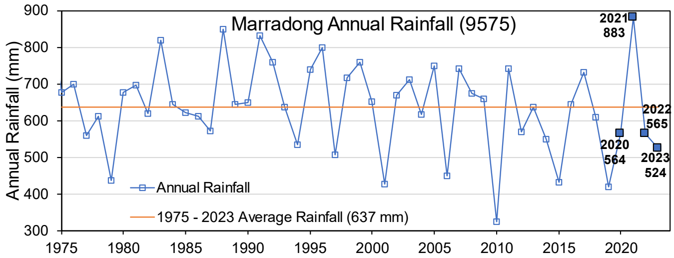
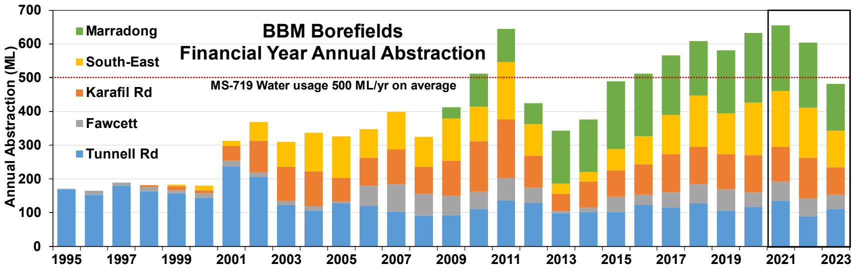
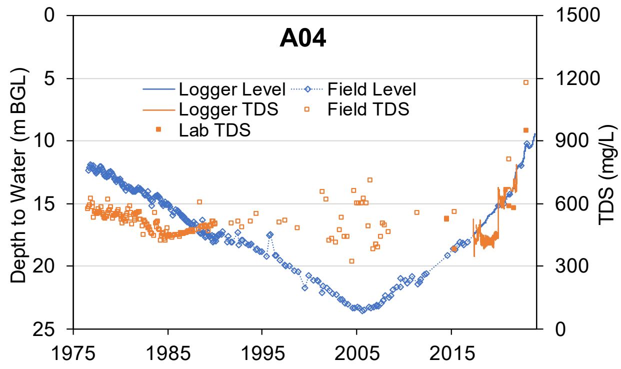
REPORT
TO
SOUTH 32 WORSLEY ALUMINA PTY LTD

BODDINGTON BAUXITE MINE TRIENNIAL AQUIFER REVIEW JULY 2020 – JUNE 2023







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January 2024

CONTENTS

TABLE OF FIGURES

SUMMARY

This report is a review of the rainfall, groundwater-abstraction, and groundwater-monitoring data from across the BBM site and interpretation of this data, with a focus on trends emerging in the last three years. The report provides a summary of the current understanding of aquifer status and gives recommendations for the ongoing groundwater-management to meet legislative requirements and guide future decision-making.

The rainfall over the review period included very high rainfall in 2021, with below average rainfall in other years, rain-days were notably high in 2023.

Groundwater abstraction has decreased over the review period, with notably low abstraction in 2022-23. This abstraction exceeds the averaged license-level of 500 ML per annum in this period but remains below this level when averaged over a longer abstraction period.

The groundwater monitoring over the review period consisted of thirty-two in-bore loggers, as well as field and laboratory sampling of an additional three bores. The loggers recorded at least daily measurements of water-level, and temperature.

There were no significant new general trends in the aquifer levels or water-quality over the review period. The water table continued to decline under forested catchments, however the decline is slower than previous periods. The continued groundwater rise at A04 should be monitored, the water table has risen above the 1976 level but is still over nine meters below the surface. Rehabilitation work has commenced in some of the catchment of A04, with more planned in coming years which is expected to slow this rise. The high rainfall of 2021 likely contributed to the steeper groundwater rise at A04 over this review period.

1. INTRODUCTION

South32 Worsley Alumina Pty Ltd (Worsley) operates the Boddington Bauxite Mine (BBM) in the north-eastern section of the Darling Plateau, approximately 120 km SSE of Perth, near the township of Boddington (Figure 1). The BBM site is situated in the northern jarrah forest with the majority of the mine site falling within the Saddleback and Marradong Timber Reserves (STR and MTR, extents shown in Figure 5). The site is surrounded mostly by cleared agricultural land. The elevation of the site varies from 200 m at the south-west river to 590 m at the top of Mt Saddleback. The major drainage from the site is into the Hotham River which runs along the northern and western edges of the site and Williams River in the south. Marradong Creek is a tributary to Hotham River, which cuts through between Marradong and Saddleback, and drains the eastern side. Hotham and Williams Rivers combine in the south-west corner of the site to form the confluence of the Murray River which meanders westward, outflowing in the Peel-Harvey Estuary next to Mandurah. Mining in Saddleback commenced in the late 1970's, while mining activities in Marradong commenced in 2009.

Figure 1: Location of Boddington Bauxite Mine

Worsley has commissioned Water & Environmental Consultants (WEC) to undertake the July 2020 – June 2023 BBM triennial aquifer review to assess the effect of bauxite-mining activities on the aquifer level and quality. The aquifers in Saddleback and Marradong are used to abstract groundwater for mining activities (primarily dust suppression) through a network of 25 bores. The aquifer catchments are also subject to clearing for mining activities. Land-clearing induced water-table rises have created many salinity problems in south-west Western Australia, and this is the major risk associated with the mining. Worsley has established a network of piezometers across the site to monitor the effects of mining (clearing, mining, water abstraction, haul roads, etc.) on the water-table and on groundwater quality. The heathland in the Tunnell Rd borefield is an identified Groundwater Dependent Ecosystem (GDE), which is sensitive to changes in groundwater level and quality, therefore more extensive monitoring occurs in this catchment. The objective of this report is to review the rainfall, groundwater-abstraction, and groundwater-monitoring data from across the BBM site and to interpret these data, with a focus on trends emerging in the last three years. The report provides a summary of the current understanding of aquifer status; and gives recommendations for the ongoing groundwater-management to meet legislative requirements and guide future decision-making.

2. BACKGROUND

2.1 Groundwater Monitoring Program & Commitments

Worsley's groundwater management and monitoring commitments are legislated by the Ministerial Statement 719, and an extract of the relevant section is given below:

Commitment Number 1 - Water Resources

Objective: *To ensure that the environmental values of surface and groundwater resources are maintained and protected from adverse impacts of bauxite mining activities and construction of bauxite transport corridors.*

Action: *Worsley will prepare and implement a Water Resource Management Plan - Mining which takes into account changing rainfall patterns and which will address the following:*

- *assessment of salinity hazard and salt storage in soils in proposed mining areas;*
- *development of predictive tools to estimate the extent of watertable rise due to mining operations;*
- *monitoring of salinity and level of groundwater in and near mining areas;*
- *monitoring of regional water quality (salinity) of streams and groundwater;*
- *contingency measures for salinity management;*
- *assessment of water dependent ecosystems in new mining areas;*
- *a process for selection of water supplies for the mine, including the evaluation of alternatives;*
- *improvement in the efficiency of water use;*
- *monitoring of water usage, groundwater level and any groundwater dependent ecosystems which may be affected by Worsley's groundwater abstraction;*
- *working arrangements for exploration and mining in public drinking water supply areas;*
- *establishment of appropriate stream buffer zones;*
- *spills management; and*
- *sediment control and drainage management in all areas where Worsley operates.*

Regarding groundwater-abstraction, the Ministerial Statement 719 entitles Worsley to use an average of 500 ML per annum of groundwater and surface-water in the vicinity of the mining areas.

Worsley's Water Management Plan defines the monitoring program established to meet the legislative requirements. This monitoring program involves in-bore loggers monitoring water-level in key monitoring bores across the mining area, with 6-monthly field water-level and water-quality measurements and laboratory water-sample analysis from these key bores. In addition to these key monitoring bores, field measurements and laboratory sampling may be expanded to other bores within the extensive network (approximately 110 bores) to provide further understanding of the groundwater in a given area. The monitoring program is summarised in Table 1. The key differences in the current monitoring program to the previous one are that telemetry water level and electrical conductivity (EC) monitoring has been replaced with simple water-level loggers; and trigger-response field and laboratory sampling has been replaced with six-monthly field visits with laboratory-sample collection. The telemetry network had several technical issues and was unnecessary for groundwater monitoring. Similarly, the EC sensors were error prone and required regular calibration, 6-monthly field measurements and laboratory sampling provides sufficient salinity monitoring. Conducting 6-monthly site visits allows regular data download from the logger, verification of the water level as well as monitoring of the salinity and other water quality indicators. The water plan is also flexible allowing the inclusion of additional bores in the 6-monthly monitoring that do not have loggers. There have also been some changes to the bores monitored due to bores being consistently dry, blockages, and recommendations from the previous reviews, the number of logger-monitored bores was increased to thirty-one.

Table 1: Current BBM Groundwater Monitoring Program

Frequency	Parameters	Type
Continuous	Water Level, Temp °C	Logger
6-Monthly (peak summer and peak winter)	Water Level, EC, Temp °C, pH and DO	Field
	pH, EC, TDS, Silicon as SiO_2, N, Ca, Mg, Na, K, Cl, SO_4, Alkalinity, Fluoride, As, Cd, Cr, Pb, Ni, Zn, Hg, Mn, Se, Al, Fe	Laboratory

The groundwater-monitoring network was reviewed by WEC (Croton, et al., 2020) and the Water Management Plan is currently undergoing a new revision.

The groundwater-monitoring program requires bi-annual total-recoverable hydrocarbons (TRH) analysis of samples from hydrocarbon-monitoring bores (HMB01/03 and HMB02/03), in compliance with the Environmental Protection Act License L5960-1983-11. These bores are located north-west and south-east of the Saddleback Oil-Water Separation Unit (bore coordinates in Appendix B). The compliance with this, and analysis of the data are not included in the aquifer review.

2.2 Climate

BBM is located in the Low Rainfall Zone (LRZ, <900 mm/yr) of the northern jarrah forest, the climate is Mediterranean with warm dry summers and much of the rainfall occurring in winter. The rainfall has declined in recent decades by over 15%, from a 1900-1974 average of 760 mm/yr to a 1975-2023 average of 637 mm/yr (BOM Marradong, Station No. 9575). The annual (calendar year) rainfall at Marradong since 1975 is shown in Figure 2, the four years covered in the review are highlighted. The rainfall in 2021 was the highest on record since 1974, while the rainfall in other review years is below the recent average.

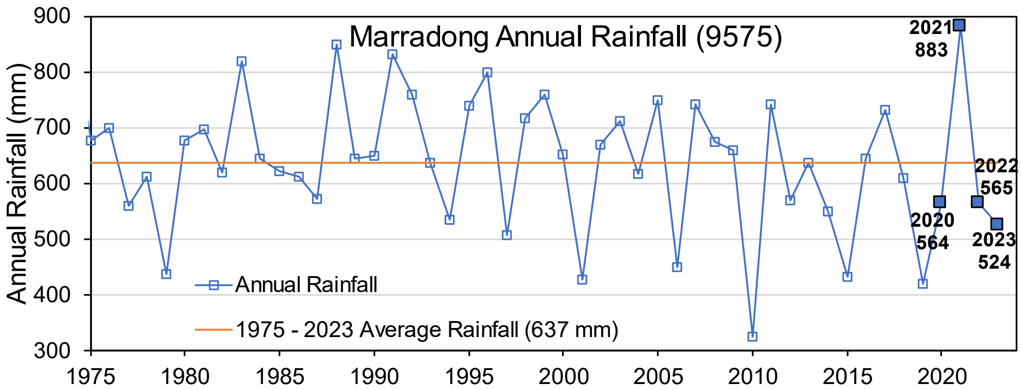

Figure 2: Annual Rainfall Plot for Marradong 1975 – 2023 (calendar years)

The monthly rainfall over the review period is shown in Figure 3 with the 1975-2023 monthly average. It can be seen that the 2021 rainfall greatly exceeded the monthly average in both March and July. The rainfall in March was mostly attributable to a storm with 131 mm falling over the 3rd and 4th March. The rainfall in July was more distributed across the month with a highest daily total of 47 mm on 27th July. Rainfall in the other years was generally below average however they all exceeded the monthly average for at least one month in autumn. While 2023 has a low total rainfall in has the highest number of rain-days since 1998 with rainfall recorded on 122 days. By comparison, 2020 and 2022 had 75 and 77 rain-days respectively, and wet 2021 had 91 rain-days, making them all below the 1975-2023 average of 97 rain-days. Higher rain-days is generally associated with greater aquifer recharge due to the higher infiltration of steady rainfall compared to storm events and the lower evapotranspiration on rain-days. High rain-days also reduces the groundwater requirements for dust suppression across the site.

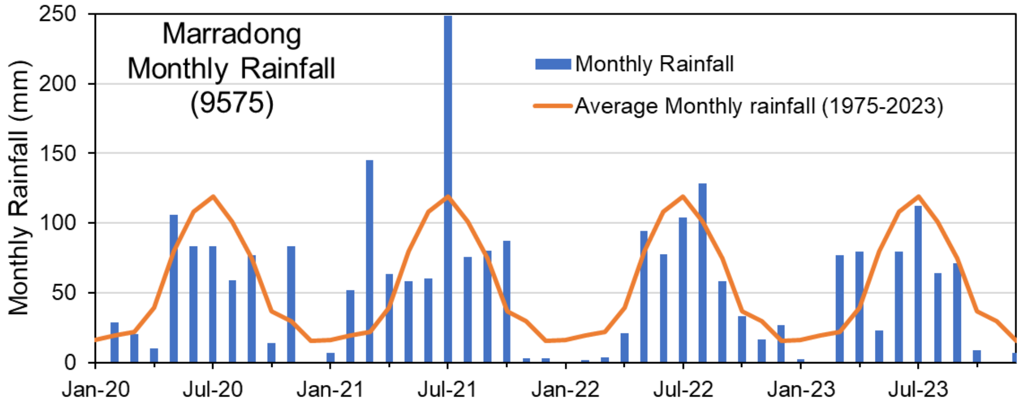

Figure 3: Monthly Rainfall at Marradong over the review period

2.3 Hydrogeology

The BBM site has up to three aquifer-layers: a shallow seasonal-aquifer, a deep weathered-zone aquifer, and a fractured-bedrock aquifer. The existence and extent of these three aquifers varies across the groundwater catchments. The soil profile in BBM typically varies from 10 m to over 50 m but averages around 25 m. The typical soil-profile in the upper- and mid-slopes involves: a shallow top layer of gravelly sand (0-2 m), in which can form a superficial aquifer; a low-permeability duricrust underlies this layer (0-3 m thick) which forms the upper section of a bauxite layer (0-10 m thick); next come the mottled and pallid zones; followed by a saprolite layer, which forms the second aquifer; below this is the fractured-rock aquifer within the bedrock. The saprolite and fractured-rock aquifers are in hydraulic-continuity and are distinguished from each other by their material properties. In the lower slopes and valley-floor the duricrust can be absent; the top-layer of gravel and the bauxite layer can form a single entity which in total is usually thinner than the mid and upper-slope layers. The near-surface soils are highly permeable, so streamflow is usually generated from lateral flows in the upper layer and in the superficial aquifer. The bedrock on the eastern edge of Saddleback and Marradong areas is composed of granites and granitic gneisses, typical of the Darling Plateau. The centre and western side of these areas has a mafic bedrock of the Saddleback group commonly known by the term “greenstone”. The fractured-rock aquifer is the most productive, and is the aquifer targeted by most abstraction-bores. The yield from this aquifer varies considerably from bore to bore due to the non-uniform nature and preferred-pathways of the fractured rock. The saprolite aquifer has considerable storage-capacity, but only moderate permeability and this makes it less suited to abstraction.

The near-surface soils are highly permeable, so streamflow is usually generated from lateral flows in the upper layer and in the superficial aquifer. The salinity is usually low in these upper layers and the low volume and high permeability of the superficial aquifer generally results in ephemeral streams, with flow periods dependent on the catchment area and superficial-aquifer thickness. As well as generating streamflow some water penetrates to the connected saprolite and fractured-rock aquifers. In forested areas these aquifers are usually disconnected from surface water with their water-table remaining at depth, even in the stream zone. Rises of this water-table can result in discharge of saline groundwater to streams, significantly affecting the stream and riparian ecosystems, as has been observed following historical clearing for agriculture in the region.

2.4 Bauxite Mining Aquifer Risks

Bauxite mining can potentially affect the aquifers via: changes to the groundwater recharge caused by clearing and revegetation, and drawdown from groundwater abstraction. There is also a risk of hydrocarbons and other chemicals entering the groundwater system from localised spills from mining related activities.

The risk of hydrocarbons and other chemicals is managed by appropriate spill prevention and management measures and by regular sampling of two hydrocarbon-monitoring bores located within the main operational area (HMB01/03 and HMB02/03). A review of the data from these hydrocarbon-monitoring bores is conducted separately and not included in this report.

The risk of excessive drawdown from groundwater abstraction is managed by: a regular review of the sustainable yields of production bores; continuous monitoring of groundwater-abstraction volumes via flowmeters; and groundwater-level observations from nearby monitoring bores. The abstraction volumes and surrounding monitoring will be discussed in this review.

Clearing and revegetation can affect groundwater levels, due to the significant role of evapotranspiration (ET) in the water balance accounting for up to 98% of rainfall in the Low Rainfall Zone (LRZ) (Croton & Dalton, 2004). The removal of vegetation for mining and associated activities (e.g. haul roads) significantly reduces the ET, which increases groundwater recharge and often raises the water-table (Croton & Dalton, 2003). This increased recharge is similar to that seen when land is cleared for agriculture; however, clearing within the bauxite mine is temporary, with prompt revegetation of most areas (with the exception of haul roads and other operational areas). The revegetation as it grows can also affect the groundwater recharge, with potential for a long-term effect if the vegetation is significantly different in composition and/or density to the pre-mining conditions.

Changes to groundwater levels are a concern both for groundwater dependent ecosystems (GDEs) and for streamflow quantity and quality where the groundwater discharges into the streamzone. The Tunnell Rd heathland in STR is a recognised GDE where changes to the groundwater level and/or quality may significantly affect this recognised ecosystem. A high level of monitoring is conducted in the Tunnell Rd heath area to examine the effect of groundwater abstraction and surrounding mining activities on the heath, which will be discussed in this review.

While changes to streamflow volumes is somewhat of a concern; the greatest surface-water risk is posed by the discharge of saline groundwater to the surface caused by a rising water-table after clearing. Dry-land salinity is a recognised problem in South-West W.A., in many places clearing for agriculture has caused the surface discharge of saline water. Due to the temporary nature of its clearing, the risk of dry-land salinity from bauxite mining is much lower than from agriculture. The risk and potential impact of dry-land salinity is dependent on the amount of salt in the soil and groundwater as well on the water-table level change.

