CADIA VALLEY OPERATIONS
AIR DISPERSION MODEL 2022

Cadia Valley Operation

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Job Number 23031563

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Cadia Valley Operations
Air Dispersion Model 2022

DOCUMENT CONTROL

Prepared by	Reviewed by
PH & AT	AT

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1 INTRODUCTION

Todoroski Air Sciences has prepared this report on behalf of Cadia Holdings Pty Limited (CHPL). The report presents air dispersion modelling for Cadia Valley Operations (CVO) during the period January 2022 to February 2023 (hereafter referred to as the Project).

The aim of the air dispersion modelling is to quantify the potential air quality impacts due to CVO operations in the surrounding environment during the January 2022 to February 2023 period. The air dispersion modelling includes contributions from all significant air emission sources at CVO, including surface activities and upcast ventilation shafts. The study was developed to provide a contemporary assessment of the potential impacts of the mine, including upcast vent emissions and to provide data for use by others.

Since the inception of this study, the New South Wales (NSW) Department of Planning and Environment (DPE) and Environment Protection Authority (EPA) have co-incidentally requested that a similar assessment be provided, (as would be consistent with this report). Details of the DPE and EPA requests are set out below.

The modelling predictions during the period are compared against the available ambient air quality monitoring at locations surrounding CVO to validate the model's performance.

The modelling period coincides with the ambient air quality monitoring conducted by Australia's Nuclear Science and Technology Organisation (ANSTO) in the area surrounding CVO, which measured $PM_{2.5}$ particulate and metal concentrations in the ambient air.

This report comprises:

- a brief background to CVO and description of the local setting;
- a review of the available meteorological and ambient air quality environment surrounding the site;
- a description of the dispersion modelling approach and emission estimation used to assess potential air quality impacts; and,
- presentation of the predicted results, validation of model performance and discussion of the potential air quality impacts.

The DPE has requested the following:

"In addition to the Department's previously required investigations into air quality management and mitigation measures and the recommendations of the Audit, the Department requires:

- *additional dust and heavy metal modelling of ventilation discharges based on measured dust and ventilation rate discharges and heavy metal content in dust to assess output and consequences on the metal content emission rate and consideration against the ambient air criteria in the Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (2022), including details of the methodology and model input data."*

The EPA has requested similar information as follows:

U8 Air Quality Impact Assessment 2023

U8.1 The licensee must engage a suitably qualified person to complete a comprehensive Air Quality Impact Assessment (AQIA) for Cadia Valley Operations in accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW using the most recent information available. The AQIA must be completed and submitted to the EPA by 14 July 2023.

The AQIA must include the following:

a) All sources of particulate and metal emissions
b) For each emission source, details of daily average and maximum operating parameters
c) An emission inventory for all emission sources with supporting information or justification for all assumptions and, where available, based on actual emission data (eg. vent shaft testing)
d) Emission rates (g/s and kg/yr) modelled including details on any hourly varying emission rates
e) Details of controls used for each source and assumed control efficiencies used in modelling
f) Use of site-specific meteorological data
g) Include metal speciation from each source with supporting information
h) Predicted incremental impacts for PM2.5, PM10, TSP, and individual metals for the current total Cadia operations
i) Source apportionment analysis of the incremental impacts for PM2.5, PM10, TSP, and individual metals to identify the major contributors to offsite impacts (eg. a specific tailings dam or specific ventilation shaft)
j) Sensitivity of predicted impacts to emissions estimates and meteorological variability
k) Discussion on the meteorological conditions resulting in the offsite impacts for each source
l) Evaluation of maximum extent of offsite impacts

This report responds to the aims of the study and EPA and DPE requests (all of which are consistent).

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2 PROJECT BACKGROUND

CVO is located in the Central Tablelands of NSW, approximately 25 kilometres (km) to the southwest of Orange and approximately 25km west-northwest of Blayney.

Gold and copper ore is extracted and processed at CVO at a rate of up to 32 million tonnes per annum (Mtpa). Increasing the on-site ore processing to 35 Mtpa is subject to Condition 6A of Schedule 2 of project approval (application no. PA 06_0295) granted on 6 January 2010 under the *Environmental Planning and Assessment Act 1979* (NSW). Crushed ore is extracted from underground mining and processed on the surface using flotation cells to produce a gold/copper concentrate slurry which is processed through a thickener and pumped to Blayney, where it is dewatered and then loaded onto trains for transport to Port Kembla. Tailings generated from the processing facilities have been deposited in the various tailings storage facilities (TSFs) at the site, notably the Northern Tailings Storage Facility (NTSF) and Southern Tailings Storage Facility (STSF) located to the south of the processing facility. Currently tailings are deposited into the Pit Tailings Storage Facility (PTSF). A number of upcast ventilation shafts are operated at the site to ensure adequate ventilation for the underground Cadia East mining operations.

Figure 2-1 presents the location of the CVO with reference to key site features and the identified mine-owned and privately-owned residences surrounding the site.

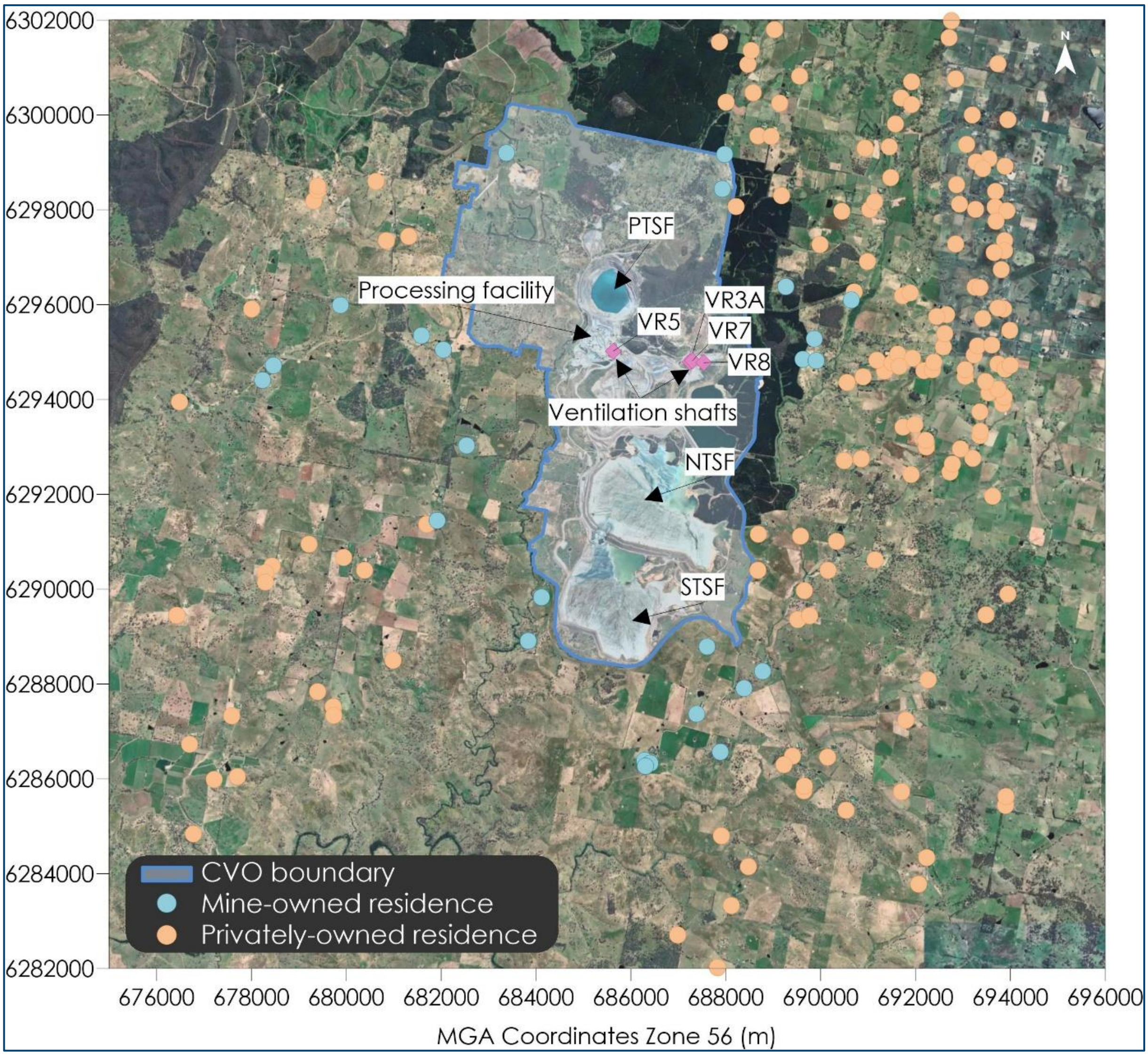


Figure 2-1: CVO setting

3 AIR QUALITY CRITERIA

Table 3-1 summarises the air quality goals that are relevant to this study as outlined in the NSW EPA document *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (**NSW EPA, 2022**) and the Texas Commission on Environmental Quality (TCEQ) *Toxicity Factor Database* (**TCEQ, 2023**).

The pollutants include dust and relevant heavy metals where monitoring was conducted. Short-term impacts for metals from TCEQ are assessed at the boundary.

Table 3-1: Air quality impact assessment criteria adopted for the Project

Pollutant	Averaging period	Concentration	Units	Assessment location
Total Suspended Particulate matter (TSP)	Annual	90	µg/m³	Receptor
Particulate matter ≤10µm (PM_{10})	Annual	25	µg/m³	Receptor
	24-hour	50	µg/m³	Receptor
Particulate matter ≤2.5µm (PM_{25})	Annual	8	µg/m³	Receptor
	24-hour	25	µg/m³	Receptor
Deposited dust	Annual	2 [a]	g/m²/month	Receptor
	Annual	4 [b]	g/m²/month	Receptor
Aluminium (Al) *	1-hour	50	µg/m³	Boundary
Antimony (Sb)	1-hour	9	µg/m³	Boundary
Arsenic (As)	1-hour	0.09	µg/m³	Boundary
Barium (Ba)	1-hour	9	µg/m³	Boundary
Beryllium (Be)	1-hour	0.004	µg/m³	Boundary
Cadmium (Cd)	1-hour	0.018	µg/m³	Boundary
Chromium (Cr) (VI compounds)	1-hour	0.09	µg/m³	Boundary
Cobalt (Co) *	1-hour	0.2	µg/m³	Boundary
Copper (Cu)	1-hour	18	µg/m³	Boundary
Lead (Pb)	Annual	0.5	µg/m³	Receptor
Manganese (Mn)	1-hour	18	µg/m³	Boundary
Mercury (Hg)	1-hour	1.8	µg/m³	Boundary
Molybdenum (Mo) *	1-hour	30	µg/m³	Boundary
Nickel (Ni)	1-hour	0.18	µg/m³	Boundary
Selenium (Se) *	1-hour	2	µg/m³	Boundary
Silver (Ag)	1-hour	1.8	µg/m³	Boundary
Tin (Sn) *	1-hour	20	µg/m³	Boundary
Vanadium (V) *	1-hour	2.2	µg/m³	Boundary
Zinc (Zn) *	1-hour	20	µg/m³	Boundary

Source: **NSW EPA, 2022** or * **TCEQ (2023)**

[a] Incremental impact [b] Total impact

4 EXISTING ENVIRONMENT

This section describes the existing environment including the meteorological and ambient air quality in the area surrounding CVO.

4.1 Local meteorological conditions

CHPL operates two on-site meteorological stations identified as Ridgeway to the north and Southern Lease Boundary to the south as shown in **Figure 4-1**.

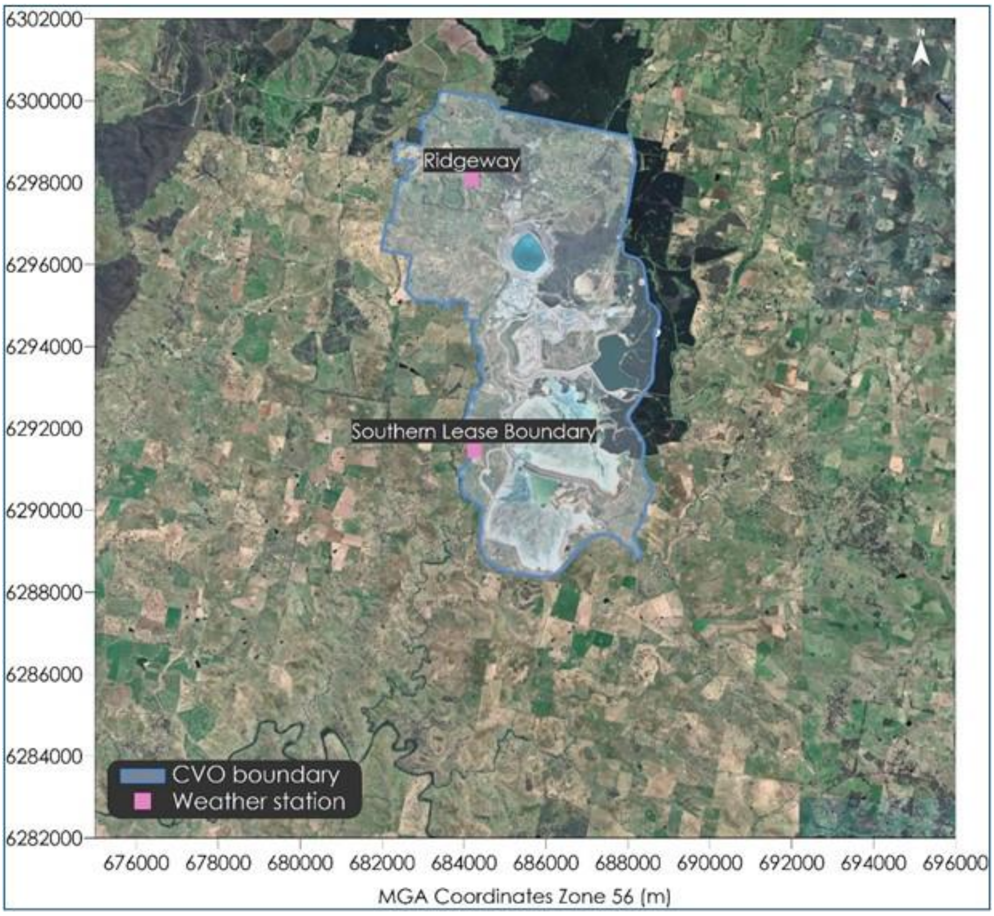


Figure 4-1: Weather station locations

Annual and seasonal windroses for the Ridgeway and Southern Lease Boundary meteorological stations during the January 2022 to February 2023 period are presented in **Figure 4-2** and **Figure 4-3** respectively.

Analysis of the windroses from both stations shows that on an annual basis winds are predominately from the northeast and southwest quadrants. The summer windroses generally show a similar distribution pattern as the annual windrose with the greatest winds from the northeast and southwest quadrants. In autumn, winds are most frequent from the north-northeast to the east-northeast and southwest with variable winds from other directions. During winter, winds from the south-southwest to the northwest are most frequent. The spring windrose shows winds are most frequent from the northeast and southwest quadrant.

Figure 4-2 : Annual and seasonal windroses – Ridgeway (January 2022 to February 2023)

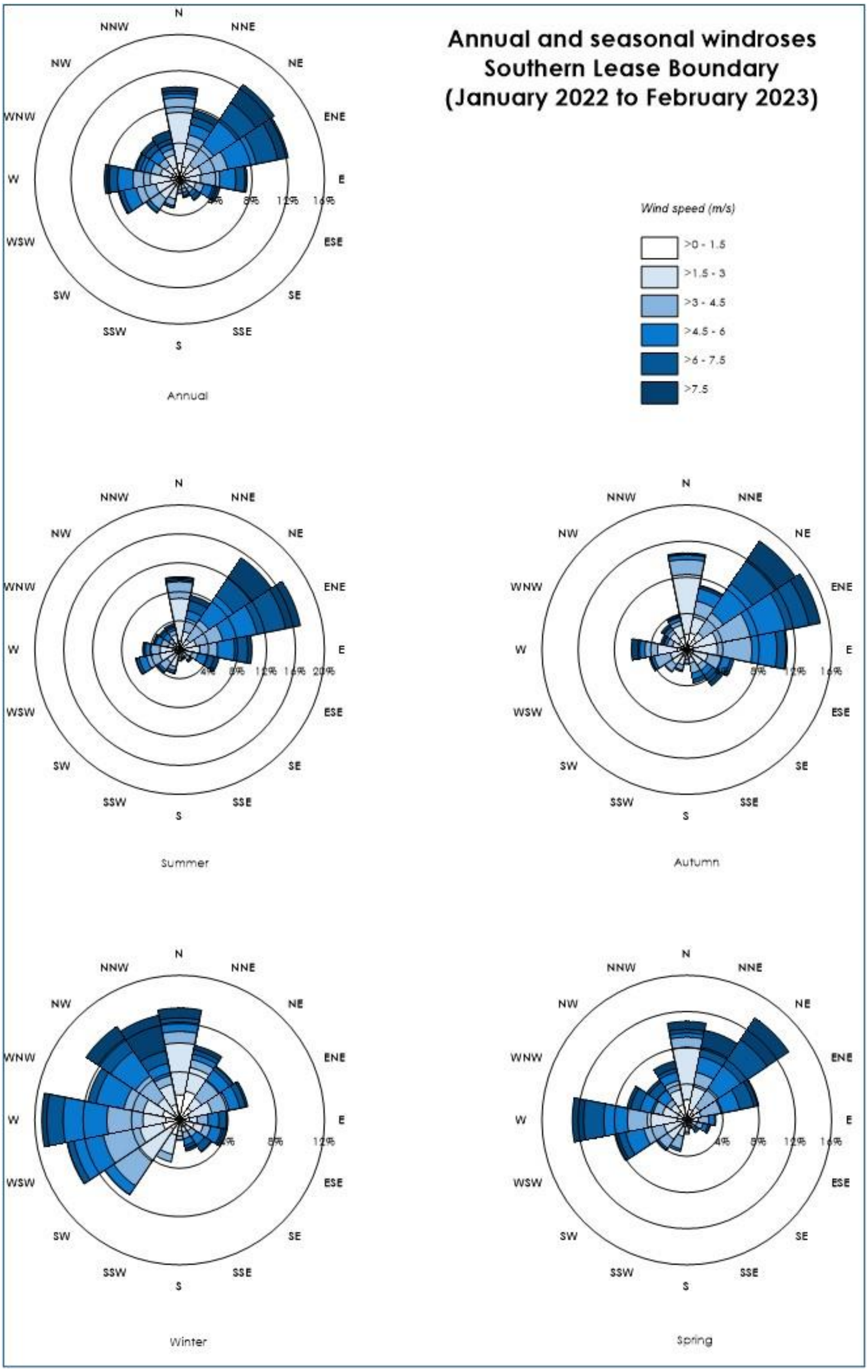


Figure 4-3 : Annual and seasonal windroses – Southern Lease Boundary (January 2022 to February 2023)

4.2 Local air quality monitoring

The main sources of particulate matter in the wider area surrounding CVO include mining, agricultural activities and emissions from local anthropogenic activities such as motor vehicle exhaust and domestic wood heaters.

CHPL operate an air quality monitoring network as part of the environmental management of the CVO. Ambient air quality monitoring includes the use of Tapered Element Oscillating Microbalance (TEOMs), Beta Attenuation Monitors (BAMs), High Volume Air Samplers (HVAS) and Deposited Dust Gauges. Each of these monitors rely on different techniques to measure and characterise the air quality surrounding the mine. **Figure 4-4** shows the approximate location of each of the monitoring stations with reference to CVO.

It should be noted that the BAMs were installed in early 2022 with the intention to replace the TEOM monitors at CVO. The TEOMs were decommissioned in mid-2022, with the exception of the Meribah TEOM which continues to operate. The BAMs are capable of measuring both $PM_{2.5}$ and PM_{10} levels whilst the installed TEOMs can only measure PM_{10}. The Woodville BAM replaces the Flyers Creek TEOM. HVAS samplers are also used in strategic locations in the monitoring network and are able to collect sufficient material suitable for metals analysis over a 24-hour period.

During the January 2022 to February 2023 period, additional analysis for ambient metal concentrations in the HVAS and deposited dust samples was also performed. The results of the metal concentrations are analysed in the following sections.

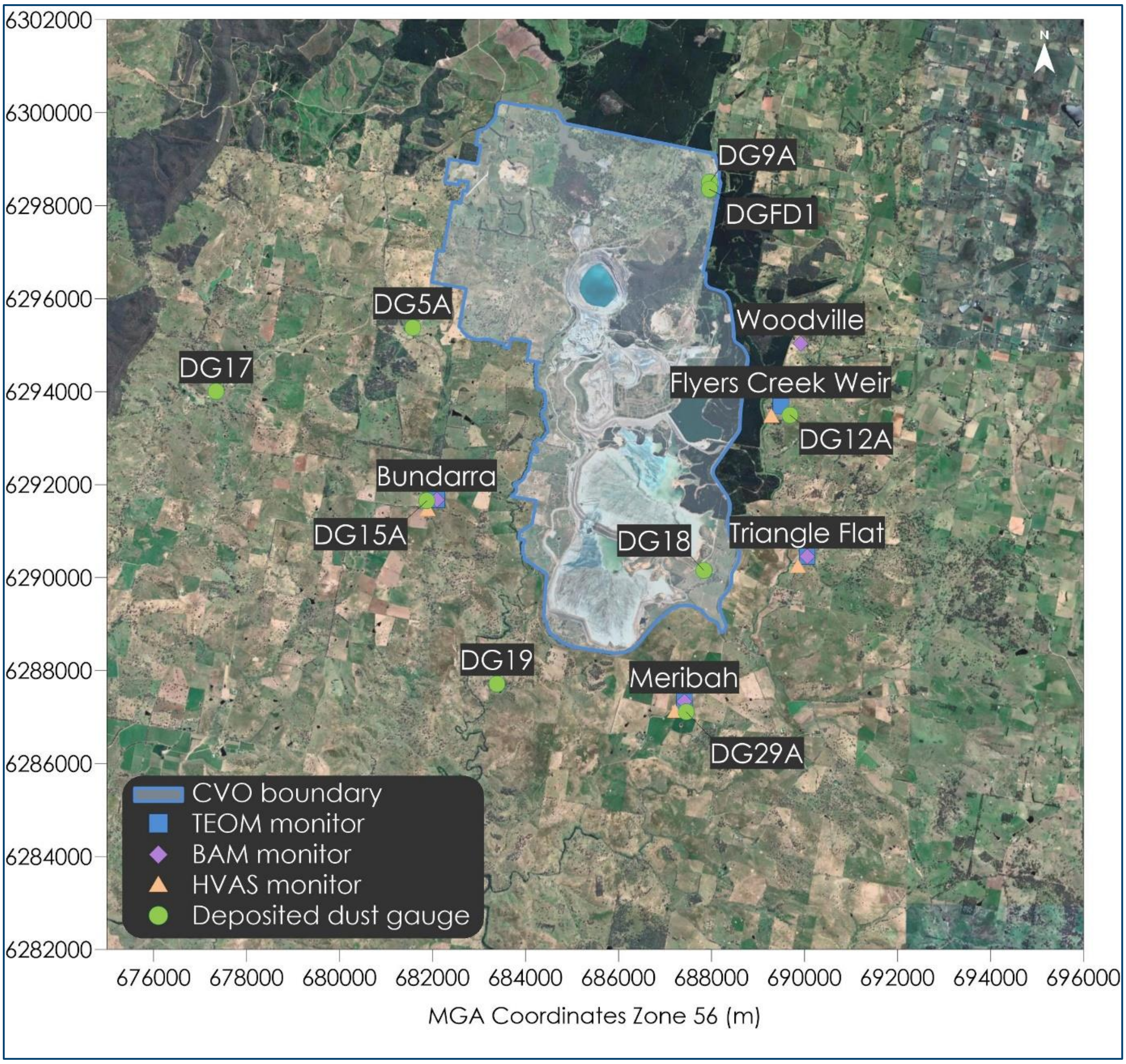


Figure 4-4: Ambient air quality monitoring locations at CVO

4.2.1 TEOM and BAM monitoring

The available 24-hour average PM_{10} concentrations from the TEOM and BAM monitoring from January 2022 to February 2023 is presented in **Figure 4-5**. A summary of the available PM_{10} monitoring data is presented in **Table 4-1**.

Air quality during the period is good with all recorded 24-hour average PM_{10} levels below the criterion of 50µg/m^3. Annual average levels are reported over a calendar period, the available data for the 2022 calendar year shows the annual average values are below the criterion of 25 µg/m^3.

Overall, there appears to be a seasonal trend with PM_{10} levels generally decreasing during the winter. Regional dust events can be seen with elevated levels being recorded at all monitors at the same time.

The Woodville monitor appears to record on occasion slightly more elevated 24-hour average levels in comparison to the other monitors at CVO, which may be due to the location relative to local emission sources.

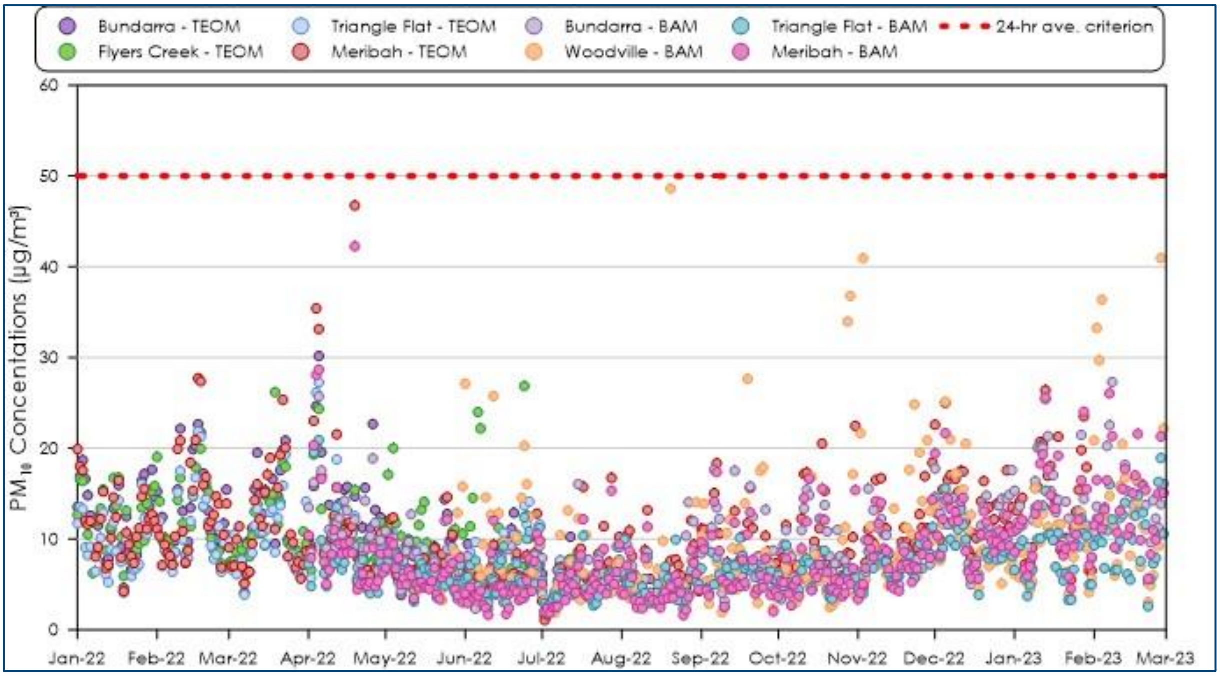


Figure 4-5: 24-hour average PM_{10} concentrations

Table 4-1: Summary of PM_{10} levels from TEOM and BAM monitoring stations (µg/m³)

Monitor	Maximum 24-hour average			Annual average		
	2022	2023	Criteria	2022	2023	Criteria
Bundarra – TEOM	30.2	-	**50**	-	-	**25**
Flyers Creek – TEOM	26.9	-	**50**	-	-	**25**
Triangle Flat – TEOM	27.3	-	**50**	-	-	**25**
Meribah – TEOM	46.7	26.4	**50**	10.0	-	**25**
Bundarra – BAM	25.7	27.3	**50**	8.2	-	**25**
Woodville – BAM	48.6	41.0	**50**	-	-	**25**
Triangle Flat – BAM	20.9	18.9	**50**	6.5	-	**25**
Meribah - BAM	42.3	26.0	**50**	7.2	-	**25**

'-' denotes less than 70% data available due to change from TEOM to BAM, or only 2 months of 2023 considered in this study.

Figure 4-6 presents the available 24-hour average $PM_{2.5}$ concentrations from the BAMs. A summary of the available $PM_{2.5}$ monitoring data is presented in **Table 4-2**.

All measured 24-hour average concentrations are below the criterion of 25µg/m³. Overall, the measured levels appear generally constant during the 2022 period and become more elevated in the January and February 2023 period.

Like the PM_{10} monitoring data, the Woodville monitor $PM_{2.5}$ data show higher levels compared to the other three locations. This would suggest a local particulate source is contributing significantly to the levels measured at this monitor.

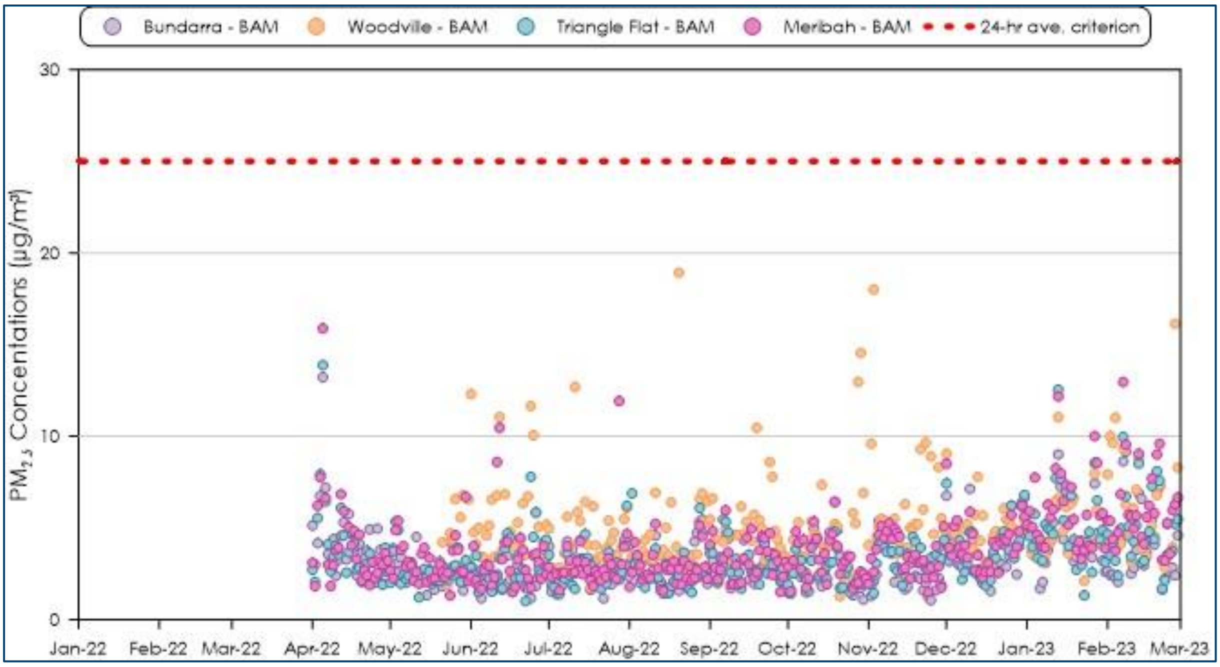


Figure 4-6: 24-hour average $PM_{2.5}$ concentrations

Table 4-2: Summary of $PM_{2.5}$ levels from BAM monitoring stations (µg/m³)

Monitor	Maximum 24-hour average			Annual average		
	2022	2023	Criteria	2022	2023	Criteria
Bundarra – BAM	13.2	9.2	**25**	3.0	-	**8**
Woodville – BAM	18.9	16.1	**25**	-	-	**8**
Triangle Flat – BAM	13.9	12.5	**25**	3.1	-	**8**
Meribah - BAM	15.9	13.0	**25**	3.4	-	**8**

'-' denotes less than 70% data available due to change from TEOM to BAM, or only 2 months of 2023 considered in this study.

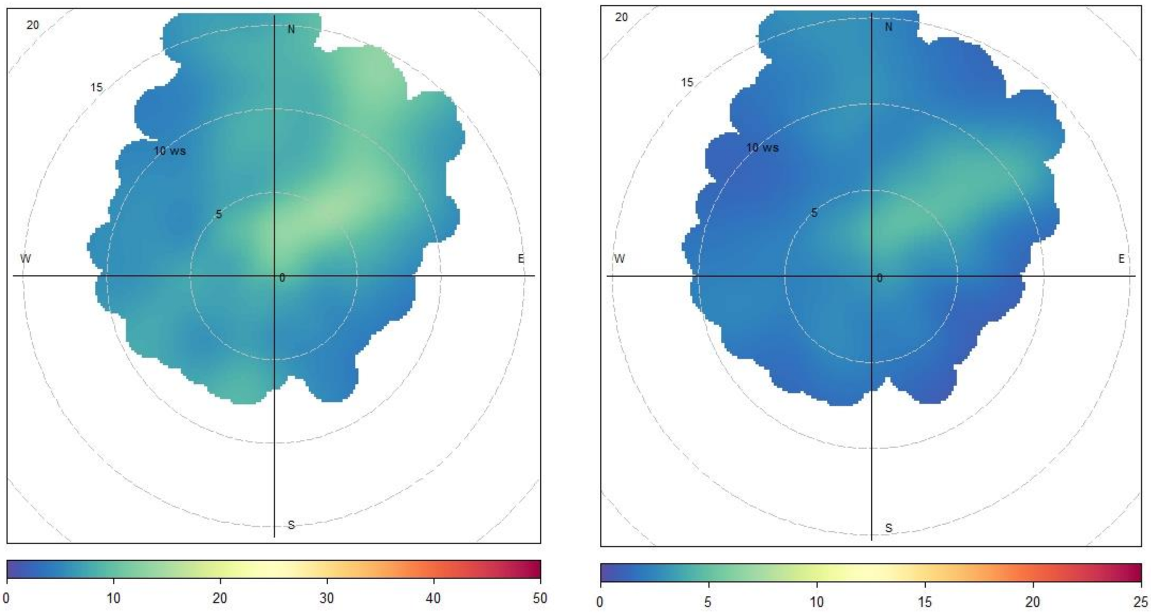
Pollution roses developed from the available hourly average BAM data with wind speed and direction data from the Ridgeway weather station are presented in **Figure 4-7**, **Figure 4-8**, **Figure 4-9** and **Figure 4-10**. To generate these polar plots, or pollution roses, the data are interpolated over the range of wind speeds and directions correlating to the dust concentration (i.e., PM_{10} or $PM_{2.5}$). These plots are useful for identifying the potential direction of dust sources relative to the monitor. The pollution roses indicate low 1-hour average levels at each of the BAMs.

Bundarra, is located west of the TSF, and a slight signature for a dust source to the northeast can be seen in both the PM_{10} and $PM_{2.5}$ pollution roses.

Woodville is located east of the mine vents and potential particulate matter signatures are seen from the west-southwest, northeast and north-northwest. The data indicate that the nominally higher particulate levels recorded at Woodville would be due to sources in a number of directions, including the mine vents and mine.

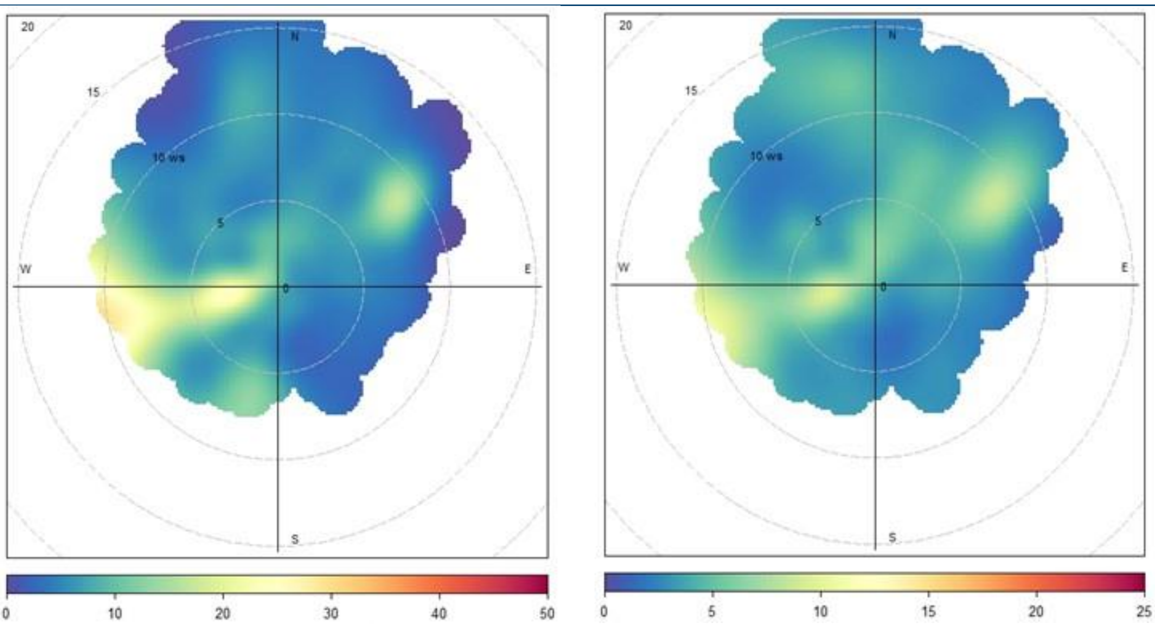
Triangle flat is east of the TSF and a faint PM_{10} signature from the northwest is seen in the pollution rose.

Meribah is south of the TSF and the PM_{10} pollution rose shows a high level from the north which is not shown in the $PM_{2.5}$ pollution rose plot. Further analysis of the Meribah PM_{10} pollution rose indicates this high level is due to a handful of elevated hourly PM_{10} levels occurring from this direction. Due to the low frequency of data occurring in the windrose at this location, the few high levels recorded appear quite prominent in the plot (the pollution rose algorithm fills in any gaps between data points with the highest surrounding data).



