WEDGETAIL
PROJECT CONSULTING

APPENDIX C: REVISED GROUNDWATER ASSESSMENT

Newcastle Sand

MAXIMUM EXTRACTION DEPTH MANAGEMENT PLAN FOR MOD 4 WESTERN EXTENSION AREA

8 April 2024

GES

DOCUMENT REGISTER

Revision	Description	Date	Comments
A	1st Draft	12/3/2026	
B	2nd Draft	25/3/2026	
C	Final	7/4/2026	
D			

THE AUTHOR

The principal consultant of GES Pty Ltd is Andrew Fulton. Andrew is a Hydrogeologist / Geologist with over twenty years' experience in a variety of geological and hydrogeological projects ranging from groundwater impact assessments, design and management of groundwater supply, mine dewatering / aquifer depressurisation, and general water management studies.

Having previously worked for the large engineering consultancies where significant experience has been gained in managing complex, multi-disciplinary water resource investigations. Andrew combines experience in hydrogeology, and geology and is familiar with multiple aspects of water resource evaluation, impact assessment and control.

This includes practical aspects such as designing and implementing monitoring programs, managing exploration and groundwater supply drilling projects, installation of production bores and borehole pumping tests, through to evaluation of environmental impacts using numerical modelling assessment techniques.

Andrew has also gained extensive experience in industrial minerals associated with Salt Lake complexes. This includes mineral exploration project program design and supervision, due diligence assessments and associated JORC compliant reporting of minerals resources.

Andrew was appointed by the Secretary of the Department of Planning, Industry and Environment on 5 October 2021.

COPYRIGHT

GES

TABLE OF CONTENTS

GES

LIST OF FIGURES

LIST OF TABLES

Executive Summary

This report focuses on a proposed extension to the Cabbage Tree Road Quarry which is the Western Extension. The maximum extraction level limits for Williamtown Sand Syndicate Pty Ltd (WSS) have been reviewed and extrapolated to the extension area, and effectively becomes the current version of the Maximum Extraction Depth Management Plan.

A MED (Maximum Extraction Depth Management Plan) has been previously developed to manage excavation constraints that are included within the Project approval where Schedule 2, Condition 6 of SSD-6125, limits excavation to within 0.7 metres of the predicted maximum groundwater level.

The Cabbage Tree Road Sand Quarry, north of Fullerton Cove lies within the Tomago Sand beds dune system. A core component of the MED is the MEL (Minimum Extraction Level) which is based on the criteria of limiting excavation to 0.7 metres of the predicted maximum groundwater level. The predicted maximum groundwater level has been formulated prior to project initiation and based on groundwater modelling and empirical methods utilising historical HWC (Hunter Water Corporation) groundwater level data.

The groundwater aquifer within the dune sands is very responsive to rainfall trends and the rainfall record in recent years has seen annual totals well above average. The high rainfall pattern experienced during 2020 – 2025 included 2020 rainfall totals that were at 80th percentile, 2021 and 2025 at 95th percentile and 2022 and 2024 at 90th percentile of historical data. While these annual totals did not set absolute records, this combined elevated rainfall event has not previously occurred, and this has presented a thorough test on the principles in which the MEL were formulated.

The groundwater model has been modified to include additional stress periods (time) which includes the high rainfall patterns of 2020 - 2025. Data from the Williamtown Bom site is the basis for the recharge trends applied and while it is now clear that there are some inconsistencies with detail rainfall patterns between Williamtown RAAF base and the quarry site, these general patterns correlate when we consider responses observed in the data.

The model validation simulation with high recharge included has shown that the model generally performs very well when considering the previously assessed maximum groundwater level.

Given the extent of the rehabilitation completed (topsoil spread, trees placed, tube stock planted and natural regeneration occurring), and that future land use in this area is conservation, there is no justification for intervention for any revision of the MEL. However, rehabilitation should ensure all sectors monitor the recruitment and success of canopy species in the rehabilitation, such that a Woodland Community is the dominant vegetation structure in the final landform. Given the natural continuum of woodland communities in the local area, suitable woodland species are available to guide the most suitable species relative to the prevailing groundwater level.

The MEL is based on a 25-meter grid system. The quarry excavator is fitted with GPS control to ensure operators can accurately extract sand down to the MEL and reinstate the landform to the correct level. In the unlikely event that the groundwater does increase above predicted levels controls are suggested to ensure quarrying is suspended in the grid cells where the groundwater exceeds the expected levels during the duration of the elevated levels.

In addition, where the MEL is determined to be less than 0.7m from the observed groundwater levels, an evaluation of the need to relevel the landform will be undertaken, where the level is not adjusted (given adverse disturbance to rehabilitation), rehabilitation will provide additional focus on the establishment of suitable canopy species in these areas.

GES

1. INTRODUCTION

Williamtown Sand Syndicate Pty Ltd (WSS) is the owner of Newcastle Sand, the operator of the Cabbage Tree Road Sand Quarry, an approved and operational sand quarry on four lots of land located at 398 Cabbage Tree Road, Williamtown (Figure 1-1), approximately 30 km from the Newcastle. The Project has a maximum extraction rate of up to 530,000 tonnes per annum of sand products over a period of up to 15 years from a resource of approximately 3.25Mt. Figure 1-2 shows an aerial photo of the current footprint from extraction activities.

Development Consent (SSD-6125) was granted by the NSW Independent Planning Commission on 9 May 2018 for construction and operation of the quarry subject to a series of conditions.

Modification No.4 to the existing approval is to enable the quarrying of a five (5) hectare sand resource located immediately west (Lot 9 DP239608) of the existing excavation areas, this is called the Western Extension. The Western Extension contains approximately 500,000 tonnes of sand and is expected to be completed in around 12 months, no extension to the existing duration of approval is required. Initial planning of the Western Extension aimed to extract a seven (7) hectare resource area, however during the assessment process biodiversity avoidance measures have resulted in a reduction in the extent of the area to be quarried. On completion of the quarrying the expectation is to return the land to uses consistent with its existing use (i.e. a dwelling, with native vegetation and open grassed areas).

The majority of the proposed Western Extension extraction area and the originally approved extraction area was dredged for heavy mineral sands in the late 1970s. This process resulted in excavation and dredging of the sand to levels significantly below the water table. Based on existing observations the resulting dredged sands are typically homogenised (i.e. natural weakly bound coffee rock layers are blended), with occasional bands of fine silts deposited in small areas depending on the positioning of the dredge.

Potential impacts to groundwater associated with the quarry include effects on groundwater hydrology and groundwater quality because of quarry removing vegetation and sediment and potentially from intersecting the water table.

Operational limitations on excavation depths have been placed on the quarry within Schedule 2, Condition 6 of SSD-6125, which states that the operator "must not undertake quarrying operations within 0.7 metres of the predicted maximum groundwater level". Condition 37 states that one of the objectives of the rehabilitation programs is "Landform rehabilitated to 1.0 metres above the predicted maximum groundwater level".

To comply with Conditions 6 and 37, Conditions 11 and 12 within Schedule 2 of the Development Consent require the preparation and implementation of a Maximum Extraction Depth (MED) Report, that might be more accurately referred to as a Minimum Extraction Level (MEL) Report as it is referring to the minimum elevation (in Australian Height Datum – AHD) that extraction can occur.

It is intended that both the originally approved extraction area and the Western Extension will comply with this MED Report.

1.1 Project Overview

Key elements of the operation of the Quarry, relevant to groundwater and extraction depth, are listed in Table 1.

Table 1: Key Aspects of the Cabbage Tree Road Sand Quarry

Aspect	**Key Aspects of the** Mod 4 Western Extension **Project**
Key elements	Sand quarry extracting up to 530,000 tonnes per annum over 15 years including the construction of an intersection with Cabbage Tree Road, sealed and gravel access roads, site office, workshop and weighbridges. Progressive rehabilitation of quarried and returning to native vegetation communities with potential future use of the facilities area
Location	398 Cabbage Tree Road, Williamtown, within the Port Stephens local government area
Area	The originally approved extraction area is approximately 42 ha. Of this area, approximately 1 ha has been avoided, 35 ha quarried and as of March 2026, about 5.9 ha remains unquarried. The Western Extension represents an additional 5 hectares of extraction area The total extraction footprint is approximately 46 hectares.

Aspect	Key Aspects of the Mod 4 Western Extension Project
Project Life	The Original Project was approved for quarrying through to 31 December 2033, allowing up to 15 years of extraction, with site rehabilitation permitted to occur beyond this timeframe. At expected demand the quarry was estimated to have an eight-year life, reduced to five years should demand require maximum extraction rates. With the first sale of material coming out of the quarry in May 2020, and an estimated 6-months remaining within the originally approved resource, the proposed western extension will see quarrying continue until late 2027. The Western Extension has been nominally split into nine (9) sectors, each sector will be quarrying within approximately four to eight weeks, varying between each sector depending on demand and the depth of the resource.
Production rate	Up to 530,000 tonnes per annum.
Extraction method	• Excavator and/or bulldozer to clear vegetation and strip topsoil. • Bulldozer or grader to windrow sand if needed. • Front-end loader to feed the processing plant. • Front-end loader or excavator and haul truck to convey sand when conveyor unsuitable.

1.2 Scope

The components of the scope are primarily to address consent Conditions 12 as listed in Table 2.

Table 2: Approval Schedule 2, Condition 12

Condition	Requirement / tasks	Where addressed
12	The Applicant must review and update the Maximum Extraction Depth Report, in consultation with Hunter Water and DoI Water.	*
a	Every two years from the date of approval of the Maximum Extraction Depth Report; and	Section 3
b	If any groundwater is encountered during quarrying operations or if directed by the Secretary.	Section 3

* To be addressed on review.