A soil-salt storage analysis of 438 boreholes was conducted in 2007 (Croton & Dalton) to evaluate the salinity risk of mining activities. This study determined a mean volumetric total soluble salt (VTSS) of 0.94 and 1.18 kg/m^3 in STR and MTR respectively, with no significant difference between the granite and greenstone bedrocks. These results were significantly lower than the 1.94 kg/m^3 suggested by previous broad studies (Tyskin & Croton, 1988).

A review of the effect of bauxite mining on the groundwater and streamflow was carried out in 2004 (Croton & Dalton, 2004) comparing two catchments, a control catchment (Hunt A, a.k.a. Bee Farm) and a mined catchment (Hunt B, a.k.a. Tunnel Rd) with monitoring commencing in both catchments in 1976. The review found mining resulted in an increase in both streamflow and salinity (from 100-200 mg/L to 200-500 mg/L), however the runoff from both catchments was very low at 0.06 and 0.08 % of rainfall in Hunt A and B respectively. Because the runoff is so small these changes are unlikely to have a significant effect at the water-resources scale. The effect is also likely to be temporary with the water table receding after rehabilitation thereby lowering the stream salt-load to pre-mining conditions. After the study was completed mining was conducted in the control catchment.

Several studies modelling the potential effect of mining on groundwater at BBM have been conducted including Groundwater Flow Analysis (GFA) conducted as part of the recent groundwater monitoring review (Croton, et al., 2020). These types of studies have guided both the placement of piezometers and prioritising the monitoring of existing ones.

The drying climate discussed previously has significantly reduced the risk of dry-land salinity at BBM. Current groundwater-levels of forested catchments are significantly below historic levels. Figure 4 shows the groundwater level at A04 (in Hunt A control catchment), Q08 (in Quindanning area), with Q08 levels adjusted to present in the same plot. Groundwater level at A04 declined steadily from 1976 levels until the commencement of mining activities in Hunt A catchment, groundwater levels have continued to decline in Q08 forested catchments.

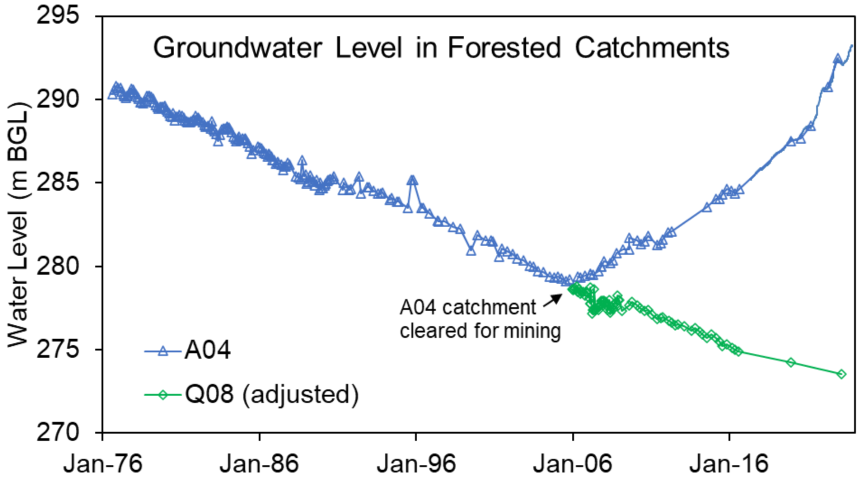

Figure 4: Groundwater level plot for A04 and Q08(adjusted)

The saprolite aquifer is the most important aquifer for monitoring, due to its large storage capacity and ability to discharge into the streamzone. Some monitoring of the fractured-rock aquifer is also useful, to observe the varied effect on this aquifer. Due to its seasonality and limited volume the shallow superficial aquifer is of little interest to general studies but may be relevant to understanding localised ecosystems of interest.

3. BOREFIELD OVERVIEW

There are six major abstraction and monitoring areas within BBM area: Karafil; Tunnell Rd; Fawcett; South-East area; Marradong; and Nichols (no abstraction) (Figure 5). The abstraction and monitoring data for each area will be discussed separately in detail in the following sections. Groundwater was abstracted from 25 production bores over the review period (red circles), 33 bores were monitored with groundwater-level loggers (blue diamonds). A further three bores were monitored with field visits (green triangles), there are many other bores in the region that are not currently being monitored, these have been left off the map for clarity. The Marradong and Saddleback Timber Reserves are outlined in yellow. Tabulated details for all shown bores are given in Appendix B. Most of the current monitoring-bores are screened in the saprolite aquifer, with a few screened in the fractured-rock aquifer. The monitoring network was established with bores near abstraction fields, bores within mining and operational catchment-areas; and control bores removed from all mining activity. As mining activities have expanded across BBM, mining has entered several control-bore catchments. Mining activities are currently commencing in the catchments of Q07 and Q08, the last monitored-bores with undisturbed-forest catchments. The oldest monitoring-bores are the “A” and “B” series of bores in the South-East area, which were commissioned in 1976; one new monitoring-bore, B04/20 was commissioned in this review period and will be discussed in the Marradong section.

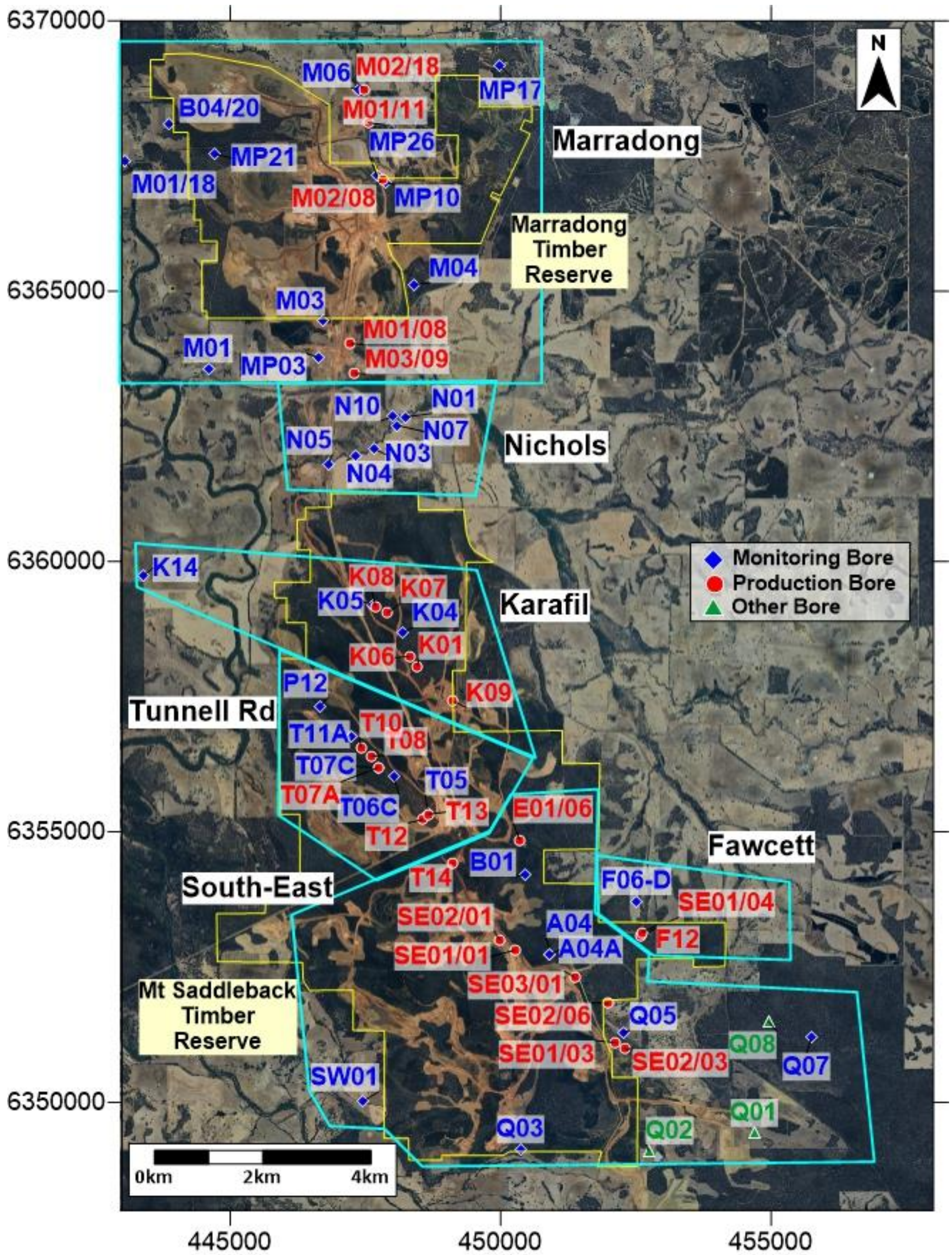

Figure 5: Map of BBM areas, timber reserves, production and monitoring bores

Water is used in the BBM area primarily for dust suppression; water is abstracted from a network of bores, and pumped into dams and other holding vessels before use. Twenty-five abstraction bores were utilised in the review period: five in Marradong; five in Karafil; five in Tunnell Rd; two in Fawcett; and eight in South-East borefield. The majority of the abstraction bores are located in the streamzones of valleys, with most accessing the fractured-rock aquifer, however some of the Karafil and Tunnell Rd bores are within the saprolite aquifer. The recommended sustainable yields were reviewed in 2015 and vary from 29 to 380 kL/day (GRM, 2015).

The total annual-abstraction from the five borefields since 1994-95 are shown in Figure 6. The abstraction data is reported on a July to June year as the demand for dust suppression is greater in summer due to the lower rainfall and higher evaporation. The total abstraction-volume decreased slightly compared to the previous review-period, with a significant drop in 2022-23. The total annual abstraction from BBM bores over the review period varied from 657 ML (in 2020-21) to 482 ML (in 2022-23). For the first two years in the review period the annual abstraction exceeded the 500 ML per annum averaged-abstraction stated in Ministerial

Statement 719, however the averaged abstraction across the last twenty years remains below this limit at 479 ML/yr. All borefields are operating significantly below their recommended sustainable yield. The combined recommended yield is 2.6 times the current average abstraction-rate, which suggests that Worsley has flexibility in meeting its water requirements with the current borefields. The abstraction from each borefield is discussed in more detail in the following sections. The only change to the production borefield was renewed abstraction of small volumes from F12 which had not been utilised since 2014.

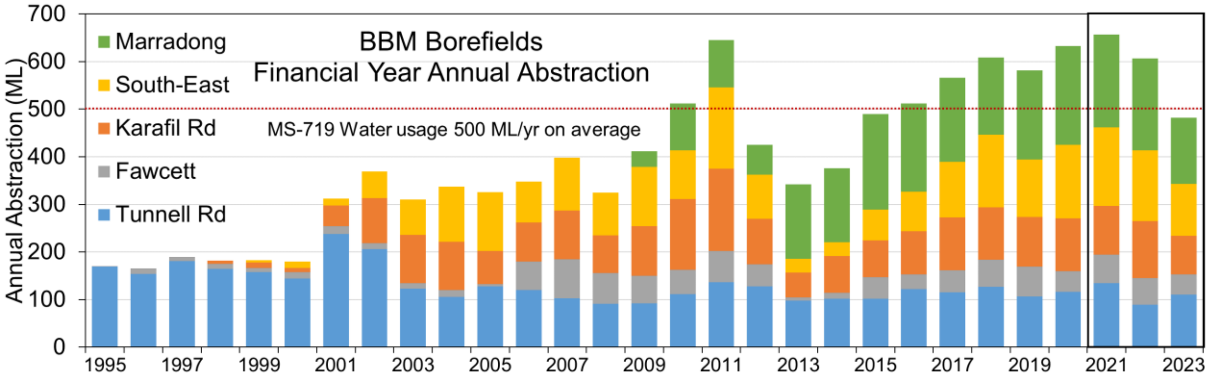

Figure 6: BBM Borefields Financial Year Annual Abstraction

4. KARAFIL

4.1 Borefield Description

Kararfil borefield is situated along a valley in the north-west of the Mt Saddleback mining area and timber reserve. There are three production-bores in use along the valley, and two active monitoring-bores in the valley, as well as a control monitoring-bore located in agricultural land on the western side of Hotham River, the location of these bores are shown in Figure 7. Along the streamzone and lower slopes there is some remnant-vegetation and several cleared operational-areas (haul roads and conveyor), the mid and upper slope have large areas of revegetation, there are cleared areas for operational infrastructure at the head of the valley. There has been a small increase in cleared areas in the south-east of the valley over the review period. Monitoring of the Karafil bores K04 and K05 commenced in 1994, pre-dating abstraction which commenced in December 1997; K14 monitoring-bore was commisioned in 2005. Production-bores K01 and K07 abstract from the saprolite aquifer, while the others abstract from the fractured-rock aquifer. All monitoring bores are screened in the saprolite aquifer. Details of the bore depths, screening intervals and aquifers, and commission years are summarised in Table 2.

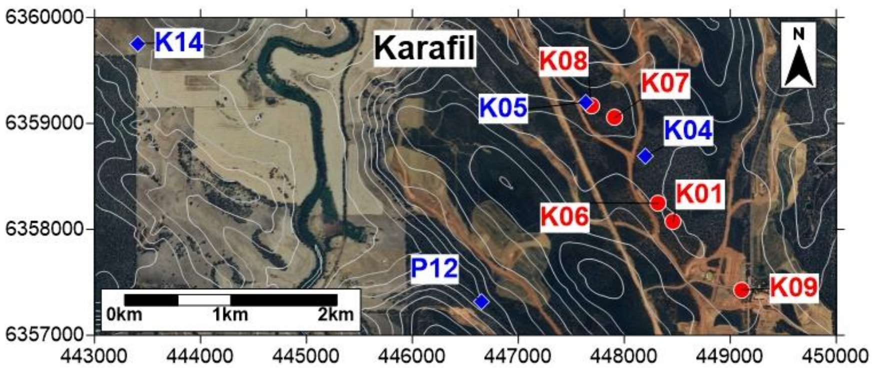

Figure 7: Location of production and monitoring bores in Karafil area

Table 2: Screening details of Karafil production and monitoring bores

Bore		Depth (m BGL)	Screening Interval (m BGL)	Screening Aquifer	Commission Year
Production Bores	K01	51.75	19.75 – 51.75	Saprolite/Saprock	1982
	K06	73.8	52.45 – 73.8	Fractured Rock	1993
	K07	43.8	37.25 – 43.8	Saprolite/Saprock	1993
	K08	97.0	59.28 – 97.0	Fractured Rock	1998
	K09	100.0	60.45 – 100.0	Fractured Rock	1998
Monitoring Bores	K04	49.52	13.65 – 49.45	Saprolite	1982
	K05	28.77	0 – 29.47	Saprolite	1982
	K14	28.06	16.06 – 28.06	Saprolite	2005

4.2 Groundwater Abstraction

Over the review period the groundwater abstraction from Karafil borefield was seasonal with low abstraction in winter, as shown in Figure 8. The overall abstraction from Karafil borefield is slightly lower than in the previous review-period due to the reduced abstraction in 2023 from K01, K06 and K08.

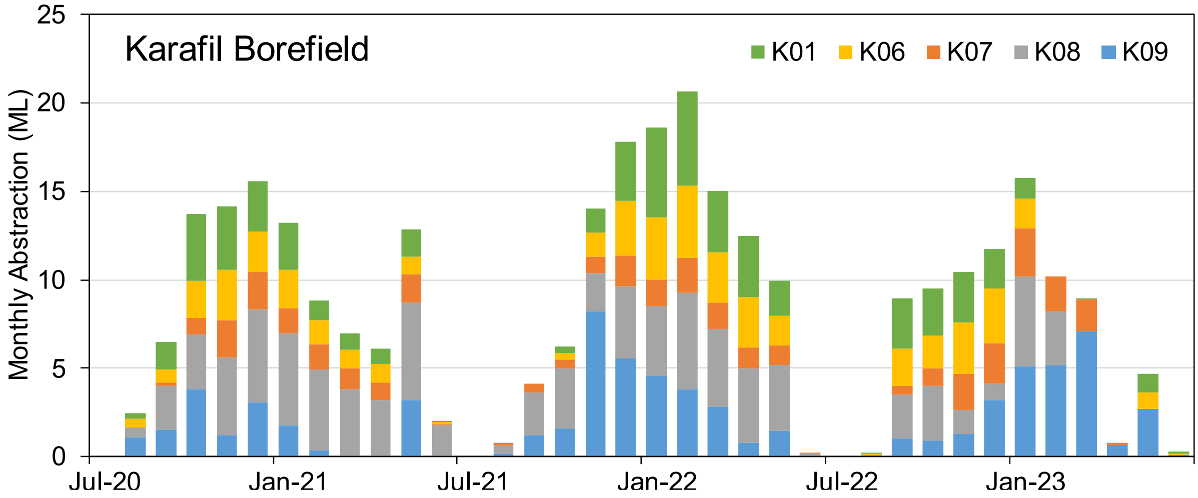

Figure 8: Karafil borefield monthly abstraction

The recommended yields and annual abstraction-volumes for each year of the review are given in Table 3. The abstraction from K08 exceeded the recommended yield in 2020-21 and 2021-22, but the overall abstraction from the borefield remains below the recommended-yield.

Table 3: Annual abstraction from Karafil production-bores

Bore	Recommended Yield		Abstraction (1st July to 30th June) (ML/yr)		
	(kL/day)	(ML/yr)	2020-21	2021-22	2022-23
K01	80	29	19	24	13
K06	80	29	15	20	13
K07	125	46	12	11	13
K08	90	33	40	34	16
K09	350	128	16	30	27
Total	725	265	102	120	81

4.3 Groundwater Monitoring

The groundwater-level and salinity plots for all monitored bores in the Karafil area are shown in Figure 9. The groundwater-level has risen at K04, with a significant rise in the high-rainfall year 2021, the autumn peaks in 2022 and 2023 were similar, areas upslope of K04 have remained cleared for the bauxite conveyor, haul-roads, and other operational infrastructure.

There was no significant change to the groundwater level at K05 which is located further downslope. K05 is located within 60 m of production bore K08, it has large seasonal fluctuations and some small variability, a plot of the logger water level and abstraction from K08 is included in Figure 9. K05 is screened in the saprolite aquifer, while production-bore K08 is screened in the fractured-rock aquifer. The two aquifers are generally hydraulically connected, however the saprolite aquifer generally has lower hydraulic-conductivity, which may contribute to the delayed and subdued response seen. Salinity decreased slightly at K04 and K05, and remains stable at K14, which also has a stable water-level. There was no significant change to other groundwater quality parameters, the laboratory testing results from this review period are presented in Appendix A. The logger at K14 was missing at the last site visit and needs to be replaced.

