Klohn Crippen Berger

Oaky Creek Coal

Final Underground Water Impact Report

DX70027A01

February 2023

EXECUTIVE SUMMARY

KCB Australia Pty Ltd (KCB) has been commissioned by Oaky Creek Holdings Pty Ltd to prepare a Final Underground Water Impact (UWIR) Report for the Oaky Creek Coal (OCC) Mine. OCC's 'Surrender Applications' for petroleum leases (PL237 and PL324) were approved by the Department of Environment and Science (DES) on 11 November 2022, and therefore a final UWIR report is required.

OCC undertook groundwater extraction as part of gas drainage activities on PL324 and PL237 prior to November 2022. The purpose of the water extraction was a mine safety requirement to remove gas from the underlying formation prior to the commencement of underground mining activities. Historical underground water extraction associated with gas drainage ranged between 75 and 131 ML/year. These volumes were between 2% and 4% of the annual volumes extracted as associated water take authorised under the *Mineral Resources Act 1989* (State of Queensland 2021b). Encountered gas from the future mining areas will be flared out to facilitate safe mining.

The hydrogeological environment at the Project includes three key hydrostratigraphic units: Quaternary alluvium, Tertiary sediments and Permian coal measures, which includes the target coal seams for gas extraction and subsequent underground mining. Groundwater monitoring records indicate limited hydraulic connection between the shallow hydrostratigraphic units (Quaternary alluvium, Tertiary sediments) and the deeper hydrostratigraphic units (Permian coal measures), where gas is extracted, and that the interbedded and hydrogeologically tight units associated with the Permian coal measures, overlying the target coal seams, act as aquitards and limit the propagation of drawdown through the sequence.

A numerical groundwater model was updated to simulate drawdown impacts associated with Long Term Affected Areas (LTAA) at the time that OCC surrendered the PLs. The established hydrogeological conceptual model, groundwater monitoring data, and numerical model predictions, indicate that drawdown of greater than the *Water Act 2000* trigger threshold values is unlikely to occur in the uppermost hydrostratigraphic units. LTAA maps have been prepared for the deeper hydrostratigraphic units and indicate that drawdown is predicted to occur greater than the trigger threshold, however the drawdown is constrained to the OCC PL footprint. No third-party water supply bores are present within the LTAA. Impacts to groundwater users, resources and environmental values are not anticipated.

OCC will continue groundwater monitoring activities across the OCCMC as part of ongoing mine monitoring requirements.

Assessment of the impact associated with OCC's pervious gas and water extraction activities at PL237 and PL324 has not identified a requirement for make good obligations. No outstanding matters as outlined in this report or in previous strategies have been identified.

TABLE OF CONTENTS

TABLE OF CONTENTS
(continued)

List of Tables

List of Figures

TABLE OF CONTENTS
(continued)

List of Appendices

TABLE OF CONTENTS

Table of Abbreviations

BOM	Bureau of Meteorology
CMA	Cumulative Management Area
CRD	Cumulative rainfall departure
DES	Department of Environment and Science
EA	Environmental Authority
ERA	Environmentally relevant activity
EV	Environmental Value
GCWS	German Creek working section
GDE	Groundwater Dependent Ecosystem
GWDB	Groundwater database
IAA	Immediately Affected Area
LTAA	Long-Term Affected Area
OCC	Oaky Creek Coal
OCCMC	Oaky Creek Coal Mining Complex
PL	Petroleum lease
UWIR	Underground Water Impact Report
WQO	Water quality objective

1 INTRODUCTION

KCB Australia Pty Ltd (KCB) has been commissioned by Oaky Creek Holdings Pty Ltd to prepare a Final Underground Water Impact (UWIR) Report for the Oaky Creek Coal (OCC) Mine. OCC's 'Surrender Applications' for petroleum leases (PL237 and PL324) were approved by the Department of Environment and Science (DES) on 11 November 2022, and therefore a final UWIR report is required.

1.1 Background

The OCC mining complex (OCCMC) is located in central Queensland between the towns of Tieri and Middlemount, approximately 100 km northeast of Emerald (Figure 1.1).

Operations at OCC are conducted in accordance with Environmental Authority (EA) EPML00942413, under the Queensland *Environmental Protection Act 1994* (State of Queensland 2022). Surface mining commenced at the OCCMC in 1982 and ended in 2006. Underground operations started in 1989. Underground mining operations are conducted by longwall extraction methods. Figure 1.2 presents the layout of OCC operations.

OCC maintains several mining leases for coal extraction purposes (ML1832, ML2004, ML70241, ML70327, ML70424). OCC also maintained two petroleum leases (PL)237 and PL324 under EA EPML00942413, held for the extraction of gas until November 2022. The extent of PL237 and PL324 are shown on Figure 1.1 and Figure 1.2.

To ensure a safe underground mining environment, gas was removed from the target coal seams via OCCs gas drainage methods. The removal of gas prior to, during and after longwall mining was a mine safety requirement. As a result of the gas extraction, groundwater was also removed. However, OCC has decided to stop selling the gas and therefore have applied to surrender these leases. If gas is encountered in the future, it will be flared out to facilitate safe mining.

Under Chapter 3 of the Queensland *Water Act 2000* (State of Queensland 2021a), petroleum tenure holders[1] are responsible for preparing an Underground Water Impact Report (UWIR) unless the PL(s) are within a declared Cumulative Management Area (CMA). OCCs PLs were not located within a CMA.

The original UWIR for PL237 and PL324 was prepared in December 2012, which came into effect on 27 February 2013. The 2012 UWIR was revised in 2015 (BlueSphere 2015) based on a more detailed assessment and interpretation of geological and hydrogeological data. It superseded the original UWIR prepared by Xstrata Coal in December 2012. An updated UWIR was prepared for submission to the Queensland Government, Department of Environment and Science (DES) to replace the 2015 UWIR (KCB 2020). The UWIR was submitted to DES in December 2020.

OCC received a decision notice in October 2021 with a direction to modify the UWIR. An updated UWIR report was produced in June 2022 (KCB 2022). OCC surrendered their petroleum leases (PL237 and PL324) in November 2022, and therefore a final UWIR report is now required (this document).

[1] Note that mining activities do not form part of this UWIR as mining activities at OCC commenced prior to December 2016

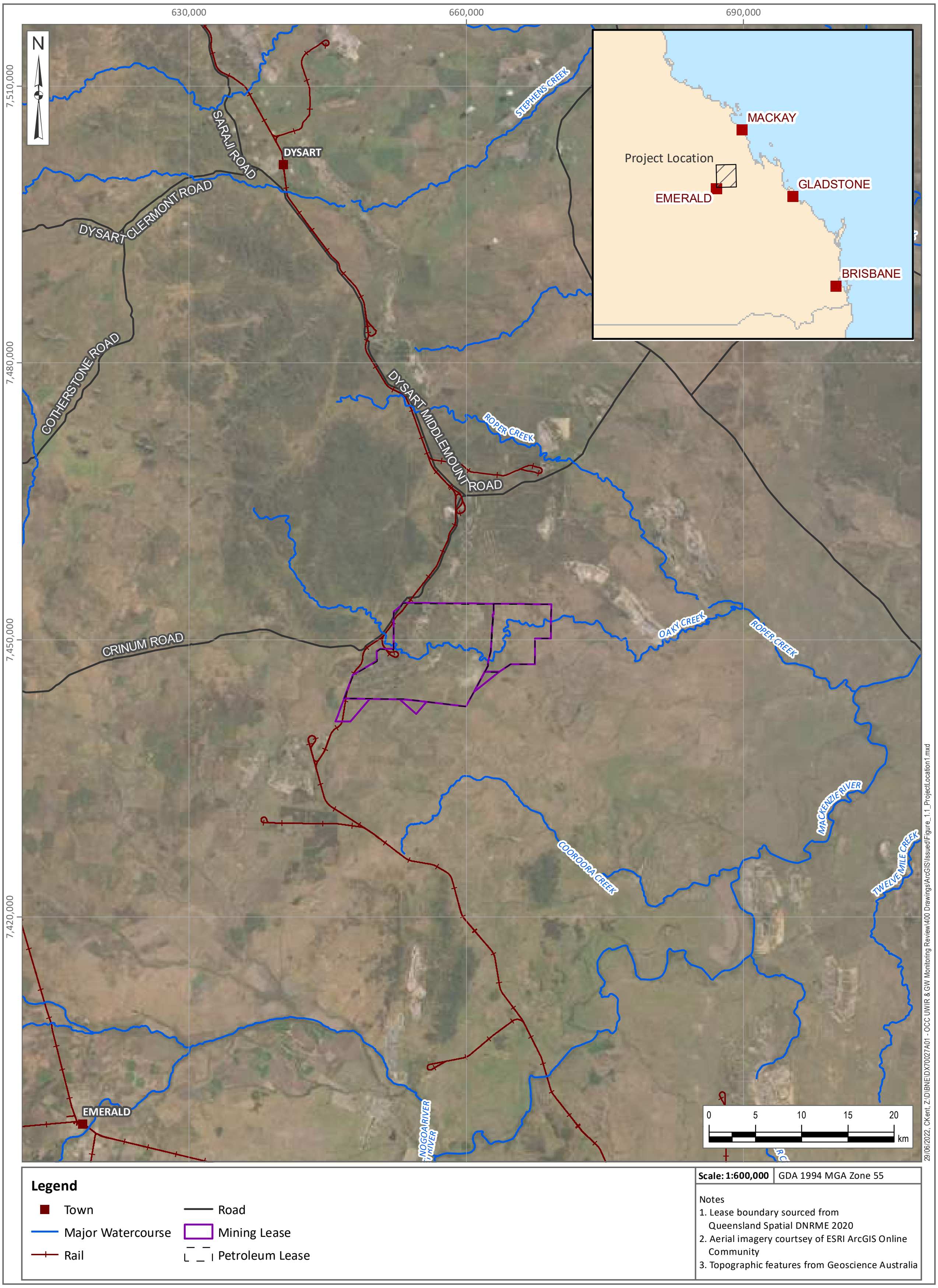

Figure 1.1 Location of the OCCMC and PL237 / PL324

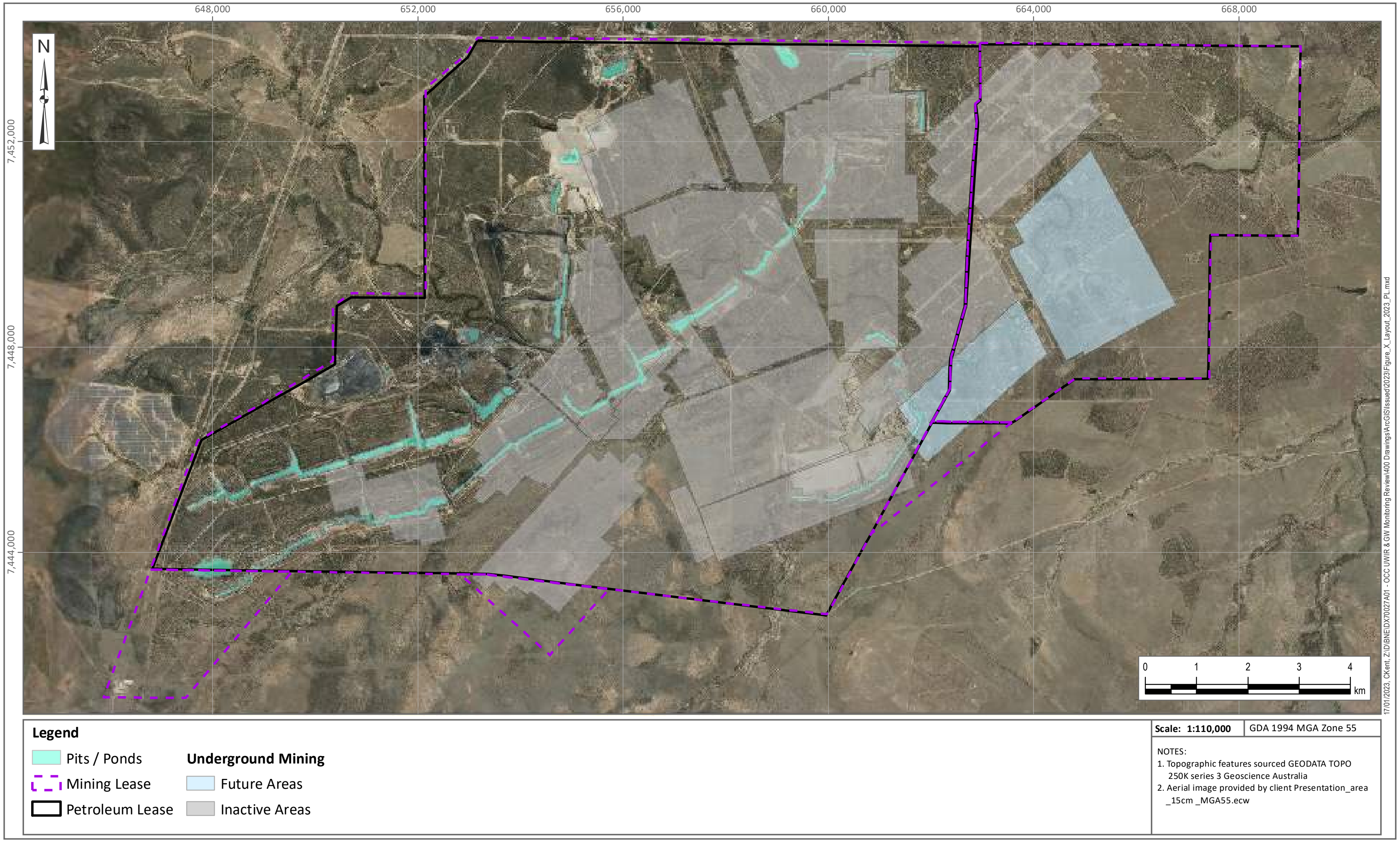

Figure 1.2 Layout of the OCCMC

1.2 Report Structure

This report has been prepared with consideration of the requirements outlined in the *Water Act 2000* guideline 'Underground water impact reports and final reports' (DES 2018a). This report is structured as follows:

Section 1: Introduction

Section 2: Regulatory Framework

Section 3: Assessment Methodology

Section 4: Underground Water Extraction

Section 5: Physical Setting

Section 6: Groundwater Regime

Section 7: Groundwater Impact Assessment

Section 8: Make Good Obligations

Section 9 and 10: Summary and Closing

Further detail of the report content in relation to the *Water Act 2000* requirements are included in Section 3

2 REGULATORY FRAMEWORK

This section describes the relevant regulations and requirements relevant to this final report.

2.1 Petroleum and Gas (Production and Safety) Act 2004

The *Petroleum and Gas (Production and Safety) Act 2004* (State of Queensland 2020a) is an *Act* relevant to exploring for, recovering and transporting by pipeline, petroleum and fuel gas, and ensuring the safe and efficient undertaking of those activities. The key purpose of this *Act* is to facilitate and regulate the undertaking of responsible petroleum activities and the development of a safe, efficient and viable petroleum and fuel gas industry.

This *Act* identifies underground water rights for petroleum tenures, and states that the holder of a petroleum tenure may take or interfere with underground water in the area of the tenure if the taking or interference happens during the course of, or results from, the carrying out of another authorised activity for the tenure. There is no limit to the volume of water that may be taken under the underground water rights and the tenure holder may use associated water for any purpose within, or outside, the area of the tenure.

2.2 Mineral Resources Act 1989

Underground and open cut mining activities are authorised under the *Mineral Resources Act 1989,* (State of Queensland 2021b)*,* which states that the holder of a mining lease may take or interfere with underground water in the area of the lease if the taking or interference happens during the course of, or results from, the carrying out of an authorised activity for the lease. Underground water taken or interfered with in this way is termed 'associated water'.

Mining activities at the OCCMC commenced prior to December 6, 2016, and therefore a UWIR is not required for the activities, including extraction of underground water, associated with mining under the *Mineral Resources Act 1989*.

2.3 Water Act 2000

General Purpose

The *Water Act 2000* (State of Queensland 2021a) is an *Act* to provide for the sustainable management of water and the management of impacts on underground water, among other purposes. This *Act* provides a framework for:

- The sustainable management of Queensland's water resources by establishing a system for the planning, allocation, and use of water;
- The sustainable and secure water supply and demand management for designated regions;
- The management of impacts on underground water caused by the exercise of underground water rights by the resource sector; and
- The effective operation of water authorities.

This *Act* covers water in a watercourse, lake or spring, underground water (or groundwater), overland flow water, or water that has been collected in a dam.

Water Act and Petroleum & Gas Activities

The *Water Act 2000* provides for the management of the impacts on underground water caused by the exercise of underground water rights by petroleum tenure holders, which are regulated under the *Petroleum and Gas (Production and Safety) Act 2004.* The *Act* also outlines the requirements for make good agreements, associated with the impacts to underground water.

Chapter 3 of the *Water Act 2000* has a stated purpose to provide for the management of impacts on underground water caused by the exercise of underground water rights by petroleum tenure holders. To achieve the stated purpose, a regulatory framework is provided, which requires:

- Tenure holders monitor and assess the impacts of the exercise of underground water rights on water bores and to enter into make good agreements with the owners of the groundwater bores as necessary;
- The preparation of UWIRs that establish underground water obligations, including obligations to monitor and manage impacts on aquifers and springs;
- Managing the cumulative impacts of the activities of two or more resource tenure holders' underground water rights on underground water; and
- Preparation of UWIR final reports including a summary of all relevant water bores, make good obligations and associated compliance requirements.

Trigger Thresholds

Under Section 362 of the *Water Act 2000*, a bore trigger threshold, for a consolidated aquifer, of 5 m applies (2 m for an unconsolidated aquifer). The 5 m threshold represents the maximum allowable groundwater level decline in a groundwater bore, due to petroleum tenure holders' activities, prior to triggering an investigation into the water level decline.

Under Section 379 of the *Water Act 2000,* a spring trigger threshold for an aquifer applies. This includes vent springs / complexes and watercourse springs (i.e. gaining streams). This threshold value (0.2 m) represents the maximum allowable decline in the water level of an aquifer in connection with a spring, at the spring location, prior to triggering an investigation into the water level decline.

2.3.1 UWIR and Final Report Requirements

As the OCCMC is not part of a CMA, a UWIR was required to be prepared under the *Water Act 2000* for the underground water extraction associated with petroleum activities in the past. Requirements of a UWIR are included in the *Water Act 2000* Section 376 and outlined in Table 2.1.

Section 377 of the *Water Act 2000* details the requirements of the final report, and states that the final report must include information from the UWIR with the exception of the following items:

- an estimate of the quantity of water to be produced in the next three years;
- a map showing the area of the aquifer where the water is predicted to decline by more than the trigger threshold in the next three years (IAA);

- a summary about underground water bores in the IAA;
- a program for conducting annual reviews of the accuracy of maps produced and giving the chief executive a summary of the outcome of each review; and
- a list of the proposed responsible tenure holders (if the responsible entity is the OGIA).

Additional requirements of a final report are outlined in Table 2.2.

A reference to the relevant section(s) of this report indicating where the requirements have been addressed is included in Table 2.1 and Table 2.2.

Table 2.1 UWIR Requirements

Water Act Section No.	Requirement	Section Addressed
376(1)(a)	An underground water impact report must include each of the following — for the area to which the report relates: (i) the quantity of water produced or taken from the area because of the exercise of any previous relevant underground water rights; and (ii) an estimate of the quantity of water to be produced or taken because of the exercise of the relevant underground water rights for a 3-year period starting on the consultation day for the report.	(i) Section 4 (ii) Not required for Final Report
376(1)(b)	For each aquifer affected, or likely to be affected, by the exercise of the relevant underground water rights: (i) a description of the aquifer; (ii) an analysis of the movement of underground water to and from the aquifer, including how the aquifer interacts with other aquifers; and (iii) an analysis of the trends in water level change for the aquifer because of the exercise of the rights mentioned in paragraph (a)(i); (iv) a map showing the area of the aquifer where the water level is predicted to decline, because of the taking of the quantities of water mentioned in paragraph (a), by more than the bore trigger threshold within 3 years after the consultation day for the report; and, (v) a map showing the area of the aquifer where the water level is predicted to decline, because of the exercise of relevant underground water rights, by more than the bore trigger threshold at any time.	Section 6 and 7 (iv) Not required for Final Report
376(1)(c)	A description of the methods and techniques used to obtain the information and predictions under paragraph (b).	Section 3
376(1)(d)	A summary of information about all water bores in the area shown on a map mentioned in paragraph (b)(iv), including the number of bores, and the location and authorised use or purpose of each bore.	(b)(iv) Not required for Final Report
376(1)(da)	A description of the impacts on environmental values that have occurred, or are likely to occur, because of any previous exercise of underground water rights.	Section 7, 8
376(1)(db)	An assessment of the likely impacts on environmental values that will occur, or are likely to occur, because of the exercise of underground water rights: i. during the period mentioned in paragraph (a)(ii); and, ii. over the projected life of the resource tenure.	Section 7, 8
376(1)(e)	A program for: i. conducting an annual review of the accuracy of each map prepared under paragraph (b)(iv) and (v); and, ii. giving the chief executive a summary of the outcome of each review, including a statement of whether there has been a material change in the information or predictions used to prepare the maps.	Not required for Final Report
376(1)(f)	A water monitoring strategy.	Section 8
376(1)(g)	A spring impact management strategy.	Section 8
376(1)(h)	If the responsible entity is the office: i. a proposed responsible tenure holder for each report obligation mentioned in the report; and, ii. for each immediately affected area—the proposed responsible tenure holder or holders who must comply with any make good obligations for water bores within the immediately affected area.	NA
376(1)(i)	The information or matters prescribed under a regulation.	NA
376(2)	However, if the underground water impact report does not show any predicted water level decline in any area of an affected aquifer by more than the bore trigger threshold during the period mentioned in subsection (1)(b)(iv) or at any time as mentioned in subsection (1)(b)(v), the report does not have to include the program mentioned in subsection (1)(e).	NA

Table 2.2 Final Report Requirements

Water Act Section No.	Requirement	
377 (2a)	A summary about underground water bores in the LTAA (including the number of bores and the location and authorised use or purpose of each bore)	Sections 6.3, 7.1 and 7.2.2
377 (2b)	A summary about how the make good obligations of the responsible tenure holder for each water bore to which the final report relates have been complied with by the holder over the term of the tenure	Section 8.2
377 (2c,d)	A summary of the make good obligation of the responsible tenure holder for each water bore that have not yet been complied with by the holder and a plan about how these obligations will be complied with	Section 8.2
377 (2d)	Statements about any matters outlined in previous strategies that have not yet been complied with, along with a timetable of planned actions to address these outstanding matters	Section 8.2

2.4 Environmental Protection Act 1994

The *Environmental Protection Act 1994* (State of Queensland 2022) is an Act with the objective to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ecologically sustainable development).

This *Act* states that 'to carry out an environmentally relevant activity (ERA) an EA is required'. A resource activity, specifically a petroleum activity, is defined as an ERA.

2.4.1 EA EPML00942413

Petroleum activities on PL237 and PL324 were authorised under the OCC EA Schedule I.

The EA also provide conditions related to groundwater monitoring (C59 to C65).

2.4.2 Environmental Values

The *Environmental Protection Act 1994* also defines an Environmental Value (EV) as:

- A quality or physical characteristic of the environment that is conducive to ecological health or public amenity or safety; or
- Another quality of the environment identified and declared to be an EV under an Environmental Protection policy or regulation.

Under the *Environmental Protection Act 1994,* the *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (State of Queensland 2020b) is established as subordinate legislation to achieve the object of the *Act* in relation to Queensland Waters. The purpose of the policy is achieved by:

- Identifying environmental values for waters and wetlands to be enhanced or protected;
- Identifying management goals for waters;
- Stating water quality guidelines and water quality objectives for enhancing or protecting the environmental values of waters;
- Providing a framework for making consistent, equitable and informed decisions about waters; and
- Monitoring and reporting on the condition of waters.

The OCCMC is located within the Mackenzie River Sub-Basin. EVs and water quality objectives (WQOs) have been defined for the Sub-basin under the E*nvironmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP)* (State of Queensland 2011; 2020b).

Groundwater and surface water EVs for the Mackenzie River Sub-Basin are presented in Table 2.3. The EPP provides WQOs to support and protect the various EVs identified for waters within the Mackenzie River catchment. The WQOs for the Mackenzie River Sub-Basin groundwaters are provided in the Mackenzie River Sub-basin Environmental Values and Water Quality Objectives according to their chemistry zone and depth category. Groundwater within the vicinity of the OCCMC is classified as 'shallow' (<30 m) and deep (>30 m) under chemistry zone 34, a saline (Na-Cl) type water.

Table 2.3 Groundwater and Surface Water Environmental Values for the Mackenzie River Sub-Basin (State of Queensland 2011)

Water	Aquatic Ecosystem	Irrigation	Farm Supply / Use	Stock Water	Aquaculture	Human Consumer	Primary Recreation	Secondary Recreation	Visual Recreation	Drinking Water	Industrial Use	Cultural And Spiritual
Mackenzie north-western tributaries – developed areas	✓			✓		✓	✓	✓	✓	✓	✓	✓
Mackenzie eastern tributaries – developed areas	✓			✓		✓	✓	✓	✓			✓
Mackenzie southern tributaries – developed areas	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓
Mackenzie main channel – developed areas	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fresh waters in undeveloped areas	✓			✓		✓	✓	✓	✓	✓		✓
Groundwater	✓	✓	✓	✓						✓	✓	✓

✓ denotes the EV is selected for protection. Blank indicates that the EV is not chosen for protection.

3 ASSESSMENT METHODOLOGY

This section describes the UWIR final report methodology, including the desktop study of relevant groundwater bores; geological and environmental information; and groundwater monitoring data.

3.1 Information and Data Sources

The following information and data sources were used in this assessment:

- The Queensland detailed geological mapping (DNRME 2018a), accessed on the Department of Natural Resources, Mines and Energy (DNRME) QSpatial website.
- The Queensland groundwater database (GWDB) (DNRME 2020). This database was searched to identify the presence of current and historical 'water bores' and groundwater monitoring bores. The database search area included the OCCMC and a surrounding radius of 5 km. The database search area was considered suitably representative of the geological and hydrogeological setting.
- The Queensland Groundwater Dependent Ecosystems (GDEs) mapping datasets (via QSpatial) were searched to identify if potential GDEs are present within the OCCMC and its surrounds.
- The Queensland spring database (via QSpatial) was also reviewed to identify if any registered springs are located in the vicinity of the OCCMC.
- OCCs previously approved UWIR (BlueSphere 2015), prepared in 2015, was reviewed as well as annual reports submitted to DES between 2016 and 2019 (SRK 2016; AGE 2017; 2018; 2019).
- OCCs groundwater monitoring data (Section 6.2), including 54 monitoring bores across the OCCMC, monitored for groundwater levels and chemistry.
- OCCs mine plans and water extraction datasets (Section 4).

3.2 Assessment Methodology

This assessment has been completed to assess potential impacts on the groundwater system from the underground water extraction at OCC for the final report period which is the proposed overall development (Long-Term Affected Areas (LTAA)).

All relevant data were collated and analysed to develop a conceptual understanding of the groundwater regime, including the key hydrostratigraphic units, groundwater flow and groundwater quality characteristics. This conceptualisation served as the basis for the development and simulation of the numerical groundwater model, which was used to undertake the prediction of potential impacts to the groundwater regime. Details of the numerical groundwater model are provided in the following section.

3.2.1 Numerical Groundwater Modelling

A 3D numerical groundwater flow model was developed to predict the extents of depressurisation and the associated impacts on the groundwater regime and the surrounding environment. The groundwater model was developed using the MODFLOW-USG platform. MODFLOW is considered to be an industry standard modelling platform. A detailed description of the groundwater model is provided in Appendix II.

The numerical groundwater model was constructed using a detailed geological model developed by OCC, which was further enhanced by inclusion of published lithological logs within the model extents. The model was calibrated to existing groundwater levels using reliable measurements from local and regional bores within the model domain.

Once calibrated, the model was used to predict the groundwater response to underground development, including changes in groundwater levels as a result of activities on OCCMC. The groundwater model allowed the impacts of the existing approved operations at the neighbouring Grasstree Mine to be distinguished from those at OCCMC.

The groundwater model has been used to specifically predict the magnitude and extent of groundwater depressurisation; with these predictions used to identify the LTAA for the final report. These predictions have also been used to assess the impacts on groundwater users and the sensitive environmental features.

4 UNDERGROUND WATER EXTRACTION

4.1 Underground Water Extraction at OCC

Underground water extraction, assessed as part of pervious UWIRs, was associated with coal seam degassing activities conducted prior to underground development and longwall mining, which is a mine safety requirement.

Gas was removed from the German Creek working section (GCWS), Aquilla and Corvus coal seams via OCCs gas drainage methods to ensure explosive atmospheres did not occur and therefore enabled safe underground mining conditions.

Water and gas were extracted for a period of six to nine months from the gas wells, after which the water volume reduced significantly and mostly gas was produced. This occurred for a period of one to three years prior to underground mining commencing.

The volume of water extracted as part of gas drainage activities has historically been measured using flow meters and / or via empirical estimation based on the operating pump capacity and hours of operation.

4.2 Previous Underground Water Extraction

Underground water extracted as part of previous gas drainage activities is presented in Figure 4.1 for the period January 2016 to September 2022. The figure presents the monthly total extraction and the cumulative total for the monitoring period. Historical monthly extraction until December 2022 ranged between 2.1 and 22.7 ML/month, with an average of 8.9 ML/month. A reduction in produced water volumes is observed between January and September 2022 where between 0 - 0.2 ML/month was extracted.

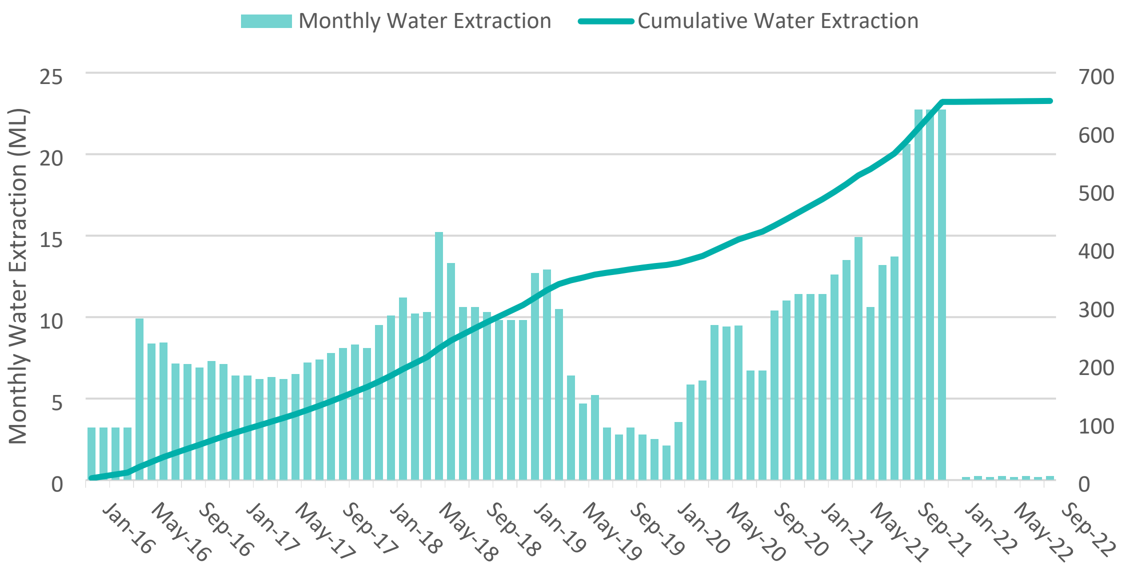

Figure 4.1 Monthly and Cumulative Underground Water Extraction (January 2016 to September 2022)

Annual total extraction from 2016 to 2022 (up to September) is provided in Table 4.1. In total, for the period presented, 650 ML of water was extracted as part gas drainage activities.

Table 4.1 Annual Extraction (2016 to 2022)

Year	Total Extraction (ML)
2016	75
2017	85
2018	131
2019	77
2020	92
2021	190
2022 (to September)	2
Total	650

For context, underground water extracted as part of previous gas activities was between 2 to 4% of the annual volumes extracted as associated water take authorised under the *Mineral Resources Act 1989* (State of Queensland 2021b).

