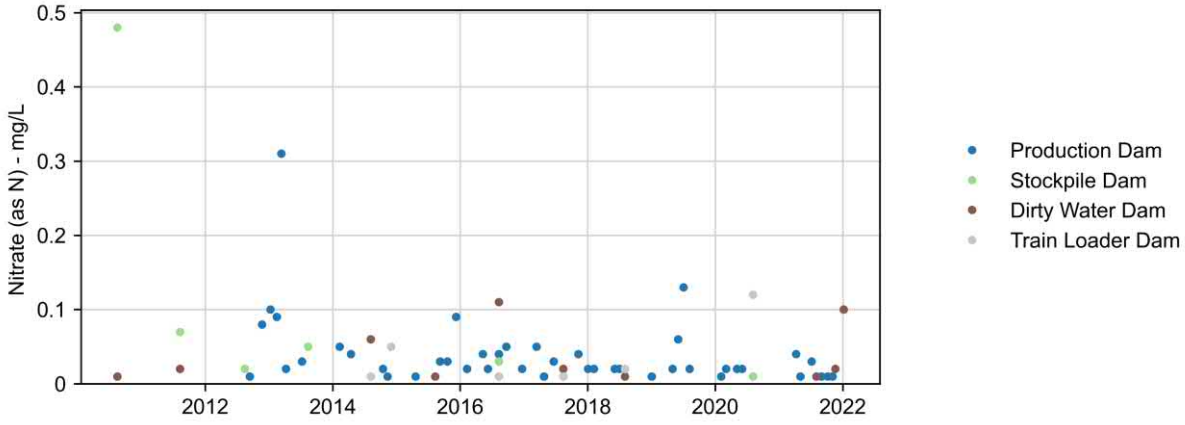


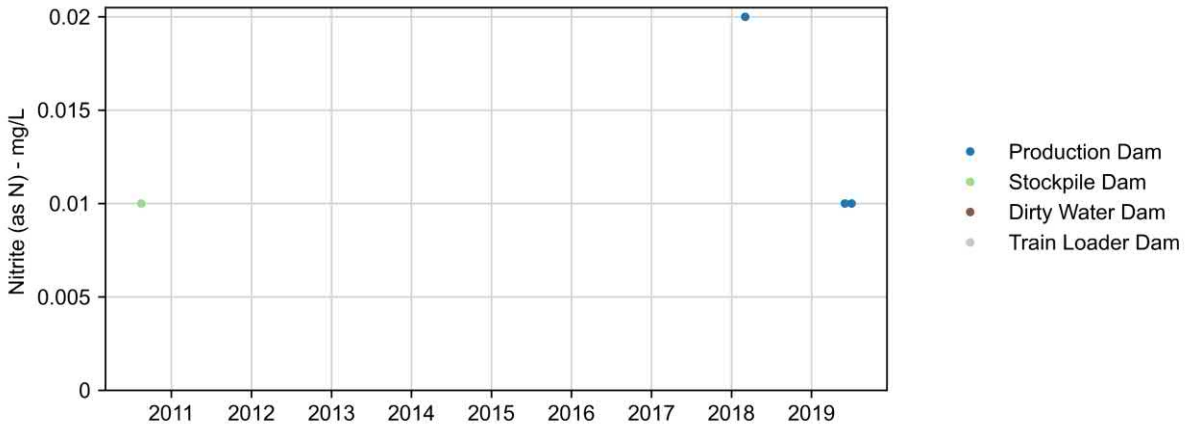

Total Suspended Solids - mg/L
0
50
100
150
200
250
2010
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

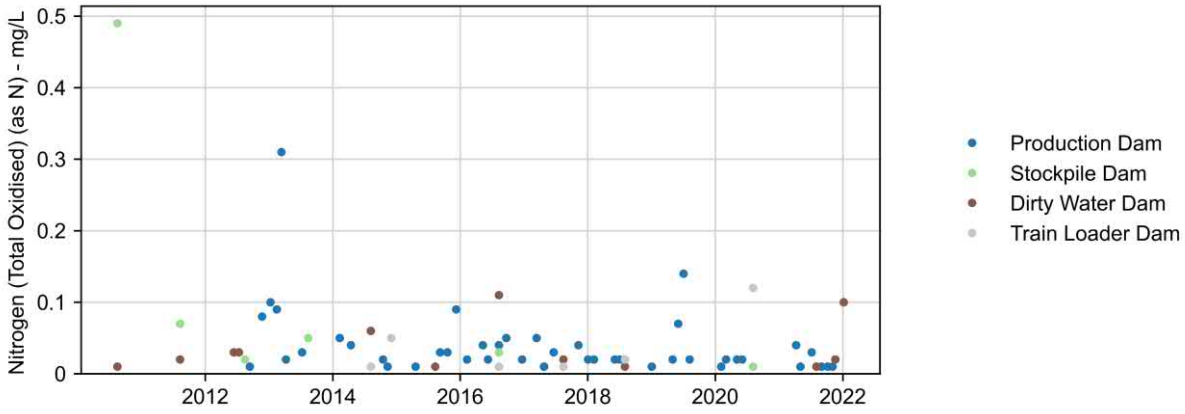

Turbidity
0
100
200
300
400
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

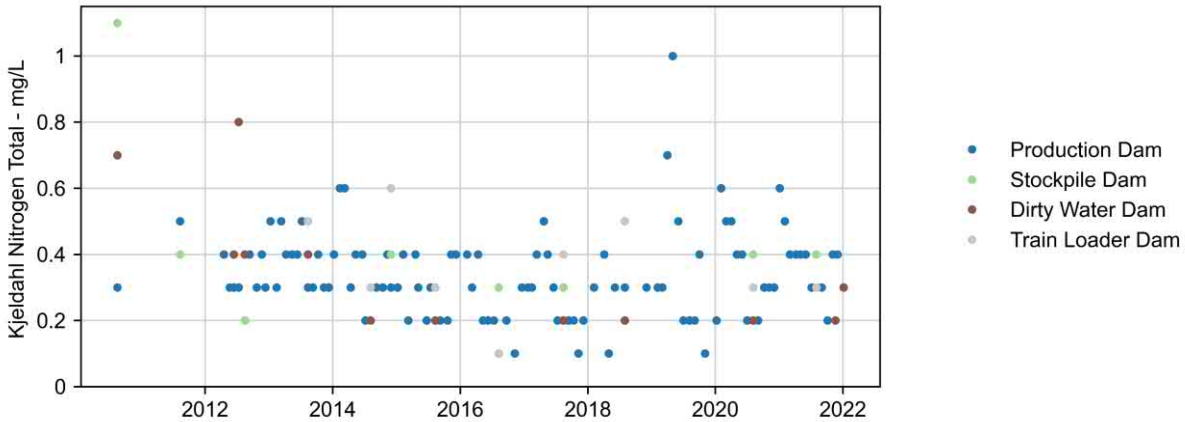
Nutrients

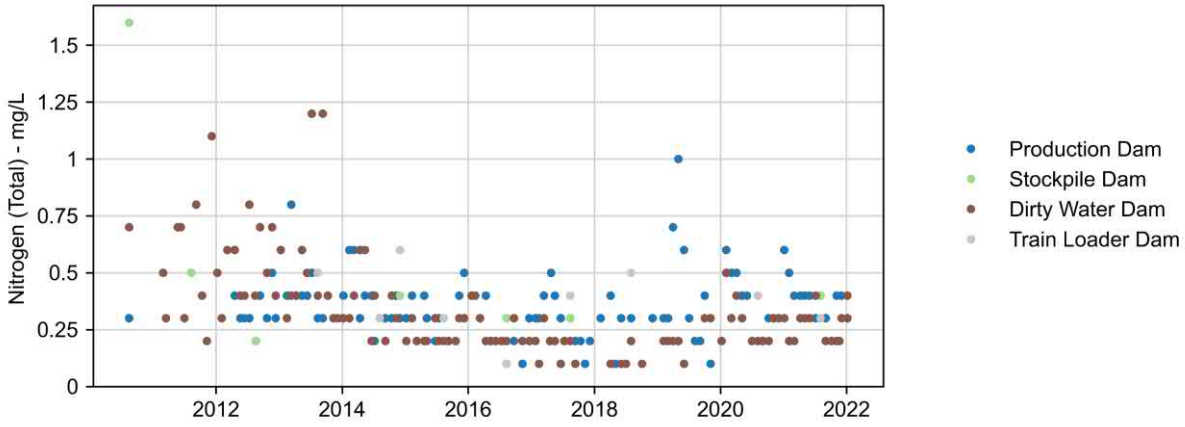

Ammonia as N - mg/L
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

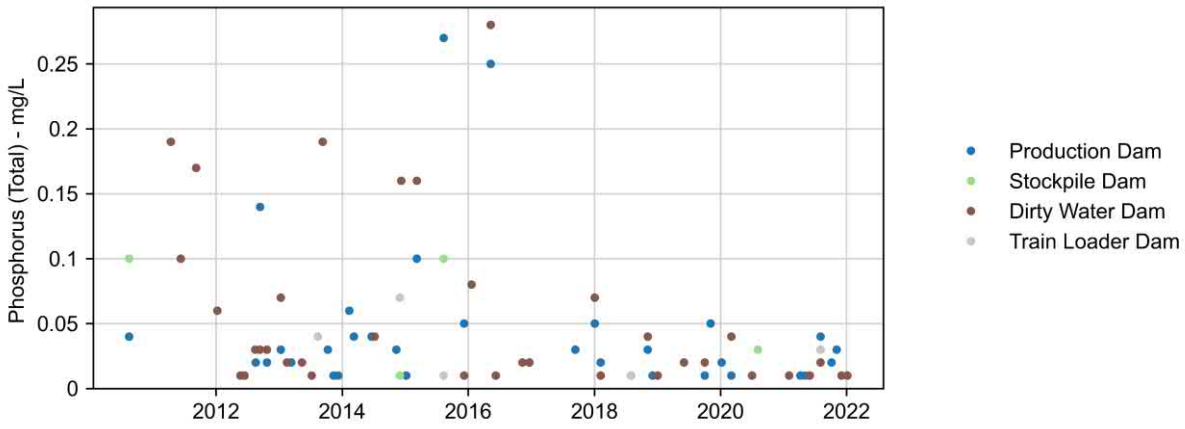

Nitrate (as N) - mg/L
0
0.1
0.2
0.3
0.4
0.5
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam


Nitrite (as N) - mg/L
0.02
0.015
0.01
0.005
0
2011
2012
2013
2014
2015
2016
2017
2018
2019
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

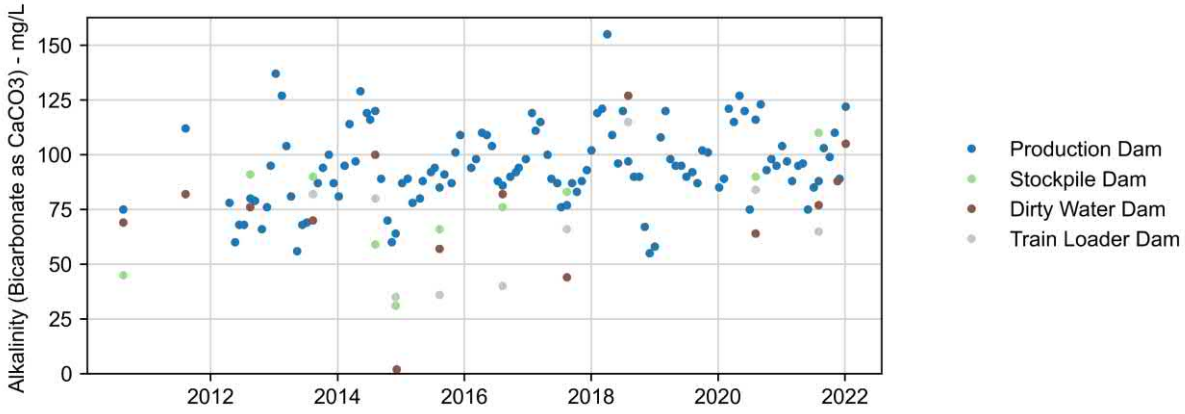

Nitrogen (Total Oxidised) (as N) - mg/L
0.5
0.4
0.3
0.2
0.1
0
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

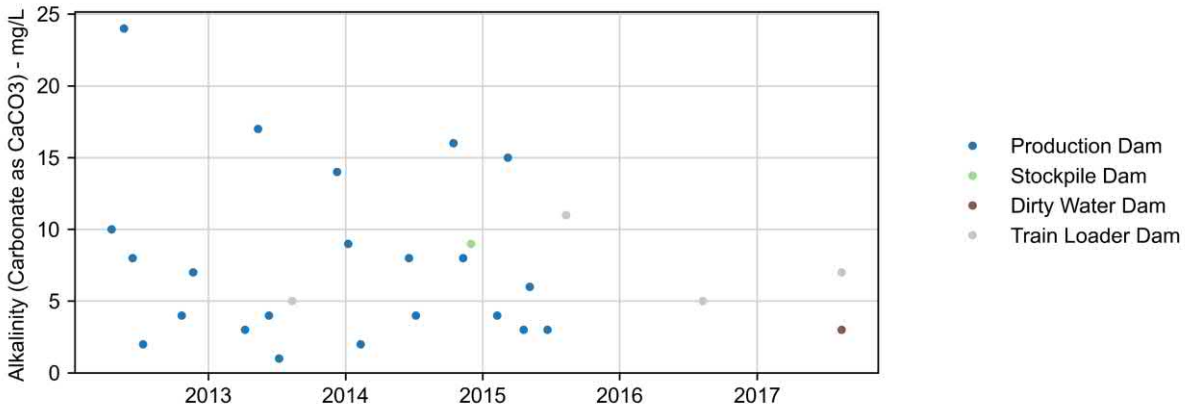

Kjeldahl Nitrogen Total - mg/L
1
0.8
0.6
0.4
0.2
0
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

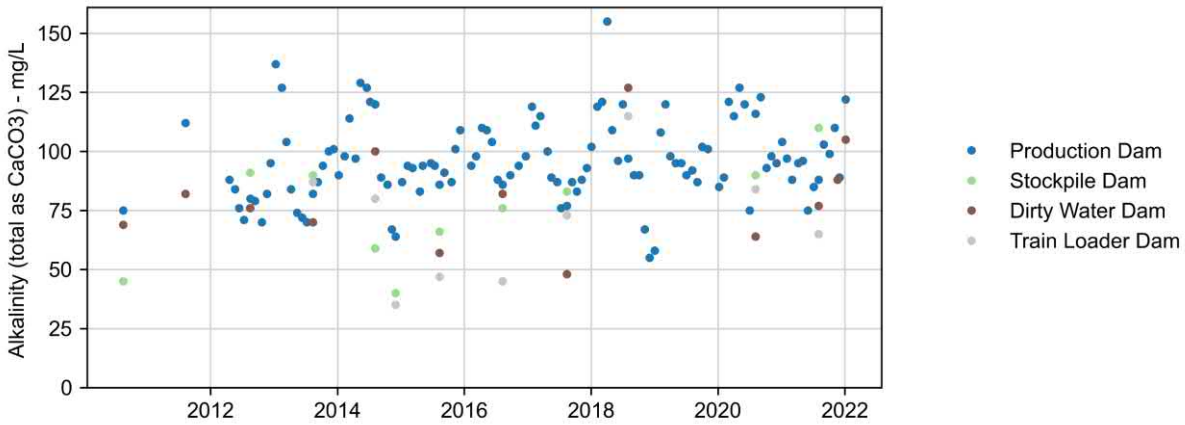

Nitrogen (Total) - mg/L
1.5
1.25
1
0.75
0.5
0.25
0
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

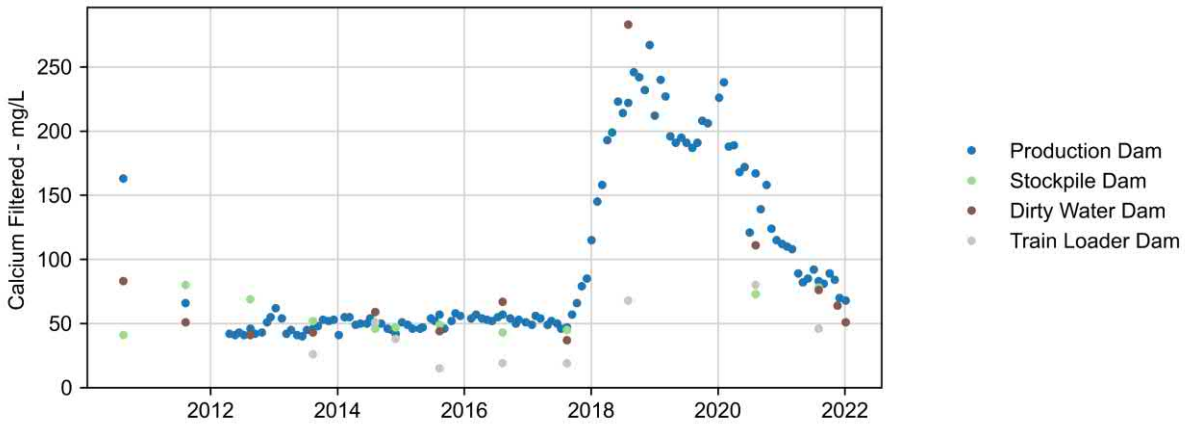

Phosphorus (Total) - mg/L
0.25
0.2
0.15
0.1
0.05
0
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

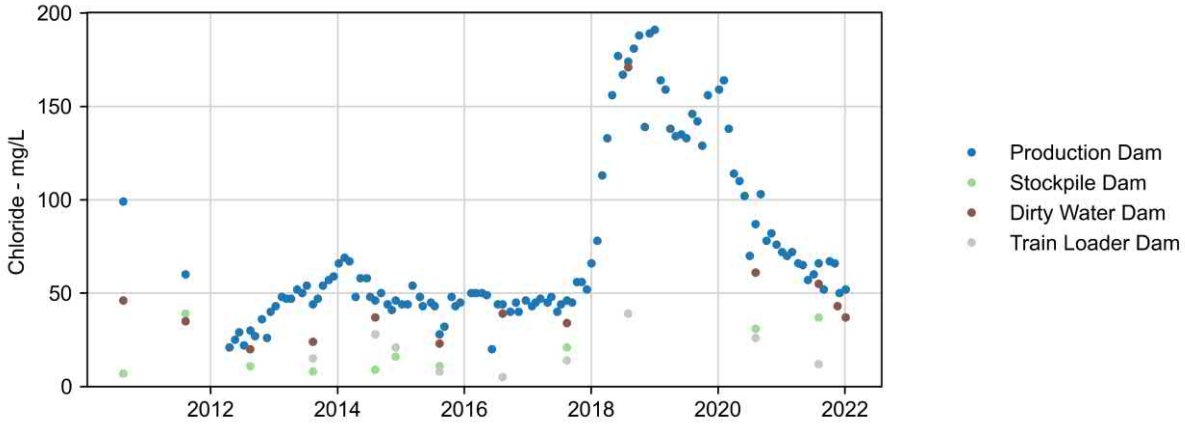
Major ions

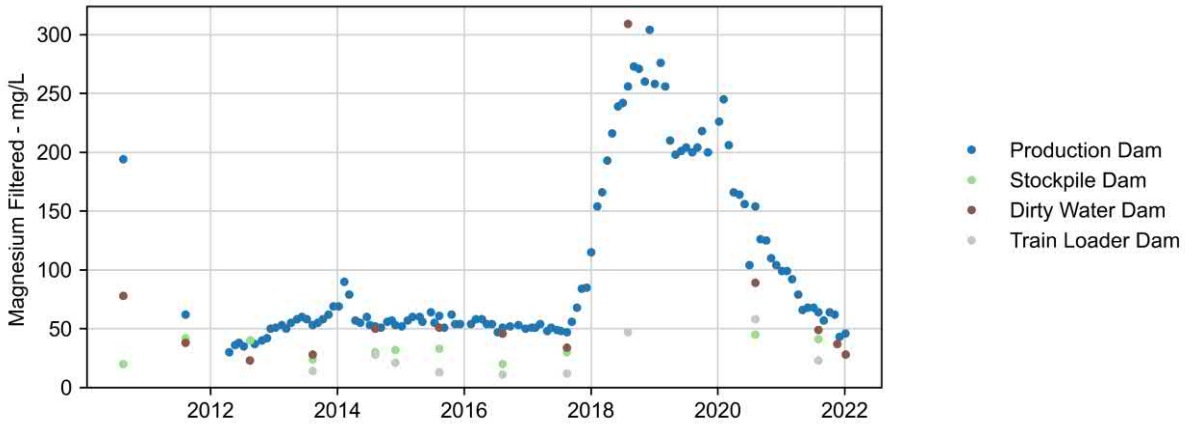

Alkalinity (Bicarbonate as CaCO3) - mg/L
150
125
100
75
50
25
0
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

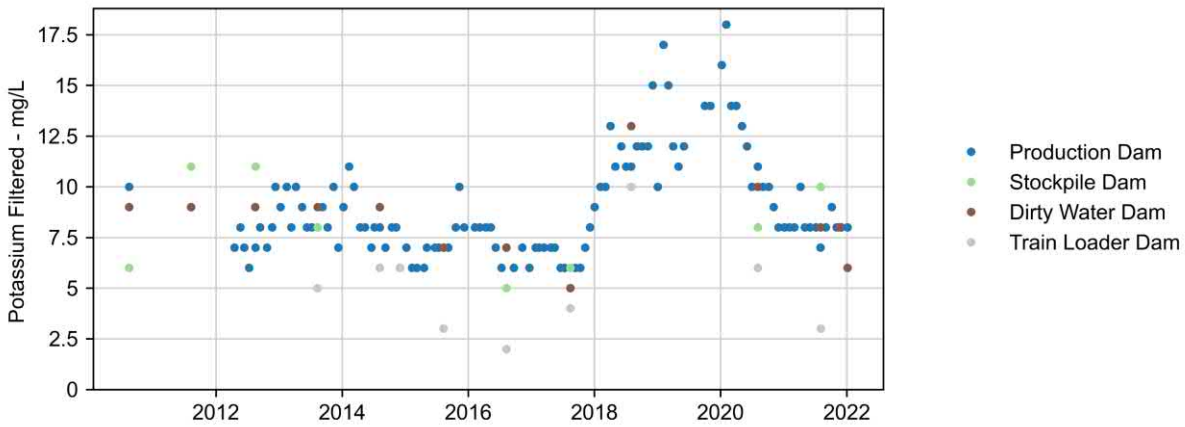

Alkalinity (Carbonate as CaCO3) - mg/L
25
20
15
10
5
0
2013
2014
2015
2016
2017
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

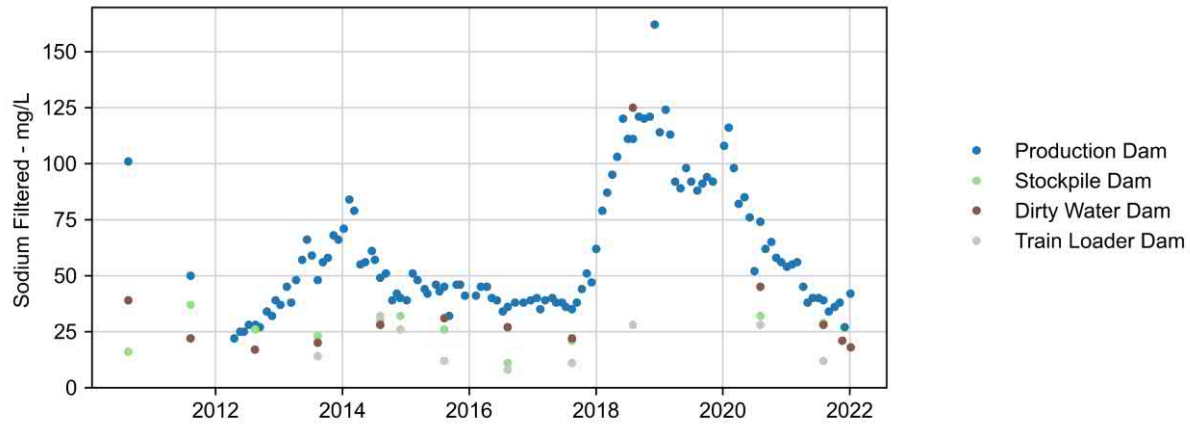

Alkalinity (total as CaCO3) - mg/L
150
125
100
75
50
25
0
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

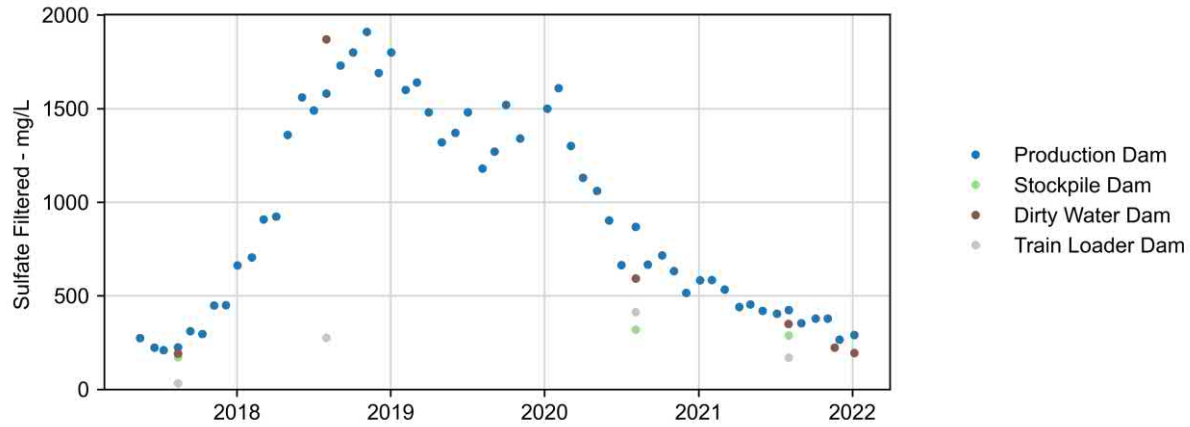

Calcium Filtered - mg/L
0
50
100
150
200
250
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

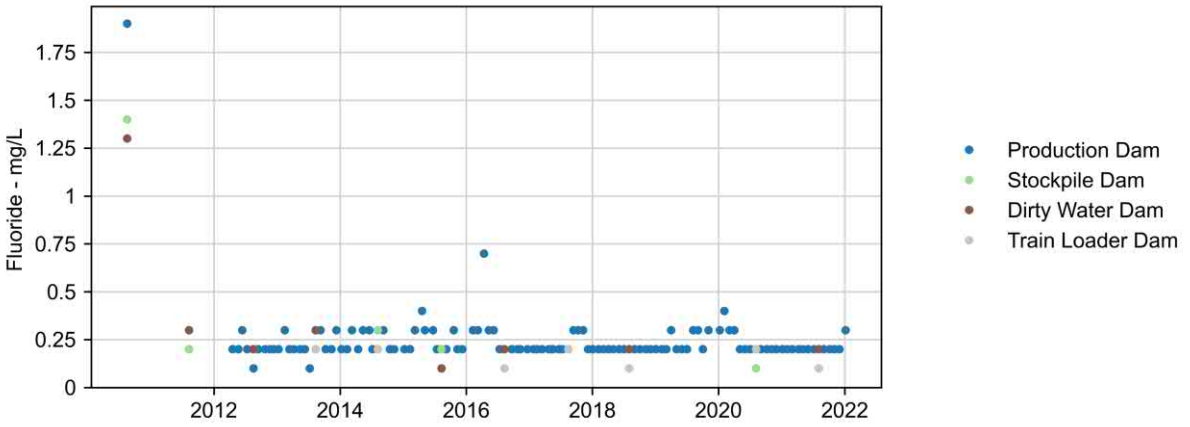

Chloride - mg/L
0
50
100
150
200
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam


Magnesium Filtered - mg/L
0
50
100
150
200
250
300
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

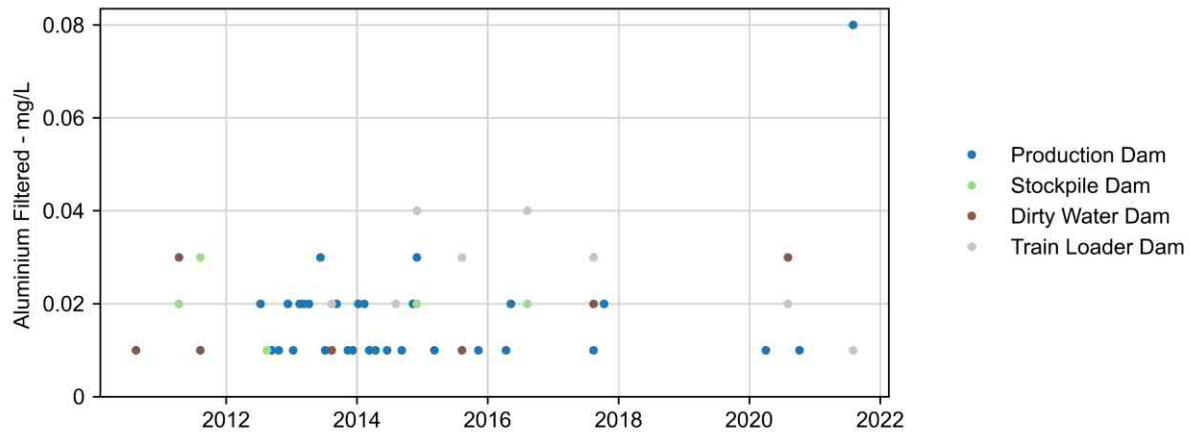

Potassium Filtered - mg/L
0
2.5
5
7.5
10
12.5
15
17.5
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

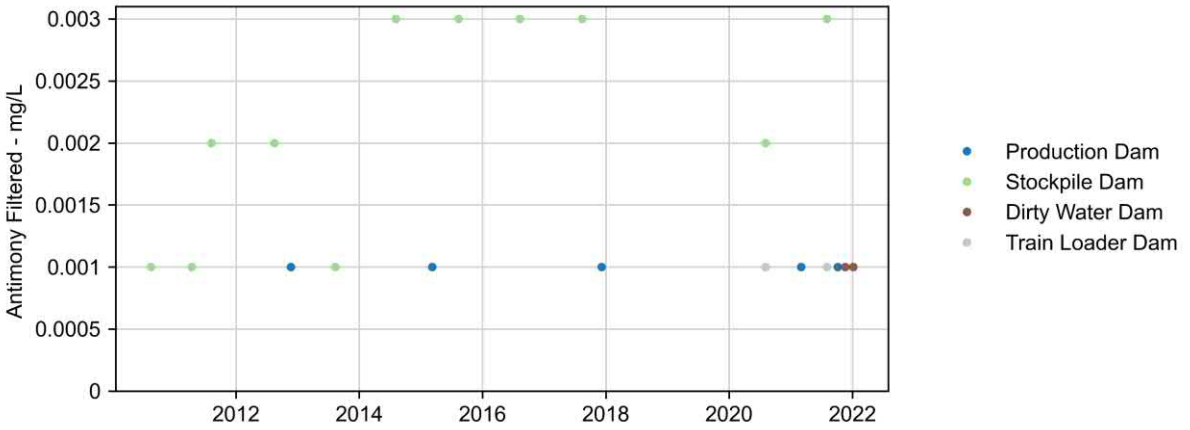

Sodium Filtered - mg/L
150
125
100
75
50
25
0
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

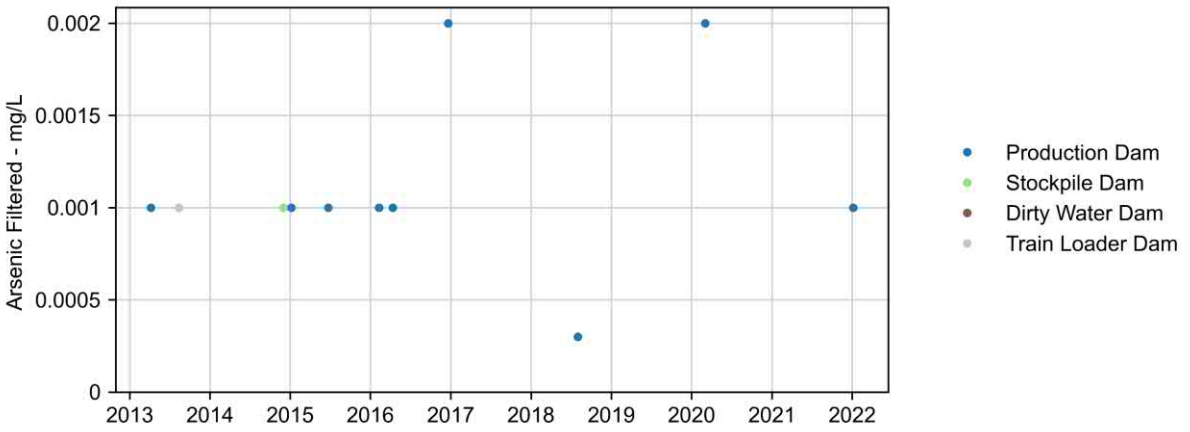

Sulfate Filtered - mg/L
2000
1500
1000
500
0
2018
2019
2020
2021
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

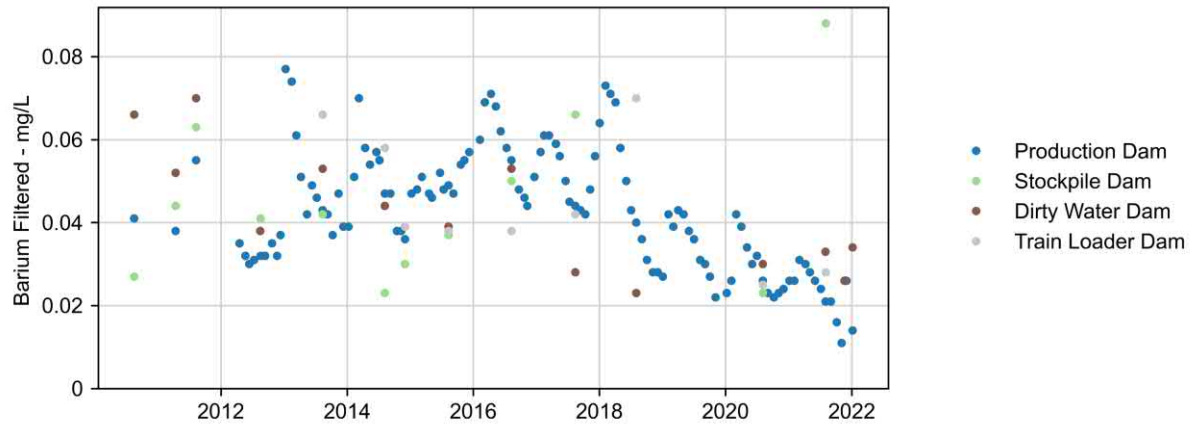

Fluoride - mg/L
1.75
1.5
1.25
1
0.75
0.5
0.25
0
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

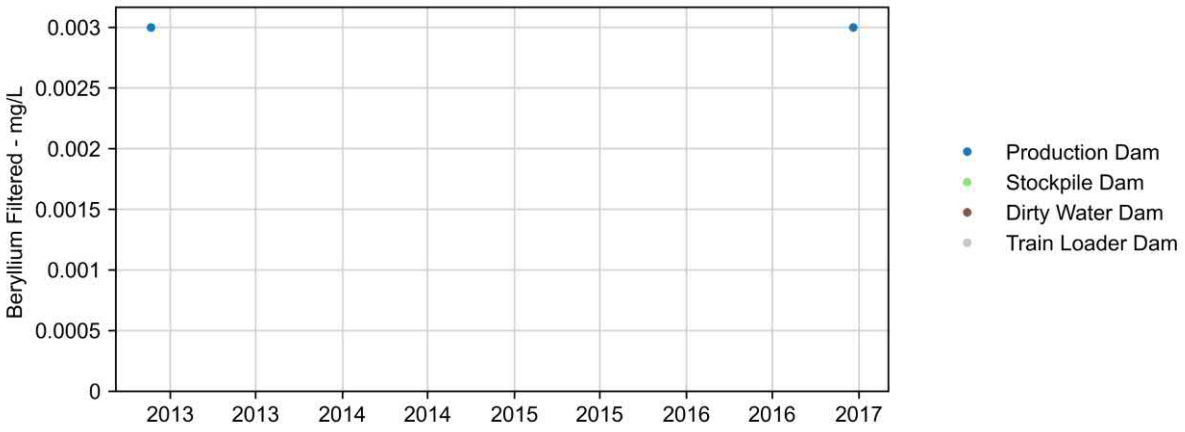
Metals (dissolved)

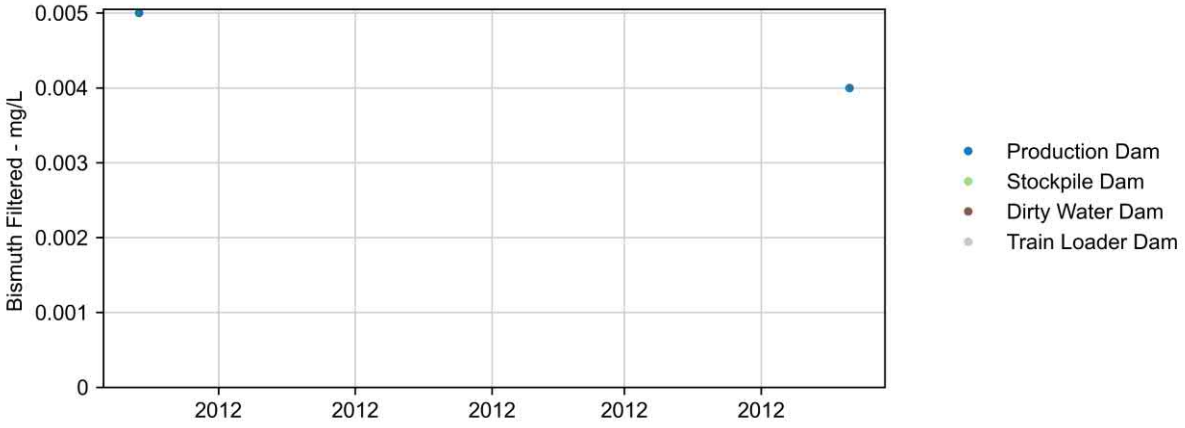


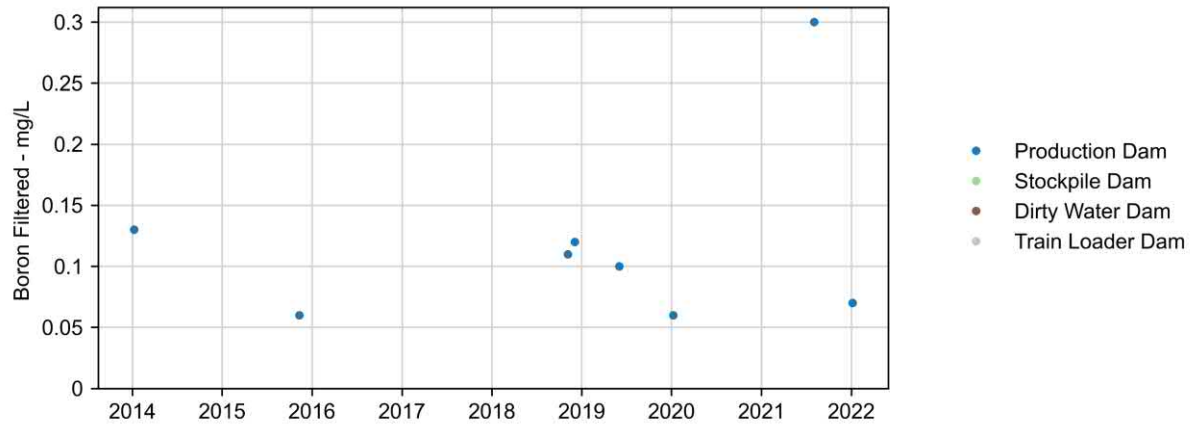




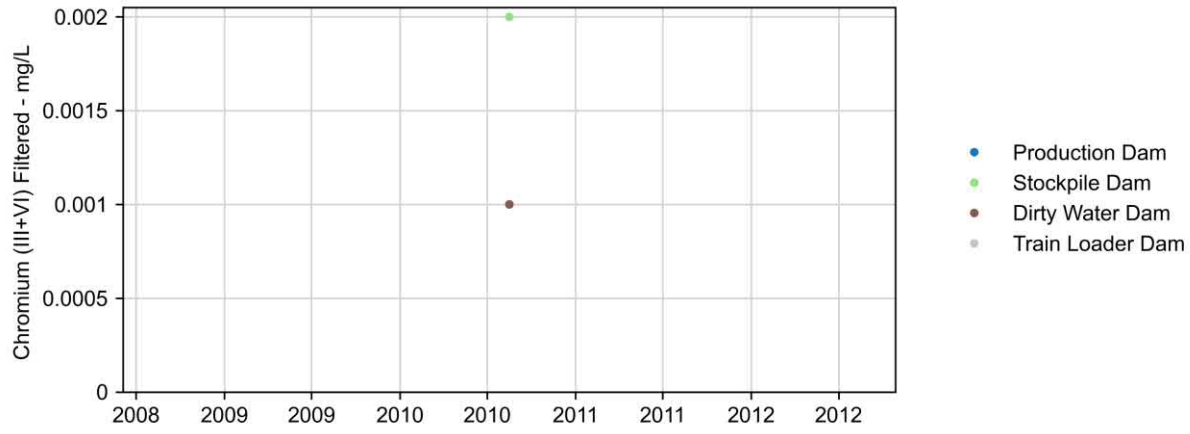


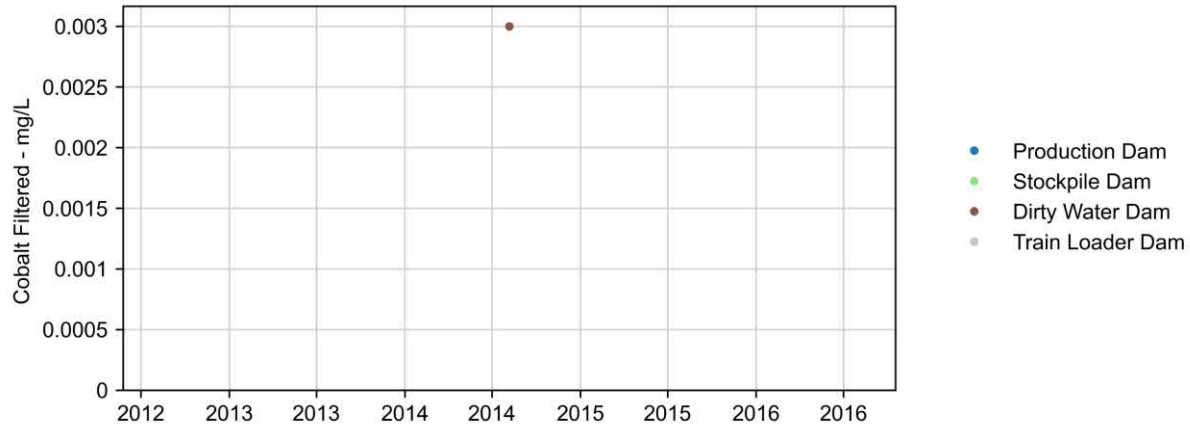

Beryllium Filtered - mg/L
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
2013
2013
2014
2014
2015
2015
2016
2016
2017
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

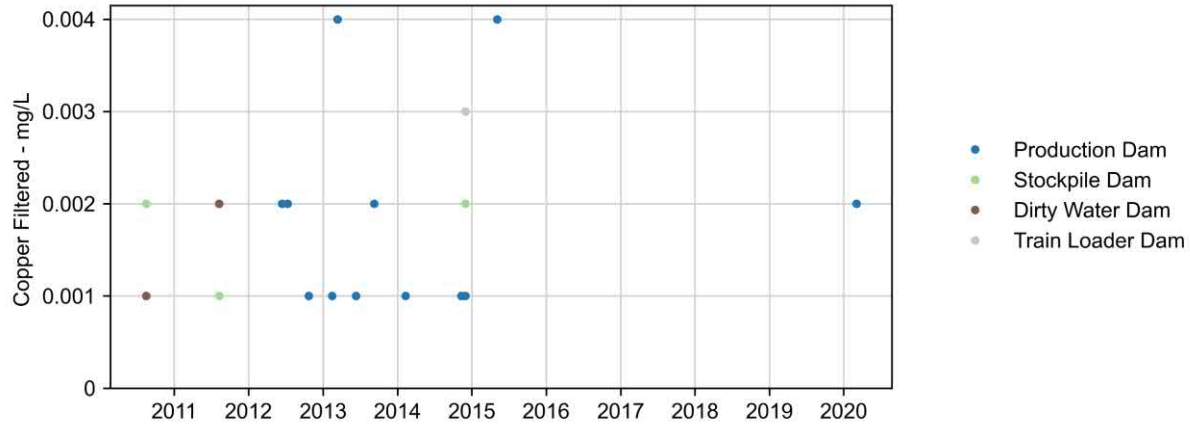

Bismuth Filtered - mg/L
0.005
0.004
0.003
0.002
0.001
0
2012
2012
2012
2012
2012
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

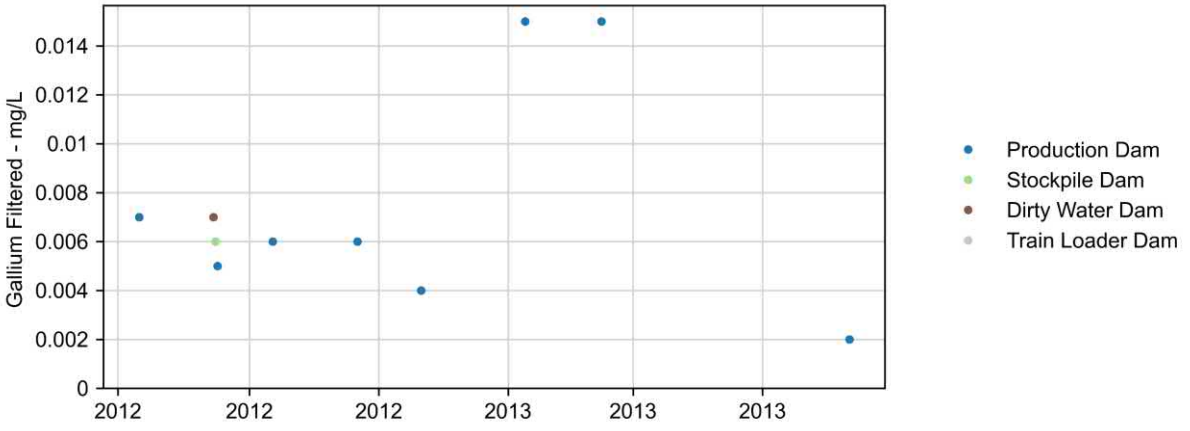

Boron Filtered - mg/L
0.3
0.25
0.2
0.15
0.1
0.05
0
2014
2015
2016
2017
2018
2019
2020
2021
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

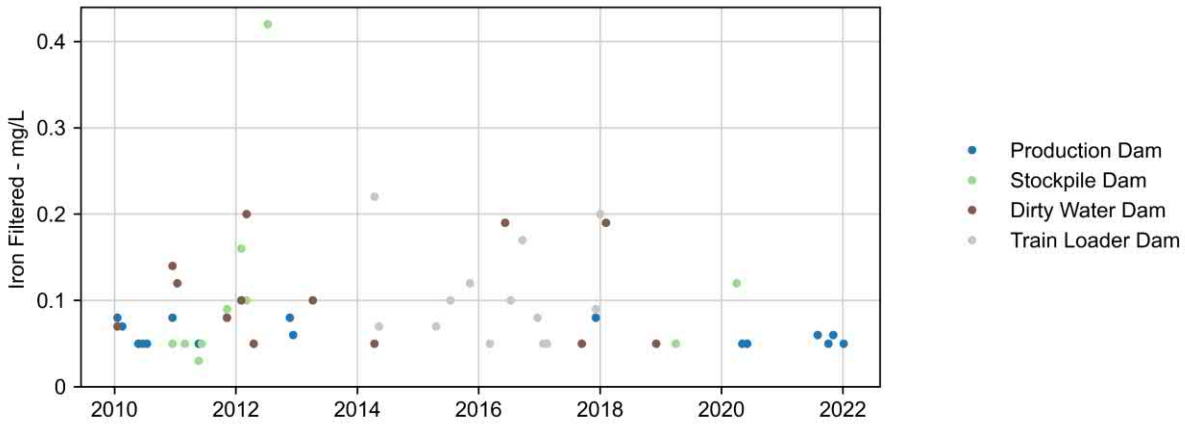

Cadmium Filtered - mg/L
0.0003
0.00025
0.0002
0.00015
0.0001
5e-05
0
2011
2011
2011
2011
2012
2012
2012
2012
2012
2012
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

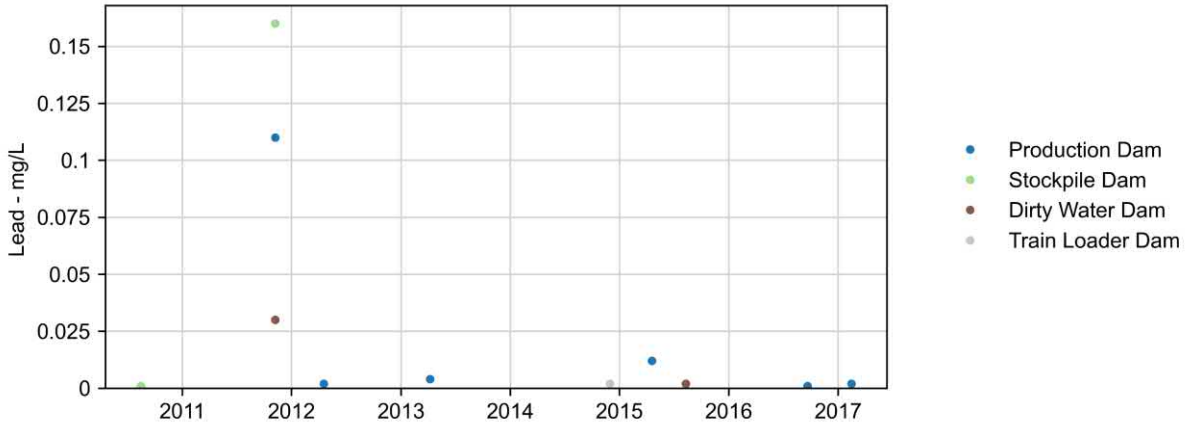

Chromium (III+VI) Filtered - mg/L
0.002
0.0015
0.001
0.0005
0
2008
2009
2009
2010
2010
2011
2011
2012
2012
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

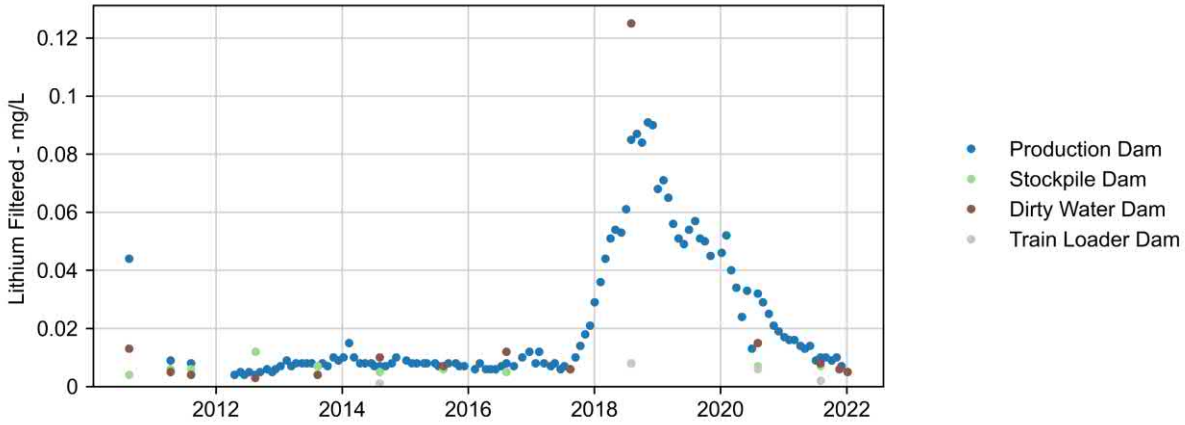

Cobalt Filtered - mg/L
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
2012
2013
2013
2014
2014
2015
2015
2016
2016
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

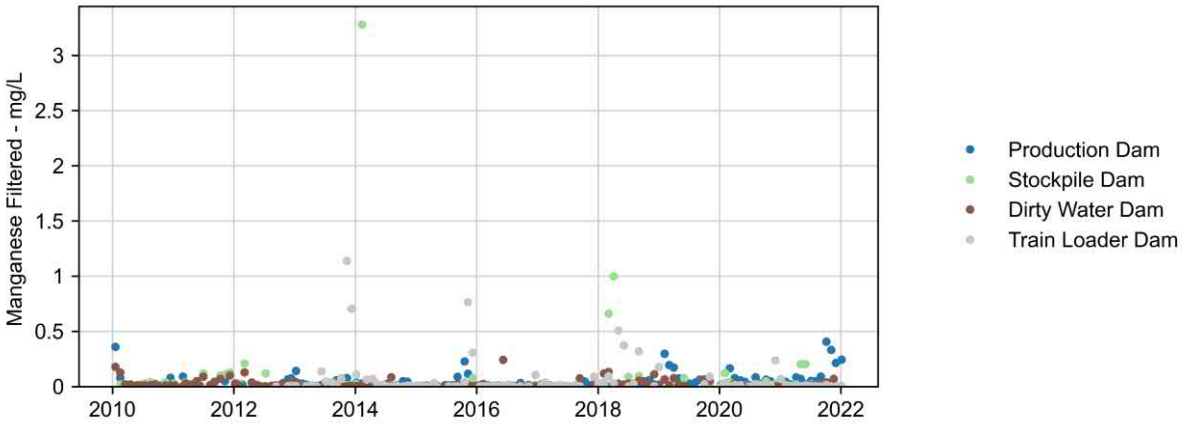

Copper Filtered - mg/L
0.004
0.003
0.002
0.001
0
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

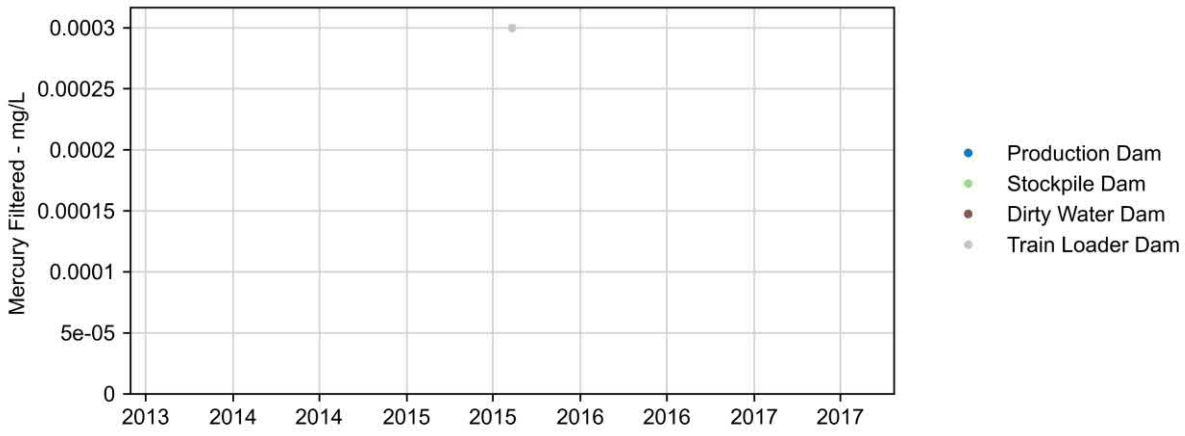

Gallium Filtered - mg/L
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
2012
2012
2012
2013
2013
2013
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

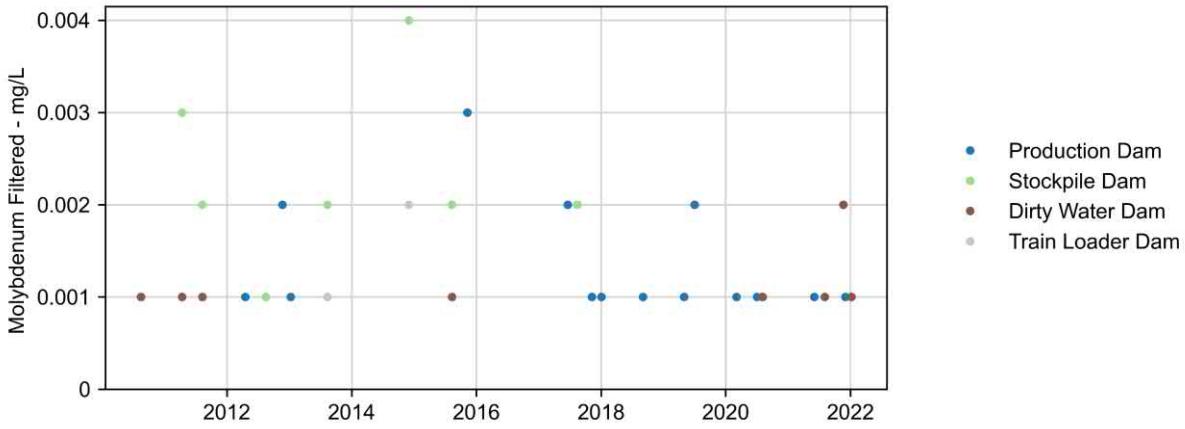

Iron Filtered - mg/L
0
0.1
0.2
0.3
0.4
2010
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

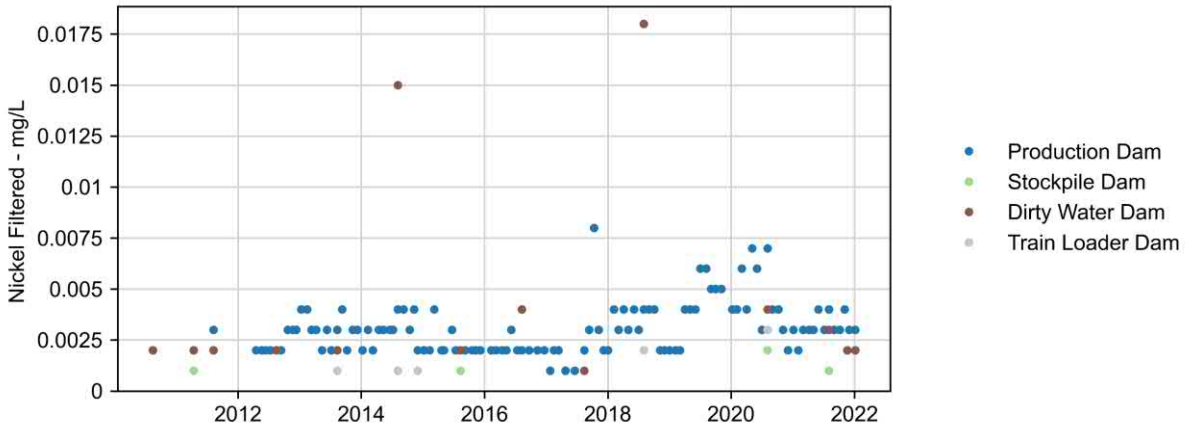

Lead - mg/L
0
0.025
0.05
0.075
0.1
0.125
0.15
2011
2012
2013
2014
2015
2016
2017
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

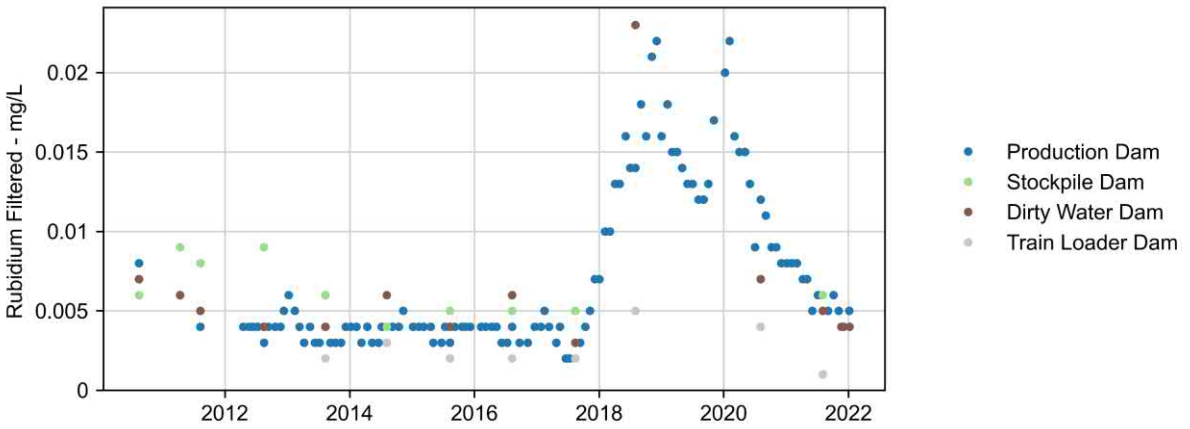

Lithium Filtered - mg/L
0
0.02
0.04
0.06
0.08
0.1
0.12
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

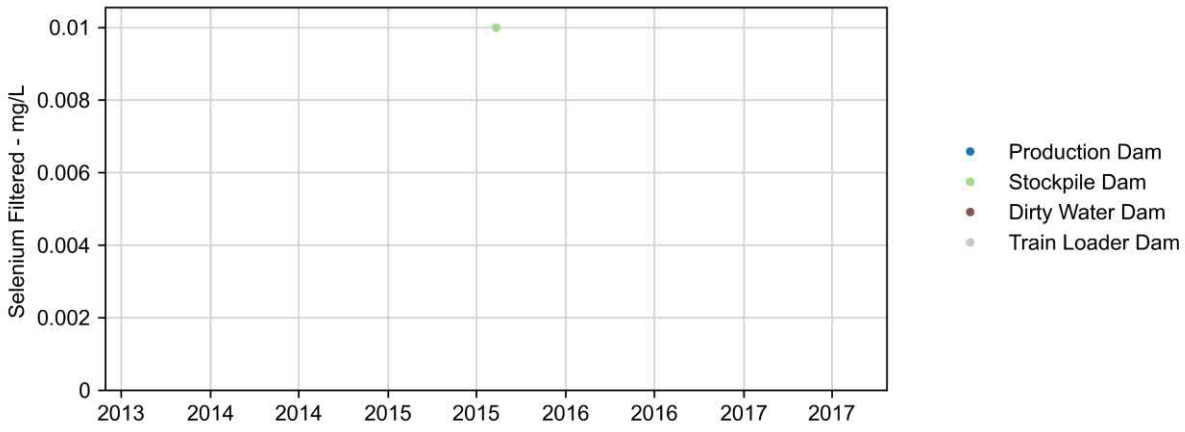

Manganese Filtered - mg/L
0
0.5
1
1.5
2
2.5
3
2010
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

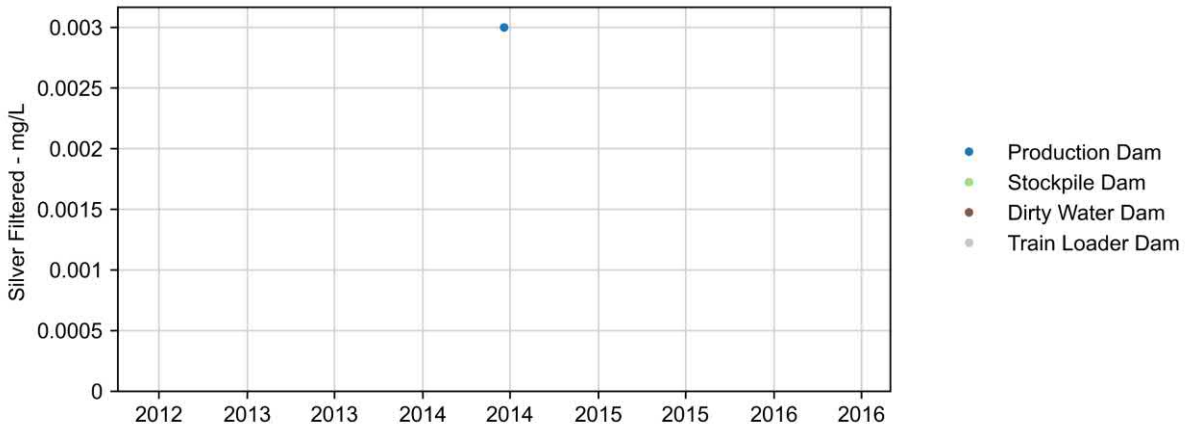

Mercury Filtered - mg/L
0.0003
0.00025
0.0002
0.00015
0.0001
5e-05
0
2013
2014
2014
2015
2015
2016
2016
2017
2017
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

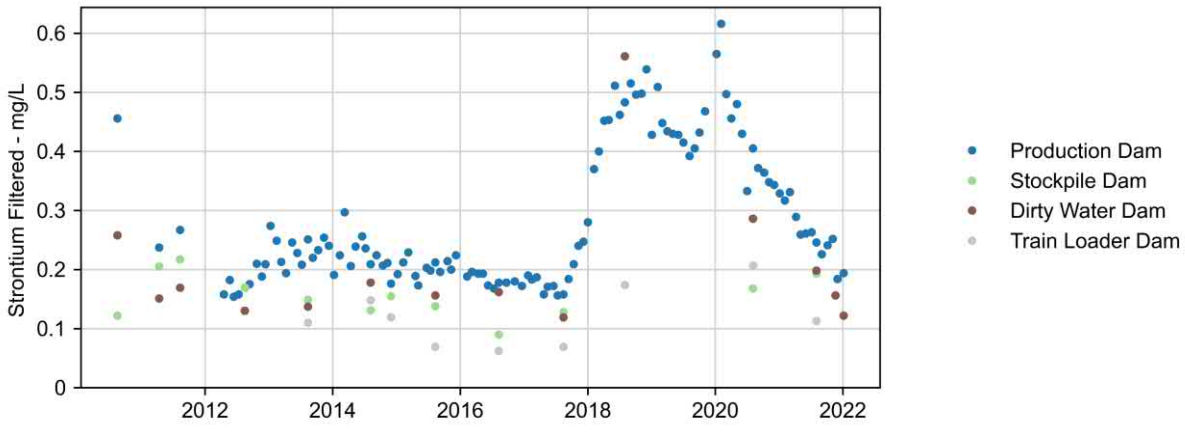

Molybdenum Filtered - mg/L
0.004
0.003
0.002
0.001
0
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

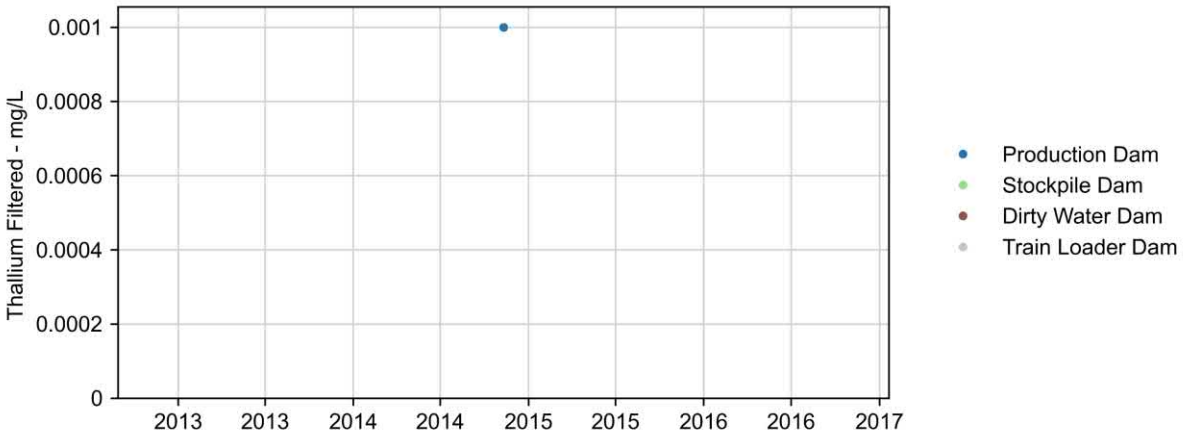

Nickel Filtered - mg/L
0.0175
0.015
0.0125
0.01
0.0075
0.005
0.0025
0
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

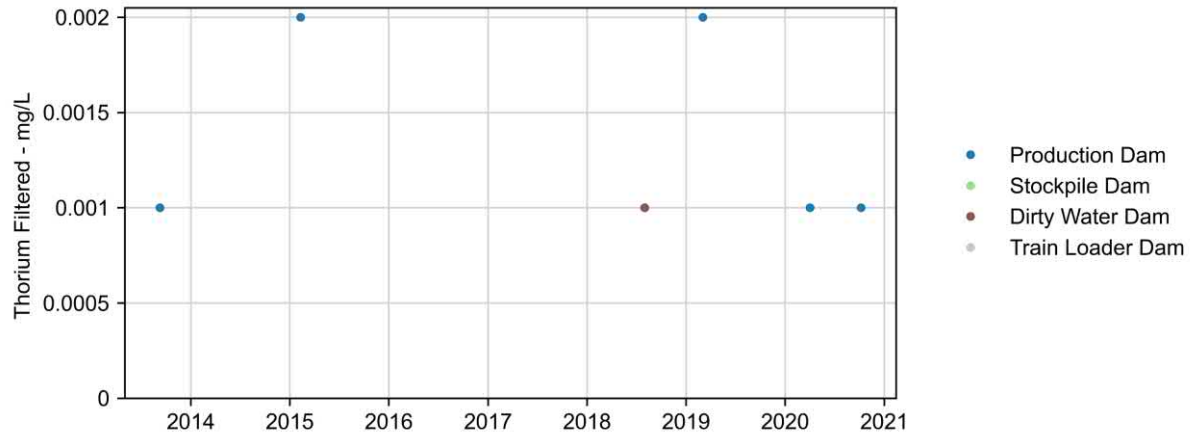

Rubidium Filtered - mg/L
0.02
0.015
0.01
0.005
0
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

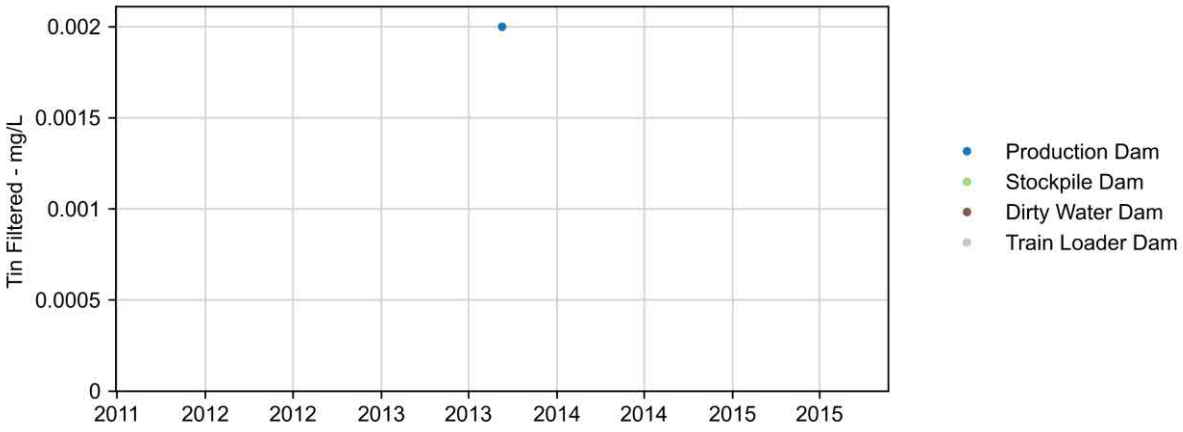

Selenium Filtered - mg/L
0.01
0.008
0.006
0.004
0.002
0
2013
2014
2014
2015
2015
2016
2016
2017
2017
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

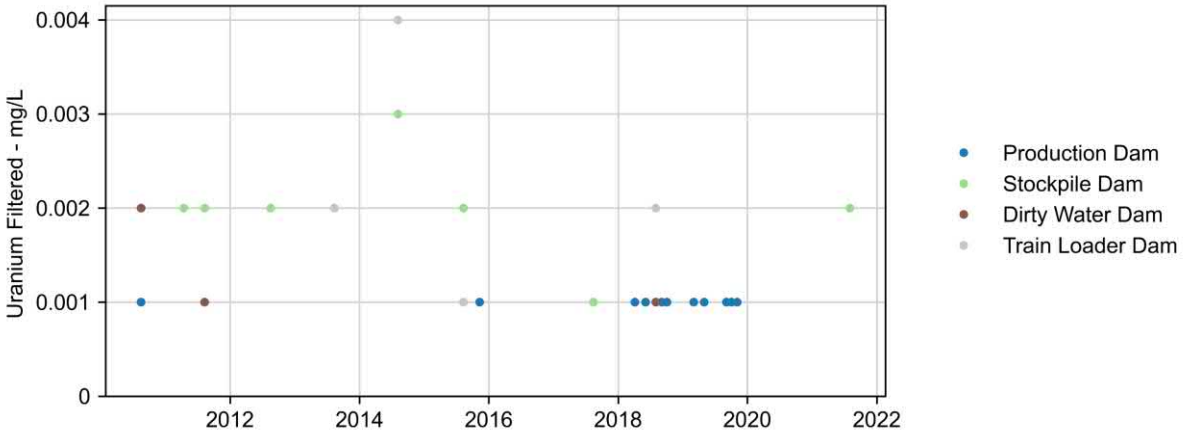

Silver Filtered - mg/L
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
2012
2013
2013
2014
2014
2015
2015
2016
2016
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

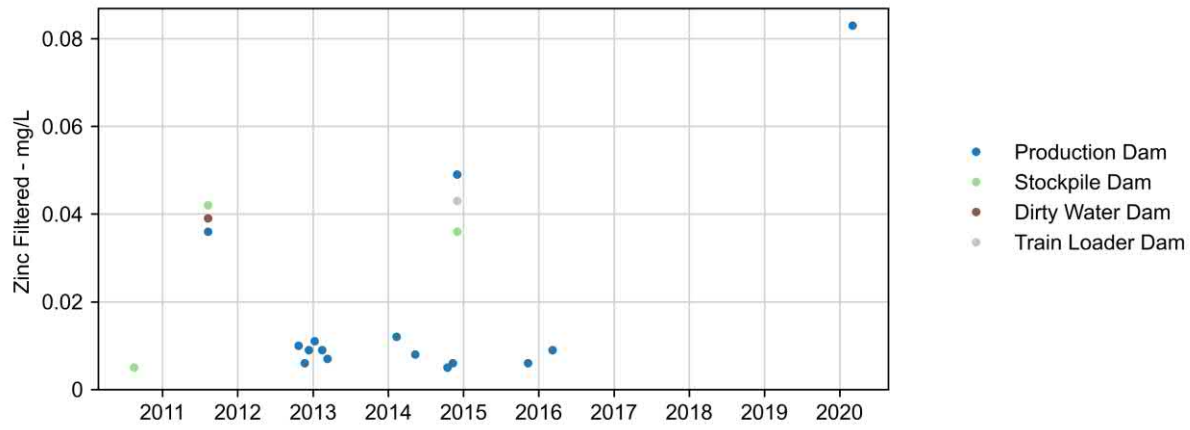

Strontium Filtered - mg/L
0.6
0.5
0.4
0.3
0.2
0.1
0
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam


Thallium Filtered - mg/L
0.001
0.0008
0.0006
0.0004
0.0002
0
2013
2013
2014
2014
2015
2015
2016
2016
2017
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

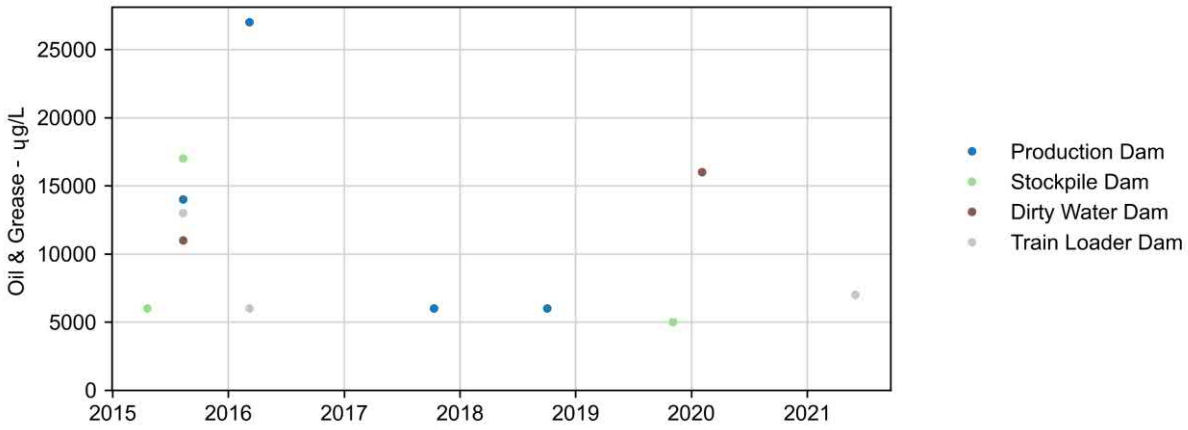

Thorium Filtered - mg/L
0.002
0.0015
0.001
0.0005
0
2014
2015
2016
2017
2018
2019
2020
2021
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

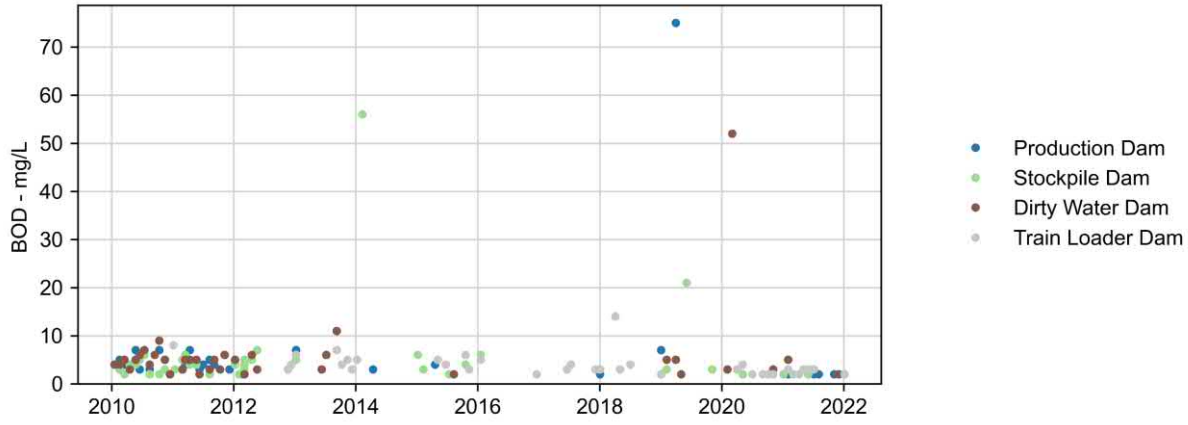

Tin Filtered - mg/L
0.002
0.0015
0.001
0.0005
0
2011
2012
2012
2013
2013
2014
2014
2015
2015
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

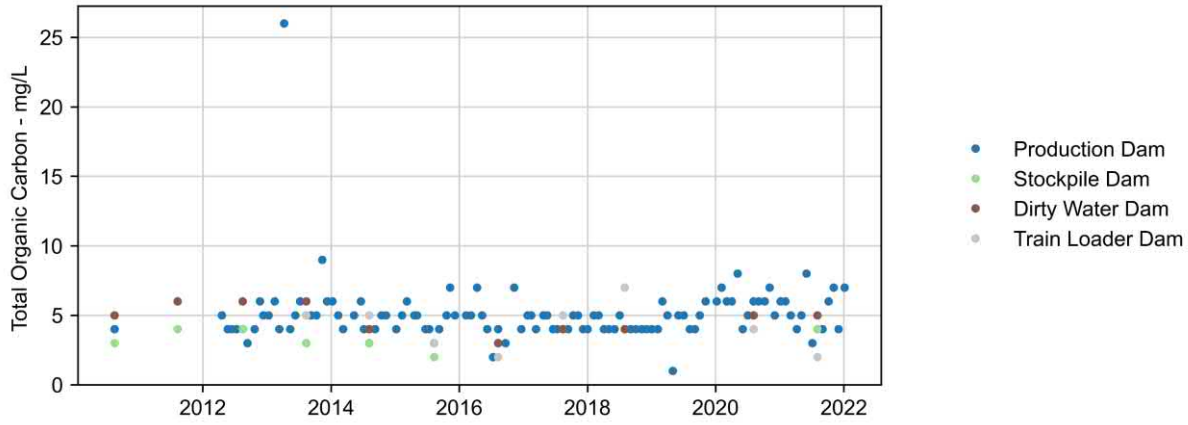

Uranium Filtered - mg/L
0.004
0.003
0.002
0.001
0
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

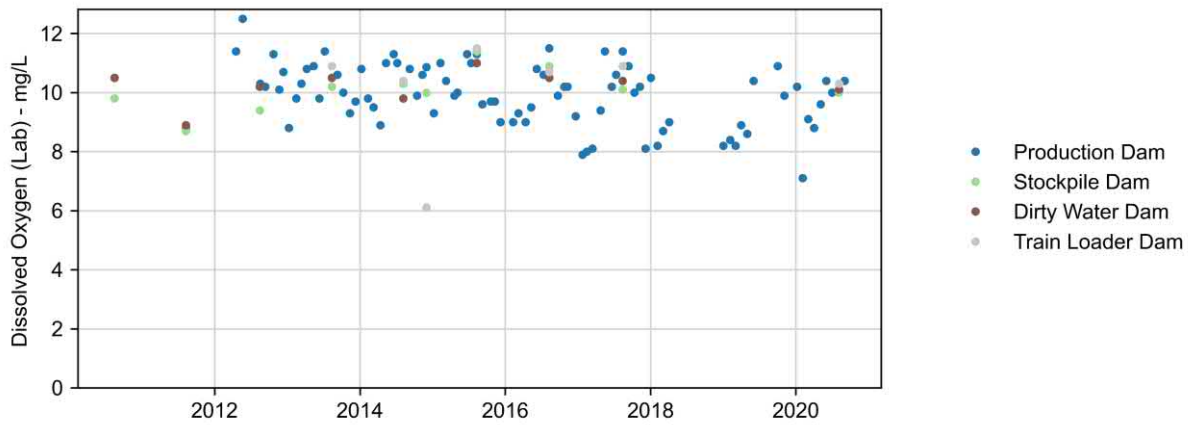

Zinc Filtered - mg/L
0.08
0.06
0.04
0.02
0
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

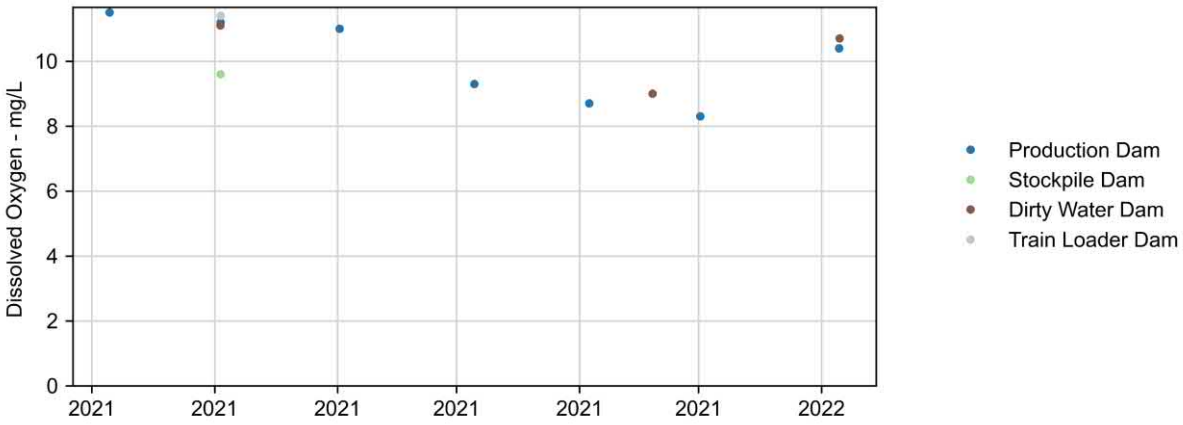
Other

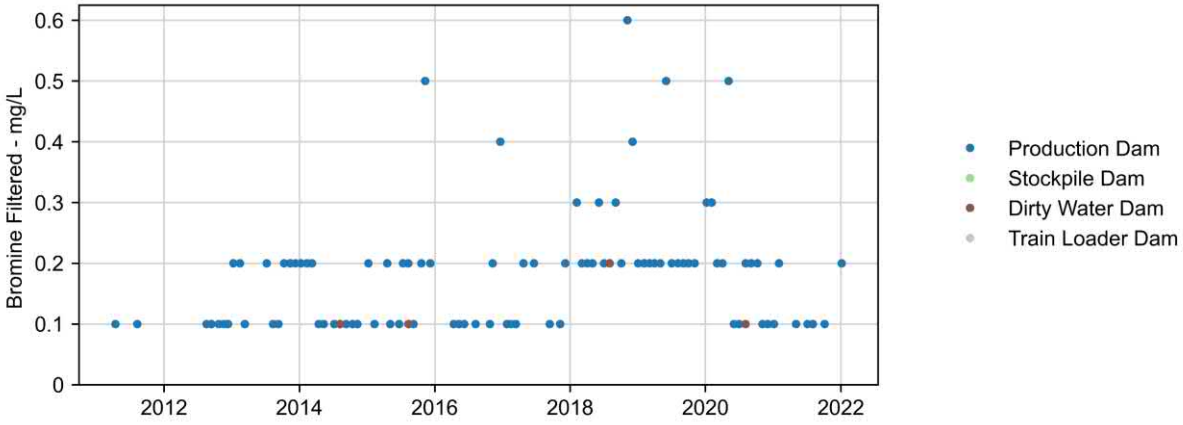

Oil & Grease - ug/L
25000
20000
15000
10000
5000
0
2015
2016
2017
2018
2019
2020
2021
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

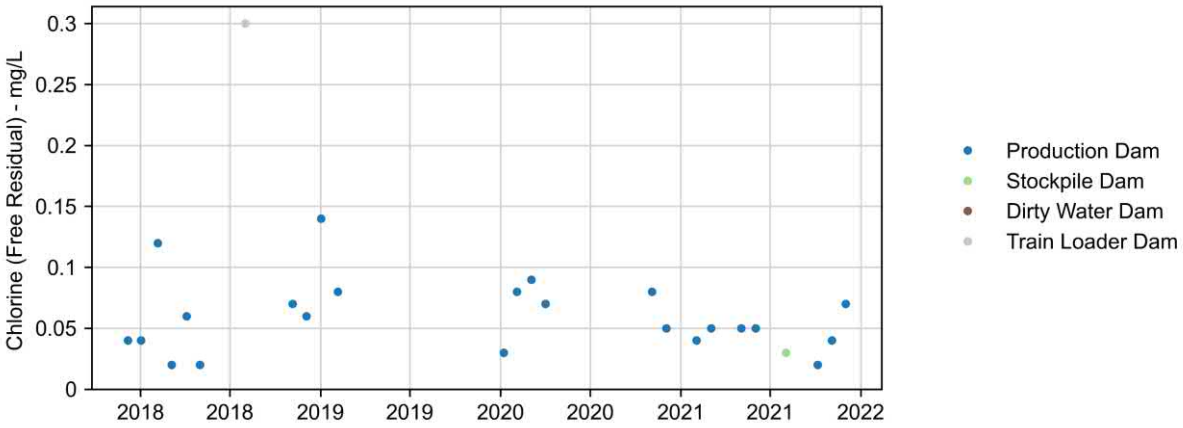

BOD - mg/L
70
60
50
40
30
20
10
0
2010
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

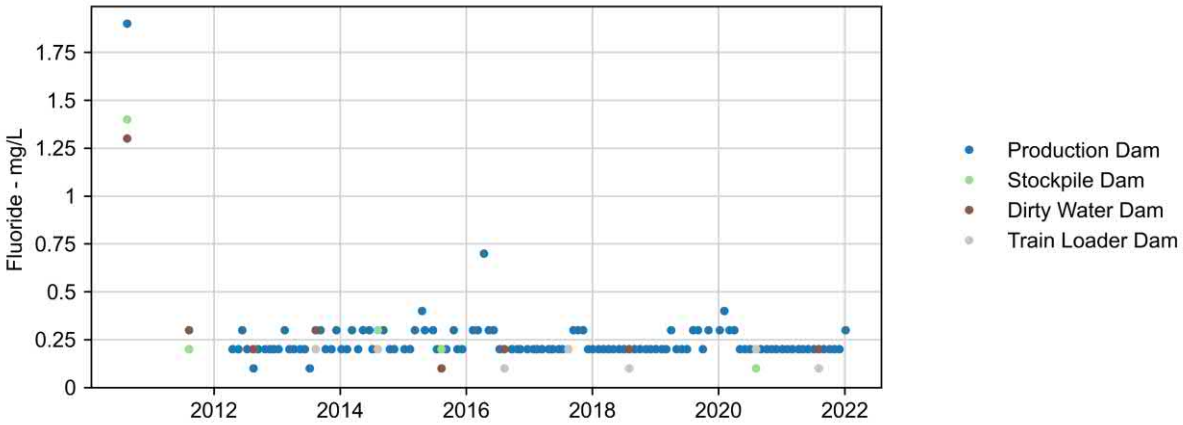

Total Organic Carbon - mg/L
25
20
15
10
5
0
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

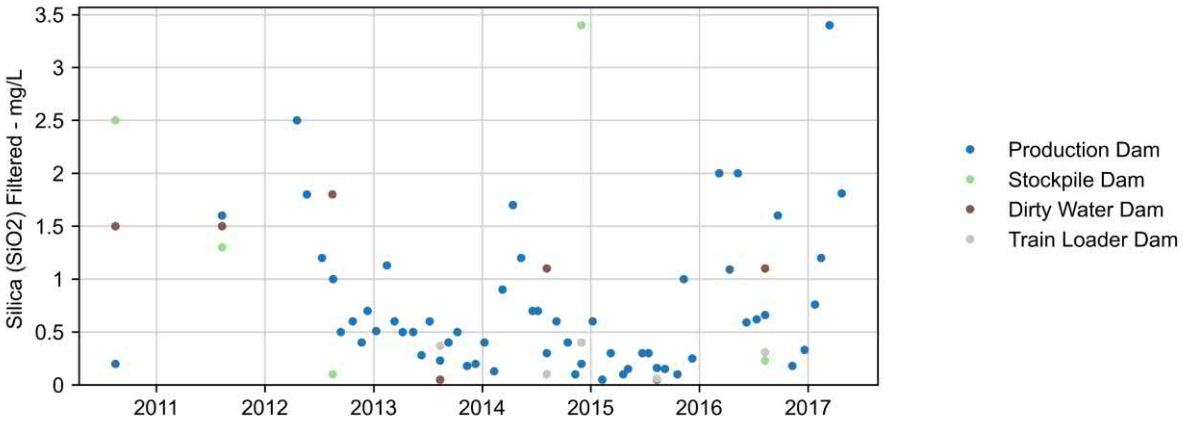

Dissolved Oxygen (Lab) - mg/L
12
10
8
6
4
2
0
2012
2014
2016
2018
2020
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

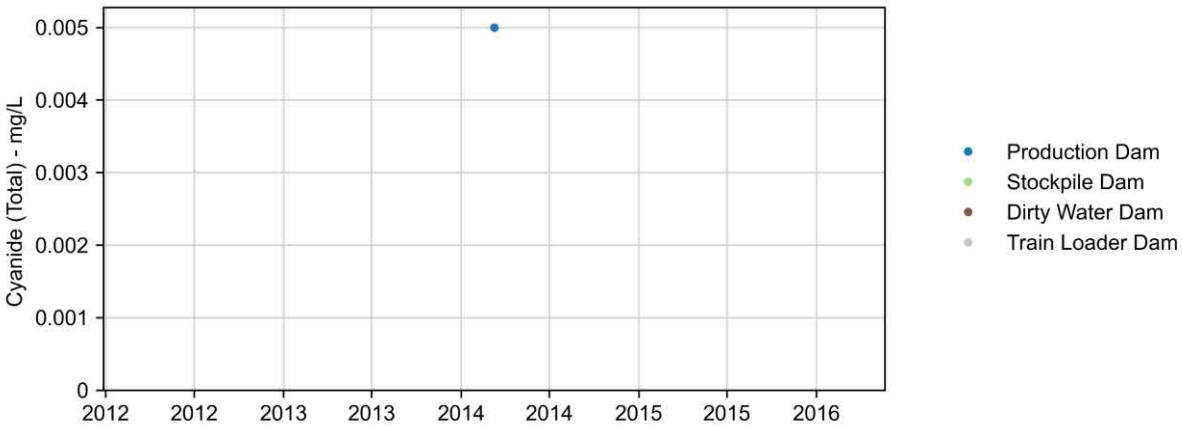

Dissolved Oxygen - mg/L
0
2
4
6
8
10
2021
2021
2021
2021
2021
2021
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam


Bromine Filtered - mg/L
0
0.1
0.2
0.3
0.4
0.5
0.6
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam


Chlorine (Free Residual) - mg/L
0
0.05
0.1
0.15
0.2
0.25
0.3
2018
2018
2019
2019
2020
2020
2021
2021
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam


Fluoride - mg/L
0
0.25
0.5
0.75
1
1.25
1.5
1.75
2012
2014
2016
2018
2020
2022
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam


Silica (SiO2) Filtered - mg/L
3.5
3
2.5
2
1.5
1
0.5
0
2011
2012
2013
2014
2015
2016
2017
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam


Cyanide (Total) - mg/L
0.005
0.004
0.003
0.002
0.001
0
2012
2012
2013
2013
2014
2014
2015
2015
2016
Production Dam
Stockpile Dam
Dirty Water Dam
Train Loader Dam

Appendix 2: 2021 Stygo Fauna Monitoring Report

Airly Mine Ecology Monitoring 2021

Airly Stygofauna Monitoring Report 2021

Centennial Airly Pty Ltd

28 March 2022

→ **The Power of Commitment**



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Document status

Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S4	0	Z. Lagerroth	S. Gray		Z. Lagerroth		28/03/2022

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Overarching Review

Statement of Compliance Question	Statement of Compliance Answer
Were all conditions of SSD_5581 and the Airly Mine Water Management Plan relating to stygofauna complied with?	Yes – There were no non-compliances relating to stygofauna monitoring in the 2021 reporting period

Details of Non-Compliances

Relevant Approval	Condition #	Condition summary	Compliance Status	Comment	Reference # addressed in Annual Review
N/A - No non-compliances relating to stygofauna during the 2021 reporting period			Compliant		

Development consent SSD-5581 (Modification 2) performance conditions relating to groundwater

Condition	Condition description	Compliant	Document
Water management plan			
Schedule 4 13.	Prior to carrying out any development under this consent, unless the Secretary agrees otherwise, the Applicant must prepare a Water Management Plan for the development to the satisfaction of the Secretary. This plan must:		
Schedule 4 13. (a)	Be prepared in consultation with the DoEE, EPA and the Water Division, by suitably qualified and experienced person/s whose appointment has been approved by the Secretary.	Yes	NA Refer to Appendix A and Appendix B of WMP (GHD 2021)
Schedule 4 13. (b)	Include detailed performance criteria and describe measures to ensure that the Applicant complies with the Water Management Performance Measures (see Table 6).	Yes	NA Refer to Section 6.1.3 of WMP (GHD 2021)
Groundwater management plan			
Schedule 4 13. (c) (iii)	Groundwater Management Plan, which is consistent with the NSW Government guideline entitled Groundwater Monitoring and Modelling Plans – Introduction for prospective mining and petroleum activities, and includes:		
	Detailed baseline data of groundwater levels, yield and quality in the region that could be affected by the development, including licensed privately-owned groundwater bores and a detailed survey/schedule of groundwater dependent ecosystems (including springs and their discharge quantity and quality).	Yes	Refer to 2021 Annual Water Monitoring Report (GHD 2022)
Schedule 4 13. (c) (iii)	Consultation with the Water Division on the installation of all new monitoring bores, the scheduled sampling and quality determination of parameters for monitoring bores.	Yes	NA Refer to Section 4.4 of the WMP (GHD 2021)
Schedule 4 13. (c) (iii)	Groundwater assessment criteria including trigger levels for investigating any potentially adverse groundwater impacts.	Yes	Refer to 2021 Annual Water Monitoring Report (GHD 2022)

Condition	Condition description	Compliant	Document
	A program to monitor and report on: – Springs and their discharge quantity and quality. – Groundwater inflows transferred to the surface water management system. – The seepage/leachate from water storages and emplacements. – Impacts of the development on: • Regional and local (including alluvial) aquifers. • Groundwater supply of potentially affected landowners. • Groundwater dependent ecosystems (including rules for the management of groundwater level impacts to protect GDEs), and riparian vegetation.	Yes	Refer to: – 2021 Annual Water Monitoring Report (GHD 2022) – Sections 4.4 and 4.5 of the WMP (GHD 2021) – Annual flora and fauna monitoring report
	A program to monitor and report on stygofauna and hyporheic fauna.	Yes	This report
	A program to review and validate the groundwater model for the development, including independent expert review.	Yes	NA Refer to Section 7.5 of the WMP (GHD 2021)
	A plan to respond to any exceedances of the performance measures.	Yes	NA Refer to Appendix E of the WMP (GHD 2021)

NA – not applicable to this report

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1. Introduction

1.1 Background

Airly Mine is an underground coal mine located near Capertee, approximately 40 km northwest of Lithgow, and owned by Centennial Airly Pty Ltd (Centennial). Airly Mine was granted Development Consent (SSD_5581) for the extension of its underground coal mine on 15 December 2016. The development consent allows Airly Mine to extract up to 1.8 million tonnes per annum (Mtpa) of run of mine (ROM) coal within the mining lease ML1331, with mining extending east of the lease into an exploration licence area (Authorisation Area 232).

Stygofauna monitoring was undertaken by Cardno (2014) to support the Environmental Impact Statement (EIS) for the Airly Mine Extension Project. A total of six bores were sampled by Cardno over four sampling events between autumn 2013 and winter 2014. No stygofauna were collected from Airly bores during this period.

GHD has undertaken eight rounds of stygofauna monitoring of Airly Mine bores since the EIS: autumn 2016, summer 2016, summer 2017, winter 2017, spring 2018, autumn 2019, spring 2020 and autumn 2021. This report outlines the results of autumn 2021 stygofauna monitoring conducted in April 2021.

1.2 Development consent

Airly Mine has development consent under Section 89E of the Environmental Planning & Assessment Act 1979 for the extension of the mine (approved 15 December 2016; NSW Government 2016).

In relation to stygofauna, the development consent states the commitment to comply with the following condition:

– 13 (c) (iii) – a program to monitor and report on stygofauna and hyporheic fauna.

1.3 Scope

GHD Pty Ltd (GHD) was engaged by Centennial to undertake stygofauna monitoring in Airly Mine groundwater bores as required by the conditions of consent of the mine extension (see Section 1.2).

The project scope is as follows:

– Collection of stygofauna samples from available groundwater bores that are suitable for sampling, once annually.
– Identification of animals to Family level or below.
– Provision of a report (annually) summarising the results of stygofauna monitoring.