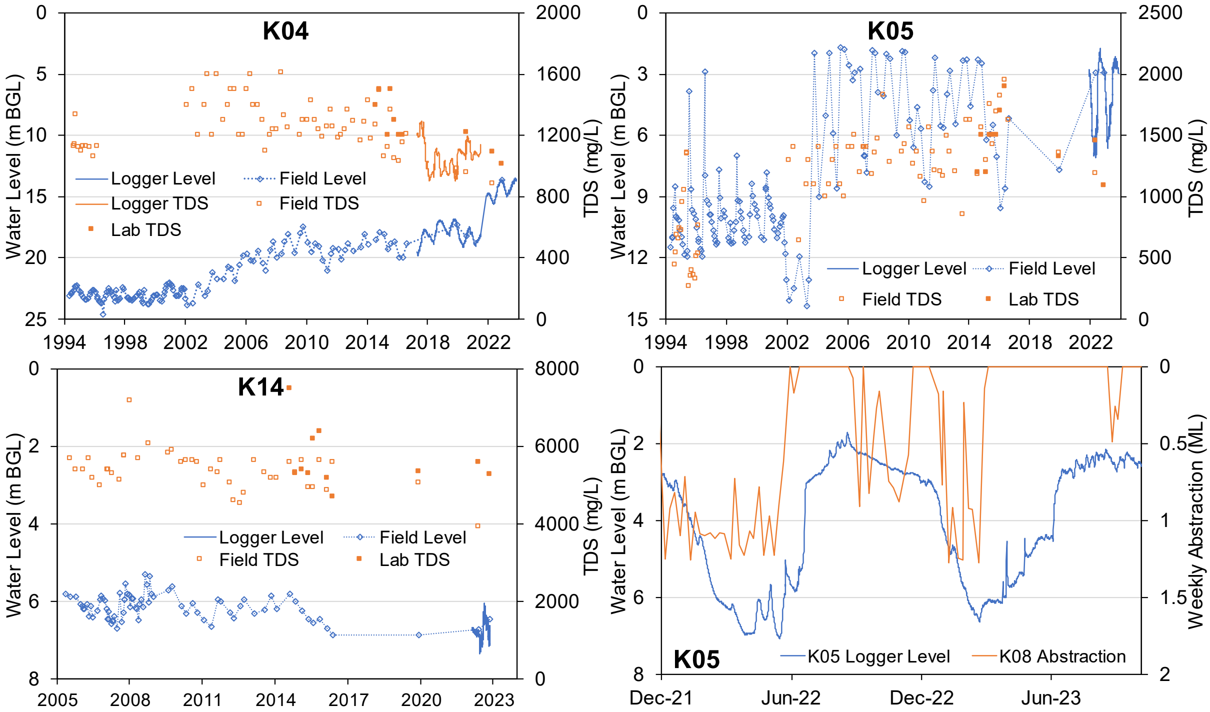

Figure 9: Groundwater-level and salinity plots for monitoring bores in Karafil area

4.4 Borefield & Monitoring Assessment

Overall, the abstraction of groundwater from Karafil borefield appears to be conducted in a sustainable way, abstraction for K08 exceeded the recommended yield for two years, however no decline in groundwater level is observed at nearby monitoring-bore K05. There is an increase in groundwater level at K04, most notably in the high rainfall year 2021, the water level still remains more than 13 m below the surface and was stable over the last autumn peaks. There is some planned rehabilitation in the catchment over the coming years, and recently rehabilitated areas will increase their water use. Overall, the aquifer appears to be in good condition with minimal effect from mining activities.

5. TUNNELL RD

5.1 Borefield Description

The Tunnell Rd borefield is situated in the next valley south of the Karafil borefield and is within the Saddleback mining-area and timber reserve. The location of production and monitoring bores within the Tunnell Rd borefield are shown in Figure 10. The five monitoring bores and four of the active production bores are located along the valley floor, prodruction bore T12 is located in the lower slopes at the head of the catchment. The upper and midslopes are a mix of mine-revegetation and areas recently cleared for mining; there are haul-roads and operational areas in the lower slopes along with areas of remanant vegetation. The heathland ecosystem in the lower Tunnell Rd valley is identified as a groundwater dependent ecosystem (GDE). Abstraction from Tunnell Rd borefield commenced in 1981, pre-dating regular monitoring-records by over ten years. Most of the production-bores in Tunnell Rd are abstracting from the saprolite aquifer with only T12 and T13 drawing from the fractured-rock aquifer. Details of the depth, screening interval and year of commission of production and monitoring bores in Tunnell Rd borefield are summarised in Table 4.

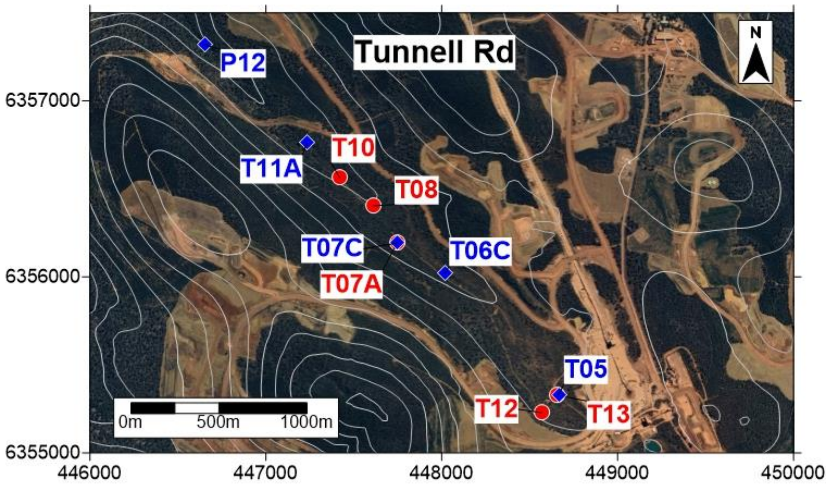

Figure 10: Location of production and monitoring bores in Tunnell Rd area

Table 4: Screening details of Tunnell Rd production and monitoring bores

Bore		Depth (m BGL)	Screening Interval (m BGL)	Screening Aquifer	Commission Year
Production Bores	**T07A**	57.0	3.0 – 57.0	Saprolite/Saprock	1981
	T08	40.3	22.3 – 40.3	Saprolite/Saprock	1981
	T10	35.3	11.3 – 35.3	Saprolite/Saprock	1990
	T12	77.29	34.63 – 76.63	Saprolite/Saprock & Fractured Rock	1992
	T13	58.0	37.2 – 58	Saprolite/Saprock & Fractured Rock	1995
Monitoring Bores	**T05**	41.5	28.0 – 41.5	Saprolite	1981
	T06C	24.7	16.0 – 24.7	Saprolite	1981
	T07C	92.0	unknown	unknown	1981
	T11A	26.1	13.03 – 25.03	Saprolite	1991
	P12	28.5	6.43 – unknown	Saprolite	1992

5.2 Groundwater Abstraction

The groundwater abstraction from Tunnell Rd borefield over the review period is shown in Figure 11. The abstraction from Tunnell Rd continues throughout the year without the seasonal pattern noted in other borefields. The abstraction from Tunnell Rd borefield in 2021-22 was the lowest in records back to 1991-92, with abstraction from T13 notably lower.

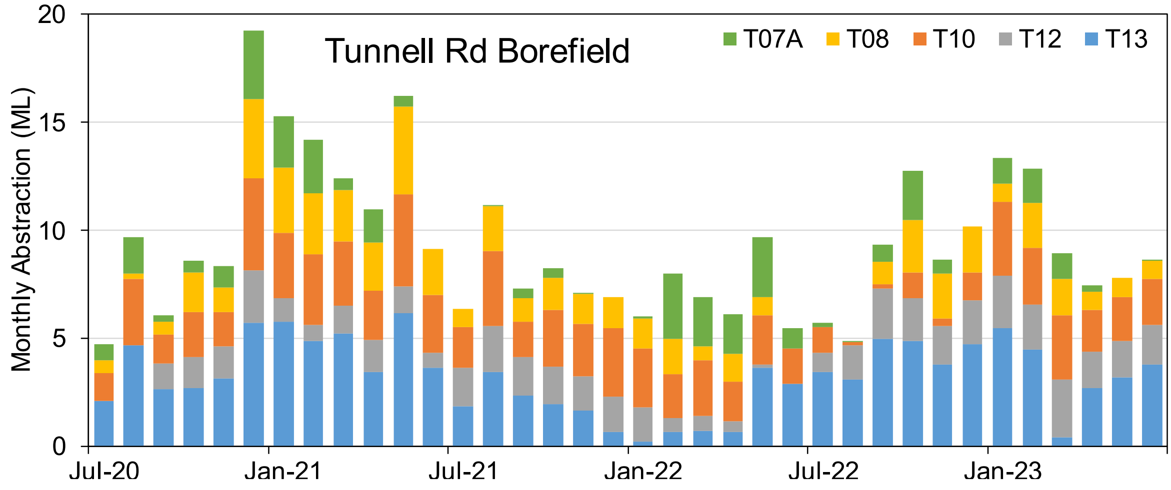

Figure 11: Tunnell Rd borefield monthly abstraction

The recommended yields and annual abstraction-volumes for each year of the review are given in Table 5. The abstraction from all bores were below their recommended yield every year.

Table 5: Annual abstraction from Tunnell Rd production bores

Bore	Recommended Yield		Abstraction (1st July to 30th June) (ML/yr)		
	(kL/day)	(ML/yr)	2020-21	2021-22	2022-23
T07A	60	22	15	12	8
T08	115	42	25	14	15
T10	150	55	32	28	19
T12	150	55	13	14	23
T13	350	128	50	21	45
Total	825	302	135	89	111

5.3 Groundwater Monitoring

Groundwater levels and salinity plots for the Tunnell Rd monitoring-bores are shown in Figure 12. There is no significant change in the groundwater level in any of the monitoring bores over the review period. The Tunnell Rd monitoring-bores have maintained a very consistent groundwater-level throughout the entire monitoring period. T06C was used as a production bore in the early period of monitoring and the levels over this period reflect that with large fluctuations and a slightly lower level. T11A was also used as a production bore, which probably explains the lower level in the early 2000's. The monitoring-bore T07C is located close to production-bore T07A, a plot of T07C water-level with T07A abstraction is included in Figure 12 showing short-term fluctuations in level due to the pump operation. Tunnell Rd has a more seasonally responsive water-table than other areas, with large fluctuations between summer and winter levels. This suggests high vertical-permeability allowing the recharge to infiltrate more rapidly, resulting in a strong seasonal-trend. The salinity is stable across the bores, as is other water-quality measurements, the laboratory-testing results from this review period are summarised in Appendix A.

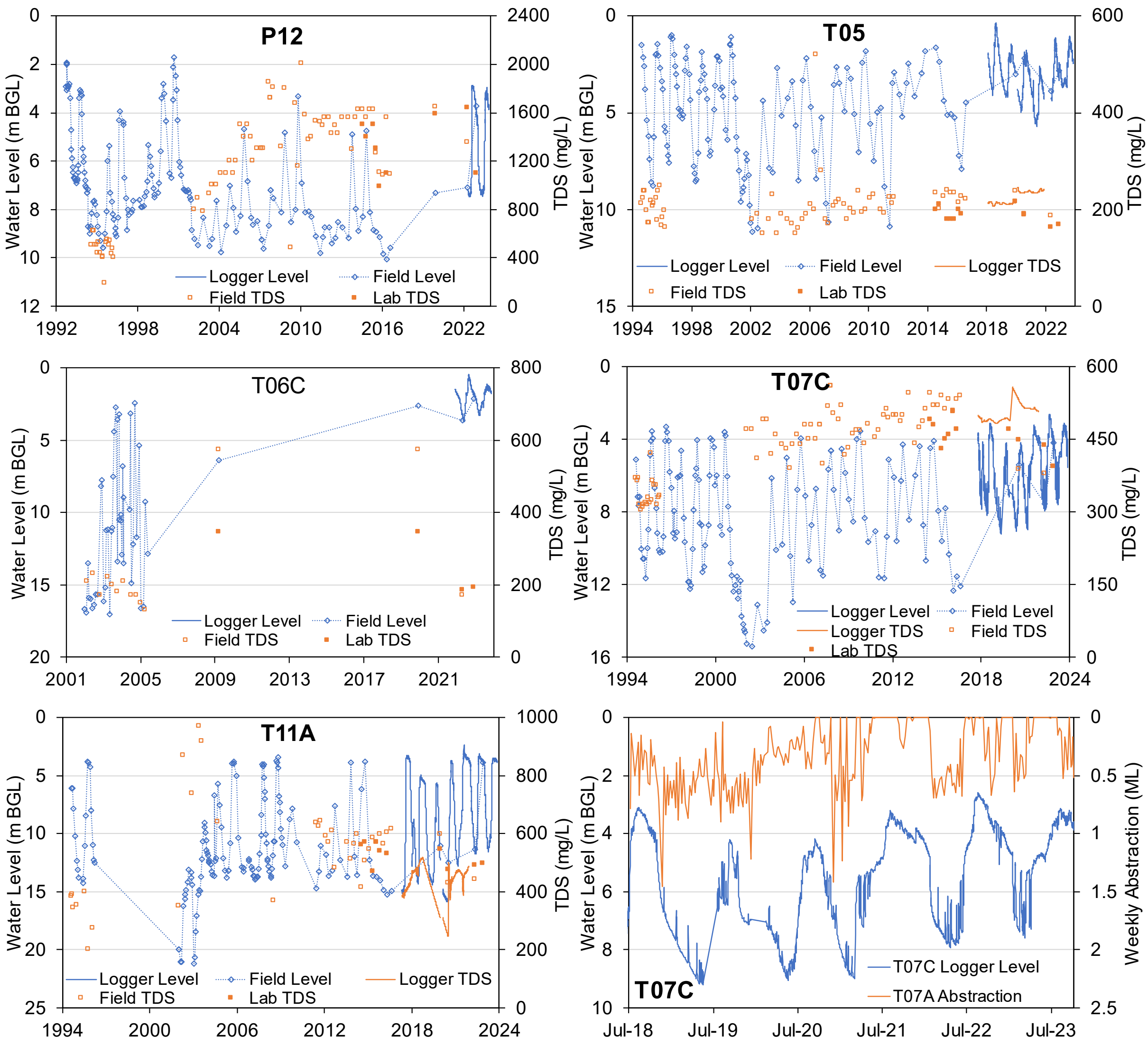

Figure 12: Groundwater level and salinity plots for Tunnell Rd bores

5.4 Borefield & Monitoring Assessment

The abstraction of groundwater from the Tunnell Rd borefield appears to have been conducted sustainably over the review period. The abstraction from all bores was within their recommended yield. The groundwater levels and quality have generally remained stable across the monitoring period suggesting that the aquifer is being well managed and the GDE is protected.

6. FAWCETT

6.1 Borefield Description

Fawcett Borefield is in the east of Mt Saddleback Timber reserve in an unmined area. There are currently two operational production-bores (SE01/04 and F12) near the head of the valley, and one monitoring-bore (F06D) in the lower slopes to the north, the location of these bores are shown in Figure 13. SE01/04 was commissioned in 2004 and abstracts from the fractured-rock aquifer, nearby F12 was commissioned in 1994 and the screening interval is unknown, but it is significantly shallower, details of all the bores are summarised in Table 6.

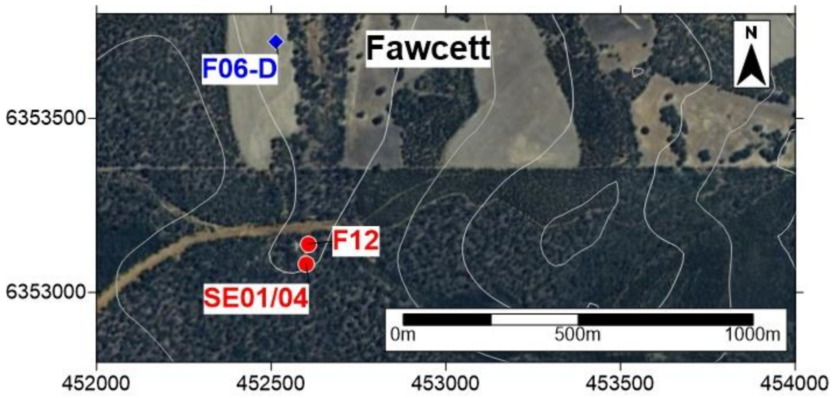

Figure 13: Location of production and monitoring bores in Fawcett area

Table 6: Screening details of Fawcett production and monitoring bores

Bore		Depth (m BGL)	Screening Interval (m BGL)	Screening Aquifer	Commission Year
Production Bores	SE01/04	120.0	60 – 120	Fractured Rock	2004
	F12	38	unknown	unknown	1994
Monitoring Bore	F06D	13.94	unknown	unknown	unknown

6.2 Groundwater Abstraction

The groundwater abstraction from Fawcett borefield over the review period is shown in Figure 14. The abstraction is somewhat seasonal with lower abstraction in winter, total volume is slightly lower than in the previous review-period. F12 had not been previously utilised for abstraction since 2014, the volumes abstracted are small with no abstraction in 2022-23.

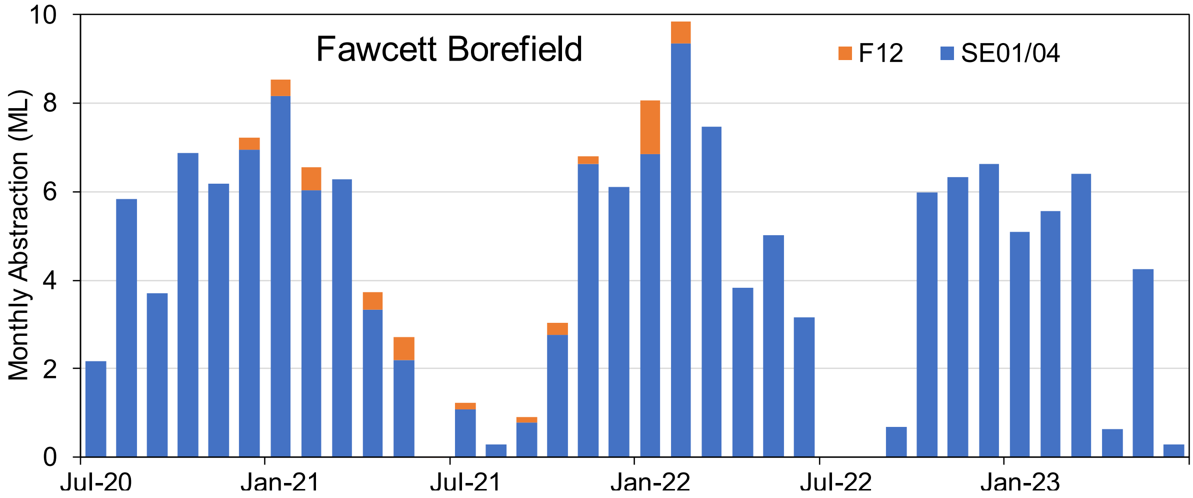

Figure 14: Fawcett borefield monthly abstraction

The recommended yield and annual abstraction-volume for each year of the review are given in Table 7. The abstraction from both bores remain below their annualised recommended-yield throughout the review period.