Bundarra – PM_{10} Bundarra – $PM_{2.5}$

Figure 4-7: Pollution roses for Bundarra (µg/m³)



Woodville – PM_{10} Woodville – $PM_{2.5}$

Figure 4-8: Pollution roses for Woodville (µg/m³)

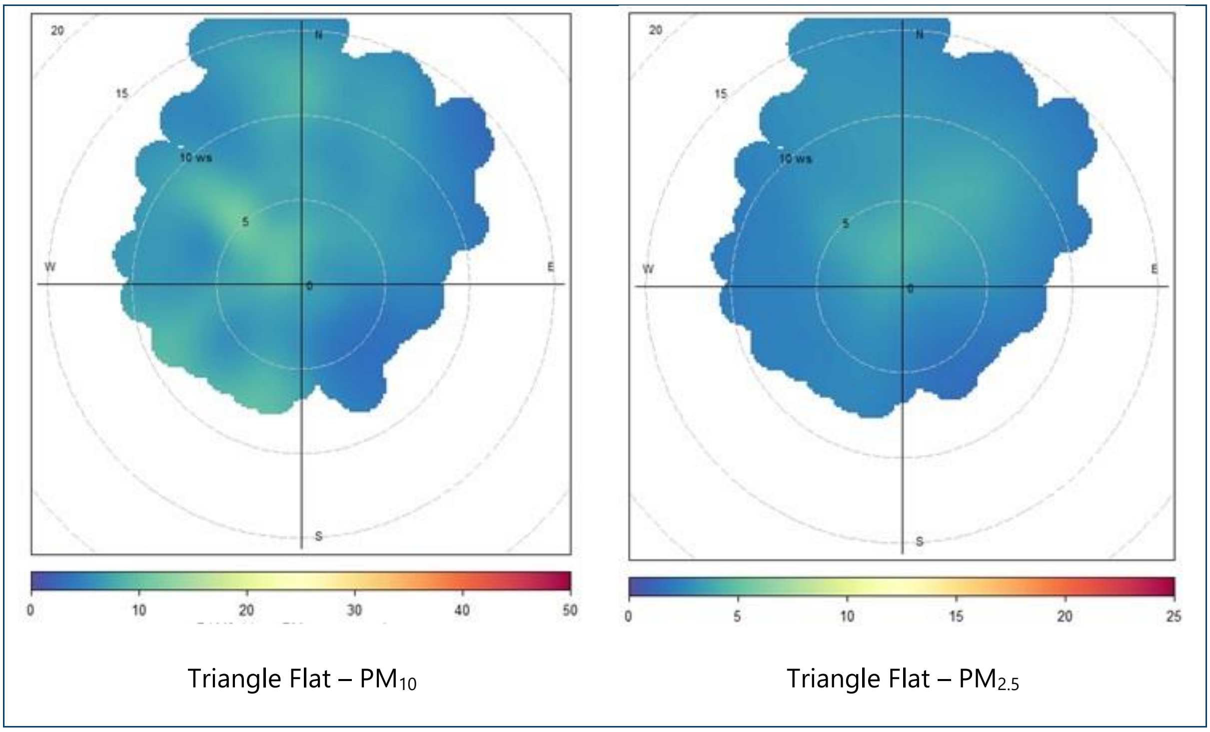


Figure 4-9: Pollution roses for Triangle Flat (µg/m³)

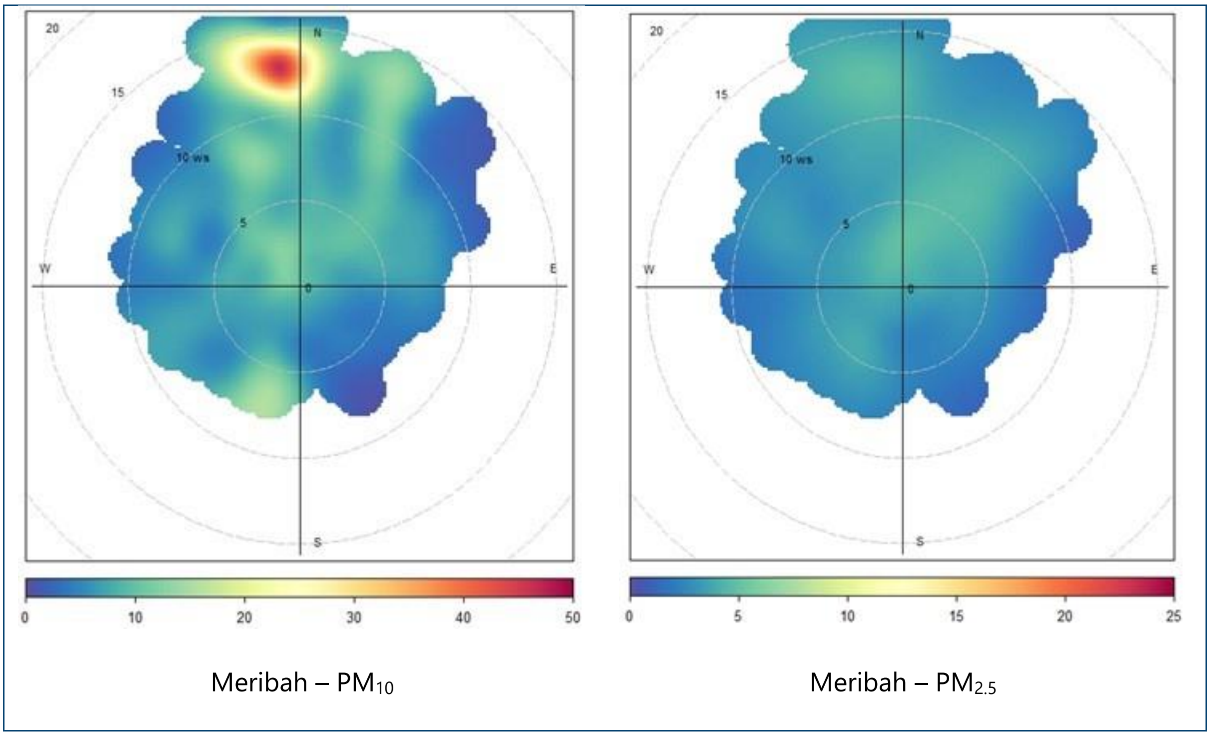


Figure 4-10: Pollution roses for Meribah (µg/m³)

4.2.2 HVAS monitoring (PM and Metals)

A summary of the available HVAS monitoring data collected between January 2022 to February 2023 is presented in **Figure 4-11**. The results indicate dust levels and metals are below the EPA criteria.

The monitoring data includes PM_{10} concentrations and concentrations for metals where a sufficient concentration in the samples were detected (i.e., above the detection level of the monitoring). These substances include; aluminium (Al), barium (Ba), chromium (Cr), copper (Cu), lead (Pb), manganese (Mn) and zinc (Zn). Most of the other sampled metals; antimony, arsenic, beryllium, cadmium, cobalt, mercury, molybdenum, nickel, selenium, silver and tin were below the detection limit or only had a few samples near detectable levels.

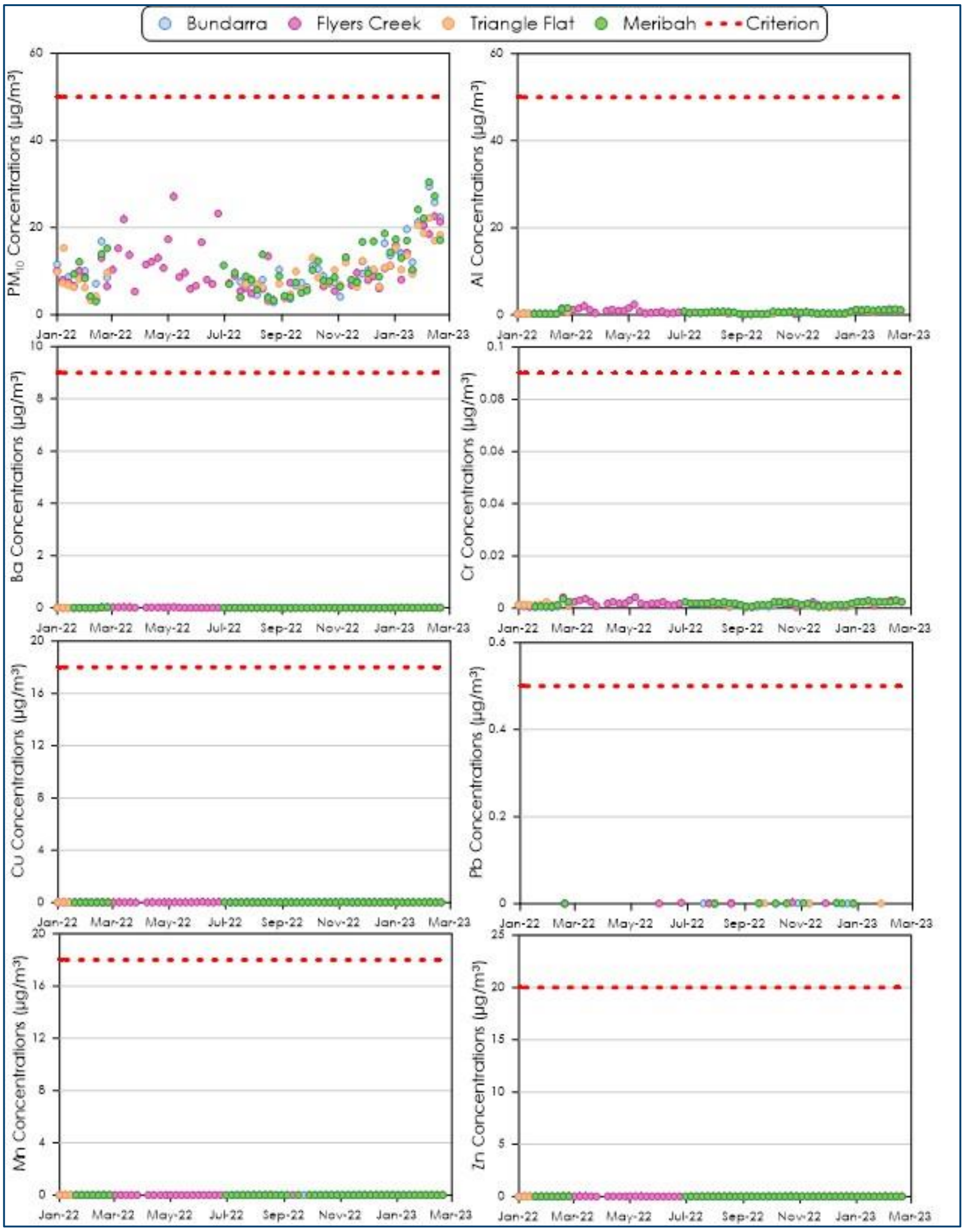


Figure 4-11: 24-hour average PM_{10} and metal concentrations from HVAS monitoring stations

A review of **Figure 4-11** indicates that the average recorded PM_{10} and metal concentrations at each monitor were generally similar over the monitoring period.

Table 4-3 presents the maximum 24-hour average measured level during the monitoring period. In general, the recorded, detectable metal concentrations were found to be low. Although there are no specific 24-hour average criteria for metals, when comparing the measured levels to the applicable 1-hour average criteria, they are well below the criteria values.

Table 4-3: Maximum 24-hour average measured level during monitoring period (µg/m³)

Pollutant	Bundarra	Flyers Creek	Triangle Flat	Meribah	1-hour average criteria	Factor of compliance
Al	1.7	2.4	1.6	1.6	**50**	20.83
Sb	<0.0006	0.0006	<0.0006	0.0006	**9**	15,000
As	0.0006	0.0012	0.0006	0.0006	**0.09**	75.0
Ba	0.05	0.05	0.06	0.06	**9**	150
Be	<0.0006	<0.0006	<0.0006	<0.0006	**0.004**	13.3
Cd	<0.0006	<0.0006	<0.0006	<0.0006	**0.018**	60.0
Cr	0.007	0.004	0.004	0.004	**0.09**	12.9
Co	<0.0006	<0.0006	<0.0006	<0.0006	**0.2**	333
Cu	0.05	0.04	0.01	0.01	**18**	360
Pb	0.002	0.003	0.001	0.001	**0.5**	167
Mn	0.013	0.009	0.011	0.014	**18**	1,286
Hg	0.0006	<0.0006	<0.0006	<0.0006	**1.8**	6,000
Mo	0.001	0.002	<0.0006	0.0006	**30**	15,000
Ni	0.001	0.001	0.001	0.001	**0.18**	180
Se	<0.0006	<0.0006	<0.0006	<0.0006	**2**	6,667
Ag	0.0008	0.0003	0.0006	0.0006	**1.8**	2,250
Sn	<0.0006	<0.0006	<0.0006	<0.0006	**20**	66,667
Zi	0.04	0.04	0.04	0.04	**20**	500

4.2.3 Deposited dust monitoring (PM and metals)

Deposited monitoring conducted throughout 2022 in the area surrounding CVO has been summarised in **Figure 4-12**. The results present the annual average insoluble solids, Al, Cu, iron (Fe), Mn, and Zn levels across the monitors. Other metals were below the limit of detection.

The detectable metals results are set out in **Table 4-4**. The only Type I or Type II metal present at any significant level in the results is manganese, which a common material found in soil across Australia.

There are no applicable EPA criteria for deposited metals, and it is noted that the measured metal levels at the monitors are generally similar.

The results indicate that the dust deposition levels are typically below the applicable deposited dust criterion of 4g/m²/month for insoluble solids with the exception of DG9A. The field duplicate monitor (DG FD1) is located within approximately 100 metres of DG9A and recorded a much lower dust deposition level. This suggests the monitor is affected by a local source unrelated to the more distant mining activity.

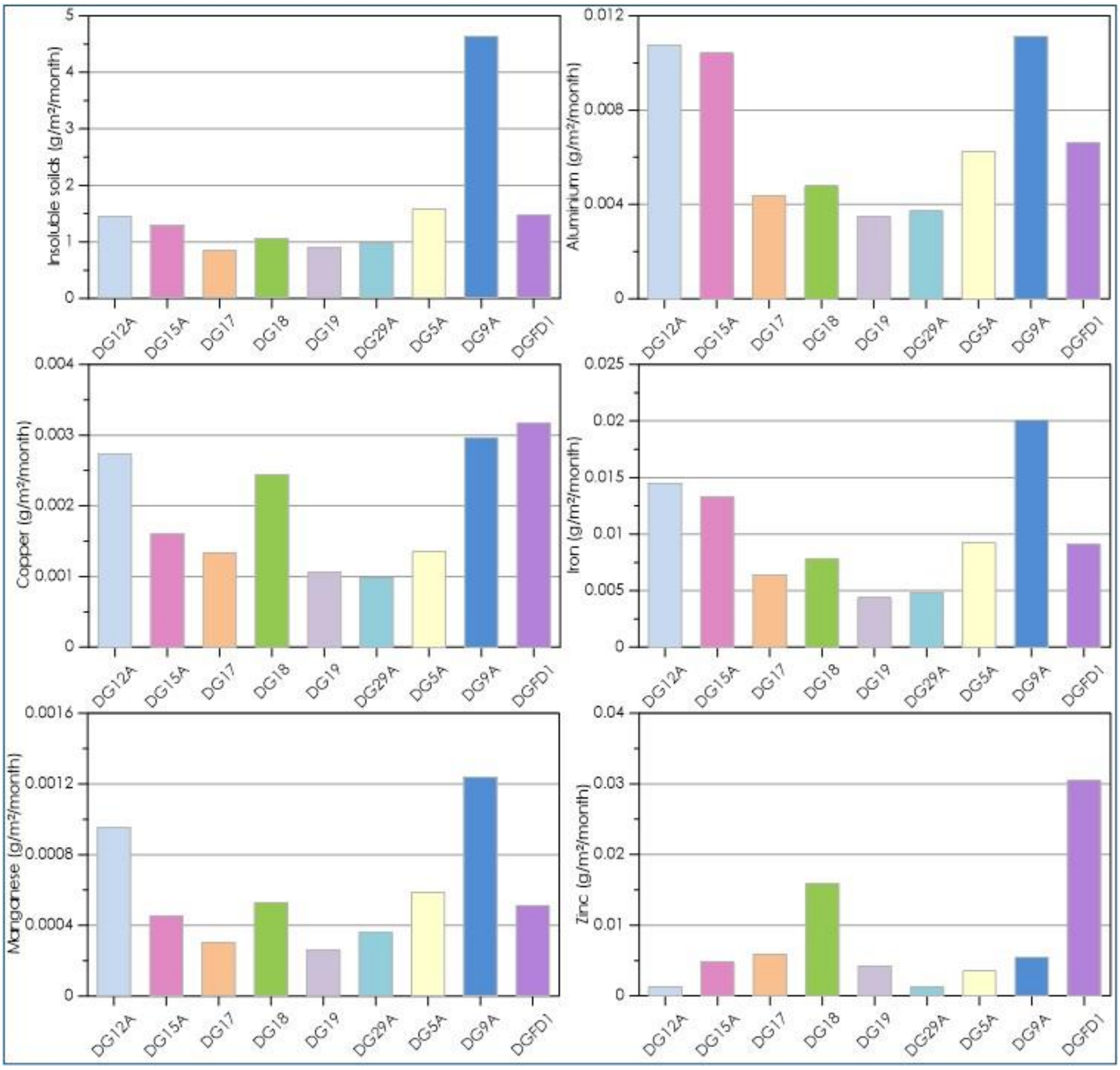


Figure 4-12: Annual average deposited dust and metal levels for 2022

Table 4-4: Summary of deposited metals (g/m³/month)

Sample Date	Location	Analyte																	
		Al	Sb	As	Ba	Be	Cd	Cr	Co	Cu	Pb	Mn	Hg	Mo	Ni	Se	Ag	Sn	Zn
Jan-22	DG12A	0.0098	<1E-4	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	0.0016	<1E-4	0.0008	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0028
Feb-22	DG12A	0.0075	<1E-4	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	0.0068	<1E-4	0.001	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.001
Mar-22	DG12A	0.0313	<1E-4	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	0.0053	<1E-4	0.0016	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0004
Apr-22	DG12A	0.0032	<1E-4	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	0.0018	<1E-4	0.0014	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0005
May-22	DG12A	0.0053	<1E-4	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	0.0028	<1E-4	0.0018	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0014
Jun-22	DG12A	0.0168	<1E-4	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	0.0055	<1E-4	0.0007	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.001
Jul-22	DG12A	0.02	<1E-4	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	0.0021	<1E-4	0.0008	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0009
Aug-22	DG12A	0.0018	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0006	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.001
Sep-22	DG12A	0.0073	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0013	<1E-4	0.0005	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0006
Sep-22	DG12A	0.0105	<1E-4	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	0.0011	<1E-4	0.001	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0012
Nov-22	DG12A	0.005	<1E-4	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	0.0011	<1E-4	0.0007	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0027
Jan-22	DG15A	0.024	<1E-4	<1E-4	0.0004	<1E-4	<1E-4	<1E-4	<1E-4	0.0019	<1E-4	0.0009	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0325
Feb-22	DG15A	0.0164	<1E-4	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	0.0022	<1E-4	0.0006	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0018
Mar-22	DG15A	0.0273	<1E-4	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	0.0038	<1E-4	0.001	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0006
Apr-22	DG15A	0.0047	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0006	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0004
May-22	DG15A	0.0063	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0027	<1E-4	0.0004	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0054
Jun-22	DG15A	0.0037	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0015	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0014
Jul-22	DG15A	0.0105	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0015	<1E-4	0.0004	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0014
Aug-22	DG15A	0.002	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0004	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0013
Sep-22	DG15A	0.0026	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0011	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0006
Sep-22	DG15A	0.0097	<1E-4	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	0.001	<1E-4	0.0005	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0001	0.0026
Nov-22	DG15A	0.0072	<1E-4	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	0.001	<1E-4	0.0004	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0042
Jan-22	DG17	0.009	<1E-4	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	0.0028	<1E-4	0.0006	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0204
Feb-22	DG17	0.0101	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0022	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0007
Mar-22	DG17	0.0062	<1E-4	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	0.0007	<1E-4	0.0007	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0009

Sample Date	Location	Analyte																	
		Al	Sb	As	Ba	Be	Cd	Cr	Co	Cu	Pb	Mn	Hg	Mo	Ni	Se	Ag	Sn	Zn
Apr-22	DG17	0.0017	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0004	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0002
May-22	DG17	0.0014	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0007	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0105
Jun-22	DG17	0.0056	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0009	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.001
Jul-22	DG17	0.0076	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0037	<1E-4	0.0005	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0012
Aug-22	DG17	0.0013	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0007	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0006
Sep-22	DG17	0.0014	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0013	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0068
Sep-22	DG17	0.0021	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0006	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0043
Nov-22	DG17	0.0017	<1E-4	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	0.0006	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0185
Jan-22	DG18	0.0029	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0007	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.001
Feb-22	DG18	0.0206	<1E-4	<1E-4	0.0004	<1E-4	<1E-4	<1E-4	<1E-4	0.0025	0.0002	0.0011	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0104
Mar-22	DG18	0.001	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0007	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0099
Apr-22	DG18	0.0035	<1E-4	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	0.0007	<1E-4	0.0007	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0037
May-22	DG18	0.0029	<1E-4	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	0.0016	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0495
Jun-22	DG18	0.0082	<1E-4	<1E-4	0.0007	<1E-4	<1E-4	<1E-4	<1E-4	0.0139	<1E-4	0.0009	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0192
Jul-22	DG18	0.0033	<1E-4	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	0.0024	<1E-4	0.0009	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0064
Aug-22	DG18	0.002	<1E-4	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	0.0004	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.009
Sep-22	DG18	0.0025	<1E-4	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	0.0024	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0255
Sep-22	DG18	0.0036	<1E-4	<1E-4	0.0004	<1E-4	<1E-4	<1E-4	<1E-4	0.0008	<1E-4	0.0007	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.025
Nov-22	DG18	0.002	<1E-4	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	0.0008	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0144
Jan-22	DG19	0.0077	<1E-4	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	0.002	<1E-4	0.0006	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0127
Feb-22	DG19	0.0028	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0011	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0007
Mar-22	DG19	0.0059	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0004	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0015
Apr-22	DG19	0.0031	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0004	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0005
May-22	DG19	0.0022	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0023	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0038
Jun-22	DG19	0.0042	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0013	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0012
Jul-22	DG19	0.0027	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0019	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0029

Sample Date	Location	Analyte																	
		Al	Sb	As	Ba	Be	Cd	Cr	Co	Cu	Pb	Mn	Hg	Mo	Ni	Se	Ag	Sn	Zn
Aug-22	DG19	0.001	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.003
Sep-22	DG19	0.0031	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0008	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0092
Sep-22	DG19	0.004	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0006	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0002	0.0075
Nov-22	DG19	0.0015	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0006	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0039
Jan-22	DG29A	0.0106	<1E-4	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	0.0011	<1E-4	0.001	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0031
Feb-22	DG29A	0.0035	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0023	<1E-4	0.0005	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0008
Mar-22	DG29A	0.0058	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0011	<1E-4	0.0005	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0013
Apr-22	DG29A	0.0023	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0004	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0004
May-22	DG29A	0.0023	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0004	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0012
Jun-22	DG29A	0.0029	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0021	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0008
Jul-22	DG29A	0.0026	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0008	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0008
Aug-22	DG29A	0.0008	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0002	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0006
Sep-22	DG29A	0.004	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0009	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0015
Sep-22	DG29A	0.0027	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0005	<1E-4	0.0004	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0011
Nov-22	DG29A	0.0033	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.001	0.0001	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0003	0.0016
Jan-22	DG5A	0.0106	<1E-4	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	0.0001	0.0012	<1E-4	0.0021	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0153
Feb-22	DG5A	0.0153	<1E-4	0.0002	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	0.0037	<1E-4	0.0012	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0023
Mar-22	DG5A	0.0107	<1E-4	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	0.0011	<1E-4	0.0005	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.001
Apr-22	DG5A	0.0035	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0006	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0007
May-22	DG5A	0.0044	<1E-4	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	0.0013	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0077
Jun-22	DG5A	0.0088	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0011	<1E-4	0.0005	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0011
Jul-22	DG5A	0.0084	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0018	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0012
Aug-22	DG5A	0.0007	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0004	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0005
Sep-22	DG5A	0.0019	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0015	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0013
Sep-22	DG5A	0.0031	<1E-4	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	0.0009	<1E-4	0.0006	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0002	0.0018
Nov-22	DG5A	0.0012	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0012	0.0001	0.0003	<1E-4	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	0.0052

Sample Date	Location	Analyte																	
		Al	**Sb**	**As**	**Ba**	**Be**	**Cd**	**Cr**	**Co**	**Cu**	**Pb**	**Mn**	**Hg**	**Mo**	**Ni**	**Se**	**Ag**	**Sn**	**Zn**
Jan-22	DG9A	0.018	<1E-4	<1E-4	0.0022	<1E-4	<1E-4	<1E-4	<1E-4	0.0065	<1E-4	0.003	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0082
Feb-22	DG9A	0.0438	<1E-4	<1E-4	0.0003	<1E-4	<1E-4	0.0001	<1E-4	0.0083	<1E-4	0.0013	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0017
Mar-22	DG9A	0.0039	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0011	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0008
Apr-22	DG9A	0.0055	<1E-4	<1E-4	0.0005	<1E-4	<1E-4	<1E-4	<1E-4	0.0033	<1E-4	0.0019	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0037
May-22	DG9A	0.0018	<1E-4	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	0.0011	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0114
Jun-22	DG9A	0.0062	<1E-4	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	0.0016	<1E-4	0.0005	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.001
Jul-22	DG9A	0.0242	<1E-4	<1E-4	0.0006	<1E-4	<1E-4	<1E-4	<1E-4	0.0048	<1E-4	0.0034	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0084
Aug-22	DG9A	0.0097	<1E-4	<1E-4	0.0004	<1E-4	<1E-4	<1E-4	0.0001	0.0025	<1E-4	0.0013	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0034
Sep-22	DG9A	0.0023	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0018	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0013
Sep-22	DG9A	0.0041	<1E-4	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	0.0007	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0121
Nov-22	DG9A	0.0028	<1E-4	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	0.0008	<1E-4	0.0012	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0068
Jan-22	DGFD1	0.01	<1E-4	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	0.0059	<1E-4	0.0006	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.076
Feb-22	DGFD1	0.0052	<1E-4	<1E-4	0.0004	<1E-4	<1E-4	<1E-4	<1E-4	0.0063	<1E-4	0.0008	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0421
Mar-22	DGFD1	0.0077	<1E-4	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	0.0034	<1E-4	0.0004	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.041
Apr-22	DGFD1	0.0027	<1E-4	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	0.005	<1E-4	0.0005	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0339
May-22	DGFD1	0.0065	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0046	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0412
Jun-22	DGFD1	0.0056	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0014	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0199
Jul-22	DGFD1	0.0072	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0012	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0106
Aug-22	DGFD1	0.0053	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0012	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0162
Sep-22	DGFD1	0.0154	<1E-4	<1E-4	0.0002	<1E-4	<1E-4	<1E-4	<1E-4	0.0044	<1E-4	0.0014	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0184
Sep-22	DGFD1	0.0032	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0008	<1E-4	0.0003	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0142
Nov-22	DGFD1	0.0038	<1E-4	<1E-4	0.0001	<1E-4	<1E-4	<1E-4	<1E-4	0.0007	<1E-4	0.0004	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	<1E-4	0.0209

4.2.4 ANSTO Monitoring

The year long study by ANSTO was made public during the preparation of this report after the modelling was completed. The ANSTO report found that ambient $PM_{2.5}$ concentrations in the areas nearest the mine are very low, (annual mean of 2.7µg/m^3) and are approximately half of the levels in the town of Orange (annual mean of 5.3µg/m^3). The maximum 24-hr average levels measured nearest the mine were also much lower than in Orange (6.8 to 8.0 µg/m^3, vs. 35.1 to 38.9 µg/m^3). Notably, the recorded levels nearest the mine are less than one third of the applicable annual average criterion of 8µg/m^3 and less than one quarter the 24-hour average criterion of 25 µg/m^3.

The report also found that the fraction of the $PM_{2.5}$ which can be attributed to soil in total (i.e., dust from the mine, tailings and vent shaft, but also from the land, farming, dirt roads etc.) was the lowest contributor to the mass of measured $PM_{2.5}$ levels at all locations in the ANSTO study.

ANSTO considered the total dust levels with the wind direction from the mine towards the sampling sites and compared these results with those when the wind was not blowing from the direction of the mine on the days with high fraction of soil material contributions in the measurement data. For example, at Millthorpe, to the east of the mine. The days where the wind blew from the mine towards the monitor all day the total dust results showed lower than average 24-hour average $PM_{2.5}$ levels. At this location, the day with the greatest soil contribution occurred when the winds blew from the mine all day. Whilst the soil fraction of the total dust on this day was highest (approximately 25.75%) the total 24-hour average $PM_{2.5}$ levels were very low at 1.83µg/m^3. The contribution of 24-hr average $PM_{2.5}$ due to all soil sources (i.e., dust from the land, farming, dirt roads, as well as the mine etc.) was approximately 0.47 µg/m^3. However, when this is compared with dust levels when the wind does not blow from the mine, the 24-hour $PM_{2.5}$ level was more than double (4.45µg/m^3), and the soil fraction was lower 7.91% and contributed 0.35µg/m^3 to the total 24-hr $PM_{2.5}$ value. The indication is that the highest contribution that may be associated with the mine at Millthorpe would be 0.12µg/m^3, which is insignificant and well within any measurement accuracy. When other locations are considered, such as Mandurama, we see that the highest soil dust levels arise when there is no tangible wind form the direction of the mine, and that the levels are higher than average, at Panuara, the fraction of soil contribution is highest, up to 62.7% of the total, however the levels remain low on all such days, and similarly high results arise when the wind is not blowing from the mine. The indication is that the mine is not contributing tangibly to the existing soil effects at the monitoring locations.

The ANSTO study results show low trace levels of Type I and Type II metals, with most of the concentration values below their respective detection levels. This is consistent with the CVO results where the only Type I and Type II metal that can be consistently measured in the surrounding environment above the detection level is manganese, a ubiquitous and common metal found in soil across Australia. Other non Type I or Type II metals were measured above detection levels often by ANSTO and by CVO, including Copper, Zinc, Aluminium and Barium, and it appears that these may be common elements in the soil in this area.

Overall, the ANSTO study shows that ambient air quality nearest the mine is excellent, complies with all criteria (the measured dust levels are approximately 1/3 or 1/4 of the criteria levels), does not contain Type I and Type II metals at levels that may exceed EPA criteria and that no significant contribution to the total levels at the monitoring locations could be identified as having come from the mine.

5 AIR DISPERSION MODELLING

The air dispersion modelling was undertaken using a combination of the CALPUFF Modelling System and The Air Pollution Model (TAPM). The model was set up in general accordance with the NSW EPA's *Generic Guidance and Optimum Model Settings for the CALPUFF Modeling System for Inclusion into the 'Approved Methods for the Modeling and Assessments of Air Pollutants in NSW, Australia'* (**TRC Environmental Corporation**, **2011**).

This is the same approach used for the most recent modification (i.e. Modification14) at CVO and presented in the *Air Quality Impacts and Greenhouse Gas Assessment Cadia Valley Operations Processing Rate Modification* (**Todoroski Air Sciences, 2020**).

5.1 Meteorological modelling

The meteorological modelling methodology applied the standard hybrid approach which includes a combination of prognostic model data from TAPM with surface observations.

The TAPM model was applied to the available data to generate a three-dimensional upper air data file for use in CALMET. The centre of analysis for the TAPM modelling used is 33deg 29min south and 149deg 0min east. The simulation involved an outer grid of 30km, with three nested grids of 10km, 3km and 1km with 35 vertical grid levels.

The CALMET initial domain was run on a 30 x 30km scale with a 0.3km grid resolution for the January 2022 to February 2023 period. The available meteorological data from four surrounding meteorological monitoring sites were included in the simulation, as noted in Table 5-1

Table 5-1 outlines the parameters used from each station.

Table 5-1: Surface observation stations used in modelling

Weather Stations (initial domain)	Parameters						
	WS	WD	CH	CC	T	RH	SLP
Orange Airport AWS (BoM) (Station No. 063303)	✓	✓	✓	✓	✓	✓	✓
Bathurst (DPIE)	✓	✓			✓	✓	
Ridgeway	✓	✓			✓	✓	✓
Southern Lease Boundary	✓	✓			✓	✓	✓

WS = wind speed, WD= wind direction, CH = cloud height, CC = cloud cover, T = temperature, RH = relative humidity, SLP = station level pressure

The seven critical parameters used in the CALMET modelling are presented in **Table 5-2**.

Table 5-2: Seven critical parameters used in CALMET

Parameter	Value
TERRAD	10
IEXTRP	-4
BIAS (NZ)	-1, -0.5, -0.25, 0, 0, 0, 0, 0
R1 and R2	8, 8
RMAX1 and RMAX2	10, 10

5.2 Meteorological modelling evaluation

The outputs of the CALMET modelling are evaluated using visual analysis of the wind fields and extract data. **Figure 5-1** presents a visualisation of the wind field generated by CALMET for a single hour of the modelling period (i.e., example only). The wind fields follow the terrain well and indicate the simulation produces realistic fine scale flow fields (such as terrain forced flows) in surrounding areas.

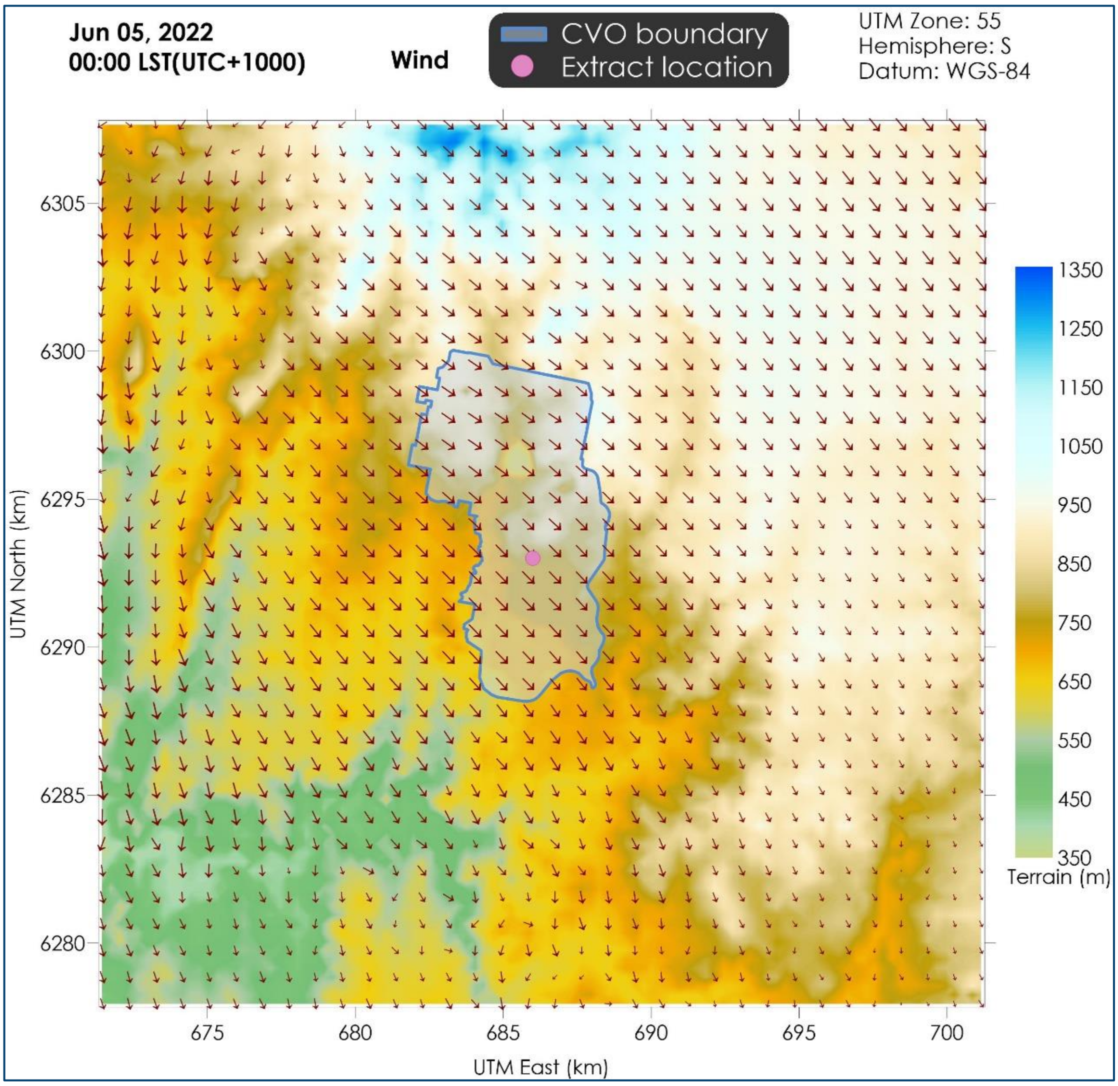


Figure 5-1: Representative 1-hour snapshot of wind field

CALMET generated meteorological data were extracted from a central point within the CALMET domain (see **Figure 5-1**) and are graphically represented in **Figure 5-2** and **Figure 5-3**.

Figure 5-2 presents the annual and seasonal windroses from the CALMET data. Overall, the windroses generated in the CALMET modelling reflect the expected wind distribution patterns of the area as determined based on the available measured data and the expected terrain effects on the prevailing winds.

Figure 5-3 includes graphs of the temperature, wind speed, mixing height and stability classification over the modelling period for the modelled year and show sensible trends considered to be representative of the area.

In conclusion, the CALMET generated meteorological data are considered suitable for use in the air dispersion modelling.