Figure 4.2 presents the location of current and historical gas drainage wells, where underground water extraction has occurred as part of gas drainage activities.

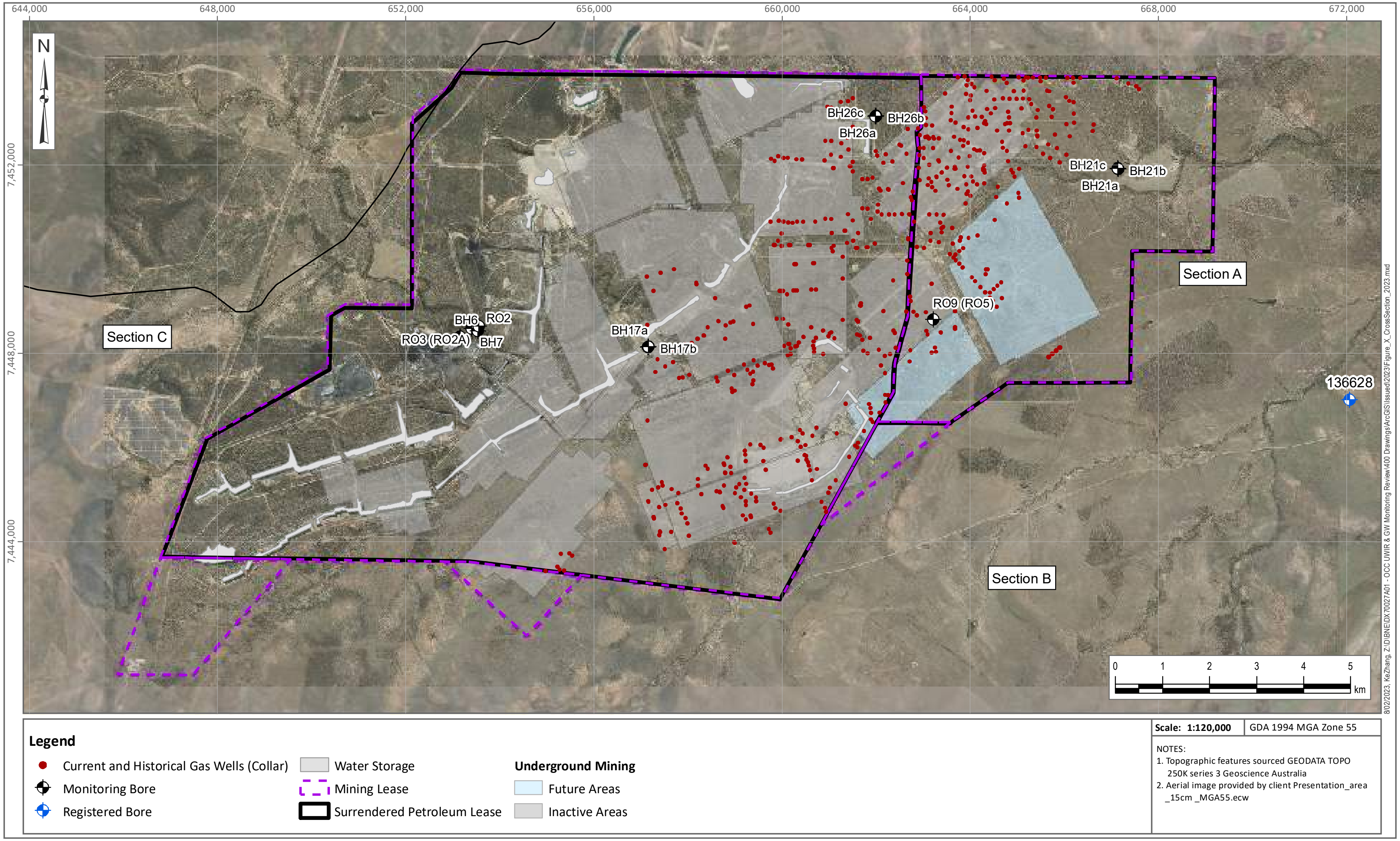

Figure 4.2 Location of Current and Historical Gas Drainage Wells

5 PHYSICAL SETTING

5.1 Climate

The climate of the area is classified as semi-arid and characterised by mild, relatively dry winters and hot summers with high rainfall, using the modified Köppen classification system (BOM 2005).

Climate statistics sourced from the Bureau of Meteorology (BOM) are presented in Table 5.1. Rainfall statistics for Booroondarra (35109), which is the closest monitoring station (25 km from OCCMC) are presented. Climate statistics for Emerald Airport (35264) are included as this is the closest station that monitors the full parameter set.

Mean maximum temperatures range between ~35°C in the summer months and ~23°C in the winter months. Mean minimum temperatures range between ~22°C in the summer months and ~9°C in the winter months. Daily evaporation rates are generally high and exceed rainfall throughout the year. The highest rainfall occurs during December to February, with the lowest rainfall occurring during April to October.

Table 5.1 Climate Statistics for Emerald Airport and Booroondarra, Site Numbers 35264 and 35109 (BOM 2022)

Site	Emerald Airport				Booroondarra
Statistic element	Mean minimum temperature	Mean maximum temperature	Mean daily evaporation (mm)	Mean rainfall (mm)	Mean rainfall (mm)
Period of record	1992 to 2022	1992 to 2022	1889 to 2022	1992 to 2022	1968 to 2022
January	22.3	34.7	7.1	80.4	109.8
February	22.1	33.9	6.8	84.8	102.9
March	20.5	32.9	6.7	58.9	73.1
April	17.1	30.0	4.9	29.0	34.4
May	13.2	26.4	3.3	22.4	34.5
June	10.3	23.4	2.9	29.7	27.9
July	9.1	23.4	2.7	18.6	27.1
August	10.1	25.5	3.8	20.4	19.7
September	13.6	29.1	4.6	26.3	16.3
October	17.2	31.9	5.7	47.8	42.6
November	19.5	33.4	7.0	55.9	57.0
December	21.5	34.5	7.3	80.0	91.9
Annual	**16.4**	**29.9**	**5.88**	**543.2**	**633.7**

Note: Emerald Airport statistics to November 2022, Booroondarra Statistics to November 2022 (Accessed December 13, 2022)

Figure 5.1 presents the daily rainfall and cumulative rainfall departure (CRD) for the rainfall station at Booroondarra for the period of January 1990 to September 2022. CRD trends are used to depict seasonality and long-term rainfall trends. They are based on actual rainfall comparison to long-term averaged conditions. CRD trends are useful for comparison against groundwater level hydrographs for groundwater systems, which show strong correlation to rainfall recharge.

For the period presented, the CRD highlights the wet-dry season cycle in the climate. Declining, below average rainfall conditions occurred up to the 2010/2011 wet season, where there was a strong response to the wet season event. Since 2017, the CRD indicates a declining overall trend up until 2020, after which an increase is observed into 2022.

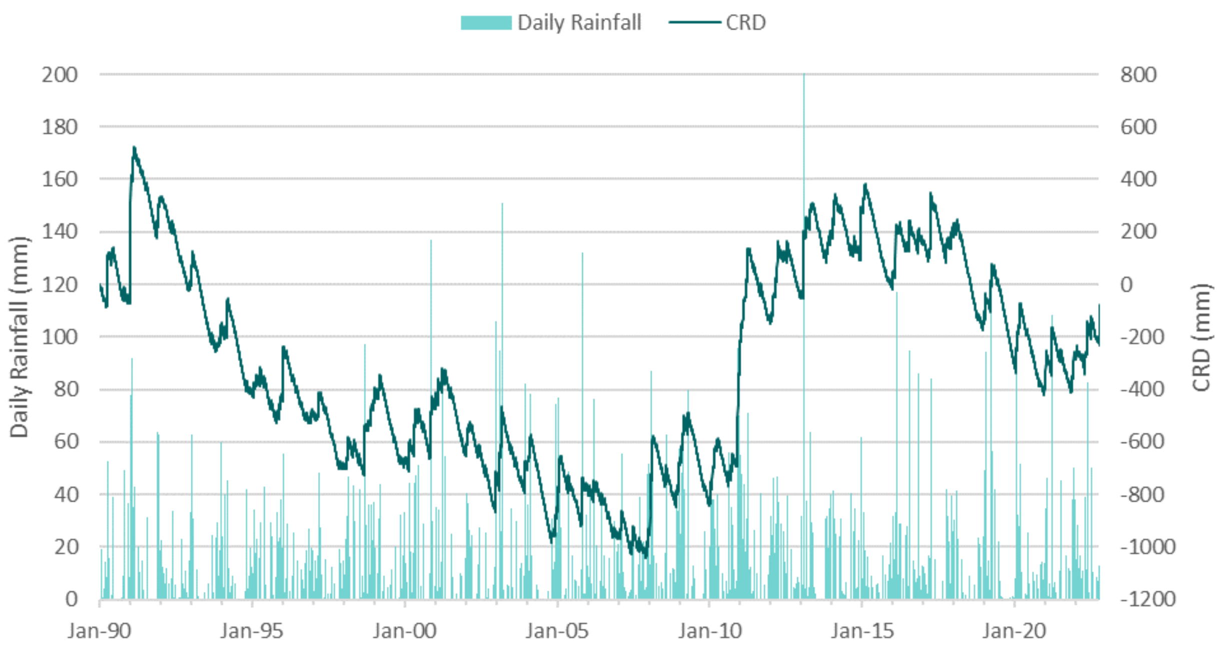

Figure 5.1 Daily Rainfall and CRD (Booroondarra), January 1, 1990 to September 30, 2022

5.2 Topography and Drainage

The OCCMC is located in the Mackenzie River catchment, a sub-basin of the upper Fitzroy Basin which covers an area of approximately 13,000 km^2. The Mackenzie River is located approximately 35 km east of the OCCMC.

The OCCMC is traversed by Oaky Creek, which drains from west to east. Tributaries of Oaky Creek include Cattle Creek, German Creek, Sandy Creek and Bul Bul Creek. These creeks are characteristically ephemeral, and typically only flow after significant rainfall events. Several creek diversions have also occurred through the OCCMC.

The topography across OCCMC ranges in elevation between ~220 mAHD[2] towards the west and 140 mAHD in the east, as presented in Figure 5.2.

[2] mAHD – metres Australian Height Datum

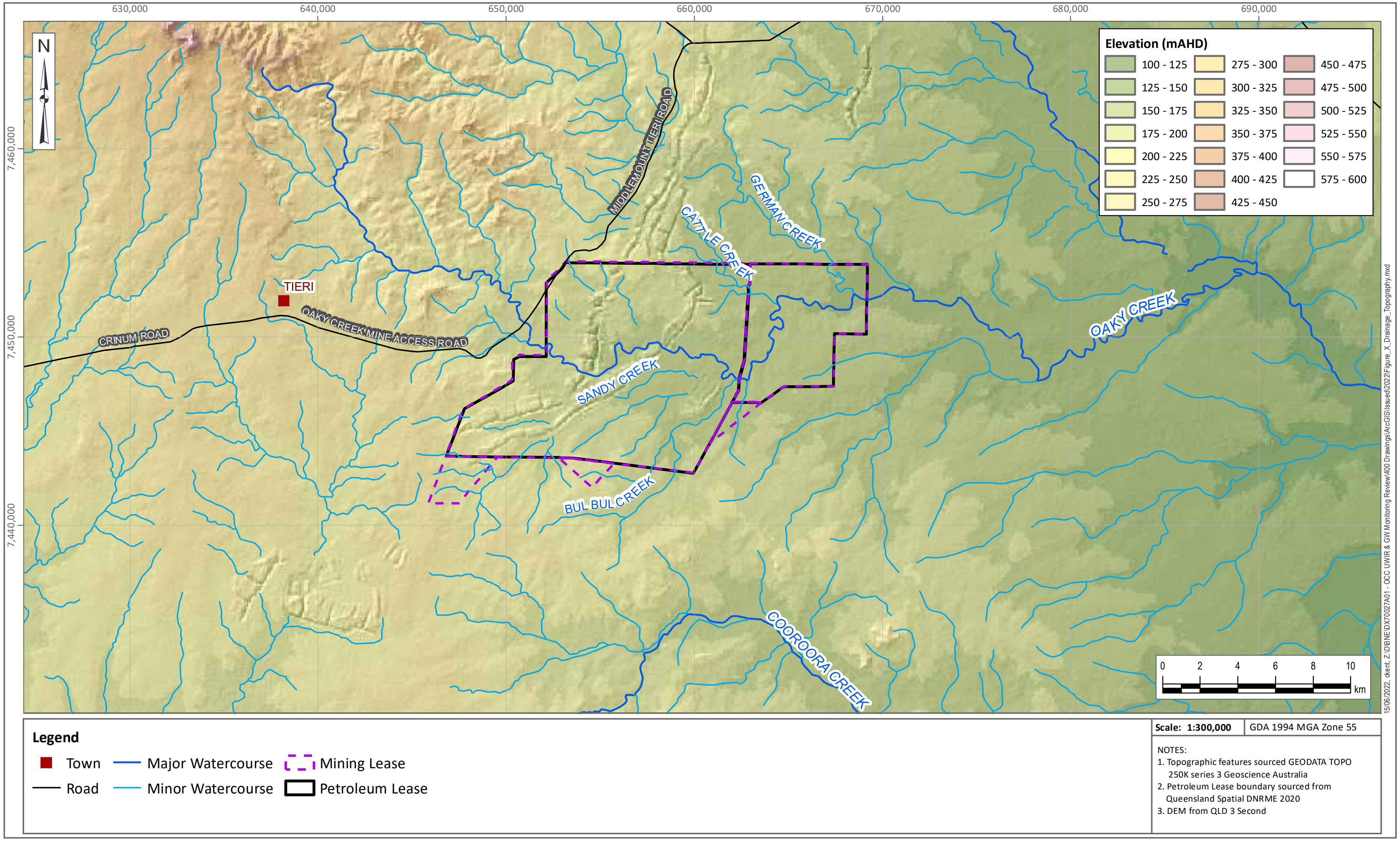

Figure 5.2 Topography and Drainage

5.3 Regional Geology

The regional geology of the OCCMC comprises sediments from the Early Permian to Middle Triassic age Bowen Basin. The Bowen Basin is an elongated, north to south trending basin extending over 160,000 km^2 from central Queensland, south beneath the Surat Basin, and into New South Wales, where it connects with the Gunnedah and Sydney basins (OGIA 2016). The Bowen Basin contains up to 10 km (thickness) of terrestrial and shallow-marine sediments (Green 1997; Korsch and Totterdell 2009).

The OCCMC is characterised by a relatively thin veneer of Quaternary alluvium, located in the vicinity of watercourses, and Tertiary sediments that unconformably overlie Permian sedimentary deposits (coal measures) that dip to the southeast. The surface and solid geology within the vicinity of OCCMC is presented in Figure 5.3 and Figure 5.4.

The Permian coal measures comprise a sedimentary sequence of coal seams and interbedded sediments including sandstones, siltstones and mudstones and minor carbonaceous mudstones and shales. The German Creek Formation is the primary coal bearing unit at the OCCMC. The German Creek Formation has been mined in two long lines of open cut pits that follow the strike of the German Creek coal seam and the Aquila coal seam. The German Creek Formation has also been the target of extensive underground operations (AGE 2016).

The lithology associated with the geological units at OCCMC is summarised in Table 5.2.

Table 5.2 Summary of Regionally Mapped Geology (DNRME 2018b)

Age	Unit		Map Code	Lithological Summary
Quaternary	Alluvium		Qa	Clay, silt, sand and gravel; flood-plain alluvium
Tertiary	Tertiary Sediments		Td	Duricrusted palaeosols at the top of deep weathering profiles, including ferricrete and silcrete; duricrusted old land surfaces
	Duaringa Formation		Tu	Mudstone, sandstone, conglomerate, siltstone, oil shale, lignite, basalt
Permian	Blackwater Group	Burngrove Formation	Pwg	Mudstone, siltstone, sandstone, coal, tuff
		Fair Hill Formation	Pwt	Lithic and feldspathic labile sandstone, quartzose sublabile sandstone, siltstone, mudstone, calcareous and tuffaceous sandstone, volcanic conglomerate, carbonaceous mudstone, coal
	Back Creek Group	Macmillan Formation	Pbn	Mudstone, siltstone, sandstone
		German Creek Formation	Pbd	Quartzose to sublabile, locally argillaceous sandstone, lithic and feldspathic sandstone, siltstone, mudstone, carbonaceous mudstone and coal
		Maria Formation	Pbi	Siltstone, mudstone, shale, feldspathic sublabile to labile sandstone, calcareous sandstone

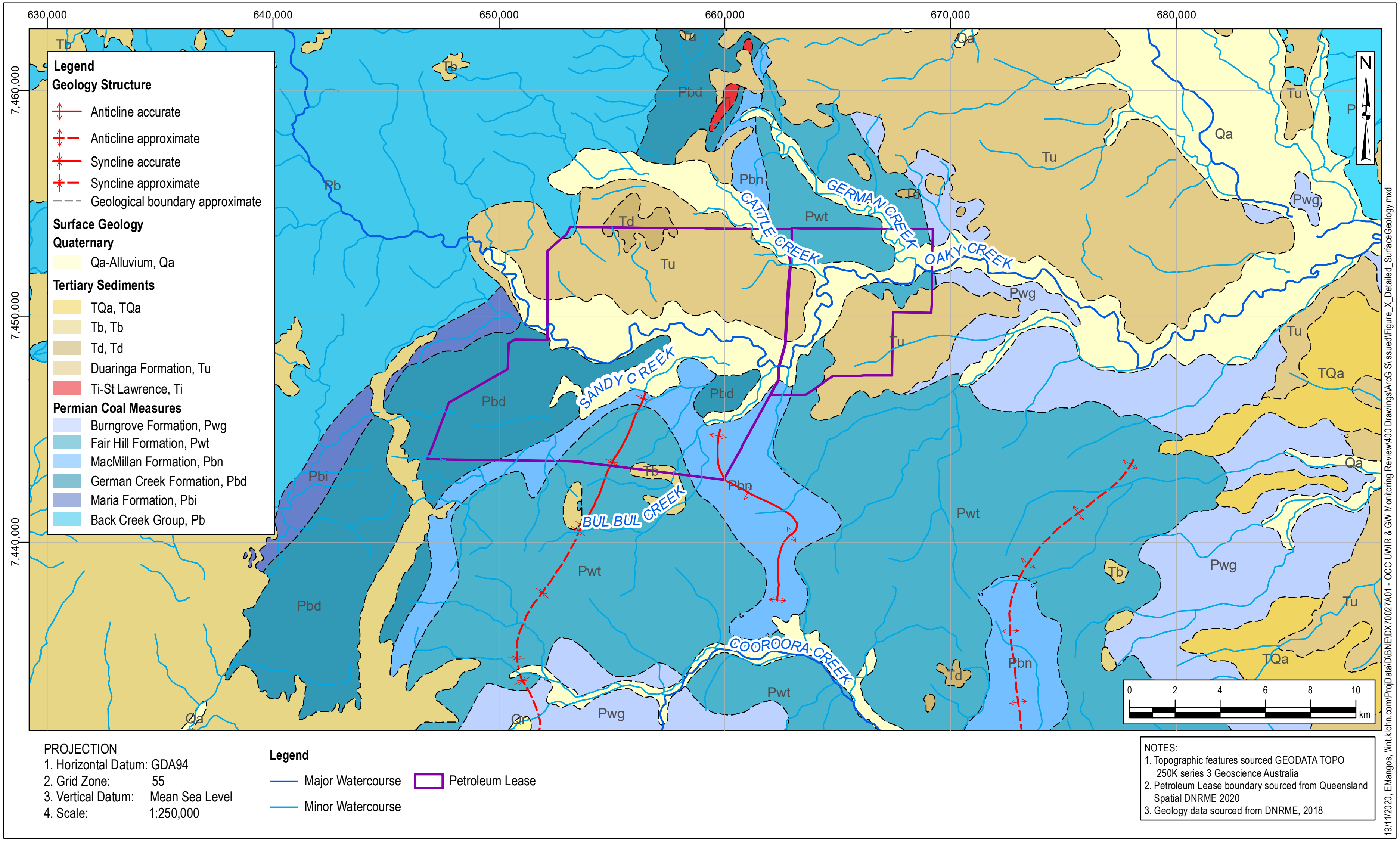

Figure 5.3 Surface Geology

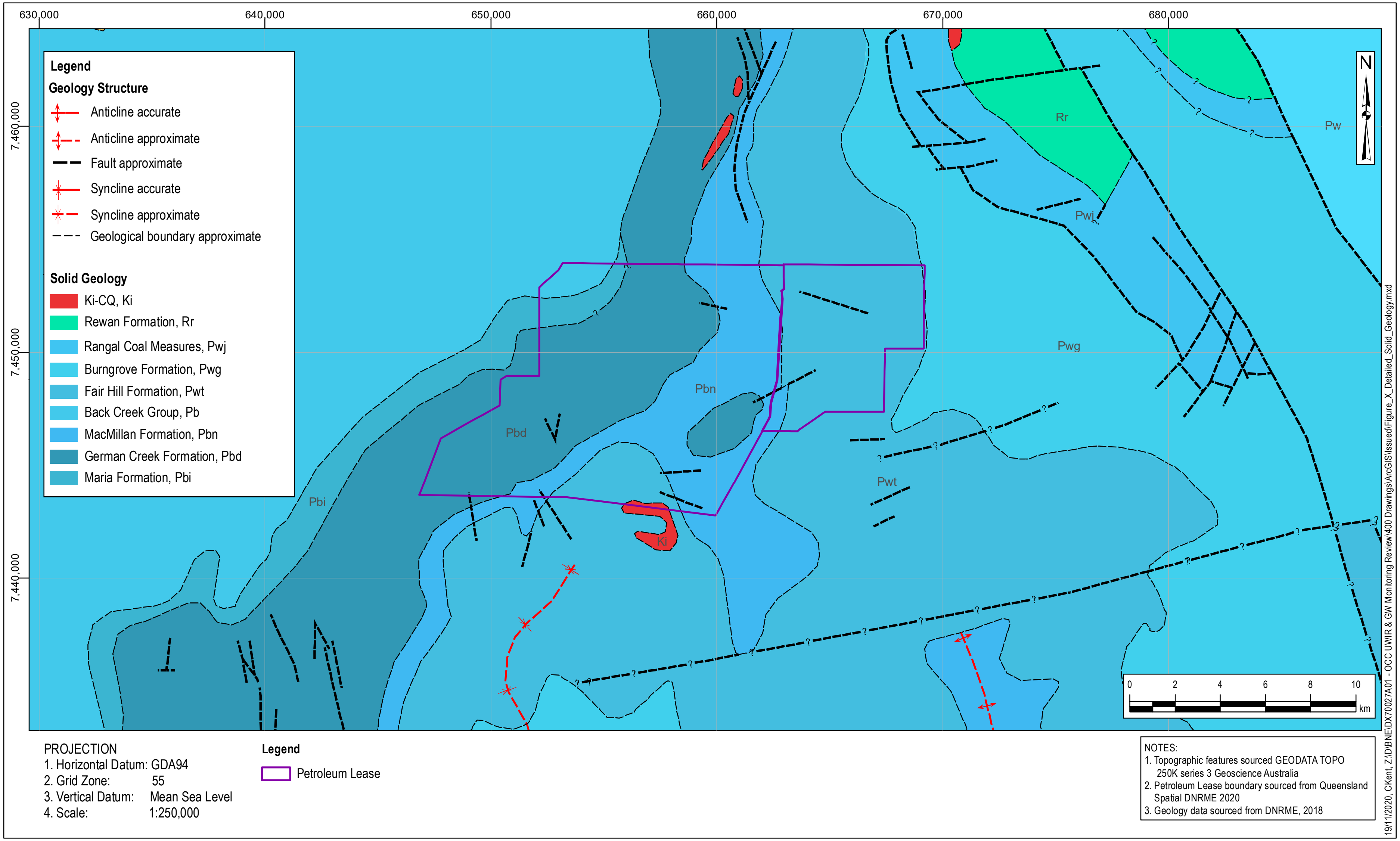

Figure 5.4 Solid Geology

5.3.1 Structural Features and Faults

The Permian sedimentary units dip to the east at approximately 5 to 10 degrees. The dipping nature of the sediments control the distribution of units in subcrop, whereby older units subcrop to the west, and younger units to the east.

Normal fault structures, commonly trending northeast to southwest, occur in the region. The faulting is occasionally associated with north to northwest trending folding. Measured displacement along mapped faults ranges from less than 5 m up to 25 m (AGE 2016).

Generally, the occurrence of dykes and sills within the area is limited. The Maywin North Dyke, ~1 m thick, is located in the south of OCC, which was exposed by mining in the historic German Creek and Aquila open cuts (AGE 2016).

6 GROUNDWATER REGIME

6.1 Hydrostratigraphic Units

6.1.1 Quaternary Alluvium

Quaternary-age alluvium is mapped as present through the OCCMC, as shown on Figure 5.3. The alluvium is described as a flood-plain alluvium and is associated with Oaky Creek, Sandy Creek and Bul Bul Creek. The alluvium typically comprises clay, silt, sand and gravel (DNRME 2018a). Drilling records from OCC monitoring bores indicate the alluvium is up to 10 m in thickness.

The hydraulic conductivity of the alluvium is estimated as ~1.1 m/d, indicating a moderate permeability (AGE 2016). The hydraulic conductivity of the alluvium estimated at surrounding tenures ranges between 0.01 and 10 m/d (KCB 2018).

Recharge to the alluvium is expected to occur as a result of direct rainfall infiltration to the alluvium and through infiltration of surface water into the creek bed during seasonal flow events. These flow events will result in discrete, short-duration recharge events through the alluvium that will dissipate to the surrounding groundwater regime. Discharge from the alluvium to underlying hydrostratigraphic units may occur.

Groundwater quality in the alluvium is variable. EC values range between 2,100 µS/cm and 26,000 µS/cm (5th and 95th percentiles), with a median value of 15,977 µS/cm (191 samples). pH ranges between 6.2 and 7.5 (pH units), with a median pH of 7.

Due to the heterogeneous nature of the alluvium, it is unlikely that this unit forms a continuous aquifer. Low yields are reported during drilling of monitoring bores screened within the alluvium, in the order of 0.1 to 0.3 L/s. There are no registered bores screened within the alluvium in the vicinity of the OCCMC, which is likely related to the low yield, poor water quality and limited saturated thickness.

6.1.2 Tertiary Sediments

Unconsolidated Tertiary sediments are mapped across the area and have been encountered in drill holes across the majority of the OCCMC to typical depths of 10 to 13 mbGL. The sediments are also visible in the exposed highwalls of the Open Cut pits. The thickness of Tertiary material increases around the creeks, particularly Oaky Creek and Cattle Creek where it can reach depths up to 20 mbGL.

Limited site-specific testing is available for the Tertiary sediments. Testing from the neighbouring Grasstree Mine suggests a moderately low hydraulic conductivity, ranging from approximately 0.01 to 0.7 m/d (KCB 2018).

Recharge to the Tertiary sediments is interpreted to occur as a result of direct rainfall infiltration, where the sediments outcrop at surface, and where present, downwards leakage from the overlying alluvium. Discharge to the underlying Permian coal measures may also occur.

Groundwater quality in the Tertiary sediments is brackish to saline, with EC values ranging between 3,500 and 30,900 µS/cm (5th and 95th percentiles), with a median value of 7,500 µS/cm. pH ranges between 6.3 and 7.8 (pH units), with a median pH of 6.9.

Groundwater yields within the Tertiary sediments are expected to be low (less than 1 L/s). There are no registered bores screened within the alluvium in the vicinity of the OCCMC, which is likely related to the low yield and poor water quality of the sediments.

6.1.3 Permian Coal Measures

The Permian coal measures include all formations within the Blackwater Group and the Back Creek Groups, which outcrop and subcrop across the OCCMC (Figure 5.3 and Figure 5.4). The Permian coal measures comprise alternating layers of fine to medium grained sedimentary rock (siltstone, sandstone) and interbedded coal.

Hydraulic conductivity of the Permian coal measures, estimated from 35 tests at OCCMC, range between 1 x 10^{-5} and 0.04 m/day (testing depths range between 58 and 340 mbGL[3]).

The Permian coal measures typically host the regional groundwater table and are therefore typically saturated throughout their full thickness. The coal seams are the primary groundwater-bearing units, and are confined by hydrogeologically tight, interbedded sedimentary units, which act as aquitards. Groundwater flow and storage within the coal seams are a function of cleating. The spacing and nature of cleating are the primary controls on hydraulic conductivity within the coal seams.

Recharge to the Permian coal measures will occur through the outcropping sediments and downward leakage from overlying units.

Groundwater quality samples collected from monitoring bores screened across the Permian coal measures record EC ranges from 4,200 mg/L to 36,800 µS/cm (5^{th} and 95^{th} percentiles), with a median of 13,800 µS/cm (from 801 samples). Groundwater quality data indicates that for most bores the groundwater is highly saline, even at relatively shallow depths. Groundwater is generally a sodium-chloride water type, with pH ranging between 6 and 9 (pH units), and a median pH of 7.

Yields associated with the Permian coal measures are variable. Records from drilling within the Permian coal measures for the OCC monitoring bores have identified yields ranging between 0.1 and 5 L/s. Due to the lower yield and high salinity, the Permian coal measures is not generally a viable groundwater source for use. This is supported by the limited number of third-party bores registered with a water supply purpose in the vicinity of the OCCMC (Section 6.3).

6.2 Groundwater Levels, Flow and Connectivity

Groundwater Monitoring

Figure 6.1 shows the location of the OCC groundwater monitoring network. Further details of the monitoring network are included in Appendix I.

The groundwater monitoring network includes 54 monitoring bores, which are screened in the three hydrostratigraphic units at varying depths. The network is used to monitor groundwater levels and quality from a range of site activities, including historical and current underground mining operations, on site water storages and waste facilities.

[3] mbGL – metres below ground level

Groundwater Contours

The inferred groundwater flow direction for the shallow geological units is shown Figure 6.2. The figure presents the elevation for March 2022, and includes monitoring bores screened across the alluvium, Tertiary sediments and shallow Permian coal measures (screens less than 34 mbGL). The contours indicate that groundwater flow is from the west to the east, consistent with the topographic gradient. Groundwater elevations range between 194 mAHD in the west and 142 mAHD in the east.