Table 7: Annual abstraction from Fawcett production bore

Bore	Recommended Yield		Abstraction (1st July to 30th June) (ML/yr)		
	(kL/day)	(ML/yr)	2020-21	2021-22	2022-23
SE01/04	200	73	58	53	42
F12	80	29	2	2	0
Total	280	102	60	56	42

6.3 Groundwater Monitoring

Groundwater levels for F06D, the Fawcett area monitoring bore, is shown in Figure 15. The logger groundwater-level at F06D show high seasonal fluctuations, with both the highest and lowest water level for this bore recorded over the review period. The salinity levels are the lowest recorded for this bore. F06D is located more than 600 m from the production bores and is not directly downslope, a plot of the abstraction from SE01/04 with the water level at F06D is included in Figure 15, abstraction may have some influence on the water level resulting in larger seasonal-fluctuations but it is difficult to determine over the short logger-monitoring-period. There was no significant change to the groundwater quality at Fawcett bores, with the full laboratory-results given in Appendix A.

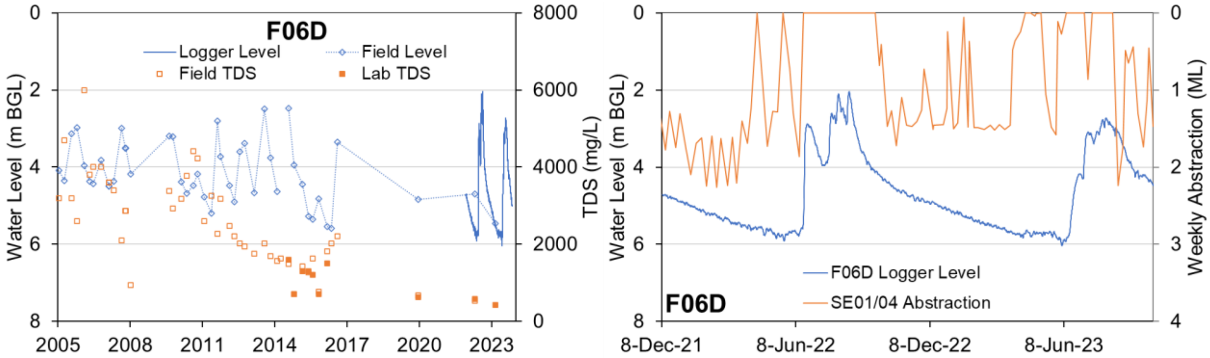

Figure 15: Groundwater level and salinity plot for Fawcett area bore F06D

6.4 Borefield & Monitoring Assessment

The abstraction from both bores is below their annualised recommended-yield, and does not appear to be significantly affecting the groundwater table in the area, but may be accentuating seasonal fluctuations. The overall level of the water-table has not changed significantly; however, the seasonal fluctuations appear larger; this may simply be due to the higher frequency of monitoring a logger permits.

7. SOUTH-EAST

7.1 Borefield Description

The South-East borefield and monitoring area covers a large area and includes all Saddleback production and monitoring bores not attributed to the previous sections, Figure 16 shows the location of all monitored bores in this area. The area consists of eight production-bores (red circles), seven telemetry-monitored bores (blue diamonds), three other occassionally monitored bores that were sampled during the review period. The largest change to landuse over the review period is mining activity in the Quindanning area with significant areas cleared for mining, and rehabilitation commencing in some areas. The production bores include the "SE" bores which lie along the south-eastern side of Mt Saddleback, along with T14 and E01/06 which lie to the north of these bores. All these production-bores abstract from the fractured-rock aquifer. The production bores were commissioned between 1998 (T14) and 2006 (SE02/06 & E01/06). The "A" and "B" piezometers were established in 1975-6 to monitor the effect of mining, with the Hunt A (aka Tunnel Rd) catchment as the unmined control, and the Hunt B (aka Bee Farm) catchment as the mined area. Prior to mining within the control catchment, a review of this program was conducted (Croton & Dalton, 2004). The Quindanning ("Q") and South-West ("SW") bores were commissioned in 2005. All monitoring bores with known lithology are screened in the saprolite aquifer, A04A is probably screened in the fractured rock aquifer based on the lithology of nearby A04, and B01 may be screened in the pallid zone given the shallow depth. Details of the screening of the bores is summarised in Table 8.

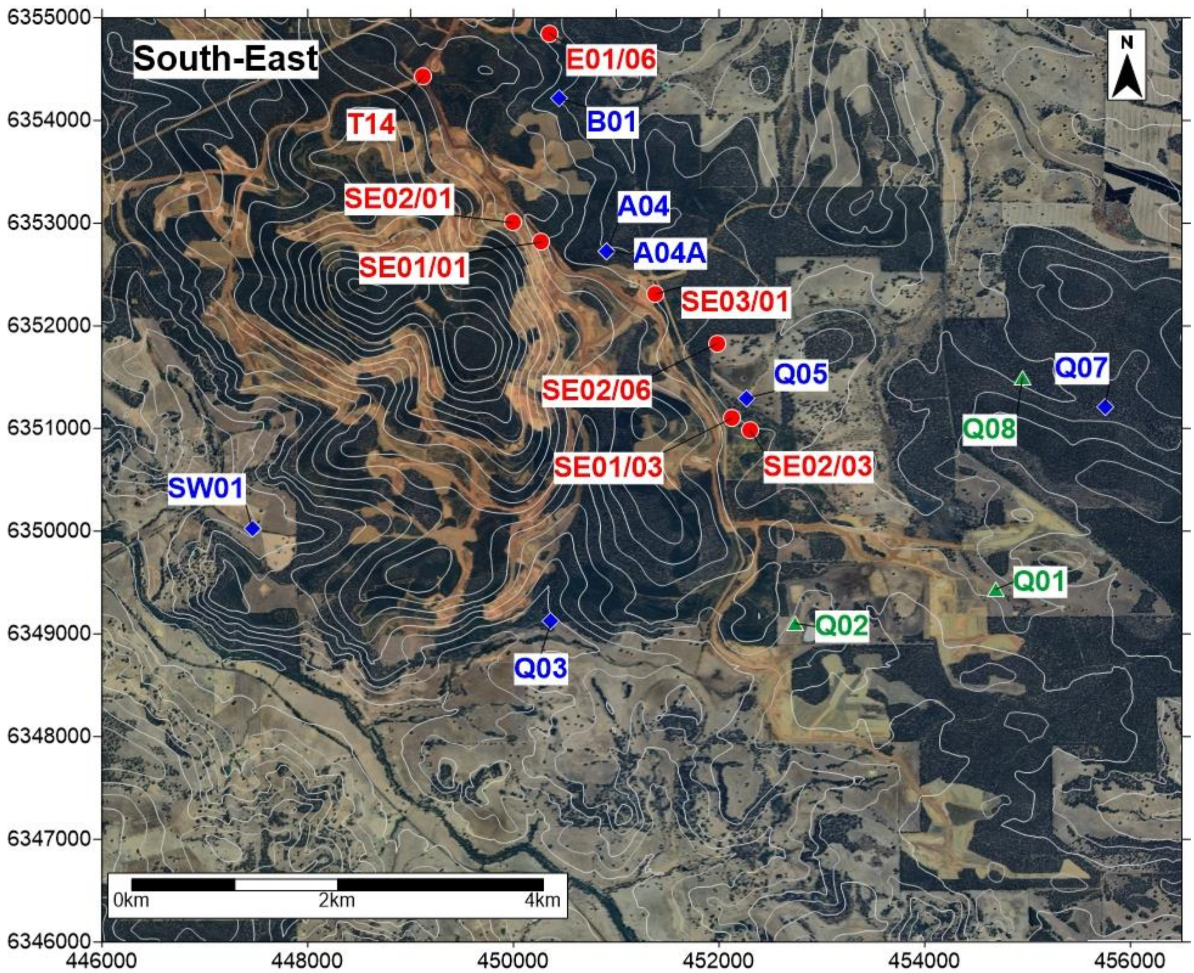

Figure 16: Location of production and monitoring bores in South-East area

Table 8: Screening details of South-East production and monitoring bores

Bore		Depth (m BGL)	Screening Interval (m BGL)	Screening Aquifer	Commission Year
Production Bores	**T14**	86.0	26.4 – 86.0	Fractured Rock	1998
	SE01/01	99.40	33.70 – 99.40	Fractured Rock	2001
	SE02/01	85.0	31.0 – 85.0	Fractured Rock	2001
	SE03/01	101.50	23.50 – 101.50	Fractured Rock	2001
	SE01/03	90.48	0.48 – 18.48 48.48 – 90.48	Laterite/Pallid & Fractured Rock	2003
	SE02/03	100.24	46.19 – 82.19 92.24 – 100.24	Fractured Rock	2003
	SE02/06	92.0	33.79 – 90.95	Fractured Rock	2006
	E01/06	91.38	41 – 91.38	Fractured Rock	2006
Monitoring Bores	**A04**	40.72	5.83 – 41.83	Saprolite	1976
	A04A	55.13	45 – 55	unknown	1976
	B01	14.17	4.95 – 14.17	unknown	1975
	Q03	39.00	8.20 – 32.20	Saprolite	2005
	Q05	40.30	20.73 – 38.73	Saprolite	2005
	Q07	34.67	16.05 – 34.05	Saprolite	2005
	SW01	36.50	23.28 – 35.28	Saprolite	2005
Occasional Monitoring Bores	**Q01**	32.50	11.09 – 29.09	Saprolite	2005
	Q02	47.50	22.77 – 46.77	Saprolite	2005
	Q08	42.84	24.76 – 42.76	Saprolite	2005

7.2 Groundwater Abstraction

The monthly abstraction-volumes from the eight production-bores over the review period are shown in Figure 17. The abstraction from the South-East is seasonal with lower abstraction during winter. The borefield abstraction over the review period is similar to the previous review-period, abstraction from SE02/01finished in November 2020.

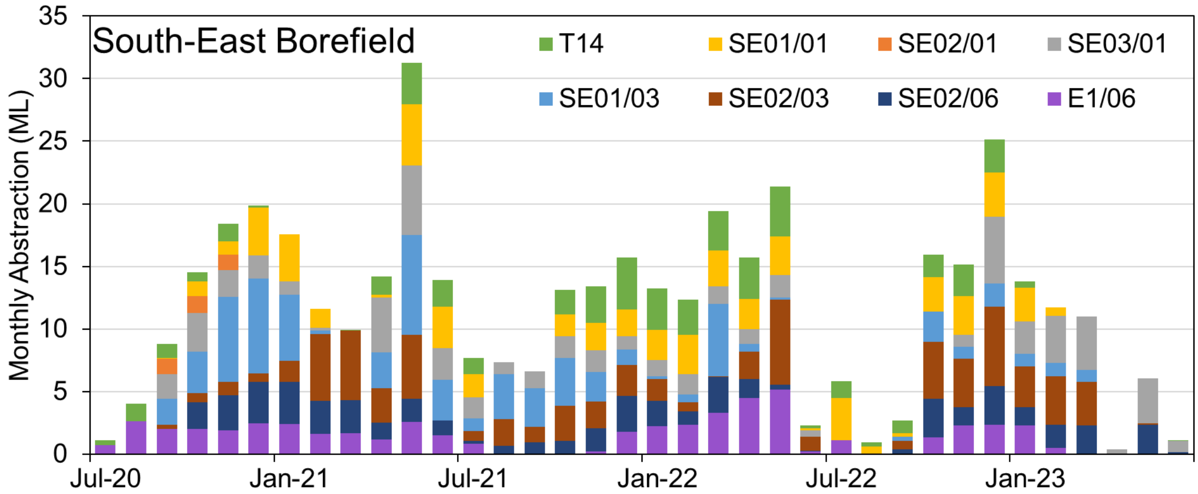

Figure 17: South-East borefield monthly abstraction

The recommended-yields and annual abstraction-volumes for each year of the review are given in Table 9. The abstraction from SE01/03 exceeded the annualised recommended-yield in 2020-21, but was below this in the later years. The abstraction from the other bores remained below their annualised recommended-yield.

Bore	Recommended Yield		Abstraction (1st July to 30th June) (ML/yr)		
	(kL/day)	(ML/yr)	2020-21	2021-22	2022-23
T14	300	110	12	27	10
SE01/01	90	33	20	22	17
SE02/01	60	22	4	0	0
SE03/01	80	29	23	16	22
SE01/03	80	29	40	22	9
SE02/03	150	55	23	24	26
SE02/06	100	37	21	15	16
E01/06	300	110	23	21	10
Total	1,060	387	165	148	110

Table 9: Annual abstraction from South-East production bores

7.3 Groundwater Monitoring

The groundwater level and salinity at B01, the northern-most bore in this area, is shown in Figure 18. The level has been stable over the recent logger-based monitoring-period and has significantly smaller seasonal fluctuations compared to previous manual monitoring. Field measurements and laboratory samples would be useful to evaluate the current salinity given the high historical range.

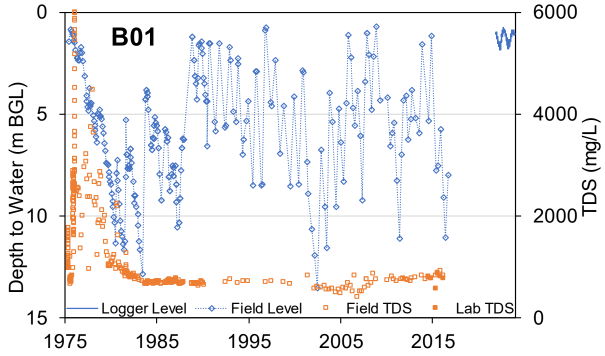

Figure 18: Groundwater level and salinity plot for B01 monitoring bore

Groundwater levels and salinity for A04 and A04A Saddleback monitoring bores are shown in Figure 19. These bores are within meters of each other but have a different screening range with A04 screened in the saprolite aquifer and A04A probably screened in the fractured rock aquifer. The significant difference in their levels and changes over time suggest the screened zones are not well connected hydraulically, the impedance between the two aquifers may be contributing to the groundwater rise at A04. Shallower screened A04 exhibits a higher water table with larger changes over time, and usually lower salinity. Over the recent monitoring-period there has been a rise in the water level at both of these bores with the levels now exceeding that of the 1970’s. A significant area upslope of these bores has remained cleared since mining of the catchment commenced in 2005, rehabilitation of some of this area has started with further areas planned in the coming years, however some areas will remain cleared for haul-roads and other operational requirements. The water table at these bores is significantly affected by mining activities due to their broad catchment areas, large bauxite bodies and several haul-roads within them, which has resulted in a lower density vegetation-cover since 2005.

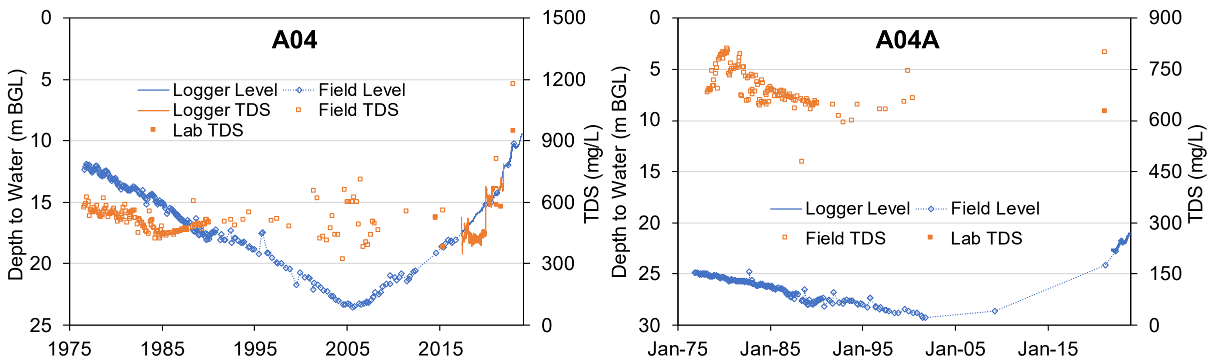

Figure 19: Groundwater level and salinity plots for A04 and A04A monitoring bores

The annual groundwater-rise at A04 for the period with logger data is shown in Figure 20, the high rainfall of 2021 resulted in a large rise in the peak groundwater-level in that year and likely contributed to the higher rise in the following year due to increased soil moisture. The rise in groundwater level in 2023 is similar to that seen in the previous review period. Several areas upslope of A04 have been rehabilitated over the review period, with other areas scheduled for 2024 and 2025. The increase in evapotranspiration from the growing vegetation in rehabilitation areas may slow the rise at A04 over the next review period if rainfall is at or below average. Figure 20 highlights the effect of a high-rainfall year on the water-table of a catchment with large cleared-areas. Continued monitoring of A04 is important due to the rising water-table and salinity, however the groundwater is over nine meters below the surface so saline groundwater discharge is unlikely over the next review period. The existing and planned revegetation work in the catchment should be monitoring for good vegetation coverage to minimise this risk.

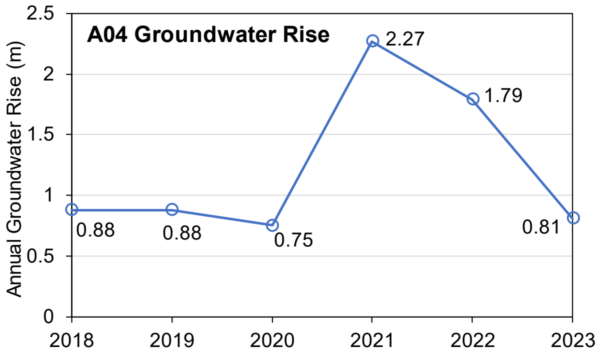

Figure 20: Groundwater level rise at A04 monitoring bore

The groundwater level and salinity plots for southern bores SW01 and Q03 are shown in Figure 21. The level at SW01 has increased since previous monitoring in 2016, but the winter low decreased from 2022 to 2023. Access to this bore on private agricultural land is often restricted, field measurements and laboratory sample collection is recommended when possible. Monitoring bore Q03 in the adjacent valley and has stable groundwater level and salinity over the entire monitoring period.