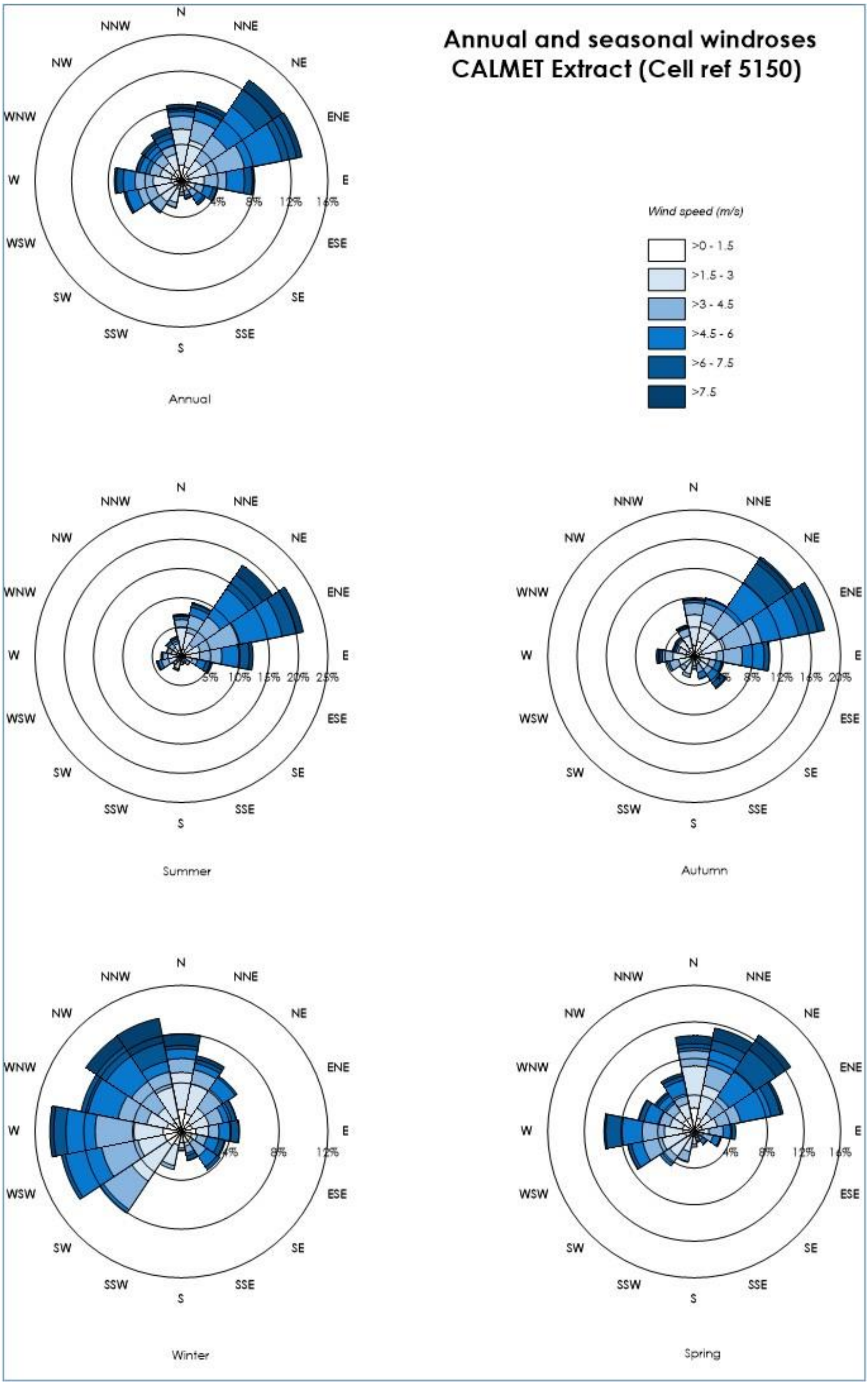


Figure 5-2: Annual and seasonal windroses from CALMET

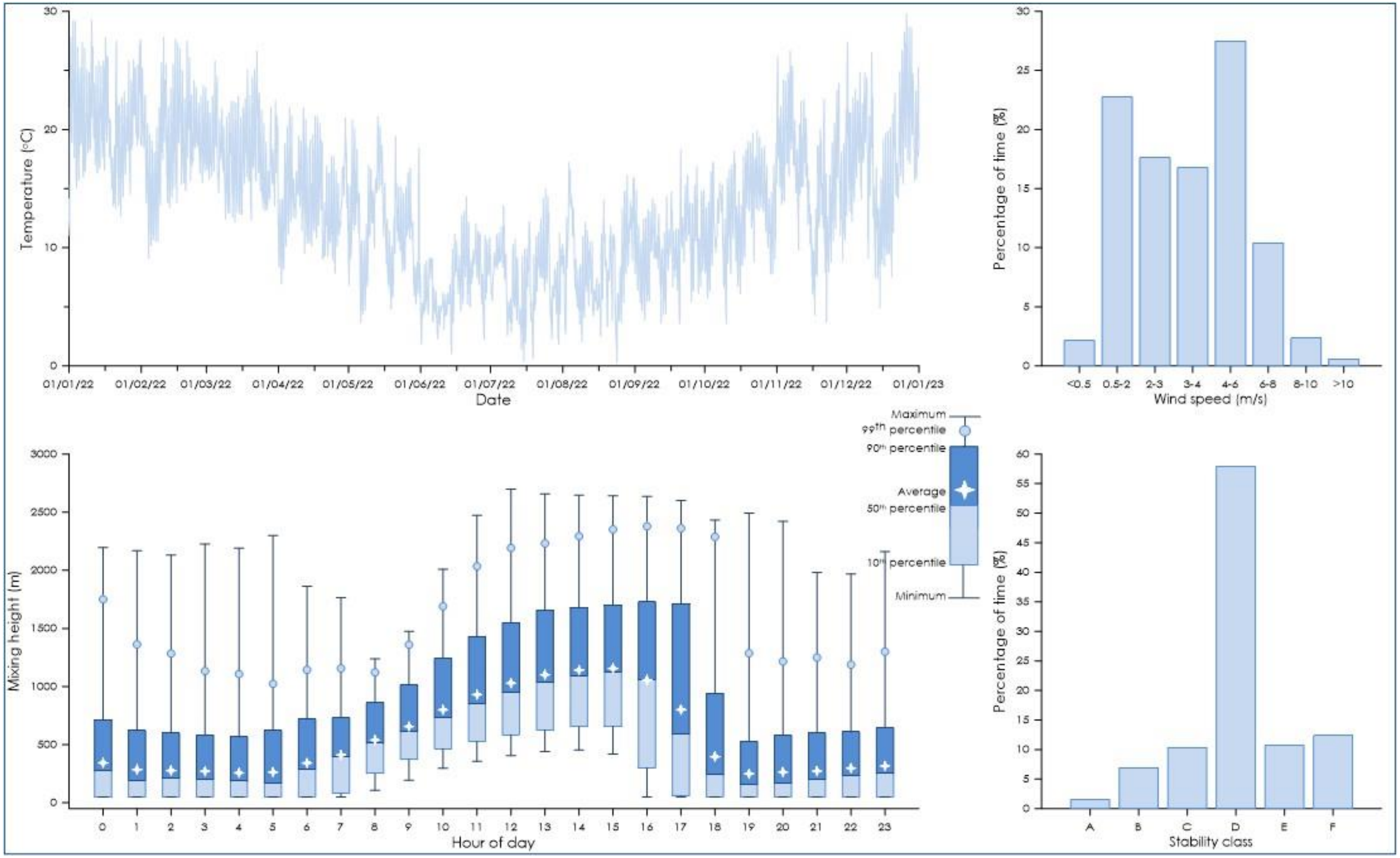


Figure 5-3: Meteorological analysis of CALMET

5.3 Dispersion modelling

Dust emissions from the operational activity at CVO were represented by a series of volume sources and were included in the CALPUFF model via an hourly varying emission file. Meteorological conditions associated with dust generation (such as wind speed) and intensity of dust generating activity were considered in calculating the hourly varying emission rate for each source. The effect of the precipitation rate (rainfall) in reducing dust emissions has not been considered in this assessment.

Both the NTSF and STSF surfaces have been modelled as emissions sources (i.e., the whole surface area is available as a wind erosion source). The dust mitigation measures implemented by CHPL to reduce potential dust emissions on the TSF surfaces have been considered in this assessment (which included mitigation of 50%).

In addition to this, emissions associated with 4x operating upcast ventilation shafts have been included in the modelling as point sources. A summary of the upcast ventilation shaft parameters is presented in **Table 5-3**. Operating parameters and potential emission rates for the upcast ventilation shafts are based on the most recent measurements conducted by **Ektimo (2022)** at the time of the modelling.

Table 5-3: Parameters for operational upcast ventilation shafts

Parameter	VR3A	VR5	VR7	VR8
Height (m)	5.6	5.6	5.6	15
Diameter (m)	5.0	5.4	6.2	10.2
Temperature (^oC)	23.3	24.5	23.5	22.5

The flow rate parameters were varied according to actual operating conditions during the January 2022 to February 2023 period as shown in **Figure 5-4**. Emissions concentrations for the upcast ventilation shafts were held constant in the modelling.

Figure 5-5 presents the modelled source locations.

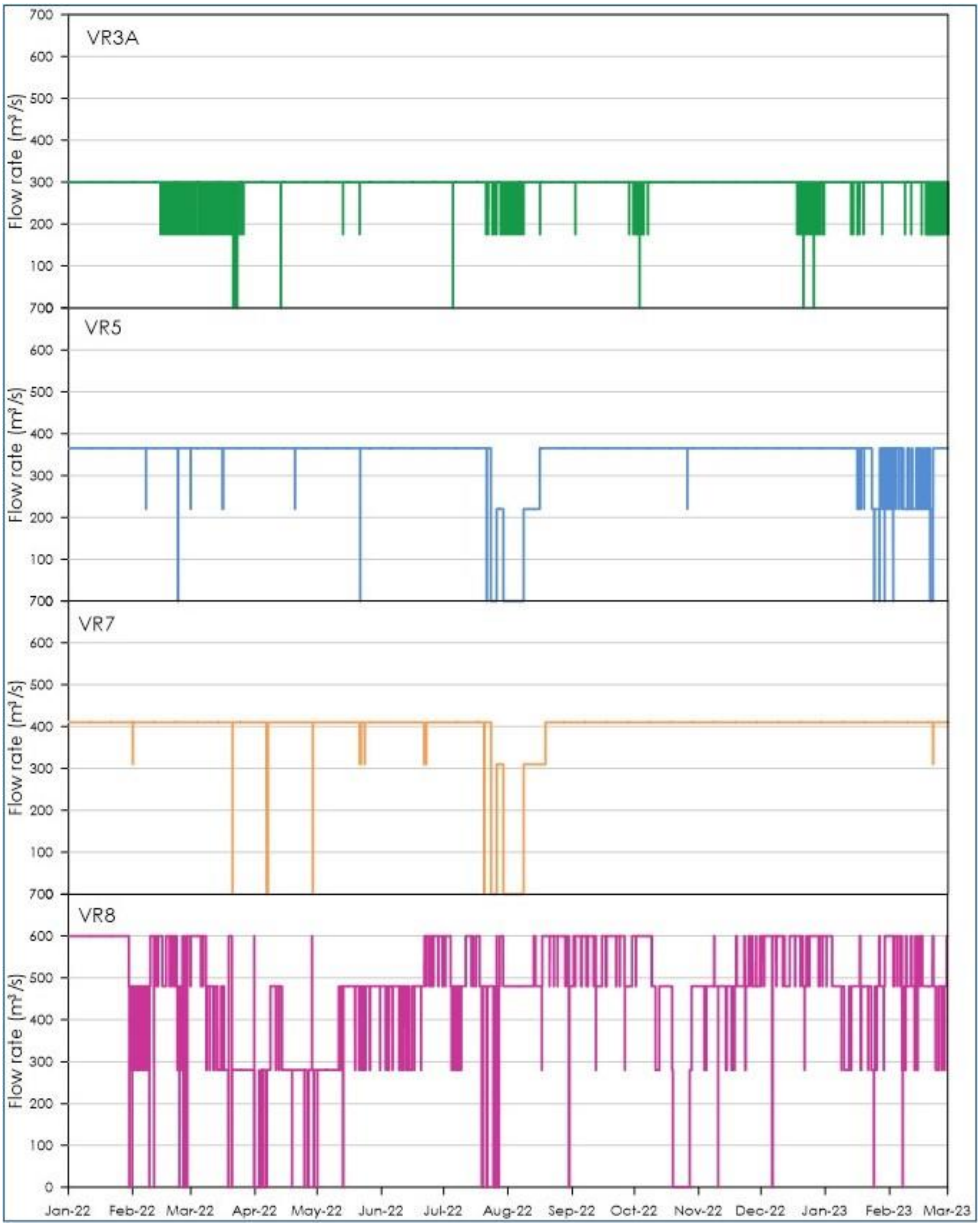


Figure 5-4: Modelled ventilation rates for upcast ventilation shafts

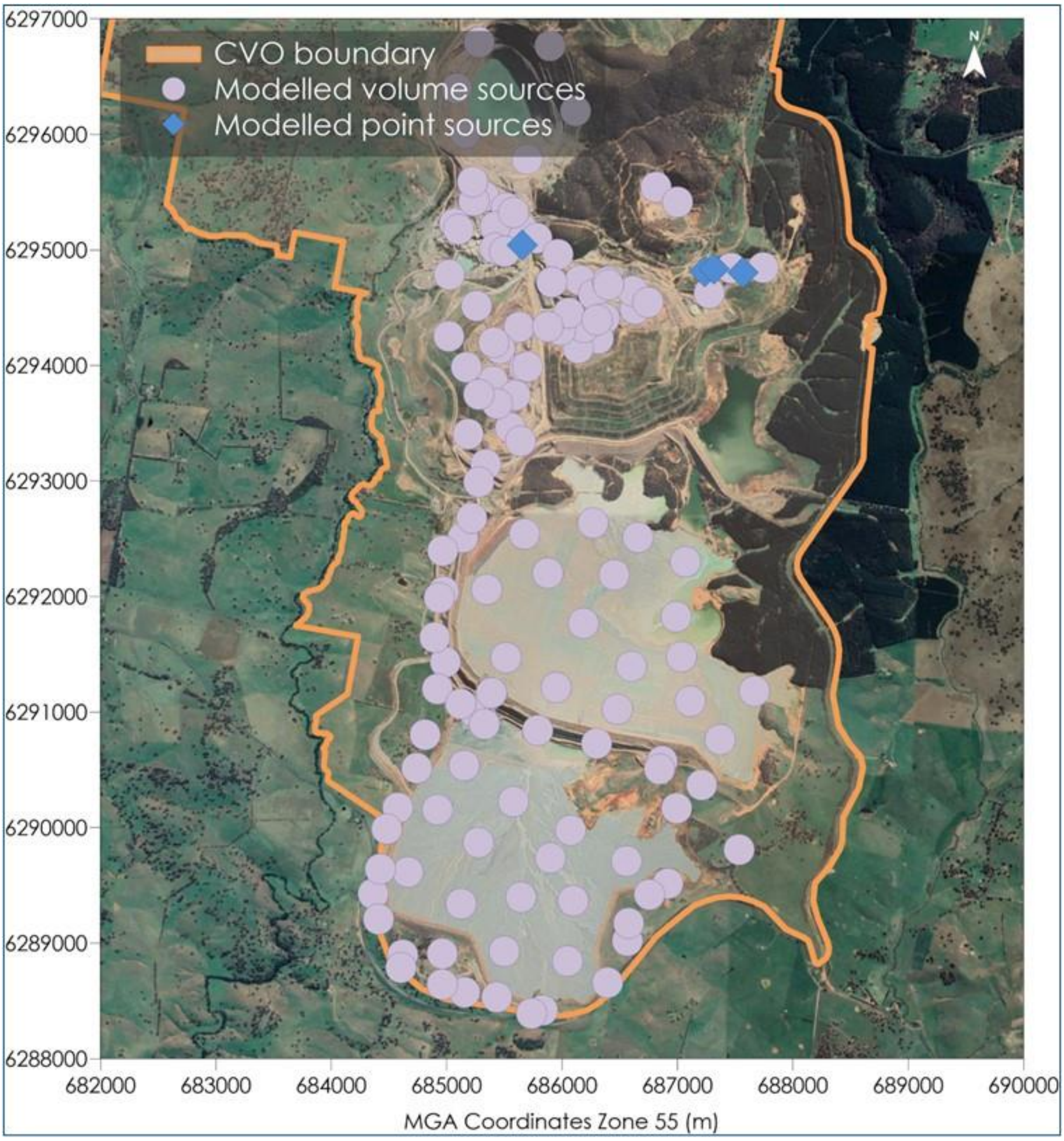


Figure 5-5: Modelled source locations

5.4 Emissions estimates

5.4.1 Dust emissions

For the air dispersion modelling period, dust emissions have been estimated by analysing the dust generating activities and utilising suitable emissions factors.

The emission factors were sourced from both locally developed (**National Pollutant Inventory, 2012**) and United States Environmental Protection Agency developed documentation (**US EPA, 1985**).

Total TSP, PM_{10} and $PM_{2.5}$ emissions from all significant activities occurring at CVO during the January 2022 to December 2022 period are presented in **Table 5-4** and during the January 2023 to February 2023 period are presented in **Table 5-5.**

The dust emissions for the periods January 2022 to December 2022 and January 2023 to February 2023 are based on actual operating production values. The intensity of activity values in the emissions inventory in **Appendix A** shows these data for each source of emissions.

The estimated emissions are commensurate with utilising reasonable best practice dust mitigation applied where feasible. The applied dust control levels are shown in the right-hand column of the emissions inventory in **Appendix A**.

Table 5-4: Summary of estimated dust emissions for the January 2022 to December 2022 period (kg/year)

CVO operations	TSP	PM_{10}	$PM_{2.5}$
CE - General construction work	430,256	79,099	45,177
CE - Loading waste to trucks	807	382	58
CE - Hauling waste to emplacement area	13,841	3,556	356
CE - Emplacing waste at dump	807	382	58
CE - Dozers working on waste rock dumps	16,839	3,096	1,768
CE - Secondary ore crushing	14,995	5,426	467
CE - Loading crushed ore to storage pile from underground	4,042	1,912	289
CE - Ore processing in mill (x5)	146,465	69,274	10,490
WE - Waste rock dumps	918,048	459,024	68,854
WE - Pit tailing storage facility	224,256	112,128	16,819
WE - Subsidence zone	336,384	168,192	25,229
WE - Plant stockpiles and exposed areas	872,496	436,248	65,437
WE - Tailings storage facilities	2,897,808	1,448,904	217,336
Grading roads	9,466	3,307	293
Conveyors and conveyor transfer points	8,788	4,156	629
Construction works on the NTSF and STSF			
Stripping topsoil & dozer activity	828,582	152,328	87,001
Loading material to haul truck	6,996	3,309	501
Hauling material to emplacement area	532,346	136,788	13,679
Unloading material at emplacement area	6,996	3,309	501
Rehandle material at emplacement area	1,399	662	100
WE - Tailings construction area	738,643	369,322	55,398
Total emissions	**8,010,259**	**3,460,803**	**610,440**

Table 5-5: Summary of estimated dust emissions for the January 2023 to February 2023 period (kg/year)

CVO operations	TSP	PM_{10}	$PM_{2.5}$
CE - General construction work	85,213	15,666	8,947
CE - Loading waste to trucks	144	68	10
CE - Hauling waste to emplacement area	2,472	635	64
CE - Emplacing waste at dump	144	68	10
CE - Dozers working on waste rock dumps	2,877	529	302
CE - Secondary ore crushing	142	51	4
CE - Loading crushed ore into trucks to feed CR01 from storage piles	77,822	36,808	5,574
CE - Loading crushed ore to storage pile from underground	724	342	52
CE - Hauling ore	23,713	6,093	609
CE - Emplacing ore at storage location or CR01	1,612	762	115
CE - Ore processing in mill (x5)	23,378	11,057	1,674
WE - waste rock dumps	148,397	74,198	11,130
WE - pit tailing storage facility	36,250	18,125	2,719
WE - subsidence zone	54,374	27,187	4,078
WE - plant stockpiles and exposed areas	141,034	70,517	10,578
WE tailings storage facilities	468,413	234,206	35,131
Grading roads	1,451	507	45
Conveyors and conveyor transfer points	1,403	663	100
Construction works on the NTSF and STSF			
Stripping topsoil + dozer activity	133,935	24,623	14,063
Loading material to haul truck	1,085	513	78
Hauling material to emplacement area	82,530	21,206	2,121
Unloading material at emplacement area	1,085	513	78
WE - tailings construction area	119,397	59,699	8,955
Total Emissions (kg/year)	**1,407,592**	**604,037**	**106,437**

5.4.2 Upcast ventilation shafts

The modelled emission rates for the upcast ventilation shafts are based on the measured concentrations in the period of interest, per **Ektimo (2022)**. A summary of the pollutant concentrations is presented in **Table 5-6**. The TSP emissions are assumed to contain metals.

Table 5-6: Summary of pollutant concentrations for upcast ventilation shafts (mg/m³)

Pollutant	VR3A	VR5	VR7	VR8
Solid particles (TSP)	62	1.3	13	360
Fine particles (PM_{10})	49	0.69	9.3	220
Fine particles ($PM_{2.5}$)	19	0.24	2.7	74
Al	3.7	0.053	0.68	13
Sb	<0.002	<0.002	<0.002	<0.003
As	0.012	<0.0008	<0.0008	0.004
Ba	0.014	0.0045	0.0058	0.049
Be	<0.0003	<0.0003	<0.0002	<0.0005
Cd	0.00057	0.00032	<0.0002	0.00054
Cr	0.0084	0.0022	0.0042	0.023
Co	0.0026	<0.0003	0.00036	0.009
Cu	0.39	0.0096	0.078	2.9
Pb	0.0056	0.036	0.0034	0.041
Mn	0.089	0.0049	0.016	0.35
Hg	<0.0003	<0.0003	<0.0002	<0.0004
Ni	0.0072	0.11	0.0048	0.017
Se	<0.002	<0.002	<0.002	<0.003
Sn	<0.001	<0.0008	<0.0008	<0.001
V	0.023	<0.0005	0.0033	0.065

5.4.3 Metal emissions from the TSF

Metal emissions from the TSF have been estimated based on metal analysis sampling of the tailings (**Serinus, 2021**).

The potential dust emissions from wind erosion on the TSFs have been assessed as containing metals as shown in **Table 5-7**. The average measured metals concentration is used in the emission modelling as the tailings areas are large and wind erosion dust from their surfaces is likely to comprised of particulates from across the area, including previously deposited surface particulates being re-suspended.

Table 5-7: Summary of metal analysis of tailings (ppm)

Pollutant	Average concentration of tailings samples
Al	12600
Sb	0.2
As	3.5
Ba	25.2
Be	0.3
Cd	<0.1
Cr	30.8
Co	11.4
Cu	498
Pb	3.7
Mn	287
Mo	16.7
Ni	12.8
Se	1.5
Ag	0.2
Sn	0.5
V	70
Zn	24

5.5 Model validation

To assess the performance of the modelling predictions, the 24-hour average PM_{10} and $PM_{2.5}$ concentrations predicted at each of the TEOM and BAM monitoring locations were compared with the measured data and visualised using quantile-quantile plots.

The modelling predictions account for the varying background level in each 24-hour period. The key assumption applied is that the upwind monitors reflect the background level at a location which is not influenced by emissions from CVO, based on the wind direction for each hourly timestep. Hence the background level is estimated to be the hourly average level at the upwind TEOMs and is added to the corresponding downwind model prediction to determine the total cumulative level.

The measured particulate emission concentrations in the upcast vent are not a reliable measure of any dust that may be transported off-site due to entrainment in the sample of large droplets of slurry material present in the bend of a duct where the air velocity is close to 100km/hr (Please note that this is not a fault in the sampling by Ektimo as there is no ideal sampling location in the ducting per the EPA Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales, nor is there any alternative approved method available that may produce more reliable results). As previously advised by TAS, the measured vent data is unreliable in terms of any dust emissions with potential to leave the site. The current modelling of the upcast vent emissions at their measured levels leads to predicted ambient concentrations above the measured levels at the ambient monitors. The as-measured validation results are "off-the-scale" at the nearby Woodville monitor which is consistent with the initial advice from TAS about unreliable vent emissions sampling data[1].

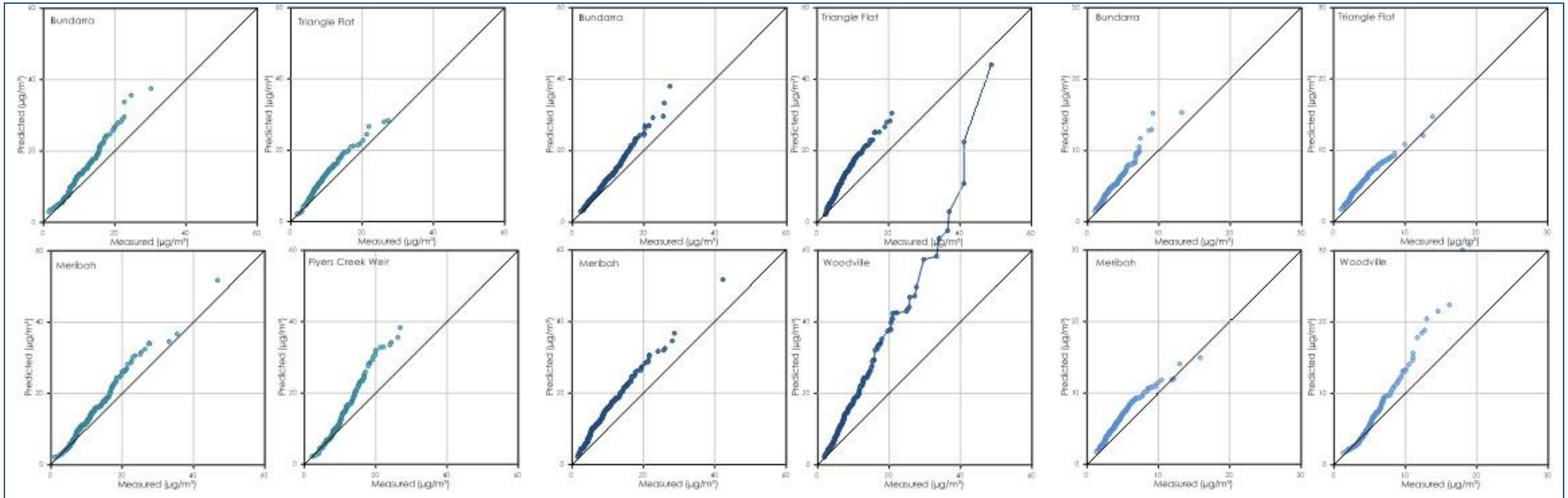
A sensitivity analysis was thus conducted whereby the upcast vent emissions applied in the model were progressively scaled down to evaluate the effect on the predicted results[2] when compared with the measured ambient concentration, (see **Figure 5-6** to **Figure 5-11**). The sensitivity analysis shows that the upcast vents have no tangible effect at any of the monitors except Woodville, where the effect of the vents is relatively clear, but does not exceed cumulative criteria limits. (The monitoring shows that 24-hour and annual average PM_{10} and $PM_{2.5}$ results are always below the EPA criteria at all monitors).

The resulting quantile-quantile plots for PM_{10} at each real-time (TEOM and BAM) for the modelling period at locations where monitoring data is available are presented in **Figure 5-6** to **Figure 5-11**. The predicted results for the BAM monitors indicate more overestimation in the modelling than the TEOM monitor locations due to the inherent differences in readings between TEOM and BAM instruments, noting that all the results appear to be within the acceptable range of variability between equivalence methods for sampling.

The validation shows that the modelling results for 24-hour average PM_{10} concentrations correlate reasonably with the measured ambient concentrations when the upcast vent emissions are scaled down by 90% (down to only 10% of the values measured in the vent). When this is done, the $PM_{2.5}$ results also correlate well with the measured values except at Woodville, where there is a large underprediction.

[1] The TAS advice about unreliable vent emissions measurements is not mentioned in the recent audit of CVO.

[2] Note that previous TAS modelling for periods without significant upcast vent emissions correlates very well with the corresponding measured ambient data and confirms that the model predictions for all other mine sources, including wind erosion from the tailings dam surfaces are accurate.



PM$_{10}$ TEOM monitoring PM$_{10}$ BAM monitoring PM$_{2.5}$ BAM Monitoring

Figure 5-6: Quantile-quantile plots of measured and predicted 24-hour average concentrations during modelling period with VR8 modelled at the measured value

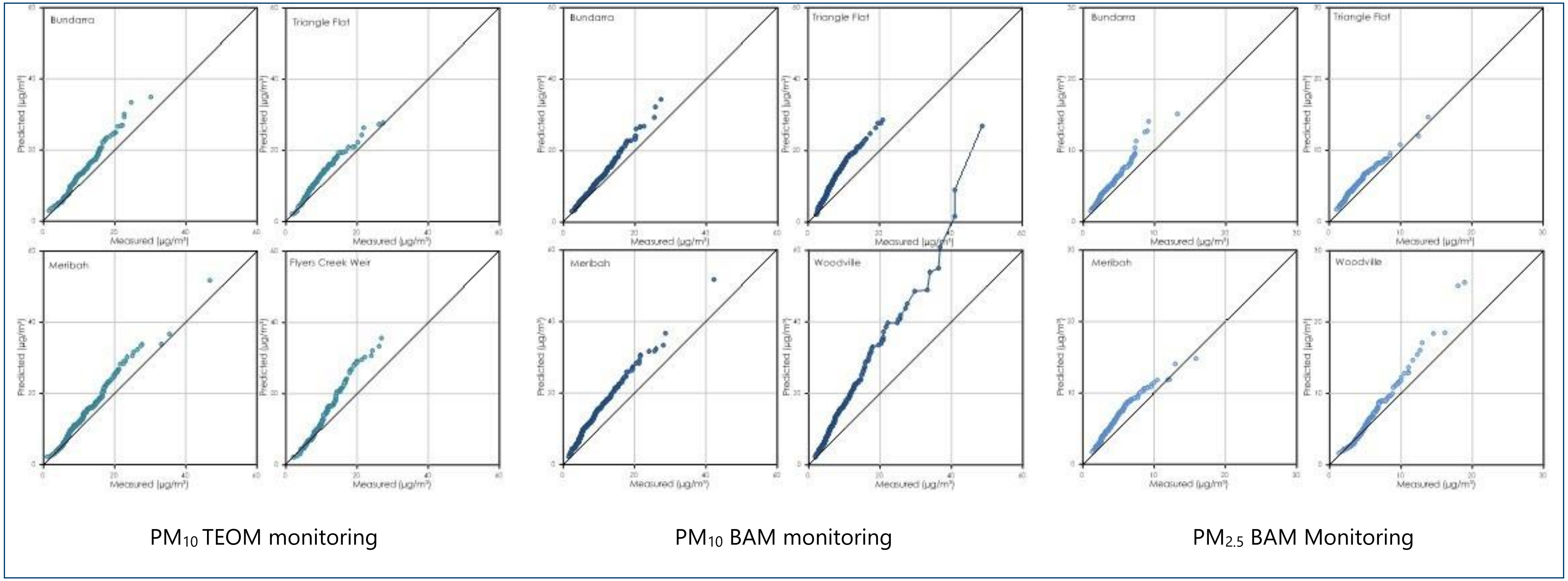
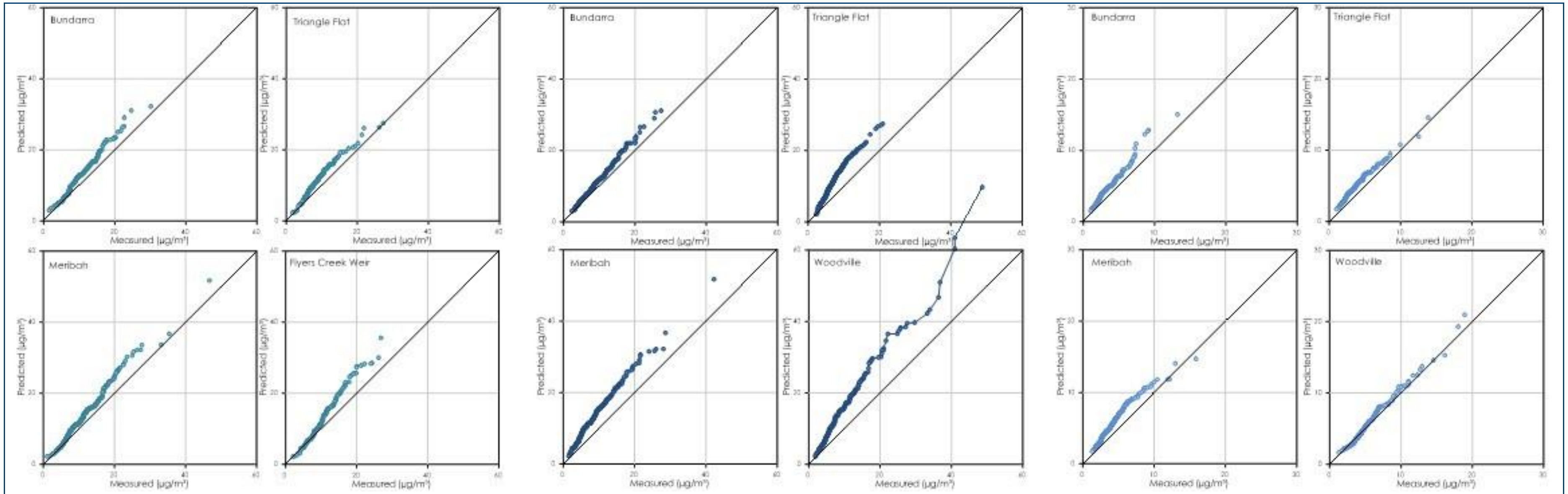


Figure 5-7: Quantile-quantile plots of measured and predicted 24-hour average concentrations during modelling period with 25% reduction for VR8

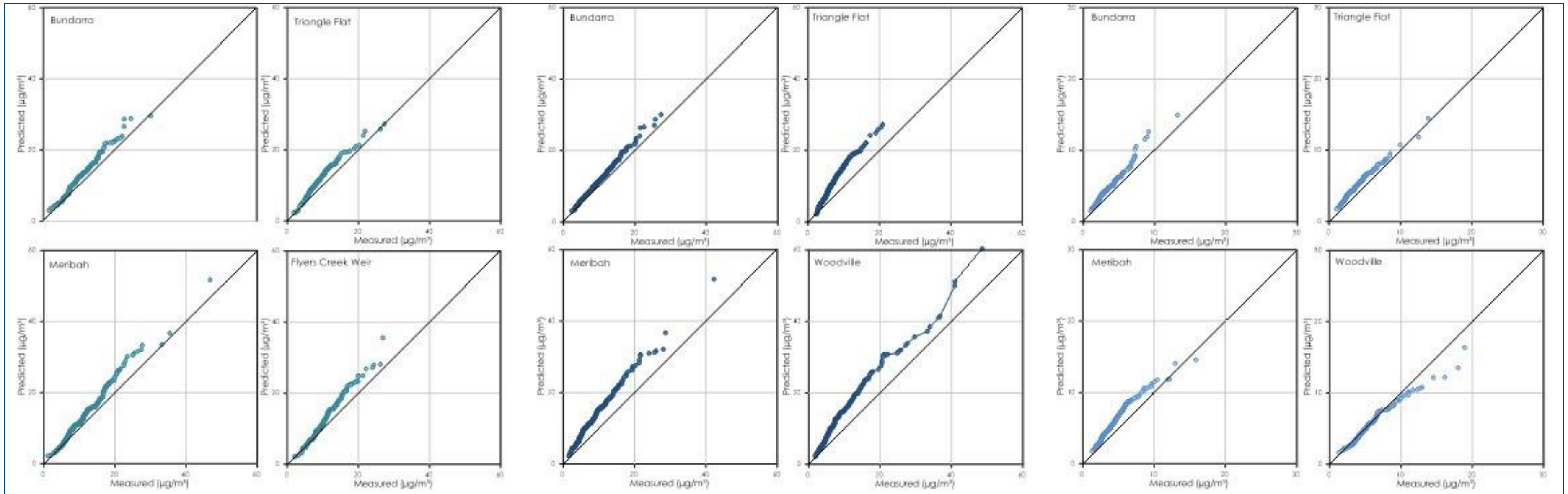


PM10 TEOM monitoring

PM10 BAM monitoring

PM2.5 BAM Monitoring

Figure 5-8: Quantile-quantile plots of measured and predicted 24-hour average concentrations during modelling period with 50% reduction for VR8

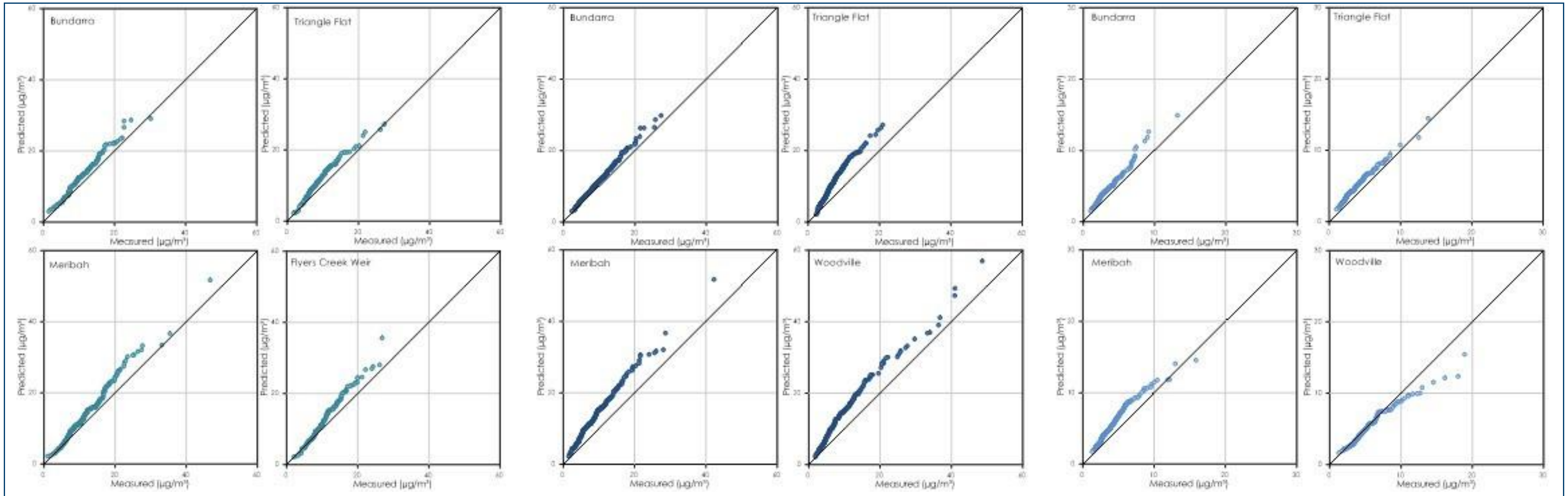


PM$_{10}$ TEOM monitoring

PM$_{10}$ BAM monitoring

PM$_{2.5}$ BAM Monitoring

Figure 5-9: Quantile-quantile plots of measured and predicted 24-hour average concentrations during modelling period with 75% reduction for VR8



PM_{10} TEOM monitoring

PM_{10} BAM monitoring

$PM_{2.5}$ BAM Monitoring

Figure 5-10: Quantile-quantile plots of measured and predicted 24-hour average concentrations during modelling period with 80% reduction for VR8

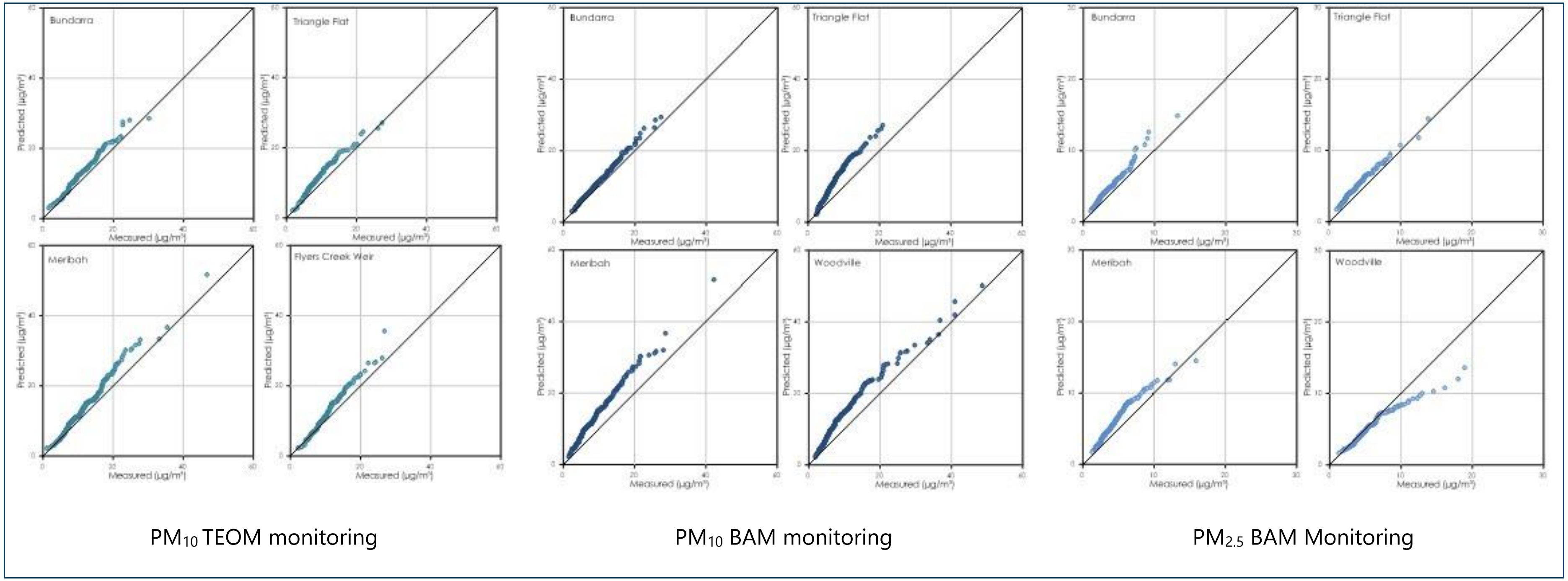


Figure 5-11: Quantile-quantile plots of measured and predicted 24-hour average concentrations during modelling period with 90% reduction for VR8

5.5.1 Model validation discussion

The validation shows that the modelling results for 24-hour average PM_{10} concentrations correlate reasonably with the measured ambient concentrations when the upcast vent emissions are scaled down by 90% (down to only 10% of the values measured in the vent). When this is done, the $PM_{2.5}$ results also correlate well with the measured values except at Woodville, where there is a large underprediction.

For the modelled 24-hour average $PM_{2.5}$ concentrations to align with the measured ambient concentrations at Woodville, the measured vent emission rates in the modelling need to be scaled down to approximately 50% of the Ektimo measured values in the vent.

However, this is problematic, because it means that (at Woodville only) the modelled $PM_{2.5}$ emission rate needs to be higher than the PM_{10} emission rate (which is not possible, given that $PM_{2.5}$ is a subcomponent of PM_{10}). For example, for VR8, (the main vent emission source) the measured PM_{10} emissions concentration needs to be scaled down from the measured level of 220 to 22 mg/m^3, whereas the $PM_{2.5}$ emission rate would need to be scaled down from 74 to 37 mg/m^3. It is not plausible for the vent emission rate to be 37mg/m^3 for $PM_{2.5}$ whilst it is also 22 mg/m^3 for PM_{10}. [3]

This indicates there may be some factor(s) at play at Woodville that is not apparent from the available data. Possible factors include each of or a combination of the following;

1. A localised source of (predominantly) $PM_{2.5}$ at Woodville which is not included in the modelling predictions.
2. Erroneous vent measurement data, mass and particle size.
3. Erroneous or biased monitoring data at Woodville.
4. An error in the modelling at Woodville, but not elsewhere.

