Alkane Resources Ltd

ABN: 35 000 689 216

Tomingley Gold Extension Project Groundwater Assessment

Prepared by

Jacobs Australia Pty Limited

July 2021

Specialist Consultant Studies Compendium

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Tomingley Gold Extension Project Groundwater Assessment

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Prepared for:	R.W. Corkery & Co. Pty Limited Level 1, 12 Dangar Road PO Box 239 BROOKLYN NSW 2083 Tel: (02) 9985 8511 Email: brooklyn@rwcorkery.com
On behalf of:	Alkane Resources Ltd PO Box 4384 VICTORIA PARK WA 6979 Tel: (08) 9227 5677 Email: info@alkane.com.au
Prepared by:	Jacobs Australia Pty Limited Level 7, 177 Pacific Highway NORTH SYDNEY NSW 2060 Tel: (02) 9928 2100 Email: ben.rose@jacobs.com Ref No: IA275200

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Contents

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Executive Summary

Alkane Resources Ltd (Alkane) (the Applicant) owns and operates Tomingley Gold Operations (TGO), an active open cut and underground gold mine, located at Tomingley, approximately 50km southwest of Dubbo in central-western NSW.

Alkane is proposing additional or modified TGO operations, plus extension of mining, both open cut and underground, about 2 km south of TGO, hereafter referred to as the Tomingley Gold Extension Project (TGEP). Collectively, TGO and TGEP are referred to as the Tomingley Gold Project (TGP).

Key proposed additional or modified TGO operations relevant to the groundwater assessment include waste rock emplacement/backfilling of two open cuts (Caloma 1 and 2) and an increase in elevation/capacity for a residue storage facility, Residue Storage Facility 2, from an approved maximum elevation of 272 mAHD to 286 mAHD.

Key proposed TGEP features relevant to the groundwater assessment include an open cut, divided into three distinct but connected open cuts, plus an underground mine under the deepest portion of open cut.

Except for a relatively deep northern portion of open cut at TGEP and an existing open cut (Wyoming 1) at TGO, the open cuts would be backfilled with waste rock in the final Tomingley Gold Project (TGP) landform. The underground mining stopes would be stabilised/backfilled with pastefill, a tailings/residue/cement mixture.

A groundwater impact assessment was undertaken to assess potential impacts to groundwater due to the additional or modified TGO operations and TGEP proposal, to support the environmental impact statement for the Project.

The groundwater impact assessment included:

- Review of relevant legislation, policy guidelines and licencing requirements.
- Review of the TGP environmental setting, including development of a conceptual hydrogeological model.
- Calculation of groundwater inflows to the open cuts and underground mines and groundwater level drawdown using an industry standard numerical groundwater flow model, MODFLOW. In accordance with the Australian Groundwater Modelling Guidelines (Barnett *et al.* 2012), the intended model confidence level classification is Class 2.
- Assessment of potential impacts to groundwater due to proposed additional or modified TGO operations and the TGEP proposal.
- Development of groundwater related mitigation and management measures.

Interpretations and results from the groundwater flow model predictions are as follows:

- An average groundwater inflow rate of 2.455 ML/d occurs for an 18 month long period with the highest modelled groundwater inflow rates. This average daily inflow rate corresponds to an annual rate of 896 ML.
- Perpetual groundwater take will occur after mining has ceased due to ongoing evaporative loss within the two open cuts where backfilling is not proposed. The predicted total post-mining groundwater inflow rate is about 0.21 ML/d, 0.31 ML/d, 0.31 ML/d and 0.30 ML/d about 37 years, 82 years, 136 years and 200 years after end of mining, respectively. At earlier times and closer to the end of mining, the groundwater inflow rate would likely be higher.
- The modelled groundwater inflow rates do not account for evaporation after the groundwater is removed from the model by the numerical boundary used to simulate dewatering. For this reason, due to evaporative losses, the groundwater inflow rate perceived onsite may be considerably lower than the model results.

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- At the end of mining, the modelled 2 m groundwater level drawdown contour extends up to 1.5 km from a TGO open cut/underground mine and up to 700 m from the TGEP open cut crest 50 m disturbance area.

  At the end of the 200 year post-mining period, the modelled 2 m groundwater level drawdown contour extends up to 5 km from an approximate centre point placed between TGO and TGEP.

- GDEs and baseflows to watercourses are not anticipated to be impacted by TGO/TGEP. The fractured rock groundwater system, which hosts the regional water table, that mining is predicted to depressurise is conceptualised to be hydraulically disconnected from overlying alluvial groundwater systems. The alluvial groundwater systes are those most likely to acts as a recharge source for the potential GDEs or baseflows to watercourses. This conceptualisation is supported by TGO/TGEP groundwater monitoring data.
- Uncertainty analysis was undertaken to assess the effect of varying model input parameter values on model predictions. None of the uncertainty scenario results alter the base case assessment main findings.

Final void equilibrium water levels for TGEP and TGO are predicted to be 180 mAHD and 200 mAHD, respectively. Thus, a perpetual groundwater sink is predicted to form.

Potential groundwater impacts due to TGO/TGEP were assessed against the NSW Aquifer Interference Policy's Minimal Impact Considerations (NSW 2012). Aside from TGO monitoring bores, the modelled 2 m groundwater level drawdown contour encroaches on 6 existing registered bores at the end of the 200 year post-mining period, the worst case scenario. However, none of these bores are assessed as relevant to the modelled drawdown results. These bores tap shallow perched alluvial groundwater systems that are conceptualised to be disconnected from the fractured rock groundwater system that the mine will drawdown. As such, they are assessed as unlikely to be impacted by mining induced drawdown. TGO/TGEP is assessed as unlikely to lower the groundwater beneficial use category beyond a distance of 40 m from an activity, which is an AIP (DPI, 2012) Minimal Impact Consideration criterion. The groundwater salinity of the fractured rock groundwater system in the vicinity of TGO/TGEP is typically saline and the beneficial use category of the groundwater is limited to industrial use.

Annual groundwater entitlement is required to cover TGO/TGEP dewatering from the Lachlan Fold Belt MDB Groundwater Source of the Water Sharing Plan for the NSW MDB Fractured Rock Groundwater Sources 2020 (NSW Government, 2020). The average modelled groundwater inflow rate for the 18 month long period between 01/01/2026 and 01/06/2027, the period of modelled highest groundwater inflow rates, is taken to inform assessment of licensing implications. The average predicted inflow rate over this period is about 2.455 ML/d, which corresponds to a rate of 896 ML/yr. Thus, entitlement in addition to the existing Mine entitlement of 220 ML/year will be required.

Trading is common in the applicable groundwater source and about 70% of the groundwater in this water source is currently unassigned. Therefore, acquiring additional entitlement is considered feasible.

Annual groundwater entitlement will also be required to cover the perpetual groundwater take that will occur after mining has ceased.

Management and mitigation measures are outlined in the report, including recommendations for ongoing groundwater monitoring.

The Project is considered to constitute a low risk to the regional groundwater systems.

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Important note about your report

The sole purpose of this report is to present the findings of a groundwater impact assessment, in connection with the proposed additional or modified TGO operations and proposed TGEP, to enable key information to be drawn into the Project's EIS. The report was commissioned by Alkane Resources Ltd and was produced in accordance with, and is limited to the scope of services set out in, the proposal/contract between Jacobs and the Client. That scope of services, as described in this report, was developed with the Client.

All reports and conclusions that deal with sub-surface conditions are based on interpretation and judgement and as a result have uncertainty attached to them. This report contains interpretations and conclusions which are uncertain, due to the nature of the investigations. No study can investigate every risk, and even a rigorous assessment and/or sampling programme may not detect all problem areas within a site.

This report is based on assumptions that the site conditions as revealed through sampling are indicative of conditions throughout the site. The findings are the result of standard assessment techniques used in accordance with normal practices and standards, and (to the best of Jacobs knowledge) they represent a reasonable interpretation of the current conditions on the site. Sampling techniques, by definition, cannot determine the conditions between the sample points and so this report cannot be taken to be a full representation of the sub-surface conditions. This report only provides an indication of the likely sub surface conditions.

Conditions encountered during mining may be different from those inferred in this report, for the reasons explained in this limitation statement. If site conditions encountered during mining are different from those encountered during the Jacobs and others' site investigations, Jacobs reserves the right to revise any of the findings, observations and conclusions expressed in this report.

The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the Project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete, then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

Except as specifically stated in this report, Jacobs makes no statement or representation of any kind concerning the suitability of the site for any purpose or the permissibility of any use.

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1. Introduction

1.1 Background

Alkane Resources Ltd (Alkane) (the Applicant) owns and operates Tomingley Gold Operations (TGO), an active gold mine, located at Tomingley, approximately 50 km southwest of Dubbo in central-western NSW (**Figure 1.1**). TGO (**Figure 1.2**) comprises both open cut and underground mining operations at the Wyoming and Caloma Deposits.

Alkane is proposing additional or modified TGO operations, plus extension of open cut and underground mining, about 2 km south of TGO, hereafter referred to as the Tomingley Gold Extension Project (TGEP). The TGEP is also known as the San Antonio and Roswell Mine Site (SAR) (**Figure 1.3**). Collectively, TGO and TGEP are referred to as the Tomingley Gold Project (TGP).

The Project has been classified as a "State Significant Development" under Schedule 1 (7(a)) of the State Environmental Planning Policy (State and Regional Development) 2011.

This report documents a groundwater impact assessment undertaken to support the environmental impact statement (EIS) for the Project.

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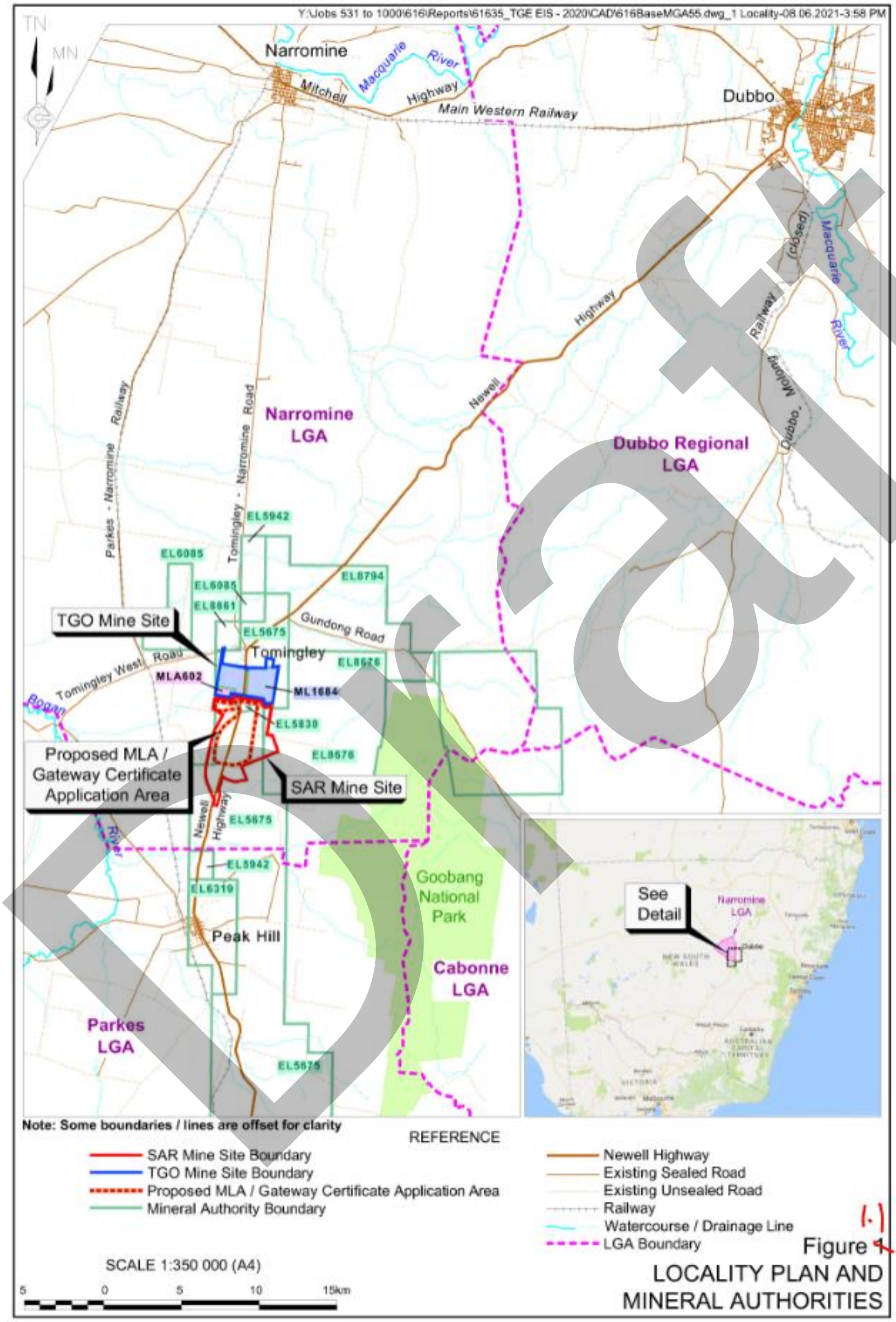

Figure 1.1: Locality plan and mineral authorities (source: RW Corkery & Co, 2021) Drafting note: Jacobs will edit the figure number to suit in final version of report

1.2 Report objective and layout

The purpose of this report is to document an assessment of potential impacts to groundwater due to the TGEP and proposed additional or modified TGO operations, to support the EIS for the Project.

Key requirements of the groundwater assessment are identified in the Secretary's Environmental Assessment Requirements (SEARs – **Section 1.4.2**) and also requirements identified through early consultation with DPIE-Water and the NSW Natural Resources Access Regulator (NRAR – **Section 1.4.1**).

The report is divided into the following sections:

- **Section 1 –** Introduction, introduces and describes the Project and outlines the objectives of the report.
- **Section 2 –** Legislative and policy context.
- **Section 3 –** Existing environment, describes elements of the existing environment relevant to groundwater. The section content is based on review of site-specific data and data/mapping available in the public domain.
- **Section 4 –** Groundwater Investigations, summarises groundwater site investigations and subsequent data analysis specifically undertaken to inform the Project's groundwater assessment
- **Section 5 –** Conceptualisation, conceptualises hydrogeology relevant to the Project.
- **Section 6 –** Numerical groundwater flow modelling, describes the development, calibration and results of numerical groundwater flow modelling undertaken for the Project.
- **Section 7 –** Groundwater impact assessment, summarises the results of the groundwater impact assessment completed for the Project.
- **Section 8 –** Management and mitigation measures, outlines groundwater related management and mitigation measures for the Project.
- **Section 9 –** Conclusion, provides a summary of assessment findings.

1.3 Project description

1.3.1 Project Overview

The Project comprises two components as follows:

- Approved TGO mining operations (**Figure 1.2**). These activities are undertaken in accordance with development consent MP 09_0155. The approved activities would continue under any new development consent, with MP 09_0155 to be surrendered following receipt of the new development consent and all required approvals for the Project. The approved activities include the following:
  - Extraction of ore and waste rock from four open cuts, with underground mining beneath three of those open cuts.
  - Construction of three out-of-pit waste rock emplacements and one in-pit emplacement.
  - Construction and use of various haul roads, a run-of-mine (ROM) pad and associated stockpiles.
  - Construction and use of a Processing Plant to process up to 1.5 million tonnes per annum (Mtpa).
  - Construction and use of two residue storage facilities comprising Residue Storage Facility 1 (to Stage 9 or a maximum elevation of 286.5m AHD) and Residue Storage Facility 2 (to Stage 2 or a maximum elevation of 272m AHD).
  - Construction and use of ancillary infrastructure.

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- The proposed SAR operations and additional or modified TGO operations, including the following (**Figure 1.2** and **Figure 1.3**).
  - Realigned Newell Highway and Kyalite Road and associated intersections with Back Tomingley West Road and McNivens Lane and Kyalite Road overpass.
  - The SAR Open Cut and Underground Mine.
  - Construction of two waste rock emplacements, namely the Caloma and SAR Waste Rock Emplacement and backfilling of the associated open cuts.
  - The SAR Amenity Bund, Haul Road and Services Road between the SAR Open Cut and the Caloma 2 Open Cut.
  - Processing of ore from the SAR deposits using the approved Processing Plant at a maximum rate of 1.75Mtpa.
  - Increased capacity for Residue Storage Facility 2, from Stage 2 to Stage 9, with a maximum elevation of 286m AHD)
  - Associated surface and underground activities and infrastructure.