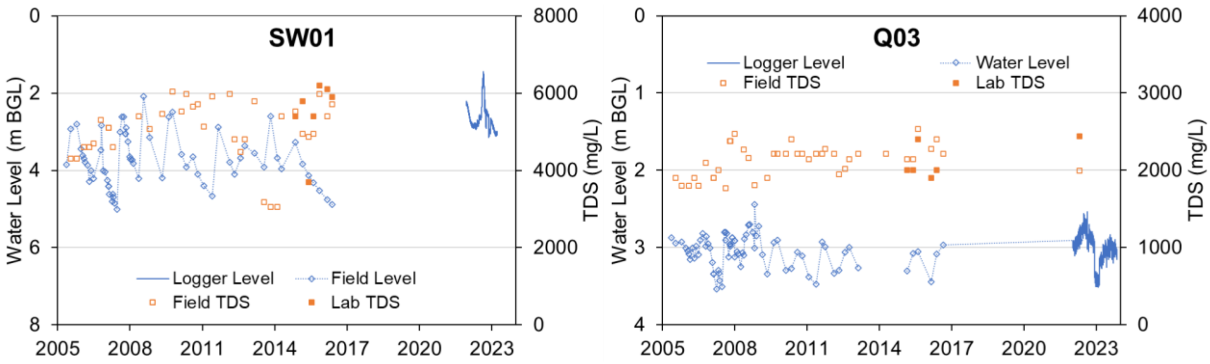

Figure 21: Groundwater level and salinity plots for SW01 and Q03 monitoring bores

Groundwater levels for Quindanning monitoring bores are shown in Figure 22. Q05 and Q07 are continuously monitored with groundwater loggers, whereas Q01, Q02 and Q08 have had field readings and laboratory samples collected to provide greater monitoring coverage while active mining is occurring in the area. There is an increase in the groundwater level at Q01, Q02 and Q05, all of which have all had land cleared recently for mining. The rise is greatest at Q05, which had plantation forestry before mining activity commenced resulting in a large change to the water balance. The water level has declined at piezometers Q07 and Q08 which are both located in forested catchments, clearing for mining in these catchments commenced in the second half of 2023. The logger in Q07 was stolen, replacing this logger should be prioritised given the mining activities starting in this catchment. The salinity has declined at Q01 and Q02 and is stable at the other bores. Rehabilitation work has already commenced in some of the Quindanning area, mine planning for the area generally has a short period of cleared vegetation with mining and rehabilitation occurring promptly. Minimising the period of low vegetation cover limits the potential effects of mining on the catchment hydrology.

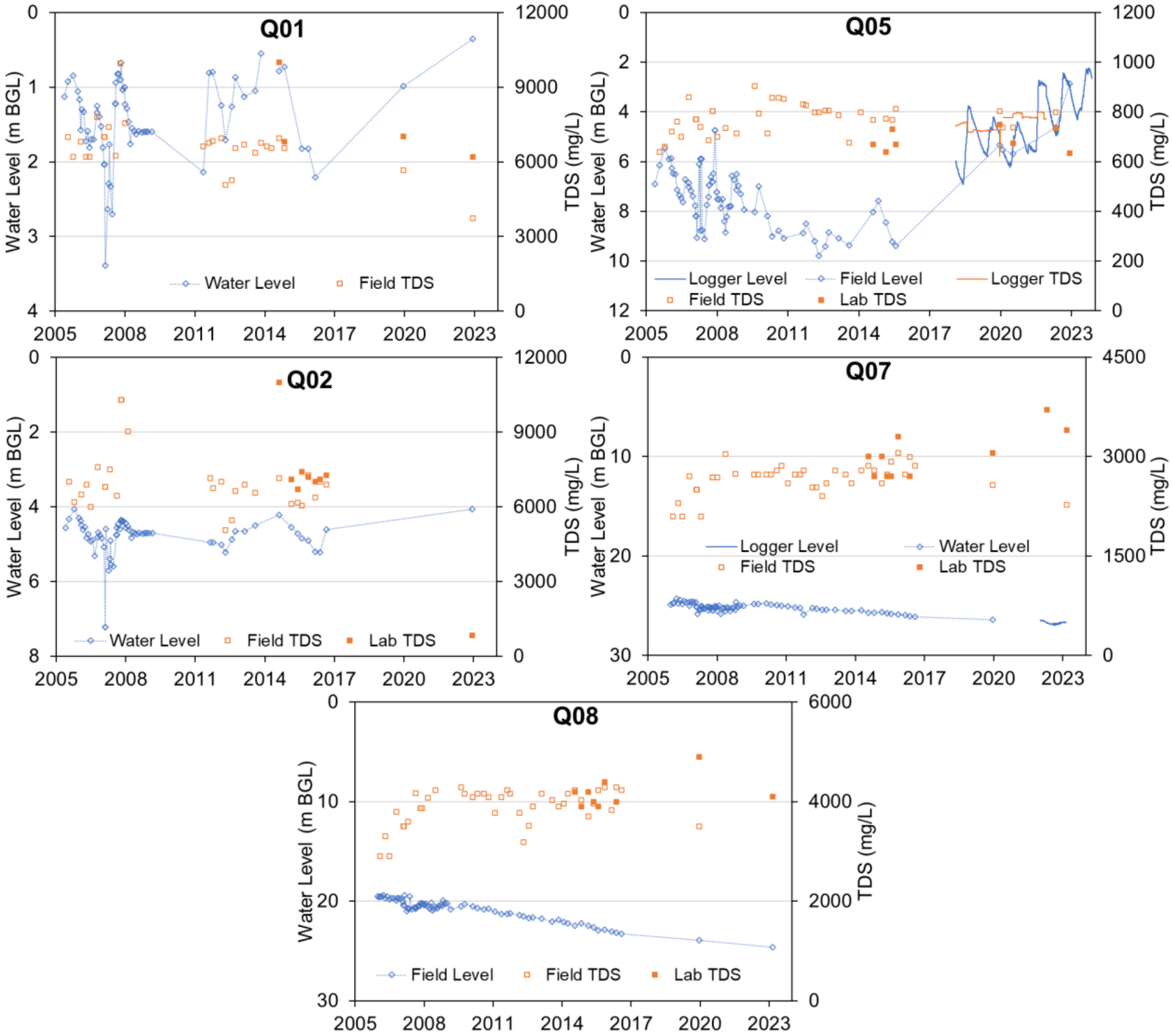

Figure 22: Groundwater level and salinity plots for Quindanning bores

7.4 Borefield & Monitoring Assessment

The abstraction from the South-East borefield is mostly within the annualised recommended yield, with only an exceedance at SE01/03 in 2020-21. The groundwater level at A04 continues to rise rapidly with the level now above the 1970's peak level, continued monitoring of this bore is recommended as well as managing rehabilitation in this catchment to limit further rises. The water level has also continued to rise at Q05, rehabilitation of this catchment has commenced so the water-table rises are likely to decrease as the vegetation grows. Changes in the water-table were smaller at other monitoring bores, and the only notable change to salinity is a rise at A04. Other water chemistry results were unremarkable and are tabulated in Appendix A. Overall, it appears that the aquifers are in reasonable condition; the increased rate of groundwater rise at A04 is noted and should be monitored, however the unusually high-rainfall of 2021 was a significant contributing factor to this rise, and increased vegetation cover in the catchment should reduce further rises. Review of the mine-plan for this catchment to ensure both the area and speed of rehabilitation has been optimised would assist in minimising the risk of further rapid rises in the water-table.

8 MARRADONG

8.1 Borefield Description

The Marradong mining area and timber reserve is located to the north of the Mt Saddleback area. The location of the production and monitoring bores in the Marradong area are shown in Figure 23. The borefield consists of five production-bores (red circles), three in the north, and two in the south of the area, and thirteen telemetry-monitored bores (blue diamonds). "M" bores were commissioned in 2005, before abstraction commenced in 2008; and "MP" bores were commissioned in 2008. Mining activity in the east of the Marradong area has been mixed with some new areas cleared for mining, and rehabilitation works starting in other areas, the majority of the eastern side has been rehabilitated. A new bore, B04/20, was drilled in search of additional water supply in 2020, it is unsuitable for production and was added to the monitoring network in 2021 (Global Groundwater, 2021). All production bores are screened in the fracture rock aquifer, with the majority of monitoring bores screened in the saprolite aquifer, screening details of the production and monitoring bores are given in Table 10.

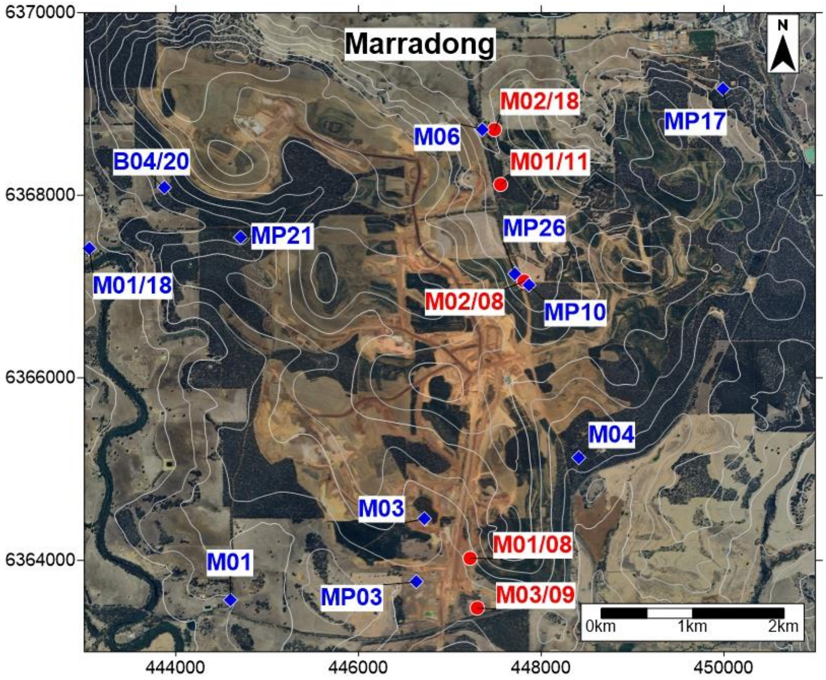

Figure 23: Location of production and monitoring bores in Marradong area

Table 10: Screening details of Marradong production and monitoring bores

Bore		Depth (m BGL)	Screening Interval (m BGL)	Screening Aquifer	Commission Year
Production Bores	**M01/08**	119.15	29.86 – 119.15	Fractured Rock	2008
	M02/08	126.4	62.50 – 124.48	Fractured Rock	2008
	M03/09	120.4	42.24 – 120.40	Fractured Rock	2009
	M01/11	96.3	30.36 – 96.30	Fractured Rock	2011
	M02/18	101.90	27.22 – 83.88	Saprolite & Fractured Rock	2018
Monitoring Bores	**M01**	23.56	10.9 – 22.9	Saprolite	2005
	M03	11.52	5 – 11	Saprolite	2005
	M04	35	15.75 – 33.75	Saprolite	2005
	M06	44.2	24.72 – 42.72	Saprolite	2005
	MP03	20	14 – 20	Saprolite	2008
	MP10	32.64	26.64 – 32.64	Pallid Zone	2008
	MP17	15.36	9.36 – 15.36	Saprolite & Fractured Rock	2008
	MP21	29.57	23.57 – 29.57	Saprolite	2008
	MP26	18.12	12.12 – 18.12	Saprolite	2008
	M01/18	102	30.70 – 36.67 44.69 – 88.56	Saprolite & Fractured Rock	2018
	B04/20	173.85	149.85 – 173.85	Fractured Rock	2020

8.2 Groundwater Abstraction

The five production bores were commissioned between 2008 and 2018, with three in the north of the area and two in the south. Groundwater abstraction from the Marradong borefield is seasonal with lower abstraction in winter, as seen in Figure 24. The recommended-yields and annual abstraction-volumes for each bore are given in Table 11. The yields of the southern bores (M01/08 and M03/09) is higher than the northern ones, and these two bores dominate the Marradong groundwater supply. The abstraction from the Marradong borefields during this review period is lower than the previous review-period due to the low volume in 2022-23. The abstraction from M02/08 is above the recommended annualised-yield during two of the three years. Abstraction from this bore was also exceeded in the previous review period and given that there has been no decline in the winter groundwater-level at nearby MP10 and MP26 (discussed in the following section) it is likely that the recommended yield is an under-estimate for the abstraction conditions and the current usage is sustainable. The total abstraction from the Marradong borefield remains below the total recommended yield.

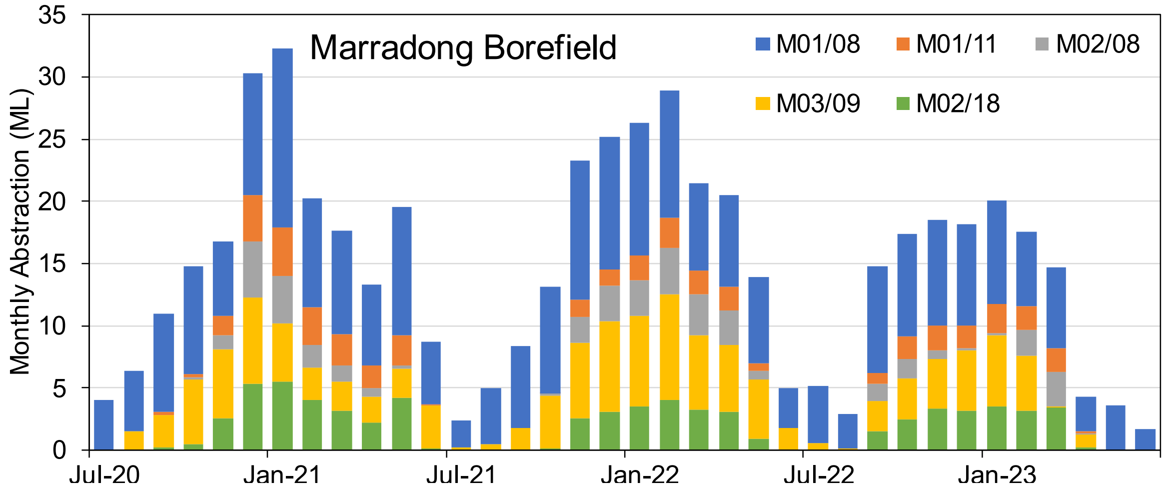

Figure 24: Marradong borefield monthly abstraction

Table 11: Annual abstraction from Marradong production bores

Bore	Recommended Yield		Abstraction (1st July to 30th June) (ML/yr)		
	(kL/day)	(ML/yr)	2020-21	2021-22	2022-23
M01/08	300	110	94	89	70
M02/08	29	11	14	18	9
M03/09	380	139	39	54	27
M01/11	86	31	20	12	13
M02/18	216	79	28	21	21
Total	1080	394	195	193	139

8.3 Groundwater Monitoring

Groundwater monitoring bores M06, MP10 and MP26 are in the same valley as production bores M02/08, M01/11, and M02/18. Over the review period there was an increase in vegetation cover in this valley catchment due to rehabilitation of several mined areas, however evapotranspiration is still likely to be lower than the pre-mining level. The groundwater levels and salinity of MP10 and MP26 are shown in Figure 25, the water level and salinity has increased at both bores. Bore MP10 is located in the valley floor, whereas MP26 is on the lower slope, resulting in about a three-meter difference in water level between the two bores, the salinity at MP26 is approximately double that at MP10. The water level at both bores has increased since previous measurements with a rise in the spring-peak water-level at MP10 of about 0.6 m above the 2017 peak. Recent logger-data suggests that the water levels are stable at MP10 and declining at MP26, no further mining is planned for the area, and rehabilitation work will continue. The salinity of both bores appears to have increased, however there is only one laboratory and one field sample were tested over the review period.

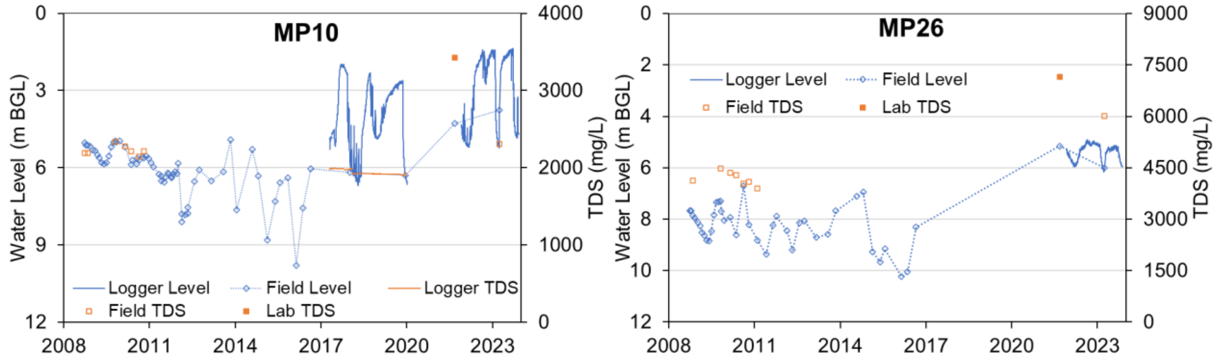

Figure 25: Groundwater level and salinity plots of MP10 and MP26 monitoring bores.

The logger water-levels for MP10 and MP26 are shown in Figure 26 with the weekly abstraction from M02/08. MP10 is 74 m from M02/08 and screened at a different depth, it displays a clear response to pumping and the level recovers when pumping ceases. MP26 is 127 m from the pumping and shows only minor fluxes from pumping over the typical seasonal groundwater-fluctuations. Abstraction from the area may have attenuated the groundwater rise resulting from catchment vegetation clearing for mining activities.

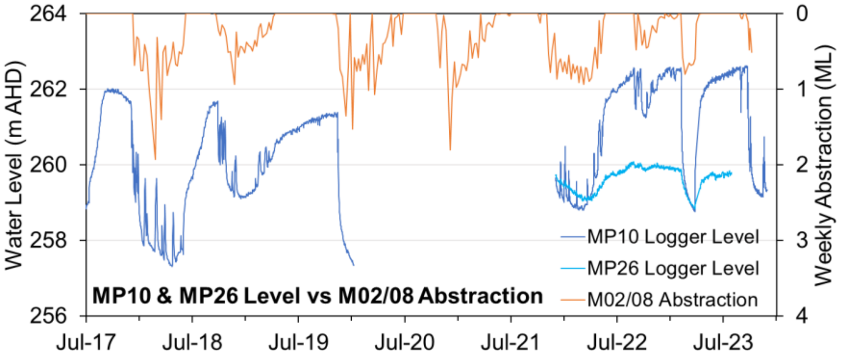

Figure 26: Groundwater level and salinity and MP10 and MP26 monitoring bores and a plot of their logger levels with weekly abstraction volumes from M02/08

The groundwater level and salinity of M06 is shown in Figure 27 as well as a plot of logger data with abstraction from M02/18 (abstraction prior to weekly records is estimated by averaging the flow recorded over the initial 8 weeks). The groundwater level has risen slightly over the review period but remains below historical water levels, the salinity is within the previous range. Abstraction from M02/18 resulted in a notable decline in the water table when it commenced in 2019, the spring peak groundwater-level has risen over the current review period, in line with a decrease in abstraction from M02/18.