As such, the situation at the Woodville monitor was considered in more detail.

<u>Potential local sources</u>. The Woodville monitor is located amongst several mine-owned dwellings which would generate wood smoke during cold periods. The monitor is also relatively close to large stands of trees/ plantations, and CVO staff indicate observing pollen from the trees. The monitor is located within approximately 50m of a dirt road between the site and the CVO. All of these are potential sources of $PM_{2.5}$, that are not included in the modelling with perhaps more significant $PM_{2.5}$ effects from the woodsmoke and pollens.

<u>Vent measurement error and bias</u>. The vent emission appears to be comprised of predominantly large mud slurry droplets. It is sampled at approximately ground level in a ninety-degree bend in the duct. The velocity of the air in this bend in the duct is approximately 100km/hr. After the sampling in the bend, the duct splits into three horizontal branches, each of the three branches have a ninety-degree bend leading into fans discharging into vertical risers. The risers taper outwards (increasing diameter with height), which causes the vertical velocity to reduce with increasing height up the vertical riser. This causes the mud slurry droplets to also reduce their vertical velocity and would facilitate greater

[3] The modelled PM_{10} concentrations would align better with the ambient monitoring data at an even lower vent emissions rate, and it is reasonable to assume the effective vent emissions would be less than 20mg/m^3 for PM_{10}.

agglomerating and thus to fall back into the duct or onto the ground next to the vent when there is a cross breeze. (A prill tower uses a similar mechanism to make round pellets by controlling the size according to the velocity) such as fertiliser etc are made). This is consistent with the authors observations of there being many tonnes of mud coating the inside of the vertical risers (necessitating larger cranes for servicing), and the stack testers van becoming entirely coated in mud slurry in a short period of time when parked near the vent. Due to this, it is not possible for stack samplers, using the required EPA sampling method, to take a reliable reading of the dust that may travel away from the vent at the available vent monitoring point.

Also, in this situation, it is possible (and perhaps quite likely) that the measured vent particulate size distribution data does not reflect the actual particle size distribution of the dust that may travel away from the vent location. As outlined previously, the required EPA compliant stack sampling method cannot avoid collecting large droplets slurry material. Due to collecting such slurry material the sampling method will certainly exaggerate the mass of potential emissions that may travel away from the vent and is thus inherently likely to also bias the particle size distribution being reported. <u>The required sampling method collects all particulate material and is not size-selective according to particulate aerodynamic diameter</u>. The sampled material is analysed in the laboratory, where the collected material is sonically disassociated in a clear liquid. Optical means are then used to measure the number and physical size of particles in the clear liquid suspension to determine the particle size distribution. As such, the particle size data may not be accurate, and this would be a likely confounding factor for the modelled discrepancy between the measured data in the vent and that in the ambient air off-site, i.e., at Woodville.

<u>Ambient measurement error and bias</u> The Woodville $PM_{2.5}$ monitor is located closest to the largest upcast vent (approximately 2.5km west of the VR8 vent). The Flyers Creek monitoring site is the same distance from the vent shaft, but there is no $PM_{2.5}$ monitoring there.

Each of the real-time monitors compare very well with the actual measured data, and generally show a tendency for some overestimation in the amount of dust emissions (as is appropriate for compliance related modelling). For example, **Figure 5-11** for PM_{10} at Woodville, the average overprediction is 45% higher than measured, even with a 90% reduction in the measurements in the vent.

Nevertheless, the data show a significant bias between the TEOM and BAM results. This is generally the case in other areas also. It is noted that a difference of up to 25% between the measured result for equivalence methods (TEOMs BAM) to reference methods (HVAS) when sampling the same air is valid and acceptable. Thus, the evident bias is normal, and is acceptable. The maximum "acceptable" bias between any two BAMs or TEOMs, or between any BAM and TEOM is thus up to 50% (one machine may be 25% low and the other 25% high). There is some potential that this may affect the readings at Woodville and may be a factor to consider further. CVO staff anecdotally report unusual short term data (1 hour averages) at times for example at Woodville. Measurements to confirm any such potential bias would be feasible, say by comparing results between co-located machines.

<u>Error in the modelling</u> cannot be ruled out but is not likely to arise only at Woodville from a model that covers all areas concurrently. It is noted that the model apportions particle size fractions according to the vent sampling and considers dry deposition, such that finer particles will travel further, (i.e., it is thus possible to scale the results validly individually for each size fraction).

6 DISPERSION MODELLING RESULTS

The dispersion modelling predictions are presented in this section. The results presented include predicted dust and metal concentrations associated with the operation in isolation (incremental impacts).

Note that the purpose of this report is to identify if there is any abnormal contribution from the mine to the measured levels over the ANSTO monitoring period. The report does not attempt to provide modelling for total dust levels for the purposes of assessing compliance, given that the actual monitoring data is most appropriate for that purpose. (Note however that cumulative background data is used to validate modelling performance relative to the measurement data).

The modelled emissions for upcast vent VR8 were scaled down by 90% of PM_{10} and TSP, and 50% for $PM_{2.5}$ in order to reasonably correlate with the actual ambient measurements at Woodville.

Each of the privately-owned and mine-owned receptors of relevance to this study as shown in **Figure 2-1**, were assessed individually as discrete receptors.

Note that privately owned receptors are located further away from CVO than the ambient dust monitors (in most cases), and hence the results at privately owned receptors in most cases will be less affected by CVO dust.

6.1 Dust results

Table 6-1 presents a summary of the highest maximum predicted level at any privately-owned receptors. Associated isopleth diagrams of the dispersion modelling predictions for air quality emissions are presented in **Figure 6-1** to **Figure 6-6**.

The results in **Table 6-1** indicate that no exceedances of the relevant criteria area predicted to arise for the assessed dust metrics.

Table 6-1: Summary of modelling predictions for dust due to CVO only (µg/m³)

Pollutant	Averaging period	Criteria	Maximum predicted results at any privately-owned receptor (CVO only)
$PM_{2.5}$ (µg/m³)	24-hr ave.	25	16.2
	Ann. ave.	-	1.3
PM_{10} (µg/m³)	24-hr ave.	50	38.3
	Ann. ave.	-	4.2
TSP (µg/m³)	Ann. ave.	-	8.2
DD (g/m²/month)	Ann. ave.	2	0.4

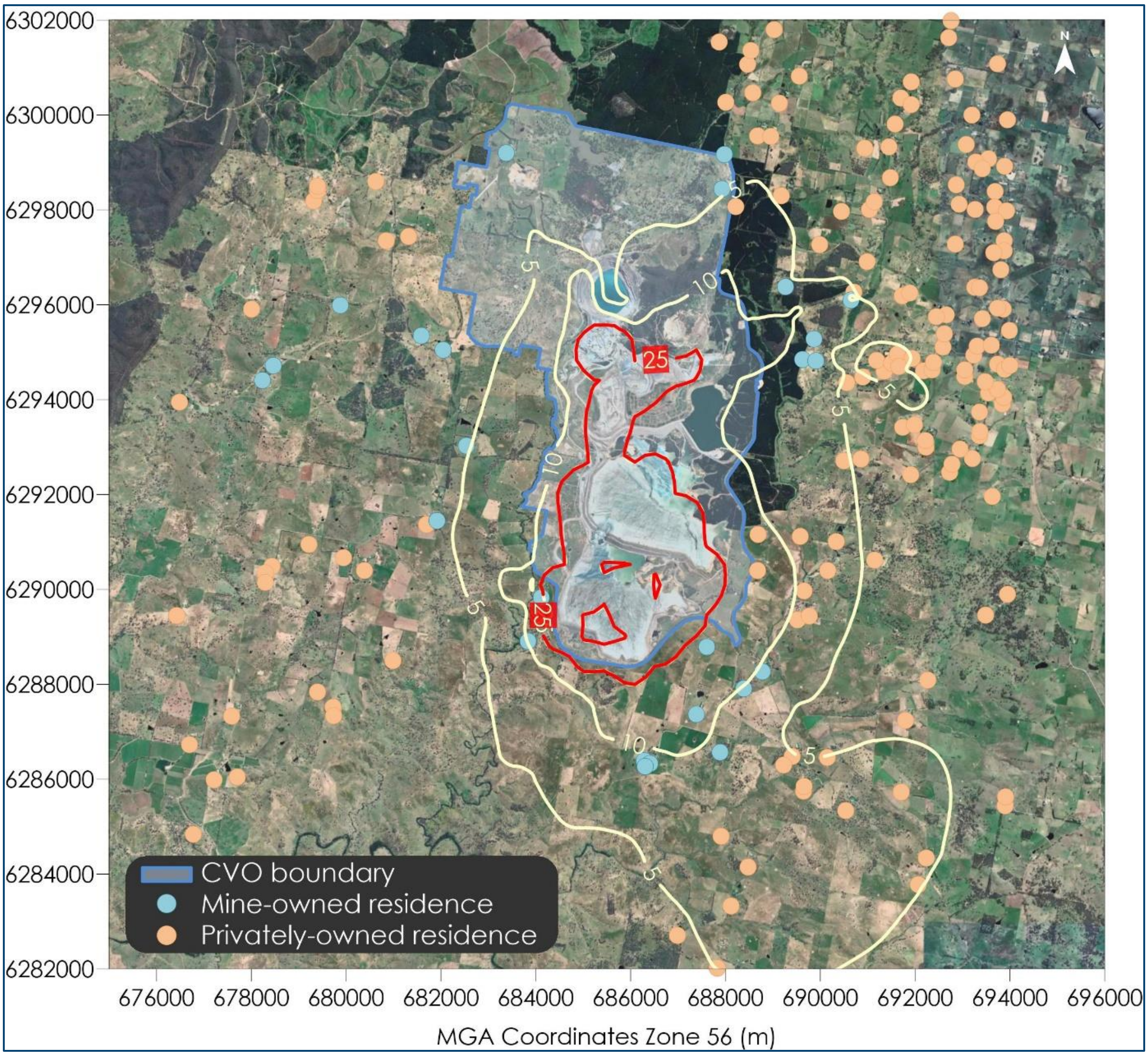


Figure 6-1: Predicted 24-hour average $PM_{2.5}$ concentrations due to emissions from CVO only during 2022 (µg/m³)

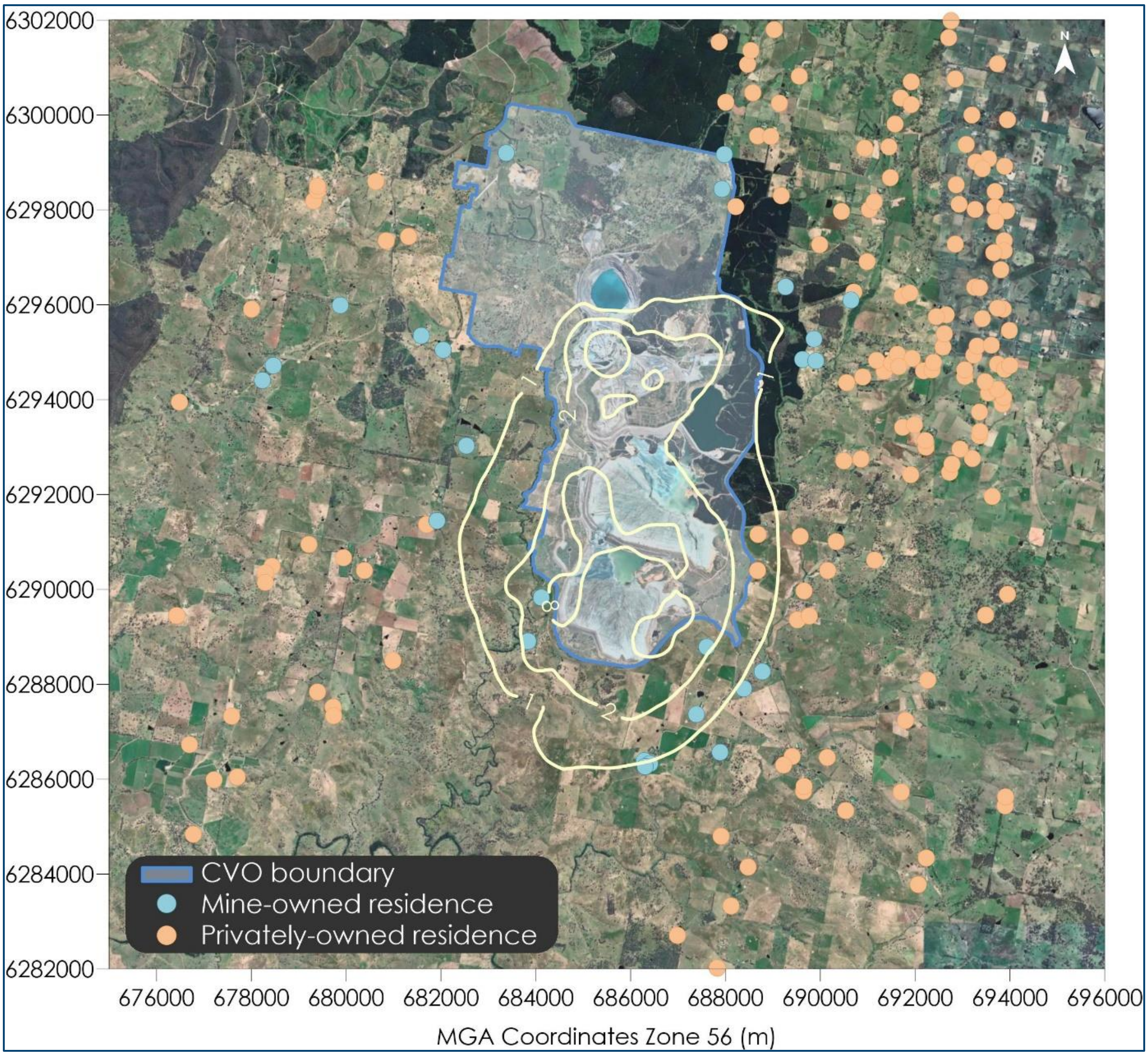


Figure 6-2: Predicted annual average $PM_{2.5}$ concentrations due to emissions from CVO only during 2022 ($\mu g/m^3$)

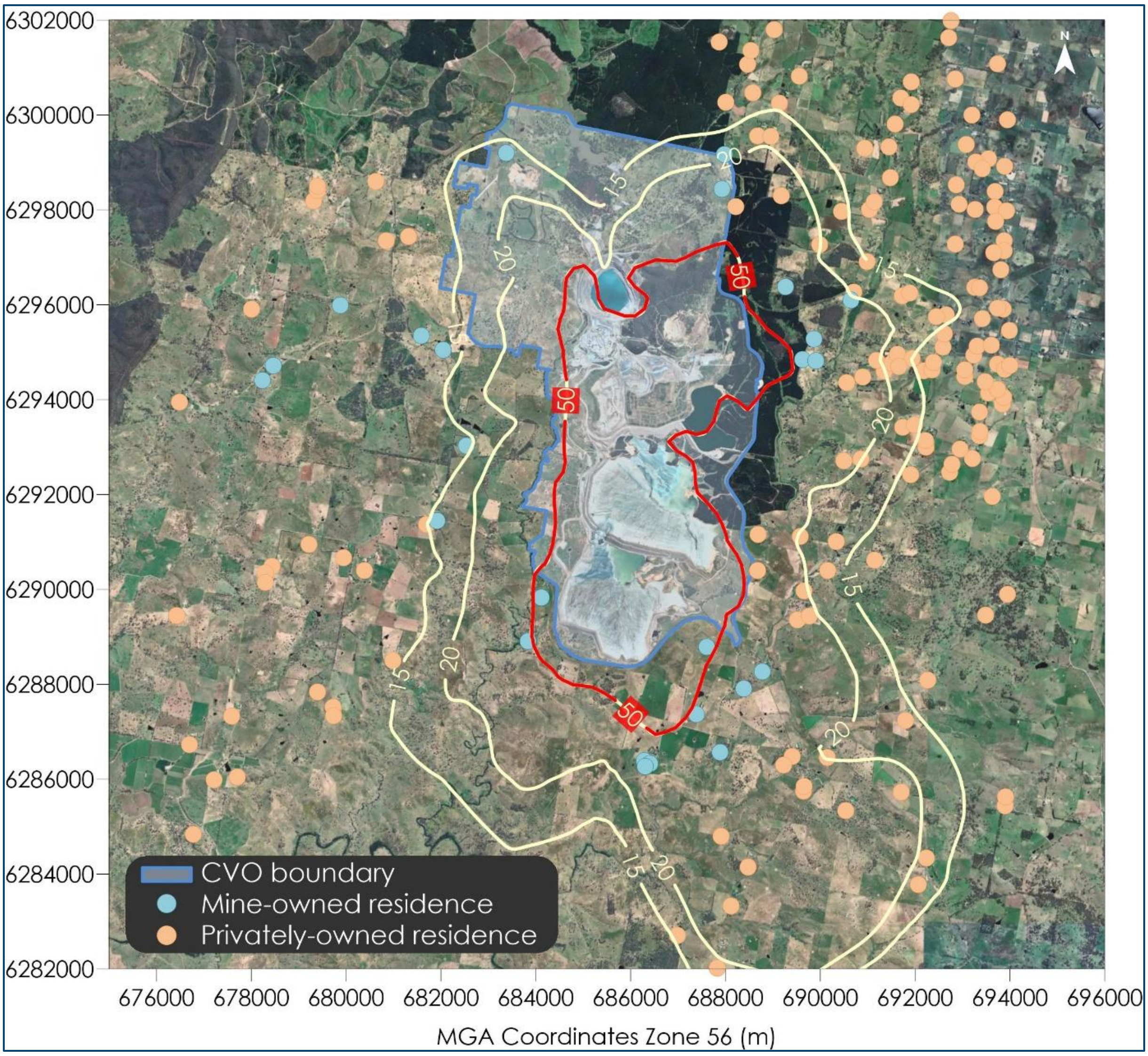


Figure 6-3: Predicted 24-hour average PM_{10} concentrations due to emissions from CVO only during 2022 (µg/m³)

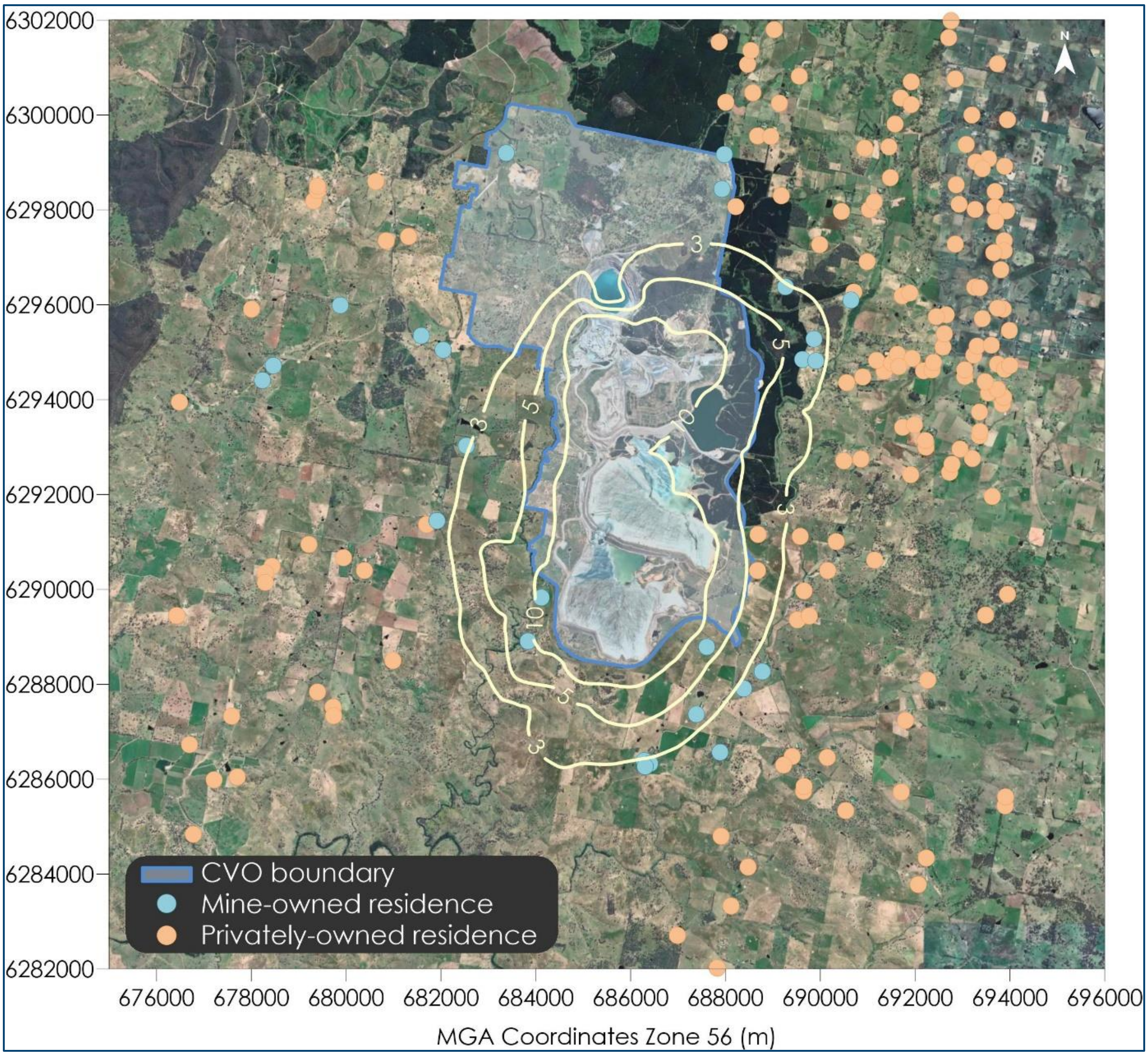


Figure 6-4: Predicted annual average PM_{10} concentrations due to emissions from CVO only during 2022 (µg/m³)

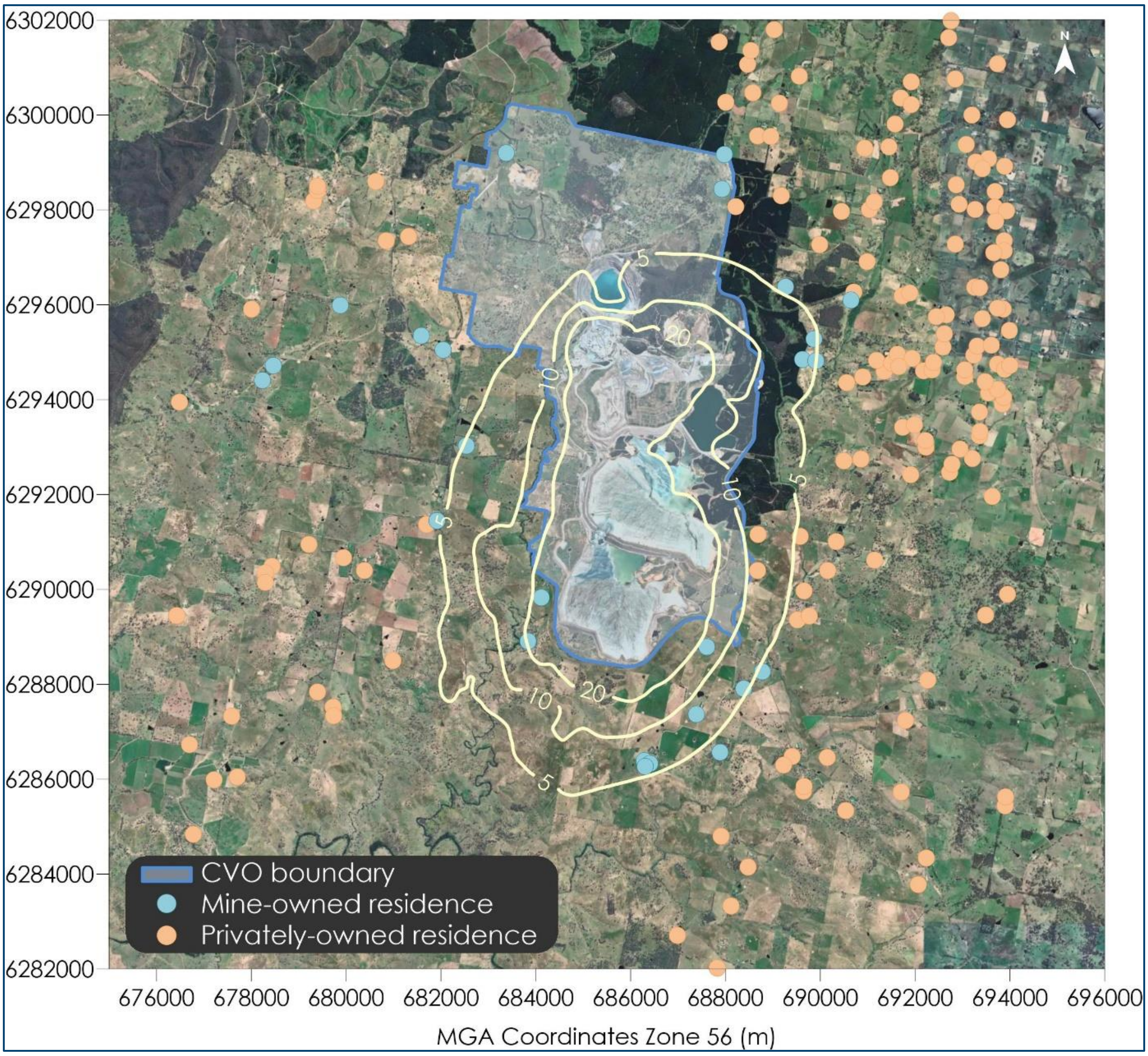


Figure 6-5: Predicted annual average TSP concentrations due to emissions from CVO only during 2022 (µg/m³)

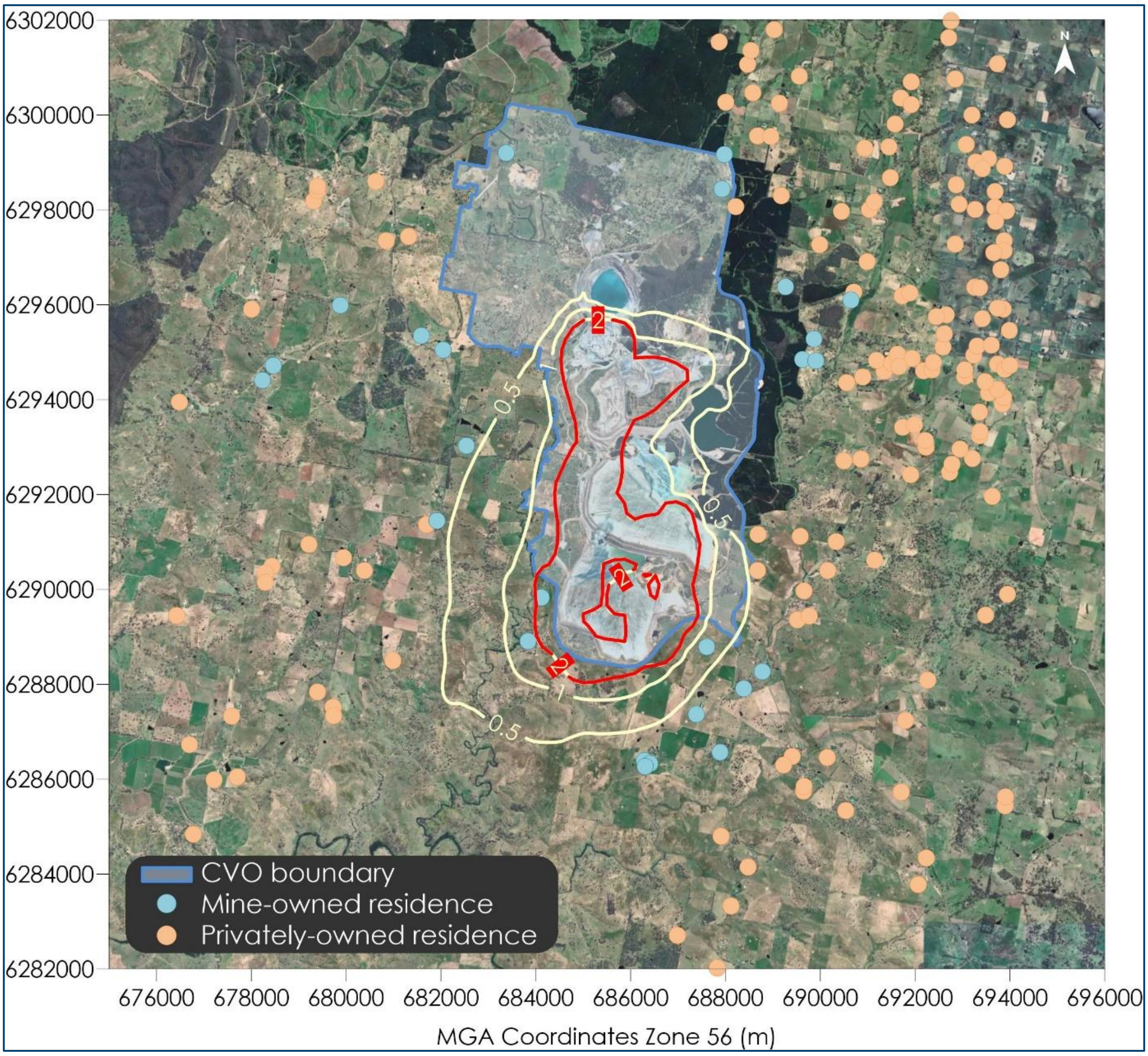


Figure 6-6: Predicted annual average dust deposition levels due to emissions from CVO only during 2022 (g/m²/month)

6.2 Metal results

Table 6-2 presents a summary of the highest maximum predicted level at any privately-owned receptors and locations off-site (i.e., at or beyond the site boundary). Associated isopleth diagrams of the dispersion modelling predictions for metal impact are presented in **Figure 6-7** to **Figure 6-24**

The results in **Table 6-2** indicate that no exceedances of the relevant criteria area predicted to arise for the assessed metals except for nickel. Nickel is predicted to marginally exceed the applicable criteria very near the site boundary[4].

Table 6-2: Summary of modelling predictions for metals (μg/m³)

Pollutant	Averaging period	Percentile	Criteria	Maximum predicted results at any privately-owned receptor	Maximum predicted results off-site	Factor of compliance
Ag	1-hr	99.9	1.8	0.00002	0.00003	60,000
Al	1-hr	99.9	50	9.8	10.7	4.67
As	1-hr	99.9	0.1	0.02	0.02	5.00
Ba	1-hr	99.9	9	0.05	0.05	180
Be	1-hr	99.9	0.004	0.0006	0.0006	6.67
Cd	1-hr	99.9	0.018	0.001	0.001	18.0
Co	1-hr	99.9	0.2	0.007	0.007	28.6
Cr	1-hr	99.9	0.1	0.03	0.03	3.33
Cu	1-hr	99.9	18	1.3	1.5	12.0
Hg	1-hr	99.9	1.8	0.0006	0.0006	3,000
Mn	1-hr	99.9	18	0.2	0.3	60.0
Mo	1-hr	99.9	30	0.001	0.003	10,000
Ni	1-hr	99.9	0.18	0.12	**0.21**[(4)]	0.86
Pb	AA	100	0.5	0.00002	0.00009	5,556
Sb	1-hr	99.9	9	0.004	0.004	2,250
Se	1-hr	99.9	2	0.004	0.004	500
Sn	1-hr	99.9	20	0.002	0.002	10,000
V	1-hr	99.9	2.2	0.06	0.06	36.7
Zn	1-hr	99.9	20	0.006	0.012	1,667

4 This potential exceedance was assessed in more detail. It is noted that the modelled particulate emissions at the nearby Woodville monitor on average overpredict the actual measurements by 45%. As this arises at the boundary only at a location similarly distant to Woodville, it is reasonable to assume the actual levels would up to 45% lower than predicted, and that there would not be any marginal exceedance. It is also pointed out that there is only one speciated metals sample for the vent emission, which adds uncertainty. Notably also there are no mine owned or private receptors in the vicinity of the boundary where the maximum impact arises.

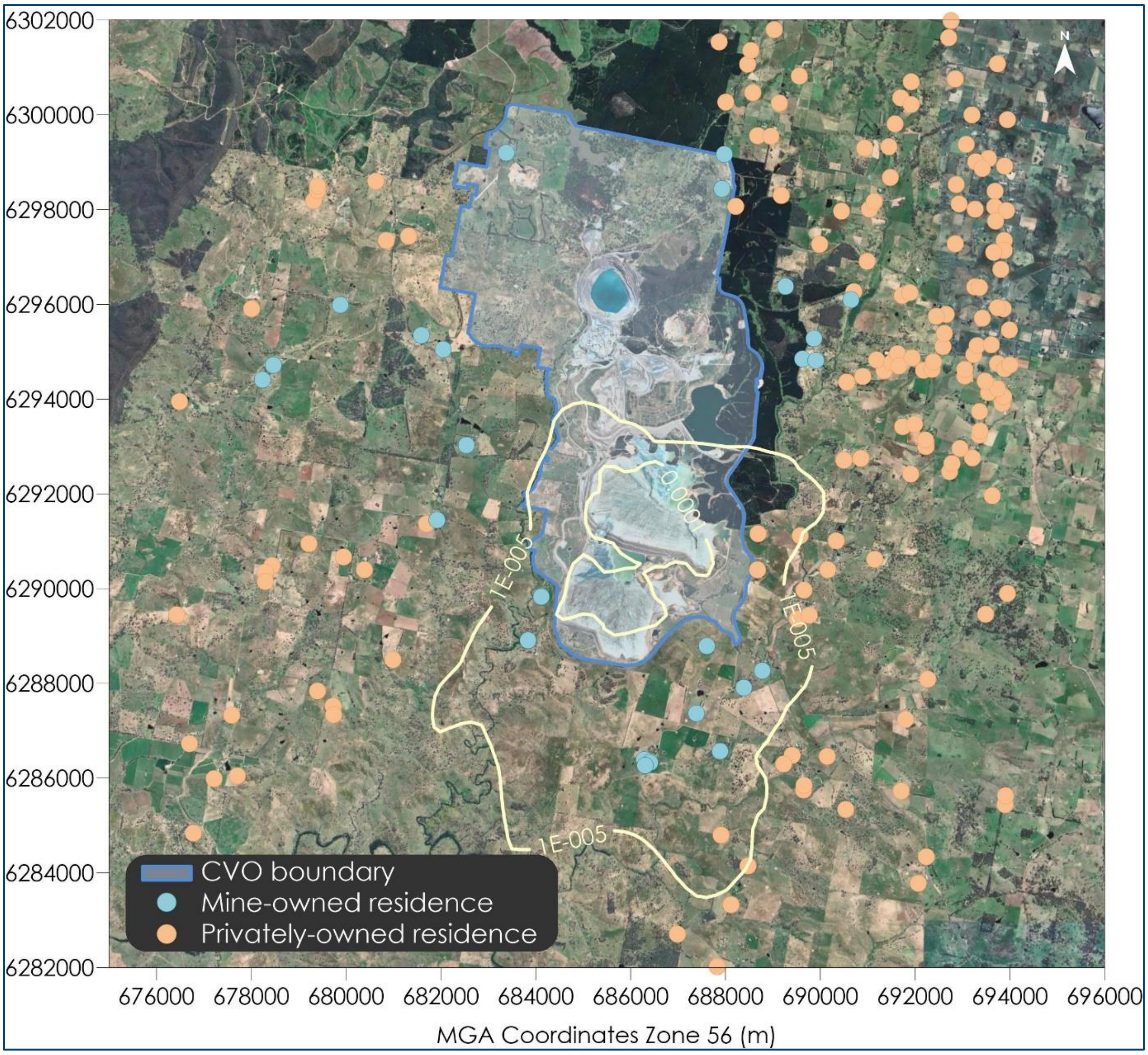


Figure 6-7: Predicted 99.9th percentile 1-hour average Ag levels (µg/m³)

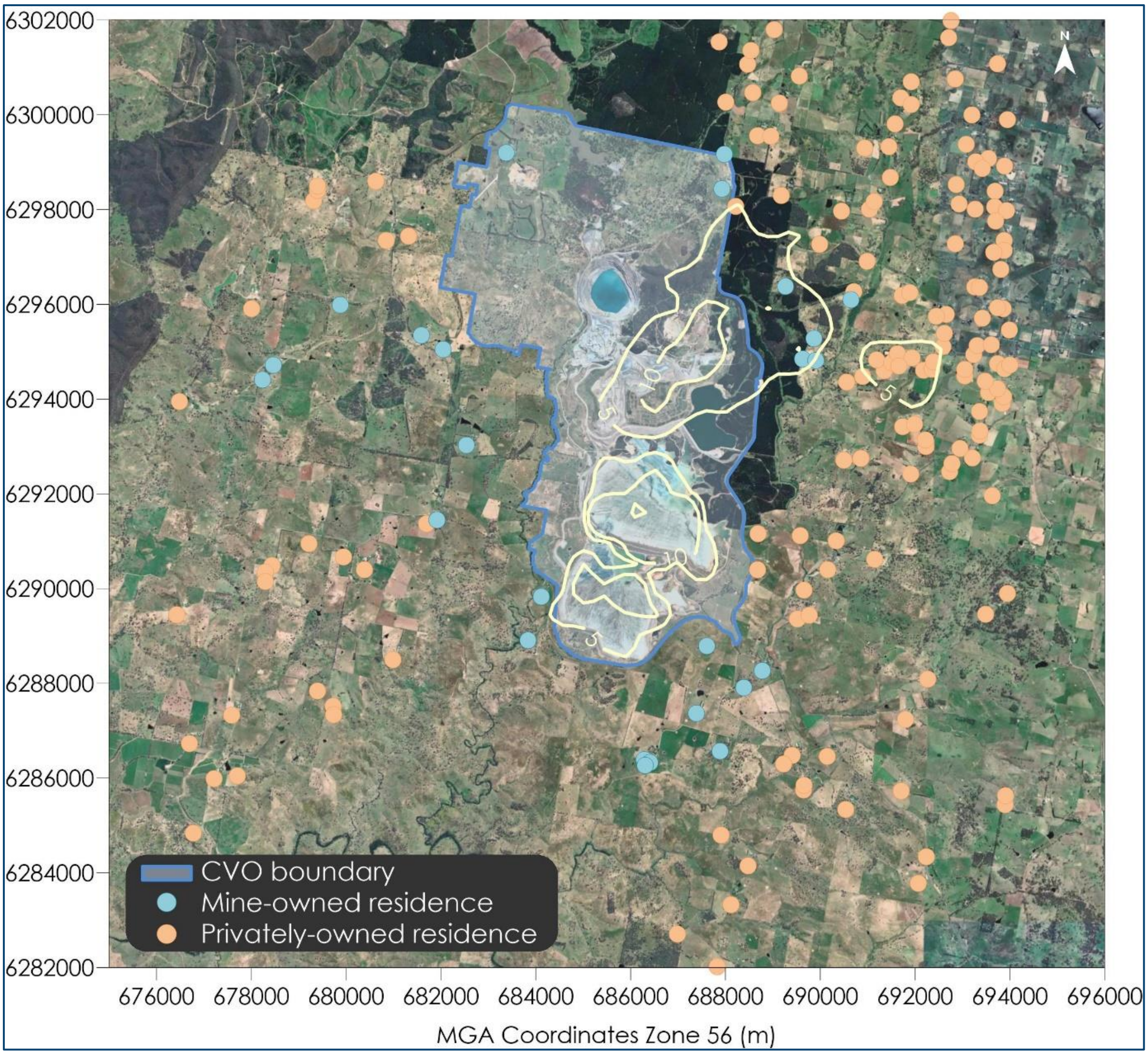


Figure 6-8: Predicted 99.9th percentile 1-hour average Al levels (µg/m³)