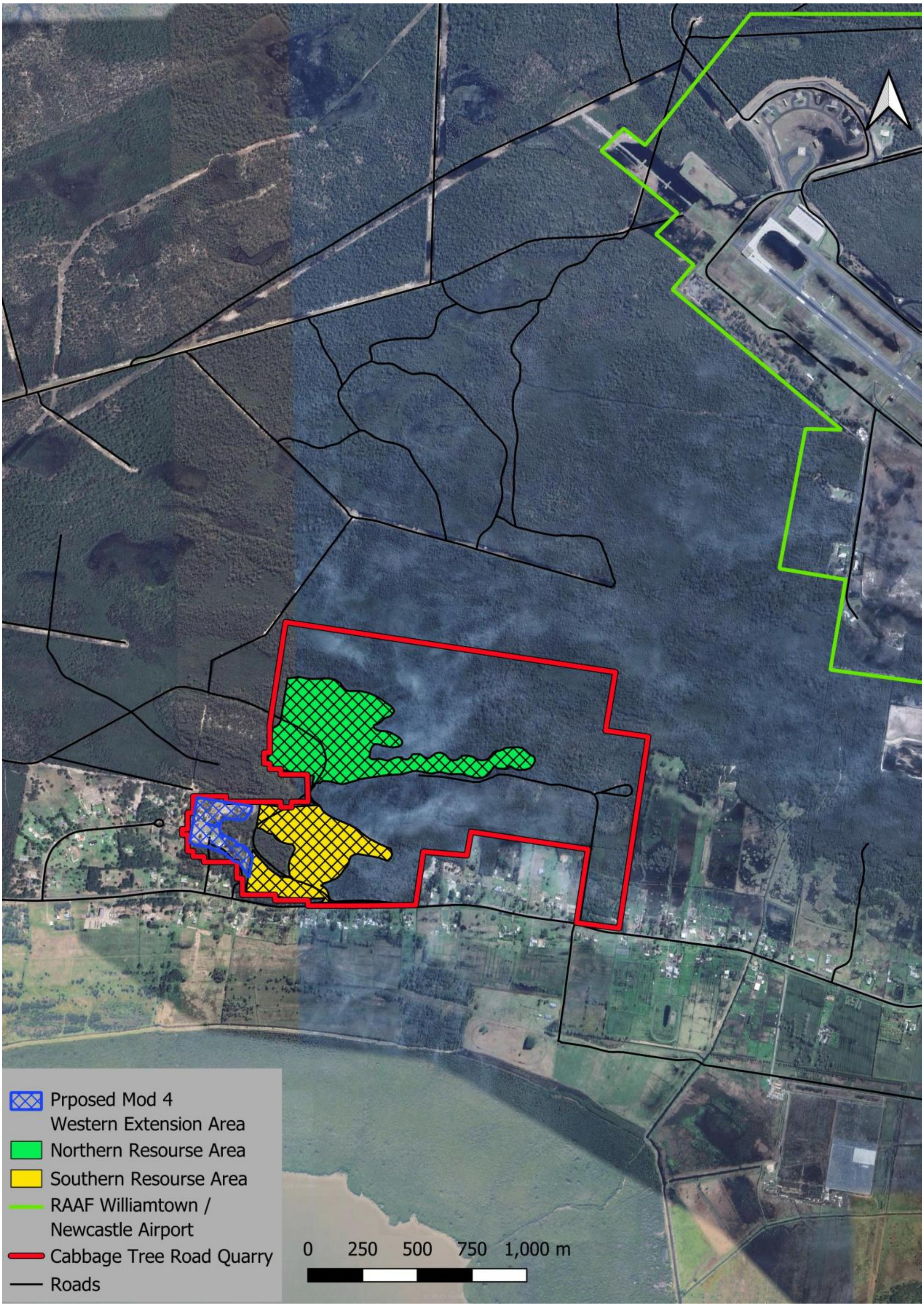

Figure 1-1: Cabbage Tree Road Sand Quarry Location

Figure 1-2: December 2025 aerial showing extent of excavation, rehabilitation, including the Western Extension

GES

2. ENVIRONMENT

2.1 Topography

The Quarry is 1.3 km north of Fullerton Cove, a tidal estuary that is part of the Hunter River system. Topography is shown on Figure 2-1, generated from SRTM data.

The site is located on the southern margin of an inner coastal dune barrier system and the landform comprises a gently sloping plain from 3 m AHD in the south to 5.5 m AHD in the north with a two prominent sand dunes reaching up to 23 m AHD elevation, separated by low lying swamp area of 2.5-4.5 m AHD that drains to the east. Importantly, the bridging section between these dunes limits surface flow of water from the west.

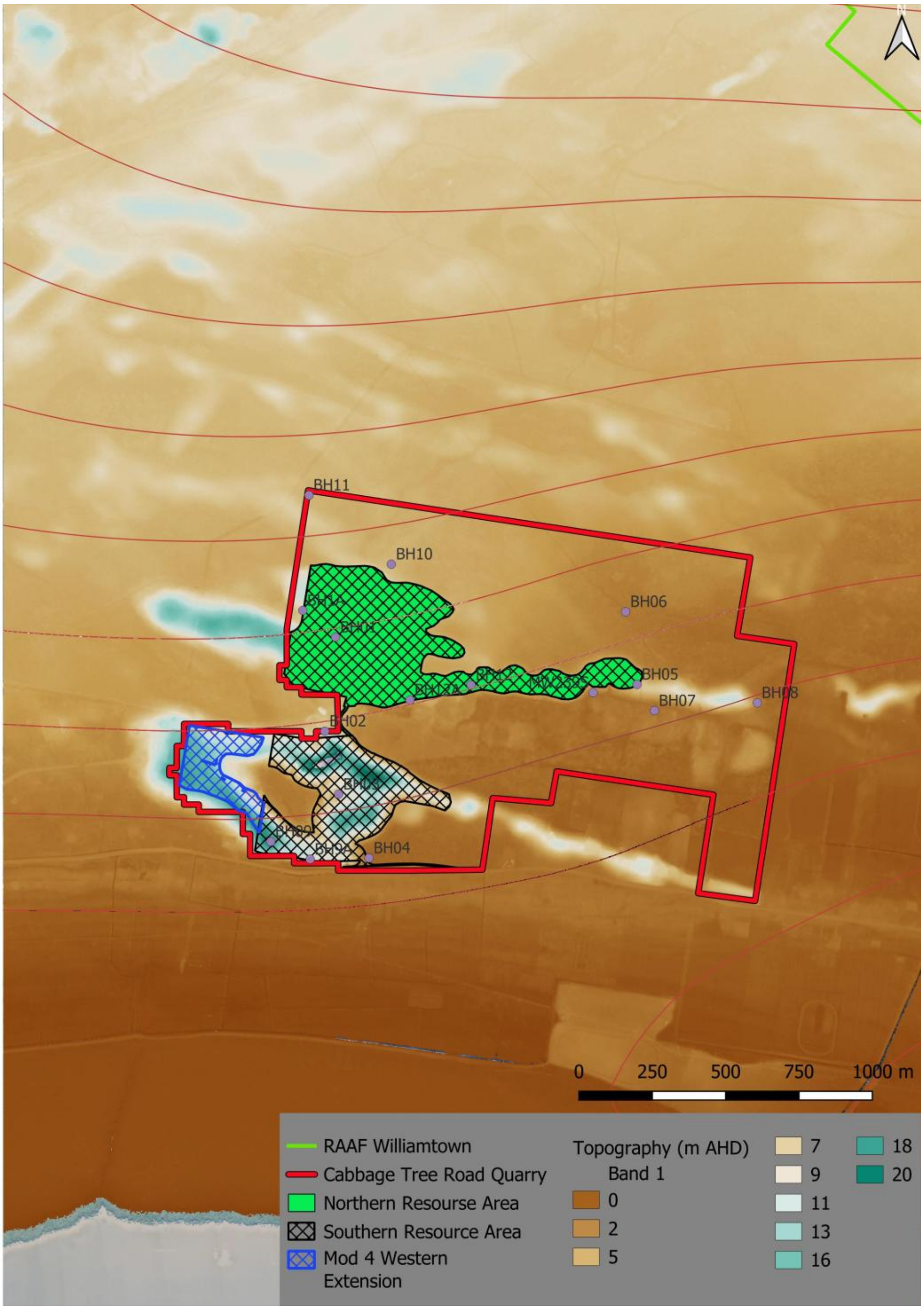

Figure 2-1: Topography

Regionally, the highest part of the Tomago Sand beds dune system is approximately 40 mAHD, approximately 4 km north-northeast the Site and just north of RAAF Williamtown. To the south, topography declines to low levels at less than 1 mAHD around the estuary of Fullerton Cove.

Within the Site boundary, the lowest topographic elevation is approximately 2 mAHD, rising to approximately 23 mAHD on the highest dune within the Site. Along the northern boundary of the site, topographic elevation is typically 6-8 mAHD (northwest) and 5-6 mAHD (northeast). Mean topographic elevation across the Site is about 5 to 6 mAHD, averaging 9.5 mAHD within the resource areas.

2.2 Climate – Rainfall and Evaporation

Rainfall and evaporation data can be obtained from the Bureau of Meteorology's (BoM) Williamtown RAAF Base station (number 061078). Rainfall averages is approximately 1127 mm/yr (period 1944- 2021), while potential evaporation is approximately 1500 -1600 mm/yr.

Figure 2-2 shows a residual rainfall curve for Williamtown RAAF Base. The residual rainfall curve shows deviation from mean monthly rainfall plotted against time. Positive slopes on the residual mass curve indicate periods of above average rainfall whereas negative slopes indicate periods of below average rainfall. Figure 2-2 shows that early 2020 experienced rainfall well in excess of the long-term average. In March 2021, Williamtown RAAF Base recorded 459mm of rainfall which is the highest recorded for a March interval.

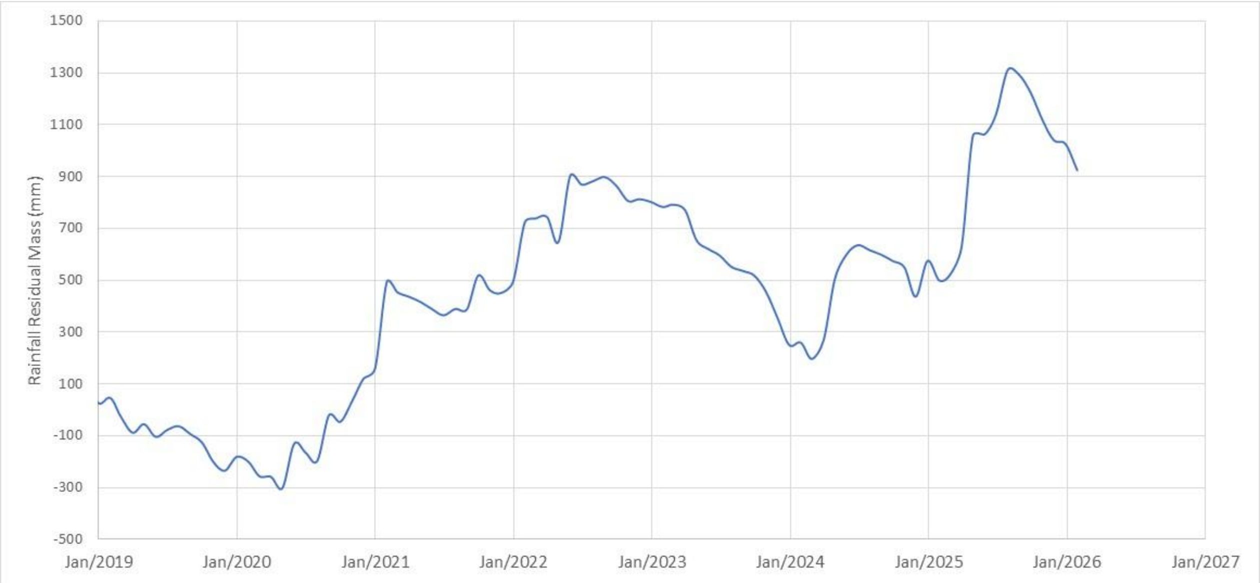

Figure 2-2: Rainfall Residual Mass Curve (Williamtown RAAF Base)

Figure 2-3 shows a combination of monthly rainfall totals and a residual rainfall mass curve (cumulative variation from average). Figure 2-3 shows cumulative monthly totals for mean, and annual totals from 2019 to 2025. This figure also shows mean and 90th percentile total rainfall statistics. In combination, these figures clearly show the high rainfall pattern experienced during 2020 – 2022. 2020 rainfall totals were at 80th percentile, 2021 and 2025 at 95th percentile and 2022 at 90th percentile of historical rainfall from Williamtown RAAF Base BoM data. This sustained high rainfall totals have not occurred previously in the historical record.