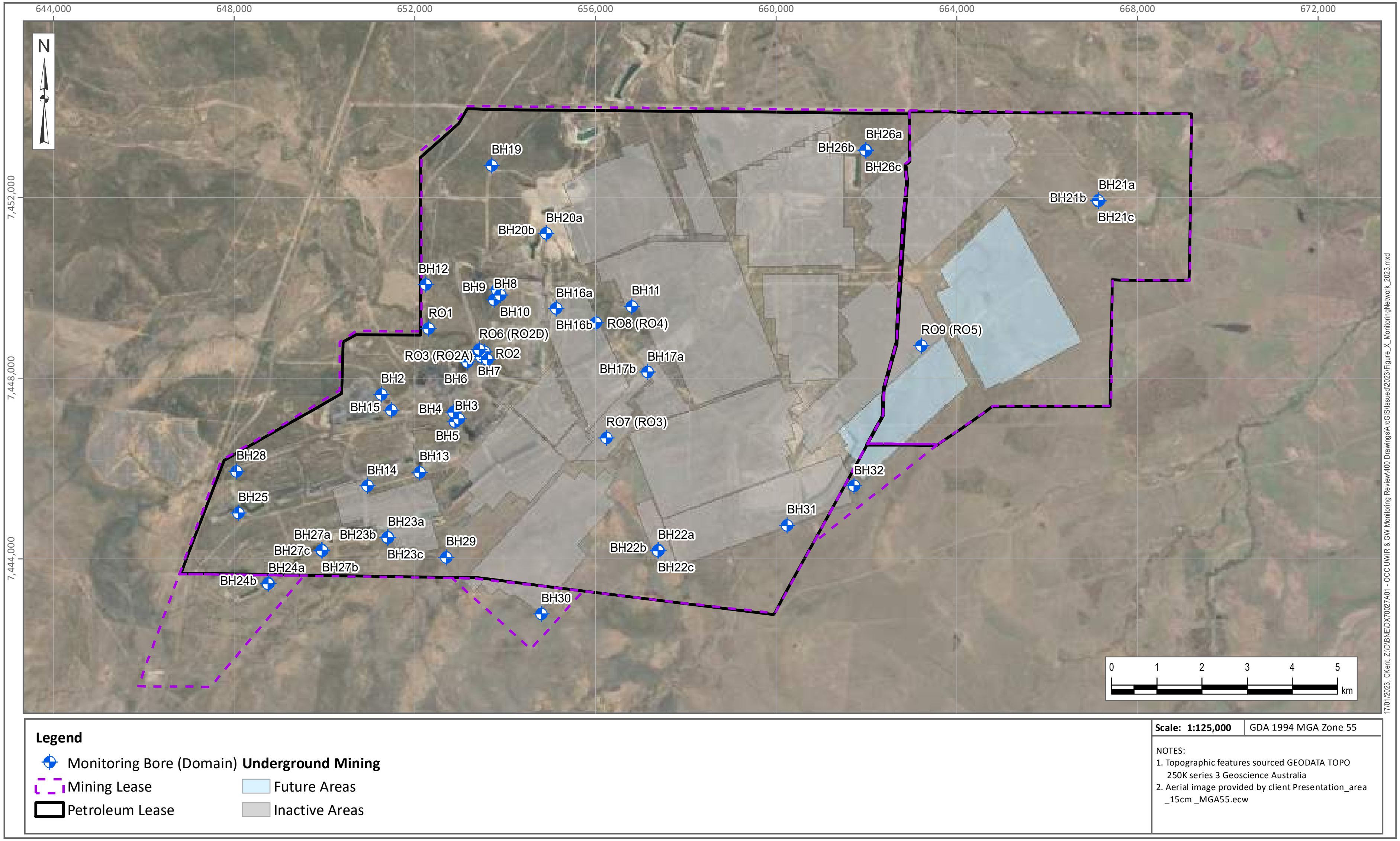

Figure 6.1 OCCMC Groundwater Monitoring Network

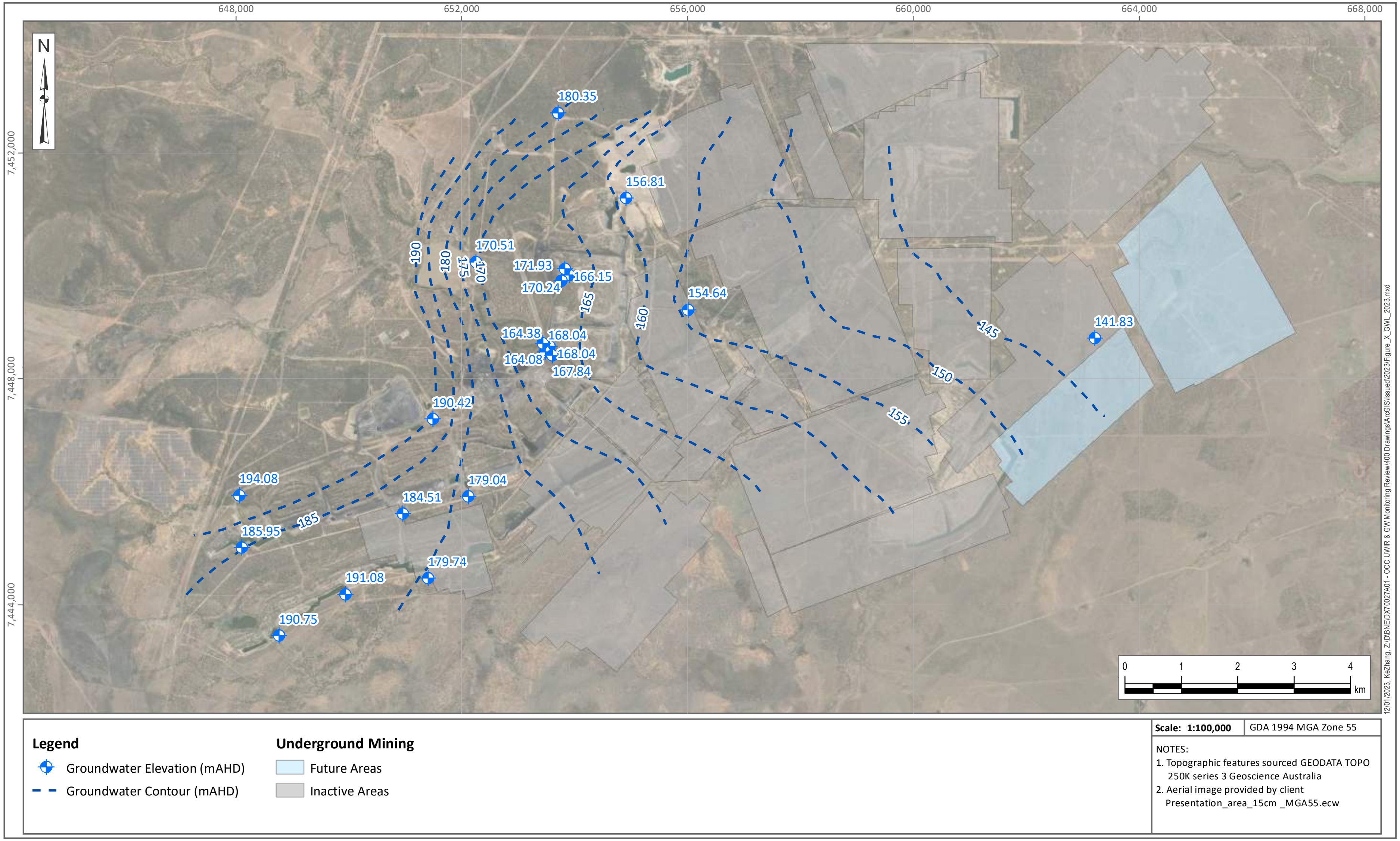

Figure 6.2 Groundwater Elevation Contours – March 2022

Transient Groundwater Levels and Hydrostratigraphic Unit Connectivity

Quaternary Alluvium and Tertiary Sediments

Figure 6.3 presents a groundwater elevation hydrograph for RO5, which is screened across the Quaternary alluvium / Tertiary Sediments. The bore has been monitored since the end of 2016 with manual dip measurements collected[4].

The bore is located adjacent to Oaky Creek, and west of the underground mining area. The hydrograph highlights the seasonality in the groundwater level response, with a strong correlation with the CRD trend for the rainfall station at Booroondarra. A decline in groundwater level has been observed since 2019, however this correlates strongly with a decline in the CRD. Since 2021, groundwater levels have shown an increase, which also correlates with the CRD trend.

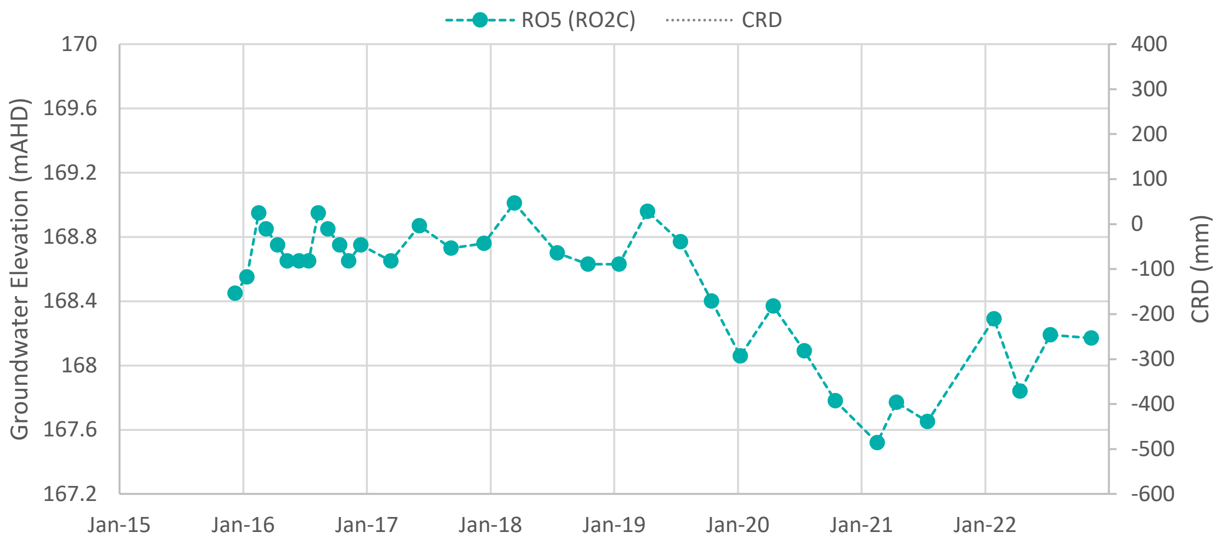

Figure 6.3 RO5 Groundwater Elevation Hydrograph – Quaternary Alluvium / Tertiary Sediments

Monitoring bore RO9, screened within the Tertiary sediments, also shows a similar response and correlation with the CRD trend (Figure 6.4). The general declining trend in the CRD until mid-2021 (which indicates below average rainfall conditions) is reflected by the groundwater level which has declined by ~3 m since 2016, and an increasing trend is observed in both the CRD and groundwater level since mid-2021.

Gas drainage activities, and extraction of groundwater (to facilitate gas extraction) have been undertaken in the vicinity of RO9. The target coal seam is ~200 m below surface at this location. The Tertiary sediments are separated from the target coal seam (and the zone of water extraction) by interbedded siltstone, sandstone and mudstone, which form effective aquitard layers that limit hydraulic connectivity and the propagation of drawdown into the overlying hydrostratigraphic units. This is clear from the monitoring record, which show a strong response to the climate trend; impact from depressurisation activities (i.e. groundwater level drawdown trend) associated with gas extraction is not evident.

[4] Note that when comparing manual dip measurements to a CRD, the peak groundwater level in the wet season and lowest level in the dry season may not have been captured due to measurement timing.

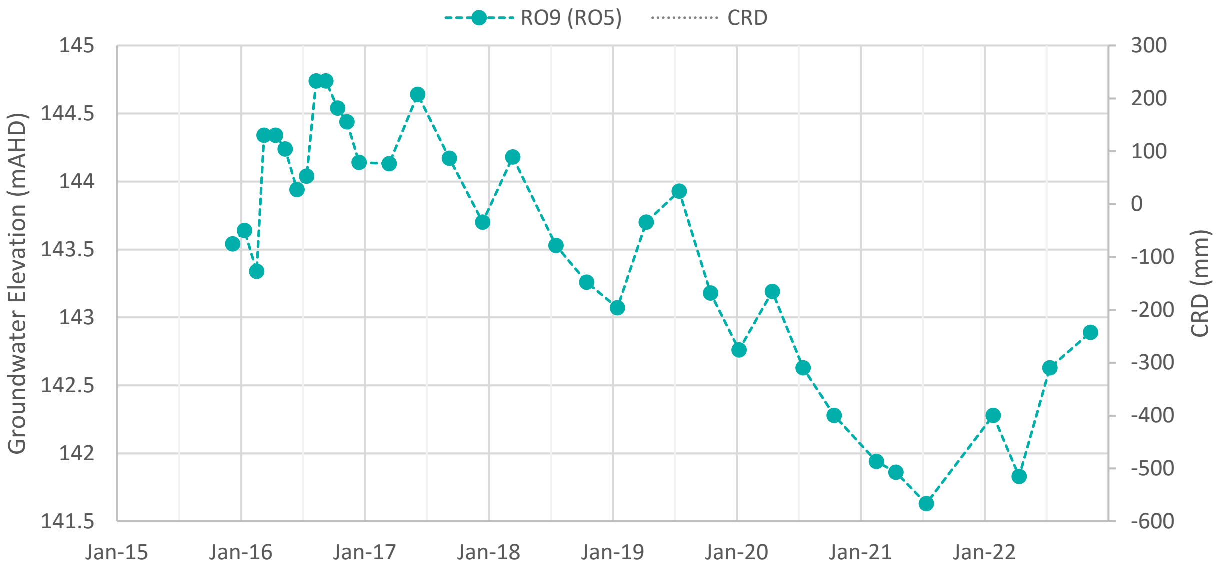

Figure 6.4 RO9 Groundwater Elevation Hydrograph – Tertiary Sediments

Permian Coal Measures

Several nested monitoring bores are installed within the Permian coal measures. The nested sites have two or three monitoring bores located in close proximity but screened at different depths within the coal measures.

For example, BH21a, BH21b and BH21c are located towards the east of the tenure, where gas drainage has recently occurred. In the deepest monitoring bore, screened across the German Creek coal seam, there has been ~45 m of drawdown in response to water extraction. The monitoring bores screened in shallower coal seams show limited connectivity with the deeper system. A schematic to illustrate the variation of lithology, which limits the propagation of drawdown to the upper sequence within the Permian coal measures, is shown in Figure 6.5. Hydrogeological cross sections are provided in Section 6.5.

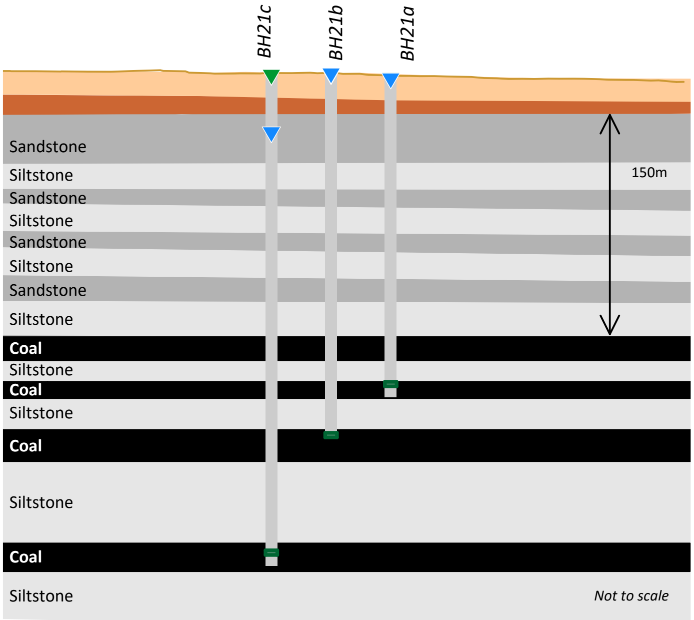

Figure 6.5 Schematic of Lithological Variation within Permian Coal Measures

Three hydrographs are presented in Figure 6.6, Figure 6.7 and Figure 6.8 for monitoring bores located within the vicinity of the underground mining areas towards the east of the tenure.

These hydrographs show the range of groundwater levels within the Permian coal measures and the variability in response across different depths. The deepest monitoring bore of these three bores is screened within the German Creek seam, which is depressurised and dewatered to allow mining activities.

For BH26a and BH22b, the monitoring record commences when drawdown has already occurred within the coal seam. These hydrographs show up to 140 m vertical difference in groundwater level elevation with the next deepest monitoring bores (BH26b and BH22a) and highlight the effectiveness of interbeds within the Permian sequence to limit drawdown propagating through the sequence.

The groundwater elevation in the monitoring bores screened in the shallower coal seams have experienced a decline of ~11 m over the monitoring duration in BH26b and BH26c; while declines in groundwater levels of ~11 m and ~25 m, respectively, at BH22a and BH22c were also observed. The data also shows an increasing trend in BH22B, which is in an area where mining has ceased, and recovery is occurring.

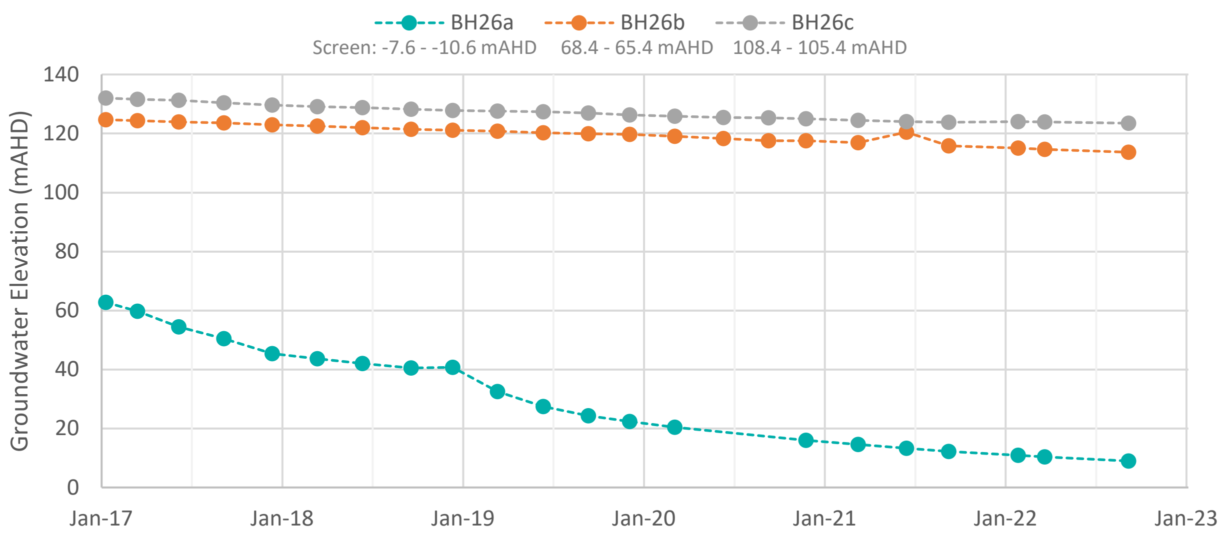

Figure 6.6 Groundwater Elevation Hydrograph – Permian Coal Measures, BH26a/b/c

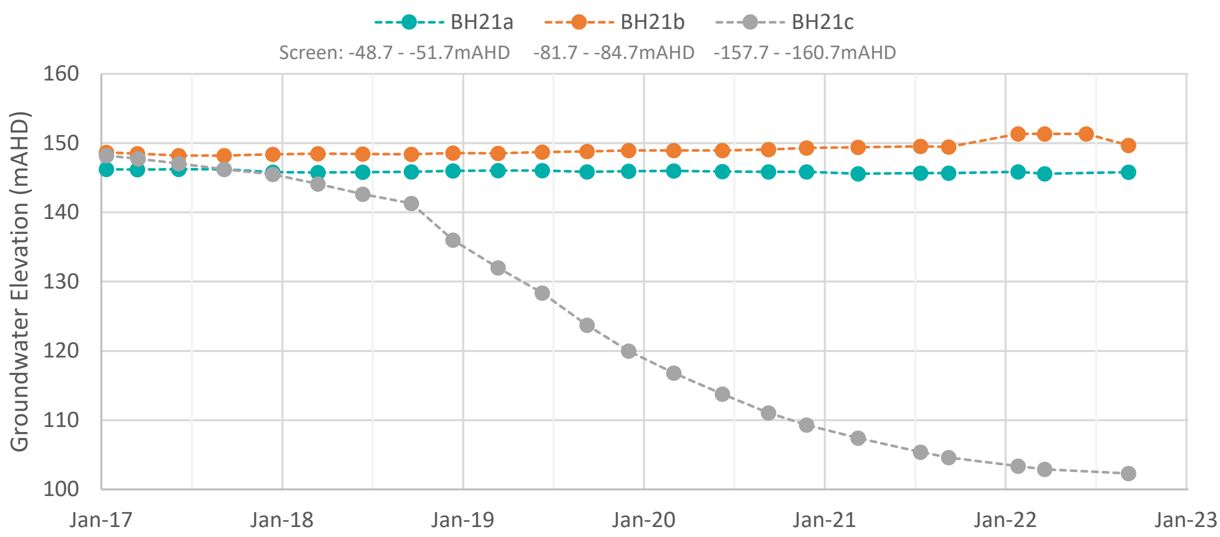

Figure 6.7 Groundwater Elevation Hydrograph – Permian Coal Measures, BH21a/b/c

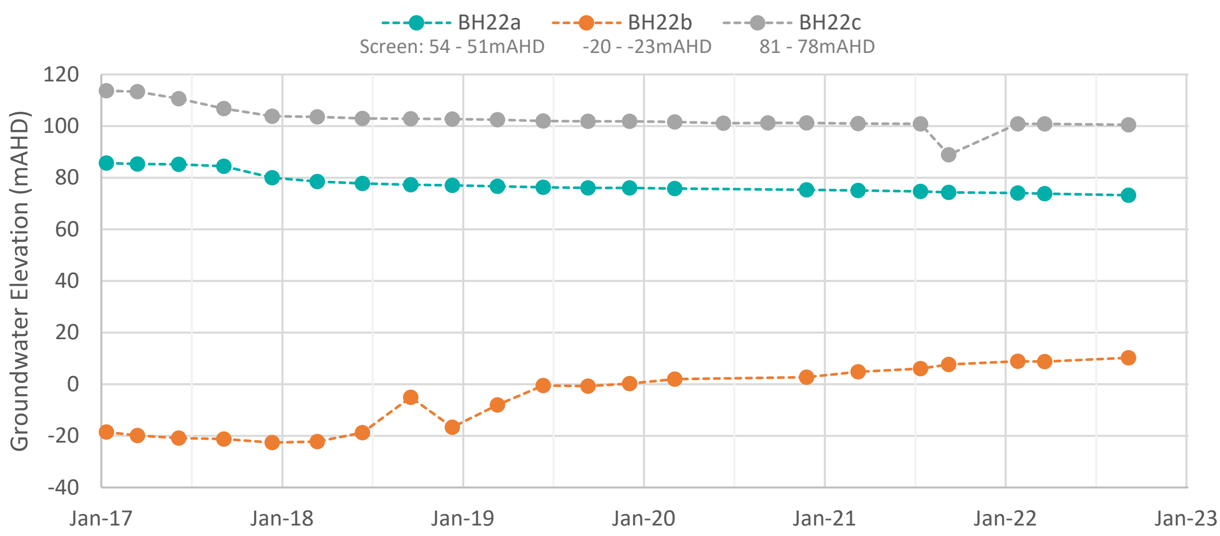

Figure 6.8 Groundwater Elevation Hydrograph – Permian Coal Measures, BH22a/b/c

The groundwater elevation hydrograph for BH32 is shown on Figure 6.9. This bore is screened within the German Creek seam, which is depressurised and dewatered to allow mining activities and is located close to the recently mined areas. The response is similar to that observed in the deeper monitoring bores discussed above, however also shows the change in water level since mid-2021 as mining has moved closer to this area.

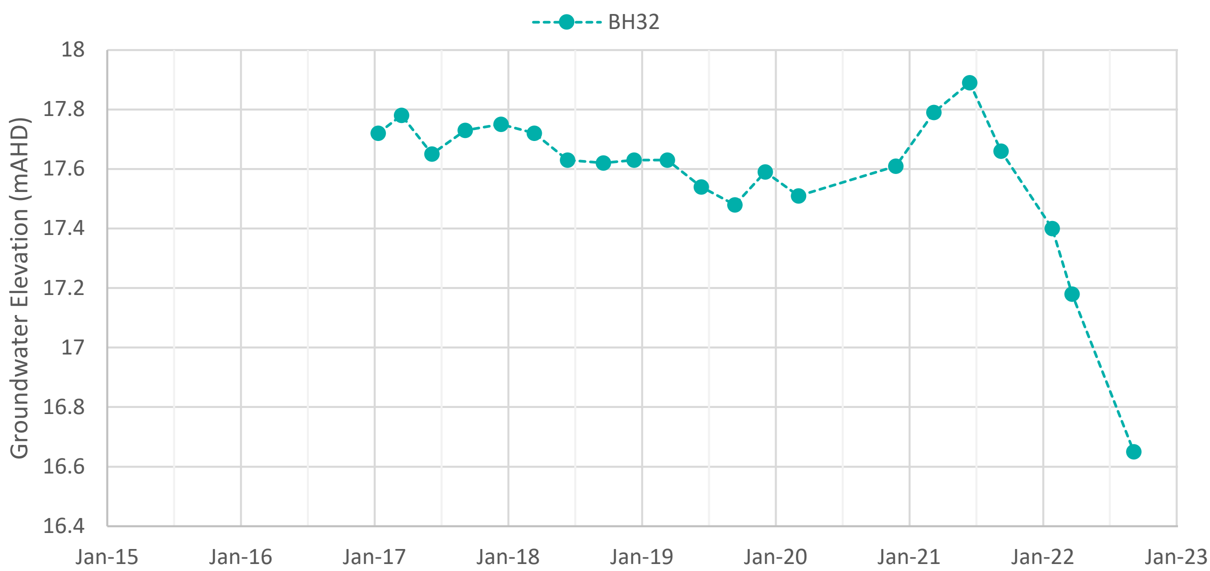

Figure 6.9 Groundwater Elevation Hydrograph – Permian Coal Measures, BH32

6.3 Registered Groundwater Bores

Within 5 km of the OCCMC, there are 70 registered groundwater bores (Figure 6.10), recorded in the groundwater database (GWDB), as of November, 2020 (DNRME 2020):

- 59 are located within the surrendered PLs (all monitoring bores except for one bore which was installed by the mine for dewatering purposes to facilitate mining) and eleven are located outside.
- The dewatering bore situated within the OCCMC mining lease and surrendered PL324 (RN 190664), was drilled in 2022 to a depth of 30 meters beneath ground level. The bore is incorrectly identified by the GWDB as a water supply bore. OCC have confirmed that the bore does not belong to a third-party. This bore's location is indicated in Figure 6.10.
- For the bores located outside of the PL:
  - Eleven bores are categorised as monitoring bores (mine and sub-artesian monitoring).
  - One bore does not include a purpose, although is located on a neighbouring mining lease, so is most likely a monitoring bore.
  - One bore is classified as a water supply bore (RN136628), located 4.3 km east of PL324. The bore is screened between 20 and 30 mbGL across interbedded siltstone and sandstone screened and is therefore inferred to be within the upper portion of the Permian coal measures. The bore was drilled in 2007. It is not known whether the bore is currently or has historically been used for water supply purposes.

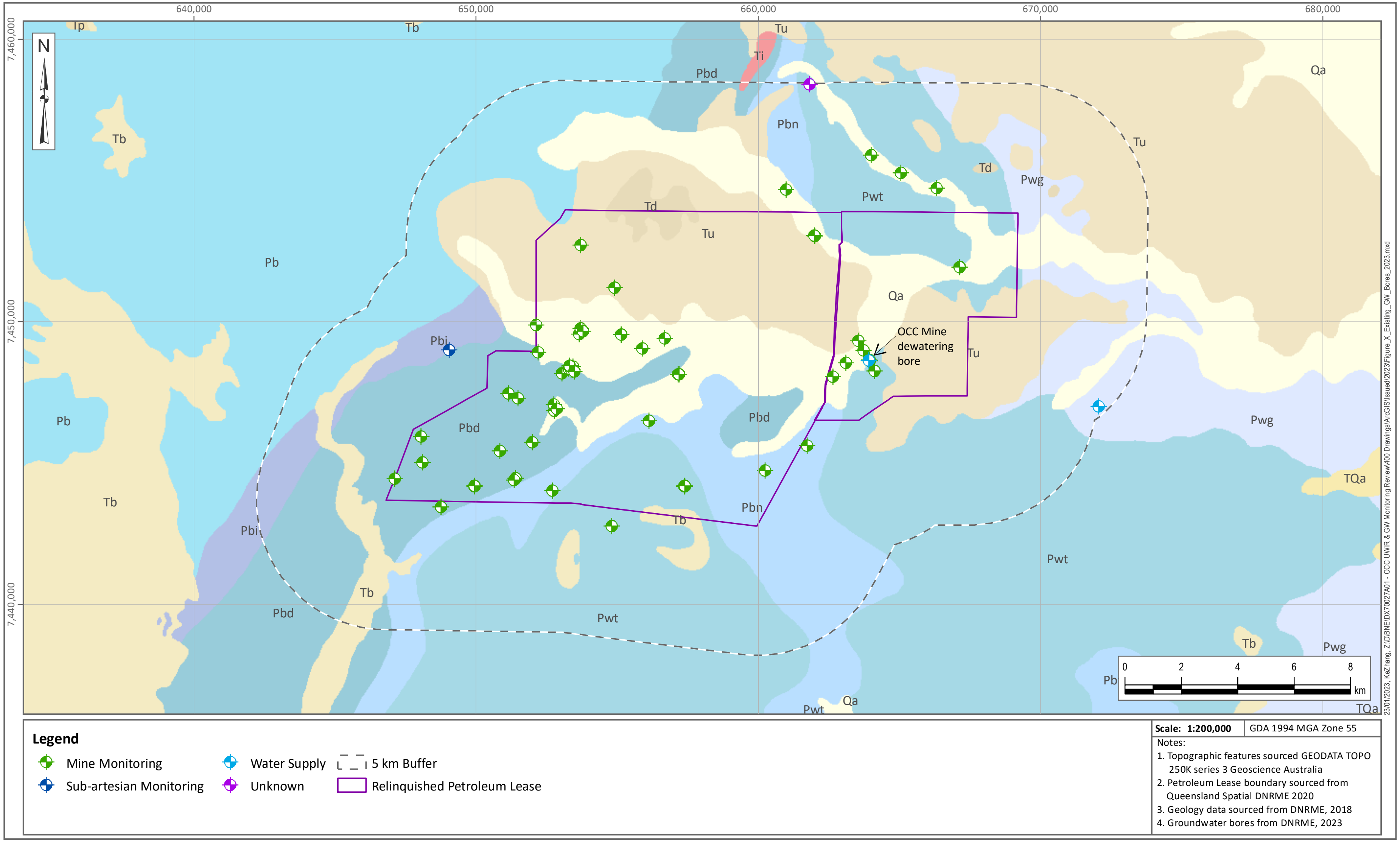

Figure 6.10 Location of GWDB Registered Bores by Facility Role (See Figure 5.3 for Geology Legend)

6.4 Groundwater and Surface Water Interaction

Groundwater-surface water interaction within the OCCMC may occur as a result of two key processes:

- Discharge of groundwater to watercourses as baseflow; and
- Recharge as leakage from watercourses.

As detailed in Section 5.2, watercourses in the area are characteristically ephemeral, and typically only flow after significant rainfall events, during which recharge may occur to the units below the watercourse. Based on monitoring data presented in Section 6.2, and the depth to the shallow groundwater table (9.5 to 10.5 mbGL), it is unlikely that groundwater discharges to surface water as baseflow. Further discussion in relation to GDEs is provided below.

6.4.1 Groundwater Dependent Ecosystems

GDEs are defined by DoEE (2015) as:

> *'Natural ecosystems which require access to groundwater on a permanent or intermittent basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services (Richardson et al. 2011). The broad types of GDE are (Eamus et al. 2006):*

- *Ecosystems dependent on the surface expression of groundwater,*
- *Ecosystems dependent on the subsurface presence of groundwater,*
- *Subterranean ecosystems.'*

Published mapping of potential GDEs are shown on Figure 6.11. The majority of the potential GDEs are mapped as being 'low confidence' with some 'moderate confidence' GDEs. The location of the potential GDEs is coincident with Oaky Creek, Sandy Creek and Bul Bul Creek.

The potential terrestrial GDEs (TGDEs) are described as being associated with Quaternary alluvial aquifers with fluctuating, intermittent groundwater connectivity regime (DES 2018b). Terrestrial vegetation is managed at OCC through conditions within their EA.

Potential surface expression GDEs are located to the west of the OCCMC. Monitoring bore RO5, shown on Figure 6.3, is located in this area. Groundwater levels at this monitoring bore have consistently been between 9.5 and 10.5 mbGL (2016 to 2020) and therefore based on this, it is considered unlikely that groundwater will express to the surface in this location, with surface water flow only from rainfall events rather than any contribution from groundwater as baseflow. The areas identified in the surface expression GDE dataset are therefore not considered as receptors.

6.4.2 Springs

There are no registered springs within the vicinity of the OCCMC. The closest registered spring is located approximately 85 km southeast of OCC, southeast of Blackwater (Figure 6.12). OCC have previously consulted with landholders, which did not reveal any anecdotal evidence to suggest the presence of springs within the immediate vicinity of the OCCMC (BlueSphere 2015).

