2024 Annual Review

Attachment D: 2023 Groundwater TARP Triggers & Investigations

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1. 2023 Groundwater TARP Triggers & Investigations

During the preparation of the 2023 Annual Review, Ulan Coal Mines Pty Limited (UCMPL) engaged Australiasian Groundwater & Environmental Consultants (AGE) to prepare the *Ulan Coal Mine Annual Groundwater Review 2023* (the 2023 Report).

To address the trigger exceedances identified by AGE in the 2023 Report, in 2024 UCMPL requested AGE to investigate the following:

- Investigate the nature and cause of the slight but persistent declines in VWP sensors in EX09, PZ29, and R894.
- Investigate trends in dissolved metals and establish a trigger protocol using the full data record and recognised water quality standards, either by strata or individual bores.
- Investigate groundwater level and quality exceedances in private bores.
- Investigate groundwater quality exceedances in NMN bores PZ28B, PZ06C, PZ24B, PZ28A, PZ06C, and PZ11A.

A summary from the *Ulan Groundwater Trigger Investigation Report 2023* (AGE, October 2024) and the *Ulan Mine Annual Groundwater Review 2024* (AGE, March 2025) is provided below.

1.1 Summary of Investigations

1.1.1 VWP EX09, PZ29 & R894

1.1.1.1 EX09

EX09 is included in the latest model build and, as it is located near the UCC, is predicted to experience substantial depressurisation in the deeper zones (over 100 m in the deep Triassic strata), moderate depressurisation (20 - 30 m) in the middle and upper Triassic strata, and minimal (within error of model) in the shallowest (Jurassic) strata (AGE, October 2024).

The deepest sensors in EX09 (where data is available) show depressurisation patterns consistent with expectations for strata impacted from mining. The shallowest sensors (Jurassic 33 m and Jurassic 50 m) record 6 m of depressurisation since the installation and a peculiar logarithmic pattern that looks similar to a response to a long-term drawdown-recovery test (AGE, October 2024).

EX09 is located near the UCC’s dewatering bores, the nearest of which are a cluster comprised of MG26, MG27, MG28, and MG29. Mining is progressing northward across the Ulan Underground Mine and is currently occurring at LW30 and LW31 (as per the mine plan schedule). Pumping from the dewatering bores would also be progressing northward and may be currently occurring at MG27, MG28, and MG29, which are the northern most bores.

Many of the deeper sensors within or near the mine footprint recorded large depressurisation, which is predicted by the numerical model and expected due to mining. However, some shallow sensors in EX09exceeded their predicted drawdowns.. A review of mine dewatering was undertaken in the 2024

Annual review and porewater pressure behaviour in EX09 appears to be related to pumping regime of the nearby dewatering bores (AGE, March 2025).

1.1.1.2 PZ29

PZ29 has been investigated previously and with considerable rigour due to its location near The Drip Previous reports have concluded that water emanating from The Drip is sourced from a localised groundwater flow regime limited to the upper Triassic and Jurassic strata and that receives recharge directly over the area near The Drip (AGE 2022c). Previous and current modelling has adapted this conceptualisation of The Drip and has predicted no impacts due to mining (it should be noted that the models do not consider variability in rainfall patterns). The observed relationship between the deep sensors and shallow sensors supports this conceptualisation of a stratified groundwater regime in that pressure head in the Jurassic sensor is 25 m higher than the pressure heads in the Triassic and 75 m higher than pressure head in the Ulan Seam. Furthermore, the Ulan Seam sensor records over 40 m of depressurisation since the installation of the array and a temporal pattern marked by abrupt changes in depressurisation rate, as expected in response to mine progression. By contrast, the shallower (Triassic) sensors show only very slight and consistent depressurisation trends (less than 3 m) with no significant changes in slope (AGE, October 2024).