In addition, the Project would include an extension of the approved mine life, likely from 31 December 2025 to 31 December 2032.

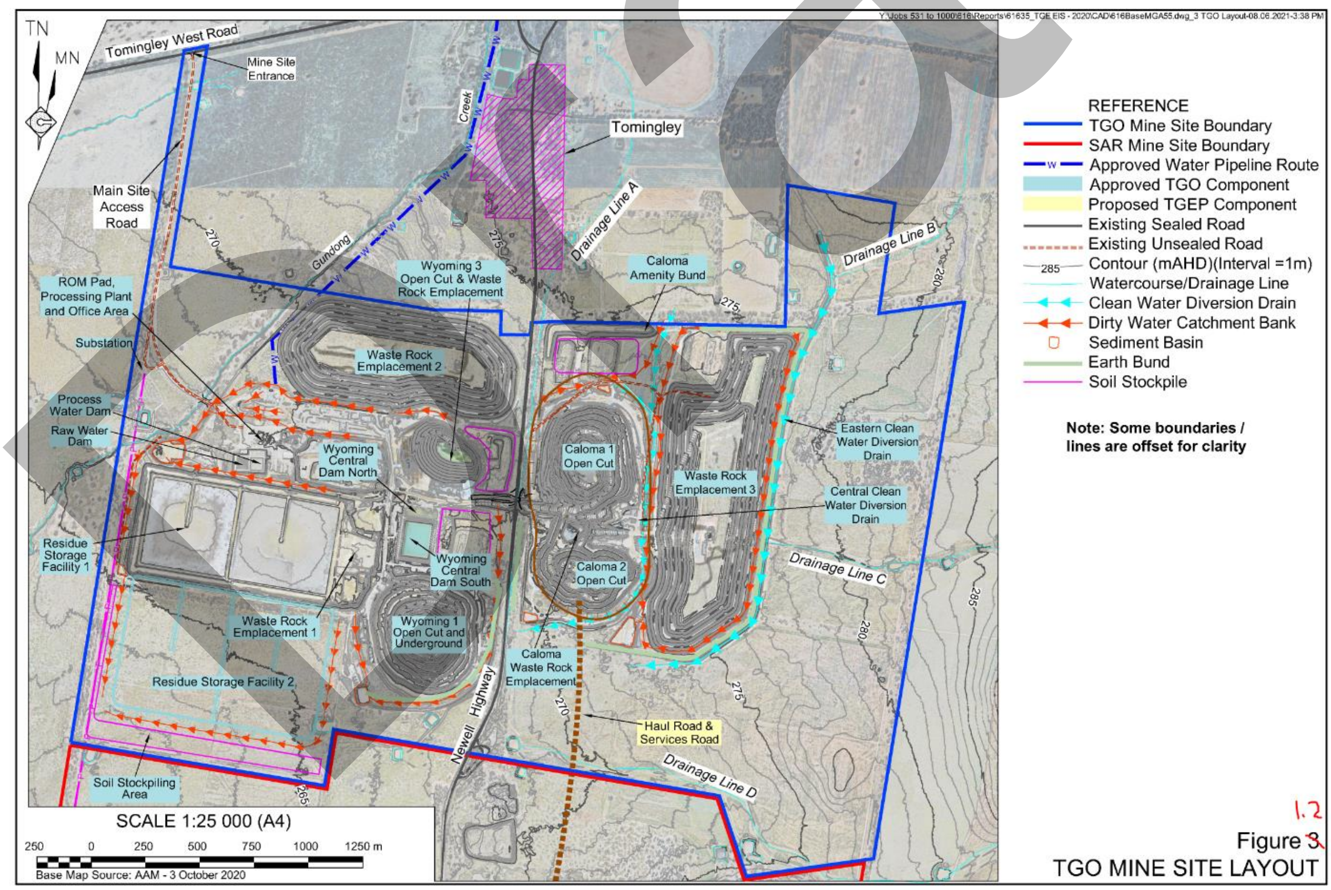

Figure 1.2: TGO mine site layout (source: RW Corkery & Co, 2021) Drafting note: Jacobs will edit the figure number to suit in final version of report

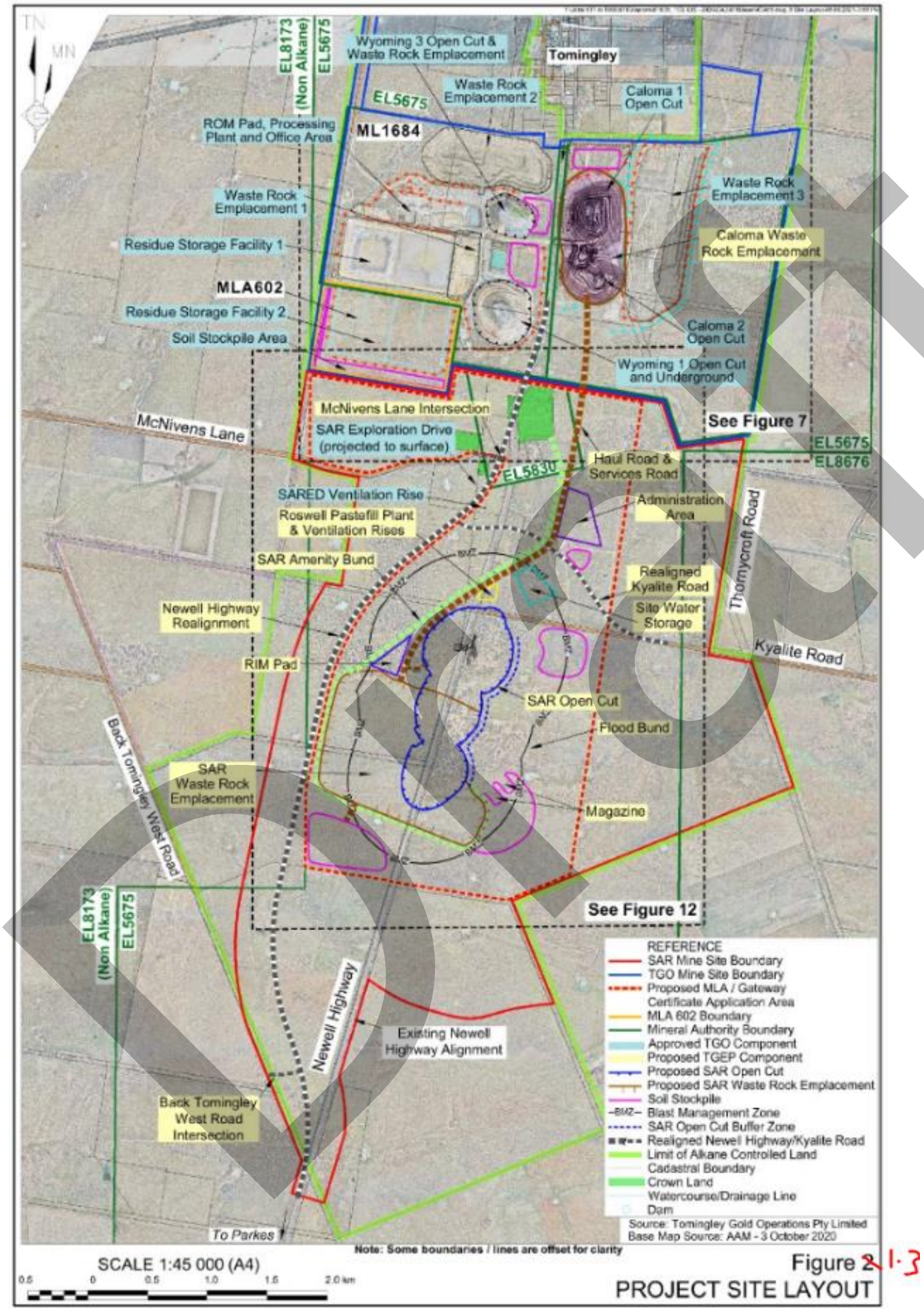

Figure 1.3: Project site layout (source: RW Corkery & Co, 2021)

1.3.2 SAR Orebody Overview

The orebodies at Roswell and San Antonio typically consist of sheeted quartz vein systems hosted within andesite and monzodiorite at Roswell and within two andesite units at San Antonio. The San Antonio deposit also has additional shear hosted orebodies. The orebodies comprise both oxide and sulphide ore zones beneath 20 m to 60 m of Cenozoic alluvial deposits. The resources at Roswell and San Antonio are open to depths of approximately 400 m below ground level (bgl) and 250 mbgl respectively.

The TGEP would principally comprise an extended open cut mine over both the Roswell and San Antonio deposits, apportioned three separate but connected open cuts to depths of about 165 mbgl to 300 mbgl, with underground mining continuing at depth beneath the northern portion of the open cut.

1.3.3 Mining Operations

1.3.3.1 Open Cut Mining

Open cut mining operations would commence in the southern section of the SAR Open Cut. Mining of the near surface material would be undertaken using conventional free dig, load and haul techniques. Once competent rock is exposed, it would be extracted using conventional drill, blast, load and haul techniques. Open cut ore would be transported to the TGO Mine Site via the proposed Haul Road. Alternatively, ore may be stockpiled within the Run-in-Min (RIM Pad) from where it would be transported to the TGO Mine Site via the proposed Haul Road.

Waste rock would be placed into the SAR or Caloma Waste Rock Emplacements (WREs).

Scheduling of open cut mining operations is in progress and the proposed schedule and rate of open cut mining will be presented in the EIS. Drafting note: Alkane/RWC to provide updated txt for section

1.3.3.2 Underground Mining

Underground mining operations would be undertaken using the SAR Exploration Drive (SARED) (**Figure 1.3**). The drive would permit access from the Wyoming 1 underground workings to the SAR deposits. The drive and a single ventilation rise were approved under the Mining Act 1992 as exploration-related activities by the Resources Regulator on 7 May 2020. That approval permits exploration drilling from underground and extraction of a bulk sample.

Following receipt of development consent, the drive would be converted from an exploration drive to a production drive. Development of additional drives for production purposes would be undertaken using traditional jumbo-based drill, blast, load and haul techniques. Stoping operations would indicatively rely upon long hole open stoping or similar methods. No surface subsidence, with the possible exception of breakthrough into the base of the open cuts, would occur.

As this stage, the Applicant has only designed underground mining operations within the Roswell deposit. Underground mining within the San Antonio deposit would also be undertaken. In addition, mineralisation within the SAR deposits remains open at depth. As a result, it is very likely that additional underground ore will be identified.

Ore would initially be transported to the TGO Mine Site via the underground drive and Wyoming 1 Portal. Ore transported via the Wyoming 1 Portal would be directly transferred to the ROM Pad using underground haul trucks. An additional portal may be established within the SAR Open Cut and ore may be bought to the surface via the SAR Portal and stockpiled within the RIM Pad from where it would be transported to the TGO Mine Site.

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Waste rock is intended to be used to backfill completed stopes or transported to surface via the Wyoming 1 or SAR Portals and placed within surface Waste Rock Emplacements.

Underground mining operations (**Figure 1.4**) would be supported by the following surface infrastructure:

- The approved SARED Ventilation Rise
- Proposed Roswell (ROS) Ventilation Rises.
- A Paste Fill Plant.

Pastefill is tailings/residue mixed with a binding agent such as cement and is used to backfill and stabilise completed underground stopes. Dewatered tailings/residue would be transported to the Pastefill Plant from the TGO Mine Site via the Services Road before being mixed with the binding agent and pumped underground. Once cured, the pastefill would have a consistency similar to cement and would enable extraction of ore that would otherwise be unable to be extracted.

Scheduling of underground mining operations is in progress and the proposed schedule and rate of underground mining will be presented in the EIS. Drafting note: Alkane/RWC to provide updated txt for section

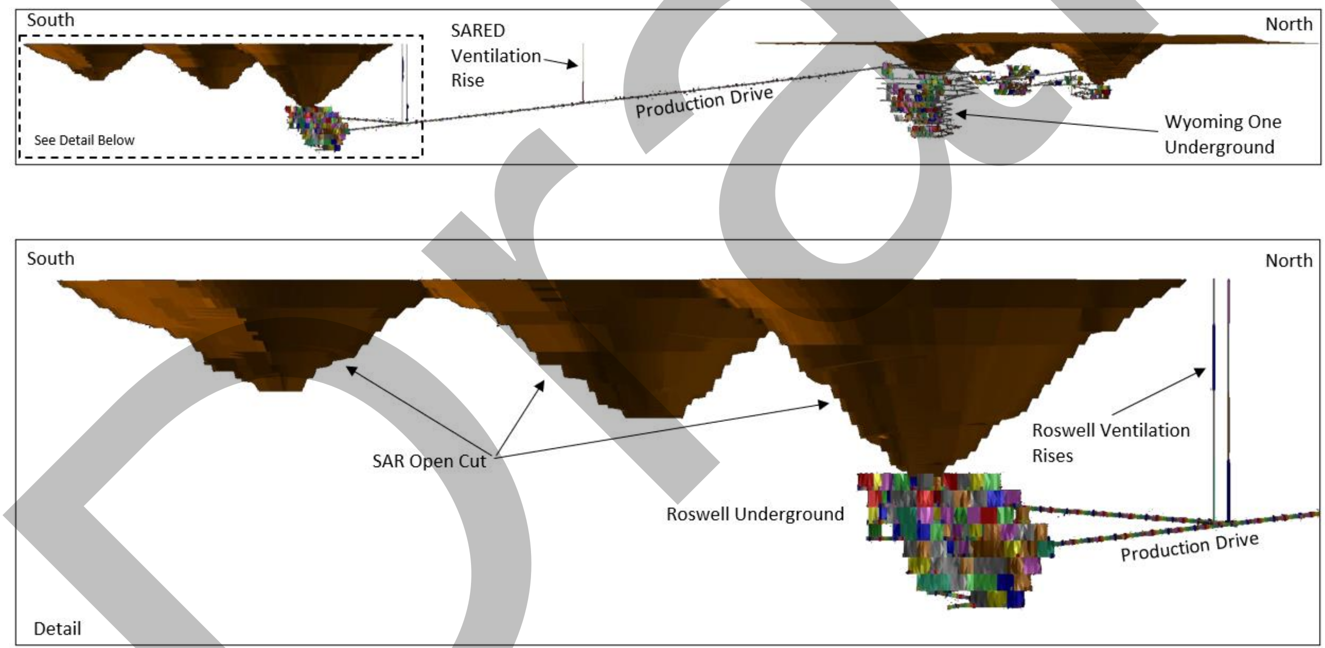

Figure 1.4: Proposed underground mining operations

1.3.4 Waste Rock Management

Waste rock from the SAR Open Cut would initially be used for site establishment operations, including construction of the SAR Amenity Bund. Subsequently, waste rock would be transported to the TGO Mine Site via the Haul Road and placed into the Caloma and Caloma 2 Open Cuts which would be completely backfilled, with a small hill constructed over the backfilled open cuts. Subsequently, waste rock would be placed into the SAR Waste Rock Emplacement, initially in an out-of-pit location, with in-pit placement of waste rock commencing following completion of the southern and central sections of the SAR Open Cut. The southern and central sections of the SAR Open Cut would also be completely backfilled to form an integrated SAR Waste Rock Emplacement.

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During waste rock placement operations in the SAR Waste Rock Emplacement, the Applicant would construct, shape and rehabilitate the outer sections of the Waste Rock Emplacement initially to minimise noise emissions and ensure that operations are, to the extent practicable, not visible from locations to the west of the Project Site.

The SAR and Caloma Waste Rock Emplacements would be designed as geomorphic landforms, with side slopes substantially less steep than the existing Waste Rock Emplacements within the TGO Mine Site. The proposed Waste Rock Emplacements would also, to the extent practicable, be designed without benches, steps or a large, flat upper surface. The intention of the design of the Waste Rock Emplacement would be to replicate a natural landform that would be less visually intrusive than "traditional" Waste Rock Emplacement designs. Design principles are presented in the EIS.