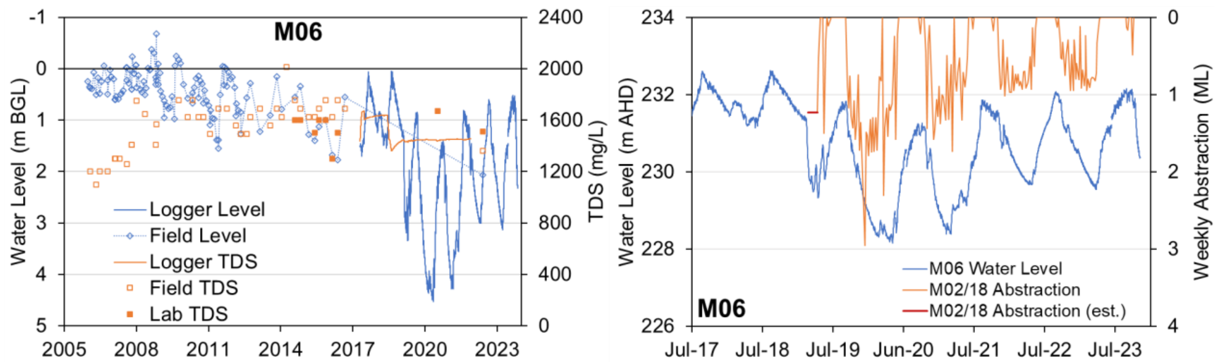

Figure 27: Groundwater level and salinity and M06 and a plot of its logger levels with weekly abstraction volumes from M02/18

In the north-east of the Marradong mining area is monitoring bore MP17, located in a plantation forest that was planted in 2008, the water level and salinity of MP17 is shown in Figure 28. The groundwater level at MP17 fell significantly while the plantation established but appears to have stabilised since 2016 with seasonal fluctuations. The small area of mining upslope of MP17 was rehabilitated in 2018 and no other mining activity is planned in the area, so no future mining related groundwater changes are anticipated.

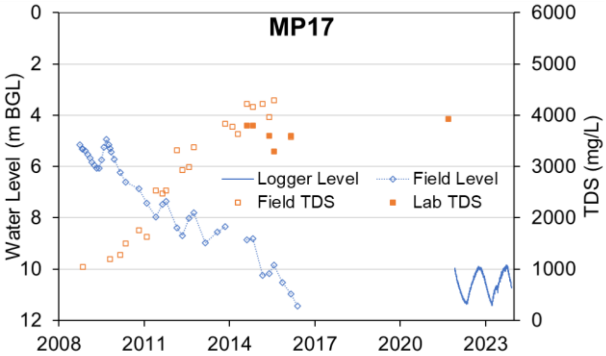

Figure 28: Groundwater level and salinity plot of MP17 monitoring bore.

In the north-west of Marradong there are three monitoring-bores MP21, M01/18, and the new bore B04/20, their water-level and salinity data are plotted in Figure 29. The new monitoring-bore, B04/20, is screened in the fractured-rock aquifer between 150 and 174 meters below ground level. The fractured-rock aquifer is usually hydraulically connected to the saprolite aquifer so the level is expected to be similar to the saprolite aquifer level in the area, but changes may be delayed and subdued due to the differences in hydraulic conductivity of the aquifers, there can also be a significant vertical salinity-gradient. There were no discernible trends over their short monitoring-periods at B04/20 or M01/18 which has screening in both the saprolite and fractured rock aquifer. The logger in MP21 was above the water level for much of the monitoring period up to December 2021, when it was rehung on a longer cable, the water level is similar to that measured in 2016. Mining activities do not appear to be significantly affecting the aquifer in this area, with groundwater remaining at depth at MP21 despite clearing of large areas of the catchment for mining, rehabilitation has commenced in the area so further significant changes due to mining are not anticipated.

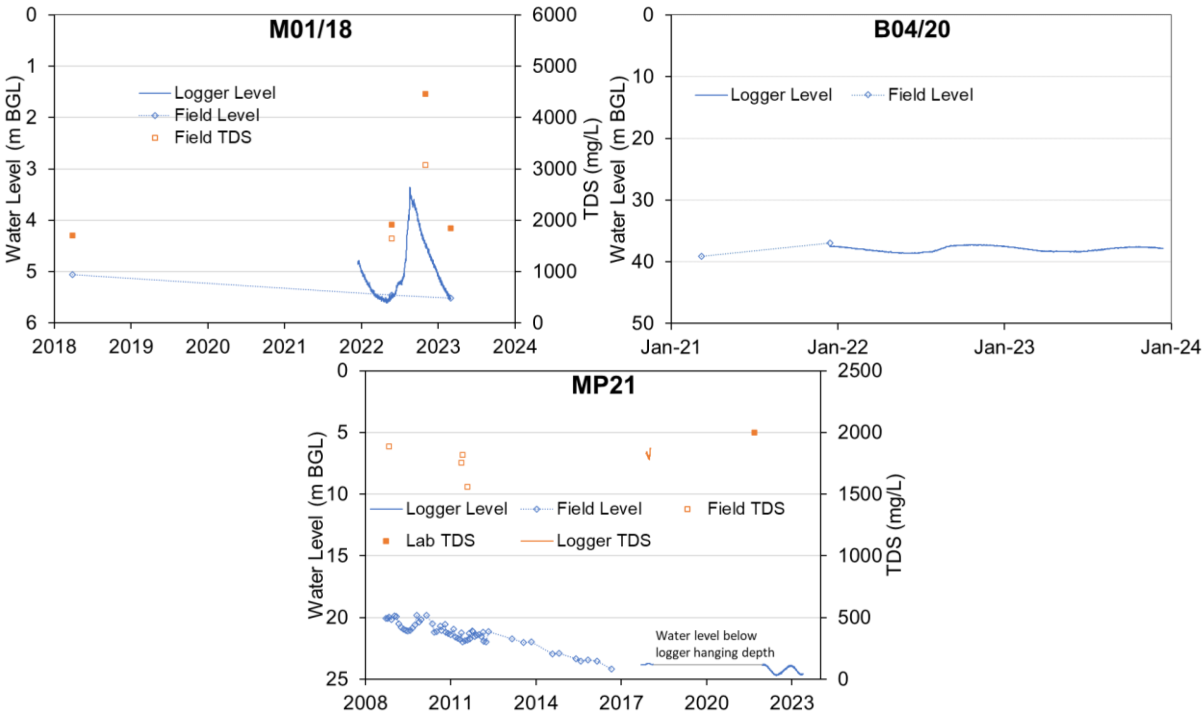

Figure 29: Groundwater level and salinity plots for MP21, M01/18 and B04/20

In the south-east of Marradong mining area monitoring bore M04 is located downslope of a large area of mining, with some clearing commencing in 2008, large areas have been rehabilitated in 2021, although about a third of the catchment remains cleared for the bauxite-conveyor, haul-roads, and other infrastructure. A plot of the groundwater level and salinity at M04 is shown in Figure 30. Over the initial ten years of monitoring the groundwater declined by 4.8 m with the majority of the catchment cleared after 2013. There is a gap in monitoring between May 2016 and May 2022 over which period the groundwater level rose by 4.7 m, and level has continued to rise by a further 2.2 m by November 2023. Most of the catchment remained clear of vegetation until 2021 when rehabilitation works occurred across a large area. The groundwater rise is expected to slow as the water use of the young vegetation increases.

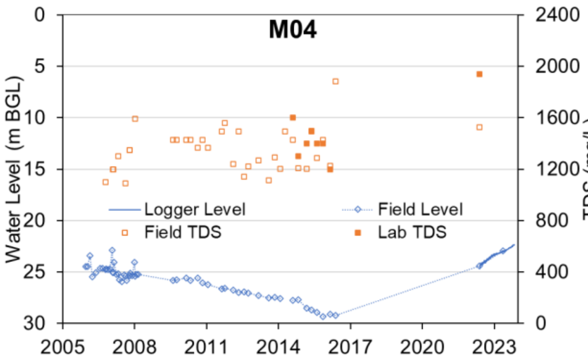

Figure 30: Groundwater level and salinity plot for M04

In the south of Marradong mining-area bores M03 and MP03 are located in the same valley, plots of their groundwater levels and salinities are shown in Figure 31. The groundwater level at M03 rose by approximately three meters between 2016 and 2022, the majority of the catchment was cleared for mining activities by 2020, with rehabilitation works commencing in 2021, the peak groundwater-level fell in 2023. MP03 is located further downslope and has had water levels near the surface since monitoring commenced in 2008, with no significant change to water levels or salinity over the monitoring period.

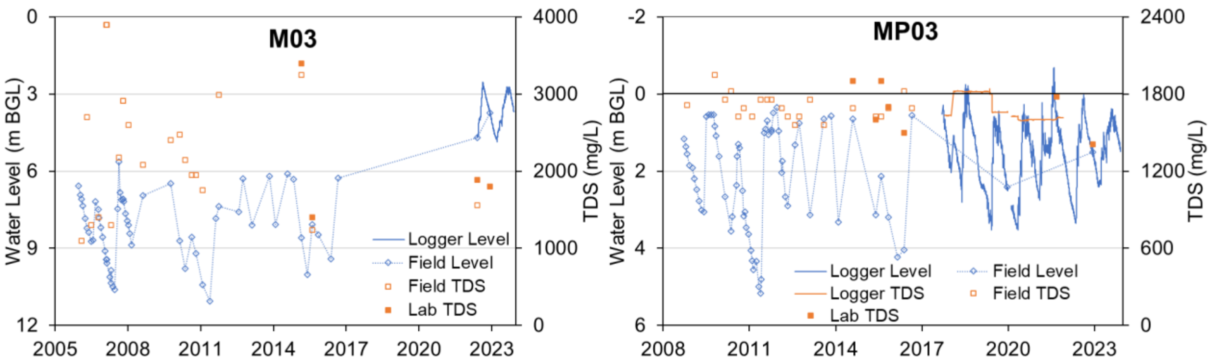

Figure 31: Groundwater level and salinity plots for M03 and MP03

M01 is located in the next valley to the west, in agricultural land down slope of areas cleared for mining between 2017 and 2022, the groundwater level and salinity plot for this bore is shown in Figure 32. The water-table is around ground level, with no significant change over the review period, the logger has been stolen with the last data downloaded in December 2021, a replacement logger will be fitted.

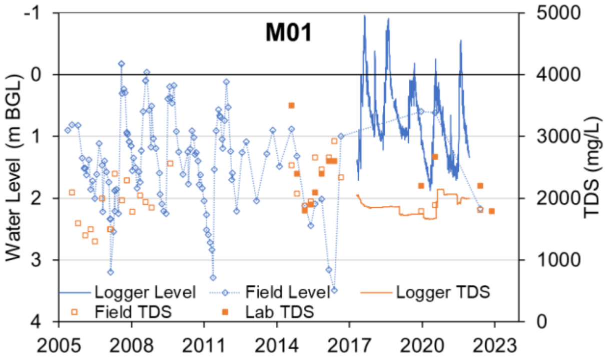

Figure 32: Groundwater level and salinity plot for M01

8.4 Borefield & Monitoring Assessment

Abstraction from Marradong borefield appears to be occurring in a sustainable manner. Abstraction from M02/08 continues to be above its annualised recommended-yield in some years, however monitoring at MP10 suggests these abstraction rates are not lowering the winter water-table level. Reduced abstraction from M02/18 has resulted in the recovery of the water table at M06 which saw a decline when this production bore was commissioned.

The addition of new bore B04/20 expands the coverage of the monitoring network. Groundwater levels have been rising at some locations due to vegetation clearing for mining, however much of the mining area is now being rehabilitated so these rises are expected to diminish as evapotranspiration increases. The Marradong mining area has transitioned over the review period from large areas of cleared vegetation to rehabilitation work commencing across most of the area. While some mining activities continue, and new vegetation takes several years to reach comparable evapotranspiration to remnant forest, it is expected that groundwater levels will stabilise over the coming years. There were no significant changes in the water chemistry, with laboratory results presented in Appendix A. Overall, it appears that the aquifer is being well managed in the Marradong area with minimal effects from mining activities.

9 NICHOLS

9.1 Borefield Description

The Nichols monitoring-borefield is located on private property to the south of the Marradong mining-area, and north of the Mt Saddleback mining-area. The locations of the monitoring bores within the Nichols borefield are shown in Figure 33. The borefield consists of five current monitoring bores (blue diamonds), monitoring bore N10 replaced monitoring bore N03 (grey square) during the review period as N10 is located downslope of mining areas, and hence is more suited to monitoring the potential effects of mining activities. There are no abstraction bores operated by Worsley in the area, N08 is a private abstraction bore, there is no information on its use. The majority of the “N” bores were commissioned in 2001, with N10 commissioned in 2005. All monitoring bores are screened in the saprolite aquifer, depth and screening data are not available for private abstraction bore N08, the screening details of monitoring bores are summarised in Table 12. The catchment of most bores is limited to agricultural land and small areas of remanant vegetation, except for N10 whose catchment extends to the north including two production bores (M03/09 and M01/08) and active mining areas.

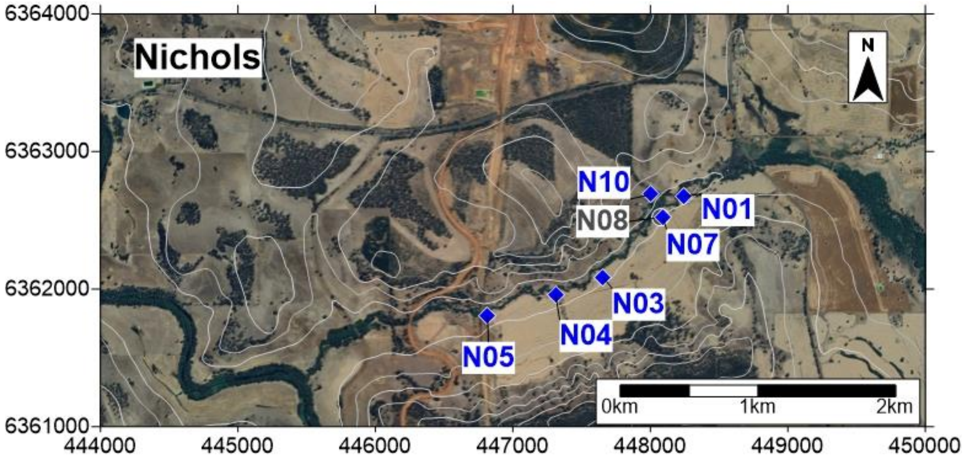

Figure 33: Location of monitoring bores in Nichols area

Table 12: Screening details of Nichols monitoring bores

Bore		Depth (m BGL)	Screening Interval (m BGL)	Screening Aquifer	Commission Year
Monitoring Bores	N01	11.45	3.45 – 9.45	Saprolite	2001
	N03	11.02	5.02 – 11.02	Saprolite	2001
	N04	8.96	2.96 – 8.96	Saprolite	2001
	N05	11.47	5.47 – 11.47	Saprolite	2001
	N07	29.5	23.5 – 29.5	Saprolite	2001
	N10	31.14	12.41 – 30.41	Saprolite	2005

9.2 Groundwater Monitoring

Groundwater level and salinity plots for the Nichols monitoring-bores are shown in Figure 35. Overall, there is little change to the groundwater levels and salinities over the entire monitoring period including the review period. The water chemistry for these bores is similarly unremarkable and is tabulated in Appendix A. Rehabilitation of most of the mined area upslope of N10 commenced in 2017 so mining activities are not expected to significantly affect this valley in the coming years.

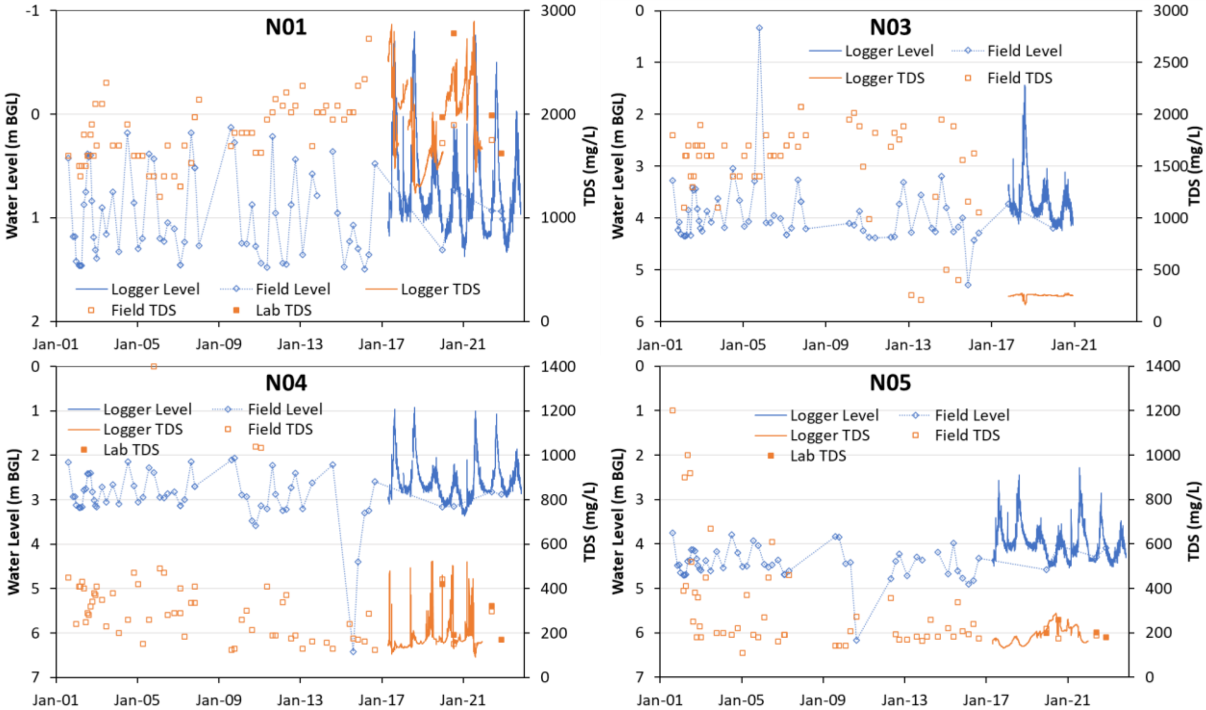

Figure 34: Groundwater level and salinity plots for Nichols bores (cont.)