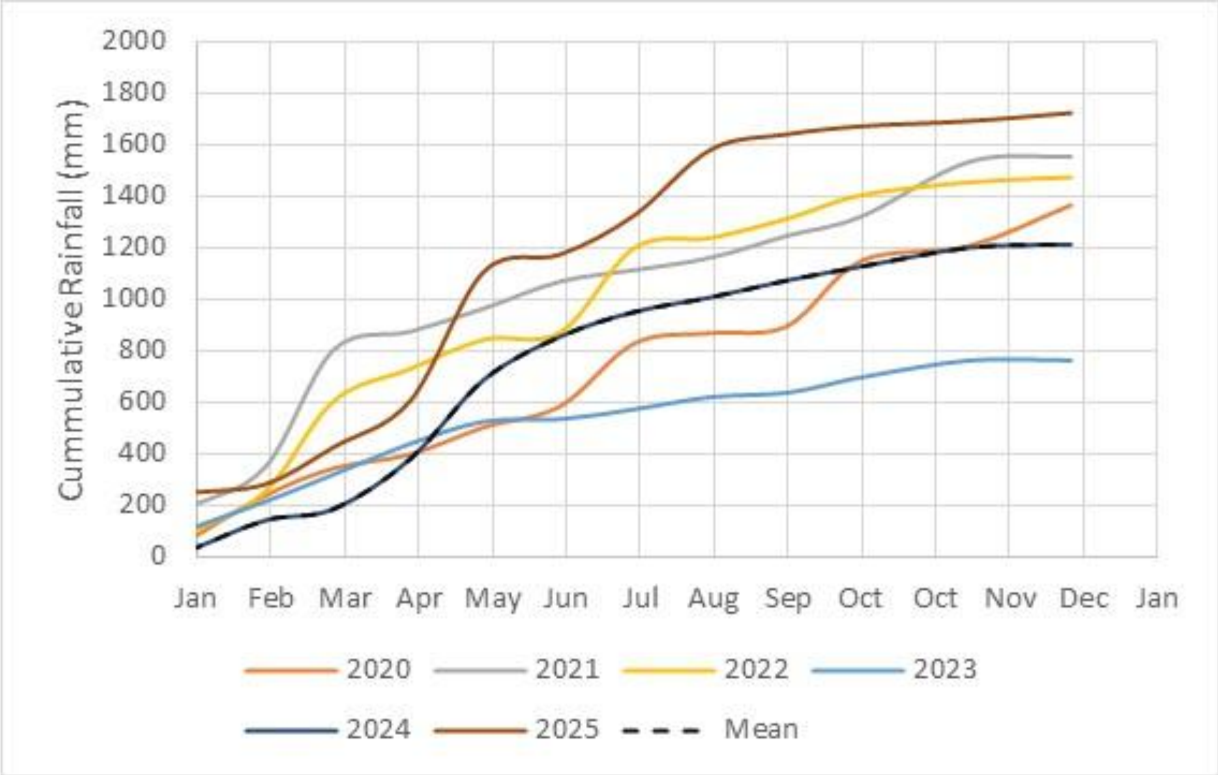

Figure 2-3: Cumulative Annual Rainfall (Williamtown RAAF BoM)

2.3 Geology

Geology in the area is typically Holocene estuarine and swamp (paludal) deposits, including the 'Tilligerry Mud Member' south of Cabbage Tree Road and remnant Pleistocene dunes of the Tomago Sand Beds.

Mineral sand mining occurred in the 1970s-90s across about 60% of the originally approved resource area, and about 100% of the Western Extension. This means that the dune sediment has been disturbed (to a depth below the water table) in these areas (Watershed, 2019).

In areas that have not been dredged, beneath the underlying unconsolidated sand deposits there is soft consolidated coffee rock with a surface that is not well understood. In places this impacts on shallow groundwater flow patterns. It is likely that where areas have been dredged there will be variability in the silt content associated with sand processing from dredging, in places this may create bands of lower permeability. This silt banding is variable and processing activities during dredging in the sand beds were adjusted to reduce potential for silt banding (owing to recharge concerns by Hunter Water), this resulted in silts being deposited within defined emplacements. It is not well understood when this operational practice changed in relation to dredging within the site.

2.4 Hydrogeology

Investigations by AECOM (2017) for the RAAF Williamtown Environmental Site Assessment (ESA), included slug testing, grain-size analysis and a pumping test occurred. This data was used to inform original groundwater modelling.

The Tomago Sand Beds consist primarily of aeolian dune sands and exhibit high hydraulic conductivity, typically >10 m/d and up to 55 m/d (AECOM, 2017). AECOM stated that "a representative hydraulic conductivity for the fine – medium sands is likely to range from 20 to 35 m/day". Specific yield ('drainable porosity') is likely to be 15-30%. Test pumping by AECOM (2017) suggested Sy = 10%, but this seems low given the lithology. Within the Tomago aquifer there are localised variations, either reducing permeability (e.g., coffee rock/indurated sand) or enhancing permeability (e.g., coarser facies, including basal coarse sands and gravels).

The Tilligerry Mud Member, deposited in the floodplains is less permeable, with measured permeability usually in the range 0.1-1 m/d (AECOM, 2017).

2.4.1 Groundwater Levels

WSS installed a network of 12 monitoring bores within the currently approved Project area. and monitoring has been undertaken routinely. An additional 7 monitoring bores have recently been installed in the proposed Western Extension Area. Locations for these bores are shown in Figure 2-4.

Note BH1, BH3, BH9 and BH12 are no longer operational and have been replaced by BH1a, BH9a and BH12a respectively.

Hydrographs for the above sites are shown in Figures 2-5 – 2-9 respectively. These also show rainfall residual mass curve (cumulative rainfall variation for average), and the maximum predicted level presented in Maximum Extraction Depth Management Plan (Watershed HydroGeo 2019).

Note that the maximum predicted water level has been exceeded for brief intervals in BH2 following periods of very high rainfall as shown in Figure 2-5.

Figure *2-6* shows earlier levels for BH3 and prior to removal, showed very little influence to stresses seen elsewhere.

Figure 2-7 shows a hydrograph for borehole BH4 and also is relatively stable with a subdued rainfall response.

It is apparent that where groundwater bores are within a topographically constrained area (such as BH2) with negligible drainage nearby, significant rainfall events result in more sustained high groundwater levels. The restricted drainage in land west of the quarry saw broad areas become ponded during the major rainfall events resulting in the more sustained groundwater levels in some bores while those closer to drains or lower elevations showed less response to major rainfall events.

Figure 2-8 shows a hydrograph for borehole MS239S and also is relatively stable, however the detailed rainfall response has not been captured in the monitoring frequency. This response is typical for this area.

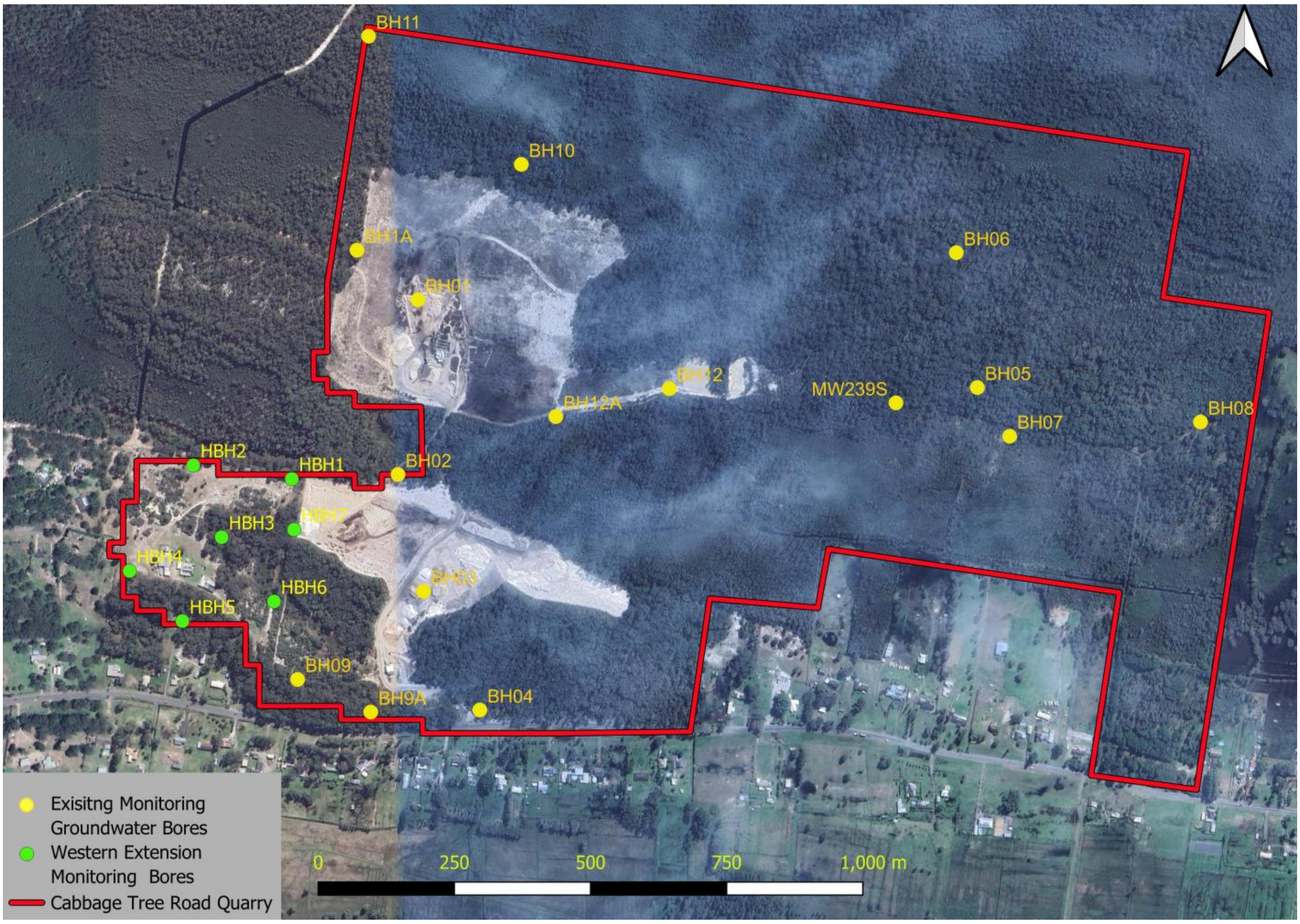

Figure 2-4: Monitoring Locations

Figure 2-5: Hydrograph for BH2

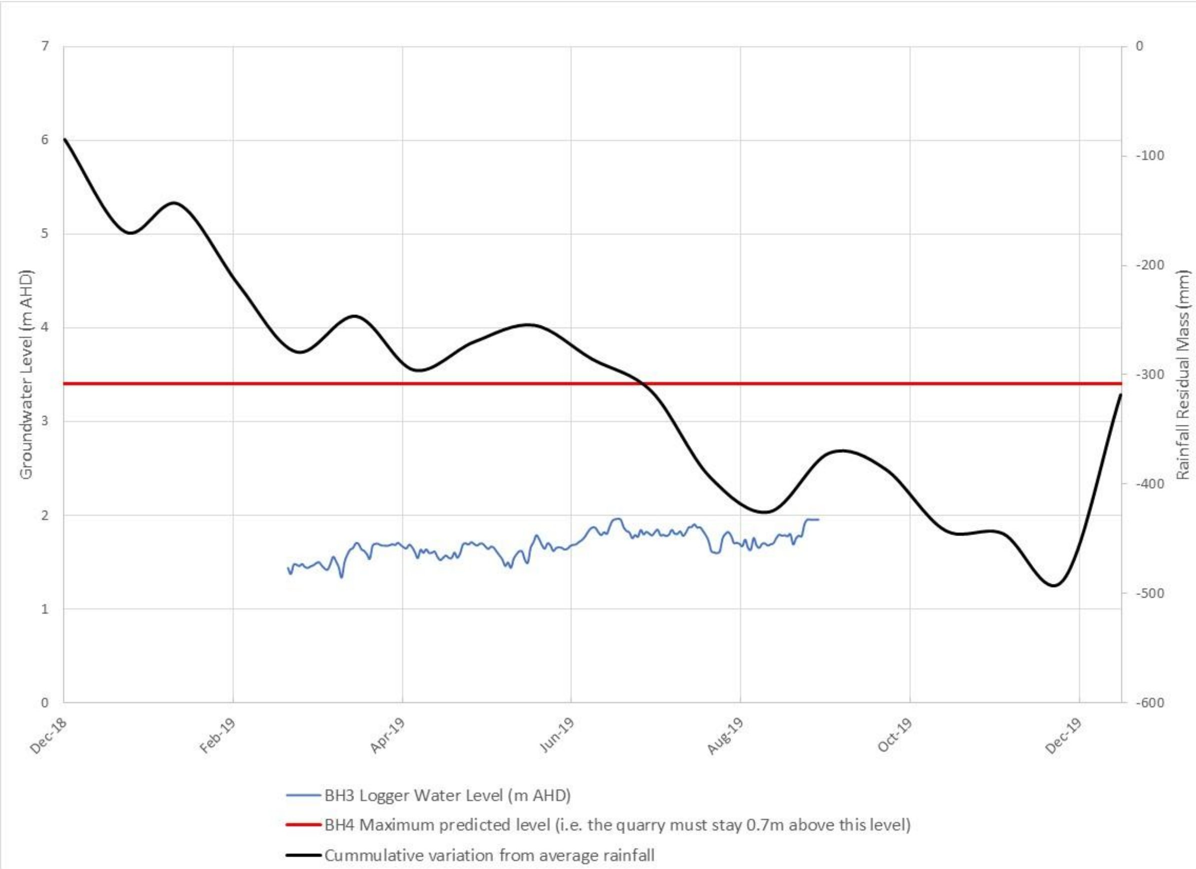

Figure 2-6: Hydrograph for BH3 (prior to removal)