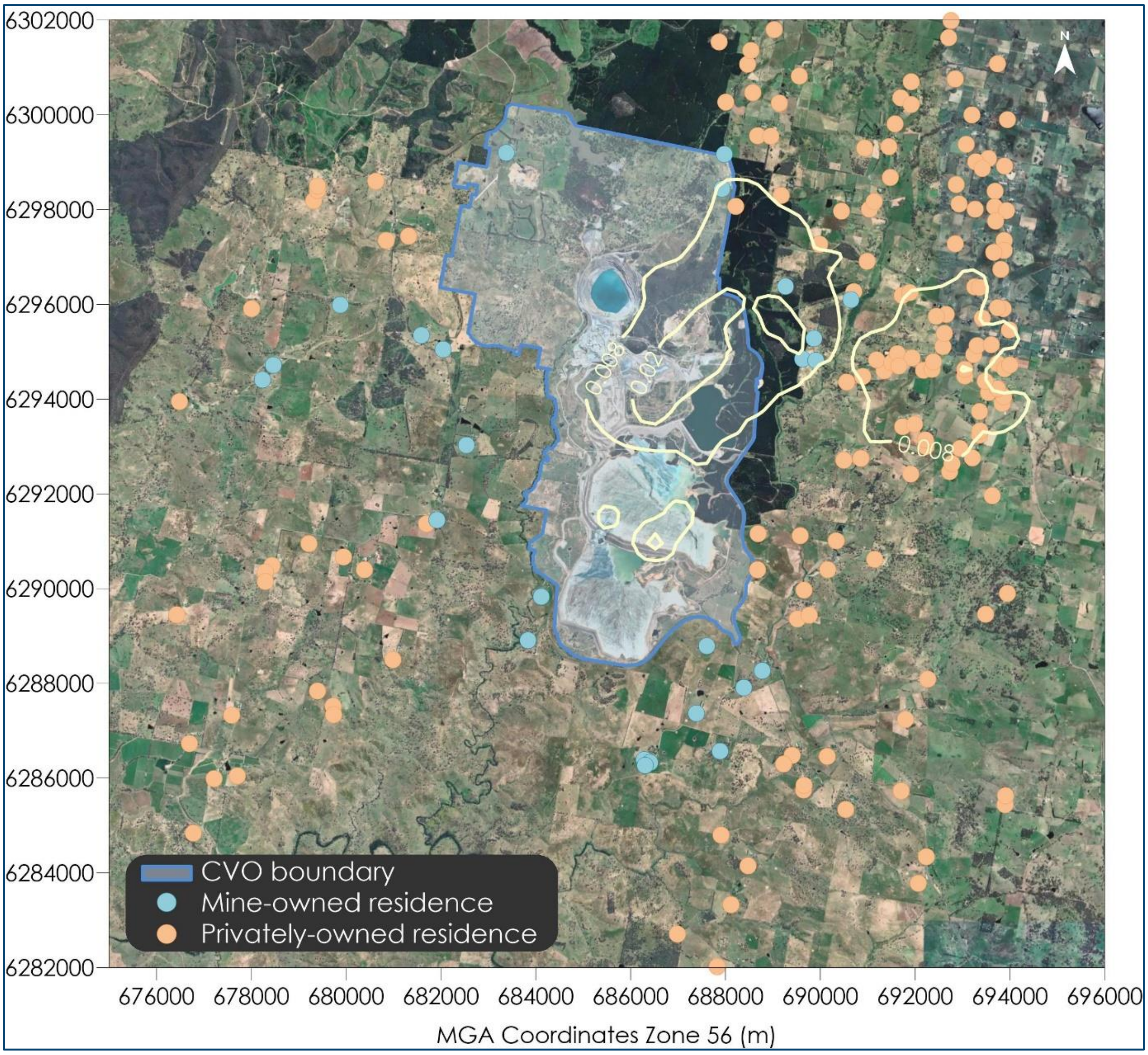


Figure 6-9: Predicted 99.9th percentile 1-hour average As levels (µg/m³)

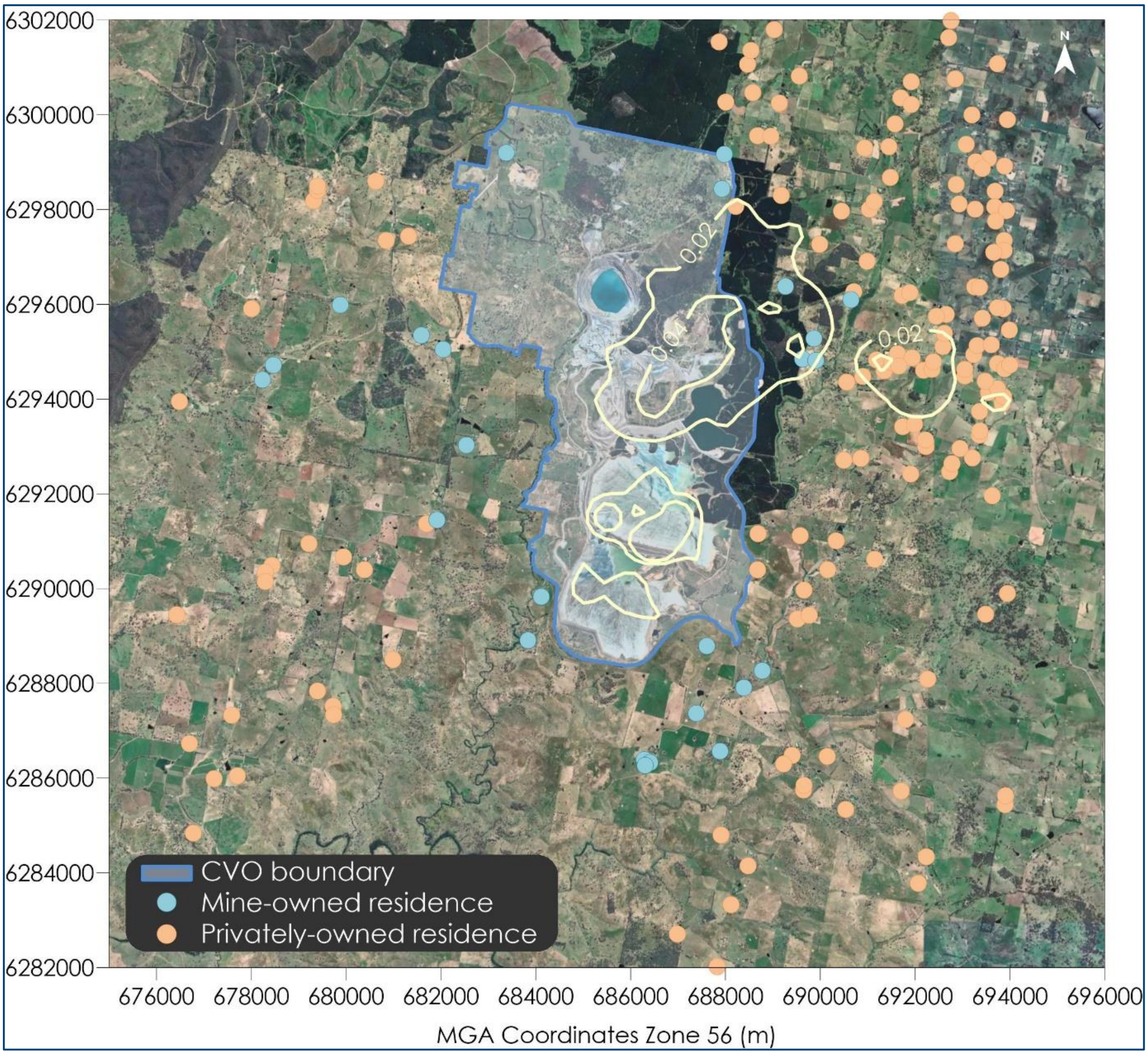


Figure 6-10: Predicted 99.9th percentile 1-hour average Ba levels (µg/m³)

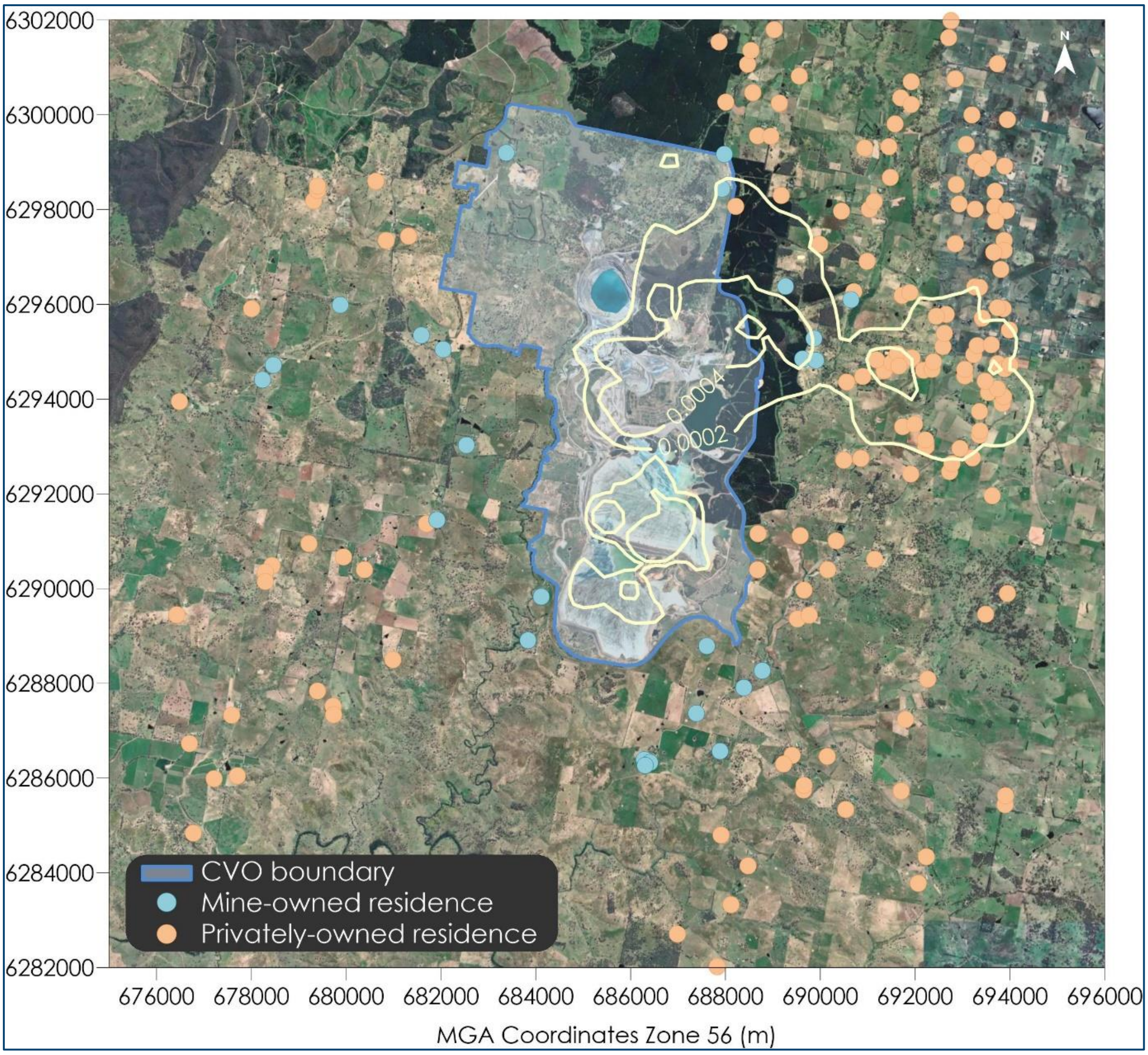


Figure 6-11: Predicted 99.9th percentile 1-hour average Be levels (µg/m³)

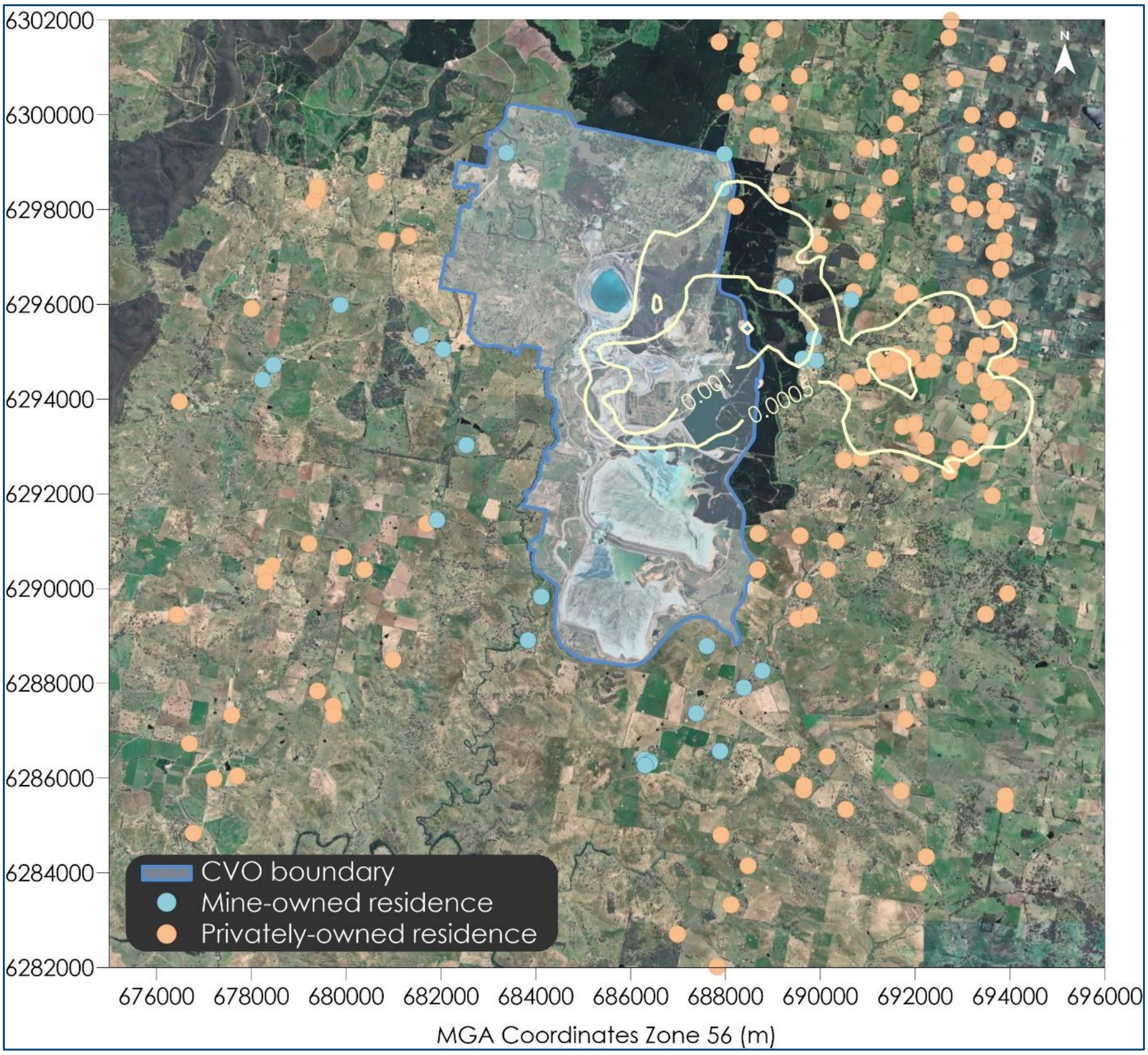


Figure 6-12: Predicted 99.9th percentile 1-hour average Cd levels (µg/m³)

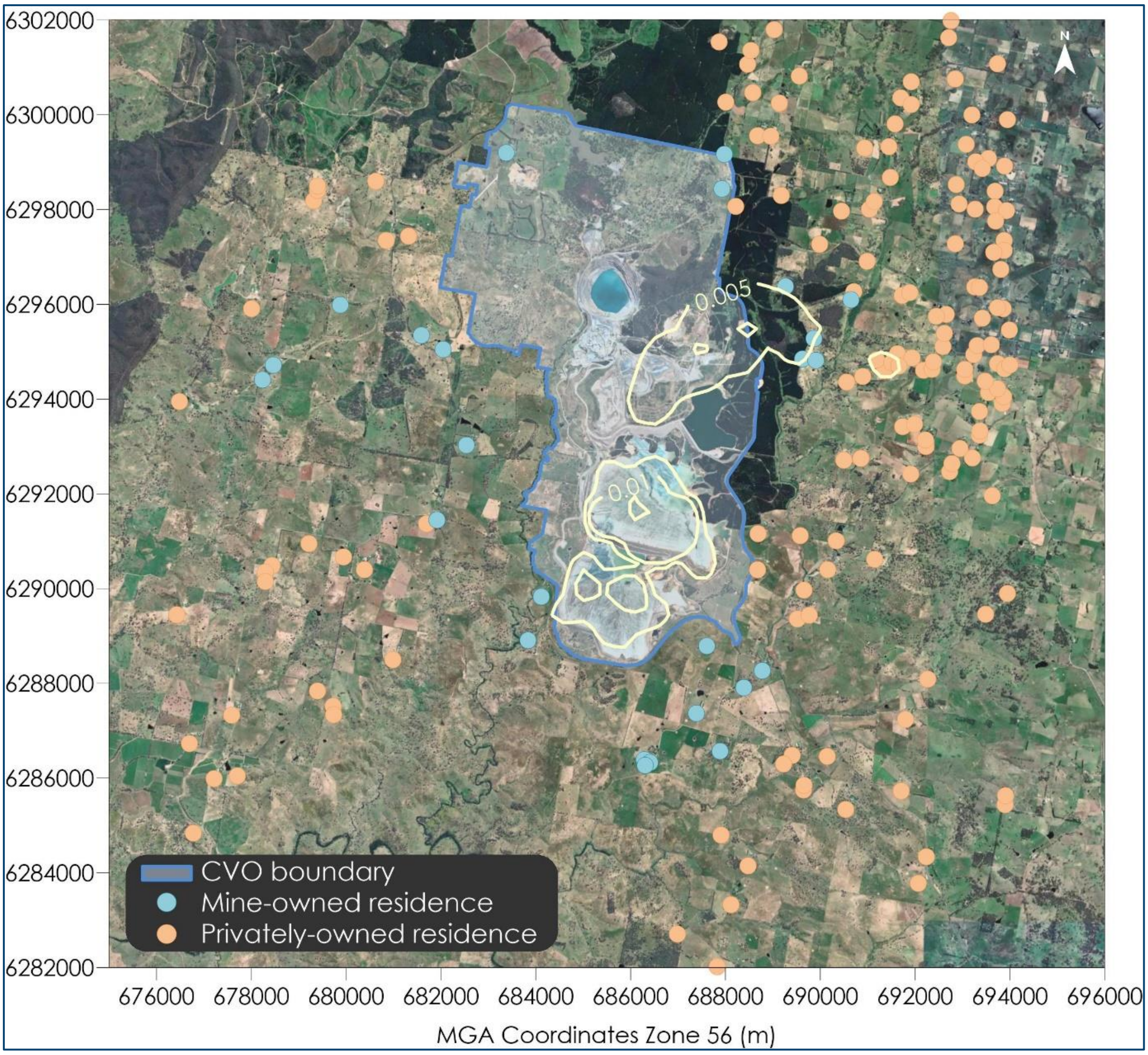


Figure 6-13: Predicted 99.9th percentile 1-hour average Co levels (µg/m³)

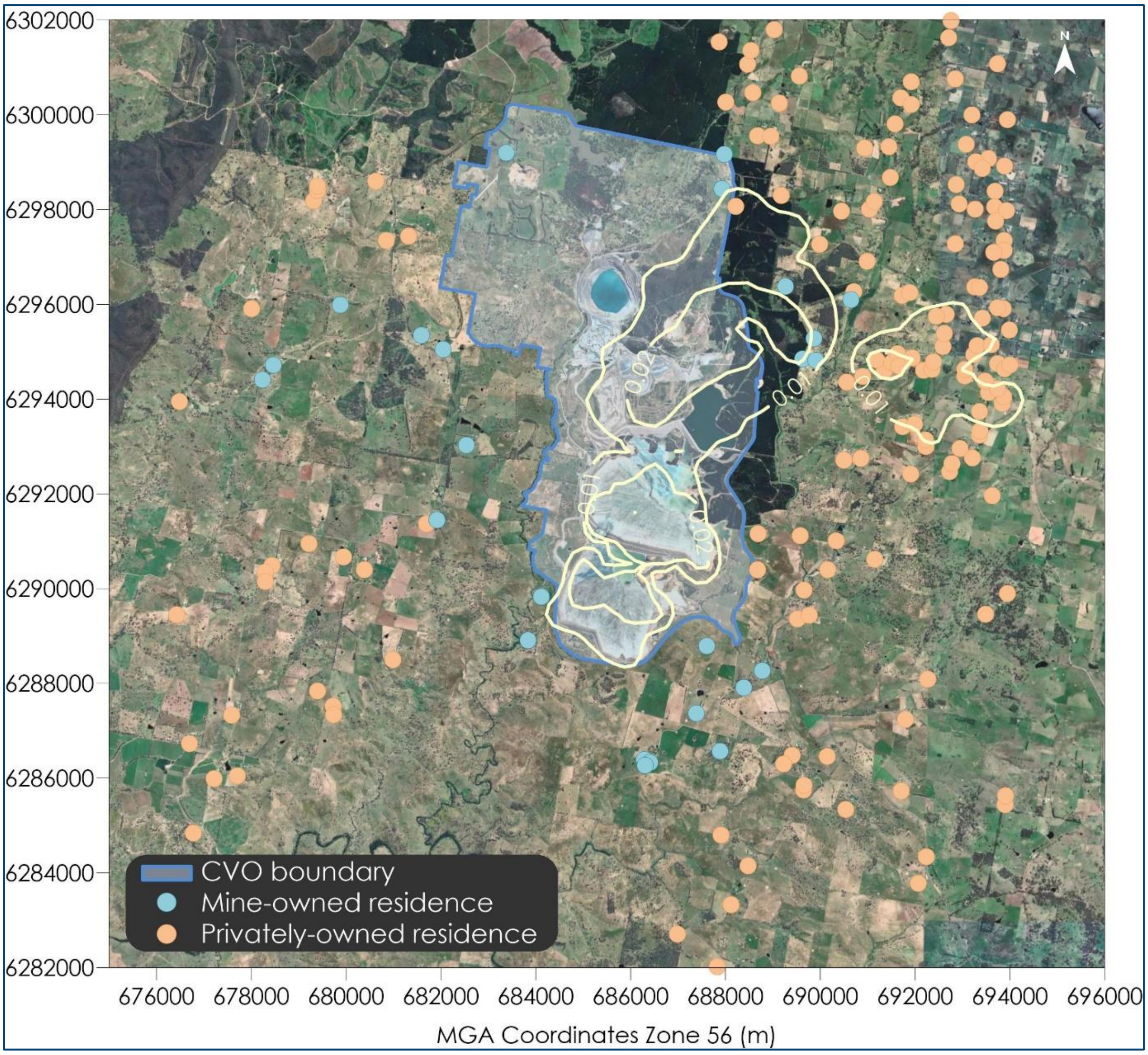


Figure 6-14: Predicted 99.9th percentile 1-hour average Cr levels (µg/m³)

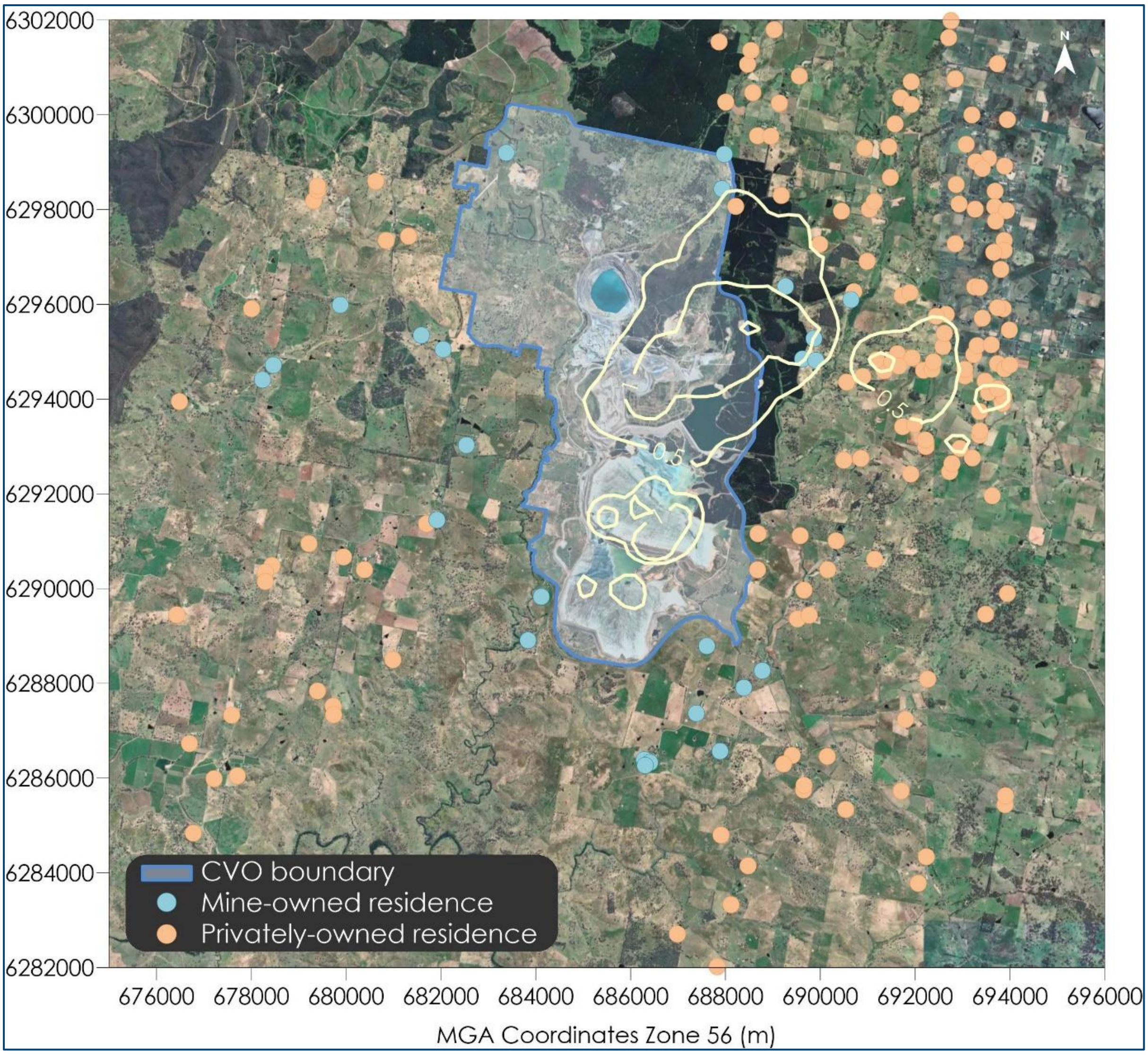


Figure 6-15: Predicted 99.9th percentile 1-hour average Cu levels (µg/m³)

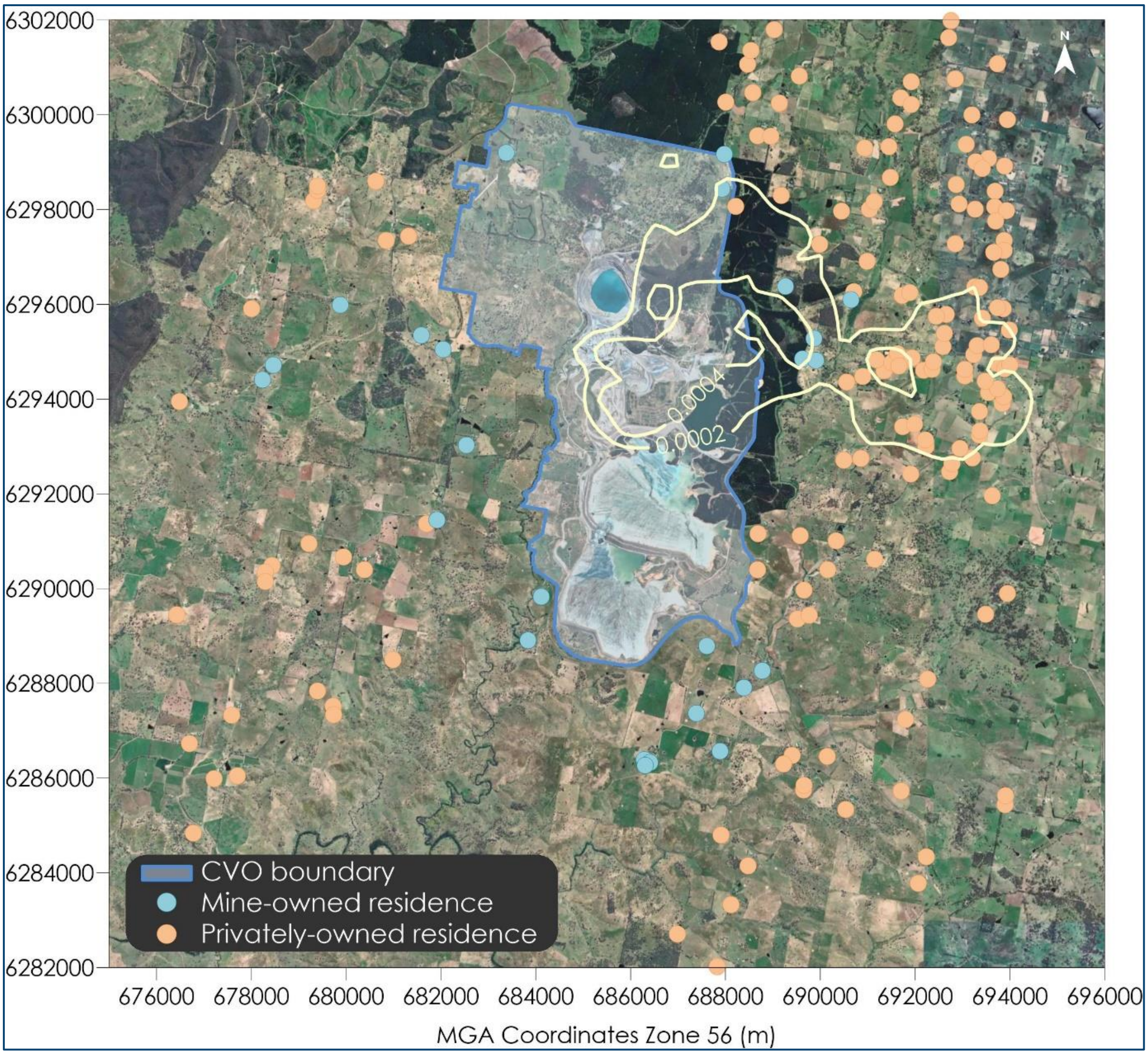


Figure 6-16: Predicted 99.9th percentile 1-hour average Hg levels (µg/m³)

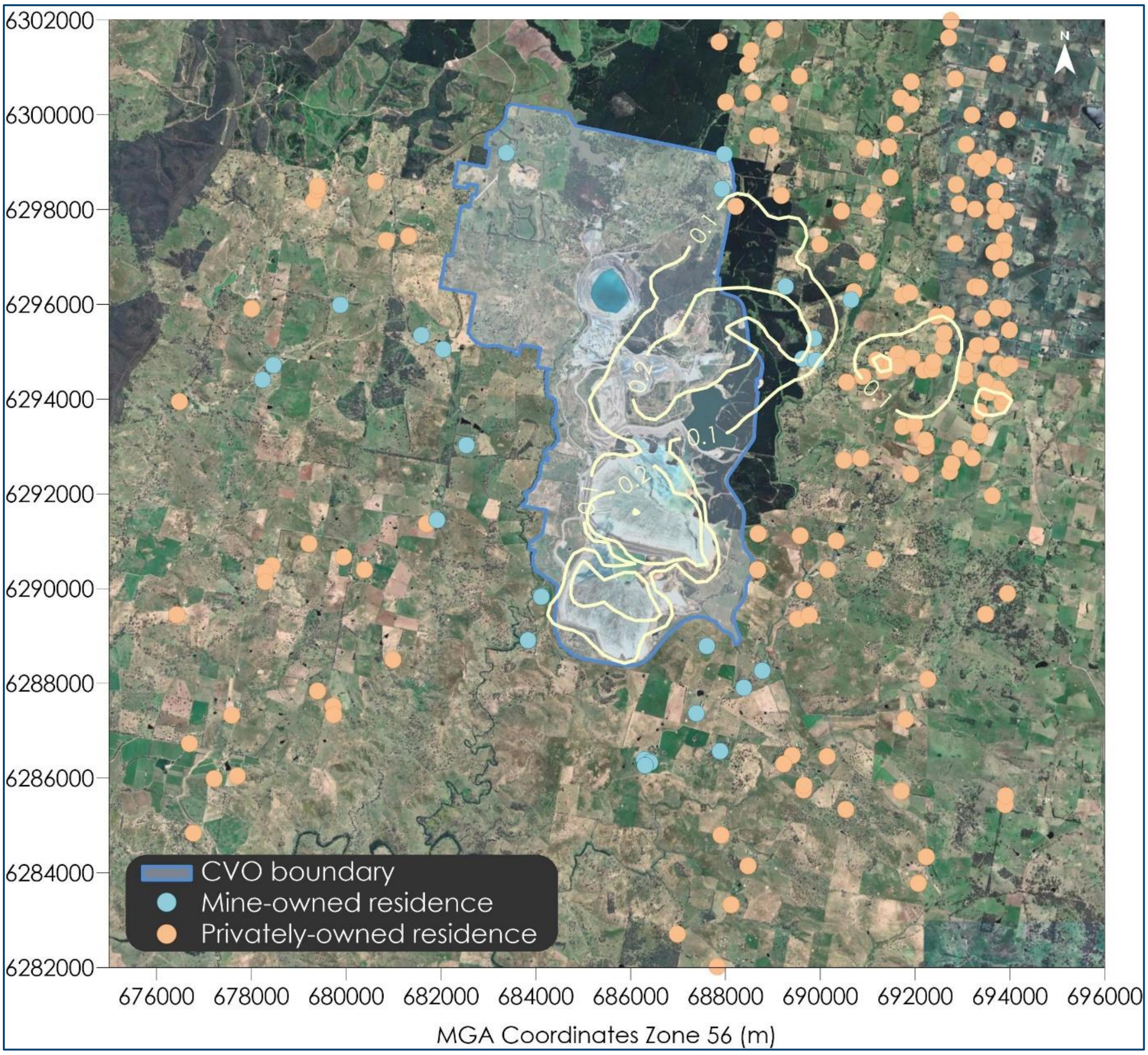


Figure 6-17: Predicted 99.9th percentile 1-hour average Mn levels (µg/m³)

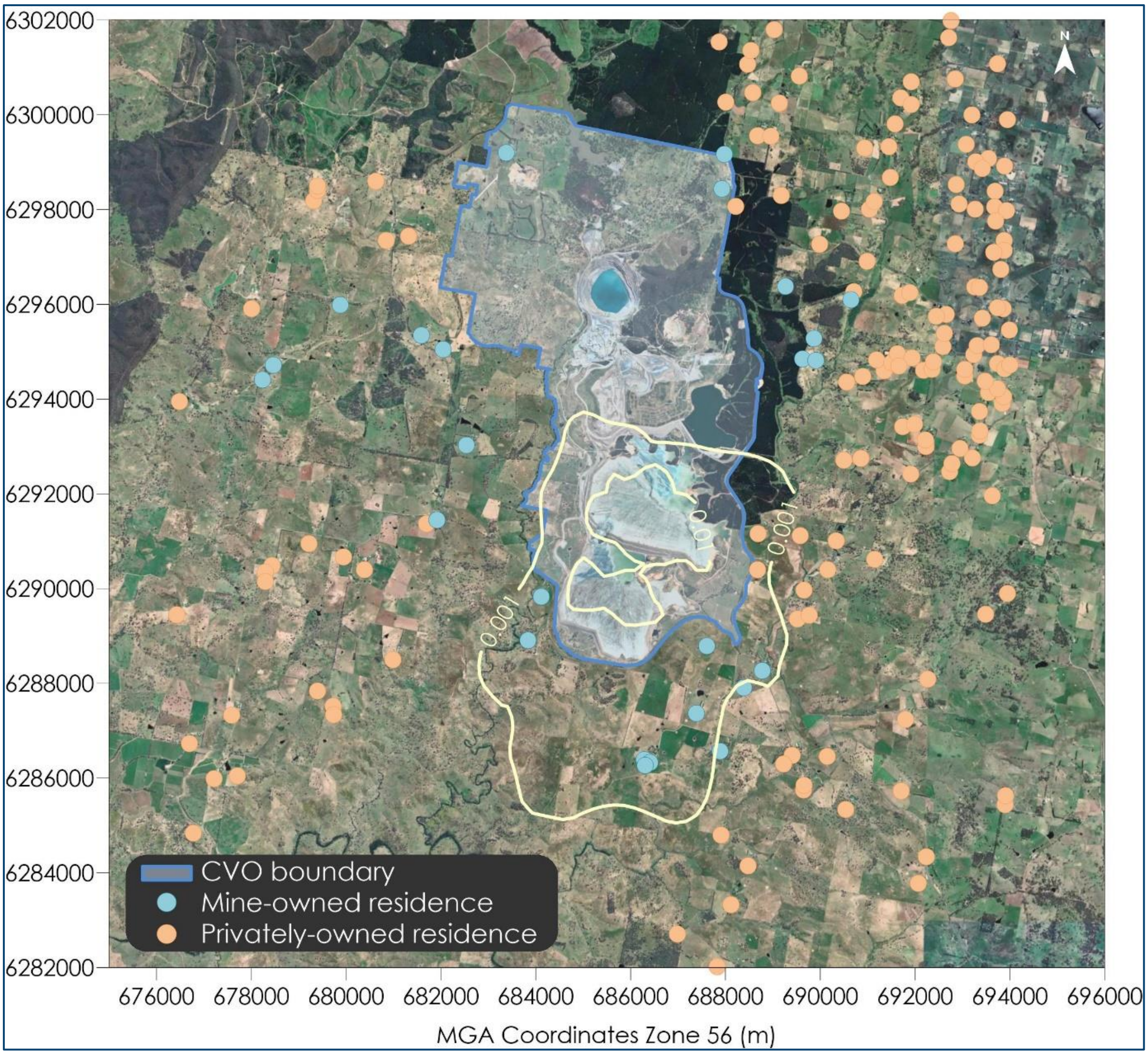


Figure 6-18: Predicted 99.9th percentile 1-hour average Mo levels (µg/m³)