1.4 Purpose of this report

This report outlines the results of stygofauna monitoring conducted in relation to Airly Mine in 2021. A summary of results from this report will be incorporated into Airly Mine's Annual Review.

1.5 Assumptions

Data have been obtained from Cardno (2014) in addition to assessments undertaken by GHD. It is assumed that the methods used by Cardno were suitable for collection of stygofauna and executed correctly.

1.6 Limitations

This report has been prepared by GHD for Centennial Airly Pty Ltd and may only be used and relied on by Centennial Airly Pty Ltd for the purpose agreed between GHD and the Centennial Airly Pty Ltd as set out in Section 1.4 of this report.

GHD otherwise disclaims responsibility to any person other than Centennial Airly Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer Section 1.5 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Centennial Airly Pty Ltd and others who provided information to GHD, which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

GHD has not been involved in the preparation of the annual review and has had no contribution to, or review of, the annual return other than in the completion of the stygofauna report. GHD shall not be liable to any person for any error in, omission from, or false or misleading statement in, any other part of annual return.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

2. Stygofauna

2.1 Types of subterranean fauna

Aquifers host a complex biodiversity of aquatic invertebrates called stygofauna. Stygofauna is a collective term for all groundwater animals (Hancock *et al*. 2005). Stygofauna can have varying levels of dependence on groundwater. A number of specific terms are used to differentiate the types of stygofauna and other subterranean fauna, including:

- **Stygoxenes** and **stygophiles** are able to utilise groundwater during at least part of their lifecycle but are not reliant upon it.
- **Stygobites** are obligate groundwater species (Hancock *et al.* 2005).
- **Phreatobites** are a type of stygobite that are specially adapted to live in the interstitial spaces of alluvial aquifers.
- **Troglofauna** are also subterranean animals but are distinct from stygofauna as they are not associated with groundwater (Humphreys 2008) e.g. cave dwelling.
- **Edaphobites** are terrestrial soil dwelling animals which can accidentally or opportunistically colonise subterranean environments.

2.2 Characteristics and risks

Stygofauna are highly endemic, often have ancient lineages with Gondwana (350 million years ago) and typically have narrow environmental tolerance ranges (Serov 2016). Because of the adaptation of stygofauna to the groundwater environment and limited connectivity between favourable habitats, some obligate stygofauna species can have restricted distributions (short range endemism) (Humphreys 2008).

Stygofauna are threatened by activities that change the quality or quantity of groundwater, disrupt the connectivity between different aquifers or between aquifers and surface systems, or remove soil pores. Disturbance of aquifers could potentially result in local population extinctions, loss of genetic diversity and even species extinctions in the case of isolated populations.

2.3 Stygofauna research in Australia

In Australia, stygofauna research has increased greatly over the last two decades, particularly in Western Australia and Queensland, where large scale mining projects have provided the impetus to develop specific guidelines or guidance documents in relation to stygofauna. Comparatively, there has been relatively little research done on stygofauna in NSW, where many large mining leases have been long-established and risks to stygofauna are only addressed in environmental impact assessments for new projects.

2.3.1 Favourable bore attributes for stygofauna

Favourable bore conditions have been defined by Hancock and Boulton (2008), the WA EPA (2007) and unpublished work conducted by GHD. The bore attributes and value ranges that are favourable for stygofauna habitation and/or collection are summarised in Table 2.1. These attributes were used to determine suitable Airly bores for stygofauna monitoring (see Section 3.3 for more detail).

Table 2.1 Favourable bore attributes for stygofauna

Attribute	Favourable values
Lithology	Alluvial (sand and gravel)
Bore depth	<50 m (max <200 m)
Bore diameter	>50 mm (to accommodate sampling equipment)
Bore construction	Preferably cased and slotted/screened through the water column. Vertically aligned (not angled)
Bore use	Observation/monitoring
pH	6.5-8.5
Electrical conductivity (EC)	<2,000 µS/cm (max <5,000 µS/cm)

Note: Preferences based on Hancock and Boulton (2008); WA EPA (2007) and unpublished data collected by GHD.

2.3.2 2016 Review of stygofauna in Australia (Hose *et al.* 2015)

In July 2016, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) published a study funded by the Australian Coal Association Research Program (ACARP) titled *Stygofauna in Australian Groundwater Systems: Extent of knowledge* (Hose *et al.* 2015). The report detailed the current extent of knowledge in terms of factors determining the presence of stygofauna, regional water accounts associated with groundwater use and threats that mining and Coal Seam Gas activities may have on stygofauna. Of most relevance to the Airly stygofauna monitoring is that the CSIRO report details the most up to date knowledge on the characteristics of environments where stygofauna have been collected.

The Hose *et al*. (2015) paper identified that greater numbers and/or diversity of stygofauna are found under the following conditions:

– Coarse gravel/sand dominated alluvium (Korbel and Hose 2015)
– Fractured rock aquifers and unconsolidated sediments with larger pore spaces (Hancock and Boulton 2008)
– “Bores from which large volumes of sediment were removed when sampling (by pump), which may reflect greater hydraulic conductivity and sediment mobility” (Korbel and Hose 2015)
– Shallow bores (< 10 m below ground) rather than deeper areas of aquifers (Hancock and Boulton 2008)

These findings are generally in agreement with the environmental preference information used to select the Airly bores, as detailed in Table 2.1.

3. Project and site background

3.1 Environmental conditions

3.1.1 Geology

The topology of Airly Mine is dominated by Mount Airly and Genowlan Mountain. The Grose sandstone of the Triassic Narrabeen Group outcrops throughout the plateau and cliffs of Mount Airly and Genowlan Mountain with small areas of Tertiary basalt outcrop at the higher elevations. The Triassic strata are up to 200 m thick.

The Permian Illawarra Coal Measures outcrop around the Triassic formations at lower elevations, including the zone between Mount Airly and Genowlan Mountain. The Lithgow Seam, within the lower Illawarra Coal Measures, is the target coal seam at Airly Mine. The seam outcrops completely within the proposed mining area for the Airly Mine Extension Project and is therefore disconnected to the areas of occurrence of this seam located several kilometres to the south and northwest, as shown in Figure 3.1.

3.1.2 Hydrogeology

Local groundwater sources

The alluvium associated with Gap Creek and Genowlan Creek is generally a silty sand material and recharged from rainfall as well as inter-aquifer flow from adjacent (primarily Permian) strata. Alluvial groundwater discharges to connected streams.

The local porous and fractured rock groundwater sources include the Narrabeen Sandstone and coal seams of the Illawarra Coal Measures. These sources are recharged by rainfall via fractures within overlaying strata, and seep out of the side of the mountains or directly into watercourses. With the majority of discharge from these sources being to seepage areas, there is minimal inter-aquifer flow to underlying regional groundwater sources.

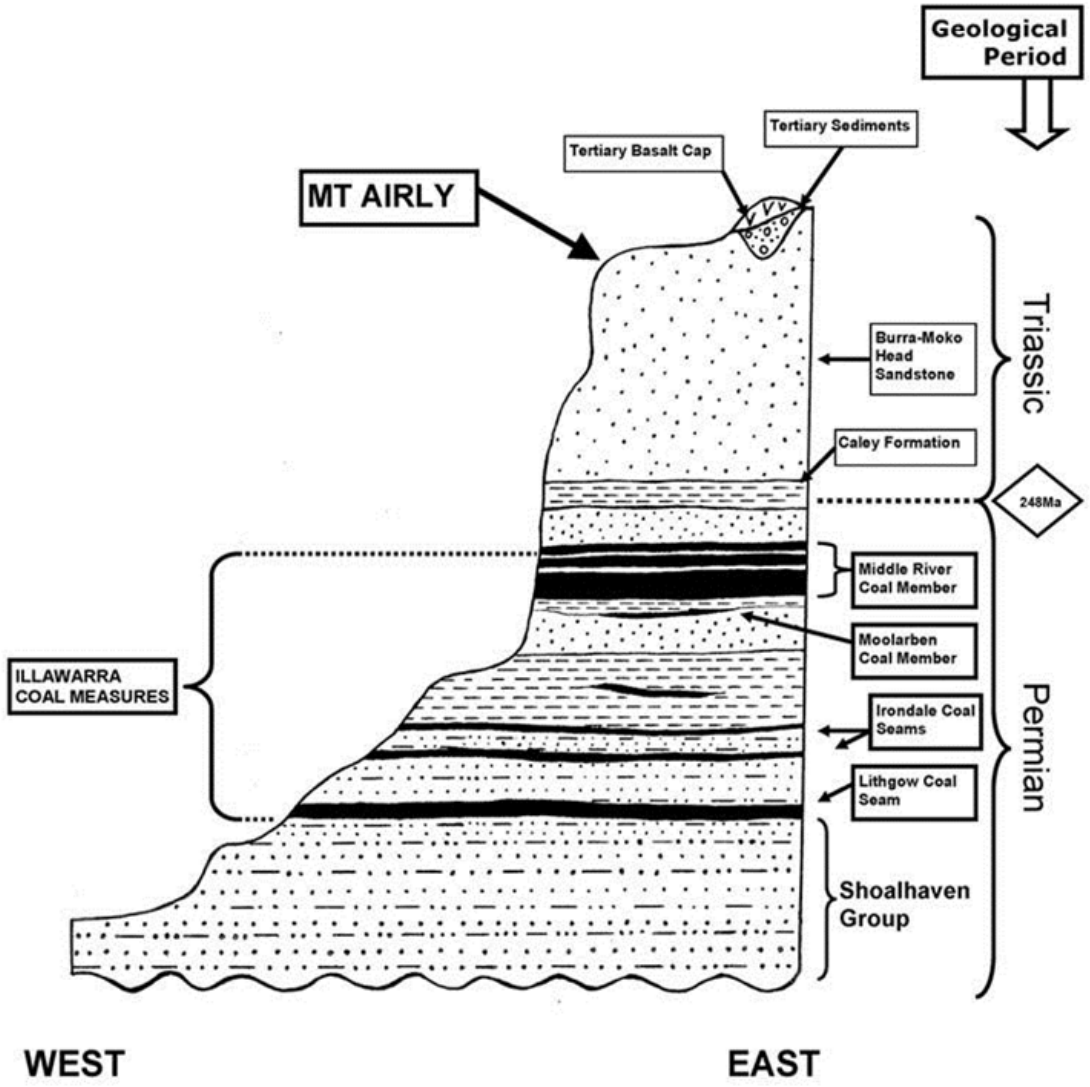
Regional groundwater sources

Regional groundwater sources occur within strata well below the coal measures and extend beyond the Airly Mine lease area.

The upper regional groundwater source occurs within siltstone and sandstone of the Shoalhaven Group. According to the Western Coalfield (Southern Part) Regional Geology 1:100,000 map, this rock formation was deposited in a marine environment and therefore the groundwater is highly brackish to saline. The existing production bore at the Airly Mine surface facilities area is installed within this groundwater source. The recharge area is predominantly to the west of Airly Mine where the Shoalhaven Group outcrops.

The lower regional groundwater source occurs within Devonian metamorphic strata containing shale, sandstone and limestone. The groundwater is slightly brackish and therefore has a lower salt content than the Shoalhaven Group and it is less sulfate dominant. Recharge areas occur to the north, south and east of Airly Mine and groundwater flow is generally to the east.

It is considered that there is minimal inter-aquifer hydraulic connection between the upper and lower regional groundwater sources, based on differences in groundwater chemistry discussed in GHD (2014).



Legend:

- Basalt
- Gravel and Sand
- Coal
- Sandstone
- Siltstone
- Interbedded Sandstone and Siltstone

NB: Not to Scale

© 2013. Whilst every care has been taken to prepare this figure, GHD make no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred by any party as a result of the figure being inaccurate, incomplete or unsuitable in any way and for any reason.

LOCATION	Airly
SEAM	NA
DRAWN	SM
CHECKED	SG
APPROVED	SG
SCALE	NTS

Airly Mine Extension Project
Hydrogeological Model Report

Geological Cross-Section

Centennial Coal

DATE Dec 2013

Figure 3-1

\\ghdnet\ghd\AU\Newcastle\Projects\22\16787\Visio\Hydrogeological Model Report\Figure2-3_Geological Cross Section.vsd

3.2 Mining operations

Coal mining to date at Airly Mine has been bord and pillar mining within the Lithgow Seam since 2014 as well as panel and pillar mining since June 2019. Groundwater drawdown impacts associated with these workings and detected to date from the groundwater monitoring network, have been isolated to the Lithgow Seam and the underlying Marrangaroo Formation (occurred in late 2015 and early 2016). These impacts are consistent with the predictions approved under SSD_5581.

There are also old shale workings within the Glen Davis Formation, developed between the late 1800s to early 1900s beneath the northern end of the Mount Airly plateau. These workings resulted in some cracking to the surface and the drainage of overlying groundwater sources (primarily Narrabeen Sandstone) into the old workings.

3.3 Stygofauna monitoring assessment program (SMAP)

Airly bores were first sampled by GHD for stygofauna under the regional program known as the stygofauna monitoring assessment program (SMAP). The SMAP was designed by GHD in 2016 to monitor stygofauna across the regional network of Centennial's bores (GHD 2016).

A Multi-Criteria Analysis (MCA) Protocol was used as a bore prioritisation tool to select the bores most likely to contain stygofauna, based on key bore attributes such as water quality, hydrogeological characteristics and bore construction details.

The following was also considered in the selection of bores for the SMAP:

- **Hydrogeology** - Cover all hydrogeological units present[1].
- **Bore location** - Geographically spread across the western region and ideally include reference bores outside the potential zone of impact (i.e. water drawdown zone)[1].
- **Bore age** - Be of varying age, in excess of six months old, and preferably undisturbed (i.e. not regularly pumped or purged)[1].
- **Historical collection of stygofauna** – presence of stygofauna in historical sampling.

The resulting score out of a maximum of five identified the suitability for stygofauna, with 5 being the most suitable. The scores were divided into four categories denoting Very Low, Low, Medium and High priority for stygofauna monitoring. Additional Airly bores have been added since development of the SMAP as outlined in Section 3.4.

3.4 Historical stygofauna monitoring

3.4.1 Baseline monitoring

Potential impacts to stygofauna from underground mining were assessed as part of the EIS for the Airly Mine Extension Project (Cardno 2014). Stygofauna samples were collected from three bores over three sampling events between May 2013 and December 2013 with an additional three bores sampled in June 2014 (Cardno 2014). Bores were sampled using bailers or pumping depending on the attributes of the bore (Cardno 2014). Cardno (2014) concluded that the results of this monitoring program may not be representative of the current environment given the small sampling effort and the limited number of available bores.

3.4.2 Post-EIS

Prior to the current monitoring event (autumn 2021), GHD had monitored a total of seven bores across seven sampling events between autumn 2016 and spring 2020. The bores monitored in historical sampling events by GHD and Cardno are outlined in Table 3.1.

ARP07SP and ARP08SP, which were sampled by Cardno in June 2014 as part of the EIS, have not been sampled by GHD. ARP07SP has been consistently dry since installation, as indicated by monthly groundwater sampling.

[1] As required by WA EPA (2007).

ARP08SP is not sampled as it does not have favourable bore attributes for stygofauna (see Table 2.1), including a narrow bore diameter (40 mm), greater than 200 metre depth below ground level, and very high EC (>6000 µS/cm) and pH (pH > 12). AM2B (production bore), which was also sampled by Cardno, has not been sampled by GHD as the bore is sealed, encasing a permanent logger which prevents sampling. AM2B-1 (old production bore) was historically monitored by GHD but was eliminated from the monitoring program following the winter 2017 monitoring event as conditions within this bore are unsuitable for the presence of stygofauna based on the water chemistry and presence of iron floc (GHD 2018).

Table 3.1 Historical stygofauna sampling events, 2013 to 2020

Sampling event	Month of monitoring	Bores sampled	Company	Purpose
Autumn 2013	May 2013	ARP05, AM2B, AM2B-1	Cardno	Airly Mine Extension EIS
Winter 2013	June 2013	ARP05, AM2B, AM2B-1		
Summer 2013	December 2013	ARP05, AM2B, AM2B-1		
Winter 2014	June 2014	ARP07, ARP08, ARP09		
Autumn 2016	March 2016	ARP09, ARP05, AM2B-1	GHD	Post EIS monitoring
Summer 2016	December 2016	ARP09, ARP05, AM2B-1		
Summer 2017	February 2017	ARP09, ARP05, AM2B-1		
Winter 2017	August 2017	ARP09, ARP05, AM2B-1, ARP11, ARP14, ARP15SP		
Spring 2018	November 2018	ARP05, ARP09, ARP11, ARP13SP ARP14, ARP15SP		
Autumn 2019	March 2019	ARP05, ARP09, ARP11, ARP13SP ARP14, ARP15SP		
Spring 2020	October 2020	ARP05, ARP09, ARP11, ARP13SP ARP14, ARP15SP		

3.4.3 Stygofauna observed to 2020

No stygofauna were collected from groundwater bores associated with Airly Mine between autumn 2013 and winter 2017.

In spring 2018, two individuals of one obligate stygofauna group (Cyclopoida) were collected from ARP11. Installed in late 2016, ARP11 is a shallow bore targeting Permian sandstone (Table 3.2). One individual of a Stygoxene (non-obligate) fauna, Gripopterygidae (stonefly), was also observed in ARP13SP in spring 2018 (GHD 2019) which is located close to Genowlan Creek.

In autumn 2019, a total of three animals were collected from ARP15SP (GHD 2020). All animals were from the Melitidae family of Amphipods. No animals were collected from ARP11, ARP13SP or ARP14 in autumn 2019, which represented a low rainfall period, during which ARP05 and ARP09 were dry.

In spring 2020, a total of nine animals were collected from ARP09. Five were from the Isotomidae family of Entomobryomorpha, three were from the Hypogastruridae family of Poduromorpha and one was from the Cyclopidae family of Copepoda. Two animals were identified in the sample from ARP13SP, one from the Isotomidae family of Entomobryomorpha and one from the Cyclopidae family of Copepoda. A total of 42 animals were collected from ARP14, all from the Parabathynellidae family of Syncarida. 34 obligate stygofauna were collected from ARP15SP; 27 from the Paramelitidae family of Amphipoda, four from the Psammaspididae family of Syncarida and three from the Cyclopidae family of Copepoda. One individual from the Lumbriculidae family of Lumbriculida was also collected in ARP15SP, which is a stygoxene (non-obligate groundwater fauna).

The obligate stygofauna collected between 2018 and 2020 are summarised in Table 3.2.

Table 3.2 Obligate stygofauna collected from Airly bores between 2018 and 2020

Sampling event	Site	Sampling method*	Number of animals (abundance)	Number of taxa (richness)	Taxa collected
Spring 2018	ARP11	50 µm net, 6 hauls	2	1	Cyclopoida (Phreatobite)
Autumn 2019	ARP15SP	50 µm net, 6 hauls	3	1	Amphipoda: Melitidae (Phreatobite)
Spring 2020	ARP09	50 µm net, 6 hauls	9	3	Entomobryomorpha: Isotomidae (Edaphobite) Poduromorpha: Hypogastruridae (Edaphobite) Copepoda: Cyclopidae (Stygobite)
	ARP13SP	50 µm net, 6 hauls	2	2	Entomobryomorpha: Isotomidae (Edaphobite) Copepoda: Cyclopidae (Stygobite)
	ARP14	50 µm net, 6 hauls	42	1	Syncarida: Parabathynellidae (Stygobite)
	ARP15SP	50 µm net, 6 hauls	34	3	Amphipoda: Paramelitidae (Stygobite) Syncarida: Psammaspididae (Stygobite) Copepoda: Cyclopidae (Stygobite)

*Fewer than six hauls may have been conducted in some circumstances due to bore characteristics

4. Methods

4.1 Survey bores

Sampling was attempted at six bores on 22 April 2021 as shown in Table 4.1. The locations of these bores are shown in Figure 4.1. ARP11 was dry during the autumn 2021 sampling event and, therefore, samples could not be collected from this bore.

The priority of some bores are identified in Figure 4.1 based on the attributes of the bore (see Section 2.3.1) as identified in the SMAP. Bores ARP11, ARP13SP, ARP14 and ARP15SP have not been assigned a priority as they were drilled after the SMAP was developed.

Photographs of bores sampled/visited in April 2021 are presented in Appendix A.

Table 4.1 Bores sampled for stygofauna, autumn 2021

Bore code	Easting (Zone 56H)	Northing (Zone 56H)	Approximate bore depth (EoH, m bgl)	Aquifer	Screen interval (m bgl) if known	Location
ARP05	224066	6333269	10.7*	Alluvial	8 - 11	Gap Creek
ARP09	225334	6332733	3.99	Alluvial	3 - 4	Genowlan Creek
ARP11	224168	6333547	15.36	Sandstone	1.25 – 15.3	Gap Creek
ARP13SP	225741	6333314	73.06	Coal seam	67.5 – 70.5	Genowlan Creek
ARP14	225738	6333335	2.30	Alluvial	0.5 - 2.3	Genowlan Creek
ARP15SP	226319	6332492	19.60	Sandstone	10 - 16	Upstream of The Oasis

Note: Locations in GDA94.

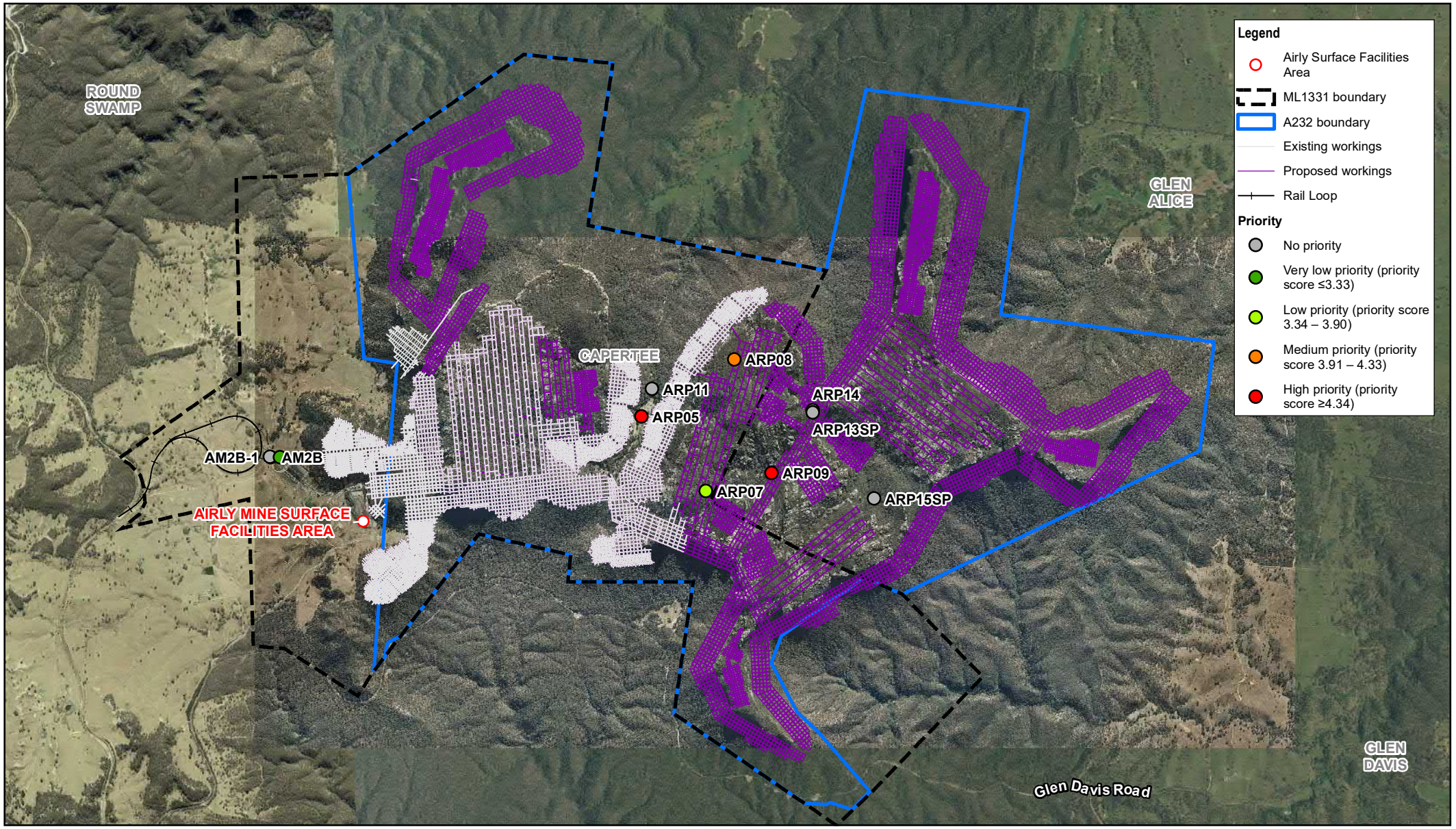
^Depth below ground level

*As measured in autumn 2021

4.2 Physical observations

The following were collected during the field survey:

– Measurements of standing water level (SWL) and end of hole (EoH) bore depth of each bore using an electronic dip probe. The standing water level is defined as the depth from the ground to the groundwater and is used to calculate the total depth of the water column.
– Recording of bore diameter, construction, purpose of bore, condition, GPS location and bore ID, presence of tree roots, surrounding land use, sampling date, time and sampling team.



CENTENNIAL

Paper Size ISO A4

0 0.35 0.7 1.05 1.4

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Centennial Pty Ltd
Airly Mine
Stygofauna Monitoring

Groundwater bores monitored for stygofauna

Project No. **12545559**
Revision No. **0**
Date **09 Mar 2022**

FIGURE 4-1

G:\22\0105001\GIS\Maps\Deliverables\Western\Airly\12545559\SFM_2021\12545559_SFM001_MonitoringLocations_0.mxd
Print date: 09 Mar 2022 - 08:12

Data source: Centennial: Mine data, 2021, Aerial Imagery; LPI: DTDB / DCDB, 2017; © Department of Customer Service 2020. Created by: tmackay

4.3 Water quality monitoring

The following *in situ* physical and chemical parameters were measured at each sampling site using a YSI multi-parameter water quality meter:

– Temperature (°C)
– pH (pH units)
– Electrical conductivity (EC) (µS/cm) as specific conductance
– Dissolved oxygen (DO) (mg/L and percent saturation)

The meter was fully calibrated prior to use, in accordance with the manufacturer's specifications. Water was extracted from the bore using a bailer and transferred to the sample cup before collecting the readings. Note that the bore was not purged prior to sampling to minimise interference to the water column. However, sampling of all bores is conducted monthly by GHD for water quality.

Turbidity (NTU) was determined through laboratory analysis at a National Association of Testing Authorities (NATA) accredited laboratory.

4.4 Stygofauna

4.4.1 Sample collection

Stygofauna monitoring was undertaken by GHD using methods consistent with the requirements for baseline surveys as defined by the WA EPA (2007; 2013) guidelines.

All sampled bores were 50 mm in diameter and a 40 mm diameter net was used for stygofauna sampling (GHD nets conform to WA EPA guideline (2007; 2013) specifications).

Nets are constructed of 50 µm nybolt mesh material, weighted at the bottom with a brass fixture and with an attached plastic collecting jar. The net was lowered to the bottom of the bore, agitated four times to dislodge resting animals and slowly retrieved. At the top of each haul, the collecting jar was rinsed into a 50 µm mesh brass sieve and the net lowered again.

Six hauls were completed for each bore following water quality sampling. Water remaining in the bailer following water quality sampling is also passed through the sieve to maximise the chance of collecting stygofauna. For each sample, the entire sieve contents were transferred to a labelled sample jar and preserved in 100% AR grade ethanol.

4.4.2 Taxonomy

Family level identification is the requirement under the Springvale Mine Extension Project Development Consent (NSW Government 2015) and has been used as the standard for Airly for consistency. Stygofauna and other animals were identified under a microscope to Family level, where possible. In some cases, the specimens were too immature or damaged to allow for identification to family level and there are some groups for which no key is available. Specimens were preserved in 100% AR grade ethanol, to allow for future genetic sequencing, if necessary.

5. Results

5.1 Environmental conditions

Figure 5.1 displays yearly rainfall totals for 2013 to December 2021, as recorded by Centennial at Airly Mine. Rainfall data from Running Stream (Brooklyn) BOM station (63012) (BOM 2021) was used for the period January to October 2013 as rainfall monitoring by Centennial began in November 2013. Long-term mean annual rainfall data was sourced from BOM (2021) for a period from 1899 to 2020.

The highest annual rainfall during the monitoring period was in 2016, which was well above the average. Rainfall during the 2017 to 2019 period was well below the long-term average for the area, with the lowest annual rainfall of 398.4 mm recorded in 2019. Rainfall in 2020 was high compared to the previous three years, with higher-than-average rainfall recorded. Annual rainfall in 2021 was slightly below average, representing the third highest annual rainfall during the monitoring period.

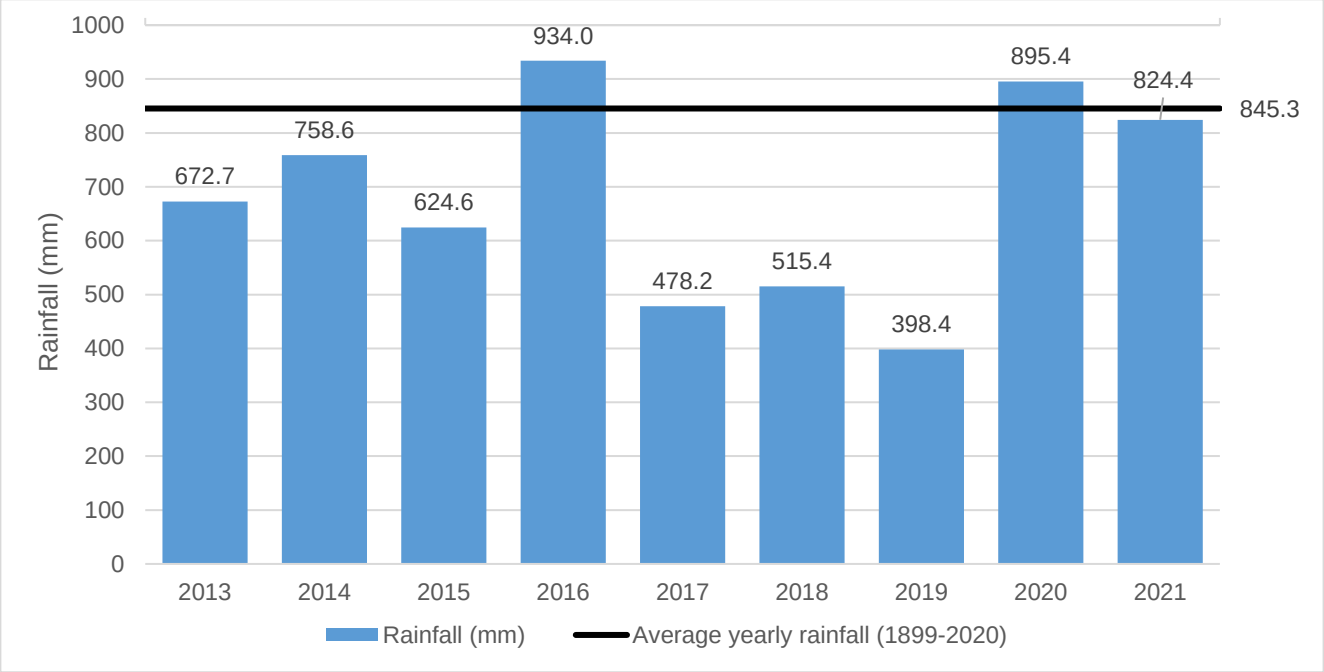


Figure 5.1 Yearly rainfall at Airly Mine from 2013 to 2021, compared to average yearly rainfall (1899-2020)

5.2 Water quality

Water quality recorded by GHD during stygofauna sampling is summarised in Table 5.1. ARP11 was dry and was consequently not sampled.

EC was below 2000 µS/cm in all five bores in autumn 2021, which is favourable for stygofauna. The highest EC was observed at ARP13SP. pH was below the prospective range in all bores except at ARP13SP where pH was within the favourable range. pH was particularly low (below 5) at ARP09. The highest dissolved oxygen saturation was observed in ARP05 followed by ARP15SP. Turbidity was elevated at ARP05 and ARP13SP, but an order of magnitude higher at ARP14.

Table 5.1 Water quality in Airly bores, on 22 April 2021

Site	Depth to water (m)^	Time (24 hr)	Temp (°C)	EC (µS/cm)	pH	DO (% sat)	Turbidity (NTU)[1]
ARP05	3.83	16:30	15.7	127.7	5.88	57.3	63.5
ARP09	2.12	15:21	14.4	45.0	4.96	38.8	2.5
ARP13SP	64.83	11:45	17.2	571.2	6.66	14.5	85.6
ARP14	0.67	12:50	14.2	90.6	6.01	19.6	663
ARP15SP	10.61	15:00	14.2	57.2	6.09	42.1	10.5
Favourable value*	NA	NA	NA	<2000	6.5-8.5	NA	NA

*Based on criteria outlined in Section 2.3.1.
^Depth below ground level
[1] Analyte was analysed in a laboratory with water samples collected on 22 April 2021

5.3 Fauna

The animals collected from Airly bores in autumn 2021 are outlined in Table 5.2. Animals were collected from all sites with water during the autumn 2021 monitoring event except for ARP13SP.

A total of one animal was collected from ARP05 in autumn 2021 from the Hypogastruridae family of Poduromorpha.

A total of six taxa were collected from ARP09, also from the Hypogastruridae family of Poduromorpha.

A total of seven animals were collected from ARP14. Six were from the Parabathynellidae family of Bathynellacea and one was from the Hypogastruridae family of Poduromorpha.

A total of 29 animals were collected from ARP15SP in autumn 2021. 24 were from the Cyclopidae family of Cyclopoida, three were from the Neoniphargidae family of Amphipoda and two were from the Psammaspididae family of Anaspidacea.

Table 5.2 Animals collected from Airly bores in autumn 2021

Site	Sampling method	Family	Type of stygofauna	Abundance	Number of taxa (richness)	Number of obligate stygofauna (richness)
ARP05	50 µm net, 6 hauls	Poduromorpha: Hypogastruridae	Phreatobite	1	1	1
Total				**1**		
ARP09	50 µm net, 6 hauls	Poduromorpha: Hypogastruridae	Phreatobite	6	1	1
Total				**6**		
ARP14	50 µm net, 6 hauls	Bathynellacea: Parabathynellidae	Phreatobite	6	2	2
		Poduromorpha: Hypogastruridae	Phreatobite	1		
Total				**7**		
ARP15SP	50 µm net, 6 hauls	Cyclopoida: Cyclopidae	Phreatobite	24	3	3
		Anaspidacea: Psammaspididae	Phreatobite	2		
		Amphipoda: Neoniphargidae	Phreatobite	3		
Total				**29**		

6. Discussion

Although stygofauna communities are commonly highly variable between seasons and patchy in distribution, the autumn 2021 monitoring results showed some commonalities with spring 2020 results (GHD 2021a). Obligate stygofauna were collected from all the shallow bores (<50 m) in autumn 2021, mirroring the results of the spring 2020 survey. The prevalence of stygofauna in 2020 and 2021 samples, following a complete absence of stygofauna prior to 2018, reflects the near-average annual rainfall in 2020-2021 and recovery of the groundwater levels.

Groundwater quality monitoring of bores in the Airly bore network identified that there were favourable conditions in all bores with water in autumn 2021, with EC and pH generally within the prospective range (see Section 2.3.1), with the exception of pH, which was slightly low in all bores except ARP13SP. ARP13SP, being deeper than 50 m, was the least prospective for stygofauna.

The highest diversity and abundance of obligate stygofauna was observed in ARP15SP in autumn 2021. Three obligate stygofauna families (Cyclopoida: Cyclopidae, Anaspidacea: Psammaspididae and Amphipoda: Neoniphargidae), were collected from ARP15SP in autumn 2021 which is the same number of obligate stygofauna families collected in this bore in spring 2020. It is not surprising that the greatest diversity was detected in ARP15SP given its shallow depth, low EC and relatively high DO. This bore also has more reliable water than some of the other shallow bores such as ARP05, ARP09 and ARP11, which have been recently dry.

Autumn 2021 is the first sampling event where stygofauna (one Poduromorpha: Hypogastruridae) have been collected in ARP05. The positive detection in this shallow alluvial bore coincides with increasing rainfall and groundwater levels in ARP05. Hypogastruridae were also observed in ARP09 and ARP14SP in autumn 2021 and the same family was previously observed in ARP09 in spring 2020. ARP05, ARP09 and ARP14SP are all shallow bores located adjacent to waterways creating similar conditions which may appeal to this type of stygofauna, including strong connectivity to surface waters.

The autumn 2021 results indicate decreased diversity in ARP09 with Cyclopodidae and Isotomidae collected in spring 2020, absent from the autumn 2021 sample. In ARP14SP, the diversity has increased since spring 2020 when Parabathynellidae was the only taxa collected, although, the number of individuals was higher in spring 2020.

In spring 2020, a single individual of the Copepoda family, Cyclopidae, was collected from ARP13SP. ARP13SP is a deeper bore (approximately 73 m), located within the Lithgow Seam. Given that ARP13SP is not prospective for stygofauna, being deeper than 50 m, it was theorised that the individual may have been transferred to the ARP13SP sample from another bore. The monitoring methods were altered in 2021 to eliminate the possibility of sample contamination. No animals were collected from ARP13SP in autumn 2021, which supports the theory of cross-contamination.

The results of the autumn 2021 survey indicate that stygofauna are prevalent in the shallow aquifers of the Airly mine area. All bores from which stygofauna were collected in autumn 2021 are installed in the shallow alluvium or shallow sandstone. Groundwater monitoring has shown that the extensive natural fracturing of the shallow sandstone results in the seepage of groundwater along the slopes of the mountains. Consequently, there is expected to be limited groundwater within this strata, and negligible drawdown is predicted for the Narrabeen Sandstone due to Airly mining operations (GHD 2014). Similarly, there is not predicted to be impacts to the majority of the shallow alluvium. Surface subsidence cracks have recently been observed at Mount Airly and are potentially associated with mining within the panel and pillar area in 2020 and 2021. However, the Airly Mine extraction plan has since been updated to reduce the area of panel extraction, and increase the width of the pillars, which is expected to reduce the likelihood of surface cracking. Therefore, the groundwater sources that support the identified stygofauna in shallow alluvial and shallow sandstone are unlikely to be impacted by mining.

Stygofauna monitoring will continue to be conducted annually, with the next round of monitoring planned for 2022.

7. Conclusion

Obligate stygofauna were collected from all shallow bores that contained water during autumn 2021 sampling. The only bore from which stygofauna were not collected in autumn 2021 was ARP13SP, which is a deeper bore that intersects the Lithgow coal seam and is, therefore, less prospective for stygofauna.

The increased prevalence of stygofauna in Airly bores compared to earlier (pre-2020) surveys is likely to be due to the increased rainfall in 2021, continuing the pattern observed in 2020 (GHD 2021a, b). The bores from which stygofauna were collected intersected the shallow sandstone strata or the shallow alluvium, including ARP15SP, which, as was the case in 2020, exhibited the most diverse and abundant stygofauna population of all the sampled bores in 2021. The groundwater levels in these shallow bores demonstrated a response to rainfall since easing of drought conditions in 2020 (GHD 2021b; 2022 *in draft*). Impacts to the shallow alluvium and sandstone were predicted to be minimal and acceptable in the EIS for Airly Mine (GHD 2014). Although some surface subsidence cracks have been recently identified at Mount Airly that may be related to mining in the panel and pillar area, the mine plan has since been updated to reduce the likelihood of surface cracking. Therefore, the likelihood of impacts from Airly mine operations to the stygofauna inhabiting shallow groundwater aquifers is low.

The next round of stygofauna monitoring will be conducted in winter 2022.

8. References

Cardno (2014) Aquatic Ecology and Stygofauna Assessment, Airly Mine Extension Project, report prepared for Centennial Coal Company Limited.

EPA (2007) *Guidance for the Assessment of Environmental Factors, Sampling Methods and Survey Considerations for Subterranean Fauna* (in accordance with the Environmental Protection Act 1986), Technical appendix to Guidance Statement No. 54, Environmental Protection Authority, Western Australia.

GHD (2022) Annual Water Monitoring Report 2021, prepared by GHD Pty Ltd for Centennial Coal Company Limited, currently in draft.

GHD (2021) *Airly Mine Water Management Plan*, prepared for Centennial Coal Company Limited.

GHD (2020a) Airly Mine stygofauna monitoring 2020, prepared by GHD Pty Ltd for Centennial Coal Company Limited.

GHD (2021b) Annual Water Monitoring Report 2020, prepared by GHD Pty Ltd for Centennial Coal Company Limited.

GHD (2020a) Airly Mine stygofauna monitoring 2020, prepared by GHD Pty Ltd for Centennial Coal Company Limited.

GHD (2020b) Airly Mine stygofauna monitoring 2019, prepared by GHD Pty Ltd for Centennial Coal Company Limited.

GHD (2019) *Airly Mine stygofauna monitoring 2018*, prepared by GHD Pty Ltd for Centennial Coal Company Limited.

GHD (2018) *Airly Mine stygofauna monitoring 2016 - 2017*, prepared by GHD Pty Ltd for Centennial Coal Company Limited.

GHD (2016) *Western Region Stygofauna Monitoring and Assessment Plan*, prepared by GHD Pty Ltd for Centennial Coal Company Limited.

GHD (2014) *Groundwater Impact Assessment, Airly Mine Extension Project*, prepared by GHD Pty Ltd for Centennial Coal Company Limited.

Golder Associates (2013) *Subsidence Predictions and Impact Assessment for Airly Mine*, prepared by Golder Associates Pty Ltd for Centennial Coal Company Limited.

Hancock, PJ, Boulton AJ and Humphreys WF (2005) *Aquifers and hyporheic zones: Towards an ecological understanding of groundwater*. Hydrogeology Journal 13, 98-111.

Hancock, PJ and Boulton, AJ (2008) Stygofauna biodiversity and endemism in four alluvial aquifers in eastern Australia. Invertebrate Systematics 22, 117-126.

Hose GC, J Sreekanth, Barron O, Pollino C (2015) *Stygofauna in Australian Groundwater Systems: Extent of knowledge*. CSIRO, Australia.

Humphreys, W.F (2008) Rising from Down Under: developments in subterranean biodiversity in Australia from a groundwater perspective. *Invertebrate Systematics* 22, 85-102.

Korbel, K and Hose, GC (2015) Water quality, habitat, site or climate? Identifying environmental correlates of the distribution of groundwater biota. *Freshwater Sciences* 34:329-343.

NSW Government (2016) *Developments Consent, Airly Mine extension project*, Department of Planning and Environment.

NSW Government (2015) *Developments Consent*, Springvale Coal Mine Underground mine extension project, Department of Planning and Environment.

Serov P. (2016) *http://www.stygoecologia.com.au/aquatic.php* (date accessed 14 January 2016).

Appendix A

Bore Photographs and Surrounds

Bore	Photograph
ARP05	
ARP09	

Bore	Photograph
ARP11	
ARP13SP	

Bore	Photograph
ARP14	
ARP15SP	

Appendix B

All Fauna Collected from Airly Bores, 2017 - 2021

Fauna collected from Airly bores between 2017 and 2021

Sampling event	Bore ID	Date sampled	Phylum	Class	Order	Family	Genus	Habitus	No. of animals
Mar-16	AM2B-1	15/03/16	*Arthropoda*	*Entognatha (Collembola)*	*Entomobryomorpha*	*Isotomidae*	*Isotomodes c.f*	*Edaphobite*	2
Dec-16	AM2B-1	02/12/16							0
Dec-16	ARP09	05/12/16	*Arthropoda*	*Entognatha (Collembola)*	*Entomobryomorpha*	*Isotomidae*	*Isotomodes c.f*	*Edaphobite*	1
Feb-17	AM2B-1	17/02/17							0
Aug-17	ARP05	09/08/17							0
Aug-17	ARP09	08/08/17							0
Aug-17	ARP11	07/08/17							0
Aug-17	ARP14	08/08/17							0
Aug-17	ARP15SP	08/08/17							0
Aug-17	AM2B-1	07/08/17	*Arthropoda*	*Entognatha (Collembola)*	*Entomobryomorpha*	*Isotomidae*		*Edaphobite*	3
Nov-18	ARP11	01/11/18	*Arthropoda*	*Maxillopoda*	*Copepoda: Cyclopoida*			*Phreatobite*	2
Nov-18	ARP13SP	01/11/18	*Arthropoda*	*Insecta*	*Plecoptera*	*Gripopterigidae*		*Stygoxene*	1
Nov-18	ARP14	01/11/18	*Arthropoda*	*Entognatha (Collembola)*	*Entomobryomorpha*	*Isotomidae*		*Edaphobite*	19
Nov-18	ARP14	01/11/18	*Arthropoda*	*Arachnida*	*Trombidiformes*	*Trombidiidae*		*Edaphobite*	1
Nov-18	ARP15SP	01/11/18							0
Mar-19	ARP11	21/03/19							0
Mar-19	ARP13SP	20/03/19							0
Mar-19	ARP14	20/03/19							0
Mar-19	ARP15SP	20/03/19	*Arthropoda*	*Malacostraca*	*Amphipoda*	*Melitidae*		*Phreatobite*	3
Oct-20	ARP09	28/10/20	*Arthropoda*	*Entognatha (Collembola)*	*Entomobryomorpha*	*Isotomidae*		*Edaphobite*	5
Oct-20		28/10/20	*Arthropoda*	*Entognatha (Collembola)*	*Poduromorpha*	*Hypogastruridae*		*Edaphobite*	3
Oct-20		28/10/20	*Arthropoda*	*Crustacea*	*Copepoda*	*Cyclopidae*		*Phreatobite*	1

Sampling event	Bore ID	Date sampled	Phylum	Class	Order	Family	Genus	Habitus	No. of animals
Oct-20	ARP15SP	28/10/20	*Arthropoda*	*Crustacea*	*Amphipoda*	*Paramelitidae*		*Stygobite*	27
Oct-20		28/10/20	*Arthropoda*	*Crustacea*	*Syncarida*	*Psammaspididae*		*Stygobite*	4
Oct-20		28/10/20	*Arthropoda*	*Crustacea*	*Copepoda*	*Cyclopidae*		*Phreatobite*	3
Oct-20		28/10/20	*Annelida*	*Oligochaeta*	*Lumbriculida*	*Lumbriculidae*		*Stygoxene*	1
Oct-20	ARP13SP	28/10/20	*Arthropoda*	*Entognatha (Collembola)*	*Entomobryomorpha*	*Isotomidae*		*Edaphobite*	1
Oct-20		28/10/20	*Arthropoda*	*Crustacea*	*Copepoda*	*Cyclopidae*		*Phreatobite*	1
Oct-20	ARP14	28/10/20	*Arthropoda*	*Crustacea*	*Syncarida*	*Parabathynellidae*		*Stygobite*	42
Apr-21	ARP05	22/04/21	*Arthropoda*	*Collembola*	*Poduromorpha*	*Hypogastruridae*		*Phreatobite*	1
Apr-21	ARP09	22/04/21	*Arthropoda*	*Collembola*	*Poduromorpha*	*Hypogastruridae*		*Phreatobite*	6
Apr-21	ARP13SP	22/04/21							0
Apr-21	ARP14	22/04/21	*Arthropoda*	*Malacostraca*	*Bathynellacea*	*Parabathynellidae*		*Phreatobite*	6
		22/04/21	*Arthropoda*	*Collembola*	*Poduromorpha*	*Hypogastruridae*		*Phreatobite*	1
Apr-21	ARP15P	22/04/21	*Arthropoda*	*Maxillopoda*	*Cyclopoida*	*Cyclopidae*		*Phreatobite*	24
		22/04/21	*Arthropoda*	*Malacostraca*	*Anaspidacea*	*Psammaspididae*		*Phreatobite*	2
		22/04/21	*Arthropoda*	*Malacostraca*	*Amphipoda*	*Neoniphargidae*		*Phreatobite*	3

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The Power of Commitment

Appendix 3: 2021 Aquatic Ecology Report

Airly Aquatic Ecology 2021

Annual report 2021

Centennial Airly Pty Ltd

28 March 2022

→ **The Power of Commitment**



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Document status

Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S4	0	J. Wyatt	Z. Lagerroth		Z. Lagerroth		28/03/2022

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Overarching Review

Statement of Compliance Question	Statement of Compliance Answer
Were all conditions of SSD_5581 and the Airly Mine Water Management Plan relating to aquatic ecosystems and stream health complied with?	Yes – There were no non-compliances relating to aquatic ecology or stream health in the 2021 reporting period

Details of Non-Compliances

Relevant Approval	Condition #	Condition summary	Compliance Status	Comment	Reference # addressed in Annual Review
N/A - No non-compliances relating to aquatic ecosystems or stream health during the 2021 reporting period			Compliant		

Development consent SSD-5581 (Modification 2) performance conditions relating to surface waters

Condition	Condition description	Compliant	Relevant section of this document
Water management performance measures			
Water discharge to Airly Creek			
Schedule 4 12.	Negligible environmental consequences for water quality (i.e. protection to 99% of all species in accordance with ANZECC guidelines) and flow in Airly Creek where it enters the Gardens of Stone National Park and Greater Blue Mountains World Heritage Area.	Yes	See discharge volumes in Section 3.2 and water quality results in Section 3.4.1 and 2021 Annual Water Monitoring Report (GHD 2022).
Gap and Genowlan Creeks			
Schedule 4 12.	No greater impact than predicted in the EIS for water, flow and quality.	Yes	See Section 3.3. No evidence of impact from mining on flow or water quality in Gap Creek as identified in 2021 Annual Water Monitoring Report (GHD 2022). Genowlan Creek has not yet been impacted by mining.
Aquatic and riparian ecosystems			
Schedule 4 12.	Maintain or improve baseline channel stability.	Yes	NA See geomorphology assessment report (GHD 2021b).
	Develop site-specific water quality objectives in accordance with ANZECC Guidelines and Using the ANZECC Guidelines and Water Quality Objectives in NSW procedures (DECC 2006) or its latest version.	Yes	SSGVs in Section 2.7.1. Refer to Site Specific Guideline Values document (GHD 2018b). Also refer to Section 6 of WMP (GHD 2021d).
Water management plan			
Schedule 4 13.	Prior to carrying out any development under this consent, unless the Secretary agrees otherwise, the Applicant must prepare a Water Management Plan for the development to the satisfaction of the Secretary. This plan must:		
Schedule 4 13. (a)	Be prepared in consultation with the DoEE, EPA and the Water Division, by suitably qualified and experienced person/s whose appointment has been approved by the Secretary.	Yes	NA Refer to Appendix A and Appendix B of WMP (GHD 2021d).

Condition	Condition description	Compliant	Relevant section of this document
Schedule 4 13. (b)	Include detailed performance criteria and describe measures to ensure that the Applicant complies with the Water Management Performance Measures (see Table 6).	Yes	NA Refer to Section 6 of WMP (GHD 2021d).
Site water balance			
Schedule 4 13. (c) (i)	Details of sources and security of water supply, including contingency supply for future reporting periods.	Yes	NA Refer to Section 3.1 and Section 3.5.1 of the WMP (GHD 2021d).
	Details of water use and management on site.	Yes	NA Refer to Section 3 of WMP (GHD 2021d) and 2021 Annual Water Monitoring Report (GHD 2022).
	Details of any off-site water discharges.	Yes	NA Refer to Section 3.5.2 of WMP (GHD 2021d) and 2021 Annual Water Monitoring Report (GHD 2022).
	Reporting procedures, including the preparation of a site water balance for each calendar year.	Yes	NA Refer to 2021 Annual Water Monitoring Report (GHD 2022) and Section 7.4 of WMP (GHD 2021d).
	Investigates and implements all reasonable and feasible measures to minimise water use on site.	Yes	NA Refer to Section 3.5.1 of WMP (GHD 2021d).
Surface water management plan			
Schedule 4 13. (c) (ii)	Detailed baseline data on water flows and quality in the watercourses that could potentially be affected by the development, including, but not limited to Gap, Genowlan and Airly Creeks.	Yes	Water quality monitoring has been undertaken in conjunction with aquatic ecology monitoring (see Section 3.4). Also refer to Section 5.1 of WMP (GHD 2021d) and 2021 Annual Water Monitoring Report (GHD 2022).
Schedule 4 13. (c) (ii)	Continuous flow monitoring at Airly village spring and the Grotto.	Yes	NA Refer to Section 5.1.2 and Section 5.3.1 of WMP (GHD 2021d) and 2021 Annual Water Monitoring Report (GHD 2022).
	Provisions for the recalculation of site-specific trigger values in relation to water discharges to Airly Creek once a minimum of two years data is obtained from the Airly Creek 'U/S' monitoring location in accordance with ANZECC guidelines.	Yes	NA Refer to Site Specific Guideline Values document (GHD 2018b) and Section 6.1.1 of WMP (GHD 2021d).
	The provision and implementation of adaptive management measures to ensure that subsequent water discharges to Airly Creek comply with the recalculated site-specific trigger values derived from the Airly Creek 'U/S' monitoring location.	Yes	NA Refer to TARPs in Appendix E of the WMP (GHD 2021d).
	A detailed description of the water management system, including the: – Clean water diversion systems – Erosion and sediment controls (mine water system) – Mine water management systems	Yes	NA Refer to Section 3.2 and Section 3.3 of WMP (GHD 2021d).

Condition	Condition description	Compliant	Relevant section of this document
	Detailed objectives and performance criteria, including trigger levels for investigating any potentially adverse impacts associated with the development for:		
	Downstream surface water quality.	Yes	SSGVs in Section 2.7.1. Also refer to Section 6 of WMP (GHD 2021d) and 2021 Annual Water Monitoring Report (GHD 2022) and Section 3.4 of this report.
	Downstream water users, including with respect to any subsidence-related flow reductions in Gap and Genowlan Creeks.	Yes	NA Refer to Section 6 of WMP (GHD 2021d).
	Stream and riparian vegetation health in Gap, Genowlan and Airly Creeks within and immediately outside of the site.	Yes	Performance criteria for instream health outlined in Table 1.1. Also refer to Section 6.2 of WMP (GHD 2021d). Riparian vegetation assessment outlined in Airly Site specific Biodiversity Management Plan (BMP).
Schedule 4 13. (c) (ii)	A program to monitor and report on:		
	Effectiveness of the mine water management system.	Yes	NA Refer to Section 4 of the WMP (GHD 2021d).
	Surface water flows, quality and geomorphology of the watercourses potentially affected by the development within and immediately outside of the site.	Yes	Refer Section 3.4 Monitoring program for surface water flows, quality and geomorphology outlined in Section 4 of WMP (GHD 2021d). Monitoring results for water quality and flow addressed in the 2021 Annual Water Monitoring Report (GHD 2022). Geomorphology assessment every two years, completed in 2020 (GHD 2021b).
	The performance measures listed in Table 6 including, but not limited to event-based monitoring of the hydrology, quality, ecotoxicology and chemical composition of water in Airly Creek under discharge conditions at points 5 and 6, or as otherwise determined in consultation with the EPA, to ensure that protection is provided to 99% of all species in the Gardens of Stone National Park and Greater Blue Mountains World Heritage Area in accordance with ANZECC guidelines.	Yes	NA Refer to Section 4 and Appendix E of WMP (GHD 2021d) and 2021 Annual Water Monitoring Report (GHD 2022).
	Reporting procedures for the results of the monitoring program.	Yes	NA Refer to Section 7.1 of WMP (GHD 2021d) and Regional WMP (GHD 2016).
	A plan to respond to any exceedances of performance measures, and repair, mitigate and/or offset any adverse surface water impacts of the development, including measures to provide compensatory water supply to any affected downstream water user.	Yes	NA Refer to Section 6.3 and Appendix E of WMP (GHD 2021d).

NA – not applicable to this report

Statement of commitments relating to aquatic ecosystems (GHD 20219b)

Commitment	Compliant	Relevant section of this document
Monitor macroinvertebrate ecology in Airly Creek at appropriate upstream and downstream locations biannually (spring and autumn).	Yes	Section 3.6

Stream health performance criteria relating to aquatic ecosystems (GHD 2021)

Aspect	Criteria	Compliant	Relevant section of this document
Geomorphic condition and watercourse stability (required every two years)			
Bed and bank stability	Negligible environmental consequences to bed and bank stability for Gap and Genowlan Creeks. Maintain or improve baseline channel stability.	Yes	NA Geomorphology assessment completed in 2020 (GHD 2021b). Subsidence monitoring is conducted as outlined the Airly Mine Annual Review.
Incisional processes and instabilities	Occurrence of erosional processes does not occur as a result of subsidence.	Yes	
Stream gradient	Change in stream gradient does not vary beyond predictions of subsidence modelling.	Yes	
Watercourse subsidence	No connective cracking between the surface and underground workings. Subsidence does not vary beyond predictions of modelling.	Yes	
Aquatic ecology (required annually in autumn and spring)			
Instream/riparian vegetation	RCE scores relating to riparian and instream vegetation within historical range and/or consistent with reference sites.	Yes	Observations regarding instream vegetation were collected as part of aquatic ecology monitoring, See Section 3.3 of this document.

Executive summary

Airly Mine has development consent under Section 89E of the Environmental Planning & Assessment Act 1979 for the extension of the mine (approved 15 December 2016) and commenced operations under this consent on 31 January 2017. The wording of Development Consent SSD-5581 has been modified twice to remove restrictions on mining (Modification 1) and to allow the receipt of up to 170 ML/year of water from Charbon Colliery by rail (Modification 2). The development consent requires a program to monitor and report on stream health for waterways that have the potential to be impacted by Airly Mine operations through subsidence or discharge of water. The purpose of this report is to present the results of aquatic ecology monitoring undertaken in 2021. Watercourse stability monitoring is conducted every second year with the next round of monitoring due to be completed in 2022.

Aquatic ecology monitoring has been undertaken within waterways with the potential to be impacted by Airly Mine, biannually since spring 2015. GHD conducted autumn 2021 monitoring between 3 and 5 May 2021 and spring 2021 monitoring between 2 and 4 November 2021. The monitoring program involved assessment of seven sites, consisting of three baseline sites, two subsidence impact sites, one background site on Airly Creek upstream from Airly Mine discharges and one impact site on Airly Creek downstream from Airly Mine's licensed licensed discharge points (LDPs). Macroinvertebrate, water and sediment samples were collected from each site in autumn and spring. Instream habitat surveys were also undertaken noting the coverage and condition of riparian and instream vegetation through completion of the riparian, channel and environmental (RCE) inventory (Peterson 1992).

Airly Mine has three LDPs under Environment Protection Licence (EPL) 12374. There was a small overflow event from the LDP2 basin on the 23 March 2021 that led to approximately 432 kilolitres discharging to a tributary of Airly Creek. This was due 97.2mm of rain falling over the five-day period prior to the overflow event (Centennial 2021a). This discharge event occurred approximately five weeks prior to autumn aquatic ecology sampling. The only discharge from LDP1 in 2021 occurred between 27 and 30 November 2021, with a total volume of approximately 15.6 megalitres discharged to a tributary of Airly Creek. The discharge quality was compliant with the concentration limits in EPL 12374 (Centennial 2021b).

The water at higher altitude sites GAP, GEN and GRO was of low ionic strength, which reflects the minimal anthropogenic disturbance and different geology of these areas, although, isolated exceedances of guideline values for chromium and aluminium are also indicative of the lithology. There was no evidence of impacts on water or sediment quality due to Airly Mine operations in 2021. Discharge impact site AIR contained similar water quality to background site AIRUS and other lower altitude sites TOR and DOG, reflecting the influence of surrounding landuse (i.e. grazing), historical land clearing and underlying geology on water quality. The LDP1 discharge occurred several weeks after spring 2021 aquatic ecology monitoring. However, water quality sampling was conducted in Airly Creek the day following cessation of discharges (1 December 2021) and results indicated a low risk of toxicity based on comparison to guideline values for aquatic ecosystem protection.

Macroinvertebrate community condition and composition in 2021 reflected the site differences, with samples collected from more pristine, higher altitude sites Gap and Genowlan Creeks showing similarities, which contrasted to the macroinvertebrate communities of lower lying sites in Dog Trap, Torbane and Airly Creeks. The communities of lower lying sites were dominated by pollution-tolerant taxa, which reflects the more saline water in these catchments and different aquatic habitat, although, diversity was also generally higher at these sites in 2021. There were improvements in the macroinvertebrate community of Torbane Creek and Dog Trap Creek in 2021, likely due to the continuing trend of higher rainfall which has flushed the waterways, provided stable habitat and improved water and instream habitat quality. There was no indication of impacts from Airly Mine discharges on the macroinvertebrate community of Airly Creek, as macroinvertebrate community condition was similar upstream and downstream of the discharge, which is consistent with the water quality results.

Panel and pillar mining was undertaken below a small section of the first order headwaters of Torbane Creek in 2019 and Gap Creek between 2020 and 2021. The results of 2021 monitoring do not suggest any impacts to the macroinvertebrate community due to this activity. Macroinvertebrate condition in Torbane Creek in 2021 was in the best observed in the 2013 to 2021 monitoring period and while macroinvertebrate community condition at GAP in 2021 was poor relative to some other sites, the quality has improved since the low observed in 2019/2020, following the three-year drought period. There was no evidence of impacts to flows or water quality in Gap Creek since panel and pillar mining commenced in this catchment (GHD 2022). Therefore, there is no evidence of impacts from subsidence on the aquatic biota of Gap Creek.

The next round of aquatic ecology monitoring will be conducted in autumn 2022.

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1. Introduction

1.1 Background

Airly Mine is an underground coal mine located near Capertee, approximately 40 km northwest of Lithgow, owned by Centennial Airly Pty Ltd (Centennial). Airly Mine was granted Development Consent (SSD-5581) for the extension of its underground coal mine on 15 December 2016. Development consent SSD-5581 has been modified twice to remove restrictions on mining (Modification 1) and to allow the receipt of up to 170 ML/year of water from Charbon Colliery by rail (Modification 2).

Airly Mine currently has approval to extract up to 1.8 million tonnes per annum (Mtpa) of run of mine (ROM) coal from the Lithgow Seam using mining methods that incorporate extraction by first workings, partial pillar extraction or panel and pillar mining. ROM and product coal are transported off site by rail for the export and domestic markets.

Aquatic ecology monitoring was undertaken by Cardno (2014) to support the Environmental Impact Statement (EIS) for the Airly Mine Extension Project. Sampling was undertaken in autumn and spring 2014 at twelve aquatic ecology monitoring sites, located on six creeks (Cardno 2014).

Thirteen rounds of aquatic ecology monitoring have been conducted since the EIS, during autumn and spring each year from spring 2015 to spring 2021. This report outlines the results of the autumn 2021 monitoring conducted between 3 and 5 May 2021 and the spring 2021 monitoring conducted between 2 and 4 November 2021.

1.2 Scope

GHD Pty Ltd (GHD) was engaged by Centennial to undertake autumn and spring 2021 aquatic ecology monitoring in waterways upstream and downstream of Airly Mine as required by the conditions of consent of the extension of the mine (see Section 1.4.2). Aquatic ecology monitoring involved the collection of macroinvertebrate, water and sediment samples in autumn and spring 2021. This report presents the results of autumn and spring 2021 aquatic ecology monitoring and also considers the previous monitoring results to assess the condition of the sites.

1.3 Purpose of this report

The purpose of this report is to present the results of aquatic ecology monitoring undertaken in 2021 and to fulfil the requirements of the development consent conditions outlined in the Airly Mine Water Management Plan (WMP) (GHD 2021d). This report is intended as a supporting document to Airly Mine's Annual Review.

1.4 Licenced discharges and development consent conditions

1.4.1 Licensed discharges

Airly Mine currently has three licenced discharge points (LDPs) under EPL 12374: LDP1, LDP2 and LDP3. The LDPs discharge infrequently into a tributary of Airly Creek. LDPs are monitored monthly during discharge and tested for several water quality parameters.

1.4.2 Development consent conditions

Airly Mine has development consent under Section 89E of the Environmental Planning & Assessment Act 1979 for the extension of the mine (approved 15 December 2016).

The performance criteria relating to stream health in waterways surrounding Airly Mine is outlined in the Airly Mine Water Management Plan (GHD 2021d) and below in Table 1.1. These criteria have been developed to ensure that potential impacts as a result of mining operations are not greater than those predicted by the environmental impact assessments for the approved Airly Mine Extension Project and subsequent modifications.

Geomorphic condition and watercourse stability monitoring is required every two years and was last conducted in 2020 (GHD 2021b). Therefore, watercourse stability is not discussed in this report.

Aquatic ecology monitoring is undertaken twice per year in autumn and spring and includes an assessment of riparian and instream vegetation as part of the riparian, channel and environmental (RCE) inventory (Peterson 1992) (see Section 2.2).

Table 1.1 Stream health performance criteria from Airly Mine Water Management Plan (GHD 2019b)

Aspect	Criteria	Addressed in this report
Bed and bank stability	Negligible environmental consequences to bed and bank stability for Gap and Genowlan Creeks.	No – visual watercourse stability monitoring conducted every two years. See GHD (2021b) for results of the most recent monitoring conducted in 2020.
Incisional processes and instabilities	Occurrence of erosional processes does not occur as a result of subsidence.	
Stream gradient	Change in stream gradient does not vary beyond predictions of subsidence modelling.	No – Centennial maintains a subsidence monitoring program which includes visual inspections, physical markers and satellite technology.
Watercourse subsidence	No connective cracking between the surface and underground workings.	
Instream/riparian vegetation	RCE scores relating to riparian and instream vegetation within historical range and/or consistent with reference sites.	Yes – see Section 3.3.

1.5 Assumptions

Historical water quality data and monthly water quality results for Airly Creek sites in 2021 were obtained from ALS. Rainfall records were obtained from Centennial. It is assumed that the data provided to GHD has been collected using suitable methods and procedures to ensure the accuracy of the results.

1.6 Scope and limitations

This report: has been prepared by GHD for Centennial Airly Pty Ltd and may only be used and relied on by Centennial Airly Pty Ltd for the purpose agreed between GHD and Centennial Airly Pty Ltd as set out in section 1.3 of this report.

GHD otherwise disclaims responsibility to any person other than Centennial Airly Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 1.5 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

2. Methodology

2.1 Study area and site selection

Seven sites near Airly Mine were visited in autumn and spring 2021. The monitoring locations are detailed in Table 2.1 and Figure 2.1. All sites were sampled for water quality, sediment quality and macroinvertebrates in both autumn and spring 2021. Only one macroinvertebrate sample was able to be collected from GAP in spring 2021 due to insufficient water.

Site DOG on Dog Trap Creek and GRO and GEN on Genowlan Creek are considered to be in a baseline state, as there has been no panel and pillar mining in these areas to date. Panel and pillar mining has been undertaken beneath small headwater sections of Torbane Creek and Gap Creek between 2019 and 2021, although, only a very small area was within the Torbane Creek catchment. Under the Airly Mine Plan, additional panel and pillar mining will be undertaken below the headwaters of Gap Creek, Genowlan Creek and Dog Trap Creek in the future, although, third order streams and higher will be avoided.

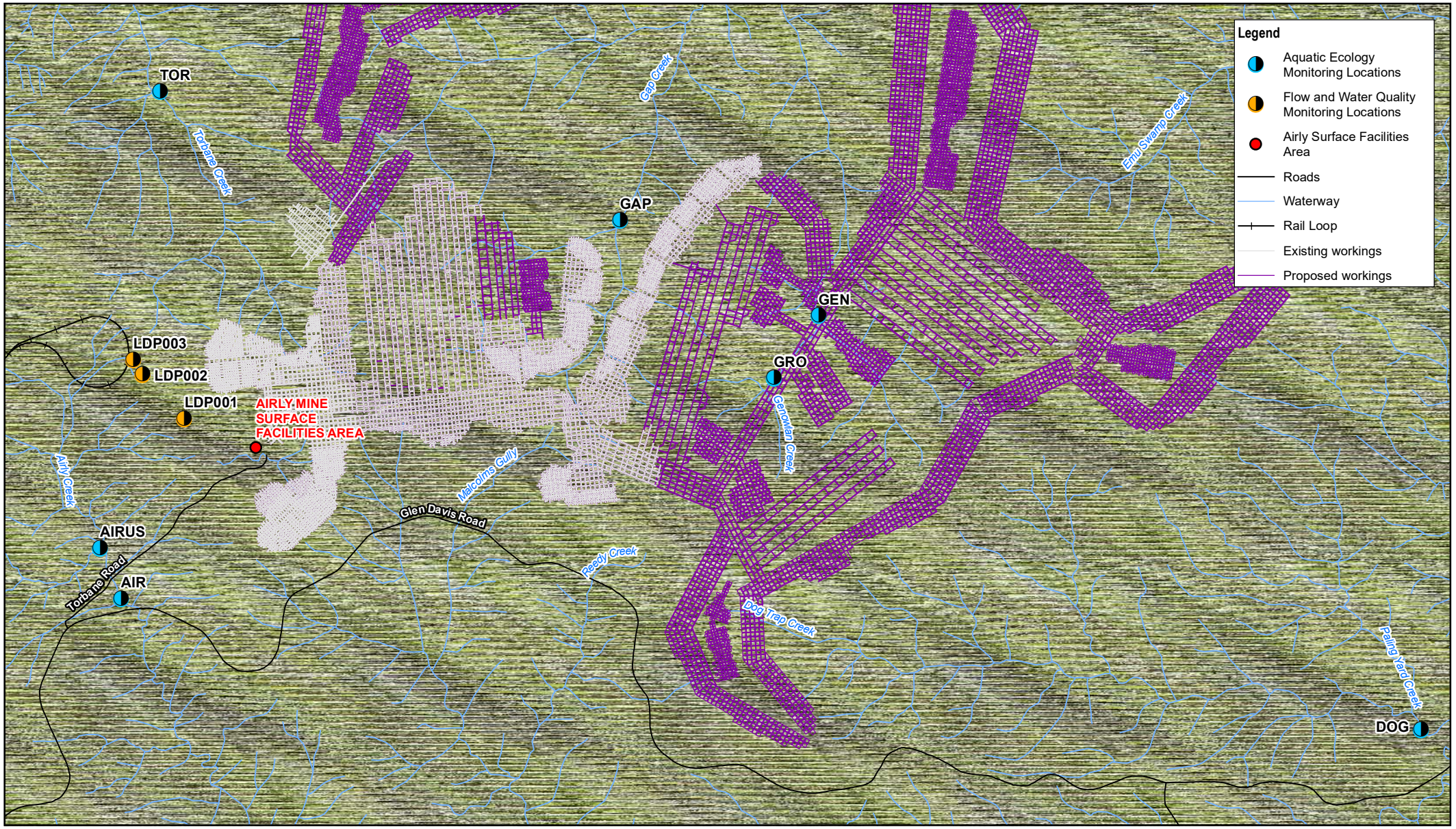
AIR on Airly Creek is classified as an impact site as it is downstream of LDP1, LDP2 and LDP3, and receives infrequent discharges of mine affected water (MAW) from Airly Mine. AIRUS is a background site located on Airly Creek, upstream of the licensed discharges from Airly Mine. Airly Creek will not be undermined.

Table 2.1 Sites sampled in autumn and spring 2021

Site code	Site name	Site type	Dates sampled		Latitude	Longitude	Altitude (m AHD)
			Autumn	Spring			
DOG	Dog Trap Creek	Baseline	05/05/21	04/11/21	-33.13475°	150.11087°	401
GAP	Gap Creek	Impact – headwaters undermined*	04/05/21	03/11/21	-33.09753°	150.04483°	701
GEN	Genowlan Creek	Baseline	04/05/21	02/11/21	-33.10456°	150.06123°	827
GRO	Upper Genowlan Creek	Baseline	04/05/21	02/11/21	-33.10860°	150.05760°	890
TOR	Torbane Creek	Impact – headwaters undermined*	05/05/21	04/11/21	-33.08764°	150.00706°	666
AIRUS	Airly Creek upstream of Airly Mine	Background (discharge)	03/05/21	04/11/21	-33.11967°	150.00018°	715
AIR	Airly Creek downstream of Airly Mine	Impact (discharge)	05/05/21	03/11/21	-33.12286°	150.00262°	714

Note: Locations in GDA94.

*Relates to secondary workings (panel and pillar mining)



[redacted]

Paper Size ISO A4

0 0.3 0.6 0.9 1.2

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Centennial Pty Ltd
Airly Mine
Aquatic Ecology Monitoring Program

Project No. **12545559**
Revision No. **0**
Date **09 Mar 2022**

Aquatic ecology monitoring locations

FIGURE 2-1

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Print date: 09 Mar 2022 - 08:12

Data source: Centennial: Mine data, 2021, Aerial Imagery; LPI: DTDB / DCDB, 2017; © Department of Customer Service 2020. Created by: fmackay

2.2 Habitat assessment

Habitat descriptions were made in the field based on visual estimates of characteristics such as stream bed composition (percentage of each substrate category e.g. sand or cobble), aquatic and riparian vegetation cover, amount of instream organic material, type of aquatic habitats and canopy cover. The mean wetted width and sample depth were also estimated.

Assessments of disturbance related to human activities were made for each site following the methodology prescribed by Turak *et al*. (2004), which ranks habitat disturbance based on instream habitat, riparian vegetation and the landuse in the greater catchment area. The assessment also included sketches of the longitudinal and cross-sectional profiles of the river reach.

Assessment of the condition of the aquatic habitat was also conducted using the RCE inventory (Peterson 1992). RCE provides a standardised approach to assess the adjacent land, condition of the banks, channel and bed using 13 indicators. The RCE Inventory has been modified by Chessman et al. (1997) to suit Australian conditions. The scoring system has been simplified to a range of 0 to 4 for each descriptor with 0 indicating the poorest condition. The total score is derived by summing the scores for each descriptor. Scores can be expressed as a percentage of the maximum score of 52.

2.3 Water quality monitoring

2.3.1 *In situ* water quality

Physico-chemical water quality parameters were measured *in situ* at each of the sampling sites using a YSI Pro Plus multi-parameter water quality meter. This meter was calibrated in accordance with Quality System/Quality Assurance (QS/QA) requirements and the manufacturer's specifications prior to its use in the field.

In situ physico-chemical measurements recorded included:

– Temperature (°C)
– pH (pH units)
– Electrical conductivity (µS/cm) – EC
– Dissolved oxygen (mg/L and % saturation) – DO

2.3.2 Laboratory analysis

Water quality samples were collected from the sampling sites shown in Table 2.1 prior to the collection of sediment and macroinvertebrate samples. Disposable nitrile gloves were worn to prevent sample contamination and for staff safety. Samples requiring analysis of dissolved metals were field filtered using a high volume 0.45 µm filter prior to collection in the sample bottle.

The chemical analyses in Table 2.2 were performed by a National Association of Testing Authorities (NATA) accredited laboratory. Ultra-trace analysis was performed in some cases as required for comparison to the relevant ANZG (2018) GVs. Laboratory certificates of analysis (COAs) are presented in Appendix A.

Table 2.2 Analytical testing – water quality

Suite	Analytes
Metals (dissolved and total)	Aluminium, arsenic*, boron, cadmium*, chromium*, copper, iron, lead, manganese, mercury, nickel, selenium*, silver*, zinc*
Anions	Chloride, sulfate, alkalinity
Cations	Calcium, sodium, potassium, magnesium
Nutrients	Ammonia, nitrate, nitrite, Total Kjeldahl Nitrogen (TKN), total nitrogen (TN), total phosphorus (TP) and reactive phosphorus
Other	Total dissolved solids (TDS), dissolved organic carbon (DOC), total suspended solids (TSS), water hardness, turbidity

* denotes that ultra-trace analysis was performed

2.4 Sediment quality monitoring

Sediment grab samples were collected following the sediment-water interface hand corer methods as outlined in the Sediment Quality Assessment guide (Simpson and Batley 2016).

Sediment samples were collected using a 100 mm diameter PVC hand corer that was pushed 200 mm into the substrate where the sediment was soft enough. Where sediment had a higher percentage of coarse particles that prevented sampling by corer, samples were collected using a plastic trowel. To account for potential variability of sediment quality within a site, sediment was collected from a minimum of two locations at each site and homogenised to produce one composite sediment sample.

The sediment samples were analysed for the parameters presented in Table 2.3 by a NATA accredited laboratory. The laboratory COAs are presented in Appendix A.

Table 2.3 Analytical testing – sediment quality

Suite	Analytes
Metals (totals and 1M HCl extractable)	Aluminium, antimony, arsenic, cadmium, chromium, copper, manganese, nickel, lead, zinc, mercury
Nutrients	Ammonia, nitrite, nitrate, nitrite plus nitrate (NO_x), TKN, TN, TP
Other	Total organic carbon

2.5 Macroinvertebrate monitoring

2.5.1 Field sampling

Field sampling followed Rapid Bioassessment (RBA) protocols in accordance with the NSW AUSRIVAS Sampling and Processing Manual (Turak *et. al.* 2004). The AUSRIVAS program is a nationally recognised, standardised sampling protocol used to assess the health of Australian rivers and was developed for Australia's National River Health Program.

Two samples were collected from Edge habitat at each site, per season, except GAP, for which there was only sufficient water for one sample in spring. Edge habitat is defined as areas within 1 m of the edge of the water, in areas of little or no flow. Sampling was conducted using a standard ISO 7828 (1983) design sweep-net with 250 µm mesh. Sampling of the Edge habitat was undertaken by sweeping the net perpendicular to the bank over approximately 10 m of discontinuous edge habitat. All available microhabitats were targeted, including overhanging terrestrial vegetation, snags, backwaters, and macrophyte. The net was washed thoroughly between each sample to remove any invertebrates retained on it.

For each RBA sample, the collected material was placed into a sorting tray and macroinvertebrates picked for a minimum of 40 minutes by experienced aquatic ecologist using forceps and pipettes. If new taxa were found between 30 and 40 minutes, sorting continued for a further 10 minutes. The processing cycle was continued up to a total maximum sorting time of 1 hour.

The objective of the RBA sorting protocol is to obtain a sample containing as diverse a fauna as possible, and hence provide a useful measure of taxa richness. Attempts were made to collect all taxa present in the sample, including rare or cryptic animals. Samples were preserved in 70 percent methylated spirits and clearly labelled with information including site, habitat, sampling method, date and sampler.

2.5.2 Laboratory processing and identification

Macroinvertebrates were examined in a GHD laboratory using Leica MZ 9.5 stereo-dissection microscopes with planachromat objectives and a zoom capability between 6.3-60x. Macroinvertebrates were identified using published taxonomic keys (Hawking 2000), unpublished working keys and an extensive specimen reference collection maintained by GHD.

Most macroinvertebrates were identified to family level with some exceptions following standard conventions of the NSW AUSRIVAS sampling and processing manual (Turak *et al*. 2004). Chironomidae (Diptera) were identified to sub-family (e.g. Orthocladiinae, Chironominae, and Tanypodinae). Groups such as Nematoda, Oligochaeta and Acarina were identified to class or order level. Microcrustacea (Ostracoda, Copepoda and Cladocera) were also identified to the order level but were not included in in richness counts to align with historical results. Microcrustacea were included in the datasets analysed using the AUSRIVAS software. The raw macroinvertebrate counts can be viewed in Appendix B.

Upon completion of identification all samples were returned to 100% ethanol for long-term archiving. GHD will ensure that archived samples are retained for the life of the project. Reference specimens will remain the property of GHD.

2.5.3 Scientific collection permit

GHD has a current NSW Department of Primary Industries Scientific Collection Permit (SCP) P07/0412.5 (Exp. 31/10/2023) to conduct macroinvertebrate sampling in NSW rivers and streams. All sampling for this project was conducted in accordance with this SCP.

2.6 Quality assurance

2.6.1 Water and sediment

In accordance with GHD's Quality Assurance (QA) protocol, one duplicate water and sediment sample was collected from autumn and spring 2021 at the same time as primary sample collection. The collection of a duplicate sample allows for the assessment of the potential level of uncertainty associated with the sampling method, preservation, transport, or laboratory analysis. The results of the primary and duplicate water and sediment samples are presented in Appendix C and Appendix D, respectively. The duplicate sediment sample collected in spring 2021 was lost by the laboratory, so results are not available.

2.6.2 Macroinvertebrates

One sample was examined by a second taxonomist to check the accuracy of identification, the results of which can be seen in Appendix E.

2.7 Data analysis

2.7.1 Water quality

Water quality results for all baseline sites (DOG, GAP, GEN, GRO and TOR) were compared to the default guideline values (DGVs) in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality as detailed below:

– DGV ranges for physical and chemical stressors outlined in Table 3.3.2 of the ANZECC (2000) guidelines.
– DGV ranges for EC and turbidity outlined in Table 3.3.3 of the ANZECC (2000) guidelines.
– Toxicant DGVs for protection of 99 percent of freshwater species as outlined in ANZG (2018).

The 99 percent species protection level was used in this analysis due to the proximity of Airly Mine to State Conservation Areas and National Parks and the conditions of consent (refer Section 1.4.2).

Water quality results for AIRUS and AIR were compared to the Site-Specific Guideline Values (SSGVs) for Airly Creek (GHD 2018b) that were derived from the background Airly Creek site AIRUS and the DGVs outlined above (ANZECC 2000; ANZG 2018). The SSGVs are presented in Table 2.4.

Dissolved metal and metalloid concentrations are more applicable for comparison to the water quality DGVs than total metal concentrations, as they are more representative of the bioavailable fractions of metals and metalloids within the water. Therefore, only dissolved concentrations have been assessed against the water quality DGVs / SSGVs.

Hardness modified guideline values (HMGVs) were calculated using the algorithms presented in Table 3.4.3 of ANZECC (2000) and the water hardness values observed during 2021. HMGVs are applicable to dissolved cadmium, chromium, lead, nickel and zinc concentrations in water samples with a water hardness greater than 30 mg/L (as $CaCO_3$). However, HMGVs were only calculated if dissolved concentrations of the relevant metal exceeded the SSGV / DGV.

Table 2.4 SSGVs applicable to Airly Creek sites (GHD 2018b)

Parameter	95% species protection level GV	99% species protection level GV	80th percentile Airly Ck u/s	SSGV
Physicochemical parameters				
EC (µS/cm)	350[1]	-	2,709	2,709
pH (pH units)	6.5-8.0[1]	-	7.4-7.8	6.5-8.0
TSS (mg/L)	-	-	5	25
Turbidity (NTU)	25[1]	-	3.3	25
Oil and grease (mg/L)	-	-	<5	5
Metals (dissolved)				
Aluminium (mg/L)	-	0.027	<0.01	0.027
Antimony (mg/L)	-	-	<0.001	0.001
Barium (mg/L)	-	-	0.017	0.017
Beryllium (mg/L)	-	-	<0.001	0.001
Boron (mg/L)	-	0.09	<0.05	0.09
Cobalt (mg/L)	-	-	0.001	0.001
Copper (mg/L)	-	0.001	<0.001	0.001
Iron (mg/L)	-	0.3	0.152	0.3
Lead (mg/L)	-	0.001	<0.001	0.001
Manganese (mg/L)	-	1.2	0.4782	1.2
Molybdenum (mg/L)	-	-	<0.001	0.001
Nickel (mg/L)	-	0.008	0.0078	0.008
Silver (mg/L)	0.00005	0.00002	<0.001	0.001[2]
Zinc (mg/L)	0.008	0.0024	0.0076	0.0076
Nutrients				
Ammonia as N (mg/L)	-	0.32	<0.03	0.32
Nitrogen (Total) (mg/L)	0.25[1]	-	0.7	0.7
Phosphorus (Total) (mg/L)	0.02[1]	-	0.056	0.056

[1] Guideline values for parameters as stressors rather than toxicants, for upland rivers in South-east Australia

[2] Based on standard LOR as ultra-trace LOR is higher than 95% species protection value

Multivariate analysis

A Piper plot was created for water samples collected in autumn and spring 2021. A Piper plot is a graphical method of presenting the major ionic chemistry of a water sample. The plot displays water samples in regard to their cation composition in the left triangle, anion composition in the right triangle, and a combination of the two in the centre diamond plot. Convergence of the sample symbols indicates a similar chemical composition.

Historical review

Long-term, time series water quality graphs were created for key analytes at impact site AIR and background site AIRUS and are presented in Appendix F. Analysis of these results allows for assessment of the influence of Airly Mine discharges on water quality in Airly Creek, as well as changes in Airly Creek water quality over time (including pre/post EIS). Data collected monthly by ALS on behalf of Centennial Airly has been graphed, along with data collected by GHD during the biannual aquatic ecology monitoring program. At AIR, data are available for a total collection period from January 2010 to November 2021, while at AIRUS data are available between April 2014 and November 2021.

2.7.2 Sediment quality

Sediment quality results were compared to the revised DGVs for sediment quality outlined in ANZG (2018). The sediment DGVs represent the thresholds above which biological effects are possible. GV-high values are also outlined, which are the thresholds above which there is a high probability of biological effects. It was identified in ANZG (2018) that the <2 mm sediment fraction should be compared to the DGVs for acid-extractable metals. As such, sediment samples collected in 2021 were sieved, and analysis of metals was undertaken on the <2 mm fraction only.

Acid-extractable (1M HCl-extractable) metal and metalloid concentrations are more applicable for comparison to the DGVs than total metals, as they are more representative of the bioavailable fractions of metals and metalloids found in sediments. Therefore, only acid-extractable metals have been assessed against the DGVs / GV-highs.

2.7.3 Macroinvertebrates

Univariate metrics

The following metrics have been calculated to allow for assessment of macroinvertebrate community health:

– Taxa richness
– EPT richness
– SIGNAL-2
– Proportion of sensitive taxa (taxa with SIGNAL-2 score ≥ 8)

Taxa richness

Taxonomic richness refers to the number of different taxa contained in a sample identified to family level, apart from certain taxa which were identified to order/class only (e.g. Oligochaeta) or to sub-family (i.e. members of the family Chironomidae). Rare and common taxa are considered equally, as richness does not take abundance into account.

EPT richness

The EPT richness is the number of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) families present in a sample. The animals within these three Orders tend to be sensitive to pollution and other disturbances, making them a useful indicator of instream health.

SIGNAL-2

SIGNAL-2 (Stream Invertebrate Grade Number – Average Level) (Chessman 2003) is a simple scoring system for macroinvertebrates of Australian rivers. SIGNAL-2 is a biotic index based on pollution sensitivity values (grade numbers) assigned to aquatic macroinvertebrates that have been derived from published and unpublished information on their tolerance to pollutants, such as sewage, salinity and nitrification.

Macroinvertebrates are assigned a grade between 1 (most tolerant) and 10 (most sensitive) and grades have been calculated for both the Order and Family taxonomic levels. Families in a sample that have not been assigned a grade are excluded from the analysis and the total number of families that have a SIGNAL-2 grade is the SIGNAL-2 richness. The overall SIGNAL-2 score for each site is calculated by the sum total of the SIGNAL-2 grade for each taxon within a sample divided by the SIGNAL-2 richness. A SIGNAL-2 score was calculated for each replicate from each site.

Proportion of sensitive taxa

The proportion of sensitive taxa is calculated as the percentage of taxa within the sample with a SIGNAL-2 of 8 or higher (Marshall *et al*. 2001). This metric allows for an additional measure of the sensitivity of the macroinvertebrate community at each site.

NSW AUSRIVAS Model

NSW AUSRIVAS Models provide a river health assessment based on predictive models of macroinvertebrate distribution. Physical and chemical data collected at each site is used to determine the predicted (expected) composition of the macroinvertebrate fauna if the site is in an undisturbed or reference condition. The AUSRIVAS assessment compares the macroinvertebrates collected at a site (Observed) to those predicted to occur (Expected) and the ratio derived indicates the band assessment of the sample data and an assessment of the level of impact at a site. The resulting statistic is known as the O/E50 and expresses the ratio of observed taxa to those with a 50% or greater probability of being collected, given the physical / chemical input variables.

The NSW combined-season eastern edge model was used for all sites in 2021. However, there was sufficient water for the collection of one macroinvertebrate sample from GAP in spring 2021, so consequently, the combined model was only able to be used for one sample from GAP. The upper limits for the AUSRIVAS model are provided in Table 2.5, along with the AUSRIVAS band labels, names and descriptions.

Rainfall data required for the AUSRIVAS environmental variables input file were obtained from the Running Stream (Brooklyn) Station (63012), which is the nearest active weather station with long-term data (BOM 2021).

Table 2.5 NSW combined-season eastern edge AUSRIVAS bands and descriptions

Band Label	Upper Limit Combined model (O/E50)	Band Name	Band Description
Band X	Infinity	More biologically diverse than reference sites	More taxa found than expected. Potential biodiversity hot-spot. Possible mild organic enrichment.
Band A	1.17	Reference condition	Most/all of the expected families found. Water quality and/or habitat condition roughly equivalent to reference sites. Impact on water quality and habitat condition does not result in a loss of macroinvertebrate diversity.
Band B	0.82	Significantly impaired	Fewer families than expected. Potential impact either on water quality or habitat quality or both, resulting in loss of taxa.
Band C	0.48	Severely impaired	Many fewer families than expected. Loss of macroinvertebrate biodiversity due to substantial impacts on water and/or habitat quality.
Band D	0.14	Extremely impaired	Few of the expected families remain. Extremely poor water and/or habitat quality. Highly degraded.

Multivariate metrics

Multivariate analyses were conducted to identify spatial and temporal trends in macroinvertebrates. Multivariate analysis allows comparisons between sites based upon macroinvertebrate community composition.

The following multivariate analyses were performed, using PRIMER 7 (Clarke and Gorley 2015) statistical analysis software:

– Non-metric Multi-Dimensional Scaling (nMDS) ordination
– ANalysis Of SIMilarities (ANOSIM)

Initially, the data were transformed to presence/absence as the AUSRIVAS sampling protocol is not a quantitative technique. Bray-Curtis was the resemblance measure used to derive the resemblance matrix between samples, which are suitable for biological data (Bray and Curtis 1957).

A nMDS ordination plot was produced to identify temporal and spatial trends in macroinvertebrate community composition. nMDS plots provide a graphical representation of the relative similarity of entities (i.e. samples) based on their attributes (i.e. macroinvertebrate community composition) within a reduced dimensional space. The more similar samples are to each other, the closer they are located within the ordination space. The nMDS ordination was performed on Bray-Curtis similarity coefficients, which are suitable for biological data (Bray and Curtis 1957). The 2-dimensional ordination plot has been displayed as this is more easily interpreted than the 3-dimensional plot. To determine if the 2-dimensional ordinations accurately represent patterns amongst the samples, the stress levels associated were considered. The stress level is a measure of the distortion produced by compressing multi-dimensional data into a reduced set of dimensions and would increase as the number of axes (i.e. dimensions) is reduced. If the stress is over 0.2, the MDS ordination must be interpreted with caution.

An ANOSIM test was performed on the macroinvertebrate similarity matrix to test whether macroinvertebrate communities were statistically different between sites. This method permutes the observed data and tests the between group similarity observed under this “random” data set. The significance of the test is determined based on whether higher or lower similarity was experienced under the permuted datasets. Interpretation of this technique is based on significance (p<5%) and strength of the relationship, denoted as R.

3. Results

3.1 Environmental conditions

Rainfall during 2021, as recorded by Centennial at Airly Mine, is displayed in Figure 3.1. November was the wettest month with 235.6 mm of rainfall recorded, though all of this occurred after the completion of spring aquatic ecology sampling. The driest month was April, during which only 2.4 mm of rainfall was recorded.

In the 30 days prior to the autumn sampling event (3 April to 2 May 2021), 2.4 mm of rainfall was recorded, of which 0.2 mm was recorded in the week prior to sampling. During sampling in autumn 2021 (3 to 5 May 2021), rainfall only occurred on 5 May 2021, with 8 mm recorded. In the 30 days prior to the spring sampling event (3 October to 1 November 2021), 37 mm of rainfall was recorded, none of which occurred in the seven days prior to sampling. On the final day of sampling in spring 2021 (4 November 2021), 10.4 mm of rainfall was recorded.

Figure 3.2 displays yearly rainfall totals for 2013 to 2021, as recorded by Centennial at Airly Mine. Rainfall data from Running Stream (Brooklyn) BOM station (63012) (BOM 2021) was used for the period January to October 2013 as recording by Centennial began in November 2013. Long-term mean annual rainfall data was sourced from BOM (2020) for a period from 1899 to 2020.

Rainfall in 2021 totalled 824.4 mm, which was less than the total rainfall in 2020, and also slightly lower than the average, but higher than most years since 2013. The highest annual rainfall was recorded in 2016, which was the only year other than 2020 when above average rainfall was observed. The lowest annual rainfall was recorded in 2019, during which 398.4 mm of rainfall was recorded. Rainfall during the 2017 to 2019 period was well below the long-term average for the area which is reflective of the state-wide drought.

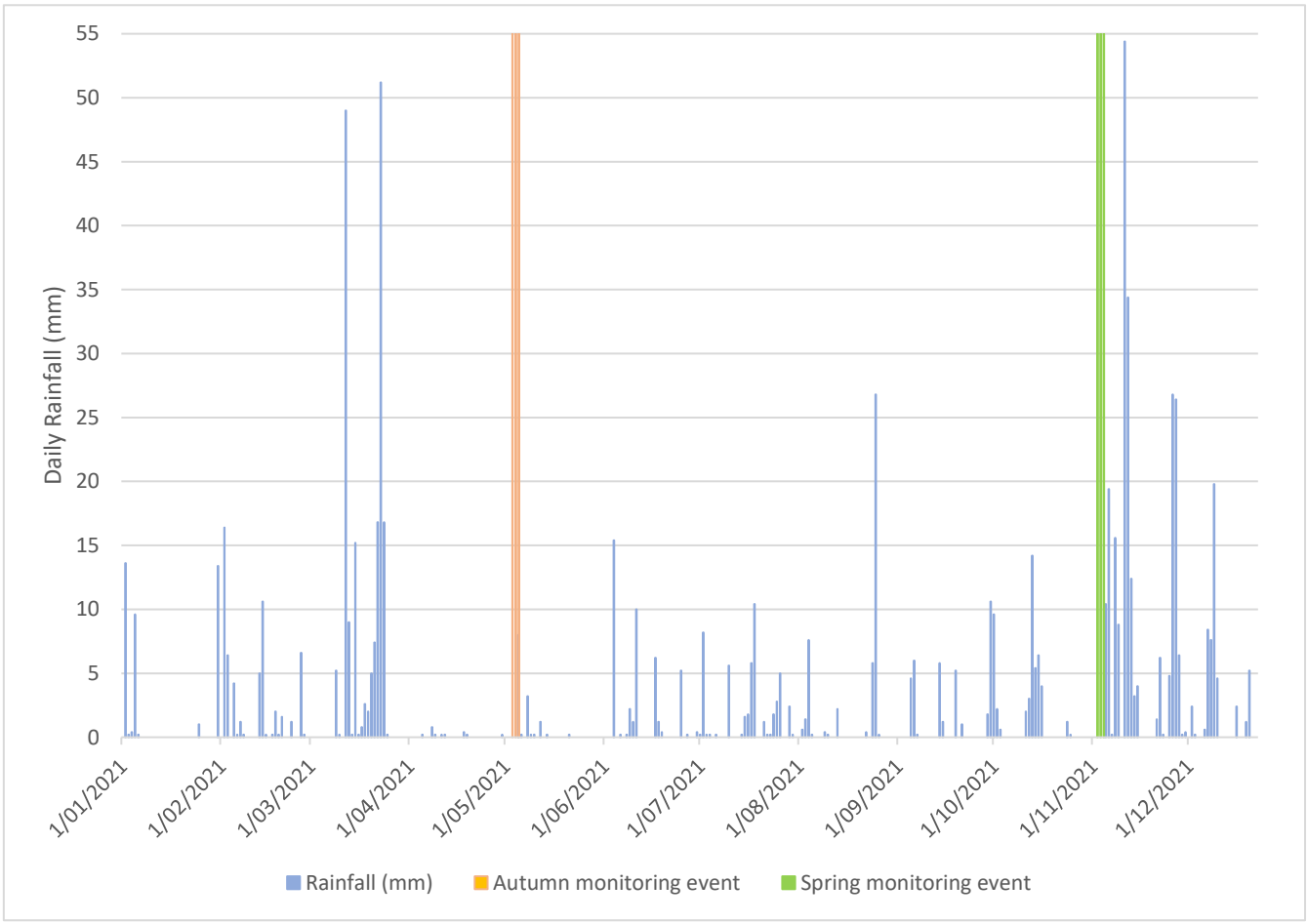


Figure 3.1 Daily rainfall at Airly Mine in 2021

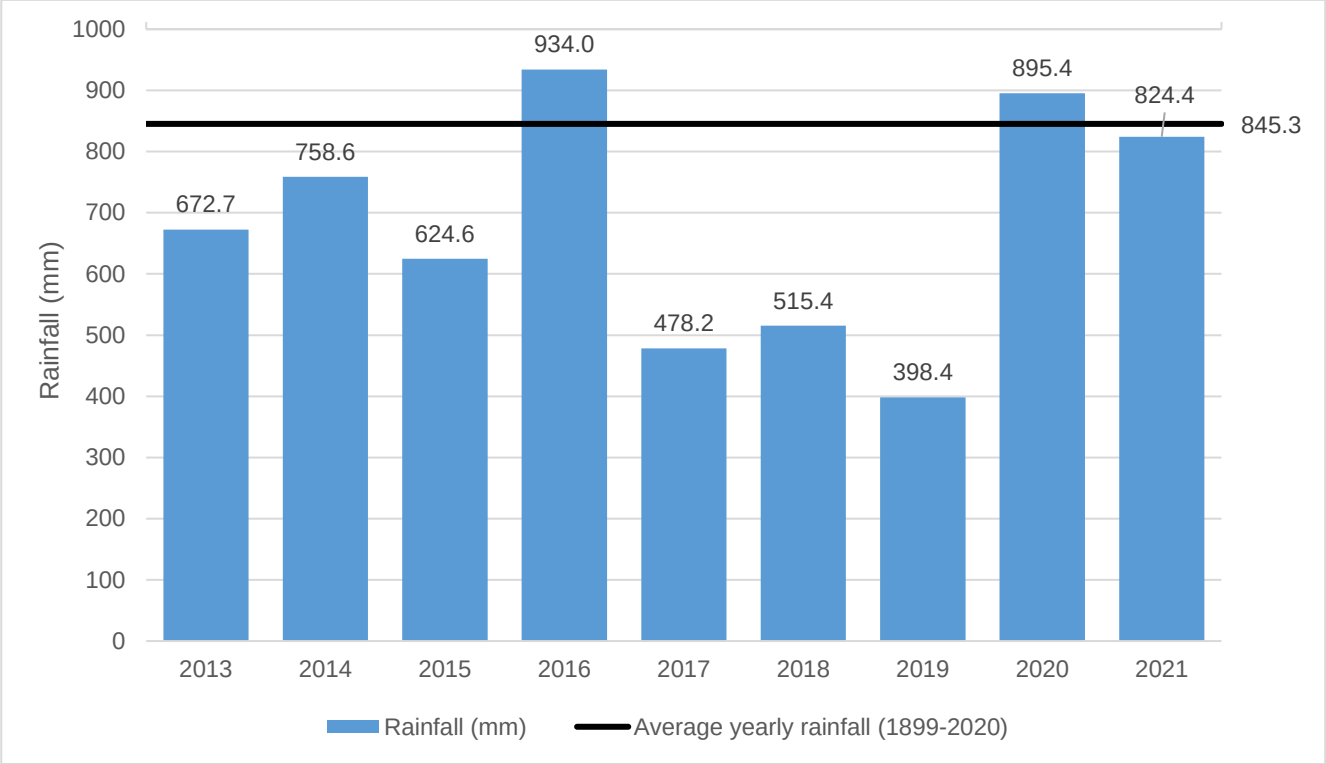


Figure 3.2 ***Yearly rainfall at Airly Mine from 2013 to 2021, compared to average yearly rainfall (1899-2020)***

3.2 Discharges from Airly Mine in 2021

There was an overflow event from the LDP2 basin on the 23 March 2021 that led to approximately 432 kL discharging to the tributary of Airly Creek. This was due to a period of intensive rainfall, with 97.2mm of rain reportedly falling over the five-day period prior to the overflow event (Centennial 2021a). This discharge event occurred approximately five weeks prior to autumn aquatic ecology sampling.