Data from shallow sensors in PZ29 were compared to the Cumulative Rainfall Departure (CRD), which shows below-average precipitation from 2012 through 2019. Groundwater levels are typically delayed in their response to climatic conditions and so it is very likely that the observed declines in shallow Triassic sensors in PZ29 are a response to multi-year below average precipitation. Additionally, nearby Triassic bore PZ24B shows a similar trend of steady decline since 2016 (AGE2024a). Therefore, it is likely that the observed decline in the Triassic sensors is a response to long-term climate patterns and not due to mining (AGE, October 2024).

In previous reviews of this data, the declines have been associated with natural variations rather than mining related drawdown however, with the recent updates and recalibration in the AOM2024, the Triassic strata at PZ29 is predicted to experience up to 10 m of total decline due to mining and up to 1 m through 2024 (while still maintaining no predicted impacts directly to The Drip). The observed drawdown, therefore, is only slightly above the predicted impacts. The discrepancy between predicted and observed drawdown is likely partly related to uncertainty in model hydraulic parameters but may also be related to climatic effects on the shallow sensors (which are not accounted for in the AOM2024) (AGE, March 2025).

1.1.1.3 R894

VWP array R894 is located northeast of the UCC project boundary and approximately 1 km from the nearest active mine panel. This array comprises four individual sensors completed within the Ulan Seam (1), Triassic strata (1) and Jurassic strata (2). The latest numerical model predicts depressurisation between less than 1 m for the shallowest Jurassic sensor, to 75 m for the Ulan Seam sensor. The model further predicts depressurisation to begin in 2014 for the deeper sensors with a predicted current rate of decline between 2 m/year and less than 0.1 m/year (AGE, October 2024).

Data from R894 shows steady depressurisation in the three deepest sensors since early 2020, which was preceded by a three year gap in the record. The rate of decline in the three functioning sensors ranges from 0.36 to 0.52 m/year with the highest rate expressed by the Ulan Seam 255 m sensor. The

Ulan Seam sensor also shows fairly abrupt changes in pressure head beginning mid-2022 which may be due to mining (AGE, October 2024).

R894 pressure head data was also compared to climate using the CRD as an illustration of long-term rainfall patterns. The CRD shows an overall declining trend between 2012 and 2019, indicating below-average rainfall. As rainfall is the dominant recharge component, groundwater pressure head, especially in shallow sensors, would be expected to respond to prolonged dry periods with declining pressure. Given the low permeability of the strata, there would also be a considerable delay in pressure head response. It is possible that the observed pressure head in R894 in the recent years is a response to this prolonged period of below-average rainfall (AGE, October 2024).

Ultimately, the observed pressure head behaviour in R894 may be due to a combination of 1) response to natural, below-average rainfall from 2012 to 2019 and 2) depressurisation as a result of mining, which is predicted by the groundwater model to be occurring in the deeper sensors. However, the erroneous behaviour of the shallowest sensor (not discussed) and the Triassic 219 m sensor before 2017 may also indicate that the sensors are no longer functioning properly, either by damage reaching the end of their lifespan (AGE, October 2024).

Data gaps exist in the record between 2017 and late 2019 but continuous data has been recorded since 2020. Data since 2022 shows a declining trend of approximately 2 m at all sensors (except for the 90 m sensor, which is clearly reporting erroneous data.). Significant declines (over 20 m) are predicted for the Ulan Seam (255 m) and deeper Triassic (219 m) sensors through 2024 but only 0.2 m decline is predicted for the 119 m sensor through 2024, as opposed to the 2.2 m observed decline (the overall decline predicted for the 119 m sensor is 13 m). Given the clearly erroneous behaviour displayed by these sensors over the period of record, the site may be reaching the end of its lifespan and UCMPL should be removed. The recently installed Jurassic monitoring bores and VWP in the vicinity of R894 and further to the North will be a sufficient replacement to this VWP (AGE, March 2025).