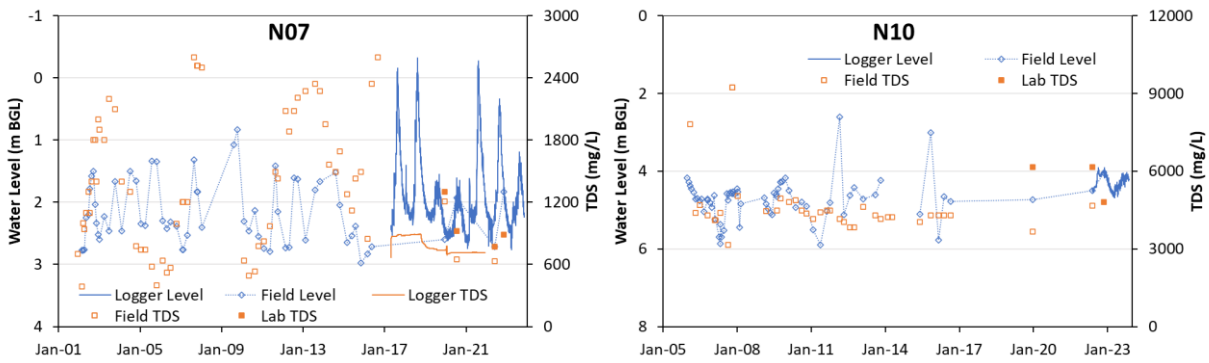

Figure 35: Groundwater level and salinity plots for Nichols bores

9.3 Borefield & Monitoring Assessment

The groundwater depths and salinities at all Nichols monitoring bores has been quite stable over the entire monitoring period, the addition of logger water-level monitoring at N10 allows for better monitoring of the potential effects of mining activities on this property, no significant trends were noted at this bore over the short period of logger monitoring with all water levels and salinities within the range of previous monitoring data. Overall, the aquifer appears to be stable in the Nichols area, the limited monitoring of N10 suggests that mining activities are being well managed and not effecting the aquifer on this property.

10. CONCLUSION & RECOMMENDATIONS

The rainfall in 2021 was significantly above the recent average, and this likely contributed to greater water-table rises in mining areas without vegetation. The abstraction from the BBM borefields decreased over the review period, the most notable decline in 2022-23 which had a high number of rain-days so reduced demand for dust suppression may have contributed to this decrease. The abstraction over the review period exceeds the averaged license-level of 500 ML per annum, however the average abstraction over twenty years remains below this limit at 479 ML per annum. The only change in the production borefield was abstraction of small volumes from F12, which had not been previously utilised since 2014. The annualised abstraction from each borefield is significantly below the total recommended-yields. Some individual bores exceeded their recommended yield, however there was no observable declines in the water-table attributable to the abstraction.

The groundwater monitoring followed the general principles of the Water Management Plan. The number of logger-monitored bores expanded over the review period, and six-monthly field visits and laboratory testing is being introduced. Some loggers have been stolen and need to be replaced.

There were no significant new trends in the overall aquifer levels or water-quality, over the review period. Declines in the water-table in forested catchments of Q07 and Q08, were smaller than recent trends, high rainfall in 2021 may have slowed this decline. Stable or rising water-levels were generally noted in mined areas, the salinity remained stable at most sites. The groundwater level at A04 rose significantly over the review period, high rainfall in 2021 likely contributed to large rises in 2021 and 2022, the salinity is also rising at this bore. Rainfall is a significant unknown factor in groundwater response to mining activities. The major aquifer risk of bauxite mining at BBM is the potential for mine-site clearing to cause groundwater-level rises, which may cause surface-discharge of saline-groundwater. A04 remains more than nine meters below the surface, rehabilitation has commenced in much of this catchment over recent years, with more scheduled for 2024-25, the growth of these areas should be monitored for good vegetation coverage to minimise this risk. Three loggers were stolen from bores over the review period (K14, Q07, and M01), it is recommended that additional spare loggers are purchased and carried on field visits so that missing or faulty loggers can be promptly replaced.

12. REFERENCES

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Appendix A – LABORATORY GROUNDWATER CHEMISTRY

Monitoring Bores

	Bore	Sample Date	EC	TDS	pH	Na^+	K^+	Mg^{2+}	Ca^{2+}	Cl^-	SO_4^{2-}	OH^-	CO_3^{2-}	HCO_3^-	Tot. Alk.	NO_3^-	NO_2^-	NO_3^-+ NO_2^-	F^-	Si as SiO_2	Total Anions	Total Cations	Ionic Balance
			μS/cm	mg/L	-	mg/L															meq/L		%
KARAFIL	K04	Jul-20	1760	1220	7.20	146	6	49	139	419	31	<1	<1	310	310	<0.01	<0.01	<0.01	<0.1	60.8	18.6	17.5	3.28
		Apr-20	1560	1090	7.62	143	5	46	117	358	27	<1	<1	268	268	<0.01	<0.01	<0.01	<0.1	55.9	16.0	16.0	0.14
		Nov-22	1510	1010	7.50	133	4	43	105	356	26	<1	<1	250	250	<0.01	<0.01	<0.01	<0.1	55.1	15.6	14.7	3.02
	K05	Apr-22	2100	1460	6.78	293	3	52	59	624	54	<1	<1	48	48	0.09	<0.01	0.09	<0.1	13.7	19.7	20.0	0.9
		Nov-22	1860	1090	8.65	263	3	35	30	565	50	<1	24	210	233	0.10	<0.01	0.10	<0.1	16.5	21.6	15.9	15.3
	K14	May-22	8120	5610	6.76	898	<1	270	270	2560	212	<1	<1	157	157	0.02	<0.01	0.02	0.2	31.8	79.8	74.8	3.24
		Nov-22	8250	5280	6.95	996	<1	310	275	2600	172	<1	<1	167	167	0.04	<0.01	0.04	0.2	31.0	80.3	82.6	1.41
TUNNELL RD	T05	Jul-20	335	190	5.7	46	<1	7	6	90	5	<1	<1	5	5	0.17	<0.01	0.17	<0.1	11.8	3.04	2.88	2.81
		May-22	317	163	5.87	44	<1	6	5	82	6	<1	<1	14	14	<0.01	<0.01	0.22	<0.1	10.8	2.72	2.66	1.13
		Nov-22	319	169	5.66	46	1	6	5	87	8	<1	<1	13	13	0.28	<0.01	0.28	<0.1	10.2	2.88	2.77	1.96
	T06C	Apr-22	293	186	6.25	45	<1	6	5	93	6	<1	<1	136	14	0.05	<0.01	0.05	<0.1	9.9	3.03	2.70	5.71
		Nov-22	375	192	6.36	54	<1	7	6	106	7	<1	<1	14	12	0.26	<0.01	0.26	<0.1	7.0	3.38	3.22	2.29
	T07C	Jul-20	703	448	7.35	54	2	30	44	135	4	<1	<1	12	168	0.02	<0.01	0.02	<0.1	53.4	7.25	7.06	1.28
		Apr-22	649	438	7.43	54	2	28	42	124	6	<1	<1	168	156	0.03	<0.01	0.03	<0.1	49.6	6.74	6.80	0.45
		Nov-22	637	394	7.20	52	2	26	38	122	5	<1	<1	153	153	0.07	<0.01	0.07	<0.1	48.5	6.60	6.35	1.96
	T11A	Jul-20	805	475	6.2	108	<1	19	17	251	12	<1	<1	12	12	0.03	<0.01	0.03	<0.1	12.8	7.91	7.11	5.32
		Apr-22	771	490	6.68	112	<1	19	17	240	14	<1	<1	25	25	0.05	<0.01	0.05	<0.1	11.9	7.56	7.28	1.87
		Nov-22	869	498	6.11	126	1	20	16	266	18	<1	<1	24	24	0.06	<0.01	0.06	<0.1	11.2	8.36	7.95	2.5
	P12	Apr-22	2350	1640	6.54	319	2	66	58	715	45	<1	<1	218	40	0.07	<0.01	0.07	<0.1	16.9	21.9	22.2	0.79
		Nov-22	1860	1100	8.99	244	2	47	39	583	38	<1	11	40	314	0.09	<0.01	0.09	<0.1	15.7	23.5	16.5	17.6
F	F06-D	Apr-22	923	576	6.32	121	<1	26	16	262	27	<1	<1	7	7	4.82	<0.01	4.82	<0.1	6.7	8.09	8.2	0.67
		Feb-23	771	423	5.49	96	1	21	14	239	25	<1	<1	2	2	6.51	<0.01	6.51	0.1	6.2	7.3	6.63	4.84
SOUTH-EAST	A04	Mar-21	898	585	6.28	121	1	21	15	265	24	<1	<1	68	68	<0.01	<0.01	<0.01	<0.1	23.6	9.33	7.76	9.17
		Sep-21	957	576	6.55	137	1	23	18	282	30	<1	<1	69	69	<0.01	<0.01	<0.01	<0.1	23	9.96	8.78	6.31
		Dec-22	1670	948	5.97	224	<1	51	33	535	74	<1	<1	44	44	0.02	<0.01	0.02	<0.1	19.3	17.5	15.6	5.81
	A04A	Mar-21	960	626	6.9	122	2	26	25	259	26	<1	<1	98	98	<0.01	<0.01	<0.01	0.2	68.9	9.8	8.74	5.72

	Bore	Sample Date	EC	TDS	pH	Na^+	K^+	Mg^{2+}	Ca^{2+}	Cl^-	SO_4^{2-}	OH^-	CO_3^{2-}	HCO_3^-	Tot. Alk.	NO_3^-	NO_2^-	NO_3^-+ NO_2^-	F^-	Si as SiO_2	Total Anions	Total Cations	Ionic Balance
			µS/cm	mg/L	-	mg/L															meq/L		%
QUINDANNING	Q01	Dec-22	9730	6190	6.74	1120	5	416	270	3420	200	<1	<1	304	113	<0.01	<0.01	<0.01	0.2	50.1	103	96.6	3.18
	Q02	Dec-22	1940	850	8.11	158	34	51	31	435	69	<1	<1	113	277	0.15	2.5	2.65	<0.1	4.5	19.2	13.5	17.6
	Q03	Apr-22	3470	2440	6.8	442	3	111	94	999	76	<1	<1	277	82	<0.01	<0.01	<0.01	<0.1	43.1	31.4	33.1	2.68
	Q05	Jul-20	1270	675	6.48	229	<1	11	6	393	16	<1	<1	82	40	<0.01	<0.01	<0.01	0.1	39.8	12.2	11.2	4.5
		Apr-22	1310	736	6.55	251	<1	12	5	408	18	<1	<1	40	38	<0.01	<0.01	<0.01	0.1	45.2	12.6	12.2	1.97
		Dec-22	1190	634	6.96	230	<1	11	5	379	16	<1	<1	38	40	0.06	<0.01	0.06	0.1	37	11.8	11.2	2.89
	Q07	Apr-22	4680	3710	7.02	441	3	228	184	1350	82	<1	<1	40	139	<0.01	<0.01	<0.01	0.2	31.6	42.6	47.2	5.17
		Feb-23	4640	3400	6.66	422	3	210	182	1460	86	<1	<1	139	150	<0.01	<0.01	<0.01	0.2	28.5	46.0	44.8	1.29
	Q08	Feb-23	6030	4100	6.58	654	7	237	193	1980	122	<1	<1	150	136	<0.01	<0.01	<0.01	0.2	37.2	61.1	57.8	2.82
MARRADONG	M01	Jul-20	3570	2670	5.83	307	2	157	140	1080	30	<1	<1	9	9	0.7	<0.01	0.7	<0.1	15.2	31.3	33.3	3.16
		May-22	2950	2200	5.44	188	2	131	134	988	8	<1	<1	5	5	0.15	<0.01	0.15	<0.1	19.6	28.1	25.7	4.53
		Nov-22	2870	1790	6	209	3	144	127	874	7	<1	<1	10	10	0.34	<0.01	0.34	<0.1	17.5	25.0	27.4	4.5
	M03	May-22	2680	1890	7	306	<1	71	90	835	32	<1	<1	145	116	0.02	<0.01	0.02	<0.1	63	26.5	23.6	5.76
		Dec-22	2820	1800	7.54	423	<1	66	72	829	36	<1	<1	151	145	<0.01	<0.01	<0.01	<0.1	70.9	27.0	27.4	0.72
	M04	May-22	2690	1940	7.29	153	2	139	124	838	38	<1	<1	116	151	0.2	<0.01	0.2	<0.1	39.3	27.4	24.3	6.01
	M06	Jul-20	2540	1670	6.78	332	4	84	46	735	40	<1	<1	112	116	0.03	<0.01	0.03	0.2	51.6	23.9	23.8	0.28
		May-22	2460	1510	6.78	315	3	71	44	763	36	<1	<1	82	112	0.09	<0.01	0.09	0.2	51.3	24.5	21.8	5.81
	MP03	Sep-21	2410	1780	7.08	260	2	83	108	746	60	<1	<1	96	82	2.17	<0.01	2.17	<0.1	24.1	23.9	23.6	0.74
		Dec-22	2180	1410	7.05	233	2	76	95	650	62	<1	<1	103	96	2.24	<0.01	2.24	<0.1	27.7	21.5	21.2	0.85
	MP10	Sep-21	4530	3430	7.28	356	2	229	196	1370	71	<1	<1	107	103	0.12	<0.01	0.12	<0.1	40	42.2	44.2	2.3
		Mar-23	-	-	-	366	3	258	188	1410	74	<1	<1	-	107	-	-	-	-	-	43.4	46.6	3.51
	MP17	Sep-21	6810	3930	3.89	1170	3	140	20	2040	144	<1	<1	<1	<1	<0.01	<0.01	<0.01	0.2	52.1	60.5	63.5	2.37
	MP21	Sep-21	2720	2000	7.07	268	3	114	97	870	55	<1	<1	44	44	<0.01	0.01	0.01	<0.1	32.1	26.6	26.0	1.16
	MP26	Sep-21	11100	7150	7.21	1390	4	390	338	3610	206	<1	<1	224	224	0.07	<0.01	0.07	<0.1	25.4	110	110	0.48
		Mar-23	-	-	-	1620	4	452	374	3610	258	<1	<1	-	233	-	-	-	-	-	112	126	6.11
	M01/18	May-22	2540	1920	7.46	165	2	107	155	774	42	<1	<1	176	176	0.08	<0.01	0.08	<0.1	42.9	26.2	23.8	4.91
		Mar-23	2450	1840	7.97	158	2	104	144	739	40	<1	<1	116	177	0.03	<0.01	0.03	<0.1	37.4	25.2	22.7	5.32

	Bore	Sample Date	EC	TDS	pH	Na^+	K^+	Mg^{2+}	Ca^{2+}	Cl^-	SO_4^{2-}	OH^-	CO_3^{2-}	HCO_3^-	Tot. Alk.	NO_3^-	NO_2^-	NO_3^-+ NO_2^-	F^-	Si as SiO_2	Total Anions	Total Cations	Ionic Balance
			µS/cm	mg/L	-	mg/L															meq/L		%
NICHOLS	N01	Jul-20	3450	2780	6.98	339	2	145	106	980	110	<1	<1	233	64	3.27	<0.01	3.27	0.1	47.9	31.2	32	1.28
		May-22	2880	1990	7.09	280	2	113	91	889	134	<1	<1	64	64	3.99	<0.01	3.99	0.1	52	29.1	26.1	5.57
		Nov-22	2300	1620	6.99	267	1	100	75	631	104	<1	<1	64	72	4.16	<0.01	4.08	0.1	49.9	21.8	24	5.77
	N04	Jul-20	256	191	7.13	35	<1	6	6	45	6	<1	<1	72	23	7.6	<0.01	7.6	<0.1	38.2	2.4	2.32	1.73
		May-22	502	322	7.29	55	<1	16	18	105	12	<1	<1	23	48	7.35	<0.01	7.35	<0.1	53.2	4.17	4.61	4.97
		Nov-22	248	170	7.3	38	<1	5	5	32	7	<1	<1	48	33	8.02	<0.01	8.02	<0.1	43.7	2.28	2.31	0.71
	N05	Jul-20	280	259	7.72	56	<1	2	<1	36	17	<1	<1	33	61	4.11	<0.01	4.11	0.5	44.5	2.59	2.6	0.24
		May-22	294	201	7.54	57	<1	2	1	38	16	<1	<1	61	55	5.02	<0.01	5.02	0.4	39.4	2.5	2.69	3.65
		Nov-22	248	179	7.71	53	<1	2	1	25	15	<1	<1	55	56	3.83	<0.01	3.83	0.5	35.1	2.41	2.52	2.21
	N07	Jul-20	1150	925	7.1	62	<1	59	60	304	59	<1	<1	56	60	6.97	<0.01	6.97	<0.1	55.6	11	10.5	2.12
		May-22	1120	773	7.47	62	<1	53	58	303	63	<1	<1	60	58	6.97	<0.01	6.97	<0.1	56.4	11	9.95	5.08
		Nov-22	1120	888	7.52	70	1	63	60	293	56	<1	<1	58	60	7.34	<0.01	7.34	<0.1	54.4	10.6	11.2	2.83
	N10	May-22	8160	6160	7.04	666	2	304	388	2410	261	<1	<1	60	178	0.3	<0.01	0.3	0.1	27.9	77	73.4	2.38
		Nov-22	6400	4800	7.02	792	1	235	255	1960	243	<1	<1	178	218	0.56	<0.01	0.56	0.2	39.2	64.7	66.5	1.4