Figure 2-7: Hydrograph for BH4

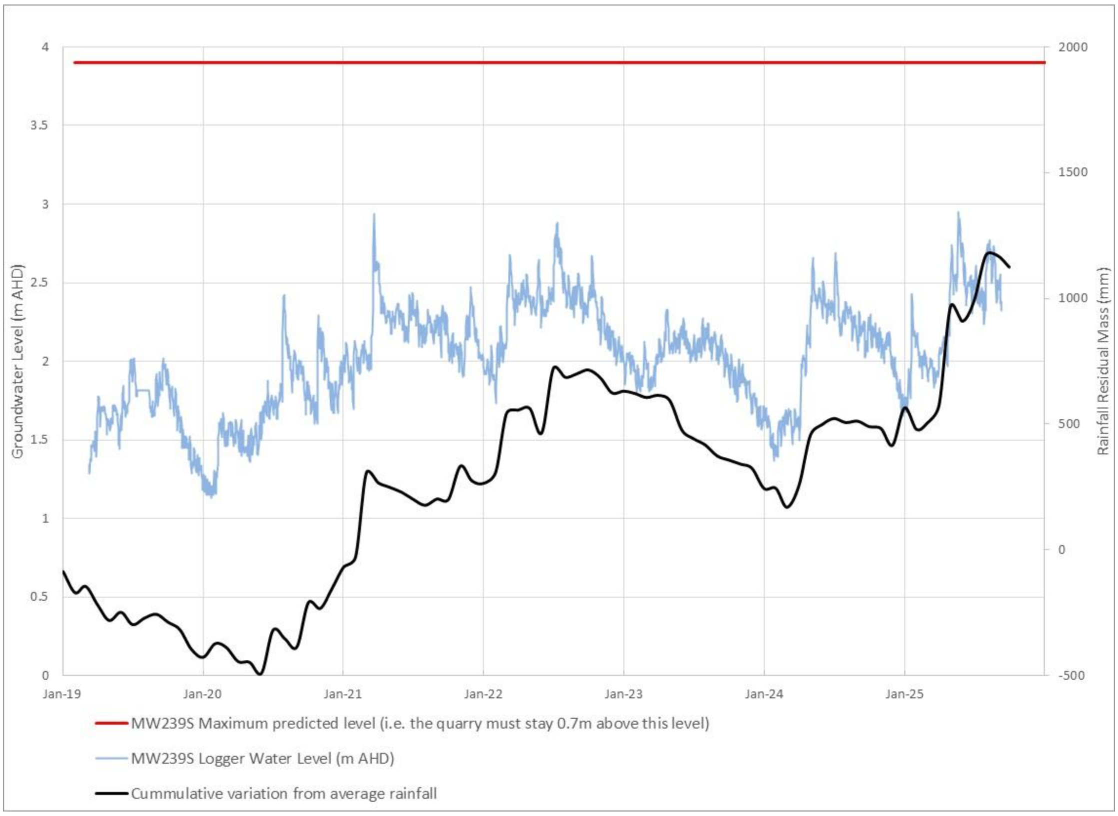

Figure 2-8: Hydrograph for MW239S

2.4.2 Groundwater Model Validation

The groundwater model used for MED assessment was originally constructed by Umwelt (2015 and 2016). In 2022, the model was reviewed against checklists from the relevant guidelines and updated in accordance with Commitment 8.3.8 (k).

The model was converted from the native Modflow 2000 software version into a more recent iteration of the USGS supported Modflow USG, an unstructured grid version of Modflow (USGS) for simulating groundwater flow processes.

Monthly stress periods were continued until late 2025 with similar recharge characteristics employed from the original Umwelt design.

Groundwater level targets included in the Umwelt, 2015 Groundwater Impact Assessment were used to verify compare and verify calibration characteristics. Minor changes were found but these were not significant.

The groundwater model used for the MED validation (GES, 2022) has been further amended for this review, with the inclusion of addition stress periods and monthly rainfall data from the Williamtown (RAAF) BoM site This model has been updated to include the end of 2025 and this includes the high rainfall events that have occurred during in the recent climate record.

Targets data was also updated with recent groundwater monitoring data from WSS site groundwater monitoring network used to test the performance against recent environmental stresses. Water levels from recently installed groundwater monitoring bores have also been included to measure the performance of the model in the proposed extension area.

No further changes were made to aquifer parameters of other boundary conditions.

2.4.3 Groundwater Model Update

The groundwater model was rerun with the latest monitoring data in order to validate the previous model outcomes with regards to maximum extraction depth planning.

Simulated (modelled) groundwater levels vs observed groundwater levels monitoring for all bores within the project area are shown below in Figures 2-9 to Figure 2-13. Groundwater contour levels across the site in contrasting rainfall pattern years are shown in Figure 2-16 for June 2020 and June 2022.

Bores in or very close to the demarcated excavation area with an applied MEL have the excavation limit level included.

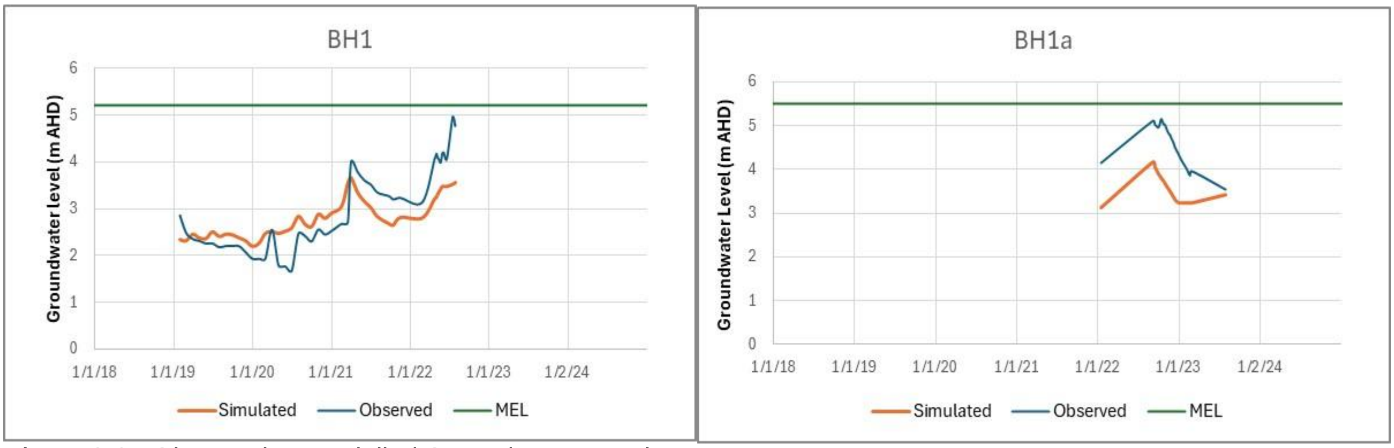

Figure 2-9: Observed vs Modelled Groundwater Levels (a) BH1 & (b) BH1a

Other monitoring locations have simulated levels systematically higher than observe such as BH 5, BH6 and BH7 although overall the qualitative calibration is good particularly within the defined excavation area.

Another key observation when comparing simulated and observed levels includes differential timing of peak levels that are the response to rainfall and this shows that although the overall trend of the Williamtown BoM data matches the key trends, detail differences point to a rainfall distribution pattern at the quarry location differs slightly from distribution pattern recorded at the Williamtown RAAF BoM site.