1.1.2 Dissolved Metals

A total of 19 NMN bores were sampled and analysed for dissolved metals required in the WMP in 2024 (Al, Sb, Ag, As, B, Ba, Cd, Cr, Cu, Fe, Pb, Li, Mn, Ni, Se, Sr, Zn, Hg). The 2024 results were compared to the historic dataset for each lithologic layer (Jurassic, Triassic, Permian) and the 95th percentile is provided in Table 1.1 (time-series plots are provided in **Error! Reference source not found.** and box-and-whisker plots summarising the statistical distribution is provided in Appendix E). For comparison to historical ranges, any bore with a measured value in 2024 that is greater than the 95th percentile of the period of record (up through 2023) is listed in Table 1.1 (AGE, March 2025).

As shown in Table 1-1 only one bore exceeded the 95th percentiles for only Barium (Ba), Chromium (Cr), and Iron (Fe) and all of these bores are completed in Triassic strata. Comments on these exceedances are as follows (AGE, March 2025):

- PZ06C exceeded the 95th percentile for Barium (Ba) and has been recording high concentrations since 2021 with a clear trend of rising values over time. PZ06C is discussed in Section **Error! Reference source not found.** above and is predicted to experience over 20 m of drawdown due to mining and this trend is likely related to groundwater level drawdown due to mining.

- PZ01A exceeded the 95th percentile for Chromium because it was one of the few readings that is over the limit of detection (0.001) and is still considered a low value
- PZ24B exceeded the 95th percentile for Iron but iron is generally high in the Triassic strata and this value is not substantially high. This is only the second measurement in PZ24B.

Overall, none of these three exceedances represent a substantial deviation from predicted behaviour and no further investigations are recommended at this time.

Table 1.1 Metal exceedance values for NMN bores

	95th percentile (mg/L)			Bores exceeded (value – mg/L)		
Analyte	**Jurassic**	**Triassic**	**Permian**	**Jurassic**	**Triassic**	**Permian**
Aluminium - Dissolved mg/L (Al)	0.219	0.571	0.279	-	-	-
Arsenic - Dissolved mg/L (As)	0.002	0.010	0.002	-	-	-
Barium - Dissolved mg/L (Ba)	0.257	0.135	0.942	-	PZ06C (0.24)	-
Boron - Dissolved mg/L (B)	0.089	0.234	0.351	-	-	-
Cadmium - Dissolved mg/L (Cd)	0.001*	0.001*	0.001*	-	-	-
Chromium - Dissolved mg/L (Cr)	0.001*	0.001*	0.024	-	PZ01A (0.004)	-
Copper - Dissolved mg/L (Cu)	0.004	0.048	0.012	-	-	-
Iron - Dissolved mg/L (Fe)	17.8	39.0	32.8	-	PZ24B (49.5)	-
Lead - Dissolved mg/L (Pb)	0.002	0.024	0.001*	-	-	-
Lithium - Dissolved mg/L (Li)	0.084	0.074	0.642	-	-	-
Manganese - Dissolved mg/L (Mn)	1.053	0.732	0.737	-	-	-
Mercury - Dissolved mg/L (Hg)	0.004	0.001*	0.001*	-	-	-
Nickel - Dissolved mg/L (Ni)	0.022	0.047	0.040	-	-	-
Selenium - Dissolved mg/L (Se)	0.010*	0.010*	0.010*	-	-	-
Silver - Dissolved mg/L (Ag)	0.001*	0.001*	0.001*	-	-	-
Strontium - Dissolved mg/L (Sr)	0.276	0.164	0.555	-	-	-
Zinc - Dissolved mg/L (Zn)	0.101	0.177	0.217	-	-	-

Notes: * indicates value is at limit of detection

1.1.3 Private Bores

1.1.3.1 Groundwater Levels

Groundwater levels in three private bores (PB11, PB12, and PB18) exceeded their predicted maximum groundwater levels in 2023. Of these three bores, only PB18 shows a persistent declining trend over the period of record whereas bores PB11 and PB12 show variable groundwater levels that range between near the previous historical maximum and minimum.