There was one discharge event from LDP1 in 2021, which occurred between 27 and 30 November 2021, after spring 2021 sampling had been completed, with a total volume of 15,640 KL. The daily discharge volumes from LDP1 were as follows:

– 27 November – 6,233 KL
– 28 November – 8,102 KL
– 29 November – 1,269 KL
– 30 November – 36 KL

The November 2021 discharge event was in response to large amounts of rainfall. There were no exceedances of the concentration limits identified by Airly in relation to this discharge event (Centennial 2021b).

There was no discharge from LDP3 in 2021.

3.3 Aquatic habitat assessment

The higher altitude creeks, particularly Genowlan Creek, are characterised by a narrow and steep series of cascades and shallow pools. Genowlan Creek at GEN is spring-fed and contained water in both autumn and spring 2021, after having dried completely during the 2019-2020 summer period. GEN is located in an upland area where riparian vegetation is almost entirely native and includes an abundance of ferns and shrubs overhanging the streams, providing shading and edge habitat for macroinvertebrates. A flow gauging weir was installed at the site in early 2019 and a clearing containing groundwater monitoring bores, and historical access track is the only other anthropogenic disturbance near the site, although, there is a foul-wheel-drive track upstream of the site.

GRO is located in upper Genowlan Creek but water is from the Grotto. Flow was observed at GRO for the majority of 2021 (based on observations from monthly groundwater sampling). Riparian habitat at GRO is similar to GEN with abundant native vegetation including overhanging ferns. Some disturbance is present at the site from the maintenance of the adjacent four-wheel-drive track.

Gap Creek flows through a steep valley area of large boulders in a native bushland area, with riparian vegetation of *Eucalyptus sp.*, shrubs and grasses. A steep four-wheel drive track runs parallel to Gap Creek, although, with riparian vegetation as a buffer along most of the reach. Gap Creek contains a flow gauging v-notch weir and small, isolated pools between boulders, with a bedrock or sandy substrate. The creek contained water for the majority of 2021, and was able to be sampled for macroinvertebrates in both autumn and spring 2021, although, one sample was able to be collected in spring 2021.

The channels of Dog Trap, Torbane and Airly Creeks are at a lower altitude and exhibit greater disturbance of the stream and riparian vegetation, with potential non-point source pollution from grazing, clearing for agriculture and growth of some exotic vegetation including grasses, blackberry (*Rubus fruticosus*) and willows (*Salix sp.*). The most heavily disturbed site is DOG, at which the riparian zone comprises pastoral grasses and exotic vegetation as a result of historical land clearing and cattle grazing. Only isolated pools were present at DOG, TOR, AIRUS and AIR in 2021.

Table 3.1 and Table 3.1 present the key data from the habitat assessments undertaken in autumn and spring 2021, respectively. The substrate composition and other instream habitat information has been used in interpreting the macroinvertebrate data in Section 3.6. Table 3.3 presents the site photographs taken in autumn and spring 2021. The photos and stream widths indicate that there was generally more water present in spring 2021 than autumn 2021.

RCE scores for each site in autumn and spring 2021 are presented in Table 1.1 and have been compared to results from 2020 monitoring, as well as results for monitoring conducted by Cardno prior to the Airly Mine extension EIS (Cardno 2014). Individual category scores were not provided in the EIS and, therefore, comparisons can only be made to the overall scores in the EIS (Cardno 2014). There was little change in the scores for RCE categories relating to riparian vegetation (see Appendix F, category 2, 3, 4) between 2020 and 2021, although, the scores at some sites did change between seasons, including GAP, GEN and GRO. Likewise, there was no consistent pattern in the scores for aquatic vegetation (category 13) between 2020 and 2021, but some differences were observed between seasons.

Overall RCE scores at impact site AIR in 2020 and 2021 were higher than those at background site AIRUS, despite being downstream of LDP1.

The condition of baseline site DOG, as estimated by the overall RCE score, has degraded most since EIS monitoring, though this site is not impacted by mining and degradation is due to impacts from agricultural landuse, including cattle grazing, and the long-term drought which caused dieback of riparian vegetation and altered the waterway hydraulics. During the drought period, water on Dog Trap Creek receded to a single isolated waterhole with poor riparian cover and a substrate dominated by silt and flow has not been observed since the drought eased in 2020. Conversely, during sampling in 2016, there was flow along the entire 100 m reach and water present within sections with bedrock, boulder and good riparian (casuarina) cover.

Table 3.1 Key aquatic habitat attributes observed in autumn 2021

Site code		DOG		GAP		GEN		GRO		TOR		AIRUS		AIR	
Habitat, replicate		Edge 1	Edge 2	Edge 1	Edge 2	Edge 1	Edge 2	Edge 1	Edge 2	Edge 1	Edge 2	Edge 1	Edge 2	Edge 1	Edge 2
Stream width: (m)	Max	6.0		3.0		5		3		3.5		4.0		6.0	
	Min	0		0.2		0.5		0.3		0		0.5		1.0	
	Mode	5.0		0.5		4		1.2		2.5		5.0		4.0	
Adjacent landuse		Native vegetation, grazing, rural residential		Native vegetation, 4WD tracks		Native vegetation, monitoring bores, recreation		Native vegetation, 4WD tracks, State Conservation Area		Grazing, native vegetation, rural residences, Airly Mine		Grazing, Airly Mine, roads		Airly Mine, access road, grazing, native vegetation	
Geomorphology		Steep valley		Steep valley		Steep valley		Steep valley		Broad valley		Broad valley		Broad valley	
% Bedrock		0	0	5	0	10	20	5	0	0	0	0	0	5	0
% Boulder		5	5	15	5	0	10	0	5	0	5	0	0	20	20
% Cobble		0	5	5	5	0	5	0	0	20	10	0	0	40	10
% Pebble		0	15	20	10	20	5	0	5	30	20	0	0	25	10
% Gravel		0	5	15	10	5	5	15	10	25	25	0	0	10	10
% Sand		0	5	35	65	60	50	70	70	15	25	5	5	0	0
% Silt/Clay		95	70	5	5	5	5	10	10	10	15	95	95	0	50
% Detritus		80	70	20	30	25	40	50	60	30	50	25	30	0	20
% Sticks (< 2 cm)		20	10	25	10	0	10	30	40	0	10	0	5	0	5
% Branches		10	0	10	5	0	10	15	10	0	20	0	10	0	5
% Logs (> 15 cm)		0	0	5	0	0	15	10	10	0	10	10	20	0	0
% Algae		0	10	15	30	10	0	60	60	30	10	20	50	0	20
% Macrophytes		100	100	0	0	40	0	0	0	70	30	90	90	0	0
% Overhanging habitat		0	0	30	20	60	80	20	30	20	80	20	10	0	60
% Blanketing silt		100	100	20	20	10	10	100	100	10	20	30	40	0	50
% Shading		80	80	30	30	80	80	100	100	25	25	5	40	90	70

Table 3.2 Key aquatic habitat attributes observed in spring 2021

Site code		DOG		GAP		GEN		GRO		TOR		AIRUS		AIR	
Habitat, replicate		Edge 1	Edge 2	Edge 1	Edge 2	Edge 1	Edge 2	Edge 1	Edge 2	Edge 1	Edge 2	Edge 1	Edge 2	Edge 1	Edge 2
Wetted width: (m)	Max	7.0		3.0		4.5		1.5		4.0		5.0		6.0	
	Min	0		0.1		0.3		0		0.3		0.3		0	
	Mode	6.0		1.0		3.5		1.0		2		3		4.0	
Adjacent landuse		Rural residential, grazing, native vegetation		Native vegetation, 4WD tracks		Native vegetation, monitoring bores, recreation		Native vegetation, 4WD tracks, State Conservation Area		Grazing, Airly Mine		Grazing, Airly Mine, roads, rural residential		Access road, Airly Mine, native vegetation, grazing	
Geomorphology		Broad valley		Steep valley		Steep valley		Steep valley		Steep valley		Broad valley		Broad valley	
% Bedrock		0	0	10	-	0	0	30	80	0	0	0	0	10	10
% Boulder		0	20	10	-	5	10	10	10	0	0	0	0	50	50
% Cobble		0	0	10	-	30	35	0	0	5	5	0	0	15	10
% Pebble		0	0	20	-	5	5	0	0	20	20	0	0	5	15
% Gravel		0	0	20	-	5	5	0	0	40	40	0	0	10	0
% Sand		0	0	25	-	50	40	60	10	30	30	0	0	0	0
% Silt/Clay		100	80	5	-	5	5	0	0	5	5	100	100	10	15
% Detritus		50	25	60	-	40	30	20	100	30	30	40	30	10	10
% Sticks (< 2 cm)		50	10	25	-	20	15	20	80	5	5	0	0	10	10
% Branches		20	5	10	-	0	5	20	70	0	0	0	0	10	10
% Logs (> 15 cm)		0	0	0	-	0	0	35	50	0	0	0	0	10	10
% Algae		0	0	40	-	50	50	0	0	0	0	10	30	15	30
% Macrophytes		100	100	10	-	0	0	0	0	80	80	90	90	15	30
% Overhanging habitat		10	10	20	-	20	15	40	100	20	20	20	20	70	60
% Blanketing silt		50	50	20	-	20	10	100	100	10	10	50	50	50	60
% Shading		0	0	30	-	80	90	70	100	30	30	10	10	60	60

Table 3.3 Site photographs taken in autumn and spring 2021

DOG	
	
Autumn 2021	Spring 2021
GAP	
	
Autumn 2021	Spring 2021
GEN	
	
Autumn 2021	Spring 2021

GRO	
	
Autumn 2021	Spring 2021
TOR	
	
Autumn 2021	Spring 2021
AIRUS	
	
Autumn 2021	Spring 2021

AIR	
	
Autumn 2021	Spring 2021

Table 3.4 RCE scores, 2020-2021

Site	Spring 2021	Autumn 2021	Spring 2020	Autumn 2020	EIS average (Cardno 2014)
DOG	48	54	48	56	71
GAP	78	80	90	90	83
GEN	85	85	90	90	90
GRO	76	72	79	83	90
TOR	69	69	69	67	73
AIRUS	48	50	48	58	NA
AIR	65	70	69	69	75

NA indicates site was not sampled prior to the EIS

3.4 Water quality

3.4.1 Water quality – 2021

The results of *in situ* and laboratory water quality analyses in autumn and spring 2021 are presented in Table 3.5 and Table 3.7 respectively. Results at Airly Creek sites AIRUS and AIR have been compared to the SSGVs, derived by GHD from the 80th percentile value of historical water quality results from AIRUS (GHD 2018b). For parameters where SSGVs did not exist, the ANZG (2018) DGV was applied. Results for potential toxicants at all other sites have been compared to the DGVs (ANZG 2018) for 99% species protection. HMGVs have been calculated for exceedances of cadmium, chromium, nickel and zinc at sites where the SSGV/DGV was exceeded and water hardness was greater than 30 mg/L. These HMGVs are displayed in Table 3.6 and Table 3.8.

Parameters measured at concentrations below the laboratory limit of reporting (LOR) at all sites have not been displayed in Table 3.5 and Table 3.7. Laboratory COAs showing data for all measured parameters are provided in Appendix A. Despite ultra-trace analysis, the LOR for chromium is higher than the DGV. Only values above the LOR will be counted as exceedances, however, it is noted that these may not be genuine exceedances.

EC exceeded the DGV at baseline sites DOG and recently impacted site TOR in both autumn and spring 2021, with the highest EC results of all background sites observed at TOR in both seasons. At the Airly Creek background site, AIRUS, EC was elevated above the SSGV in spring only. At the impact site, AIR, EC was below the SSGV during both sampling events, with both results below those observed at background site AIRUS. EC was below the DGV at background sites GEN and GRO and recently impacted site GAP in both seasons, with results at Genowlan Creek sites GEN and GRO lower than those at GAP.

The pH results at DOG in both autumn and spring 2021 were within the DGV range, whilst pH at TOR was below the DGV in autumn 2021. The pH at all other sites was below the lower DGV in both autumn and spring, except for GAP, where the spring result was above the upper DGV. Monthly monitoring identified other instances of the pH DGV being exceeded in Gap Creek in 2021 (GHD 2022). The pH at background site AIRUS was within the SSGV range during both autumn and spring 2021, while at impact site AIR, pH was within the SSGV during autumn, but above the upper SSGV in spring 2021.

The DO saturations of all sites in autumn 2021 were below the lower DGV, with the result at DOG the lowest level of 22.6% saturation. In spring, DO saturation was below the lower DGV at all baseline sites, GAP and TOR, with the result at DOG indicating hypoxic conditions at 16.7% saturation. During autumn 2021 both Airly Creek sites had DO levels below the lower DGV, whilst in spring AIRUS was below the DGV and AIR was supersaturated (128.9%), exceeding the upper DGV.

TDS results reflected EC results, with the highest results observed at Airly Creek sites AIRUS and AIR, and recently impacted site TOR and background site DOG in both autumn and spring. TDS results were lowest in both seasons at GEN and GRO.

In both autumn and spring, TSS results were highest at GAP, though all results were below the DGV. Turbidity at GAP exceeded the DGV during autumn 2021, whilst all other sites turbidity was below the DGV in both autumn and spring. Waters at GEN and GRO were clearest, with all TSS results below 5 mg/L and all turbidity results below 2 NTU.

Water hardness was elevated at DOG and TOR, and Airly Creek sites AIRUS and AIR in both seasons, with the hardest water in both autumn and spring recorded at TOR. Water at GEN and GRO was very soft during both sampling events of 2021.

The Piper plot displays the cation and anion composition of water samples (Figure 3.3). Water at higher altitude sites GAP, GEN, and GRO, was sodium chloride type, though concentrations of all ions were low. The ionic composition of water at TOR was similar to Airly Creek sites AIRUS and AIR, and consistent between seasons, with water displaying a calcium magnesium sulfate dominance. Water at DOG was of a similar composition, though contained a stronger dominance of calcium and bicarbonate ions.

There were no exceedances of the SSGV/DGV for any dissolved metal at discharge impact site AIR in autumn or spring 2021, although the dissolved nickel concentration was equal to the SSGV in autumn (Table 3.7). At the background Airly Creek site, AIRUS, in autumn 2021 concentrations of all dissolved metals were similar to those at AIR, expect for manganese which was almost twice the concentration. No exceedances of any SSGV or DGV were observed at AIRUS during autumn 2021. In spring 2021, the only dissolved metal to exceed the SSGV/DGV at AIRUS was chromium, though the concentration was below the calculated HMGV (see Table 3.7). Chromium and manganese concentrations were higher at the background site AIRUS than at AIR during spring 2021, while concentrations of all other dissolved metals were similar between the two sites.

Dissolved aluminium concentrations exceeded the DGV at background sites GAP, GEN, and GRO in autumn, and at GRO only in spring. It is noted, however, that these sites also recorded pH values less than 6.5, and therefore the DGV value limit does not apply. The aluminium concentration at GRO was the highest observed at all sites during both seasons. Dissolved aluminium was below the DGV at all other sites.

Dissolved chromium concentrations exceeded the DGV at both GAP and GRO in autumn, and only GRO in spring, with the results observed at GRO the highest of all sites in both seasons. At TOR, concentrations of dissolved nickel exceeded the DGV in autumn, however, the concentration was below the HMGV (see Table 3.6). In spring, the dissolved copper concentration at TOR exceeded the DGV.

Dissolved zinc concentrations also exceeded the DGV at sites GAP, GEN, and GRO in autumn, and at GEN and GRO only in spring. There were also exceedances of the DGV in autumn at TOR, and in spring at DOG, GAP, and TOR, however, these results were below the relevant HMGVs (Table 3.6 and Table 3.8). HMGVs do not apply to GEN and GRO due to the low water hardness at these sites. There were no other exceedances of the guidelines for any of the other dissolved metal concentrations any these higher altitude sites.

In autumn 2021, concentrations of NO_x exceeded the DGV at all sites, with the highest concentration observed at GEN. In spring 2021, concentrations of NO_x exceeded the DGV at DOG, GEN, TOR and AIRUS, but were below the DGV at all other sites, including at discharge impact site AIR.

In autumn, TN and TP concentrations were highest at recently impacted site GAP, exceeding the DGV. In spring, TOR had the highest concentration of TN of all the baseline sites, with this concentration exceeding the DGV. TN at the Airly Creek sites relative to other sites, however, these concentrations were below the SSGV. In spring, TP concentrations were below the DGV/SSGV at all sites.

Oil and grease concentrations were below detection limits at all sites during autumn 2021. The oil and grease concentration at discharge impact site AIR exceeded the SSGV in spring. Although there are no DGV limits for oil and grease at other sites, it should be noted that the oil and grease concentration at GAP in spring was 285 mg/L, well above the SSGV limit of 5 mg/L which only applies to the Airly Creek sites. However, this is expected to be a laboratory testing error as no oily sheen was observed on site and the sample tested from GAP in October 2021 as part of the annual monitoring suite.

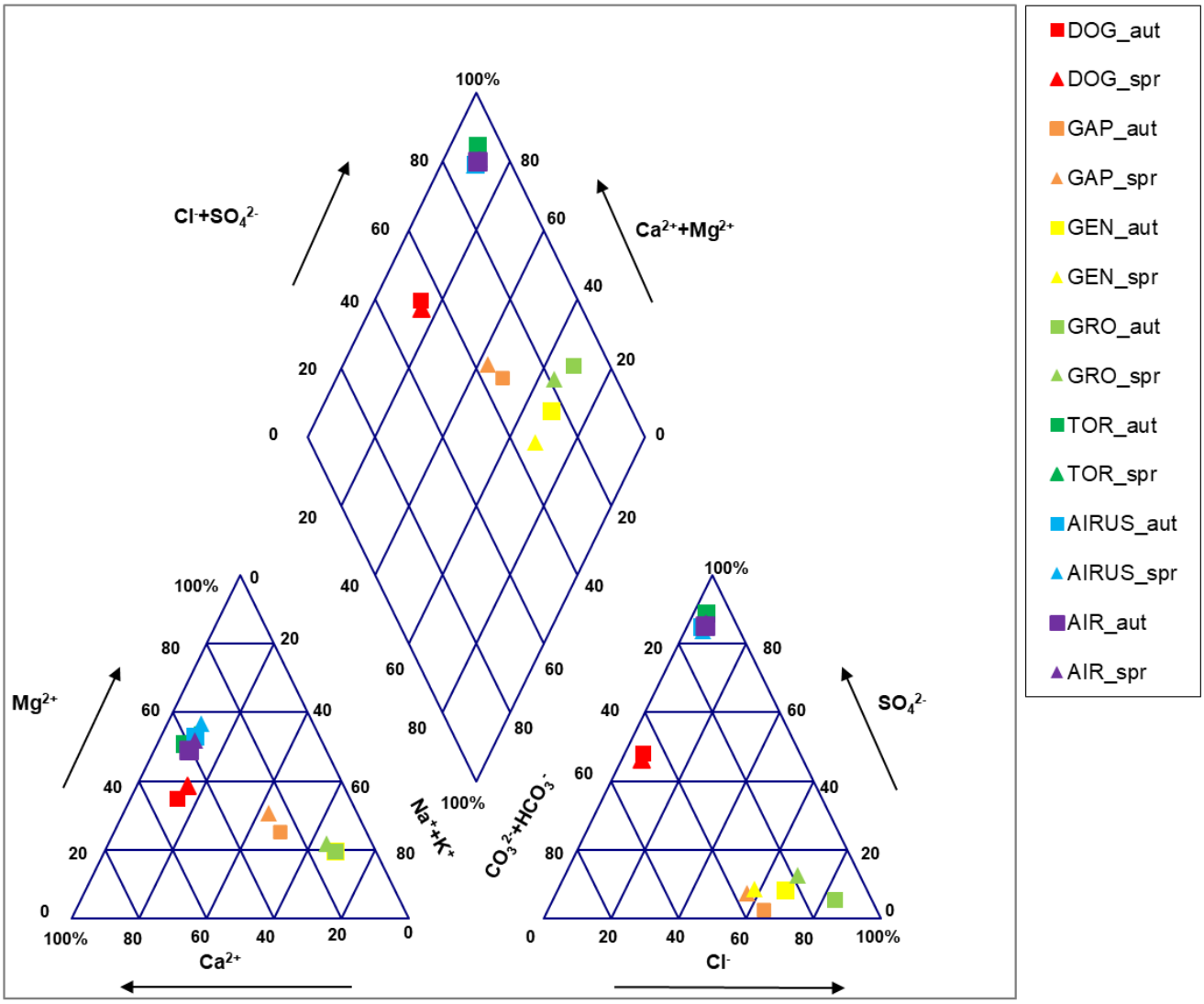


Figure 3.3 Piper plot displaying cation and anion composition of water samples collected in autumn and spring 2021

Table 3.5 Results of laboratory analysis of water samples collected in autumn 2021

Analyte	Units	LOR	Baseline			Headwaters undermined		DGV	Background	Impact	SSGV
			DOG	GEN	GRO	GAP	TOR		AIRUS	AIR	
			5/05/2021	4/05/2021	4/05/2021	4/05/2021	5/05/2021		3/05/2021	5/05/2021	
			8:20	8:45	11:00	13:30	11:15		15:20	13:40	
Physico-chemical parameters											
Temperature^	° C	0.1	13.4	13	13.1	13.4	12.5	NA	11.9	11.8	NA
EC^	µS/cm	1	**1522**	79	50	114	**2893**	350	2666	2501	2709
pH^	pH unit	0.1	7.6	**5.7**	**5.2**	**6.4**	**5.5**	6.5 - 8.0	7.1	7.5	6.5 - 8.0
DO^	% sat.	0.1	**22.6**	**46.5**	**51.9**	**67.1**	**51.8**	90 - 110	**30.7**	**75.1**	NA
DO^	mg/L	0.01	2.35	4.9	5.75	7	5.46	NA	3.28	8	NA
TDS	mg/L	1	916	38	30	73	1740	NA	1660	1500	NA
TSS	mg/L	5	8	<5	<5	17	10	25	10	5	25
Turbidity	NTU	0.1	1	0.4	1.3	**36.3**	0.9	25	4.7	2.4	25
Total hardness	mg/L	1	832	7	<1	25	1820	NA	1560	1470	NA
Major ions											
Bicarbonate alkalinity	mg/L	1	420	6	2	14	146	NA	190	156	NA
Total alkalinity	mg/L	1	420	6	2	14	146	NA	190	156	NA
Sulfate as SO_4	mg/L	1	418	2	<1	1	1710	NA	1470	1340	NA
Chloride	mg/L	1	34	12	11	19	57	NA	60	60	NA
Calcium	mg/L	1	198	1	<1	5	325	NA	255	266	NA
Magnesium	mg/L	1	82	1	<1	3	244	NA	224	196	NA
Potassium	mg/L	1	3	1	<1	2	10	NA	6	8	NA
Sodium	mg/L	1	59	6	6	10	68	NA	78	73	NA

Analyte	Units	LOR	Baseline			Headwaters undermined		DGV	Background	Impact	SSGV
			DOG	GEN	GRO	GAP	TOR		AIRUS	AIR	
			5/05/2021	4/05/2021	4/05/2021	4/05/2021	5/05/2021		3/05/2021	5/05/2021	
			8:20	8:45	11:00	13:30	11:15		15:20	13:40	
Dissolved metals											
Aluminium	mg/L	0.01	<0.01	**0.04***	**0.28***	**0.15***	<0.01	0.027	<0.01	<0.01	0.027
Arsenic	mg/L	0.0002	0.0004	<0.0002	<0.0002	0.0003	0.0003	0.0008	0.0004	0.0004	NA
Chromium	mg/L	0.0002[+]	<0.0002	<0.0002	**0.0008**	**0.0006**	<0.0002	0.00001	<0.0002	<0.0002	NA
Copper	mg/L	0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.001	<0.001	<0.001	0.001
Iron	mg/L	0.05	<0.05	<0.05	0.15	0.22	<0.05	NA	<0.05	<0.05	0.3
Manganese	mg/L	0.001	0.05	0.008	0.014	0.02	0.134	1.2	0.257	0.133	1.2
Nickel	mg/L	0.001	0.001	0.002	0.001	0.002	**0.009**	0.008	0.007	0.008	0.008
Selenium	mg/L	0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0002	0.005	<0.0002	<0.0002	NA
Zinc	mg/L	0.001	0.001	**0.007**	**0.003**	**0.005**	**0.003**	0.0024	0.003	0.007	0.0076
Nutrients											
Ammonia	mg/L	0.01	<0.01	<0.01	0.03	0.06	<0.01	0.32	<0.01	<0.01	0.32
Nitrate	mg/L	0.01	0.05	0.14	0.05	0.02	0.04	NA	0.03	0.03	NA
NO_x	mg/L	0.01	**0.05**	**0.14**	**0.05**	**0.02**	**0.04**	0.015	**0.03**	**0.03**	NA
TKN	mg/L	0.1	0.2	<0.1	0.2	0.4	0.2	NA	0.2	0.2	NA
TN	mg/L	0.1	0.2	0.1	0.2	**0.4**	0.2	0.25	0.2	0.2	0.7
TP	mg/L	0.01	0.01	<0.01	<0.01	**0.04**	<0.01	0.02	<0.01	<0.01	0.056
Other parameters											
DOC	mg/L	1	<1	2	11	6	7	NA	9	5	NA
Oil & Grease	mg/L	5	<5	<5	<5	<5	<5	NA	<5	<5	5
Fluoride	mg/L	0.1	0.3	<0.1	<0.1	<0.1	0.4	NA	0.2	0.2	NA

Values in **yellow** indicate exceedances of the DGVs. Values in **green** exceed the DGV but are below the relevant HMGV (See Table 3.6). NA = No DGV applies.

* The DGV applies to aluminium concentrations for pH >6.5. ^ Denotes parameter was recorded *in situ.* [+]Despite ultra-trace analysis, the LOR for chromium is higher than the DGV.

Table 3.6 HMGVs (in mg/L) for nickel and zinc in autumn 2021

Metal	TOR	
	HMGV	Observed concentration
Nickel	0.262	0.009
Zinc	0.079	0.003

Values in **yellow** indicate exceedances of the HMGVs

Table 3.7 Results of laboratory analysis of water samples collected in spring 2021

Analyte	Units	LOR	Baseline			Headwaters undermined		DGV	Background	Impact	SSGV
			DOG	GEN	GRO	GAP	TOR		AIRUS	AIR	
			4/11/2021	2/11/2021	2/11/2021	3/11/2021	4/11/2021		4/11/2021	3/11/2021	
			11:20	10:55	14:30	11:30	8:40		13:20	14:45	
Physico-chemical parameters											
Temperature^	° C	0.1	19	12	13.3	14.8	15.5	NA	15.5	17.6	NA
EC^	µS/cm	1	**1572**	56	39	165	**3092**	350	**2722**	2496	2709
pH^	pH unit	0.1	7.5	**6**	**5.8**	**8.1**	7.6	6.5 – 8.0	7.9	**8.2**	6.5 – 8.0
DO^	% sat.	0.1	**16.7**	**37.2**	**59.8**	**32**	**31.4**	90 – 110	**40.1**	**128.9**	NA
DO^	mg/L	0.01	1.54	4.01	6.2	3.23	3.1	NA	3.97	12.17	NA
TDS	mg/L	1	982	31	22	94	1990	NA	1530	1650	NA
TSS	mg/L	5	18	<5	<5	<5	6	25	10	22	25
Turbidity	NTU	0.1	3.5	0.8	0.5	9.2	1.4	25	1.6	1.8	25
Total hardness	mg/L	1	721	4	<1	38	1820	NA	1480	1450	NA
Major ions											
Bicarbonate alkalinity	mg/L	1	477	8	3	25	201	NA	166	156	NA
Total alkalinity	mg/L	1	477	8	3	25	201	NA	166	156	NA
Sulfate as SO_4	mg/L	1	445	2	2	5	1750	NA	1220	1480	NA
Chloride	mg/L	1	43	10	8	28	73	NA	58	66	NA
Calcium	mg/L	1	157	<1	<1	7	295	NA	218	244	NA

Analyte	Units	LOR	Baseline			Headwaters undermined		DGV	Background	Impact	SSGV
			DOG	GEN	GRO	GAP	TOR		AIRUS	AIR	
			4/11/2021	2/11/2021	2/11/2021	3/11/2021	4/11/2021		4/11/2021	3/11/2021	
			11:20	10:55	14:30	11:30	8:40		13:20	14:45	
Magnesium	mg/L	1	80	1	<1	5	262	NA	227	204	NA
Potassium	mg/L	1	2	1	<1	2	7	NA	3	4	NA
Sodium	mg/L	1	58	6	5	12	89	NA	75	77	NA
Dissolved metals											
Aluminium	mg/L	0.01	<0.01	0.02	**0.19***	0.02	<0.01	0.027	<0.01	<0.01	0.027
Arsenic	mg/L	0.0002	0.0005	<0.0002	<0.0002	0.0002	0.0005	0.0008	0.0005	0.0003	NA
Chromium	mg/L	0.0002+	<0.0002	<0.0002	**0.0007**	<0.0002	0.0002	0.00001	**0.0002**	<0.0002	NA
Cobalt	mg/L	0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.0014	<0.001	<0.001	0.09
Copper	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	**0.002**	0.001	<0.001	<0.001	0.001
Iron	mg/L	0.05	<0.05	<0.05	0.06	0.06	<0.05	NA	<0.05	<0.05	0.3
Manganese	mg/L	0.001	0.053	0.004	0.005	0.092	0.26	1.2	0.044	0.025	1.2
Nickel	mg/L	0.001	<0.001	0.001	<0.001	0.001	0.008	0.008	0.004	0.004	0.008
Zinc	mg/L	0.001	**0.004**	**0.007**	**0.003**	**0.004**	**0.006**	0.0024	0.003	0.004	0.0076
Nutrients											
Ammonia	mg/L	0.01	0.01	<0.01	<0.01	0.03	0.01	0.32	0.01	<0.01	0.32
Nitrate	mg/L	0.01	0.02	0.06	<0.01	<0.01	0.02	NA	0.03	<0.01	NA
NO_x	mg/L	0.01	**0.02**	**0.06**	<0.01	<0.01	**0.02**	0.015	**0.03**	<0.01	NA
TKN	mg/L	0.1	0.1	<0.1	0.1	0.2	0.3	NA	0.6	0.4	NA
TN	mg/L	0.1	0.1	<0.1	0.1	0.2	**0.3**	0.25	0.6	0.4	0.7
TP	mg/L	0.01	<0.01	<0.01	<0.01	0.02	<0.01	0.02	0.02	0.02	0.056
Other parameters											
DOC	mg/L	1	4	2	5	4	10	NA	10	8	NA
Oil & grease	mg/L	5	<5	<5	<5	285	<5	NA	<5	**7**	5
Fluoride	mg/L	0.1	0.2	<0.1	<0.1	<0.1	0.3	NA	0.2	0.2	NA

Values in **yellow** indicate exceedances of the DGVs. Values in **green** exceed the DGV but are below the relevant HMGV (See Table 3.8). NA = No DGV applies.

* The DGV applies to aluminium concentrations for pH >6.5. ^ Denotes parameter was recorded *in situ*. [+]Despite ultra-trace analysis, the LOR for chromium is higher than the DGV.

Table 3.8 HMGVs (in mg/L) for chromium and zinc in spring 2021

Metal	DOG		GAP		TOR		AIRUS	
	HMGV	Observed concentration	HMGV	Observed concentration	HMGV	Observed concentration	HMGV	Observed concentration
Chromium	NA	NA	NA	NA	NA	NA	0.081	0.0002
Zinc	0.039	0.004	0.003	0.003	0.079	0.006	NA	NA

Values in **yellow** indicate exceedances of the HMGVs

3.4.2 Historical review – Airly Creek

Long-term, time series water quality graphs are provided in Appendix F for key analytes at impact site AIR and background site AIRUS.

During all sampling events in 2021, EC was within the historical range of results at both AIR and AIRUS, with less variability than has been observed during previous years. Historically, EC results are commonly above the SSGV. In 2021, EC at both AIR and AIRUS showed an increasing trend between January and June, before decreasing from June to December, with the December results at both AIR and AIRUS the lowest observed at the sites since 2019. There has been no notable difference observed between the sites during the majority of the historical monitoring period, although, the highest concentrations were observed at AIR.

In situ pH at both AIR and AIRUS was within the DGV range during the majority of sampling events in 2021, though pH was slightly above the upper DGV in October 2021 at AIRUS and in November 2021 at AIR. pH was generally higher at AIRUS than AIR, although, pH has remained within the DGV range for most of the monitoring period.

Since 2010 TDS concentrations have been highly variable, particularly in 2018 and 2019 when the range of concentrations was greatest. TDS at AIR in 2019 was generally very high, with concentrations observed well above the previous range of results at the site. Results in 2020 had returned to within the previous range at AIR. The results from 2021 were within a similar range of results to those recorded between 2012 and 2017. TDS concentrations were generally similar between AIR and AIRUS for most of the monitoring period.

TSS results have been low at AIR and AIRUS since spring 2014, with the majority of results during this time below the DGV, including all results from both AIR and AIRUS throughout 2021.

The ammonia concentration at AIR in April 2019 exceeded the DGV for the only time during the historical monitoring period. All other ammonia concentrations were below the DGV at both sites during all sampling events including samples from 2021. Historically, similar concentrations of ammonia have been observed at both AIR and AIRUS.

TN concentrations at Airly Creek sites since 2010 have been generally below the SSGV. In 2021, TN was elevated in concentrations slightly above the SSGV at AIR in February, March and July 2021. All other results in 2021, including all results at AIRUS, were below the SSGV. TN was elevated in concentrations well above the SSGV during 2019, as well as during late-2012 to early 2013. There have been no notable differences between TN levels at AIR and AIRUS during periods in which data were collected for both sites.

TP concentrations throughout 2021 were low and were similar to results from 2020. All 2021 results were within the historical range for the sites, of which the majority of historical results have been below the DGV. There have been no notable differences in TP concentrations between the AIR and AIRUS sites.

The majority of dissolved aluminium concentrations have remained below the DGV at both Airly Creek sites during the historical monitoring period, and there were no exceedances of the DGV for dissolved aluminium at either site in 2021. In April 2019, the highest dissolved aluminium concentration observed to date was recorded at AIR, with this result many times higher than the DGV, though no concurrent result from AIRUS was available.

Dissolved cobalt concentrations were generally below the SSGV at both AIR and AIRUS for all samples collected during the historical monitoring period, including all samples collected in 2021. The only exceedances of the SSGV for dissolved cobalt observed during the historical monitoring period were two samples collected from AIR in 2019, when the concentrations were well above the usual range of results for the site.

Dissolved copper concentrations were below detectable limits at both sites in all samples collected in 2021 and were therefore below the DGV. Dissolved copper concentrations were commonly elevated at AIR during the 2010 to 2015 period, as well as in 2020, while several results from AIRUS were also above the DGV in 2014.

Dissolved iron concentrations at AIR and AIRUS throughout 2021 were below the SSGV in all samples, except for the sample collected from AIR in February, which was elevated at over 10 times the SSGV. The majority of iron concentrations since 2010 been below the SSGV at both sites, although, concentrations were elevated above the typical historical range of results during 2017 and 2019. The highest iron concentrations to date at both sites were recorded in 2019.

Dissolved manganese concentrations were below the DGV during all sampling events between June 2010 and October 2016. Recent dissolved manganese concentrations at AIR and AIRUS have been much higher, with the majority of results between July 2017 and April 2020 exceeding the DGV at both sites, though results were generally higher at AIR than AIRUS. The dissolved manganese results at both AIR and AIRUS in 2021 were all below the DGV, except for the sample collected from AIR in February, which was at a similar concentration to the elevated results observed at the site in 2019 and 2020. Dissolved manganese concentrations during all sampling events were higher at AIR than at AIRUS.

Dissolved nickel concentrations at AIR prior to 2019 were generally consistent and remained below or close to the DGV. However, results during 2019 and early-2020 at AIR were elevated above the DGV and the historical range of results. There were no corresponding results at AIRUS for 2019 as the site was dry. Results from April 2020 onward had returned to with the historical range and were generally similar between AIR and AIRUS. In 2021, there were three exceedances of the DGV observed at AIR, and one exceedance of the DGV observed at AIRUS, though these concentrations were similar to those observed historically.

The highest dissolved zinc concentrations have been recorded at AIR, with the highest concentration recorded in the 2010 to 2021 monitoring period observed at AIR in April 2019. There were more frequent exceedances of the SSGV at both sites between 2012 and 2016, however, there were multiple exceedances at AIR in 2020. In 2021, dissolved zinc concentrations at AIR exceeded the SSGV on the 4 Jan and 7 April and on both occasions, the concentration at AIRUS was below the SSGV. However, at the observed concentrations the potential toxicity would be ameliorated by the recorded water hardness.

3.5 Sediment quality

Laboratory analysis results for the autumn and spring 2021 sediment samples are presented in Table 3.9 and Table 3.10 respectively, including a comparison to the sediment DGVs in ANZG (2018). Parameters measured at concentrations below the LOR at all sites have not been presented in Table 3.9 and Table 3.10. Laboratory COAs showing data for all measured parameters are provided in Appendix A.

There were no exceedances of the DGVs for any parameter at impact site AIR, or at the background site AIRUS in autumn 2021. During spring 2021 the only exceedance of the DGVs was antimony from AIRUS but did not exceed the GV-high.

Acid-extractable (1M HCl-extractable) aluminium was highest in autumn at AIR, in spring the concentration was almost three times less. Manganese was most concentration at TOR during spring 2021, and several times higher than when compared to autumn.

Concentrations of copper and lead were highest during autumn at AIR and reduced when sampled in spring 2021. Nickel concentrations were elevated in spring and were the highest of all sites in 2021, although still below the DGV.

TN was comprised primarily of TKN at all sites during autumn and spring 2021. TN was highest at AIRUS in both seasons. TP followed a similar trend as TN with the highest concentrations observed were from AIRUS during both seasons.

Table 3.9 Laboratory analysis of sediment samples collected in autumn 2021

Analyte	Units	LOR	Baseline					Background	Impact	DGV	GV-high
			DOG	GAP	GEN	GRO	TOR	AIRUS	AIR		
1M HCl-extractable metals											
Aluminium	mg/kg	50	290	<50	440	250	350	440	1600	NA	NA
Arsenic	mg/kg	1	<1.0	<1.0	<1.0	<1.0	<1.0	1.4	1.2	20	70
Cadmium	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	1.5	10
Chromium	mg/kg	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.2	80	370
Cobalt	mg/kg	0.5	1.9	<0.5	2.1	<0.5	1.3	2.2	2.7	NA	NA
Copper	mg/kg	1	3	<1.0	<1.0	<1.0	3.6	3.4	8.5	65	270
Lead	mg/kg	1	5	1.8	1.1	<1.0	4.6	4.5	11.5	50	220
Manganese	mg/kg	10	98	15	41	<10	98	74	41	NA	NA
Nickel	mg/kg	1	2.4	<1.0	<1.0	<1.0	2.8	5.4	5.5	21	52
Zinc	mg/kg	1	4.9	<1.0	3.6	<1.0	4.9	12.5	21.2	200	410
Nutrients											
Nitrate	mg/kg	0.1	<0.1	0.1	0.5	0.2	<0.1	0.6	0.1	NA	NA
NOx	mg/kg	0.1	<0.1	0.1	0.5	0.2	<0.1	0.6	0.1	NA	NA
TKN	mg/kg	20	980	100	620	150	380	2970	860	NA	NA
TN	mg/kg	20	980	100	620	150	380	2970	860	NA	NA
TP	mg/kg	2	211	85	74	36	172	446	332	NA	NA
Other parameters											
TOC	%	0.02	1.47	0.2	1.04	0.45	0.37	3.66	1	NA	NA

Results highlighted in **yellow** indicate exceedances of the DGV. Results highlighted in **orange** indicate exceedances of the GV-high.

Table 3.10 Laboratory analysis of sediment samples collected in spring 2021

Analyte	Units	LOR	Baseline					Background	Impact	DGV	GV-high
			DOG	GAP	GEN	GRO	TOR	AIRUS	AIR		
1M HCl-extractable metals											
Aluminium	mg/kg	50	320	120	210	620	340	740	540	NA	NA
Antimony	mg/kg	1	<1.0	<1.0	<1.0	<1.0	<1.0	**8.6**	<1.0	2	25
Arsenic	mg/kg	1	<1.0	<1.0	<1.0	<1.0	<1.0	1.5	<1.0	20	70
Cobalt	mg/kg	0.5	1.2	1.3	1.2	<0.5	13	3.3	3.5	NA	NA
Copper	mg/kg	1	3.3	<1.0	<1.0	<1.0	3.8	6.3	5.8	65	270
Lead	mg/kg	1	6.6	1.7	<1.0	<1.0	6.4	6.7	8.4	50	220
Manganese	mg/kg	10	47	85	27	<10	808	116	276	NA	NA
Nickel	mg/kg	1	2.4	<1.0	<1.0	<1.0	14.1	6.8	7.7	21	52
Zinc	mg/kg	1	6.1	2.1	1.4	<1.0	20.1	15.2	22.3	200	410
Nutrients											
Nitrate	mg/kg	0.1	0.2	0.1	0.1	<0.1	0.2	0.1	0.2	NA	NA
NOx	mg/kg	0.1	0.2	0.1	0.1	<0.1	0.2	0.1	0.2	NA	NA
TKN	mg/kg	20	1090	70	50	490	700	2170	920	NA	NA
TN	mg/kg	20	1090	70	50	490	700	2170	920	NA	NA
TP	mg/kg	2	167	39	36	42	192	343	232	NA	NA
Other parameters											
TOC	%	0.02	2.26	0.31	0.23	1.48	2.19	4.1	0.74	NA	NA

Results highlighted in **yellow** indicate exceedances of the DGV. Results highlighted in **orange** indicate exceedances of the GV-high.

3.6 Macroinvertebrates

3.6.1 Univariate results – autumn and spring 2021

The highest taxa richness results were observed in samples collected from the baseline site TOR during both sampling events, with the highest results recorded in autumn 2021 (Figure 3.4). There was no overall temporal trend of diversity throughout 2021, with some replicate samples having a greater number of taxa in autumn than in spring, whilst the opposite also occurred whereby some replicate samples had greater diversity in spring. At baseline site TOR, there was a decrease in taxa richness in both samples between autumn and spring, while at impact site AIR, there was an increase in diversity. Taxa richness results were lowest at baseline site GRO during both seasons and taxa richness was also low at baseline site GEN. At GAP creek, the headwater of which have been recently undermined, taxa richness was below the average recorded during the EIS but higher than at some baseline sites. Taxa richness was generally similar between background site AIRUS and impact site AIR, when taking into account the within-site variability.

The highest number of EPT taxa were collected from GEN in autumn 2021, with one replicate sample containing five EPT taxa, as well as both replicate samples at DOG in spring (Figure 3.5). Sites DOG and GRO showed an improvement in the number of EPT taxa present between autumn and spring. Conversely, the baseline site GEN and both Airly Creek sites, AIR and AIRUS, had less EPT taxa in spring when compared to autumn. All samples collected contained at least one EPT taxon, with baseline site GRO having the least EPT taxa of all sites in autumn, and equal lowest with the impact site AIR in spring. Despite some variability between samples, EPT richness was similar between background site AIRUS and impact site AIR in both autumn and spring. The EPT richness was lower in 2021 than the EIS average at DOG in autumn, GRO, GAP and GEN, although, the EPT richness at GAP and the spring result at GEN was very close to the average. At TOR and AIR, EPT richness was higher than the EIS average by up to three taxa.

The highest SIGNAL-2 scores were observed at baseline site GEN in both autumn and spring 2021, with the autumn result slightly higher than spring (Figure 3.6). SIGNAL-2 scores were generally lowest at Airly Creek sites AIR and AIRUS. The lowest score in autumn was observed in one sample from AIRUS, while the lowest score in spring was observed at AIR. SIGNAL-2 scores were very consistent between samples and seasons at all sites. The SIGNAL-2 scores were similar between Airly Creek sites and the other lower altitude, broad valley sites DOG and TOR. SIGNAL-2 was generally higher at the higher altitude, less disturbed sites GEN, GRO and GAP, although, of these three sites, the SIGNAL-2 scores were lowest at GAP. The SIGNAL-2 scores were below the EIS average at GRO, GEN and GAP, while at DOG, TOR and AIR, SIGNAL-2 was consistent with or higher than the EIS average.

In 2021, sensitive taxa (taxa with SIGNAL-2 of 8 or higher) were collected from each sample at baseline sites DOG, and GEN and recently impacted GAP, with the exception of one replicate sample at baseline site GRO in autumn (Figure 3.7). No other sites, including both Airly Creek sites, contained any sensitive taxa. Baseline site GEN had the highest proportion of sensitive taxa in both seasons. Of the sites where sensitive taxa were observed, the lowest proportion was at baseline site DOG.

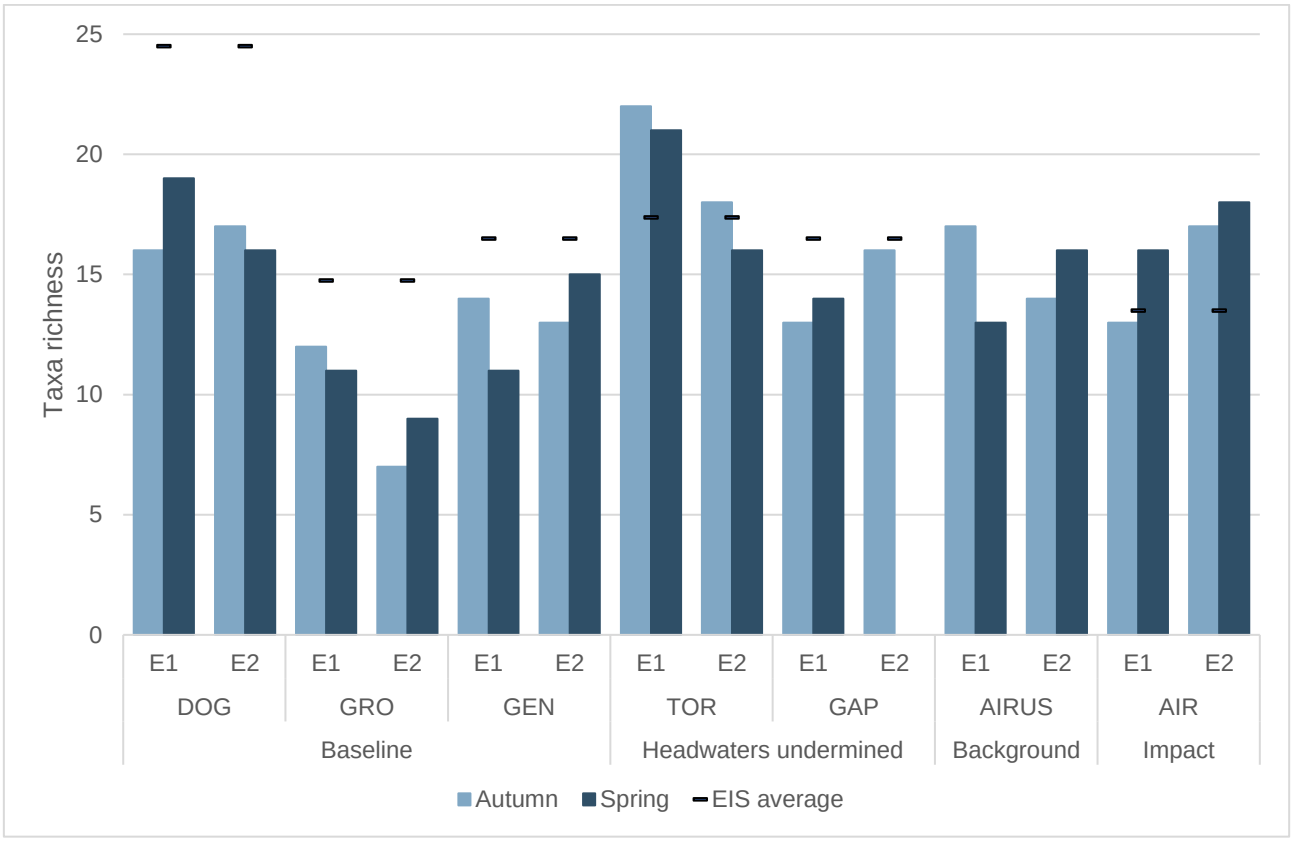


Figure 3.4 *Taxa richness in macroinvertebrate samples, autumn and spring 2021*

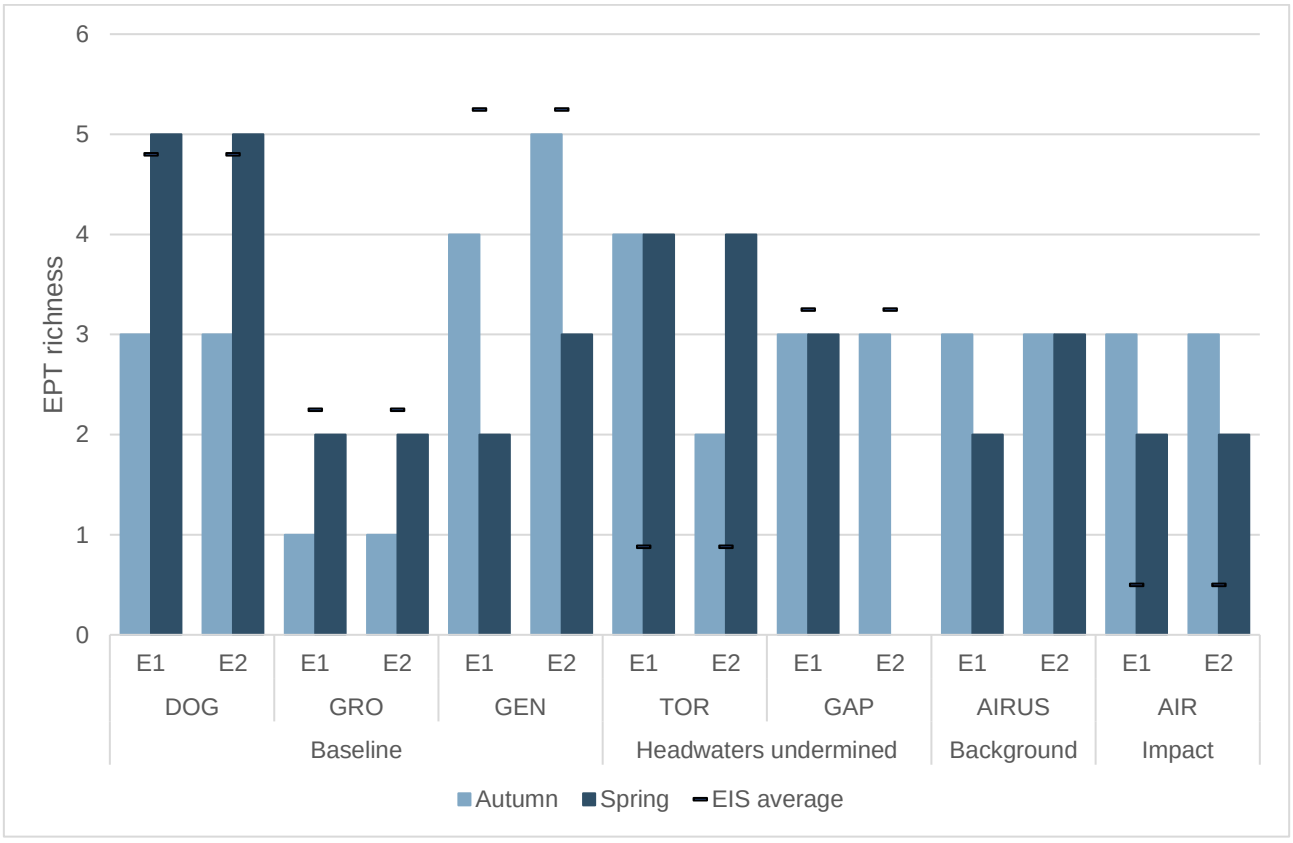


Figure 3.5 *EPT richness in macroinvertebrate samples, autumn and spring 2021*

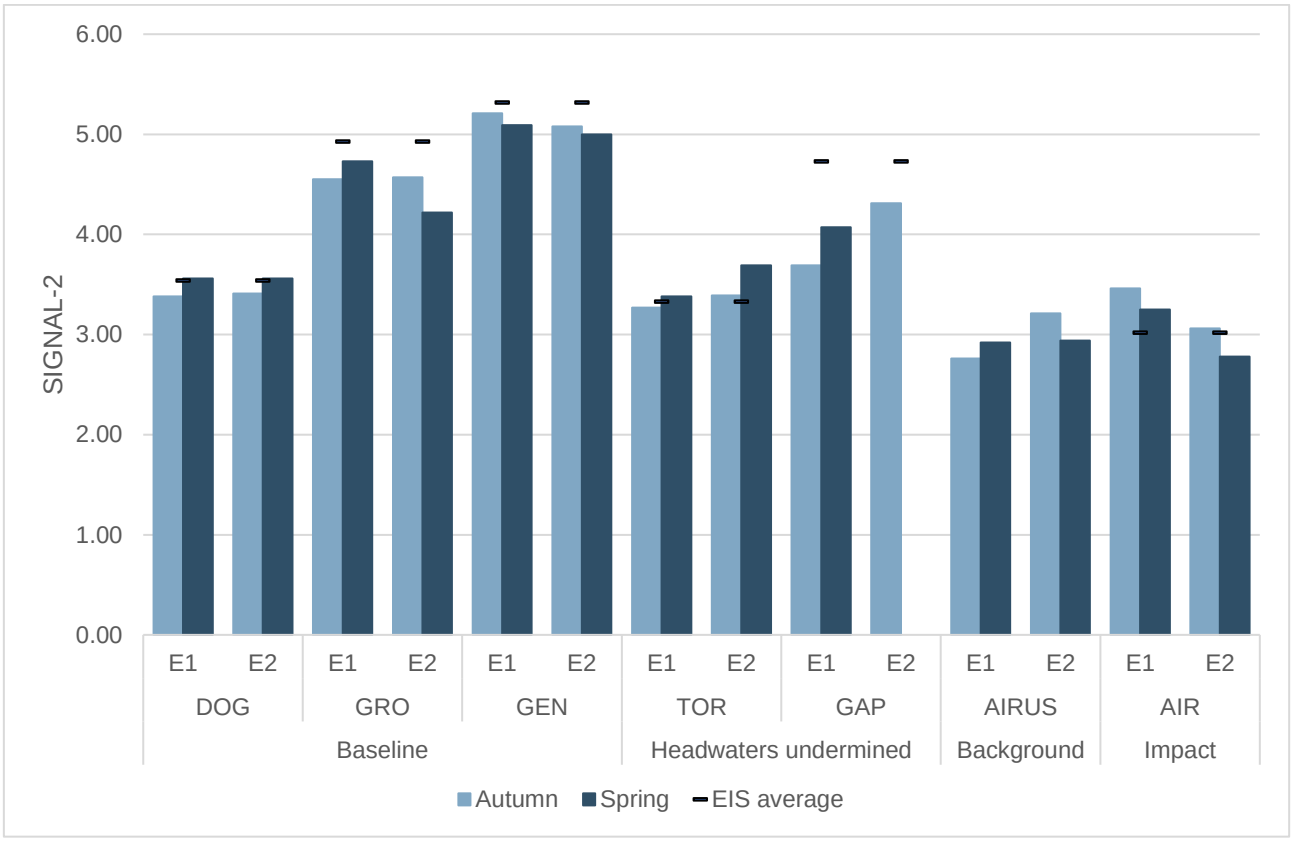


Figure 3.6 ***SIGNAL-2 scores for macroinvertebrate samples, autumn and spring 2021***

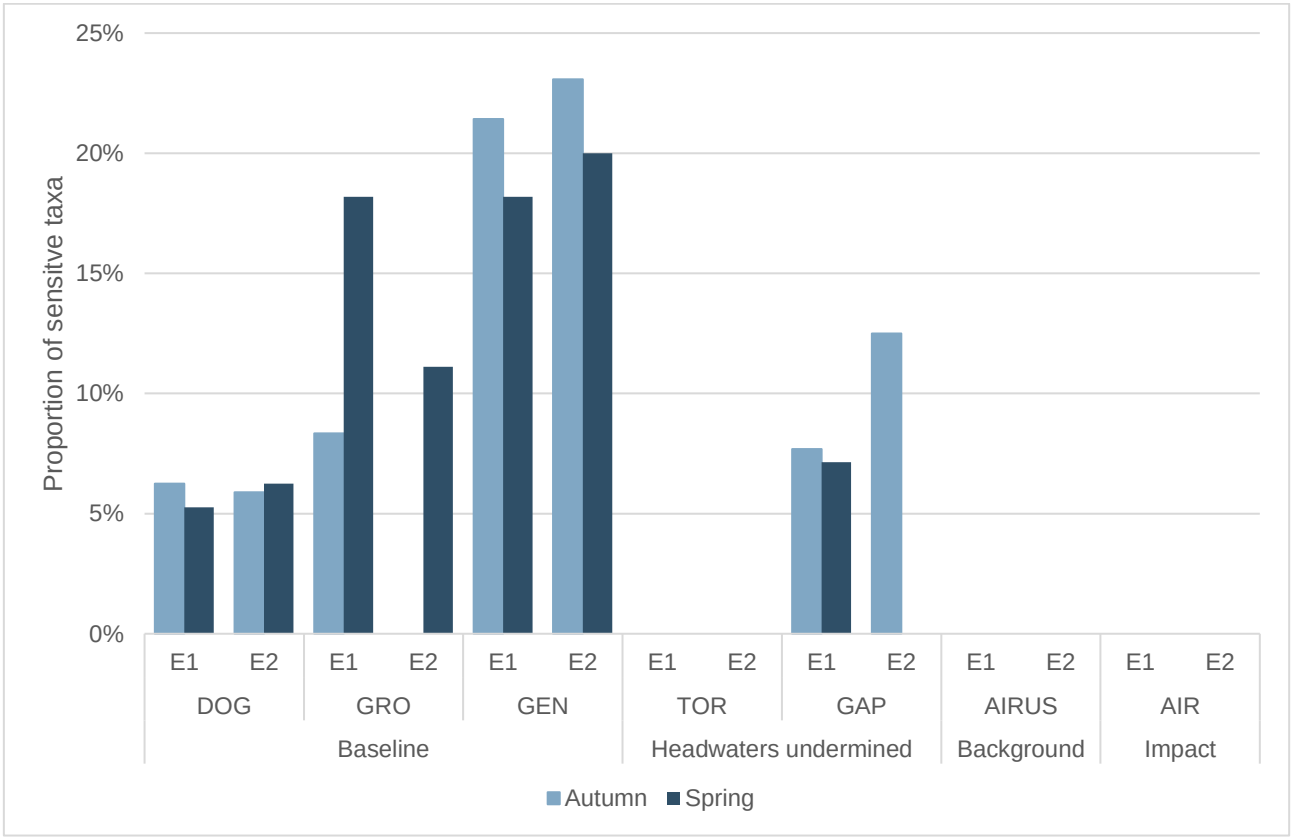


Figure 3.7 ***Proportion of sensitive taxa in macroinvertebrate samples, autumn and spring 2021***

3.6.2 AUSRIVAS

The results of AUSRIVAS modelling are presented in Figure 3.8. The NSW combined-season eastern edge model was used for all sites in 2021, though as only one macroinvertebrate sample was able to be collected from GAP in spring, only one combined season replicate could be analysed in AUSRIVAS. In order for the AUSRIVAS model to run, the alkalinity at DOG was reduced to 300 mg/L, as the elevated alkalinity at this site caused the site conditions to be outside the experience of the model. As such, these results should be interpreted with caution.

All samples collected from baseline sites DOG and recently impacted TOR received a Band A result indicating the site is similar to reference condition, with one sample from DOG having the highest overall AUSRIVAS O/E 50 score, but as discussed above the result from DOG should be viewed with caution. The baseline sites GEN, and recently impacted site GAP have been allocated to band B indicating some impairment in the macroinvertebrate communities. The lowest O/E50 score was from baseline site GRO, with one sample being allocated to Band B while the other sample received Band C. Band C indicates that the site is severely impaired, with fewer taxa than expected due to poor water quality or habitat quality.

The background site in Airly Creek, AIRUS, was allocated a Band A as well as a Band B. While the samples from the impact site, AIR, both received a Band B, however the O/E50 score was much less at AIR than at AIRUS.

Table 3.11 displays the inventory of taxa that were predicted by the AUSRIVAS model to be found at these sites at a probability of 50 percent or greater but were not collected during 2021. One sample collected from DOG as analysed by the model was missing the fewest (eight) taxa. Both samples from TOR were missing nine taxa. Baseline sites GEN and GRO were missing the most taxa that were expected by the model to be collected, with 15 and 16 taxa missing from the two replicates from GEN, and 16 taxa missing from both replicates from GRO. The impact site AIR was missing more taxa (14 and 13) than background site AIRUS (10 and 11).

Based on the SIGNAL-2 scores of the missing taxa, baseline site GEN was missing more sensitive taxa, with an average SIGNAL-2 score ranging between 5.20 and 5.69 (Table 3.11). Missing taxa at this site included the beetle Elmidae (SIGNAL-2 = 7), the damselfly Synlestidae (SIGNAL-2 = 7), and the caddisflies Hydrobiosidae (SIGNAL-2 = 8), Conoesucidae (SIGNAL-2 = 7), and Calamoceratidae (SIGNAL-2 = 7).

While the baseline site DOG had the lowest total of missing taxa, it also had the lower SIGNAL-2 of the missing taxa meaning that most of the taxa missing were pollution tolerant. The SIGNAL-2 score of missing taxa at this site ranged between 3.30 and 3.63. The only taxon that was missing at this site that was not missing from any other location in this study was the snail family *Physidae* (SIGNAL-2 = 1).

The average SIGNAL-2 of missing taxa at discharge impact site AIR was 3.93 and 4.46 compared 4.50 and 4.27 at background site AIRUS. The average SIGNAL-2 of missing taxa at recently impacted site GAP was 5.17, which is slightly below the average SIGNAL-2 of missing taxa at baseline sites GEN, and similar to the results at baseline site GRO.

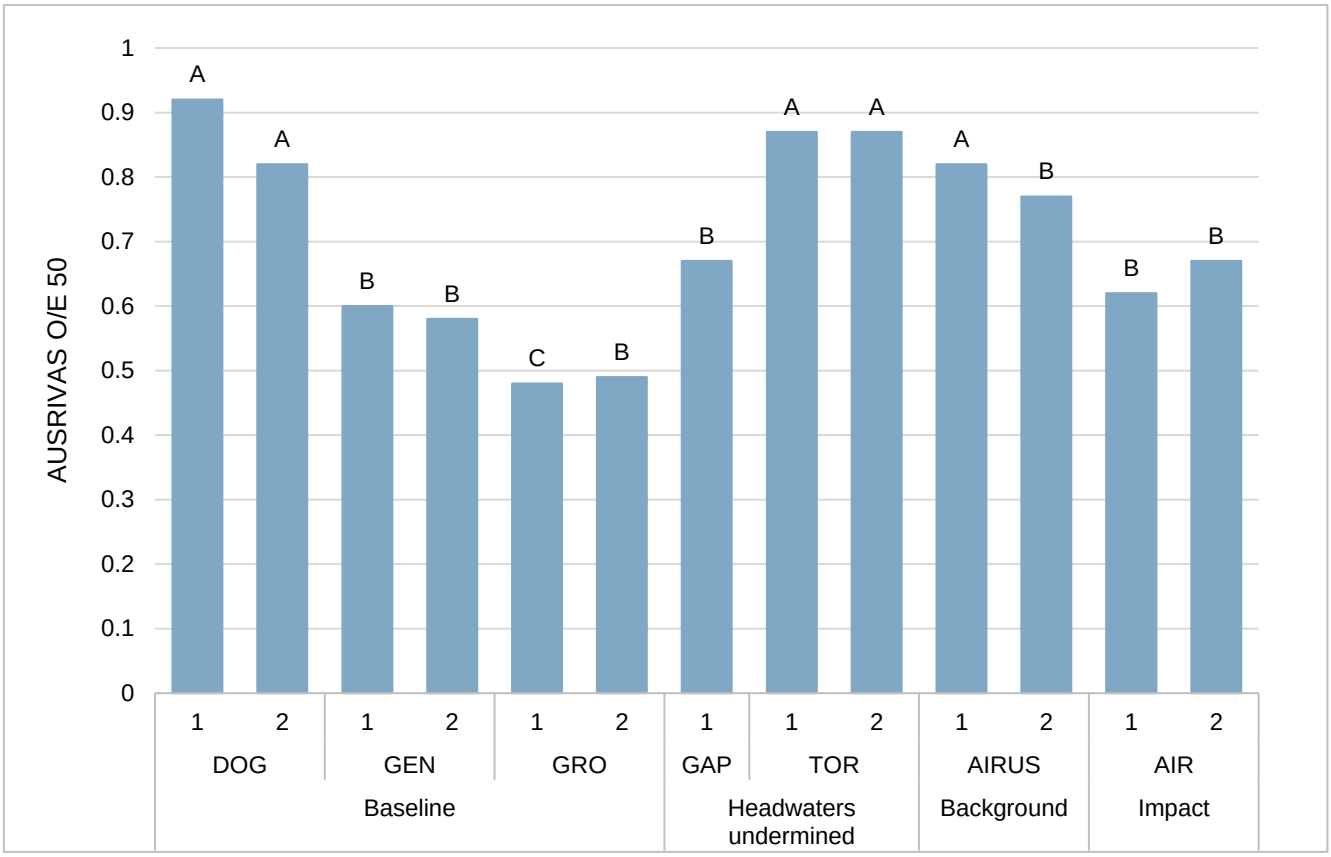


Figure 3.8 ***AUSRIVAS OE/50 results for 2021***

Table 3.11 Inventory of macroinvertebrate taxa predicted at ≥50% by AUSRIVAS modelling but not collected in 2021

Taxon Name	SIGNAL-2	Baseline									Background		Impact	
		DOG		GAP	GEN		GRO		TOR		AIRUS		AIR	
		1	2	1	1	2	1	2	1	2	1	2	1	2
Physidae	1	X	X											
Oligochaeta	2		X						X	X		X	X	
Acarina	6							X					X	X
Atyidae	3	X	X						X	X	X	X	X	X
Gyrinidae	4			X			X	X	X	X	X	X	X	X
Hydrophilidae	2		X		X		X			X			X	
Hydraenidae	3	X	X				X	X	X	X			X	X
Elmidae	7			X	X	X	X	X						
Tipulidae	5	X	X						X		X	X	X	X
Dixidae	7						X	X						
Ceratopogonidae	4		X		X		X				X	X		X
Simuliidae	5			X	X	X	X	X						
Tanypodinae	4										X	X	X	X
Orthocladiinae	4	X			X									X
Baetidae	5			X	X	X	X	X						
Oniscigastridae	8					X								
Leptophlebiidae	8								X	X	X	X	X	X
Caenidae	4			X	X	X	X	X			X		X	X
Gerridae	4	X	X	X	X	X	X	X	X	X	X	X	X	X
Corixidae	2			X	X	X	X	X						
Notonectidae	1							X					X	
Synlestidae	7			X	X	X	X	X						
Aeshnidae	4			X			X	X						
Gomphidae	5	X	X	X			X		X	X	X	X	X	X
Corduliidae	5					X								

Taxon Name	SIGNAL-2	Baseline									Background		Impact	
		DOG		GAP	GEN		GRO		TOR		AIRUS		AIR	
		1	2	1	1	2	1	2	1	2	1	2	1	2
Gripopterygidae	8			X	X	X	X	X						
Notonemouridae	6					X								
Hydrobiosidae	8				X	X		X						
Hydroptilidae	4					X						X		
Ecnomidae	4	X	X		X	X			X	X	X	X	X	X
Conoesucidae	7				X	X								
Calamoceratidae	7			X	X	X	X	X						
Total missing taxa		**8**	**10**	**12**	**15**	**16**	**16**	**16**	**9**	**9**	**10**	**11**	**14**	**13**
Average SIGNAL-2 of missing taxa		**3.63**	**3.30**	**5.17**	**5.20**	**5.69**	**4.88**	**5.13**	**4.22**	**3.89**	**4.50**	**4.27**	**3.93**	**4.46**

3.6.3 Multivariate analysis – 2021

The non-metric MDS plot demonstrates the relative similarity in macroinvertebrate community composition of samples collected in autumn and spring 2021 (Figure 3.9). All macroinvertebrate samples collected in 2021 have been grouped displaying at least 40 percent similarity in community composition. Samples are generally grouped according to site, indicating differences in community composition between sites, although, there was some overlap in samples from the Airly Creek sites and the Genowlan Creek sites.

All but one sample collected at discharge impact site AIR are grouped with samples from the recently impacted site TOR, and the background Airly Creek site AIRUS, displaying a minimum of 60 percent similarity in macroinvertebrate community composition. The AIR sample that is not grouped with the TOR and AIRUS samples is from autumn 2021, indicating indicates variability in the community composition between replicate samples during autumn at this site.

The samples from baseline site DOG are in a separate group from all other baseline sites and Airly Creek sites, with a minimum of 60 percent similarity. Samples collected from baseline sites GEN and GRO, and recently impacted GAP are positioned separately in the plot and grouped together with a minimum of 50 percent similarity. Within this group, the macroinvertebrate community composition was more similar between GRO and GEN than GAP.

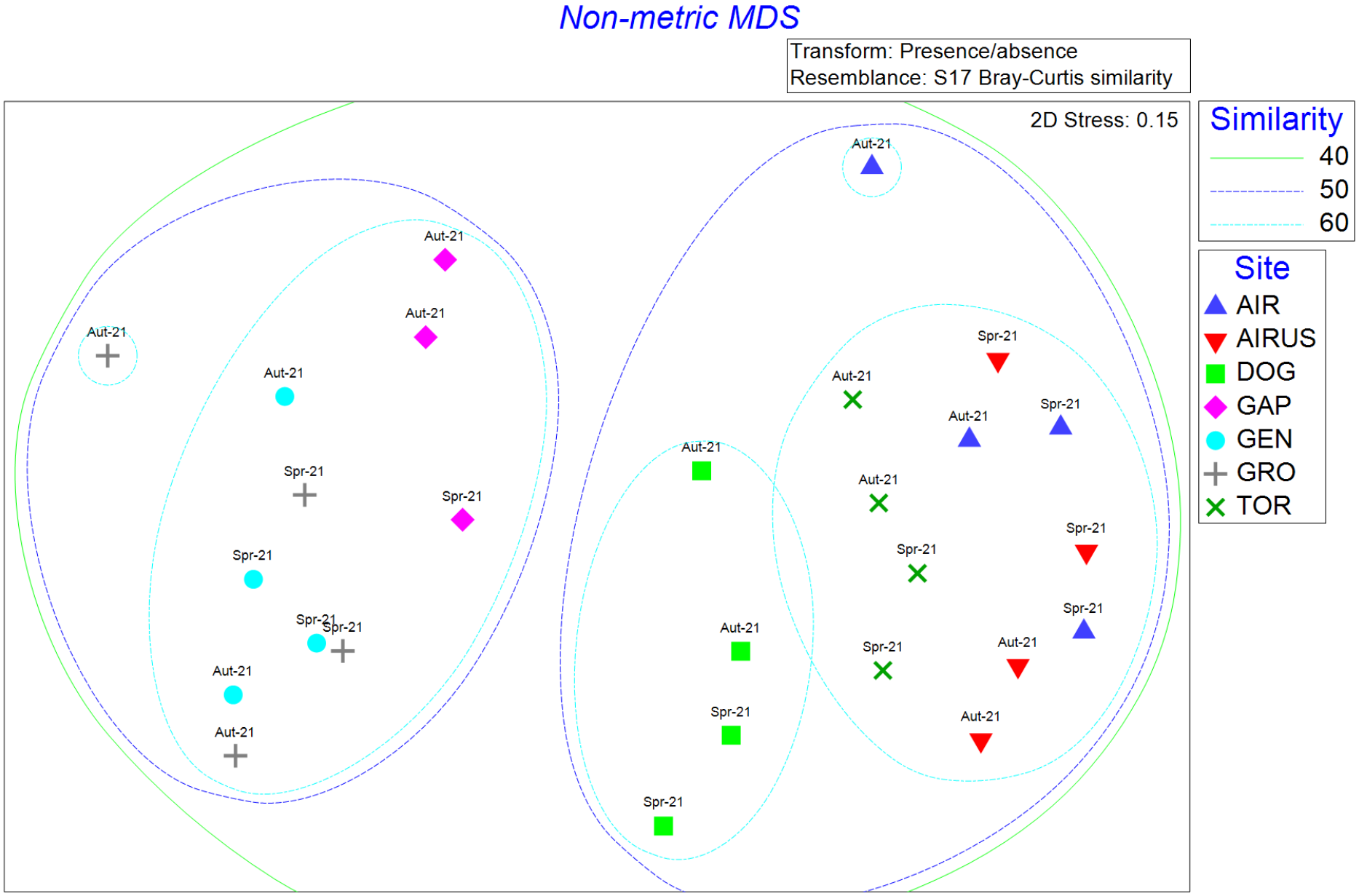


Figure 3.9 ***MDS demonstrating relative similarity in community composition between samples, autumn and spring 2021***

3.6.4 Historical review

The non-metric MDS presented as Figure 3.10 shows the relative similarity in the macroinvertebrate community between 2013 and 2021. The stress of the nMDS plot is less than 0.2, indicating that the pattern in the multivariate dataset is being reasonably well-represented by the 2-dimensional plot. Data from replicate samples were pooled to create a single point for each site and sampling event. It is noted that there were seven occasions during which only one replicate sample was able to be collected, including autumn 2016 at AIR, autumn and spring 2018 at DOG, autumn 2019 and spring 2021 at GAP, and autumn 2016 and autumn 2019 at GRO. These samples have been removed from the analysis. Site GAP, GRO and TOR have been frequently dry accounting for the reduced number of points for these sites. Sites GAP, GRO and GEN were only sampled once during the EIS survey period, and AIRUS was added to the program in spring 2016.

Samples from the higher altitude sites GEN, GAP and GRO are grouped together within the MDS plot, indicating that the composition of macroinvertebrate communities at these sites are similar, and have remained so over time. Similarly, samples from DOG, TOR, AIR and AIRUS are also grouped together in the plot. Variability in the macroinvertebrate composition has been observed over time at some sites, particularly at GAP, TOR and AIR.

Community composition at Torbane Creek site TOR has changed over time with the samples collected from autumn 2014, spring 2015 and autumn 2016, distinct in their community composition, while samples collected from spring 2016 onwards were similar to the Airly Creek and Dog Trap Creek samples. At AIRUS, the macroinvertebrate communities in autumn and spring 2021 were separated in the plot from other AIRUS samples, indicating greater similarity to the macroinvertebrate community at AIR than had previously been observed. Similarly, the sample collected from DOG in autumn 2021 was positioned showing greater similarity to the large grouping of samples collected from AIRUS prior to 2021 than to other samples collected from DOG historically. The samples collected from GEN, GRO and AIR in 2021 were similar to those previously collected.

ANOSIM detected a significant difference ($p < 0.05$) in community composition between sites. Pairwise tests determined that the macroinvertebrate community composition of all pairs of sites were significantly different ($p < 0.05$) with the exception of the groupings AIRUS and TOR and AIR and AIRUS (Appendix H).

An additional non-metric MDS has been presented as Figure 3.11, which shows the similarity in macroinvertebrate community composition for all samples collected at Airly Creek sites AIR and AIRUS, noting that AIRUS was not sampled prior to spring 2016. As the stress level for the MDS exceeded 0.20, the MDS plot should be interpreted with caution. The plot indicates a minimum of 40 percent similarity between all Airly Creek samples. All samples collected from AIRUS during the 2016 to 2021 monitoring period are plotted within the range of results at AIR, indicating that the between-site variability in community composition is similar to within-site variability or temporal variability. There has been a minor shift in the community composition at AIR over time, with the majority of samples collected from 2013 to 2019 clustering separately from the large grouping which contains all samples collected from AIR and AIRUS in 2020 and 2021, as well as some samples from previous sampling events. ANOSIM confirmed that there was no significant difference ($p > 0.05$) in community composition between AIR and AIRUS (Appendix H).

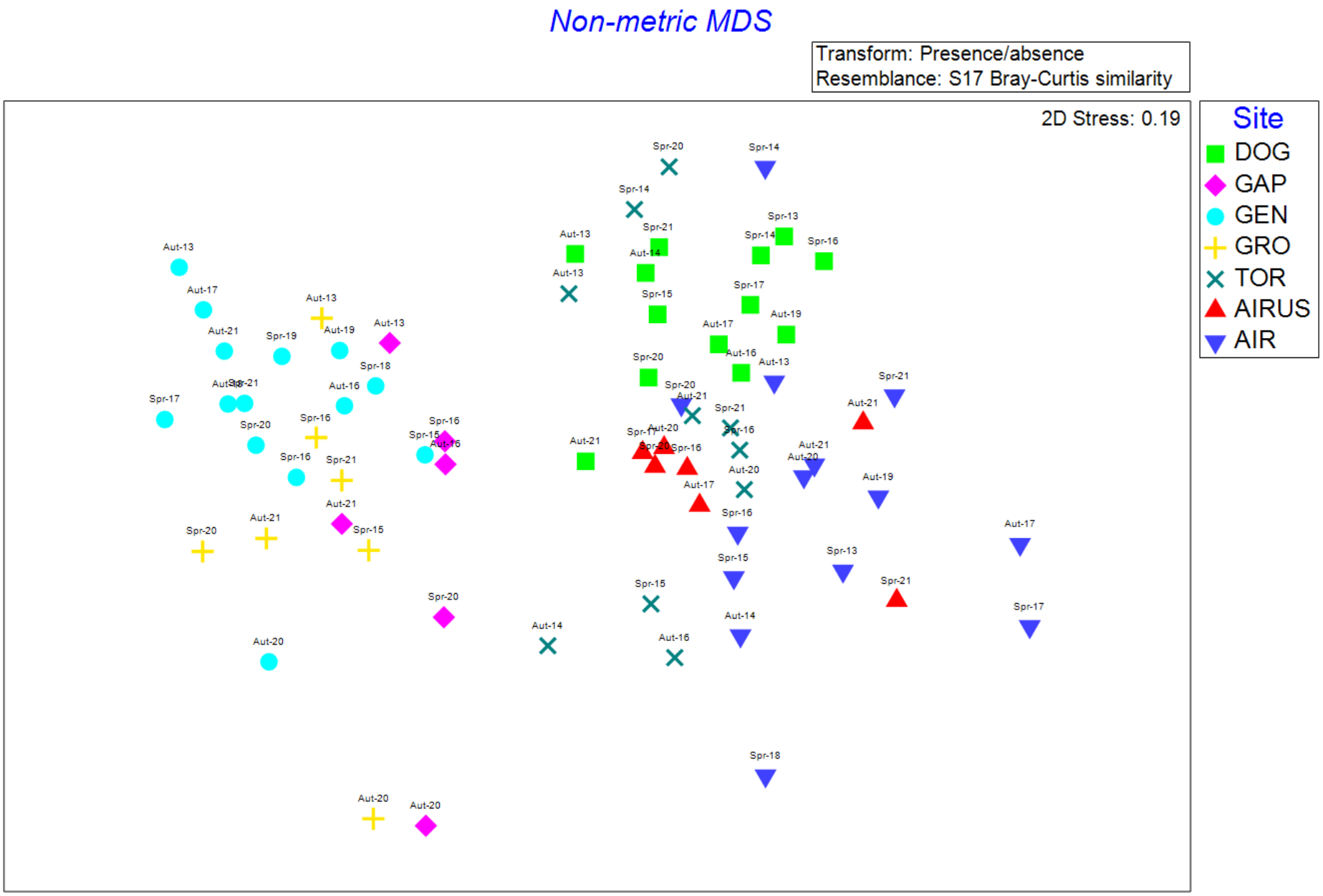


Figure 3.10 *MDS demonstrating relative similarity in community composition between sites, 2013-2021*

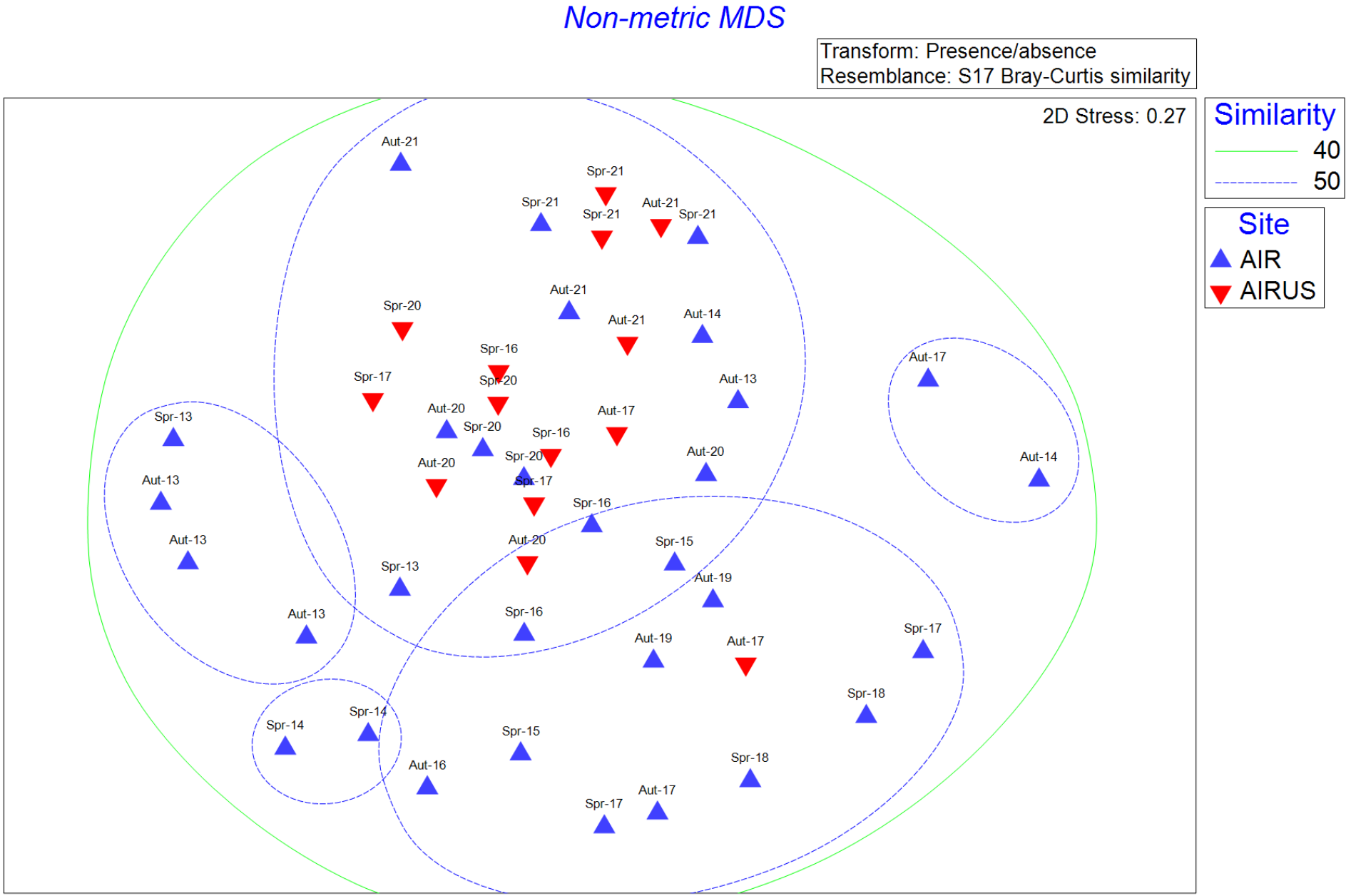


Figure 3.11 *MDS demonstrating relative similarity in community composition between Airly Creek samples, 2013-2021*

4. Discussion

4.1 Water quality

The water quality monitoring results for 2021 show that Airly Creek background and discharge impact sites AIRUS and AIR, and baseline sites DOG and TOR, contain water with a conductivity, and a similar ionic composition of calcium magnesium type. The elevated EC observed at AIR in 2020 was not attributable to Airly Mine, as the conductivity was slightly higher at background site, AIRUS. Additionally, there was only a small discharge from LDP2, approximately five weeks prior to autumn 2021 sampling. This November 2021 discharge event from LDP1 occurred after the spring survey (3-5 November 2021) and therefore this study is unable to determine whether the discharge had caused any adverse impacts in the receiving environment. The high salinity and ionic composition of the lower altitude sites is instead indicative of the grazing which occurs in the upstream catchments of Airly, Torbane and Dog Trap Creeks, and groundwater inputs to the site from the Shoalhaven Group, which is an early Permian marine formation in which groundwater has an elevated EC in the order of 4000 µS/cm. Only the background site, AIRUS, in spring 2021 exceeded the EC SSGV, which were calculated based on the naturally saline waters observed upstream in Airly Creek. The conductivity, whilst natural to these sites, remains consistently elevated and at this level still has the potential to be a physical stressor to aquatic organisms.

Some surface flow was observed in 2021, though the gentle flows that are typical for these sites do not contribute significant aeration to the water. This resulted in the generally low DO saturations observed at the sites which were sampled, as decomposition of detritus in the pool refugia consumes DO. At both AIR and AIRUS in autumn 2021 the DO was below the DGV, whist in spring the DO at AIR above the DGV range and AIRUS was below. The was some macrophyte and algal growth present within the water body at AIR in spring, which may have contributed to the super saturation dissolved oxygen. Algae and macrophytes can contribute to a diurnal cycle of DO saturations, due to the production of oxygen through photosynthesis during the daytime, and respiration and night (ANZECC 2000). This site was sampled during mid-afternoon on a sunny day, which is likely to have contributed to the higher DO observed at this time. This process may have also contributed to the higher pH observed at this site, through the removal of carbon dioxide during photosynthesis (ANZECC 2000). However, this may not be the only cause of increased DO levels at this site, as there were other sites present within this study that had higher proportions of macrophytes and algal growth within their respective study site. Another factor that may have contributed is the low cover of detritus and small woody debris at AIR in spring in comparison to other sites. Decomposition of algal matter, detritus, and small woody debris, including leaf packs can decrease the DO in a water body through the oxidation of organic matter by decomposers. Thereby a combination of a small amount of decomposing matter and active photosynthesis in the water body at AIR may have led to a super saturation of DO during spring, a combination of which did not occur in any other site during 2021.

Turbidity exceeded the DGV at GAP in autumn 2021 with 36.3 NTU, which was much less than the result from autumn 2020 with a turbidity of 4510 NTU. The turbidity in spring 2020 was low and below the DGV, and with no rain prior to sampling it is therefore difficult to define the cause of the elevated result in autumn 2021.

Concentrations of dissolved metals at discharge impact site AIR and background site AIRUS were generally low in 2021, with no exceedances of the DGVs/SSGVs in autumn or spring. There were minimal differences in concentrations of dissolved metals between sites AIR and AIRUS, except for higher chromium at AIRUS in spring, indicating no evidence of water quality impacts from Airly Mine operations. There was an exceedance of the SSGV for oil and grease at AIR in spring 2021, however, as there were no discharges between March 2021 and spring 2021 monitoring, this result is unlikely to be attributable to Airly Mine.

The DGV for dissolved zinc was exceeded at GAP, GEN, GRO, and TOR in autumn 2021, and all baseline sites in spring. Zinc concentrations have commonly exceeded the DGV at these sites (GHD 2020, GHD 2019, GHD 2018a) suggesting that the zinc originates from the local lithology. As the zinc concentrations observed at GAP, GEN and GRO were below the DGV for the protection of 95% of aquatic species, the potential impact to macroinvertebrates would be limited to the most sensitive taxa.

Concentrations of dissolved aluminium were also elevated in exceedance of the DGV at GAP, GEN and GRO in autumn and only GRO in spring 2021, with the highest concentration observed in both seasons at GRO. As with zinc, this presence of aluminium across all sites, including baseline sites GRO and GEN, indicates that the local lithology is the likely source. The pH was less than 6.5 at these sites on each occasion that exceeded the DGV for aluminium, the DGV only applies to water of pH > 6.5, and therefore, is not considered to be an exceedance of the guidelines. Aluminium is considered likely to be more toxic to aquatic communities when combined with acidic water with pH < 5.5 (ANZG 2020). This indicates that the concentrations of dissolved aluminium may have had an adverse effect on macroinvertebrates, particularly at GRO where the pH was lowest.

Dissolved chromium that was detected above the LOR in water samples for the first time in 2019 at GAP, GRO and AIRUS persisted in 2020. Chromium concentrations exceeded the DGV at GAP and GRO in autumn 2021, and at GRO only in spring 2021. It is likely that the source of chromium is the local lithology, and as elevated chromium was observed at baseline and background sites, Airly Mine is unlikely to be a contributing factor.

Nutrient concentrations, including nitrate, NO_x, TKN, and TN, at all baseline sites in 2021, were generally higher in autumn than spring. However, in the Airly Creek sites, AIR and AIRUS, nutrient concentrations, in particular NO_x, TKN, and TN were higher in spring in comparison to autumn. These results are likely to have been influenced by the associated runoff from rainfall in each of the catchments to influence the nutrient concentrations. The runoff in the higher altitude, low disturbance catchments of Gap and Genowlan Creeks may have had a lower concentration of nutrients than the upper Airly Creek catchment.

Oil and grease were below detection limits at all sites during autumn 2021. As discussed, oil and grease exceeded the SSGV limit in the impact site AIR during spring. Although the SSGV only applies to Airly Creek, it should be noted that a concentration of 285 mg/L was observed at GAP during spring, which far exceeds the SSGV for Airly Creek. This result is most likely a laboratory error or may be due to runoff from an adjacent 4WD track. There is no known mechanism for impacts from Airly Mine operations on oil and grease concentrations in Gap Creek.

The long-term plots of monthly water quality for AIRUS and AIR (refer to Appendix F) show that all measured water quality parameters in 2021 at AIR and AIRUS were within the historical range of results for the sites. This demonstrates a continued improvement in results from those observed in 2019 when frequent exceedances were recorded. Conditions were very dry in 2019, consequently, leading to concentrated runoff from surrounding grazing areas unrelated to mine discharges, and a concentration of contaminants in isolated pools due to evaporation. The wetter conditions since beginning in early-2020 have provided flushing and dilution of these concentrated agricultural contaminants in Airly Creek.

There were minimal differences in water quality between sites AIR and AIRUS in autumn 2021, despite an overflow discharge from LDP2 in March 2021, approximately five weeks prior to aquatic ecology monitoring. There was no discharge from LDP1 into Airly Creek from Airly Mine up until 27 November 2021, with the four-day discharge event occurring after the spring aquatic ecology survey. Water quality samples were collected at Airly Creek sites by ALS on 1/12/2021, the day following the cessation of discharge. There some differences in water quality between AIRUS and AIR, including some elevated metal concentrations at AIR (relative to AIRUS) indicating some potential influence of the discharge on water quality in Airly Creek. However, concentrations of most metals were low and the only exceedance of the SSGVs/DGVs was for dissolved nickel, although, there was no exceedances of the concentration limits for LDP1 (EPL 12374), including dissolved nickel. Further, based on the recorded water hardness, the nickel concentration observed at AIR on 1/12/2021 was well below the HMGV. Therefore, from the water quality data collected during 2021 aquatic ecology sampling, Airly has met the EIS prediction of negligible environmental consequences to water quality. There was also no evidence of impacts to flows or water quality in Gap Creek or Torbane Creek due to undermining of some of the headwater streams of these watercourses between 2019 and 2021 (GHD 2022).

4.2 Sediment quality

In 2021, only one exceedance of the DGVs for sediment quality was observed at AIRUS in spring, with the antimony concentration exceeding the DGV, but not the GV-high. There were no other exceedances of any sediment DGV at impact site AIR, or at any other site. Consequently, there is no evidence of any impact to aquatic organisms from Airly Mine discharges on sediment quality in Airly Creek, as none of the DGVs, which represent the effect thresholds of potential contaminants in sediment, were exceeded.

4.3 Macroinvertebrates

Rainfall in the 2017 to 2019 period at Airly Mine was below average, with rainfall recorded at the mine in 2017 and 2018 below the fifth and tenth percentiles of annual rainfalls, respectively. In 2019, the rainfall at Airly Mine was less than the lowest historical annual rainfall volume recorded since 1899 at the BOM Running Stream station. These dry conditions resulted in low water levels and many dry sites in the study area, particularly in 2019, and consequently, poor conditions for macroinvertebrates. In 2020, however, rainfall was above the long-term average, and these improved conditions helped to create more favourable conditions for macroinvertebrates (GHD 2021c). This trend continued throughout 2021, with annual rainfall slightly less than the long-term average, thereby creating a more stable environment to allow for recovery of the macroinvertebrate communities. These results are evident in the number of sensitive taxa (SIGNAL-2 ≥8) collected. 2020 was the first year of sampling since 2017 that sensitive taxa had been collected from a site other than GEN. In 2021 sensitive taxa were collected in all replicate samples in autumn and spring at DOG, GAP, and GEN, and all but one sample from GRO. This demonstrates the improvements to the macroinvertebrate communities corresponding to the increased rainfall.

In 2021, as has been the case during recent years of monitoring, samples collected at GEN contained the highest SIGNAL-2 scores, and the highest proportion of sensitive taxa. Located in the headwaters of Genowlan Creek, site GEN is spring fed and contains a heterogenous substrate including boulders, cobbles, gravel, and sand, as well as low proportions of silt and clays blanketing the substrate. The site is also well shaded and contains other aquatic habitats including detritus, small woody debris and algae. Therefore, the site displays a high level of good quality and diverse aquatic habitat types and with greater water reliability, can support more sensitive macroinvertebrate taxa than other high altitude sites. The mayfly family Leptophlebiidae (Ephemeroptera; SIGNAL-2 = 8), and caddisfly family Leptoceridae (Trichoptera; SIGNAL-2 = 6) were the most common EPT taxa at GEN, as they were collected in both replicate samples during both autumn and spring 2021 surveys.

TOR had the greatest diversity of taxa of all sites in both the autumn and spring 2021 surveys, it also had a high diversity of EPT taxa throughout 2021. This demonstrates substantial improvement at this site, likely due to the sustained water availability since 2020, as this site was dry between 2017 and 2019. However, no sensitive taxa (taxa with SIGNAL-2 of 8 or higher) were observed at this site in 2021, thereby the SIGNAL-2 scores at this site were the lowest of all baseline sites. Similar to GEN, during wetter periods, TOR contains a wide variety of substrates including cobbles, pebble, gravel, and sand, as well as low proportions of silt and clays blanketing the substrate. The site is also well shaded and contains other aquatic habitats including detritus, small woody debris and algae. These good quality and diverse habitats can support a wide range of macroinvertebrate taxa from many functional feeding groups and sensitive taxa. The lack of sensitive taxa in 2021, despite good quality habitat, suggests that it is a combination of high levels of EC, sulfate, and water hardness, in contrast to the low ionic strength waters of Genowlan Creek, that is preventing habitation by sensitive taxa.

A small section of the first order headwaters of Torbane Creek was undermined in 2019. The results of 2020 / 2021 do not suggest any impacts to the macroinvertebrate community of Torbane Creek as a result. In fact, taxa richness and PET richness in 2021 were the highest observed at this site during the 2013 to 2021 monitoring period, indicating that macroinvertebrate community condition has improved over time in response to prolonged water availability.

As mentioned in section 4.1, the dissolved aluminium concentrations in water were elevated at the baseline sites GEN and recently impacted site GAP in autumn 2021, and baseline site GRO in both autumn and spring. The highest concentrations were observed at GRO in both surveys. Aluminium is known to be more toxic to aquatic species in acidic waters, such as those observed at GRO (ANZECC 2000), which may have contributed to the poor macroinvertebrate community condition recorded at the site in 2021 and previous years. GRO recorded the lowest taxa richness and EPT richness of all sites in 2021. However, habitat limitations would also be a factor influencing the macroinvertebrate community in this section of Genowlan Creek. Due to earlier disturbances from maintenance of the adjacent 4WD track, this site has been reduced to a very narrow section of bedrock covered by ferns, with limited variety of habitat. The 2021 results for GRO indicate some recovery compared to the poor macroinvertebrate condition observed in autumn 2020, however, macroinvertebrate community condition is still low relative to the EIS sampling period (2013-2014). As the Genowlan Creek catchment has not been undermined as yet, the results are unlikely to be associated with Airly Mine operations.

Secondary workings (panel and pillar mining) commenced under the first order stream headwaters of Gap Creek in 2020, with further undermining occurring in 2021. Although macroinvertebrate community condition in 2021 was relatively poor, relative to some other sites, the quality has improved since the low observed in 2019/2020, following a three-year drought period. There has been no evidence of changes to flows in Gap Creek following the undermining, as determined through monthly water quality monitoring and the Gap Creek flow gauge (GHD 2022), located just upstream of the aquatic ecology monitoring location GAP. The flows in Gap Creek in 2021 were increased in 2021, relative to the pre-mining monitoring history, mirroring the increased rainfall. Therefore, there is no reason to suspect that there is any impact from Airly mining on the aquatic biota of Gap Creek.

The macroinvertebrate communities in Airly Creek in both autumn and spring 2021 had lower overall taxa richness and EPT richness than occurred the spring 2020 survey (GHD 2021a). There were no sensitive taxa in any of the macroinvertebrate samples collected in Airly Creek throughout 2021. All other indices including number of taxa, EPT richness, and SIGNAL-2, were similar at AIR and AIRUS during both autumn and spring surveys in 2021. The multivariate MDS analysis also indicated the similarities of the macroinvertebrate communities at these sites in 2021 further indicating that a similar set of macroinvertebrate families live at the two sites. Consequently, there is no evidence of impact of Airly mine discharges on Airly Creek, including the discharge from LDP2 in March. This is to be expected given the low volume discharges in 2021 prior to aquatic ecology monitoring. It is acknowledged that the discharge from LDP1 in November 2021 occurred after macroinvertebrate monitoring had already been completed and, therefore the influence of the November discharge event on Airly Creek cannot be determined. The November 2021 discharge event was in response to large amounts of rainfall. Due to the dilution from rainfall, the compliance with the concentration limits of EPL 12374 (Centennial 2021b), and lack of exceedances of the DGVs for aquatic ecosystem protection (see Section 4.1), the risk of toxic impacts is low. Given the volume of discharge recorded (approximately 15.6 ML over four days), scouring impacts on Airly Creek and the associated aquatic habitats and biota are also not expected.