1.3.5 Processing Operations and Residue Management

Ore will be processed using the existing Processing Plant. The Applicant would add a second (primary) ball mill between the existing crushing circuit and the existing (secondary) ball mill. This would permit the Processing Plant to achieve the approved production rate of 1.5 Mtpa when processing hard rock. However, the SAR deposits include a substantial proportion of oxide ore. As a result, production rates when processing this softer material would increase to 1.75 Mtpa.

The Project would require additional capacity to store residue/tailings. RSF2 was approved to Stage 2 or a maximum elevation of 272 mAHD. Development consent would be sought to increase the height of RSF2 to incorporate Stage 9 of RSF2, with a maximum elevation of 286 mAHD. This would result in RSF2 having approximately the same final elevation as the approved RSF1.

1.3.6 Water Management

The Project Site and surrounding areas generally slope gently from east to west, with occasional low rises. Surface water flows are typically limited to small, indistinct watercourses. Surface water primarily flows east to west as sheet flow, with water pooling on the eastern side of the current Newell Highway. In extreme rainfall events, the Highway floods, typically once every 3 to 4 years.

Surface water diversion structures would be constructed during the initial site establishment phase of the Project. The Applicant proposes to construct a series of low, grass covered contour banks to the east of the proposed disturbance area. The contour banks would be designed to convey water at non-erosive velocities, with the contour banks overtopping in rainfall events that exceed their design criteria. A Flood Bund would be constructed to the east of the SAR Open Cut to provide protection from extreme rainfall events.

Culverts would be installed under the relocated Newell Highway, Haul Road and Services Road and gaps would be left in the SAR Amenity Bund. Where existing culverts under the section of the Newell Highway to be decommissioned are inadequate, sections of the road would be removed. Potentially sediment-laden or dirty water would be retained within the disturbed section of the Mine Site and would be used for mining-related purposes. Dirty water would be prevented from being discharged from site.

Water removed from the underground workings would be pumped to a surface storage facility and would be used for mining-related purposes. Mine water would be prevented from being discharged from site.

The current water supply for TGO is drawn from the Woodlands Borefield located approximately 35 km north of the mine site in the Lower Macquarie alluvial aquifer. Groundwater extraction from the borefield for the purpose of mineral ore processing is permitted under WAL20270 with an annual extraction limit of 1,000 ML.

There is no proposed change in water use associated with the TGEP and the same licenced allocation will continue to be used for both the TGO and TGEP water supply. Therefore, the assessment of groundwater supply does not form part of the current groundwater assessment.

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1.3.7 Final Landform, Land Use, Rehabilitation and Mine Closure

The approved and proposed final landform would include the following:

- Two bunded and fenced final voids, namely the approved and existing Wyoming 1 Open Cut and a proposed void within the northern section of the SAR Open Cut.
- Three fully backfilled open cuts, namely the approved Wyoming 3 and proposed Caloma and Caloma 2 Open Cuts.
- Three shaped and rehabilitated Waste Rock Emplacements, namely the approved and existing WRE2 and WRE3 and the proposed SAR Waste Rock Emplacement.
- Water management structures.
- The realigned Newell Highway and Kyalite Road would be retained. The Haul Road overpass on Kyalite Road would be removed or retained in consultation with Narromine Shire Council.

All infrastructure not required for the final land use would be removed or reduced in size, indicatively including the following:

- The Haul Road Amenity Bund and Haul Road would be removed. The Services Road would be reduced in size to facilitate ongoing management of the land post-mining.
- The Administration Area would be largely removed, with those structures suitable for the final land use retained. This may include sheds and limited hardstand areas.
- The magazines, RIM Pad, Pastefill Plant and other infrastructure would all be removed.
- All entrances to the underground workings would be sealed.

The final land use would comprise a mixture of agriculture and nature conservation.

Rehabilitation would be undertaken progressively, with the outer face of the SAR Waste Rock Emplacement rehabilitated as each lift is established, on an indicatively annual cycle throughout the life of the Project. Rehabilitation of other sections of the Project Site would be undertaken at the end of mine life. A Rehabilitation Management Plan describing the proposed rehabilitation operations and providing detailed completion criteria would be prepared in accordance with the guidelines relevant at that time.

Following completion of all rehabilitation operations and confirmation that the relevant completion criteria have been achieved, the Applicant would relinquish the Mining Lease.

1.4 Study area

A specific groundwater 'study area' was not adopted for the groundwater assessment. However, data review was generally concentrated to within an area of between 5 km and 10 km from TGP. Data for the broad scale standing water level contouring was collected from a larger data review area, which was about 55 km by 55 km and centred around TGP. These contours demonstrate the dominant regional groundwater flow directions.

1.4.1 DPIE Water and NRAR Consultation

Early consultation regarding a preliminary scope of works for the Project's groundwater assessment was undertaken with DPIE Water in September 2020. DPIE (2020) concluded that the proposed scope was generally satisfactory but recommended some amendments and provided comment on the preliminary scope. These comments were considered in finalising the Project's groundwater assessment scope.

The DPIE (2020) comments and a response/reference to relevant report sections are summarised in **Table 1.1**.

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Table 1.1: Coverage of DPIE (2020) comments relating to groundwater

DPIE (2020) comment relating to groundwater	**Response/coverage in report**
General	
Reference should be made to Department terminology including water sharing plan, groundwater source name, bore numbering conventions and existing water access licences.	Reference has been made to Water Sharing Plan (WSP), groundwater source name, state bore I.D. numbers and existing water access licences throughout various report sections, most notably in **Section 2.2** (for water policy/legislation elements) and **Section 3.4** and **7.1** (state bore I.D.s).
Groundwater Testing and Analysis	
We recommend that the proponent reconsiders the use of airlifting as a methodology to test aquifer parameters and collect water quality samples. *There are a range of limitations in using airlifting to determine yield, aquifer parameters and water quality of an aquifer:* • *airlifting does not provide a constant pumping rate from which to satisfactorily interpret aquifer parameters from* • *airlifting can over-estimate yields* • *airlifting will alter the pH of water through addition of carbon dioxide making the samples no longer representative of the site* • *airlifting is generally used in the development of bores. Please do not try to do these separate tasks at the same time as the results will not be representative and will be rendered unusable.* • *whilst airlifting can be used to undertake aquifer parameter testing and collection of water samples the confidence in the results will be low given the above limitations.*	<u>Water quality sampling</u> Only a single water quality sample from one TGEP monitoring bore was collected during airlifting and subsequently tested. Aside from this single sample, TGEP water quality samples were collected using hydrasleeves, to ensure representative water quality samples were collected. <u>Aquifer parameters</u> A multi-faceted approach has been applied to investigate groundwater system hydraulic characteristics. Whilst airlifting yields have been considered, other approaches were used, such as water level recovery after airlifting, packer testing, and groundwater inflow rate observations from the existing open cuts and underground mine. Groundwater quality and hydraulic testing is covered in **Sections 4.3** and **4.4**, respectively.
Can you please: • *pay attention to the recording of the recovery test results as its analysis is likely to be more indicative of the aquifer parameters.* • *survey monitoring bores so that groundwater levels can be measured in metres Australian Height Datum and compared to one another.* • *include Form As or any bore construction information relating to the monitoring bores in the report so assessment of whether the monitoring bores have been appropriately designed for their intended purpose can be made.* • *carefully consider the methodology for groundwater quality sampling so as not to introduce further errors into the water quality results.*	Water level recovery after airlifting was recorded and is covered in **Section 4.4.3**. Ground level or top of casing level has been surveyed at the TGP monitoring bores. Groundwater levels are compared in the datum of mAHD. TGEP/TGO monitoring bore construction details are summarised in **Section 4.2**. It is understood that Form As have been submitted for the recent TGEP bores. As outlined above, TGEP groundwater quality samples were typically collected using hydrasleeves, to ensure representative sample collection.

Groundwater Modelling and Monitoring	
Can you please: • *Include a site water balance.* • *provide evidence so that the Department has confidence in your chosen model classification. This is particularly true on the range of model parameters.* • *ensure the conceptual groundwater model includes site cross sections.* • *include a groundwater monitoring plan with a proposal to include a trigger action and response plan in order to manage potential impacts if they arise.*	A combined surface water and groundwater water balance is outside of the groundwater assessment scope and is provided in the Project's EIS. Groundwater model water balance volumes are included in **Section 6.6.1.4** and **6.6.2.4** and predicted groundwater inflow rates are discussed in **Section 6.8.1**. Groundwater model classification is justified in **Section 6.4**.

1.4.2 Secretary's Environmental Assessment Requirements

An EIS must be prepared in response to requirements set out by the Secretary of the NSW Department of Planning, Industry and Environment (DPIE). These requirements are known as the Secretary's Environmental Assessment Requirements (SEARs).

Key issues relating to groundwater, as identified in the SEARs (NSW DPIE, 2021), are provided in **Table 1.2**. **Table 1.2** also includes direction to the relevant section(s) within this report where each issue has been addressed. Additionally, **Table 1.3** outlines coverage of issues identified by other government agencies for consideration.

Drafting note: suggest this table is deleted in final groundwater report. Much of the table is not relevant to groundwater and it may be better to only present the SEARs.

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Table 1.2: Coverage of SEARs relating to groundwater

Summarised or Paraphrased Relevant Requirement	Coverage in report
The EIS must address the following specific issues with the level of assessment of likely impacts proportionate to the significance of, or degree, of impact on, the issue, within the context of the project location and the surrounding environment and having regard to applicable NSW Government policies and guidelines, including: ▪ an assessment of the likely impacts of the development on the quantity and quality of surface, and groundwater resources, having regard to the NSW Aquifer Interference Policy;	Surface water elements covered in Project's surface water assessment. Groundwater elements covered in **Section 7**.
▪ an assessment of the hydrological characteristics of the site and downstream;	Covered in Project's surface water assessment.
▪ an assessment of the likely impacts of the development on aquifers, watercourses, riparian land, water-related infrastructure and systems and other water users, including impacts to water supply from dams, and riparian and licensed water users;	Surface water elements covered in Project's surface water assessment. Groundwater elements covered in **Section 7**.
▪ a detailed site water balance, including a description of site water demands, water disposal methods (inclusive of volume and frequency of any water discharges), water supply and transfer infrastructure and water storage structures, and measures to minimise water use;	Covered in Project's ##### assessment. Drafting note RWC to insert relevant assessment report.
▪ demonstration that water for the construction and operation of the development, for the life of the project, can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan (WSP), and include an assessment of the current market depth where water entitlement is required to be purchased;	Coverage of groundwater take is addressed in **Section 7.4**
▪ a description of the measures proposed, including monitoring activities and methodologies, to ensure the development can operate in accordance with the requirements of any relevant WSP or water source embargo;	Demonstration that the Project can operate in accordance with the relevant WSP is covered in **Sections 2.1**, **2.2** and **7.4**.
▪ a detailed description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate surface and groundwater impacts;	Management and mitigation measures, including a preliminary groundwater monitoring program are outlined in **Section 8**.

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Summarised or Paraphrased Relevant Requirement	Coverage in report
▪ a description of construction erosion and sediment controls, how the impacts of the development on areas of erosion, salinity or acid-sulphate risk, steep gradient land or erodible soils types would be managed and any contingency requirements to address residual impacts; and	Covered in Project's ##### assessment. Drafting note RWC to insert relevant assessment report.
▪ an assessment of the potential flooding impacts of the project;	Covered in Project's surface water assessment.

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Table 1.3: Coverage of issues identified by other government agencies for consideration

Agency / Organisation	Summary or Paraphrased Relevant Requirement	Relevant Section(s)
Biodiversity, Conservation and Science Directorate 06/07/2021	The EIS must map the following features relevant to water and soils including: a. Acid sulfate soils (Class 1, 2, 3 or 4 on the Acid Sulfate Soil Planning Map);	Covered in Project's ###### assessment. Drafting note RWC to insert relevant assessment report.
	b. Rivers, streams, wetlands, estuaries (as described in s4.2 of the Biodiversity Assessment Method);	Covered in Project's surface water assessment.
	c. Wetlands as described in s4.2 of the Biodiversity Assessment Method;	Covered in Project's surface water assessment.
	d. Groundwater;	**Section 3.4**
	e. Groundwater dependent ecosystems;	**Section 3.5**
	f. Proposed intake and discharge locations.	Covered in Project's ###### assessment. Drafting note RWC to insert relevant assessment report.
	The EIS must describe background conditions for any water resource likely to be affected by the development, including: a. Existing surface and groundwater;	Background groundwater conditions are described in **Section 4.2** and **4.3**
	b. Hydrology, including volume, frequency and quality of discharges at proposed intake and discharge locations;	Covered in Project's surface water assessment.

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Agency / Organisation	Summary or Paraphrased Relevant Requirement	Relevant Section(s)
	c. Water Quality Objectives (as endorsed by the NSW Government) including groundwater as appropriate that represent the community's uses and values for the receiving waters;	The groundwater Water Quality Objective is outlined in **Section 2.5**
	d. Indicators and trigger values/criteria for the environmental values identified at (c) in accordance with the ANZECC (2000) Guidelines for Fresh and Marine Water Quality and/or local objectives, criteria or targets endorsed by the NSW Government;	Trigger values are covered in the preliminary monitoring program, **Section 8.3**
	e. Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions.	Covered in Project's ###### assessment. Drafting note RWC to insert relevant assessment report.
	The EIS must assess the impacts of the development on water quality, including: a. The nature and degree of impact on receiving waters for both surface and groundwater, demonstrating how the development protects the Water Quality Objectives where they are currently being achieved, and contributes towards achievement of the Water Quality Objectives over time where they are currently not being achieved. This should include an assessment of the mitigating effects of proposed stormwater and wastewater management during and after construction;	Groundwater quality is assessed in **Section 7.5**, **7.6** and **7.7**.
	b. Identification of proposed monitoring of water quality.	Groundwater monitoring covered in **Section 8.3**
	The EIS must assess the impact of the development on hydrology, including: a. Water balance including quantity, quality and source;	Covered in Project's ###### assessment. Drafting note RWC to insert relevant assessment report.

Agency / Organisation	Summary or Paraphrased Relevant Requirement	Relevant Section(s)
	b. Effects to downstream rivers, wetlands, estuaries, marine waters and floodplain areas;	Covered in Project's surface water assessment.
	c. Effects to downstream water-dependent fauna and flora including groundwater dependent ecosystems;	Assessment of potential impacts to groundwater dependent ecosystems is covered in **Section 7.2**.
	d. Impacts to natural processes and functions within rivers, wetlands, estuaries and floodplains that affect river system and landscape health such as nutrient flow, aquatic connectivity and access to habitat for spawning and refuge (e.g. river benches);	Covered in Project's ##### assessment. Drafting note RWC to insert relevant assessment report.
	e. Changes to environmental water availability, both regulated/licensed and unregulated/rules-based sources of such water;	**Section 7.4**
	f. Mitigating effects of proposed stormwater and wastewater management during and after construction on hydrological attributes such as volumes, flow rates, management methods and re-use options;	Covered in Project's surface water assessment.
	g. Identification of proposed monitoring of hydrological attributes.	Covered in Project's surface water assessment.
	Flooding	
	The EIS must map the following features relevant to flooding as described in the Floodplain Development Manual 2005 including: a. Flood prone land;	Flooding covered in Project's surface water assessment.
	b. Flood planning area, the area below the flood planning level;	
	c. Hydraulic categorisation (floodways and flood storage areas);	
	d. Flood hazard.	