PB11 is located north of the UCC in the broad plain of the Talbragar River and the bore depth is currently unknown. The latest model predicted 2.3 m of total drawdown at this bore beginning around 2018 and reaching 0.14 m by 2024. The groundwater level data for this bore shows a cumulative groundwater level decline of 11.23 m (first groundwater level – last groundwater level) but the 2022 measurement was the shallowest groundwater level recorded and over 15 m higher than the 2023 measurement. The status of use of PB11 is currently unknown but if the bore were in use regularly, it would explain the large fluctuations in groundwater level, as the groundwater level could have been drawn down considerably due to recent pumping, and slowly recovering, just prior to taking measurements (AGE, October 2024).

PB12 is located adjacent to the Goulburn River east of the UCC and has groundwater levels that are generally consistent with the elevation of the Goulburn River. The shallow water levels (around 5 mBGL), shallow bore depth (24 m), and pattern of variability observed over the period of record further supports the finding that the bore is completed within an aquifer that is efficiently hydraulically connected to the Goulburn River. This bore is predicted (in the newest model) to experience less than 0.2 m over the timeframe of the model, which is further consistent with the assumption of connection to the Goulburn River (AGE, October 2024).

PB18 is 18 m deep and located west of the UCC along a tributary to Cockabutta Creek near several other private bores. PB18 is showing a persistent decline in groundwater level since 2013 and a cumulative drawdown of around 2.5 m. The latest groundwater model predicts only 0.2 m of drawdown in PB18. Other bores near PB18 show similar levels of cumulative drawdown over the period of record which suggests that the observed groundwater level behaviour in PB18 is not isolated to that bore but instead part of localised groundwater level changes in that area (AGE, October 2024).

Two dedicated monitoring bores (P1A and P1B) were recently installed in this area in 2023 (see AGE 2023a). Although data only exists from these bores since February 2023, both bores show a declining trend (1.5 m in P1A and 1 m in P1B to-date) but recent data over the past few months shows a stabilising of groundwater levels. Data from these bores will be reviewed in the upcoming annual review and will be compared to PB18 and other bores in this area (AGE, October 2024).

Four additional private bores (PB10, PB12, PB18, and PB45) recorded cumulative groundwater level declines in 2024 that exceeded the predicted declines and these are also listed in **Error! Reference source not found.**. Private bores are often subject to frequent use and the one-time groundwater level measurement may be influenced by recent usage rather than represent natural conditions. Furthermore, there is sometimes little construction information available for private bores so there is uncertainty in assigning bore depth in the numerical model which can lead to uncertainty in predicted impacts. The groundwater level hydrographs for private bores are presented in **Error! Reference source not found.** along with time-series plots of EC and pH (AGE, March 2025).

Private bores PB10, PB12, and PB45 show considerably large fluctuations over the full period of record with groundwater levels ranging over 7 m, 1 m, and 14 m, respectively, and no persistent declining trends. Given the large year-to-year fluctuations in these bores the latest values are likely in line with natural variability are ongoing use (AGE, March 2025).

PB18 has groundwater level records since 2012 and shows a clear and persistent declining trend since 2013 but an overall decline of slightly over 2 m (AGE, March 2025).

Groundwater levels were measured in 32 private bores during 2024, 22 of which are required by the WMP. Five of the private bores exceeded their predicted drawdowns which were not predicted to be influenced by mining (one of these bores, PB18, is likely not in the correct model layer in the AOM2024). Given the variability in the groundwater level record, the declines are attributed to bore use, climate, or surface water connection, rather than mining-related impacts. Declines for all bores within the 2 m drawdown zone were less than the predicted impacts. No community concerns have been raised in regards to private bores in 2024 (AGE, March 2025).

1.1.3.2 Groundwater Quality

A number of private bores exceeded their EC water quality trigger and one of those bores (PB19) also exceeded its pH water quality trigger (see Section **Error! Reference source not found.**). These trigger values are based on the historic record (from around 2009) and are updated regularly. Since private bores are measured annually, and sometimes not accessible, the length of record varies for each bore. For example, PB29 has 14 annual EC measurements while PB11 has only 8. The dearth of information at some bores makes setting triggers problematic, as the record may not capture the full, natural variability of the bore, and so it is important to assess data from trends rather than absolute values (AGE, October 2024).