Despite the similarity in water quality between the Airly Creek sites, the similarities in the macroinvertebrate community is surprising considering that the habitat is very different between the two sites. The substrate at AIRUS is dominated by silt/clay, and instream habitat is dominated by macrophytes (submerged macrophyte and fringing sedges) and willow roots and the shading and overhanging habitat is limited to two large willows. In contrast, AIR has a diverse substrate with bedrock, boulder, cobble, pebble, and gravel and low coverage of macrophytes but a higher proportion of overhanging vegetation (mostly grasses but also small casuarinas and eucalypts) and shading present. Water quality, altitude and surrounding landuse appear to be more dominating factors in the determination of the macroinvertebrate community present within Airly Creek than habitat quality and availability.

The macroinvertebrate community at lowland sites DOG, TOR, AIRUS and AIR were dominated by tolerant taxa, with very few or no sensitive taxa collected from these sites. These results were consistent with catchments impacted by grazing and historic land clearing and the lower altitude. Samples collected from these sites commonly contained Baetidae (Ephemeroptera; SIGNAL-2 = 5), and Aeshnidae (Odonata; SIGNAL-2 = 4), that were not collected from any of the upland baseline sites GAP, GEN or GRO. The Baetidae family are small mayflies that can be found in a variety of freshwater habitats, are strong swimmers and are scrapers that feed upon detritus and algae within the water body, while the Aeshnidae family are large predatory dragonfly whereby larvae can also be found in a variety of habitats, preferring still waters. Conversely, the upland sites contained sensitive taxa including, Leptophlebiidae (Ephemeroptera; SIGNAL-2 = 8) that were not found, or were collected infrequently, at any of the lowland, more disturbed, sites. Overall, the greater sensitivity of the taxa observed at the upland sites, as evident by the number of sensitive taxa present and their proportion to the overall number of taxa present at each site, reflects the minimal anthropogenic impacts, and generally improved water and sediment quality, relative to the lowland sites.

These differences in macroinvertebrate sensitivity were also reflected in the non-metric MDS, which indicated similar macroinvertebrate community compositions at lowland sites, TOR, AIR and AIRUS, relative to upland sites GEN, GRO and GAP. The different macroinvertebrate community composition at upland sites would be reflecting a number of natural site differences including different ionic composition and different environmental conditions (e.g. altitude, temperature, position in the catchment), as well as habitat changes (e.g. greater amount of overhanging habitat, branched algae instream at GEN, flowing water).

Overall, the results of 2021 aquatic ecology monitoring do not indicate impacts from Airly Mine discharges on Airly Creek or impacts from undermining on Gap Creek or Torbane Creek.

5. Conclusions

Although the annual rainfall in 2021 was slightly below the long-term average, building on the higher-than-average rainfall in 2020, it provided an additional recovery period from the very low rainfall period between 2017 and 2019. The influence of the drought on the macroinvertebrate community was evident through the low number of taxa, number of EPT taxa, and SIGNAL-2 scores in particular from sites AIRUS and AIR during that period, and the increase in these metrics since 2019.

There were no impacts to water or sediment quality in 2021 that were attributable to Airly Mine, due to discharges to Airly Creek, or undermining of the Gap Creek or Torbane Creek headwaters. Impacts to water quality observed in Airly Creek, Torbane Creek and Dog Trap Creek were instead indicative of historical land clearing, the agricultural landuse in the catchments, and the influence of saline groundwater from marine-deposited geology on Airly Creek. In contrast, Genowlan and Gap Creeks exhibited superior water and sediment quality that is indicative of their location in a densely forested, relatively undisturbed catchment, and at a higher elevation, with flowing water.

Macroinvertebrate community condition in 2021 reflected the site differences, with samples collected from more pristine, higher altitude sites Gap and Genowlan Creeks showing similarities, which contrasted to the macroinvertebrate communities observed at lower lying sites in Dog Trap, Torbane and Airly Creeks. Samples from the lower lying sites were dominated by tolerant taxa, which reflected the poorer quality water and aquatic habitat in these catchments. As far as can be determined, macroinvertebrate community condition appears to be unaffected by Airly Mine operations. This is to be expected given the small volume and infrequency of discharges from Airly Mine LDPs to date and the lack of impacts to flows in Gap Creek due to undermining (GHD 2022). The only discharges in 2021 were a small volume overflow from LDP2 approximately five weeks prior to autumn 2021 sampling and discharge from LDP1 between 27 and 30 November, several weeks after the spring survey, in response to high rainfall. Based on the water quality in Airly Creek following the November 2021 discharge event, it is unlikely that there would have been adverse impacts upon the receiving environment.

The next round of aquatic ecology monitoring will be conducted in autumn 2022.

6. References

ANZECC (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Australia and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

ANZG (2018) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality,* Australian and New Zealand Governments and Australian state and territory governments.

ANZG (2020) *Aluminium in freshwater and marine water,* https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/water-quality-toxicants/toxicants/aluminium-2000.

Bray, JR and Curtis, JT (1957) *An ordination of the upland forest communities of Southern Wisconsin*. Ecol. Monogr. 27:325-349.

Bureau of meteorology (2021) Rainfall obtained for station 063012 from http://www.bom.gov.au/climate/data/index.shtml?bookmark=136. Accessed 19 January 2021.

Cardno (2014), *Aquatic Ecology and Stygofauna Assessment*, Airly Mine Extension Project, report prepared for Centennial Airly Pty Ltd.

Centennial (2021a) Environmental Protection Licence 12374: Monthly Environmental Monitoring Report. Airly Mine: March 2021.

Centennial (2021b) Environmental Protection Licence 12374: Monthly Environmental Monitoring Report. Airly Mine: November 2021.

Chessman BC (2003). New sensitivity grades for Australian river macroinvertebrates. *Marine and Freshwater Research* 54, 95-104.

Chessman, BC, Growns, JE and Kotlash, AR (1997) Objective derivation of macroinvertebrate family sensitivity grade numbers for the SIGNAL biotic index: application to the Hunter River system, New South Wales, *Marine and Freshwater Research*, 48(2), 159–72.

Clarke, KR, Gorley, RN (2015). *PRIMER v7: User Manual/Tutorial*. PRIMER-E, Plymouth, 296pp.

GHD (2022) *2021 Annual Water Monitoring Report, in draft*. Prepared by GHD Pty Ltd for Centennial Coal Company Limited.

GHD (2021a) *2020 Annual Water Monitoring Report*. Prepared by GHD Pty Ltd for Centennial Coal Company Limited.

GHD (2021b) *Airly 2020 watercourse stability monitoring report*. Prepared for Centennial Airly Pty Ltd.

GHD (2021c) *Airly Aquatic Ecology Monitoring Annual Report 2020.* Prepared for Centennial Airly Pty Ltd.

GHD (2021d) *Airly Mine Water Management Plan*. Report prepared for Centennial Airly Pty Ltd.

GHD (2020) *Airly Aquatic Ecology Monitoring Annual Report 2019*. Prepared for Centennial Airly Pty Ltd.

GHD (2019) *Airly Aquatic Ecology Monitoring Annual Report 2018*. Prepared for Centennial Airly Pty Ltd.

GHD (2018a) *Airly Aquatic Ecology Monitoring, Spring 2017*. Prepared for Centennial Airly Pty Ltd.

GHD (2018b) *Airly Mine: Site specific guideline values,* prepared for Centennial Airly Pty Ltd.

GHD (2016) *Western Operations: Regional Water Management Plan*, prepared by GHD Pty Ltd for Centennial Coal Company Limited.

ISO (1983). *Water Quality: Methods of Biological Sampling - Handnet Sampling of Aquatic Benthic Macroinvertebrates*. Draft ISO International Standard.

Marshall, C, Harch, BD, Choy, SC, Smith, MJ (2001) Chapter 8: Aquatic macroinvertebrates as indicators of ecosystem health, Design and Implementation of Baseline Monitoring (DIBM3) final report, http://www.watercentre.org/portfolio/rhef/project-resources/publications/SmithStorey2001_Ch11.pdf.

Peterson RC (1992) The RCE: a Riparian, Channel, and Environment Inventory for small streams in the agricultural landscape, *Freshwater Biology,* 27(2), 295–306.

Simpson SL and Batley G (2016) *Sediment Quality Assessment*, A Practical Guide, second edition, CSIRO Publishing.

Turak E, Waddell N and Johnstone G (2004). *New South Wales (NSW) Australian River Assessment System (AUSRIVAS) Sampling and Processing Manual 2004* http://ausrivas.ewater.com.au/index.php/manuals-a-datasheets?id=55.

Appendices

Appendix A

Laboratory certificates of analysis

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES2116690**	Page	: 1 of 5
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MS ZOE LAGERROTH	Contact	: Angus Harding
Address	: Level 3, GHD Tower, 24 Honeysuckle Drive Newcastle NSW 2300 Newcastle	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: 07 3859 7800	Telephone	: +61 2 8784 8555
Project	: 12545559 Airly Autumn 2021	Date Samples Received	: 05-May-2021 12:50
Order number	: 12545559	Date Analysis Commenced	: 05-May-2021
C-O-C number	: ----	Issue Date	: 13-May-2021 14:15
Sampler	: Tegan Hopwood		
Site	:		
Quote number	: EN/005		
No. of samples received	: 3		
No. of samples analysed	: 3		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EG020: It is recognised that total concentration is less than dissolved for some metal analytes. However, the difference is within experimental variation of the methods.
- EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	GEN	GRO	GAP	----	----
			Sampling date / time	04-May-2021 08:30	04-May-2021 11:00	04-May-2021 13:30	----	----
Compound	CAS Number	LOR	Unit	ES2116690-001	ES2116690-002	ES2116690-003	--------	--------
				Result	Result	Result	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**5.82**	**4.95**	**5.84**	----	----
EA006: Sodium Adsorption Ratio (SAR)								
^ Sodium Adsorption Ratio	----	0.01	-	**1.01**	**1.44**	**0.87**	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**59**	**46**	**113**	----	----
EA016: Calculated TDS (from Electrical Conductivity)								
Total Dissolved Solids (Calc.)	----	1	mg/L	**38**	**30**	**73**	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	<5	**17**	----	----
EA045: Turbidity								
Turbidity	----	0.1	NTU	**0.4**	**1.3**	**36.3**	----	----
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**7**	<1	**25**	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**6**	**2**	**14**	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**6**	**2**	**14**	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**2**	<1	**1**	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**12**	**11**	**19**	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**1**	<1	**5**	----	----
Magnesium	7439-95-4	1	mg/L	**1**	<1	**3**	----	----
Sodium	7440-23-5	1	mg/L	**6**	**6**	**10**	----	----
Potassium	7440-09-7	1	mg/L	**1**	<1	**2**	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.04**	**0.28**	**0.15**	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	**0.001**	<0.001	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	**0.001**	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Manganese	7439-96-5	0.001	mg/L	**0.008**	**0.014**	**0.020**	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	GEN	GRO	GAP	----	----
				Sampling date / time	04-May-2021 08:30	04-May-2021 11:00	04-May-2021 13:30	----	----
Compound	CAS Number	LOR	Unit		ES2116690-001	ES2116690-002	ES2116690-003	--------	--------
					Result	Result	Result	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Nickel	7440-02-0	0.001	mg/L		**0.002**	**0.001**	**0.002**	----	----
Boron	7440-42-8	0.05	mg/L		<0.05	<0.05	<0.05	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	**0.15**	**0.22**	----	----
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.05**	**0.33**	**1.16**	----	----
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.001	**0.001**	----	----
Copper	7440-50-8	0.001	mg/L		<0.001	<0.001	**0.002**	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	**0.002**	----	----
Manganese	7439-96-5	0.001	mg/L		**0.007**	**0.014**	**0.067**	----	----
Nickel	7440-02-0	0.001	mg/L		**0.001**	<0.001	**0.002**	----	----
Boron	7440-42-8	0.05	mg/L		<0.05	<0.05	<0.05	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	**0.29**	**1.45**	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.00004	mg/L		<0.00004	<0.00004	<0.00004	----	----
EG035T: Total Mercury by FIMS									
Mercury	7439-97-6	0.00004	mg/L		<0.00004	<0.00004	<0.00004	----	----
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS									
Arsenic	7440-38-2	0.2	µg/L		<0.2	<0.2	**0.3**	----	----
Cadmium	7440-43-9	0.05	µg/L		<0.05	<0.05	<0.05	----	----
Chromium	7440-47-3	0.2	µg/L		<0.2	**0.8**	**0.6**	----	----
Selenium	7782-49-2	0.2	µg/L		<0.2	<0.2	<0.2	----	----
Silver	7440-22-4	0.1	µg/L		<0.1	<0.1	<0.1	----	----
Zinc	7440-66-6	1	µg/L		**7**	**3**	**5**	----	----
EG094T: Total metals in Fresh water by ORC-ICPMS									
Arsenic	7440-38-2	0.2	µg/L		<0.2	<0.2	**0.5**	----	----
Cadmium	7440-43-9	0.05	µg/L		<0.05	<0.05	<0.05	----	----
Chromium	7440-47-3	0.2	µg/L		**0.4**	**0.9**	**1.4**	----	----
Selenium	7782-49-2	0.2	µg/L		<0.2	<0.2	<0.2	----	----
Silver	7440-22-4	0.1	µg/L		<0.1	<0.1	<0.1	----	----
Zinc	7440-66-6	1	µg/L		**7**	**5**	**8**	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		<0.1	<0.1	<0.1	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		<0.01	**0.03**	**0.06**	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	GEN	GRO	GAP	----	----
				Sampling date / time	04-May-2021 08:30	04-May-2021 11:00	04-May-2021 13:30	----	----
Compound	CAS Number	LOR	Unit		ES2116690-001	ES2116690-002	ES2116690-003	--------	--------
					Result	Result	Result	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	<0.01	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		**0.14**	**0.05**	**0.02**	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**0.14**	**0.05**	**0.02**	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		<0.1	**0.2**	**0.4**	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		**0.1**	**0.2**	**0.4**	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		<0.01	<0.01	**0.04**	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	<0.01	<0.01	----	----
EN055: Ionic Balance									
ø Total Anions	----	0.01	meq/L		**0.50**	**0.35**	**0.84**	----	----
ø Total Cations	----	0.01	meq/L		**0.42**	**0.26**	**0.98**	----	----
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		**2**	**11**	**6**	----	----
EP020: Oil and Grease (O&G)									
Oil & Grease	----	5	mg/L		<5	<5	<5	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES2116982**	Page	: 1 of 5
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MS ZOE LAGERROTH	Contact	: Angus Harding
Address	: Level 3, GHD Tower, 24 Honeysuckle Drive Newcastle NSW 2300 Newcastle	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: 07 3859 7800	Telephone	: +61 2 8784 8555
Project	: 12545559 Airly Autumn 2021	Date Samples Received	: 06-May-2021 14:00
Order number	: 12545559	Date Analysis Commenced	: 06-May-2021
C-O-C number	: ----	Issue Date	: 14-May-2021 17:17
Sampler	: Tegan Hopwood		
Site	:		
Quote number	: EN/005		
No. of samples received	: 3		
No. of samples analysed	: 3		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EG094: It is recognised that total concentration is less than dissolved for some metal analytes. However, the difference is within experimental variation of the methods.
- EG020: It is recognised that total concentration is less than dissolved for some metal analytes. However, the difference is within experimental variation of the methods.
- EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	DOG	TOR	AIR	----	----
			Sampling date / time	05-May-2021 08:30	05-May-2021 11:30	05-May-2021 13:30	----	----
Compound	CAS Number	LOR	Unit	ES2116982-001	ES2116982-002	ES2116982-003	--------	--------
				Result	Result	Result	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**8.05**	**7.54**	**7.65**	----	----
EA006: Sodium Adsorption Ratio (SAR)								
^ Sodium Adsorption Ratio	----	0.01	-	**0.89**	**0.69**	**0.83**	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**1410**	**2680**	**2300**	----	----
EA016: Calculated TDS (from Electrical Conductivity)								
Total Dissolved Solids (Calc.)	----	1	mg/L	**916**	**1740**	**1500**	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	**8**	**10**	**5**	----	----
EA045: Turbidity								
Turbidity	----	0.1	NTU	**1.0**	**0.9**	**2.4**	----	----
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**832**	**1820**	**1470**	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**420**	**146**	**156**	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**420**	**146**	**156**	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**418**	**1710**	**1340**	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**34**	**57**	**60**	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**198**	**325**	**266**	----	----
Magnesium	7439-95-4	1	mg/L	**82**	**244**	**196**	----	----
Sodium	7440-23-5	1	mg/L	**59**	**68**	**73**	----	----
Potassium	7440-09-7	1	mg/L	**3**	**10**	**8**	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Manganese	7439-96-5	0.001	mg/L	**0.050**	**0.134**	**0.133**	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	DOG	TOR	AIR	----	----
				Sampling date / time	05-May-2021 08:30	05-May-2021 11:30	05-May-2021 13:30	----	----
Compound	CAS Number	LOR	Unit		ES2116982-001	ES2116982-002	ES2116982-003	--------	--------
					Result	Result	Result	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Nickel	7440-02-0	0.001	mg/L		**0.001**	**0.009**	**0.008**	----	----
Boron	7440-42-8	0.05	mg/L		<0.05	<0.05	<0.05	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	<0.05	----	----
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		<0.01	<0.01	<0.01	----	----
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Copper	7440-50-8	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Manganese	7439-96-5	0.001	mg/L		**0.090**	**0.154**	**0.132**	----	----
Nickel	7440-02-0	0.001	mg/L		<0.001	**0.009**	**0.008**	----	----
Boron	7440-42-8	0.05	mg/L		<0.05	<0.05	<0.05	----	----
Iron	7439-89-6	0.05	mg/L		**0.07**	**0.06**	**0.10**	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.00004	mg/L		<0.00004	<0.00004	<0.00004	----	----
EG035T: Total Mercury by FIMS									
Mercury	7439-97-6	0.00004	mg/L		<0.00004	<0.00004	<0.00004	----	----
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS									
Arsenic	7440-38-2	0.2	µg/L		**0.4**	**0.3**	**0.4**	----	----
Cadmium	7440-43-9	0.05	µg/L		<0.05	<0.05	<0.05	----	----
Chromium	7440-47-3	0.2	µg/L		<0.2	<0.2	<0.2	----	----
Selenium	7782-49-2	0.2	µg/L		<0.2	**0.2**	<0.2	----	----
Silver	7440-22-4	0.1	µg/L		<0.1	<0.1	<0.1	----	----
Zinc	7440-66-6	1	µg/L		**1**	**3**	**7**	----	----
EG094T: Total metals in Fresh water by ORC-ICPMS									
Arsenic	7440-38-2	0.2	µg/L		**0.5**	**0.4**	**0.4**	----	----
Cadmium	7440-43-9	0.05	µg/L		<0.05	<0.05	<0.05	----	----
Chromium	7440-47-3	0.2	µg/L		<0.2	<0.2	<0.2	----	----
Selenium	7782-49-2	0.2	µg/L		<0.2	**0.3**	<0.2	----	----
Silver	7440-22-4	0.1	µg/L		<0.1	<0.1	<0.1	----	----
Zinc	7440-66-6	1	µg/L		<1	**3**	**7**	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.3**	**0.4**	**0.2**	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		<0.01	<0.01	<0.01	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	DOG	TOR	AIR	----	----
				Sampling date / time	05-May-2021 08:30	05-May-2021 11:30	05-May-2021 13:30	----	----
Compound	CAS Number	LOR	Unit		ES2116982-001	ES2116982-002	ES2116982-003	--------	--------
					Result	Result	Result	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	<0.01	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		**0.05**	**0.04**	**0.03**	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**0.05**	**0.04**	**0.03**	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**0.2**	**0.2**	**0.2**	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		**0.2**	**0.2**	**0.2**	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**0.01**	<0.01	<0.01	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	<0.01	<0.01	----	----
EN055: Ionic Balance									
ø Total Anions	----	0.01	meq/L		**18.0**	**40.1**	**32.7**	----	----
ø Total Cations	----	0.01	meq/L		**19.3**	**39.5**	**32.8**	----	----
ø Ionic Balance	----	0.01	%		**3.26**	**0.77**	**0.12**	----	----
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		<1	**7**	**5**	----	----
EP020: Oil and Grease (O&G)									
Oil & Grease	----	5	mg/L		<5	<5	<5	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES2116685**	Page	: 1 of 5
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MS ZOE LAGERROTH	Contact	: Angus Harding
Address	: Level 3, GHD Tower, 24 Honeysuckle Drive Newcastle NSW 2300 Newcastle	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: 07 3859 7800	Telephone	: +61 2 8784 8555
Project	: 12545559 Airly Autumn 2021	Date Samples Received	: 05-May-2021 12:30
Order number	: 12545559	Date Analysis Commenced	: 05-May-2021
C-O-C number	: ----	Issue Date	: 13-May-2021 14:15
Sampler	: Tegan Hopwood		
Site	:		
Quote number	: EN/005		
No. of samples received	: 2		
No. of samples analysed	: 2		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

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This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW

General Comments

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Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

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Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EG020: It is recognised that total concentration is less than dissolved for some metal analytes. However, the difference is within experimental variation of the methods.
- EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	AIRUS	AIRD	----	----	----
			Sampling date / time	03-May-2021 14:00	03-May-2021 15:00	----	----	----
Compound	CAS Number	LOR	Unit	ES2116685-001	ES2116685-002	--------	--------	--------
				Result	Result	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.61**	**7.63**	----	----	----
EA006: Sodium Adsorption Ratio (SAR)								
^ Sodium Adsorption Ratio	----	0.01	-	**0.86**	**0.86**	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**2560**	**2550**	----	----	----
EA016: Calculated TDS (from Electrical Conductivity)								
Total Dissolved Solids (Calc.)	----	1	mg/L	**1660**	**1660**	----	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	**10**	**10**	----	----	----
EA045: Turbidity								
Turbidity	----	0.1	NTU	**4.7**	**2.8**	----	----	----
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**1560**	**1570**	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**190**	**187**	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**190**	**187**	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**1470**	**1460**	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**60**	**62**	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**255**	**258**	----	----	----
Magnesium	7439-95-4	1	mg/L	**224**	**226**	----	----	----
Sodium	7440-23-5	1	mg/L	**78**	**78**	----	----	----
Potassium	7440-09-7	1	mg/L	**6**	**6**	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	----	----	----
Cobalt	7440-48-4	0.001	mg/L	**0.001**	**0.001**	----	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.257**	**0.309**	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	AIRUS	AIRD	----	----	----
				Sampling date / time	03-May-2021 14:00	03-May-2021 15:00	----	----	----
Compound	CAS Number	LOR	Unit		ES2116685-001	ES2116685-002	--------	--------	--------
					Result	Result	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Nickel	7440-02-0	0.001	mg/L		**0.007**	**0.009**	----	----	----
Boron	7440-42-8	0.05	mg/L		<0.05	<0.05	----	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	----	----	----
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.06**	**0.08**	----	----	----
Cobalt	7440-48-4	0.001	mg/L		**0.001**	**0.002**	----	----	----
Copper	7440-50-8	0.001	mg/L		<0.001	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L		**0.344**	**0.464**	----	----	----
Nickel	7440-02-0	0.001	mg/L		**0.007**	**0.007**	----	----	----
Boron	7440-42-8	0.05	mg/L		<0.05	<0.05	----	----	----
Iron	7439-89-6	0.05	mg/L		**0.48**	**0.75**	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.00004	mg/L		<0.00004	<0.00004	----	----	----
EG035T: Total Mercury by FIMS									
Mercury	7439-97-6	0.00004	mg/L		<0.00004	<0.00004	----	----	----
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS									
Arsenic	7440-38-2	0.2	µg/L		**0.4**	**0.4**	----	----	----
Cadmium	7440-43-9	0.05	µg/L		<0.05	<0.05	----	----	----
Chromium	7440-47-3	0.2	µg/L		<0.2	<0.2	----	----	----
Selenium	7782-49-2	0.2	µg/L		<0.2	<0.2	----	----	----
Silver	7440-22-4	0.1	µg/L		<0.1	<0.1	----	----	----
Zinc	7440-66-6	1	µg/L		**3**	**2**	----	----	----
EG094T: Total metals in Fresh water by ORC-ICPMS									
Arsenic	7440-38-2	0.2	µg/L		**0.5**	**0.6**	----	----	----
Cadmium	7440-43-9	0.05	µg/L		<0.05	<0.05	----	----	----
Chromium	7440-47-3	0.2	µg/L		**0.3**	**0.3**	----	----	----
Selenium	7782-49-2	0.2	µg/L		<0.2	<0.2	----	----	----
Silver	7440-22-4	0.1	µg/L		<0.1	<0.1	----	----	----
Zinc	7440-66-6	1	µg/L		**3**	**5**	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.2**	**0.3**	----	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		<0.01	**0.02**	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	AIRUS	AIRD	----	----	----
				Sampling date / time	03-May-2021 14:00	03-May-2021 15:00	----	----	----
Compound	CAS Number	LOR	Unit		ES2116685-001	ES2116685-002	--------	--------	--------
					Result	Result	----	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		**0.03**	**0.02**	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**0.03**	**0.02**	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**0.2**	**0.3**	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		**0.2**	**0.3**	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		<0.01	**0.04**	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	<0.01	----	----	----
EN055: Ionic Balance									
ø Total Anions	----	0.01	meq/L		**36.1**	**35.9**	----	----	----
ø Total Cations	----	0.01	meq/L		**34.7**	**35.0**	----	----	----
ø Ionic Balance	----	0.01	%		**1.96**	**1.22**	----	----	----
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		**9**	**8**	----	----	----
EP020: Oil and Grease (O&G)									
Oil & Grease	----	5	mg/L		<5	<5	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES2116691**	Page	: 1 of 6
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MS ZOE LAGERROTH	Contact	: Angus Harding
Address	: Level 3, GHD Tower, 24 Honeysuckle Drive Newcastle NSW 2300 Newcastle	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: 07 3859 7800	Telephone	: +61 2 8784 8555
Project	: 12545559 Airly Autumn 2021	Date Samples Received	: 05-May-2021 12:50
Order number	: 12545559	Date Analysis Commenced	: 07-May-2021
C-O-C number	: ----	Issue Date	: 21-May-2021 17:44
Sampler	: Tegan Hopwood		
Site	:		
Quote number	: EN/005		
No. of samples received	: 6		
No. of samples analysed	: 6		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EG005T (Total Metals by ICP-AES): Sample (EB2113054_002) shows poor matrix spike recovery due to sample heterogeneity. Confirmed by visual inspection.
- EG035-SDH (1M HCl Extractable Mercury) Sample (ES2116686_004) shows poor matrix spike recovery due to
- EG005T (Total Recoverable Metals by ICP-AES): Sample (EB2113054_001) shows poor duplicate results due to matrix interference. Confirmed by re-extraction and re-analysis.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	GEN	GRO	GAP	GEN <2000um	GRO <2000um
			Sampling date / time	04-May-2021 08:30	04-May-2021 11:00	04-May-2021 13:30	04-May-2021 08:30	04-May-2021 11:00
Compound	CAS Number	LOR	Unit	ES2116691-001	ES2116691-002	ES2116691-003	ES2116691-004	ES2116691-005
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	**24.6**	**23.5**	**21.8**	**----**	**----**
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES								
Aluminium	7429-90-5	50	mg/kg	**----**	**----**	**----**	**440**	**250**
Antimony	7440-36-0	1.0	mg/kg	**----**	**----**	**----**	<1.0	<1.0
Arsenic	7440-38-2	1.0	mg/kg	**----**	**----**	**----**	<1.0	<1.0
Cadmium	7440-43-9	0.1	mg/kg	**----**	**----**	**----**	<0.1	<0.1
Cobalt	7440-48-4	0.5	mg/kg	**----**	**----**	**----**	**2.1**	<0.5
Chromium	7440-47-3	1.0	mg/kg	**----**	**----**	**----**	<1.0	<1.0
Copper	7440-50-8	1.0	mg/kg	**----**	**----**	**----**	<1.0	<1.0
Lead	7439-92-1	1.0	mg/kg	**----**	**----**	**----**	**1.1**	<1.0
Manganese	7439-96-5	10	mg/kg	**----**	**----**	**----**	**41**	<10
Nickel	7440-02-0	1.0	mg/kg	**----**	**----**	**----**	<1.0	<1.0
Silver	7440-22-4	1.0	mg/kg	**----**	**----**	**----**	<1.0	<1.0
Zinc	7440-66-6	1.0	mg/kg	**----**	**----**	**----**	**3.6**	<1.0
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**----**	**----**	**----**	**860**	**530**
Antimony	7440-36-0	5	mg/kg	**----**	**----**	**----**	<5	<5
Arsenic	7440-38-2	5	mg/kg	**----**	**----**	**----**	<5	<5
Cadmium	7440-43-9	1	mg/kg	**----**	**----**	**----**	<1	<1
Chromium	7440-47-3	2	mg/kg	**----**	**----**	**----**	<2	<2
Cobalt	7440-48-4	2	mg/kg	**----**	**----**	**----**	**5**	<2
Copper	7440-50-8	5	mg/kg	**----**	**----**	**----**	<5	<5
Lead	7439-92-1	5	mg/kg	**----**	**----**	**----**	<5	<5
Manganese	7439-96-5	5	mg/kg	**----**	**----**	**----**	**75**	<5
Nickel	7440-02-0	2	mg/kg	**----**	**----**	**----**	<2	<2
Silver	7440-22-4	2	mg/kg	**----**	**----**	**----**	<2	<2
Zinc	7440-66-6	5	mg/kg	**----**	**----**	**----**	**5**	<5
EG035-SDH: 1M HCl extractable Mercury by FIMS								
Mercury	7439-97-6	0.10	mg/kg	**----**	**----**	**----**	<0.10	<0.10
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	**----**	**----**	**----**	<0.1	<0.1
EK055: Ammonia as N								
Ammonia as N	7664-41-7	20	mg/kg	<20	<20	<20	**----**	**----**
EK057G: Nitrite as N by Discrete Analyser								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	GEN	GRO	GAP	GEN <2000um	GRO <2000um
				Sampling date / time	04-May-2021 08:30	04-May-2021 11:00	04-May-2021 13:30	04-May-2021 08:30	04-May-2021 11:00
Compound	CAS Number	LOR	Unit		ES2116691-001	ES2116691-002	ES2116691-003	ES2116691-004	ES2116691-005
					Result	Result	Result	Result	Result
EK057G: Nitrite as N by Discrete Analyser - Continued									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg		<0.1	<0.1	<0.1	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg		**0.5**	**0.2**	**0.1**	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		**0.5**	**0.2**	**0.1**	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		**620**	**150**	**100**	----	----
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		**620**	**150**	**100**	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		**74**	**36**	**85**	----	----
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		**1.04**	**0.45**	**0.20**	----	----
GEO26: Sieving									
-2000µm	----	0.01	%		----	----	----	**92.4**	**89.8**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	GAP <2000um	----	----	----	----
				Sampling date / time	04-May-2021 13:30	----	----	----	----
Compound	CAS Number	LOR	Unit		ES2116691-006	--------	--------	--------	--------
					Result	----	----	----	----
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES									
Aluminium	7429-90-5	50	mg/kg		<50	----	----	----	----
Antimony	7440-36-0	1.0	mg/kg		<1.0	----	----	----	----
Arsenic	7440-38-2	1.0	mg/kg		<1.0	----	----	----	----
Cadmium	7440-43-9	0.1	mg/kg		<0.1	----	----	----	----
Cobalt	7440-48-4	0.5	mg/kg		<0.5	----	----	----	----
Chromium	7440-47-3	1.0	mg/kg		<1.0	----	----	----	----
Copper	7440-50-8	1.0	mg/kg		<1.0	----	----	----	----
Lead	7439-92-1	1.0	mg/kg		**1.8**	----	----	----	----
Manganese	7439-96-5	10	mg/kg		**15**	----	----	----	----
Nickel	7440-02-0	1.0	mg/kg		<1.0	----	----	----	----
Silver	7440-22-4	1.0	mg/kg		<1.0	----	----	----	----
Zinc	7440-66-6	1.0	mg/kg		<1.0	----	----	----	----
EG005(ED093)T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg		**420**	----	----	----	----
Antimony	7440-36-0	5	mg/kg		<5	----	----	----	----
Arsenic	7440-38-2	5	mg/kg		<5	----	----	----	----
Cadmium	7440-43-9	1	mg/kg		<1	----	----	----	----
Chromium	7440-47-3	2	mg/kg		<2	----	----	----	----
Cobalt	7440-48-4	2	mg/kg		<2	----	----	----	----
Copper	7440-50-8	5	mg/kg		<5	----	----	----	----
Lead	7439-92-1	5	mg/kg		<5	----	----	----	----
Manganese	7439-96-5	5	mg/kg		**30**	----	----	----	----
Nickel	7440-02-0	2	mg/kg		<2	----	----	----	----
Silver	7440-22-4	2	mg/kg		<2	----	----	----	----
Zinc	7440-66-6	5	mg/kg		<5	----	----	----	----
EG035-SDH: 1M HCl extractable Mercury by FIMS									
Mercury	7439-97-6	0.10	mg/kg		<0.10	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	----	----	----	----
GEO26: Sieving									
-2000µm	----	0.01	%		**90.0**	----	----	----	----

Inter-Laboratory Testing

Analysis conducted by ALS Brisbane, NATA accreditation no. 825, site no. 818 (Chemistry) 18958 (Biology).

(SOIL) EP003: Total Organic Carbon (TOC) in Soil

(SOIL) GEO26: Sieving

(SOIL) EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES

(SOIL) EG035-SDH: 1M HCl extractable Mercury by FIMS

(SOIL) EG035T: Total Recoverable Mercury by FIMS

(SOIL) EG005(ED093)T: Total Metals by ICP-AES

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES2116981**	Page	: 1 of 6
Amendment	: **1**		
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MS ZOE LAGERROTH	Contact	: Angus Harding
Address	: Level 3, GHD Tower, 24 Honeysuckle Drive Newcastle NSW 2300 Newcastle	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: 07 3859 7800	Telephone	: +61 2 8784 8555
Project	: 12545559	Date Samples Received	: 06-May-2021 14:00
Order number	: Airly Autumn 2021	Date Analysis Commenced	: 10-May-2021
C-O-C number	: ----	Issue Date	: 08-Jun-2021 14:25
Sampler	: Tegan Hopwood		
Site	:		
Quote number	: EN/005		
No. of samples received	: 6		
No. of samples analysed	: 6		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

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- Analytical Results

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Signatories

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Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

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^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Amendment (08/06/2021): This report has been amended and re-released to allow the reporting of additional analytical data, specifically method EG005-SDH: Mn, Co, Al and EG005T: Mn for samples DOG, TOR, and AIR (<2000um fractions).
- EG005T (Total Metals by ICP-AES): Sample (EB2113054_002) shows poor matrix spike recovery due to sample heterogeneity. Confirmed by visual inspection.
- EG035-SDH (1M HCl Extractable Mercury) Sample (ES2116686_004) shows poor matrix spike recovery due to
- EG005T (Total Recoverable Metals by ICP-AES): Sample (EB2113054_001) shows poor duplicate results due to matrix interference. Confirmed by re-extraction and re-analysis.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	DOG	TOR	AIR	DOG <2000um	TOR <2000um
			Sampling date / time	05-May-2021 08:30	05-May-2021 11:30	05-May-2021 13:30	05-May-2021 08:30	05-May-2021 11:30
Compound	CAS Number	LOR	Unit	ES2116981-001	ES2116981-002	ES2116981-003	ES2116981-004	ES2116981-005
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	29.8	22.0	38.0	----	----
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES								
Aluminium	7429-90-5	50	mg/kg	----	----	----	290	350
Antimony	7440-36-0	1.0	mg/kg	----	----	----	<1.0	<1.0
Arsenic	7440-38-2	1.0	mg/kg	----	----	----	<1.0	<1.0
Cadmium	7440-43-9	0.1	mg/kg	----	----	----	<0.1	<0.1
Cobalt	7440-48-4	0.5	mg/kg	----	----	----	1.9	1.3
Chromium	7440-47-3	1.0	mg/kg	----	----	----	<1.0	<1.0
Copper	7440-50-8	1.0	mg/kg	----	----	----	3.0	3.6
Lead	7439-92-1	1.0	mg/kg	----	----	----	5.0	4.6
Manganese	7439-96-5	10	mg/kg	----	----	----	98	98
Nickel	7440-02-0	1.0	mg/kg	----	----	----	2.4	2.8
Silver	7440-22-4	1.0	mg/kg	----	----	----	<1.0	<1.0
Zinc	7440-66-6	1.0	mg/kg	----	----	----	4.9	4.9
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	----	----	----	3560	3850
Antimony	7440-36-0	5	mg/kg	----	----	----	<5	<5
Arsenic	7440-38-2	5	mg/kg	----	----	----	6	6
Cadmium	7440-43-9	1	mg/kg	----	----	----	<1	<1
Chromium	7440-47-3	2	mg/kg	----	----	----	8	9
Cobalt	7440-48-4	2	mg/kg	----	----	----	4	3
Copper	7440-50-8	5	mg/kg	----	----	----	6	8
Lead	7439-92-1	5	mg/kg	----	----	----	8	8
Manganese	7439-96-5	5	mg/kg	----	----	----	156	164
Nickel	7440-02-0	2	mg/kg	----	----	----	8	14
Silver	7440-22-4	2	mg/kg	----	----	----	<2	<2
Zinc	7440-66-6	5	mg/kg	----	----	----	20	40
EG035-SDH: 1M HCl extractable Mercury by FIMS								
Mercury	7439-97-6	0.10	mg/kg	----	----	----	<0.10	<0.10
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	----	----	----	<0.1	<0.1
EK055: Ammonia as N								
Ammonia as N	7664-41-7	20	mg/kg	<20	<20	<20	----	----
EK057G: Nitrite as N by Discrete Analyser								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	DOG	TOR	AIR	DOG <2000um	TOR <2000um
			Sampling date / time	05-May-2021 08:30	05-May-2021 11:30	05-May-2021 13:30	05-May-2021 08:30	05-May-2021 11:30
Compound	CAS Number	LOR	Unit	ES2116981-001	ES2116981-002	ES2116981-003	ES2116981-004	ES2116981-005
				Result	Result	Result	Result	Result
EK057G: Nitrite as N by Discrete Analyser - Continued								
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg	<0.1	<0.1	<0.1	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg	<0.1	<0.1	**0.1**	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	<0.1	<0.1	**0.1**	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	**980**	**380**	**860**	----	----
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	**980**	**380**	**860**	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	**211**	**172**	**332**	----	----
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**1.47**	**0.37**	**1.00**	----	----
GEO26: Sieving								
-2000µm	----	0.01	%	----	----	----	**94.9**	**91.5**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	AIR <2000um	----	----	----	----
				Sampling date / time	05-May-2021 13:30	----	----	----	----
Compound	CAS Number	LOR	Unit		ES2116981-006	--------	--------	--------	--------
					Result	----	----	----	----
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES									
Aluminium	7429-90-5	50	mg/kg		**1600**	----	----	----	----
Antimony	7440-36-0	1.0	mg/kg		<1.0	----	----	----	----
Arsenic	7440-38-2	1.0	mg/kg		**1.2**	----	----	----	----
Cadmium	7440-43-9	0.1	mg/kg		<0.1	----	----	----	----
Cobalt	7440-48-4	0.5	mg/kg		**2.7**	----	----	----	----
Chromium	7440-47-3	1.0	mg/kg		**2.2**	----	----	----	----
Copper	7440-50-8	1.0	mg/kg		**8.5**	----	----	----	----
Lead	7439-92-1	1.0	mg/kg		**11.5**	----	----	----	----
Manganese	7439-96-5	10	mg/kg		**41**	----	----	----	----
Nickel	7440-02-0	1.0	mg/kg		**5.5**	----	----	----	----
Silver	7440-22-4	1.0	mg/kg		<1.0	----	----	----	----
Zinc	7440-66-6	1.0	mg/kg		**21.2**	----	----	----	----
EG005(ED093)T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg		**8580**	----	----	----	----
Antimony	7440-36-0	5	mg/kg		<5	----	----	----	----
Arsenic	7440-38-2	5	mg/kg		**9**	----	----	----	----
Cadmium	7440-43-9	1	mg/kg		<1	----	----	----	----
Chromium	7440-47-3	2	mg/kg		**14**	----	----	----	----
Cobalt	7440-48-4	2	mg/kg		**5**	----	----	----	----
Copper	7440-50-8	5	mg/kg		**14**	----	----	----	----
Lead	7439-92-1	5	mg/kg		**17**	----	----	----	----
Manganese	7439-96-5	5	mg/kg		**97**	----	----	----	----
Nickel	7440-02-0	2	mg/kg		**15**	----	----	----	----
Silver	7440-22-4	2	mg/kg		<2	----	----	----	----
Zinc	7440-66-6	5	mg/kg		**58**	----	----	----	----
EG035-SDH: 1M HCl extractable Mercury by FIMS									
Mercury	7439-97-6	0.10	mg/kg		<0.10	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	----	----	----	----
GEO26: Sieving									
-2000µm	----	0.01	%		**90.6**	----	----	----	----

Inter-Laboratory Testing

Analysis conducted by ALS Brisbane, NATA accreditation no. 825, site no. 818 (Chemistry) 18958 (Biology).

(SOIL) EP003: Total Organic Carbon (TOC) in Soil

(SOIL) GEO26: Sieving

(SOIL) EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES

(SOIL) EG035-SDH: 1M HCl extractable Mercury by FIMS

(SOIL) EG035T: Total Recoverable Mercury by FIMS

(SOIL) EG005(ED093)T: Total Metals by ICP-AES

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES2116686**	Page	: 1 of 4
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MS ZOE LAGERROTH	Contact	: Angus Harding
Address	: Level 3, GHD Tower, 24 Honeysuckle Drive Newcastle NSW 2300 Newcastle	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: 07 3859 7800	Telephone	: +61 2 8784 8555
Project	: 12545559 Airly Autumn 2021	Date Samples Received	: 05-May-2021 12:30
Order number	: 12545559	Date Analysis Commenced	: 07-May-2021
C-O-C number	: ----	Issue Date	: 21-May-2021 17:44
Sampler	: Tegan Hopwood		
Site	:		
Quote number	: EN/005		
No. of samples received	: 4		
No. of samples analysed	: 4		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- It is recognised that EG005T (Total Metals by ICP-AES) is less than EG005-SDH (1m HCl Extractable Metals) for AIRUS (ES2116686_003) and AIRD(ES2116686_004). However, the difference is within experimental variation of the methods.
- EG005T (Total Metals by ICP-AES): Sample (EB2113054_002) shows poor matrix spike recovery due to sample heterogeneity. Confirmed by visual inspection.
- EG035-SDH (1M HCl Extractable Mercury) Sample AIRD (ES2116686_004) shows poor matrix spike recovery due to sample heterogeneity. Confirmed by re-extraction and re-analysis.
- EG005T (Total Recoverable Metals by ICP-AES): Sample (EB2113054_001) shows poor duplicate results due to matrix interference. Confirmed by re-extraction and re-analysis.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	AIRUS	AIRD	AIRUS <2000um	AIRD <2000um	----
			Sampling date / time	03-May-2021 14:00	03-May-2021 15:00	03-May-2021 14:00	03-May-2021 15:00	----
Compound	CAS Number	LOR	Unit	ES2116686-001	ES2116686-002	ES2116686-003	ES2116686-004	--------
				Result	Result	Result	Result	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	44.9	49.6	----	----	----
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES								
Aluminium	7429-90-5	50	mg/kg	----	----	440	490	----
Antimony	7440-36-0	1.0	mg/kg	----	----	<1.0	<1.0	----
Arsenic	7440-38-2	1.0	mg/kg	----	----	1.4	1.8	----
Cadmium	7440-43-9	0.1	mg/kg	----	----	0.1	0.1	----
Cobalt	7440-48-4	0.5	mg/kg	----	----	2.2	2.4	----
Chromium	7440-47-3	1.0	mg/kg	----	----	<1.0	<1.0	----
Copper	7440-50-8	1.0	mg/kg	----	----	3.4	3.8	----
Lead	7439-92-1	1.0	mg/kg	----	----	4.5	4.6	----
Manganese	7439-96-5	10	mg/kg	----	----	74	72	----
Nickel	7440-02-0	1.0	mg/kg	----	----	5.4	6.0	----
Silver	7440-22-4	1.0	mg/kg	----	----	<1.0	<1.0	----
Zinc	7440-66-6	1.0	mg/kg	----	----	12.5	14.7	----
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	----	----	2610	1540	----
Antimony	7440-36-0	5	mg/kg	----	----	<5	<5	----
Arsenic	7440-38-2	5	mg/kg	----	----	<5	<5	----
Cadmium	7440-43-9	1	mg/kg	----	----	<1	<1	----
Chromium	7440-47-3	2	mg/kg	----	----	6	3	----
Cobalt	7440-48-4	2	mg/kg	----	----	3	2	----
Copper	7440-50-8	5	mg/kg	----	----	5	<5	----
Lead	7439-92-1	5	mg/kg	----	----	6	<5	----
Manganese	7439-96-5	5	mg/kg	----	----	71	50	----
Nickel	7440-02-0	2	mg/kg	----	----	8	6	----
Silver	7440-22-4	2	mg/kg	----	----	<2	<2	----
Zinc	7440-66-6	5	mg/kg	----	----	22	15	----
EG035-SDH: 1M HCl extractable Mercury by FIMS								
Mercury	7439-97-6	0.10	mg/kg	----	----	<0.10	<0.10	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	----	----	<0.1	<0.1	----
EK055: Ammonia as N								
Ammonia as N	7664-41-7	20	mg/kg	<20	<20	----	----	----
EK057G: Nitrite as N by Discrete Analyser								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	AIRUS	AIRD	AIRUS <2000um	AIRD <2000um	----
				Sampling date / time	03-May-2021 14:00	03-May-2021 15:00	03-May-2021 14:00	03-May-2021 15:00	----
Compound	CAS Number	LOR	Unit		ES2116686-001	ES2116686-002	ES2116686-003	ES2116686-004	--------
					Result	Result	Result	Result	----
EK057G: Nitrite as N by Discrete Analyser - Continued									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg		<0.1	<0.1	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg		**0.6**	<0.1	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		**0.6**	<0.1	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		**2970**	**3030**	----	----	----
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		**2970**	**3030**	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		**446**	**483**	----	----	----
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		**3.66**	**3.93**	----	----	----
GEO26: Sieving									
-2000µm	----	0.01	%		----	----	**57.6**	**56.4**	----

Inter-Laboratory Testing

Analysis conducted by ALS Brisbane, NATA accreditation no. 825, site no. 818 (Chemistry) 18958 (Biology).

(SOIL) EP003: Total Organic Carbon (TOC) in Soil

(SOIL) GEO26: Sieving

(SOIL) EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES

(SOIL) EG035-SDH: 1M HCl extractable Mercury by FIMS

(SOIL) EG035T: Total Recoverable Mercury by FIMS

(SOIL) EG005(ED093)T: Total Metals by ICP-AES

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES2139648**	Page	: 1 of 5
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MS Tegan Hopwood	Contact	: Sarah Mathew
Address	: Level 3, GHD Tower, 24 Honeysuckle Drive Newcastle 2300	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: 02 4910 7760	Telephone	: +61-2-8784 8555
Project	: 12545559	Date Samples Received	: 03-Nov-2021 09:30
Order number	: Airly Spring 2021	Date Analysis Commenced	: 03-Nov-2021
C-O-C number	: ----	Issue Date	: 10-Nov-2021 10:28
Sampler	: Tegan Hopwood		
Site	:		
Quote number	: EN/005		
No. of samples received	: 2		
No. of samples analysed	: 2		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

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Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW

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LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EG020: It is recognised that total concentration is less than dissolved for some metal analytes. However, the difference is within experimental variation of the methods.
- EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	GEN	GRO	----	----	----
			Sampling date / time	02-Nov-2021 11:00	02-Nov-2021 14:30	----	----	----
Compound	CAS Number	LOR	Unit	ES2139648-001	ES2139648-002	--------	--------	--------
				Result	Result	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**6.25**	**5.51**	----	----	----
EA006: Sodium Adsorption Ratio (SAR)								
^ Sodium Adsorption Ratio	----	0.01	-	**1.13**	**1.20**	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**48**	**34**	----	----	----
EA016: Calculated TDS (from Electrical Conductivity)								
Total Dissolved Solids (Calc.)	----	1	mg/L	**31**	**22**	----	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	<5	----	----	----
EA045: Turbidity								
Turbidity	----	0.1	NTU	**0.8**	**0.5**	----	----	----
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**4**	<1	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**8**	**3**	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**8**	**3**	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**2**	**2**	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**10**	**8**	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	<1	<1	----	----	----
Magnesium	7439-95-4	1	mg/L	**1**	<1	----	----	----
Sodium	7440-23-5	1	mg/L	**6**	**5**	----	----	----
Potassium	7440-09-7	1	mg/L	**1**	<1	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.02**	**0.19**	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.004**	**0.005**	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	GEN	GRO	----	----	----
				Sampling date / time	02-Nov-2021 11:00	02-Nov-2021 14:30	----	----	----
Compound	CAS Number	LOR	Unit		ES2139648-001	ES2139648-002	--------	--------	--------
					Result	Result	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Nickel	7440-02-0	0.001	mg/L		**0.001**	<0.001	----	----	----
Boron	7440-42-8	0.05	mg/L		<0.05	<0.05	----	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	**0.06**	----	----	----
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.05**	**0.24**	----	----	----
Cobalt	7440-48-4	0.001	mg/L		<0.001	**0.001**	----	----	----
Copper	7440-50-8	0.001	mg/L		<0.001	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L		**0.004**	**0.006**	----	----	----
Nickel	7440-02-0	0.001	mg/L		<0.001	<0.001	----	----	----
Boron	7440-42-8	0.05	mg/L		<0.05	<0.05	----	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	**0.16**	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.00004	mg/L		<0.00004	<0.00004	----	----	----
EG035T: Total Mercury by FIMS									
Mercury	7439-97-6	0.00004	mg/L		<0.00004	<0.00004	----	----	----
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS									
Arsenic	7440-38-2	0.2	µg/L		<0.2	<0.2	----	----	----
Cadmium	7440-43-9	0.05	µg/L		<0.05	<0.05	----	----	----
Chromium	7440-47-3	0.2	µg/L		<0.2	**0.7**	----	----	----
Selenium	7782-49-2	0.2	µg/L		<0.2	<0.2	----	----	----
Silver	7440-22-4	0.1	µg/L		<0.1	<0.1	----	----	----
Zinc	7440-66-6	1	µg/L		**7**	**3**	----	----	----
EG094T: Total metals in Fresh water by ORC-ICPMS									
Arsenic	7440-38-2	0.2	µg/L		<0.2	<0.2	----	----	----
Cadmium	7440-43-9	0.05	µg/L		<0.05	<0.05	----	----	----
Chromium	7440-47-3	0.2	µg/L		**0.2**	**0.9**	----	----	----
Selenium	7782-49-2	0.2	µg/L		<0.2	<0.2	----	----	----
Silver	7440-22-4	0.1	µg/L		<0.1	<0.1	----	----	----
Zinc	7440-66-6	1	µg/L		**8**	**3**	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		<0.1	<0.1	----	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		<0.01	<0.01	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	GEN	GRO	----	----	----
				Sampling date / time	02-Nov-2021 11:00	02-Nov-2021 14:30	----	----	----
Compound	CAS Number	LOR	Unit		ES2139648-001	ES2139648-002	--------	--------	--------
					Result	Result	----	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		**0.06**	<0.01	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**0.06**	<0.01	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		<0.1	**0.1**	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		<0.1	**0.1**	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		<0.01	<0.01	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	<0.01	----	----	----
EN055: Ionic Balance									
ø Total Anions	----	0.01	meq/L		**0.48**	**0.33**	----	----	----
ø Total Cations	----	0.01	meq/L		**0.37**	**0.22**	----	----	----
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		**2**	**5**	----	----	----
EP020: Oil and Grease (O&G)									
Oil & Grease	----	5	mg/L		<5	<5	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES2139824**	Page	: 1 of 5
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MS Tegan Hopwood	Contact	: Sarah Mathew
Address	: Level 3, GHD Tower, 24 Honeysuckle Drive Newcastle 2300	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: 02 4910 7760	Telephone	: +61-2-8784 8555
Project	: 12545559	Date Samples Received	: 04-Nov-2021 10:00
Order number	: Airly spring 2021	Date Analysis Commenced	: 04-Nov-2021
C-O-C number	: ----	Issue Date	: 11-Nov-2021 16:29
Sampler	: Tegan Hopwood		
Site	:		
Quote number	: EN/005		
No. of samples received	: 2		
No. of samples analysed	: 2		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EG020: It is recognised that total concentration is less than dissolved for some metal analytes. However, the difference is within experimental variation of the methods.
- EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	GAP	AIR	----	----	----
			Sampling date / time	03-Nov-2021 11:30	03-Nov-2021 14:30	----	----	----
Compound	CAS Number	LOR	Unit	ES2139824-001	ES2139824-002	--------	--------	--------
				Result	Result	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**6.99**	**8.01**	----	----	----
EA006: Sodium Adsorption Ratio (SAR)								
^ Sodium Adsorption Ratio	----	0.01	-	**0.85**	**0.88**	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**144**	**2540**	----	----	----
EA016: Calculated TDS (from Electrical Conductivity)								
Total Dissolved Solids (Calc.)	----	1	mg/L	**94**	**1650**	----	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	**22**	----	----	----
EA045: Turbidity								
Turbidity	----	0.1	NTU	**9.2**	**1.8**	----	----	----
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**38**	**1450**	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**25**	**156**	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**25**	**156**	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**5**	**1480**	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**28**	**66**	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**7**	**244**	----	----	----
Magnesium	7439-95-4	1	mg/L	**5**	**204**	----	----	----
Sodium	7440-23-5	1	mg/L	**12**	**77**	----	----	----
Potassium	7440-09-7	1	mg/L	**2**	**4**	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.02**	<0.01	----	----	----
Cobalt	7440-48-4	0.001	mg/L	**0.001**	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.092**	**0.025**	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	GAP	AIR	----	----	----
				Sampling date / time	03-Nov-2021 11:30	03-Nov-2021 14:30	----	----	----
Compound	CAS Number	LOR	Unit		ES2139824-001	ES2139824-002	--------	--------	--------
					Result	Result	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Nickel	7440-02-0	0.001	mg/L		**0.001**	**0.004**	----	----	----
Boron	7440-42-8	0.05	mg/L		<0.05	<0.05	----	----	----
Iron	7439-89-6	0.05	mg/L		**0.06**	<0.05	----	----	----
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.36**	**0.03**	----	----	----
Cobalt	7440-48-4	0.001	mg/L		**0.001**	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L		<0.001	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L		**0.089**	**0.059**	----	----	----
Nickel	7440-02-0	0.001	mg/L		**0.002**	**0.004**	----	----	----
Boron	7440-42-8	0.05	mg/L		<0.05	<0.05	----	----	----
Iron	7439-89-6	0.05	mg/L		**0.44**	**0.15**	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.00004	mg/L		<0.00004	<0.00004	----	----	----
EG035T: Total Mercury by FIMS									
Mercury	7439-97-6	0.00004	mg/L		<0.00004	<0.00004	----	----	----
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS									
Arsenic	7440-38-2	0.2	µg/L		**0.2**	**0.3**	----	----	----
Cadmium	7440-43-9	0.05	µg/L		<0.05	<0.05	----	----	----
Chromium	7440-47-3	0.2	µg/L		<0.2	<0.2	----	----	----
Selenium	7782-49-2	0.2	µg/L		<0.2	<0.2	----	----	----
Silver	7440-22-4	0.1	µg/L		<0.1	<0.1	----	----	----
Zinc	7440-66-6	1	µg/L		**4**	**4**	----	----	----
EG094T: Total metals in Fresh water by ORC-ICPMS									
Arsenic	7440-38-2	0.2	µg/L		**0.4**	**0.4**	----	----	----
Cadmium	7440-43-9	0.05	µg/L		<0.05	<0.05	----	----	----
Chromium	7440-47-3	0.2	µg/L		**0.4**	<0.2	----	----	----
Selenium	7782-49-2	0.2	µg/L		<0.2	<0.2	----	----	----
Silver	7440-22-4	0.1	µg/L		<0.1	<0.1	----	----	----
Zinc	7440-66-6	1	µg/L		**4**	**4**	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		<0.1	**0.2**	----	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**0.03**	<0.01	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	GAP	AIR	----	----	----
				Sampling date / time	03-Nov-2021 11:30	03-Nov-2021 14:30	----	----	----
Compound	CAS Number	LOR	Unit		ES2139824-001	ES2139824-002	--------	--------	--------
					Result	Result	----	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		<0.01	<0.01	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		<0.01	<0.01	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		0.2	0.4	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		0.2	0.4	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		0.02	0.02	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	<0.01	----	----	----
EN055: Ionic Balance									
ø Total Anions	----	0.01	meq/L		1.39	35.8	----	----	----
ø Total Cations	----	0.01	meq/L		1.33	32.4	----	----	----
ø Ionic Balance	----	0.01	%		----	4.95	----	----	----
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		4	8	----	----	----
EP020: Oil and Grease (O&G)									
Oil & Grease	----	5	mg/L		285	7	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES2140006**	Page	: 1 of 5
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MS Tegan Hopwood	Contact	: Sarah Mathew
Address	: Level 3, GHD Tower, 24 Honeysuckle Drive Newcastle 2300	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: 02 4910 7760	Telephone	: +61-2-8784 8555
Project	: 12545559	Date Samples Received	: 05-Nov-2021 09:25
Order number	: Airly spring 2021	Date Analysis Commenced	: 05-Nov-2021
C-O-C number	: ----	Issue Date	: 12-Nov-2021 11:06
Sampler	: Tegan Hopwood		
Site	:		
Quote number	: EN/005		
No. of samples received	: 4		
No. of samples analysed	: 4		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

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- Analytical Results

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Signatories

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Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW

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Where moisture determination has been performed, results are reported on a dry weight basis.

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Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

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^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EG020/EG094: It is recognised that total concentration is less than dissolved for some metal analytes. However, the difference is within experimental variation of the methods.
- EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	TOR	DOG	AIRDS	AIRUS	----
			Sampling date / time	04-Nov-2021 08:30	04-Nov-2021 11:00	04-Nov-2021 11:30	04-Nov-2021 13:30	----
Compound	CAS Number	LOR	Unit	ES2140006-001	ES2140006-002	ES2140006-003	ES2140006-004	--------
				Result	Result	Result	Result	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.91**	**8.13**	**8.14**	**8.13**	----
EA006: Sodium Adsorption Ratio (SAR)								
^ Sodium Adsorption Ratio	----	0.01	-	**0.91**	**0.94**	**0.98**	**0.85**	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**3060**	**1510**	**1450**	**2360**	----
EA016: Calculated TDS (from Electrical Conductivity)								
Total Dissolved Solids (Calc.)	----	1	mg/L	**1990**	**982**	**942**	**1530**	----
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	**6**	**18**	**9**	**10**	----
EA045: Turbidity								
Turbidity	----	0.1	NTU	**1.4**	**3.5**	**2.2**	**1.6**	----
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**1820**	**721**	**775**	**1480**	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**201**	**477**	**476**	**166**	----
Total Alkalinity as CaCO3	----	1	mg/L	**201**	**477**	**476**	**166**	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**1750**	**445**	**445**	**1220**	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**73**	**43**	**43**	**58**	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**295**	**157**	**162**	**218**	----
Magnesium	7439-95-4	1	mg/L	**262**	**80**	**90**	**227**	----
Sodium	7440-23-5	1	mg/L	**89**	**58**	**63**	**75**	----
Potassium	7440-09-7	1	mg/L	**7**	**2**	**1**	**3**	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	----
Copper	7440-50-8	0.001	mg/L	**0.002**	<0.001	<0.001	<0.001	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	----
Manganese	7439-96-5	0.001	mg/L	**0.260**	**0.053**	**0.058**	**0.044**	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	TOR	DOG	AIRDS	AIRUS	----
				Sampling date / time	04-Nov-2021 08:30	04-Nov-2021 11:00	04-Nov-2021 11:30	04-Nov-2021 13:30	----
Compound	CAS Number	LOR	Unit		ES2140006-001	ES2140006-002	ES2140006-003	ES2140006-004	--------
					Result	Result	Result	Result	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Nickel	7440-02-0	0.001	mg/L		**0.008**	<0.001	<0.001	**0.004**	----
Boron	7440-42-8	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	----
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	----
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.02**	**0.05**	**0.04**	**0.02**	----
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Copper	7440-50-8	0.001	mg/L		<0.001	<0.001	<0.001	**0.003**	----
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Manganese	7439-96-5	0.001	mg/L		**0.369**	**0.084**	**0.079**	**0.057**	----
Nickel	7440-02-0	0.001	mg/L		**0.010**	**0.001**	<0.001	**0.003**	----
Boron	7440-42-8	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	----
Iron	7439-89-6	0.05	mg/L		**0.18**	**0.10**	**0.15**	**0.18**	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.00004	mg/L		<0.00004	<0.00004	<0.00004	<0.00004	----
EG035T: Total Mercury by FIMS									
Mercury	7439-97-6	0.00004	mg/L		<0.00004	<0.00004	<0.00004	<0.00004	----
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS									
Arsenic	7440-38-2	0.2	µg/L		**0.5**	**0.5**	**0.5**	**0.5**	----
Cadmium	7440-43-9	0.05	µg/L		<0.05	<0.05	<0.05	<0.05	----
Chromium	7440-47-3	0.2	µg/L		**0.2**	<0.2	<0.2	**0.2**	----
Selenium	7782-49-2	0.2	µg/L		<0.2	<0.2	<0.2	<0.2	----
Silver	7440-22-4	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	----
Zinc	7440-66-6	1	µg/L		**6**	**4**	**4**	**3**	----
EG094T: Total metals in Fresh water by ORC-ICPMS									
Arsenic	7440-38-2	0.2	µg/L		**0.4**	**0.8**	**0.5**	**0.5**	----
Cadmium	7440-43-9	0.05	µg/L		<0.05	<0.05	<0.05	<0.05	----
Chromium	7440-47-3	0.2	µg/L		<0.2	<0.2	<0.2	<0.2	----
Selenium	7782-49-2	0.2	µg/L		**0.2**	<0.2	<0.2	<0.2	----
Silver	7440-22-4	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	----
Zinc	7440-66-6	1	µg/L		**3**	**4**	**5**	**3**	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.3**	**0.2**	<0.1	**0.2**	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**0.01**	**0.01**	<0.01	**0.01**	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	TOR	DOG	AIRDS	AIRUS	----
				Sampling date / time	04-Nov-2021 08:30	04-Nov-2021 11:00	04-Nov-2021 11:30	04-Nov-2021 13:30	----
Compound	CAS Number	LOR	Unit		ES2140006-001	ES2140006-002	ES2140006-003	ES2140006-004	--------
					Result	Result	Result	Result	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		**0.02**	**0.02**	**0.02**	**0.03**	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**0.02**	**0.02**	**0.02**	**0.03**	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**0.3**	**0.1**	**0.1**	**0.6**	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		**0.3**	**0.1**	**0.1**	**0.6**	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		<0.01	<0.01	**0.02**	**0.02**	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
EN055: Ionic Balance									
ø Total Anions	----	0.01	meq/L		**42.5**	**20.0**	**20.0**	**30.4**	----
ø Total Cations	----	0.01	meq/L		**40.3**	**17.0**	**18.2**	**32.9**	----
ø Ionic Balance	----	0.01	%		**2.63**	**8.15**	**4.53**	**4.03**	----
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		**10**	**4**	**4**	**10**	----
EP020: Oil and Grease (O&G)									
Oil & Grease	----	5	mg/L		<5	<5	**8**	<5	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES2139649**	Page	: 1 of 4
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MS Tegan Hopwood	Contact	: Sarah Mathew
Address	: Level 3, GHD Tower, 24 Honeysuckle Drive Newcastle 2300	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: 02 4910 7760	Telephone	: +61-2-8784 8555
Project	: 12545559	Date Samples Received	: 03-Nov-2021 09:30
Order number	: Airly Spring 2021	Date Analysis Commenced	: 08-Nov-2021
C-O-C number	: ----	Issue Date	: 19-Nov-2021 18:49
Sampler	: Tegan Hopwood		
Site	:		
Quote number	: EN/005		
No. of samples received	: 4		
No. of samples analysed	: 4		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

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This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Wisam Marassa	Inorganics Coordinator	Sydney Inorganics, Smithfield, NSW

General Comments

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Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EG005T (Total Metals by ICP-AES): EB2132350_021 shows poor duplicate results due to sample heterogeneity. This has been confirmed by visual inspection.
- EG005T (Total Metals by ICP-AES): Sample Name (EB2132428_019) shows poor duplicate results due to sample heterogeneity. This has been confirmed by visual inspection.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	GEN	GRO	GEN -2000um	GRO -2000um	----
			Sampling date / time	02-Nov-2021 11:00	02-Nov-2021 14:30	02-Nov-2021 11:00	02-Nov-2021 14:30	----
Compound	CAS Number	LOR	Unit	ES2139649-001	ES2139649-002	ES2139649-003	ES2139649-004	--------
				Result	Result	Result	Result	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	21.9	21.6	----	----	----
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES								
Aluminium	7429-90-5	50	mg/kg	----	----	210	620	----
Antimony	7440-36-0	1.0	mg/kg	----	----	<1.0	<1.0	----
Arsenic	7440-38-2	1.0	mg/kg	----	----	<1.0	<1.0	----
Cadmium	7440-43-9	0.1	mg/kg	----	----	<0.1	<0.1	----
Cobalt	7440-48-4	0.5	mg/kg	----	----	1.2	<0.5	----
Chromium	7440-47-3	1.0	mg/kg	----	----	<1.0	<1.0	----
Copper	7440-50-8	1.0	mg/kg	----	----	<1.0	<1.0	----
Lead	7439-92-1	1.0	mg/kg	----	----	<1.0	<1.0	----
Manganese	7439-96-5	10	mg/kg	----	----	27	<10	----
Nickel	7440-02-0	1.0	mg/kg	----	----	<1.0	<1.0	----
Silver	7440-22-4	1.0	mg/kg	----	----	<1.0	<1.0	----
Zinc	7440-66-6	1.0	mg/kg	----	----	1.4	<1.0	----
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	----	----	750	750	----
Antimony	7440-36-0	5	mg/kg	----	----	<5	<5	----
Arsenic	7440-38-2	5	mg/kg	----	----	<5	<5	----
Cadmium	7440-43-9	1	mg/kg	----	----	<1	<1	----
Chromium	7440-47-3	2	mg/kg	----	----	<2	<2	----
Cobalt	7440-48-4	2	mg/kg	----	----	2	<2	----
Copper	7440-50-8	5	mg/kg	----	----	<5	<5	----
Lead	7439-92-1	5	mg/kg	----	----	<5	<5	----
Manganese	7439-96-5	5	mg/kg	----	----	58	12	----
Nickel	7440-02-0	2	mg/kg	----	----	<2	<2	----
Silver	7440-22-4	2	mg/kg	----	----	<2	<2	----
Zinc	7440-66-6	5	mg/kg	----	----	<5	<5	----
EG035-SDH: 1M HCl extractable Mercury by FIMS								
Mercury	7439-97-6	0.10	mg/kg	----	----	<0.10	<0.10	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	----	----	<0.1	<0.1	----
EK055: Ammonia as N								
Ammonia as N	7664-41-7	20	mg/kg	<20	<20	----	----	----
EK057G: Nitrite as N by Discrete Analyser								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	GEN	GRO	GEN -2000um	GRO -2000um	----
				Sampling date / time	02-Nov-2021 11:00	02-Nov-2021 14:30	02-Nov-2021 11:00	02-Nov-2021 14:30	----
Compound	CAS Number	LOR	Unit		ES2139649-001	ES2139649-002	ES2139649-003	ES2139649-004	--------
					Result	Result	Result	Result	----
EK057G: Nitrite as N by Discrete Analyser - Continued									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg		<0.1	<0.1	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg		**0.1**	<0.1	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		**0.1**	<0.1	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		**50**	**490**	----	----	----
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		**50**	**490**	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		**36**	**42**	----	----	----
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		**0.23**	**1.48**	----	----	----
GEO26: Sieving									
-2000µm	----	0.01	%		----	----	**87.4**	**90.9**	----

Inter-Laboratory Testing

Analysis conducted by ALS Brisbane, NATA accreditation no. 825, site no. 818 (Chemistry) 18958 (Biology).

(SOIL) EG005(ED093)T: Total Metals by ICP-AES

(SOIL) EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES

(SOIL) EG035-SDH: 1M HCl extractable Mercury by FIMS

(SOIL) GEO26: Sieving

(SOIL) EG035T: Total Recoverable Mercury by FIMS

(SOIL) EP003: Total Organic Carbon (TOC) in Soil

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES2139823**	Page	: 1 of 4
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MS Tegan Hopwood	Contact	: Sarah Mathew
Address	: Level 3, GHD Tower, 24 Honeysuckle Drive Newcastle 2300	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: 02 4910 7760	Telephone	: +61-2-8784 8555
Project	: 12545559	Date Samples Received	: 04-Nov-2021 10:00
Order number	: Airly Spring 2021	Date Analysis Commenced	: 08-Nov-2021
C-O-C number	: ----	Issue Date	: 22-Nov-2021 09:10
Sampler	: Tegan Hopwood		
Site	:		
Quote number	: EN/005		
No. of samples received	: 4		
No. of samples analysed	: 4		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

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Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Vincent Muller		Brisbane Inorganics, Stafford, QLD
Wisam Marassa	Inorganics Coordinator	Sydney Inorganics, Smithfield, NSW

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LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EG005T-Total Metals by ICP-AES: Sample EB2131230-064 shows poor matrix spike recovery due to sample heterogeneity. Confirmed by visual inspection.
- EG005-SDH-1M HCl Extractable Metals by ICP-AES: Sample 'AIR' (ES2139823-004) shows poor matrix spike recovery due to sample heterogeneity. Confirmed by re-extraction and re-analysis.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	GAP	AIR	GAP -2000um	AIR -2000um	----
				Sampling date / time	03-Nov-2021 11:30	03-Nov-2021 14:30	03-Nov-2021 11:30	03-Nov-2021 14:30	----
Compound	CAS Number	LOR	Unit		ES2139823-001	ES2139823-002	ES2139823-003	ES2139823-004	--------
					Result	Result	Result	Result	----
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%		**20.4**	**32.8**	----	----	----
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES									
Aluminium	7429-90-5	50	mg/kg		----	----	**120**	**540**	----
Antimony	7440-36-0	1.0	mg/kg		----	----	<1.0	<1.0	----
Arsenic	7440-38-2	1.0	mg/kg		----	----	<1.0	<1.0	----
Cadmium	7440-43-9	0.1	mg/kg		----	----	<0.1	<0.1	----
Cobalt	7440-48-4	0.5	mg/kg		----	----	**1.3**	**3.5**	----
Chromium	7440-47-3	1.0	mg/kg		----	----	<1.0	<1.0	----
Copper	7440-50-8	1.0	mg/kg		----	----	<1.0	**5.8**	----
Lead	7439-92-1	1.0	mg/kg		----	----	**1.7**	**8.4**	----
Manganese	7439-96-5	10	mg/kg		----	----	**85**	**276**	----
Nickel	7440-02-0	1.0	mg/kg		----	----	<1.0	**7.7**	----
Silver	7440-22-4	1.0	mg/kg		----	----	<1.0	<1.0	----
Zinc	7440-66-6	1.0	mg/kg		----	----	**2.1**	**22.3**	----
EG005(ED093)T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg		----	----	**440**	**3350**	----
Antimony	7440-36-0	5	mg/kg		----	----	<5	<5	----
Arsenic	7440-38-2	5	mg/kg		----	----	<5	**6**	----
Cadmium	7440-43-9	1	mg/kg		----	----	<1	<1	----
Chromium	7440-47-3	2	mg/kg		----	----	**2**	**11**	----
Cobalt	7440-48-4	2	mg/kg		----	----	<2	**5**	----
Copper	7440-50-8	5	mg/kg		----	----	<5	**12**	----
Lead	7439-92-1	5	mg/kg		----	----	<5	**13**	----
Manganese	7439-96-5	5	mg/kg		----	----	**140**	**303**	----
Nickel	7440-02-0	2	mg/kg		----	----	<2	**16**	----
Silver	7440-22-4	2	mg/kg		----	----	<2	<2	----
Zinc	7440-66-6	5	mg/kg		----	----	**6**	**56**	----
EG035-SDH: 1M HCl extractable Mercury by FIMS									
Mercury	7439-97-6	0.10	mg/kg		----	----	<0.10	<0.10	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		----	----	<0.1	<0.1	----
EK055: Ammonia as N									
Ammonia as N	7664-41-7	20	mg/kg		<20	<20	----	----	----
EK057G: Nitrite as N by Discrete Analyser									

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	GAP	AIR	GAP -2000um	AIR -2000um	----
				Sampling date / time	03-Nov-2021 11:30	03-Nov-2021 14:30	03-Nov-2021 11:30	03-Nov-2021 14:30	----
Compound	CAS Number	LOR	Unit		ES2139823-001	ES2139823-002	ES2139823-003	ES2139823-004	--------
					Result	Result	Result	Result	----
EK057G: Nitrite as N by Discrete Analyser - Continued									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg		<0.1	<0.1	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg		**0.1**	**0.2**	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		**0.1**	**0.2**	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		**70**	**920**	----	----	----
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		**70**	**920**	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		**39**	**232**	----	----	----
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		**0.31**	**0.74**	----	----	----
GEO26: Sieving									
-2000µm	----	0.01	%		----	----	**77.2**	**38.4**	----

Inter-Laboratory Testing

Analysis conducted by ALS Brisbane, NATA accreditation no. 825, site no. 818 (Chemistry) 18958 (Biology).

(SOIL) EP003: Total Organic Carbon (TOC) in Soil

(SOIL) GEO26: Sieving

(SOIL) EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES

(SOIL) EG035-SDH: 1M HCl extractable Mercury by FIMS

(SOIL) EG035T: Total Recoverable Mercury by FIMS

(SOIL) EG005(ED093)T: Total Metals by ICP-AES

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES2140009**	Page	: 1 of 6
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MS Tegan Hopwood	Contact	: Sarah Mathew
Address	: Level 3, GHD Tower, 24 Honeysuckle Drive Newcastle 2300	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: 02 4910 7760	Telephone	: +61-2-8784 8555
Project	: 12545559	Date Samples Received	: 05-Nov-2021 09:25
Order number	: Airly spring 2021	Date Analysis Commenced	: 09-Nov-2021
C-O-C number	: ----	Issue Date	: 23-Nov-2021 13:28
Sampler	: Tegan Hopwood		
Site	:		
Quote number	: EN/005		
No. of samples received	: 7		
No. of samples analysed	: 6		

Accreditation No. 825
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Signatories	*Position*	*Accreditation Category*
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Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

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LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EG005T-Total Metals by ICP-AES: High LCS recovery deemed acceptable as all associated analyte results are less than LOR.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	TOR	DOG	AIRUS	TOR <2000um	DOG <2000um
			Sampling date / time	04-Nov-2021 08:30	04-Nov-2021 11:00	04-Nov-2021 13:30	04-Nov-2021 08:30	04-Nov-2021 11:00
Compound	CAS Number	LOR	Unit	ES2140009-001	ES2140009-002	ES2140009-004	ES2140009-005	ES2140009-006
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	33.6	35.5	43.2	----	----
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES								
Aluminium	7429-90-5	50	mg/kg	----	----	----	340	320
Antimony	7440-36-0	1.0	mg/kg	----	----	----	<1.0	<1.0
Arsenic	7440-38-2	1.0	mg/kg	----	----	----	<1.0	<1.0
Cadmium	7440-43-9	0.1	mg/kg	----	----	----	<0.1	<0.1
Cobalt	7440-48-4	0.5	mg/kg	----	----	----	13.0	1.2
Chromium	7440-47-3	1.0	mg/kg	----	----	----	<1.0	<1.0
Copper	7440-50-8	1.0	mg/kg	----	----	----	3.8	3.3
Lead	7439-92-1	1.0	mg/kg	----	----	----	6.4	6.6
Manganese	7439-96-5	10	mg/kg	----	----	----	808	47
Nickel	7440-02-0	1.0	mg/kg	----	----	----	14.1	2.4
Silver	7440-22-4	1.0	mg/kg	----	----	----	<1.0	<1.0
Zinc	7440-66-6	1.0	mg/kg	----	----	----	20.1	6.1
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	----	----	----	1930	1380
Antimony	7440-36-0	5	mg/kg	----	----	----	<5	<5
Arsenic	7440-38-2	5	mg/kg	----	----	----	7	<5
Cadmium	7440-43-9	1	mg/kg	----	----	----	<1	<1
Chromium	7440-47-3	2	mg/kg	----	----	----	10	5
Cobalt	7440-48-4	2	mg/kg	----	----	----	19	2
Copper	7440-50-8	5	mg/kg	----	----	----	8	<5
Lead	7439-92-1	5	mg/kg	----	----	----	13	10
Manganese	7439-96-5	5	mg/kg	----	----	----	1220	69
Nickel	7440-02-0	2	mg/kg	----	----	----	27	6
Silver	7440-22-4	2	mg/kg	----	----	----	<2	<2
Zinc	7440-66-6	5	mg/kg	----	----	----	47	18
EG035-SDH: 1M HCl extractable Mercury by FIMS								
Mercury	7439-97-6	0.10	mg/kg	----	----	----	<0.10	<0.10
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	----	----	----	<0.1	<0.1
EK055: Ammonia as N								
Ammonia as N	7664-41-7	20	mg/kg	<20	<20	<20	----	----
EK057G: Nitrite as N by Discrete Analyser								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	TOR	DOG	AIRUS	TOR <2000um	DOG <2000um
				Sampling date / time	04-Nov-2021 08:30	04-Nov-2021 11:00	04-Nov-2021 13:30	04-Nov-2021 08:30	04-Nov-2021 11:00
Compound	CAS Number	LOR	Unit		ES2140009-001	ES2140009-002	ES2140009-004	ES2140009-005	ES2140009-006
					Result	Result	Result	Result	Result
EK057G: Nitrite as N by Discrete Analyser - Continued									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg		<0.1	<0.1	<0.1	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg		**0.2**	**0.2**	**0.1**	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		**0.2**	**0.2**	**0.1**	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		**700**	**1090**	**2170**	----	----
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		**700**	**1090**	**2170**	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		**192**	**167**	**343**	----	----
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		**2.19**	**2.26**	**4.10**	----	----
GEO26: Sieving									
-2000µm	----	0.01	%		----	----	----	**76.4**	**95.5**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	AIRUS <2000um	----	----	----	----
				Sampling date / time	04-Nov-2021 13:30	----	----	----	----
Compound	CAS Number	LOR	Unit		ES2140009-008	--------	--------	--------	--------
					Result	----	----	----	----
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES									
Aluminium	7429-90-5	50	mg/kg		**740**	----	----	----	----
Antimony	7440-36-0	1.0	mg/kg		**8.6**	----	----	----	----
Arsenic	7440-38-2	1.0	mg/kg		**1.5**	----	----	----	----
Cadmium	7440-43-9	0.1	mg/kg		**0.1**	----	----	----	----
Cobalt	7440-48-4	0.5	mg/kg		**3.3**	----	----	----	----
Chromium	7440-47-3	1.0	mg/kg		<1.0	----	----	----	----
Copper	7440-50-8	1.0	mg/kg		**6.3**	----	----	----	----
Lead	7439-92-1	1.0	mg/kg		**6.7**	----	----	----	----
Manganese	7439-96-5	10	mg/kg		**116**	----	----	----	----
Nickel	7440-02-0	1.0	mg/kg		**6.8**	----	----	----	----
Silver	7440-22-4	1.0	mg/kg		<1.0	----	----	----	----
Zinc	7440-66-6	1.0	mg/kg		**15.2**	----	----	----	----
EG005(ED093)T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg		**3000**	----	----	----	----
Antimony	7440-36-0	5	mg/kg		<5	----	----	----	----
Arsenic	7440-38-2	5	mg/kg		<5	----	----	----	----
Cadmium	7440-43-9	1	mg/kg		<1	----	----	----	----
Chromium	7440-47-3	2	mg/kg		**8**	----	----	----	----
Cobalt	7440-48-4	2	mg/kg		**5**	----	----	----	----
Copper	7440-50-8	5	mg/kg		**8**	----	----	----	----
Lead	7439-92-1	5	mg/kg		**10**	----	----	----	----
Manganese	7439-96-5	5	mg/kg		**143**	----	----	----	----
Nickel	7440-02-0	2	mg/kg		**11**	----	----	----	----
Silver	7440-22-4	2	mg/kg		<2	----	----	----	----
Zinc	7440-66-6	5	mg/kg		**28**	----	----	----	----
EG035-SDH: 1M HCl extractable Mercury by FIMS									
Mercury	7439-97-6	0.10	mg/kg		<0.10	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	----	----	----	----
GEO26: Sieving									
-2000µm	----	0.01	%		**89.4**	----	----	----	----

Inter-Laboratory Testing

Analysis conducted by ALS Brisbane, NATA accreditation no. 825, site no. 818 (Chemistry) 18958 (Biology).

(SOIL) EP003: Total Organic Carbon (TOC) in Soil

(SOIL) GEO26: Sieving

(SOIL) EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES

(SOIL) EG035-SDH: 1M HCl extractable Mercury by FIMS

(SOIL) EG035T: Total Recoverable Mercury by FIMS

(SOIL) EG005(ED093)T: Total Metals by ICP-AES

Appendix B

Raw macroinvertebrate data

Autumn 2021

Class/Order	Lowest Taxon	SIGNAL-2	DOG		GAP		GEN		GRO		TOR		AIRUS		AIR	
			1	2	1	2	1	2	1	2	1	2	1	2	1	2
Acarina	Acarina sp.	6		1			2		2			1	2	2		
Coleoptera	Dytiscidae	2	11	17	9	5	6	3	3	3	11	17	8	6	6	2
Coleoptera	Gyrinidae	4		1								1				
Coleoptera	Haliplidae	2														1
Coleoptera	Hydraenidae	3			1		2									
Coleoptera	Hydrochidae	4	1								1					
Coleoptera	Hydrophilidae	2											1			
Coleoptera	Scirtidae	6	2		6	4	6	1	5	5	2					4
Crustacea	Cladocera sp.												6	3		
Crustacea	Copepoda sp.		2		1						2		1			
Crustacea	Ostracoda sp.		2	8	10	8					2	8	7	2	9	8
Diptera	Athericidae	8				1										
Diptera	Ceratopogonidae	4	2			1		1		1	2				1	
Diptera	Chironominae	3	17	9	13	9	1	9	1	1	17	9	3	4	2	1
Diptera	Culicidae	1	4	1	3	1					4	1	1		2	
Diptera	Dixidae	7				1		1							2	
Diptera	Orthocladiinae	4		1	1	1			1			1				
Diptera	Stratiomyidae	2	2	1							2	1	1			3
Diptera	Tanypodinae	4		1	9	9	6	5	5	3		1				
Diptera	Tipulidae	5				1										
Ephemeroptera	Baetidae	5	5	7							5	7	4	5	5	7
Ephemeroptera	Caenidae	4												2		
Ephemeroptera	Leptophlebiidae	8	3	4	14	2	11	3			3	4				
Gastropoda	Ancylidae	4												1		
Gastropoda	Gastropoda sp.															
Gastropoda	Physidae	1											4	3	1	4

Class/Order	Lowest Taxon	SIGNAL-2	DOG		GAP		GEN		GRO		TOR		AIRUS		AIR	
			1	2	1	2	1	2	1	2	1	2	1	2	1	2
Gastropoda	Planorbidae	2												1	1	2
Hemiptera	Corixidae	2	1	2							1	2	2	6		
Hemiptera	Micronectidae	2											1		1	1
Hemiptera	Notonectidae	1	2	2			1	1	1		2	2	2	1		2
Hemiptera	Veliidae	3	3	3	4	1	3	2			3	3		1	2	3
Megaloptera	Corydalidae	7					1		1	1						
Odonata: Epiprocta	Aeshnidae	4	4	1							4	1	6	2		1
Odonata: Epiprocta	Corduliidae	5													1	2
Odonata: Epiprocta	Epiprocta sp.															
Odonata: Epiprocta	Telephlebiidae	9					2		1							
Odonata: Zygoptera	Coenagrionidae	2		1								1	2	3		3
Odonata: Zygoptera	Lestidae	1	2	1							2	1				
Odonata: Zygoptera	Zygoptera sp.								1							
Oligochaeta	Oligochaeta sp.	2	1		2	2			1		1		1			2
Trichoptera	Helicopsychidae	8						1								
Trichoptera	Hydropsychidae	6						1								
Trichoptera	Hydroptilidae	4			1	2							1		4	1
Trichoptera	Leptoceridae	6	1	3	7	10	12	8	9	6	1	3	4	9	1	3
Trichoptera	Philorheithridae	8					1	1								
Trichoptera	Polycentropodidae	7					1									
Trichoptera	Trichoptera sp.															
Turbellaria	Dugesiidae	2			2	1							1			

Spring 2021

Class/Order	Lowest Taxon	SIGNAL-2	DOG		GAP		GEN		GRO		TOR		AIRUS		AIR	
			1	2	1	2	1	2	1	2	1	2	1	2	1	2
Acarina	Acarina sp.	6	4	2	1			2	4		1	7				
Coleoptera	Dytiscidae	2	9	9	12		4	3	4	4	5	6	7	9	9	4
Coleoptera	Gyrinidae	4	1													
Coleoptera	Haliplidae	2														2
Coleoptera	Hydraenidae	3						1					1	2		
Coleoptera	Hydrochidae	4													1	
Coleoptera	Hydrophilidae	2	6		1					1	2			1		1
Coleoptera	Scirtidae	6			3		2	1	6	5		1				
Crustacea	Copepoda sp.				1					1		1		1		
Crustacea	Ostracoda sp.		2	3	18		9				7	5	2	4	5	2
Diptera	Ceratopogonidae	4	4		1						2				1	
Diptera	Chironominae	3	1	1	20		2	10	8	9	3	1	7	13	1	1
Diptera	Culicidae	1			1						2		2			
Diptera	Dixidae	7			4		4	3			1	2				1
Diptera	Orthocladiinae	4						4	3	4	5	2	3	2	5	
Diptera	Sciomyzidae	2									2			1		
Diptera	Stratiomyidae	2		2							2	1		3	2	1
Diptera	Tanypodinae	4	4	7	8		2	6	3	6						
Ephemeroptera	Baetidae	5	4	2							2	4	3	2	3	2
Ephemeroptera	Caenidae	4	1	1							1	1		1		
Ephemeroptera	Leptophlebiidae	8	2	5	7		7	6	1	1						
Gastropoda	Gastropoda sp.															
Gastropoda	Lymnaeidae	1														1
Gastropoda	Physidae	1										1	3	2	1	2
Gastropoda	Planorbidae	2									2		4	3		2
Hemiptera	Corixidae	2		2							2	6	6	3	2	4

Class/Order	Lowest Taxon	SIGNAL-2	DOG		GAP		GEN		GRO		TOR		AIRUS		AIR	
			1	2	1	2	1	2	1	2	1	2	1	2	1	2
Hemiptera	Hydrometridae	3	1												1	
Hemiptera	Nepidae	3														1
Hemiptera	Notonectidae	1	8	3	1		1	1	2		1	1				1
Hemiptera	Veliidae	3	2	2	2		2	1	1	2	2		1	3	2	2
Megaloptera	Corydalidae	7					3									
Odonata: Epiprocta	Aeshnidae	4		3							1	3	4	1	3	1
Odonata: Epiprocta	Corduliidae	5									1				1	
Odonata: Epiprocta	Epiprocta sp.		1													
Odonata: Epiprocta	Telephlebiidae	9					1	2	1							
Odonata: Zygoptera	Argiolestidae	5						2								
Odonata: Zygoptera	Coenagrionidae	2	1								3	1	4	4	2	8
Odonata: Zygoptera	Lestidae	1	5	2												
Odonata: Zygoptera	Zygoptera sp.															
Trichoptera	Helicopsychidae	8						1								
Trichoptera	Hydroptilidae	4	1	1	1						6	3				
Trichoptera	Leptoceridae	6	3	2	6		8	10	3	4	1	1	3	3	2	2
Turbellaria	Dugesiidae	2	3	1											1	1

Appendix C

Water quality QA

Analyte	Units	LOR	Autumn 2021		Spring 2021	
			AIRUS	Duplicate	DOG	Duplicate
			3/05/2021	3/05/2021	4/11/2021	4/11/2021
Physico-chemical parameters						
TDS	mg/L	1	1660	1660	982	942
TSS	mg/L	5	10	10	18	9
Turbidity	NTU	0.1	4.7	2.8	3.5	2.2
Total Hardness as $CaCO_3$	mg/L	1	1560	1570	721	775
Major ions						
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	190	187	477	476
Carbonate Alkalinity as $CaCO_3$	mg/L	1	<1	<1	<1	<1
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	<1	<1	<1	<1
Total Alkalinity as $CaCO_3$	mg/L	1	190	187	477	476
Sulfate as SO_4 - Turbidimetric	mg/L	1	1470	1460	445	445
Chloride	mg/L	1	60	62	43	43
Calcium	mg/L	1	255	258	157	162
Magnesium	mg/L	1	224	226	80	90
Potassium	mg/L	1	6	6	2	1
Sodium	mg/L	1	78	78	58	63
Dissolved metals						
Aluminium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01
Arsenic	mg/L	0.0002	0.0004	0.0004	0.0005	0.0005
Boron	mg/L	0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	mg/L	0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Chromium	mg/L	0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Cobalt	mg/L	0.001	0.001	0.001	<0.001	<0.001
Copper	mg/L	0.001	<0.001	<0.001	<0.001	<0.001
Iron	mg/L	0.05	<0.05	<0.05	<0.05	<0.05
Lead	mg/L	0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	0.257	0.309	0.053	0.058
Mercury	mg/L	0.00004	<0.00004	<0.00004	<0.00004	<0.00004
Nickel	mg/L	0.001	0.007	0.009	<0.001	<0.001
Selenium	mg/L	0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Silver	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Zinc	mg/L	0.001	0.003	0.002	0.004	0.004
Nutrients						
Ammonia as N	mg/L	0.01	<0.01	0.02	0.01	<0.01
Nitrite as N	mg/L	0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	0.03	0.02	0.02	0.02
Nitrite + Nitrate as N	mg/L	0.01	0.03	0.02	0.02	0.02
Total Kjeldahl Nitrogen as N	mg/L	0.1	0.2	0.3	0.1	0.1
Total Nitrogen as N	mg/L	0.1	0.2	0.3	0.1	0.1

Analyte	Units	LOR	Autumn 2021		Spring 2021	
			AIRUS	Duplicate	DOG	Duplicate
			3/05/2021	3/05/2021	4/11/2021	4/11/2021
Total Phosphorus as P	mg/L	0.01	<0.01	0.04	<0.01	0.02
Reactive Phosphorus as P	mg/L	0.01	<0.01	<0.01	<0.01	<0.01
Other parameters						
DOC	mg/L	1	9	8	4	4
Oil & grease	mg/L	5	<5	<5	<5	8
Fluoride	mg/L	0.1	0.2	0.3	0.2	<0.1

Appendix D

Sediment quality QA

Analyte	Units	LOR	Autumn 2021	
			AIRUS	Duplicate
1M HCl-extractable metals				
Aluminium	mg/kg	50	440	490
Antimony	mg/kg	1	<1.0	<1.0
Arsenic	mg/kg	1	1.4	1.8
Cadmium	mg/kg	0.1	0.1	0.1
Chromium	mg/kg	1	<1.0	<1.0
Cobalt	mg/kg	0.5	2.2	2.4
Copper	mg/kg	1	3.4	3.8
Lead	mg/kg	1	4.5	4.6
Manganese	mg/kg	10	74	72
Mercury	mg/kg	0.1	<0.10	<0.10
Nickel	mg/kg	1	5.4	6.0
Silver	mg/kg	1	<1.0	<1.0
Zinc	mg/kg	1	12.5	14.7
Nutrients				
Ammonia	mg/kg	20	<20	<20
Nitrite	mg/kg	0.1	<0.1	<0.1
Nitrate	mg/kg	0.1	0.6	<0.1
NOx	mg/kg	0.1	0.6	<0.1
TKN	mg/kg	20	2970	3030
TN	mg/kg	20	2970	3030
TP	mg/kg	2	446	483
Other parameters				
TOC	%	0.02	3.66	3.93
Moisture content	%	1	44.9	49.6

Appendix E

Macroinvertebrate taxonomy QA

Macroinvertebrate Identification QA/QC Data Sheet

Identifier: ZB **Processing Date:**

Project #: 12545559 **LIMS/Sample #:** 116412 **Sample Code:** 117TORP1

Site Name: **Site Code:** TOR

Collection Date: 05/05/2021 **Method/Habitat:** Sweep **Collected By:**

Taxonomic Id Level: Family **Pass/Fail Rate:** 95% **QA/QC By:** PM

Incorrect Identification	Correct Identification	Error Code

Number of Taxa (species/families): 19
Number Identified Incorrectly: 0
Percentage Correct: 100%
Pass or Fail: Pass

Training Received For Incorrect Taxa? (N/A) **QA Date:** 11/03/2022

Senior Taxonomist P. Maiden
Identifier Z. Billingham

Notes:
Please refer to .\General\Ecology Files\Quality Assurance\Quality Assurance for the Victorian River Health Program.pdf for an explanation of how rates are calculated.

Error Codes:

1. **ID adult/larvae not identified**
2. **Complete misidentification**
3. **Could *reasonably* be identified to a finer taxonomic resolution**
4. **Identification has been taken too far based on specimen condition (small or damaged)***
5. **Miscount***
6. **Taxon not recorded on the data sheet**
7. **Inappropriate Identification based on larval exuviae, shells or if the specimen was obviously dead when collected**

* These are NOT included in error rate calculations

Macroinvertebrate Identification QA/QC Data Sheet

Identifier: ZB **Processing Date:**

Project #: 12545559 **LIMS/Sample #:** 116623 **SampleCode:** 118GROP1

Site Name: **Site Code:** GRO

Collection Date: 02/11/2021 **Method/Habitat:** Sweep **Collected By:**

Taxonomic Id Level: Family **Pass/Fail Rate:** 95% **QA/QC By:** PM

Incorrect Identification	Correct Identification	Error Code

Number of Taxa (species/families): 10
Number Identified Incorrectly: 0
Percentage Correct: 100%
Pass or Fail: Pass

Training Received For Incorrect Taxa? (N/A) **QA Date:** 11/03/2022

Senior Taxonomist P. Maiden
Identifier Z. Billingham

Notes:
Please refer to .\General\Ecology Files\Quality Assurance\Quality Assurance for the Victorian River Health Program.pdf for an explanation of how rates are calculated.