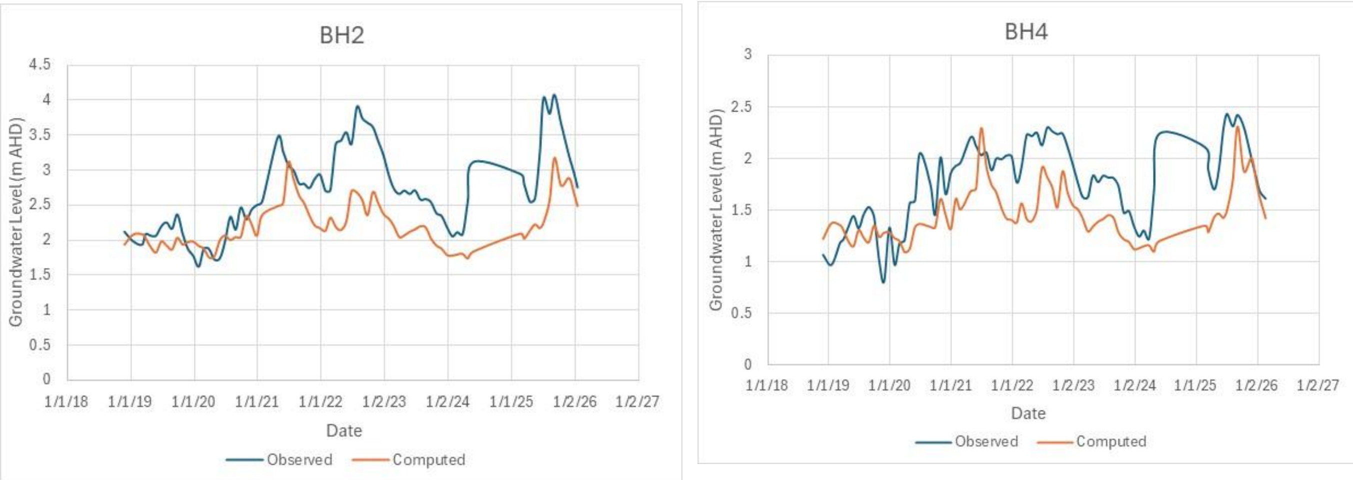

Figure 2-10: Observed vs Modelled Groundwater Levels (a) BH2 & (b) BH4

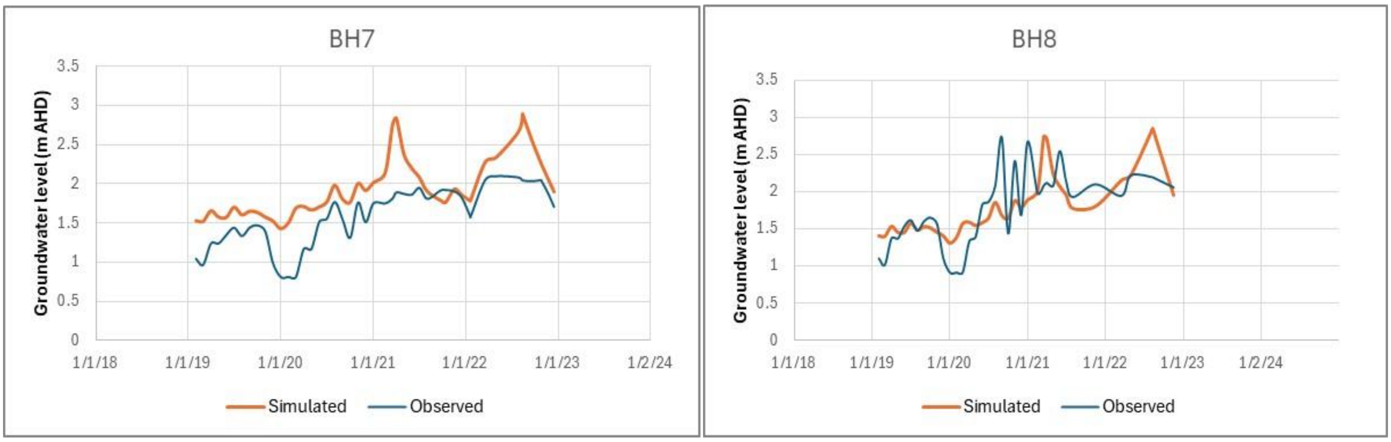

Figure 2-11: Observed vs Modelled Groundwater Levels (a) BH7 & (b) BH8

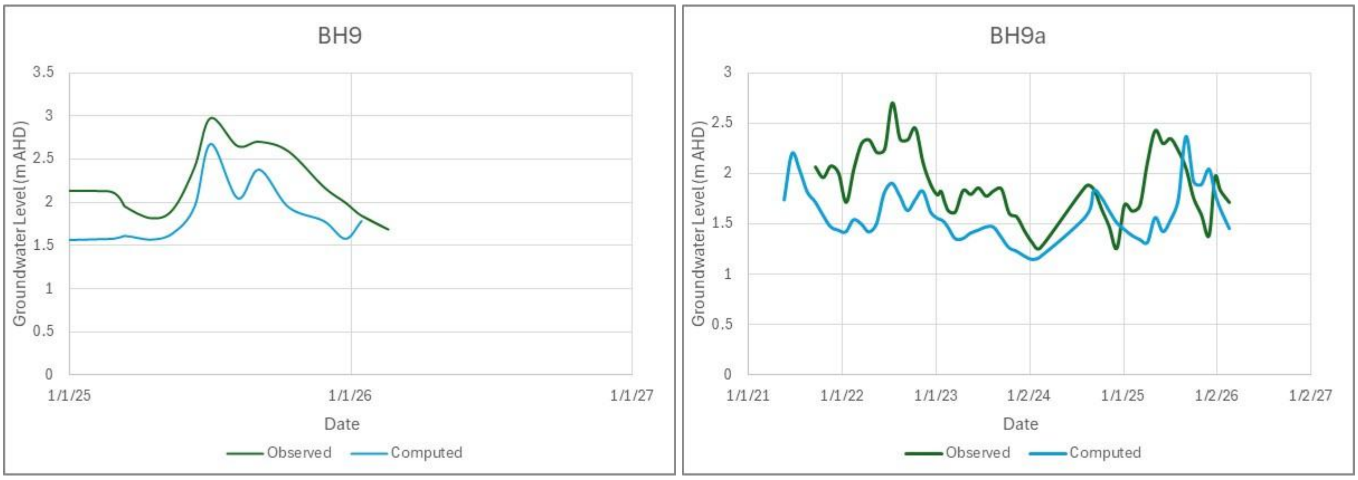

Figure 2-12: Observed vs Modelled Groundwater Levels (a) BH9 & (b) BH9a

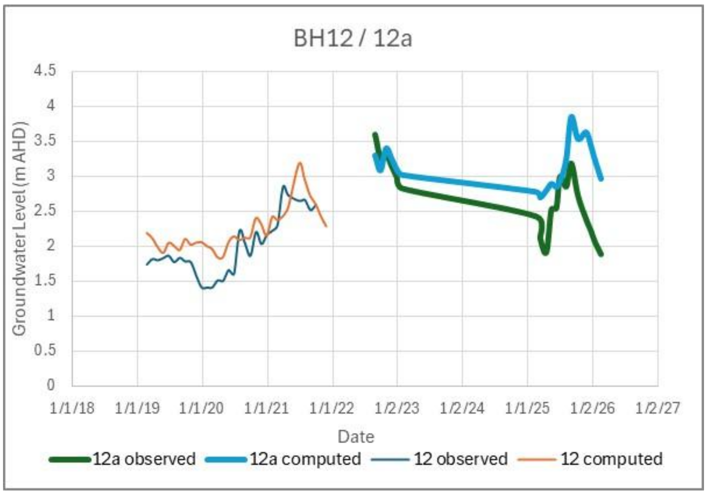

Figure 2-13: Observed vs Modelled Groundwater Levels ***BH12***

2.4.4 Groundwater Levels in Mod 4 Western Extension Area

The seven groundwater monitoring bores recently installed in the proposed Mod 4 Western Extension Area have been included as monitoring targets within the updated groundwater model.

The comparison of observed and simulated groundwater levels in the proposed extension area is shown in Figures 2-14 – 2-17. For the limited data set available, there is reasonable correlation between observed and simulated levels. The exception to this is HBH3, where there is approximately 2m differential between the simulated and observed levels. This level is an outlier in the localised groundwater system. Note also that the groundwater level in HBH3 is more than 1 meter above that of HBH1 and HBH2. Both of which are upgradient of HBH3.

The elevated level has been assessed to be associated with property located within this extension area and more specifically the localised storm water and septic system discharge associated with the property.