	Bore	Sample Date	Dissolved Metals (mg/L)											
			Al	As	Cd	Cr	Cu	Ni	Pb	Zn	Mn	Se	Fe	Hg
KARAFIL	K04	Jul-20	<0.01	<0.001	<0.0001	<0.001	<0.001	0.002	<0.001	0.01	0.787	<0.01	0.12	<0.0001
		Apr-20	<0.01	<0.001	<0.0001	<0.001	<0.001	0.003	<0.001	<0.005	0.703	<0.01	<0.05	<0.0001
		Nov-22	<0.01	<0.001	<0.0001	<0.001	<0.001	0.004	<0.001	0.005	0.686	<0.01	<0.05	<0.0001
	K05	Apr-22	<0.01	<0.001	<0.0001	<0.001	<0.001	0.002	<0.001	<0.005	0.003	<0.01	<0.05	<0.0001
		Nov-22	<0.01	<0.001	<0.0001	<0.001	<0.001	0.001	<0.001	<0.005	0.003	<0.01	<0.05	<0.0001
	K14	May-22	<0.01	<0.001	0.0032	<0.001	0.004	0.002	<0.001	<0.005	0.084	<0.01	0.05	<0.0001
		Nov-22	<0.01	<0.001	0.0019	<0.001	0.004	0.003	<0.001	0.008	0.085	<0.01	<0.05	<0.0001
TUNNELL RD	T05	Jul-20	<0.01	<0.001	<0.0001	0.002	0.011	0.005	<0.001	0.026	0.004	<0.01	<0.05	<0.0001
		May-22	0.03	<0.001	<0.0001	0.002	0.002	0.004	<0.001	0.006	0.008	<0.01	<0.05	0.0002
		Nov-22	<0.01	<0.001	<0.0001	0.002	0.002	0.004	<0.001	0.013	0.008	<0.01	<0.05	<0.0001
	T06C	Apr-22	<0.01	<0.001	<0.0001	<0.001	<0.001	0.001	<0.001	<0.005	0.003	<0.01	<0.05	<0.0001
		Nov-22	<0.01	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.01	<0.05	<0.0001
	T07C	Jul-20	<0.01	<0.001	<0.0001	<0.001	<0.001	0.011	<0.001	<0.005	0.004	<0.01	0.05	<0.0001
		Apr-22	<0.01	<0.001	<0.0001	<0.001	0.001	<0.001	<0.001	<0.005	<0.001	<0.01	<0.05	<0.0001
		Nov-22	<0.01	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.01	<0.05	<0.0001
	T11A	Jul-20	<0.01	<0.001	<0.0001	0.002	0.002	0.006	<0.001	0.008	0.002	<0.01	<0.05	<0.0001
		Apr-22	<0.01	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.01	<0.05	<0.0001
		Nov-22	<0.01	<0.001	<0.0001	0.002	<0.001	0.010	<0.001	<0.005	0.004	<0.01	<0.05	<0.0001
	P12	Apr-22	<0.01	<0.001	<0.0001	<0.001	0.002	0.002	<0.001	<0.005	0.004	<0.01	0.14	<0.0001
		Nov-22	<0.01	<0.001	<0.0001	<0.001	<0.001	0.002	<0.001	<0.005	0.002	<0.01	<0.05	<0.0001
F	F06-D	Apr-22	0.08	<0.001	<0.0001	<0.001	<0.001	0.001	<0.001	<0.005	0.021	<0.01	<0.05	<0.0001
		Feb-23	0.13	<0.001	<0.0001	<0.001	<0.001	0.001	<0.001	0.014	0.019	<0.01	<0.05	<0.0001
SOUTH-EAST	A04	Mar-21	<0.01	<0.001	<0.0001	<0.001	<0.001	0.002	<0.001	0.018	0.097	<0.01	9.71	<0.0001
		Sep-21	<0.01	<0.001	<0.0001	<0.001	<0.001	0.001	<0.001	0.02	0.088	<0.01	17	<0.0001
		Dec-22	0.02	<0.001	<0.0001	<0.001	<0.001	0.002	<0.001	<0.005	0.028	<0.01	9.74	<0.0001
	A04A	Mar-21	0.02	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	0.485	<0.01	3.77	<0.0001

	Bore	Sample Date	Dissolved Metals (mg/L)											
			Al	As	Cd	Cr	Cu	Ni	Pb	Zn	Mn	Se	Fe	Hg
QUINDANNING	Q01	Dec-22	<0.01	<0.001	<0.0001	<0.001	<0.001	0.031	<0.001	<0.005	0.223	<0.01	<0.05	<0.0001
	Q02	Dec-22	0.06	<0.001	<0.0001	<0.001	0.001	0.001	0.003	0.006	0.013	<0.01	1.51	<0.0001
	Q03	Apr-22	<0.01	<0.001	<0.0001	<0.001	0.004	0.010	<0.001	0.012	0.260	<0.01	0.86	<0.0001
	Q05	Jul-20	<0.01	<0.001	<0.0001	<0.001	0.004	0.003	<0.001	0.062	0.623	<0.01	0.94	<0.0001
		Apr-22	<0.01	<0.001	<0.0001	<0.001	<0.001	0.002	<0.001	0.028	0.409	<0.01	0.15	<0.0001
		Dec-22	<0.01	<0.001	<0.0001	<0.001	<0.001	0.004	<0.001	0.028	0.516	<0.01	<0.05	<0.0001
	Q07	Apr-22	<0.01	<0.001	0.0001	<0.001	0.001	0.006	<0.001	0.031	0.057	<0.01	7.43	<0.0001
		Feb-23	<0.01	<0.001	0.0001	<0.001	0.003	0.004	<0.001	0.013	0.054	<0.01	<0.05	<0.0001
	Q08	Feb-23	<0.01	<0.001	<0.0001	<0.001	<0.001	0.004	<0.001	0.021	1.470	<0.01	<0.05	<0.0001
MARRADONG	M01	Jul-20	0.05	<0.001	0.0002	<0.001	0.020	0.089	<0.001	0.162	0.474	<0.01	<0.05	<0.0001
		May-22	0.07	<0.001	0.0001	<0.001	0.003	0.091	<0.001	0.185	0.447	<0.01	<0.05	<0.0001
		Nov-22	0.04	<0.001	<0.0001	<0.001	0.001	0.090	<0.001	0.172	0.464	<0.01	<0.05	<0.0001
	M03	May-22	<0.01	<0.001	<0.0001	<0.001	<0.001	0.017	<0.001	0.008	0.062	<0.01	0.13	<0.0001
		Dec-22	<0.01	<0.001	<0.0001	<0.001	<0.001	0.010	<0.001	0.007	0.048	<0.01	<0.05	<0.0001
	M04	May-22	<0.01	<0.001	0.0003	<0.001	<0.001	0.035	<0.001	0.023	0.120	<0.01	<0.05	<0.0001
	M06	Jul-20	<0.01	<0.001	0.0002	<0.001	0.009	0.027	<0.001	0.059	0.211	<0.01	0.50	<0.0001
		May-22	<0.01	<0.001	<0.0001	<0.001	<0.001	0.012	<0.001	0.014	0.166	<0.01	0.63	<0.0001
	MP03	Sep-21	<0.01	<0.001	<0.0001	<0.001	<0.001	0.006	<0.001	0.006	0.001	<0.01	<0.05	<0.0001
		Dec-22	<0.01	<0.001	<0.0001	<0.001	<0.001	0.005	<0.001	0.011	0.001	<0.01	<0.05	<0.0001
	MP10	Sep-21	<0.01	<0.001	<0.0001	<0.001	<0.001	0.003	<0.001	<0.005	0.002	<0.01	<0.05	<0.0001
		Mar-23		<0.001	<0.0001	0.026	0.028	0.020	0.010	0.019	0.016		0.24	
	MP17	Sep-21	7.19	<0.001	<0.0001	<0.001	0.144	0.007	0.047	0.020	0.159	<0.01	<0.05	<0.0001
	MP21	Sep-21	<0.01	<0.001	<0.0001	<0.001	<0.001	0.01	<0.001	0.006	0.081	<0.01	<0.05	<0.0001
	MP26	Sep-21	<0.01	<0.001	<0.0001	<0.001	<0.001	0.003	<0.001	<0.005	0.004	<0.01	<0.05	<0.0001
		Mar-23		<0.001	<0.0001	0.145	0.052	0.026	0.056	0.020	0.124		<0.05	
	M01/18	May-22	<0.01	<0.001	<0.0001	<0.001	<0.001	0.003	<0.001	0.042	0.857	<0.01	0.18	<0.0001
		Mar-23	<0.01	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	0.094	0.003	<0.01	<0.05	<0.0001

	Bore	Sample Date	**Dissolved Metals** (mg/L)											
			Al	**As**	**Cd**	**Cr**	**Cu**	**Ni**	**Pb**	**Zn**	**Mn**	**Se**	**Fe**	**Hg**
NICHOLS	**N01**	Jul-20	<0.001	<0.0001	<0.001	0.004	0.009	<0.001	0.011	0.003	<0.01	<0.05	<0.0001	<0.001
		May-22	<0.001	<0.0001	<0.001	<0.001	0.002	<0.001	0.013	0.002	<0.01	<0.05	<0.0001	<0.001
		Nov-22	<0.001	<0.0001	<0.001	<0.001	0.004	<0.001	<0.005	0.002	<0.01	0.06	<0.0001	<0.001
	N04	Jul-20	<0.001	<0.0001	<0.001	0.004	0.009	<0.001	0.011	0.003	<0.01	<0.05	<0.0001	<0.001
		May-22	<0.001	<0.0001	<0.001	<0.001	0.002	<0.001	0.013	0.002	<0.01	<0.05	<0.0001	<0.001
		Nov-22	<0.001	<0.0001	<0.001	<0.001	0.004	<0.001	<0.005	0.002	<0.01	0.06	<0.0001	<0.001
	N05	Jul-20	<0.001	<0.0001	<0.001	0.004	0.009	<0.001	0.011	0.003	<0.01	<0.05	<0.0001	<0.001
		May-22	<0.001	<0.0001	<0.001	<0.001	0.002	<0.001	0.013	0.002	<0.01	<0.05	<0.0001	<0.001
		Nov-22	<0.001	<0.0001	<0.001	<0.001	0.004	<0.001	<0.005	0.002	<0.01	0.06	<0.0001	<0.001
	N07	Jul-20	<0.001	<0.0001	<0.001	0.004	0.003	<0.001	0.013	0.001	<0.01	<0.05	<0.0001	<0.001
		May-22	<0.001	<0.0001	<0.001	<0.001	0.006	<0.001	0.037	<0.001	<0.01	<0.05	<0.0001	<0.001
		Nov-22	<0.001	<0.0001	<0.001	0.002	0.009	<0.001	0.083	0.002	<0.01	<0.05	<0.0001	<0.001
	N10	May-22	<0.001	0.0002	<0.001	<0.001	0.013	<0.001	0.015	0.009	<0.01	<0.05	<0.0001	<0.001
		Nov-22	<0.001	<0.0001	<0.001	0.002	0.006	<0.001	0.025	0.003	<0.01	<0.05	<0.0001	<0.001

Production Bores

	Bore	Sample Date	EC	TDS	pH	Al	As	Cd	Cr	Cu	Ni	Pb	Zn	Mn	Se	Fe	Hg	NO_3^-+ NO_2^-	Total Kjeldahl Nitrogen as N	Total Nitrogen as N	Total Phosphorus as P	Turbidity
			µS/cm	mg/L	-	mg/L																NTU
KARAFIL	K01	Nov-22	1220	1020	7.41	<0.01	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	0.436	<0.01	0.13	<0.0001	<0.01	<0.1	<0.1	0.02	36.8
KARAFIL	K06	Nov-22	1670	1430	7.26	<0.01	<0.001	<0.0001	<0.001	<0.001	0.002	<0.001	<0.005	0.527	<0.01	0.42	<0.0001	<0.01	<0.1	<0.1	0.01	35.2
KARAFIL	K07	Nov-22	2560	2120	7.38	<0.01	<0.001	<0.0001	<0.001	<0.001	0.004	<0.001	<0.005	0.332	<0.01	<0.05	<0.0001	<0.01	<0.1	<0.1	0.01	25.6
KARAFIL	K08	Nov-22	2320	2170	7.04	<0.01	<0.001	<0.0001	<0.001	0.001	0.002	<0.001	0.022	0.994	<0.01	0.81	<0.0001	<0.01	<0.1	<0.1	<0.01	21.5
KARAFIL	K09	Nov-22	1600	1200	6.56	<0.01	<0.001	<0.0001	<0.001	0.002	0.007	<0.001	0.011	0.790	<0.01	<0.05	<0.0001	0.40	<0.1	0.4	<0.01	10.9
TUNNELL RD	T07A	Nov-22	350	186	6.45	<0.01	<0.001	<0.0001	<0.001	<0.001	0.011	<0.001	<0.005	0.004	<0.01	0.05	<0.0001	0.06	<0.1	<0.1	0.04	9.1
TUNNELL RD	T08	Nov-22	666	459	6.60	<0.01	<0.001	<0.0001	<0.001	0.013	0.007	0.001	0.012	0.008	<0.01	<0.05	<0.0001	0.03	<0.1	<0.1	<0.01	1.2
TUNNELL RD	T10	Nov-22	566	403	6.19	<0.01	<0.001	<0.0001	<0.001	0.004	0.006	<0.001	0.083	0.065	<0.01	0.06	<0.0001	0.05	<0.1	<0.1	<0.01	3.4
TUNNELL RD	T12	Nov-22	564	447	6.72	<0.01	<0.001	<0.0001	<0.001	<0.001	0.004	<0.001	0.007	0.324	<0.01	5.27	<0.0001	<0.01	<0.1	<0.1	0.06	10.9
TUNNELL RD	T13	Nov-22	618	504	7.07	<0.01	<0.001	<0.0001	<0.001	<0.001	0.001	<0.001	<0.005	0.204	<0.01	1.93	<0.0001	<0.01	<0.1	<0.1	0.03	20.1
F	SE01/04	Nov-22	7300	5780	6.97	<0.01	<0.001	<0.0001	<0.001	<0.001	0.004	<0.001	0.006	1.10	<0.01	2.32	<0.0001	<0.01	<0.1	<0.1	0.07	130
SOUTH-EAST	T14	Nov-22	992	776	6.89	<0.01	<0.001	<0.0001	<0.001	<0.001	0.002	<0.001	0.036	0.402	<0.01	6.99	<0.0001	0.01	<0.1	<0.1	0.10	33.2
SOUTH-EAST	E01/06	Nov-22	1550	1300	7.29	<0.01	<0.001	<0.0001	<0.001	<0.001	0.040	<0.001	0.010	0.450	<0.01	3.87	<0.0001	<0.01	<0.1	<0.1	0.02	9.1
SOUTH-EAST	SE01/01	Nov-22	1360	1040	7.62	<0.01	<0.001	0.0001	<0.001	0.001	0.003	<0.001	<0.005	0.432	<0.01	0.05	<0.0001	<0.01	<0.1	<0.1	0.05	4.5
SOUTH-EAST	SE01/03	Nov-22	4560	3780	7.13	<0.01	<0.001	0.0001	<0.001	<0.001	0.012	<0.001	0.122	0.731	<0.01	<0.05	<0.0001	<0.01	<0.1	<0.1	0.05	13
SOUTH-EAST	SE02/03	Nov-22	5060	4420	7.34	<0.01	<0.001	<0.0001	<0.001	<0.001	0.002	<0.001	<0.005	0.701	<0.01	0.40	<0.0001	0.06	<0.1	<0.1	0.04	72.1
SOUTH-EAST	SE02/06	Nov-22	2260	1630	6.58	<0.01	<0.001	<0.0001	<0.001	<0.001	0.010	<0.001	0.032	0.212	<0.01	<0.05	<0.0001	1.58	0.2	1.8	0.03	0.2
MARRADONG	M01/08	Nov-22	4060	3380	7.25	<0.01	<0.001	<0.0001	<0.001	0.003	<0.001	<0.001	0.017	0.472	<0.01	<0.05	<0.0001	0.01	<0.1	<0.1	<0.01	39.1
MARRADONG	M01/11	Nov-22	3300	2740	7.12	<0.01	<0.001	<0.0001	<0.001	<0.001	0.002	<0.001	0.021	0.526	<0.01	0.77	<0.0001	<0.01	<0.1	<0.1	<0.01	14.8
MARRADONG	M02/08	Nov-22	3980	4030	6.91	<0.01	<0.001	0.0001	<0.001	<0.001	0.008	<0.001	0.090	0.932	<0.01	0.87	<0.0001	0.02	<0.1	<0.1	<0.01	6.9
MARRADONG	M03/09	Nov-22	2540	2300	7.62	<0.01	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	0.006	0.758	<0.01	<0.05	<0.0001	0.06	<0.1	<0.1	<0.01	39.0
MARRADONG	M02/18	Nov-22	5160	4460	6.93	<0.01	<0.001	<0.0001	<0.001	<0.001	0.007	<0.001	0.011	0.810	<0.01	5.18	<0.0001	<0.01	<0.1	<0.1	0.01	16.1

Appendix B – TABULATED BORE DETAILS

	Type	Sitename	Easting (MGA)	Northing (MGA)	Ground Level (mAHD)	Depth (mBGL)
KARAFIL	Production	K01	448461	6358069	316.64	36.80
		K06	448323	6358245	318.91	52.45
		K07	447912	6359053	287.45	37.23
		K08	447689	6359167	282.42	59.28
		K09	449106	6357428	333.26	60.45
	Monitor-ed	K04	448201	6358692	306.97	49.52
		K05	447639	6359200	281.68	28.77
		K14	443405	6359753	226.90	46.30
TUNNELL RD	Production	T07A	447746	6356195	310.26	54.65
		T08	447612	6356112	310.00	33.35
		T10	447419	6356564	297.21	31.91
		T12	448567	6355229	338.19	44.12
		T13	448655	6355326	330.67	41.50
	Monitored	T05	448665	6355330	330.99	40.78
		T06C	447893	6356112	310.00	33.35
		T07C	447749	6356192	310.33	91.38
		T11A	447233	6356762	287.94	23.07
		P12	446652	6357319	258.55	24.52
FAWCETT	Prod.	SE1/04	452600	6353081	278.99	>100
		F12	452605	6353136	278.00	36.31
	Mon.	F06-D	452516	6353719	269.73	13.94
SOUTH-EAST	Production	T14	449124	6354434	371.95	52.21
		E01/06	450352	6354844	312.00	71.14
		SE1/01	450273	6352815	346.00	93.38
		SE1/03	452128	6351103	304.54	84.56
		SE2/01	449990	6353004	372.84	76.97
		SE2/03	452300	6350985	302.90	83.21
		SE2/06	451984	6351828	290.00	73.81
		SE3/01	451382	6352309	316.76	93.77
	Monitored	A04	450910	6352727	302.67	40.72
		A04A	450912	6352729	302.889	55.13
		B01	450448	6354216	298.07	13.52
		SW01	447462	6350024	218.98	34.55
		Q03	450368	6349132	233.55	39.00
		Q05	452265	6351297	285.69	40.30
		Q07	455751	6351213	285.08	34.67
	Other	Q01	454690	6349434	296.08	32.50
		Q02	452738	6349104	295.90	47.50
		Q08	454950	6351498	273.67	42.84
HMB		HBM1/03	449294	6357156	340.88	29.58
		HBM2/03	449144	6357327	334.34	32.15

	Type	Sitename	Easting (MGA)	Northing (MGA)	Ground Level (mAHD)	Depth (mBGL)
MARRADONG	Production	M01/08	447225	6364030	271.84	119.15
		M01/11	447556	6368114		96.3
		M02/08	447815	6367051	261.98	126.4
		M03/09	447297	6363478	257.82	120.4
		M02/18	447489	6368715		83.9
	Monitored	M01	444595	6363563	220.00	23.56
		M03	446721	6364459	264.31	11.52
		M04	448410	6365125	261.31	35.00
		M06	447361	6368724	232.68	44.20
		MP03	446637	6363763	245	20
		MP10	447863	6367013	264	32.64
		MP17	449988	6369163	260	15.36
		MP21	444712	6367538	255	29.57
		MP26	447713	6367138	265	18.12
		M01/18	443052	6368715		88.6
		B04/20	443871	6368082		173.85
NICHOLS	Monitored	N01	448246	6362674	199.84	9.36
		N03*	447655	6362087	199.34	10.95
		N04	447310	6361957	196.60	7.76
		N05	446815	6361804	196.13	11.22
		N07	448091	6362521	200.69	29.69
		N10	448007	6362689	206.93	31.00

*Monitoring of N03 ceased during the review period