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Agency / Organisation	Summary or Paraphrased Relevant Requirement	Relevant Section(s)
	The EIS must describe flood assessment and modelling undertaken in determining the design flood levels for events, including a minimum of the 5% Annual Exceedance Probability (AEP), 1% AEP, flood levels and the probable maximum flood, or an equivalent extreme event.	
	The EIS must model the effect of the proposed development (including fill) on the flood behaviour under the following scenarios: a. Current flood behaviour for a range of design events as identified in 14 above. This includes the 0.5% and 0.2% AEP year flood events as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change.	
	Modelling in the EIS must consider and document: a. Existing council flood studies in the area and examine consistency to the flood behaviour documented in these studies;	
	b. The impact on existing flood behaviour for a full range of flood events including up to the probable maximum flood, or an equivalent extreme flood;	
	c. Impacts of the development on flood behaviour resulting in detrimental changes in potential flood affection of other developments or land. This may include redirection of flow, flow velocities, flood levels, hazard categories and hydraulic categories;	
	d. Relevant provisions of the NSW Floodplain Development Manual 2005.	
	The EIS must assess the impacts on the proposed development on flood behaviour, including: a. Whether there will be detrimental increases in the potential flood affectation of other properties, assets and infrastructure;	
	b. Consistency with Council floodplain risk management plans;	
	c. Consistency with any Rural Floodplain Management Plans;	
	d. Compatibility with the flood hazard of the land;	
	e. Compatibility with the hydraulic functions of flow conveyance in floodways and storage in flood storage areas of the land;	
	f. Whether there will be adverse effect to beneficial inundation of the floodplain environment, on, adjacent to or downstream of the site;	
	g. Whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of riverbanks or watercourses;	
	h. Any impacts the development may have upon existing community emergency management arrangements for flooding. These matters are to be discussed with the NSW SES and Council;	
	i. Whether the proposal incorporates specific measures to manage risk to life from flood. These matters are to be discussed with the NSW SES and Council;	

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Agency / Organisation	**Summary or Paraphrased Relevant Requirement**	**Relevant Section(s)**
	j. Emergency management, evacuation and access, and contingency measures for the development considering the full range or flood risk (based upon the probable maximum flood or an equivalent extreme flood event). These matters are to be discussed with and have the support of Council and the NSW SES;	
	k. Any impacts the development may have on the social and economic costs to the community as consequence of flooding.	
DPIE Water and Natural Resources Access Regulator 29/06/2021	The identification of an adequate and secure water supply for the life of the project. This includes confirmation that water can be sourced from an appropriately authorised and reliable supply. This is also to include an assessment of the current market depth where water entitlement is required to be purchased.	**Section 2.1**, **2.2** and **7.4**
	A detailed and consolidated site water balance.	Covered in Project's ###### assessment. Drafting note RWC to insert relevant assessment report.
	Assessment of impacts on surface and ground water sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts.	Groundwater related elements are assessed in **Section 7** and management/ mitigation measures are covered in **Section 8**.
	Proposed surface and groundwater monitoring activities and methodologies.	Groundwater monitoring is covered in **Section 8.3**.
	Consideration of relevant legislation, policies and guidelines, including the NSW Aquifer Interference Policy (2012), the Guidelines for Controlled Activities on Waterfront Land (2018) and the relevant Water Sharing Plans (available at https://www.industry.nsw.gov.au/water).	**Section 2**, **7.4** and **7.7**.
Narromine Shire Council 07/07/2021	The EIS shall consider the potential for groundwater contamination as well as the contamination of nearby watercourses. Contamination and mitigation measures shall be detailed in the EIS along with preventative measures to contain runoff and sediments from the proposed mine impacting on water resources.	**Section 7.5**

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Agency / Organisation	Summary or Paraphrased Relevant Requirement	Relevant Section(s)
	Additionally, the proposal shall consider the impact of the proposed extraction methods on the soil profile and stability of the site along with erosion and sediment control measures, including surface water runoff management.	Covered in Project's ###### assessment. Drafting note RWC to insert relevant assessment report.
	A comprehensive assessment of the potential impacts on the intermittent watercourses and dams on neighbouring properties from stormwater flows including an assessment of potential water discharge quantities and qualities against receiving water shall be provided within the EIS.	Covered in Project's surface water assessment.
	An assessment of the impact of water diversions on public roads and realigned roads should be made.	Covered in Project's surface water assessment.

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Agency / Organisation	Summary or Paraphrased Relevant Requirement	Relevant Section(s)
NSW Resource Regulator (drafting note: Jacobs has added this to the RWC table content)	▪ Where a void, is proposed to remain as part of the final landform, include: - a constraints and opportunities analysis of final void options, including backfilling, to justify that the proposed design is the most feasible and environmentally sustainable option to minimise the sterilisation of land post-mining; - a geotechnical assessment to identify the likely long-term stability risks associated with the proposed remaining high wall(s) and low wall(s) along with associated measures that will be required to minimise potential risks to public safety; and - an assessment of the long-term erosional stability of pit walls that will remain as part of the final rehabilitated landform; - outcomes of the surface and groundwater assessments in relation to the likely final water level in the void. This should include an assessment of the potential for fill and spill along with measures required be implemented to minimise associated impacts to the environment and downstream water users. ▪ Where the mine includes underground workings: - determine (with reference to the groundwater assessment) the likelihood and associated impacts of groundwater accumulating and subsequently discharging (e.g. acid or neutral mine drainage) from the underground workings post cessation of mining; and - consideration of the likely controls required to either prevent or mitigate against these risks as part of the closure plan for the site.	Assessment of final void water levels and quality is covered in **Section 7.6**. Drafting note: currently the draft report does not address the content highlighted cyan colour

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2. Legislative and policy context

The legislative and policy context relevant to groundwater is summarised in the following sections.

2.1 Water Act 1912 and Water Management Act 2000

Water resources in NSW are administered under the Water Act 1912 and the Water Management Act 2000 (WM Act) by the DPIE-Water. In general, the WM Act governs the issue of water access licences (WALs) and approvals for those water sources (rivers, lakes, estuaries and groundwater) in NSW where Water Sharing Plans (WSPs) have commenced. The WSPs for the Project have commenced and water management for the Project is therefore generally governed under the WM Act. The WSPs relevant to the Project are outlined in **Section 2.2**.

Ordinarily, if an activity leads to a take from a groundwater or surface water source covered by a WSP, then an approval and / or licence is required. In general, the WM Act requires:

- a WAL to take water;
- a water supply works approval to construct a work; and
- a water use approval to use the water.

Where an activity leads to a take from a groundwater or surface water source not covered by a WSP or consists of an activity not specifically addressed by the WM Act, then the activity is managed through the Water Act 1912. In such cases, the Water Act 1912 requires:

- a licence to extract groundwater or surface water using any type of work; and
- a water supply work approval to construct a work.

It is noted that, as the Project is considered to be a State Significant Development, under Section 4.41 (1g) of the EP&A Act 1979, the authorisation provided by a water use approval under Section 89 of the WM Act, a water management work approval under Section 90 of the WM Act or an activity approval under Section 91 WM Act are not required. Rather, this authorisation is provided by a development consent.

Thus, if the Project's groundwater / surface water extraction is assessed and approved as part of the State Significant Development proposal, only a WAL would be required. A WAL is required for dewatering and other taking of water from any water source which is covered by a WSP under the WM Act. A WAL authorises the taking of a share of water from a specified water source in accordance with the volumetric entitlement in the WAL. That entitlement is measured by the number of units assigned to the WAL and the annual volumetric value of a unit for that water source as determined by the Minister administering the WM Act. Units can be transferred from one WAL to another. A WAL is held personally and may be transferred and otherwise dealt with in accordance with the WM Act.

Alkane currently holds the WALs shown in **Table 2.1** and six groundwater works approvals under the Water Act 1912 as summarised in **Table 2.2**. Background information on WAL20270 is provided in **Section 1.3.6**.

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Table 2.1: WALs held by the mine

Water Access License number	Extraction limit (ML/year)	Water Sharing Plan Water Source	Description
Surface water			
WAL 35321	22	Upper Bogan River Water Source	Water Supply Works and Water Use
Groundwater			
WAL 20270	1,000	Lower Macquarie Zone 6 Groundwater Source	Aquifer (Woodlands Borefield)
WAL 28643	220	Lachlan Fold Belt MDB Groundwater Source	Dewatering

Table 2.2: Water Act 1912 licenses held by the Mine

<table>
<tr><th>License number</th><th>Issue date</th><th>Expiry date</th><th>Purpose</th></tr>
<tr><td>80BL245428</td><td rowspan="5">23 September 2009</td><td rowspan="6">Perpetuity</td><td rowspan="6">Groundwater monitoring</td></tr>
<tr><td>80BL245429</td></tr>
<tr><td>80BL245430</td></tr>
<tr><td>80BL24531</td></tr>
<tr><td>80BL245432</td></tr>
<tr><td>80BL620426</td><td>27 October 2014</td></tr>
</table>

2.2 Water Sharing Plans

The Project resides in the Lachlan Fold Belt MDB Groundwater Source of the Water Sharing Plan for the NSW MDB Fractured Rock Groundwater Sources 2020 (NSW Government, 2020). Te Lachlan Fold Belt MDB Groundwater Source is subdivided into management zones and the Project resides in the 'Lachlan Fold Belt MDB (Other) Management Zone'.

As at March 2021, the NSW Water Register (Water NSW, 2021a) indicates the groundwater source has 1,098 WALs and a total share component of 75,819 units/ML. The WSP (NSW Government 2020) indicates the groundwater source has a long-term average annual extraction limit (LTAEL) of 253,788 ML/year. Thus, about 70% of the groundwater in this water source is currently unassigned. Trading in this water source is common, and in the 2020/2021 water/financial year there were 52 records of transfer trading (Water NSW, 2021a).

Surface water WSPs are potentially relevant to the groundwater assessment if the Project causes baseflow reductions to nearby watercourses due to groundwater level drawdown. With regards to surface water, the Project resides in the Upper Bogan River Water Source of the Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources 2012. In relation to the Upper Bogan River Water Source, the NSW Water Register (Water NSW, 2021a) indicates this surface water source has 27 WALs and a total share component of 1,849 units/ML. The register indicates that the volume of water made available to all the WALs is 1,849 ML.

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As outlined in **Section 1.3.6**, the Mine water supply is extracted from groundwater from an off-site source; that is, the Lower Macquarie Zone 6 Groundwater Source of the Water Sharing Plan for the Macquarie-Castlereagh Groundwater Sources 2020 (NSW Government, 2020a). The borefield and groundwater source are located approximately about 35 km to the north of TGO. The water is used for processing.

2.3 NSW Aquifer Interference Policy (2012)

The NSW Aquifer Interference Policy (AIP) (DPI, 2012) outlines 'Minimal Impact Considerations' for water table and groundwater pressure drawdown at high priority groundwater dependent ecosystems (GDEs) (as identified in the WSP), high priority culturally significant sites (as identified in the WSP) and existing groundwater supply bores. Water quality impact considerations are also outlined.

Different 'Minimal Impact Considerations' from DPI (2012) are applicable to different groundwater source types. In the context of the AIP, the Project is characterised to reside in the 'porous and fractured rock water sources' sub-category of the 'less productive groundwater sources' category. This characterisation is made on the basis that groundwater systems in the vicinity of TGP do not simultaneously have existing bores that can yield greater than 5 L/s and a total dissolved solids concentration of <1,500 mg/L, which is the NSW DPI (2012) criteria used distinguish a 'highly productive' groundwater source from a 'less productive groundwater source'.

Small perched discrete alluvial groundwater systems exist within the vicinity of TGP. These groundwater systems are not recognised as being part of a distinct alluvial water source in the WSP. Therefore, potential impacts to these alluvial groundwater systems have been assessed against the criterium applicable for the 'less productive' 'porous and fractured rock water sources' category.

In accordance with the AIP (DPI, 2012), the Minimal Impact Considerations outlined in **Table 2.3** apply.

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Table 2.3: AIP (DPI, 2012) Minimal Impact Considerations - Less Productive Groundwater Sources

Water Source	*Water Table*	*Water Pressure*	*Water Quality*
Porous and fractured rock groundwater sources	*1. Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40m from any: (a) high priority GDE; or (b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan. A maximum of a 2m decline cumulatively at any water supply work. 2. If more than 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40m from any: (a) high priority GDE; or (b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan then appropriate studies would be required to demonstrate to the Minister's satisfaction that the variation would not prevent the long-term viability of the dependent ecosystem or significant site. If more than 2m decline cumulatively at any water supply work, then make good provisions should apply.*	*1. A cumulative pressure head decline of not more than a 2m decline, at any water supply work. 2. If the predicted pressure head decline is greater than requirement 1 above, then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline would not prevent the long-term viability of the affected water supply works unless make good provisions apply.*	*1. Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40m from the activity. 2. If condition 1 is not met then appropriate studies would be required to demonstrate to the Minister's satisfaction that the change in groundwater quality would not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply works.*

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2.4 National Water Quality Management Strategy

The National Water Quality Management Strategy (NWQMS) (Australian Government, 2018) is the adopted national approach to protecting and improving water quality in Australia. It consists of several guideline documents, of which certain documents relate to protection of surface water resources and others relate to the protection of groundwater resources.

The primary document relevant to the assessment of groundwater risks for the proposal is the Guidelines for Groundwater Quality Protection in Australia (Australian Government, 2013). This document sets out a high-level risk-based approach to protecting or improving groundwater quality for a range of groundwater beneficial uses (called 'environmental values'), including aquatic ecosystems, primary industries (including irrigation and general water users, stock drinking water, aquaculture and human consumption of aquatic foods), recreational and aesthetic values (e.g. swimming, boating and aesthetic appeal of water bodies), drinking water, industrial water and cultural values.

For the purpose of the groundwater assessment, the industrial water 'environmental value' is considered potentially applicable in the vicinity of TGP. The other 'environmental values' are not applicable due to the high salinity of the groundwater.

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG) (Australian and New Zealand Governments, 2018) provide a framework for conserving ambient water quality in rivers, lakes, estuaries and marine waters and list a range of environmental values assigned to that waterbody. The ANZG (2018) recommended guideline values have been considered in the assessment of existing groundwater quality.

2.5 Groundwater quality objective

The groundwater quality objective for the Project is to ensure construction and operation of the project has a neutral or beneficial effect to groundwater quality.

For the purpose of this assessment, a neutral or beneficial effect to groundwater quality is defined as an effect that does not lower the beneficial use category of the groundwater system, or an effect that raises the beneficial use category of the groundwater system.

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3. Existing environment

3.1 Climate

For the purpose of this assessment, climate data has been obtained from both the onsite Automatic Weather Station (Alkane AWS) and from Queensland Government's online SILO database of Australian climate data. The onsite AWS climatic record which commenced in October 2013 is considered relatively short for the purposes of analysing long term climatic trends and as such, is supplemented with the use of the SILO dataset. The long-term statistics for the onsite AWS are presented alongside the SILO dataset which has a significantly longer historical record, with data commencing from 1889.

SILO data can be acquired for individual weather station points, or as point or gridded dataset with a resolution of approximately 5 km x 5 km. The SILO data used in this report is a point dataset from January 1970 and consists of interpolated daily data. The SILO data was extracted for the now closed Tomingley weather station (Bureau of Meteorology station # 050091) point Latitude -32.60 degrees north and Longitude 148.20 degrees east.

Key rainfall and evaporation statistics are provided in **Table 3.1**.

The climate statistical trends between the SILO and the Alkane AWS dataset are in general agreeance except for the months of February and March which can be attributed to the relatively short dataset of Alkane AWS. Mean monthly pan evaporation exceeds mean monthly rainfall for all months in both datasets. Mean monthly FAO56 Penman-Monteith evaporation (SILO) exceeds mean monthly rainfall for all months. The difference between evaporation and rainfall is most pronounced during summer months.

Table 3.1: Tomingley (Lat -32.60 N, Long 148.20 E) and Alkane AWS rainfall and evaporation summary (Source: SILO)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual total
Mean monthly rainfall (mm) (Alkane)[1]	65	35	85	46	37	40	44	37	42	46	61	65	603
Mean monthly rainfall (mm) (SILO)[2]	59	50	51	41	44	37	44	39	42	45	53	56	562
Mean monthly pan evaporation (mm) (Alkane)[1]	244	207	165	118	81	53	69	95	127	171	204	229	1762
Mean monthly pan evaporation (mm) (SILO)[2]	278	221	189	120	73	48	53	77	114	172	218	272	1833
Mean monthly FAO56 evaporation (mm) (SILO)[2]	203	164	146	98	63	43	46	66	95	139	168	199	1432
Rainfall surplus (mm) (Alkane)[3]	-179	-171	-80	-72	-45	-13	-24	-58	-85	-125	-143	-165	-1158
Rainfall surplus (mm) (SILO)[3]	-219	-171	-137	-79	-29	-11	-8	-38	-72	-127	-164	-216	-1271

Notes: [1] Based on record from Oct 2013 to end of Apr 2021. [2] Based on record from 1970 to Apr 2021. [3] Calculated by subtracting pan evaporation from rainfall.

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3.2 Topography and drainage

Topography and watercourses in the region of TGO and the TGEP are presented on **Figure 3.1**.