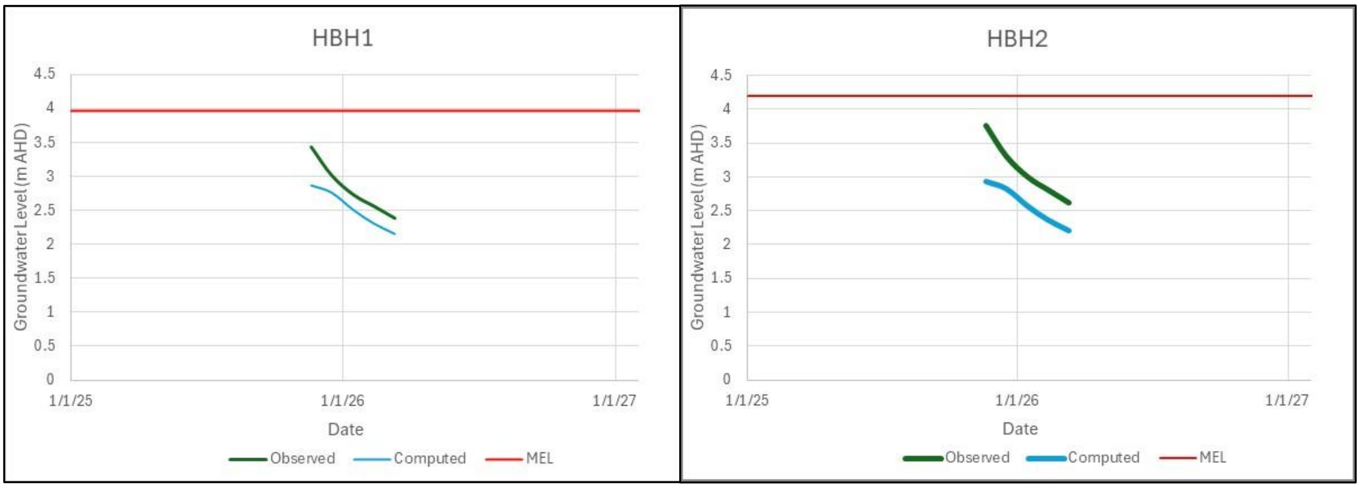

Figure 2-14:** Observed vs Modelled Groundwater Levels* ***(a) HBH1 & (b) HBH2

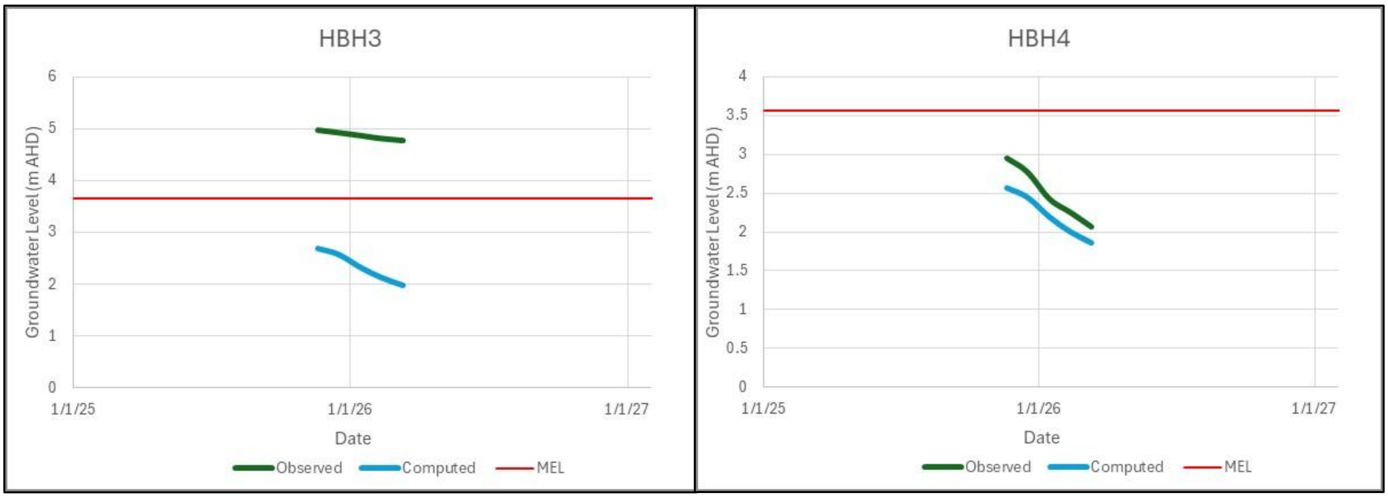

Figure 2-15: Observed vs Modelled Groundwater Levels (a) HBH3 & (b) HBH4

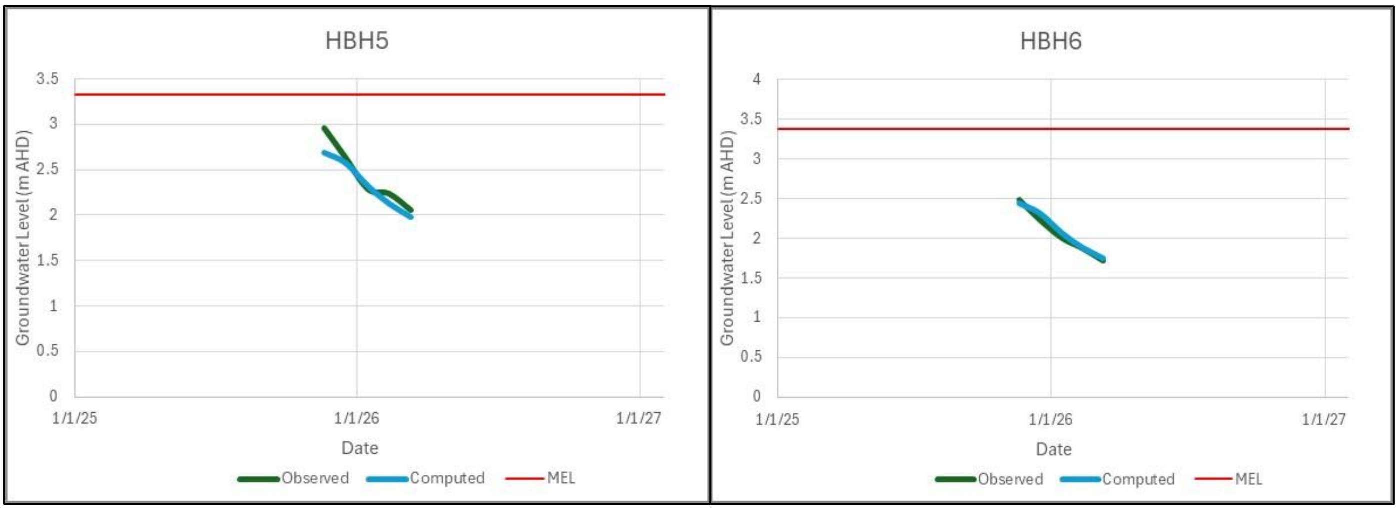

Figure 2-16: Observed vs Modelled Groundwater Levels (a) HBH5 & (b) HBH6

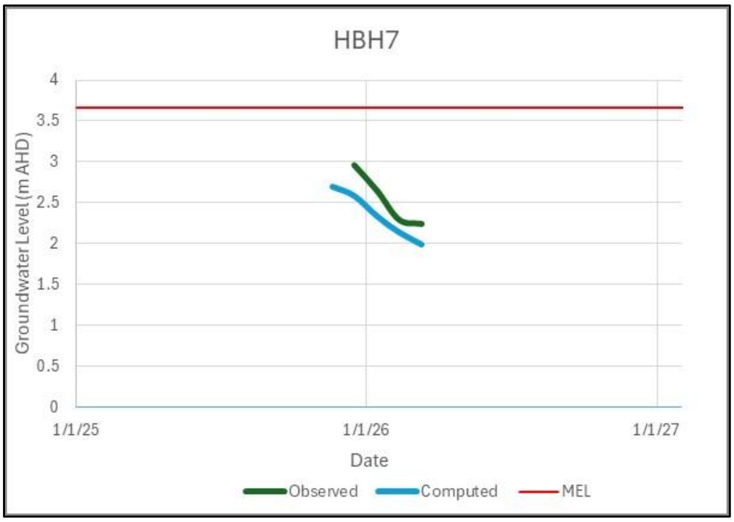

Figure 2-17: Observed vs Modelled Groundwater Levels HBH7

2.5 Elevated Groundwater Level at HBH3

Monitoring of HBH3 shows groundwater levels are unusually elevated and do not conform to expected and measured gradients within the originally approved extraction area. Considering HBH3 is located downgradient of the onsite dwelling it is considered likely that the elevated water levels are solely related to one or a combination of the following mechanisms:

- Impervious roof areas and associated stormwater runoff.
- Impervious gravel driveway areas and associated runoff.
- Onsite effluent irrigation system located below the dwelling (see Figure 2.18 and Plate 1).
- Potential mains water leakage.

Two additional supplementary groundwater monitoring bores were installed to further investigate this groundwater mound. Figure 2-18 shows groundwater monitoring locations including HBH8 and HBH9 and elevated groundwater contours, showing substantial elevation downgradient and adjacent to the dwelling.

Figure 2-18: Groundwater Monitoring Locations including HBH8 and HBH9

Additional geochemistry testing was undertaken including general field geochemistry, groundwater was analytically tested for nutrients including:

- Nitrate (as N).
- Ammonia (as N)
- Total Phosphorous
- Free Chlorine
- Fluoride
- E. coli
- Total Coliforms

Plate 1: Irrigation spigot in relation to HBH3

The additional well installation and analytical testing was aimed at testing for suspected domestic / anthropogenic origin of the elevated groundwater levels around HBH3.

Table 3 shows results of supplementary analytical testing focusing on parameters that would show a domestic waste as a source.

Table 3: Supplementary Analytical Geochemistry and Microbiological Results

Parameter	HBH2	HBH3	HBH6	HBH8	HBH9
Nitrate (as N).	<0.005	0.14	0.27	0.15	1.1
Ammonia (as N)	0.07	<0.02	<0.02	0.07	0.04
Total Phosphorous	<0.05	<0.05	<0.05	<0.05	<0.05
Free Chlorine	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoride	0.1	<0.1	<0.1	0.5	<0.1
E. coli	<100	<10	<10	<100	<100
Total Coliforms	7,000	130	~50	>100,000	>100,000

These anthropogenic origin mechanisms are supported by the following evidence:

- Lower EC levels at HBH3 and the downgradient well HBH6 when compared to the upgradient wells HBH1 and HBH2.

- Higher nitrogen levels, particularly in HBH9 (closest to source), this is consistent with expectations with proximity to source and groundwater gradient related to concentrations.
- Very high coliforms in HBH8 and HBH9, significantly elevated in HBH2 and slightly elevated in HBH6.The high Total Coliform data is relatively inconsistent between bores and may suggest influence of other environmental conditions as opposed to just the location of the onsite effluent disposal system.

Note also that there was an elevated Fluoride level in HBH8 suggesting reticulated water source, however no chlorination products (chlorine) were found. However, potential chlorine (reticulation) and Phosphorous (domestic waste water) are expected to have attenuated rapidly if present in the source water.

While this elevated groundwater is expected to dissipate once the dwelling and associated infrastructure is removed the following management measure is proposed to reduce the potential for interaction with these elevated groundwater levels:

- Extraction depth will be limited in this area to 0.7m above the measured groundwater level in HBH3 / HBH8 / HBH9 to avoid interaction with the water table.
- Once HBH3 / HBH8 / HBH9 levels become consistent with expected groundwater gradients (i.e. a relatively gradual grade between HBH2 and HBH6), the extraction floor will be as per the established MEL.

2.5.1 Groundwater Geochemistry in Mod 4 Western Extension Area

Electrical Conductivity (EC) from recent observations of groundwater geochemistry in Mod 4 Western Extension are included in Figure 2-18 where the range in salinity value is 78 – 223 µS/cm. Of note are the consistent and very low salinity levels observed in HBH3 and HBH6. HBH3 is thought to be the focus of enhanced recharge through septic and storm water input. This low salinity level supports the hypothesis of this being an anthropogenic effect, that on cessation of the dwelling being inhabited are expected to lower to expected EC and groundwater levels. Operational adjustments to the extraction floor have been developed such that quarrying does not work within the water table.

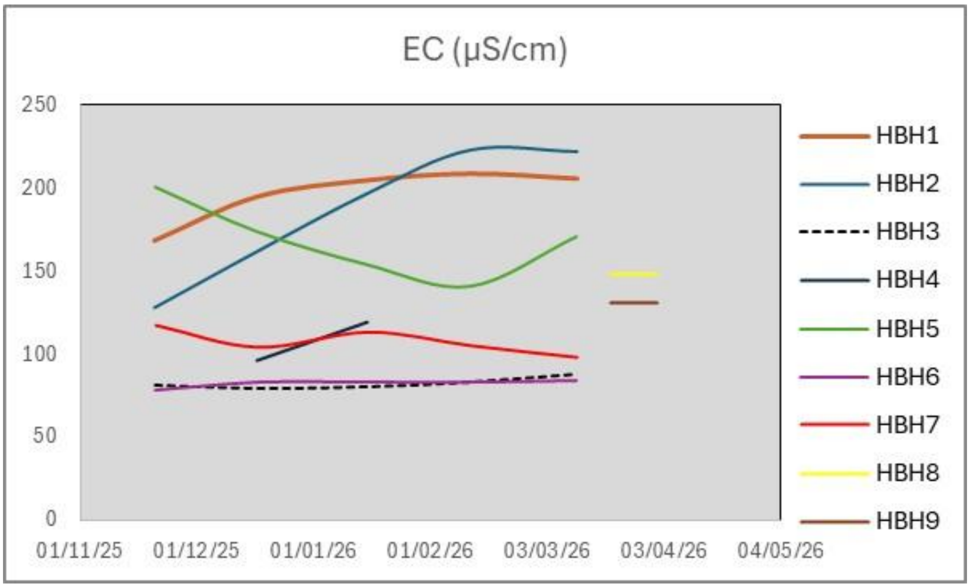

Figure 2-19: Electrical Conductivity in Mod 4 Western Extension Area

2.6 Estimated Maximum Groundwater Level

2.6.1 Background

The elevation of the quarry floor within the currently approved area has been determined by being greater than 0.7 m above the maximum predicted groundwater levels, during operation, and rehabilitated to 1.0 m above this groundwater level after extraction. This level has proven to be appropriate with minor short-term exceedances occurring in periods of sustained high rainfall. These exceedances have occurred within the northern resource area, and the majority of this area, excluding the narrow eastern dune, is now in rehabilitation.

Therefore, the estimated maximum groundwater levels previously presented by Watershed (2019) still provides a logical and still relevant basis for estimation of potential high groundwater levels based on four decades of sub regional observation data. The estimated maximum groundwater levels developed by Watershed utilised:

- HWC and site groundwater levels.
- Numerical modelling (MODFLOW modelling described in Umwelt 2015 and 2016).
- Comparison and correlation of the 2014-15 data available from the on-Site bores with the HWC records.
- Additional interpolation of maximum groundwater level observed at the HWC bores (rather than the 95th percentile). As noted in Section 2.3, record rainfall levels in March 2020 provided conditions for maximum groundwater levels to be encountered.

This rationale has been transferred to the proposed extension area modification with model results showing recent levels for monitoring conducted on recently installed groundwater monitoring bores correlated to modelled levels.

Figure 2-20 shows the maximum predicted water level which has been adopted and is the result of interpolation of long term HWC data derived by Watershed HydroGeo (2019). These contours are shown alongside the maximum modelled groundwater levels from Umwelt (2016).

In estimating daily maximum groundwater levels from a sequence of monthly data (as per the HWC dataset), Watershed considered the timing of heavy rainfall in relation to the maximum water levels at key bores from the HWC dataset Based on logger data from site bores (RCA, 2015), Watershed noted groundwater levels recede at approximately 2 cm per day, and using this, an allowance for the period of time between the maxima at each bore and preceding heavy rainfall has been applied using this approximated recession rate. These assumptions are generally still valid.

This is up to:

- 0.02 m at bore SK4942 (max water level measured within 1 day of heavy rainfall).
- 0.4 m at bore SK5992 (based on 20 days recession between preceding heavy rainfall and second highest water level recorded on 12/07/2009).
- 0.02 m at bore SK3508 (based on 1 day recession prior to water level recorded 30/05/1990).
- 0.10 m at bore F8 (based on 5 days recession prior to water level recorded 7/07/2013).

As noted above in recent monitoring within on-site monitoring:

- 0.008 m BH2 (max water level measured within 1 day of heavy rainfall recorded 3/4/21 and 0.26m recession within 1 week).