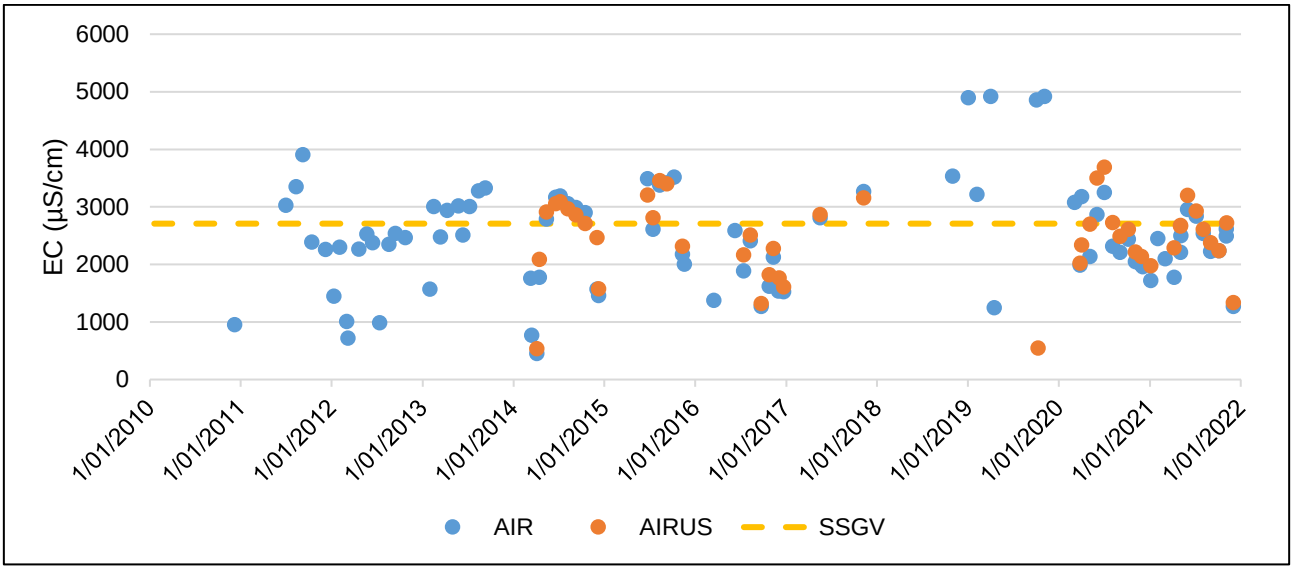
Error Codes:

1. **ID adult/larvae not identified**
2. **Complete misidentification**
3. **Could *reasonably* be identified to a finer taxonomic resolution**
4. **Identification has been taken too far based on specimen condition (small or damaged)***
5. **Miscount***
6. **Taxon not recorded on the data sheet**
7. **Inappropriate Identification based on larval exuviae, shells or if the specimen was obviously dead when collected**

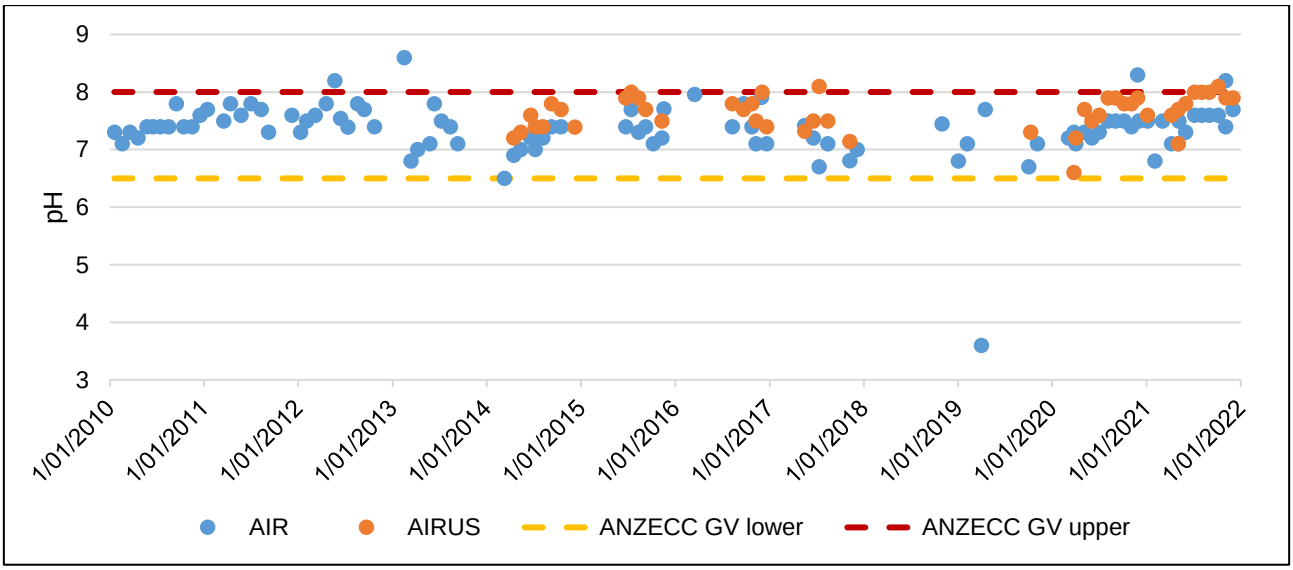
* These are NOT included in error rate calculations

Appendix F

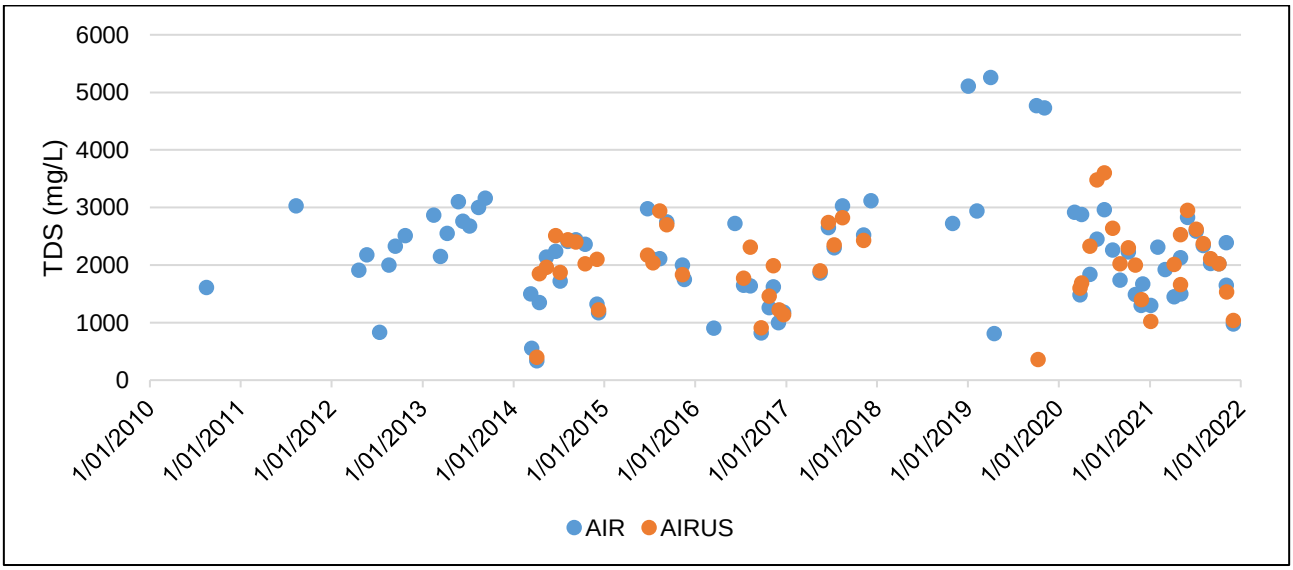
Long term water quality figures



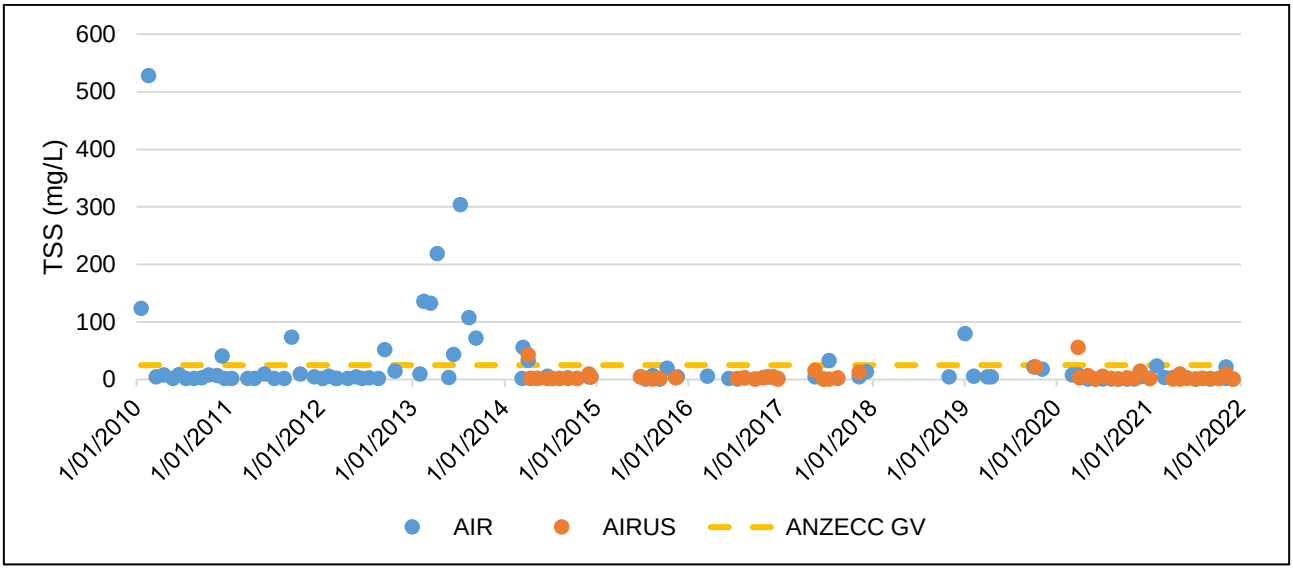
EC at AIR and AIRUS, January 2010 to December 2021



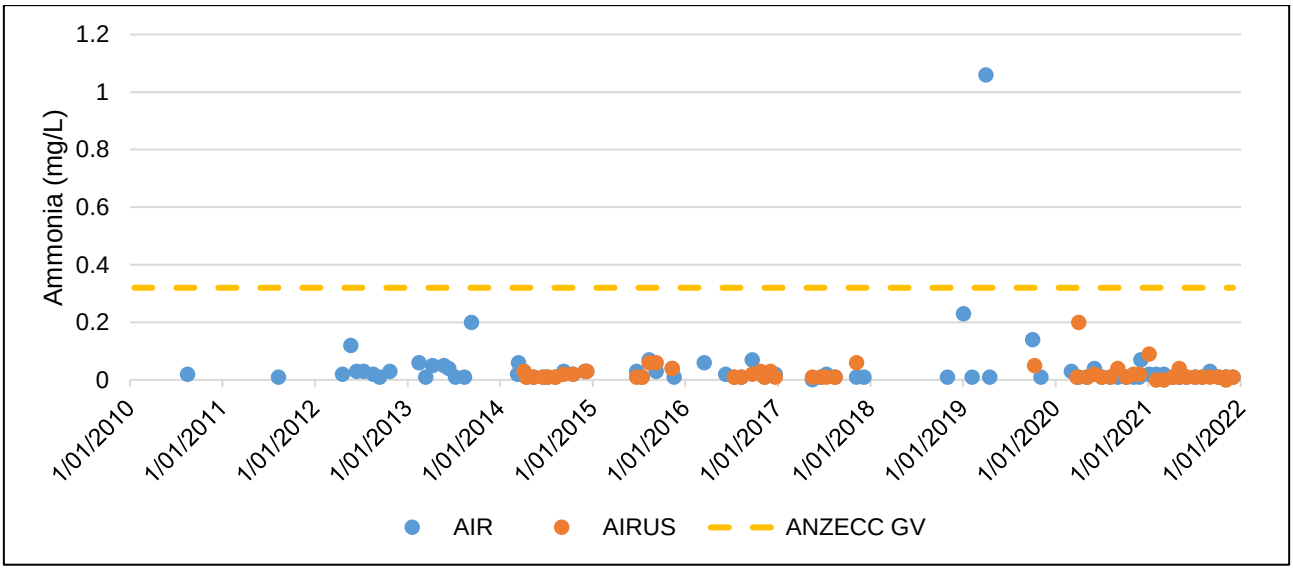
pH at AIR and AIRUS, January 2010 to December 2021



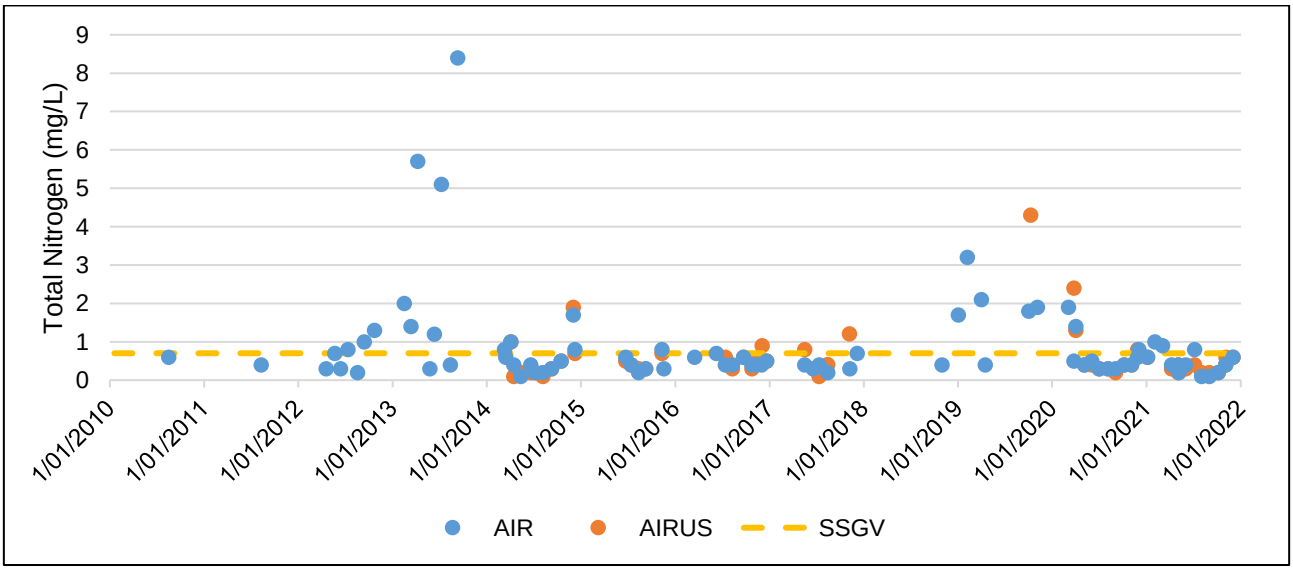
Total dissolved solids at AIR and AIRUS, January 2010 to December 2021



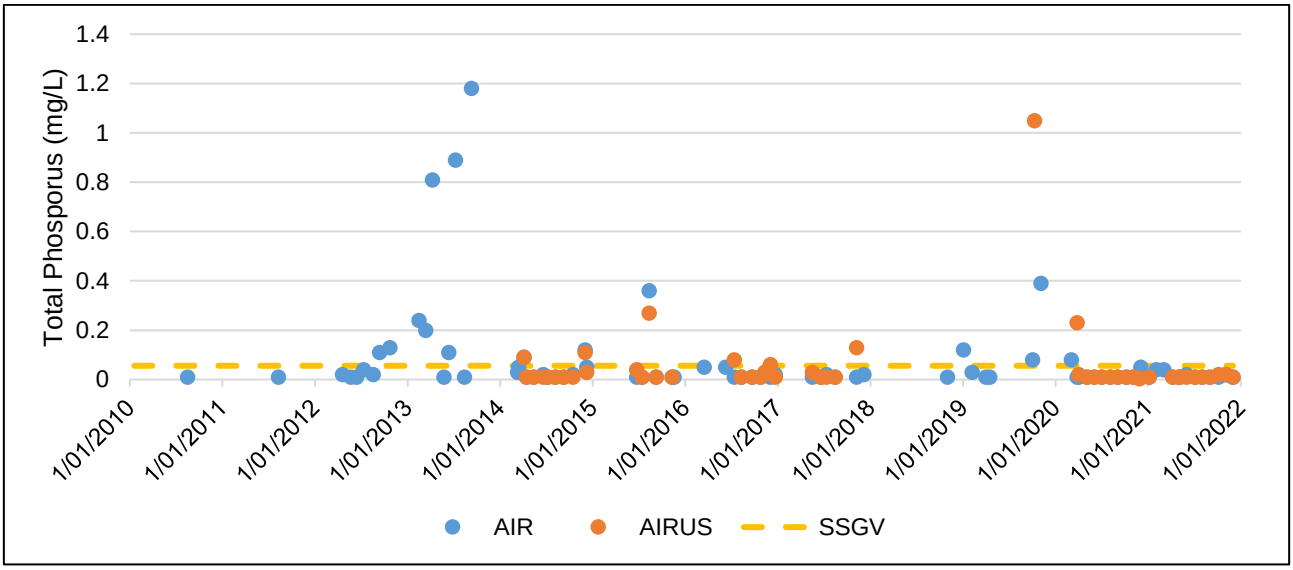
Total suspended solids at AIR and AIRUS, January 2010 to December 2021



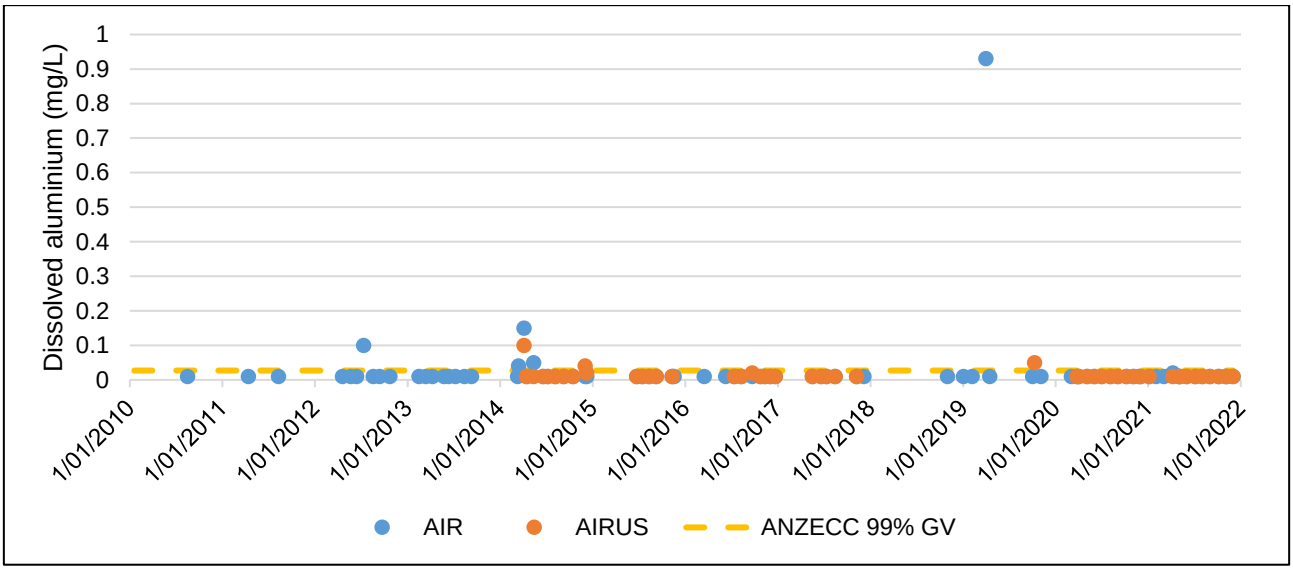
Ammonia at AIR and AIRUS, January 2010 to December 2021



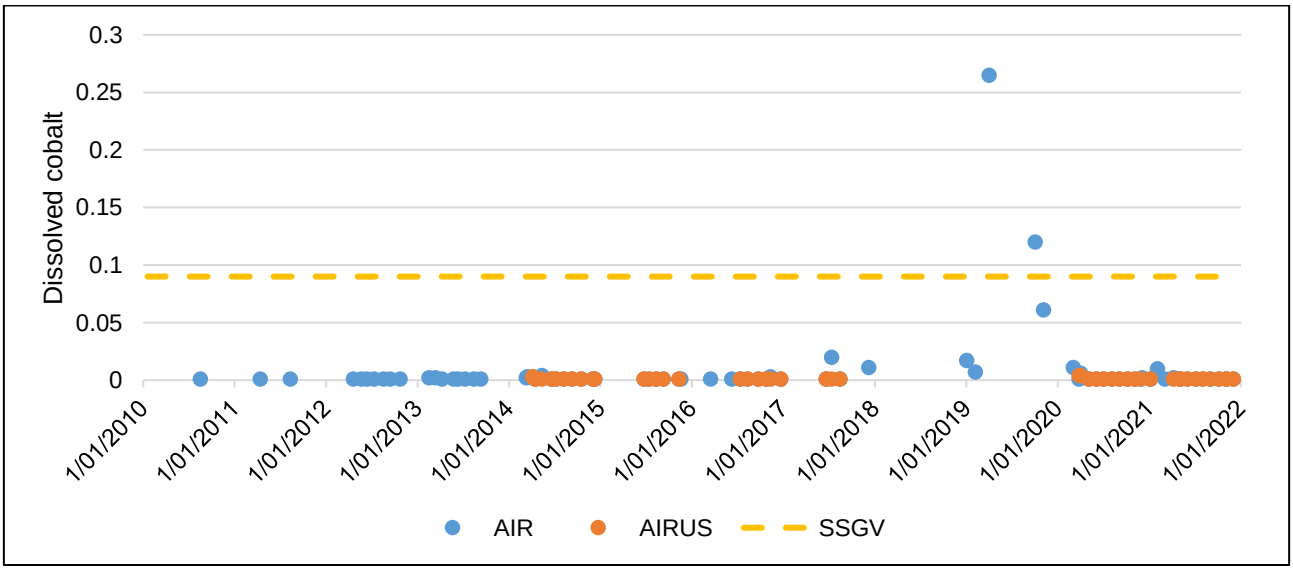
Total nitrogen at AIR and AIRUS, January 2010 to December 2021



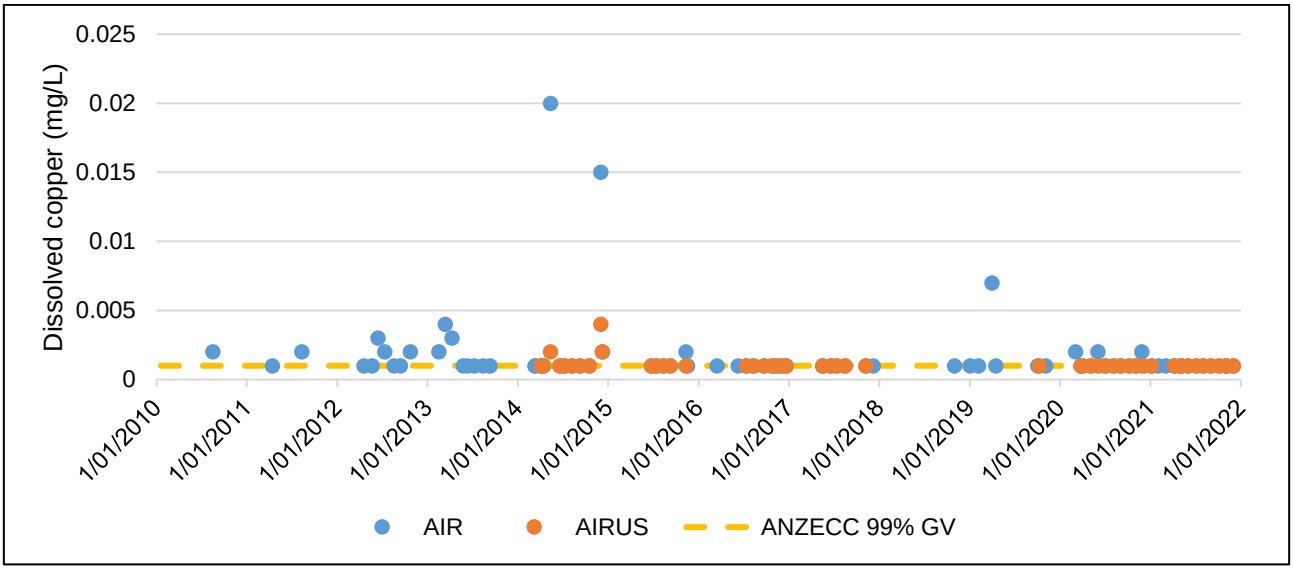
Total phosphorus at AIR and AIRUS, January 2010 to December 2021



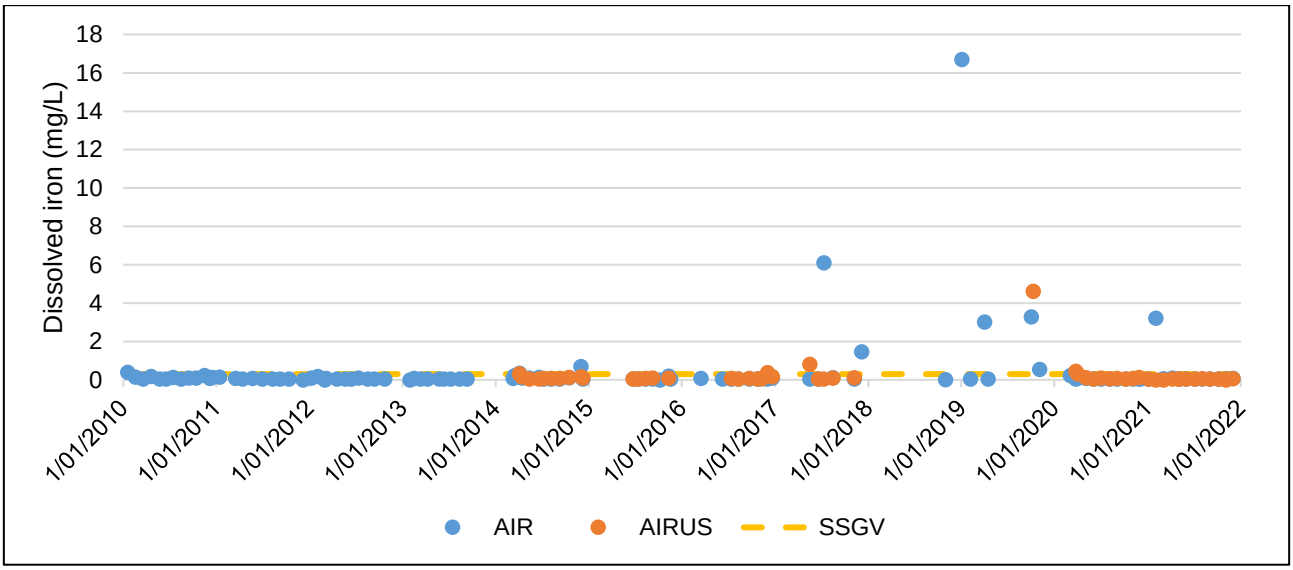
Dissolved aluminium at AIR and AIRUS, January 2010 to December 2021



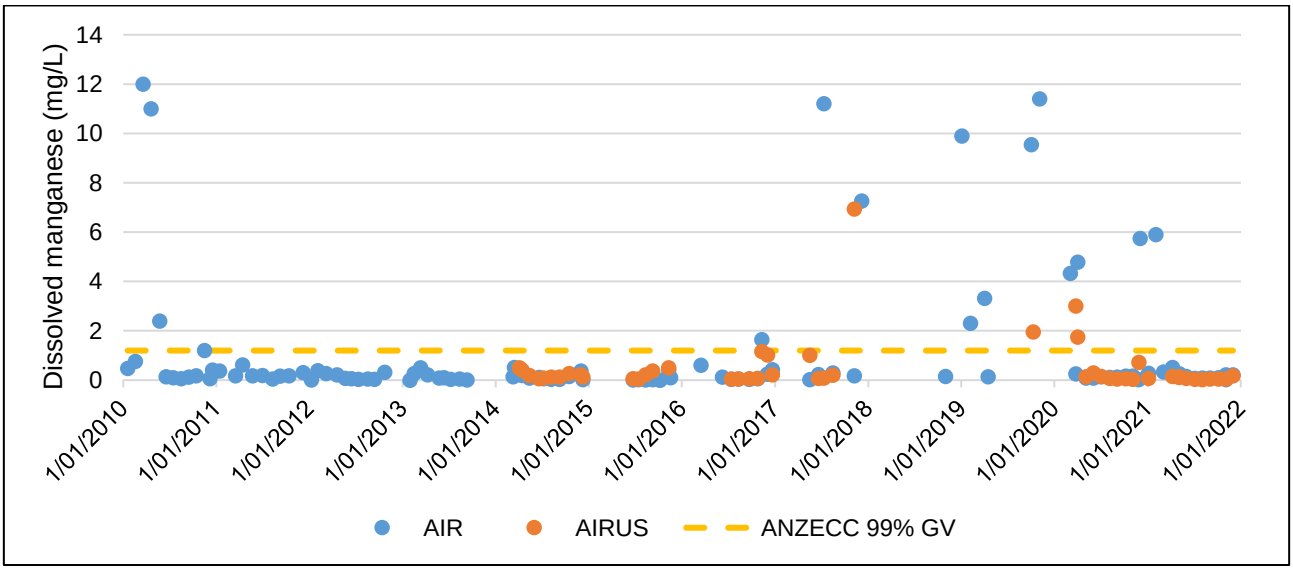
Dissolved cobalt at AIR and AIRUS, January 2010 to December 2021



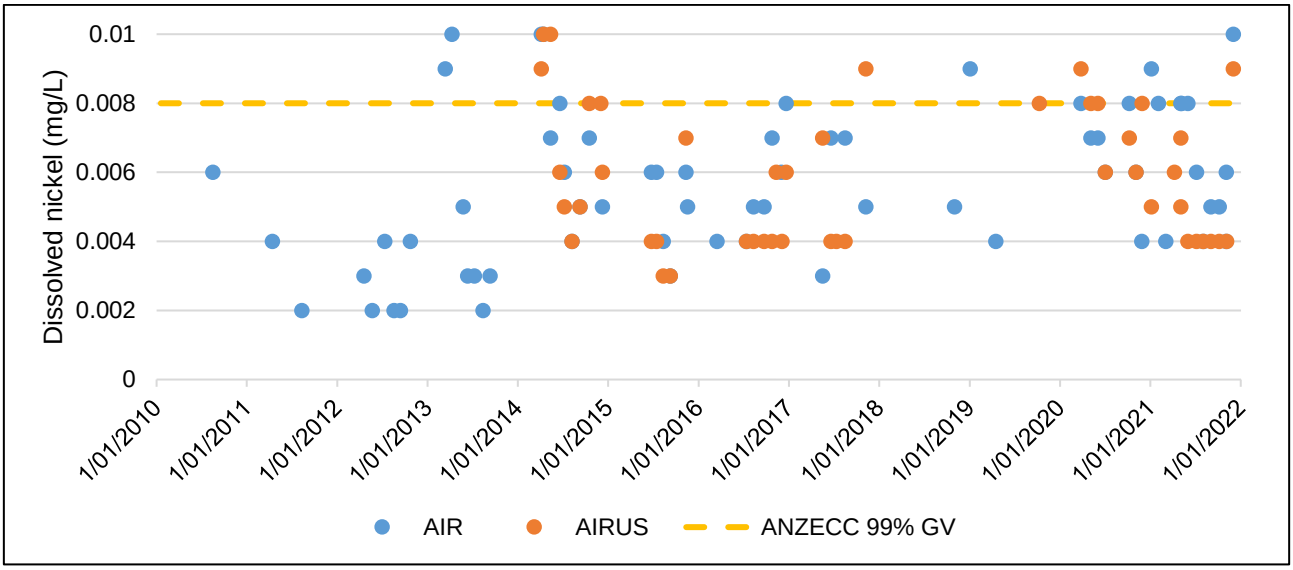
Dissolved copper at AIR and AIRUS, January 2010 to December 2021



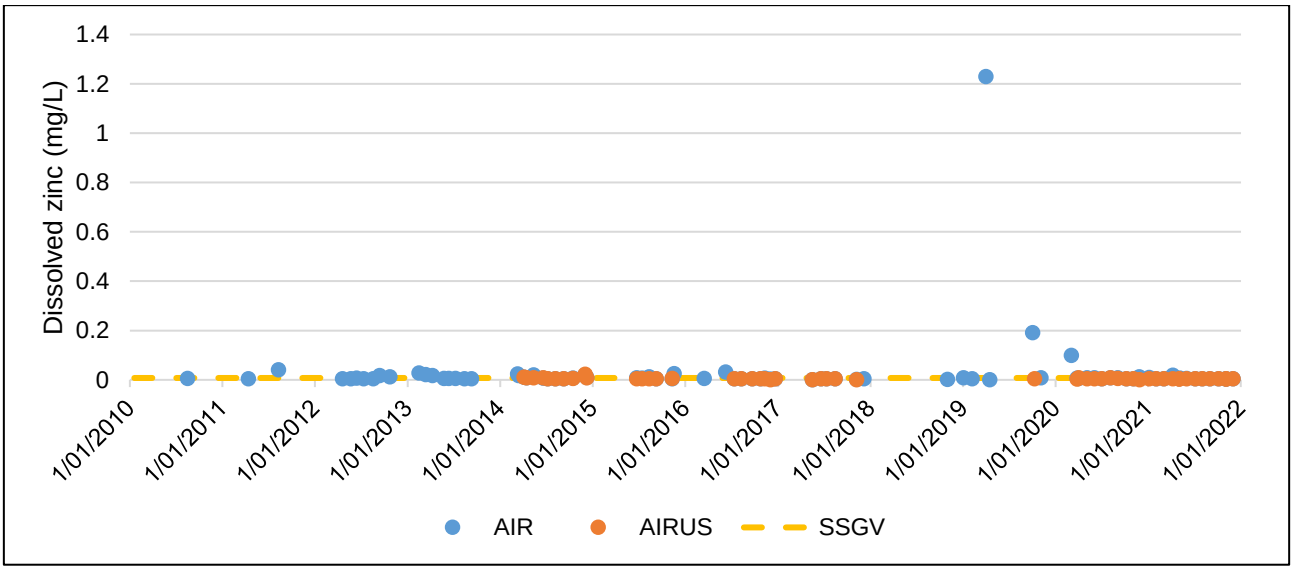
Dissolved iron at AIR and AIRUS, January 2010 to December 2021



Dissolved manganese at AIR and AIRUS, January 2010 to December 2021



Dissolved nickel at AIR and AIRUS, January 2010 to December 2021



Dissolved zinc at AIR and AIRUS, January 2010 to December 2021

Appendix G

RCE Scores, 2020-2021

RCE scores – 2020 to 2021, GAP, GEN, GRO

Site	GAP				GEN				GRO			
Category	**Spr-21**	**Aut-21**	**Spr-20**	**Aut-20**	**Spr-21**	**Aut-21**	**Spr-20**	**Aut-20**	**Spr-21**	**Aut-21**	**Spr-20**	**Aut-20**
1. Land use pattern beyond immediate riparian zone	4	4	4	4	4	4	4	4	4	4	4	4
2. Width of riparian strip of woody vegetation	4	4	3	4	3	4	4	4	3	3	3	4
3. Completeness of riparian strip of woody vegetation	4	4	3	4	4	4	4	2	3	3	3	2
4. Vegetation of riparian zone within 10 m of channel	4	3	4	4	4	4	4	4	4	4	4	4
5. Stream bank structure	1	3	4	4	4	4	3	4	2	2	2	3
6. Bank undercutting	4	3	4	4	4	3	2	4	1	2	3	3
7. Channel form	3	3	4	4	3	3	4	4	4	3	3	3
8. Riffle/pool sequence	2	4	4	3	4	3	4	4	3	4	4	4
9. Retention devices in stream	4	4	4	4	4	4	3	4	4	4	4	3
10. Channel sediment accumulations	2	2	2	2	2	3	4	2	2	2	2	3
11. Stream bottom	3	2	3	2	3	3	3	3	3	1	3	2
12. Stream detritus	3	3	4	4	4	3	4	4	4	4	3	4
13. Aquatic vegetation	4	4	4	4	3	4	2	4	4	3	3	4
RCE score	**42**	**43**	**47**	**47**	**46**	**46**	**45**	**47**	**41**	**39**	**41**	**43**
RCE percentage (%)	**81%**	**83%**	**90%**	**90%**	**88%**	**88%**	**87%**	**90%**	**79%**	**75%**	**79%**	**83%**

RCE scores – 2020 to 2021, TOR, DOG

Site	TOR				DOG			
Category	**Spr-21**	**Aut-21**	**Spr-20**	**Aut-20**	**Spr-21**	**Aut-21**	**Spr-20**	**Aut-20**
1. Land use pattern beyond immediate riparian zone	2	2	2	3	2	2	2	3
2. Width of riparian strip of woody vegetation	4	4	3	4	2	2	2	3
3. Completeness of riparian strip of woody vegetation	4	4	3	3	1	1	2	2
4. Vegetation of riparian zone within 10 m of channel	3	3	3	3	4	3	3	3
5. Stream bank structure	3	3	3	3	3	3	3	2
6. Bank undercutting	3	2	2	1	3	4	4	2
7. Channel form	4	3	4	4	3	3	3	2
8. Riffle/pool sequence	2	2	3	3	2	2	2	3
9. Retention devices in stream	2	1	3	3	1	2	1	2
10. Channel sediment accumulations	2	3	2	2	0	0	0	1
11. Stream bottom	3	3		1	0	2	0	2
12. Stream detritus	3	3		1	3	3	2	1
13. Aquatic vegetation	2	4	3	4	2	2	1	3
RCE score	**37**	**37**	**31**	**35**	**26**	**29**	**25**	**29**
RCE percentage (%)	**71%**	**71%**	**60%**	**67%**	**50%**	**56%**	**48%**	**56%**

RCE scores – 2020 to 2021, AIRUS, AIR

Site	AIRUS				AIR			
Category	**Spr-21**	**Aut-21**	**Spr-20**	**Aut-20**	**Spr-21**	**Aut-21**	**Spr-20**	**Aut-20**
1. Land use pattern beyond immediate riparian zone	2	2	2	3	3	2	4	3
2. Width of riparian strip of woody vegetation	2	2	2	2	3	3	4	4
3. Completeness of riparian strip of woody vegetation	1	1	1	2	2	3	4	2
4. Vegetation of riparian zone within 10 m of channel	2	2	2	1	3	3	3	3
5. Stream bank structure	3	3	3	3	3	3	3	2
6. Bank undercutting	3	4	3	3	2	2	2	1
7. Channel form	4	4	3	4	3	4	4	3
8. Riffle/pool sequence	2	2	2	2	2	4	2	3
9. Retention devices in stream	3	3	1	2	2	3	3	3
10. Channel sediment accumulations	0	0	0	0	4	3	1	1
11. Stream bottom	0	0	0	2	3	3	3	2
12. Stream detritus	2	3		2	2	2	2	3
13. Aquatic vegetation	2	1	3	4	3	3	1	3
RCE score	**26**	**27**	**22**	**30**	**35**	**38**	**36**	**33**
RCE percentage (%)	**50%**	**52%**	**42%**	**58%**	**67%**	**73%**	**69%**	**63%**

Appendix H

ANOSIM Output

ANOSIM
Analysis of Similarities

One-Way - A

Resemblance worksheet
Name: Resem7
Data type: Similarity
Selection: All

Factors

Place	Name	Type	Levels
A	Site	Unordered	7

Site levels
AIR
AIRUS
DOG
GAP
GEN
GRO
TOR

Tests for differences between unordered Site groups
Global Test
Sample statistic (R): 0.606
Significance level of sample statistic: 0.01%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Pairwise Tests

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
AIR, AIRUS	-0.116	85.6	170544	9999	8562
AIR, DOG	0.363	0.01	77558760	9999	0
AIR, GAP	0.71	0.01	490314	9999	0
AIR, GEN	0.933	0.01	77558760	9999	0
AIR, GRO	0.89	0.01	1307504	9999	0
AIR, TOR	0.144	2.7	3268760	9999	266
AIRUS, DOG	0.283	0.6	170544	9999	60
AIRUS, GAP	0.732	0.02	6435	6435	1
AIRUS, GEN	0.948	0.01	116280	9999	0
AIRUS, GRO	0.902	0.01	11440	9999	0
AIRUS, TOR	-0.009	51	19448	9999	5097
DOG, GAP	0.803	0.01	490314	9999	0
DOG, GEN	0.936	0.01	77558760	9999	0
DOG, GRO	0.901	0.01	1307504	9999	0
DOG, TOR	0.414	0.01	3268760	9999	0
GAP, GEN	0.361	0.2	319770	9999	14
GAP, GRO	0.346	0.1	24310	9999	12
GAP, TOR	0.596	0.01	43758	9999	0
GEN, GRO	0.369	0.04	817190	9999	3
GEN, TOR	0.91	0.01	1961256	9999	0
GRO, TOR	0.897	0.01	92378	9999	0

Outputs
Plot: Graph42
Worksheet: Resem10

ANOSIM
Analysis of Similarities

One-Way - A

Resemblance worksheet
Name: Resem6
Data type: Similarity
Selection: All

Factors

Place	Name	Type	Levels
A	Site	Unordered	2

Site levels
AIR
AIRUS

Tests for differences between unordered Site groups
Global Test
Sample statistic (R): -0.098
Significance level of sample statistic: 94.5%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 9449

Outputs
Plot: Graph43

Appendix 4: 2021 Ecological Monitoring Report

AIRLY BMP SEASONAL ECOLOGICAL MONITORING

Flora and Fauna Monitoring Report 2021



149004
2.0
29 March 2022

rpsgroup.com

Document status

Version	Purpose of document	Authored by	Reviewed by	Approved by	Review date
1.0	Frist Draft for client review	Rhys Corrigan Tara Boreham	Mark Aitkens	Mark Aitkens	23/02/2022
2.0	Final report following client comments	Tara Boreham			29/03/2022

Approval for issue

Mark Aitkens  23 February 2022

This report was prepared by RPS within the terms of RPS' engagement with its client and in direct response to a scope of services. This report is supplied for the sole and specific purpose for use by RPS' client. The report does not account for any changes relating the subject matter of the report, or any legislative or regulatory changes that have occurred since the report was produced and that may affect the report. RPS does not accept any responsibility or liability for loss whatsoever to any third party caused by, related to or arising out of any use or reliance on the report.

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EXECUTIVE SUMMMARY

Centennial Airly Pty Ltd operates an approved coal mining lease to extract thermal coal at Airly and Genowlan Mountains, which form part of the Mugii Murum-ban State Conservation Area. Approval for the Airly Mine is specified under State Significant Development 5581 (SSD-5581).

Biodiversity monitoring throughout the Development Consent Area for SSD-5581 is currently being undertaken in compliance with the Airly Biodiversity Management Plan (BMP; Centennial 2019) required by consent condition 17, Schedule 4 of SSD-5581.

This 2021 annual monitoring report addresses the biodiversity-related conditions of consent outlines in SSD-5581. Schedule 3, Condition 2 of the SD-5581 development consent specifies the following requirements:

- Negligible environmental consequences for the threatened species, threatened populations, endangered ecological communities (EECs) and groundwater dependent ecosystems (with the exception of those listed below); and
- No environmental consequences for *Pultenaea* sp. Genowlan Point population and Genowlan Point *Allocasuarina nana* Heathland community (addressed in a separate report prepared by National Parks).

This monitoring report comprises information pertaining to the first of the two aforementioned requirements, whereas the second requirement is addressed in a separate monitoring report prepared by National Parks.

The 2021 monitoring results show that threatened species, threatened populations, EECs and groundwater dependent ecosystems are persisting in the study area, with negligible environmental consequences. The following Airly Site Specific BMP priorities are outlined below.

Mount Vincent's Mint-bush (*Prostanthera stricta*)

Percent cover of *P. stricta* across all transects in 2021 have substantially increased since the 2020 survey period. All plots are above their pre-burn (2015 to 2018) average percent cover with the exception of Transects 3 and 5.

Capertee Stringybark (*Eucalyptus cannonii*)

Condition assessments of *E. cannonii* through photo monitoring showed little change during the last year.

Capertee Rough-barked Apple-Redgum-Yellow Box Grassy Woodland (MU20)

Capertee Rough-barked Apple – Redgum – Yellow Box Grassy Woodland (MU20) plot surveys demonstrated the highest plant species richness to date in BAM quadrants 1 and 2. Native plant species richness in 2021 was also greater than results for the years 2015-2018, with each plot recording more species than the mean for all years.

Exotic Species

Weeds of concern which have an individual cover of 5% or greater include *Anthoxanthum odoratum* (BAM 1)*, Dactylis glomerata* (BAM 1) and *Senecio jacobaea* (BAM 3 and 4). BAM quadrant 1 had the highest exotic plant cover, with a total cover of 26.8%. Of the 20 exotic species, two are High Threat Weeds (HTW) and one is a Weed of National Significance (WoNS). Weed control works have been carried out throughout 2021 around the pit-top and paddocks. These works have targeted HTW species including *Hypericum perforatum* (St. John's Wort), *Rosa rubiginosa* (Sweet Briar) and *Rubus fruticosus species aggregate* (Blackberry). Additional weed works have been planned for 2022. It is recommended that *Centaurea spp*. (Thistle) is also a targeted in subsequent years.

Glossy-black Cockatoos (*Calyptorhynchus lathami*)

Continued monitoring of Glossy-Black Cockatoos has shown that this species persists on site, with evidence of feeding (chewed orts) and the presence of individuals recorded opportunistically throughout the study area.

Large Forest Owls

No roost sites displayed indirect evidence of use (i.e. white wash and pellets); however, a Sooty Owl (*Tyto tenebricosa*; *Biodiversity Conservation Act* 2016 [BC Act]: Vulnerable) was observed on Mt Airly during spotlighting near roost site 3 in November 2021.

Diurnal birds, including threatened and regionally significant woodland bird species

Five of the 70 recorded diurnal bird species are listed as threatened under the BC Act which include Dusky Woodswallow (*Artamus cyanopterus*; BC Act: Vulnerable), Gang-gang Cockatoo (*Callocephalon fimbriatum*; BC Act: Vulnerable), Glossy Black-Cockatoo (*Calyptorhynchus lathami*; BC Act: Vulnerable), Brown Treecreeper (*Climacteris picumnus victoriae*; BC Act: Vulnerable) and Scarlet Robin (*Petroica boodang*; BC Act: Vulnerable). Bird species richness is stable across years within all seven transects.

Cave-dwelling microbats

Two of the three target microbat species were detected at a definite confidence level during both spring and summer surveys, being the Eastern Horseshoe-bat (*Rhinolophus megaphyllus*) and the Large-eared Pied-bat (*Chalinolobus dwyeri;* BC Act: Vulnerable; *Environment Protection and Biodiversity Conservation Act* 1999 [EPBC Act]: Vulnerable). Whilst not definite, it is likely that given the high number of calls, and location at a known bat roost, the Eastern Bent-winged Bat (*Miniopterus orianae oceanensis*) is also roosting in the study area. The adits are likely to be the location of the Eastern Horseshoe Bat (*Rhinolophus megaphyllus*) maternity colony.

Other targeted fauna/vertebrate census

Of the 35 vertebrate species (excluding birds and microbats) detected during the 2021 monitoring period, three are listed as threatened under the BC Act and/or EPBC Act. The following are noteworthy observations:

- The Koala (*Phascolarctos cinereus*; BC Act: Vulnerable; EPBC Act: Endangered) was detected by a passive acoustic survey (i.e. song meter) at the base of Airly Mountain;
- Rosenberg's Goanna (*Varanus rosenbergi*: BC Act: Vulnerable) was observed at Point Hatteras for the second year in a row; and
- The Greater Glider (*Petauroides Volans*; EPBC Act: Vulnerable) is persisting in the Grotto and base of Mount Airly.

Feral species

Feral species, other than domestic cattle, were recorded infrequently during the 2021 surveys. Feral animal control works have been conducted targeting feral dogs and cats which have been successful at reducing numbers. Cats were not observed during the 2021 monitoring period, and feral dogs were observed only once by means of camera trap.

Recommendations

Two exotic species observed are classed as high threat weeds (HTWs) these being *Hypericum perforatum* (St. Johns Wort) and *Rosa rubiginosa* (Sweet Briar). One exotic species is listed as a WoNS under the *Biosecurity Act* 2015 which is *Rubus fruticosus* (Blackberry complex). Significant weed infestations have been noted along Torbane Road and behind the Pit-Top. It is recommended that weed infestations are treated to reduce spread of weeds via vehicle movement to sensitive areas such as Mount Airly, Point Hatteras and the Grotto.

Glossy-black Cockatoo Site 2 has displayed a decrease in *Allocasurina* canopy cover, and dying trees were noted. It is recommended that photo monitoring is conducted at Glossy-Black Cockatoo sites to better understand the trends of *Allocasuarina* canopy cover.

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1 INTRODUCTION

1.1 Background

Centennial Airly Pty Ltd operates an approved coal mining lease to extract thermal coal at Airly and Genowlan Mountains, which form part of the Mugii Murum-ban State Conservation Area (SCA; **Figure 1**). Approval for the Airly Mine is specified under State Significant Development 5581 (SSD-5581).

Biodiversity monitoring throughout the Development Consent Area for SSD-5581 is currently being undertaken in compliance with the Airly Biodiversity Management Plan (BMP; Centennial 2019) required by consent condition 17, Schedule 4 of SSD-5581.

Monitoring within the Airly Development Consent Area was developed by the Centre for Mine Land Rehabilitation (CMLR) and was commenced in 2012 by the University of Queensland (UQ), with RPS further refining the program since 2015. In accordance with the site BMP, the monitoring program has been and will continue to be conducted in line with the Development Consent (SSD-5581) with the exception of the areas which have restricted access and are being monitored by NSW National Parks and Wildlife Service (NPWS) [i.e. *Pultenaea sp*. Genowlan Point and Genowlan Point *Allocasuarina nana* Heathland Endangered Ecological Community (EEC)].

Previous flora and fauna monitoring for the Airly Mine was developed and implemented by the CMLR and was based on a Before-After-Control-Impact (BACI) approach and has been ongoing since 2012. The 2021 monitoring by RPS is based on the prior monitoring program with variation where necessary to reflect operational circumstances.

The survey effort in 2021 was conducted over two separate weeks, the first in February 2021 as soon as access to the area was granted. The remaining survey effort was completed in November 2021.

1.2 Study Area

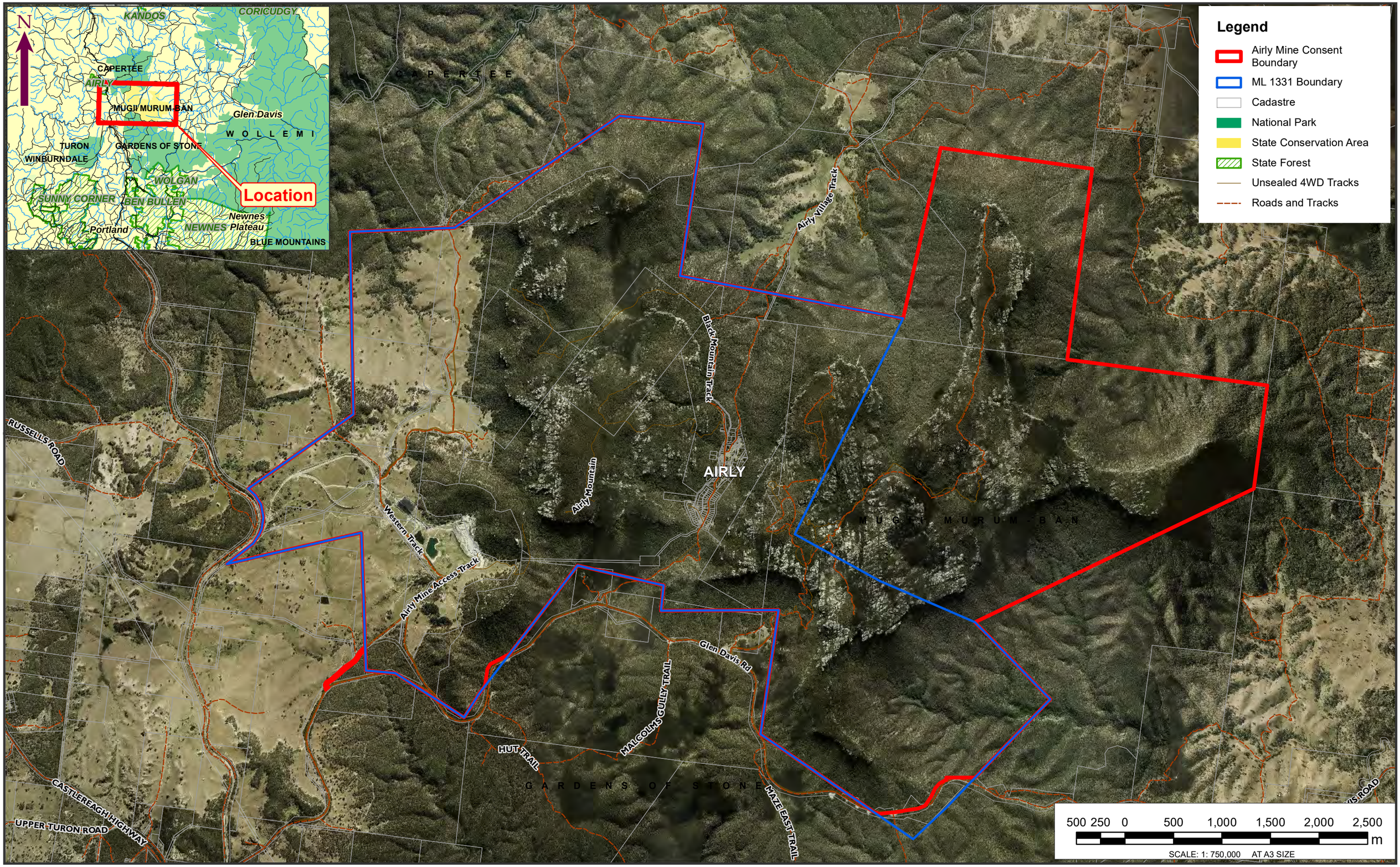
The study area is defined as the Airly Mine Consent Boundary, as shown in **Figure 1**, and is located on and around the mesas at Mount Airly and Genowlan Mountain within the Mugii Murum-ban SCA. This area contains a range of habitat types such as dry eucalypt forests, wet forests, gullies and gorges, and heath scrubs on rocky outcrops.

Vegetation communities mapped within the study area include over 365 hectares (ha) of sandstone escarpment and pagoda features (RPS 2014, DEC 2004) identified by the Department of Planning, Industry and Environment (DPIE) as sensitive to longwall mining subsidence (i.e. potential to destabilise slopes and escarpments, ultimately altering habitat niches). The practice of mining has the potential to alter / reduce the availability of habitat suitable for rare and threatened flora and fauna. Therefore, monitoring the species that are present, their ecology and natural variation before, during and after mining is integral in assessing any impacts incurred by underground mining.

Remaining areas are comprised of a mixture of rural areas, existing mining infrastructure, roads, easements, and tracks associated with recreational activities through Mt Airly and Genowlan Mountain. The study area is characterised by steep and rugged topography. Site elevation varies from 1,000 m above sea level at Mount Airly, to less than 400 m in the south-eastern section of the study area.

1.3 Objectives

This report documents the methods and results obtained from the Summer (February) and Spring (November) 2021 monitoring works as specified in the EP BMP (RPS 2018) for the study area. Discussion and recommendations are provided where relevant to compliance matters.



TITLE : FIGURE 1: SITE LOCATION

LOCATION : AIRLY

DATUM:GDA2020

PROJECTION: GDA2020 MGA Zone 56

DATE : **1/02/2022**

PURPOSE: **BMP**

VERSION (PLAN BY): A A3 (natalie.wood)

PATH: S:\Centennial\All Jobs\149004 Airly BMP Seasonal Ecological Monitoring 2021\10 - Drafting\Arcgis Map Documents\Eco\BMP Report Figures\149004 BMP Figure 1 Location A A3 20220201.mxd

CLIENT: **CENTENNIAL**

JOB REF: **PR149004**

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1.4 Compliance

This annual monitoring addresses the biodiversity-related conditions of consent outlines in SSD-5581. Schedule 3, Condition 2 of the SD-5581 development consent specifies the following requirements:

- Negligible environmental consequences for the threatened species, threatened populations, EECs and groundwater dependent ecosystems (with the exception of those listed below); and
- No environmental consequences for *Pultenaea sp*. Genowlan Point population and Genowlan Point *Allocasuarina nana* Heathland community (addressed in a separate report prepared by National Parks)

This monitoring report comprises information pertaining to the first of the two aforementioned requirements, whereas the second requirement is addressed in a separate monitoring report prepared by National Parks.

Annual monitoring is conducted with reference to the Airly Site Specific BMP and Airly Mine Splitting and Quartering Extraction Plan (ML1331) - Biodiversity Management Plan (EP BMP (RPS 2018)), which were developed in response to Schedule 4, Condition 17 of SD_5581.

The following Airly Site Specific BMP priorities and the sections in which they are addressed in this report are provided in **Table 1-1** below. Biodiversity related conditions of Development Consent SSD_5581 that are considered within this report are provided in **Table 1-2**.

Table 1-1: Biodiversity monitoring requirements

Monitoring type	Location addressed in report
Capertee Rough-barked Apple-Redgum-Yellow Box Grassy Woodland (MU20)	**Section 3.2.3**
Glossy-black Cockatoos (*Calyptorhynchus lathami*)	**Section 3.3.1**
Large Forest Owls	**Section 3.3.2**
Mount Vincent's Mint-bush (*Prostanthera stricta*)	**Section 3.2.1**
Capertee Stringybark (*Eucalyptus cannonii*)	**Section 3.2.2**
Diurnal birds, including threatened and regionally significant woodland bird species	**Section 3.3.3**
Cave-dwelling microbats	**Section 3.3.4**
Other targeted fauna/vertebrate census	**Section 3.3.5**
Feral species	**Section 3.3.6**

Table 1-2: Compliance with biodiversity related conditions of Development Consent SSD_5581

Schedule/ Condition	Action	Compliant
Schedule 3 Condition 2	Negligible environmental consequences to threatened species, threatened populations, EEC and groundwater dependant ecosystems	Yes
Schedule 4 Condition 15	Prior to carrying out any development under this consent that would cause surface disturbance, the Applicant must prepare a Biodiversity Management Plan for the development to the satisfaction of the Secretary. This Plan Must:	
	a. Be prepared in consultation with BCD and DoEE;	Yes – As per Airly Site Specific BMP
	b. Established baseline data for existing remnant vegetation and habitat on site, including mapping of the location of *Pultenaea sp*. Genowlan Point;	Yes – Baseline data has been established and outlined in the 'Baseline Data – Terrestrial Ecology' section of the Airly Site Specific BMP. Mapping of *Pultenaea sp.* Genowlan Point has been conducted independently by NSW National Parks and Wildlife Services (NPWS).
	c. Describe the short, medium and long-term measures that would be implemented to manage the remnant vegetation and habitat on site, including but not limited to; – *Prostanthera stricta* (Mt. Vincent Mintbush); – *Eucalyptus cannonii* (Capertee Stringybark); – *Pultenaea sp.* Genowlan Point; and – Genowlan Point *Allocasuarina nana* Heathland.	Yes – Management measures for *Prostanthera stricta* and *Eucalyptus cannonii* are managed via monitoring programs outlined in this report. Management measures for *Pultenaea sp*. Genowlan Point and Genowlan Point *Allocasuarina nana* Heathland will be undertaken and described by NSW NPWS.
	d. Include a detailed description of the measures that would be implemented to: – Minimise the impacts to fauna of site, including undertaking pre-clearance surveys; – Avoid and mitigate the spread of *Phytopthora cinnamon*; – Control weeds and Feral pests including, but not limited to goats, rabbits, European Red Fox, cats and pigs; – Manage salinity; – Control erosion; – Control Access; and – Manage bushfire risk	Yes; – Western Region BMP Section 4.3 Surface disturbance activities describes the procedure for all surface disturbance activities, including the completion of the Centennial Coal Land Disturbance Protocol. – Measures to avoid and mitigate the spread of *P. cinnamomi* are addressed in the Management section of the Airly Site Specific BMP – Management in State Conservation Area undertaken by NPWS. The incursion and spread of weeds and feral animals is monitored opportunistically as part of the annual Airly monitoring program – Addressed in Airly Water Management Plan – Addressed in Airly Water Management Plan – Control access is currently being implemented via the use of gates and signage throughout the Airly lease – Implemented as per Airly Site Specific BMP
	e. Include a program to monitor and report on the effectiveness of these measures and progress against the detailed performance and completion criteria;	Yes – Management Section of the Airly Site Specific BMP describes the monitoring program to demonstrate the effectiveness of management

Schedule/ Condition	Action	Compliant
		measures. The requirements for reporting against the BMP are included in the Western Region BMP Section 5.4.
	f. Include details of who would be responsible for monitoring, reviewing and implementing the plan	Yes – Identification of responsible persons for monitoring, reviewing and implementing the Western Region BMP are included in Section 5.1 of that BMP.
Schedule 6 Condition 11	a. describe the development (including any rehabilitation) that was carried out in the previous calendar year, and the development that is proposed to be carried out over the current calendar year;	Yes - Addressed within the Airly Mine Annual Review document
	b. Include a comprehensive review of the monitoring results and compliance record of the development over the previous calendar year, which includes a comparison of these results against: – the relevant statutory requirements, limits or performance measures/criteria; – the monitoring results of the previous years; and – the relevant predictions in the documents listed under condition 2(a) and the IPRP's Report;	Yes - Addressed within Sections 2, 3 and 4 of this report. Note: IPRP's report does not have any specific recommendations relating to ecological monitoring
	c. Identify any non-compliance over the last year, and describe what actions were (or are being) taken to ensure compliance;	Yes – There were no non-compliance issues relating to biodiversity monitoring criteria during the monitoring period of 2021. Any non-compliances outside of biodiversity monitoring and management have been addressed with in the non-compliance section of the Airly Mine 2020 Annual Review.
	d. Identify any trends in the monitoring data over the life of the development;	Yes - Addressed in Sections 3 and 4 of this report.
	e. Identify any discrepancies between the predicted and actual impacts of the development, and analyse the potential cause of any significant discrepancies; and	Yes - There have been no discrepancies between the predicted and actual impacts of Airly Mine operations on any ecological parameters. See Section 3 and 4 of this report.
	f. describe what measures will be implemented over the next year to improve the environmental performance of the development.	Recommended improvement opportunities are provided in Section 4 of this report.

2 METHODS

2.1 Overview

2.1.1 Monitoring Approach

The Sustainable Minerals Institute (SMI CMLR) applied the principles of a Before After Control Impact (BACI) monitoring design in developing the monitoring program in the BMP (SMI CMLR 2013). In a BACI design, data is simultaneously collected at 'Impact' and 'Control' sites, before and after an impact occurs, thus establishing a comparative quantitative dataset suitable for determining causation where significant change is detected within an 'impact site'.

2.1.2 Airly Monitoring Program

Annual flora and fauna monitoring at Airly Colliery in 2021 was completed in both summer, from February 1st to the 5th February, and spring, from 1st November to 5th November[1].

The monitoring methods performed in the annual monitoring program are in line with the BMP for Cliff Line Zone of First Workings within ML1331 for the Airly Mine (RPS 2018). Details on which methods were completed in the February and November monitoring events are provided below in **Table 2-1**. The location of each monitoring site is illustrated on **Figure 2**.

Table 2-1: Target Species and Monitoring Methods

Target Species	Monitoring Methods	February 2021 Monitoring	November 2021 Monitoring
Prostanthera stricta	Point intercept method and floristic density plots in permanent survey sites	4/11 *P. stricta* sites completed (Plots 6-9)	9/11 *P. stricta* sites completed (1-5, 7, 9, 12, 13)
Eucalyptus cannonii	Eighteen individual trees1 assessed for condition, crown extent and growth changes	*E. cannonii* Sites 1-15 completed	Plots 16, 17 and 18 not completed due to poor weather conditions and mountain closures
Capertee Rough-barked Apple – Redgum – Yellow Box Grassy Woodland (MU 20)	Repeated BAM plots to assess vegetation condition	4/4 Plots completed	No plots were completed in November 2021 due to poor weather conditions.
Glossy Black-Cockatoos	Percent cover of *Allocasuarina* species present at permanent survey sites and the presence of chewed orts was recorded	4/6 Completed (Sites 5, 3, 2, and unknown).	Sites 1 and 4 not completed due to poor weather conditions and mountain closures
Large Forest Owls	Targeted call-playback, spotlighting and surveys near previously identified roost trees/habitat	Site 3 and 4 completed	Site 1, 3 and 4 completed. Site 2 is no longer accessible due to road closures.
Diurnal Birds	30-minute surveys across permanent transects and opportunistic surveys	7 sites completed	7 sites completed

[1] Notes: 1) Monitoring surveys sites for *E. cannonii* increase during the Spring 2017-Summer-2018 monitoring program from eight (8) to eighteen (18) locations in consultation with DPIE (formerly OEH), including sites within the New Hartley Shale Mine Potential Interaction Area.

Target Species	Monitoring Methods	February 2021 Monitoring	November 2021 Monitoring
Cave-Dwelling Microbats	Anabat units to detect presence of microbat species	Completed (5 anabats over 4 nights)	Completed (6 anabats over 4 nights)
Other Targeted Species (Spotted-tailed Quoll (*Dasyurus maculatus*), Broad-headed Snakes (*Hoplocephalus bungaroides*), Rosenberg's Goanna (*Varanus rosenbergi and Phascolarctos cinereus (Koala)*	Suitable habitat for these species was targeted via camera trapping/ opportunistic sightings	Spotlighting and baited camera trapping completed (14 camera traps)	Spotlighting and baited camera trapping completed. Opportunistic sightings recorded (7 camera traps)
Vertebrate Census and Feral Species	Camera trapping/ opportunistic sightings	Opportunistic sightings recorded	Spotlighting, camera trapping and opportunistic sightings completed

2.1.3 Limitations

In reviewing the design of the SMI CMLR (2013) monitoring program it is noted that it resembles a more simplistic Before-After monitoring framework. This is apparent in the transition of 'control' sites to 'impact' sites as the mining face progresses. As indicated in a BACI monitoring model, a 'Before-After' model is able to detect change over time; however, is unable to accurately define causation for this change (i.e. is it mining related?). While repeated measures methods have been adopted for most monitoring activities (i.e. sampling the exact same area or transect), a Before-After monitoring framework cannot distinguish between the effects of external unrelated variables such as bushfire, rainfall or drought and those originating from operational activities. These design flaws are irreconcilable unless the program is revised to include control sites that are permanent quarantined from an operational related impact.

2.2 Flora

The following sections detail the monitoring methods utilised in the 2021 surveys for the threatened flora species: *Prostanthera stricta*, *Eucalyptus cannonii*, as well as the Capertee Rough-barked Apple – Redgum – Yellow Box Grassy Woodland (MU 20), which is commensurate with White Box Yellow Box Blakely's Gum Woodland Box Gum Woodland (BGW). BGW is listed as endangered under the *Biodiversity Conservation Act* 2016 (BC Act) and critically endangered under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).

2.2.1 *Prostanthera Stricta* (Mount Vincent Mint-bush)

Prostanthera stricta is monitored using 50m long point intercept transects located across the study area. Start and end points coordinates are staked out and these coordinates are accurately recorded using a differential GPS units.

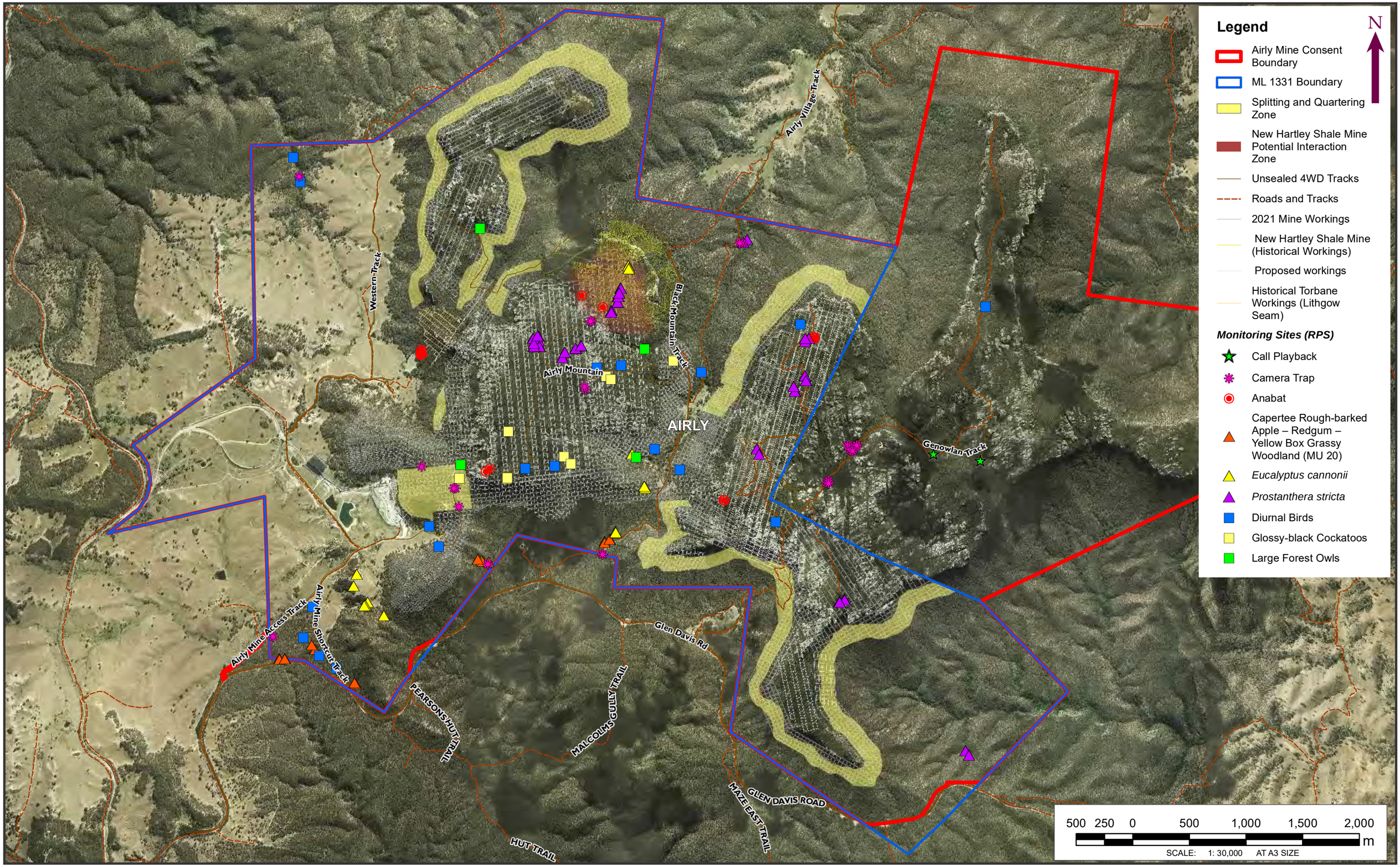
The point intercept method was used to determine the density of *P. stricta* populations across 11 separate 50m transects (**Figure 3**). Any section of *P. stricta* that was seen to be overhanging or underneath the transect lines were measured to the nearest 5mm. (Elzinga et al, 2001). Once transect point data was recorded, a percentage cover score was calculated for each transect. Additionally, floristic data within 5x5m plots is also collected. These plots were carried out at the start of each transect with the aim to record all vascular flora present at the time of the survey. This data is then compared with previous seasons data to determine if any change has occurred.

2.2.2 *Eucalyptus cannonii*

Individuals of the threatened species *Eucalyptus cannonii* are permanently monitored. The following assessments are conducted during each monitoring period:

a. Condition
    i. Crown density %;
    ii. Crown extent %; and
    iii. Crown epicormic growth extent %
b. Contextual
    i. Tree species;
    ii. Height;
    iii. Diameter at Breast Height (DBH);
    iv. Geographic position;
    v. Altitude; and
    vi. Date and time.

Data collected is analysed against previous monitoring events to examine for change.



TITLE : FIGURE 2: FLORA AND FAUNA MONITORING SITES

LOCATION : AIRLY

DATUM:GDA2020

PROJECTION: GDA2020 MGA Zone 56

DATE : **24/02/2022**

PURPOSE: **BMP**

VERSION (PLAN BY): A A3 (Natalie.Wood)

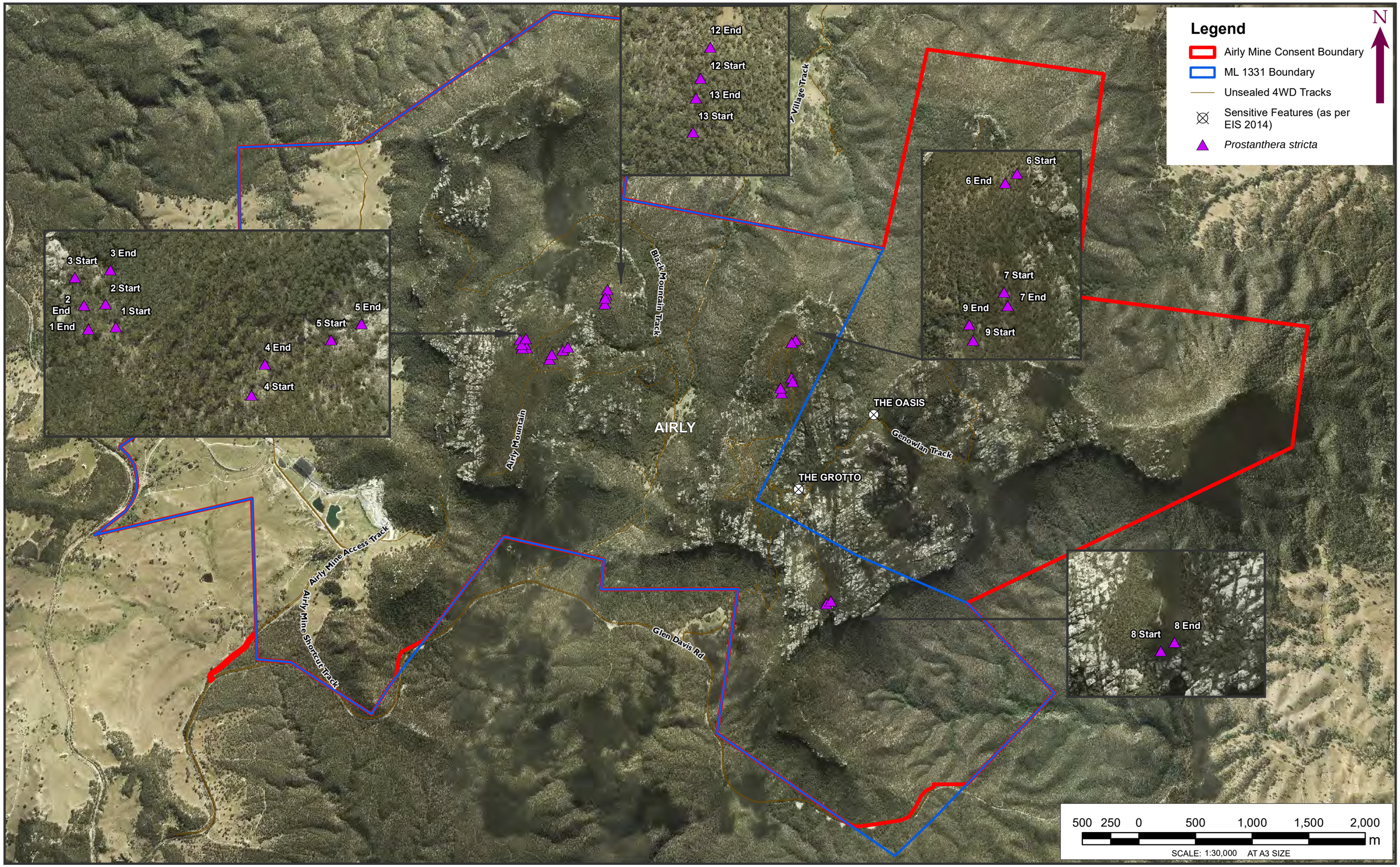
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CLIENT: **CENTENNIAL**

JOB REF: **PR149004**

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TITLE : FIGURE 3: *Prostanthera stricta* MONITORING SITES

LOCATION : AIRLY

DATUM:GDA2020

PROJECTION: GDA2020 MGA Zone 56

DATE : **1/02/2022**

PURPOSE: **BMP**

VERSION (PLAN BY): A A3 (natalie.wood)

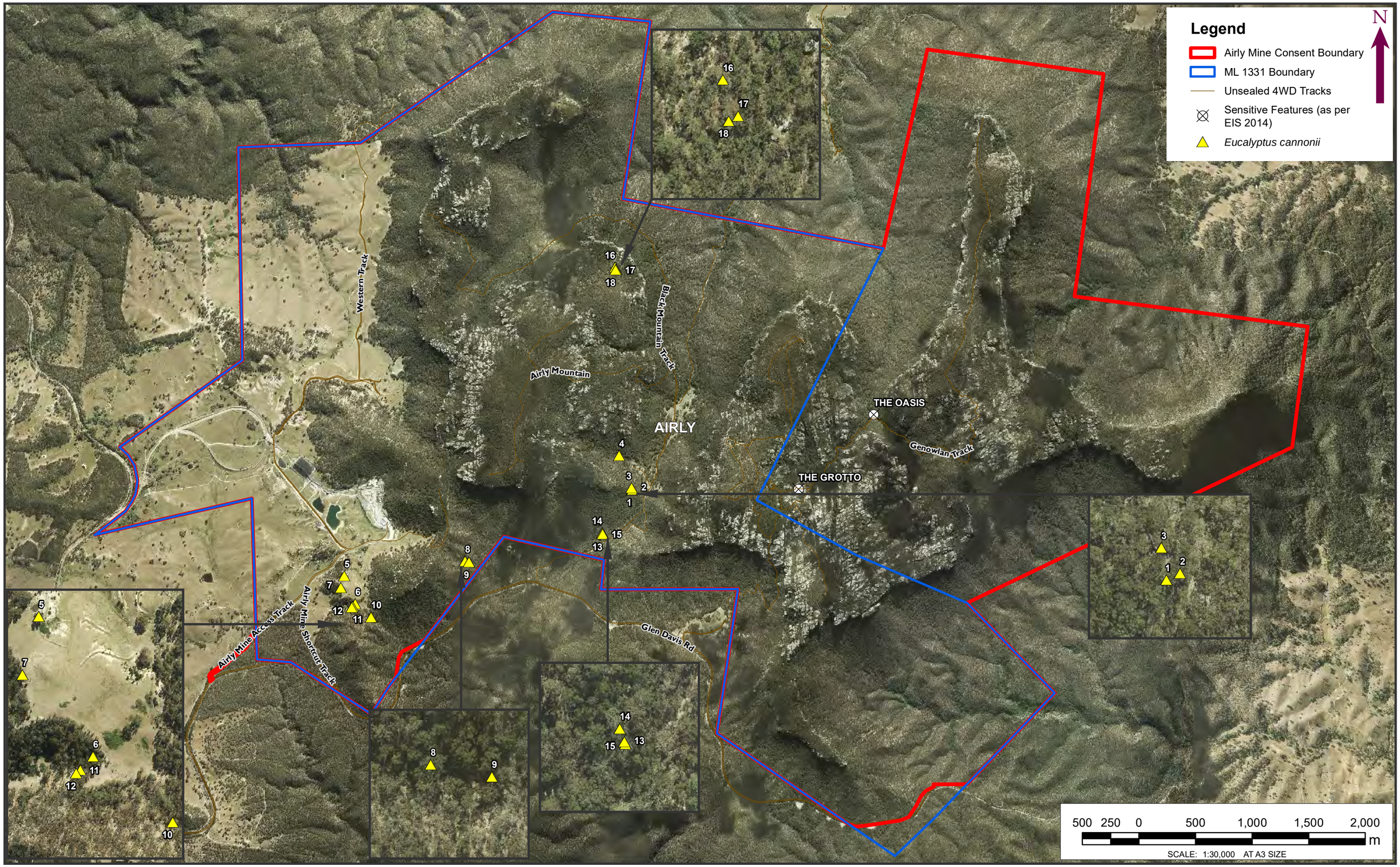
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CLIENT: **CENTENNIAL**

JOB REF: **PR146412**

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TITLE : FIGURE 4: *Eucalyptus cannonii* MONITORING SITES

LOCATION : AIRLY

DATUM:GDA2020

PROJECTION: GDA2020 MGA Zone 56

DATE : **1/02/2022**

PURPOSE: **BMP**

VERSION (PLAN BY): A A3 (natalie.wood)

PATH: S:\Centennial\All Jobs\149004 Airly BMP Seasonal Ecological Monitoring 2021\10 - Drafting\Arcgis Map Documents\Eco\BMP Report Figures\149004 BMP Figure 4 Eucalyptus cannonii A A3 20220201.mxd

CLIENT: **CENTENNIAL**

JOB REF: **PR149004**

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2.2.3 Box Gum Woodland

BGW plots were monitored using plots measuring flora composition, vegetation structure and ecological function as defined by the Biodiversity Assessment Methodology (BAM). Four established BAM plots have been used to gather repeated monitoring data, the location of these plots illustrated in **Figure 5**. These plots were originally established to collect data under the previous BioBanking Assessments Method (BBAM), with data collection transitioned to BAM methodology following the commencement of the BC Act.

The start and end points of each BAM plot (i.e. 50 m central transect) are marked with wooden stakes and labelled. Location data for each of these points was recorded using a differential GPS in MGA2020 (Zone 56). Photographs were taken of each BAM plot from a standardised point coincident with the transect origin (i.e. recorded GPS point) at an approximate height of 1.5 m. A horizontal field of view of approximately 40 degrees is achieved, which is within the central angle of view for human vision (i.e. 40-60 degrees).

Site attributes and variables measured within a 1,000m^2 BAM plot are provided in **Table 2-2** below. Cover and abundance for each plant species was estimated in accordance with **Table 2-3**.

Table 2-2: BAM Plot: Site Attributes and Measurement method

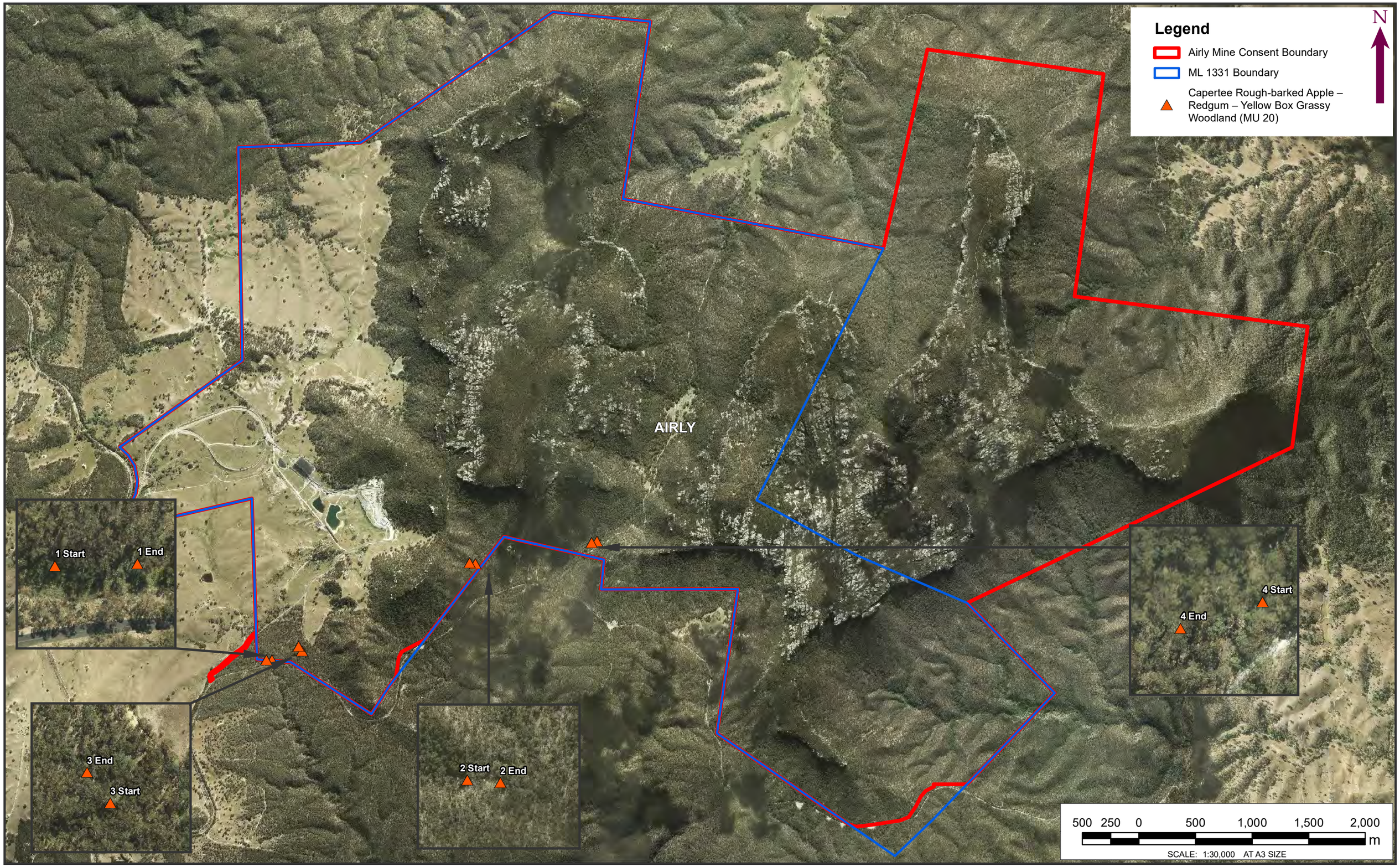
Site Attribute	Measurement Method
Stratum (and layer)	Stratum and layer in which each species occurs
Growth form	Growth form for each recorded species
Species name	Scientific name and common name
Cover	Estimate the % foliage cover across the plot of each species rooted in or overhanging the plot. Cover is recorded in decimals of less than 1%, or whole numbers up to 5%, or to the nearest 5% where greater than 5% cover

Table 2-3: Cover and Abundance

Attribute	Survey Requirement
Abundance rating	For species with cover less than or equal to 5%, count or estimate the number of individuals or shoots of each species within the plot, using the following intervals: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 50, 100, 500, 1,000, 1,500, 2,000 etc. Numbers above 20 are estimates only, and the recorded abundance is the upper end of each class (e.g. 50 represents an estimated abundance of between 20-50). For species with cover greater than 5%, abundance estimates are not required but may be recorded if required

2.2.4 Exotic species

Exotic species establishment was estimated in conjunction with the BAM plots. Within the 20 x 20 m quadrant at each site the total cover and abundance of exotic species was recorded. Total exotic species is calculated and exotic species with a cover of 5% or greater are discussed.



TITLE : FIGURE 5: MU20 (Capertee Rough-barked Apple- Redgum- Yellow-box Grassy Woodland) BAM Plots

LOCATION : AIRLY

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **1/02/2022**

PURPOSE: **BMP**

VERSION (PLAN BY): A A3 (natalie.wood)

PATH: S:\Centennial\All Jobs\149004 Airly BMP Seasonal Ecological Monitoring 2021\10 - Drafting\Arcgis Map Documents\Eco\BMP Report Figures\149004 BMP Figure 5 Capertee Rough- (MU 20) A A3 20220201.mxd

CLIENT: **CENTENNIAL**

JOB REF: **PR149004**

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2.3 Fauna

2.3.1 Glossy Black Cockatoos

Monitoring for evidence of Glossy Black-Cockatoos was undertaken in February and November 2021. Glossy Black-Cockatoos have a particular diet and feed only on the seeds in cones of She-oaks (*Casuarina and Allocasuarina sp*., but specifically *Allocasuarina littoralis* (Black She-oak)) within the Airly mining lease. Those cones, referred to as 'orts' are then discarded, leaving evidence of Glossy Black- Cockatoo activity. The orts can thus be used to detect recent activity of Glossy Black-Cockatoos in the locality.

Monitoring involves surveying for the presence of chewed orts within six 50 x 50 m stands of *Allocasuarina littoralis* in order to determine recent utilisation of the habitat as shown in **Figure 6**. Attributes measured within each 50 m^2 search area include:

- Per cent canopy cover and per cent *Allocasuarina* species cover;
- Presence of orts; and
- Presence of Glossy Black Cockatoos.

Additionally, if any Glossy-Black Cockatoo individuals were observed outside of these plots they are recorded by GPS location and photos are taken where practicable.

2.3.2 Large Forest Owls

Monitoring for evidence of Large Forest Owls was undertaken in November 2021. This monitoring targets previously known areas of owl activity (e.g. roost or sighting), looking for any evidence of Powerful Owls, Sooty Owls and Marked Owls presence within these areas. The method for monitoring these species is discussed below.

- Visiting areas of previous sightings/roosts and recording any evidence of owl pellets and/or individuals;
- Call playback using a megaphone, broadcasting calls to seek a response;
- Spotlighting across two nights following call playback; and
- Installation and analysis of song meter data across a survey week in summer.

The location of owl roost/previous sighting sites are provided in **Figure 7**. Spotlighting, call playback and song meter placement completed in 2021 are displayed in **Figure 10**.

2.3.3 Diurnal Birds

Threatened bird species are monitored using permanent transects, diurnal bird surveys and opportunistic surveys throughout the study area. Previously established sites are used to continue monitoring for threatened bird species and allow for comparisons between seasons/years. Sites included four habitat types; grassland, woodland, wet forest and pagoda shrubland, the locations of which are shown in **Figure 8**. Target bird species are listed in **Table 2-4**.

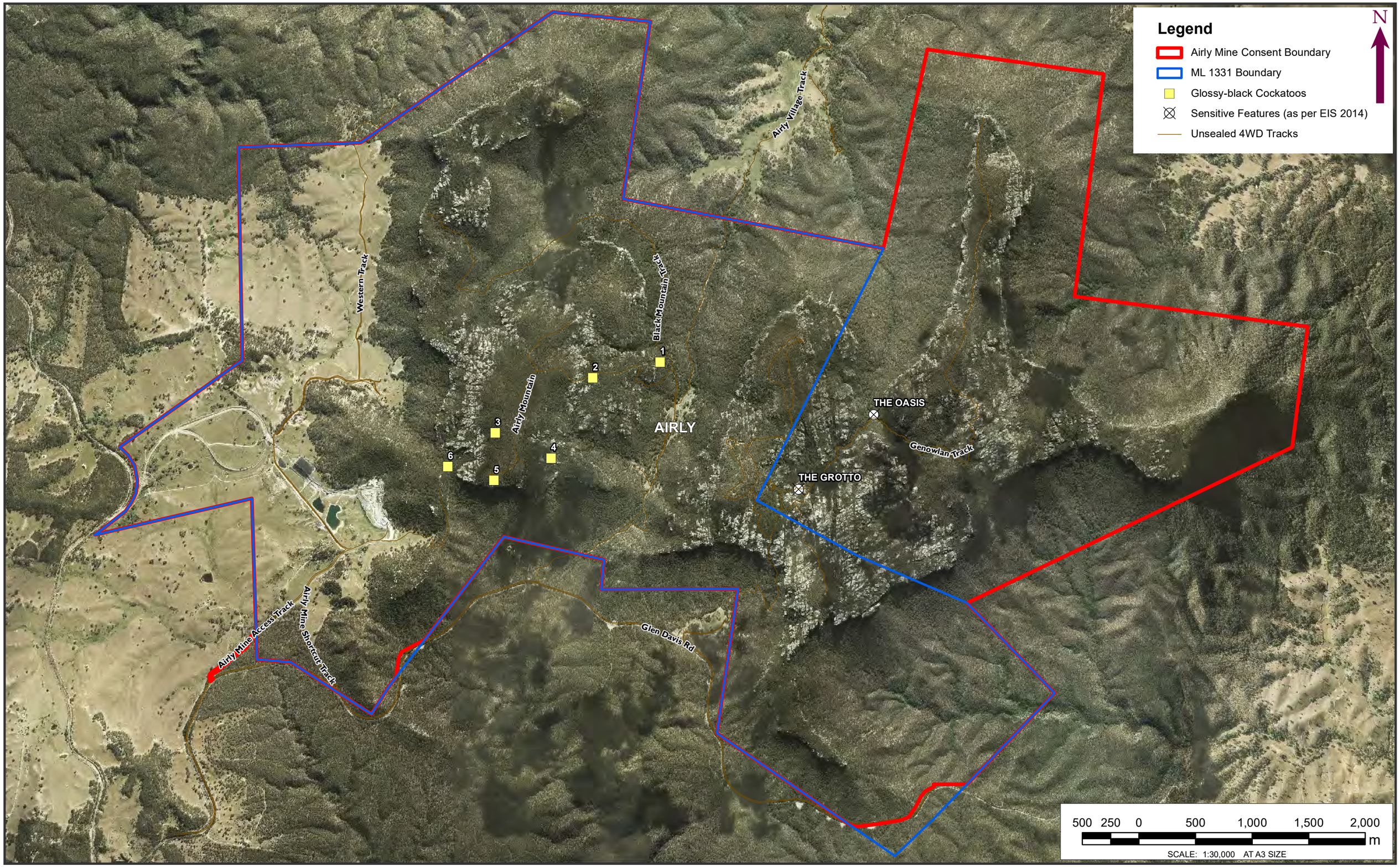
Table 2-4: Target Bird Species

Scientific Name	Common Name	Conversation Status
Anthochaera phrygia	Regent Honeyeater	Critically Endangered under EPBC Act Critically Endangered under BC Act
Melithreptus gularis	Black-chinned Honeyeater	Vulnerable under BC Act
Climacteris picumnus	Brown Treecreeper	Vulnerable under BC Act
Stagonopleura guttata	Diamond Firetail	Vulnerable under BC Act
Petroica phoenicea	Flame Robin	Vulnerable under BC Act
Petroica boodang	Scarlet Robin	Vulnerable under BC Act
Melanodryas cucullata cucullata	Hooded Robin	Vulnerable under BC Act
Callocephalon fimbriatum	Gang-gang Cockatoo	Vulnerable under BC Act

Scientific Name	Common Name	Conversation Status
Pachycephala inornata	Gilbert's Whistler	Vulnerable under BC Act
Calyptorhynchus lathami	Glossy Black-Cockatoo	Vulnerable under BC Act
Glossopsitta pusilla	Little Lorikeet	Vulnerable under BC Act
Grantiella picta	Painted Honeyeater	Vulnerable under BC Act
Ninox strenua	Powerful Owl	Vulnerable under BC Act
Tyto tenebricosa	Sooty Owl	Vulnerable under BC Act
Chthonicola sagittatus	Speckled Warbler	Vulnerable under BC Act
Daphoenositta chrysoptera	Varied sittella	Vulnerable under BC Act
Pomatostomus temporalis	Grey-crowned Babbler	Vulnerable under BC Act
Artamus cyanopterus	Dusky Woodswallow	Vulnerable under BC Act

The methodology includes prescribed transects, conducted for approximately 20 minutes by two personnel with all birds observed and heard being documented. Variables that may influence bird presence include type of habitat disturbance, amount of flowering vegetation, and weather conditions.

During 2021 diurnal bird species were also detected through the placement of song meters within the study area.



TITLE : FIGURE 6: Glossy-black Cockatoo Monitoring Sites

LOCATION : AIRLY

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **1/02/2022**

PURPOSE: **BMP**

VERSION (PLAN BY): A A3 (natalie.wood)

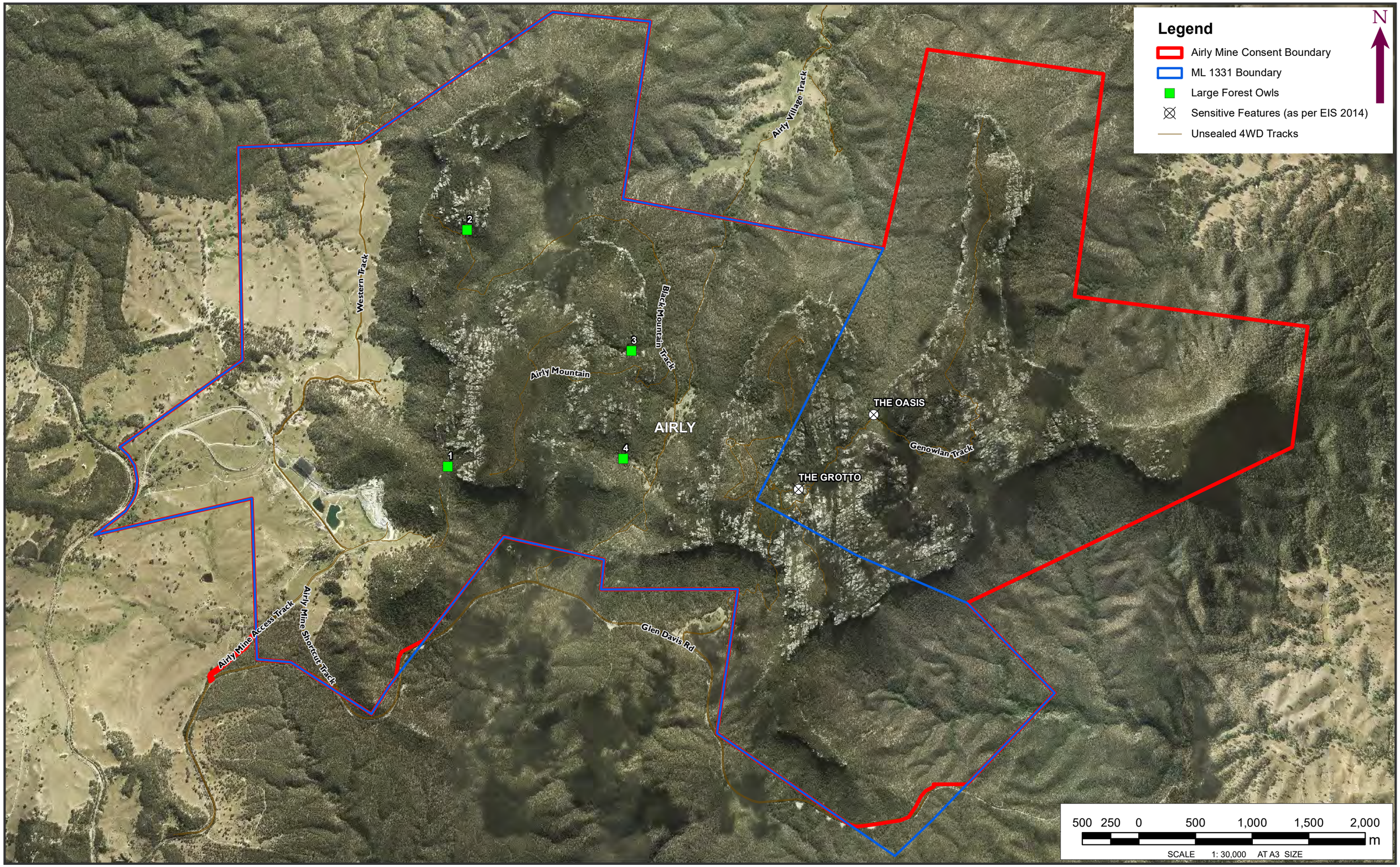
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CLIENT: **CENTENNIAL**

JOB REF: **PR149004**

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TITLE : FIGURE 7: Large Forest Owl roosts, and observations

LOCATION : AIRLY

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **1/02/2022**

PURPOSE: **BMP**

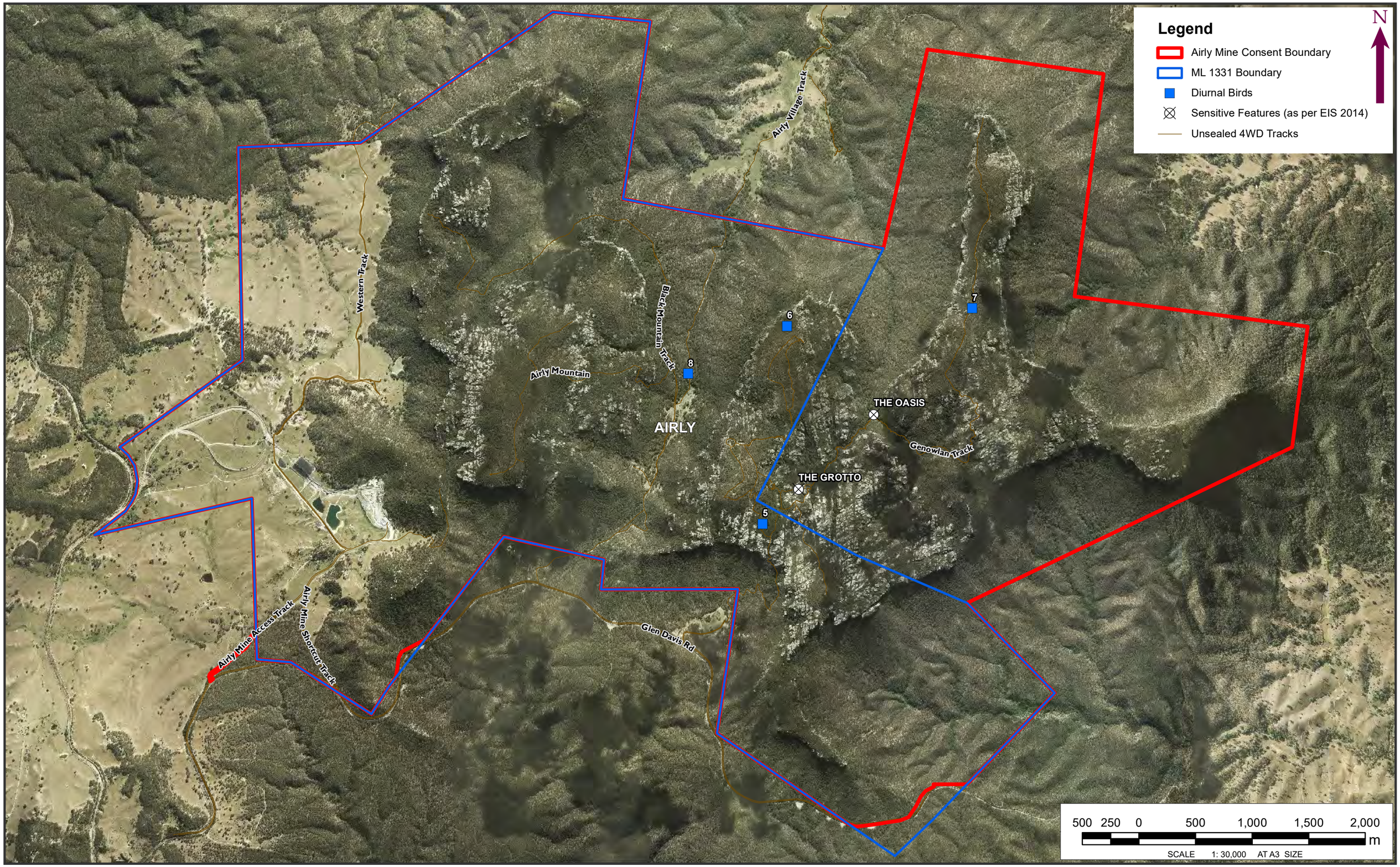
VERSION (PLAN BY): A A3 (natalie.wood)

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CLIENT: **CENTENNIAL**
JOB REF: **PR149004**

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TITLE : FIGURE 8: Diurnal Bird Transect Sites

LOCATION : AIRLY

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **1/02/2022**

PURPOSE: **BMP**

VERSION (PLAN BY): A A3 (natalie.wood)

PATH: S:\Centennial\All Jobs\149004 Airly BMP Seasonal Ecological Monitoring 2021\10 - Drafting\Arcgis Map Documents\Eco\BMP Report Figures\149004 BMP Figure Figure 8 Diurnal Birds A A3 20220201.mxd

CLIENT: **CENTENNIAL**

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2.3.4 Cave-dwelling Microbats

Anabats were used to record ultrasonic bat calls of targeted cave-dwelling bats that are known to occur in specific habitat types at Airly. Anabats were deployed at six sites including two adit roosts to evaluate foraging habitat and roosting habitat. Target bat species are listed in **Table 2-5**. Anabat locations for 2021 are provided in **Figure 9**.