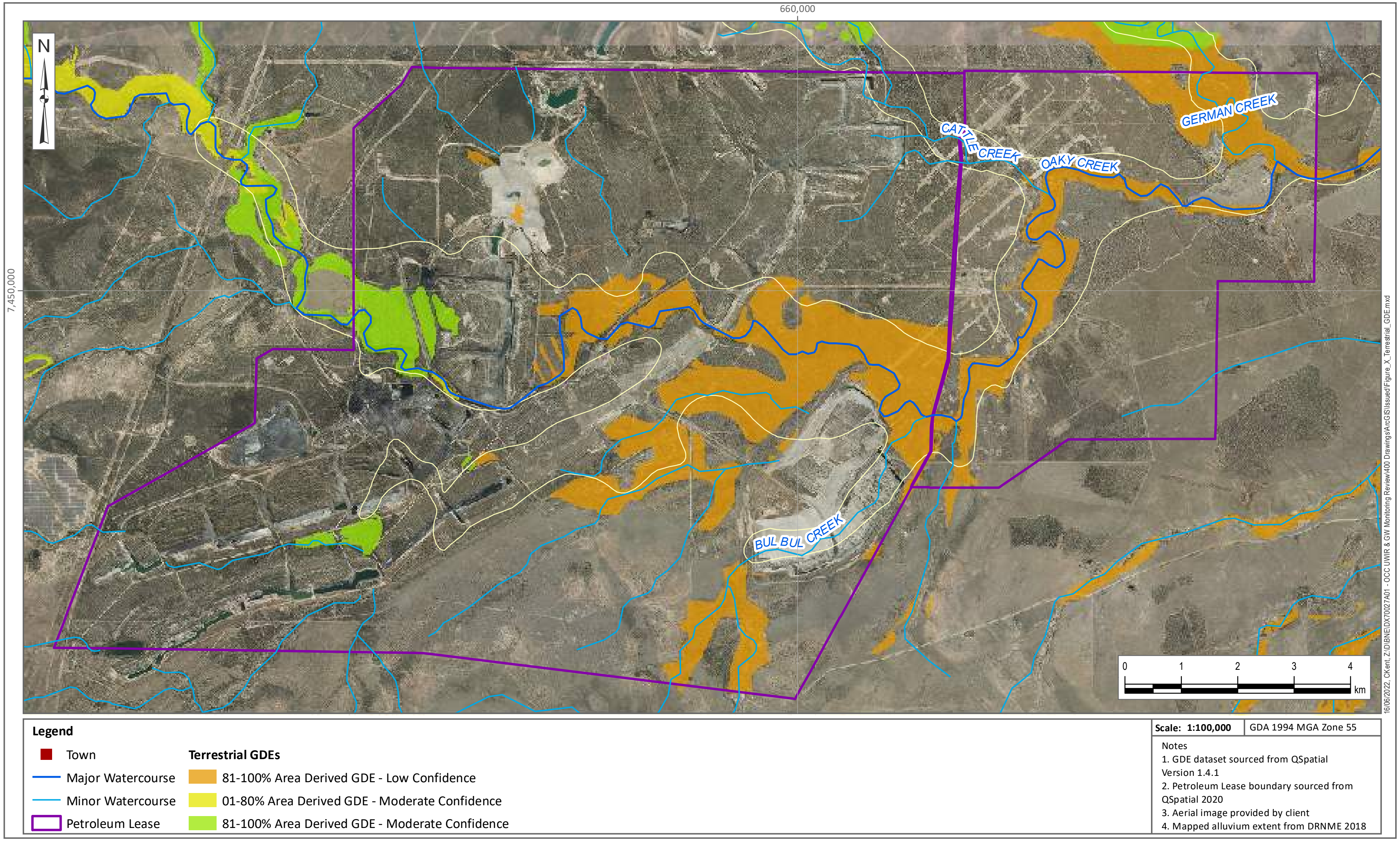

Figure 6.11 Location of Mapped Potential Terrestrial GDEs

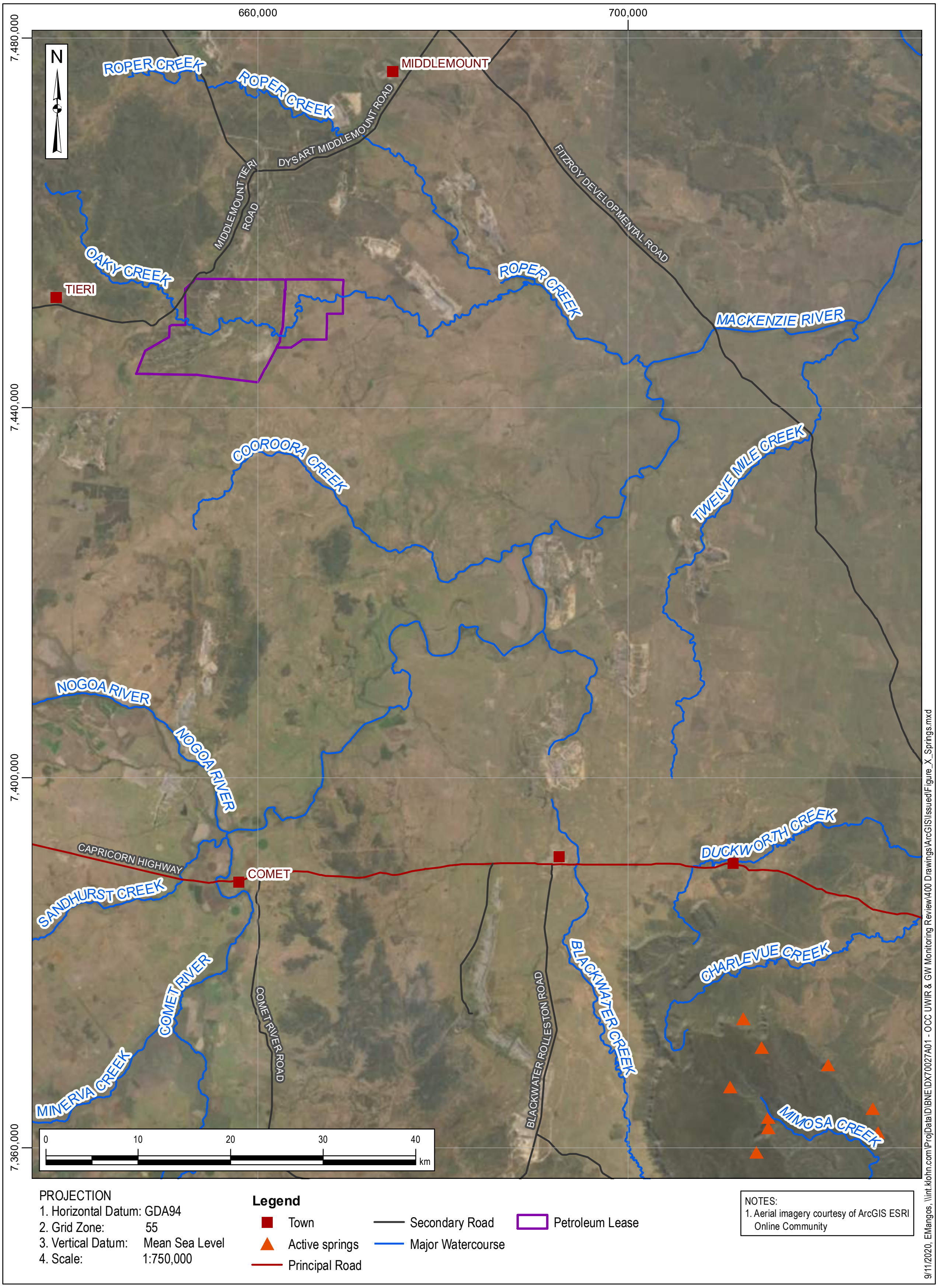

Figure 6.12 Location of Registered Springs

6.5 Hydrogeological Conceptual Model Summary

The hydrogeological conceptual model is supported by hydrogeological cross sections (section lines presented in Figure 6.13) presented on Figure 6.14, Figure 6.15 and Figure 6.16. A summary of the conceptual model is provided in the following:

- Hydrostratigraphic units include Quaternary alluvium, Tertiary sediments and the Permian coal measures.
- Hydrograph responses show a strong correlation with the CRD trend in the Quaternary alluvium and Tertiary sediments. Although fluctuation in groundwater level has occurred in recent years, this is attributed to changes in rainfall conditions rather than mining-related activities. Available monitoring records do not indicate drawdown impacts from historical depressurisation and dewatering activities in these geological units. This indicates limited connectivity between the shallow system and the deeper Permian coal measures.
- Groundwater levels within the Permian coal measures experience drawdown as a result of gas drainage activities and underground dewatering, however, based on the volume of water removed and the duration of water abstraction, the majority of the drawdown is attributed to underground mining activities rather than degassing activities. The upper interbeds of the Permian coal measures provide an effective barrier to limit the propagation of drawdown to the shallow hydrostratigraphic units.

6.5.1 Site-Specific Groundwater Environmental Values

Groundwater hosted in the hydrostratigraphic units underlying the OCCMC is generally of a poor quality with low yields and high salinity. There are limited beneficial uses for the groundwater, which is supported by the limited number of water supply bores in the vicinity of the OCCMC. One landholder bore is identified as a potential water supply bore, however limited information is available for this bore.

Although potential GDEs are mapped across the OCCMC, it is unlikely these mapped areas are actually GDEs, given the majority are classified as ‘low confidence’ and the depth to groundwater, which is at least 9 mbGL.

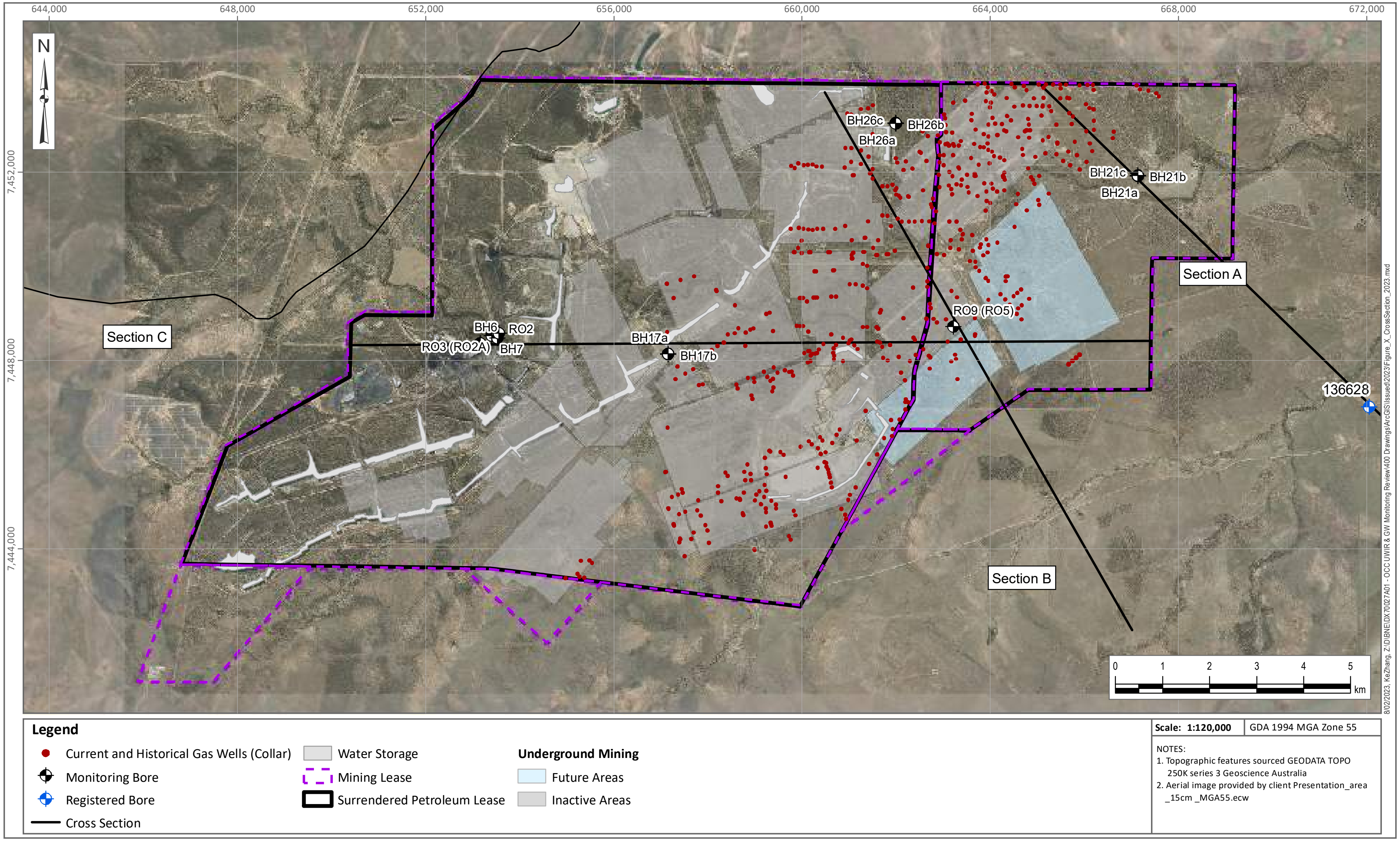

Figure 6.13 Location of Hydrogeological Cross Sections

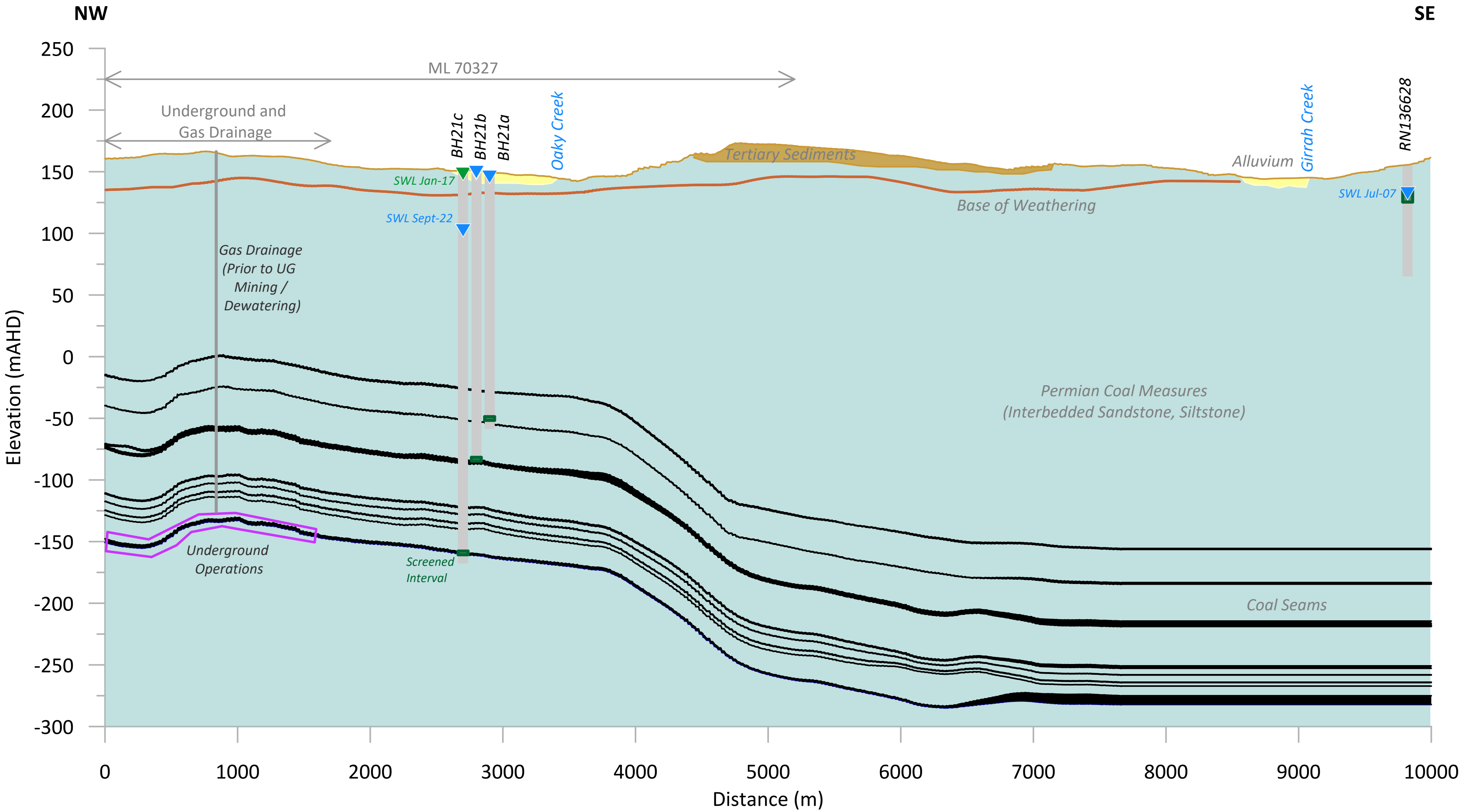

Figure 6.14 Hydrogeological Cross Section A

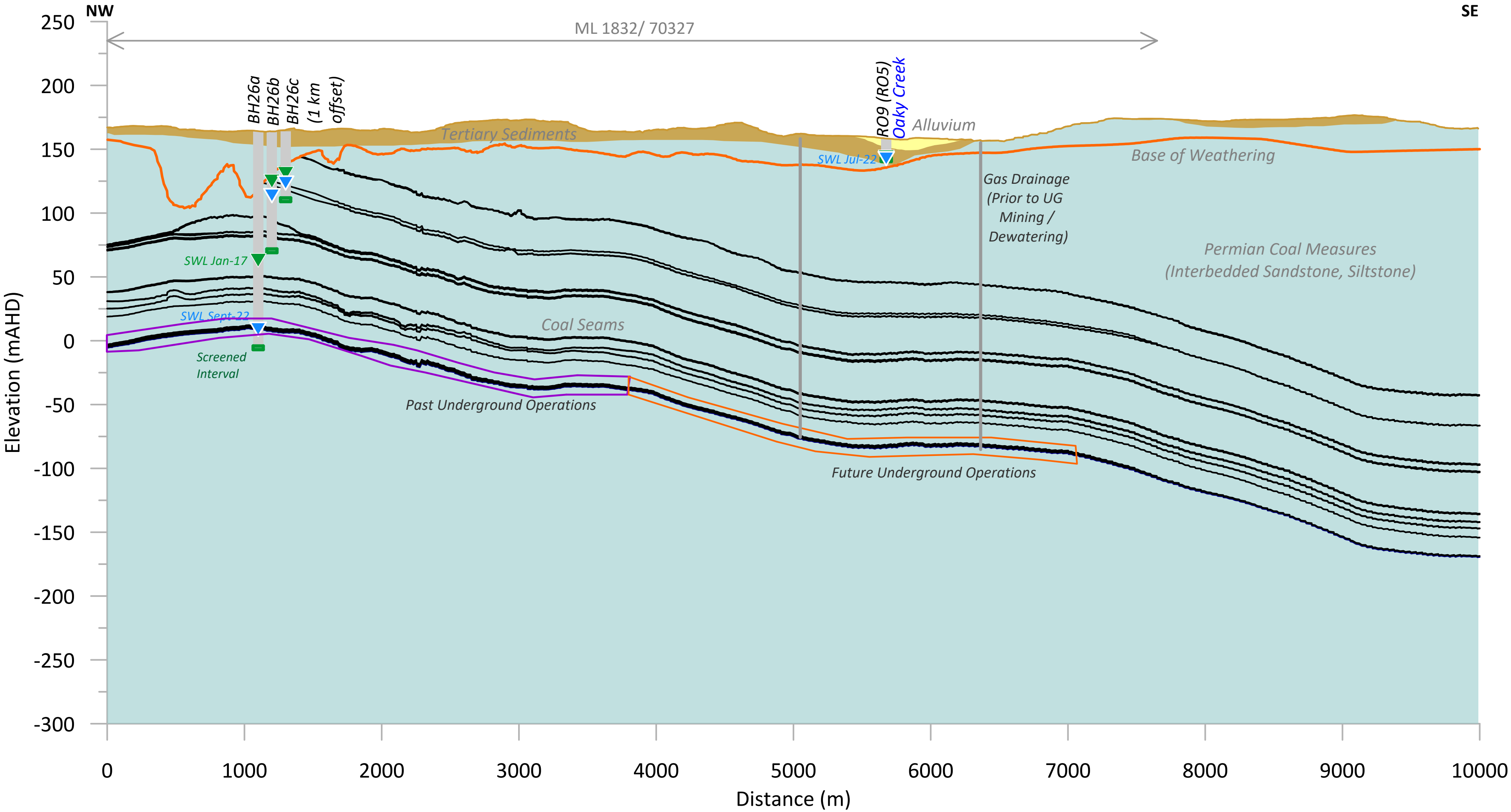

Figure 6.15 Hydrogeological Cross Section B

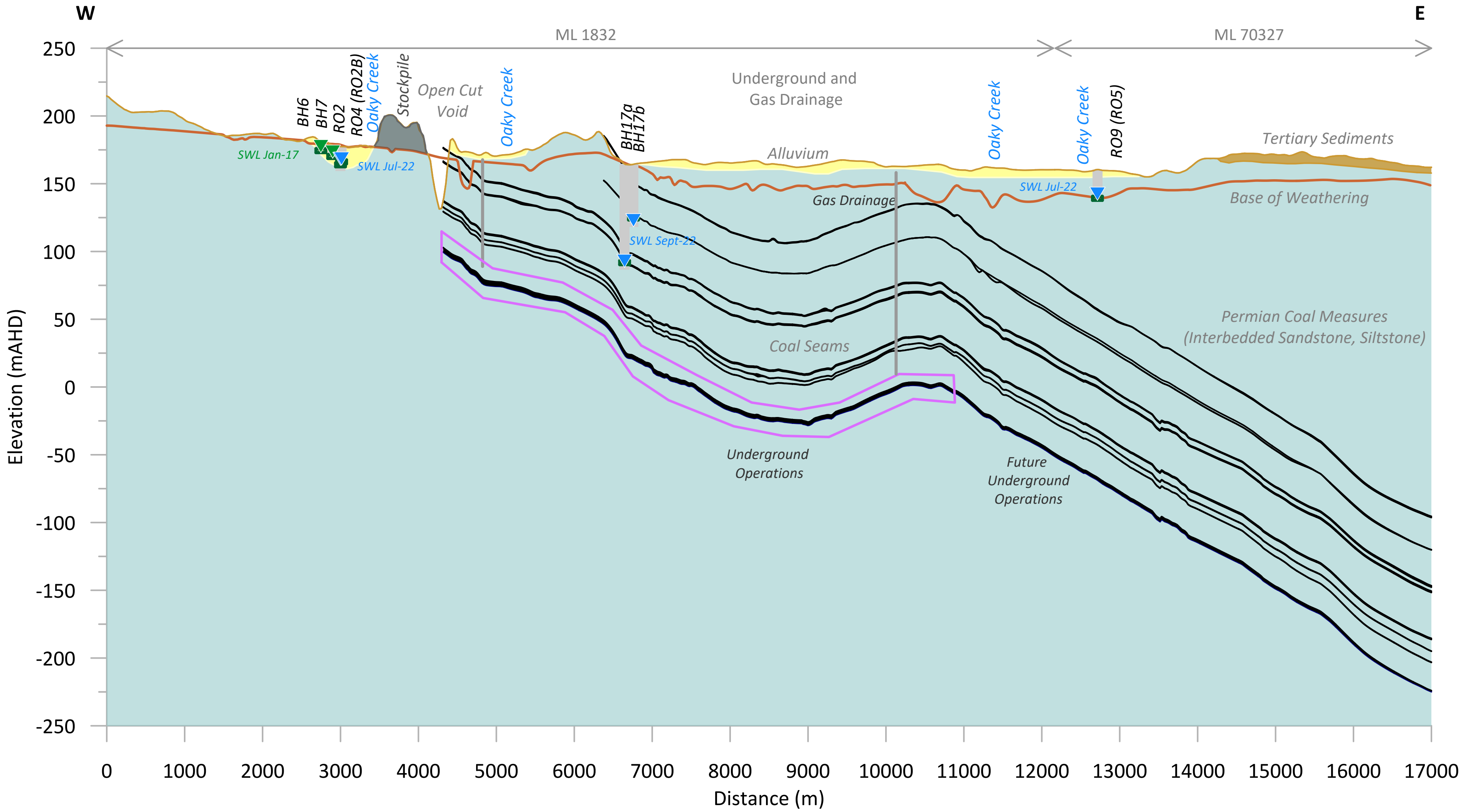

Figure 6.16 Hydrogeological Cross Section C

7 GROUNDWATER IMPACT ASSESSMENT

7.1 Predictive Simulations

Details of the groundwater model construction and calibration are provided in Appendix II.

Two predictive model scenarios were simulated to allow assessment of potential impacts to surrounding water resource as a result of the underground water extraction at OCC. These scenarios comprised:

- Scenario A – Cumulative Scenario; which comprises existing mining activities associated with the adjacent Grasstree Mine and the mining activities associated with OCC.
- Scenario B – Current Conditions Scenario; which comprises the activities identified in Scenario A, with the OCC activities removed.

Groundwater level drawdown associated with the OCC activities is estimated based on the difference between the drawdown results from Scenario A and Scenario B, which provides a Project-only scenario. Scenario A provides the cumulative drawdown within the vicinity of the Project area.

The predictive simulation was completed for the entire duration of the approved mining development (until the PL's were surrendered in November 2022), with the predicted drawdowns extracted from the model upon surrender of the PL's to represent the drawdown of the LTAA.

7.1.1 Scenario Results

Numerical modelling outputs for the scenarios detailed in the previous section have been used to assess the extent and magnitude of drawdown related to underground water extraction at OCC. Results are presented for model layer 6 representing the Aquilla coal seam, and model layer 12, which represents the German Creek seam (target for mining / gas extraction). No drawdown greater than the trigger threshold is predicted in layer 1, representing the Quaternary alluvium or model layer 2 representing the Tertiary sediments.

Drawdown predicted at the end of 2022 (LTAA) is presented in Figure 7.1 Key observations from the predicted drawdowns include:

- Predicted drawdown/depressurisation is limited to the eastern area of the OCCMC, where the future underground development is planned.
- The highest drawdown is predicted in the German Creek seam, which was the target for gas extraction and remains the target for mining.
- Drawdown is predicted to only occur directly within the OCCMC and does not extend outside of the surrendered PLs and MLs.

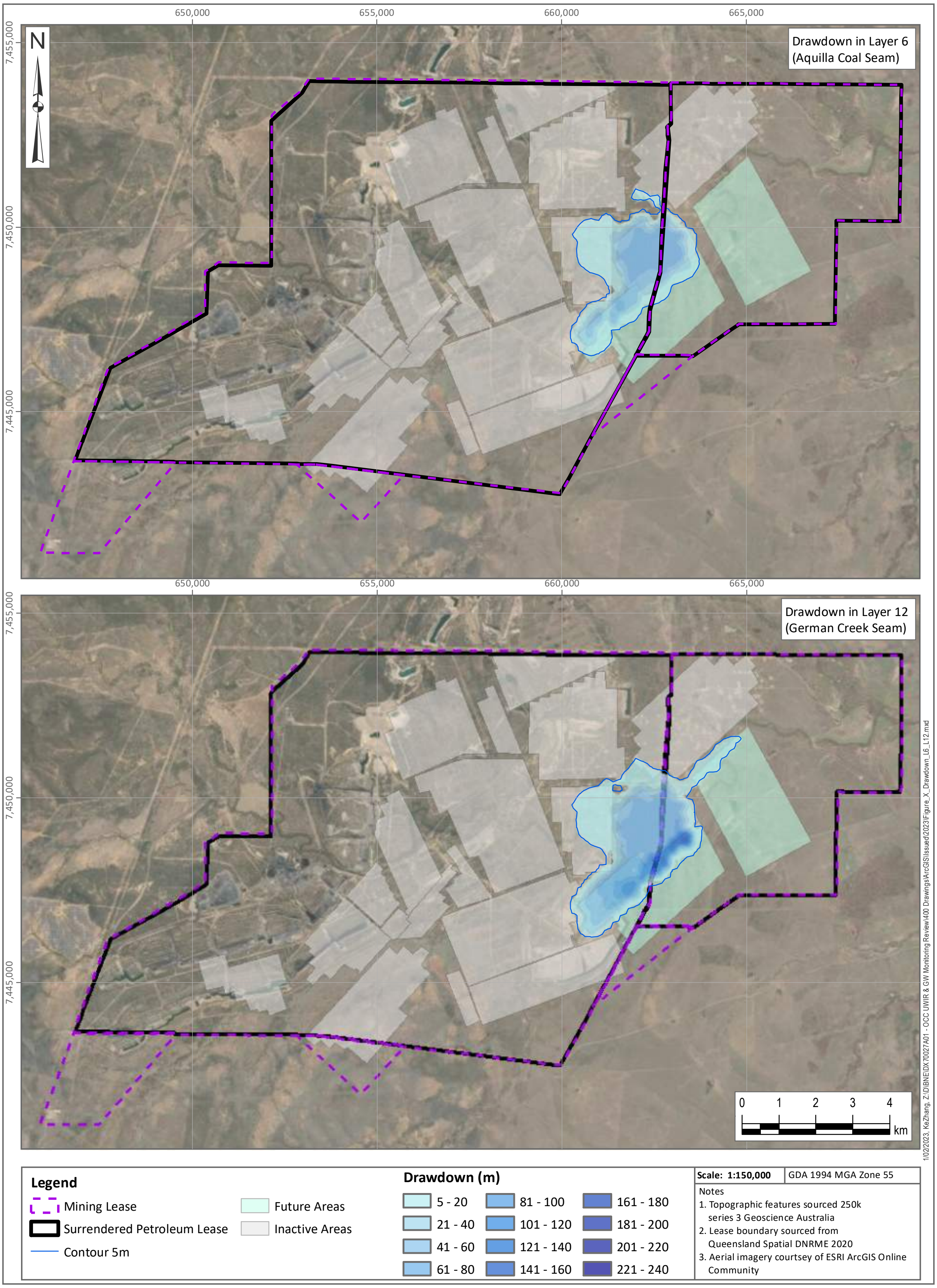

Figure 7.1 LTAA Predicted Drawdown in Layer 6 (Aquilla Coal Seam) and in Layer 12 (German Creek seam)

7.2 Impact Assessment

Groundwater level drawdown/depressurisation predictions from the numerical modelling results presented in Section 7.1.1 identify that drawdown/depressurisation is predicted to occur within the OCCMC footprint. This section describes the potential impacts to groundwater resources, users and sensitive receptors.

7.2.1 Impacts on Groundwater Resources

Underground water extraction is authorised under the *Petroleum and Gas (Production and Safety) Act 2004* (Section 2.1). Potential impacts as result of underground water extraction may include:

- Decline in groundwater level / pressure at water bores, reducing water availability and potentially impacting groundwater EVs;
- Reduction in groundwater head resulting in reduction of groundwater discharge at spring complexes, potentially causing degradation of GDEs; and
- Reduction of baseflow to watercourses, potentially resulting in reduced availability of water to GDEs and reduced water availability to potential users downstream.

The above potential impacts, where receptors exist within the vicinity of the OCCMC, are assessed against the *Water Act 2000* trigger thresholds as outlined in Section 2.3

7.2.2 Impacts on Groundwater Users

Potential long-term impacts to groundwater bores have been assessed against the *Water Act 2000* bore trigger threshold of 2 m for an unconsolidated aquifer (e.g., alluvium), and 5 m for a consolidated aquifer (Tertiary sediments and Permian coal measures), using the drawdown predictions from the numerical model (Section 7.1.1).

As detailed in Section 6.3, there are 70 registered groundwater bores within a 5 km radius of the OCCMC. There is only one bore registered with a water supply purpose, located 4.3 km east of the mine, one dewatering bore used by OCC for mine dewatering purposes with the remainder used as monitoring bores:

- LTAA drawdown is not predicted to extend outside of the OCCMC boundaries, and therefore the water supply bore located 4.3 km to the east of the mine (RN136628) and well outside of the LTAA is not predicted to experience a drawdown that exceeds the trigger thresholds (>5 m). Furthermore, the bore card for the water supply bore (RN136628) indicates that the screen interval for this bore is located between 20 and 30 mbGL. The depth to the coal seams is estimated to be at least 300 mbGL in this area, which is overlain by interbedded sandstone / siltstone units. No impact on this bore is anticipated. The bore is not located on a mining tenure.
- The dewatering bore situated within the OCCMC mining lease and surrendered PL324 (RN190664) is <u>incorrectly</u> identified by the GWDB as a water supply bore. OCC have confirmed that the bore does not belong to a third-party. This bore's location is indicated in Figure 6.10.