Table 4: MEL Mod 4 Extension for Williamtown Sand Quarry

Area	**Sectors**	**Estimated extraction month/ Year**	**MEL variation per sector (m AHD)**			**Extraction Status March 2026**
			Min	**Median**	**Max**	
	WE1	09/2026	4.1	4.3	4.5	Approval Pending
	WE2	09/2026	4.5	4.5	4.6	Approval Pending
	WE3	11/2026	4.5	4.6	4.7	Approval Pending
	WE4	12/2026	4.4	4.5	4.6	Approval Pending

	WE5	03/2027	4.3	4.4	4.5	Approval Pending
	WE6	05/2027	4.1	4.3	4.5	Approval Pending
	WE7	06/2027	4.1	4.2	4.3	Approval Pending
	WE8	08/2027	4.1	4.1	4.2	Approval Pending
	WE9	10/2027	3.9	4.0	4.1	Approval Pending

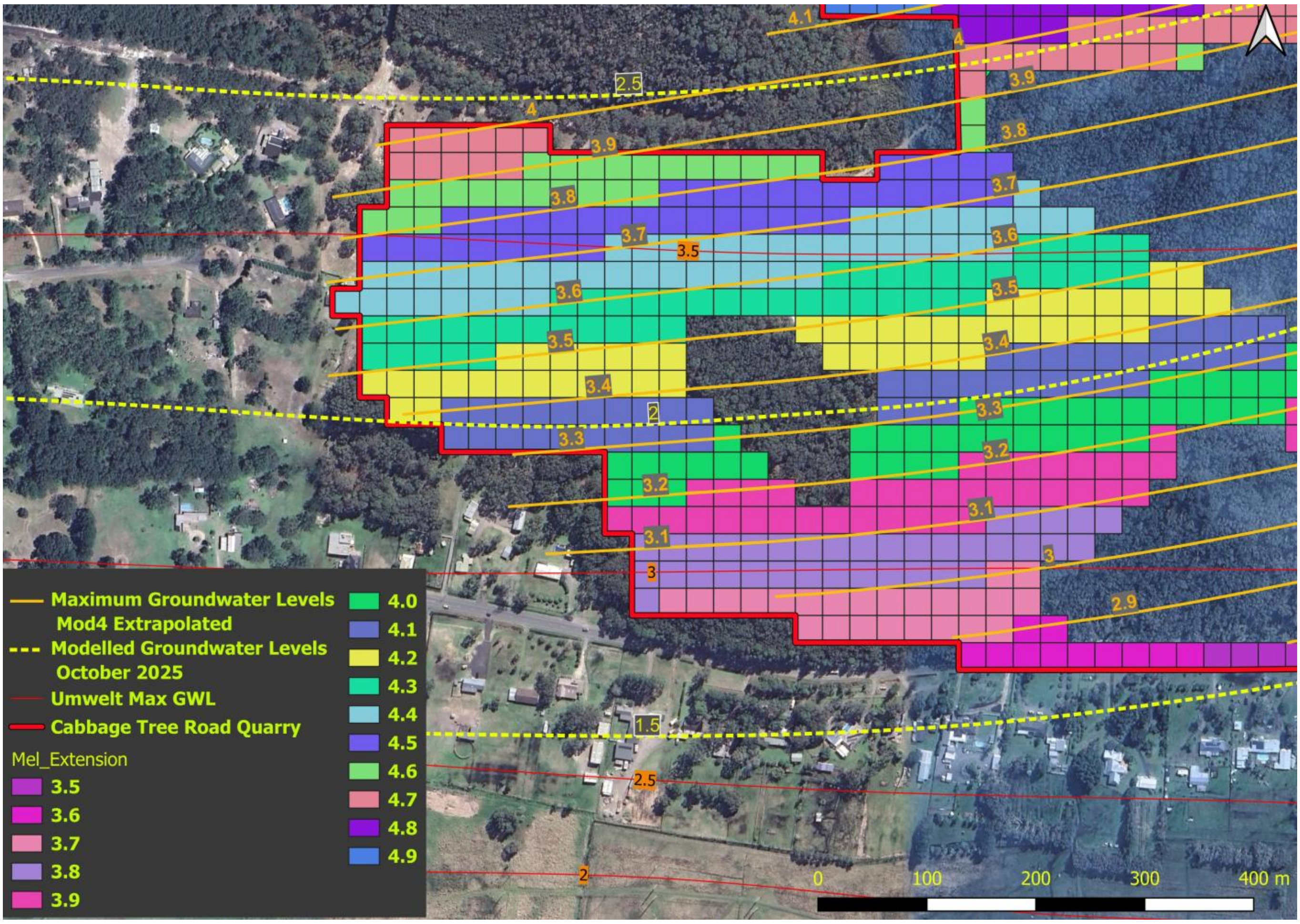

Figure 2-20: Modelled and Interpolated Maximum Groundwater Levels

2.7 Modification 4 Area Western Extension Minimum Excavation Levels (MEL)

Based on the preceding section on the estimated maximum groundwater levels, the MEL has been provided in Table 3 for the Western Extension. Figure 2-20 shows minimum excavation level (MEL) calculated on a 25 x 25 m grid. Figure 2-20 also shows the resource area staging of Western Extension (WE) Sectors 1 – 9. Each Sector within the Western Extension is likely to approximate four to eight weeks of extraction at maximum extraction rates, over the 12 months period of extraction.

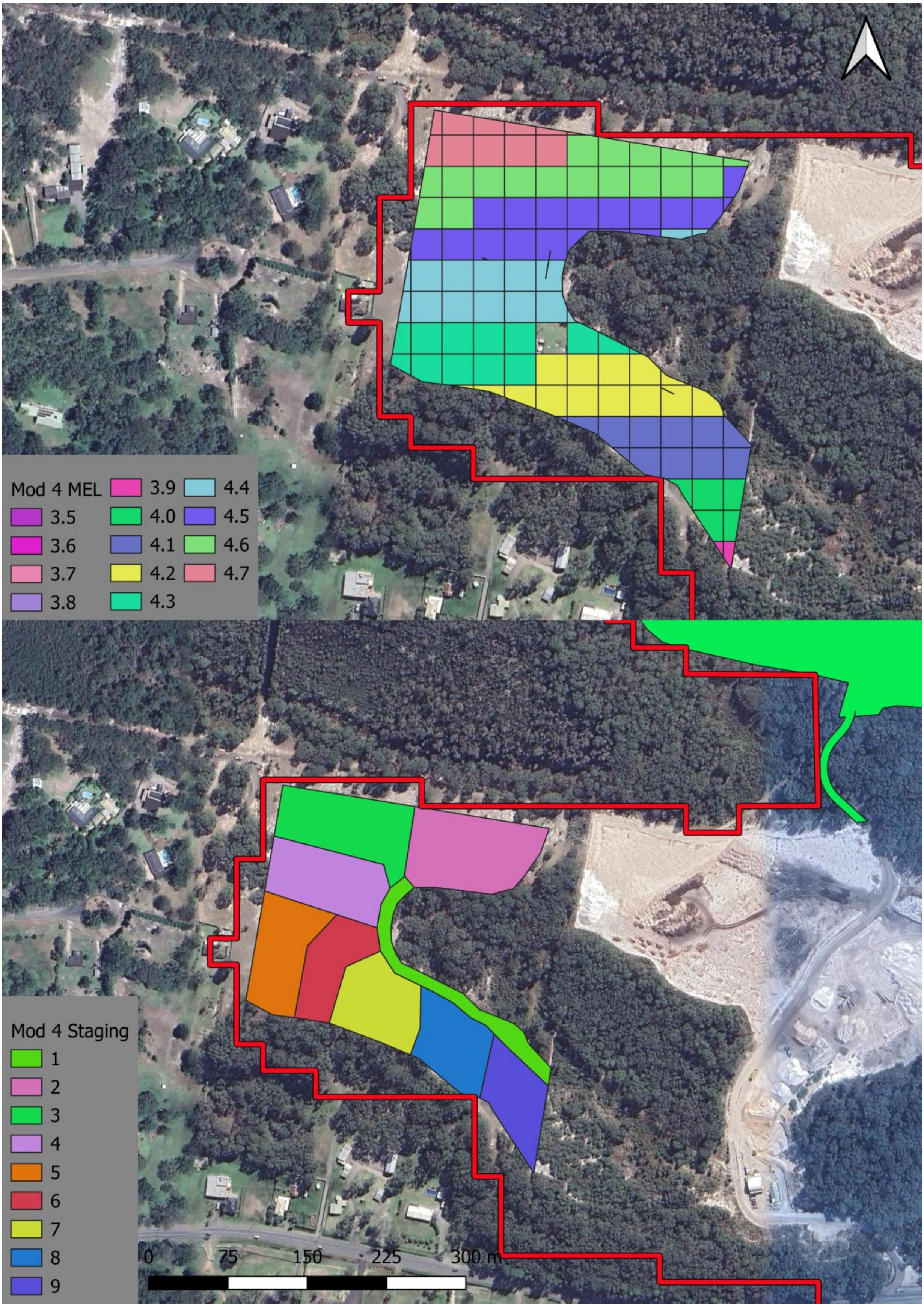

Figure 2-21: Minimum Extraction Level (m AHD) & Resource Area Development Area

3. MONITORING AND COMPLIANCE

The key requirements of the operator regarding operating above the maximum water table are:

- Ensuring that a sufficient depth of topsoil is stripped and stockpiled to meet the difference between operational floor elevation (MEL) and rehabilitated elevation, which is to be >0.3 m above MEL.
- Maintaining the floor elevation above MEL.
- Monitoring for rising water levels, which respond to natural stresses and potentially as a result of or enhanced by the operation of the quarry.

3.1 Monitoring - Floor Elevation

It is understood that the operation utilises GPS control for Loading / Excavating machinery. It is recommended that this level of control continues.

WSS has installed the excavator with a GPS tracking, linked to a nearby base station that will be accessed by subscription to the local network. This system tracks the elevation of the excavator bucket and will alert operators where necessary. Key aspects of this monitoring system are:

The excavator is fitted with a GPS receiver / sensor to record the base elevation of the bucket.

- The excavator will have a pre-loaded boundary with corresponding visual alarm to limit the potential for extraction beyond the approved lateral boundaries of the Resource Areas.
- The system will have a pre-loaded set of elevation data (i.e. MEL surface), with a visual alarm system warning the operator of a breach of the MEL.
- GPS trace (X, Y, Z) to be saved daily to allow periodic analysis and verification of GPS performance. Commitment 8.3.18 (q) requires weekly review of the working floor elevation.

3.2 Routine survey

Surveys by a registered surveyor of current working areas, recently extracted areas and recently rehabilitated sectors to be undertaken, as per Commitment 8.3.18 (s). UAV/drone surveys recommended if accuracy can be achieved. This will allow confirmation of:

- Working floor is at or above MEL (max. groundwater level + 0.7 m).
- Rehabilitated areas are, on average, higher than MEL, as per the condition of maximum groundwater level +1.0 m.
- Rehabilitated areas will require sufficient survey to demonstrate the predominant level of rehabilitated surface is at or above the required level. Given the surface will be likely to be subject to slumping and compression (from vehicles, rehabilitation planting and log placement, rainfall etc), the recording of the levels at multiple locations within each sector (>20, preferably more) will be essential. UAV survey would achieve this, providing analysis of a ‘point cloud’.

Doing this quarterly will allow the performance of the GPS tracking system to be verified and ensure that rehabilitation areas meet the required elevation. Practically, it is recommended that the survey of rehabilitation areas is conducted before re-vegetation measures occur.

3.3 Monitoring – Groundwater Levels

A network of groundwater monitoring bores exists on site and a number of these bores have already or will be destroyed or decommissioned due to quarry operations at some point during excavation.

The status of these bores is summarised in Table 4. While groundwater levels remain relatively low, most on-site bores will be dipped monthly.