The TGEP is situated on relatively gently sloping, rolling to flat terrain with dominant fall to the west. Typical topographic gradients are of the order of 1:250. Surface elevations in the TGEP area are typically of the order of 265 mAHD to 270 mAHD. The rolling terrain continues north and south of the TGEP. To the west towards the Bogan River, the gentle slopes flatten even further; whereas, to the east, slopes increase towards the foothills of the Harveys Range that in places is in excess of 500 mAHD.

The TGEP is situated in the Bogan River catchment between the ephemeral Gundong and Bulldog Creeks which both drain west to the Bogan River, approximately 10 km to 12 km to the south and southwest of the TGEP. In this locality, the Bogan River itself is also ephemeral, flowing only after large or sustained rainfall events. Both Gundong Creek and Bulldog Creek rise on the western flanks of the Harveys Range and are third order drainages as they cross the Newell Highway. Water courses rising on the east of the Harveys Range ultimately drain east to the Macquarie River.

A number of ephemeral and poorly defined drainage channels also exist in the area, typically draining to the west or south-west, with numerous small dams established along the drainage lines.

More detail on local surface water and catchments is provided in the Project's surface water assessment.

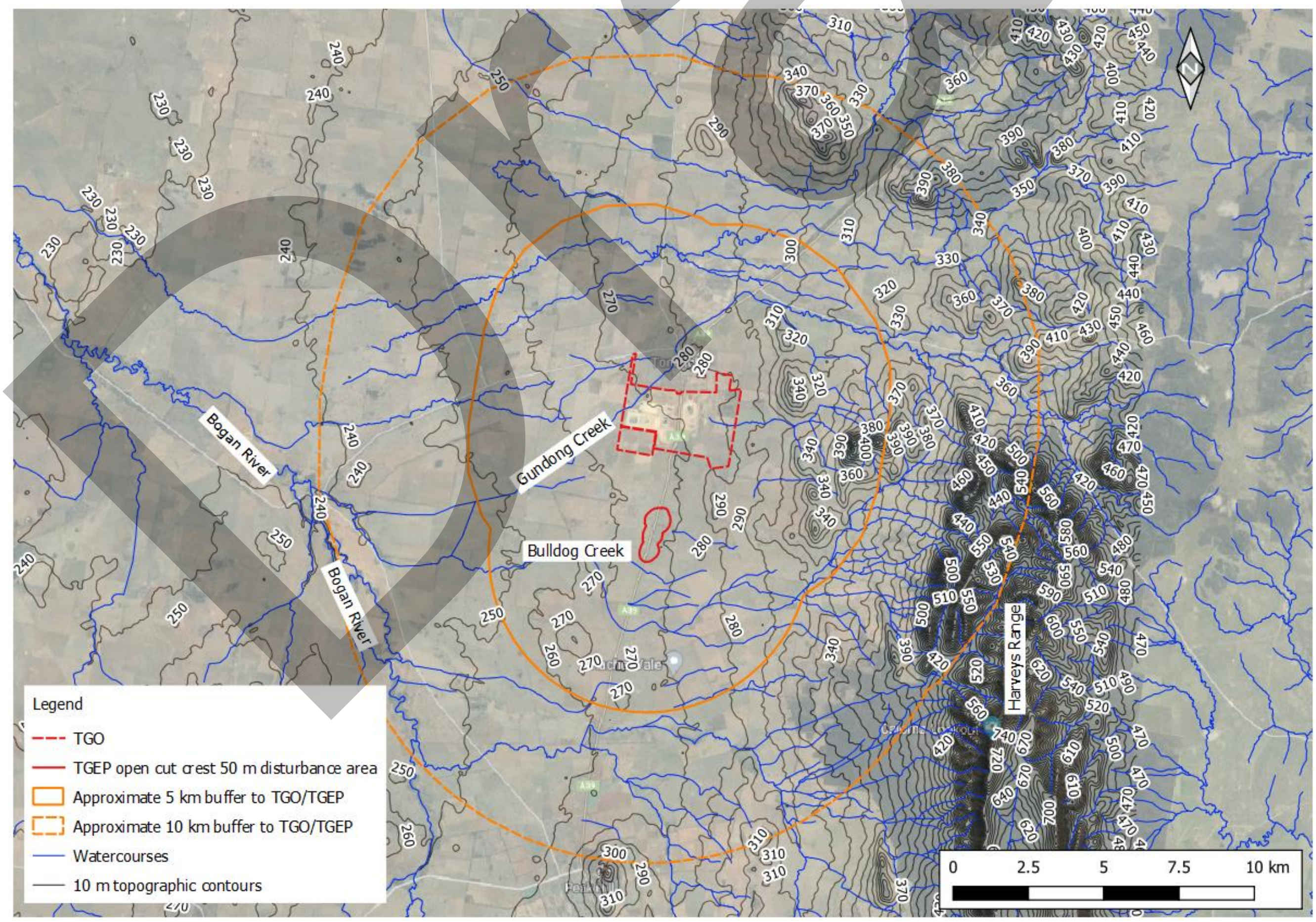

Figure 3.1: Topography and drainage

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3.3 Geology

Regionally TGP is located in the eastern zone of the Lachlan Foldbelt in an area known as the Macquarie Arc. The Macquarie Arc consists of igneous and fore arc accretionary deposits of Ordovician and Silurian age.

The Impax Group (2011) indicates that '*within the Macquarie Arc, several individual belts of mafic to intermediate volcanic, intrusive, volcaniclastic and turbiditic rocks have been identified. These sequences are segmented by a number of generally north–south to north-northwest trending arc-parallel structures, many of which are thought to be thrust faults or major strike-slip faults. The volcanic belts comprise Ordovician to early Silurian rocks with predominantly mafic to andesitic composition and display a spectrum of rock types including lavas, breccias, volcaniclastic sandstone and siltstone, and the monzonitic to dacitic intrusions'*.

The Impax Group (2011) indicates the TGP is '*located near the eastern margin of the Junee-Narromine volcanic belt, just east of the interpreted Parkes Thrust. This structure separates the flat lying Goonumbla volcanic complex from a thin slice of north-south trending andesitic volcanics (Mingelo volcanics) (The Impax Group, 2011). The late Ordovician Mingelo volcanics are overlain by meta-sediments thought to be equivalents of the early Silurian Cotton formation'*.

The Impax Group (2011) indicates the '*deformation of the Lachlan Fold Belt is complex and reflects multiple events. The Ordovician rocks west of the Parkes thrust are weakly deformed, with broad open folds and sub-greenschist metamorphic assemblages. In contrast, the Ordovician-Silurian sequences east of the fault, including the rocks hosting the deposits at TGO and TGEP, exhibit tight to isoclinal folding, strong axial planar cleavage with greenschist metamorphic assemblages. Northwest trending transverse structures are also evident in regional magnetic and gravity data, and rarely as faults mappable in outcrop. These structures appear to be long lived fundamental crustal breaks that were irregularly reactivated throughout the geological development of the Macquarie Arc. They also show a relationship to intrusive centres and mineralisation where the structures intersect and occasionally offset the arc parallel structures. The TGEP deposits themselves are interpreted as orogenic gold systems positioned within a major structural zone'*.

The Parkes Special 1:100,000 Geological Sheet (Krynen *et al.*,1990) indicates that the majority of the TGEP area is covered by Cainozoic alluvial and colluvial deposits with occasional outcrops of Ordovician Mingelo volcanics and Silurian siltstones of the Cotton and Mumbidgle Formations (**Figure 3.2**). Geological mapping in the Narromine 1:250,000 Geological Sheet (Sherwin,1997) (**Figure 3.3**) and Narromine 1:250,000 Metallogenic Series Sheet (Bowman et.al, 1980) (**Figure 3.4**) is generally similar to Parkes Geological Sheet, however there are some differences.

The Cainozoic deposits typically comprise alluvial clays to sandy clays with thicknesses ranging from 20 m to 60 m. At the historic Myalls United gold mine, located between TGO and TGEP, the basement rocks (Cotton Formation) outcrop on a low rise. There is potential for minor sandy alluvial deposits within the main drainage channels with a minor alluvial aquifer associated with Gundong Creek.

The geotechnical report for the TGEP (WSP, 2021) describes five geotechnical horizons, and differentiates the Cainozoic alluvium into Quaternary and Tertiary alluvial deposits, although the characteristics are very similar.

The WSP (2021) geotechnical horizons are as follows:

1. Quaternary Alluvium (QA) of brown sandy clays, sandy silty clays and minor sands and gravels.

2. Tertiary Alluvium (TA) of grey mottled red orange sandy clays and silty clays and sands.

3. Saprolite defined as extremely weathered rock with soil consistency and relict geological structure and referred to operationally as saprock.

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4. Weathered Rock (WR) oxidised and highly to moderately weathered rock.

5. Slightly Weathered and Fresh Rock (SW/FR).

The alluvial deposits are characterised from ten samples (WSP, 2021). Average grainsize analysis results from all ten samples indicate a composition of approximately 12% sand, 86% fines (silt and clay) with the balance being gravel at approximately 2%. Particle size distribution testing did not separate the silt and clay fractions. The samples are generally represented as silty clay with sand and trace gravel and are of moderate to high plasticity indicating a dominance of clay.

The regolith profile at TGEP is generally well developed with weathering and oxidation extending to around 70 mbgl.

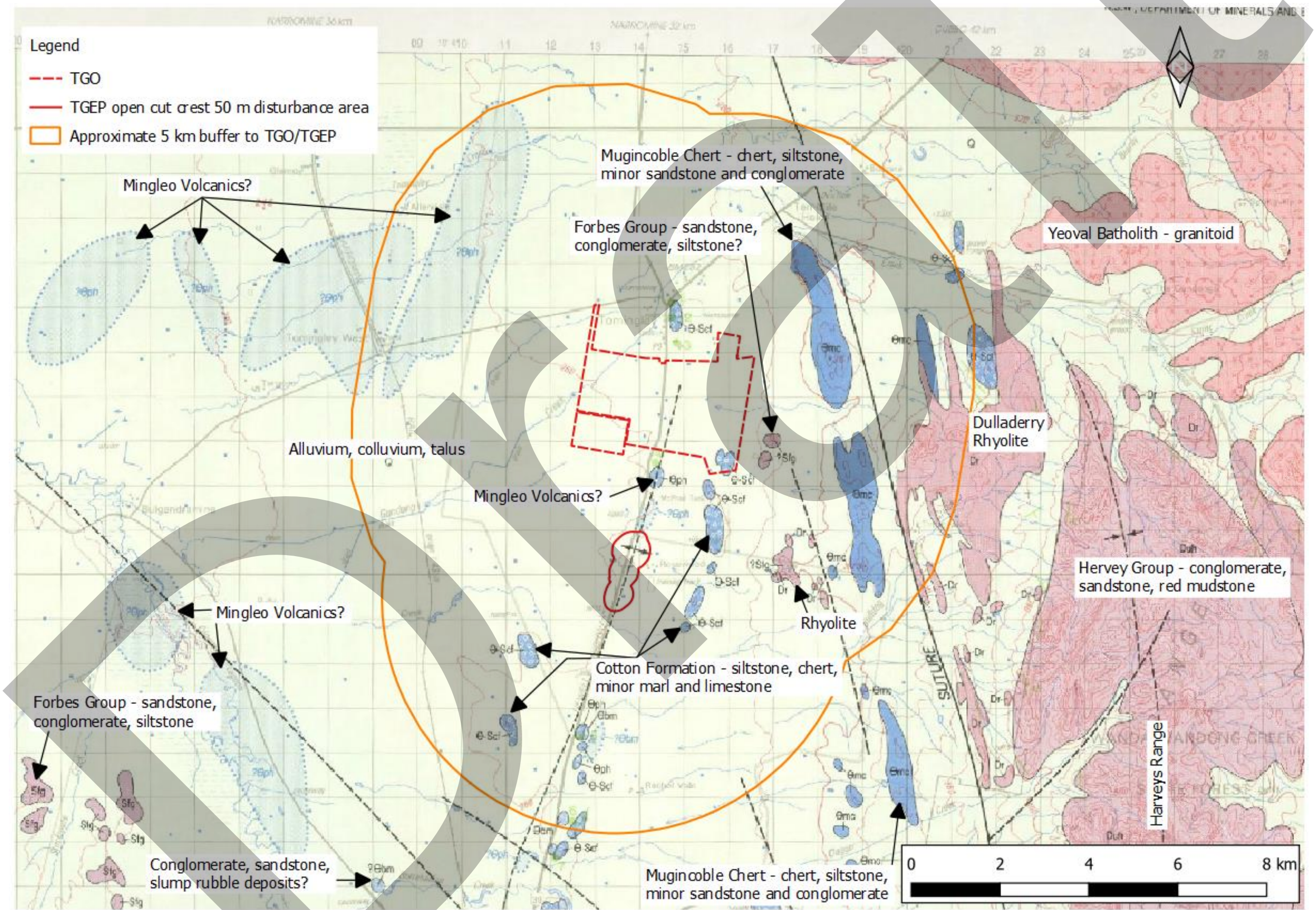

Figure 3.2: Regional Geology, extract from Parkes Special 1:100,000 Geology Sheet (Krynen et.al, 1990)

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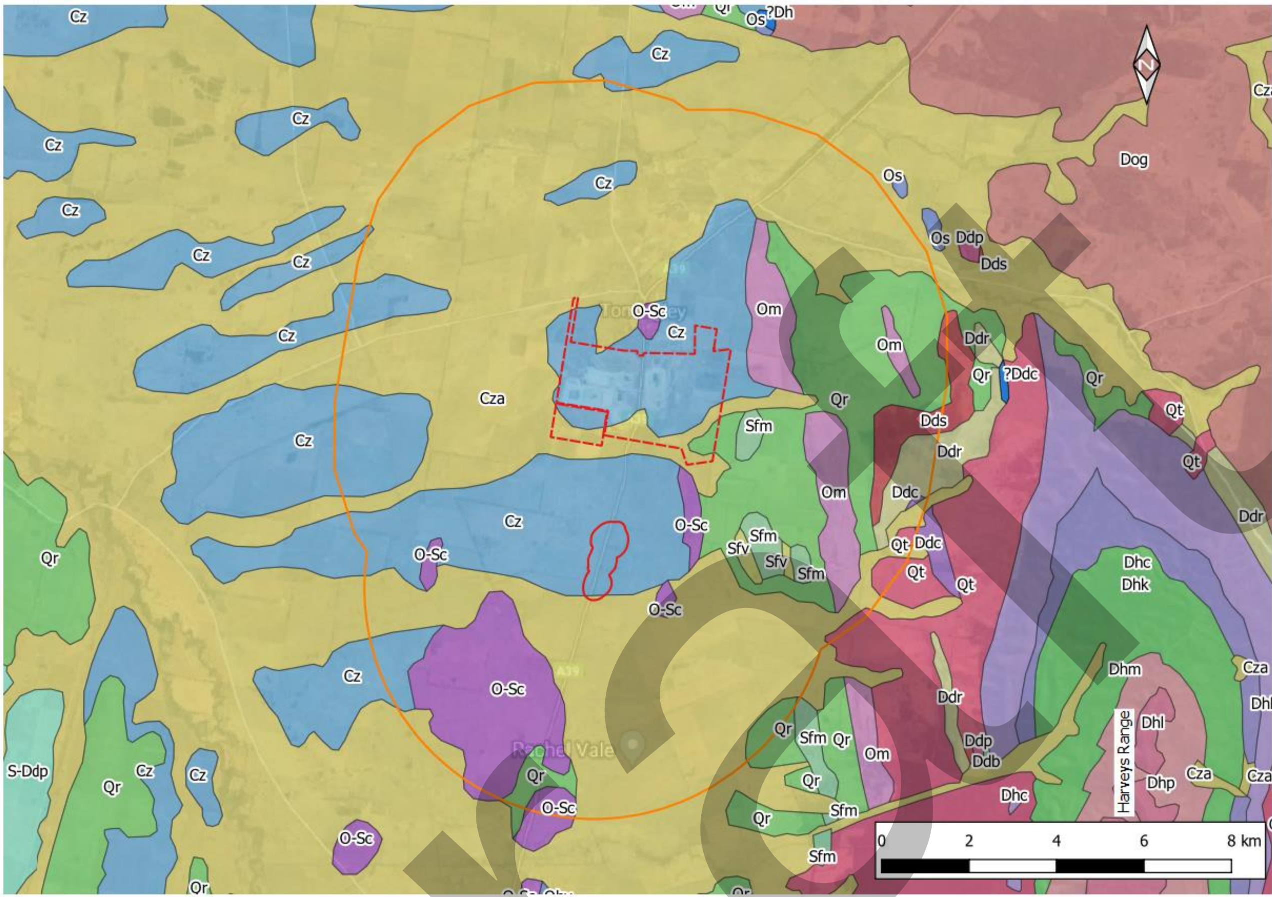