EC for the seven bores that exceeded water quality triggers in 2023. The majority of bores that exceeded EC triggers show no clear trend of increasing EC over the period of record, or only a small increase over time that is further underlain by a year-to-year variability (exceptions are PB29 and PB24, both of which show an increasing trend in EC since 2010). More specifically, most of the bores show an increase in EC between 2022 and 2023 that was preceded by a decrease between 2021 and 2022 (exception is PB11), meaning that the latest EC values are not part of a persistent trend (AGE, October 2024).

Groundwater level records for these private bores were also reviewed as part of this assessment and show no clear trends Except for PB11, which shows large variability in groundwater levels and a range of 20 m, these private bores show relatively stable groundwater levels (especially considering these bores may be in use periodically) (AGE, October 2024).

Ultimately, the EC exceedances in these private bores does not appear to be part of any significant long-term trends but, instead, may be related to recent climate patterns (i.e. lower than average rainfall in 2023 ahead of sampling). This is supported by the fact that these bores are located several kilometres apart and spread around the UCC, and so it is also unlikely that the observed exceedances are due to mining (AGE, October 2024).

Groundwater quality exceedances were also evaluated in Private Bores with trigger values derived as part of this report from the full historic record (up through 2023). Stage 2 EC exceedances were identified in three private bores and Stage 2 pH exceedances (high or low) were identified in 10 private bores. Neither pH nor EC (however, pH values were not substantially different from historic values) and many of these bores also showed considerable variability in values. The exceedances were attributed to either natural variability or influence from bore use (which is not recorded) (AGE, March 2025).

1.1.4 NMN

1.1.4.1 Groundwater Quality

Bores proximal to the mine footprint are expected to experience variation in groundwater conditions related to groundwater level drawdown caused by mining. Rising trends in EC are expected as drawdown occurs in bores and salts become concentrated within the reduced water volume in the borehole, Similarly, changes in dissolved concentrations of ions can have significant impacts on pH. All bores listed that exceeded trigger values in 2023 have been predicted to experience significant declines due to mining that range from 2 m in PZ28B up to over 150 m in PZ06A. Observed groundwater level data shows that each of these bores, except PZ28A and PZ28B, have experienced significant drawdown since 2016 and show a clear persistent groundwater level trend. Therefore, the water quality trends are very likely due to the effects of mining and are within the predicted response. These observations, therefore, do not pose unexpected harm to the environment (AGE, October 2024).

Although PB06B was investigated due to an exceedance of its Stage 2 Low pH trigger, which is only slightly lower than the previous minimum, it also records an overall decreasing trend in EC from around 1200 µS/cm until 2020 to less than 900 µS/cm in 2024. Although a decrease in EC is not a concern for trigger exceedances and does not fit the model of increasing EC with decreasing groundwater level, it does indicate that there is a significant change in chemistry occurring in PZ06B, which is likely responsible for the change in pH (AGE, October 2024).

In 2024, two bore (PZ06B and PZ11A) exceeded their prescribed Stage 2 Low pH trigger levels and two bores (PZ24B and PZ06A) exceeded their Stage 2 EC triggers (AGE, March 2025).

Groundwater quality triggers for NMN bores were re-derived recently (AGE 2023[1]) and 2024 EC and pH data were compared against these triggers. Two of the NMN bores exceeded Stage 2 Low pH triggers and two exceeded Stage 2 EC triggers. All these bores are predicted to experience drawdown due to mining and the exceedances are likely largely attributed to water quality changes due to dewatering of the intersected strata. Average EC and pH from all bores across all strata were in line with historic values indicating no major change to groundwater quality overall (AGE, March 2025).

[1] AGE. (2023). Ulan NMN Trigger Derivation. July 2023. Proj. No. UCM5020.001

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