In summary, no bores with a third-party water supply purpose are present with the LTAA.

7.2.3 Impacts on Surface Drainage

Numerical modelling predicted no drawdown within the surficial Quaternary alluvium which is potentially hydraulically connected to the surface water systems across OCCMC. There will be no discernible impacts to the surface water system, or surface water users as a result of underground water extraction from OCCMC.

7.2.4 Impacts on Springs

The nearest spring complex to the Project area is approximately 85 km southeast of OCCMC, (Figure 6.12). Predicted depressurisation/drawdown from the OCCMC will not propagate to the spring locations, therefore, no impacts to surrounding spring complexes are predicted.

7.2.5 Impacts on GDEs

Section 6.4.1 included a discussion on the potential TGDEs that have been mapped in the vicinity of the Project area. Published mapping of potential GDEs are shown on Figure 6.11. The potential TGDEs are described as being associated with the Quaternary alluvium which has a fluctuating, intermittent groundwater connectivity regime (DES 2018b). Based on the hydrogeological conceptual model (including levels and quality), potential GDEs mapped within the area are considered low confidence and unlikely to be reliant on shallow groundwater.

The predicted groundwater level drawdowns from the numerical modelling (Section 7.1.1) indicate that no drawdown is predicted in the Quaternary alluvium. Drawdown resulting from the underground water extraction is not predicted to propagate to the shallow Quaternary alluvium, therefore, there will be no impacts to the mapped potential TGDEs as a result of the underground water extraction at OCCMC.

8 ASSESSMENT SUMMARY

8.1 Summary

OCCs 'Surrender Applications' for petroleum leases (PL237 and PL324) were approved by the DES in November 2022, and therefore a final UWIR report is required.

Part A: Underground Water Extractions

OCC undertook groundwater extraction as part of their gas drainage activities on PL324 and PL237 prior to November 2022. The purpose of the water extraction was a mine safety requirement to remove gas before underground mining activities commence.

Historical underground water extraction associated with gas extraction ranged between 75 and 131 ML/year. These volumes were between 2% and 4% of the annual volumes extracted as associated water take authorised under the *Mineral Resources Act 1989* (State of Queensland 2021b).If gas is encountered in the future mining areas, it will be flared out to facilitate safe mining.

Part B: Aquifer Information and Underground Water Flow

The three hydrostratigraphic units present across the OCCMC are discussed in Section 6. These include Quaternary alluvium associated with surface drainages; Tertiary sediments, which are part of the shallow system; and, the Permian coal measures, which was the primary target for gas extraction prior to underground mining.

The shallow systems show a strong response to climate trends, and from the available monitoring records, drawdown impacts from historical depressurisation and dewatering activities have not been observed.

Part C: Water Level Decline

A review of the monitoring data across the OCCMC shows drawdown associated with mining activities in the German Creek coal seam. However, groundwater elevation monitoring data from the Permian coal measures shows that the interbedded nature of the unit provides an effective barrier to the propagation of drawdown into the shallower hydrostratigraphic units.

Groundwater has been extracted at OCCMC as part of operations since 1982. The hydrogeological conceptual model, monitoring data and groundwater model supports the interpretation that drawdown of greater than the trigger threshold is unlikely to occur in the uppermost hydrostratigraphic units (e.g., Quaternary alluvium). This is further supported by numerical groundwater model predictions, which predict no drawdown in the alluvial unit.

Part C: Long Term Affected Area Water Supply Bores

Drawdown predicted at the end of 2022 (the LTAA) is limited to the eastern area of the OCCMC, where the future underground development is planned. The highest drawdown is predicted in the German Creek seam, which was the target for gas extraction and remains the target for mining. Drawdown associated with the LTAA is predicted to only occur directly within the OCCMC and does not extend outside of the relinquished PLs and the MLs.

There are 70 registered groundwater bores within a 5 km radius of the OCCMC. There is only one third-party bore registered with a water supply purpose, located 4.3 km east of the mine and therefore well beyond the extent of the LTAA.

Based on the hydrogeological understanding of the area, review of available monitoring data and the groundwater model results, it is unlikely that groundwater levels in the third-party bore will have an induced drawdown greater than the *Water Act 2000* trigger threshold value (5 m) due to water volumes extracted as part of previous gas drainage activities.

In summary, no third-party bores with a water supply purpose are present with the LTAA.

Part D: Impact on Environmental Values

Groundwater hosted in the hydrostratigraphic units underlying the OCCMC is generally of a poor quality with low yields and high salinity. There are limited beneficial uses for the groundwater, which is supported by the limited number of water supply bores in the vicinity of the OCCMC.

Based on the hydrogeological conceptual model (including levels and quality), potential GDEs mapped within the area are considered low confidence and unlikely to be reliant on shallow groundwater. Groundwater level impact associated with previous gas drainage is not predicted in the shallow groundwater system.

Groundwater and surface water EVs for the Mackenzie River Sub-Basin as defined under the E*nvironmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP)* (State of Queensland 2011; 2020b) are provided in Table 2.3. Based on the numerical model predictions, conceptual understanding of the OCCMC and surrounding area, impacts to EVs are not anticipated.

As the gas drainage was completed prior to underground mining, impacts associated with surface subsidence have not been considered as part of this final UWIR. Impacts from subsidence induced by mining will remain to be monitored and managed through the EA framework (Conditions F29 and 33).

Part E: Water Monitoring Strategy

OCC's groundwater monitoring program is executed to facilitate an understanding of the groundwater system through collecting groundwater levels and quality information. The monitoring program is completed as a requirement of relevant OCC EA conditions as well as providing data to support the assessment of impacts from operations, including historical gas drainage activities.

OCC will continue with their existing groundwater monitoring program. Further details of OCC's monitoring program, including the network, parameters monitored, and sampling procedure are included in Appendix I.

Part F: Spring Impact Management Strategy

The closest registered spring is 85 km from the OCCMC; therefore, a spring impact management strategy is not required.

8.2 Make Good Obligations and Outstanding Matters

It is not anticipated that any water supply bores will be impacted due to OCC's historical associated water take at PL237 and PL324. No third-party water supply bores are present within the LTAA.

In summary, assessment of the impact associated with OCC's previous gas and water extraction activities at PL237 and PL324 has not identified a requirement for make good obligations.

No outstanding matters as outlined in this report or in previous strategies have been identified.

9 CLOSING

This report is an instrument of service of KCB Australia Pty Ltd (KCB). The report has been prepared for the use of Glencore Oaky Creek Coal (Client) for the specific application to the OCC Final UWIR and may be published or disclosed by the Client to the Queensland Government.

KCB has prepared this report in a manner consistent with the level of care, skill and diligence ordinarily provided by members of the same profession for projects of a similar nature at the time and place the services were rendered; however, the use of this report will be at the user's sole risk absolutely and in all respects, and KCB makes no warranty, express or implied. This report may not be relied upon by any person other than the Client or Queensland Government without KCB's written consent.

Use of or reliance upon this instrument of service by the Client is subject to the following conditions:

1. The report is to be read in full, with sections or parts of the report relied upon in the context of the whole report.
2. The Executive Summary is a selection of key elements of the report. It does not include details needed for the proper application of the findings and recommendations in the report.
3. The observations, findings and conclusions in this report are based on observed factual data and conditions that existed at the time of the work and should not be relied upon to precisely represent conditions at any other time.
4. The report is based on information provided to KCB by the Client or by other parties on behalf of the Client (Client-supplied information). KCB has not verified the correctness or accuracy of such information and makes no representations regarding its correctness or accuracy. KCB shall not be responsible to the Client for the consequences of any error or omission contained in Client-supplied information.
5. KCB should be consulted regarding the interpretation or application of the findings and recommendations in the report.

KCB AUSTRALIA PTY LTD.

REFERENCES

AGE. 2016. 'Oaky Creek 1 Closure - Numerical Groundwater Modelling (G1819)'. AGE.

———. 2017. 'Oaky Creek Underground Water Impact Report - 2017 Annual Review'.

———. 2018. 'Oaky Creek Underground Water Impact Report - 2018 Annual Review'.

———. 2019. 'Oaky Creek Underground Water Impact Report - 2019 Annual Review'.

BlueSphere. 2015. 'Oaky Creek Underground Water Impact Report'. Prepared by BlueSphere Environmental For Oaky Creek Coal.

BOM. 2005. 'Climate Classification of Australia'. Australian Government Bureau of Meteorology. http://www.bom.gov.au/jsp/ncc/climate_averages/climate-classifications/index.jsp?maptype=kpngrp#maps.

———. 2021. 'Climate Statistics'.

DES. 2018a. 'Guideline: Water Act 2000 - Underground Water Impact Reports and Final Reports'. ESR/2016/2000 Version 3.02. Queensland Government, Department of Environment and Science. https://environment.des.qld.gov.au/__data/assets/pdf_file/0036/88398/rs-gl-uwir-final-report.pdf.

———. 2018b. 'Queensland Groundwater Dependent Ecosystems and Potential GDE Aquifer Mapping, Version 1.5'. State of Queensland, Department of Environment and Science. https://wetlandinfo.ehp.qld.gov.au/wetlands/ecology/aquatic-ecosystems-natural/groundwater-dependent/.

DNRME. 2018a. 'Detailed Surface Geology - Queensland'. State of Queensland, Department of Natural Resources, Mines and Energy.

———. 2018b. 'Queensland Globe - Detailed Surface Geology. Department of Natural Resources, Mines and Energy.' May 2018. https://qldglobe.information.qld.gov.au/.

———. 2020. 'Queensland Groundwater Database - October 2020'. Queensland Government, Department of Natural Resources, Mines and Energy.

DoEE. 2015. 'Modelling Water-Related Ecological Responses to Coal Seam Gas Extraction and Coal Mining'. Canberra: Commonwealth of Australia, Department of the Environment and Energy.

Eamus, D, R Froend, R Loomes, G Hose, and B Murray. 2006. 'A Functional Methodology for Determining the Groundwater Regime Needed to Maintain the Health of Groundwater-Dependent Vegetation'. *Australian Journal of Botany* 54: 97–114.

Green, PM. 1997. 'The Surat and Bowen Basins, South-East Queensland'. *Brisbane: Queensland Department of Mines and Energy*.

KCB. 2018. 'Grasstree Extension Project'. Prepared by Klohn Crippen Berger Ltd for Hansen Bailey Pty Ltd.

———. 2020. 'Oaky Creek Underground Water Impact Report'.

———. 2022. 'Underground Water Impact Report Update'.

Korsch, RJ, and JM Totterdell. 2009. 'Subsidence History and Basin Phases of the Bowen, Gunnedah and Surat Basins, Eastern Australia'. *Australian Journal of Earth Sciences* 56 (3): 335–53.

OGIA. 2016. 'Hydrogeological Conceptualisation Report for the Surat Cumulative Management Area'. State of Queensland, The Office of Groundwater Impact Assessment, Department of Natural Resources and Mines.

Richardson, E, E Irvine, R Froend, P Book, S Barber, and B Bonneville. 2011. 'Australian Groundwater Dependent Ecosystems Toolbox Part 2: Assessment Tools'. Canberra: National Water Commission.

SRK. 2016. 'Oaky Creek Coal UWIR Annual Review'.

State of Queensland. 2011. 'Environmental Protection (Water) Policy 2009. Mackenzie River Sub-Basin Environmental Values and Water Quality Objectives Basin No. 130 (Part), Including All Waters of the Mackenzie River Sub-Basin'.

———. 2020a. *Petroleum and Gas (Production and Safety) Act 2004*. https://www.legislation.qld.gov.au/view/pdf/current/act-2004-025.

———. 2020b. *Environmental Protection (Water and Wetland Biodiversity) Policy 2019*. https://www.legislation.qld.gov.au/view/html/inforce/current/sl-2019-0156.

———. 2021a. *Water Act 2000*. https://www.legislation.qld.gov.au/view/pdf/inforce/current/act-2000-034.

———. 2021b. *Mineral Resources Act 1989*. https://www.legislation.qld.gov.au/view/pdf/inforce/current/act-1989-110.

———. 2022. *Environmental Protection Act 1994*. https://www.legislation.qld.gov.au/view/pdf/inforce/current/act-1994-062.

APPENDIX I

OCC Monitoring Network Details

Appendix I OCC Monitoring Program

Table I-1 Summary of Groundwater Chemistry Parameters

Parameter group	Parameters
Field results	pH, EC
Physical	pH, Conductivity, TDS
Major Ions	Ca, Mg, Na, K, HCO_3, CO_3, SO_4, Cl
Nutrients	NO_2, NO_3, NH_3, total N
Dissolved Metals	Al, As, Ba, Be, B, Cd, Co, Cr, Cu, Fe, Hg, Ni, Pb, Mn, Mo, Se, Ag, U, V, Zn)
Total Metals	Al, As, Ba, Be, B, Cd, Co, Cr, Cu, Fe, Hg, Ni, Pb, Mn, Mo, Se, Ag, U, V, Zn
Organics	TPH (C6-C36), TRH (C6-C40) / BTEX

Table I-2 Groundwater Monitoring Bores at OCC

Monitoring Bore	Easting[1]	Northing[1]	Elevation (mAHD[2])	Screen from	Screen to	Lithology	Hydrogeology Unit
BH6	653162	7448360	178.42	2.5	5.5	Clayey Sand / Sandy Clay	Quaternary Alluvium
BH7	653400	7448529	174.12	2.5	5.5	Sand	Quaternary Alluvium
RO1	652306	7449095	179.65	5.5	8.5	Sandy Clay	Quaternary Alluvium
RO2	653530	7448480	173.64	6	9	Sandy Clay	Quaternary Alluvium
RO3 (RO2A)	653551	7448581	177.52	12.4	15.4	Sandy Clay / Clay	Quaternary Alluvium
RO4 (RO2B)	653476	7448480	177.08	11.6	14.6	Silty Clay / Sand Clay	Quaternary Alluvium
RO5 (RO2C)	653605	7448416	178.35	9	12	Clay / Sandy Clay	Quaternary Alluvium / Tertiary Sediments
RO6 (RO2D)	653435	7448629	177.08	9	12	Clay / Sandy Clay	Quaternary Alluvium
RO8 (RO4)	656009	7449226	166.62	8	11	Sandy Clay / Sand	Quaternary Alluvium
BH11	656803	7449591	169.74	7.8	13.8	Sandy clay	Tertiary Sediments
RO9 (RO5)	663217	7448720	155.74	15	18	Clay / Sand / Sandy Clay	Tertiary Sediments
BH10	653900	7449840	190.71	23	20	Weathered Sandstone / Siltstone / Fresh Siltstone	Permian Coal Measures
BH12	652249	7450070	181.61	21	30	Sandstone	Permian Coal Measures
BH13	652112	7445919	184.47			Unknown	Permian Coal Measures
BH14	650952	7445614	190.21			Unknown	Permian Coal Measures
BH15	651486	7447290	196.99	15.5	18.5	Siltstone	Permian Coal Measures
BH16a	655137	7449540	177.82	9	12	Sandstone / Coal	Permian Coal Measures
BH16b	655139	7449548	177.82	77	80	Siltstone / Coal	Permian Coal Measures
BH17a	657155	7448136	168.25	42	45	Siltstone / Coal	Permian Coal Measures
BH17b	657156	7448141	168.25	75	78	Siltstone / Coal	Permian Coal Measures
BH19	653706	7452712	189.83	16	19	Siltstone	Permian Coal Measures
BH2	651262	7447640	195.88	13	19	Siltstone	Permian Coal Measures
BH20a	654907	7451203	177.37	18	21	Sandstone / Coal	Permian Coal Measures

Monitoring Bore	Easting[1]	Northing[1]	Elevation (mAHD[2])	Screen from	Screen to	Lithology	Hydrogeology Unit
BH20b	654915	7451208	177.37	97	100	Sandstone / Coal	Permian Coal Measures
BH21a	667144	7451926	151.33	200	203	Siltstone / Coal	Permian Coal Measures
BH21b	667135	7451928	151.33	233	236	Siltstone / Coal	Permian Coal Measures
BH21c	667140	7451936	151.33	309	312	Siltstone / Coal	Permian Coal Measures
BH22a	657386	7444188	186.99	133	136	Siltstone / Coal	Permian Coal Measures
BH22b	657394	7444185	186.99	207	210	Siltstone / Coal	Permian Coal Measures
BH22c	657388	7444183	186.99	106	109	Siltstone / Coal	Permian Coal Measures
BH23a	651405	7444472	188.37	32	35	Coal	Permian Coal Measures
BH23b	651402	7444464	188.37	70	73	Coal	Permian Coal Measures
BH23c	651396	7444470	188.59	129	132	Coal	Permian Coal Measures
BH24a	648759	7443456	203.08	25	28	Siltstone / Coal	Permian Coal Measures
BH24b	648754	7443451	203.18	120	123	Siltstone / Coal	Permian Coal Measures
BH25	648099	7445015	216.18	35.3	38.3	Siltstone / Coal	Permian Coal Measures
BH26a	661993	7453049	160.4	168	171	Coal and Sandstone	Permian Coal Measures
BH26b	661996	7453041	160.4	92	95	Interbedded Sandstone / Siltstone / Coal	Permian Coal Measures
BH26c	661987	7453042	160.4	52	55	Interbedded Sandstone / Siltstone / Coal	Permian Coal Measures
BH27a	649940	7444186	201.73	31	34	Siltstone / Coal	Permian Coal Measures
BH27b	649950	7444183	201.5	51	54	Siltstone / Coal	Permian Coal Measures
BH27c	649947	7444192	201.86	131	134	Siltstone / Coal	Permian Coal Measures
BH28	648055	7445939	204.85	12.3	15.3	Siltstone	Permian Coal Measures
BH29	652704	7444032	192.76	169	172	Coal	Permian Coal Measures
BH3	652890	7447039	183.06	10	16	Clay (Weathered Siltstone)	Permian Coal Measures
BH30	6548077	7442777	203.88	245	248	Coal	Permian Coal Measures
BH31	660242	7444740	171.86	158	161	Interbedded Sandstone / Siltstone / Coal	Permian Coal Measures
BH32	661732	7445616	168.71	165	168	Coal	Permian Coal Measures
BH4	652862	7447250	184.46	10.5	16.5	Clayey Sand / Sandy Clay (Weathered Permian)	Permian Coal Measures
BH5	652972	7447100	184.45	17.5	23.5	Weathered Siltstone	Permian Coal Measures
BH8	653763	7449735	179.07	25	31	Siltstone / Sandstone	Permian Coal Measures
BH9	653822	7449953	190.26	23	29	Weathered Siltstone	Permian Coal Measures

Monitoring Bore	Easting[1]	Northing[1]	Elevation (mAHD[2])	Screen from	Screen to	Lithology	Hydrogeology Unit
RO7 (RO3)	656242	7446681	171.87	12.5	15.5	Sandstone	Permian Coal Measures

[1] Coordinates are in GDA94 Zone 55
[2] mAHD – meters above Australian Height Datum
[3] mbGL - meters below ground level

APPENDIX II

Numerical Groundwater Model

Appendix II
Numerical Groundwater Model

II-1 MODEL OBJECTIVES

A numerical groundwater model has been constructed to support the preparation of a Final Underground Water Impact Report (UWIR) for the Oaky Creek Coal Mining Complex (OCCMC), with the objectives of assessing changes in groundwater levels as part of their water extraction activities on PL324 and PL237 prior to November 2022.The objectives of the modelling include:

- Assess changes to local and regional groundwater flow patterns due to the dewatering associated with underground mine development at OCC; and
- Assess Project-specific drawdown on groundwater resources, users, and the environment.

The numerical groundwater model has been used to identify the potential Long-Term Affected Areas (LTAA) resulting from the previous development of the OCCMC:

- A LTAA is defined under the *Water Act 2000* (State of Queensland 2021) as an area where the water level in an aquifer is predicted to decline by more than the bore trigger threshold, at any time due to the extraction of water associated with resource operations.

The numerical groundwater model has been constructed and simulated with consideration of the Australian Groundwater Modelling Guidelines (Barnett et al. 2012).

II-2 MODEL CONSTRUCTION

II-2.1 Model Code

MODFLOW-USG was used as the modelling platform to simulate groundwater flow for this Project. MODFLOW-USG is a centre finite volume code, which supports the construction of structured and unstructured model grids and contains robust solution methods and simulation capabilities, including the ability to handle complex, variably saturated / unsaturated flow. This enables effective representation of features such as river flow, water storages, in-pit storage interaction with the groundwater regime and localised subsidence-induced fracturing.

II-2.2 Units and Datum

The time unit for the model is days and the length unit is metres. The horizontal datum for the Project is GDA94. The vertical datum is the Australian Height Datum (AHD) in metres.

II-2.3 Model Domain Extents and Cells

The model domain is shown in Figure II-2.1. The area of the model extent is approximately 1,805 km^2. The model boundaries correspond to:

- North: Roper Creek, a local catchment divide;

- East: Roper Creek (east of existing mines);
- West: local catchment divide; and
- South: Cooroora Creek and a local catchment of Oaky Creek.

The external model boundaries are represented using General Head Boundaries (GHB). These boundaries represent regional groundwater levels at the model extents and provide/control groundwater flux to/from the model domain. This approach was adopted because the modelled system boundaries do not represent the terminal groundwater flow system boundaries and were part of a more regional groundwater system.

The numerical model uses a USG quadtree refinement approach to generate an irregular mesh shown in Figure II-2.1. The range of model grid cell sizes are between 50 m and 400 m and the total number of active cells is ~53,700. The mesh/grid is refined in the areas of the mining operations, spoils (waste rock), watercourses (Oaky Creek, Sandy Creek, Bul Bul Creek, Cattle Creek, Roper Creek and Cooroora Creek) and surface water storage features (e.g., dams).

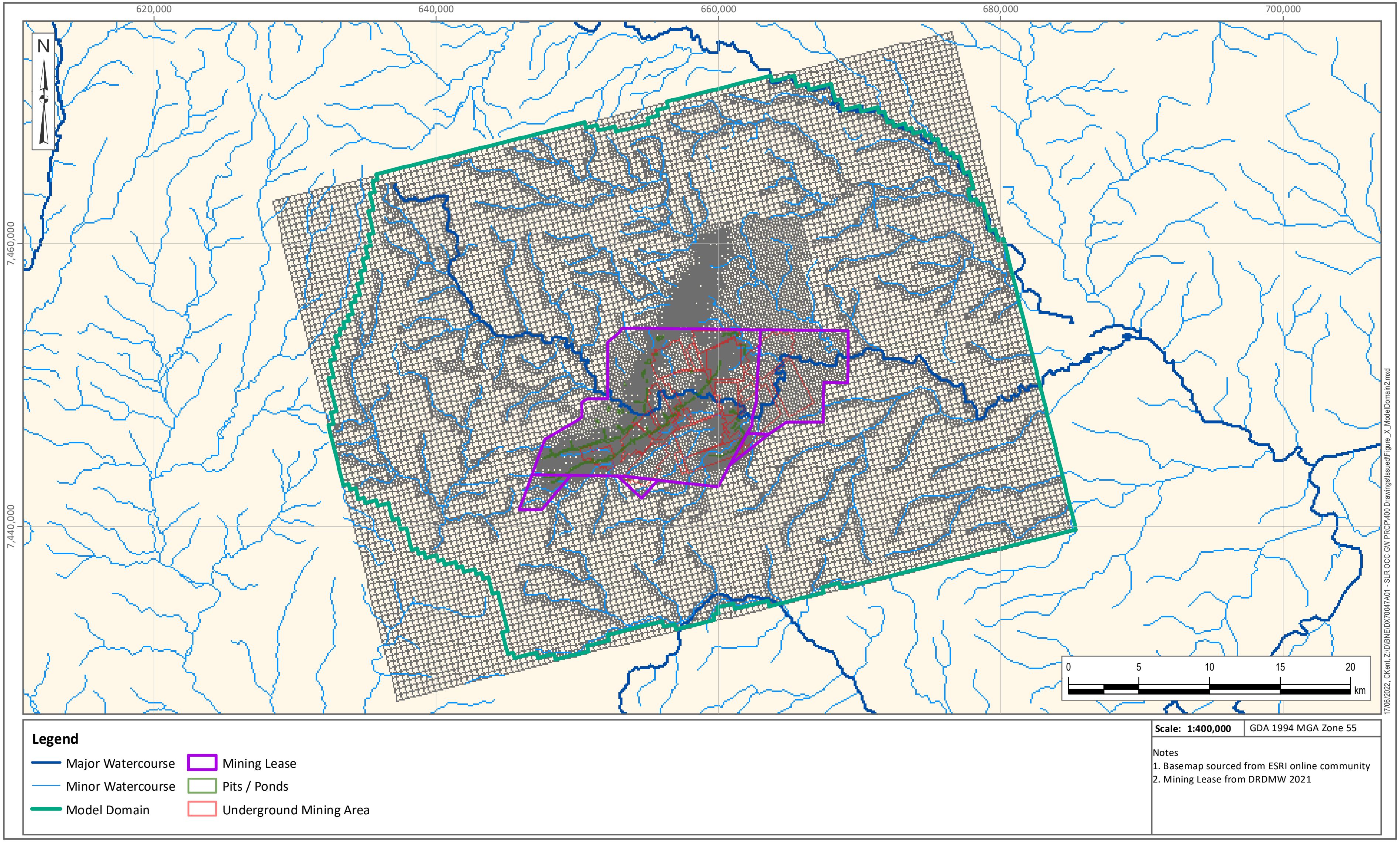

Figure II-2.1 Model Domain and Grid Refinement

II-2.4 Model Layering

Fourteen (14) model layers were required to adequately represent the hydrostratigraphic units and subsidence-fracture zones that have developed above the longwall panels. The model layers for this assessment are summarised in Table II-2.1.

The model layering was based on the OCCMC geological model, which incorporated the entire mining lease area. Outside of the mining lease area, the geological model was supplemented with data from the Queensland Groundwater Database (GWDB). Figure II-2.2, Figure II-2.3 and Figure II-2.4 present the base elevation of the model layers. The top surface of the model was constructed based on the 2021 LiDAR surface for the mining area, supplemented by the Queensland one second digital elevation model (DEM) outside of the Mine area.

Table II-2.1 Model Layers

<table>
<tr><th>Model Layer</th><th colspan="2">Proposed Layer Represented Geological Units</th></tr>
<tr><td rowspan="2">1</td><td colspan="2">Quaternary Alluvium (where present)</td></tr>
<tr><td colspan="2">Tertiary Sediments (where no Alluvium)</td></tr>
<tr><td>2</td><td colspan="2">Tertiary Regolith (weathered)</td></tr>
<tr><td>3</td><td>Fairhill Formation</td><td rowspan="10">German Creek Formation in the northwest outcrop area</td></tr>
<tr><td>4</td><td>Macmillan Formation</td></tr>
<tr><td>5</td><td>German Creek Formation interburden</td></tr>
<tr><td>6</td><td>Aquila Seam</td></tr>
<tr><td>7</td><td>German Creek Formation interburden</td></tr>
<tr><td>8</td><td>Tieri Seam</td></tr>
<tr><td>9</td><td>German Creek Formation interburden</td></tr>
<tr><td>10</td><td>Corvus Seam</td></tr>
<tr><td>11</td><td>German Creek Formation interburden</td></tr>
<tr><td>12</td><td>German Creek Seam</td></tr>
<tr><td>13</td><td colspan="2">German Creek Formation underburden</td></tr>
<tr><td>14</td><td colspan="2">German Creek Formation underburden</td></tr>
</table>