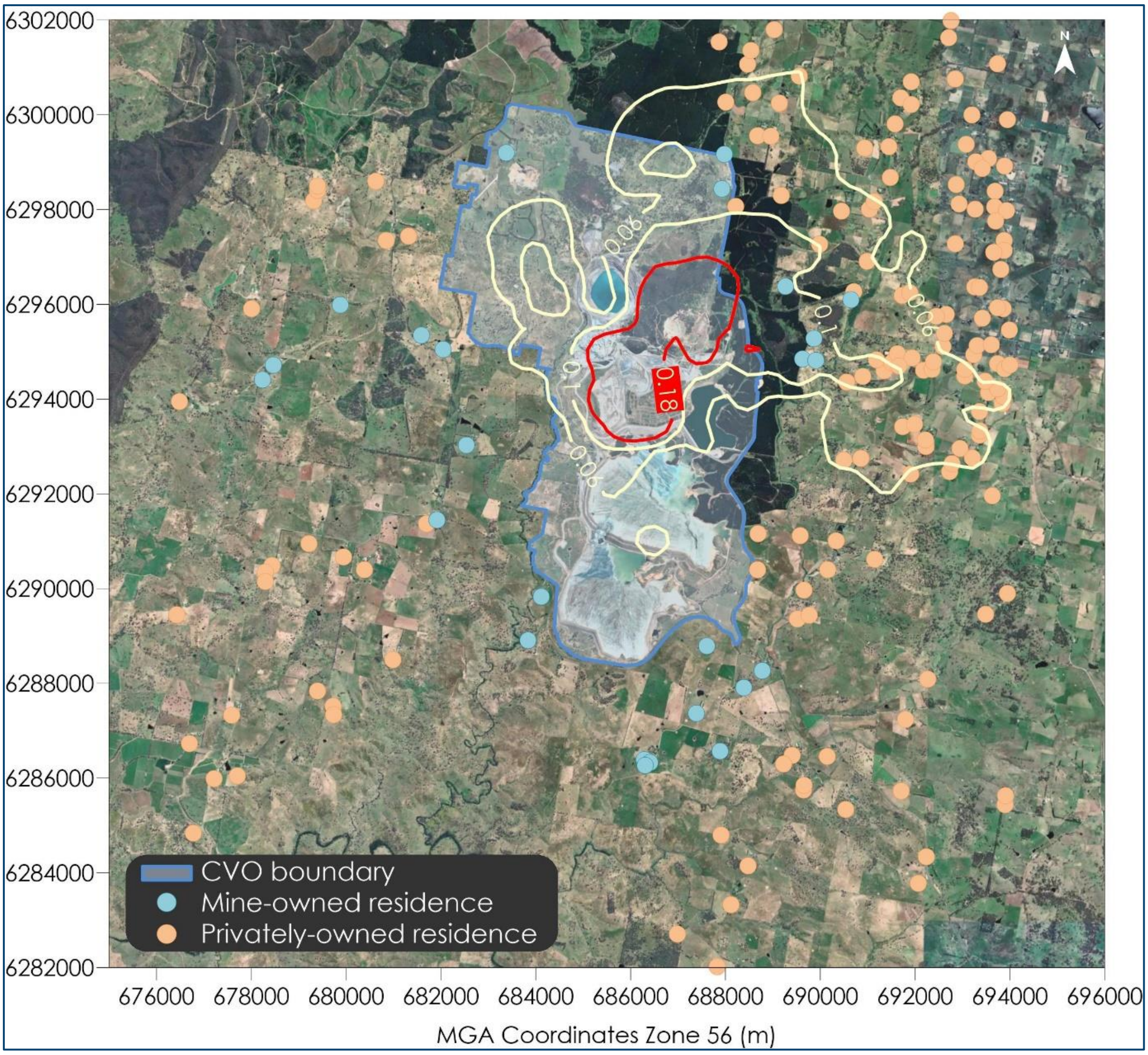


Figure 6-19: Predicted 99.9th percentile 1-hour average Ni levels (µg/m³)

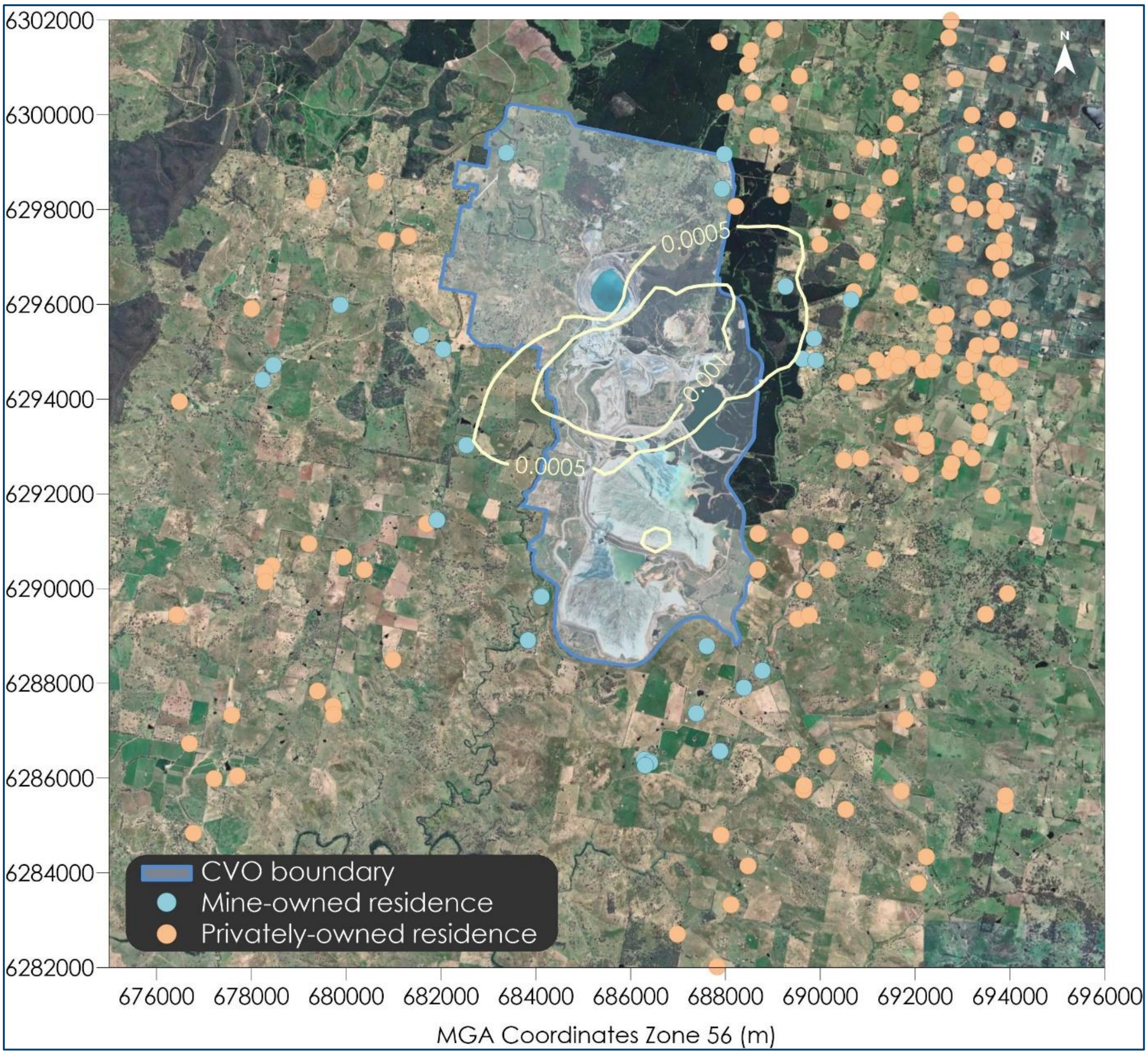


Figure 6-20: Predicted 100th percentile annual average Pb levels (µg/m³)

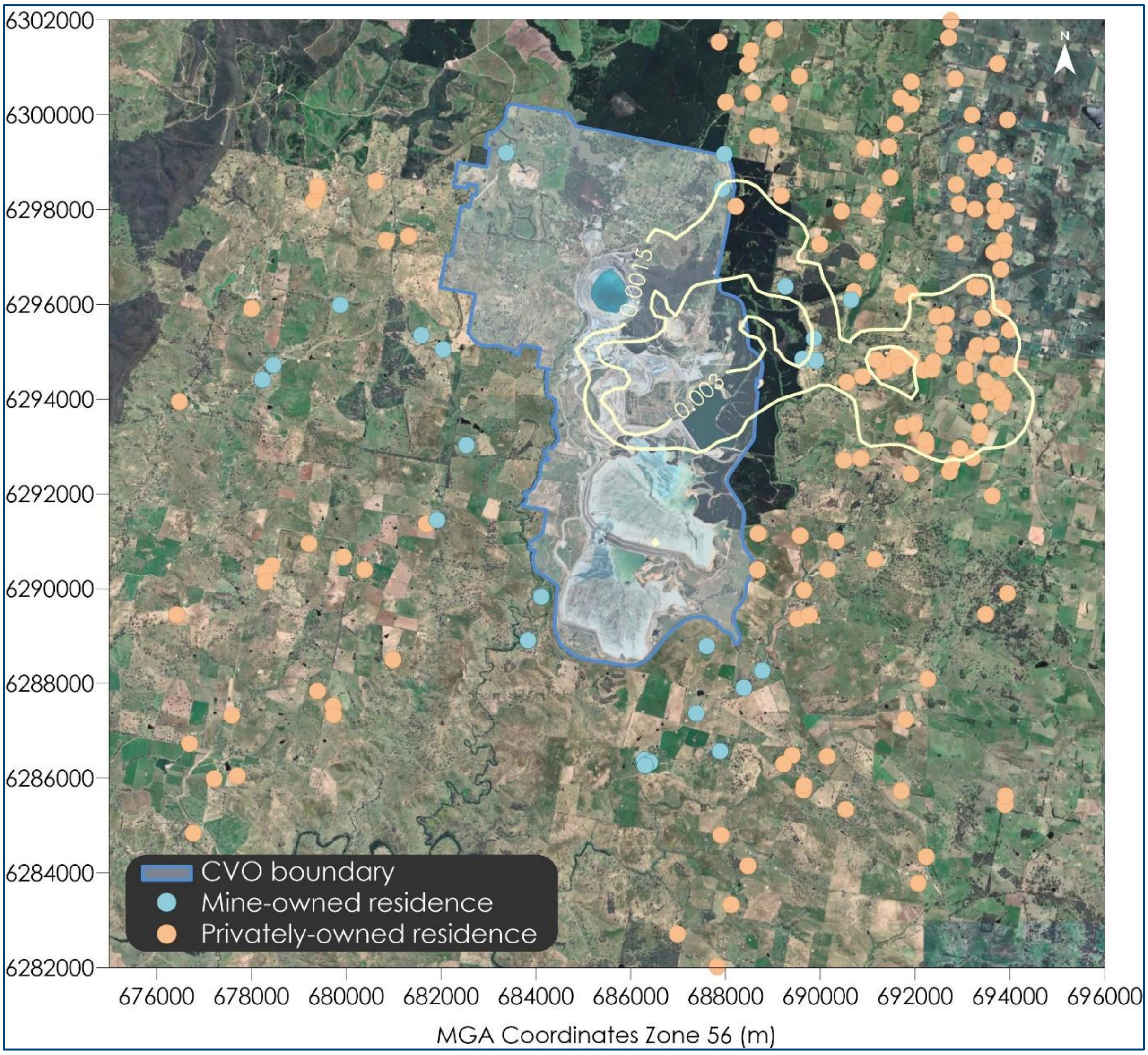


Figure 6-21: Predicted 99.9th percentile 1-hour average Sb levels (µg/m³)

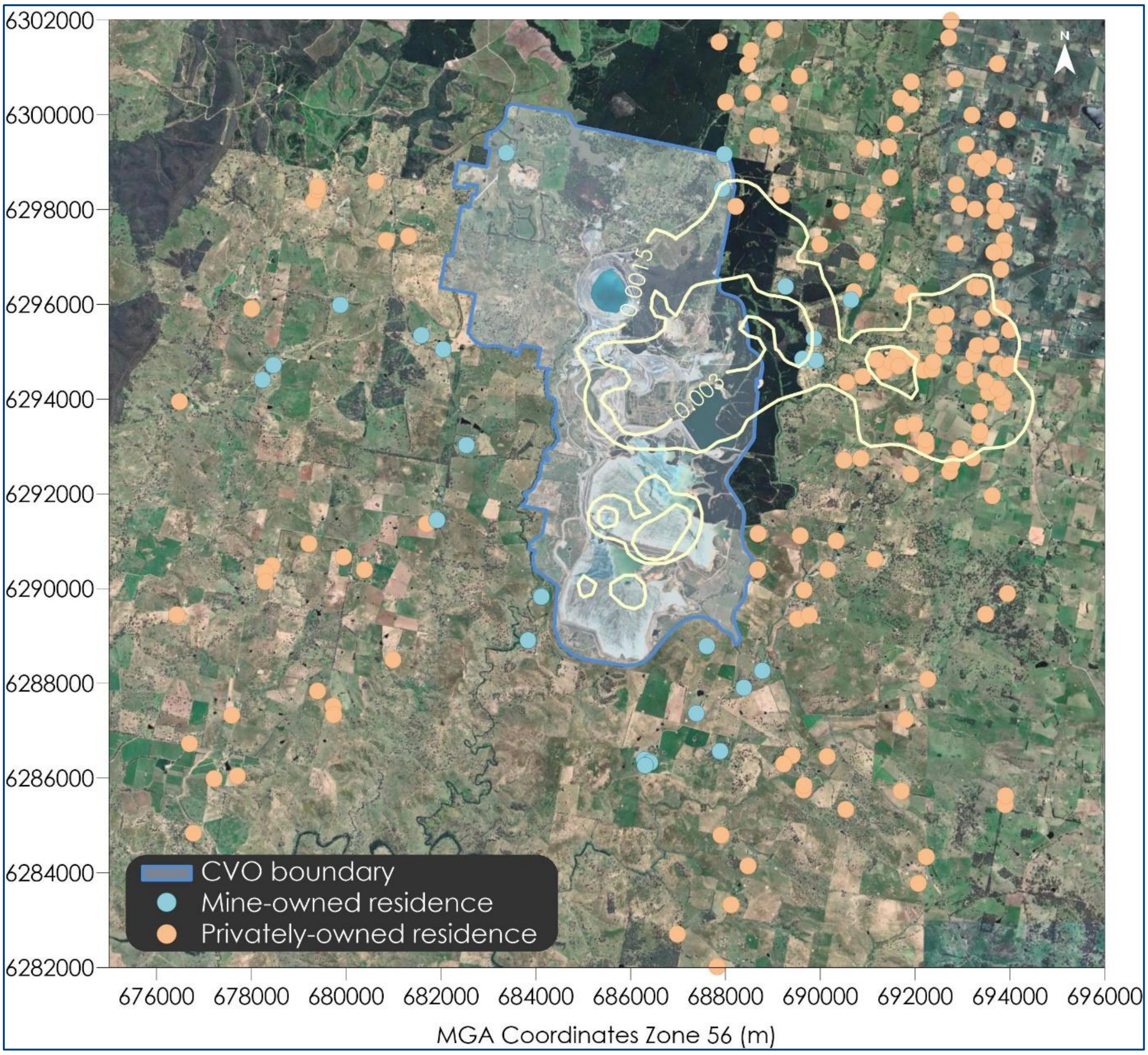


Figure 6-22: Predicted 99.9th percentile 1-hour average Se levels (µg/m³)

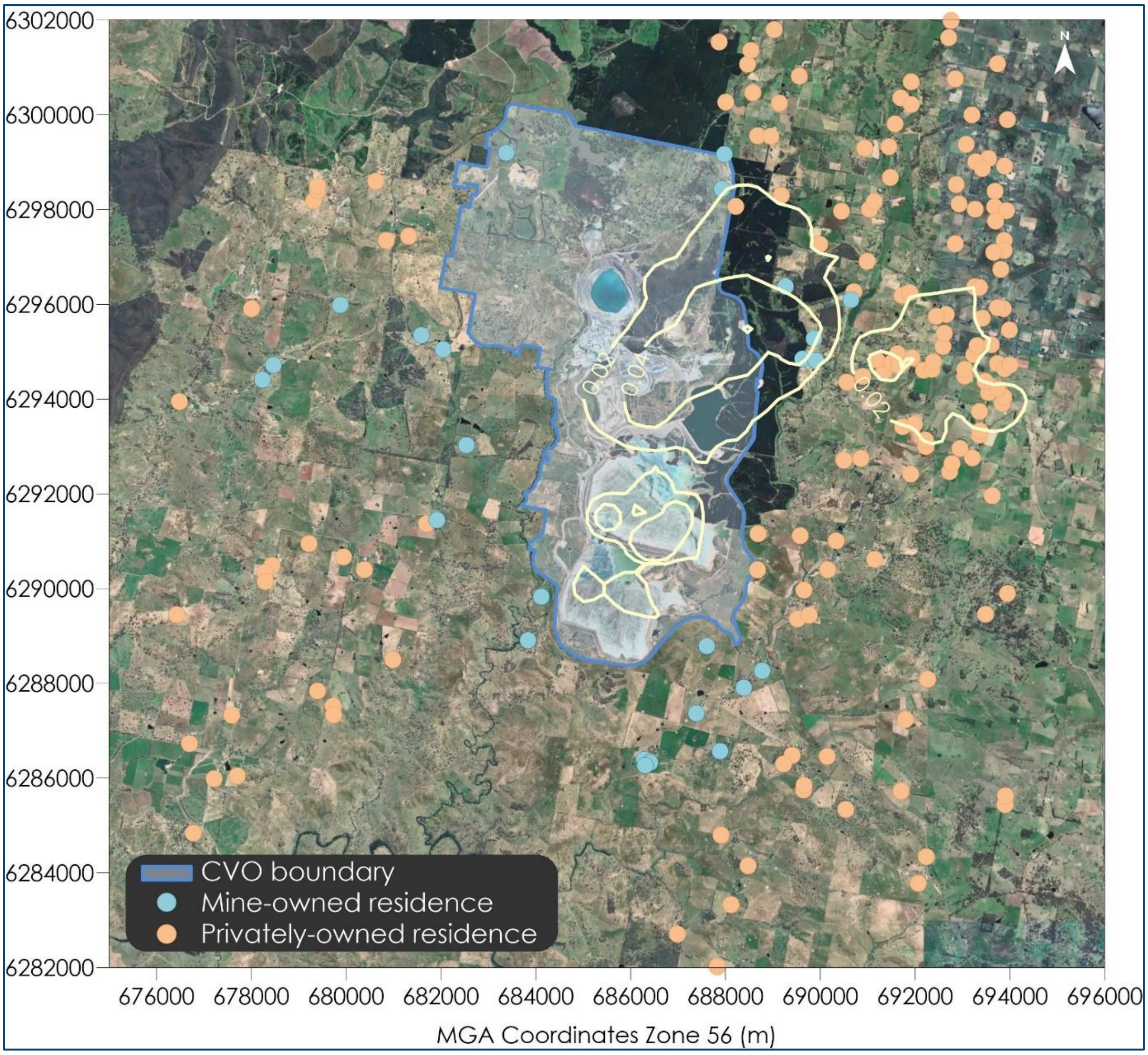


Figure 6-23: Predicted 99.9th percentile 1-hour average V levels (µg/m³)

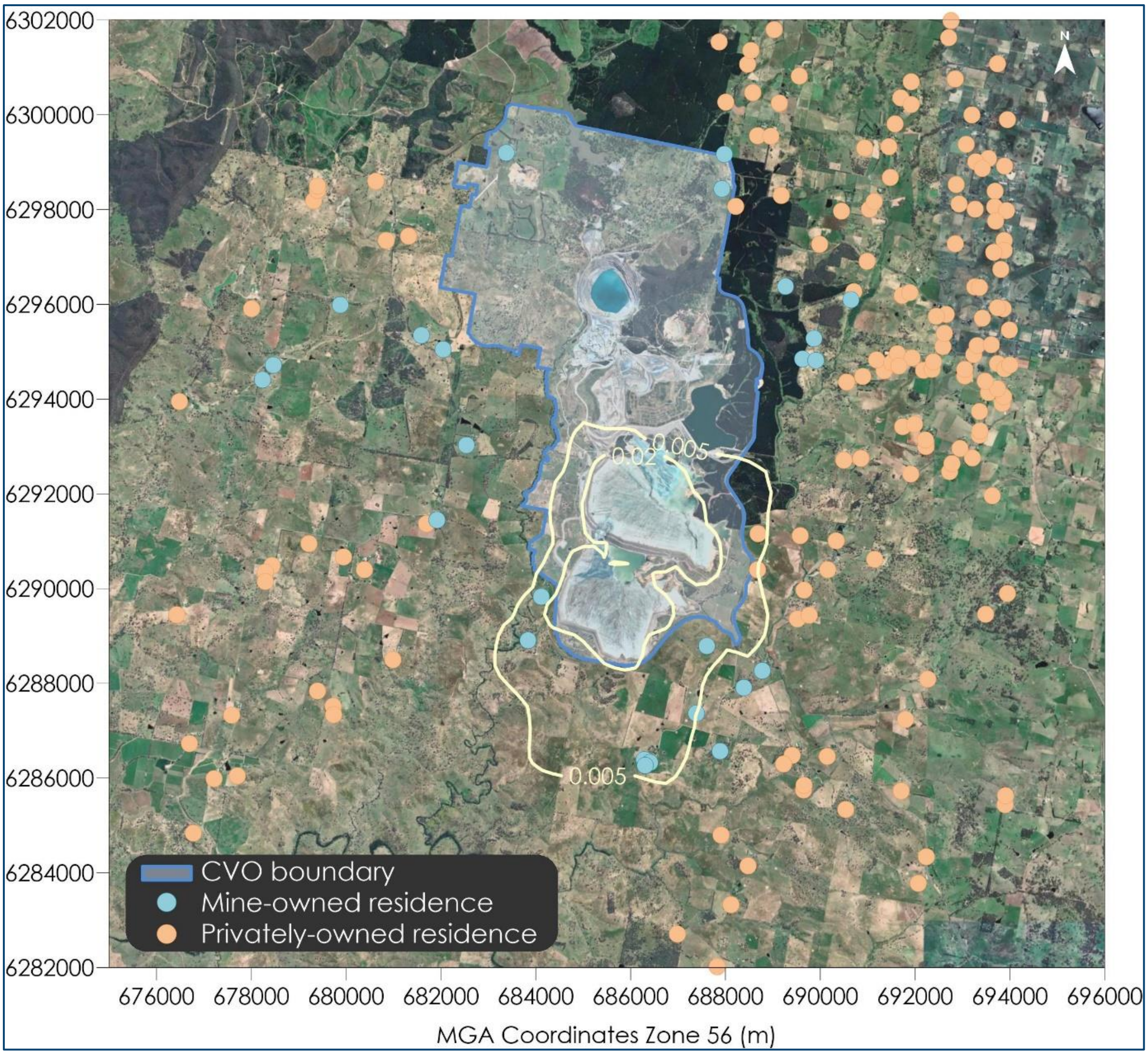


Figure 6-24: Predicted 99.9th percentile 1-hour average Zn levels (µg/m³)

Predicted metal deposition levels are summarised in highest maximum predicted level at any privately-owned receptors, locations off-site (i.e., beyond the site boundary) and the maximum predicted level of the modelling domain. It should be noted that there are no applicable criteria for metal deposition.

Isopleths of the predicted metal deposition is presented in **Appendix B**.

Table 6-3: Summary of modelling predictions for metal deposition (g/m²/month)

Pollutant	Averaging period	Percentile	Maximum predicted results at any privately-owned receptor	Maximum predicted results off-site	Maximum predicted results domain
Ag	AA	100	2.3E-08	1.4E-07	2.8E-06
Al	AA	100	2.2E-03	9.5E-03	1.7E-01
As	AA	100	2.6E-06	5.4E-06	4.9E-05
Ba	AA	100	7.8E-06	2.1E-05	3.5E-04
Be	AA	100	1.3E-07	4.5E-07	8.0E-06
Cd	AA	100	2.6E-07	9.7E-07	1.7E-05
Co	AA	100	1.9E-06	8.5E-06	1.6E-04
Cr	AA	100	5.9E-06	2.4E-05	4.3E-04
Cu	AA	100	2.3E-04	4.5E-04	6.9E-03
Hg	AA	100	1.1E-07	4.4E-07	8.0E-06
Mn	AA	100	5.3E-05	2.2E-04	4.0E-03
Mo	AA	100	2.0E-06	1.2E-05	2.3E-04
Ni	AA	100	5.3E-05	2.6E-04	5.8E-03
Pb	AA	100	1.9E-05	9.0E-05	1.9E-03
Sb	AA	100	8.5E-07	3.1E-06	5.4E-05
Se	AA	100	9.1E-07	3.1E-06	5.4E-05
Sn	AA	100	3.7E-07	1.3E-06	2.2E-05
V	AA	100	8.2E-06	2.0E-05	3.3E-04
Zn	AA	100	8.2E-06	4.9E-05	9.6E-04

6.3 Source apportionment analysis

Source apportionment analysis is conducted at the two most impacted monitoring locations off-site, Meribah and Woodville.

The analysis investigates the maximum possible contribution from key sources or groups of sources at the CVO during the period of maximum impact (annual, 24-hr or 1-hr average). Please note that for metals the maximum 100th percentile impact (not the 99.9th) is used, both for conservatism and to identify the most impacting source. The results of the analysis are presented in **Table 6-4** and **Table 6-5** for Meribah and Woodville, respectively, noting that potential contributions and impacts would generally be less in other locations. The maximum contribution is shaded in light blue in the table.

The analysis shows that dust impacts from the CVO at Meribah are predominantly due to wind erosion from the TSF and from temporary construction activities.

The results for Woodville indicate that general CVO activities contribute to PM_{10} (and potentially that the vent contributes to $PM_{2.5}$, or that there is an unaccounted factor for local $PM_{2.5}$ at Woodville).

The metals emissions appear to be affected by the data from the individual mine vent emissions, noting that only one set of results is available, and the results appear to be sensitive to any variability in this.

Table 6-4: Meribah - Source apportionment analysis at time of maximum impact

Pollutant	Averaging period	CVO General Activity	Wind Erosion - TSF	Construction Activity	VR3A	VR5	VR7	VR8
PM_{25}	24-hr ave.	29.3%	55.1%	15.4%	0.1%	0.0%	0.0%	0.1%
PM_{25}	Ann. ave.	4.3%	8.3%	76.7%	2.3%	0.0%	0.4%	7.9%
PM_{10}	24-hr ave.	24.5%	62.5%	13.0%	0.1%	0.0%	0.0%	0.0%
PM_{10}	Ann. ave.	10.5%	17.1%	68.0%	2.1%	0.0%	0.5%	1.7%
TSP	Ann. ave.	7.5%	13.9%	75.7%	1.3%	0.0%	0.3%	1.2%
DD	Ann. ave.	10.8%	41.4%	45.8%	0.7%	0.0%	0.2%	1.1%
Al	1-hr ave.	0.0%	0.0%	0.0%	34.8%	0.0%	12.1%	53.1%
Sb	1-hr ave.	0.0%	0.0%	0.0%	31.2%	31.3%	37.0%	0.5%
As	1-hr ave.	0.0%	0.0%	0.0%	92.8%	0.9%	3.5%	2.8%
Ba	1-hr ave.	0.0%	0.0%	0.0%	30.2%	0.4%	23.6%	45.8%
Be	1-hr ave.	0.0%	0.0%	0.0%	35.7%	35.6%	28.2%	0.6%
Cd	1-hr ave.	0.0%	0.0%	0.0%	56.2%	31.6%	11.7%	0.6%
Cr	1-hr ave.	0.0%	0.0%	0.0%	31.8%	0.3%	30.0%	37.9%
Co	1-hr ave.	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Cu	1-hr ave.	0.0%	0.0%	0.0%	21.7%	0.0%	8.2%	70.1%
Pb	Ann. ave.	0.0%	0.0%	0.0%	3.2%	96.6%	0.2%	0.0%
Mn	1-hr ave.	0.0%	0.0%	0.0%	32.9%	0.1%	11.1%	55.9%
Hg	1-hr ave.	0.0%	0.0%	0.0%	35.7%	35.6%	28.2%	0.5%
Mo	1-hr ave.	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Ni	1-hr ave.	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%
Se	1-hr ave.	0.0%	0.0%	0.0%	31.2%	31.3%	37.0%	0.5%
Ag	1-hr ave.	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sn	1-hr ave.	0.0%	0.0%	0.0%	36.2%	29.0%	34.4%	0.4%
Zn	1-hr ave.	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
V	1-hr ave.	0.0%	0.0%	0.0%	40.0%	0.0%	10.8%	49.2%

Table 6-5: Woodville - Source apportionment analysis at time of maximum impact

Pollutant	Averaging period	CVO General Activity	Wind Erosion - TSF	Construction Activity	VR3A	VR5	VR7	VR8
PM_{25}	24-hr ave.	1.9%	0.0%	0.2%	25.9%	0.1%	2.7%	69.1%
PM_{25}	Ann. ave.	18.6%	0.2%	17.8%	16.0%	0.2%	2.3%	44.9%
PM_{10}	24-hr ave.	76.6%	0.0%	1.3%	11.1%	0.0%	1.8%	9.3%
PM_{10}	Ann. ave.	60.6%	0.5%	15.1%	12.9%	0.1%	2.5%	8.3%
TSP	Ann. ave.	56.6%	0.5%	20.5%	10.9%	0.2%	2.3%	9.0%
DD	Ann. ave.	53.5%	1.2%	22.2%	7.9%	0.2%	2.4%	12.6%
Al	1-hr ave.	0.0%	0.0%	0.0%	58.9%	0.8%	16.8%	23.5%
Sb	1-hr ave.	0.0%	0.0%	0.0%	27.2%	26.1%	42.1%	4.6%
As	1-hr ave.	0.0%	0.0%	0.0%	94.7%	0.0%	2.2%	3.1%
Ba	1-hr ave.	0.0%	0.0%	0.0%	42.6%	13.2%	27.3%	16.9%
Be	1-hr ave.	0.0%	0.0%	0.0%	31.5%	30.1%	32.4%	5.9%
Cd	1-hr ave.	0.0%	0.0%	0.0%	52.1%	28.1%	14.2%	5.6%
Cr	1-hr ave.	0.0%	0.0%	0.0%	42.7%	10.8%	33.2%	13.3%
Co	1-hr ave.	0.0%	0.0%	0.0%	60.1%	3.3%	12.9%	23.6%
Cu	1-hr ave.	0.0%	0.0%	0.0%	45.9%	1.1%	14.2%	38.8%
Pb	Ann. ave.	0.0%	0.7%	0.0%	16.2%	57.9%	25.1%	0.0%
Mn	1-hr ave.	0.0%	0.0%	0.0%	56.4%	3.0%	15.6%	25.1%
Hg	1-hr ave.	0.0%	0.0%	0.0%	31.9%	30.5%	32.8%	4.8%
Mo	1-hr ave.	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Ni	1-hr ave.	0.0%	0.0%	0.0%	5.9%	86.5%	6.1%	1.6%
Se	1-hr ave.	0.0%	0.0%	0.0%	27.2%	26.1%	42.1%	4.6%
Ag	1-hr ave.	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sn	1-hr ave.	0.0%	0.0%	0.0%	32.0%	24.6%	39.7%	3.6%
Zn	1-hr ave.	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
V	1-hr ave.	0.0%	0.0%	0.0%	64.4%	0.7%	14.3%	20.7%

7 SUMMARY AND CONCLUSIONS

This report has assessed the potential for impacts to arise from CVO activities, based on detailed actual emissions data, production information and ambient monitoring data. This includes emissions from the mine upcast vents and from construction works to rectify the tailings storage facility containment.

The study found that the actual ambient monitoring data showed no exceedances of the EPA criteria at any time at any location. This is consistent with the concurrent ANSTO measurements. The data indicates that air quality around the CVO is very good.

The study also considered metals concentrations from the key sources, being the Tailings Storage Facilities (TSF) and the mine vents. These two sources may contain material different to the local environment, noting that roads etc on the site are comprised of endemic material which is consistent with the material in the general locality.

There is a significant body of reliable dust and metals measurements for the TSFs. The normal operations of the TSF's are currently suspended due to a dam failure, and hence may produce fugitive air quality emissions on some days. This can be seen in the ambient monitoring data and is also apparent in the modelling results which align very well in the vicinity of the TSF's. Importantly, the ambient monitoring and the modelling results did not find that the dust levels near the TSF were exceeding EPA criteria, or that any dust contribution from high dust episodes from the TSF was making a significant impact or that led to any exceedances of the criteria for particulates or metals.

The modelled predictions align well with the ambient monitoring data for PM_{10} when the mine vent emissions are scaled down very significantly. This is necessary, as the mine vent sampling is unreliable (too high to be plausible) due to collecting mud slurry droplets in the high velocity bend that is sampled etc., as discussed in detail in Section 5.5 of this report.

The modelling data do not align well with the ambient $PM_{2.5}$ monitoring data at Woodville. Whilst the maximum effects of the vent emissions would arise near Woodville, it is also clear from the ambient data that the effect of the emissions from the vents is relatively low, noting that all the monitoring data is below ambient criteria. For the effects of the mine vent emissions to align with the ambient monitoring results, the mine vent $PM_{2.5}$ emissions would need to be higher than the mine vent PM_{10} emissions (which is not possible), hence the issue warrant further investigation.

There are several plausible or likely factors for this discrepancy which are discussed in detail in this report but cannot be quantified at this time. The factors include the likely presence of localised $PM_{2.5}$ dust sources near the Woodville monitor, such as wood heaters, pollens, and dust from nearby dirt roads. There are also likely issues in the vent particle mass and particle size distribution measurements, and possible issues in the monitoring data at Woodville. Potentially there may be an error in the modelling, but for such an error to only arise at Woodville is unlikely. The issue warrants closer attention, and it would be feasible for example to test the veracity or bias in the $PM_{2.5}$ ambient monitoring data at Woodville, as suggested in this report. Nevertheless, there is significant amount of ambient air quality monitoring data which only shows a relatively low effect on particulate levels from the direction of the mine vents.

The modelling and monitoring results indicate to exceedances of the EPA dust or metals criteria at any receptor location. Modelling results for the available metals data for emissions from the mine vents indicate that all metals, apart from nickel would be well below the criteria at any location at the boundary or beyond. The modelled results show that nickel levels may be marginal near the boundary near the mine vent, however due to the likely overprediction in the modelling, it is unlikely that there is any actual exceedance in practice. In any case, this does not occur in any location near people or dwellings, either mine owned or private.

Overall, the study found no impact in the area around the CVO that may affect any persons or exceed EPA criteria but identified some anomalies near Woodville.

As it is understood that the CVO has installed pollution controls to abate mine vent emissions (which are not considered in this report), this anomaly at Woodville may no longer be relevant.

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Appendix A

Dust Emission Calculations

Emission Calculation

The mining schedule and mine plan designs provided by the Proponent have been combined with emissions factor equations that relate to the quantity of dust emitted from particular activities based on intensity, the prevailing meteorological conditions, and composition of the material being handled.

Emission factors and associated controls have been sourced from:

- United States (US) EPA AP42 Emission Factors (**US EPA, 1985 and Updates**);
- National Pollutant Inventory document, *Emission Estimation Technique Manual for Mining, Version 3.1* (**NPI, 2012**); and,
- NSW EPA document, *NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining*, prepared by Katestone Environmental (**Katestone Environmental, 2011**).

The emission factor equations used for each dust generating activity are outlined in **Table A-1** below. A detailed dust emission inventory for the modelled scenario is presented in **Table A-2** and **Table A-3**.

Control factors include the following:

- Hauling on unpaved surfaces – 85% control for watering of trafficked areas.
- Conveyor transfer points – 70% control for enclosures.
- Conveyor – 70% control for enclosed conveyors.
- Crusher – 90% control for enclosure.
- Wind erosion – 50% control for watering

Table A-1: Emission factor equations

Activity	Emission factor equation		
	TSP	PM_{10}	$PM_{2.5}$
Loading / emplacing overburden	$EF = 0.74 \times 0.0016 \times \left(\frac{U}{2.2}^{1.3} / \frac{M}{2}^{1.4}\right) kg/tonne$	$EF = 0.35 \times 0.0016 \times \left(\frac{U}{2.2}^{1.3} / \frac{M}{2}^{1.4}\right) kg/tonne$	$EF = 0.053 \times 0.0016 \times \left(\frac{U}{2.2}^{1.3} / \frac{M}{2}^{1.4}\right) kg/tonne$
Hauling on unsealed surfaces	$EF = \left(\frac{0.4536}{1.6093}\right) \times 4.9 \times (s/12)^{0.7} \times (1.1023 \times M/3)^{0.45} kg/VKT$	$EF = \left(\frac{0.4536}{1.6093}\right) \times 1.5 \times (s/12)^{0.9} \times (1.1023 \times M/3)^{0.45} kg/VKT$	$EF = \left(\frac{0.4536}{1.6093}\right) \times 0.15 \times (s/12)^{0.9} \times (1.1023 \times M/3)^{0.45} kg/VKT$
Dozers on overburden	$EF = 2.6 \times s^{1.2} / M^{1.3} \; kg/hr$	$EF = (0.45 \times s^{1.5} / M^{1.4}) \times 0.75 \; kg/hr$	$EF = (2.6 \times s^{1.2} / M^{1.3}) \times 0.105 \; kg/hr$
Secondary ore crushing	$EF = (0.0027 + 0.0125) \; kg/t$	$EF = (0.0012 + 0.0043) \; kg/t$	$PM10 \times (0.00005/0.00027) \; kg/t$
Wind erosion on exposed areas, stockpiles	$EF = 3{,}504 \; kg/ha/year$	$0.5 \times TSP$	$0.075 \times TSP$
Grading roads	$EF = 0.0034 \times (S)^{2.5}$	$EF = 0.0056 \times (S)^{2} \times 0.6$	$EF = 0.0034 \times (S)^{2.5} \times 0.031$

EF = emission factor, U = wind speed (m/s), M = moisture content (%), s = silt content (%), W = average weight of vehicle (tonne), VKT = vehicle kilometres travelled (km), S = mean vehicle speed (kph).