Legend
- - - TGO
— TGEP open cut crest 50 m disturbance area
Approximate 5 km buffer to TGO/TGEP

Narromine250RockUnit_MGAz55
- Cz - Alluvium but without any obvious meanders
- Cza - Alluvium, dominantly red silt with some pebble bands and quartz grit; includes relict meanders but currently is being eroded
- Ddb - Basaltic members
- Ddc - Lithic conglomerate
- Ddp - Quartz feldspar porphyry
- Ddr - Massive and flow banded rhyolite
- Dds - Lithic conglomerate to fine siliceous sediments
- Dhc - Interbedded fine to medium reddish sandstone and reddish-purple mudstone with locally developed quartz pebble conglomerate
- Dhk - Reddish siltstone with some thick sandstone beds
- Dhl - Medium grained quartzose, flaggy laminate to thickly massive or crossbedded sandstone
- Dhm - Coarse to medium grained reddish sandstone
- Dhp - Thick to flaggy bedded, cross bedded medium grained sandstone
- Dog - Medium to coarse grained pink granite
- Obv - Andesitic lavas and volcanogenic sandstone and conglomerate
- Om - Probable silicified fine sediment lacking clear sedimentary structures
- Os - Undifferentiated siltstone, phyllite and shale
- O-Sc - Siltstone and minor chert
- Qr - Residual deposits
- Qt - Scree and talus deposits
- S-Ddp - Shale, siltstone and fine grained sandstone
- Sfm - Fine grained sandstone, siltstone and mudstone
- Sfv - Siliceous volcanics

Figure 3.3: Regional Geology, extract from Narromine 1:250,000 Geological Sheet (Sherwin, 1997)

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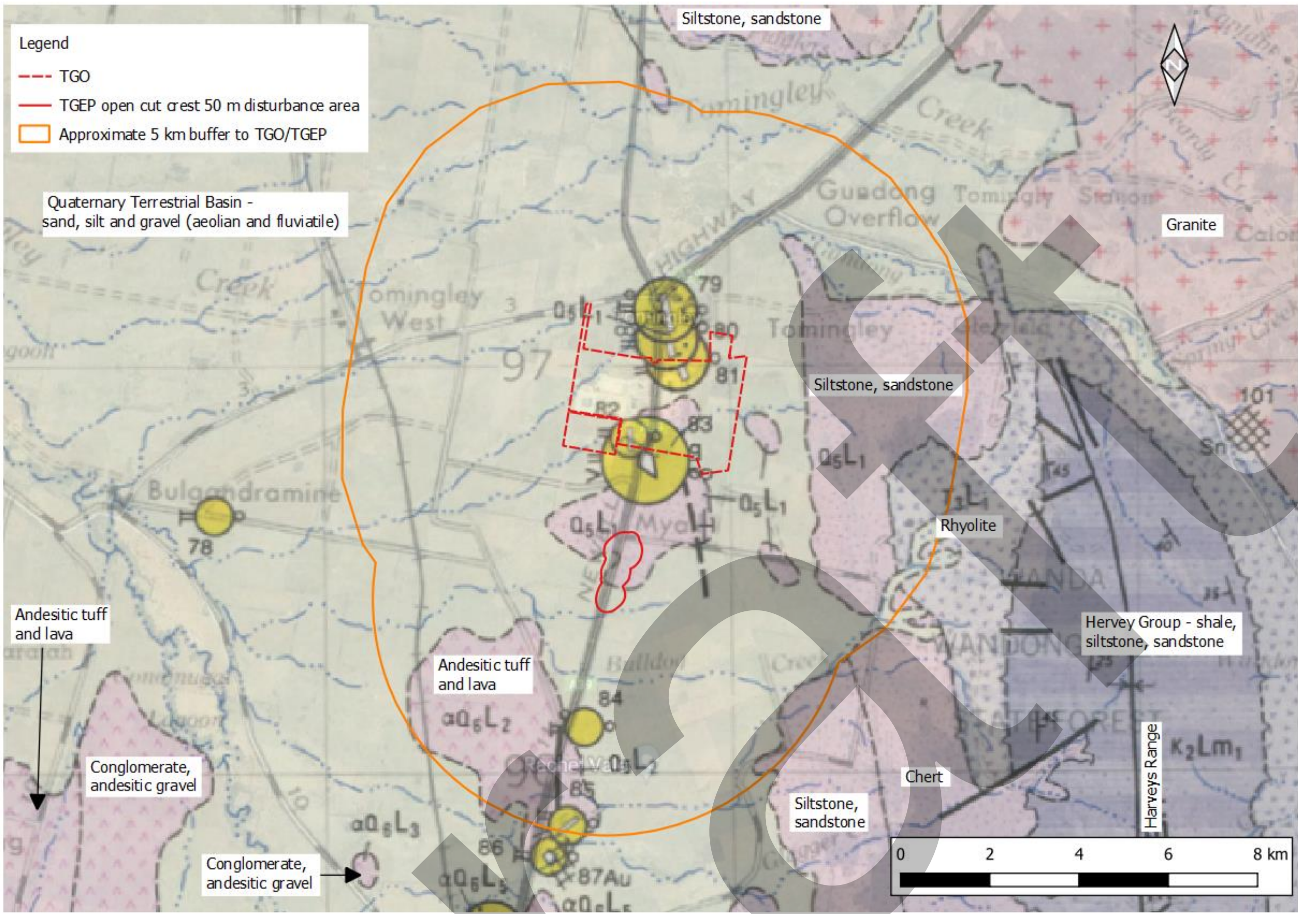

Figure 3.4: Regional Geology, extract from Narromine 1:250,000 Metallogenic Series Sheet (Bowman et.al, 1980)

The sedimentary units are thick and extend to levels far below sea level, as is shown by the partial extract of the regional geological cross section (**Figure 3.5**) from Bowman et.al (1980).

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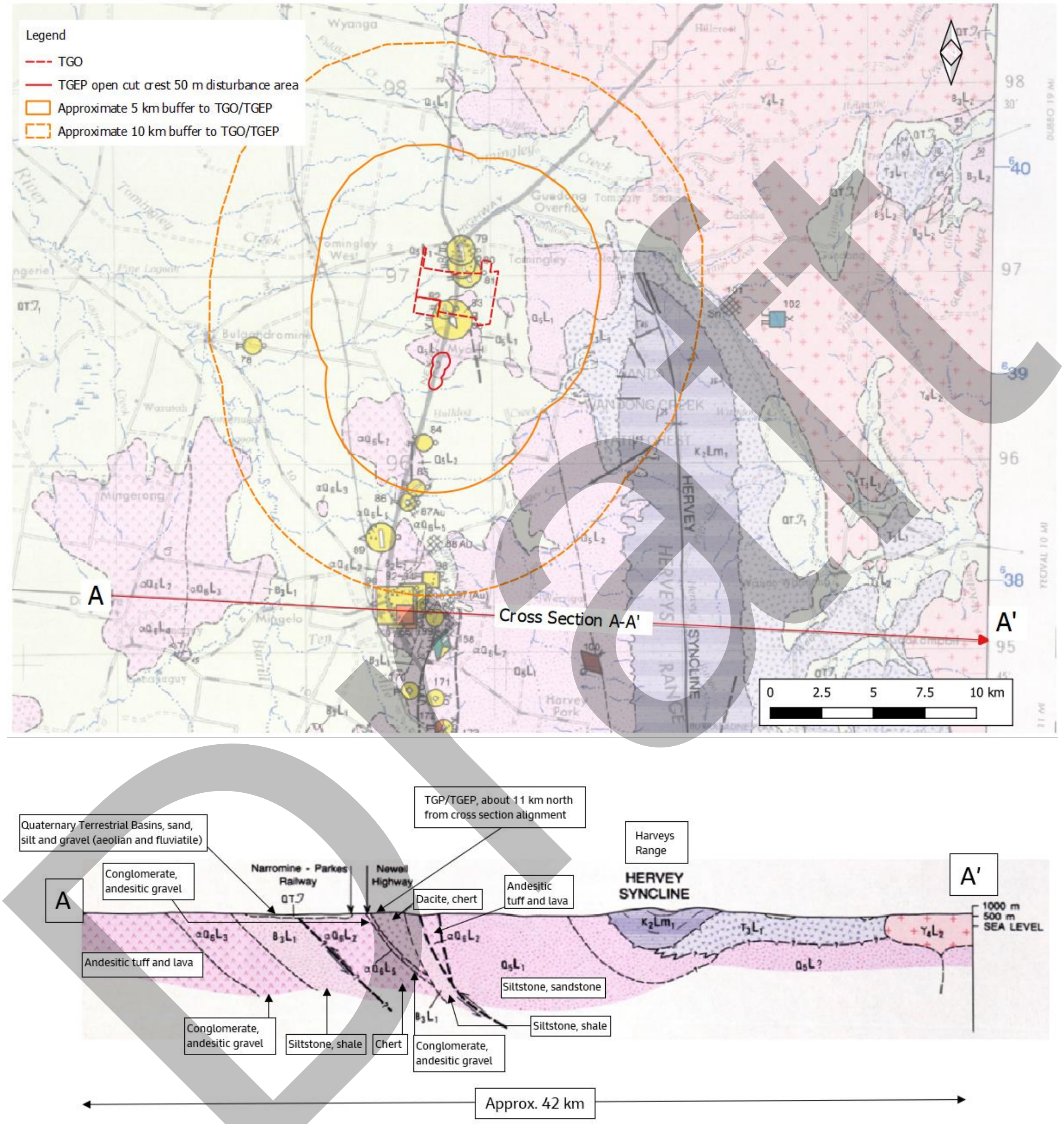

Figure 3.5: Partial regional geological cross section extract from Narromine 1:250,000 Metallogenic Series Sheet (Bowman et.al, 1980)

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3.4 Groundwater Users

Registered bores within the Australian Groundwater Explorer (BoM, 2021a) and Water NSW (2021b) online bore databases were reviewed to identify groundwater users and assess groundwater levels/flow directions in the region of the TGP. The review also informed calibration of the numerical groundwater flow model (refer **Section 6**).

3.4.1 Groundwater users within 10km of TGEP

The Australian Groundwater Explorer (BoM, 2021a) identifies 34 groundwater works within a 10 km buffer to TGO/TGEP. These registered groundwater works are shown on **Figure 3.6** and are summarised in Appendix A.

Of the 34 registered groundwater works within 10km:

- 13 bores are recorded as being used for general water supply purposes, including water supply, stock, household use, irrigation and commercial and industrial use. Seven of these bores (GW045137, GW045134, GW037395, GW803148, GW045135, GW045136 and GW034897) are located within a combined 5 km buffer to TGO/TGEP. However, all of the seven bores are greater than 5 km from the proposed TGEP open cut.
- The depth of the 13 bores used for general water supply purposes ranges from 1.8 m to 121.9 m.
- The remaining 21 bores have a purpose of either monitoring (20 bores) or exploration (1 bore).
- Bores used for general water supply purposes within a combined 5 km buffer to TGO/TGEP have depths of 1.8 m, 3.7 m, 4.5 m, 5.2 m, 5.8 m, 12.2 m and18.3 m. The relatively shallow depths and locations of these bores suggests they are likely to be associated with perched groundwater in the Gundong Creek alluvial aquifer (or in the case of GW034897 a perched aquifer associated with Tomingley Creek) and not connected to the regional water table.
- None of the bores within 10 km have available water level data available within the BoM (2021a) database. However, eight of the bores have water level data in the WaterNSW (2021b) database. Standing water level depths range from 0.9 mbgl to 44 mbgl (**Figure 3.7**). Standing water levels are discussed further in **Section 3.4.2**.