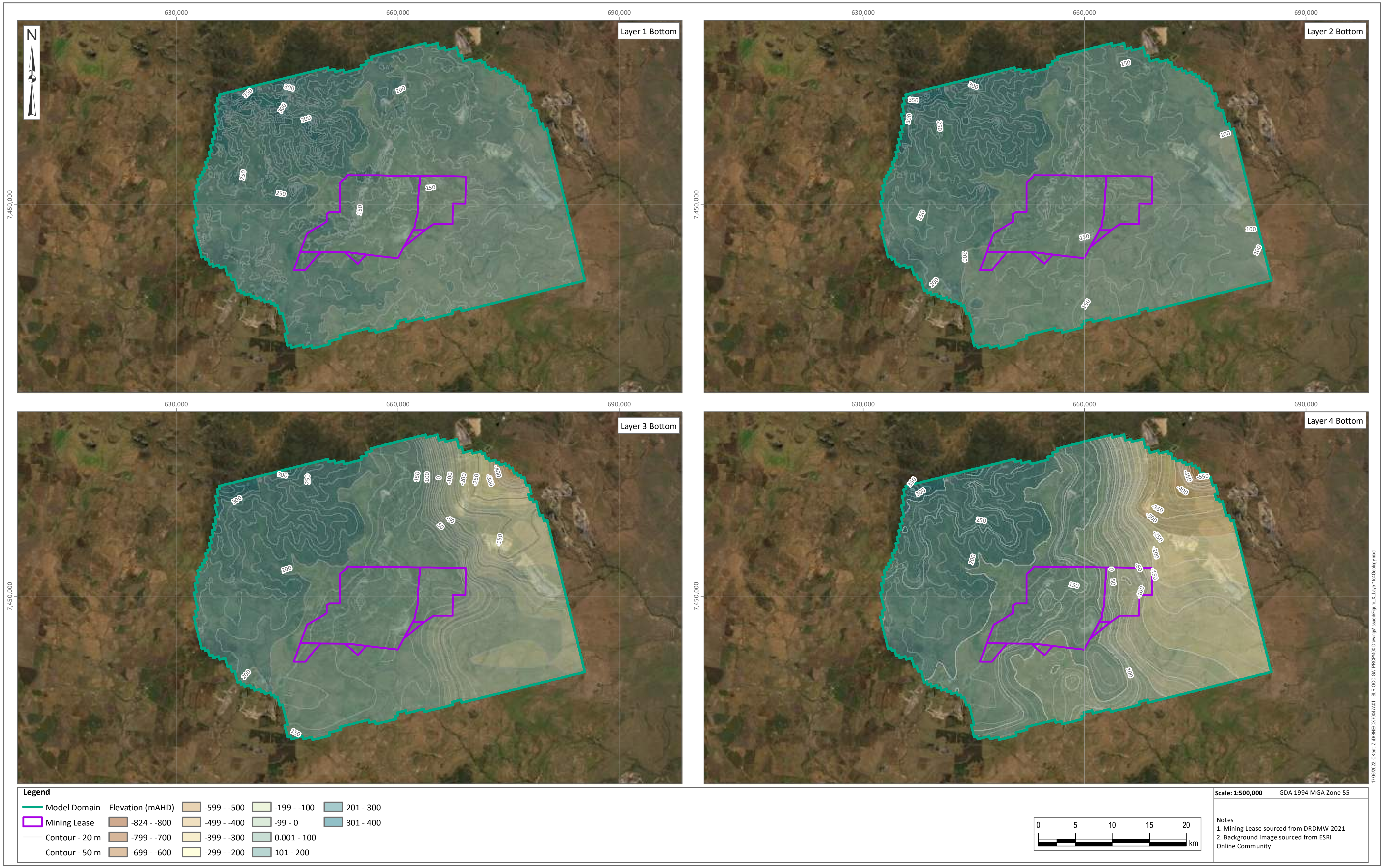

Figure II-2.2 Base Elevation of Layers 1 to 4

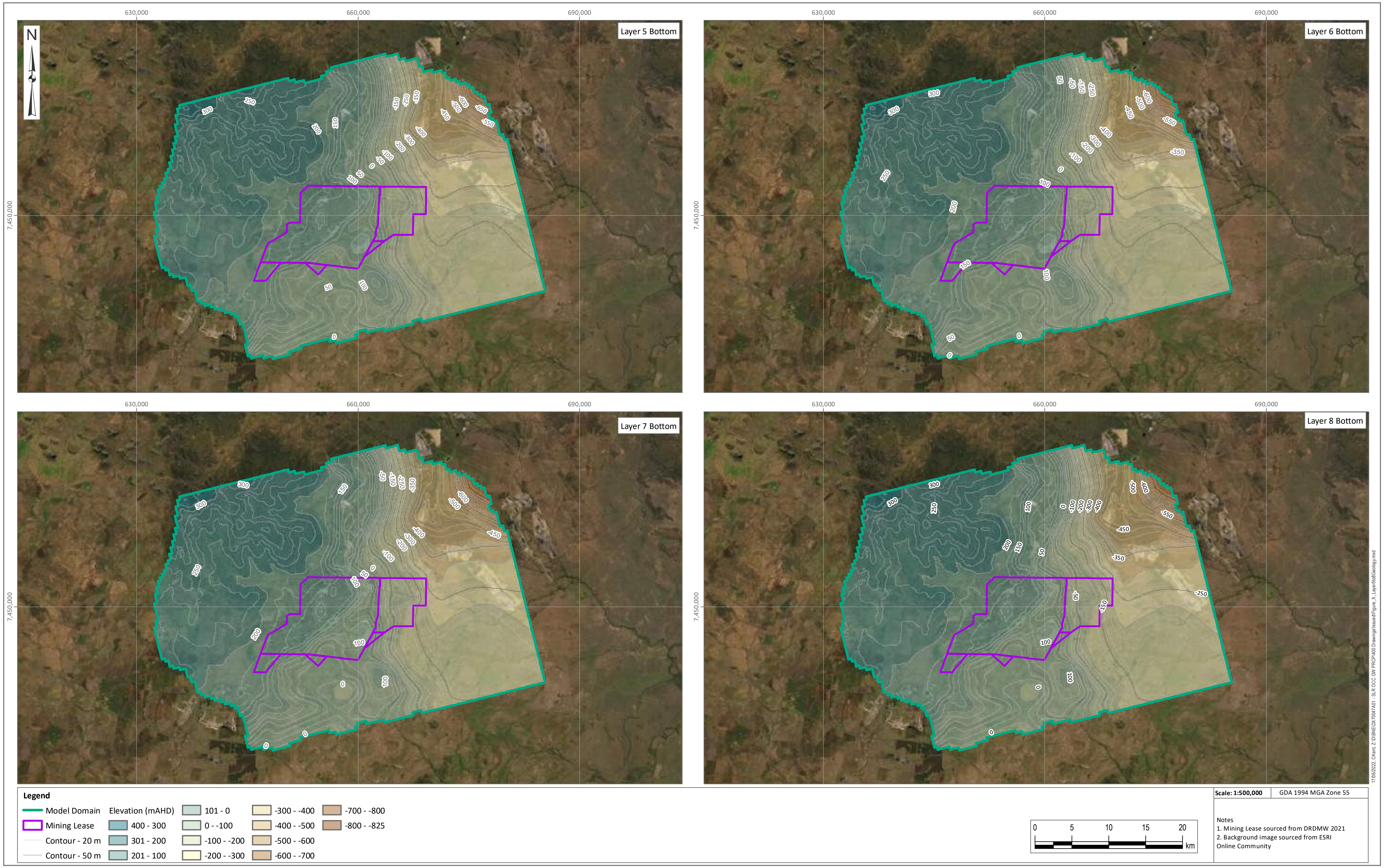

Figure II-2.3 Elevation of Layers 5 to 8

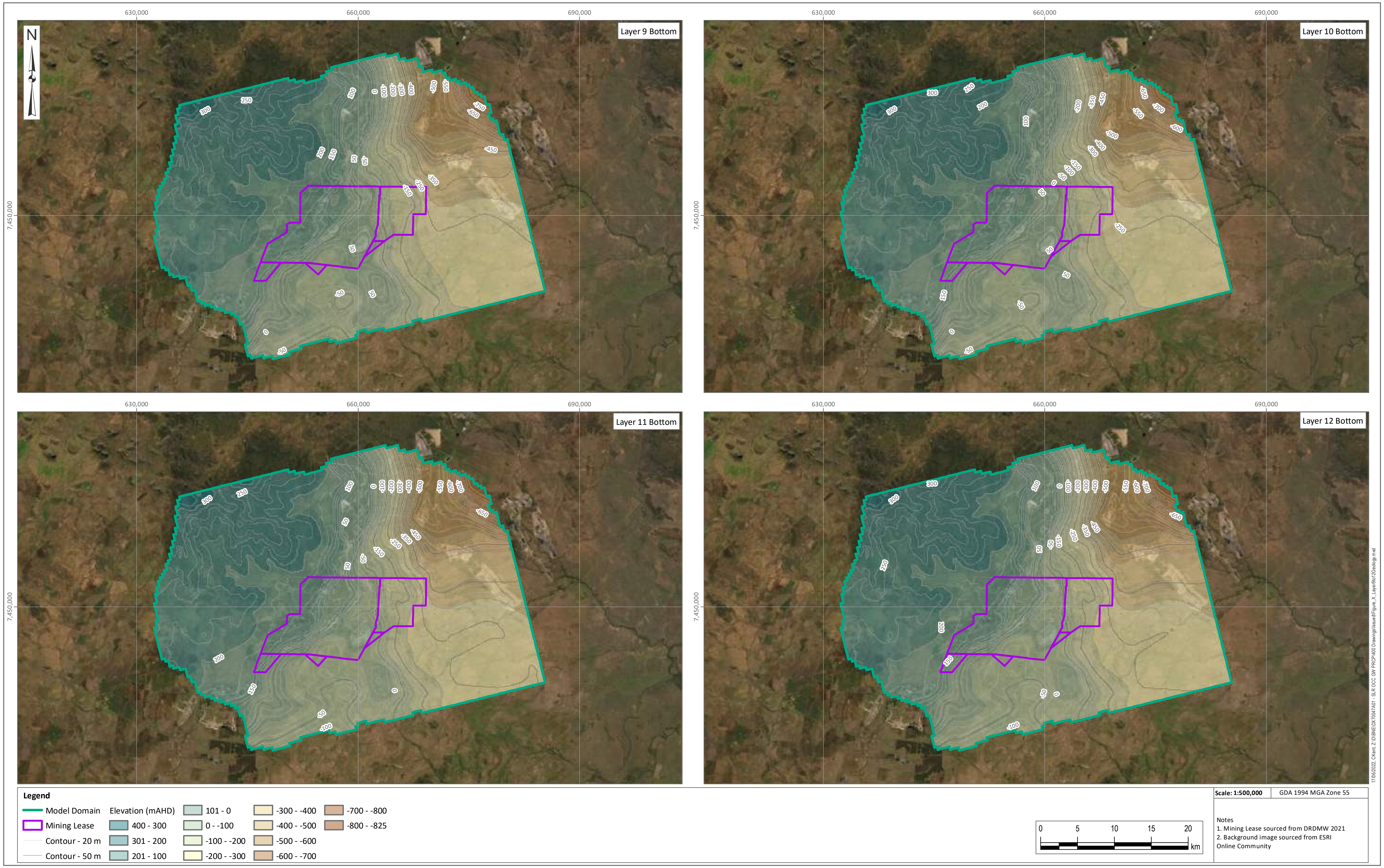

Figure II-2.4 Elevation of Layers 9 to 12

II-2.5 Boundary Conditions

Boundary conditions are mathematical statements within the model domain and along boundaries of the domain that specify the dependent variable (head) or the derivative of the dependent variable (flux). The following boundary conditions were established in the model:

Recharge

Recharge across the model domain was assigned at surface and zoned to account for varying rates across the different geological units. The zonation of recharge is shown on Figure II-2.5.

Recharge rates are defined and calibrated as a percentage of annual rainfall. A rate of <5% of mean annual rainfall is targeted based on previous modelling studies in the vicinity of the Project area (AGE 2016; KCB 2018). A slightly higher recharge rate is assigned to surficial alluvium to account for leakage from drainage during seasonal rainfall events.

Evapotranspiration

Evapotranspiration was applied to Layer 1 using the EVT package. Similar to the recharge, the evapotranspiration zones were defined in terms of surficial units. The evapotranspiration rate for each zone was calibrated with PEST in the range between 70 mm/annum and 10 mm/annum. These range of values were sourced from the average areal potential evapotranspiration map, which is based on a standard 30-year climatology from 1961-1990 (Chiew et al. 2002). An extinction depth between 0.5 m and 3 m was calibrated and applied in the model.

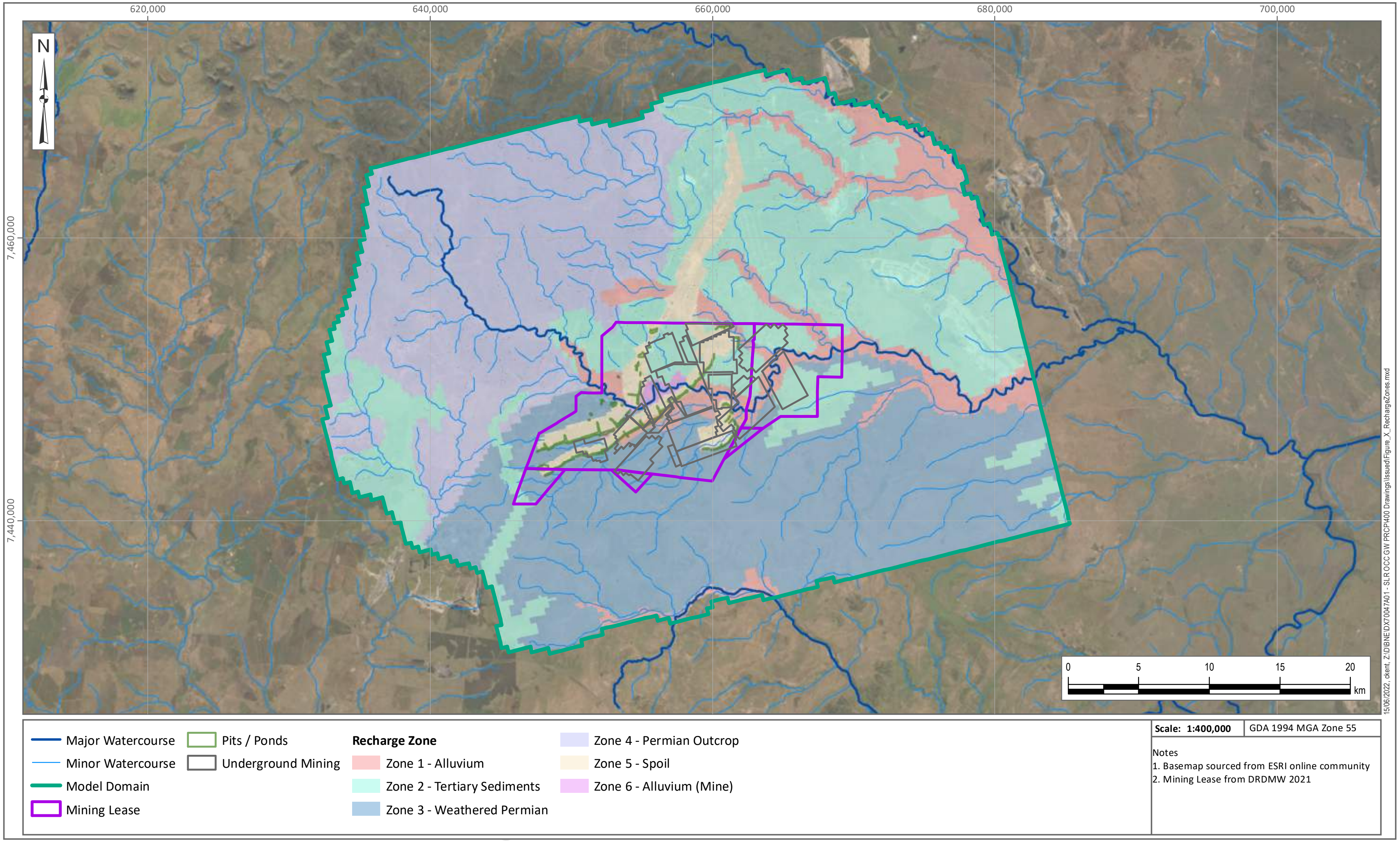

Figure II-2.5 Recharge Zones

Drains

Drains (DRN) are established to represent the underground panels in the historical and future mining areas (Figure II-2.7). The drains are assigned with head elevation equivalent to 0.1 m above the base of the coal seam within each active panel. The timing for activation of the drain cells across the OCCMC and neighbouring mines is shown on Figure II-2.6.

Watercourses across the model domain are simulated using DRN boundaries. This allows groundwater to discharge into the drainage line where the head in the surrounding geological units is above the base of the creek due to rainfall recharge. Where the head in the surrounding groundwater is below the base of the creek a MODFLOW drain does not contribute any flux into groundwater. This boundary condition has been applied to the drainage lines within the model domain due to the ephemeral nature of surface water drainage across the Project site and the lack of surface water flow contribution to the underlying groundwater system.

General Head

Water storages including dams and voids are modelled using GHB to represent the interaction between surface water and groundwater. The available data for the water levels are shown in Figure II-2.8. Prior to 2015, no data was available. In the absence of data, the voids were assumed to be dry at the end of mining (at the elevation of the coal seam) and assumed to recover linearly to the 2015 levels.

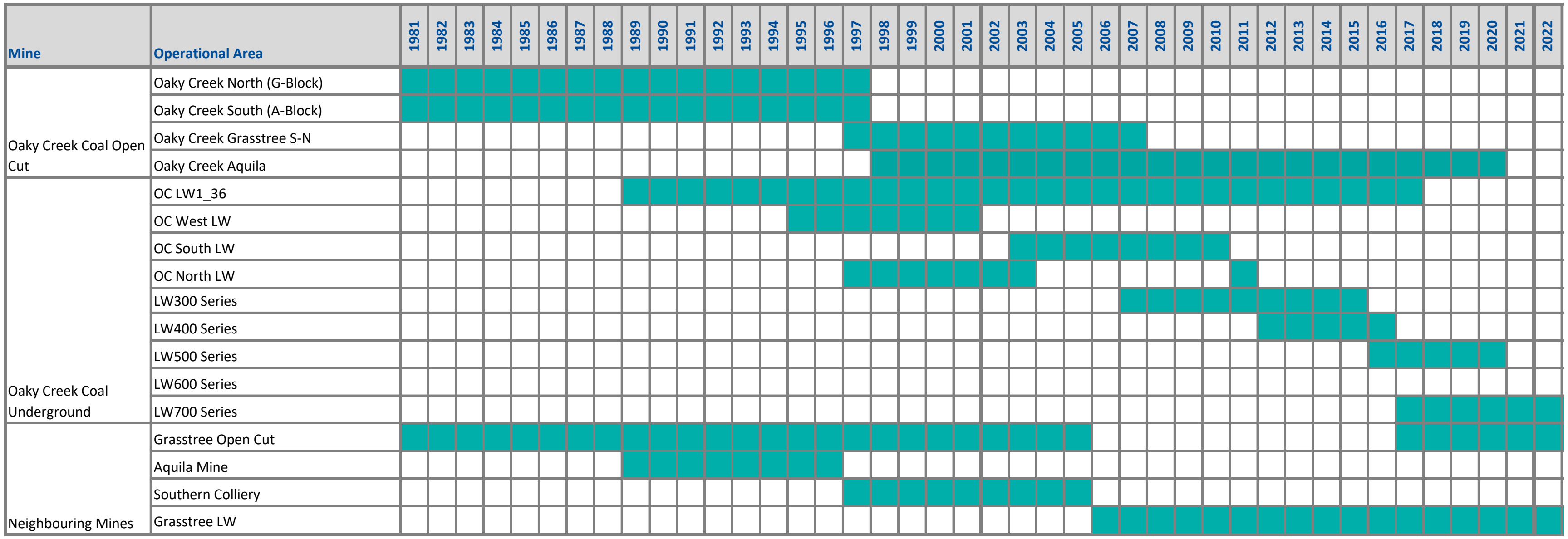

Figure II-2.6 Mining Sequence at OCC and Neighbouring Mines

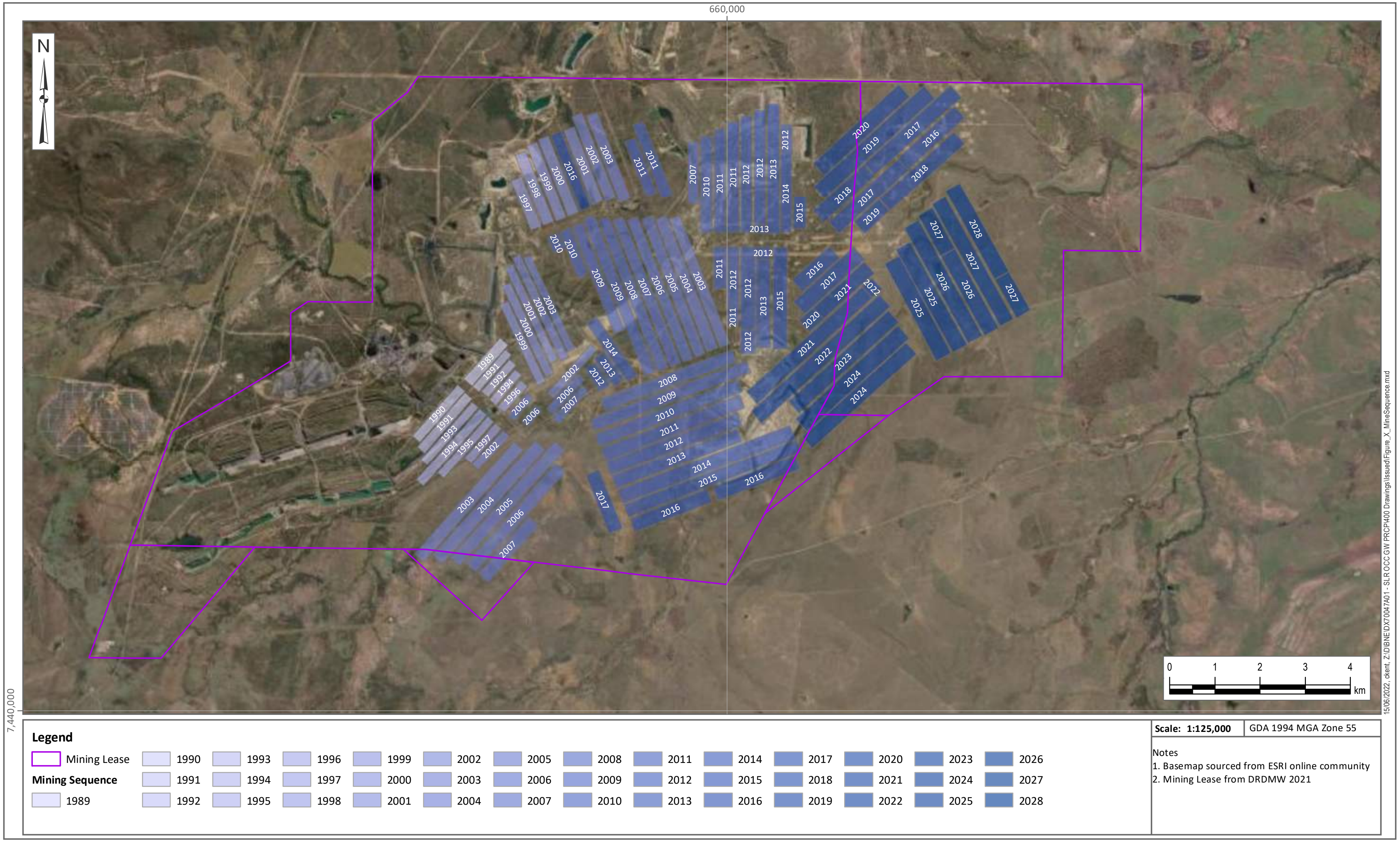

Figure II-2.7 Historical and Future Mining Areas (only mining areas up until 2022 were included)

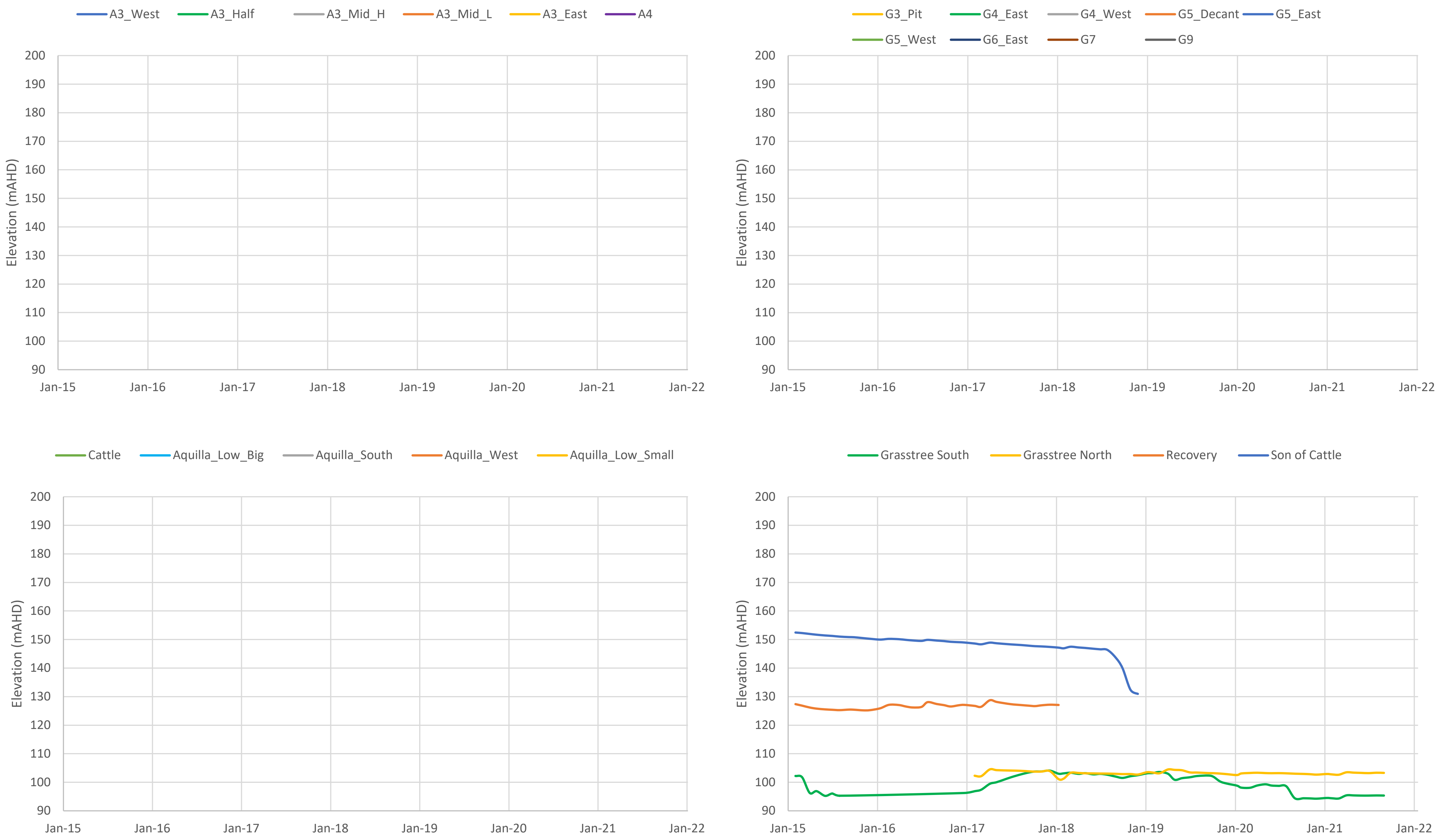

Figure II-2.8 Void Levels (2015 to 2021)

II-2.6 Model Timing and Stress Periods

The calibration model simulating the early OCCMC development period between January 1981 and December 2001 comprises 84 seasonal/quarterly stress periods. The calibration model simulating the period 2002 to 2021 comprises 131 stress periods which includes 52 seasonal/quarterly stress periods from January 2002 to December 2014 and 79 monthly stress periods from January 2015 to July 2021. The model stress periods were rationalised based on the mining sequence (Figure II-2.6) and the available in-pit levels and groundwater monitoring data.

II-2.7 Initial Material Parameters

Initial model parameters were considered from two previous groundwater models within the vicinity of the OCCMC (AGE 2016; KCB 2018). Table II-2.2 summarises the hydraulic conductivity parameters from the AGE model (2016) and the 2018 Grasstree Mine model (KCB 2018), which also included portions of the OCCMC. These values were assigned as the initial values and adjusted (judiciously) through the model calibration process.

Table II-2.2 Reference Hydraulic Conductivity Values

Proposed Model		AGE Model (2016)		Grasstree Model (2018)	
Zone	Unit	Kh (m/d)	Kv (m/d)	Kh (m/d)	Kv (m/d)
1	Alluvium (where present)	1.123	0.1123	1.12	0.11
2	Sediments (where no Alluvium)	0.199	0.0199	0.1	0.02
3	Tertiary Regolith (weathered)	0.014	0.0141	0.05	0.01
4	Fairhill Formation	0.02	0.002	0.004	0.0005
5	Macmillan Formation	0.02	0.002	0.007	0.0007
6	Aquila coal seam	0.017	0.0017	0.017	0.0086
7	Interburden	0.009	0.0009	0.005	0.0005
8	Tieri Coal Seam	-	-	0.005	0.0005
9	Interburden	0.005	0.0005	0.005	0.0005
10	Corvus Seam	-	-	0.013	0.0086
11	Interburden	0.005	0.0005	0.003	0.0003
12	German Creek coal seam	0.008	0.0008	0.01	0.0086
13	Underburden / Basement	0.005	0.0005	0.002	0.0002
14	Spoil	0.1	0.04	1.0	0.1
15	Void	1000	1000	100	100
	Fracturing zone	1.0	0.1	0.1~1.28	0.1~1.34

Previous model parameters for storage are summarised in Table II-2.3. Storage parameters are not considered in steady state models but will be adjusted within reasonable limits during transient calibration.

Table II-2.3 Reference Storage Parameters

Proposed Model		AGE Model (2016)		Grasstree Model (2018)	
Zone	Unit	Sy	Ss (1/m)	Sy	Ss (1/m)
1	Alluvium (where present)	0.1	0.001	0.1	0.001
1	Sediments (where no Alluvium)	0.1	0.001	0.01	0.0001
2	Tertiary Regolith (weathered)	0.1	0.001	0.01	1.0×10^{-5}
3	Fairhill Formation	0.005	5.0×10^{-5}	0.002	5.0×10^{-5}
4	Macmillan Formation	0.005	5.0×10^{-5}	0.001	1.0×10^{-5}
5	Aquila coal seam	0.001	1.0×10^{-5}	0.005	5.0×10^{-5}

Proposed Model		AGE Model (2016)		Grasstree Model (2018)	
Zone	Unit	Sy	Ss (1/m)	Sy	Ss (1/m)
6	Interburden	0.001	$1.0x10^{-5}$	0.001	$1.0x10^{-5}$
7	Tieri Coal Seam	-	-	0.005	$5.0x10^{-5}$
8	Interburden	0.001	$1.0x10^{-5}$	0.001	$1.0x10^{-5}$
9	Corvus Seam	-	-	0.005	$5.0x10^{-5}$
10	Interburden	0.001	$1.0x10^{-5}$	0.001	$1.0x10^{-5}$
11	German Creek coal seam	0.001	$1.0x10^{-5}$	0.003	$5.0x10^{-5}$
12	Underburden	0.001	$1.0x10^{-5}$	0.001	$1.0x10^{-5}$
13	Spoil	0.1	$1.0x10^{-4}$	0.1	$1.0x10^{-4}$
14	Void	1.0	$5.0x10^{-6}$	1	$5.0x10^{-4}$
15	Fracture Zone (goaf)	0.6	$5.0x10^{-6}$	0.1~0.5	$5.0x10^{-5}$

II-3 FRACTURE ZONE APPROACH

Subsidence fracturing, which occurs as a result of longwall panel development, is represented in the model. Continuous cracking heights and extents were assessed based on reviewed literature and KCB's previous experience. In a previous study at OCCMC, a fracture extent height of 90 m to 110 m above the target seam was predicted (Seedman Geotechnics 2011). The approach to representing continuous fracturing comprised:

- A ramp function was used to represent continuous fracturing. Permeability within the fracture zone is assumed to increase by a factor of 10 to 100 relative to the host rock (nominal assumption to achieve essentially 'free draining' conditions within this zone) (Seedman Geotechnics 2011; Tammetta 2015). The factor was preliminarily calibrated within the fracture zone above the existing underground panels with the measured dewatering rate and groundwater level.
- Geological units that are partially intersected by continuous fracturing are assumed to be fully fractured.

II-4 MODEL CALIBRATION

Model calibration was performed to align the groundwater flow system in the numerical groundwater model with the site observations, through the adjustment and optimisation of model parameters within pre-reviewed data bounds. The calibrated model forms the starting point for the transient predictive simulations used to assess the impact of depressurisation on groundwater system.

II-4.1 Calibration Overview

Development of a preliminary steady state (pre-Mine) model, a verification model and a transient model was included in the calibration process:

- Steady State – to provide initial conditions for the verification model;
- Verification Model – from 1981 to 2001 – limited data; and
- Transient Model – from 2002 to 2021 (calibration).

A preliminary steady state model simulation, which excluded mining operations, was used to establish the initial groundwater levels for the transient calibration. The steady state calibration was considered appropriate for the broad-scale optimisation of hydraulic parameters and boundary conditions. Calibration was performed by applying both an automated PEST approach and a manual trial-and-error approach. Both approaches assumed that all hydraulic parameter values were able to be modified, within realistic/conceptual bounds, to achieve a better calibration fit.

The verification model considered the period January 1981 to December 2001 to account for the influence of early mining operations on the groundwater system. The model was not calibrated as insufficient data was available for the period, however, the model was validated through comparison between the modelled groundwater levels at the end of simulation and the observed levels from early bores (drilled 2002 and 2003) to provide an approximate initial condition for the transient model calibration.

A transient calibration was conducted using a transient model simulation for the period January 2001 to July 2021 to account for the influence of underground mining, void conditions, dewatering and recharge/discharge on the current groundwater system. A transient calibration allowed available time-variant data (e.g., void water levels, dewatering rates, and monitoring groundwater levels) to be simulated in the groundwater model.

The following performance metrics were used to assess the quality of the model calibration:

- The Root Mean Squared (RMS) and Scaled Root Mean Squared (Scaled RMS) Error for the model-predicted versus observed hydraulic heads for 21 monitoring bore locations in steady state model.
- A scatterplot to show systematic/unsystematic nature and magnitude of over-prediction or under-prediction of hydraulic heads at all the calibration targets. A correlation coefficient is calculated to indicate the strength of relationship between observed and computed heads on the scatterplot.
- Hydrographs show the observed and modelled groundwater level variations over time. Vertical hydraulic gradients between coal seam measures and various coal seams are also compared in eight pairs of monitoring locations.
- Groundwater flow budget throughout the calibration process to confirm if the groundwater flow system is honouring the conceptual model.

II-4.2 Calibration Targets

Table II-4.1 presents a summary of the calibration and validation targets by hydrostratigraphic unit for the three modelling stages. Figure II-4.1, Figure II-4.2 and Figure II-4.3 presents the calibration targets used in the steady state, verification, and transient model.