Table A-2: Dust Emissions Inventory – January 2022 to December 2022

CVO operations																					
Activity	**TSP emission**	**PM10 emission**	**PM25 emission**	**Intensity**	**Units**	**EF - TSP**	**EF - PM10**	**EF - PM25**	**Units**	**Var. 1**	**Units**	**Var. 2**	**Units**	**Var. 3 (TSP / PM10 / PM2.5)**	**Units**	**Var. 4**	**Units**	**Var. 5**	**Units**	**Control**	**Units**
CE - General construction work	430,256	79,099	45,177	138,385	h/y	3.109	0.572	0.326	kg/h	5	S.C. (%)	3.85	M.C. (%)								
CE - Loading waste to trucks	807	382	58	827,705	t/y	0.001	0.000	0.000	kg/t	2.06	ave. $(ws/2.2)^{1.3}$	3.85	M.C. (%)								
CE - Hauling waste to emplacement area	13,841	3,556	356	827,705	t/y	0.111	0.029	0.003	kg/t	199	t/load	3.92	km/return trip	5.7 / 1.5 / 0.1	kg/VKT	5	S.C. (%)	243.8	Ave weight (tonnes)	85	% Control
CE - Emplacing waste at dump	807	382	58	827,705	t/y	0.001	0.000	0.000	kg/t	2.06	ave. $(ws/2.2)^{1.3}$	3.85	M.C. (%)								
CE - Dozers working on waste rock dumps	16,839	3,096	1,768	5,416	h/y	3.109	0.572	0.326	kg/h	5	S.C. (%)	3.85	M.C. (%)								
CE - Secondary ore crushing	14,995	5,426	467	4,932,538	t/y	0.030	0.011	0.001	kg/t											90	% Control
CE - Loading crushed ore to storage pile from underground	4,042	1,912	289	4,145,282	t/y	0.001	0.000	0.000	kg/t	2.06	ave. $(ws/2.2)^{1.3}$	3.85	M.C. (%)								
CE - Ore processing in mill (x5)	146,465	69,274	10,490	150,216,255	t/y	0.001	0.000	0.000	kg/t	2.06	ave. $(ws/2.2)^{1.3}$	3.85	M.C. (%)								
WE - waste rock dumps	918,048	459,024	68,854	262	ha	3504	1752	263	kg/ha/y												
WE - pit tailing storage facility	224,256	112,128	16,819	64	ha	3504	1752	263	kg/ha/y												
WE - subsidence zone	336,384	168,192	25,229	96	ha	3504	1752	263	kg/ha/y												
WE - plant stockpiles and exposed areas	872,496	436,248	65,437	249	ha	3504	1752	263	kg/ha/y												
WE tailings storage facilities	2,897,808	1,448,904	217,336	827	ha	3504	1752	263	kg/ha/y												
Grading roads	9,466	3,307	293	15,380	km	0.615	0.215	0.019	kg/VKT	8	km/h										
Conveyors and conveyor transfer points	8,788	4,156	629	30,043,251	t/y	0.001	0.000	0.000	kg/t	2.06	ave. $(ws/2.2)^{1.3}$	3.85	M.C. (%)							70	% Control
Tailings Construction Work																					
Stripping topsoil + dozer activity	828,582	152,328	87,001	266,500	h/y	3.109	0.572	0.326	kg/h	5	S.C. (%)	3.85	M.C. (%)								
Loading material to haul truck	6,996	3,309	501	7,174,831	t/y	0.001	0.000	0.000	kg/t	2.06	ave. $(ws/2.2)^{1.3}$	3.85	M.C. (%)								
Hauling material to emplacement area	532,346	136,788	13,679	7,174,831	t/y	0.495	0.127	0.013	kg/t	199	t/load	17.4	km/return trip	5.7 / 1.5 / 0.1	kg/VKT	5.0	S.C. (%)	244	Ave weight (tonnes)	85	% Control
Unloading material at emplacement area	6,996	3,309	501	7,174,831	t/y	0.001	0.000	0.000	kg/t	2.06	ave. $(ws/2.2)^{1.3}$	3.85	M.C. (%)								
Rehandle material	1,399	662	100	1,434,966	t/y	0.001	0.000	0.000	kg/t	2.06	ave. $(ws/2.2)^{1.3}$	3.85	M.C. (%)								
WE - tailings construction area	738,643	369,322	55,398	210.8	ha	3504	1752	262.8	kg/ha/y												
Total Emissions (kg/year)	**8,010,259**	**3,460,803**	**610,440**																		

Table A-2: Dust Emissions Inventory – January 2023 to February 2023

Activity	TSP emission	PM10 emission	PM25 emission	Intensity	Units	EF - TSP	EF - PM10	EF - PM25	Units	Var. 1	Units	Var. 2	Units	Var. 3 (TSP / PM10 / PM2.5)	Units	Var. 4	Units	Var. 5	Units	Control	Units
CVO operations																					
CE - General construction work	85,213	15,666	8,947	27,408	h/y	3.109	0.572	0.326	kg/h	5	S.C. (%)	3.85	M.C. (%)								
CE - Loading waste to trucks	144	68	10	147,800	t/y	0.001	0.000	0.000	kg/t	2.06	ave. $(ws/2.2)^{1.3}$	3.85	M.C. (%)								
CE - Hauling waste to emplacement area	2,472	635	64	147,800	t/y	0.111	0.029	0.003	kg/t	199	t/load	3.92	km/return trip	5.7 / 1.5 / 0.1	kg/VKT	5	S.C. (%)	243.8	Ave weight (tonnes)	85	% Control
CE - Emplacing waste at dump	144	68	10	147,800	t/y	0.001	0.000	0.000	kg/t	2.06	ave. $(ws/2.2)^{1.3}$	3.85	M.C. (%)								
CE - Dozers working on waste rock dumps	2,877	529	302	925	h/y	3.109	0.572	0.326	kg/h	5	S.C. (%)	3.85	M.C. (%)								
CE - Secondary ore crushing	142	51	4	46,558	t/y	0.030	0.011	0.001	kg/t											90	% Control
CE - Loading crushed ore into trucks to feed CR01 from storag	77,822	36,808	5,574	826,548	t/y	0.094	0.045	0.007	kg/t	198.92	ave. $(ws/2.2)^{1.3}$	3.85	M.C. (%)								
CE - Loading crushed ore to storage pile from underground	724	342	52	742,034	t/y	0.001	0.000	0.000	kg/t	2.06	ave. $(ws/2.2)^{1.3}$	3.85	M.C. (%)								
CE - Hauling ore	23,713	6,093	609	1,568,581	t/y	0.101	0.026	0.003	kg/t	157	t/load	2.9	km/return trip	5.5 / 1.4 / 0.1	kg/VKT	5	S.C. (%)	225.0	Ave weight (tonnes)	85	% Control
CE - Emplacing ore at storage location or CR01	1,612	762	115	1,568,581	t/y	0.001	0.000	0.000	kg/t	2.17	ave. $(ws/2.2)^{1.3}$	3.85	M.C. (%)								
CE - Ore processing in mill (x5)	23,378	11,057	1,674	23,976,901	t/y	0.001	0.000	0.000	kg/t	2.06	ave. $(ws/2.2)^{1.3}$	3.85	M.C. (%)								
WE - waste rock dumps	148,397	74,198	11,130	262	ha	566	283	42	kg/ha/y												
WE - pit tailing storage facility	36,250	18,125	2,719	64	ha	566	283	42	kg/ha/y												
WE - subsidence zone	54,374	27,187	4,078	96	ha	566	283	42	kg/ha/y												
WE - plant stockpiles and exposed areas	141,034	70,517	10,578	249	ha	566	283	42	kg/ha/y												
WE tailings storage facilities	468,413	234,206	35,131	827	ha	566	283	42	kg/ha/y												
Grading roads	1,451	507	45	2,357	km	0.615	0.215	0.019	kg/VKT	8	km/h										
Conveyors and conveyor transfer points	1,403	663	100	4,795,380	t/y	0.001	0.000	0.000	kg/t	2.06	ave. $(ws/2.2)^{1.3}$	3.85	M.C. (%)							70	% Control
Tailings Construction Work																					
Stripping topsoil + dozer activity	133,935	24,623	14,063	43,078	h/y	3.109	0.572	0.326	kg/h	5	S.C. (%)	3.85	M.C. (%)								
Loading material to haul truck	1,085	513	78	1,112,321	t/y	0.001	0.000	0.000	kg/t	2.06	ave. $(ws/2.2)^{1.3}$	3.85	M.C. (%)								
Hauling material to emplacement area	82,530	21,206	2,121	1,112,321	t/y	0.495	0.127	0.013	kg/t	199	t/load	17.4	km/return trip	5.7 / 1.5 / 0.1	kg/VKT	5.0	S.C. (%)	244	Ave weight (tonnes)	85	% Control
Unloading material at emplacement area	1,085	513	78	1,112,321	t/y	0.001	0.000	0.000	kg/t	2.06	ave. $(ws/2.2)^{1.3}$	3.85	M.C. (%)								
WE - tailings construction area	119,397	59,699	8,955	211	ha	566	283	42	kg/ha/y												
Total Emissions (kg/year)	**1,407,592**	**604,037**	**106,437**																		

Appendix B
Isopleth Diagrams – Metal Deposition

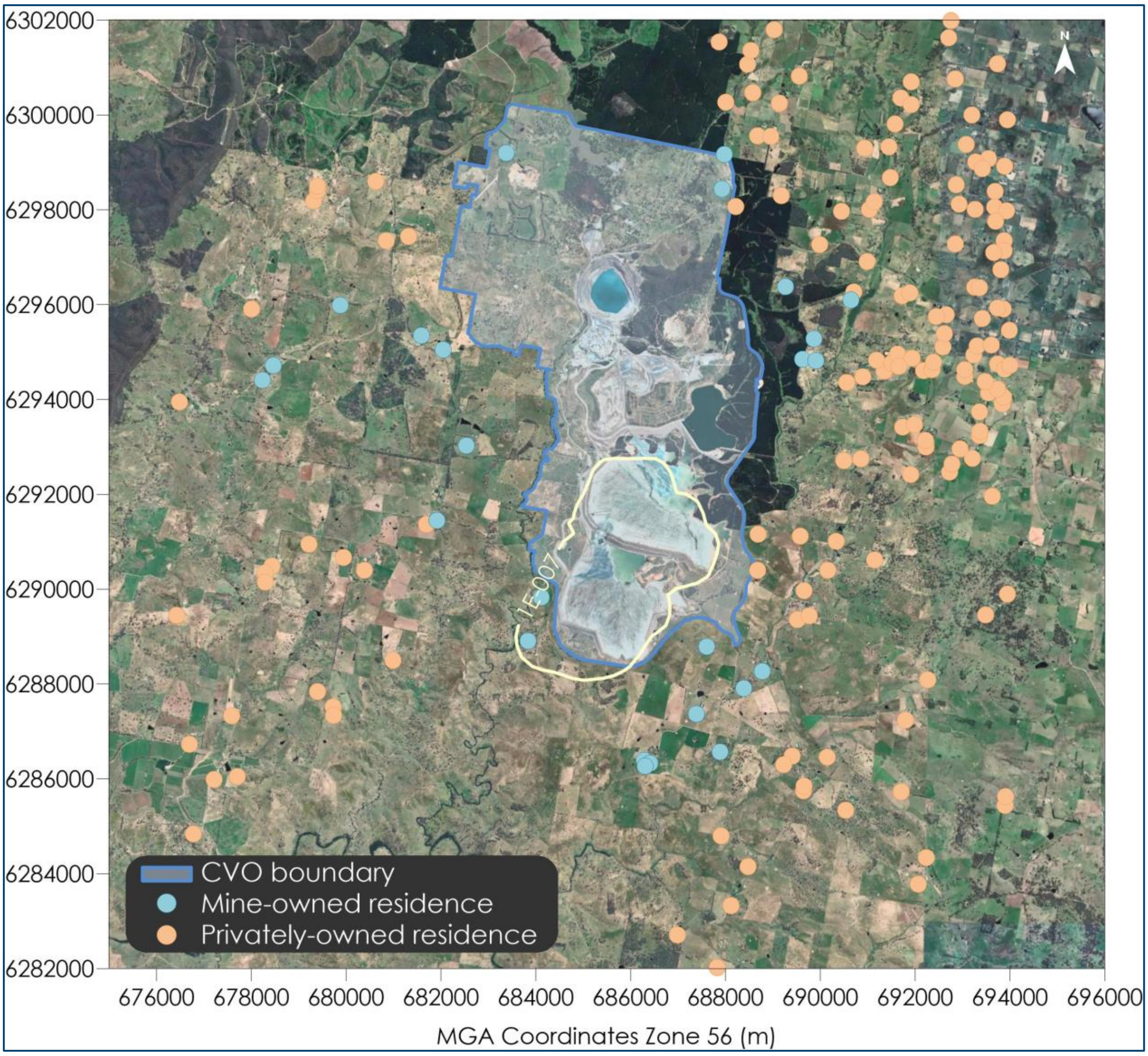

Figure B-1: Predicted 100th percentile annual average Ag deposition levels (g/m²/month)

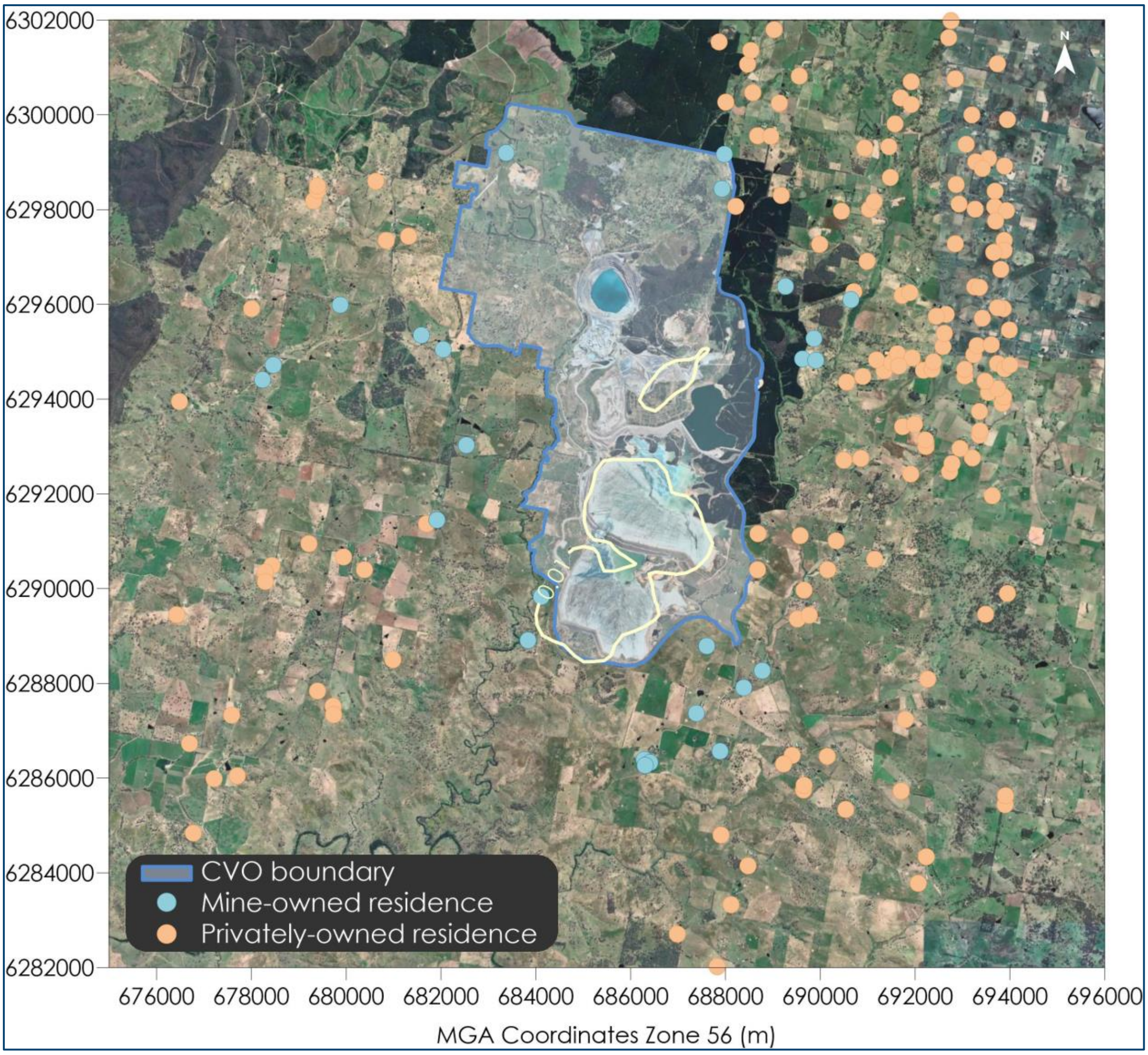

Figure B-2: Predicted 100th percentile annual average Al deposition levels (g/m²/month)

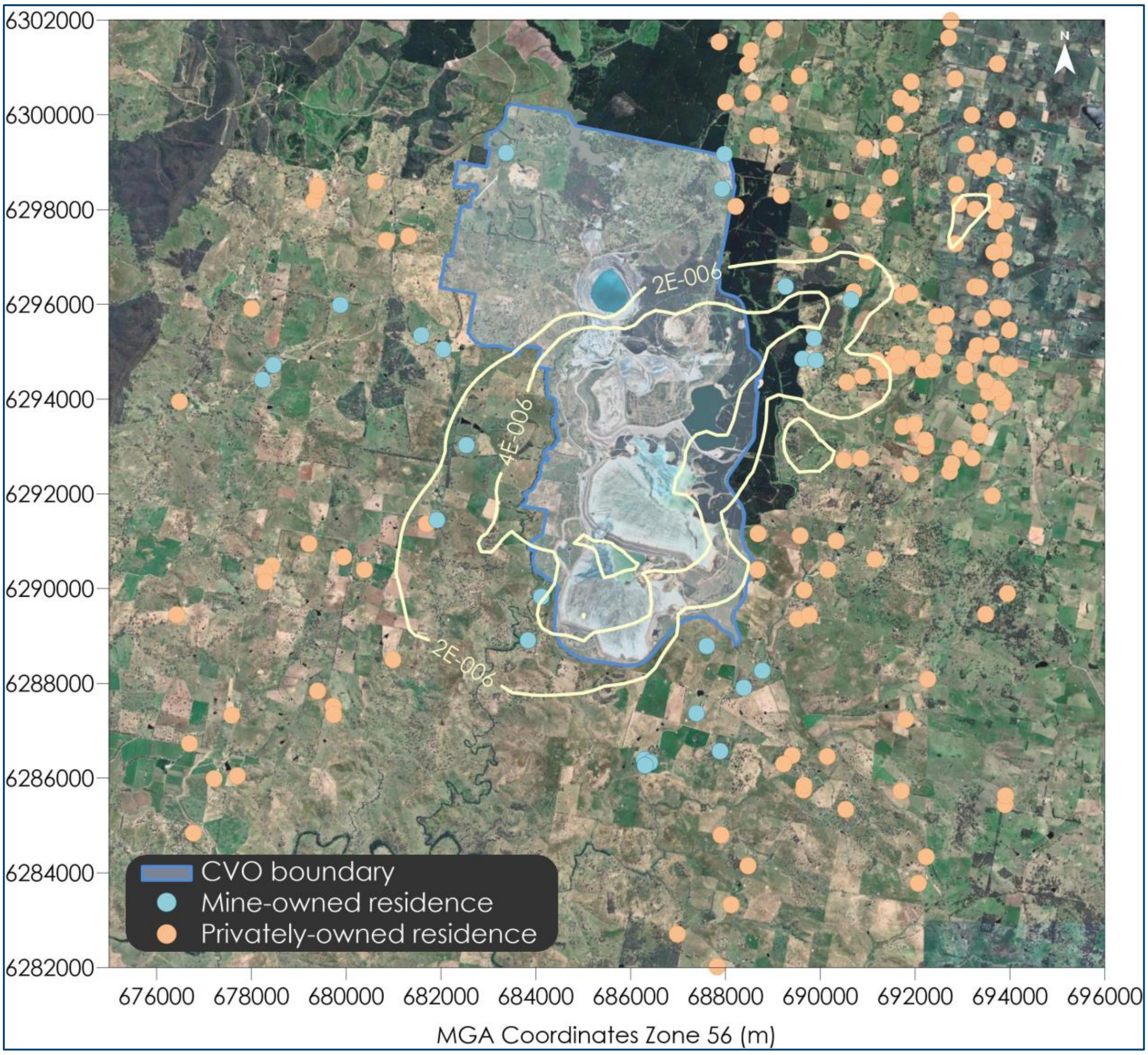

Figure B-3: Predicted 100th percentile annual average As deposition levels (g/m²/month)

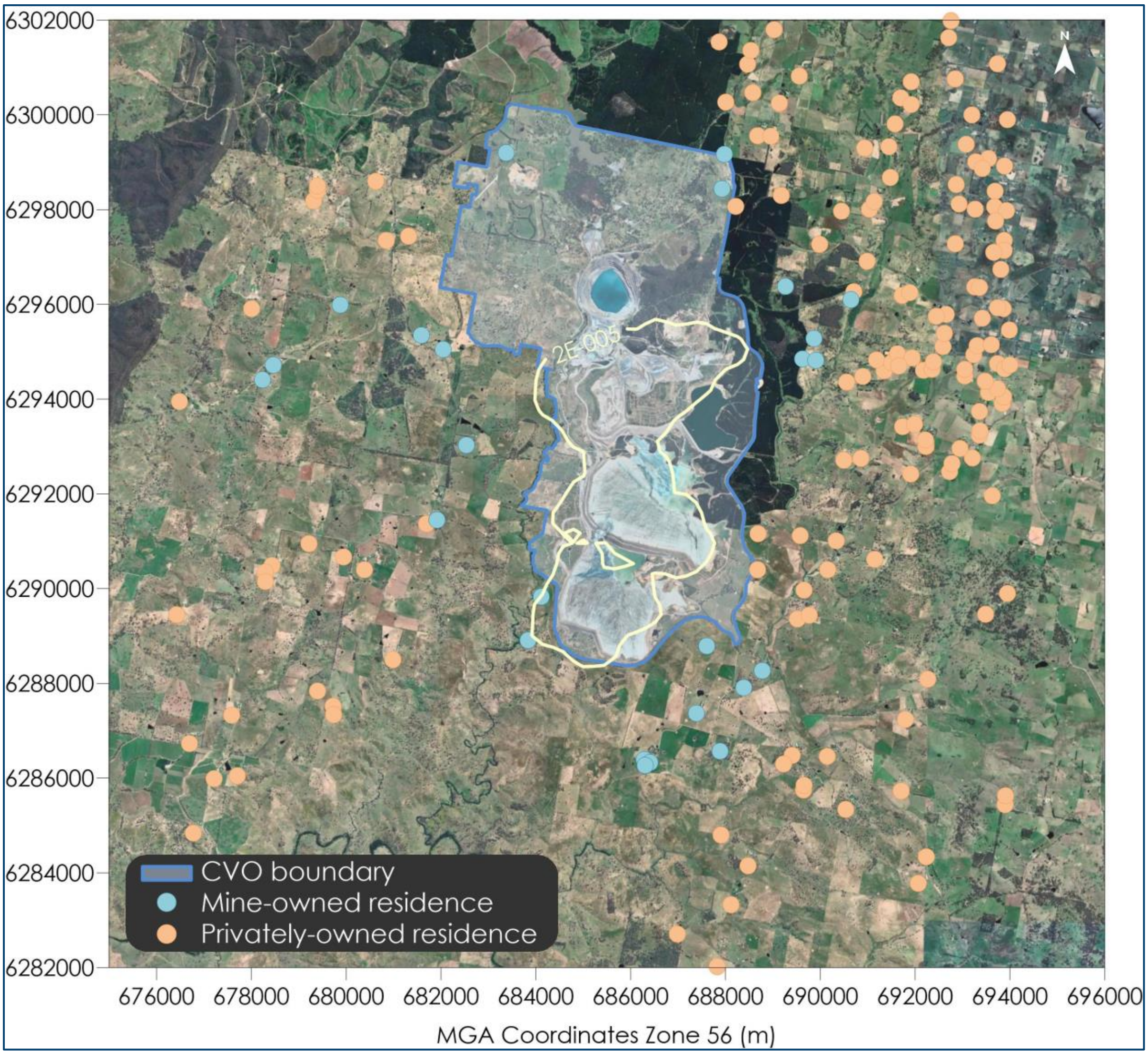

Figure B-4: Predicted 100th percentile annual average Ba deposition levels (g/m²/month)

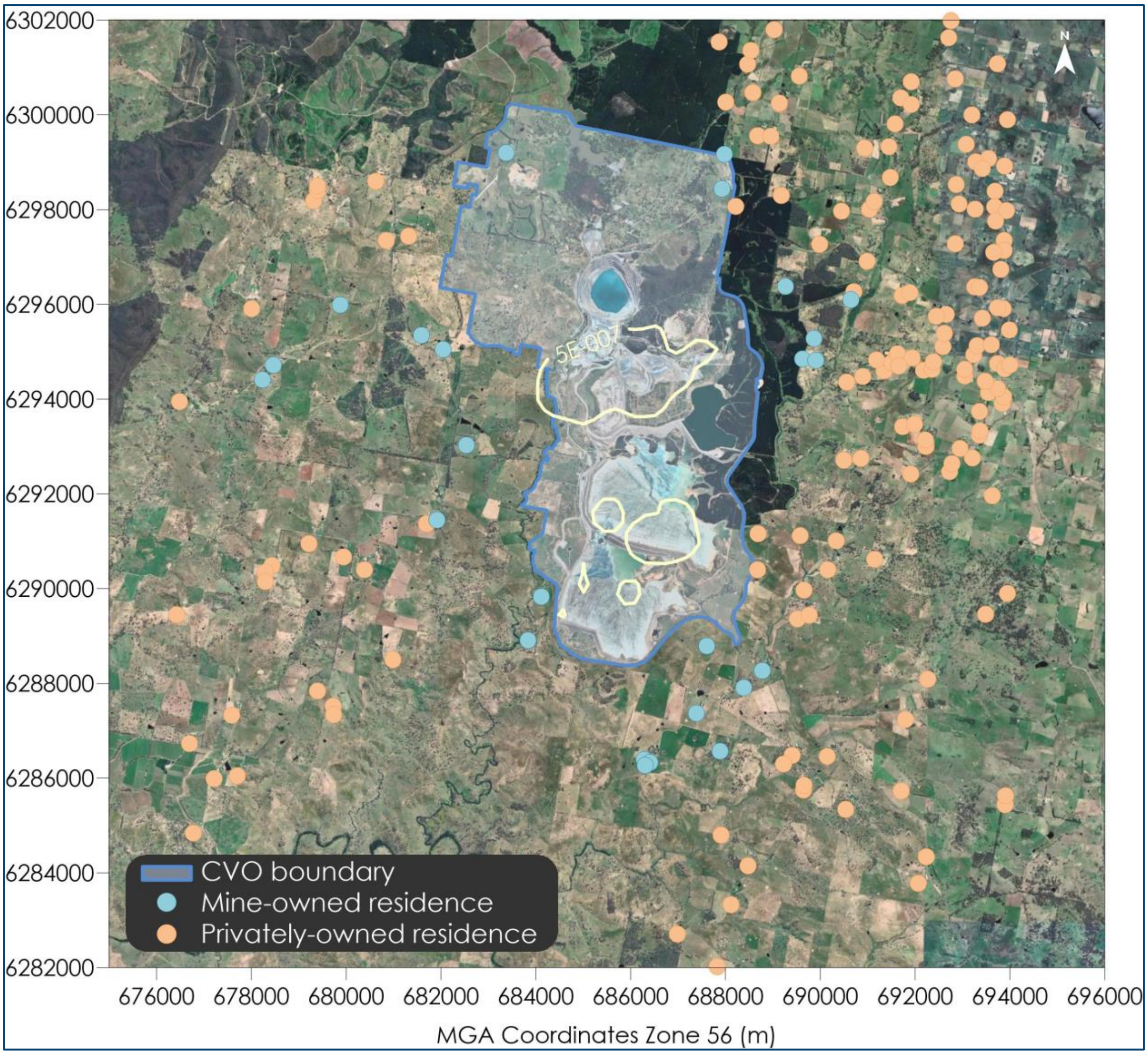

Figure B-5: Predicted 100th percentile annual average Be deposition levels (g/m²/month)

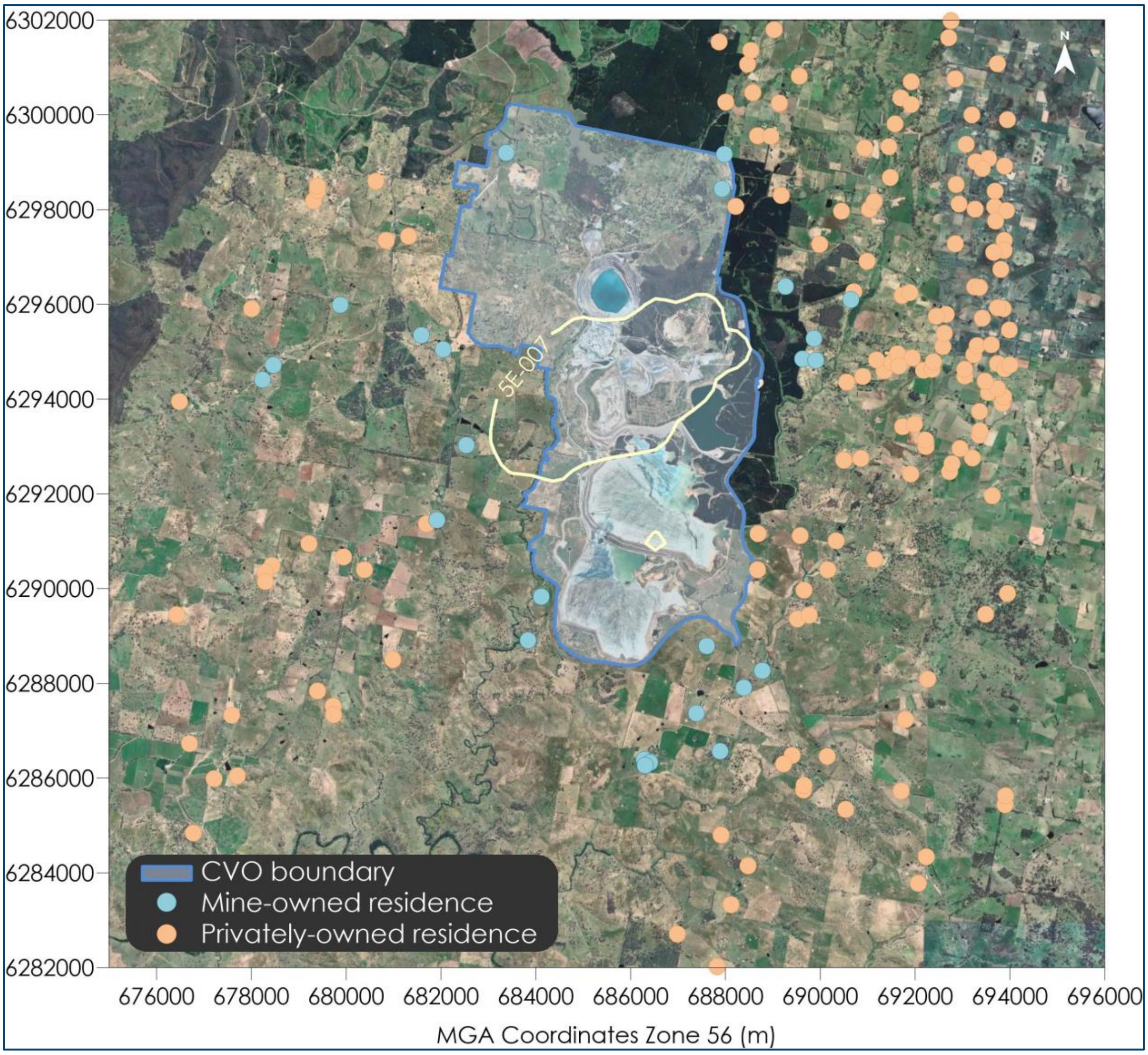

Figure B-6: Predicted 100th percentile annual average Cd deposition levels (g/m²/month)

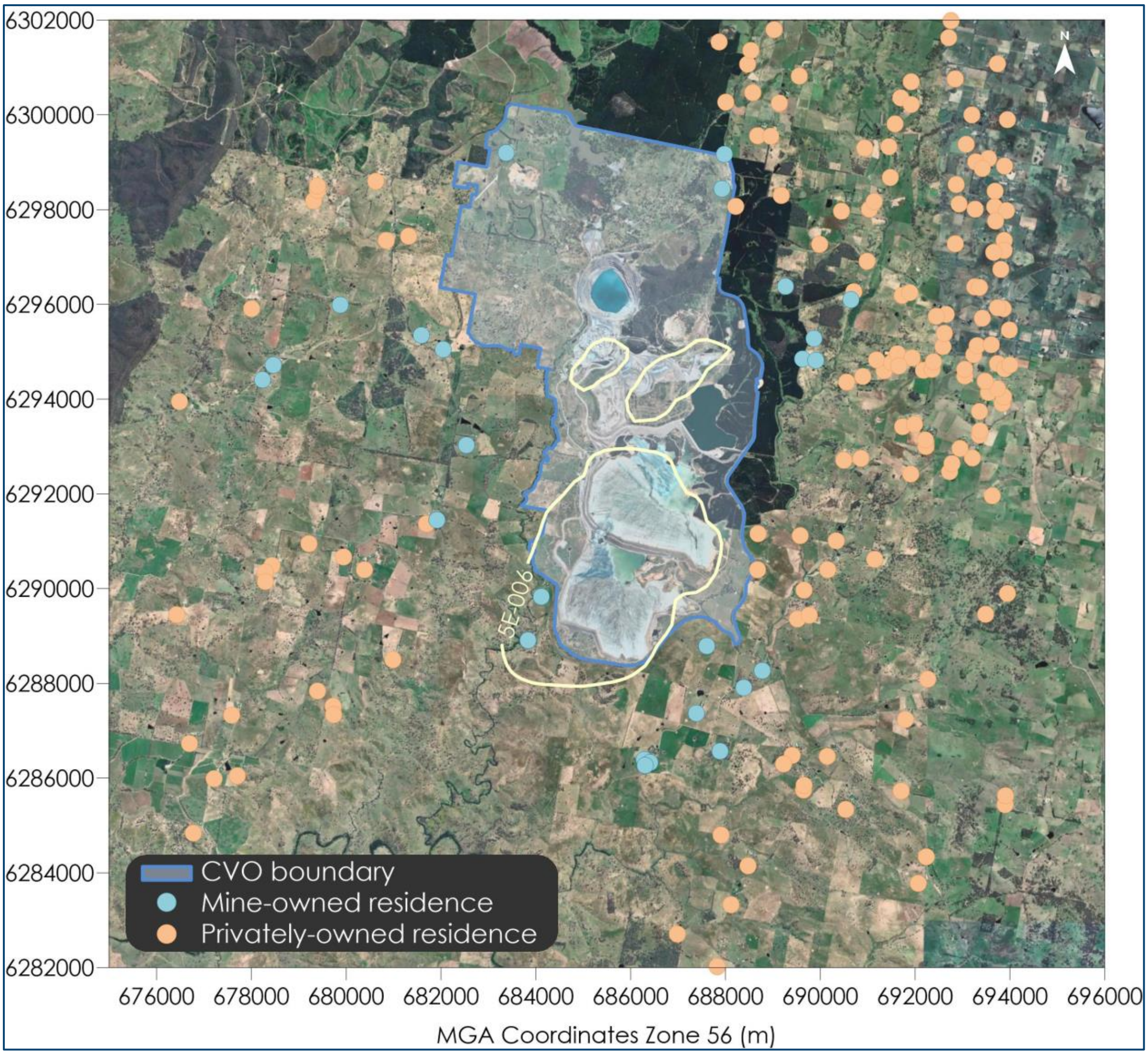

Figure B-7: Predicted 100th percentile annual average Co deposition levels (g/m²/month)

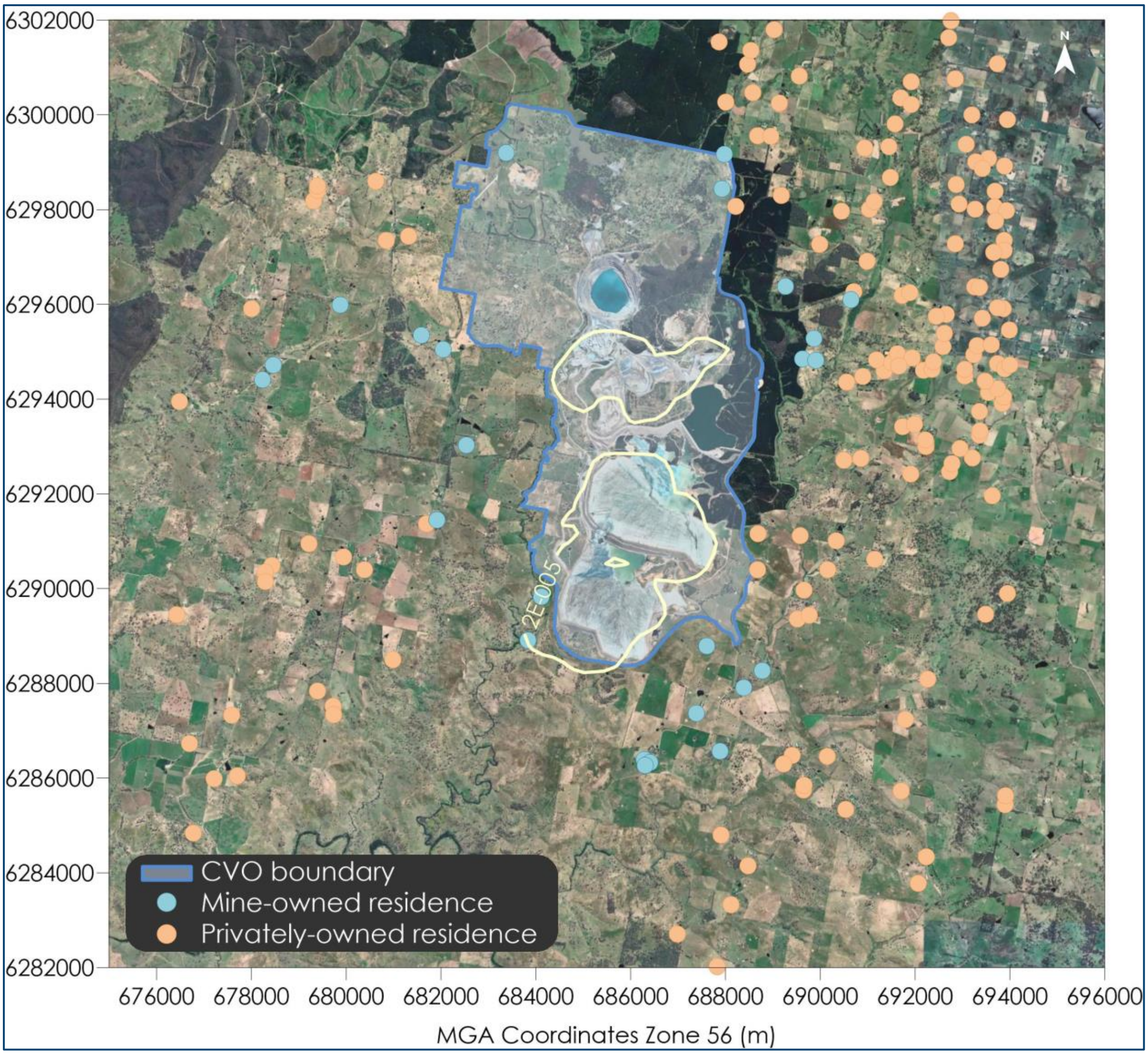

Figure B-8: Predicted 100th percentile annual average Cr deposition levels (g/m²/month)

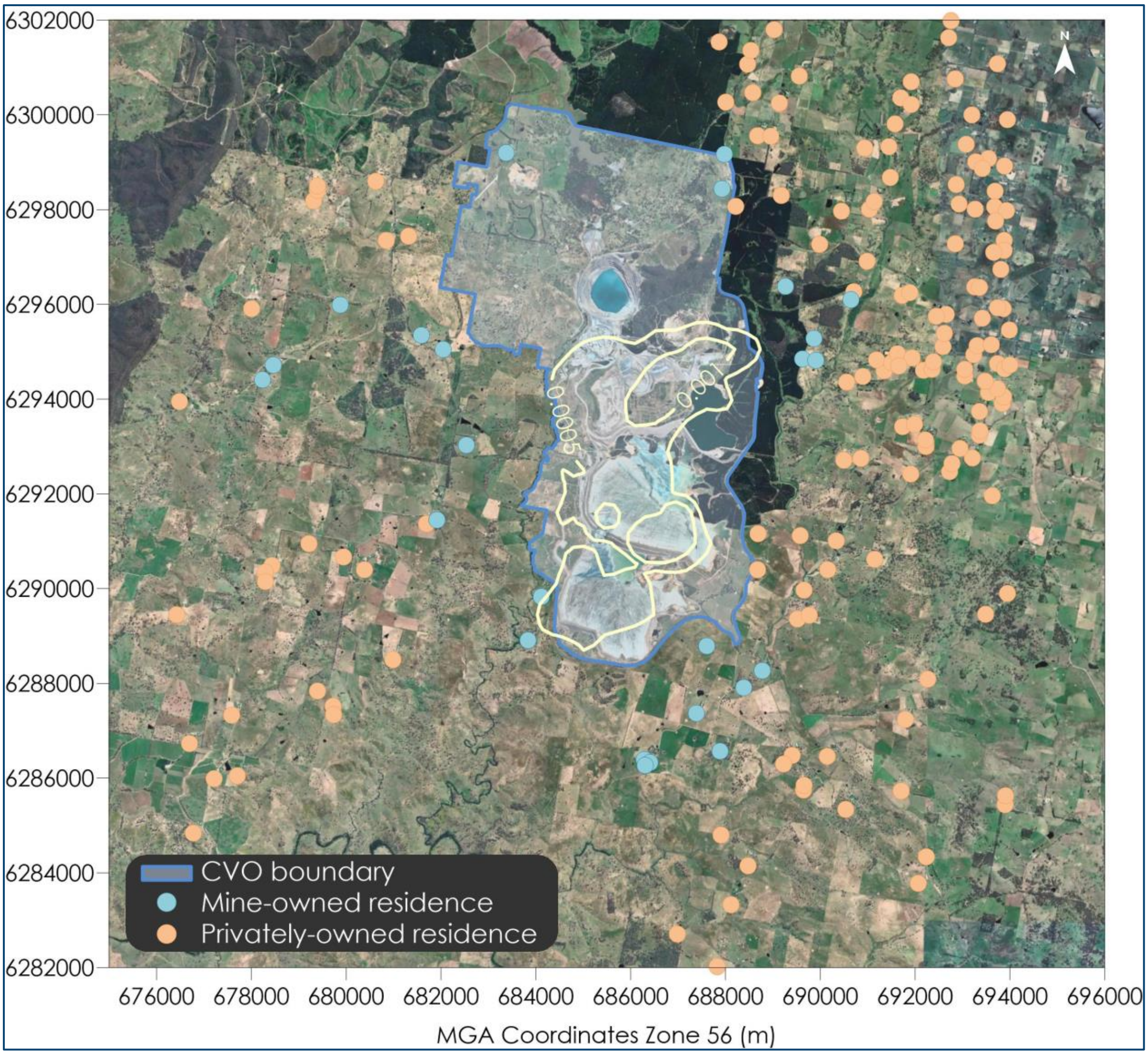

Figure B-9: Predicted 100th percentile annual average Cu deposition levels (g/m²/month)