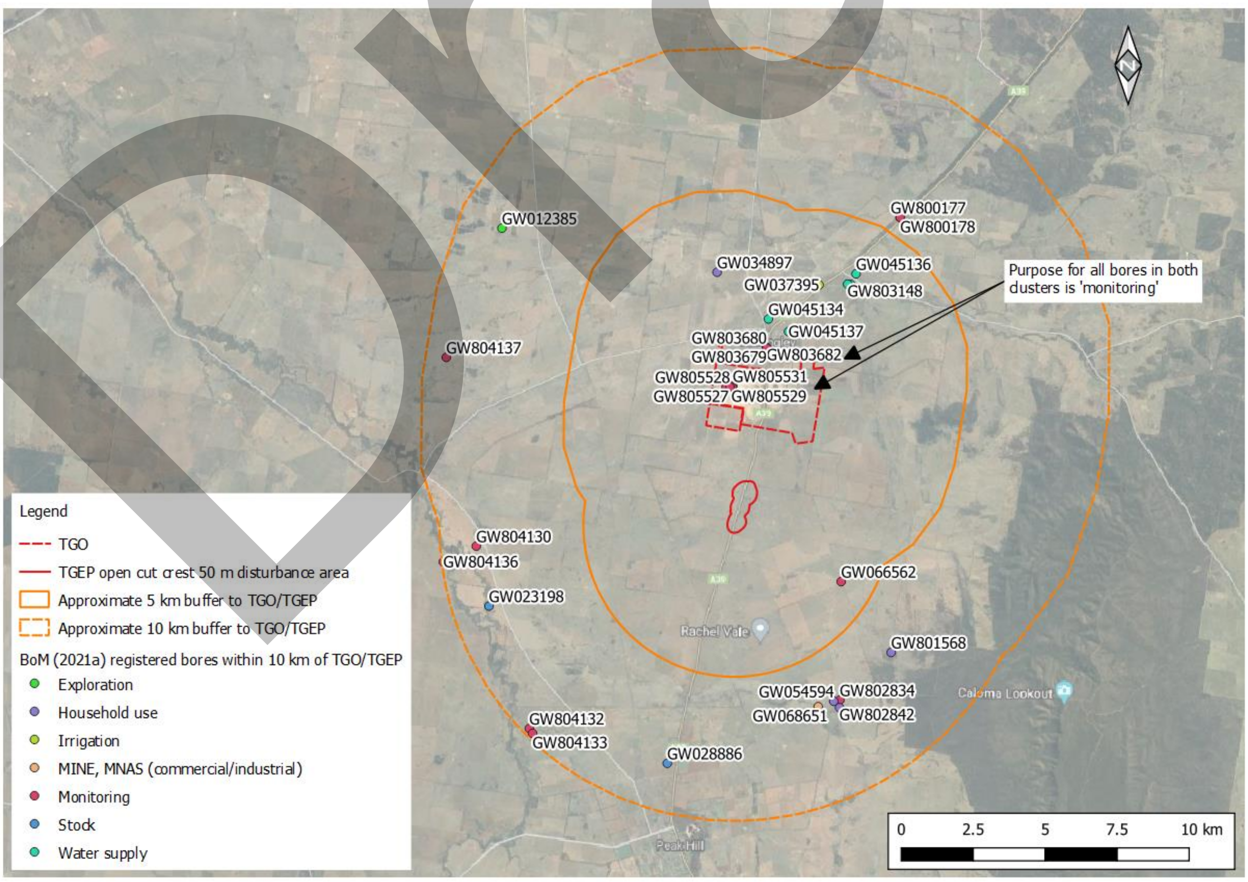

Figure 3.6: BoM (2021a) registered bores within 10 km buffer to TGO/TGEP

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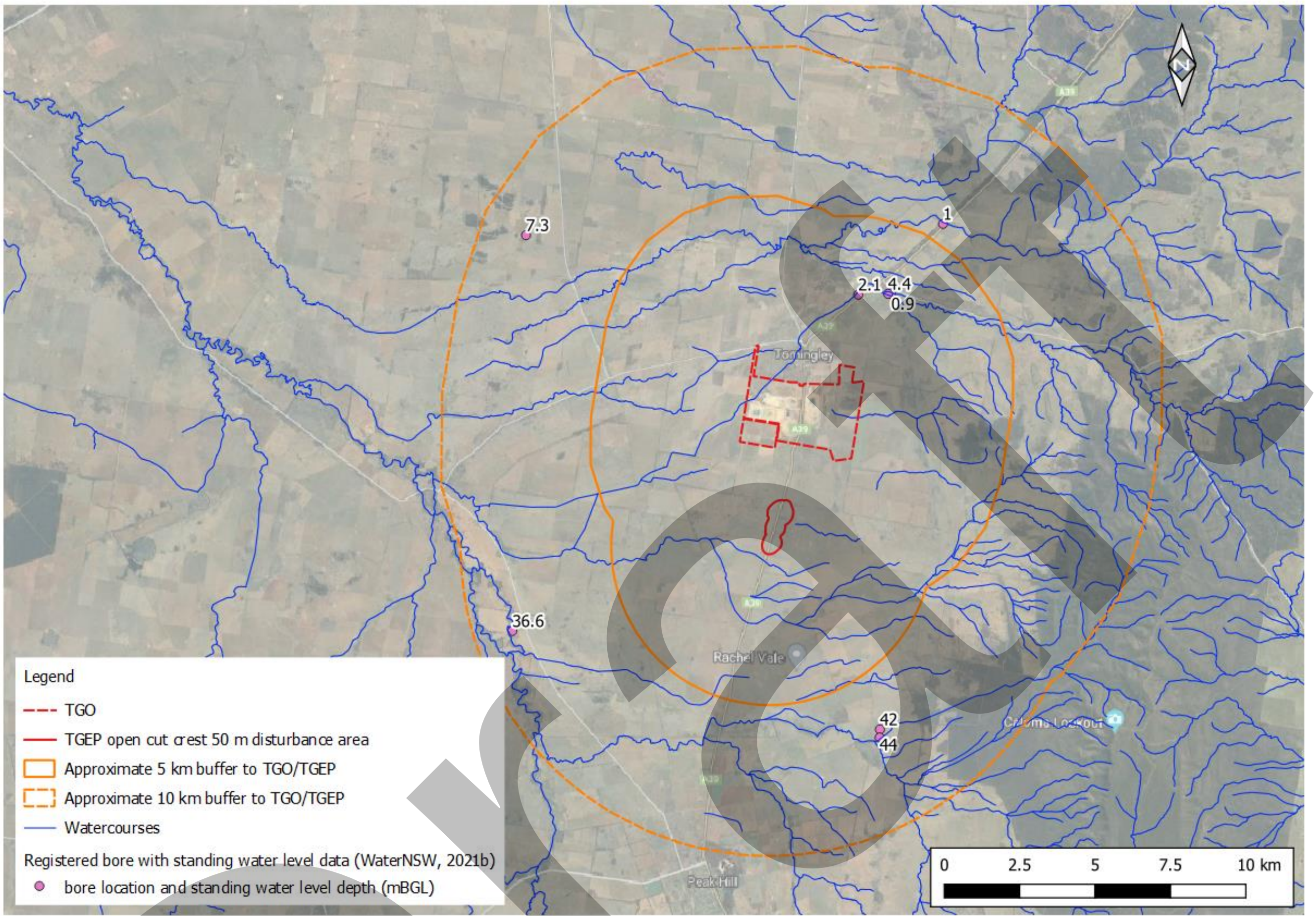

Figure 3.7: Standing water level depth for registered bores within 10 km buffer to TGO/TGEP (WaterNSW, 2021b)

3.4.2 Regional groundwater flow

Groundwater level/depth contouring was undertaken to investigate regional groundwater flow directions, broad groundwater levels/depth trends and to inform assessment of whether groundwater is likely to be providing significant baseflow to watercourses in the vicinity of TGP.

For the contouring exercise, the analysis extent was increased from that used to assess registered bores in the vicinity of TGP (**Section 3.4.1**) to an approximate 55 km by 55 km area centred over TGP.

Groundwater level/depth contours derived from registered bore standing water level data (WaterNSW, 2021b) and site groundwater levels (discussed in **Section 4.2**) are presented in the datums of mAHD and mbgl in **Figure 3.8** and **Figure 3.9**, respectively.

Water levels (WaterNSW, 2021b) from registered bores are typically recorded at bore construction and so represent a broad temporal spread. Also, the water level data (WaterNSW, 2021b) comprises a mixture of water levels from different depths and potentially different groundwater systems. No attempt has been made to isolate the water level data into separate groundwater system types or depth zones. Hence, the contouring is influenced by groundwater levels associated with a range of groundwater systems (e.g. perched alluvial, regional alluvial and regional fractured rock). In spite of these limitations, the contouring is considered suitable for

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assessment of regional groundwater flow directions, broad groundwater levels/depth trends and to inform assessment of whether groundwater is likely to be providing significant baseflow to watercourses in the vicinity of TGP.

The composite groundwater level contours (**Figure 3.8**) generally indicate that groundwater flows from areas of relatively high elevation towards areas of relatively low elevation. Groundwater flow directions are down-gradient orthogonal to the contour lines and are generally consistent with the surface water drainage directions. In the vicinity of TGP groundwater flow is indicated to the west, with flow then to the northwest consistent with Bowen River drainage system. West from the Harveys Range and foothills, hydraulic gradient are relatively steep but flatten just to the east of TGEP.

Although not apparent in the contours, it is noted that preferential flow, coincident with the dominant structural orientation may occur; however, the regional flow direction indicated on **Figure 3.8**, is generally orthogonal to the major structural orientations (sub north-south).

It is noted that groundwater flow direction is interpreted to be falsely indicated in some areas of Harveys Range, where a groundwater flow divide is interpreted to exist in reality. Due to contour point distribution, except for the southern portion of Harveys Range, the interpreted groundwater flow divide is not shown by the contours. In the southern area of the range, where contour point distribution is considered reasonable, the groundwater flow divide is represented by the contours. In reality, this groundwater flow divide is interpreted as likely to extend along the entirety of Harveys Range.

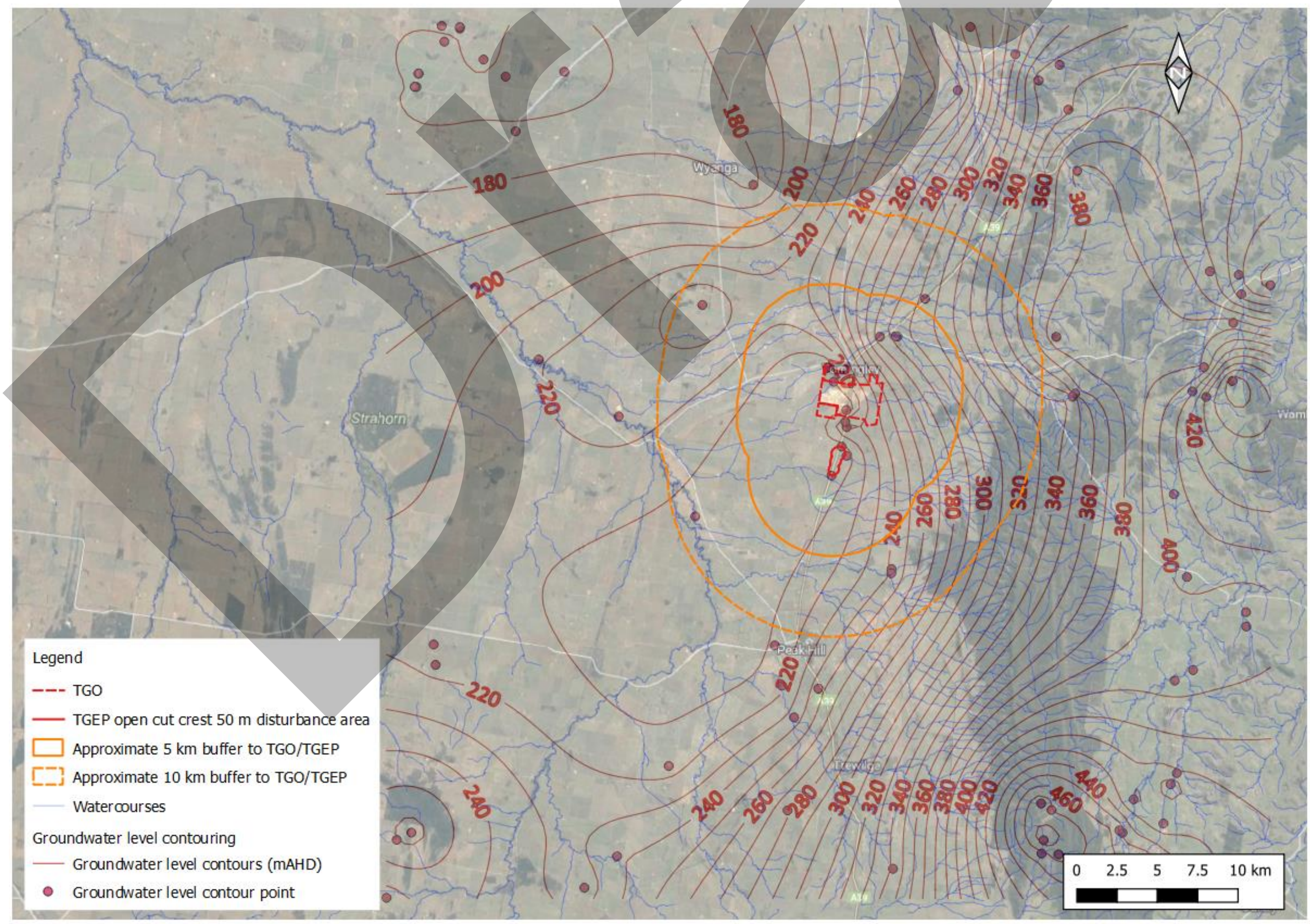

Figure 3.8: Groundwater level (mAHD) contours

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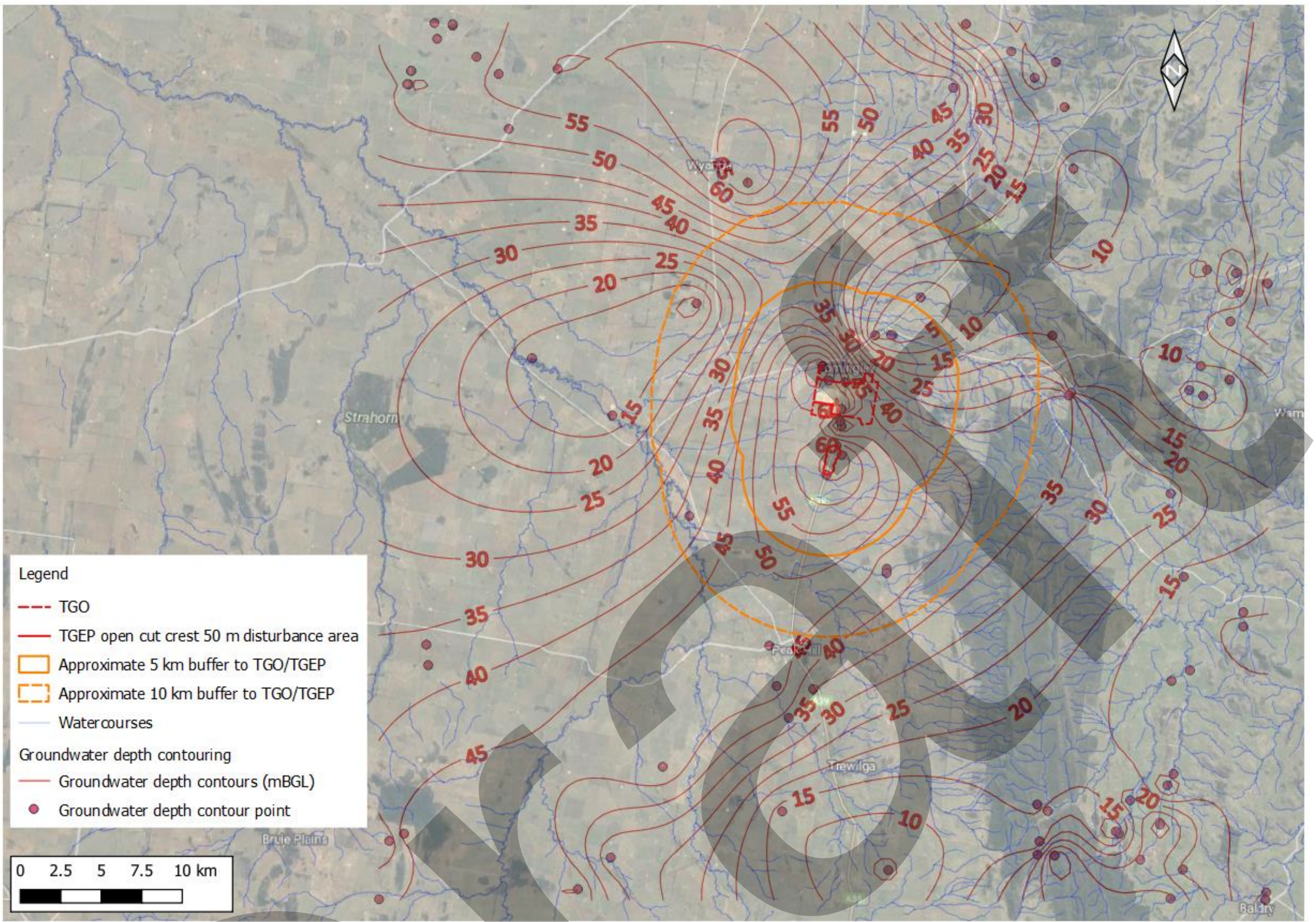

Figure 3.9: Groundwater depth (mbgl) contours

The groundwater depth contours indicate groundwater depths in the area of TGP of about 60 mbgl. The contoured groundwater depths are generally far below ground levels in the vicinity of major rivers and creeks, which suggests baseflow to watercourses is not regionally significant.

3.5 Groundwater Dependent Ecosystems

The potential for GDEs in the vicinity of TGP was assessed through review of the BoM's GDE Atlas (BOM, 2021b and high priority GDE mapping in the Water Sharing Plan (WSP) (NSW Government, 2020).

3.5.1 BoM (2021b) Terrestrial GDEs

There are several isolated tracts of high potential terrestrial GDE mapped in the vicinity of TGO and TGEP (**Figure 3.10**). These areas are associated with Gundong Creek and Bulldog Creek and are located greater than 800 m from current/proposed mining. The potential GDEs contain a variety of trees, shrubs and sedges including:

- Eucalyptus sideroxylon , Eucalyptus macrocarpa, Eucalyptus macrocarpa, Eucalyptus camaldulensis subsp. Camaldulensis
- Acacia deanei subsp. Deanei, Acacia hakeoides, Acacia stenophylla , Acacia salicina
- Dodonaea viscosa subsp. Spatu
- Callitris endlicheri

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- Muehlenbeckia florulenta
- Eleocharis
- Paspalidium jubiflorum

It is noted that none of the trees noted above are obligatre phreatophytes, while Muehlenbeckia florulenta (tangled lignum) and Eleocharis (sedges) are typically associated with wetland environments.