Table II-4.1 Summary of Calibration Targets

Hydrostratigraphic Unit	Number of Calibration Targets		
	Steady State	Verification	Transient
Alluvium	6	2	10
Tertiary/Weathered Regolith	2	0	2
Permian	12	7	28
Permian (German Creek)	1	0	13
Total	21	9	53

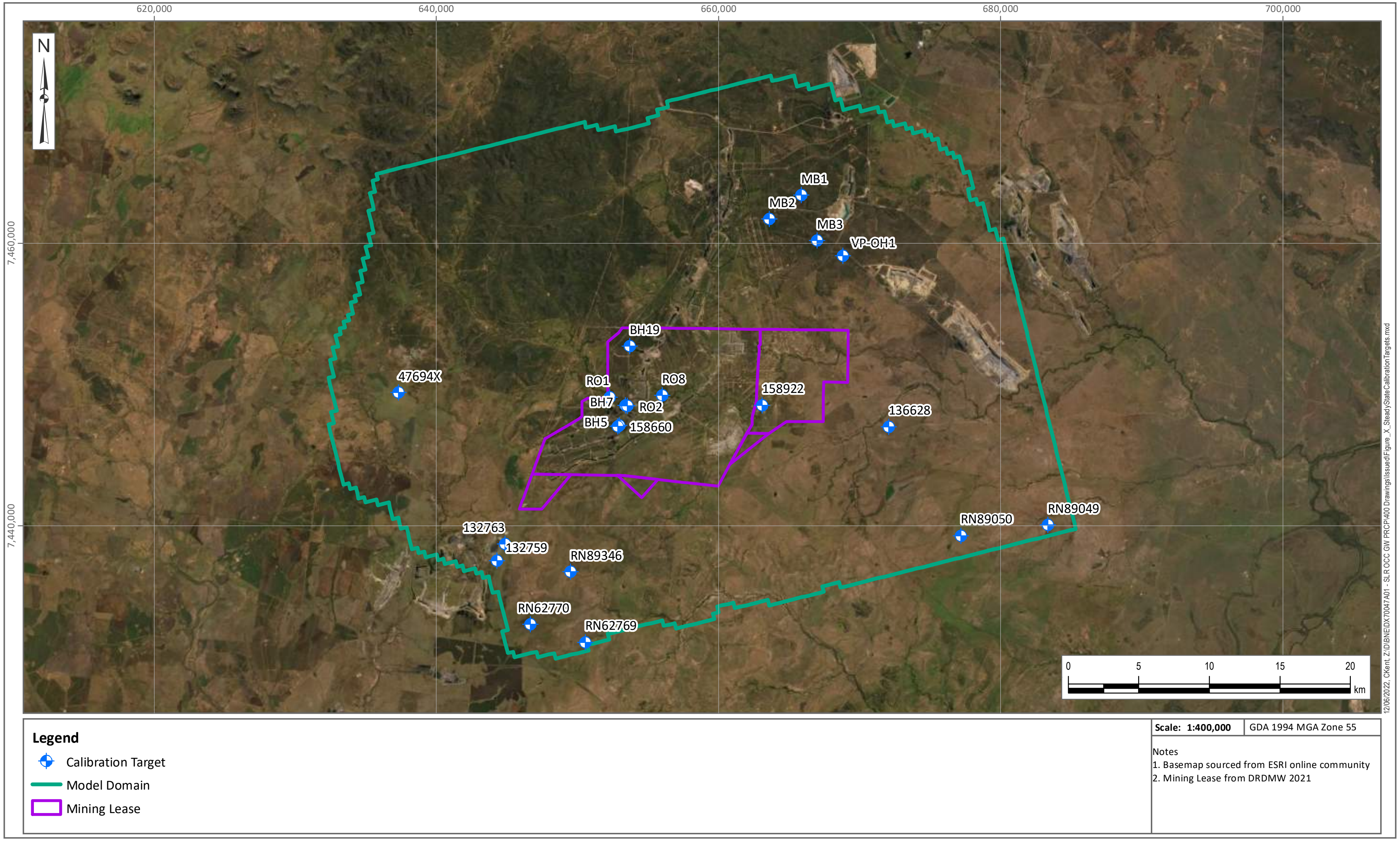

Figure II-4.1 Steady State Model Targets

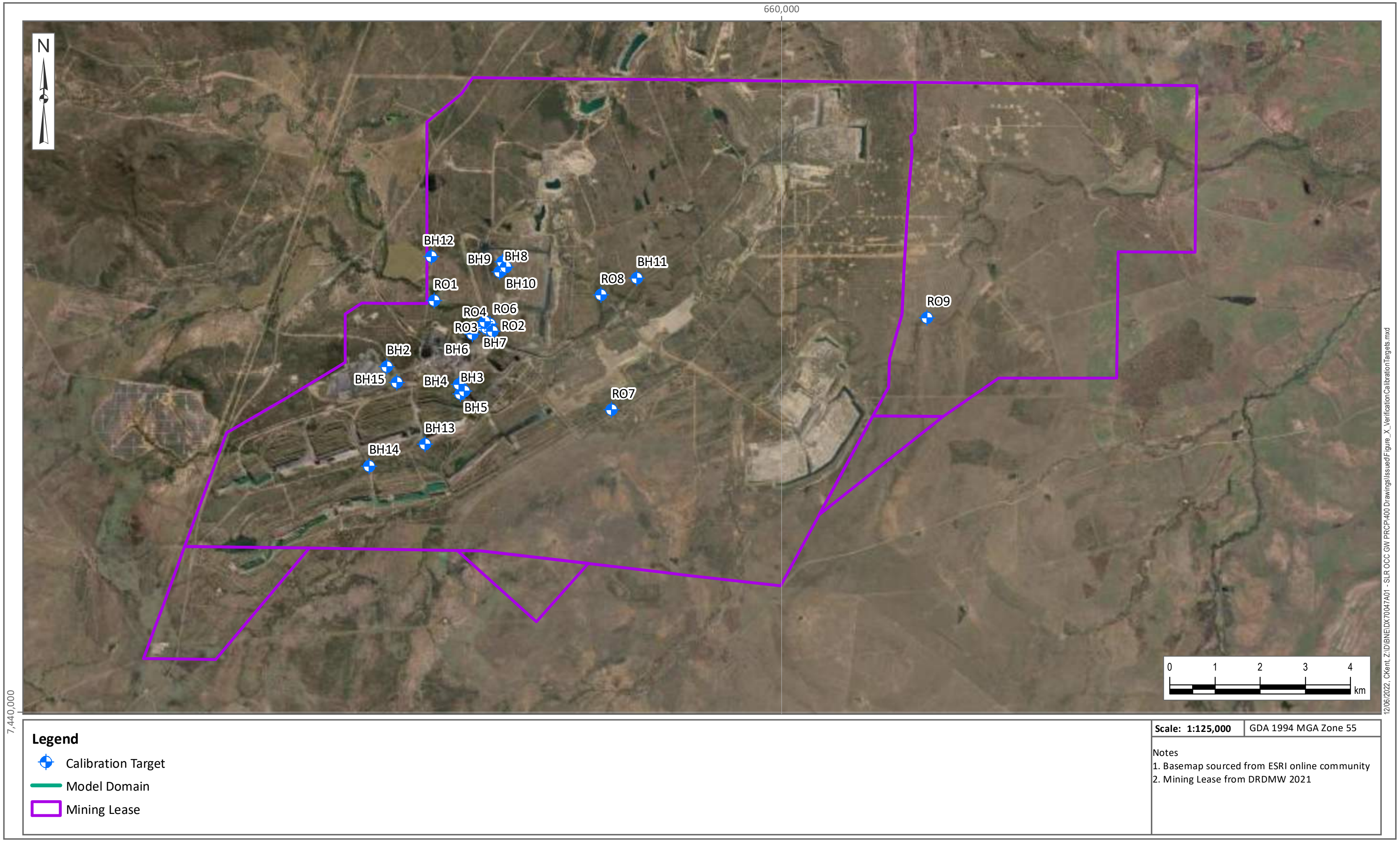

Figure II-4.2 Verification Model Targets

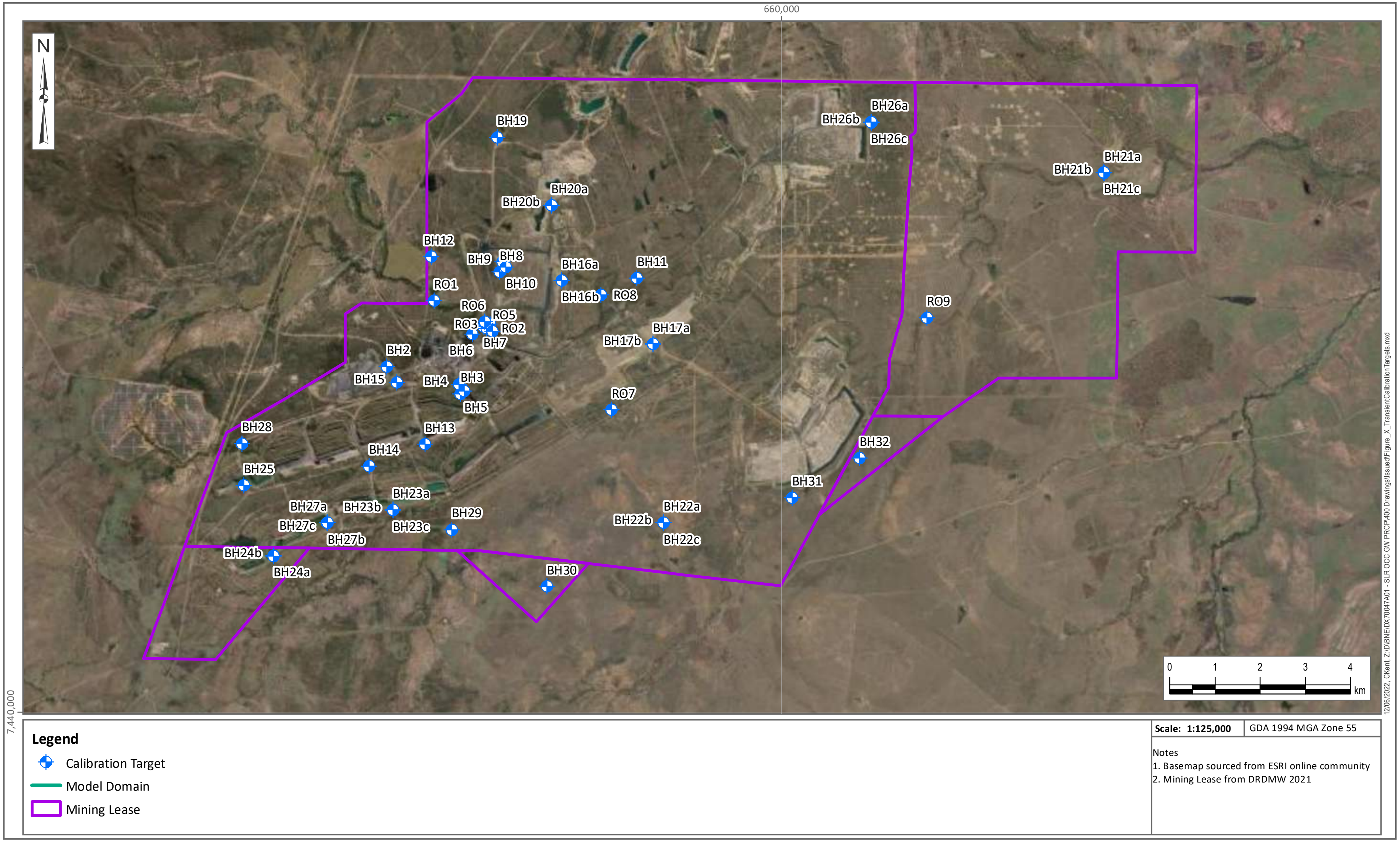

Figure II-4.3 Transient Model Targets

A total of 21 targets were selected and used in the steady state calibration. Limited data was available for the pre-mining period; therefore, data was used, with consideration of: (1) regional bores with a good spatial distribution across the model domain and data as close to 1981 as possible; (2) bores within the mining area with relatively static levels over a period of at least five years.

For the transient calibration period (2002 to 2021), groundwater level data from 53 bores were used as calibration targets (see Figure II-4.3); comprising, ten monitoring bores in the alluvium, two bores in Tertiary sediments and 41 bores installed in the Permian, with records between 2002 and 2016.

II-4.3 Steady State Calibration

The objectives of the steady state calibration were to optimise the hydraulic boundary and hydraulic parameters across the model domain and reduce model uncertainty. The optimisation includes:

- GHBs along the model boundary;
- Hydraulic conductivity for each hydrostratigraphic unit; and
- Preliminary recharge and evapotranspiration rates.

Groundwater levels selected from the 21 bores, including six OCCMC bores, four bores located within the neighbouring Grasstree Mine (KCB 2018) and 11 regional bores from the Department of Regional Development, Manufacturing and Water (DRDMW) Groundwater Database (GWDB) (DRDMW 2021).

Calibration Statistics

A scatter plot of predicted versus observed hydraulic heads is presented in Figure II-4.4. The calibration statistics from the steady state calibration are summarised in Table II-4.2. This table shows the Mean Sum of Residuals (MSR) error values for all the monitoring bores is less than 1 m, the total SRMS value is less than 5%, and the correlation coefficients are higher than 99%; indicating a good agreement between the modelled and measured groundwater levels being achieved.

Table II-4.2 Summary of Steady State Model Calibration

Statistical Metric	Calibration Results
MSR	0.61 (m)
RMS Error	3.63
Scaled RMS	3.4 (%)
Correlation Coefficient	99.4 (%)
Total calibration targets: 21	

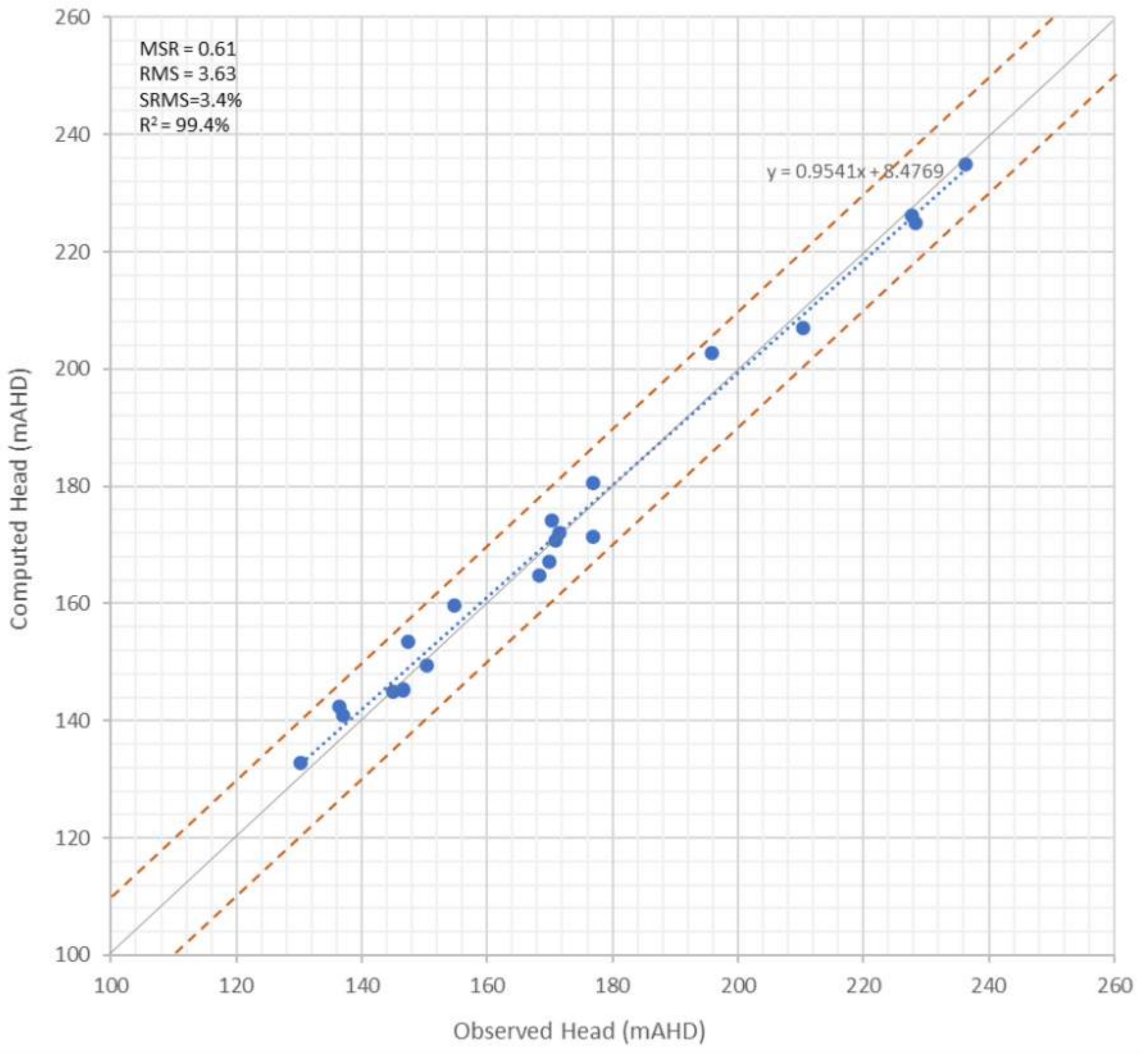

Figure II-4.4 Steady State Calibration - Observed versus Computed Heads

Calibrated Water Budget

The modelled water balance and mass balance error for the steady state calibration simulation defines the difference between model inflows and model outflows. An error of 1%, or less, in a groundwater model water budget is typically considered acceptable for a regional groundwater aquifer system (Anderson and Woessner 1991). The water budget and mass balance error for the steady state calibration simulation are outlined in Table II-4.3. The water balance error is less than the target 0.1% indicating that the model is stable and has an adequate level of accuracy for the simulation of groundwater-related fluxes.

Table II-4.3 Water Budget and Mass Balance Error for Steady State Simulation

Water Budget Item	Inflow (m^3/day)	Outflow (m^3/day)
Recharge	1441.9	-
GHB Throughflow	521.9	451.6
Evapotranspiration	-	1507.4
River Drain	-	4.8
TOTAL	1963.8	1963.8
Mass Balance Error	0.0%	

Calibration Sensitivity

Prior to the transient calibration, PEST calibration runs were conducted. The result of a normalised sensitivity coefficient[1] (NSC) calculated for each model parameter from the final PEST calibration is shown in Figure II-4.5. In this figure, hydraulic conductivity (K) values are referenced to specific hydrostratigraphic units, which have consistent values across the applied volume in the model. K_x and K_z indicate horizontal and vertical K, respectively. Recharge values (RCH) and evapotranspiration (EV) values reference specific recharge and evapotranspiration in the model. Conductance (C) for DRN and GHBs are specified to each reach number. These results indicate:

- Hydraulic conductivities (K_x and K_z) of the alluvium, weathered Permian and Tertiary units are the most sensitive parameters. Variation in those values influence head gradients in shallow aquifers and allow recharge to be transmitted into the groundwater system.
- Recharge rates for alluvium and weathered Permian and DRN boundary conditions for Oaky Creek (C3) and Sandy Creek (C4) are the next most sensitive parameters, which is consistent with the conceptual understanding of the importance of rainfall recharge and leakage into the groundwater system.
- Calibration SRMS is less sensitive to parameters such as conductance in GHB for North and East boundaries and hydraulic conductivity for deeper hydrostratigraphic units. This is due to the availability of monitoring data (less than 10% of target values) in those units, close to the boundaries, used for PEST calibration.

[1] Normalised sensitivity coefficient – a dimensionless number which indicates the sensitivity of the SRMS error to the various model input parameters.

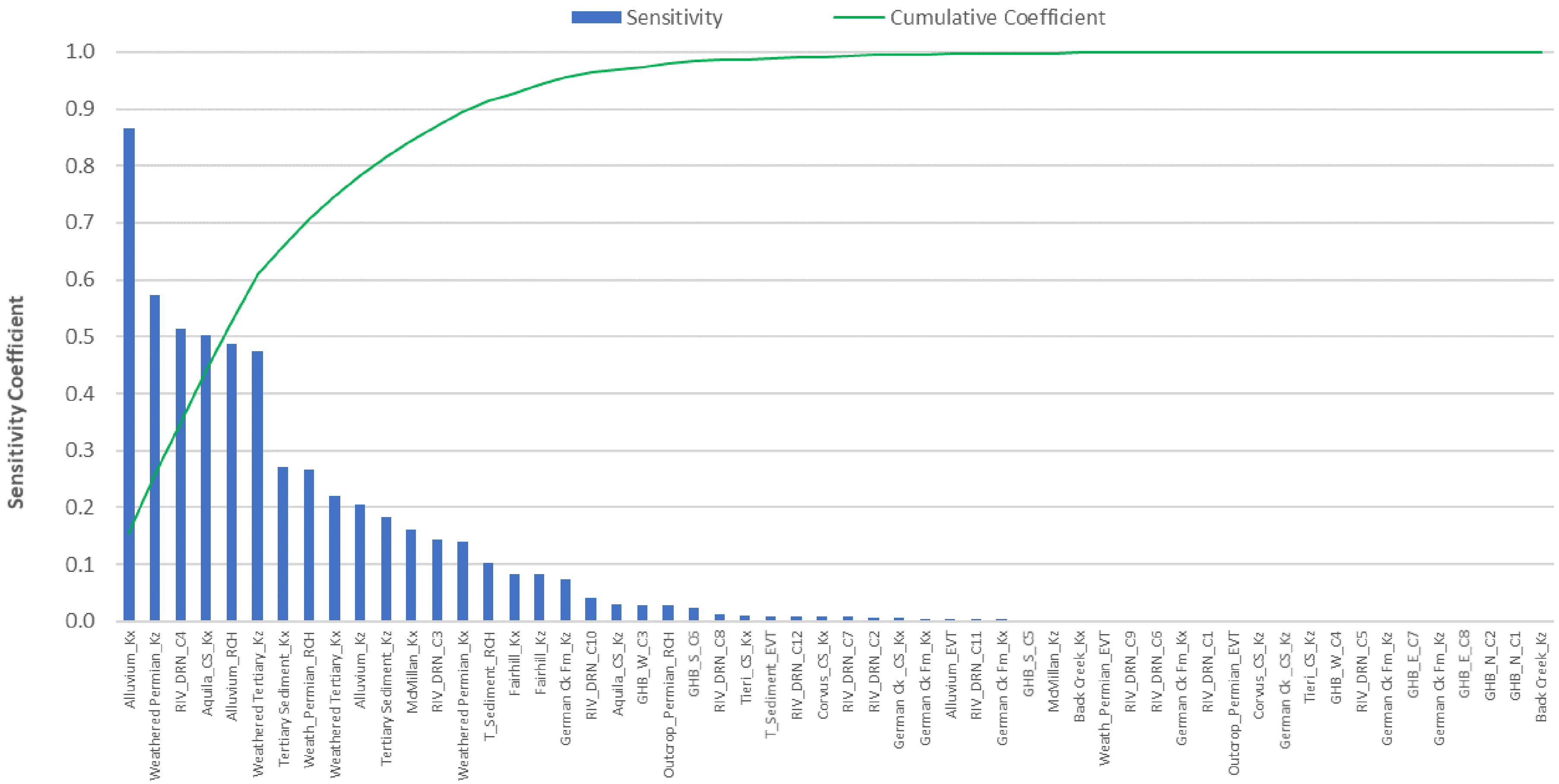

Figure II-4.5 Normalised Sensitivity Coefficient for Various Model Parameters

II-4.4 Verification Model (1981 to 2001)

The verification model considered the period January 1981 to December 2001 to account for the influence of early mining operations on the groundwater system. The model was not calibrated as limited transient data was available, however, the model was validated with comparisons of the modelled groundwater level from the final stress period with site observation bore groundwater levels from bores drilled between 2002 and 2003. Figure II-4.6 shows a scatter plot of the verification model for the observed and modelled heads. The calibration statistics show a good alignment between the modelled and measured values. This process illustrates the simulated final head level from the verification model can be used as an approximate initial condition for the transient model calibration.

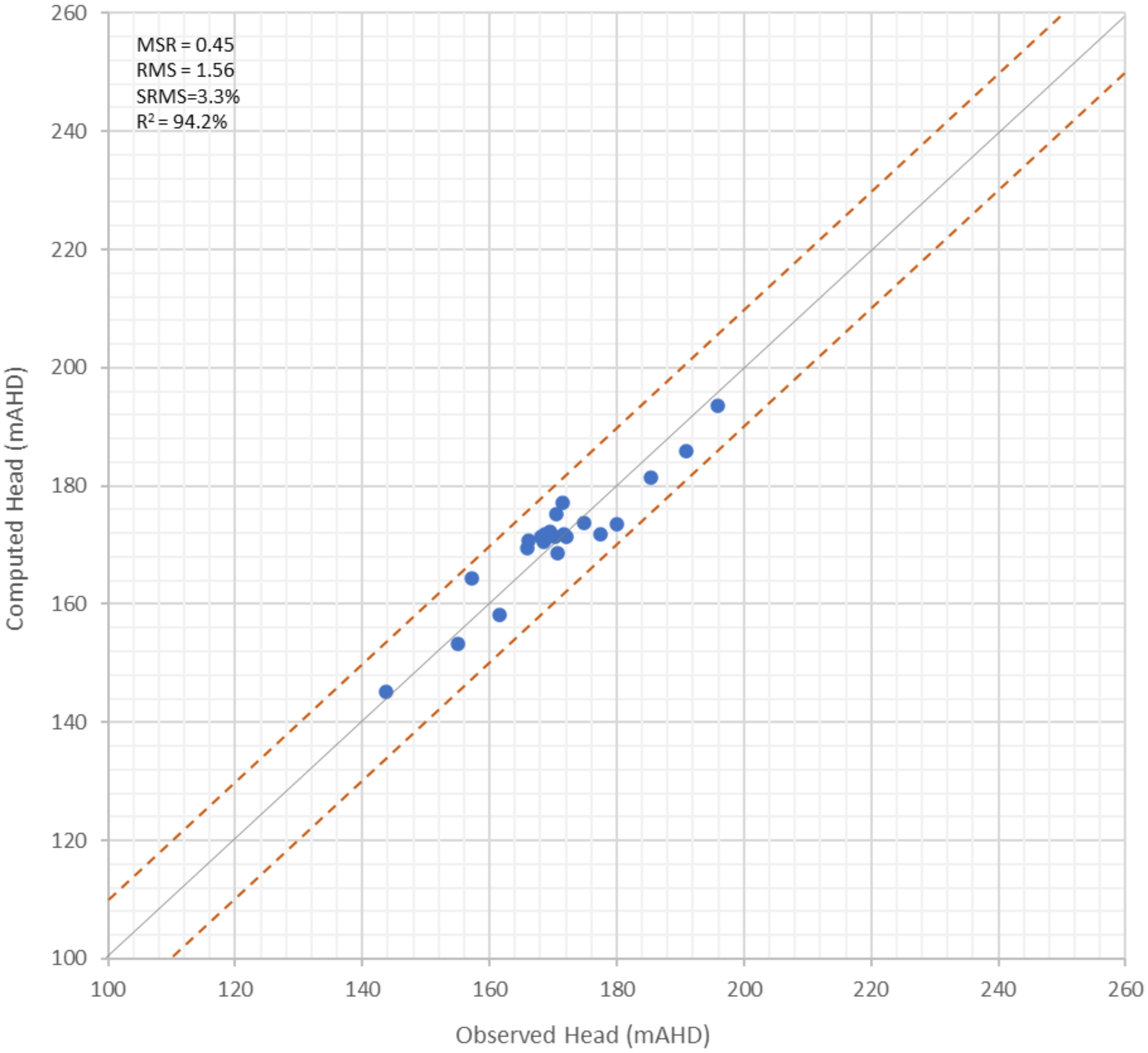

Figure II-4.6 Verification - Observed versus Modelled Heads

II-4.5 Transient Model Calibration (2002 to 2021)

II-4.5.1 Calibration Summary

Transient model calibration was performed based on the initial results from the calibrated steady state and verification model. The observed groundwater levels recorded over the 20 years (2002 to 2021) from monitoring bores at OCCMC and in-pit water levels recorded from 2015 to 2021 are used in the calibration. The calibration was conducted using a manual trial-and-error process.

Model parameters and boundary conditions were adopted from the steady state calibrated model as the starting conditions. The main challenges and then assumptions made for this simulation are:

- Limited monitoring data was available in the vicinity of the open pits to verify the groundwater response during mining operations in this regime.
- The open pit mining / backfilling process also had limited information. Google Earth images were used to infer the mining sequence.
- The longwall mining sequence was available in an annualised sequence for the OC1 Mine. No monitoring data was available.
- Dewatering data was not available for individual open cut voids, however, a total dewatering rate for open cut voids and longwall panels was available, which was also used in the model calibration.

Figure II-4.7 presents the calibration variance (measured versus modelled) for the transient calibration. Calibration was considered fair to good, with a MSR of -0.15 m, SRMS of 3.8% and 96% of correlation conference between the observed and modelled groundwater levels. Minor outliers were observed in the calibration data set, but these are identified to be attributed to uncertainty in the mining sequence.

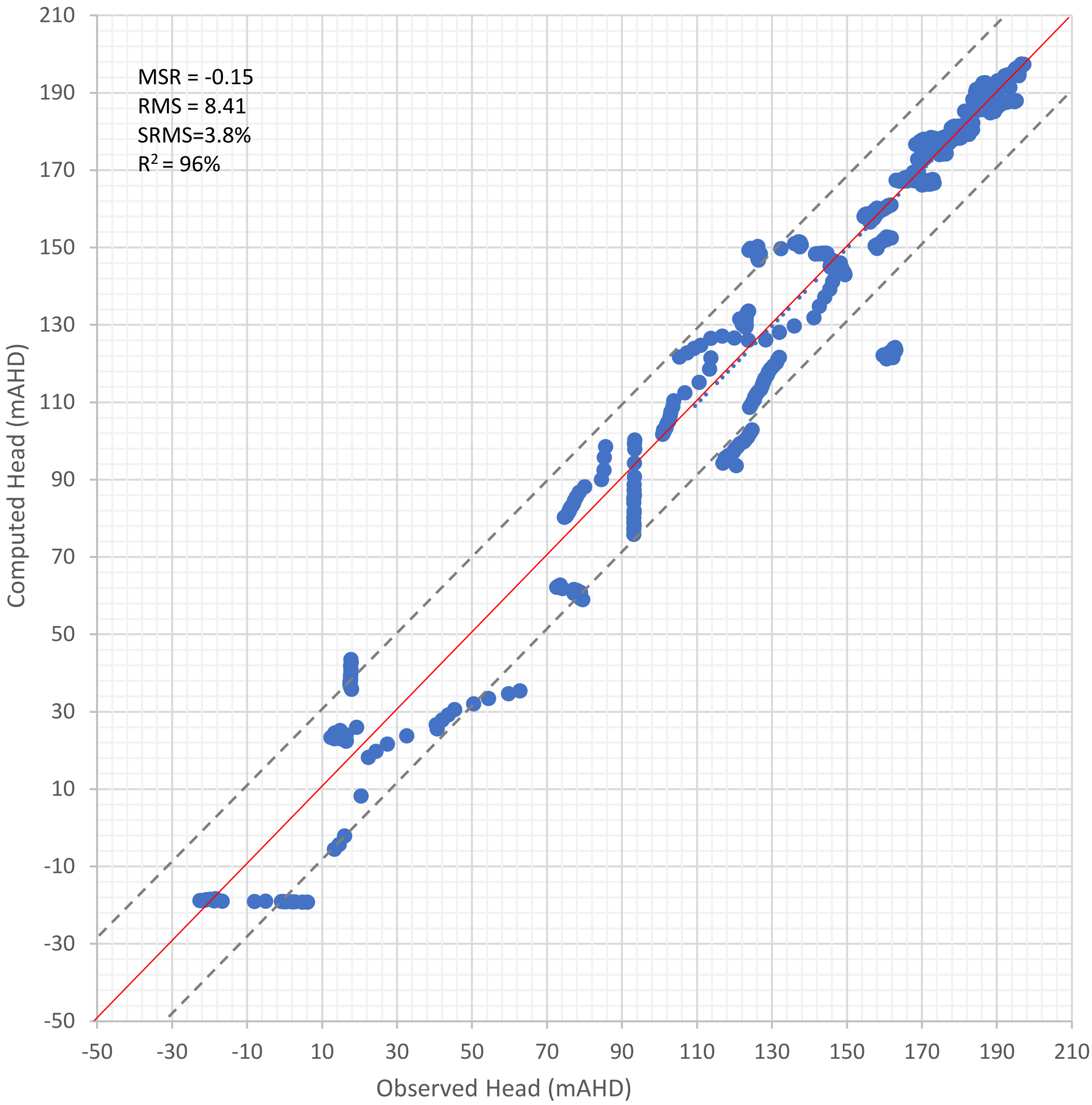

Figure II-4.7 Transient Calibration Observed versus Computed Heads

II-4.5.2 Calibrated Transient Hydrographs

Hydrographs showing measured versus modelled groundwater heads are provided in Figure II-4.8, Figure II-4.9 and Figure II-4.10. Modelled heads are displayed as dashed lines with the available observation data shown as points. The following comments are made related to the transient calibration:

- 367 data points were available across 12 monitoring bores for the alluvium and Tertiary sediments units in model layers 1 and 2 were available for the calibration. A good calibration is achieved across the shallow monitoring bores RO2, RO4 and RO5, located adjacent to Oaky Creek and west of G7 pit. Some over-prediction in levels is predicted for RO1, RO7 and BH7.