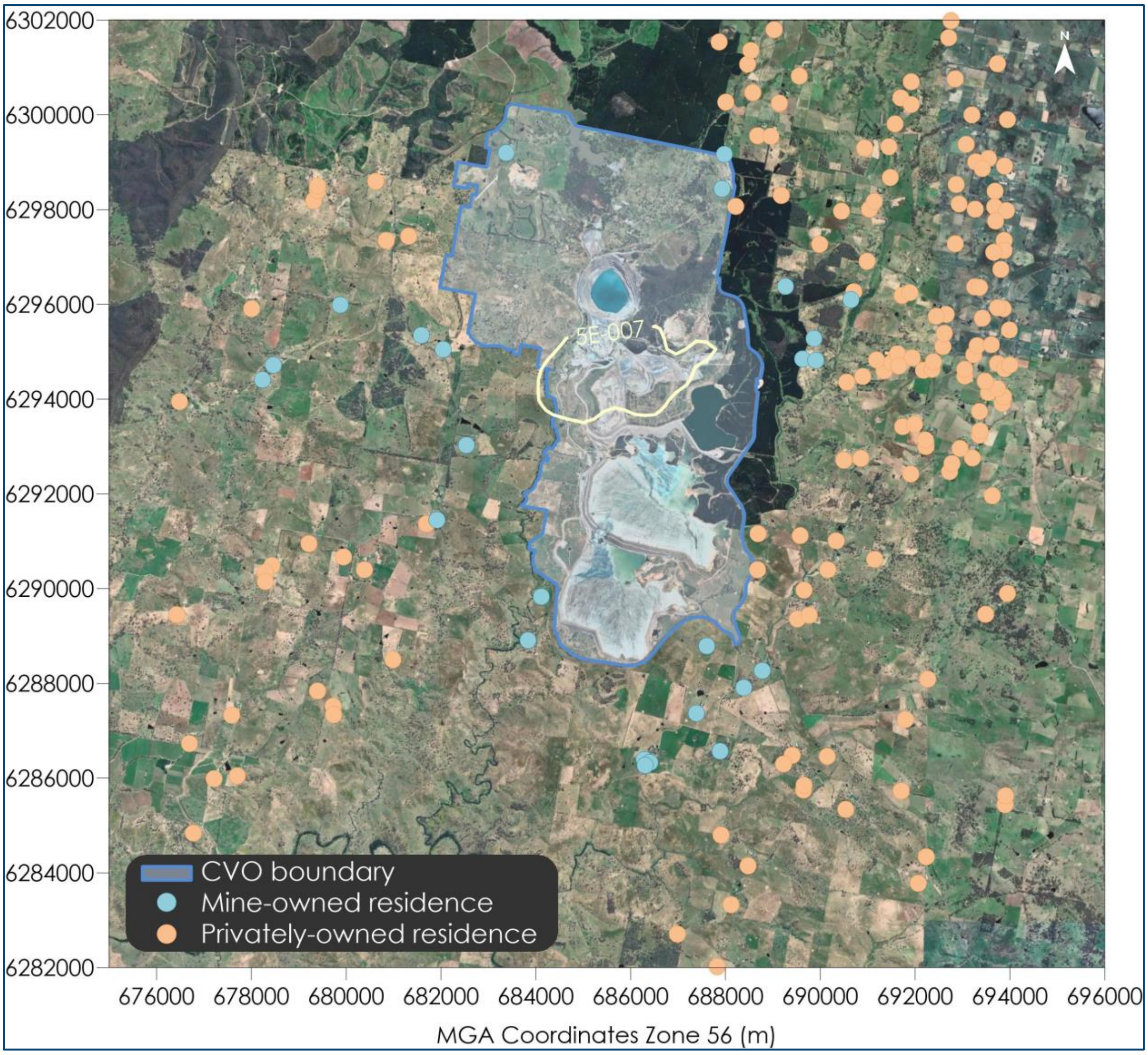

Figure B-10: Predicted 100th percentile annual average Hg deposition levels (g/m²/month)

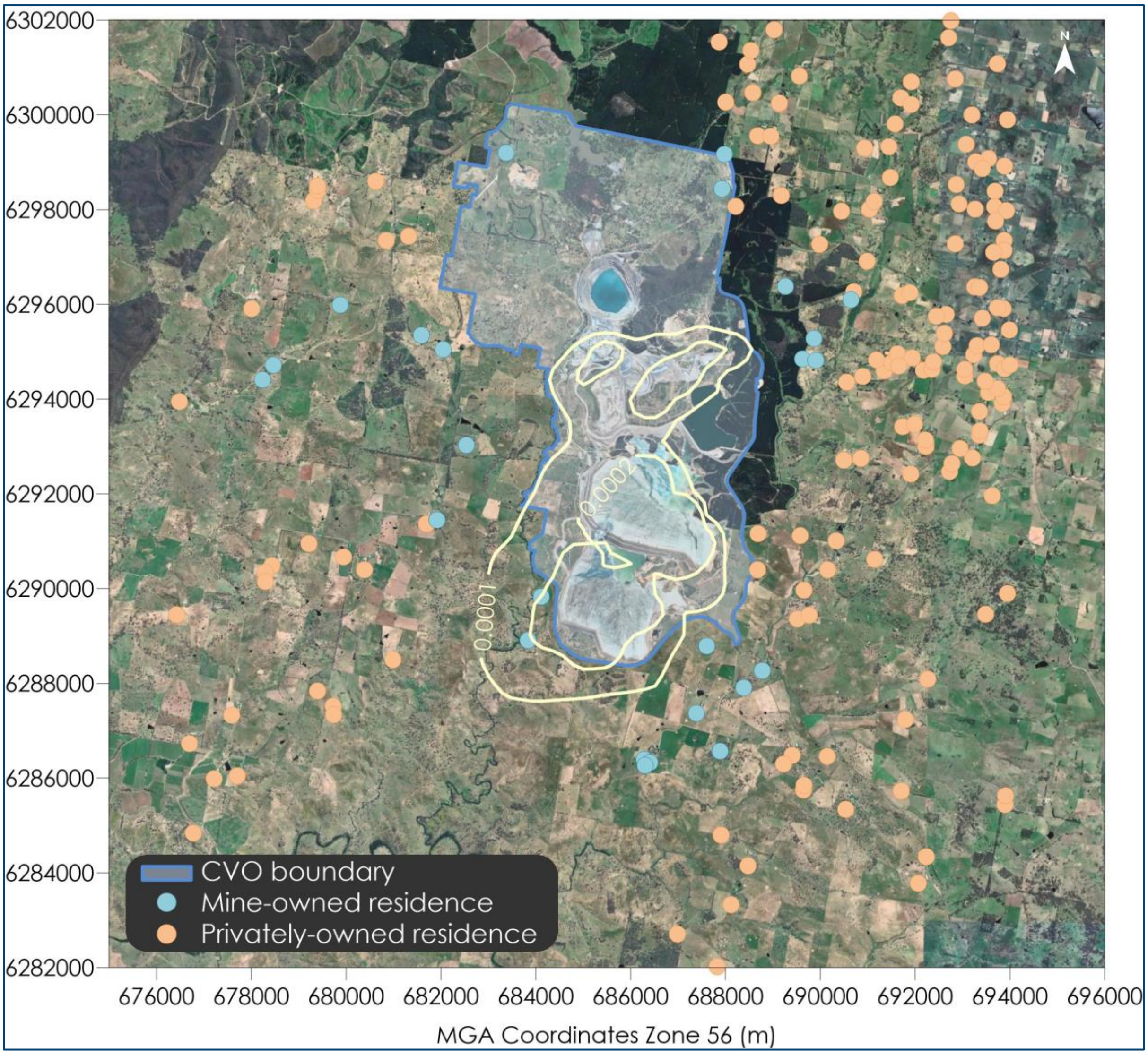

Figure B-11: Predicted 100th percentile annual average Mn deposition levels (g/m²/month)

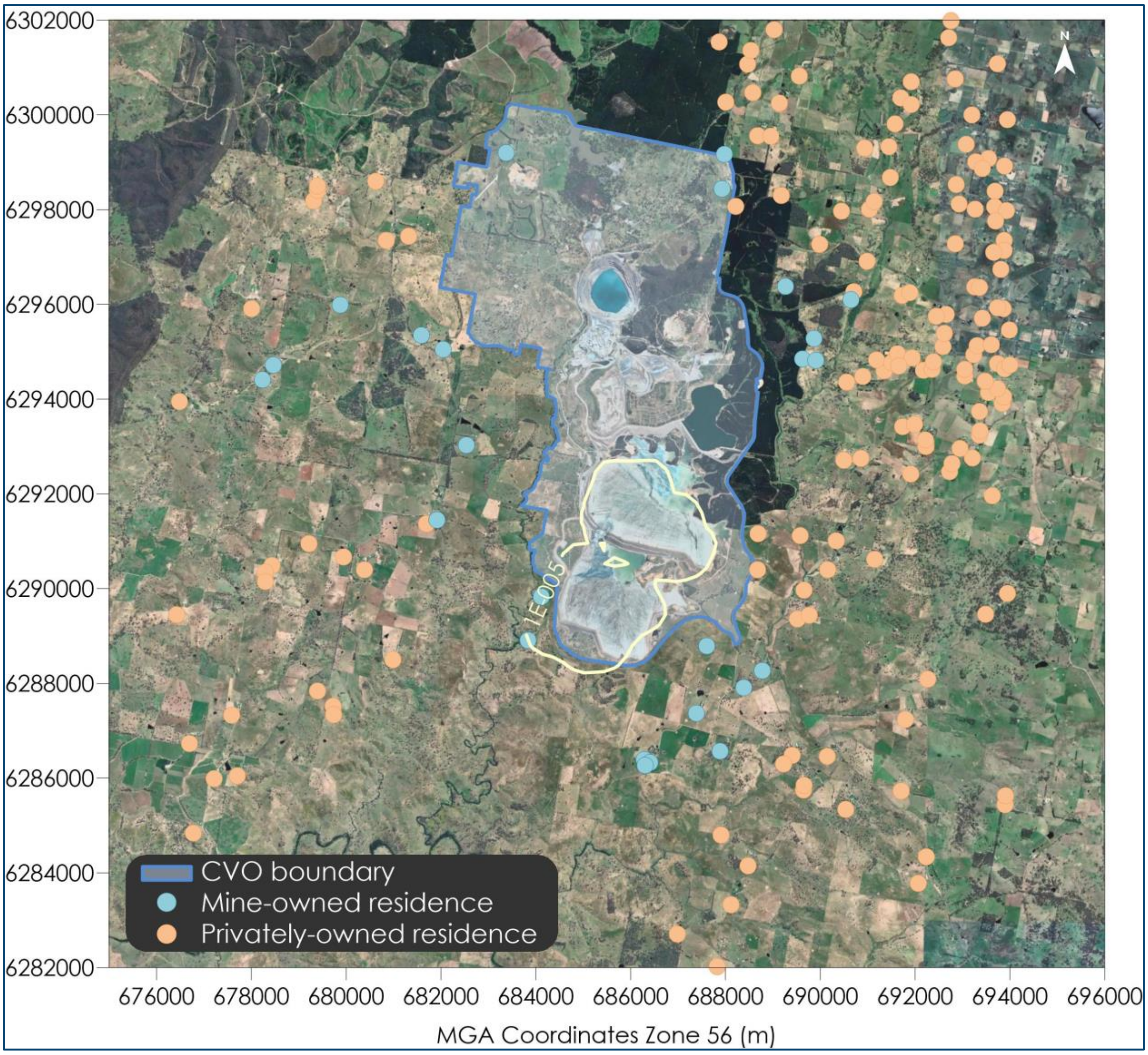

Figure B-12: Predicted 100th percentile annual average Mo deposition levels (g/m²/month)

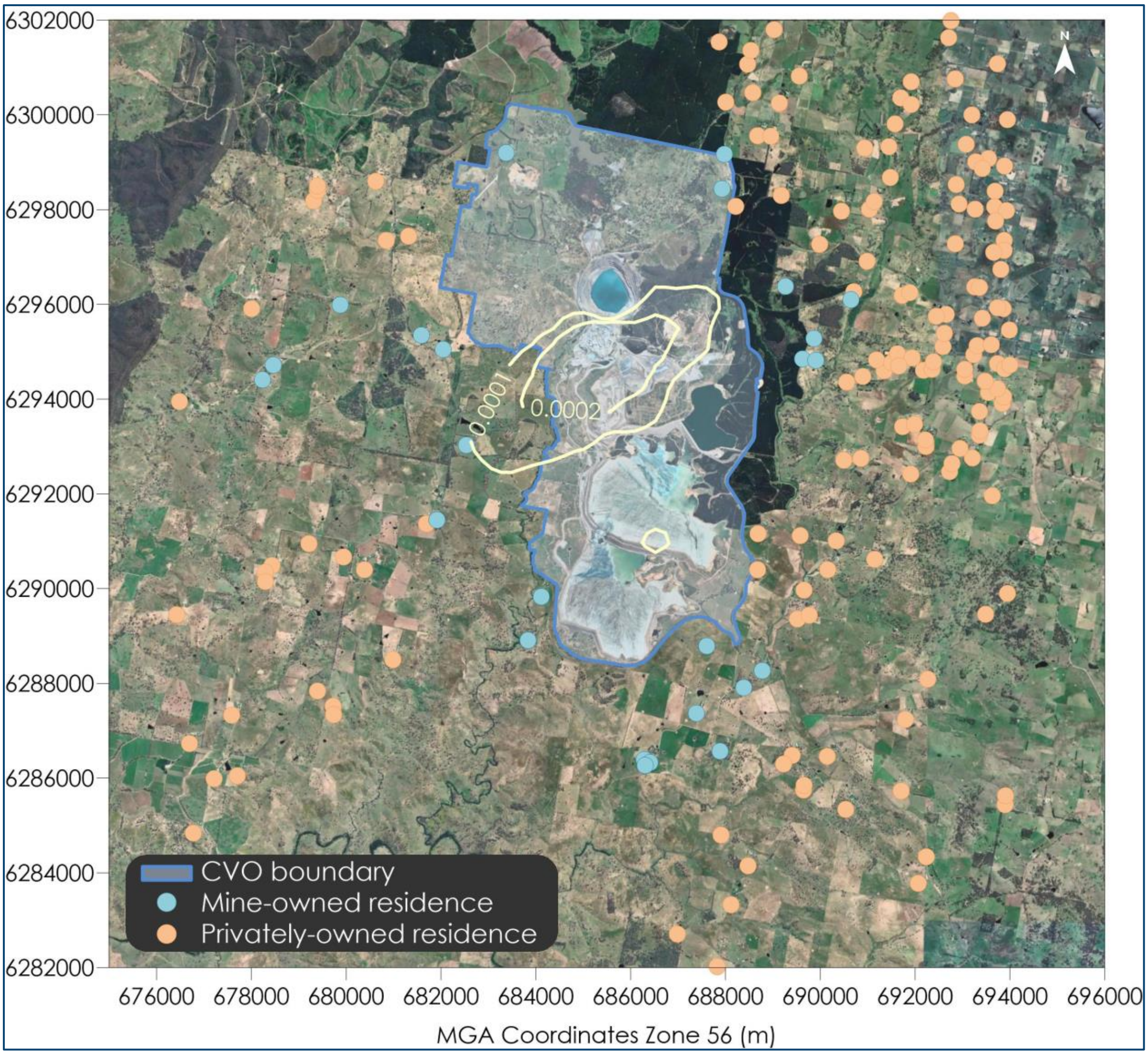

Figure B-13: Predicted 100th percentile annual average Ni deposition levels (g/m²/month)

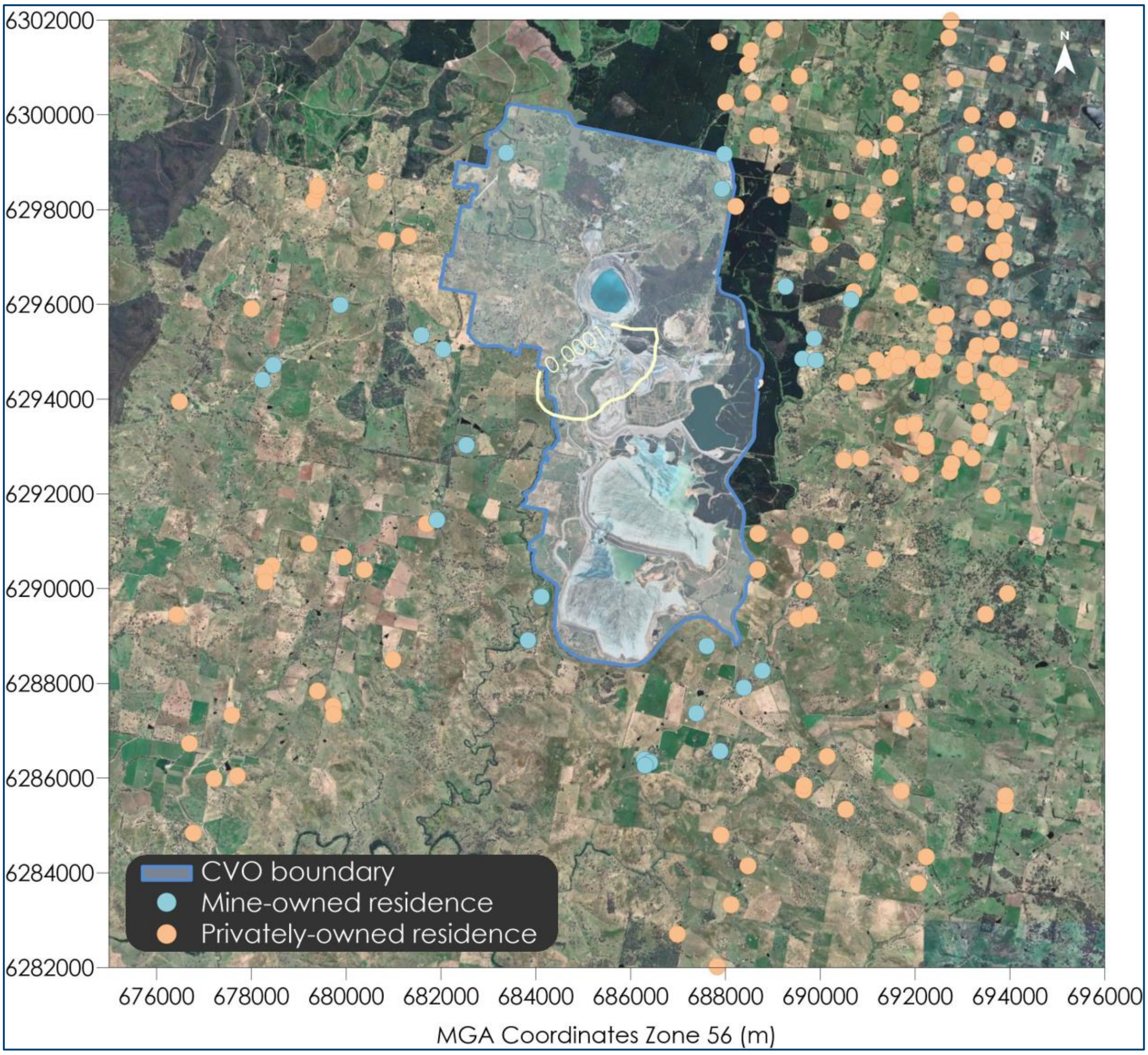

Figure B-14: Predicted 100th percentile annual average Pb deposition levels (g/m²/month)

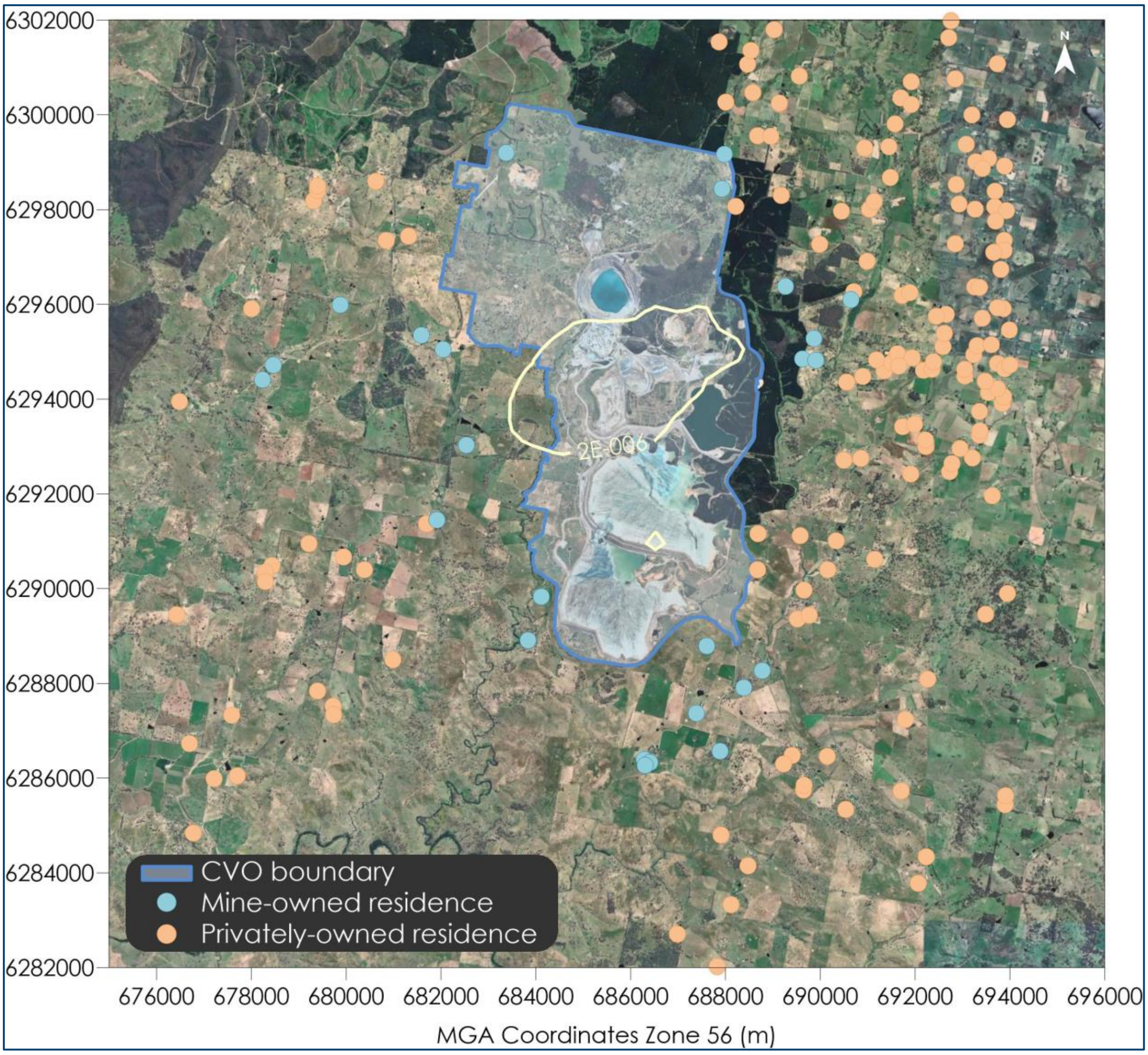

Figure B-15: Predicted 100th percentile annual average Sb deposition levels (g/m²/month)

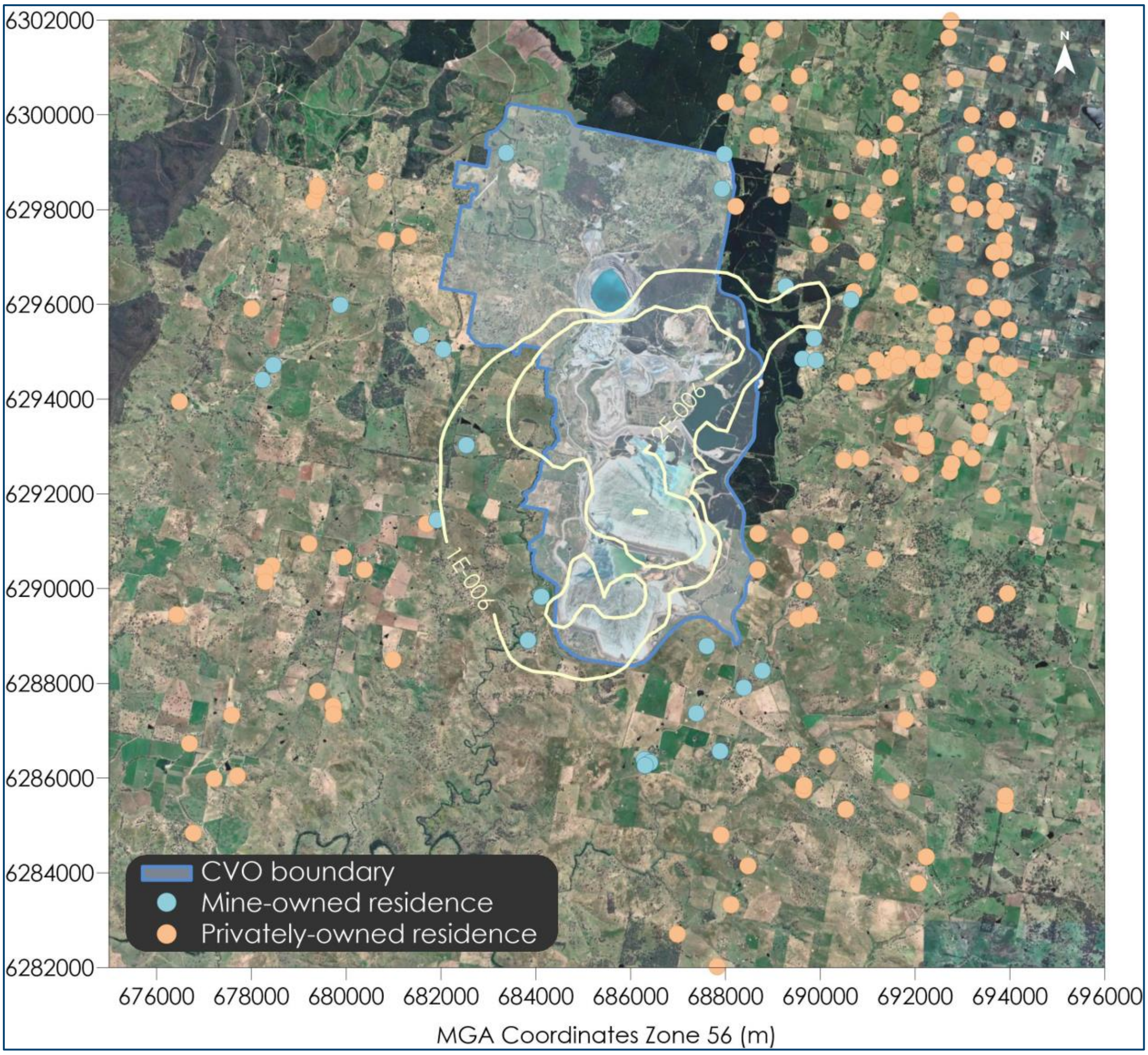

Figure B-16: Predicted 100th percentile annual average Se deposition levels (g/m²/month)

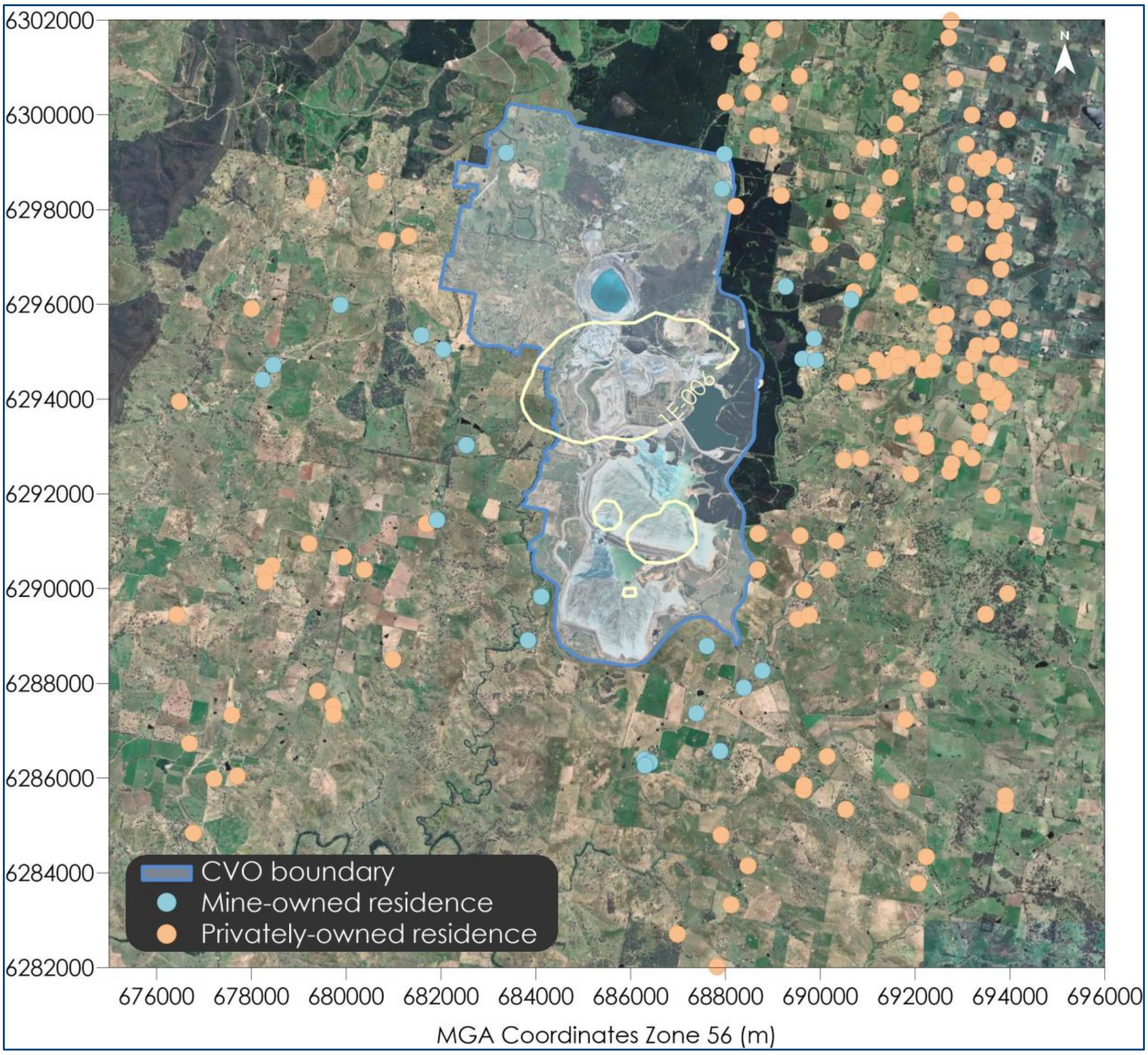

Figure B-17: Predicted 100th percentile annual average Sn deposition levels (g/m²/month)

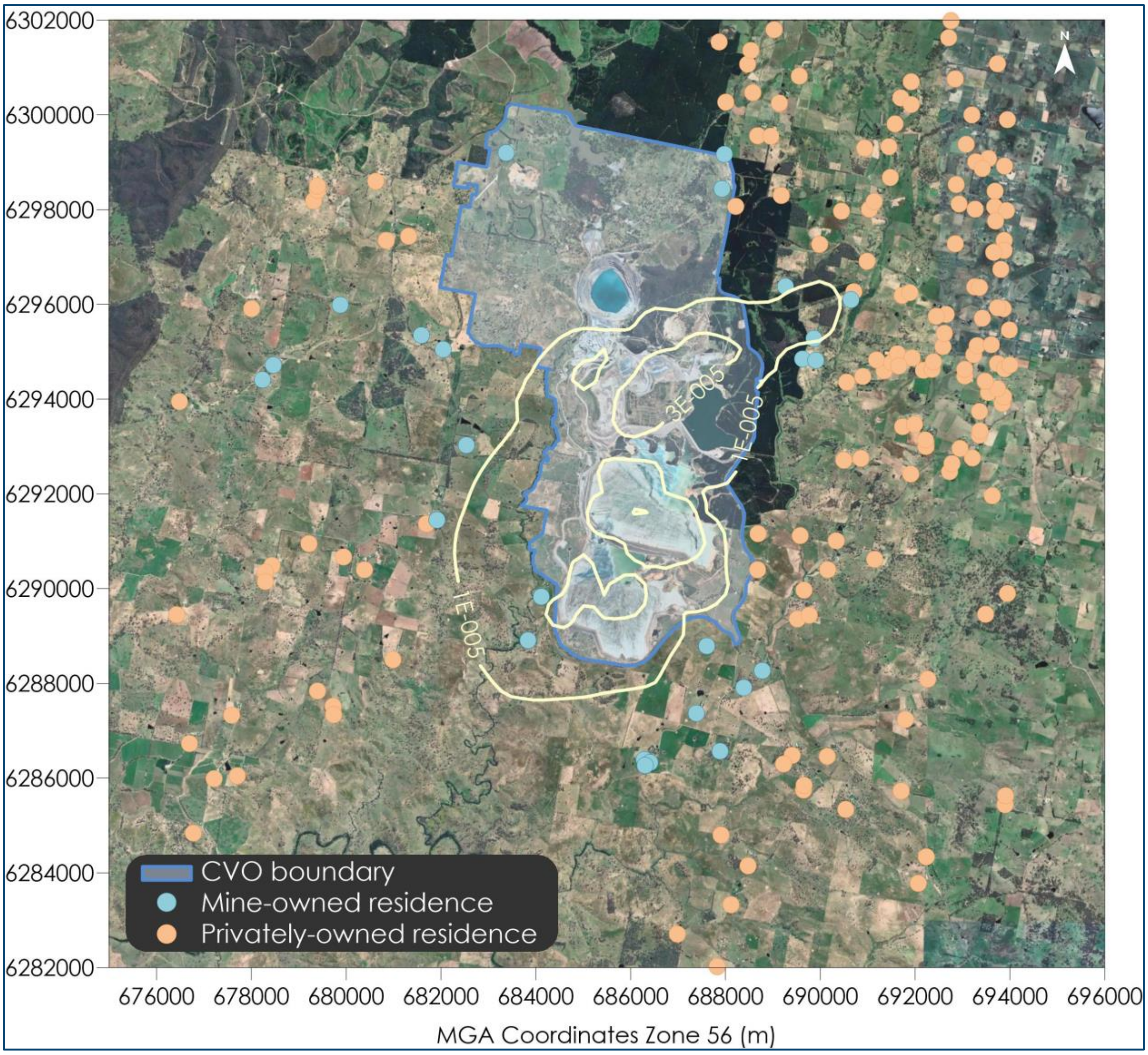

Figure B-18: Predicted 100th percentile annual average V deposition levels (g/m²/month)

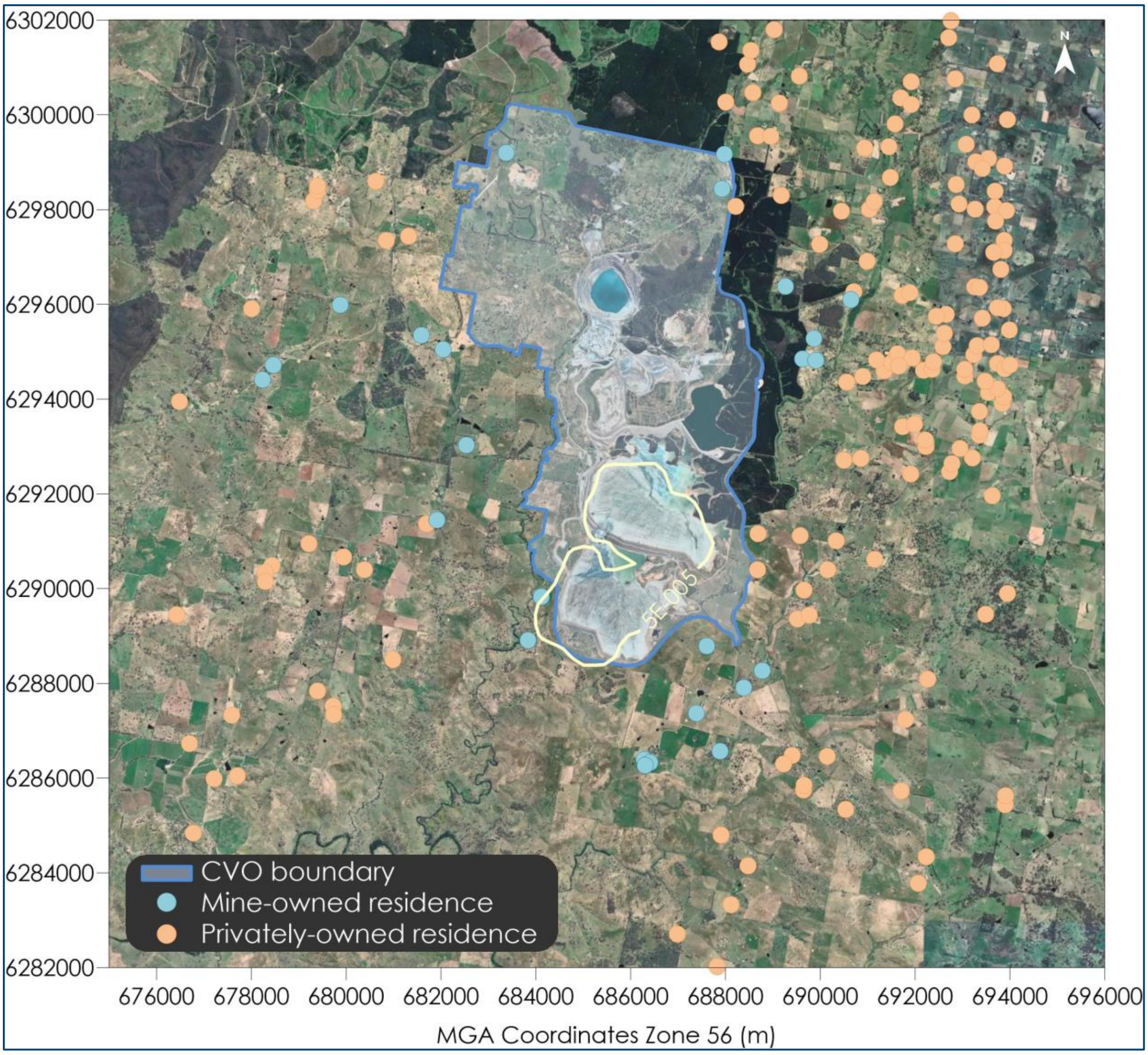

Figure B-19: Predicted 100th percentile annual average Zn deposition levels (g/m²/month)