Table 5: Monitoring Bore Network

Bore	Constructed By	Operational for life of Quarry?	Max GEL (mAHD)		Monitoring Method	Operational
			Measured#	Inferred*		
BH1	WSS	N – Year 3	4.97	4.5	dip	No
BH1A	WSS	Y from Year 3	5.15	4.8	dip	Yes
BH2	WSS	Y	4.26	3.8	datalogger	Yes
BH3	WSS	N -Year 1	1.56	3.44	N/A	No
BH4	WSS	Y	2.29	3.0	datalogger	Yes
BH5	WSS	Y	2.43	4	dip	Yes
BH6	WSS	Y	3.36	4.4	dip	Yes
BH7	WSS	Y	2.09	3.7	dip	Yes
BH8	WSS	Y	2.72	4	dip	Yes
BH9	WSS	N -Year 7	2.71	3	dip	Yes
BH9A	WSS	Y	2.55	3	datalogger	Yes
BH10	WSS	Y	5.01	4.9	dip	No
BH11	WSS	Y	6.14	5.5	datalogger	No
BH12	WSS	N -Year 3	3.03	4	dip	No
BH12A	WSS	Y	3.59	4	dip	Yes
MW239S	AECOM	Y	2.51	3.9	datalogger	Yes
HBH1	Douglas Partners	Y	3.87	N/A	dip	Yes
HBH2	Douglas Partners	Y	3.98	N/A	dip	Yes
HBH3	Douglas Partners	Y	3.65	N/A	dip	Yes
HBH4	Douglas Partners	Y	3.56	N/A	dip	Yes
HBH5	Douglas Partners	Y	3.32	N/A	dip	Yes
HBH6	Douglas Partners	N late 2027	3.38	N/A	dip	Yes
HBH7	Douglas Partners	Y	3.66	N/A	dip	Yes
HBH8	Total Drilling	N early 2027	3.75	N/A	dip	Yes
HBH9	Total Drilling	N mid 2027	3.42	N/A	dip	Yes

* Water level has been inferred from comparison of short record for each site BH vs long-term HWC dataset. Quarry extraction floor level to be 0.7m above this level, rehabilitation level 1.0m.

Note the difference between the measured and inferred shows an underestimate for bores on the western side of the quarry where the slower surface drainage and surface ponding exists on land west of the quarry and an overestimation on the eastern side of the quarry where the surface drainage is more direct with less constraint to drainage.

GES

3.4 Trigger Action and Response Plan (TARP)

3.4.1 Extraction Management

Table 5 provides guidance on the evaluation of the extraction floor level against the established Minimum Extraction Level.

Table 6: Compliance Measures for quarry Floor Elevation

Level	Trigger Levels - variance from the Operational Level (MEL or Rehab Level)			Comment	Response
	L75	L90	L98		
Compliant	0	0.1	0.2	Tolerances allowed to accommodate localised slumping and compaction	Demonstrate compliance via quarterly audits and Annual Reporting.
Non - Compliant	<0	<0.1	<0.2	Non-compliance triggered if 2 of 3 breached. #	Report to DPHI, HWC, NSW DCCEEW. Manual survey area(s) of where L75, L90, L98 have failed. Confirm accuracy of initial GPS/survey data. Re-grade non-compliant areas as required by DPHI, confirm with survey. Review MEL, operational and rehab methods.
# consistent with Schedule 5, Condition 8 and Condition 9, in the event a non-compliance is identified, Newcastle Sand must immediately notify the Secretary of DPHI, and within seven (7) days of the incident provide the secretary and any relevant agencies a detailed report on the incident.					

L75 = 75% of all elevation measurements within a sector are above operational or rehab level minus X m.

L90 = 90% of all elevation measurements within a sector are above operational or rehab level minus X m.

L98 = 98% of all elevation measurements within a sector are above operational or rehab level minus X m.

X = metres variance for each of L75, L90 and L98 as stated above.

Repeated breaches of floor elevation TARP might mean that the elevation control needs to be strengthened via:

- Improvement to GPS tracking system/base station.
- More frequent independent surveying and pegging of the working floor.
- “Stabilisation” of the floor (DPE, 2016).
- An increase in the specified MEL to allow a factor-of-safety, e.g. by 0.2 m to 0.9 m above maximum predicted groundwater level, in agreement with DPE and other stakeholders.

To date, extraction management using both GPS equipped excavator, hand held GPS spot checks and routine surveying has been shown by annual surveys by a registered surveyor to be achieving the correct extraction floor and final land form.

3.4.2 Changes in Groundwater Levels

Groundwater level monitoring will be carried out, for the following core reasons:

- Early warning, to ensure quarrying does not inadvertently occur within groundwater, risking contamination.
- Early warning, to ensure quarrying does not create a ponded landform.
- To ensure the prediction of maximum groundwater levels from historical data remain robust.

- To provide awareness where predicted groundwater levels may warrant greater focus on matching the correct vegetation structure with groundwater levels if predictions are not accurate.

Groundwater monitoring will be conducted at the sites identified in Table 4, with actions based on Table 6.

Table 6 provides for the evaluation of groundwater levels relative to the predicted minimum extraction level. Importantly it should be noted that increasing groundwater levels alone does not represent a failure or breach of the consent or the TARP, but a mechanism to evaluate if the maximum predicted groundwater level is adequate in maintaining sufficient depth of cover above the groundwater table.

Table 7: Groundwater Level Monitoring TARP rules

Level	Trigger	Action and Response	Report to
0	Groundwater levels more than 0.5 m below inferred maximum level at **HBH2.** (Table 4).	Standard operations – monthly dipping of operational on-site monitoring bores.	n/a
1	Groundwater levels within 0.5 m below inferred maximum level (Table 4) at any on-site bore.	Weekly (or more frequent) monitoring (dipping) of groundwater levels at the six (6) nearest bores (e.g. 3 upgradient and 3 down gradient) to the current extraction area until water level declines to below Level 1 trigger.	Internal and environmental consultant. Include note in Annual Report.
2	Groundwater levels within 0.25 m of inferred maximum historical level (Table 3-1) at any on-site bore.	Weekly (or more frequent) monitoring (dipping) of groundwater levels at the six (6) nearest bores (e.g. 3 upgradient and 3 down gradient) to the current extraction area until water level declines to below Level 1 trigger. Review of MEL in context of recent climate. WSS to issue letter.	Weekly (or more frequent) monitoring (dipping) of groundwater levels. Re-analysis and review of MEL. WSS to issue letter to DPE documenting groundwater level and rainfall trends, and review and recommendations regarding of MEL.
3	Groundwater levels within resource area rise above previously inferred maximum groundwater level (Table 4). I.e. Groundwater levels are within 0.7m of the extraction floor.	Discontinuation of sand extraction in the areas of groundwater mound for the period of the mound limited to MEL grid panels (25m) directly influence by the mound. Analysis of recent data by hydrogeologist, including site data and data from local HWC wells and local Defence wells (if available). Revision of MEL if justified. Remediation of earlier excavations to revised MEL if justified OR adjustment of planting schedule to include more woodland species suitable at lower elevations.	WSS to issue letter to DPHI, DCCEEW and HWC, documenting groundwater level trends, and revision (if necessary) of MEL. Letter to evaluate of risks in retaining existing MEL in rehabilitated areas, with consideration to disturbance caused by adjustment of floor level (e.g. access, vegetation condition, soil handling) against risks of a higher groundwater than expected.

3.4.1 Justification of TARP

It should be noted the key reasons and justification for monitoring the groundwater levels and maintaining a 0.7m extraction floor and 1m rehabilitation level are:

- That the final landform and associated vegetation community is comparable to the original community in structure, i.e. woodland is not replaced by wetland or heath. In this regard occasional fluctuations in groundwater levels that may exceed the maximum predicted groundwater level, are short term transient events and are unlikely to have a significant effect on vegetation community structure providing water levels do not remain elevated. In areas where groundwater elevations are determined to be potentially above predictions, revegetation efforts should consider active establishment of canopy species from vegetation communities onsite that are well suited to higher groundwater levels, so as to maintain this commitment. Vegetation that would be suitable includes:
  - Swamp Mahogany - Paperbark Swamp Forest (dominated by *Eucalyptus robusta* (Swamp Mahogany) and *Melaleuca quinquenervia* (Broad-leaved Paperbark); OR
  - Tomago Sand Swamp Woodland (dominated by *Eucalyptus parramattensis* subsp. *decadens,* with *Eucalyptus signata* (Scribbly Gum) and *Eucalyptus piperita* (Sydney Peppermint)
- The maximum predicted groundwater level provides a safety mechanism not found with past sand mining activities in the sand beds. Past sand mining activities typically relied on regular monitoring in advance of extraction, where extraction was permitted to occur at any level providing it was not within groundwater, this resulted in over extraction in dry periods and ponding in the final landform. With the established monitoring and predictive monitoring this is not able to occur at this quarry.
- That operations do not occur within the groundwater table where there may be increased risk of contamination of the groundwater when it is elevated.
- Extraction does not occur within zones of sand where sulphide minerals have the potential to oxidise and become mobilised in the groundwater. In this regard, sands intercepted by isolated peaks of groundwater in response to rainfall are unlikely to have sulphidic minerals subject to oxidation. Those sands that are typically are of the highest risk, is more aligned with the average or low-level groundwater table that are less frequently oxidised. It is estimated that the MEL is 2-4m above these low levels.

4. RECOMMENDATIONS

Generally, there is reasonable correlation between observed and computed water levels. There is no systematic over or under reporting of simulated results. It is noteworthy that the extreme high-water levels within BH2 and BH11 due to very high rainfall in 2021 and 2025 has not been simulated by the model. It should also be noted that the range of variability has been simulated generally. BH11 is outside the excavation area and to the north of the northern resource area. The northern resource area is now complete, excepting a narrow finger to the east adjacent to MW239S (with very good model alignment), and excavation is now focused in the southern resource area. However, overall, the verification period shows the model performs adequately.

The proposed extension area has levels from recently installed monitoring bores which shows that groundwater levels correlate to modelled results, excepting those wells influenced by the onsite anthropogenic sources.

4.1 Monitoring

Monitoring of groundwater levels to continue at monthly intervals at all the sites in Table 4. Data loggers have been installed in a number of monitoring bores which includes:

- BH2.
- BH4.
- MW239S.
- BH9A.
- HBH2 (to be installed)
- HBH5 (to be installed)

Periodic dipping at regular interval (data logger downloads) should be undertaken to confirm logger accuracy. Monitoring to occur in line with the other groundwater monitoring detailed in the approved Soil and Water Management Plan.

4.2 Elevated Groundwater Level at HBH3

Monitoring of HBH3 shows groundwater levels are unusually elevated and do not conform to expected and measured gradients within the originally approved extraction area.

Extraction depth will be limited in this area to 0.7m above the measured groundwater level in HBH3 / HBH8 / HBH9 to avoid interaction with the water table.

Once HBH3 / HBH8 / HBH9 levels become consistent with expected groundwater gradients (i.e. a relatively gradual grade between HBH2 and HBH6), the extraction floor will be as per the established MEL.

4.3 Modelling

This review of the groundwater model provides updates to include additional stress periods and rainfall data to late 2025. With an estimated completion by late 2027 no further model review is considered warranted, but rather a focus on monitoring and alignment of adopted vegetation communities for rehabilitation should remain the focus.

4.4 Post Excavation Monitoring

Given a fundamental objective of the MEL relates to leaving a final landform with that can support a woodland vegetation community rather than a heath, it is recommended that Post Excavation Monitoring be focused on the establishment of the preferred vegetation community structure. Where MEL review suggests that groundwater levels have been higher for short periods, rehabilitation monitoring should consider health and structure of canopy species to validate the objectives. Given vegetation surrounding the quarry at similar elevations to the finished floor level supports woodland communities, achieving woodland structure in the event of minor changes in maximum ground water levels should be readily achievable.