- 944 data points across 41 bores screened within the Permian units were available for calibration. A fair to good calibration was achieved for the Permian units, with over/under-prediction of levels observed in BH5 and BH3, located upgradient of the G7 pit; and BH9 and BH10 located near the G6 pit. The variance may be related to the uncertainty in the pit sequence/backfill timing.
- Six monitoring locations have nested monitoring bore screened at different depths (Figure II-4.10). A fair to good calibration was achieved at these nested sites, with the vertical separation between the coal seams reasonably replicated within the model.

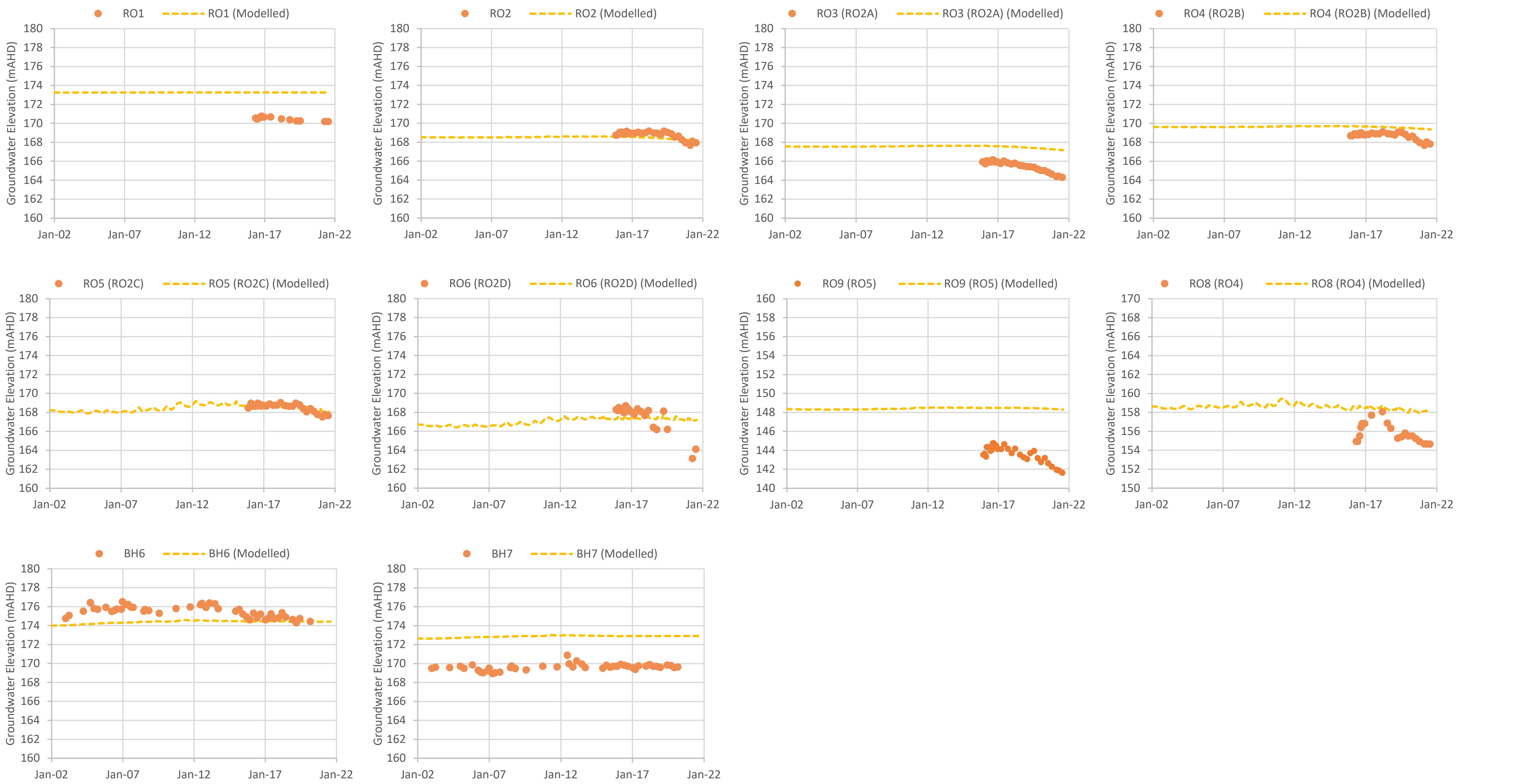

Figure II-4.8 Alluvium / Tertiary Sediments Transient Calibration Hydrographs

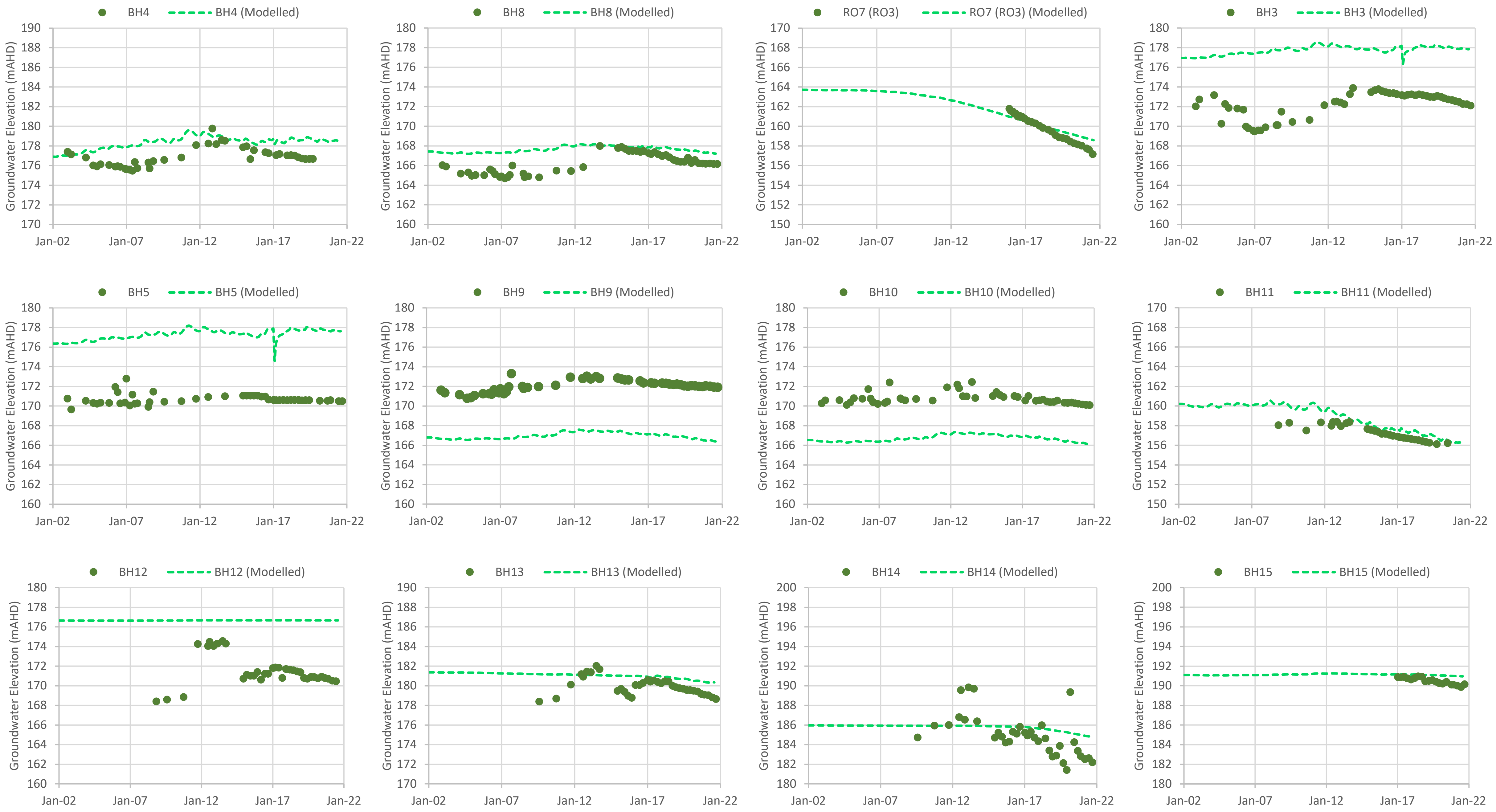

Figure II-4.9 Permian Transient Calibration Hydrographs

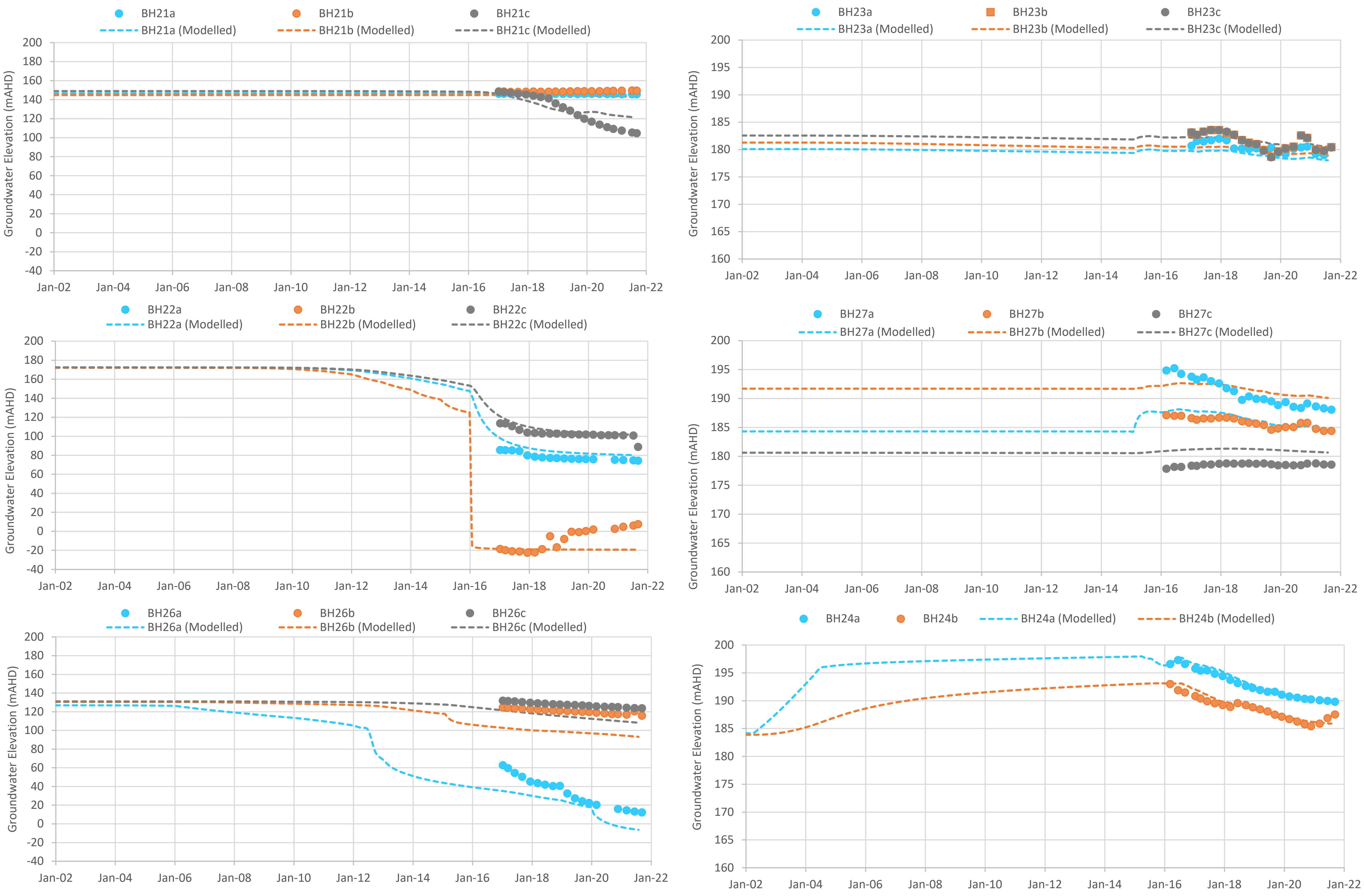

Figure II-4.10 Transient Calibration Hydrographs – Nested Monitoring Bores

II-4.5.3 Calibrated Flow Rate

Figure II-4.11 present the measured and calibrated dewatering / inflow rate for the transient model. The figures show (1) the dewatering rates are within the expected ranges from the reported measurements; (2) the trend of modelled dewatering rates follows the expected range of site measurements.

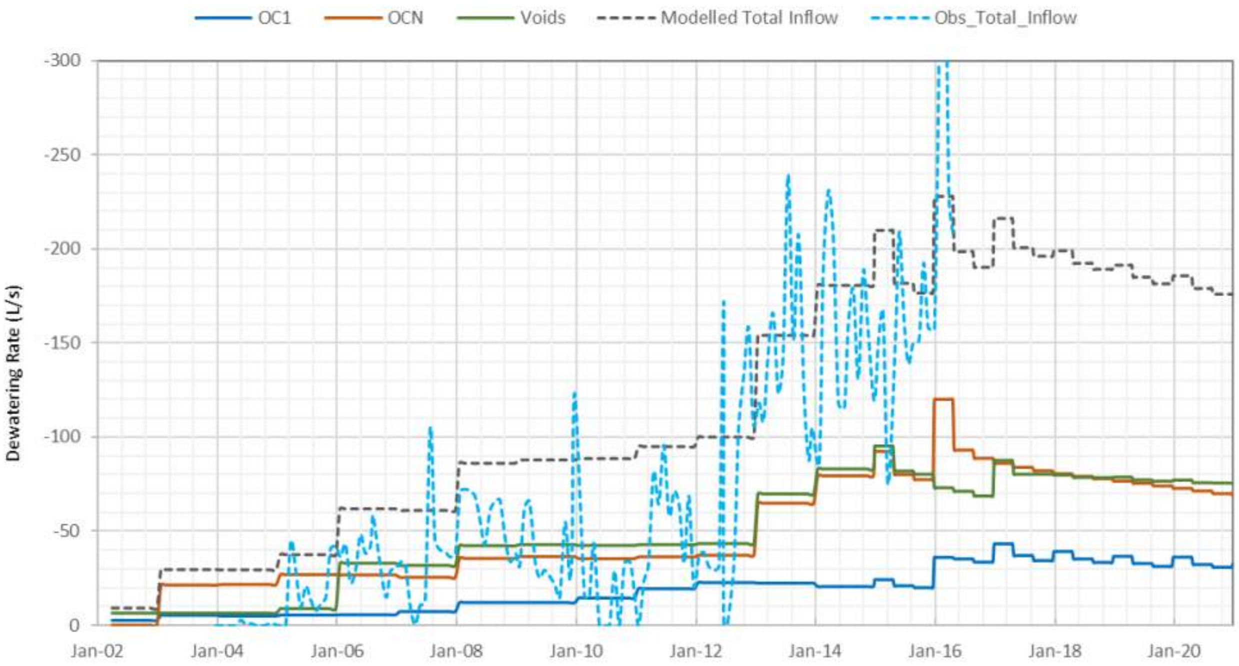

Figure II-4.11 Flow to Underground and Voids (Transient Model)

II-4.5.4 Water Balance

The water balance error over the entire calibration period is 0.01% (<the target 1%), which indicates that the model is numerically stable and has achieved an accurate numerical solution. The transient water balance from the model boundary conditions is summarised in Table II-4.4 and is illustrated in Figure II-4.12. The simulation results in the table and figure shows:

- Open cut voids both gain and lose water within the system (inflow/outflow), depending on their water level and the gradient to/from the surrounding hydrostratigraphic units.
- Void seepage and rainfall recharge provide more than 80% of inflow in the model domain.
- Underground mining operations account for approximately 30% of outflow, and the groundwater flow into the voids accounts for ~45% of outflow from the system over the calibration period. Inflow into the open cut voids decreased from 2002 to 2021, as operations moved to the underground area and flow increased from underground activities.
- Regional net flow contributes 0.5 ML/day to the model regime, ~3.4% of total inflow.
- There is 8.6% of net flow (storage) loss, which caused by removal of water associated with mining activities.

Table II-4.4 Water Budget and Mass Balance Error for Transient Simulation

Water Balance Item	Inflow From Boundary		Outflow From Boundary	
	Inflow Rate (ML/day)	% of Total Inflow	Outflow Rate (ML/day)	% of Total Outflow
Mine drainage	-	-	12.4	31.5%
River drainage	-	-	1.4	3.5%
Recharge	7.7	21.2%	-	-
General head flow through open cuts	22.3	61.5%	17.6	44.6%
General head flow through boundary	6.3	17.3%	5.9	14.9%
Evapotranspiration	-	-	3.2	8.2%
TOTAL	36.3	-	39.4	-
Total Net Flow (Storage Loss)	**3.1**			**8.6%**

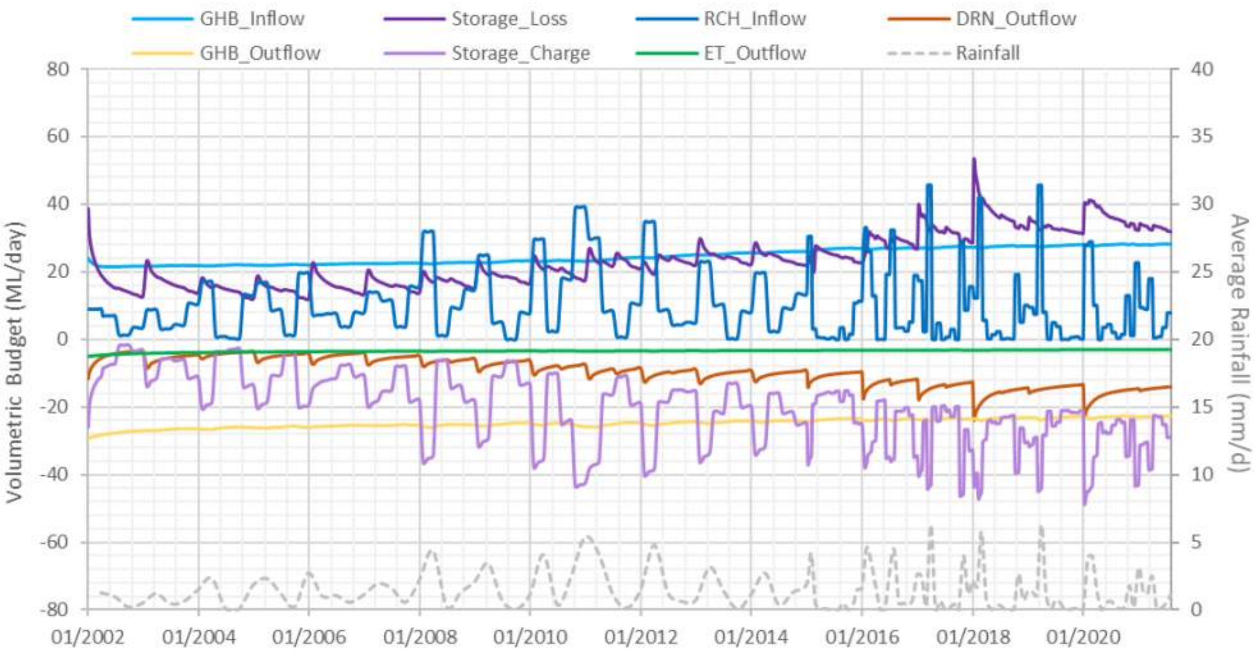

Figure II-4.12 Transient Water Balance

II-4.5.5 Calibrated Model Parameters

Table II-4.5 presents the final calibrated model parameters.

The recharge and evapotranspiration rates were adjusted during calibration. The final rates are summarised in Table II-4.6. The rates are presented as averages, with recharge varying seasonally for each year.

Table II-4.7 outlines the final calibrated parameters (multiplier factor) for each fracture zone.

Table II-4.5 Calibrated Hydraulic Conductivity and Storage Parameters

Geo Unit	Zone ID	Kh (m/d)	Kv (m/d)	Ratio (Kh/Kv)	Ss	Sy
Alluvium	1	1E+00	3E-01	5	1E-04	5E-02
Tertiary Sediment	2	2E-01	3E-02	5	2E-05	3E-02
Weathered Tertiary	3	1E-02	1E-03	8	2E-05	2E-02
Weathered Permian	14	1E-03	1E-04	10	2E-05	2E-02
MacMillan Fm	4	5E-03	5E-04	10	2E-05	1E-02
German Creek Fm	5	2E-03	2E-04	10	2E-05	1E-02
Aquila Seam	6	2E-02	1E-02	2	5E-05	2E-02
German Creek Fm	7	2E-03	2E-04	10	1E-05	1E-02
Tieri Seam	8	2E-02	4E-03	4	5E-05	2E-02
German Creek Fm	9	2E-03	1E-04	13	1E-05	1E-02
Corvus Seam(s)	10	1E-02	3E-03	4	5E-05	2E-02
German Creek Fm	11	2E-03	1E-04	12	1E-05	1E-02
German Creek Seam(s)	12	3E-02	5E-02	1	5E-05	2E-02
German Ck Fm Underburden	13	1E-04	5E-06	20	1E-05	1E-03
Landfill	15	5E-01	1E-01	5	1E-04	2E-01
Void (Excavated Pits)	16	1E+02	1E+02	1	1E-03	1E+00

Table II-4.6 Calibrated Recharge and Evapotranspiration Rates

Zone	Unit	% of Rainfall	Rate (m/d)	EVT (m/d)	Extinction Depth (m)
1	Alluvium	0.70%	8.67E-06	1.86E-03	3
2	Weathered Tertiary	0.51%	6.28E-06	6.55E-04	2
3	Weathered Permian	0.12%	1.48E-06	6.55E-04	2
4	Outcrop Permian	0.01%	1.60E-07	6.55E-04	1
5	Spoil	1.77%	2.20E-05	2.17E-03	3
6	Alluvium (Mine)	1.00%	1.24E-05	-	-

Table II-4.7 Fracture Zone Hydraulic Properties

Layer	Fracturing Unit	Average Thickness	Height Above Seam (m)	Goaf Kh_ Upper Bound	Goaf Kh_ Lower Bound	Calibrated Kh	Calibrated Kv	Multiple Factor
5	German Creek Fm	35	125	0.100	2.50E-03	0.01	0.001	5
6	Aquila Seam	3	90	0.293	1.47E-02	0.11	0.08	6
7	German Creek Fm	30	87	0.115	2.86E-03	0.02	0.01	10
8	Tieri Seam	2	57	0.742	3.71E-02	0.30	0.10	20
9	German Creek Fm	30	55	0.250	6.25E-03	0.02	0.02	12
10	Corvus Seam(s)	2	25	1.037	5.18E-02	0.62	0.46	54
11	German Creek Fm	20	23	0.422	1.05E-02	0.10	0.11	69
12	German Creek Seam(s)	3	3	100.0	7.33E-02	3.00	3.00	100

II-4.5.6 Overall Calibration Performance

Barnett et al. (2012) developed a system to classify the confidence level of groundwater flow models based on the adopted calibration process and the predictive capability of the model. Three classes of models were developed: Class 1, Class 2, and Class 3. A Class 3 model has the greatest confidence level, and a Class 1 model has the least. Factors that are considered when determining model confidence level are:

- Data availability;
- Calibration procedures;
- Consistency between calibration and predictive analyses; and
- Stresses applied on the model and associated simulation results.

The model outlined in this report is considered a Class 2 model based on the following:

- The local geological model used to support development of the groundwater model domain was constructed using site specific geological investigation data. 53 groundwater monitoring bores were used for transient calibration, with more than 90% of these monitoring bores within the OCCMC, or in the vicinity of OCCMC.
- Key calibration statistics (SMRS <5%; R^2 > 90%) were acceptable and meet agreed targets in transient model calibration.
- Detailed transient calibration was undertaken over a 20-year period, and the long-term trends replicated in the major hydrostratigraphic units (Alluvium, Tertiary sediments, and Permian) within and in the vicinity of OCCMC.
- Seasonal fluctuations are adequately simulated for the key shallow bores in Alluvium (e.g., RO2 and RO5).
- The transient calibration covered the most recent period (from year 2001 and 2021), and 53 monitoring bores and data observed over this period are used in the calibration.
- Abstraction data (mine dewatering rate from the previous studies) were used for model calibration.
- Water dams and in-pit water levels/storage are used in the calibration.
- Model parameters were calibrated within the ranges identified as part of the conceptualisation.
- Model water balance error is less than 0.5%.
- The predictive model duration is shorter than the calibration period.

The calibration model meets the criteria for a Class 2 model. The calibrated model is therefore deemed to be a suitable tool for assessing the dewatering and associated drawdown impacts from the proposed OCCMC operations.

II-5 MODEL PREDICTIONS

II-5.1 Predictions Overview

Predictive simulations have been undertaken to identify the potential LTAA resulting from development of the OCCMC operations. These proposed simulations are required to predict the LTAA extent. The following simulations have been undertaken:

- Prediction Simulations – Cumulative Impacts (without OCC): This simulation includes existing surrounding operations and approved groundwater abstraction that have potential to influence groundwater levels across the OCCMC complex (as available). This simulation does not include the OCCMC complex.
- Prediction Simulations – Project Impacts: This simulation will be the same as the above cumulative impacts predictive simulation but will include operations from the OCCMC complex. The difference between this simulation and the cumulative impacts simulation without the Project identifies the incremental groundwater impacts from the Project and allows calculation of the LTAA extent.

II-5.2 Prediction Scenario Results

II-5.2.1 Drawdown Extent

The following prediction simulation was completed to define the groundwater impacts because of the Project:

- The LTAA is defined using the final operational year drawdown extent (end of 2022).

Figure II-5.1 show the drawdown results for Layer 6 (Aquila Coal Seam) and Layer 12 (German Creek seam). The 5 m drawdown contours are highlighted (consolidated aquifer drawdown trigger threshold) and shows that the drawdown does not extend beyond the mining lease. There is no drawdown predicted for the alluvium (Layer 1) or the Tertiary sediments (Layer 2), that exceeds the trigger threshold.

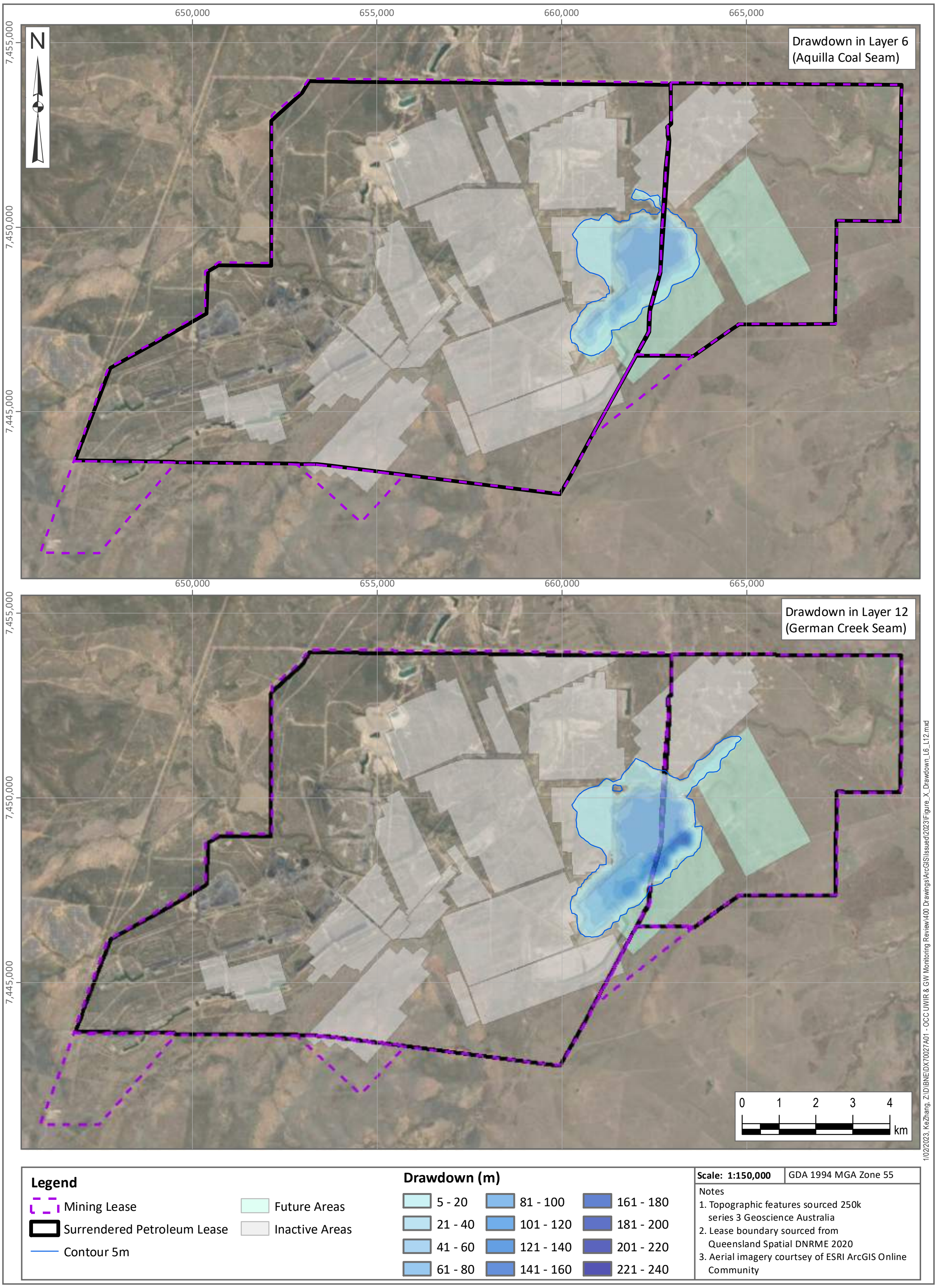

Figure II-5.1 Drawdown in Layer 6 (Aquilla Seam) and Layer 12 (German Creek Seam)

REFERENCES

AGE. 2016. 'Oaky Creek No.1 Closure - Numerical Groundwater Modelling'. Prepared for Glencore Oaky Creek Coal.

Barnett, B, LR Townley, V E A Post, RE Evans, RJ Hunt, LJM Peeters, S Richardson, AD Werner, A Knapton, and A Boronkay. 2012. 'Australian Groundwater Modelling Guidelines'. Waterlines Report. Canberra: National Water Commission.

Chiew, Francis, QJ Wang, Fiona McConachy, Ross James, William Wright, and Graham deHoedt. 2002. 'EVAPOTRANSPIRATION MAPS FOR AUSTRALIA'. In. Melbourne: Institute of Engineers Australia.

DRDMW. 2021. 'Queensland Groundwater Database - February 2021'. Queensland Government, Department of Regional Development, Manufacturing and Water.

KCB. 2018. 'Grasstree Extension Project Environmental Assessment Report (Groundwater Report)'. http://epbcnotices.environment.gov.au/_entity/annotation/8c190395-1620-e811-886f-005056ba00a8/a71d58ad-4cba-48b6-8dab-f3091fc31cd5?t=1520899200369.

Seedman Geotechnics. 2011. 'Oaky Creek Coal Pty Ltd. Life of Mine Subsidence Deformations". OAKY-06.Docx. October 2011.'

State of Queensland. 2021. *Water Act 2000*. https://www.legislation.qld.gov.au/view/pdf/inforce/current/act-2000-034.

Tammetta, Paul. 2015. 'Estimation of the Change in Hydraulic Conductivity Above Mined Longwall Panels'. *Groundwater* 53 (1): 122–29. https://doi.org/10.1111/gwat.12153.