Table 2-5: Target Microbat Species

Scientific Name	Common Name	Conversation Status
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Vulnerable under BC Act Sensitive to geological instability
Rhinolophus megaphyllus	Eastern Horseshoe bat	Sensitive to geological instability
Chalinolobus dwyeri	Large-eared Pied bat	Vulnerable under BC Act and EPBC Act Sensitive to geological instability

The identification of bat echolocation calls recorded during surveys was undertaken using Anabat Insight (Titley Electronics, Version 2.0.2) software. Reference calls were obtained from the NSW database and from the authors personal collection. Each call sequence ('pass') was assigned to one of five categories, according to the confidence with which an identification could be made, being:

- Definite - Pass identified to species level and could not be confused with another species;
- Probable - Pass identified to species level and there is a low chance of confusion with another species
- Possible - Pass identified to species level but short duration or poor quality of the pass increases the chance of confusion with another species;
- Species group - Pass could not be identified to species level and could belong to one of two or more species. Occurs more frequently when passes are short or of poor quality; and
- Unknown - Either background 'noise' files or passes by bats which are too short and/or of poor quality to confidently identify.

2.3.5 Other Target Fauna

Other targeted fauna included the threatened Spotted-tailed Quoll (*Dasyurus maculatus maculatus*) and Rosenberg's Goanna (*Varanus rosenbergi*) which have previously been detected within the Airly mining lease site. Stationary infrared cameras were deployed during fauna monitoring periods in areas of suitable habitat as shown in **Figure 10**. Gully habitats were targeted for the Spotted-tailed Quoll, whereas lower lying rocky habitats were targeted for the Rosenberg's Goanna. At each location, a tin of sardines was used to attract species. **Table 2-6** lists the additional target fauna for the program.

Due to recent sightings, June 2018, November 2021 and January 2021 Koalas were also targeted, as this species is uncommonly recorded within the area. Passive acoustic surveys utilising song meters were placed within the Airly BMP to detect Koala bellows.

Table 2-6: Additional Target Fauna Species

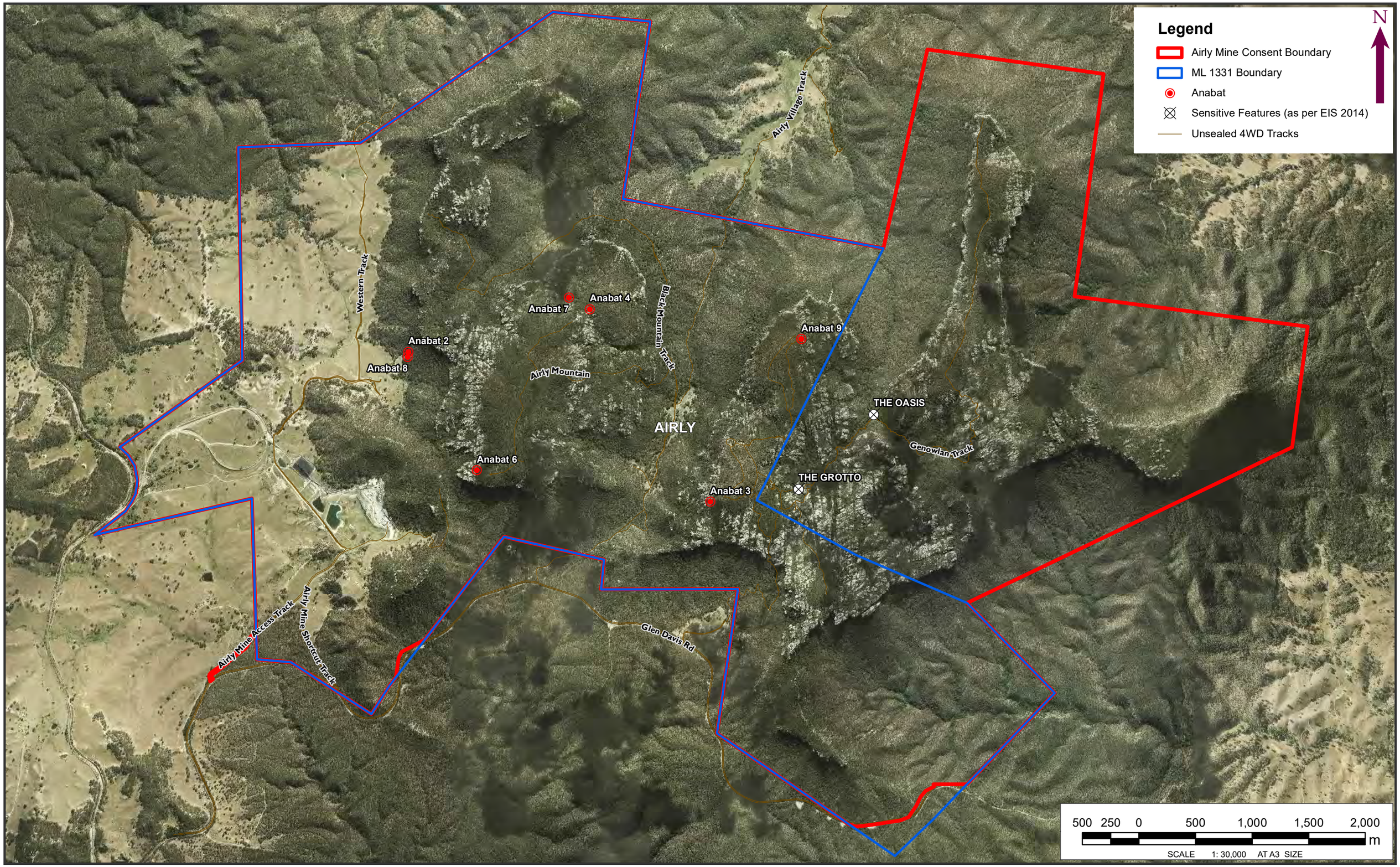
Scientific Name	Common Name	Conversation Status
Dasyurus maculatus	Spotted-tailed Quoll	Vulnerable under BC Act Endangered under EPBC Act Sensitive to habitat alteration
Varanus rosenbergi	Rosenberg's Goanna	Vulnerable under BC Act
Hoplocephalus bungaroides	Broad-headed Snake	Endangered under BC Act Vulnerable under EPBC Act
Phascolarctos cinereus	Koala	Vulnerable under BC Act Endangered under EPBC Act

2.3.6 Vertebrate Census

During all other monitoring events, all vertebrate fauna species observed or heard opportunistically were recorded. The inventory is aimed at the following:

- Recording basic presence/absence of all vertebrates within the study area, regardless of their potential sensitivity to undermining or conservation status;
- Detecting new or rare species that may require future monitoring, but have not been recorded within the study area previously; and
- Detection of feral fauna species.

Passive monitoring techniques were used (i.e. camera traps, as discussed in **Section 2.3.5** above) in addition to opportunistic observations.



TITLE : FIGURE 9: Microbat monitoring sites (Anabat locations)

LOCATION : AIRLY

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **24/02/2022**

PURPOSE: **BMP**

VERSION (PLAN BY): A A3 (Natalie.Wood)

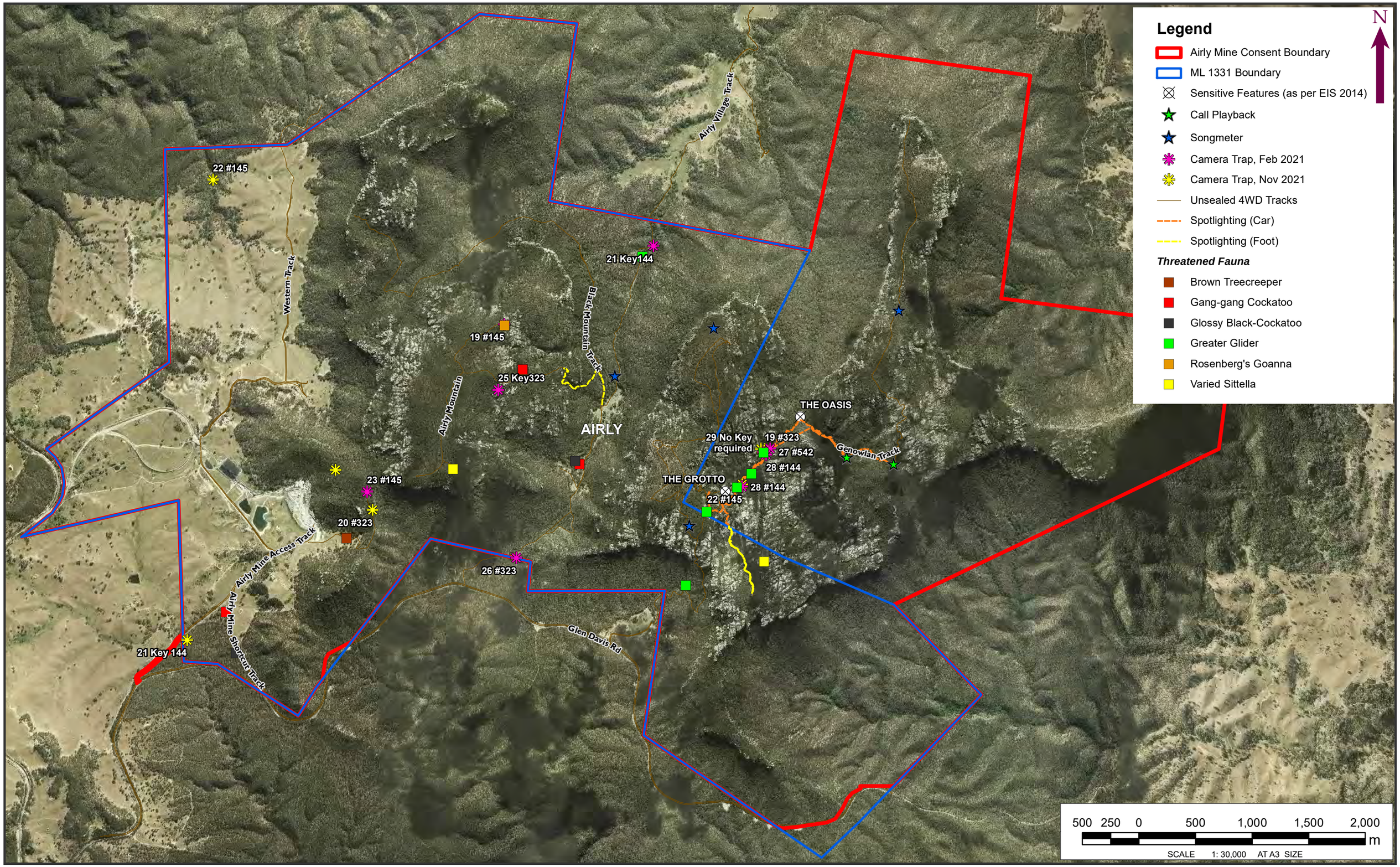
PATH: S:\Centennial\All Jobs\149004 Airly BMP Seasonal Ecological Monitoring 2021\10 - Drafting\Arcgis Map Documents\Eco\BMP Report Figures\149004 BMP Figure 9 Microbat A A3 20220201.mxd

CLIENT: **CENTENNIAL**

JOB REF: **PR149004**

RPS AUSTRALIA EAST PTY LTD (ABN 44 140 292 762)
Unit 2A, 45 Fitzroy Street, Carrington, NSW, Australia, 2294 PO Box 120, Carrington, NSW, 2294
T: 02 4940 4200 F: 02 4940 4299 www.rpsgroup.com.au

MAKING COMPLEX EASY



TITLE : FIGURE 10: Other Threatened Fauna Monitoring Sites.

LOCATION : AIRLY

DATUM:GDA 1994

PROJECTION: GDA 1994 MGA Zone 56

DATE : **24/02/2022**

PURPOSE: **BMP**

VERSION (PLAN BY): A A3 (Natalie.Wood)

PATH: S:\Centennial\All Jobs\149004 Airly BMP Seasonal Ecological Monitoring 2021\10 - Drafting\Arcgis Map Documents\Eco\BMP Report Figures\149004 BMP Figure 10 Th Fauna Monitoring A A3 20220201.mxd

CLIENT: **CENTENNIAL**

JOB REF: **PR149004**

RPS AUSTRALIA EAST PTY LTD (ABN 44 140 292 762)
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3 RESULTS

3.1 Weather

The Bureau of Meteorology (BOM) and Geoscience Australia provides the weather details for all survey periods as outlined in **Table 9** and **Table 10**. Weather data is collected from Lithgow (Cooerwull) {station 063226}.

Table 3-1: Temperature, Rainfall and Day Length during the February 2021 Monitoring Period

Date	Min Temp (°C)	Max Temp (°C)	Rainfall (mm)	Sun Rise – Sun Set
01/02/2021	15.2	27.2	0.2	05:23 - 19:04
02/02/2021	12.7	22.8	34.6	05:24 - 19:03
03/02/2021	10.3	20.8	0	05:25 - 19:03
04/02/2021	10.7	26.2	0	05:26 - 19:02
05/02/2021	13.7	27.4	3.8	05:27 - 19:01

BOM- http://www.bom.gov.au/climate/dwo/202102/html/IDCJDW2075.202102.shtml
Geoscience AUS- http://www.ga.gov.au/geodesy/astro/sunrise.jsp

Table 3-2: Temperature, Rainfall and Day Length during the November 2021 Monitoring Period

Date	Min Temp (°C)	Max Temp (°C)	Rainfall (mm)	Sun Rise – Sun Set
01/11/2021	3.6	18.4	0	05:01 - 18:27
02/11/2021	5.0	20.1	0	05:00 - 18:28
03/11/2021	4.6	22.1	0	04:59 - 18:28
04/11/2021	13.1	15.8	6.8	04:58 - 18:29
05/11/2021	11.6	16.7	18.6	04:57 - 18:30

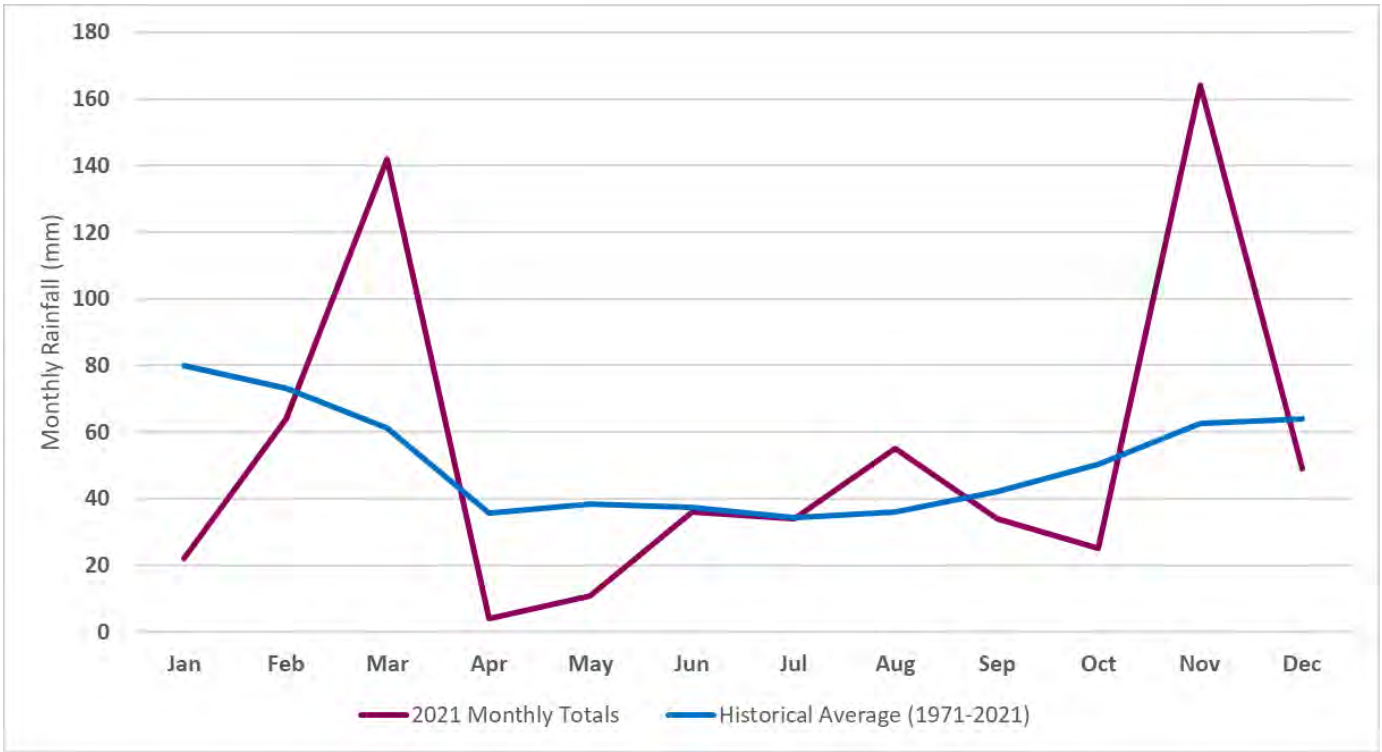
BOM- http://www.bom.gov.au/climate/dwo/202102/html/IDCJDW2075.202102.shtml
Geoscience AUS- http://www.ga.gov.au/geodesy/astro/sunrise.jsp

Rainfall for 2020 and 2021 are displayed in **Graph 3-1** and **Graph 3-2** below. Rainfall in 2020 was sporadic, with significant peaks and lows. Periods of high and low rainfall in 2021 were generally consistent with previous rain fall patterns of 2020. The average rainfall across 2020 was 70mm, around 19mm more than the historical average.

Rainfall in 2021 was less than the previous year, averaging 53mm per month, 2mm less than the historical average (BOM 2021). Rainfall was below the historical average 9 months of the year with significant rainfall events only occurring in March, August and October 2021.



Graph 3-1: 2020 monthly rainfall (mm) compared to historical average monthly rainfall (1971-2020) for Glen Alice (BOM 2021).



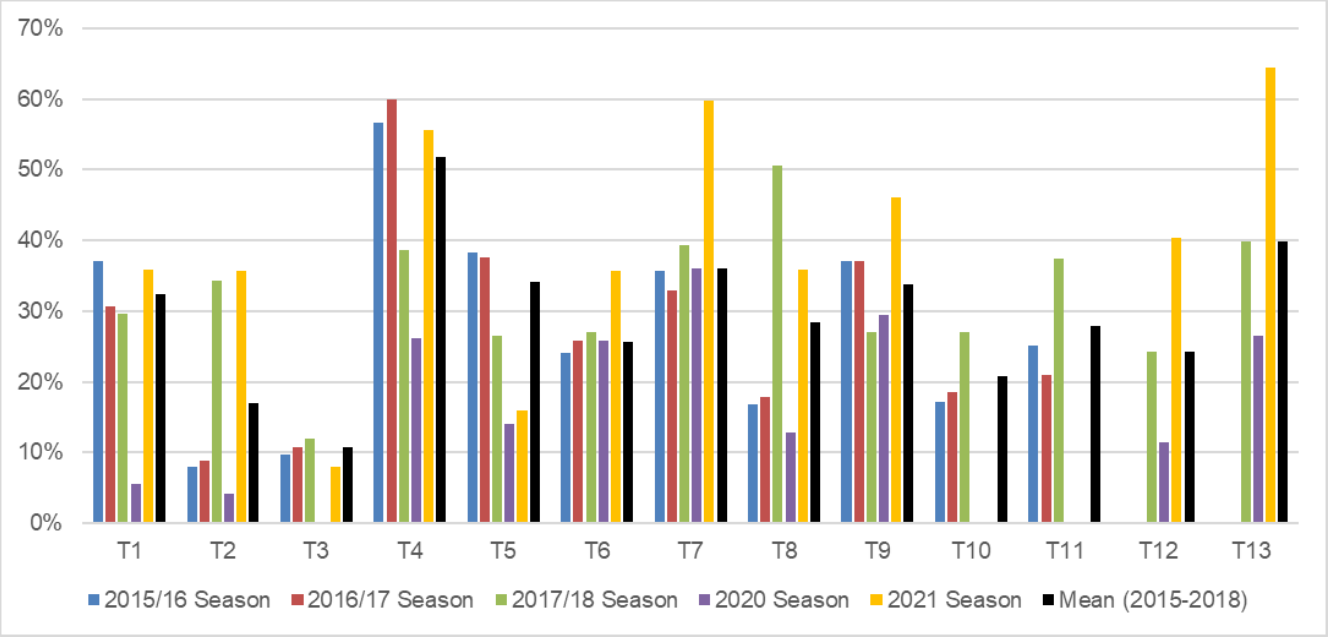
Graph 3-2: 2021 monthly rainfall (mm) compared to historical average monthly rainfall (1971-2021) for Glen Alice (BOM 2021).

3.2 Flora Results

3.2.1 *Prostanthera stricta* (Mount Vincient Mint-bush)

Eleven transects were completed in across the monitoring program. The controlled burn across Mount Airly in 2018 resulted in the reduction of *P. stricta* percent cover in the 2020 monitoring period, however these populations have almost recovered to their pre-fire percent cover, as seen in Transects 1, 2, 3 and 4.

The results of *P. stricta* monitoring in are shown in **Graph 3-3**. All plots in 2021 exhibited a significant increase in percent cover of *P. stricta* over the 50 m when compared with the 2020 survey period. All the plots are above their pre burn (2015 to 2018) average percent cover except for Transects 3 and 5. No data has been collected from Transects 10 and 11 since 2017/18 reporting period.

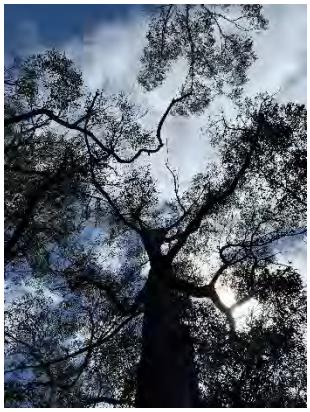
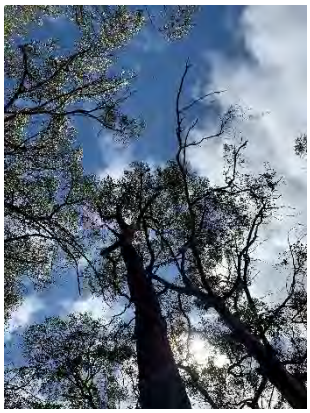
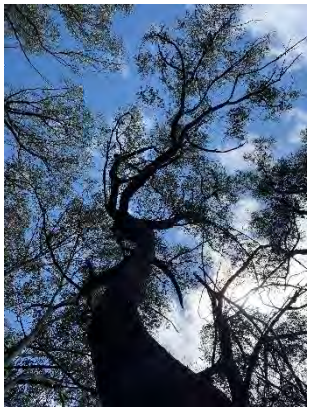


Graph 3-3: Proportional percent cover of *Prostanthera stricta* over the 50 m plot

3.2.2 *Eucalyptus cannonii* (Capertee Stringybark)

Fifteen *E. cannonii* locations were monitored (see **Table 3-3**) with photo monitoring undertaken at each of these locations. The condition assessments performed did not give any indication of any changes in the health of *E. cannonii* individuals.

Table 3-3: Condition Assessment for *Eucalyptus cannonii*

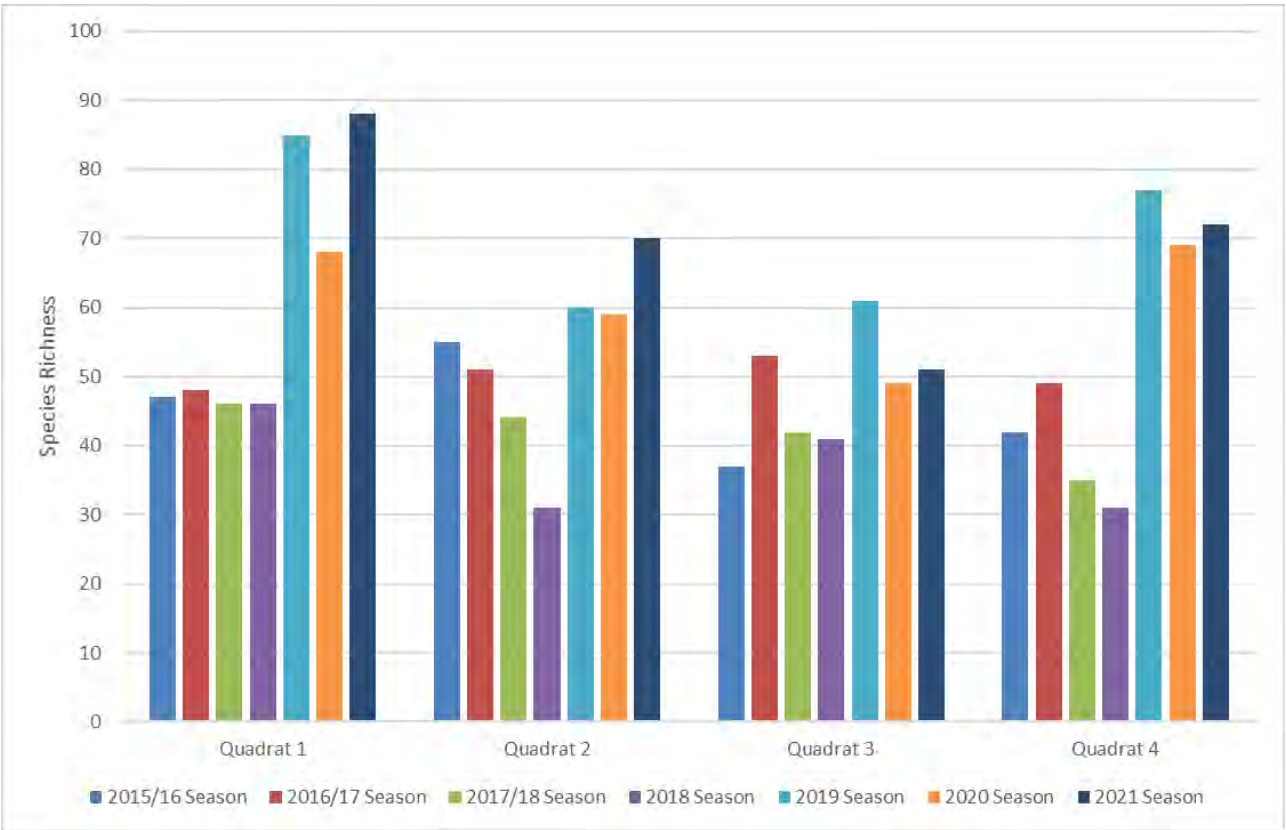
Site	Crown density (%)	Crown extent (%)	Height (m)	DBH (cm)	Signs of Subsidence	Signs of erosion	Photo Monitoring Point	
1	30	80	17	80	No	No		
2	70	85	15	40	No	No		
3	70	60	16	50	No	No		

Site	Crown density (%)	Crown extent (%)	Height (m)	DBH (cm)	Signs of Subsidence	Signs of erosion	Photo Monitoring Point
4	40	70	20	95	No	Yes (creek bank).	 
5	85	90	20	83	No	No	
6	50	50	15	39	No	No	
7	70	95	15	49	No	No	
8	60	85	23	76.07	No	No	
9	65	85	25	79.25	No	No	
10	50	50	17	44	No	No	
11	70	70	17	33	No	No	
12	60	60	22	78	No	Yes, lots of loose dirt and fallen trees.	
13	50	70	18	60	No	No	 

Site	Crown density (%)	Crown extent (%)	Height (m)	DBH (cm)	Signs of Subsidence	Signs of erosion	Photo Monitoring Point
14	70	80	18	65	No	No	
15	35	70	16	55	No	Minimal	

3.2.3 Capertee Rough-barked Apple – Redgum – Yellow Box Grassy Woodland (MU 20)

Capertee Rough-barked Apple – Redgum – Yellow Box Grassy Woodland (MU20) plots were surveyed in February 2021. **Graph 3-4** below shows comparative native species richness in MU20 plots that have been surveyed repeatedly since 2015. There was a substantial increase in native species richness in quadrats 1 and 2 in the 2021 surveys period with Plot 1 having the highest species richness (n=88). Species richness in 2021 was also greater than the mean richness of years 2015-2018, with each plot recording more species than the mean for all years. See **Apx Table 1** for the full flora inventory.



Graph 3-4: Comparative native species richness of surveyed MU20 plots across surveys

3.2.4 Exotic species

A total of 20 exotic species were detected in the Study area which is a decrease from 26 exotic species in the 2020 reporting period. See **Apx Table 1** for the full flora inventory.

Three exotic species have a cover of 5% or greater, which are *Senecio jacobaea, Anthoxanthum odoratum* and *Dactylis glomerata* which occur in quadrats 1, 3 and 4. BAM plot 1 had a weed cover of 20% or greater. See **Table 3-4.** Quadrat 1 has seen a reduction in exotic species cover from the 2020 reporting year to the 2021 reporting year; however, has seen a substantial increase since 2019. Quadrats 3 and 4 have also seen an increase in exotic species cover.

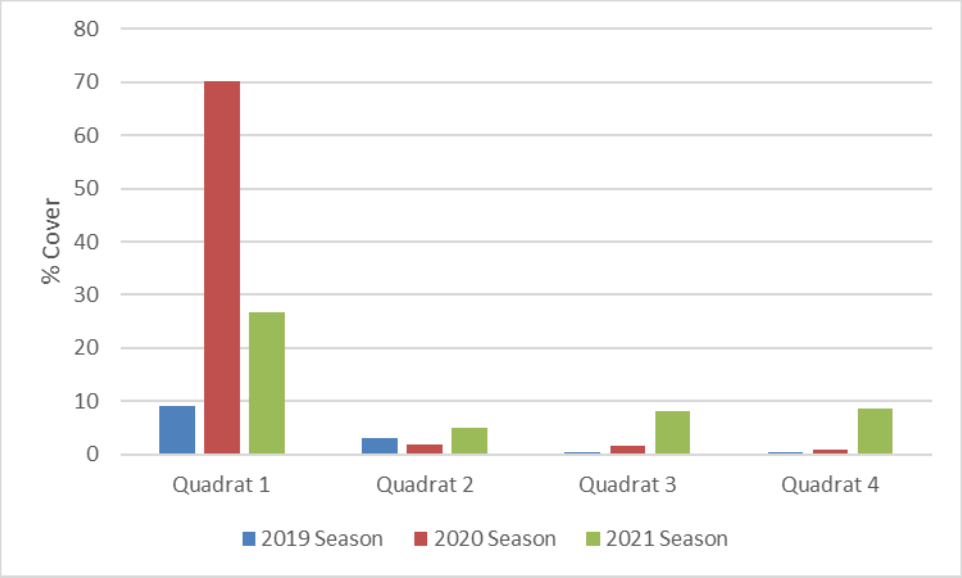
Table 3-4: Total weed cover within BAM plots

Quadrant	Total % cover	Exotic species with a cover of 5% of greater
1	26.8	*Anthoxanthum odoratum* *Dactylis glomerata*
2	4.9	-
3	8.2	*Senecio jacobaea*
4	8.7	*Senecio jacobaea*

Exotic species with Biosecurity duties, their management requirements under the *Biosecurity Act* 2015, and status as a Weed of National Significance (WoNS) and or High Threat Weed (HTW), are listed in **Table 3-5.** Of the 20 exotic species, two are HTWs and one is a WoNs.

Significant weed infestations have been noted along Torbane Road and behind the Pit-Top **(see Plate 3-1**). Weed control works have been carried out throughout 2021 around the pit-top and paddock areas including along Torbane Road, and works would be carried into 2022. These works have targeted HTW species *Hypericum perforatum* (St. John's Wort), *Rosa rubiginosa* (Sweet Briar) and *Rubus fruticosus species aggregate* (Blackberry). It is recommended that *Centaurea spp.* (Thistle) is also a targeted in subsequent years.

Plots BAM 1 and BAM 3 do not occur within the SCA, but occur on Crown land and are not under Centennial obligation. Plots BAM 2 and BAM 3 do occur within the SCA, and it is recommended that National Parks and Wildlife be informed of exotic species present, and the capacity to which they are present.



Graph 3-5: Comparative exotic species % cover of surveyed MU20 plots



Plate 3-1: Weed infestation of Thistle and *Senecio jacobaea* adjacent Torbane Road and behind the Pit Top

Table 3-5: Biosecurity duties for weeds occurring within the study area

Scientific Name	Common Name	High Threat Weed	WoNs	Biosecurity Duty
Briza minor	Shivery Grass	No	No	N/A
Briza spp.		No	No	N/A
Briza maxima	Quaking Grass	No	No	N/A
Centaurea spp.	Thistle	No	No	**General Biosecurity Duty** All plants are regulated with a general biosecurity duty to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable.
Centaurium erythraea	Common Centaury	No	No	N/A
Cirsium vulgare	Spear Thistle	No	No	**General Biosecurity Duty** All plants are regulated with a general biosecurity duty to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable.
Conyza spp.	A Fleabane	No	No	**General Biosecurity Duty** All plants are regulated with a general biosecurity duty to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable.
Echium plantagineum	Patterson's Curse	No	No	**General Biosecurity Duty** All plants are regulated with a general biosecurity duty to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable.
Holcus lanatus	Yorkshire Fog	No	No	N/A
Hypericum perforatum	St. Johns Wort	Yes	No	**General Biosecurity Duty** All plants are regulated with a general biosecurity duty to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable.

Scientific Name	Common Name	High Threat Weed	WoNs	Biosecurity Duty
				Central Tablelands Regional Recommended Measure (for Regional Priority - Asset Protection) Land managers should mitigate the risk of new weeds being introduced to their land. Land managers should mitigate spread from their land. The plant should not be bought, sold, grown, carried or released into the environment. Protect grazing land that is free of St. John's wort
Hypochoeris radicata	Catsear	No	No	N/A
Lolium spp.	A Ryegrass	No	No	N/A
Lysimachia arvensis	Scarlet Pimpernel	No	No	N/A
Melinus repens	Red Natal Grass	No	No	N/A
Plantago lanceolata	Lamb's Tongues	No	No	N/A
Rosa spp.		No	No	N/A
Rosa rubiginosa	Sweet Briar	Yes	No	N/A
Rubus fruticosus	Blackberry complex	No	Yes	**General Biosecurity Duty** All plants are regulated with a general biosecurity duty to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable. **Prohibition on certain dealings** Must not be imported into the state, sold, bartered, exchanged or offered for sale. **Central Tablelands Regional Recommended Measure** (for Regional Priority - Asset Protection) Land managers should mitigate the risk of new weeds being introduced to their land. Land managers should mitigate spread from their land. The plant should not be bought, sold, grown, carried or released into the environment. Protect conservation areas, natural environments and primary production lands that are free of blackberry
Senecio jacobaea	Ragwort	Yes	No	**General Biosecurity Duty** All plants are regulated with a general biosecurity duty to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable.

Scientific Name	Common Name	High Threat Weed	WoNs	Biosecurity Duty
Solanum nigrum	Black-berry Nightshade	No	No	N/A
Trifolium spp.	A Clover	No	No	N/A
Cerastium glomeratum	Mouse-ear Chickweed	No	No	N/A
Phalaris aquatica	Phalaris	No	No	N/A
Apiaceae indeterminate	Umbellifers	No	No	N/A
Poaceae indeterminate	Grasses, reeds and bamboos	No	No	N/A
Petrorhagia spp.		No	No	N/A

3.3 Fauna Results

3.3.1 Glossy Black Cockatoos

The presence of Glossy Black Cockatoos was confirmed through opportunistic sightings of individuals and the presence of 'orts' at six separate monitoring locations. During the 2021 monitoring period, sites 1 and 6 were not surveyed due to road closures and poor weather conditions at time of survey (see **Table 3-6**). Site 2 displayed the lowest use of *Allocasurina* feed species, with only a few recently chewed orts. Site 2 also has displayed a decrease *Allocasurina* canopy cover, and dying trees were noted.

No Glossy Black Cockatoos were observed at the monitoring sites; however, Glossy Black Cockatoo presence was confirmed by calls recorded by passive acoustics surveys (i.e. Song Meter) in November 2021.

Table 3-6: Evidence of Glossy Black Cockatoo's at Survey Sites

Site Number	Total Canopy Cover (%)	*Allocasurina* Canopy Cover (%)	Orts Present (P) or Absent (A)	Glossy Black Presence (P) or Absence (A)
1	-	-	-	-
2	30	15	P	A
3	35	25	P	A
4	-	-	-	-
5	40	25	P	A
6	25	50	P	A

3.3.2 Forest Owls

Three of four locations where Powerful and Sooty Owls have previously been observed were surveyed in February and November 2021 (sites 1, 3 and 4). Site 2 was inaccessible due to a landslide at the base of Mount Airly. Searches were conducted for owl pellets and whitewash. No roost sites displayed indirect evidence of use (i.e. white wash and pellets); however, a Sooty Owl (*Tyto tenebricosa*; BC Act: Vulnerable) was observed on Mt Airly during spotlighting near roost site 3 in November 2021.

Additional nocturnal bird species detected include the Eastern Barn Owl, Australian Owlet-nightjar and Tawny Frogmouth. See for the full fauna inventory.



Plate 3-2: Sooty Owl (*Tyto tenebricosa*; BC Act: Vulnerable) observed on Mt Airly during spotlighting

3.3.3 Diurnal Birds

A total of 70 bird species were detected during the 2021 monitoring period of which 52 were detected during the diurnal bird transects. The additional 18 species were detected through opportunistic sightings and camera trap observations. See **Apx Table 2** for the full fauna inventory.

Five of the recorded diurnal bird species are listed as threatened under the BC Act. See **Table 3-7** for a summary of the threatened bird species recorded in the 2021 survey period.

Table 3-7: Threatened diurnal bird species recorded within the 2021 monitoring period

Scientific Name	Common Name	Observation Type and Method	Count	BC Act	EPBC Act
Artamus cyanopterus	Dusky Woodswallow	O, birding and opportunistic	1	Vulnerable	Not Listed
Callocephalon fimbriatum	Gang-gang Cockatoo	O, opportunistic	1	Vulnerable	Not Listed
Calyptorhynchus lathami	Glossy Black-Cockatoo	O, opportunistic	4	Vulnerable	Not Listed
Climacteris picumnus victoriae	Brown Treecreeper	O, camera trap	1	Vulnerable	Not Listed
Petroica boodang	Scarlet Robin	OW, birding and opportunistic	5	Vulnerable	Not Listed

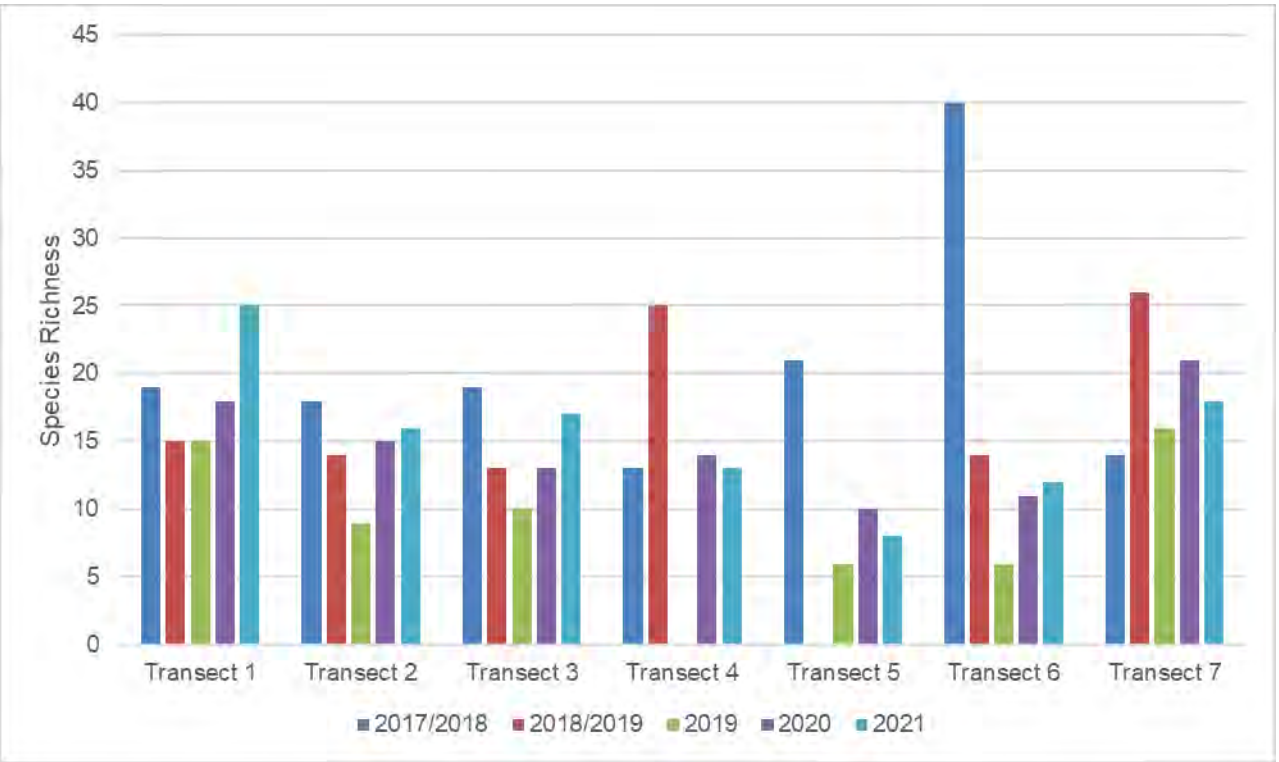
O = Observed, W = Heard

The Varied Sitella (*Daphoenositta chrysoptera*; BC Act: Vulnerable) was observed in 2020, however was not observed during this reporting period.

The most common bird species was the Superb Lyrebird which was heard calling in five of the seven birding transects and observed in over 50 days of camera trap footage. Other common bird species noted across five or more birding transects include the Crimson Rosella (*Platycercus elegans*), Noisy Friarbird (*Philemon*

corniculatus), Spotted Pardalote (*Pardalotus punctatus*) and Yellow-faced Honeyeater (*Lichenostomus chrysops*). Cryptic bird species such as the Bassian Thrush (*Zoothera lunulate*) was only detected by camera trap footage.

Bird species richness is generally stable across years within all seven transects. However, there was a decrease in species richness in Transect 6 between years 2017/2018 to 2018/2019, though species richness has stabilised in the last four monitoring years as shown in **Graph 3-6**.



Graph 3-6: Bird species richness per transect across years

3.3.4 Cave-Dwelling Microbats

A total of five Anabat detectors were installed over four nights in February 2021 and six Anabat detectors over four nights in November 2021. A total of 31,101 call sequences were recorded, of which 6,424 call sequences were able to be analysed (i.e. were not 'noise' files or bat calls of short length). Of the bat calls, 2,848 call sequences (44 %) were able to be confidently identified (those classified as either definite or probable identifications) to species level. Species recorded in the 2021 monitoring period, confidence level and their BC Act and EPBC Act status are summarised in **Table 3-8**.

Two of the three target microbat species were detected at a definite confidence level during both spring and summer surveys, being the Eastern Horseshoe-bat (*Rhinolophus megaphyllus*) and the Large-eared Pied-bat (*Chalinolobus dwyeri*; BC Act: Vulnerable; EPBC Act: Vulnerable). The Eastern Bent-winged Bat (*Miniopterus orianae oceanensis*) was possibly detected at Anabat 8 (see **Figure 9**), however calls of the Large Forest Bat (*Vespadelus troughtoni*) overlap in this region and it can't be distinguished reliably from bat calls. However, given the high number of calls, and location at a known bat roost, it is likely that the Eastern Bent-winged Bat (*Miniopterus orianae oceanensis*) is roosting there.

One threatened microbat species, the Large-eared Pied Bat (*Chalinolobus dwyeri*; BC Act: Vulnerable; EPBC Act: Vulnerable) was confidently detected in the 2021 monitoring period. Three threatened microbat species, Eastern Bent-winged Bat (*Miniopterus orianae oceanensis*; BC Act: Vulnerable), Large-footed Myotis (*Myotis macropus;* BC Act: Vulnerable) and the Greater Broad-nosed Bat (*Scoteanax rueppellii*; BC Act: Vulnerable) were possible detections in the 2021 monitoring period.

Due to the high number of calls of the Eastern Horseshoe Bat (*Rhinolophus megaphyllus*) during the November maternity time, the adits (Anabats 2 and 8) are likely to be a maternity colony of this species. The complete bat call analysis is in **Appendix C**.

Table 3-8: Microbat species recorded in the 2021 monitoring period

Species Name	Common Name	Confidence	Anabat	BC Act	EPBC Act
Austronomus australis	White-striped Free-tailed Bat	Definite	4, 7	Not Listed	Not Listed
Chalinolobus dwyeri	Large-eared Pied Bat	Definite	4, 7, 9	Vulnerable	Vulnerable
Chalinolobus gouldii	Gould's Wattled Bat	Definite	4	Not Listed	Not Listed
Chalinolobus morio	Chocolate Wattled Bat	Definite	4, 8	Not Listed	Not Listed
Rhinolophus megaphyllus	Eastern Horseshoe Bat	Definite	2, 4, 7, 8	Not Listed	Not Listed
Vespadelus darlingtoni	Large Forest Bat	Definite	4	Not Listed	Not Listed
Falsistrellus tasmaniensis	Eastern Falsistrelle	Probable	7	Not Listed	Not Listed
Miniopterus orianae oceanensis	Eastern Bent-winged Bat	Probable	2, 4, 7, 8	Vulnerable	Not Listed
Myotis macropus	Large-footed Myotis	Probable	7	Vulnerable	Not Listed
Nyctophilus geoffroyi	Lesser long-eared bat	Probable	7	Not Listed	Not Listed
Nyctophilus gouldi	Gould's long-eared bat	Probable	7	Not Listed	Not Listed
Ozimops ridei	Ride's Free-tailed Bat	Probable	4, 7, 8	Not Listed	Not Listed
Scoteanax rueppellii	Greater Broad-nosed Bat	Probable	7	Vulnerable	Not Listed
Scotorepens orion	Eastern Broad-nosed Bat	Probable	7	Not Listed	Not Listed
Vespadelus regulus	Southern Forest Bat	Probable	4, 7, 8	Not Listed	Not Listed

3.3.5 Other Targeted Fauna/Vertebrate Census

A total of 35 vertebrate species (excluding birds and microbats) were detected during the 2021 monitoring period. This included:

- Four frog species;
- 20 mammal species; and
- Seven reptiles.
- Of the 35 vertebrate species (excluding birds and microbats), three are listed as threatened under the BC Act and/or EPBC Act. Of note, the Koala was detected by means of song meter at the base of Airly Mountain. See **Table 3-9** for threatened fauna species recorded in the 2021 survey period. The Spotted-tailed Quoll (*Dasyurus maculatus;* BC Act: Vulnerable; EPBC Act: Endangered) has not been observed since 2012. See **Apx Table 2** for the full fauna inventory.

Table 3-9: Threatened fauna species (excluding birds and microbats) recorded during the 2021 survey period

Scientific Name	Common Name	Observation Type and Method	Count	BC Act	EPBC Act
Phascolarctos cinereus	Koala	W, song meter	1	Vulnerable	Endangered
Varanus rosenbergi	Rosenberg's Goanna	O, opportunistic	1	Vulnerable	Not Listed
Petauroides volans	Greater Glider	O, spotlighting	7	Not Listed	Vulnerable

O = Observed, W = Heard



Plate 3-3: Rosenberg's Goanna (*Varanus rosenbergi*: BC Act: Vulnerable) observed at Pt Hatteras



Plate 3-4: Greater Glider (*Petauroides Volans*; EBPC Act: Vulnerable) observed during spotlighting

3.3.6 Feral Species

Three feral fauna species were recorded during the 2021 reporting period which are the European Fox (*Vulpes vulpes*), European Cattle (*Bos taurus*) and feral dogs (*Canus lupis*). Foxes and dogs were only recorded on two occasions in the camera traps. No cats (*Felis catus*) or Rabbits (*Oryctolagus cuniculus*) were recorded in the 2021 monitoring period, however where present in the 2020 period. See **Apx Table 2** for the full fauna inventory.

Centennial Airly actively participate in feral species management strategies (Airly Cat Trapping Program, Local Land Services District Wild Dog Control, engaging third-party feral species control). Apex Predator Solutions have been engaged to undertake feral animal control targeting feral dog and cat trapping. Feral species control has proven to be successful with a consistent decline of targeted species, with no cats observed in the 2021 monitoring period, and only two dog observed by means of camera trap. Additional species are targeted through firearm control including feral pigs, goats, rabbits and foxes.

4 DISCUSSION AND RECOMMENDATIONS

This annual monitoring addresses the biodiversity-related conditions of consent outlines in SSD-5581. Schedule 3, Condition 2 of the SD-5581 development consent specifies the following requirements:

- Negligible environmental consequences for the threatened species, threatened populations, EECs and groundwater dependent ecosystems (with the exception of those listed below); and
- No environmental consequences for *Pultenaea* sp. Genowlan Point population and Genowlan Point *Allocasuarina nana* Heathland community (addressed in a separate report prepared by National Parks).

This monitoring report comprises information pertaining to the first of the two aforementioned requirements, whereas the second requirement is addressed in a separate monitoring report prepared by National Parks.

The 2021 monitoring results have displayed that threatened species, threatened populations, EECs and groundwater dependent ecosystems are still persisting in the study area, with negligible environmental consequences. Further discussion is provided below.

4.1 Flora

4.1.1 *Prostanthera stricta* (Mount Vincent Mint-bush)

Percent cover of *P. stricta* across all transects in 2021 have substantially increased since the 2020 survey period. All the plots are above their pre-burn (2015 to 2018) average percent cover with the exception of Transects 3 and 5. Weather in later 2020 and 2021 have provided suitable conditions due to higher rainfall and lower temperatures for population recovery.

4.1.2 *Eucalyptus cannonii* (Capertee Stringybark)

Condition assessments of *E. cannonii* through photo monitoring showed little change during the last year. Whilst ill health of large canopy trees such as *E. cannonii* can be slow to detect, there were no discernible changes worthy of further investigation during the 2021 survey period.

4.1.3 Capertee Rough-barked Apple – Redgum – Yellow Box Grassy Woodland (MU 20)

Capertee Rough-barked Apple – Redgum – Yellow Box Grassy Woodland (MU20) plot surveys demonstrated the highest plant species richness to date in BAM quadrants 1 and 2. Species richness in 2021 was also greater than the mean richness of years 2015-2018, with each plot recording more species than the mean for all years.

4.1.4 Exotic species

A total of 20 exotic species were detected in the Study area which is a decrease from 26 exotic species in the 2020 reporting period. Weeds of concern which have an individual cover of 5% or greater include *Anthoxanthum odoratum* (BAM 1)*, Dactylis glomerata* (BAM 1) and *Senecio jacobaea* (BAM 3 and 4). BAM quadrant 1 had the highest exotic plant cover, with a total cover of 26.8%. Of the 20 exotic species, two are HTWs and one is a WoNs. Plots BAM 1 and BAM 3 do not occur within State Conservation Area, but occur on Crown land and are not under Centennial obligation. Plots BAM 2 and BAM 3 do occur within a State Conservation Area, and it is recommended that National Parks and Wildlife be informed of exotic species present, and the capacity to which they are present.

Weed control works have been carried out throughout 2021 around the pit-top and paddock areas including along Torbane Road, and works would be carried into 2022. These works have targeted *Hypericum perforatum* (St. John's Wort), *Rosa rubiginosa* (Sweet Briar) and *Rubus fruticosus species aggregate* (Blackberry). It is recommended that *Centaurea spp.* (Thistle) is also a targeted in subsequent years.

4.2 Fauna

4.2.1 Glossy Black Cockatoos

Continued monitoring of Glossy-Black Cockatoos has shown that this species persists on site, with evidence of feeding (chewed orts) and the presence of individuals recorded opportunistically throughout the study area. No Glossy Black Cockatoos were observed at the monitoring sites. Site 2 displayed the lowest use of *Allocasurina* feed species, with only a few recently chewed orts. Site 2 also has displayed a decrease *Allocasurina* canopy cover, and dying trees were noted. It is recommended that photo monitoring is conducted at Glossy-Black Cockatoo sites to better understand the trends of *Allocasuarin*a canopy cover.

4.2.2 Forest Owls

No roost sites displayed indirect evidence of use (i.e. white wash and pellets) however a Sooty Owl (*Tyto tenebricosa*; BC Act: Vulnerable) was observed on Mt Airly during spotlighting near roost site 3 in November 2021. Prey items for forest owls such as small mammals including bush rats, sugar gliders and greater gliders were recorded on site. Additional nocturnal bird species detected include the Eastern Barn Owl, Australian Owlet-nightjar and Tawny Frogmouth.

4.2.3 Diurnal Birds

A total of 70 bird species were detected during the 2021 monitoring period of which 52 were detected during the diurnal bird transects. The additional 18 species were detected through opportunistic sightings and camera trap observations. Five of the recorded diurnal bird species are listed as threatened under the BC Act which include Dusky Woodswallow (*Artamus cyanopterus*; BC Act: Vulnerable), Gang-gang Cockatoo (*Callocephalon fimbriatum*; BC Act: Vulnerable), Glossy Black-Cockatoo (*Calyptorhynchus lathami*; BC Act: Vulnerable), Brown Treecreeper (*Climacteris picumnus victoriae*; BC Act: Vulnerable) and Scarlet Robin (*Petroica boodang*; BC Act: Vulnerable). Bird species richness is generally stable across years within all seven transects. However, there was a decrease in species richness in Transect 6 between years 2017/2018 to 2018/2019, though species richness has stabilised in the last four monitoring years.

4.2.4 Cave-Dwelling Microbats

Two of the three target microbat species were detected at a definite confidence level during both spring and summer surveys, being the Eastern Horseshoe-bat (*Rhinolophus megaphyllus*) and the Large-eared Pied-bat (*Chalinolobus dwyeri*; BC Act: Vulnerable; EPBC Act: Vulnerable). Whilst not definite, it is likely that given the high number of calls, and location at a known bat roost, the Eastern Bent-winged Bat (*Miniopterus orianae oceanensis*) is also roosting in the study area. The adits are likely to be the location of the Eastern Horseshoe Bat (*Rhinolophus megaphyllus*) maternity colony. Three other threated microbat species were possible detected within the study area which are Eastern Bent-winged Bat (*Miniopterus orianae oceanensis*; BC Act: Vulnerable), Large-footed Myotis (*Myotis macropusI;* BC Act: Vulnerable) and the Greater Broad-nosed Bat (*Scoteanax rueppellii*; BC Act: Vulnerable).

4.2.5 Other Targeted Fauna/Vertebrate Census

A total of 35 vertebrate species (excluding birds and microbats) were detected during the 2021 monitoring period. Of these, three are listed as threatened under the BC Act and/or EPBC Act. Of note, the Koala (*Phascolarctos cinereus*; BC Act: Vulnerable; EPBC Act: Endangered) was detected by means of song meter at the base of Airly Mountain, Rosenberg's Goanna (*Varanus rosenbergi*: BC Act: Vulnerable) was observed at Point Hatteras for the second year in a row and the Greater Glider (*Petauroides Volans*; EPBC Act: Vulnerable) is persisting in the Grotto and base of Mount Airly. The Spotted-tailed Quoll (*Dasyurus maculatus;* BC Act: Vulnerable; EPBC Act: Endangered) has not been observed since 2012.

4.2.6 Feral Species

Feral species, other than domestic cattle, were recorded infrequently during the 2021 surveys. No cats (*Felis catus*) or Rabbits (*Oryctolagus cuniculus*) were recorded in the 2021 monitoring period, however where present in the 2020 period.

Centennial Airly actively participate in feral species management strategies (Airly Cat Trapping Program, Local Land Services District Wild Dog Control, engaging third-party feral species control). Apex Predator Solutions have been engaged to undertake feral animal control targeting feral dog and cat trapping. Feral species control has proven to be successful with a consistent decline of targeted species, with no cats observed in the 2021 monitoring period, and only two dog observed by means of camera trap. Additional species are targeted through firearm control including feral pigs, goats, rabbits and foxes.

4.3 Recommendations

Significant weed infestations have been noted along Torbane Road and behind the Pit-Top **(see Plate 3-1**). Weed control works have been carried out throughout 2021 around the pit-top and paddock areas including along Torbane Road, and works would be carried into 2022. These works have targeted HTW species *Hypericum perforatum* (St. John's Wort), *Rosa rubiginosa* (Sweet Briar) and *Rubus fruticosus species aggregate* (Blackberry). It is recommended that *Centaurea spp.* (Thistle) is also a targeted in subsequent years.

Plots BAM 1 and BAM 3 do not occur within the SCA, but occur on Crown land and are not under Centennial obligation. Plots BAM 2 and BAM 3 do occur within the SCA, and it is recommended that National Parks and Wildlife be informed of exotic species present, and the capacity to which they are present.

Glossy-black Cockatoo Site 2 has displayed a decrease in *Allocasurina* canopy cover, and dying trees were noted. It is recommended that photo monitoring is conducted at Glossy-Black Cockatoo sites to better understand the trends of *Allocasuarina* canopy cover.

5 REFERENCES

BOM (2021) Weather Station Directory - Glen Alice. Accessed January 2021. http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=139&p_display_type=dataFile&p_startYear=&p_c=&p_stn_num=061334

Churchill (2009). Australian Bats.

Centennial (2019) Western Region Biodiversity Management Plan, Airly Site Specific Biodiversity Management Plan. Prepared by RPS for Centennial.

DECC (2008a). Descriptions for NSW (Mitchell) Landscapes Version 2 (2002).

DEC (2006), The Vegetation of the Western Blue Mountains. Unpublished report funded by the Hawkesbury Nepean Catchment Management Authority, Department of Environment and Conservation, Hurstville.

DPIE (2021c). BioNet Vegetation Classification. Accessed 8/12/2021. Web Link: https://www.environment.nsw.gov.au/research/Visclassification.htm

DPIE (2007). Bionet NSW Landscapes 30/11/2007 Mitchell Landscapes. NSW Office of Environment and Heritage.

Elzinga, C.L., Salzer, D.W., Willoughby, J.W., Gibbs, J.P. (2001) Monitoring Plant and Animal Populations: A Handbook for Field Biologists. Blackwell Scientific Publications, Abingdon, UK.

Gorrod, E. and Keith, D. (2008) Evaluating vegetation condition measure for cost effective biodiversity investment planning. Australian Centre of Excellence for Risk Analysis.

Harden, G.J. (1993). Flora of New South Wales Volume 4 revised edition. NSW University Press, Sydney NSW.

Harden, G.J. (2000). Flora of New South Wales Volume 1 revised edition. NSW University Press, Sydney NSW.

Harden, G.J. (2002). Flora of New South Wales Volume 2 revised edition. NSW University Press, Sydney NSW.

McCaffrey, N., McKenna, P., Glenn, V., Fletcher, A. and Erskine. P. (2015) Research and monitoring of flora and native vegetation at Airly Mine and Mugii Murum-ban State Conservation Area, NSW. Centre for Mine Land Rehabilitation, QLD.

Menkhorst and Knight (2010). A Field Guide to the Mammals of Australia

OEH (2013) Alteration of habitat following subsidence due to longwall mining as a key threatening process-fact sheet. Accessed online 5 December 2016 from: http://www.environment.nsw.gov.au/threatenedspecies/LongwallMining.htm

OEH (2017) Spotted-tailed Quoll – Profile. Accessed online 23 February, 2018. Available at: http://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10207

RPS (2020) Airly Mine Flora and Fauna Monitoring Report 2019. Report to Centennial Coal.

RPS (2019) Airly Mine Flora and Fauna Monitoring Report 2019. Report to Centennial Coal.

RPS (2018) Airly Mine Splitting and Quartering Extraction Plan (ML1331)- Biodiversity Management Plan (EP-BMP). Report to Centennial Coal.

RPS (2017a) Airly Mine Flora and Fauna Monitoring Report 2016/2017. Report to Centennial Coal.

RPS (2017b) Airly Mine Seasonal Flora and Fauna Monitoring Report 2015/2016. Report to Centennial Coal.

RPS (2014), Airly Mine Extension Project Flora and Fauna Assessment, March 2014, RPS Australia East

Pty Ltd. Williams, E., Thomson, B., Erskine, P. and Fletcher, A. (2015) Airly Mine 2014 Fauna Research and Monitoring. Centre for Mine Land Rehabilitation, QLD.

Underwood, AJ (1992) ‘Beyond BACI: the detection of environmental impacts on populations in the real, but variable, world’. Journal of Experimental Marine Biology and Ecology, vol. 161, no. 2, pp. 145-78.

Appendix A
Flora Species List

Apx Table 1: Flora species recorded within BAM plots 2021

Scientific Name	Exotic	Common Name	1 Cover	1 Abundance	2 Cover	2 Abundance	3 Cover	3 Abundance	4 Cover	4 Abundance
Acacia dawsonii		Poverty Wattle	2	8						
Acacia dealbata		Silver Wattle	2	4						
Acacia falciformis		Broad-leaved Hickory			10	7	15	15		
Acacia implexa		Hickory Wattle							1	2
Acacia obtusifolia							1	5	2	2
Acacia spp.		Wattle							0.1	1
Acaena echinata		Sheep's Burr	0.2	15					0.1	5
Acaena novae-zelandiae		Bidgee-widgee	0.8	20	0.8	15	0.8	15		
Acrotriche rigida					0.8	1			2	5
Adiantum aethiopicum		Common Maidenhair	0.8	10					0.1	20
Amyema spp.		Mistletoe			0.2	3				
Anagallis arvensis	*	Scarlet Pimpernel	1	60			0.1	8		
Anthosachne scabra		Wheatgrass, Common Wheatgrass							0.2	15
Anthoxanthum odoratum	*	Sweet Vernal Grass	10	60						
Aristida ramosa		Purple Wiregrass	10	80	0.5	30	1	40	0.8	40
Arthropodium milleflorum		Pale Vanilla-lily	0.5	15						
Asperula conferta		Common Woodruff	0.8	30	0.4	15			0.5	25
Asperula spp.		Woodruff			0.1	5	0.2	15		
Asplenium flabellifolium		Necklace Fern							0.1	8
Astroloma humifusum		Native Cranberry	0.2	1			0.2	2	0.8	6
Austrodanthonia caespitosa		Ringed Wallaby Grass			3	40				
Austrodanthonia spp.							5	60		
Austrostipa scabra		Speargrass			0.1	10				
Austrostipa spp.							8	40		
Billardiera scandens		Hairy Apple Berry			0.2	3			0.1	1
Bromus hordeaceus	*	Soft Brome	0.8	15						
Bursaria spinosa		Native Blackthorn			8	10			5	15
Calotis hispidula		Bogan Flea	0.1	15						
Carex appressa		Tall Sedge	1	10						
Cassinia cunninghamii									0.2	4
Cassinia spp.			0.1	5	0.1	3				
Cenchrus spp.			1	20						
Cerastium glomeratum	*	Mouse-ear Chickweed	0.2	25						

Scientific Name	Exotic	Common Name	1 Cover	1 Abundance	2 Cover	2 Abundance	3 Cover	3 Abundance	4 Cover	4 Abundance
Cheilanthes sieberi		Rock Fern	0.8	20	0.8	10	0.1	10		
Cirsium vulgare	*	Spear Thistle			3	15	0.8	10	0.5	40
Clematis glycinoides		Headache Vine			5	40	0.8	60	3	30
Conyza spp.	*		0.1	5	0.8	15	0.8	20	0.1	5
Coronidium spp.					0.2	10			1	15
Correa reflexa		Native Fuschia							0.5	10
Crassula spp.		Stonecrop	0.3	15						
Cyclospermum leptophyllum	*	Slender Celery	0.8	20						
Cynoglossum australe			1	50	15	100	4	80		
Cyperus sphaeroideus			0.8	40						
Cyperus spp.									0.1	5
Dactylis glomerata	*	Cocksfoot	10	80						
Daucus glochidiatus		Native Carrot			0.1	4				
Desmodium rhytidophyllum									0.1	20
Desmodium varians		Slender Tick-trefoil			0.8	40			0.2	30
Dianella revoluta		Blueberry Lily	0.8	10			1	15		
Dichelachne spp.			5	60	8	50			4	40
Dichondra repens		Kidney Weed	0.1	10	0.3	80	2	30	0.5	50
Dipodium spp.							0.1	10		
Dysphania spp.									0.1	2
Echinopogon caespitosus		Bushy Hedgehog-grass	8	60	5	60	10	60		
Echinopogon ovatus		Forest Hedgehog Grass	0.8	15			1	30	0.4	40
Echium vulgare	*	Viper's Bugloss	0.1	20						
Eleocharis spp.		Spike-rush, Spike-sedge	0.8	30						
Eucalyptus blakelyi		Blakely's Red Gum	5	2					0.5	1
Eucalyptus cannonii		Capertee Stringybark			20	1				
Eucalyptus dalrympleana		Mountain Gum	0.1	3						
Eucalyptus macrorhyncha		Red Stringybark	15	4					4	1
Eucalyptus melliodora		Yellow Box			5	1	10	5	15	2
Eucalyptus polyanthemos		Red Box	0.1	2	15	2		999	15	5
Euchiton japonicus					2	40	1	40	0.1	5
Euchiton sphaericus		Star Cudweed	0.2	8	8	80			0.8	20
Facelis retusa	*				0.1	5				

Scientific Name	Exotic	Common Name	1 Cover	1 Abundance	2 Cover	2 Abundance	3 Cover	3 Abundance	4 Cover	4 Abundance
Fimbristylis dichotoma		Common Fringe-sedge			0.1	30				
Galium binifolium			0.4	35	0.1	4				
Galium leiocarpum			0.1	10	0.1	15				
Galium spp.									0.2	15
Geitonoplesium cymosum		Scrambling Lily							0.2	15
Geranium homeanum			0.8	40					0.2	8
Geranium solanderi		Native Geranium			2	25	0.8	25		
Glycine clandestina		Twining glycine	0.1	30			0.8	20	0.1	8
Glycine tabacina		Variable Glycine					0.5	70		
Gonocarpus tetragynus		Poverty Raspwort			0.5	60	0.2	15	0.2	10
Goodenia ovata		Hop Goodenia			0.1	1				
Hackelia latifolia									2	30
Haloragis heterophylla		Variable Raspwort	1	80						
Hardenbergia violacea		False Sarsaparilla							0.2	2
Hemarthria uncinata		Matgrass	10	80						
Hibbertia acicularis									0.1	3
Hibbertia obtusifolia		Hoary Guinea Flower	0.1	1						
Holcus lanatus	*	Yorkshire Fog	2	50						
Hordeum spp.	*		0.2	15						
Hydrocotyle laxiflora		Stinking Pennywort	0.3	25	1	80				
Hydrocotyle spp.							2	40		
Hypericum gramineum		Small St John's Wort	0.8	30	0.1	10	0.8	10		
Hypericum japonicum			0.1	15	0.8	20				
Hypochaeris radicata	*	Catsear	0.2	10	0.2	10	0.2	15	0.1	3
Hypoxis hygrometrica		Golden Weather-grass	0.2	20						
Indigofera australis		Australian Indigo			5	25			4	10
Isolepis cernua		Nodding Club-rush	0.1	10						
Isolepis spp.		Club-rush	0.1	5						
Jacksonia scoparia		Dogwood							0.1	2
Juncus filicaulis			2	50						
Juncus planifolius			0.1	5						
Juncus spp.							0.1	2		
Lagenifera stipitata		Blue Bottle-daisy					0.1	10	0.1	10

Scientific Name	Exotic	Common Name	1 Cover	1 Abundance	2 Cover	2 Abundance	3 Cover	3 Abundance	4 Cover	4 Abundance
Lepidium spp.					0.2	15				
Lepidosperma cf. laterale					2	40				
Lepidosperma gunnii									0.5	10
Lepidosperma laterale		Variable Sword-sedge					1	10	5	20
Leucochrysum spp.									3	30
Lindsaea linearis		Screw Fern	0.2	15					0.2	20
Lomandra confertifolia		Matrush							0.1	3
Lomandra longifolia		Spiny-headed Mat-rush	0.8	10	35	30	50	40	20	50
Lomandra multiflora		Many-flowered Mat-rush			0.1	2			0.1	3
Melichrus urceolatus		Urn Heath	0.1	2	0.2	3				
Mentha satureioides		Native Pennyroyal			0.5	12	1	20		
Microlaena stipoides		Weeping Grass	2	40	3	100			4	80
Microtis spp.			0.1	15						
Monotoca scoparia			0.3	5	0.1	1				
Myoporum montanum		Western Boobialla			8	11			8	10
Nematolepis squamea		Satinwood							0.1	1
Opercularia spp.							0.8	40		
Oxalis perennans					0.2	40		10	0.2	100
Oxalis spp.			0.2	15						
Pellaea paradoxa			0.8	15						
Persoonia linearis		Narrow-leaved Geebung	0.1	1						
Pimelea curviflora		Rice Flower			0.1	10				
Plantago debilis		Shade Plantain			0.8	20			0.8	6
Plantago gaudichaudii		Narrow Plantain	1	40	5	60	0.5	10	0.8	30
Plantago lanceolata	*	Lamb's Tongues			0.8	20				
Poa labillardierei		Tussock	8	30	5	30	5	40	3	60
Poa sieberiana var. cyanophylla			0.2	4						
Podolobium scandens		Netted Shaggy Pea					0.2	10		
Poranthera ericifolia					0.1	10				
Poranthera microphylla		Small Poranthera	0.1	10	0.2	40	0.3	50	0.1	5
Prunella vulgaris	*	Self-heal	0.8	20						

Scientific Name	Exotic	Common Name	1 Cover	1 Abundance	2 Cover	2 Abundance	3 Cover	3 Abundance	4 Cover	4 Abundance
Pterostylis spp.		Greenhood	0.1	2						
Ranunculus inundatus		River Buttercup	8	50						
Rorippa spp.			0.8	20						
Rosa rubiginosa	*	Sweet Briar	0.2	2			0.8	3		
Rubus fruticosus	*	Blackberry complex	0.1	2			0.2	3		
Rubus parvifolius		Native Raspberry			0.1	2			1	5
Rumex brownii		Swamp Dock	0.3	2						
Rytidosperma caespitosum		Ringed Wallaby Grass	40	100					0.5	20
Rytidosperma pallidum		Redanther Wallaby Grass; Silvertop Wallaby Grass			5	40	20	100	3	60
Scaevola aemula		Fairy Fan-flower			1	20				
Schenkia australis		Spike Centaury	0.2	20	0.1	15				
Schoenus ericetorum			0.1	5						
Schoenus spp.							0.1	2		
Scutellaria humilis		Dwarf Skullcap	0.2	15	0.8		0.2	15	0.1	8
Scutellaria spp.					2	20				
Senecio hispidulus		Hill Fireweed			0.1	5				
Senecio jacobaea	*	Ragwort	0.2	15			5	40	8	50
Senecio quadridentatus		Cotton Fireweed	0.2	8	0.1	1	0.5	20	0.5	25
Sigesbeckia orientalis		Indian Weed			0.8	20			5	400
Solanum nigrum	*	Black-berry Nightshade	0.1	1			0.1	3		
Solanum prinophyllum		Forest Nightshade					0.8	10	0.8	5
Sonchus spp.		Sowthistle							0.1	8
Stellaria pungens		Prickly Starwort	0.5	20						
Stellaria spp.		Prickly Starwort					0.1	5		
Stylidium spp.			0.1	1						
Themeda australis			2	50						
Themeda triandra									2	40
Trifolium spp.	*						0.2	30		
Typha orientalis		Broad-leaved Cumbungi	0.3	12						
Verbena spp.			0.2	15						
Veronica plebeia		Trailing Speedwell			0.2	10			0.1	5
Vittadinia cuneata			0.1	2	0.2	15	0.8	20	0.8	60
Wahlenbergia communis		Tufted Bluebell	0.3	40	0.4	40			0.8	20
Wahlenbergia gracilis		Sprawling Bluebell			0.2	15	0.2	10		

Appendix B
Fauna species List

Apx Table 2: Fauna species recorded in 2021 monitoring period

Family	Scientific Name	Common Name	Exotic	Obs. Type	Method	BC Act	EPBC Act
Amphibia	*Crinia signifera*	Common eastern froglet		W	Spotlighting	Not Listed	Not Listed
Amphibia	*Limnodynastes dumerilii*	Eastern Banjo Frog		W	Songmeter	Not Listed	Not Listed
Amphibia	*Litoria dentata*	Bleating Tree Frog		W	Songmeter	Not Listed	Not Listed
Amphibia	*Litoria peronii*	Peron's Tree Frog		W	Songmeter	Not Listed	Not Listed
Aves	*Acanthiza lineata*	Striated Thornbill		W	Birding	Not Listed	Not Listed
Aves	*Acanthiza pusilla*	Brown Thornbill		OW	Birding	Not Listed	Not Listed
Aves	*Aegotheles cristatus*	Australian Owlet-nightjar		W	Songmeter	Not Listed	Not Listed
Aves	*Alisterus scapularis*	Australian King-Parrot		W	Songmeter	Not Listed	Not Listed
Aves	*Anthochaera carunculata*	Red Wattlebird		W	Songmeter	Not Listed	Not Listed
Aves	*Anthochaera chrysoptera*	Little Wattlebird		W	Birding	Not Listed	Not Listed
Aves	*Artamus cyanopterus*	Dusky Woodswallow		O	Birding	Vulnerable	Not Listed
Aves	*Cacatua galerita*	Sulphur-crested Cockatoo		OW	Birding	Not Listed	Not Listed
Aves	*Cacomantis flabelliformis*	Fan-tailed Cuckoo		W	Songmeter	Not Listed	Not Listed
Aves	*Callocephalon fimbriatum*	Gang-gang Cockatoo		O	Opportunistic	Vulnerable	Not Listed
Aves	*Calyptorhynchus lathami*	Glossy Black-Cockatoo		M	Opportunistic	Vulnerable	Not Listed
Aves	*Centropus phasianinus*	Pheasant coucal		OW	Birding	Not Listed	Not Listed
Aves	*Chenonetta jubata*	Australian Wood Duck		OW	Birding	Not Listed	Not Listed
Aves	*Cinclosoma punctatum*	Spotted quail-thrush		O	Camera Trap	Not Listed	Not Listed
Aves	*Climacteris picumnus victoriae*	Brown Treecreeper		O	Camera Trap	Vulnerable	Not Listed
Aves	*Colluricincla harmonica*	Grey Shrike-thrush		O	Camera Trap	Not Listed	Not Listed
Aves	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike		W	Birding	Not Listed	Not Listed
Aves	*Corcorax melanorhamphos*	White-winged Chough		W	Songmeter	Not Listed	Not Listed
Aves	*Corcorax melanorhamphus)*	White-winged Chough		OW	Birding	Not Listed	Not Listed
Aves	*Cormobates leucophaea*	White-throated Treecreeper		W	Songmeter	Not Listed	Not Listed
Aves	*Corvus coronoides*	Australian Raven		OW	Birding	Not Listed	Not Listed

Family	Scientific Name	Common Name	Exotic	Obs. Type	Method	BC Act	EPBC Act
Aves	*Cracticus tibicen*	Australian Magpie		W	Songmeter	Not Listed	Not Listed
Aves	*Dacelo novaeguineae*	Laughing Kookaburra		W	Birding	Not Listed	Not Listed
Aves	*Eopsaltria australis*	Eastern Yellow Robin		W	Birding	Not Listed	Not Listed
Aves	*Falco cenchroides*	Nankeen Kestrel		OW	Opportunistic	Not Listed	Not Listed
Aves	*Gerygone olivacea*	White-throated Gerygone		W	Birding	Not Listed	Not Listed
Aves	*Glossopsitta concinna*	Musk Lorikeet		W	Birding	Not Listed	Not Listed
Aves	*Glossopsitta sp.*	Little or Musk Lorikeet		OW	Birding	Not Listed	Not Listed
Aves	*Grallina cyanoleuca*	Magpie Lark		OW	Birding	Not Listed	Not Listed
Aves	*Gymnorhina tibicen*	Australian Magpie		OW	Birding	Not Listed	Not Listed
Aves	*Leucosarcia picata*	Wonga Pigeon		W	Songmeter	Not Listed	Not Listed
Aves	*Lichenostomus chrysops*	Yellow-faced Honeyeater		O	Birding	Not Listed	Not Listed
Aves	*Macropygia phasianella*	Brown Cuckoo-Dove		OW	Birding	Not Listed	Not Listed
Aves	*Malurus cyaneus*	Superb Fairy-wren		OW	Birding	Not Listed	Not Listed
Aves	*Megalurus mathewsi*	Rufous Songlark		OW	Birding	Not Listed	Not Listed
Aves	*Meliphaga lewinii*	Lewin's Honeyeater		W	Birding	Not Listed	Not Listed
Aves	*Melithreptus albogularis*	White-throated Honeyeater		O	Birding	Not Listed	Not Listed
Aves	*Menura novaehollandiae*	Superb Lyrebird		OW	Birding	Not Listed	Not Listed
Aves	*Microeca fascinans*	Jacky Winter		OW	Birding	Not Listed	Not Listed
Aves	*Myiagra cyanoleuca*	Satin Flycatcher		OW	Birding	Not Listed	Not Listed
Aves	*Myiagra rubecula*	Leaden Flycatcher		W	Birding	Not Listed	Not Listed
Aves	*Ninox novaeseelandiae*	Southern Boobook		W	Songmeter	Not Listed	Not Listed
Aves	*Origma solitaria*	Rock Warbler		O	Camera Trap	Not Listed	Not Listed
Aves	*Oriolus sagittatus*	Olive-backed Oriole		W	Birding	Not Listed	Not Listed
Aves	*Pachycephala pectoralis*	Golden Whistler		OW	Birding	Not Listed	Not Listed
Aves	*Pachycephala rufiventris*	Rufous Whistler		W	Birding	Not Listed	Not Listed
Aves	*Pardalotus punctatus*	Spotted Pardalote		W	Birding	Not Listed	Not Listed

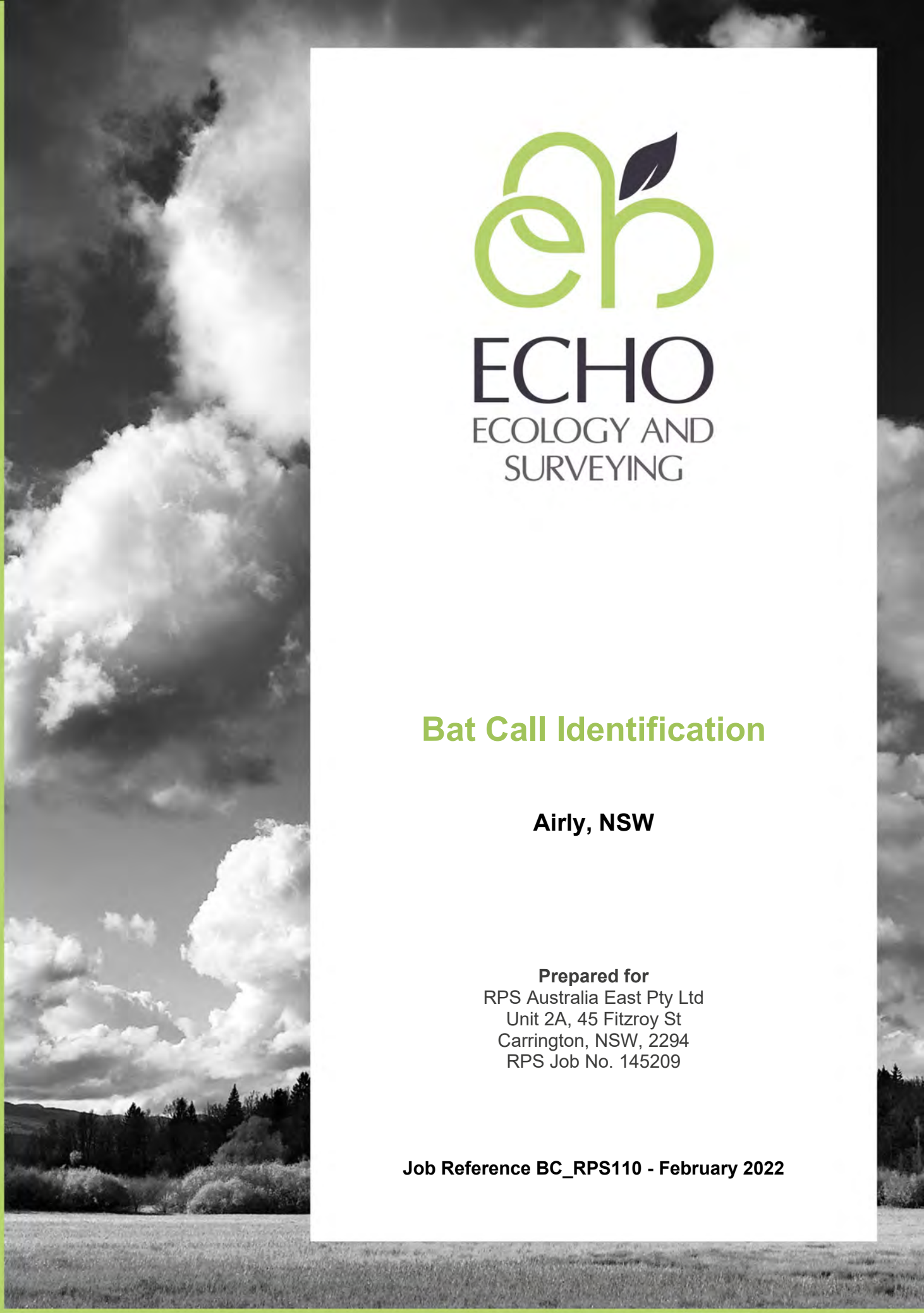
Family	Scientific Name	Common Name	Exotic	Obs. Type	Method	BC Act	EPBC Act
Aves	*Pardalotus striatus*	Striated Pardalote		W	Songmeter	Not Listed	Not Listed
Aves	*Petroica boodang*	Scarlet Robin		W	Birding	Vulnerable	Not Listed
Aves	*Philemon corniculatus*	Noisy Friarbird		OW	Birding	Not Listed	Not Listed
Aves	*Platycercus adscitus adscitus x eximius*	Eastern/Pale-headed Rosella		W	Songmeter	Not Listed	Not Listed
Aves	*Platycercus elegans*	Crimson Rosella		OW	Birding	Not Listed	Not Listed
Aves	*Platycercus eximius*	Eastern Rosella		OW	Birding	Not Listed	Not Listed
Aves	*Podargus strigoides*	Tawny Frogmouth		O	Spotlighting	Not Listed	Not Listed
Aves	*Pomatostomus superciliosus*	White-browed Babbler		W	Birding	Not Listed	Not Listed
Aves	*Psephotus haematonotus*	Red Rumped Parrot		O	Birding	Not Listed	Not Listed
Aves	*Psophodes olivaceus*	Eastern Whipbird		W	Songmeter	Not Listed	Not Listed
Aves	*Ptilonorhynchus violaceus*	Satin Bowerbird		OW	Birding	Not Listed	Not Listed
Aves	*Rhipidura albiscapa*	Grey Fantail		OW	Birding	Not Listed	Not Listed
Aves	*Rhipidura leucophrys*	Willie Wagtail		OW	Birding	Not Listed	Not Listed
Aves	*Scythrops novaehollandiae*	Channel-billed Cuckoo		W	Songmeter	Not Listed	Not Listed
Aves	*Scythrops novaehollandiae*	Channel-billed cuckoo		OW	Birding	Not Listed	Not Listed
Aves	*Sericornis frontalis*	White-browed Scrubwren		O	Birding	Not Listed	Not Listed
Aves	*Strepera graculina*	Pied Currawong		OW	Birding	Not Listed	Not Listed
Aves	*Strepera versicolor*	Grey Currawong		OW	Birding	Not Listed	Not Listed
Aves	*Todiramphus sanctus*	Sacred Kingfisher		OW	Birding	Not Listed	Not Listed
Aves	*Turnix velox*	Little Button-quail		O	Birding	Not Listed	Not Listed
Aves	*Tyto javanica*	Eastern Barn Owl		W	Songmeter	Not Listed	Not Listed
Aves	*Tyto novaehollandiae*	Sooty Owl		OW	Spotlighting	Vulnerable	Not Listed
Aves	*Tyto tenebricosa*	Sooty Owl		W	Songmeter	Vulnerable	Not Listed
Aves	*Vanellus miles*	Masked Lapwing		OW	Birding	Not Listed	Not Listed
Aves	*Zoothera lunulata*	Bassian Thrush		O	Camera Trap	Not Listed	Not Listed
Insect	*Heteronympha merope*	Common brown		O	Camera Trap	Not Listed	Not Listed

Family	Scientific Name	Common Name	Exotic	Obs. Type	Method	BC Act	EPBC Act
Mammalia	*Antechinus sp.*	Unidentified Antechinus		O	Camera Trap	Not Listed	Not Listed
Mammalia	*Antechinus stuartii*	Brown Antechinus		O	Camera Trap	Not Listed	Not Listed
Mammalia	*Bos taurus*	Cattle	*	O	Opportunistic	Not Listed	Not Listed
Mammalia	*Canis lupis*	Dog	*	O	Camera Trap	Not Listed	Not Listed
Mammalia	*Macropus giganteus*	Eastern Grey Kangaroo		O	Opportunistic	Not Listed	Not Listed
Mammalia	*Macropus rufogriseus*	Red Necked Wallaby		O	Opportunistic	Not Listed	Not Listed
Mammalia	*Petauroides volans*	Greater Glider		O	Spotlighting	Not Listed	Vulnerable
Mammalia	*Petaurus breviceps*	Sugar Glider		W	Songmeter	Not Listed	Not Listed
Mammalia	*Petaurus notatus*	Krefft's glider		O	Camera Trap	Not Listed	Not Listed
Mammalia	*Phascolarctos cinereus*	Koala		W	Songmeter	Vulnerable	Vulnerable
Mammalia	*Pseudocheirus peregrinus*	Common Ringtail Possum		O	Spotlighting	Not Listed	Not Listed
Mammalia	*Rattus fuscipes*	Bush Rat		O	Camera Trap	Not Listed	Not Listed
Mammalia	*Rattus sp.*	Unidentified Rat		O	Camera Trap	Not Listed	Not Listed
Mammalia	*Tachyglossus aculeatus*	Short-beaked echidna		O	Camera Trap	Not Listed	Not Listed
Mammalia	*Trichosurus vulpecula*	Brush Tailed Possum		O	Spotlighting	Not Listed	Not Listed
Mammalia	*Vombatus ursinus*	Common Wombat		O	Camera Trap	Not Listed	Not Listed
Mammalia	*Vulpes vulpes*	Fox	*	O	Camera Trap	Not Listed	Not Listed
Mammalia	*Wallabia bicolor*	Swamp Wallaby		O	Camera Trap	Not Listed	Not Listed
Mammalia		Unidentified Microbat		OW	Spotlighting	Not Listed	Not Listed
Mammalia		Unidentifiable murid		O	Camera Trap	Not Listed	Not Listed
Reptilia	*Ctenotus taeniolatus*	Copper-tailed Skink		O	Opportunistic	Not Listed	Not Listed
Reptilia	*Gekkonidae*	Unidentified Gecko		O	Opportunistic	Not Listed	Not Listed
Reptilia	*Pogona barbata*	Eastern Bearded Dragon		O	Opportunistic	Not Listed	Not Listed
Reptilia	*Rankinia diemensis*	Mountain Dragon		O	Opportunistic	Not Listed	Not Listed
Reptilia	*Tiliqua scincoides*	Eastern Blue-tongue Lizard		O	Camera Trap	Not Listed	Not Listed
Reptilia	*Varanus rosenbergi*	Rosenberg's Goanna		O	Opportunistic	Vulnerable	Not Listed

Family	Scientific Name	Common Name	Exotic	Obs. Type	Method	BC Act	EPBC Act
Reptilia	*Varanus varius*	Lace monitor		O	Camera Trap	Not Listed	Not Listed
Microbat	*Austronomus australis*	White-striped Free-tailed Bat		Definite	Anabat	Not Listed	Not Listed
Microbat	*Chalinolobus dwyeri*	Large-eared Pied Bat		Definite	Anabat	Vulnerable	Vulnerable
Microbat	*Chalinolobus gouldii*	Gould's Wattled Bat		Definite	Anabat	Not Listed	Not Listed
Microbat	*Chalinolobus morio*	Chocolate Wattled Bat		Definite	Anabat	Not Listed	Not Listed
Microbat	*Rhinolophus megaphyllus*	Eastern Horseshoe Bat		Definite	Anabat	Not Listed	Not Listed
Microbat	*Vespadelus darlingtoni*	Large Forest Bat		Definite	Anabat	Not Listed	Not Listed
Microbat	*Falsistrellus tasmaniensis*	Eastern Falsistrelle		Probable	Anabat	Not Listed	Not Listed
Microbat	*Miniopterus orianae oceanensis*	Eastern Bent-winged Bat		Probable	Anabat	Vulnerable	Not Listed
Microbat	*Myotis macropus*	Large-footed Myotis		Probable	Anabat	Vulnerable	Not Listed
Microbat	*Nyctophilus geoffroyi*	Lesser long-eared bat		Probable	Anabat	Not Listed	Not Listed
Microbat	*Nyctophilus gouldi*	Gould's long-eared bat		Probable	Anabat	Not Listed	Not Listed
Microbat	*Ozimops ridei*	Ride's Free-tailed Bat		Probable	Anabat	Not Listed	Not Listed
Microbat	*Scoteanax rueppellii*	Greater Broad-nosed Bat		Probable	Anabat	Vulnerable	Not Listed
Microbat	*Scotorepens orion*	Eastern Broad-nosed Bat		Probable	Anabat	Not Listed	Not Listed
Microbat	*Vespadelus regulus*	Southern Forest Bat		Probable	Anabat	Not Listed	Not Listed

O = Observed; W = heard

Appendix C
Bat Call Analysis



ECHO
ECOLOGY AND
SURVEYING

Bat Call Identification

Airly, NSW

Prepared for
RPS Australia East Pty Ltd
Unit 2A, 45 Fitzroy St
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RPS Job No. 145209

Job Reference BC_RPS110 - February 2022

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This report has been prepared to document the analysis of digital ultrasonic bat echolocation calls received from a third party. The data was not collected by the author and as such no responsibility is taken for the quality of data collection or for the suitability of its subsequent use.

This report was authored by



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1.0 INTRODUCTION

This report has been commissioned by RPS Australia East Pty Ltd to analyse bat echolocation call data collected from Airly, NSW. Data was provided electronically to the author. This report documents the methods involved in analysing bat call data and the results obtained only.

2.0 METHODS

2.1 Call Identification

The identification of bat echolocation calls recorded during surveys was undertaken using Anabat Insight (Titley Electronics, Version 2.0.2) software. Files from Anabat Express units (.zca) were first converted to .zc (max 15s duration) and a noise filter was applied (EE_Allbats.als, ZC – auto, Smoothness - 4). The identification of calls was undertaken with reference to Pennay et al. (2004) and through the comparison of recorded reference calls from the Sydney Basin. Reference calls were obtained from the NSW database and from the authors personal collection.

A list of potentially occurring echolocating bat species for the region (approximately 50 – 100 km radius) was obtained from the Australasian Bat Society – Bat Map (https://www.ausbats.org.au/batmap.html) and was used to constrain the identification of bat calls.

Each call sequence ('pass') was assigned to one of five categories, according to the confidence with which an identification could be made, being:

- Definite - Pass identified to species level and could not be confused with another species
- Probable - Pass identified to species level and there is a low chance of confusion with another species
- Possible - Pass identified to species level but short duration or poor quality of the pass increases the chance of confusion with another species
- Species group - Pass could not be identified to species level and could belong to one of two or more species. Occurs more frequently when passes are short or of poor quality

- Unknown - Either background 'noise' files or passes by bats which are too short and/or of poor quality to confidently identify.

Call sequences that were less than three pulses in length were not analysed and were assigned to 'Unknown' and only search phase calls were analysed. Furthermore, some species are difficult to differentiate using bat call analysis due to overlapping call frequencies and similar shape of plotted calls and in these cases calls were assigned to species groups.

The total number of passes (call sequences) per unit per night was tallied to give an index of activity.

Nomenclature follows the Australian Faunal Directory (https://biodiversity.org.au/afd; downloaded 15 June 2020).

The echolocation call characteristics used to differentiate species for the region and the identification potential for each species are described in Appendix A.

2.2 Log file review

We reviewed the log files for each night of recording and have summarised the detector settings, recording duration and any errors. This may be used to confirm survey effort, the use of correct detector settings and may help diagnose missing data.

2.3 Limitations

The identification of bat species from echolocation calls in many Australian regions is not straightforward. Our reference call libraries tend to be relatively small, some species vary their call frequency with region and bat behaviour may also influence call shapes and frequencies. Additional factors may add to the level of uncertainty of species identification from echolocation calls such as short call sequences, high levels of noise and missing echolocation pulses. Some species share overlapping echolocation call characteristics and some overlap so much that we are unable to differentiate between species with our current knowledge.

To assist with the interpretation of our results within this context of uncertainty, we provide a qualitative indication of the confidence of bat call identification by assigning confidence levels (Definite, Probable, Possible and Species Groups). We have also provided a list of the general identification potential for each species potentially occurring within your sample region (Appendix A). For a more complete species inventory, bat call recording should be combined with other survey methods such as trapping.

It should be noted that the activity levels recorded at different sites may not be readily able to be compared. Activity levels should not be compared among species as different species have different detectability due to factors such as call loudness, foraging strategy and call identifying features. Activity comparisons among sites are dependent on many variables which need to be carefully controlled during data collection and statistically analysed. Influential variables include wind, rain, temperature, duration of recording, season, detector and microphone sensitivity, detector placement, weather protection devices etc.

The bat call identification results presented in this report should be interpreted with these limitations in mind and in many cases trapping and habitat assessment should also be undertaken in conjunction with bat call recording.

3.0 RESULTS

Calls were recorded in zero crossings format using Anabat Express bat detectors (Titley Scientific).

A total of 31,101 call sequences were recorded, of which 6,424 call sequences were able to be analysed (ie were not 'noise' files or bat calls of short length). Of the bat calls, 2,848 call sequences (44 %) were able to be confidently identified (those classified as either definite or probable identifications) to species level (Table 3-1). Species recorded confidently within the site include:

- *Austronomus australis* (White-striped Free-tailed Bat)
- *Chalinolobus dwyeri* (Large-eared Pied Bat)
- *Chalinolobus gouldii* (Gould's Wattled Bat)
- *Chalinolobus morio* (Chocolate Wattled Bat)
- *Rhinolophus megaphyllus* (Eastern Horseshoe Bat)
- *Vespadelus darlingtoni* (Large Forest Bat)

Additionally, the following bat species potentially occurred within the site, but could not be confidently identified (those calls classified as possible or as a species group):

- *Falsistrellus tasmaniensis* (Eastern Falsistrelle)
- *Miniopterus orianae oceanensis* (Eastern Bent-winged Bat)
- *Myotis macropus* (Large-footed Myotis)
- *Nyctophilus geoffroyi* (Lesser long-eared bat)
- *Nyctophilus gouldi* (Gould's long-eared bat)
- *Ozimops ridei* (Ride's Free-tailed Bat)
- *Scoteanax rueppellii* (Greater Broad-nosed Bat)
- *Scotorepens orion* (Eastern Broad-nosed Bat)
- *Vespadelus regulus* (Southern Forest Bat)

- *Vespadelus troughtoni* (Eastern cave bat)
- *Vespadelus vulturnus* (Little Forest Bat)

It should be noted that additional bat species may be present within the site but were not recorded by the detectors (or are difficult to identify by bat call) and habitat assessment should be used in conjunction with these results to determine the likelihood of occurrence of other bat species.

Table 3-1 below summarises the results of the bat call analysis.

3.1 Log file review

The log file review indicated that there were some issues with some detectors resulting in inaccurate nightly tallies or incomplete datasets. Full details are provided in Appendix B.

Table 3-1: Results of bat call analysis (number of passes per site per night)

Key: V – Vulnerable; E – Endangered; X – listed as. For species group identifications where one or more of the species are listed as threatened, the species initials that are listed as threatened have been entered into the EPBC Act, BC Act, Species Credit, Ecosystem Credit and/or SAII columns

CONFIDENCE	IDENTIFICATION	EPBC ACT	BC ACT	SPECIES CREDIT	ECOSYSTEM CREDIT	SAII	February_2021										November_2021			
							Anabat 1 2102		Anabat 10 2102		Anabat 2 2102		Anabat 6 2102		Anabat 9 2102		Anabat 2 2111			
							2/02/2021	3/02/2021	2/02/2021	3/02/2021	2/02/2021	3/02/2021	2/02/2021	3/02/2021	2/02/2021	3/02/2021	1/11/2021	2/11/2021	3/11/2021	5/11/2021
DEFINITE	*Austronomus australis*	-	-	-	-	-	-	-	7	4	1	-	3	1	2	-	-	-	-	-
	Chalinolobus dwyeri	V	V	X	-	Breeding	-	-	2	7	1	-	2	-	-	-	-	-	-	-
	Chalinolobus gouldii	-	-	-	-	-	-	1	1	-	-	-	1	1	-	-	-	-	-	-
	Chalinolobus morio	-	-	-	-	-	-	-	2	-	-	-	1	-	-	-	-	-	-	-
	Rhinolophus megaphyllus	-	-	-	-	-	505	612	2	-	73	148	-	-	3	9	67	58	62	-
	Vespadelus darlingtoni	-	-	-	-	-	-	-	2	1	-	-	-	1	-	-	-	-	-	-
PROBABLE	*Austronomus australis*	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-
	Chalinolobus dwyeri	V	V	X	-	Breeding	-	-	-	-	-	2	-	-	-	-	-	-	-	-
	Chalinolobus gouldii	-	-	-	-	-	-	-	1	5	-	-	1	2	-	-	-	-	-	-
	Chalinolobus morio	-	-	-	-	-	-	-	3	1	-	-	-	1	-	-	-	-	-	-
	Rhinolophus megaphyllus	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
	Vespadelus darlingtoni	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
POSSIBLE	*Chalinolobus dwyeri*	V	V	X	-	Breeding	-	1	6	5	-	3	-	1	-	-	-	-	-	-
	Chalinolobus gouldii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPECIES GROUPS	*Chalinolobus gouldii / Ozimops ridei*	-	-	-	-	-	-	-	10	22	1	-	10	7	2	2	-	-	-	-
	Chalinolobus morio / Vespadelus vulturnus / Vespadelus troughtoni	-	Vt	Vt	-	Vt	198	351	158	150	8	13	3	11	9	31	4	1	3	-
	Falsistrellus tasmaniensis / Scotorepens orion / Scoteanax rueppellii	-	Ft Sr	-	Ft Sr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Miniopterus orianae oceanensis / Vespadelus darlingtoni / Vespadelus regulus	-	Moo	Moo	Moo	Moo	1	-	3	1	-	2	3	-	-	-	-	-	-	-

CONFIDENCE	IDENTIFICATION	EPBC ACT	BC ACT	SPECIES CREDIT	ECOSYSTEM CREDIT	SAII	February_2021										November_2021			
							Anabat 1 2102		Anabat 10 2102		Anabat 2 2102		Anabat 6 2102		Anabat 9 2102		Anabat 2 2111			
							2/02/2021	3/02/2021	2/02/2021	3/02/2021	2/02/2021	3/02/2021	2/02/2021	3/02/2021	2/02/2021	3/02/2021	1/11/2021	2/11/2021	3/11/2021	5/11/2021
	Miniopterus orianae oceanensis / Vespadelus vulturnus	-	Moo	Moo	Moo	Moo	10	7	13	16	2	6	1	6	-	-	1	1	-	-
	Myotis macropus / Nyctophilus geoffroyi / Nyctophilus gouldi	-	Mm	Mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Vespadelus darlingtoni / Vespadelus regulus	-	-	-	-	-	-	-	6	7	-	-	-	4	-	1	-	-	-	-
	Vespadelus vulturnus / Vespadelus troughtoni	-	Vt	Vt	-	Vt	33	56	23	24	1	2	-	1	-	2	-	-	-	-
UNKNOWN	Unknown	-	-	-	-	-	116	154	26	37	19	35	11	6	15	19	18	15	10	-
	'Noise' files	-	-	-	-	-	257	242	1515	255	81	477	408	287	2075	1630	68	39	36	1201
TOTAL							**1121**	**1425**	**1780**	**535**	**188**	**688**	**445**	**329**	**2106**	**1694**	**158**	**114**	**111**	**1201**

CONFIDENCE	IDENTIFICATION	EPBC ACT	BC ACT	SPECIES CREDIT	ECOSYSTEM CREDIT	SAII	November_2021																	
							Anabat 4 2111							Anabat 6 2111		Anabat 7 2111					Anabat 8 2111		Anabat 9 2111	
							31/10/2021	1/11/2021	2/11/2021	3/11/2021	4/11/2021	5/11/2021	6/11/2021	4/11/2021	5/11/2021	1/11/2021	2/11/2021	3/11/2021	4/11/2021	5/11/2021	1/11/2021	4/11/2021	1/11/2021	3/11/2021
DEFINITE	*Austronomus australis*	-	-	-	-	-	-	3	-	-	3	-	-	-	-	-	1	4	6	-	-	-	-	-
	Chalinolobus dwyeri	V	V	X	-	Bree ding	-	-	-	2	-	-	-	-	-	1	-	-	-	-	-	-	-	1
	Chalinolobus gouldii	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
	Chalinolobus morio	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Rhinolophus megaphyllus	-	-	-	-	-	-	1	-	2	-	-	-	-	-	-	-	2	-	-	1180	3	-	-
	Vespadelus darlingtoni	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PROBABLE	*Chalinolobus dwyeri*	V	V	X	-	Bree ding	-	-	-	-	-	-	-	-	-	1	-	2	-	-	1	-	-	2
	Chalinolobus gouldii	-	-	-	-	-	1	2	1	1	-	3	-	-	-	-	-	-	1	-	12	-	-	-

CONFIDENCE	IDENTIFICATION	EPBC ACT	BC ACT	SPECIES CREDIT	ECOSYSTEM CREDIT	SAII	November_2021																
							Anabat 4 2111							Anabat 6 2111		Anabat 7 2111					Anabat 8 2111		Anabat 9 2111	
							31/10/2021	1/11/2021	2/11/2021	3/11/2021	4/11/2021	5/11/2021	6/11/2021	4/11/2021	5/11/2021	1/11/2021	2/11/2021	3/11/2021	4/11/2021	5/11/2021	1/11/2021	4/11/2021	1/11/2021	3/11/2021
	Chalinolobus morio	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
	Rhinolophus megaphyllus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-
	Vespadelus darlingtoni	-	-	-	-	-	-	4	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
POSSIBLE	*Chalinolobus dwyeri*	V	V	X	-	Breeding	-	1	-	1	-	-	-	-	-	-	3	2	-	-	-	-	-	-
	Chalinolobus gouldii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-
SPECIES GROUPS	*Chalinolobus gouldii / Ozimops ridei*	-	-	-	-	-	1	-	2	7	2	11	-	-	-	-	5	-	-	-	2	-	-	-
	Chalinolobus morio / Vespadelus vulturnus / Vespadelus troughtoni	-	Vt	Vt	-	Vt	26	86	41	9	-	13	-	-	-	24	45	43	3	-	510	30	-	-
	Falsistrellus tasmaniensis / Scotorepens orion / Scoteanax rueppellii	-	Ft Sr	-	Ft Sr	-	-	-	-	-	-	-	-	-	-	2	-	4	1	-	-	-	-	-
	Miniopterus orianae oceanensis / Vespadelus darlingtoni / Vespadelus regulus	-	Moo	Moo	Moo	Moo	-	4	2	2	1	1	-	-	-	-	3	-	-	-	14	-	-	-
	Miniopterus orianae oceanensis / Vespadelus vulturnus	-	Moo	Moo	Moo	Moo	2	24	18	10	7	9	-	-	-	-	3	-	-	-	970	-	-	-
	Myotis macropus / Nyctophilus geoffroyi / Nyctophilus gouldi	-	Mm	Mm	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-
	Vespadelus darlingtoni / Vespadelus regulus	-	-	-	-	-	-	10	4	-	-	-	-	-	-	1	1	-	-	-	2	-	-	-
	Vespadelus vulturnus / Vespadelus troughtoni	-	Vt	Vt	-	Vt	5	19	15	3	-	-	-	-	-	1	16	6	-	-	295	7	-	-
UNKNOWN	Unknown	-	-	-	-	-	11	32	41	22	9	13	-	1	-	17	21	24	6	-	60	37	2	-
	'Noise' files	-	-	-	-	-	722	517	795	2911	1804	721	3	2748	50	256	316	544	3350	2	200	358	24	8
TOTAL							**768**	**704**	**920**	**2971**	**1826**	**772**	**3**	**2749**	**50**	**304**	**415**	**632**	**3367**	**2**	**3251**	**435**	**26**	**11**

4.0 SAMPLE CALLS

A sample of the calls actually identified from the site for each species is given below.

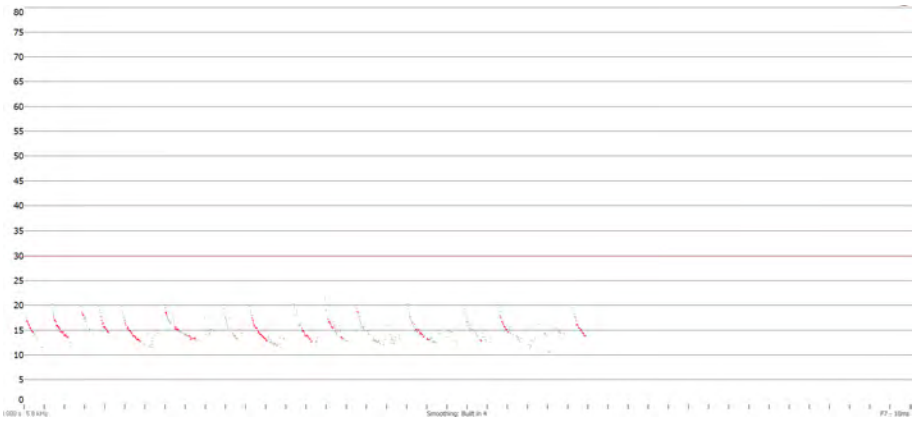


Figure 4-1: *Austronomus australis* definite call

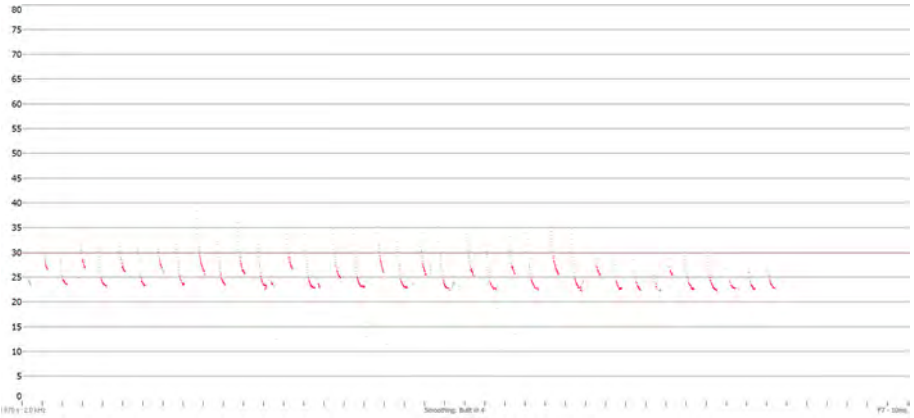


Figure 4-2: *Chalinolobus dwyeri* definite call

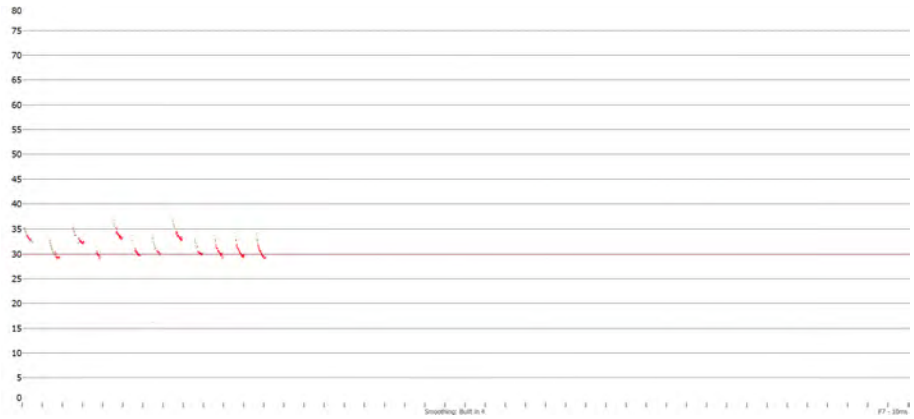


Figure 4-3: *Chalinolobus gouldii* definite call



Figure 4-4: *Chalinolobus morio* definite call

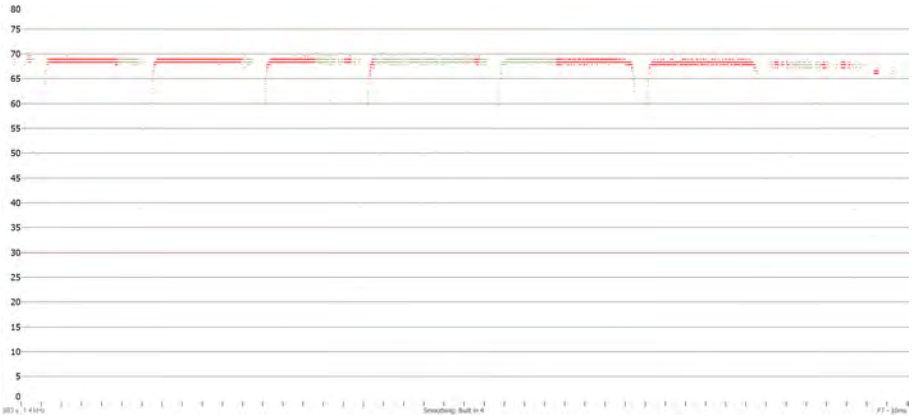


Figure 4-5: *Rhinolophus megaphyllus* definite call

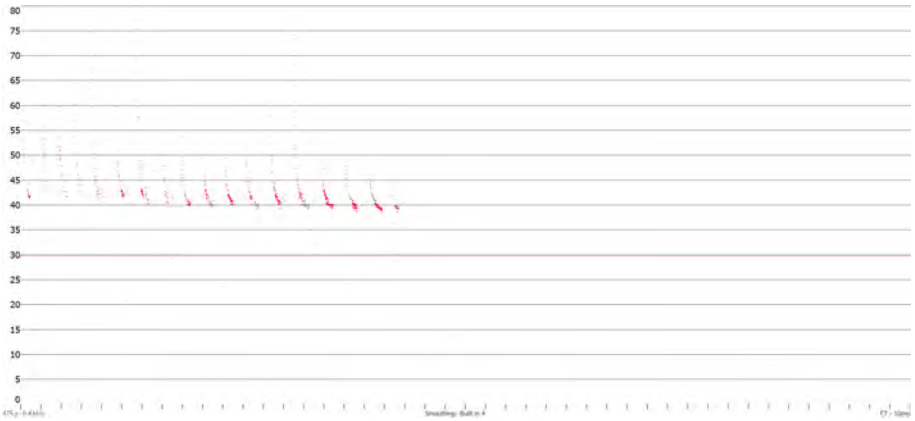


Figure 4-6: *Vespadelus darlingtoni* definite call

5.0 REFERENCES

Adams, M. D., Law, B.S., French, K.O. (2009). "Vegetation structure influences the vertical stratification of open- and edge-space aerial-foraging bats in harvested forests." Forest Ecology and Management 258(9): 2090-2100.

Adams, M. D., Law, B.S., French, K.O. (2010). Reliable automation of bat call identification for eastern New South Wales, Australia, using classification trees and AnaScheme software. *Acta Chiropterologica* 12(1): 231-245.

Australasian Bat Society Incorporated (undated) *Standards for reporting bat detector surveys*, http://batcall.csu.edu.au/abs/issues/ABS_Anabat_survey_standards.pdf

Churchill, S. (2008). *Australian Bats.* Second Edition Allen & Unwin; Crows Nest, NSW.

Corben, C. (2010) Feeding buzzes, *Australasian Bat Society Newsletter*, 35:40-44.

Law, B.S., Reinhold, L. and Pennay, M. (2002). Geographic variation in the echolocation calls of Vespadelus spp. (Vespertilionidae) from New South Wale and Queensland, Australia. *Acta Chiropterologica* 4: 201-215.

Pennay, M., Law, B. and Reinhold, L. (2004). *Bat calls of New South Wales: Region based guide to the echolocation calls of Microchiropteran bats*. NSW Department of Environment and Conservation, Hurstville.

Reinhold, L., Law, B., Ford, G. and Pennay, M. (2001a). *Key to the bat calls of south-east Queensland and north-east New South Wales*. Queensland Department of Natural Resources and Mines, State Forests of New South Wales, University of Southern Queensland, and New South Wales National Parks and Wildlife Service, Australia.

Reinhold, L., Herr, A., Lumsden, L., Reardon, T., Corben, C., Law, B., Prevett, P., Ford, G., Conole, L., Kutt, A., Milne, D. and Hoye, G. (2001b). Geographic variation in the echolocation calls of Gould's wattled bat *Chalinolobus gouldii*. *Australian Zoologist* 31: 618-624.

Van Dyck, S. and Strahan, R. (Eds.) (2008). *The Mammals of Australia: Third Edition*. New Holland; Sydney.

APPENDIX A SPECIES IDENTIFICATION CONFIDENCE AND CHARACTERISTICS – SYDNEY BASIN

Table A1: Identification confidence and characteristics of bat echolocation calls from the Blue Mountains - Sydney basin region

Scientific Name	Common Name	Identification Potential	Identification characteristics
Austronomus australis	White-striped Free-tailed Bat	High	Good quality calls unlikely to be confused. However, partial calls may be confused with social calls of other bat species and insects.
Chalinolobus dwyeri	Large-eared Pied Bat	High	Calls may overlap with *Saccolaimus flaviventris*. However, good quality call sequences are unlikely to be confused due to small pulse shape and alternating pulses in *Chalinolobus dwyeri*.
Chalinolobus gouldii	Gould's Wattled Bat	Mod - High	Overlaps with *Ozimops ridei* and *Scoteanax rueppellii*. In good quality recordings, differentiated from *Ozimops ridei* by curved pulses and from *Scoteanax rueppellii* by alternating pulse frequencies.
Chalinolobus morio	Chocolate Wattled Bat	Mod - High	Overlaps with *Vespadelus vulturnus, Vespadelus pumilus, Vespadelus troughtoni* and possibly with *Miniopterus orianae oceanensis* in some areas. Differentiated from *Vespadelus* spp. by the presence of down-sweeping tails on pulses and generally little doppler effect that is typically displayed by *Vespadelus* spp. Not differentiated from *Miniopterus orianae oceanensis* where they overlap in characteristic frequency.
Falsistrellus tasmaniensis	Eastern Falsistrelle	Low	Overlaps in characteristic frequency with *Scotorepens orion* and *Scoteanax rueppellii*. *Falsistrellus tasmaniensis* is most frequently recorded from more elevated locations in the region. However, some records exist from coastal lowlands and so included it in our species groups in coastal areas as a precautionary measure. We do not distinguish *Falsistrellus tasmaniensis* from *Scotorepens orion* where they overlap in frequency due to overlapping call characteristics.

Scientific Name	Common Name	Identification Potential	Identification characteristics
Miniopterus orianae oceanensis	Eastern Bent-winged Bat	Low – Mod	Overlaps in characteristic frequency with *Vespadelus darlingtoni, Vespadelus regulus* and possibly with *Chalinolobus morio*. Differentiated from *Vespadelus* spp. by characteristic one-phase 'stepped' feeding buzz (if present) and generally little doppler effect (that is typically displayed by *Vespadelus* spp.). Not differentiated from *Chalinolobus morio* where they overlap in characteristic frequency.
Myotis macropus	Large-footed Myotis	Low - Mod	Overlaps in call features with *Nyctophilus* spp. Differentiated from *Nyctophilus* spp. in good quality call sequences with pulse intervals < 75 ms, initial slope > 400 OPS and often with a central kink and varying slopes among pulses.
Nyctophilus geoffroyi	Lesser long-eared bat	Low	Overlaps in call features with *Nyctophilus gouldi* and *Myotis macropus*. Differentiated from *Myotis macropus* by pulse intervals > 95 ms and an initial slope of < 300 OPS. However, *Nyctophilus geoffroyi* and *Nyctophilus gouldi* are unable to be differentiated from each other.
Nyctophilus gouldi	Gould's long-eared bat	Low	Overlaps in call features with *Nyctophilus geoffroyi* and *Myotis macropus*. Differentiated from *Myotis macropus* by pulse intervals > 95 ms and an initial slope of < 300 OPS. However, *Nyctophilus geoffroyi* and *Nyctophilus gouldi* are unable to be differentiated from each other.
Ozimops ridei	Ride's Free-tailed Bat	Mod	Overlaps in characteristic frequency with *Micronomus norfolkensis* and *Chalinolobus gouldii*. Differentiated from *Chalinolobus gouldii* in long call sequences with mostly flat pulse shapes. Differentiated from *Micronomus norfolkensis* in long call sequences with little pulse alternation.
Phoniscus papuensis	Golden-tipped Bat	Low	Has a very quiet call that is not often recorded by bat detectors.
Rhinolophus megaphyllus	Eastern Horseshoe Bat	High	Long duration, flat calls at characteristic frequency of 66 – 70kHz, unlikely to be confused with any other species.

Scientific Name	Common Name	Identification Potential	Identification characteristics
Saccolaimus flaviventris	Yellow-bellied Sheath-tailed Bat	Mod - High	Calls may overlap with *Chalinolobus dwyeri*. However, good quality call sequences are unlikely to be confused due to *Chalinolobus dwyeri* having small pulse shape and alternating pulses. The harmonics of *Saccolaimus flaviventris* assist identification in full spectrum (.WAV) recordings. The characteristic frequency of the fundamental (first harmonic) is 10-12 kHz, the second (loudest harmonic) is 20-25kHz and the third harmonic 30-35kHz.
Scoteanax rueppellii	Greater Broad-nosed Bat	Low – Mod	Overlaps in characteristic frequency with *Chalinolobus gouldii*, *Micronomus norfolkensis*, *Scotorepens orion* and *Falsistrellus tasmaniensis*. Differentiated from *Micronomus norfolkensis* in long call sequences with mostly curved pulse shapes. Differentiated from *Chalinolobus gouldii* only in long call sequences with no alternating pulse frequencies. Differentiated from *Scotorepens orion* and *Falsistrellus tasmaniensis* by long pre-characteristic sections. Usually only identified at a probable confidence level.
Scotorepens orion	Eastern Broad-nosed Bat	Low	Overlaps in characteristic frequency with *Falsistrellus tasmaniensis* and *Scoteanax rueppellii*. *Falsistrellus tasmaniensis* is most frequently recorded from more elevated locations in the region. However, some records exist from coastal lowlands and so included it in our species groups in coastal areas as a precautionary measure. We do not distinguish *Falsistrellus tasmaniensis* from *Scotorepens orion* where they overlap in frequency due to overlapping call characteristics.
Vespadelus darlingtoni	Large Forest Bat	Low - Mod	Overlaps in characteristic frequency with *Miniopterus orianae oceanensis* and *Vespadelus regulus*. Differentiated from *Miniopterus orianae oceanensis* by a two-phase feeding buzz (where present) or by substantial doppler effect (typically displayed by *Vespadelus* spp.). Only differentiated from *Vespadelus regulus* where they do not overlap in characteristic frequency.
Vespadelus regulus	Southern Forest Bat	Low	Overlaps in characteristic frequency with *Vespadelus darlingtoni, Vespadelus vulturnus* and *Miniopterus orianae oceanensis*. Differentiated from *Miniopterus orianae oceanensis* by a two-phase feeding buzz (where present) or by substantial doppler effect (typically displayed by *Vespadelus* spp.). Usually unable to be differentiated from *Vespadelus darlingtoni* and *Vespadelus vulturnus* in this region where they overlap in frequency.

Scientific Name	Common Name	Identification Potential	Identification characteristics
Vespadelus troughtoni	Eastern cave bat	Low	Overlaps in characteristic frequency with *Chalinolobus morio* and *Vespadelus vulturnus*. Differentiated from *Chalinolobus morio* in long call sequences with few down-sweeping tails on pulses and by the doppler effect that is typically displayed by *Vespadelus* spp. However, unable to be differentiated from *Vespadelus vulturnus* in this region.
Vespadelus vulturnus	Little Forest Bat	Low	Overlaps in characteristic frequency with *Chalinolobus morio* and *Vespadelus troughtoni*. Differentiated from *Chalinolobus morio* in long call sequences with few down-sweeping tails on pulses and by the doppler effect that is typically displayed by *Vespadelus* spp. Only differentiated from *Vespadelus troughtoni* in calls with a characteristic frequency 47-48kHz.

APPENDIX B LOG FILE REVIEW

Table B1: Log file review results

Folder	Log file name	Unit Type	Set to Record?	Setting Mode	Data Division	Sensitivity	Firmware	GPS	Entire Night?	Errors?	Comments
Feb 2021 \Anabat 1 2102\	SN395661 2021-02-02 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.09942 150.01723	Yes	None	
Feb 2021 \Anabat 1 2102\	SN395661 2021-02-03 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.09935 150.01764	Yes	Buffer Overflow	2 x Buffer Overflow messages. Likely some very minor data loss.
Feb 2021 \Anabat 2 2102\	SN409322 2021-02-02 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.099 150.01765	Yes	None	
Feb 2021 \Anabat 2 2102\	SN409322 2021-02-03 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.09904 150.01766	Yes	Buffer Overflow	1 x Buffer Overflow messages. Likely some very minor data loss.
Feb 2021 \Anabat 6 2102\	SN507272 2021-02-02 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.09903 1 50.05489	Yes	None	

Folder	Log file name	Unit Type	Set to Record?	Setting Mode	Data Division	Sensitivity	Firmware	GPS	Entire Night?	Errors?	Comments
Feb 2021 \Anabat 6 2102\	SN507272 2021-02-03 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.099 150.05498	Yes	None	
Feb 2021 \Anabat 9 2102\	SN507284 2021-02-02 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.11098 150.0465	Yes	None	
Feb 2021 \Anabat 9 2102\	SN507284 2021-02-03 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.11158 150.04596	Yes	None	
Feb 2021 \Anabat 9 2102\	SN507284 2021-02-04 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.13478 149.92947	Yes	None	
Feb 2021 \Anabat 10 2102\	SN507191 2021-02-02 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.10887 150.02348	Yes	None	
Feb 2021 \Anabat 10 2102\	SN507191 2021-02-03 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.10894 150.02345	Yes	None	
Nov 2021 \Anabat 2 2111\	SN409322 2021-11-01 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.09904 1 50.01765	Yes	None	
Nov 2021 \Anabat 2 2111\	SN409322 2021-11-02 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.09903 150.01761	Yes	None	

Folder	Log file name	Unit Type	Set to Record?	Setting Mode	Data Division	Sensitivity	Firmware	GPS	Entire Night?	Errors?	Comments
Nov 2021 \Anabat 2 2111\	SN409322 2021-11-03 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.09904 150.01777	Yes	None	
Nov 2021 \Anabat 2 2111\	SN409322 2021-11-04 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.09904 150.01777	Yes	Buffer Overflow	3 x Buffer Overflow messages. Likely some very minor data loss.
Nov 2021 \Anabat 2 2111\	SN409322 2021-11-05 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.09897 150.01782	Yes	None	
Nov 2021 \Anabat 4 2111\	SN620364 2021-10-31 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.09607 150.03481	Yes	Timezone issue Buffer Overflow	Time zone likely incorrect and time stamps and nightly tallies will be incorrect 3 x Buffer Overflow messages. Likely some very minor data loss.
Nov 2021 \Anabat 4 2111\	SN620364 2021-11-01 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.09604 1 50.03484	Yes	Timezone issue Buffer Overflow	Time zone likely incorrect and time stamps and nightly tallies will be incorrect 1 x Buffer Overflow messages. Likely some very minor data loss.

Folder	Log file name	Unit Type	Set to Record?	Setting Mode	Data Division	Sensitivity	Firmware	GPS	Entire Night?	Errors?	Comments
Nov 2021 \Anabat 4 2111\	SN620364 2021-11-02 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.09607 150.03484	Yes	Timezone issue Buffer Overflow	Time zone likely incorrect and time stamps and nightly tallies will be incorrect Multiple Buffer Overflow messages. Likely some data loss.
Nov 2021 \Anabat 4 2111\	SN620364 2021-11-03 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.096 150.03484	Yes	Timezone issue Buffer Overflow	Time zone likely incorrect and time stamps and nightly tallies will be incorrect 4 x Buffer Overflow messages. Likely some very minor data loss.
Nov 2021 \Anabat 4 2111\	SN620364 2021-11-04 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.09613 150.03479	Yes	Timezone issue	Time zone likely incorrect and time stamps and nightly tallies will be incorrect
Nov 2021 \Anabat 4 2111\	SN620364 2021-11-05 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.09602 150.03486	Yes	Timezone issue Buffer Overflow	Time zone likely incorrect and time stamps and nightly tallies will be incorrect Multiple Buffer Overflow messages. Likely some data loss.

Folder	Log file name	Unit Type	Set to Record?	Setting Mode	Data Division	Sensitivity	Firmware	GPS	Entire Night?	Errors?	Comments
Nov 2021 \Anabat 7 2111\	SN507250 2021-11-01 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.09216 150.03356	Yes	None	
Nov 2021 \Anabat 7 2111\	SN507250 2021-11-02 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.09454 150.03804	Yes	None	
Nov 2021 \Anabat 7 2111\	SN507250 2021-11-03 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.09494 150.03262	Yes	None	
Nov 2021 \Anabat 7 2111\	SN507250 2021-11-04 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.09504 150.03252	Yes	None	
Nov 2021 \Anabat 7 2111\	SN507250 2021-11-05 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.09489 150.03239	Yes	None	
Nov 2021 \Anabat 8 2111\	SN507239 2021-11-01 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.09714 150.01618	Yes	Buffer Overflow	Multiple Buffer Overflow messages. Likely some data loss.
Nov 2021 \Anabat 8 2111\	SN507239 2021-11-02 log.csv	Anabat Express	Yes	Night	8	115	V5507J		Yes	Buffer Overflow	Multiple Buffer Overflow messages. Likely some data loss. Not Analysed

Folder	Log file name	Unit Type	Set to Record?	Setting Mode	Data Division	Sensitivity	Firmware	GPS	Entire Night?	Errors?	Comments
Nov 2021 \Anabat 8 2111\	SN507239 2021-11-03 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.09945 150.01769	Yes	Buffer Overflow	Multiple Buffer Overflow messages. Likely some data loss. Not Analysed
Nov 2021 \Anabat 8 2111\	SN507239 2021-11-04 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.09945 150.01769	Yes	None	
Nov 2021 \Anabat 8 2111\	SN507239 2021-11-05 log.csv	Anabat Express	Yes	Night	8	115	V5507J	-33.09947 150.01759	Yes	None	Not Analysed

Appendix 5:2021 Subsidence Monitoring Report

Centennial Coal: **Airly Mine**

Review of Monitored Subsidence and Subsidence Impacts during 2021

DOCUMENT REGISTER

Revision	Description	Author	Checker	Date
01	Draft issue	DK		28-Feb-22

Report produced to: For submission to the Department of Planning, Industry and Environment.

Background reports available at *www.minesubsidence.com*[1]:

Introduction to Longwall Mining and Subsidence (Revision A)

General Discussion of Mine Subsidence Ground Movements (Revision A)

[1] Direct link: http://www.minesubsidence.com/index_files/page0004.htm

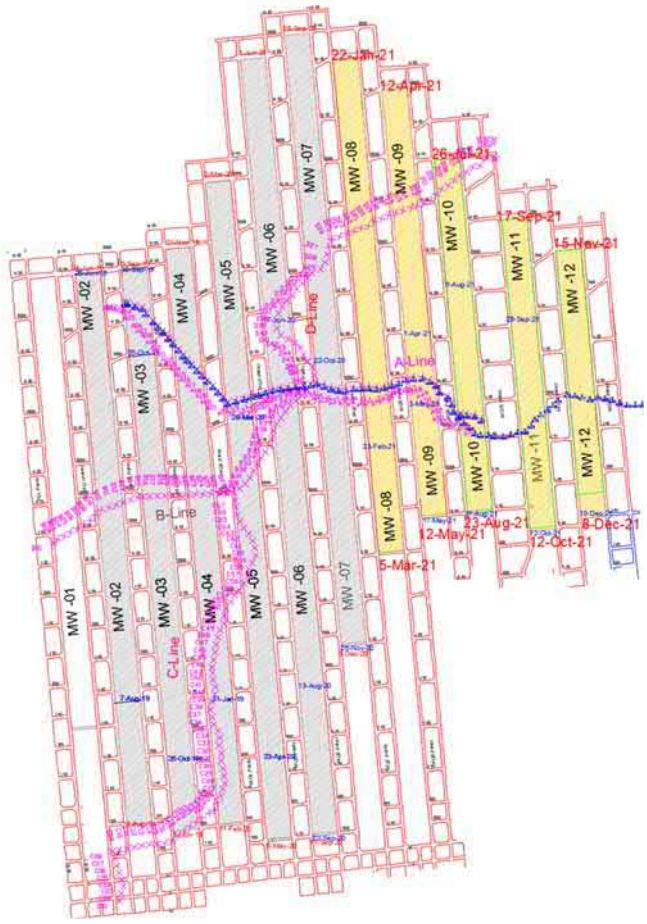
Airly Mine (Airly) is an existing underground coal mine that is located 5 kilometres (km) north-east of the village of Capertee, 40 km north-northwest of Lithgow and 171 km north-west of Sydney. Centennial Airly Pty Limited (CA) is the operator of Airly and CA is a wholly owned subsidiary of Centennial Coal Company Limited.

Airly was approved subject to various development consent conditions, including a requirement for an Annual Review of the environmental performance to the satisfaction of the Secretary of the Department of Planning and Environment. These conditions require that a review should include a comprehensive review of:

- the subsidence monitoring results over the previous calendar year:
- a comparison of these results against the relevant statutory requirements, limits or performance measures/criteria;
- a discussion of these results against previous years and the relevant predictions in the EIS, including the identification of any non-compliance over the last year,
- an identification of any trends in the monitoring data over the life of the development;
- an identification of any discrepancies between the predicted and actual impacts of the development, with an analysis of the potential cause of any significant discrepancies; and
- a description of what measures are proposed to be implemented over the next year to improve the environmental performance of the development.

This report provides these required subsidence monitoring and impact reviews. MW02 to MW04 were extracted in 2019. MW05 to MW07 were extracted during 2020.

The locations of the five mini walls that were extracted at Airly during 2021, i.e., MW08 to MW12, are highlighted in yellow in the following sketch.



The maximum observed subsidence that was observed in 2020 over MWs 02 to 07 was 612 mm at peg B22, which is located over MW04 far exceeded the maximum predicted subsidence before mining commenced of 70 mm and the maximum predicted subsidence in the EIS of 125 mm.

The maximum observed subsidence that was observed in 2021 over MWs 02 to 12 was 713 mm at peg B28, which is located over W05.

Fortunately, only minor impacts have been observed at Airly. These recently observed impacts are relatively minor with surface cracking being observed around the edges of the subsidence bowl over MW 02 to MW10, where the subsidence exceedance occurred. The levels of incremental subsidence over MWs 11 and 12 have been less than 125 mm.

No mining induced cliffs falls have occurred.

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1.1. Background

Airly Mine (Airly) is an existing underground coal mine that is located 5 kilometres (km) north-east of the village of Capertee, 40 km north-northwest of Lithgow and 171 km north-west of Sydney. Centennial Airly Pty Limited (CA) is the operator of Airly and CA is a wholly owned subsidiary of Centennial Coal Company Limited.

The surface areas over Airly are characterised by a steep and rugged topography with large areas of cliffs, minor cliffs, pagodas and significant rock outcrops. The topography is dominated by Mount Airly and Genowlan Mountain which are two large mesas that sit broadly within the landscape of the Capertee Valley, which measures over 30 km from north to south and east to west. The valley is surrounded by sandstone cliffs and steep talus slopes similar to those found on Mount Airly and Genowlan Mountain. Both Mount Airly and Genowlan Mountain are clearly visible for tens of kilometres in all directions.

The surface topography on the two mesas varies from gently undulating to steep sided valleys, major cliff lines, pagodas and gorges. Most of the surface areas over Airly are located within the Mugii Murrum-ban State Conservation Area (MMSCA) that has significant natural and cultural heritage values and contains significant mineral resources. The MMSCA was gazetted in 2011 to protect environmental and cultural heritage values while permitting mining and exploration.

Airly gained development approval in 1993 to extract longwall panels with up to 1.8m of subsidence beneath Mount Airly and Genowlan Mountain. Before extracting these longwalls, Airly initially commenced extracting coal using bord and pillar mining methods around the base of Mount Airly, the first of two large mesas that Airly planned to mine beneath. However, only trial mining was undertaken on some initial access headings and first workings when CA acquired the mine in 1997. Further trial mining was undertaken in 1998 with the coal being transported by road to the Mount Piper Power Station. Further development occurred in 2009 with the construction of a rail loop and other surface infrastructure, however, mining continued using only bord and pillar methods on access headings while mine planning progressed.

As part of the Airly Mine Extension Project EIS in 2014, CA developed a conservative approach to mining throughout the lease which employed different mining methods in different areas, each targeted to suit each specific area, referred to as ‘mining zones’. The EIS report was predominantly based on the premise that low levels of subsidence within each of the mining zones would avoid surface cracking and minimise risks of impacts to cliff lines, pagodas, and other natural features, as had been successfully undertaken for twenty years at the Centennial Clarence Mine.

A key objective of this conservative approach was to minimise risk of surface impacts through appropriate mine design to reduce subsidence. Sensitive high cliffs and escarpments located on the external parts of the Mount Airly, and Genowlan Mountain mesas were protected by a Cliff Line Zone (CLZ) of First Workings (i.e., no secondary extraction). The Panel and Pillar Mining Zones (PPMZs), located in the centres of the mesas, were designed with mini wall extraction of narrow panels (around four times narrower than conventional longwalls) and large chain pillars that were designed in order to limit subsidence. This 2014 EIS report, which was prepared by Golder Associates, predicted the maximum subsidence over the PPMZ areas of the mine, after the extraction of 61 m wide mini wall panel widths and 29.5 m chain pillars, would be less than 125 mm, tilts would be less than 2.5 mm/m and strains would be less than 2 mm/m. It was assessed that, at these low subsidence values, no surface cracking, rock falls or cliff impacts were expected.

In 2016, the Department of Planning, Industry and Environment commissioned an Independent Review Panel (IRP) to review and report on the accuracy and reliability of mine subsidence impacts presented in the EIS. The IRP comprised Dr Ken Mills (Strata Control Technology, SCT), Professor Ismet Canbulat (University of NSW, UNSW) and Don Kay (Mine Subsidence Engineering Consultants, MSEC). The IRP report, titled “*Report of the Independent Review Panel established to review and report on the accuracy and reliability of mine subsidence impacts on sensitive features across the Airly Mine Extension Project Application Area*”, dated July 2016, advised that the various proposed partial mining systems were considered conservative by comparisons with industry standards and could be expected to maintain surface subsidence movements at low levels.

This IRP report noted that cliff formations often experience rock falls due to natural weathering and erosion and, hence full protection, even with an ultra-conservative mine design was not possible. This IRP report also advised that, whilst the protection zones proposed were appropriate to provide the required level of protection to cliff formations and the proposed methods of extraction had the potential to avoid significant impacts on the cliffs, steep slopes and pagoda, high confidence subsidence monitoring over the initial panel and pillar mining areas should be undertaken to confirm the levels of ground movement that were being monitored over the early mini walls were as low as those being predicted.

In December 2016, Airly was granted approval to extend its operations for another 20 years and this approval included the extraction of mini walls within a panel and pillar zone beneath the Mount Airly and Genowlan Mountain mesas and near massive cliff lines.

Because of the various unknowns associated with the unique mine design, the approval Conditions of Consent required the setting up of a further IRP that would provide ongoing advice to Airly on the preparation of Extraction Plans and their implementation in order to meet the performance measures, particularly those relating to cliffs and pagoda formations, to the satisfaction of the Department of Planning, Industry and Environment.

1.2. Development Consent Performance Measures

The 2016 Development Consent adopted the following definitions for rock formations and set the following performance measures for the following definitions;

Cliffs within a 26.5 degree angle of draw of the Airly underground mine workings	No greater subsidence impacts or environmental consequences than predicted in the EIS *(ie occasional rock falls, displacement or dislodgment of boulders or slabs of less than 30 m^3, or fracturing, that do not impact Aboriginal heritage, EECs or public safety)*, that in total do not impact more than 2% of the total area of such cliffs
Pagodas within a 26.5 degree angle of draw of the Airly underground mine workings (other than pagodas affected by the New Hartley interaction zone)	No greater subsidence impacts or environmental consequences than predicted in the EIS *(ie occasional rock falls, displacement or dislodgment of boulders or slabs of less than 30 m^3, or fracturing, that do not impact Aboriginal heritage, EECs or public safety)*, that in total do not impact more than 2% of the total area of such pagodas
Pagodas within a 26.5 degree angle of draw of the New Hartley interaction zone	No greater subsidence impacts or environmental consequences than predicted in the EIS
Minor cliffs	No greater subsidence impacts or environmental consequences than predicted in the EIS
Steep slopes	No greater subsidence impacts or environmental consequences than predicted in the EIS

An updated subsidence prediction report was provided for CA by Strata^2 (March 2019), which advised that the maximum short-term subsidence over the whole Airly mine was likely to be 70 mm and the long-term maximum subsidence was predicted to be 110 mm.

This Strata^2 report confirmed the 2014 EIS advice that, at these low subsidence values, no surface cracking, rock falls or cliff impacts were expected. This report also advised that:

- the mine design was built on successful experience in other locations, especially Clarence Colliery;
- the mini wall mine design was considered to be unique in a mesa environment; and
- high confidence/accuracy subsidence monitoring would be undertaken over the initial mining areas.

1.3. Airly subsidence monitoring results prior to 2021

However, after extracting the first three mini walls on Mount Airly, i.e., MW02, MW03 & MW04, CA advised that the observed subsidence had exceeded the maximum predicted subsidence of 125 mm.

After Airly extracted Mini Wall 5, (MW05), in April 2020, the maximum observed subsidence had increased to 297 mm and, after MW06 was extracted in September 2020, the maximum observed subsidence had increased to 548 mm.

After Airly extracted MW07 in November 2020, the maximum observed subsidence was 612 mm at Peg B22. Tensile strain was a maximum of 1.7mm/m at Peg B9 and compressive strain was a maximum of 4.6mm/m at Peg B22, above the MW4 goaf. Tilt was a maximum of 11.9mm/m between Pegs B9 to B13, over the MW02 goaf.

Despite the increased levels of subsidence, no surface cracking or cliff falls were found on the Mount Airly mesa after the extraction of MW04, despite the maximum subsidence being measured at that time of 297mm.

The previous Annual Subsidence Report for 2020, dated February 2021, Report No AIR-018-Rev0, was prepared by Strata^2 for CA. This report advised that further reviews had been undertaken of the empirical subsidence monitoring results in the Western Coalfields. On comparing the subsidence monitoring results from different collieries, it became immediately evident there was a major difference in pillar behaviour between the Lithgow and Katoomba Seams, with the stronger and stiffer environment of the Katoomba Seam resulting in with significantly less subsidence.

This Strata^2 2020 Report then confirmed that the fundamental reason for the exceedance of the subsidence magnitudes put forward at the EIS stage was that the original calibration was based largely on a combined Lithgow / Katoomba Seam database and the difference in subsidence outcomes between seams was not anticipated.

After enough data became available to develop a Lithgow Seam-specific calibration, the differences between seams became clearer and Strata^2 advised that; the Airly data was consistent with other Lithgow Seam experiences; and There was nothing unique to the Airly environment (despite mid-angle faults at the seam horizon that could translate to appreciably different pillar compression outcomes.

This Strata^2 2020 Report, also advised that the key features of the surface impacts over MWs 02 to 07 were:

i) Minor surface subsidence impacts first became apparent at an Smax of 403mm (after the extraction of a third of MW06). The first observed surface crack impact was a tensile crack over the western panel edge of MW01, near GNSS 5. Subsequently, other similar cracks were found across the mesa.
ii) No impacts were evident at the location of maximum subsidence of 612mm, even though this was also the location of the maximum compressive strain of 4.6mm/m.
iii) The topography and vegetation masked most of the small surface cracking impacts.

iv) Cracks first became evident over minor cliff and pagoda areas over the southern half of MW05. Smax over MW06 ranges from around ~370mm in the northern plateau area (depth of ~270m) to 150-250mm in the south at depths of 210-230m, where the cracking is evident. Again, the cracks are essentially tensile, noting:

- These isolated cracks had negligible impact on the stability of the associated rock structures, including caves up to 9m deep, and therefore did not trigger the TARP.
- The surface features, especially the caves, are practically inaccessible and the minor cracking does not therefore represent a loss of public amenity. It is suggested that any future monitoring of the cracking in this area focus on the potential use of drone technology, given the safety concerns associated with access (i.e., scrambling over remote and steep rock formations and slippery creek beds).
- The tensile cracks at the margins of the overall extraction area are attributed in part to largescale overburden "plate" movements that occur in cycles associated with the extraction of individual panels.

This 2020 Report also advised that the chain pillar widths, where the Depths of Cover (DoC) are up to 300 m, should have been at least 39.1 m wide.

1.4. Airly mine plan prior to 2021 and panel extraction during 2021

The following sketch, Fig. 1.1, shows the mini wall panels that were extracted prior to the end of December in 2020, i.e., the subject of the previous Annual Subsidence Report and those mini wall panels that were extracted in 2021 (highlighted in yellow). This plan shows the dates when the various mini walls were extracted (in **red** at the commencing and finishing ends of each mini wall panel, and the location of the mini wall face at the times when the survey lines were monitored (in **blue**). Fig. 1.3 shows similar detail against a surface RL image.

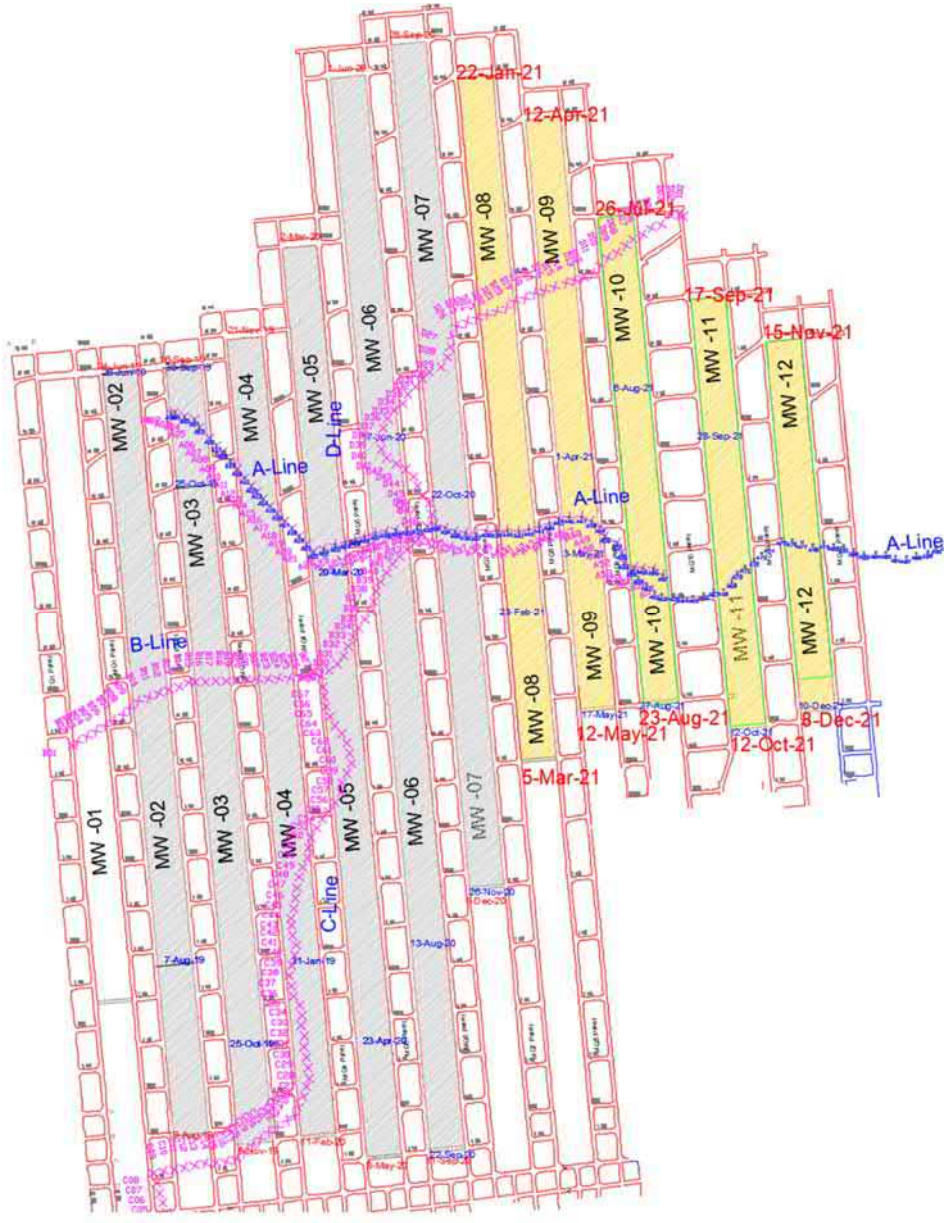


Fig. 1.1 Mount Airly location of mini wall panels, subsidence monitoring lines and pegs, monitoring survey dates, and dates of commencing and finishing of panels (MSEC)

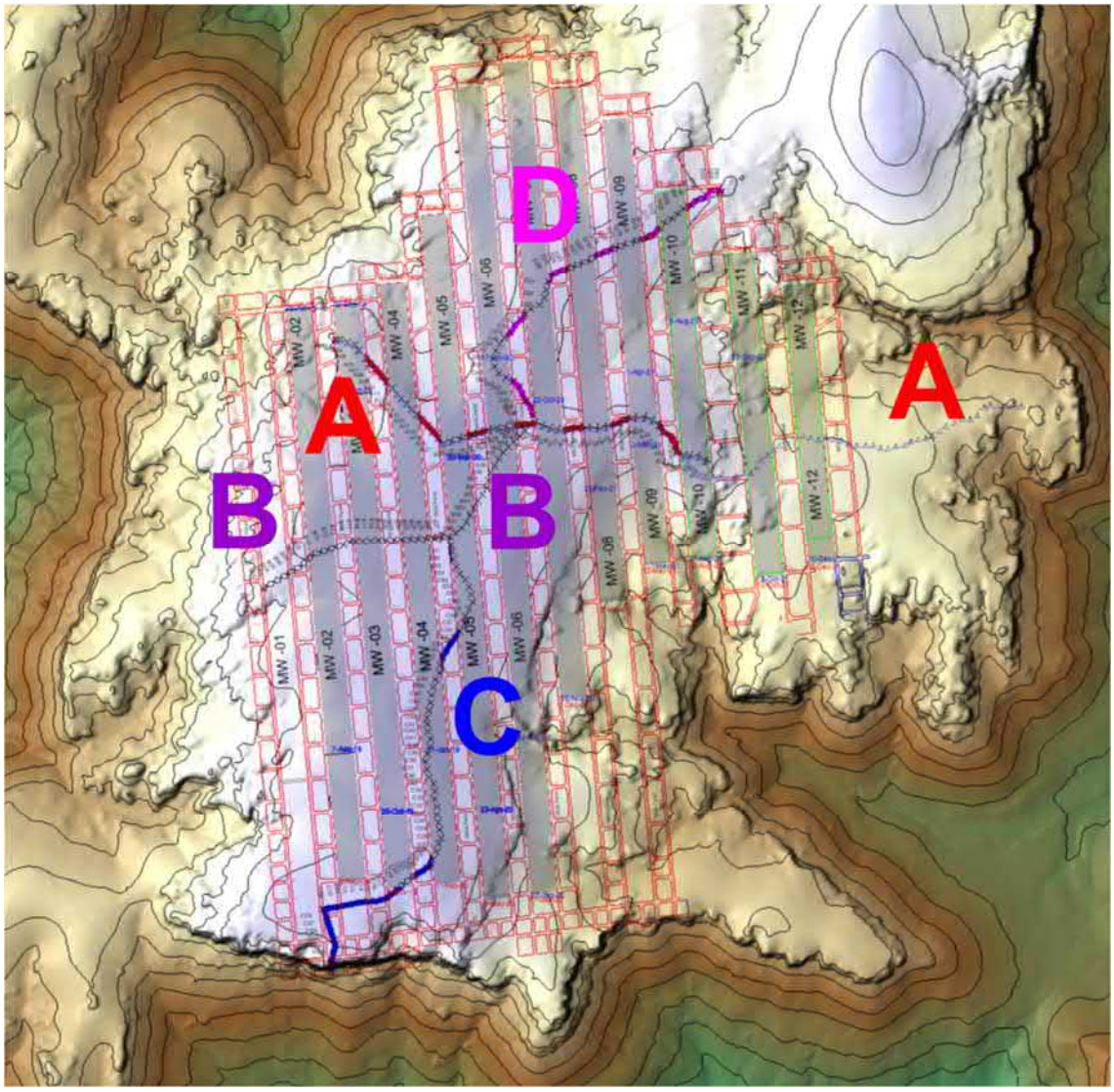


Fig. 1.2 3D image of surface levels over Mount Airly, the location of the mini wall panels, subsidence monitoring lines and pegs, monitoring survey dates, and dates of commencing and finishing of panels (MSEC)

1.5. Reviews of Airly subsidence monitoring results prior to 2021

The increased levels of subsidence that were observed over MWs 02 to 07 can be best appreciated by reviewing Fig. 1.3 and Fig. 1.4.

Fig. 1.3 shows the observed total subsidence, tilt and strain profiles across the Mount Airly mesa after MWs 02 to 07 were extracted along a cross section, called the combined B-A Lines, plotted as perpendicular distances from the initial goaf edge of MW2.

Fig. 1.4 shows both the observed total and incremental subsidence profiles after MWs 02 to 07 were extracted along the combined B-A Lines, plotted as perpendicular distances from the initial goaf edge of MW2 Fig. 1.4 also shows these incremental profiles plotted from the advancing goaf edges of each panel.

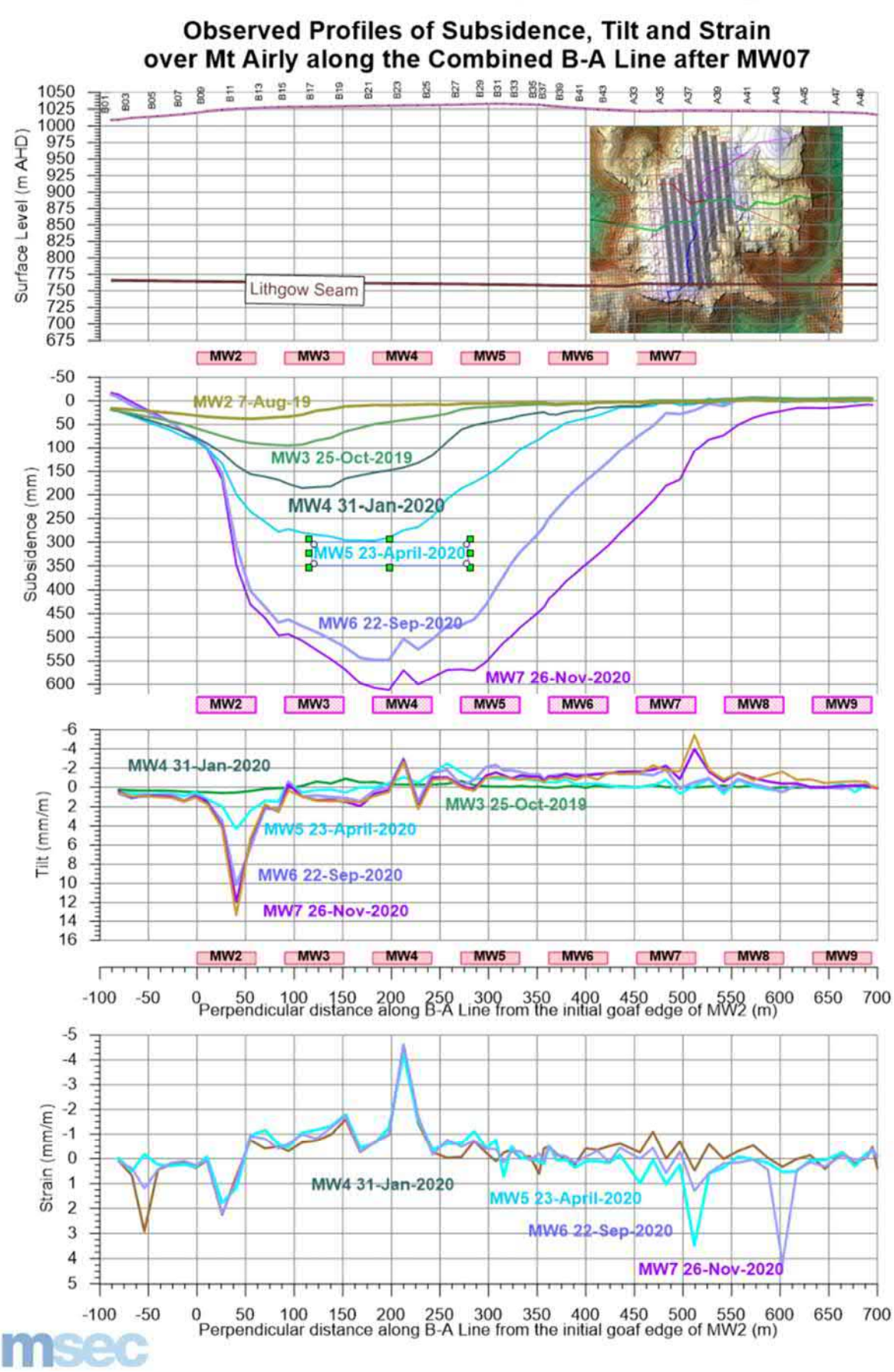


Fig. 1.3 Observed total subsidence, tilt and strain profiles after MWs 02 to 07 (MSEC)

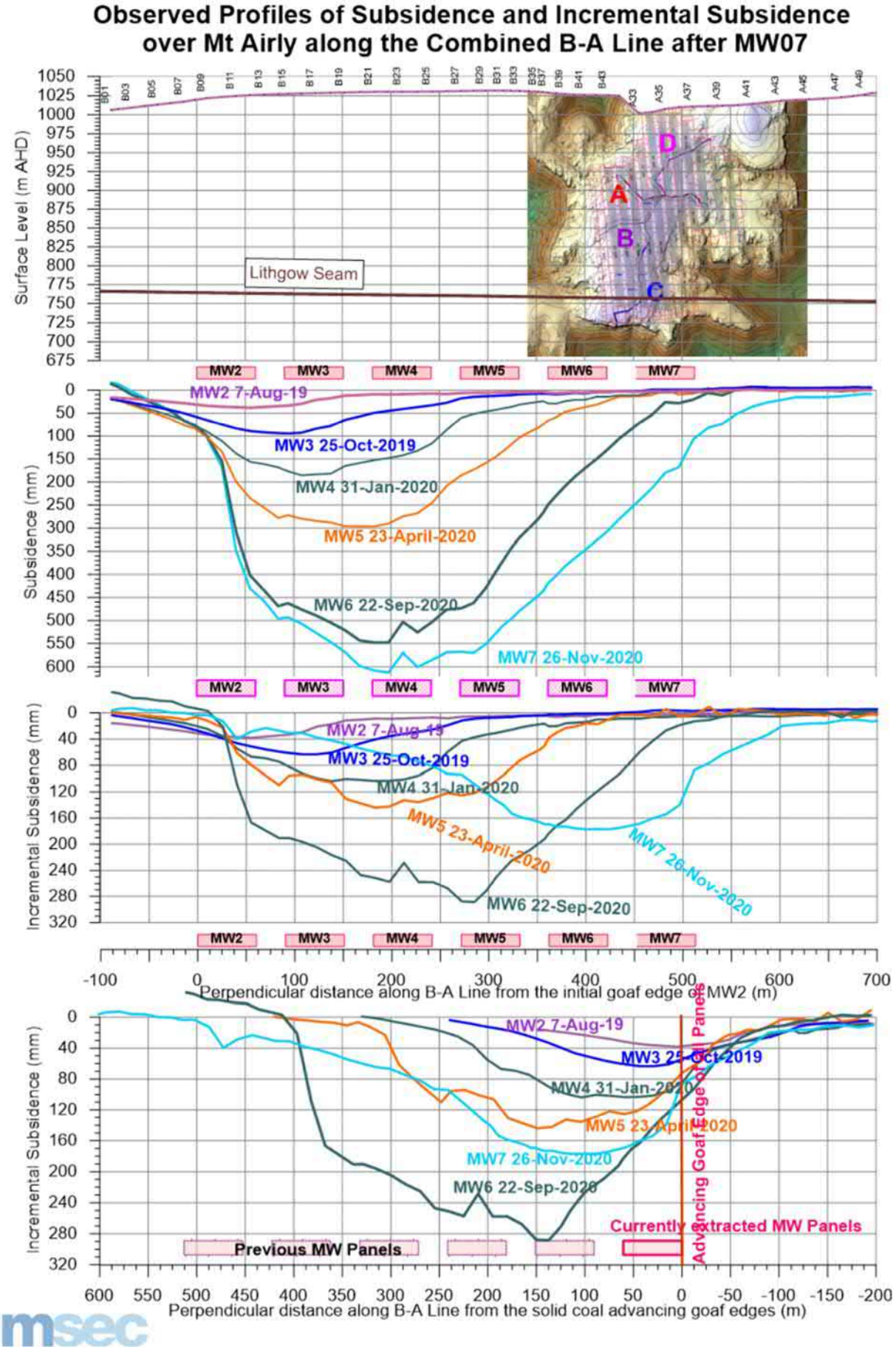


Fig. 1.4 Observed total and incremental subsidence profiles after MWs 02 to 07 (MSEC)

The incremental subsidence profiles in Fig. 1.4 show the additional or extra subsidence caused by the extraction by each of the mini wall panels. These observed incremental profiles were calculated by subtracting the subsidence measured at the survey pegs at the beginning of a panel from the subsidence measured at the end of a panel. For example, the incremental subsidence profile for MW06 was calculated by subtracting the monitored subsidence at each peg at 23-April 2020 from the monitored subsidence at each peg at 22-Sep-2020.

Incremental subsidence profiles indicate the strata performance of the panels and the pillars over the mined panels.

If the designed chain pillars and the strata overlying the chain pillars had been stable and only experienced elastic compression or squashing, then little incremental subsidence over the previously extracted panels would be measured over each of the previous chain pillars. However, it can be noted from Fig. 1.4 that the incremental subsidence measured after by the extraction of each panel spread over many panels and this indicates that the chain pillars and/or the strata overlying the chain pillars were not stable. But it can be noted that incremental subsidence was monitored over or above MW2 as each mini wall panel was extracted up to MW08.

For example, when MW06 was extracted, the incremental subsidence profile for MW06 indicated that:

- the surface over the MW06/05 chain pillar was compressed by more than 200 mm;
- the surface over the MW05/04 chain pillar was compressed by more than 270 mm;
- the surface over the MW04/03 chain pillar was compressed by more than 560 mm;
- the surface over the MW03/02 chain pillar was compressed by more than 180 mm; and
- the surface beyond the MW02 initial goaf edge was raised up by more than 20 mm, and
- the surface ahead of the advancing MW06 goaf edge was compressed over 100 mm.

The greatest increase in observed incremental subsidence occurred when MW06 was extracted. Afterwards reduced observed incremental subsidence was monitored, but when MW07 was extracted, incremental subsidence was observed over the six pervious mini walls, i.e., MWs 02 to 07, but by smaller amounts than were monitored when MW06 was extracted.

It can be noted that the area where the maximum subsidence coincides with an area that has:

- the greatest DoC;
- many normal faults crossing through Mount Airly, the Lithgow seam and its overburden; and
- several pillars with two faults crossing through them.

Fig. 1.5, shows the DoC over MW02 to 09 ranges from 180 to 280 m and, where the maximum subsidence occurred over MW04 & MW05, the DoC over ranged up to 280 m.

Fig. 1.6 and Fig. 1.7 show that many normal faults occur across Mount Airly at a spacing of approximately every 50 m, with throws of 0.2 to 0.7 m and a dip of between 20 to 50° towards the southeast. In other words, most of the chain pillars have at least one fault within them and immediately above them and some of pillars have two faults cutting across them.

The presence of these regularly spaced faults, with throws of an average 0.3 m and with average dip angles of 45°, could result in shearing and subsidence along the dip of these faults and horizontal movements towards the south-east. These faults, probably result in increased failures within the pillars and in the relatively weak overlying strata, (as sketched Fig. 1.8).

Based on the mathematical modelling that was undertaken for CA by Dr Chengguo Zhang of UNSW using the two-dimensional model, UDEC, he concluded that the increased subsidence was caused by the squashing and shearing within the shales, mudstones, claystones and weaker coal seams that overlie the Lithgow Coal Seam.

Dr Zhang' model also found that the regularly spaced faults had a significant effect on both the magnitude of mining-induced subsidence and the shape of the mining profiles over the mined panels.

Dr Zhang commented that the modelling results did not match the observed levels of subsidence until the effects of these faults was included in his UDEC model.

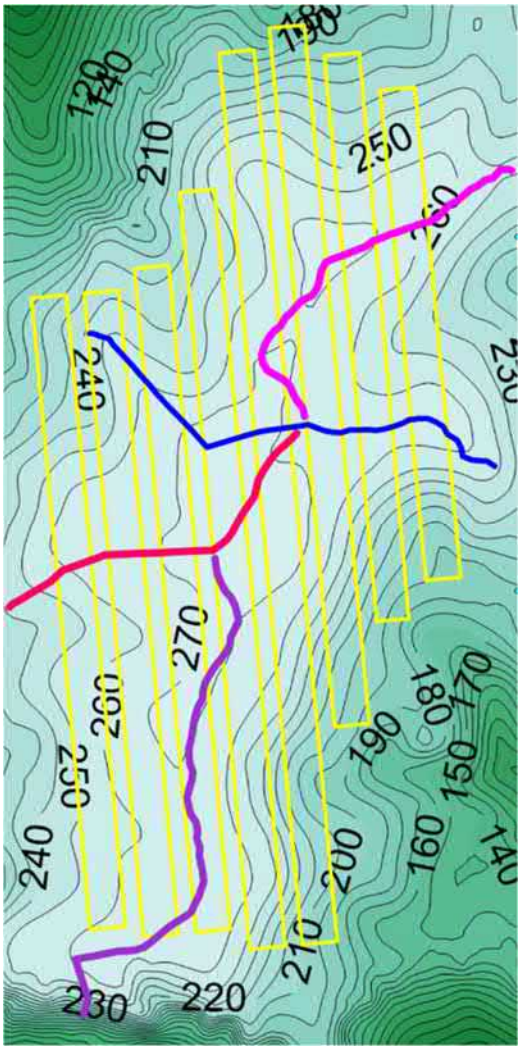


Fig. 1.5 Depths of Cover over Mount Airly mesa (MSEC)

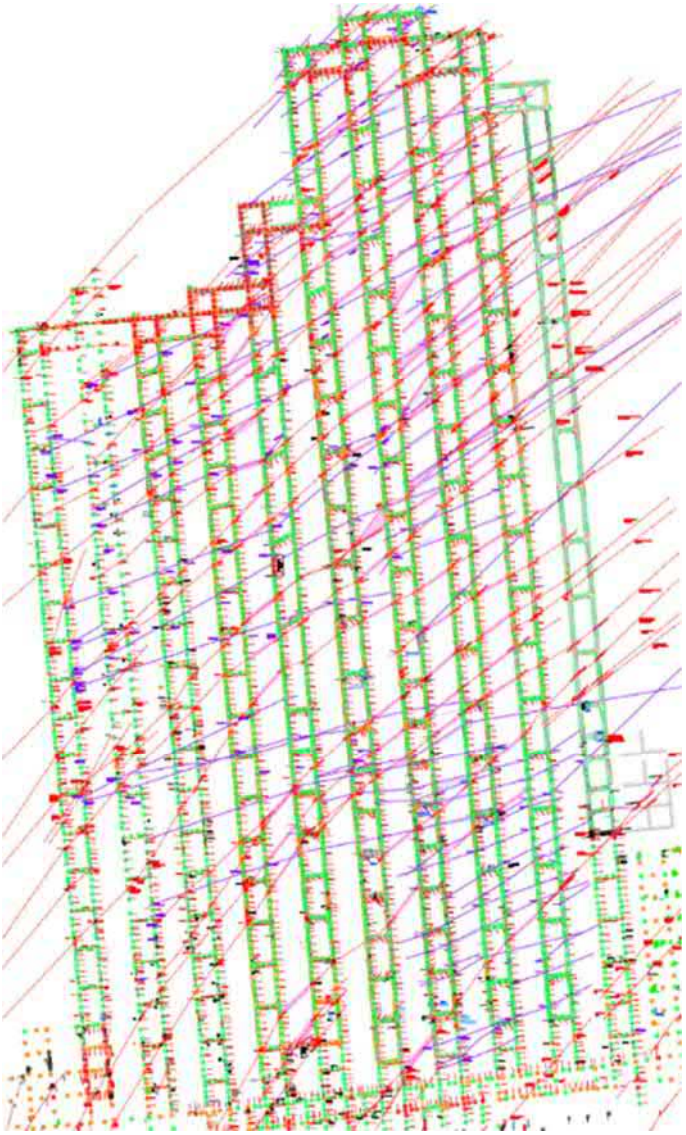


Fig. 1.6 Known geological structures (at seam level in the Mount Airly mine workings) (Source: CA)

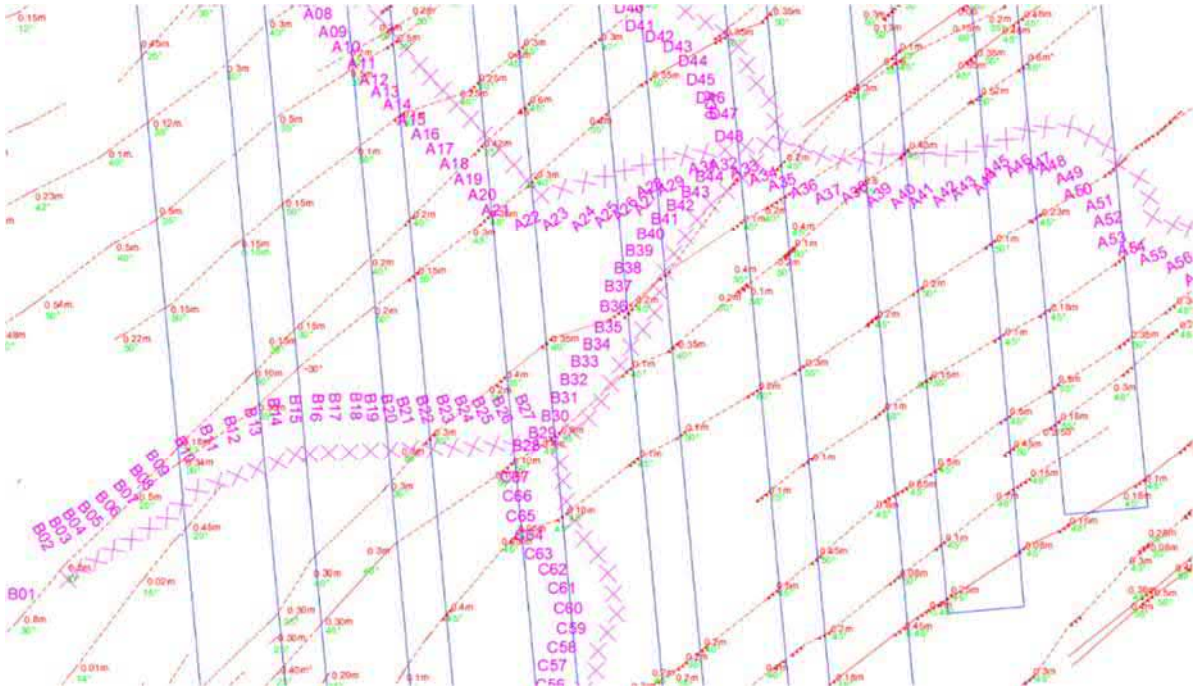


Fig. 1.7 Detailed view on faults over pillars near the B-A Line over Mount Airly (CA & MSEC).

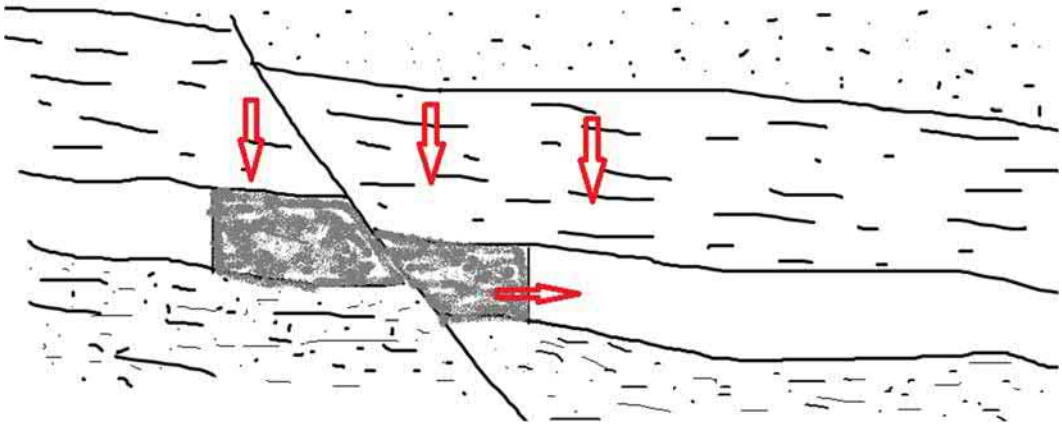


Fig. 1.8 Possible increased vertical & horizontal movements along faults at pillars (MSEC).

Despite the increased levels of subsidence, no cliff falls were found on the Mount Airly mesa after the extraction of MW07, despite the maximum subsidence being measured at that time of 612 mm.

Further mathematical modelling work was undertaken by Yvette Heritage of SCT using FLAC that was based on the available subsidence monitoring up to 2021. This report, SCT AIRLY5240, dated January 2021, also found, that the increased subsidence was rock failure and softening of the strata above the narrow pillars, that then compressed under the abutment load, (i.e., similar conclusion to Dr Zhang's UDEC modelling). This report advised that the two-dimensional model, FLAC modelling indicated that the mechanism for increased subsidence was the primarily a function of weak strata, abutment load, reduced confinement due to adjacent goafs and pillar width.

2.1. Airly subsidence monitoring results over MWs 8 to 10, during January to August 2021

The increased levels of subsidence that were observed over MWs 02 to 10 can be best seen in Fig. 2.1 and Fig. 2.2.

Fig. 2.1 shows the observed total subsidence, tilt and strain profiles across the Mount Airly mesa after MWs 02 to 10 were extracted along a cross section, called the combined B-A Lines, plotted as perpendicular distances from the initial goaf edge of MW2.

Fig. 2.2 shows both the observed total and incremental subsidence profiles after MWs 02 to 10 were extracted along the combined B-A Lines, plotted as perpendicular distances from the initial goaf edge of MW2 Fig. 1.4 also shows these incremental profiles plotted from the advancing goaf edges of each panel.

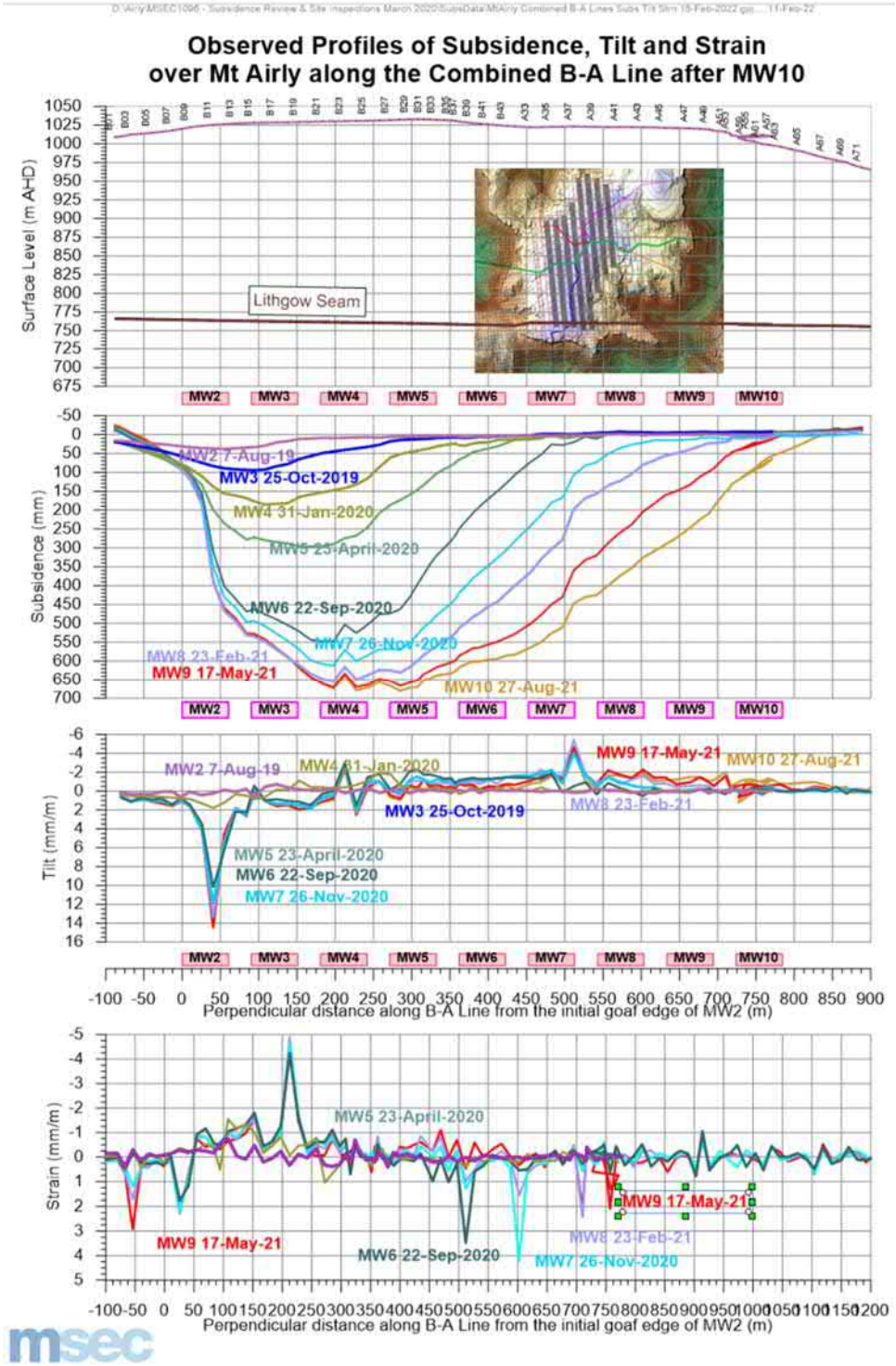


Fig. 2.1 Observed total subsidence, tilt and strain profiles after MWs 02 to 10 (MSEC)

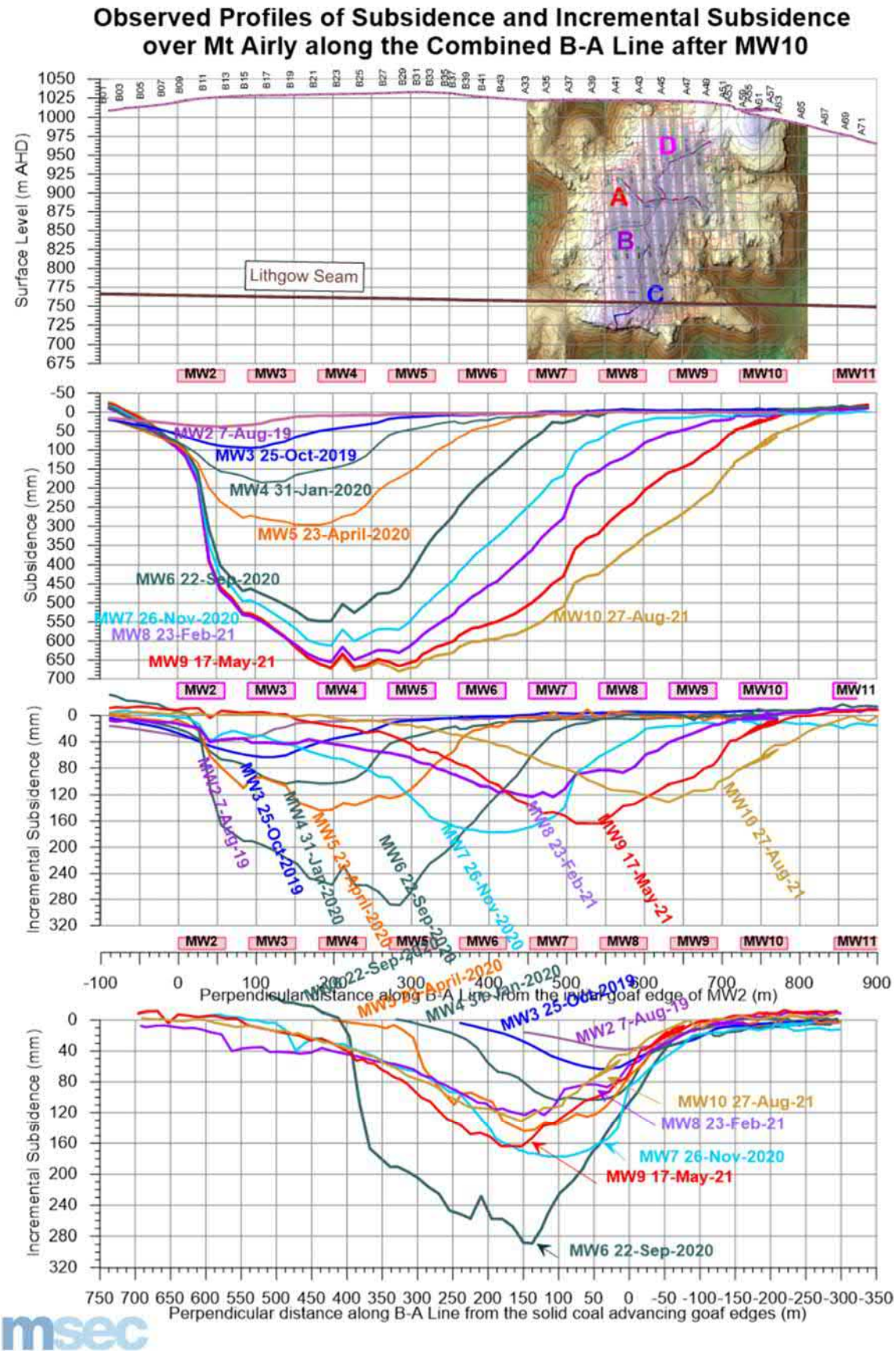


Fig. 2.2 Observed total and incremental subsidence profiles after MWs 02 to 10 (MSEC)

It can be noted that MWs 08, 09 and 10 resulted in lower incremental subsidence than MW06 and 07. However they still show increased levels of subsidence occurring over the earlier panels, which indicated that the strata over the chain pillars is still failing. The extraction of MW06 still provided the highest maximum incremental subsidence profiles.

2.2. Airly Mine layout redesign during 2021

After extensive consultations, a revised mine design for the Mt Airly mesa was approved in 2021 for MWs 11 and MW12, which most importantly included a substantially increased chain pillar width between MW10 and MW11.

Panel widths for all mini walls has remained the same at 61 m wide. The chain pillars for MWs 02 to 10 were 29.5 m wide, whilst the larger chain pillar width between MW10 and MW11 was 60 m. The chain pillar width between MW11 and MW12 was 40 m. Extraction in MW11 commenced in September 2021 and MW12 was fully extracted in December 2021.

2.3. Airly subsidence monitoring results after MW12, December 2021

The following four plots show the monitored subsidence levels that were observed over MWs 02 to 12. Fig. 2.3, Fig. 2.4, Fig. 2.5 and Fig. 2.6.

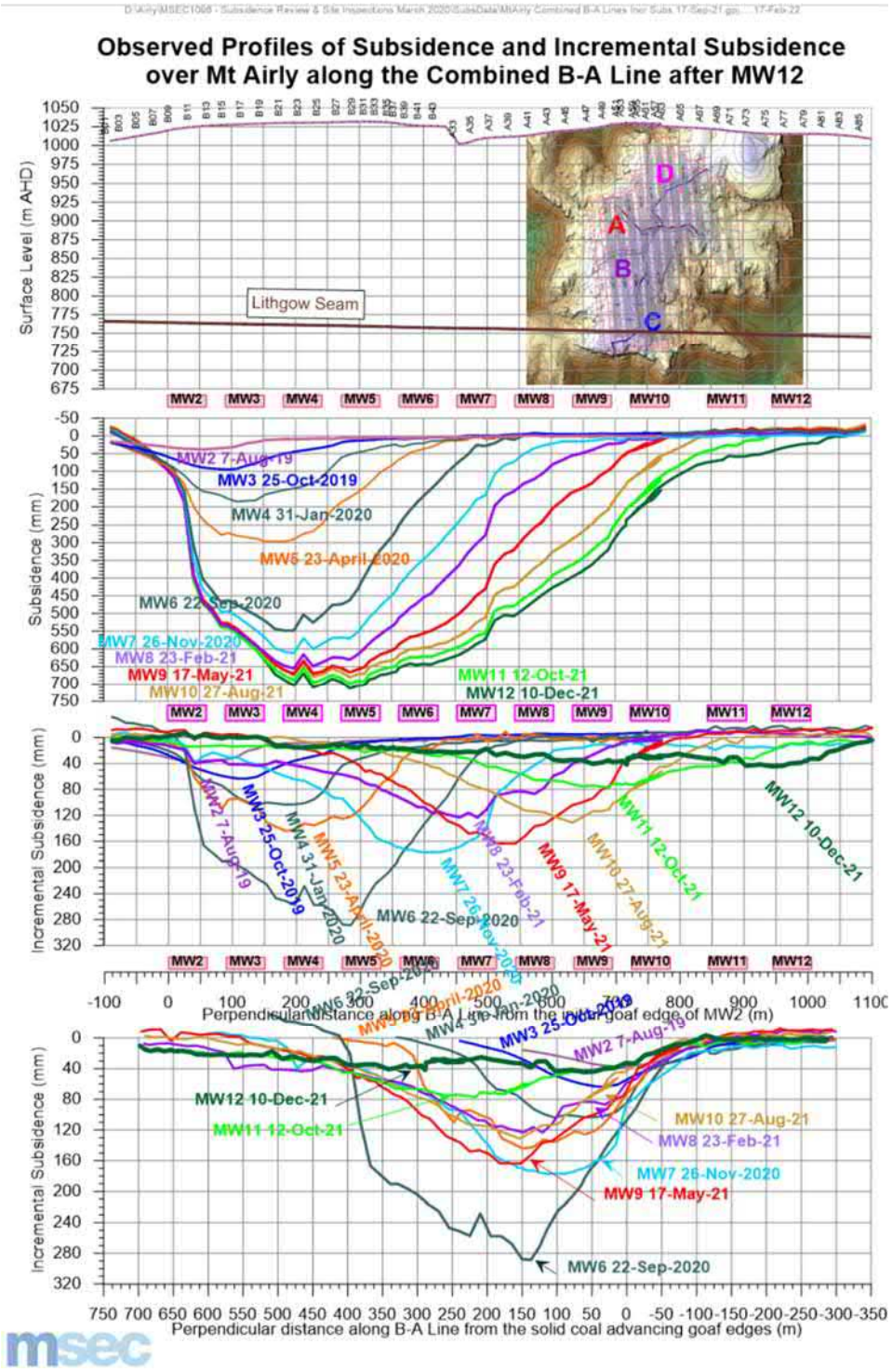


Fig. 2.3 Observed total subsidence, tilt and strain profiles after MWs 02 to 12 (MSEC)

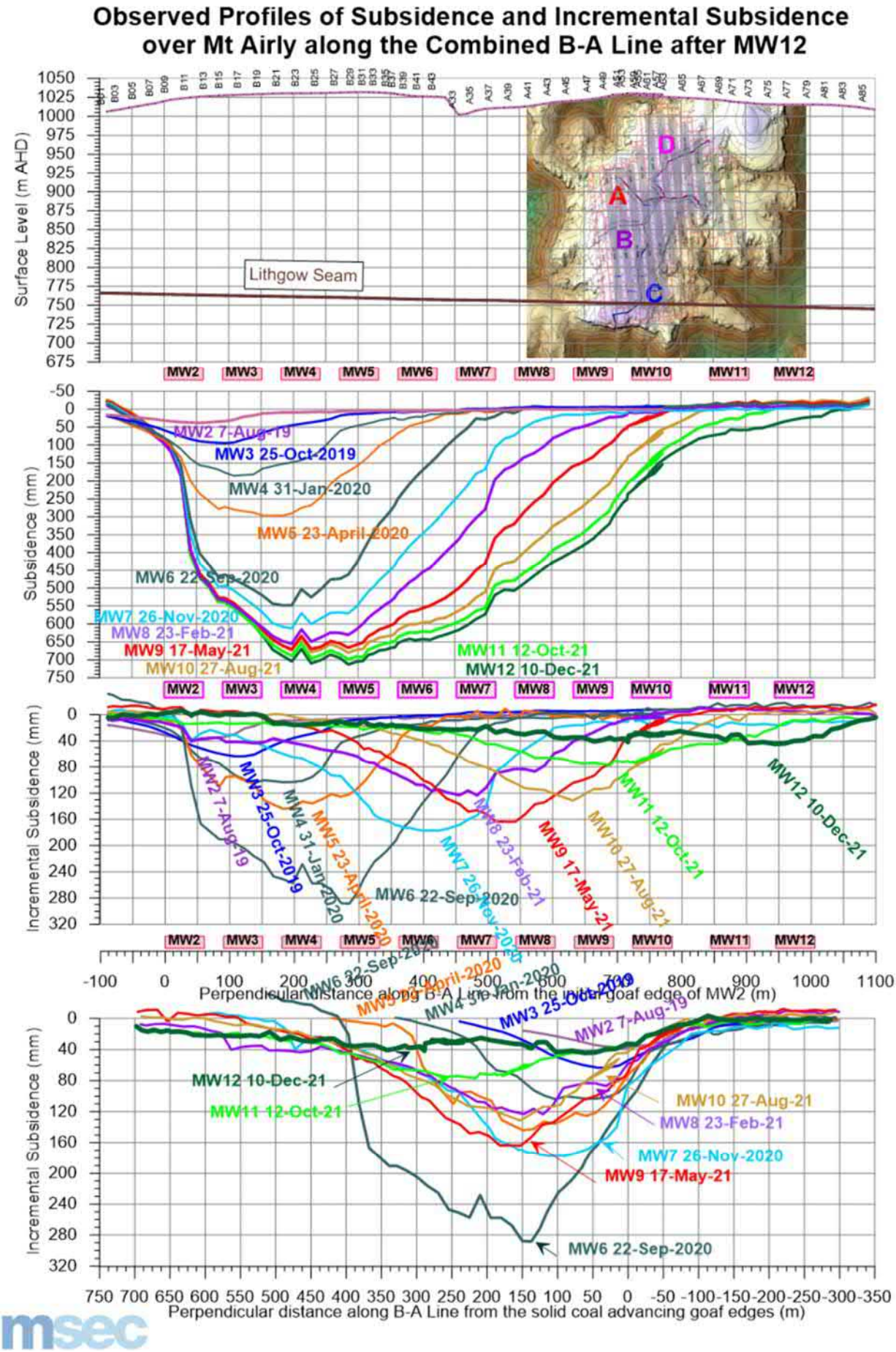


Fig. 2.4 Observed total and incremental subsidence profiles after MWs 02 to 12 (MSEC)

Fig. 2.3, above, shows the observed total subsidence, tilt and strain profiles across the Mount Airly mesa after MWs 02 to 12 were extracted along a cross section, called the combined B-A Lines, plotted as perpendicular distances from the initial goaf edge of MW2.

Fig. 2.4, above, shows both the observed total and incremental subsidence profiles after MWs 02 to 12 were extracted along the combined B-A Lines, plotted as perpendicular distances from the initial goaf edge of MW2 Fig. 2.4 also shows these incremental profiles plotted from the advancing goaf edges of each panel.

Fig. 2.5, below, shows the observed total subsidence contours over the Mount Airly mesa after MWs 02 to 12 and Fig. 2.6, below, shows both the observed horizontal movement contours after MWs 02 to 12 were extracted.

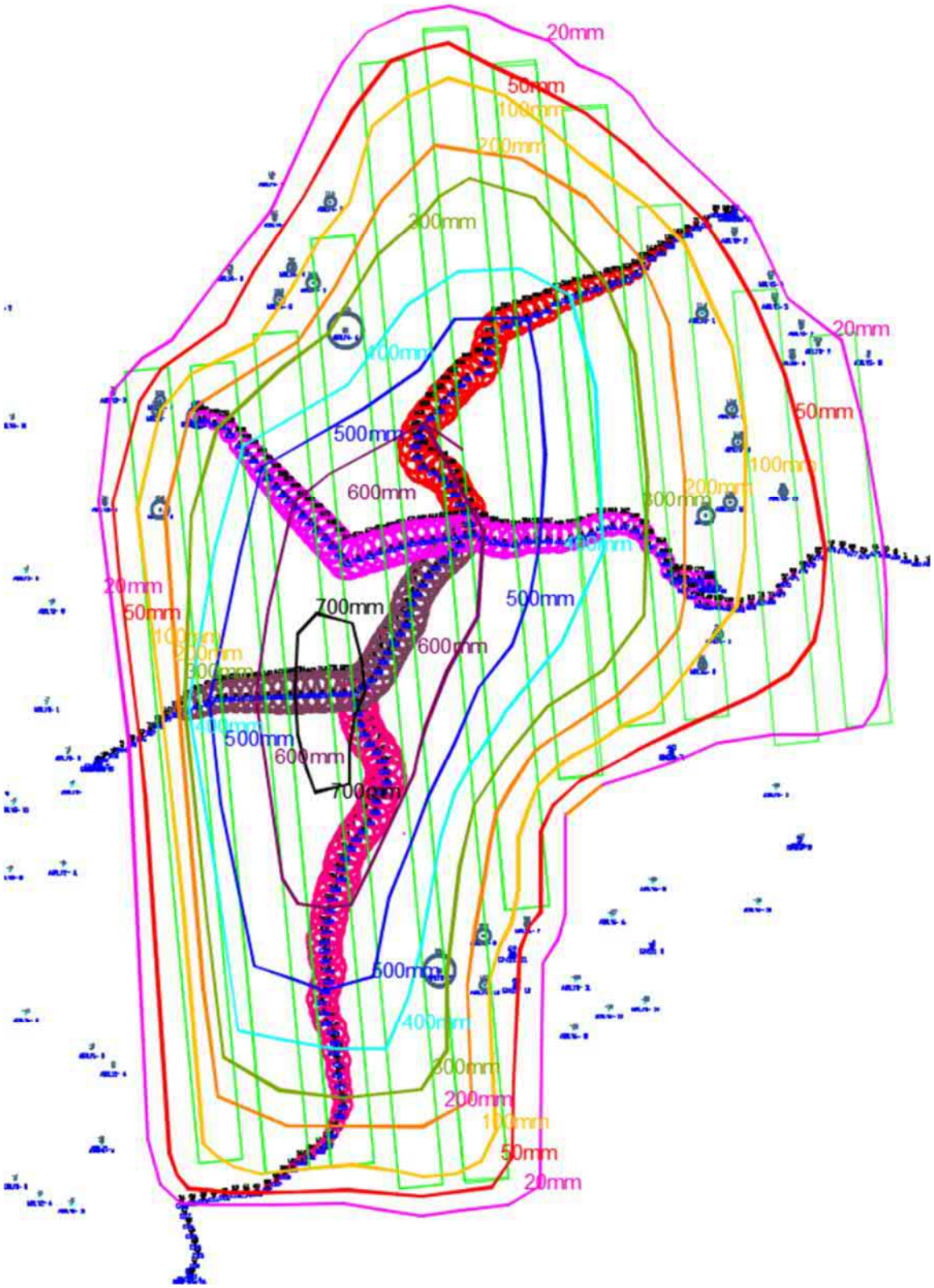


Fig. 2.5 Observed total horizontal movement contours after MWs 02 to 12 (MSEC)

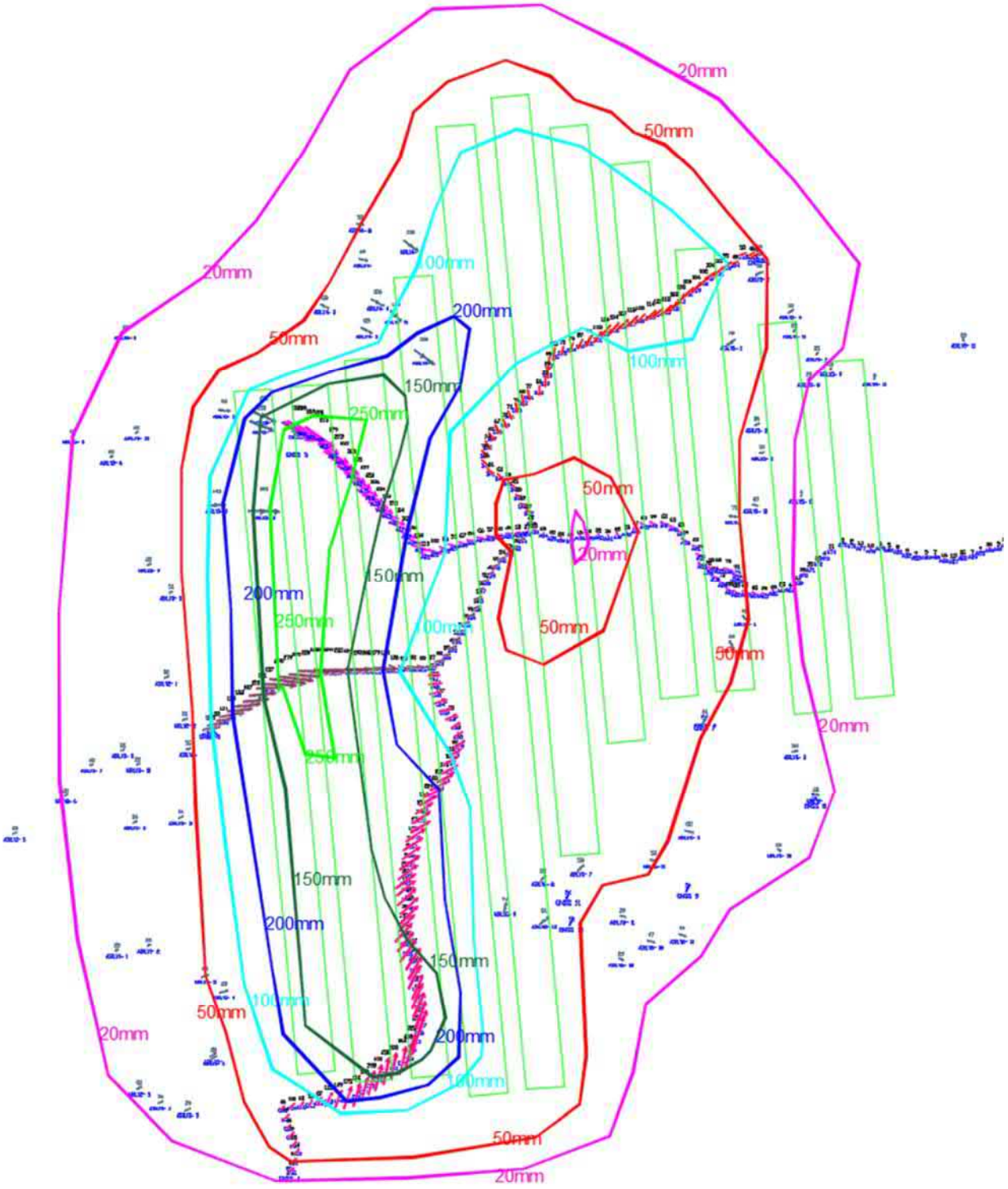


Fig. 2.6 Observed horizontal movement contours after MWs 2 to 9 (MSEC)

The Table below shows that the measured maximum total and incremental subsidence over the mini wall panels.

Panel	Survey Date	Panel Extraction End Date	Maximum Subsidence (mm)	Incremental Subsidence (mm)
MW2	7-Aug-19	19-Aug-19	38	38
MW3	25-Oct-19	5-Nov-19	95	63
MW4	31-Jan-20	11-Feb-20	186	104
MW5	23-Apr-20	8-May-20	297	144
MW6	22-Sep-20	11-Sep-20	548	289
MW7	26-Nov-20	1-Dec-20	612	177
MW8	23-Feb-21	5-Mar-21	655	123
MW9	17-May-21	12-May-21	670	164
MW10	27-Aug-21	23-Aug-21	680	131
MW11	12-Oct-21	12-Oct-21	690	44
MW12	10-Dec-21	8-Dec-21	713	44

2.4. Comparison of subsidence monitoring results for MW11 & MW12 against predictions

The report, SCT AIRLY5240, dated January 2021, predicted, using the FLAC model, that the extra subsidence caused by extracting MW11 and 12 would not exceed 125mm over MWs11 &12.

This report included the following plots. Taking the difference between the total predicted subsidence after MW12 from the observed subsidence after MW10 indicated that this model predicted an additional subsidence of up to approximately 80 mm due to the extraction of MWs 11 & 12.

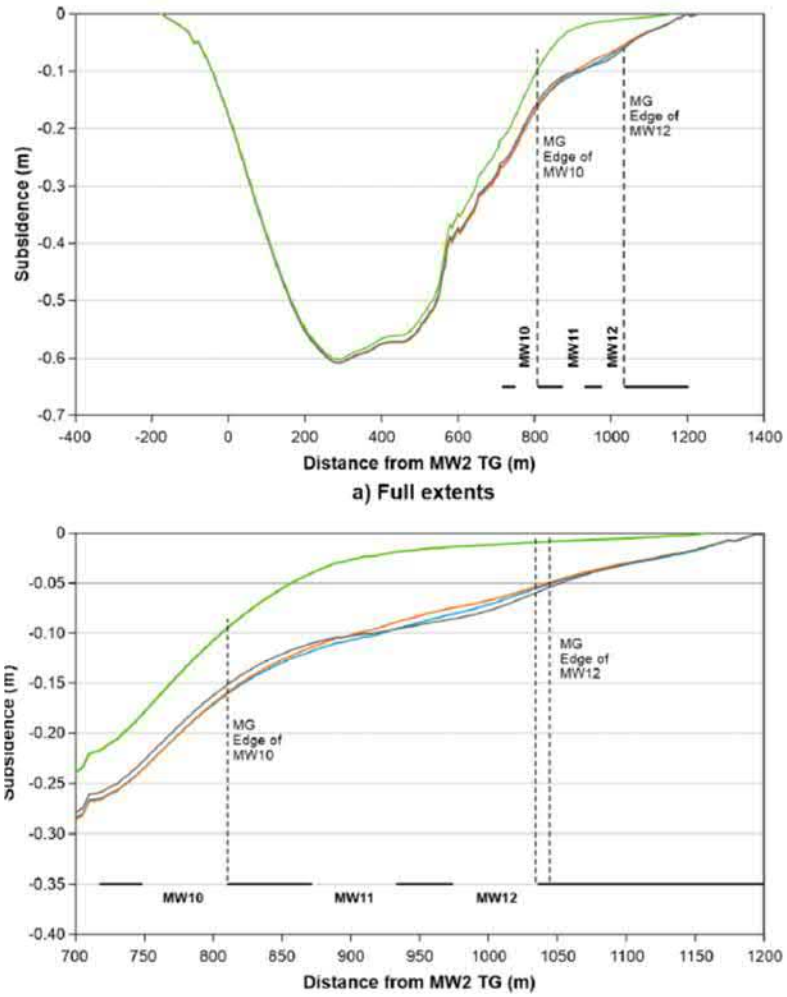


Fig. 2.7 Predicted subsidence profiles after MWs 11 & 12 (SCT)

Fig. 2.8, shows both the observed total subsidence profiles after MWs 11 to 12 were extracted along the combined B-A Lines, plotted as perpendicular distances from the initial goaf edge of MW2 Fig. 2.8 also shows the incremental subsidence profiles of MW11, MW12 and the combined MWs11 & 12, plotted from the initial goaf edge of MW2 and the advancing goaf edges of each panel. It can be noted that the observed subsidence over MWs11 and MWs 12 is less than 125mm and the maximum observed subsidence due to the extraction of MWs 11 & 12 combined is less than 80 mm.

That is, the observed subsidence is less than the predicted subsidence for MWs 11 & 12.

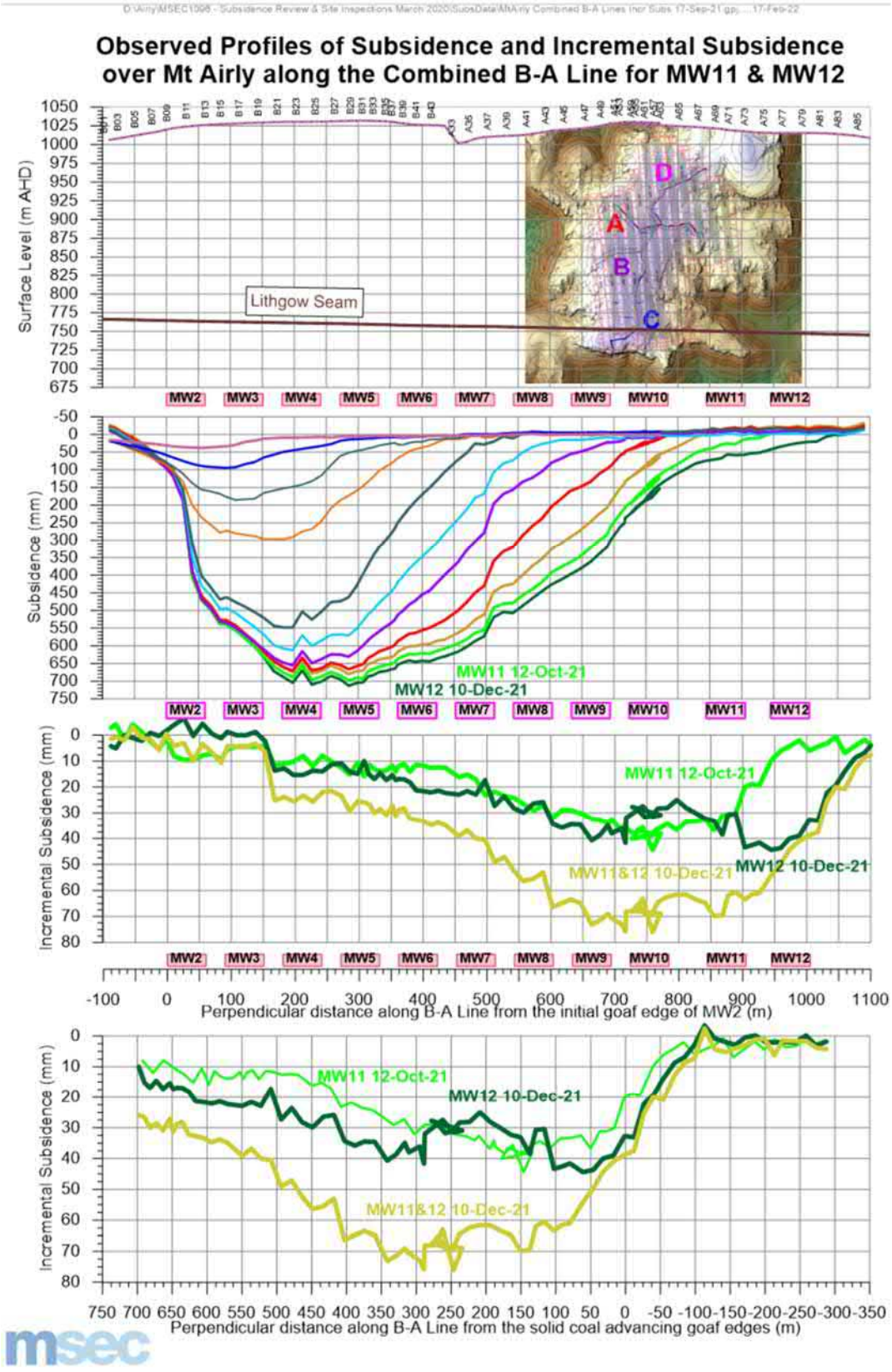


Fig. 2.8 Observed total and incremental subsidence profiles after MWs 11 and 12 (MSEC)

3.1. Predicted impacts

The 2014 Airly EIS report, which was prepared by Golder Associates, predicted the maximum subsidence over the PPMZ areas of the mine, after the extraction of a 2.8 m thick seam, 61 m wide mini wall panel widths and 30 m chain pillars, would be less than 125 mm, tilts would be less than 2.5 mm/m and strains would be less than 2 mm/m.

It was assessed that, at these low subsidence values, no surface cracking, rock falls or cliff impacts were expected.

3.2. Observed impacts

Despite the increased levels of subsidence of up to 713 mm, no cliff falls were found on the Mount Airly mesa after the extraction of MW12.

However, the surveying and environmental staff at Airly have found increased levels of surface cracking, generally around the perimeter of the increased subsidence bowl. The following plans and photos indicate the extent of surface cracking that has been observed at Airly to date.

As the revised chain pillar design is limiting subsidence to low to negligible subsidence levels, no future surface cracking is expected over the proposed new extraction panels.



Fig. 3.1 Locations where subsidence cracking has been observed after MWs 11 and 12 (Airly)

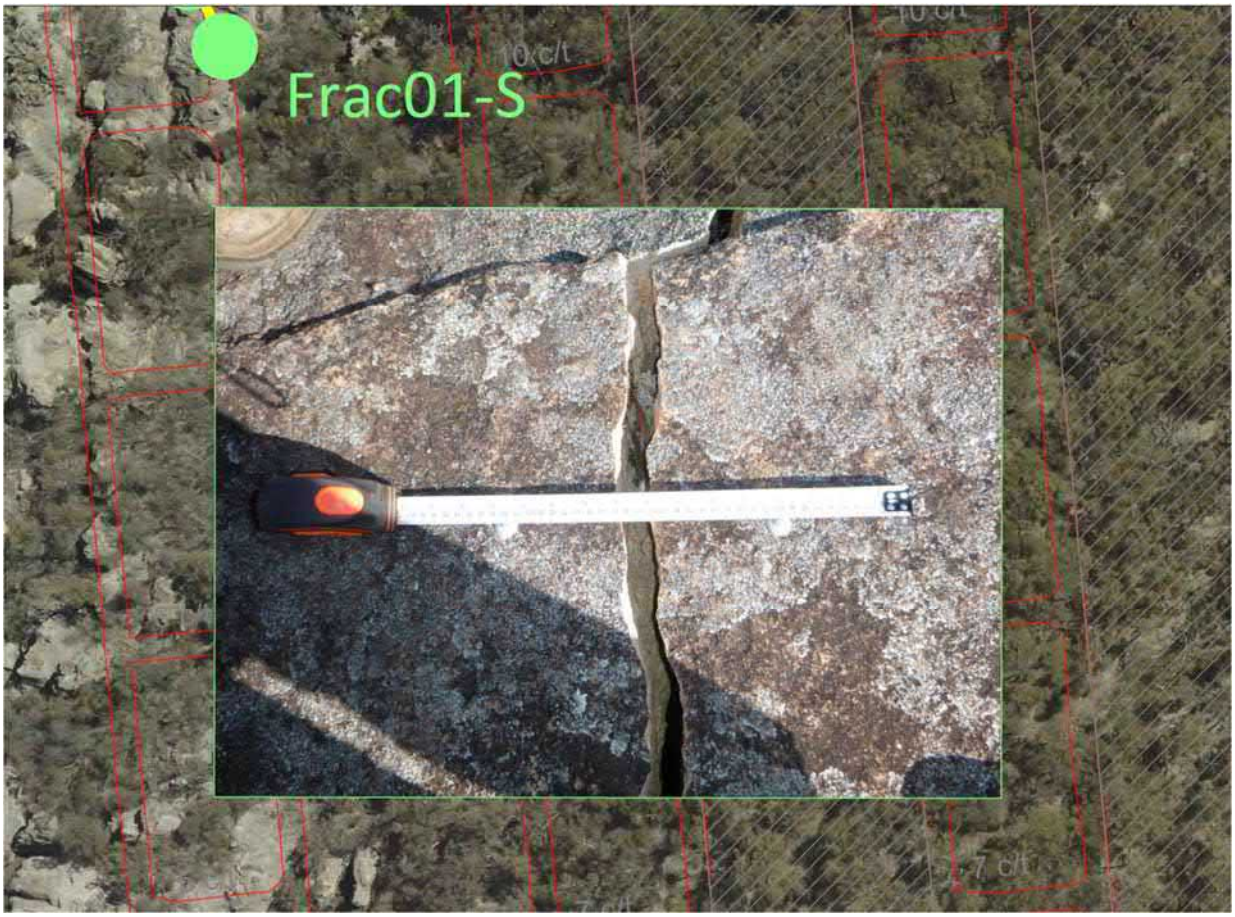


Fig. 3.2 Locations where subsidence crack Frac01-S (Airly)

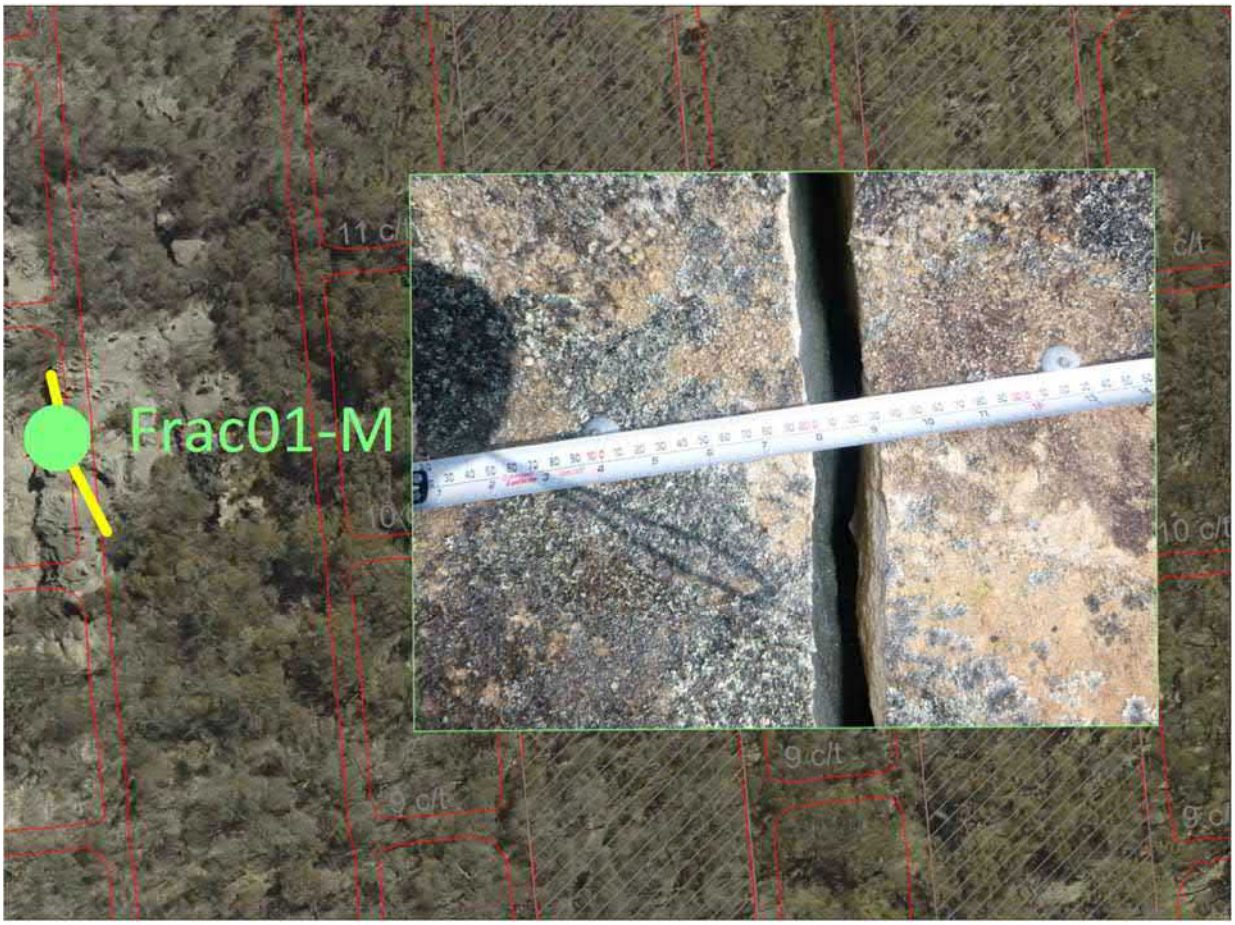


Fig. 3.3 Locations where subsidence crack Frac01-S (Airly)

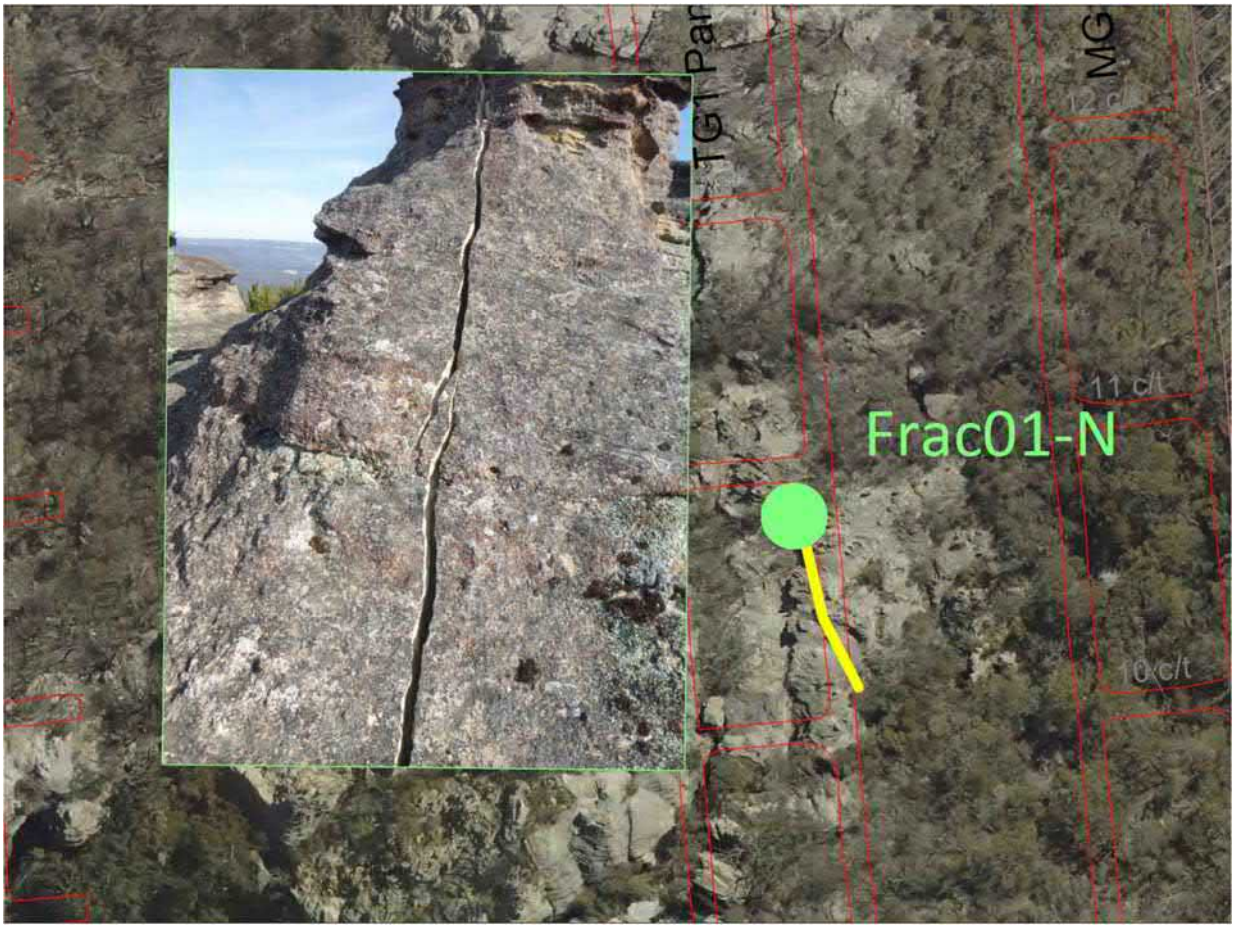


Fig. 3.4 Locations where subsidence crack Frac01-S (Airly)

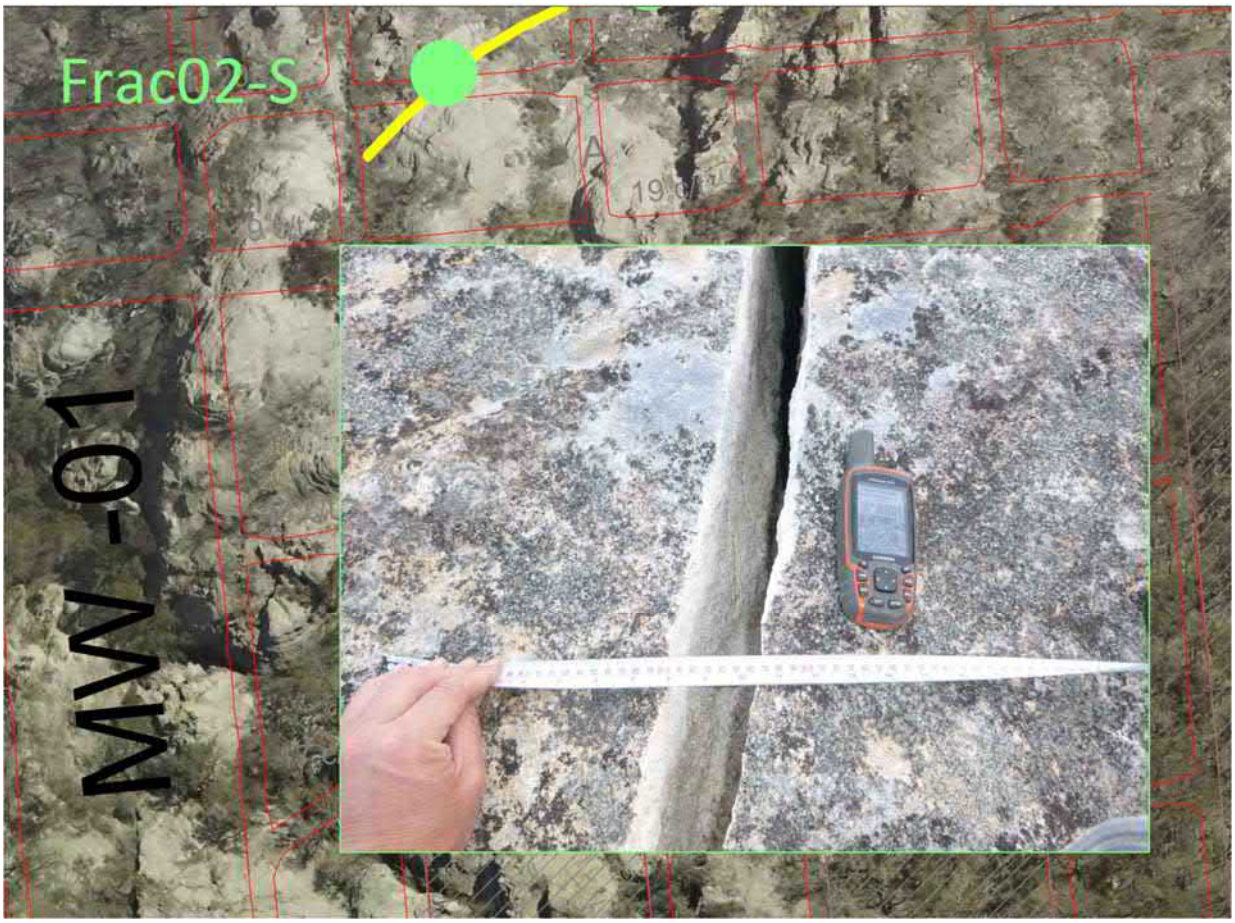


Fig. 3.5 Locations where subsidence crack Frac01-S (Airly)



Fig. 3.6 Locations where subsidence crack Frac01-S (Airly)



Fig. 3.7 Locations where subsidence crack Frac01-S (Airly)

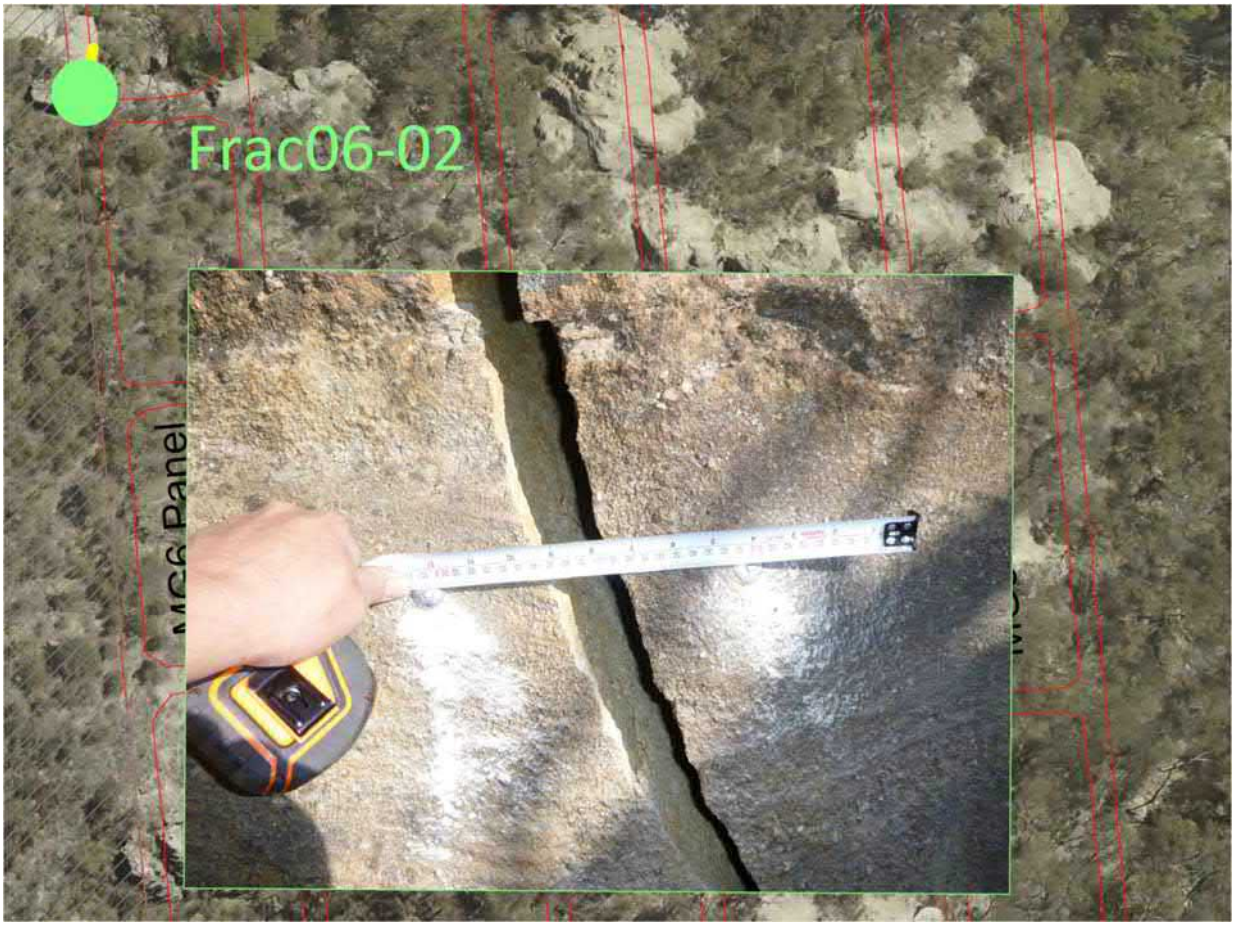


Fig. 3.8 Locations where subsidence crack Frac01-S (Airly)

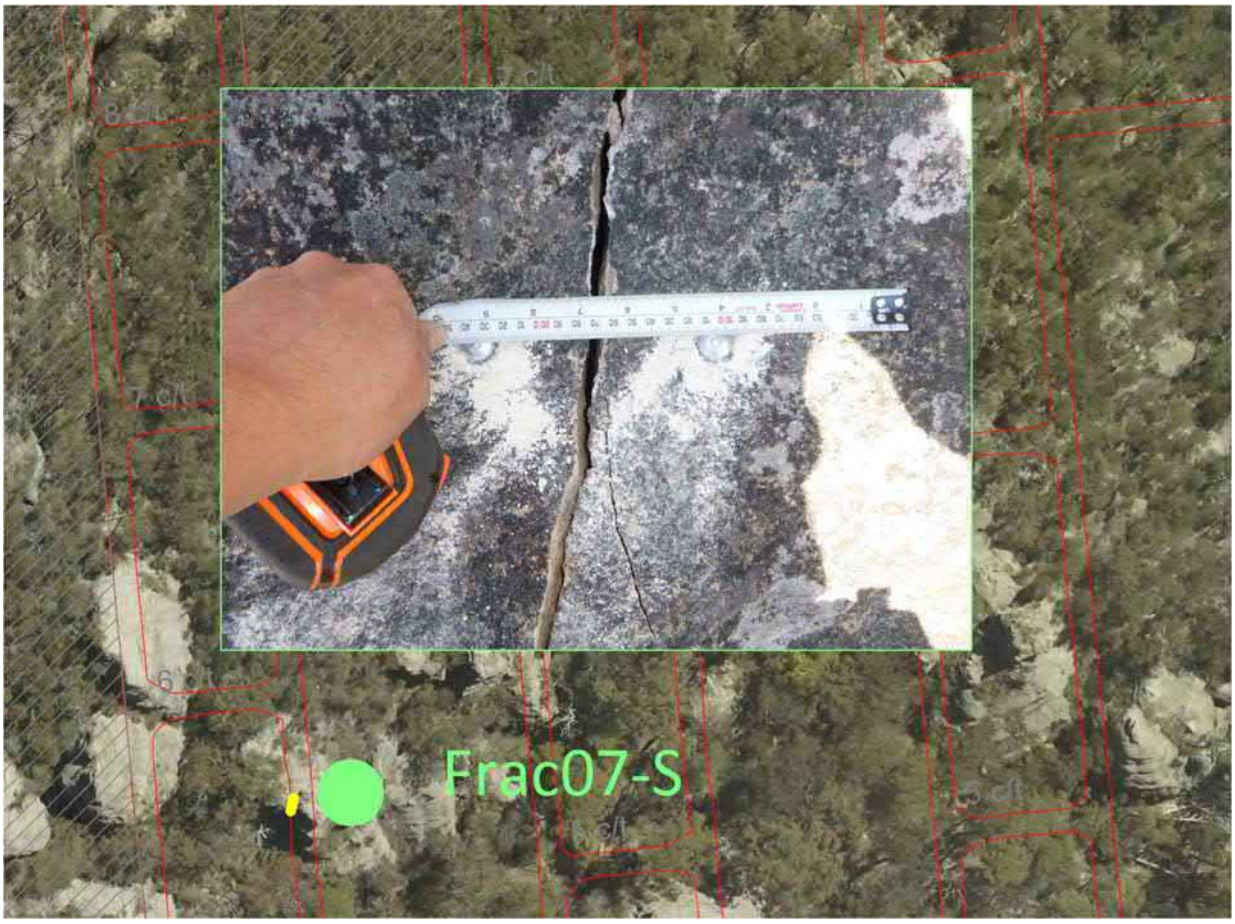


Fig. 3.9 Locations where subsidence crack Frac01-S (Airly)

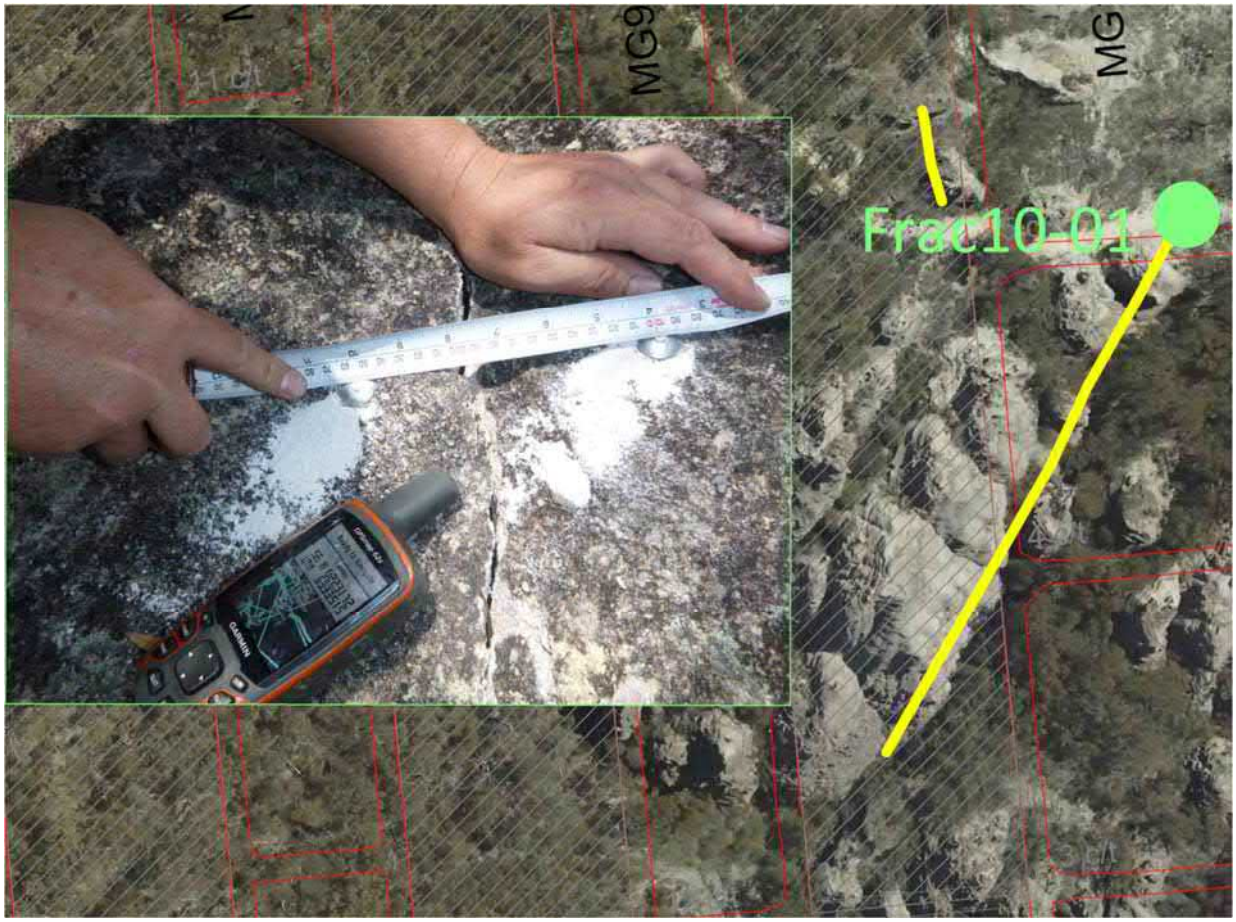


Fig. 3.10 Locations where subsidence crack Frac01-S (Airly)

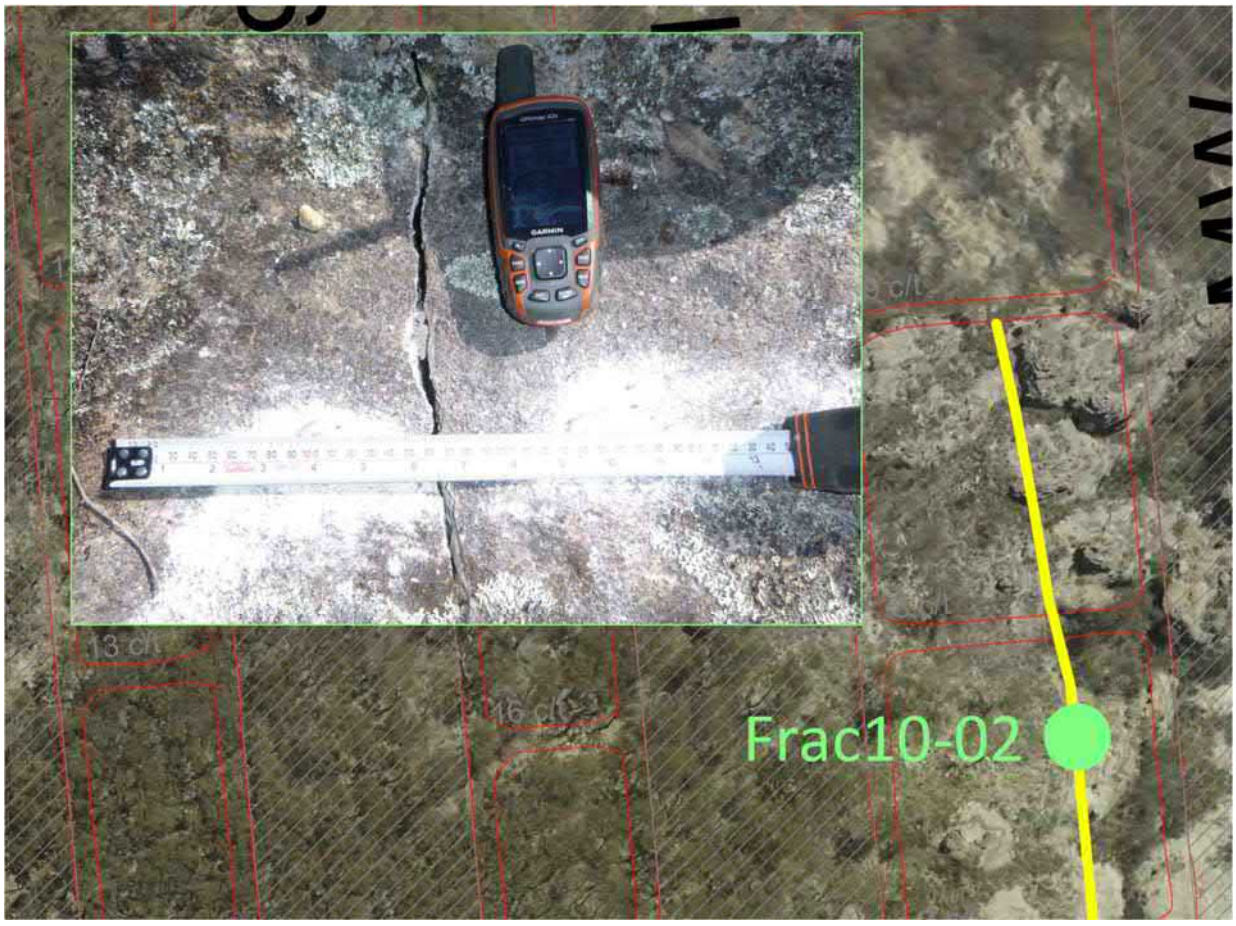


Fig. 3.11 Locations where subsidence crack Frac01-S (Airly)



Fig. 3.12 Locations where subsidence crack Frac01-S (Airly)



Fig. 3.13 Locations where subsidence crack Frac01-S (Airly)



Fig. 3.14 Locations where subsidence crack Frac01-S (Airly)

APPENDIX A. GLOSSARY OF TERMS, ABBREVIATIONS AND DEFINITIONS

Glossary of Terms, Abbreviations and Definitions

Some of the more common mining terms used in the report are defined below:

Airly	Airly Mine.
Angle of draw	The angle of inclination from the vertical of the line connecting the goaf edge of the workings and the limit of subsidence (which is usually taken as 20 mm of subsidence).
AoD	Angle of draw.
AHD	Australian Height Datum.
CA	Centennial Airly Pty Limited.
Chain pillar	A block of coal left unmined between the longwall extraction panels.
Cover depth (H)	The depth of cover measured from the surface to the top of the seam. Cover depth is often provided as an average over the area of the panel.
Cliffs	Continuous rockfaces having minimum heights of 10 metres, minimum lengths of 20 metres and minimum slopes of 2 to 1, i.e., having minimum angles to the horizontal of 63°
CLZ	Cliff Line Zone
Closure	The reduction in the horizontal distance between the valley sides. The magnitude of closure, which is typically expressed in the units of *millimetres (mm)*, is the greatest reduction in distance between any two points on the opposing valley sides. It should be noted that the observed closure movement across a valley is the total movement resulting from various mechanisms, including conventional mining induced movements, valley closure movements, far-field effects, downhill movements and other possible strata mechanisms.
Critical area	The area of extraction at which the maximum possible subsidence of one point on the surface occurs.
Curvature	The change in tilt between two adjacent sections of the tilt profile divided by the average horizontal length of those sections, i.e., curvature is the second derivative of subsidence. Curvature is usually expressed as the inverse of the **Radius of Curvature** with the units of *1/kilometres (km-1)*, but the value of curvature can be inverted, if required, to obtain the radius of curvature, which is usually expressed in *kilometres (km)*. Curvature can be either **hogging** (i.e., convex) or **sagging** (i.e., concave).
DoC	Depth of cover or cover depth.
DTIRIS	NSW Dept of Trade & Investment, Regional Infrastructure & Service
EIS	Environmental Impact Study
Extracted seam	The thickness of coal that is extracted. The extracted seam thickness is thickness normally given as an average over the area of the panel.
Effective extracted seam thickness (T)	The extracted seam thickness modified to account for the percentage of coal left as pillars within the panel.
Face length	The width of the coalface measured across the longwall panel.
Far-field movements	The measured horizontal movements at pegs that are located beyond the longwall panel edges and over solid unmined coal areas. Far-field horizontal movements tend to be bodily movements towards the extracted goaf area and are accompanied by very low levels of strain.
FLAC	Fast Lagrangian Analysis of Continua, is numerical modelling software for 2D geotechnical analysis of soil, rock, groundwater, and ground support
GNSS	Global Navigation Satellite System.
Goaf	The void created by the extraction of the coal into which the immediate roof layers collapse.
Goaf end factor	A factor applied to reduce the predicted incremental subsidence at points lying close to the commencing or finishing ribs of a panel.
Horizontal displacement	The horizontal movement of a point on the surface of the ground as it settles above an extracted panel.
IEP	Independent Expert Panel
Inflection point	The point on the subsidence profile where the profile changes from a convex curvature to a concave curvature. At this point the strain changes sign and subsidence is approximately one half of S max.
Incremental subsidence	The difference between the subsidence at a point before and after a panel is mined. It is therefore the additional subsidence at a point resulting from the excavation of a panel.

IRP	Independent Review Panel
Kms	Kilometres.
m	metres
MGA56	Map Grid Australia Zone 56
MW	Mini Wall
MWs	Mini Walls
Minor Cliffs	Continuous rockfaces having heights between 5 metres and 10 metres, minimum lengths of 20 metres and a minimum slope of 2 to 1.
MMSCA	Mugii Murrum-ban State Conservation Area.
MSEC	Mine Subsidence Engineering Consultants.
Pagoda	a conical or sub conical rock formation, whether smooth, platy, stepped or terraced, generally between 5 and 20 metres in height that is not a cliff or minor cliff
Panel	The plan area of coal extraction.
PPMZ	Panel and Pillar Mining Zone**.**
PM	Permanent Mark.
Panel length (L)	The longitudinal distance along a panel measured in the direction of (mining from the commencing rib to the finishing rib.
Panel width (Wv)	The transverse distance across a panel, usually equal to the face length plus the widths of the roadways on each side.
Panel centre line	An imaginary line drawn down the middle of the panel.
Pillar	A block of coal left unmined.
Pillar width (Wpi)	The shortest dimension of a pillar measured from the vertical edges of the coal pillar, i.e., from rib to rib.
RFS	NSW Rural Fire Service.
SCT	Strata Control Technology.
Shear deformations	The horizontal displacements that are measured across monitoring lines and these can be described by various parameters including; horizontal tilt, horizontal curvature, mid-ordinate deviation, angular distortion and shear index.
steep slope	An area of land having a gradient between 1 in 3 (33% or 18.3^0) and 2 in 1 (200% or 63.4^0)
Strain	The change in the horizontal distance between two points divided by the original horizontal distance between the points, i.e., strain is the relative differential displacement of the ground along or across a subsidence monitoring line. Strain is dimensionless and can be expressed as a decimal, a percentage or in parts per notation. **Tensile Strains** are measured where the distance between two points or survey pegs increases and **Compressive Strains** where the distance between two points decreases. Whilst mining induced **strains** are measured **along** monitoring lines, ground **shearing** can occur both vertically, and horizontally **across** the directions of the monitoring lines.
Sub-critical area	An area of panel smaller than the critical area.
Subsidence	The vertical movement of a point on the surface of the ground as it settles above an extracted panel, but, 'subsidence of the ground' in some references can include both a vertical and horizontal movement component. The vertical component of subsidence is measured by determining the change in surface level of a peg that is fixed in the ground before mining commenced and this vertical subsidence is usually expressed in units of *millimetres (mm)*. Sometimes the horizontal component of a peg's movement is not measured, but in these cases, the horizontal distances between a particular peg and the adjacent pegs are measured.
Subsidence Effects	The deformations of the ground mass surrounding a mine, sometimes referred to as 'components' or 'parameters' of mine subsidence induced ground movements, including vertical and horizontal displacements, tilts, curvatures, strains, upsidence and closure.
Subsidence Impacts	The physical changes or damage to the fabric or structure of the ground, its surface and natural features, or built structures that are caused by the subsidence effects. These impacts considerations can include tensile and shear cracking of the rock mass, localised buckling of strata, bed separation, rock falls, collapse of overhangs, failure of pillars, failure of pillar floors, dilation, slumping and also include subsidence depressions or troughs.
Subsidence Consequences	The knock-on results of subsidence impacts, i.e., any change in the amenity or function of a natural feature or built structure that arises from subsidence impacts.

	Consequence considerations include public safety, loss of flows, reduction in water quality, damage to artwork, flooding, draining of aquifers, the environment, community, land use, loss of profits, surface improvements and infrastructure. Consequences related to natural features are referred to as environmental consequences.
Super-critical area	An area of panel greater than the critical area.
Tilt	The change in the slope of the ground as a result of differential subsidence and is calculated as the change in subsidence between two points divided by the horizontal distance between those points. Tilt is, therefore, the first derivative of the subsidence profile. Tilt is usually expressed in units of *millimetres per metre (mm/m)*. A tilt of 1 mm/m is equivalent to a change in grade of 0.1 %, or 1 in 1000.
UCS	Uniaxial Compressive Strength
UDEC	Universal Distinct Element Code - a two-dimensional numerical program that simulates the quasi-static or dynamic response to loading of media containing multiple intersecting joint structures. – for 2D modelling of Jointed and Blocky material
UNSW	University of New South Wales
Uplift	An increase in the level of a point relative to its original position.
Upsidence	Upsidence results from the dilation or buckling of near surface strata at or near the base of the valley. The term uplift is used for the cases where the ground level is raised above the pre-mining level, i.e., when the upsidence is greater than the subsidence. The magnitude of upsidence, which is typically expressed in the units of *millimetres (mm)*, is the difference between the observed subsidence profile within the valley and the conventional subsidence profile which would have otherwise been expected in flat terrain.

Appendix 6: 2021 Noise Monitoring Report

AIRLY COAL MINE

Annual Noise Monitoring
December 2021

Prepared for:

Centennial Airly Pty Limited
Glen Davis Road
CAPERTEE NSW 2846



SLR Ref: 610.18774-R03
Version No: -v1.0
January 2022

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Centennial Airly Pty Limited (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
610.18774-R03-v1.0	18 January 2022	Nicholas Vandenberg	Martin Davenport	Martin Davenport

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APPENDICES

Appendix A Acoustic Terminology
Appendix B Calibration Certificates

1 Introduction

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Centennial Airly to conduct the 2021 annual noise compliance monitoring for the Airly Coal Mine (ACM) as guided by the Centennial Coal Noise Management Plan Western Region (NMP) April 2018.

The purpose of this assessment was to determine the noise contribution from Airly Coal Mine operations, in accordance with the Airly Environment Protection Licence (EPL) No. 12374 and the Conditions of Approval (CoA) SSD_5581, Schedule 4, Condition 2.

The report uses specialist acoustic terminology. An explanation of common terms is provided in **Appendix A**.

2 Relevant Noise Criteria

2.1 Conditions of Approval Noise Limits

EPL 12374 does not contain any requirements relation to noise, however, Schedule 4, Condition 2 of SSD_5581 provides operational noise limits for sensitive receivers, which are provided in **Table 1**.

Table 1 Noise Impact Assessment Criteria (dBA)

Land	Day $L_{Aeq(15min)}$	Evening $L_{Aeq(15min)}$	Night $L_{Aeq(15min)}$	Night L_{Amax}
Any residence on privately-owned land	35	35	35	52
	$L_{Aeq(period)}$ – When in Use			
A17 (Camp ground)	50			N/A
A18 (Nissen Hut)	50			N/A

Note: Daytime 7.00 am - 6.00 pm; Evening 6.00 pm - 10.00 pm; Night-time 10.00 pm - 7.00 am, On Sundays and Public Holidays, Daytime 8.00 am -6.00 pm; Evening 6.00 pm - 10.00 pm; Night-time 10.00 pm - 8.00 am.

SSD_5581 goes on to state:

"Noise generated by the development is to be measured in accordance with the relevant requirements of the NSW Industrial Noise Policy. Appendix 8 sets out the meteorological conditions under which these criteria apply and the requirements for evaluating compliance with these criteria. However, these criteria do not apply if the Applicant has a negotiated agreement with the owner/s of the relevant residence or land to generate higher noise levels, and the Applicant has advised the Department in writing of the terms of this agreement."

Appendix 8 of SSD_5581 outlines the conditions under which the noise criteria is applicable.

1. The noise criteria in **Table 1** are to apply to a receiver under all meteorological conditions except under:
    a. Wind speeds greater than 3 m/s at 10m above ground level; or
    b. Stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level; or
    c. Stability category G temperature inversion conditions

2. Except for wind speed at microphone height, the data to be used for determining meteorological conditions shall be that recorded by the meteorological station required under Condition 8 of Schedule 4.
3. Attended monitoring is to be used to evaluate compliance with the relevant conditions of this consent.
4. Unless the Secretary agrees otherwise, this monitoring is to be carried out in accordance with the relevant requirements for reviewing performance set out in the NSW Industrial Noise Policy (as amended from time to time), in particular the requirements relating to:
    a. monitoring locations for the collection of representative noise data;
    b. meteorological conditions during which collection of noise data is not appropriate;
    c. equipment used to collect noise data, and conformity with Australian Standards relevant to such equipment; and
    d. modifications to noise data collected, including for the exclusion of extraneous noise and/or penalties for modifying factors apart from adjustments for duration.

3 Operational Noise Monitoring Methodology

3.1 General Requirements

All acoustic instrumentation employed throughout the monitoring programme has been designed to comply with the requirements of AS IEC 61672.1 – 2004 *Electroacoustics—Sound level meters - Specifications* and carries current National Association of Testing Authorities (NATA) or manufacturer calibration certificates.

Instrument calibration was checked before and after each measurement survey, with the variation in calibrated levels not exceeding ±0.5 dBA.

Noise measurements and assessments in this report have been prepared in accordance with Australian Standard AS 1055-1997 "*Description and Measurement of Environmental Noise*" Part 1, 2 and 3 and with reference to the Noise Policy for Industry (NPfI) and the NMP.

The objectives of the noise monitoring assessment were as follows:

- Measure the noise contribution from Airly Coal Mine operations at the ANM1, ANM2 and ANM3 locations as per the long-term noise monitoring locations outlined in the NMP.
- Ascertain all sources of noise within each of the noise surveys, including estimated contribution or maximum level of each source.
- Assess the noise emissions of Airly Coal Mine operations, in relation to the PA/EPL/CoA limits for the site and with regard to wind speed and direction during the noise surveys.

3.2 Operator Attended Noise Monitoring

3.2.1 Methodology

Operator attended noise measurements were conducted during the day, evening and night-time periods at the three noise monitoring locations.

The objective of the operator attended noise monitoring was to measure $L_{Aeq(15minute)}$ noise levels at the nearest potentially affected receptors to determine the noise contribution of mining activities associated with Airly Coal Mine, and to assist in defining noise sources and the character of noise in the area.

Operator attended noise measurements were conducted using one-third octave integrating B&K 2250 and B&K 2270 sound level meters (s/n 3006694 and 3029485 respectively). Calibration certificates for all acoustic instrumentation used throughout the monitoring programme is provided in **Appendix B**.

3.2.2 Quarterly Attended Noise Monitoring Locations

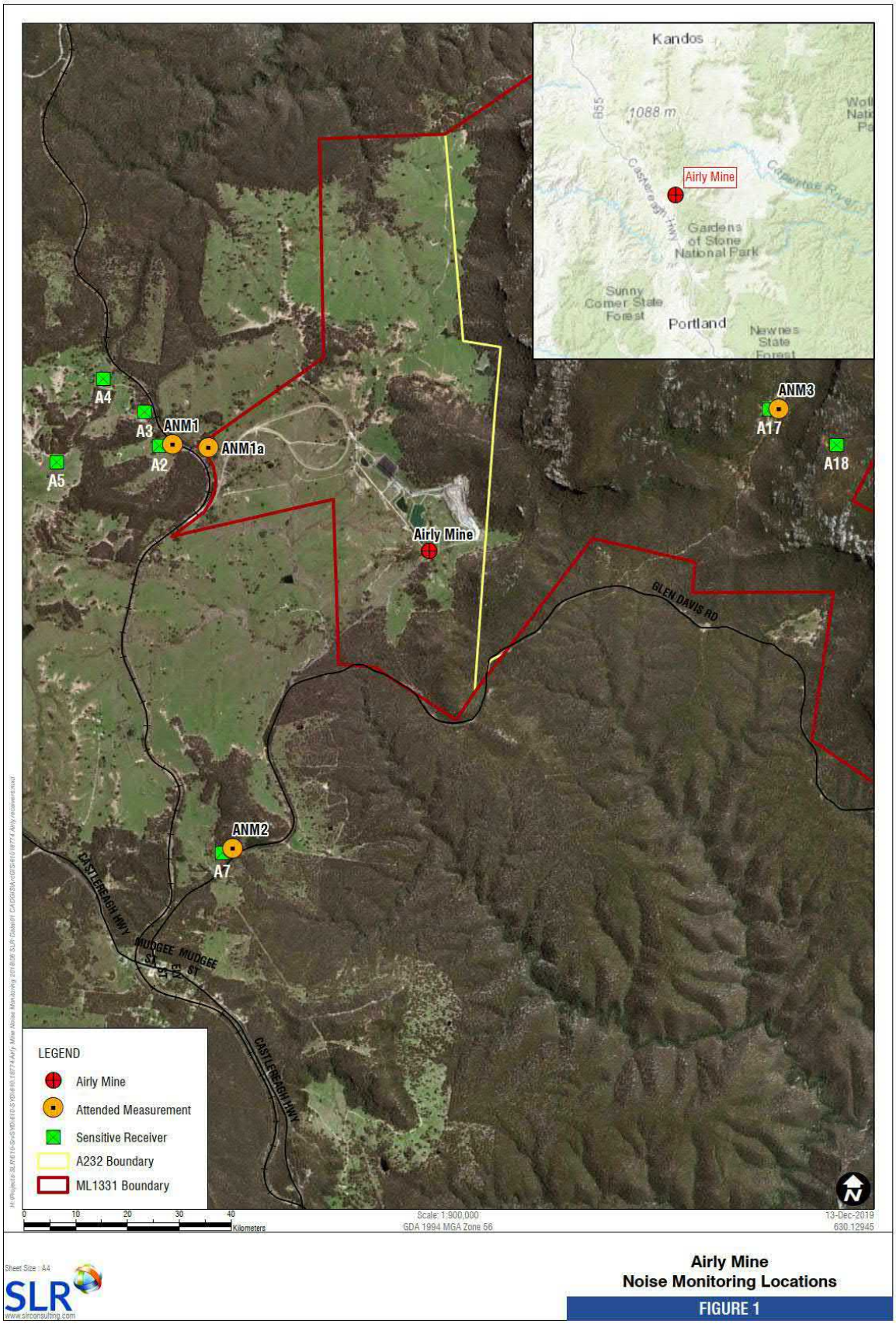
Operator attended noise surveys were conducted at the locations provided in **Table 2** to determine the character and contribution of noise sources, including ACM pit top operations, in relation to the total ambient noise level.

An aerial photograph showing the approximate locations of the noise monitoring locations is provided in **Figure 1**.

Table 2 Noise Monitoring Locations

Location	Description
ANM1	To the west of pit top operations near the Airly Coal Mine rail Loop. Due to property access agreements, monitoring at ANM1 was undertaken on mine owned land at the point most representative of sensitive receivers A2 to A5 being location ANM1a as shown in **Figure 1**. It is understood this is to be updated in the next revision of the Noise Management Plan for Airly Coal Mine.
ANM2	To the south of pit top operations and representative of sensitive receivers A7 and A8. ANM2 is close to Glen Davis Rd and the Castlereagh Highway.
ANM3	To the east of pit top operations. ANM3 is located in the Mount Airly Camping Area grounds and is representative of sensitive receivers A17 and A18.

Figure 1 Attended Noise Monitoring Locations



4 Results and Discussion

4.1 Results of Operator Attended Monitoring

Operator attended noise measurements were conducted during the daytime, evening and night-time periods on Tuesday 21 December 2021.

Weather conditions during the surveys were relatively warm with temperatures up to 33°C during the day and down to 13°C during the night.

Weather conditions were generally 1-3 m/s during the daytime period and were relatively calm during the evening and night-time monitoring periods.

A summary of the operator attended measurements, including the estimated contribution of noise sources, is contained within **Table 3**, **Table 4** and **Table 5.**

Table 3 Attended Noise Survey Results Location – ANM1

Period	Date/Start Time/ Weather	Primary Noise Descriptor (dBA re 20 µPa)					Criteria	Description of Noise Emissions and Typical Maximum Noise Levels (dBA)
		LAmax	LA1	LA10	LA90	LAeq		
Day	21/12/2021 13:14 31°C 2-3 m/s SW	58	53	47	37	44	35 dBA LAeq(15minute)	*Site related noise events:* *Dozer audible at times – <40 dBA* **Airly Coal Mine Estimated Contribution** **LAeq(15minute) <30 dBA** *Other noise events:* Trees rustling - <37 to 58 dBA Bids – 43 to 47 dBA Insects – 37 to 41 dBA
Evening	21/12/2021 21:26 21°C <0.5m/s SW	54	42	40	37	39		*Site related noise events:* *Conveyor/CHP – <30-32 dBA* *Onsite Impacts – <30 dBA* **Airly Coal Mine Estimated Contribution** **LAeq(15minute) -<30 dBA** *Other noise events:* Birds - 41 to 54 dBA Insects - 39 to 43 dBA

Period	Date/Start Time/ Weather	Primary Noise Descriptor (dBA re 20 µPa)					Criteria	Description of Noise Emissions and Typical Maximum Noise Levels (dBA)
		LAmax	LA1	LA10	LA90	LAeq		
Night	21/12/2021 22:05 14°C 0-1 m/s SW	58	41	40	35	38	35 dBA LAeq(15minute) 52 dBA LAmax	*Site related noise events: Conveyor/CHP – <30-36 dBA* **Airly Coal Mine Estimated Contribution** **LAeq(15minute) 30 dBA** **LAmax ~36 dBA** *Other noise events:* Birds – 58 dBA Insects – 40 to 44 dBA Traffic – 39 to 41 dBA

Table 4 Attended Noise Survey Results Location – ANM2

Period	Date/Start Time/ Weather	Primary Noise Descriptor (dBA re 20 µPa)					Criteria	Description of Noise Emissions and Typical Maximum Noise Levels (dBA)
		LAmax	LA1	LA10	LA90	LAeq		
Day	21/12/2021 14:00 31°C 1-3 m/s SW	57	43	38	33	36	35 dBA LAeq(15minute)	*Site related noise events: Inaudible* **Airly Coal Mine - Inaudible** *Other noise events:* Traffic – 38 to 41 dBA Birds – 43 to 57 dBA Wind – 37 to 41 dBA
Evening	21/12/2021 20:02 22°C Calm	49	41	35	29	33		*Site related noise events: Inaudible* **Airly Coal Mine - Inaudible** *Other noise events:* Traffic – 34 to 47 dBA Birds – 40 to 49 dBA Insects – 30 to 36 dBA Plane – 32 to 36 dBA
Night	21/12/2021 22:52 13°C 1m/s SW	52	47	43	30	39	35 dBA LAeq(15minute) 52 dBA LAmax	*Site related noise events: Inaudible* **Airly Coal Mine - Inaudible** *Other noise events:* Traffic – 30-38 dBA Insects – 41-52 dBA Frogs – 48 to 52 dBA

Table 5 Attended Noise Survey Results Location – ANM3

Period	Date/Start Time/ Weather	Primary Noise Descriptor (dBA re 20 µPa)					Criteria	Description of Noise Emissions and Typical Maximum Noise Levels (dBA)
		LAmax	LA1	LA10	LA90	LAeq		
Day	21/12/2021 14:11 31°C 2 m/s NW/SW	61	53	46	36	43	50 dBA LAeq(period)	*Site related noise events: Inaudible* **Airly Coal Mine - Inaudible** *Other noise events:* Insects – 36 to 46 dBA Trees rustling – 36 dBA Birds – 38 to 61 dBA
Evening	21/12/2021 20:03 23°C Calm	56	46	43	40	42		*Site related noise events: Inaudible* **Airly Coal Mine - Inaudible** *Other noise events:* Insects – 38-43 dBA Birds – 40 to 56 dBA Plane – 33 dBA
Night	21/12/2021 22:49 13°C Calm	42	35	33	30	32	50 dBA LAeq(period)	*Site related noise events: Inaudible* **Airly Coal Mine - Inaudible** *Other noise events:* Insects – 30-34 dB Plane – <30 Offsite bang - <42 dBA

4.1.1 Discussion of Results

No modification factors for low frequency noise or tonal noise is required to be applied for all monitoring locations.

4.1.2 Operational Compliance Assessment

Results of the operator attended noise measurement contributions from Airly Coal Mine operations compared with the relevant noise criteria are summarised in **Table 6**.

Table 6 Operational Noise Assessment

Location	Estimated LAeq(15minute) Contribution dBA			Noise Criteria LAeq(15minute) dBA			Compliance		
	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
ANM1	<30	<30	30	35	35	35	Yes	Yes	Yes
ANM2	I/A	I/A	I/A	35	35	35	Yes	Yes	Yes
ANM3	I/A	I/A	I/A	50	50	50	Yes	Yes	Yes

Note: I/A = Inaudible

Table 6 indicates that compliance with the relevant operational noise criteria was achieved at all of the noise monitoring locations during all periods.

4.1.3 Sleep Disturbance

Results of the sleep disturbance measurements compared with the relevant noise criteria are summarised in **Table 7**

Table 7 Sleep Disturbance Assessment

Location	Airly L_{Amax} Noise Level Contribution dBA	Noise Criteria L_{Amax} dBA	Compliance
ANM1	~36	52	Yes
ANM2	Inaudible	52	Yes
ANM3	Inaudible	NA	NA[1]

Note 1: No sleep disturbance criteria applicable for ANM3.

Table 7 indicates that compliance with the relevant sleep disturbance noise criteria was achieved at all noise monitoring locations.

5 Conclusion

An assessment of noise emissions from Airly Coal Mine, has been conducted by SLR for 2021.

Operator attended noise measurements were conducted at noise monitoring locations ANM1, ANM2 and ANM3 during the day, evening and night-time periods on Tuesday 21 December 2021.

The assessment and analysis of the results of the operator attended noise monitoring has shown that Airly Coal Mine noise emission levels were in compliance with the CoA/EPL noise limits at all monitoring locations during the day, evening and night-time noise monitoring periods.

APPENDIX A

Acoustic Terminology

1 Sound Level or Noise Level

The terms 'sound' and 'noise' are almost interchangeable, except that in common usage 'noise' is often used to refer to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure capable of evoking the sense of hearing. The human ear responds to changes in sound pressure over a very wide range. The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (abbreviated as dB) scale reduces this ratio to a more manageable size by the use of logarithms.

The symbols SPL, L or L_P are commonly used to represent Sound Pressure Level. The symbol L_A represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2×10^{-5} Pa.

2 'A' Weighted Sound Pressure Level

The overall level of a sound is usually expressed in terms of dBA, which is measured using a sound level meter with an 'A-weighting' filter. This is an electronic filter having a frequency response corresponding approximately to that of human hearing.

People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dBA or 2 dBA in the level of a sound is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness. The table below lists examples of typical noise levels

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130	Threshold of pain	Intolerable
120	Heavy rock concert	Extremely noisy
110	Grinding on steel	
100	Loud car horn at 3 m	Very noisy
90	Construction site with pneumatic hammering	
80	Kerbside of busy street	Loud
70	Loud radio or television	
60	Department store	Moderate to quiet
50	General Office	
40	Inside private office	Quiet to very quiet
30	Inside bedroom	
20	Recording studio	Almost silent

Other weightings (eg B, C and D) are less commonly used than A-weighting. Sound Levels measured without any weighting are referred to as 'linear', and the units are expressed as dB(lin) or dB.

3 Sound Power Level

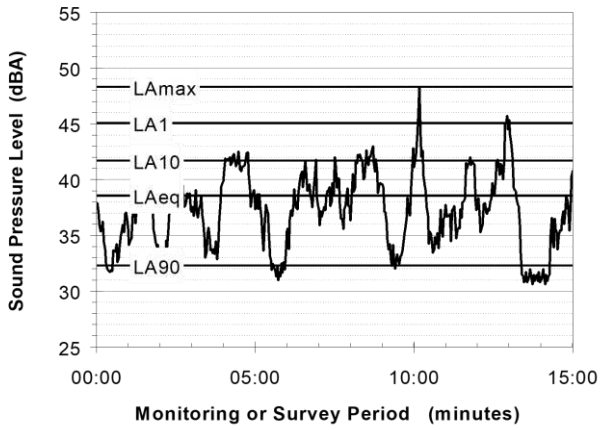
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or L_W, or by the reference unit 10^{-12} W.

The relationship between Sound Power and Sound Pressure may be likened to an electric radiator, which is characterised by a power rating, but has an effect on the surrounding environment that can be measured in terms of a different parameter, temperature.

4 Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels L_{AN}, where L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the L_{A1} is the noise level exceeded for 1% of the time, L_{A10} the noise exceeded for 10% of the time, and so on.

The following figure presents a hypothetical 15 minute noise survey, illustrating various common statistical indices of interest.



Of particular relevance, are:

L_{A1} The noise level exceeded for 1% of the 15 minute interval.

L_{A10} The noise level exceeded for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

L_{A90} The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

L_{Aeq} The A-weighted equivalent noise level (basically the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

When dealing with numerous days of statistical noise data, it is sometimes necessary to define the typical noise levels at a given monitoring location for a particular time of day. A standardised method is available for determining these representative levels.

This method produces a level representing the 'repeatable minimum' L_{A90} noise level over the daytime and night-time measurement periods, as required by the EPA. In addition, the method produces mean or 'average' levels representative of the other descriptors (L_{Aeq}, L_{A10}, etc).

5 Tonality

Tonal noise contains one or more prominent tones (ie distinct frequency components) and is normally regarded as more offensive than 'broad band' noise.

6 Impulsiveness

An impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.

7 Frequency Analysis

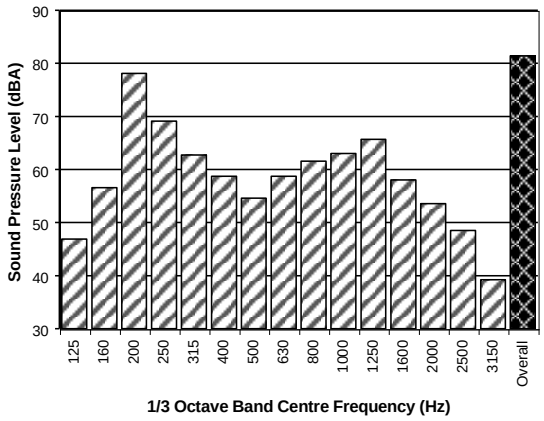
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters but is now normally carried out using Fast Fourier Transform (FFT) analysers.

The units for frequency are Hertz (Hz), which represent the number of cycles per second.

Frequency analysis can be in:

- Octave bands (where the centre frequency and width of each band is double the previous band)
- 1/3 octave bands (3 bands in each octave band)
- Narrow band (where the spectrum is divided into 400 or more bands of equal width)

The following figure shows a 1/3 octave band frequency analysis where the noise is dominated by the 200 Hz band. Note that the indicated level of each individual band is less than the overall level, which is the logarithmic sum of the bands.



8 Vibration

Vibration may be defined as cyclic or transient motion. This motion can be measured in terms of its displacement, velocity or acceleration. Most assessments of human response to vibration or the risk of damage to buildings use measurements of vibration velocity. These may be expressed in terms of 'peak' velocity or 'rms' velocity.

The former is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as 'peak particle velocity', or PPV. The latter incorporates 'root mean squared' averaging over some defined time period.

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (aligned toward the source) and transverse.

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level V, expressed in mm/s can be converted to decibels by the formula 20 log (V/V_o), where V_o is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used by some organizations.

9 Human Perception of Vibration

People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as 'normal' in a car, bus or train is considerably higher than what is perceived as 'normal' in a shop, office or dwelling.

10 Over-Pressure

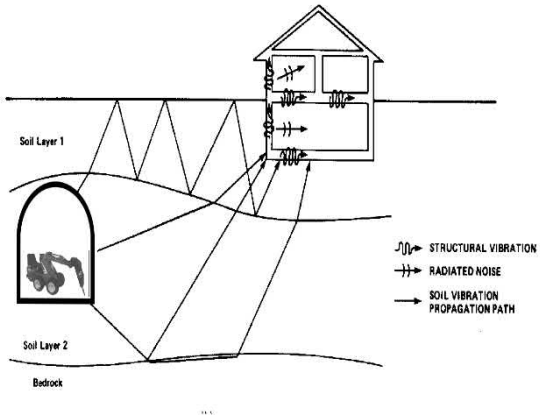
The term 'over-pressure' is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

11 Ground-borne Noise, Structure-borne Noise and Regenerated Noise

Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed 'structure-borne noise', 'ground-borne noise' or 'regenerated noise'. This noise originates as vibration and propagates between the source and receiver through the ground and/or building structural elements, rather than through the air.

Typical sources of ground-borne or structure-borne noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

The following figure presents the various paths by which vibration and ground-borne noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.



The term 'regenerated noise' is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect of the discharge grill in the airstream. This secondary noise is referred to as regenerated noise

APPENDIX B

Calibration Certificates

HBK HOTTINGER BRÜEL & KJÆR

The Calibration Laboratory
Skodsborgvej 307, DK-2850 Nærum, Denmark

ilac-MRA DANAK CAL Reg.No. 307 Member of EA MLA

CERTIFICATE OF CALIBRATION

No: CDK2007175 Page 1 of 12

CALIBRATION OF

Sound Level Meter:	Brüel & Kjær Type 2270	No: 3029485 Id: -
Microphone:	Brüel & Kjær Type 4189	No: 3260622
PreAmplifier:	Brüel & Kjær Type ZC-0032	No: 30123
Supplied Calibrator:	None	
Software version:	BZ7222 Version 4.7.6	Pattern Approval: -
Instruction manual:	BE1712-22	

CUSTOMER

SLR Consulting Australia Pty Ltd
Sub Base Platypus
Tenancy 201 / 120 High Street
2060 North Sydney
New South Wales, Australia

CALIBRATION CONDITIONS

Preconditioning: 4 hours at 23°C ± 3°C

Environment conditions: *See actual values in sections.*

SPECIFICATIONS

The Sound Level Meter Brüel & Kjær Type 2270 has been calibrated in accordance with the requirements as specified in IEC 61672-1:2013 class 1. Procedures from IEC 61672-3:2013 were used to perform the periodic tests. The accreditation assures the traceability to the international units system SI.

PROCEDURE

The measurements have been performed with the assistance of Brüel & Kjær Sound Level Meter Calibration System 3630 with application software type 7763 (version 8.2 - DB: 8.20) by using procedure B&K proc 2270, 4189 (IEC 61672:2013).

RESULTS

Calibration Mode: **Calibration as received.**

The reported expanded uncertainty is based on the standard uncertainty multiplied by a coverage factor $k = 2$ providing a level of confidence of approximately 95 %. The uncertainty evaluation has been carried out in accordance with EA-4/02 from elements originating from the standards, calibration method, effect of environmental conditions and any short time contribution from the device under calibration.

Date of calibration: 2020-10-30

Susanne Jørgensen
Calibration Technician

Date of issue: 2020-10-30

Erik Bruus
Approved Signatory

Reproduction of the complete certificate is allowed. Parts of the certificate may only be reproduced after written permission.

CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: SLM 26583 & FILT 5697

Equipment Description:	Sound Level Meter		
Manufacturer:	B & K		
Model No:	2250	**Serial No:**	3006994
Microphone Type:	4952	**Serial No:**	3017903
Preamplifier Type:	-	**Serial No:**	-
Filter Type:	1/3 Octave	**Serial No:**	3006994
Comments:	All tests passed for class 1. (See over for details)		
Owner:	SLR Consulting Australia Pty Ltd 120 High Street North Sydney, NSW 2060		
Ambient Pressure:	1009 hPa ±1.5 hPa		
Temperature:	24 °C ±2° C	**Relative Humidity:**	57% ±5%
Date of Calibration:	18/03/2020	**Issue Date:**	19/03/2020
Acu-Vib Test Procedure:	AVP10 (SLM) & AVP06 (Filters)		

CHECKED BY: ..... **AUTHORISED SIGNATURE:** .....
Hein Soe

Accredited for compliance with ISO/IEC 17025 - Calibration
The results of the tests, calibration and/or measurements included in this document are traceable to Australian/national standards.

NATA
WORLD RECOGNISED ACCREDITATION

ACU-VIB
ELECTRONICS

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Accredited Lab. No. 9262
Acoustic and Vibration Measurements

CERTIFICATE OF CALIBRATION

CERTIFICATE NO: C29756

EQUIPMENT TESTED : Sound Level Calibrator

Manufacturer: B & K
Type No: 4231 **Serial No:** 2218228
Owner: SLR Consulting Australia Pty Ltd
120 High Street
North Sydney, NSW 2060
Tests Performed: Measured Output Pressure level, Frequency & Distortion
Comments: See Details overleaf. All Test Passed.

Parameter	Pre-Adj	Adj Y/N	Output: (dB re 20 µPa)	Frequency (Hz)	THD&N (%)
Level1:	NA	N	93.96 dB	999.96 Hz	0.71 %
Level2:	NA	N	113.99 dB	999.96 Hz	0.40 %
Uncertainty			±0.11 dB	±0.05%	±0.20 %
Uncertainty (at 95% c.l.) k=2					

CONDITION OF TEST:

Ambient Pressure 997 hPa ±1 hPa
Temperature 22 °C ±1° C
Relative Humidity 40 % ±5%

Date of Receipt : 09/06/2021
Date of Calibration : 11/06/2021
Date of Issue : 11/06/2021

Acu-Vib Test Procedure: AVP02 (Calibrators)
Test Method: AS IEC 60942 - 2017

CHECKED BY: .....

AUTHORISED SIGNATURE: .....
Jack Klett

Accredited for compliance with ISO/IEC 17025 - Calibration

Results of the tests, calibration and/or measurements included in this document are traceable to SI units through reference equipment that has been calibrated by the Australian National Measurement Institute or other NATA accredited laboratories demonstrating traceability.

This report applies only to the item identified in the report and may not be reproduced in part.

The uncertainties quoted are calculated in accordance with the methods of the ISO Guide to the Uncertainty of Measurement and quoted at a coverage factor of 2 with a confidence interval of approximately 95%.

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Accredited Lab No. 9262
Acoustic and Vibration Measurements

Acu-Vib Electronics
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Page 1 of 2 Calibration Certificate
AVCERT02.1 Rev.2.0 14.04.2021

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Appendix 7: 2021 IEA Action Update

CENTENNIAL



AIRLY MINE

Response to Independent Environmental Audit Recommendations

Action Status Update - March 2022

Centennial Coal
Environment Matters

Airly Mine Response to the 2021 Independent Environmental Audit Recommendations

- Action Status Update as of March 2022

The following tables are representative of Airly Mine's Response to the Auditor's Recommendations (RAR) identified within the May 2021 Independent Environmental Audit (IEA) Report. This document was originally prepared to satisfy Schedule 6, Condition 13 of the Airly Mine Development Consent (SSD_5581).

The 2021 IEA Report, inclusive of Airly Mine's RAR, was accepted by the Department of Planning, Industry and Environment (DPIE) on 1 June 2021. A status update column has been added to the below tables for the sole purpose of providing a transparent update as part of the 2021 Annual Review.

Table 1. Airly Mine Response the IEA Recommendations listed within Table 2-2 of the 2021 IEA Report

SSD 5581 Condition ID	IEA - Recommendation	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of March 2022)
Schedule 2 Condition 1 **Obligation to minimise harm to the Environment** In addition to meeting the specific performance measures and criteria established under this consent, the Applicant must implement all reasonable and feasible measures to prevent and/or minimise any harm to the environment that may result from the construction, operation, or rehabilitation of the development.	NV1 AIR IEA 2021 As the exceedance of SSD_5581 Schedule 3 Condition 2 subsidence impact performance measure is currently under investigation by DPIE, no further recommendations have been made.	It is Centennial's position that Airly is Compliant with Schedule 2, Condition 1. The following points are made: • it is noted that harm to the environment has been minimised by implementing a conservative mine design in different areas of the lease to minimise impacts. • all extraction has been undertaken in accordance with the mine design	N/A	**N/A** Still under investigation by DPIE.

SSD 5581 Condition ID	IEA - Recommendation	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of March 2022)
		parameters approved by the EIS and subsequent Extraction Plans. • Centennial has adopted a more conservative mine design to further reduce to the potential impacts to cliffs as a result of mining, operating with a 26.5 degree angle of draw set back from the tops of cliffs within the cliff line zone around all miniwall panels (not just the first four as required by consent and significantly greater than the approved 8 degree angle of draw). • A range of adaptive management measures have been implemented, further demonstrating Centennial's commitment to minimise harm and operate in accordance with the mining schedule and EIS. • The consent allows for impacts to occur and in many respects, impacts		

SSD 5581 Condition ID	IEA - Recommendation	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of March 2022)
		have been less than predicted. Although subsidence cracking was not expected (and therefore not allowed), it is not indicative of the work that Centennial has done to minimise impacts to the environment. • The proactive minimisation of impacts has come at a significant loss of resource and cost to the Company. Centennial will actively engage with DPIE during its investigation in regard to these matters		
Schedule 2 Condition 2 **Terms of Consent** The Applicant must carry out the development (a) generally in accordance with the EIS and the Mining schedule (see Figure 3 in Appendix 2)	NV2 AIR IEA 2021 As the exceedance of SSD_5581 Schedule 3 Condition 2 subsidence impact performance measure is currently under investigation by DPIE, no further recommendations have been made.	It is Centennial's position that Airly is Compliant with Schedule 2, Condition 2. The following points are made: A conceptual Trigger Action Response Plan (TARP) was included in the EIS which identified the measures that would be undertaken should the mine experience greater then predicted subsidence.	N/A	**N/A** Still under investigation by DPIE.

SSD 5581 Condition ID	IEA - Recommendation	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of March 2022)
		A refined TARP was included as part of the Mt Airly Panel and Pillar Extraction Plan which was approved by the Department of Planning, Industry and Environment on 31 May 2021. Centennial is of the position that Airly has operated in accordance with the approved TARP following the identification of subsidence exceeding the 125 mm. In this regard, Airly has carry out the development generally in accordance with the EIS..		
Schedule 3 Condition 2 **Performance Measures – Natural and Heritage Features, etc** The Applicant must ensure that the development does not cause any exceedances of the performance measures (Table 1): All other land not covered by a performance measure above: No greater subsidence impacts or environmental consequences	NC3 AIR IEA 2021 As the exceedance of SSD_5581 Schedule 3 Condition 2 subsidence impact performance measure is currently under investigation by DPIE, no further recommendations have been made.	Airly acknowledged an exceedance of this performance criteria in Notification submitted 24 November 2020.	N/A	**N/A**

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than predicted in the EIS				
Schedule 4 Condition 15 **Biodiversity Management Plan** Prior to carrying out any development under this consent that would cause surface disturbance, the Applicant must prepare a Biodiversity Management Plan for the development to the satisfaction of the Secretary. This plan must: (d) include a detailed description of the measures that would be implemented to: control weeds and feral pests including, but not limited to goats, rabbits, European Red Fox, cats and pigs;	R1 AIR IEA 2021 Develop a regular weed inspection and treatment regime; and raise awareness of Centennial Airly's weed control obligations under SSD_5581, by informing lessees of Centennial Airly's aim to continue to progress the control and suppression of weeds and minimise potential weed impacts on the adjacent Mugii Murum-ban State Conservation Area.	A1 AIR IEA 2021: Centennial will develop a weed inspection and control program for Airly operational mine owned land. Additionally, Centennial will provide a letter to all neighbouring lessees detailing Airly Mine's current and planned weed control program. This letter will emphasise the overall aim to continue to progress the control and suppression of weeds and minimise potential weed impacts on the adjacent Mugii Murum-ban State Conservation Area.	July 2021	**Action Completed.** Airly Mine weed inspection and control program developed on 11 June 2021. Letter sent to neighbouring lessees (3) on 9 July 2021.
Schedule 4 Condition 15 **Biodiversity Management Plan** Prior to carrying out any development under this consent that would cause surface disturbance, the Applicant must prepare a Biodiversity Management Plan for the development to the satisfaction of the Secretary. This plan must:	R2 AIR IEA 2021 Correct weed management reference numbering in the Western Region Biodiversity Management Plan Appendix B Airly e.g. the Airly site-specific Biodiversity Management Plan references Section 4.4.2 in the RBMP for weed management. There is no Section 4.4.2, alternatively Section 6.6.2	A2 AIR IEA 2021: Centennial will correct the reference numbering of the Western Region Biodiversity Management Plan during the next revision.	September 2021	**Action Completed.** Reference numbering of the Western Region Biodiversity Management Plan (WRBMP) was corrected during a revision of the document on 2 June 2021. Subsequently, in response to the resubmission of the revised WRBMP, the Department of Planning &

SSD 5581 Condition ID	IEA - Recommendation	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of March 2022)
(d) include a detailed description of the measures that would be implemented to: control weeds and feral pests including, but not limited to goats, rabbits, European Red Fox, cats and pigs;	includes weed management treatment and timing.			Environment requested a full revision of the document including full consultation with stakeholders. In March 2022, Centennial Western sites (Inclusive of Airly Mine) commenced the consultation process and full revision of the WRBMP. It is anticipated that the document will be submitted for approval by May 2022.
Schedule 6 Condition 2 **Management Plan Requirements** The Applicant must ensure that the management plans required under this consent are prepared in accordance with any relevant guidelines, and include: (b) a description of: • the relevant statutory requirements (including any relevant approval, licence or lease conditions); (e) a contingency plan to manage any unpredicted impacts and their consequences; (f) a program to investigate and implement ways to improve the	R3 AIR IEA 2021 Consult with DPIE regarding the approval status of new and/or revised environmental management plans, programs and strategies.	A3 AIR IEA 2021: Resubmit any management plans previously submitted and not approved through the Departments online portal system to formally recommence the assessment and approval of any management plans and track progress.	September 2021	**Action Completed.** This action was addressed as part of the submission of the Pt Hatteras Extraction Plan on 8 September 2021. Consultation with the Department has prompted additional revisions and consultation in relation to the Western Region Biodiversity Management Plan (WRBMP) and the Airly Water Management Plan (WMP). Airly Mine is currently in the process or revision and updating these documents

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environmental performance of the development over time; (g) a protocol for managing and reporting any: • incidents; • complaints; • non-compliances with statutory requirements; and • exceedances of the impact assessment criteria and/or performance criteria; and (h) a protocol for periodic review of the plan.				to satisfy the Departments requests. It is anticipated that the WRBMP and the Airly WMP will be submitted for approval in May 2022.
Schedule 6 Condition 8 **Community Consultative Committee** The Applicant must operate a Community Consultative Committee for the development to the satisfaction of the Secretary. This CCC must be operated in accordance with the Guidelines for Establishing and Operating Community Consultative Committees for Mining Projects (Department of Planning, 2007) or its latest version.	R4 AIR IEA 2021 CCC Chair to provide an Annual Report to DPIE (in accordance with Community Consultative Committee Guidelines, State Significant Projects (DPIE, November 2016).	A4 AIR IEA 2021: Submit a letter to the Airly CCC Chair reminding them of the Chair's obligations to provide an Annual Report to DPIE in accordance with the CCC Guidelines.	July 2021	**Action Completed.** Letter sent to Airly CCC Chair on 15 June 2021.
Schedule 3 Condition 3	R5 AIR IEA 2021	A4 AIR IEA 2021:	July 2021	**Action Completed.**

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Performance Measure – Built Features The Applicant must ensure that the development does not cause any exceedances of the performance measures in Table 2 to the satisfaction of the Secretary. Other built features and improvements including Airly Camp Ground, walking and 4WD tracks, fences and gates: Use should be maintained wherever practicable in consultation with BCD	Consult with NPWS to agree on a program for maintenance of Mugii Murum-ban State Conservation Area access and trail management and meet SSD_5581 Schedule 3 Condition 3 performance measures for *'Other built features and improvements including Airly Camp Ground, walking and 4WD tracks, fences and gates'*.	Submit a letter to the NPWS proposing an access maintenance program for the Muggii Murum-ban State Conservation Area and seek their endorsement of the program.		Following consultation with NPWS, endorsement of the proposed access track maintenance program for Mt Airly and Mt Genowlan received from NPWS on 4 June 2021.
Schedule 4 Condition 8 **Meteorological Monitoring** Prior to commencement of development under this consent and for the life of the development, the Applicant must ensure that there is a meteorological station in the vicinity of the site that: (a) complies with the requirements in the Approved Methods for Sampling of Air Pollutants in New South Wales guideline and the NSW Industrial Noise Policy; and (b) is capable of continuous real-time measurement of atmospheric stability	R6 AIR IEA 2021 Include on the 6-month and 12-month weather station verification report, that the weather station has been assessed against the Approved Methods for Sampling of Air Pollutants in New South Wales guideline and the NSW Industrial Noise Policy and is capable of continuous real-time measurement of atmospheric stability category determined by the sigma theta method in	A6 AIR IEA 2021: This action is currently being undertaken however, Airly Mine will ensure that the next verification report includes specific written confirmation that the Meteorological Station complies with the relevant guidelines and the requirements of Schedule 4 Condition 8 of SSD_5581.	December 2021	**Action Completed.** Verification reports from ALS now includes specific written confirmation that the Meteorological Station complies with the relevant guidelines and the requirements of Schedule 4 Condition 8 of SSD_5581. Updated verification report received October 2021.

<table>
<tr><th>SSD 5581 Condition ID</th><th>IEA - Recommendation</th><th>Airly Mine Response / Action Plan</th><th>Timeframe for Completion of Action</th><th>Status Update for 2021 Annual Review (as of March 2022)</th></tr>
<tr><td>category determined by the sigma theta method in accordance with the NSW Industrial Noise Policy.</td><td>accordance with the NSW Industrial Noise Policy.</td><td></td><td></td><td></td></tr>
<tr><td>Schedule 4 Condition 10
Water Pollution
Unless an EPL authorises otherwise, the Applicant must comply with Section 120 of the POEO Act.</td><td>R7 AIR IEA 2021
Reduce the sediment load and potential for surface water contamination in the area adjacent to the train loading bay sump to prevent loss of containment to the Airly Creek catchment area and potential breach of Section 120 POEO Act; and assess the impact of reed growth on the capacity of the 35 ML Discharge Dam and conduct corrective actions if required.</td><td>A7 AIR IEA 2021:
Install sediment control structures in area adjacent to the train loading bay sump;
Confirm the volume of reeds growing in the Discharge Dam and produce an action plan to correct if the capacity of the dam is reduced by more than 2ML.</td><td>December 2021</td><td>Action Completed
Sediment control structures installed adjacent to train loading sump on 14/9/2021.
Reed volume calculation in the Discharge Dam was completed on 24 May 2021. Reed volume estimated to be 0.491ML. Therefore, no action is required at this stage.</td></tr>
<tr><td>Schedule 4 Condition 12
Water Management Performance Measures
The Applicant must comply with the performance measures in Table 6 to the satisfaction of the Secretary.<table><tr><td>Chemical and petroleum storage</td><td>Chemical and hydrocarbon products to be stored in bunded areas in</td></tr></table></td><td>R8 AIR IEA 2021
Monitor the effectiveness of recent improvements in hydrocarbon and chemical storage in the pit top area against Australian Standards and take corrective action where required; progress improvements to the storage of waste oils in the workshop; and provide capacity in bunds to</td><td>A8 AIR IEA 2021:
Centennial will:
Complete a review of the effectiveness of the recent improvements in hydrocarbon and chemical storage areas;
Install a new filter drainage bin in the workshop; and</td><td>December 2021</td><td>Action Completed.
All 3 required actions were completed in November 2021.
Improvements to the Hydrocarbon and Chemical Storage area are working well.
New filter drainage bin, inclusive of new plumbing to a new</td></tr>
</table>

SSD 5581 Condition ID		IEA - Recommendation	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of March 2022)
	accordance with relevant Australian Standards	contain leaks and spills and prevent bund overflow.	• Include a check within the weekly environmental inspection report to monitor the Pit Top diesel bund sump capacity.		self bunded waste oil container was completed in November 2021; • Weekly inspection report has been updated to include an inspection of the Pit Top diesel bund sump capacity.
Schedule 4 Condition 14 **Independent Expert Review** As part of any Independent Environmental Audit of the development (see condition 12 of schedule 6), the Applicant must commission an independent expert whose appointment has been endorsed by the Secretary, to carry out a review of the Groundwater Management Plan for the development, including the groundwater model. This review must include a: (a) review of all available monitoring data; (b) comparison of predicted and actual groundwater impacts; and (c) review of the effectiveness of the Groundwater Management Plan for the		R9 AIR IEA 2021 Confirm acceptability of the independent expert review process, to meet the requirements of SSD_5581 Schedule 4 Condition 12, with DPIE.	A9 AIR IEA 2021: Submit a letter to DPIE seeking confirmation of endorsement of Mr Noel Merrick of SLR.	May 2021	**Action Completed.** Endorsement request letter sent to DPIE on 6 May 2021. DPIE provided confirmation of endorsement of Mr Noel Merrick of SLR on 19 May 2021.

SSD 5581 Condition ID	IEA - Recommendation	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of March 2022)
development, including the groundwater model**.**				
Schedule 6 Condition 1 **Environmental Management Strategy** Prior to carrying out any development under this consent, the Applicant must prepare an Environmental Management Strategy for the development to the satisfaction of the Secretary. This strategy must: (f) include: a clear plan depicting all the monitoring to be carried out in relation to the development.	R10 AIR IEA 2021 Consult with DPIE to confirm if the current approach is acceptable where the Environmental Management Strategy references management plans required by SSD_5581, and that these separate management plans include the monitoring requirements to meet SSD_5581 Schedule 4, Condition 1 (f).	No action proposed. The EMS was approved by DPIE in 2017.	N/A	**N/A**
EPL12374 P1.3 LDPs are identified in EPL12374 for the purposes of the monitoring and/or the setting of limits for pollutants to water from the point.	R11 AIR IEA 2021 Clearly label EPL 12374 licensed discharge monitoring points.	A10 AIR IEA 2021: Install signs at LDPs	December 2021	**Action Completed.** LDP signs installed in October 2021.
EPL12374 M5.2	R12 AIR IEA 2021 Clearly indicate the public complaints line on the Centennial Airly website.	A11 AIR IEA 2021: Update the Centennial Airly website to clearly identify the public complaints number (02 6359 2100).	July 2021	**Action Completed.** Centennial Airly website was updated to clearly identify the complaints telephone number on 15 May 2021.
ML1331 – 3(f)	R13 AIR IEA 2021	A12 AIR IEA 2021:	March 2022	**Action Completed.**

SSD 5581 Condition ID	IEA - Recommendation	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of March 2022)
The lease holder must prepare a Rehabilitation Report to the satisfaction of the Minister. The report must: iii. be prepared in accordance with any relevant annual reporting guidelines published on the Department's website at www.resources.nsw.gov.au/environment	Engage with DPIE and the Resources Regulator to agree on the format of the Annual Review on how to meet the requirements of the Annual Review Guideline (DPIE, 2015) and the Form and Way Annual Rehabilitation Report and Forward Program for Small and Large Mines (Resources Regulator, September 2020).	Centennial seek endorsement from the Department and Resources Regulator of a revised Annual Review Template to confirm it adequately addresses the requirements of the Annual Review Guideline and the Annual Rehabilitation Reporting requirements.		Consultation has been undertaken with DPIE. Suggested revisions have been made to the Centennial Annual Review Template. 2021 Annual Review will be submitted by 31 March 2022.
	R14 AIR IEA 2021 DPIE and Centennial Airly to consider directing the IEP to conduct independent third-party reviews of the subsidence findings in the Annual Review, in particular assessment of whether Airly are meeting the requirements for the performance measures as defined in the Development Consent.	No action proposed. Centennial understands that the IEP is engaged by DPIE as required.	N/A	**N/A**

Table 2. Airly Mine Response to the 'Opportunities for Improvement' listed IER of the Groundwater Management Plan (GWMP) Report

IER of GWMP – Opportunities for Improvement	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of September 2021)
The groundwater monitoring requirements of the current WMP (GHD, 2019) are generally considered to be appropriate based on project risks to groundwater values. However, a number of opportunities for improvement are suggested:	N/A	N/A	**N/A**
• The WMP groundwater level triggers should be reviewed and updated for unsaturated / non-operational VWP sensors.	Noted. The VWP's that are not working do not have trigger values. A review of the groundwater level triggers in relation to VWP's will be undertaken during the next revision of the Water Management Plan.	September 2021	**Action Completed.** Groundwater trigger levels in relation to VWP's were reviewed and the revised Water Management Plan was submitted on 24 August 2021.
• As mining progresses, additional monitoring locations should be considered in the northeast towards Genowlan Point prior to mining progression into the area.	Noted. Additional monitoring bores in the northeast towards Genowlan Point will be reviewed and considered during the next revision of the Water Management Plan.	September 2021	**Action Completed.** The are no accessible drilling locations for additional groundwater monitoring bores to the northeast towards Genowlan Point. Revised water Management Plan was submitted on 24 August 2021.

IER of GWMP – Opportunities for Improvement	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of September 2021)
• Review monitoring locations for Gap Creek and Genowlan Creek alluvial standpipes and consider the replacement of dry bores ARP05 and ARP09 with standpipes in deeper sections of the alluvium to allow continued monitoring of alluvial groundwater levels and quality.	Noted. The replacement/relocation of dry bores ARP05 and ARP09 will be reviewed and considered within the next revision of the Water Management Plan.	September 2021	**Action Completed.** Review was undertaken in August 2021. Both bores have since recovered and are functioning. Installation of additional locations not feasible due to access and environmental constraints.
• Whilst the groundwater quality analytical suite has been significantly improved by the removal of a large number of parameters that had no practical use within the monitoring program, a number of parameters remain for which there are no water quality guideline values, and which are unlikely to result from mining activity. Some further rationalisation of the suite could be undertaken without significant impact on the groundwater quality monitoring objectives.	Noted. The groundwater quality analytical suite will be revised during the next revision of the Water Management Plan.	September 2021	**Action Completed.** The analytical suite has been reduced in the WMP (August 2021). Implementation of the changes is pending regulatory approval.
• Consider including a requirement to review predicted drawdowns against groundwater level observations in the annual monitoring report.	Noted. The requirement for annual reporting of predicted drawdowns against the groundwater level observations will be included in the next Water Management Plan revision.	September 2021	**Action Completed.** Predicted drawdowns form the basis of trigger values. Groundwater levels are assessed in relation to trigger values in the Annual report.

IER of GWMP – Opportunities for Improvement	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of September 2021)
• Consider stipulations relating to the presentation of data in the annual monitoring report as suggested below.	Noted. Stipulation relating to the presentation of data as per the below suggestions will be considered during the next revision of the Water Management Plan.	September 2021	**Action Completed.** Annual Report data presentation has been amended where required.
Following review of the 2020 Annual Water Monitoring Report (GHD, 2021), a number of improvements to the presentation of annual water monitoring data are recommended, some of which could be specified in the WMP to aid data interpretation, the identification of trends and demonstrate compliance with the WMP:	N/A	N/A	N/A
• VWP hydrographs: o Should be plotted on appropriate vertical and horizontal scales to allow more detailed interpretation and evaluation of pressure responses.	Noted. Will be revised within the next Annual Water Monitoring Report.	March 2022	**Action Completed.** Hydrographs have been updated with display of historical data to allow for comparison of trends. Vertical scales retained to show initial pressures. Particularly relevant for VWPs without trigger levels.
o Should be annotated where VWPs have become unsaturated.	Noted. Will be revised within the next Annual Water Monitoring Report.	March 2022	**Action Completed.** VWP charts are annotated with logger functionality. Boreholes/standpipes annotated with saturation status.

IER of GWMP – Opportunities for Improvement	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of September 2021)
○ Should include trigger levels (TLs should also be included on standpipe hydrographs).	Noted. This has been completed in past and will be reinstated within the next Annual Water Monitoring Report.	March 2022	**Action Completed.** TLs included on graphs with trigger levels.
○ Should include plots of rainfall excess / deficit (also should be included on standpipe hydrographs).	Noted. A rainfall graph is already included in the annual report. This action will be reviewed during the draft phase of the next Annual Water Monitoring Report. If the inclusion of rainfall correlation on all graphs doesn't overcrowd and confuse the data, this recommendation will be adopted.	March 2022	**Action Completed.** Rainfall included in separate graphic only. Excess/deficit included on standpipe graphs.
• WQ time series data should be thoroughly checked for anomalies / errors and allow easy differentiation of the time series for each individual bore when data for all bores is plotted on the same chart.	Noted. Graphics are currently being reviewed and will be amended where needed, specifically, plots for arsenic and beryllium as identified.	March 2022	**Action Completed.** All charts have been reviewed and updated.
• The flow monitoring data for Gap Creek and Genowlan Creek should be plotted with a logarithmic vertical scale to provide detail for periods of low flow / baseflow conditions.	Noted. Will be included in next Annual Water Monitoring Report.	March 2022	**Action Completed.** **- Not implemented due to indiscernible data.** Logarithmic scales produced indiscernible data. The existing

IER of GWMP – Opportunities for Improvement	Airly Mine Response / Action Plan	Timeframe for Completion of Action	Status Update for 2021 Annual Review (as of September 2021)
			plots were maintained for visual clarity.
• The monitoring report would benefit from clear concise tabulation of monitoring requirements, compliance with requirements, and trigger level breaches. Such a table would allow easy identification of whether each monitoring location had been monitored in accordance with the WMP for the specified parameters (quality, levels, flow etc) at the specified frequency, with explanations provided for where this was not possible e.g. bore dry, VWP no longer functioning etc.	Such information is tabulated in a series of tables throughout the report. These will be combined into a single additional overarching summary table within the next Annual Water Monitoring Report.	March 2022	**Action Completed.** A summary table is included in the annual report.
• Explanation should be provided for any monitoring parameters or locations specified in the WMP which are not presented in the annual monitoring report and the lack of dynamic response in model predictions.	Each Annual Water Monitoring Report states discrepancies to the Water Management Plan requirements. A review of water pressures in comparison to model predictions will be included in the next Annual Water Monitoring Report.	March 2022	**Action Completed.** All parameters and locations are presented in the Annual Report. Predicted drawdowns form the basis of trigger values. Groundwater levels are assessed in relation to trigger values in the Annual report.

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