There are several isolated tracts of low potential terrestrial GDE mapped in the vicinity of TGO and TGEP (**Figure 3.10).**

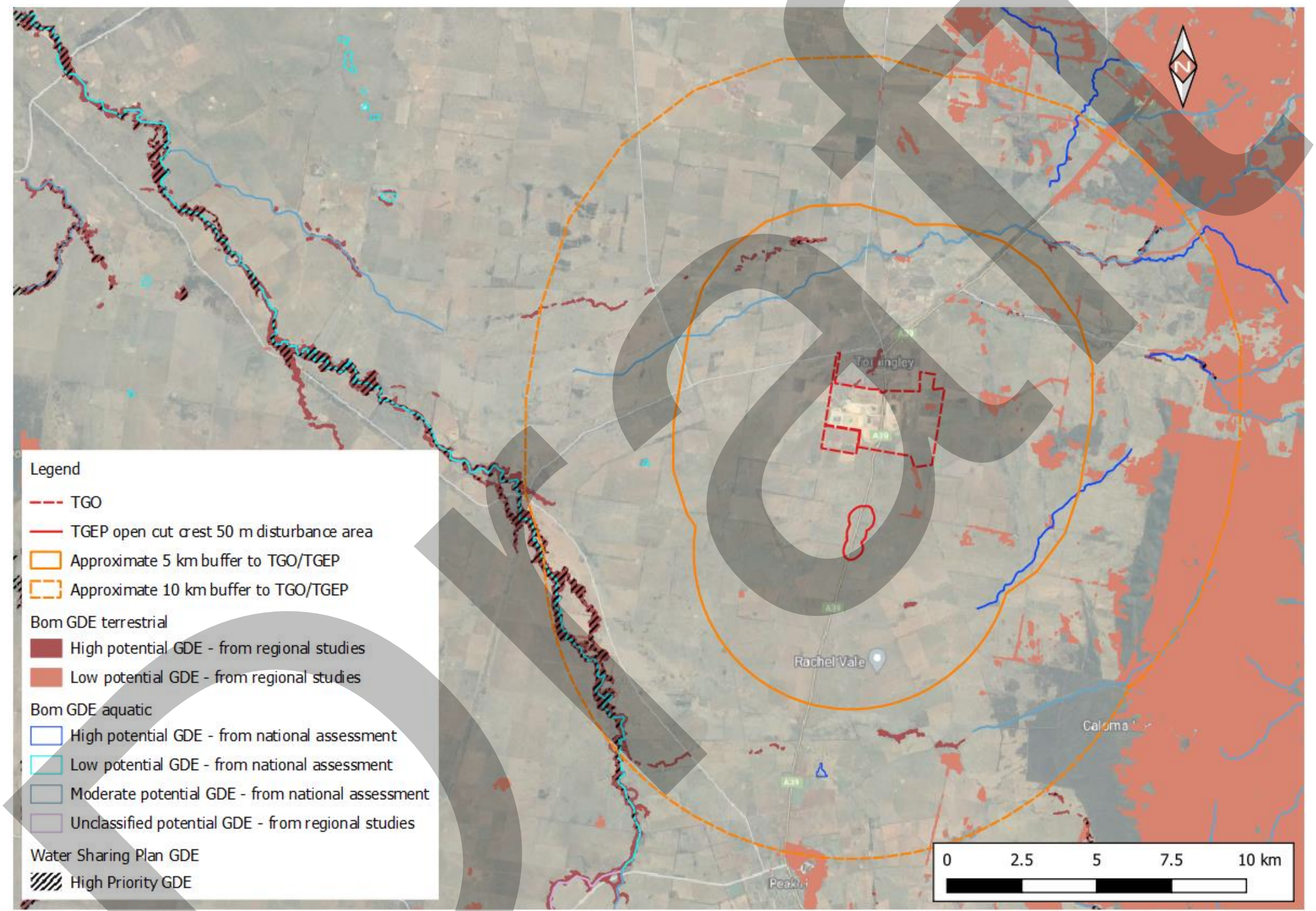

Figure 3.10: BoM (2021b) potential GDEs and WSP (NSW Government, 2020) High Priority GDEs

3.5.2 BoM (2021b) Aquatic GDEs

Mapped potential aquatic GDEs in the region of TGP are shown in **Figure 3.10.** Within a combined 5 km buffer to TGO/TGEP, mapped potential aquatic GDEs comprise Tomingley Creek, a portion of Bulldog Creek and a very small (30 m long by 20 m wide) portion of Gundong Creek located about 2.9 km north east of TGO. These mapped potential aquatic GDEs are located greater than 4 km from existing and proposed mining.

3.5.3 WSP High Priority GDEs

Mapped High Priority GDEs in the region of TGP are shown in **Figure 3.10**. There are no mapped High Priority GDEs close to TGO or TGEP. The largest area of mapped High Priority GDEs are located about 8.5 km south east

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of TGEP, in the vicinity of the Bogan River. Additional relatively small tracts of High Priority GDEs are located north, north east and east of TGO, with the closest located about 5.8 km north north-west of TGO mining.

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4. Groundwater Investigations

4.1 Resource Drilling

Water strike data from resource drilling was reviewed as a first pass assessment of groundwater level and potential for any high yielding zones or structures that may warrant further, more detailed, investigation.

Water strike data are collected by Alkane geologists during reverse circulation (RC) drilling and include observations of water strike depths and a qualitative assessment of water strike strength. Indicators of water strike strength are as follows:

- Strength 0 - water not observed;
- Strength 1 - water table, a trickle of water, samples might be damp;
- Strength 2 - weak, water at end of rod, first sample can be wet;
- Strength 3 - medium, flowing whilst drilling; and
- Strength 4 - strong, driller could not hold water back, samples very wet, hole terminated.

Water strike data are present in plan view and section view for TGEP on **Figure 4.1** and **Figure 4.2**.

Key observations from **Figure 4.1** and **Figure 4.2** are noted as follows:

- Water strike strengths of 4, requiring termination of the drill-hole are relatively infrequent.
- Water strike strengths of 3 appear to be more frequent in the northern Roswell deposit compared to those at San Antonio. This may be indicative of more frequent, or more open, fracturing. However, there is also the possibility that the increased concentration is the result in increased concentration of drilling.
- In all cases the first water strike is below the base of the transported alluvium (**Figure 4.2**), suggesting that the alluvial deposits are likely to be predominantly unsaturated.
- First water strike depths appear to be relatively uniform at depths of the order of 60 mbgl to 100 mbgl. This depth is inferred to be associated with the transition from saprolite (predominantly clay material) to saprock with relic structures and enhanced permeability.
- The upper most water strike strength is typically water strike strength 1. However, whilst the vast majority of water strikes with a strength of 1 occur at relatively shallow depths (i.e. typically of the order of 60 mbgl to 100 mbgl), there are instances where water strikes with a strength of 1 occur at depths greater than approximately 150 mbgl.
- Water strike strengths of 3 typically occur at depths greater than 100 mbgl.

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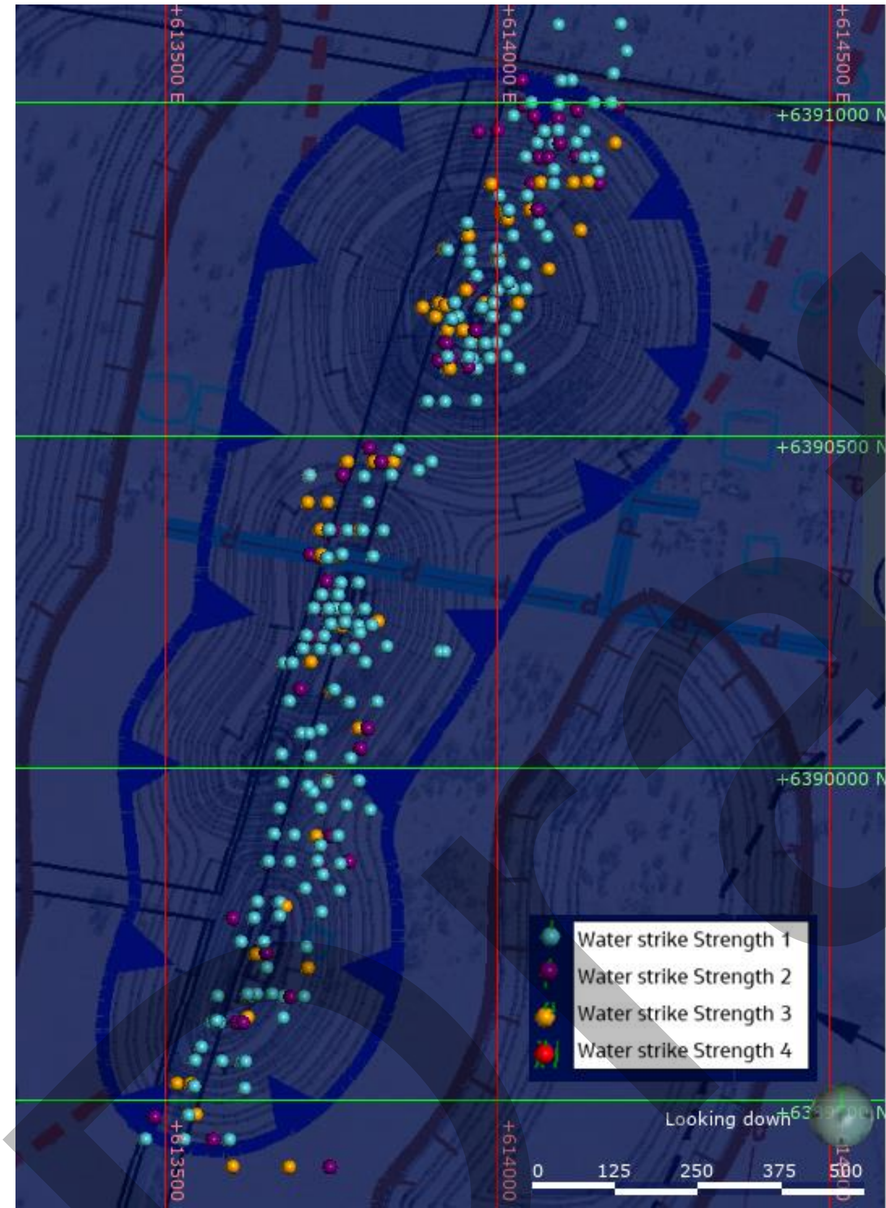

Figure 4.1: TGEP Water Strike Data - Plan View

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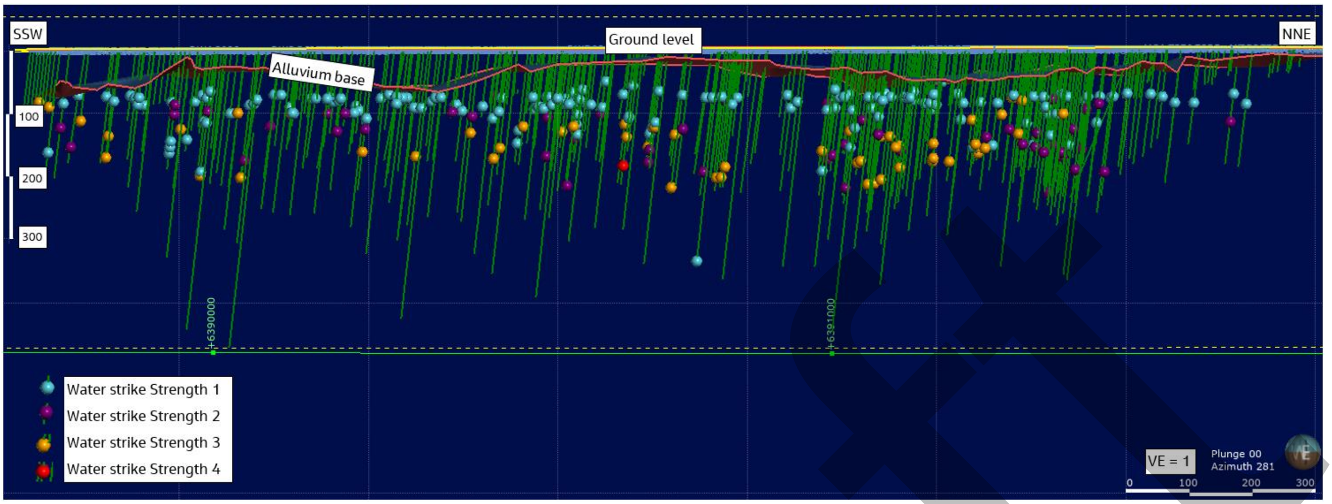

Figure 4.2: TGEP Water Strike Data - Section View

4.2 Groundwater Levels

Excepting shallow bores that monitor tailings, Alkane operate a network of seven monitoring bores at TGO and have recently installed four monitoring bores at TGEP. Details of the groundwater monitoring bores are summarised in **Table 4.1** with locations shown on **Figure 4.3**.

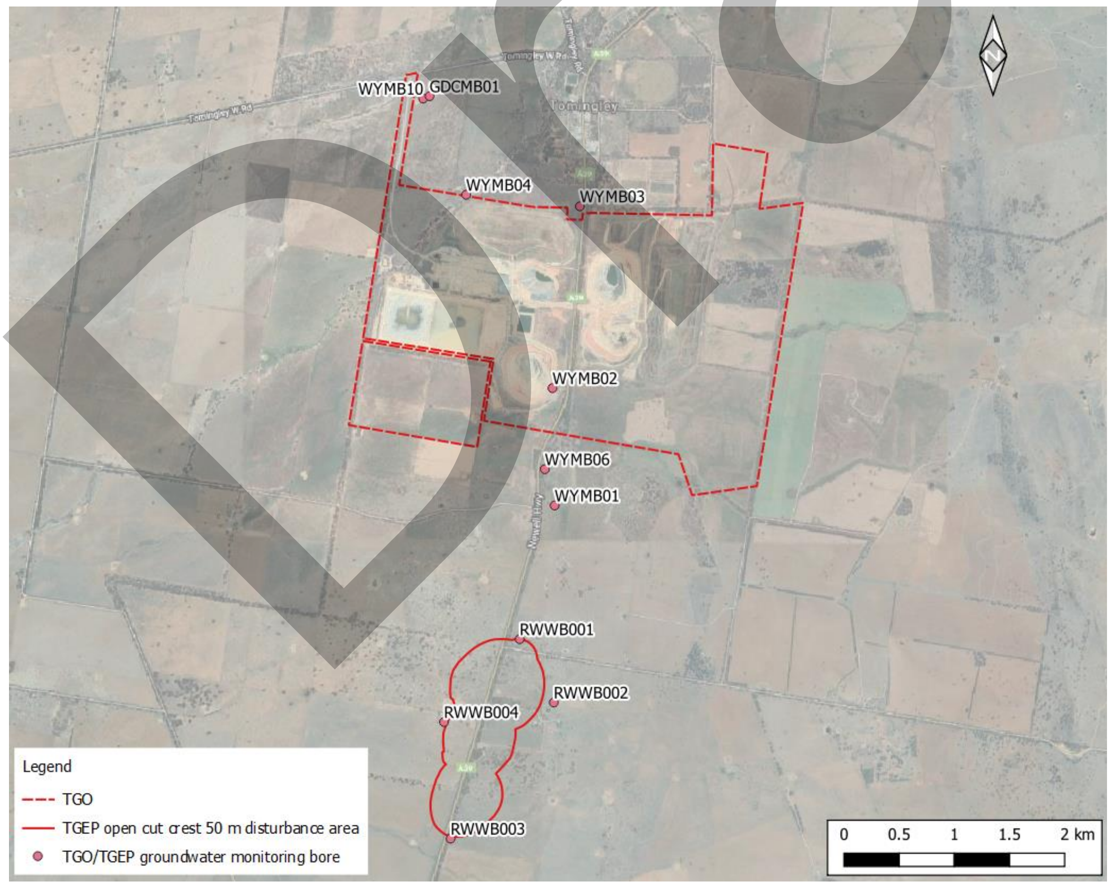

Figure 4.3: TGO/TGEP groundwater monitoring bores

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Table 4.1: Monitoring bore details

Monitoring bore	Easting	Northing	Ground level (mAHD)	Top of casing (mAHD)	Screen interval (mBGL)	Gravel pack interval (mBGL)	Screened Lithology	Depth to base of alluvium (mBGL)
TGEP groundwater monitoring bores								
RWWB001	614132	6391126	269	269.57	120 – 150	110 – 150	Monzodiorite, fresh, unoxidised, grey and blue, fine grained, feldspathic	39
RWWB002	614441	6390553	274	274.58	120.2 – 150.2	110 – 150.2	Volcaniclastic sandstone, fresh, unoxidised, grey and green, coarse grained, poorly sorted	31
RWWB003	613506	6389321	272	272.55	40.5 – 70.5	40.5 – 70.5	Alluvium, clay, red brown to 56 m. Large (40 mm – 80 mm) gravels from somewhere within alluvium caused hole collapse during drilling. Saprolite from 56 to 70 m; quartz, completely oxidised, brown orange, clayey. At 70 m the saprolite clay transitions to saprolite rock.	56
RWWB004	613446	6390376	271	271.69	28 – 52	20 – 52	Alluvium, clay and sand layers, poorly sorted, some pebbly layers, variable colour. Transitions to saprolite clay at 40 m.	40
TGO groundwater monitoring bores								
WYMB01	614449	6392336		270.42	78 – 81 and 84 – 90	60 – 90	Feldspar phyric volcanic, fresh, fine grained, brown to green	5
WYMB02	614429	6393398		268.52	96 – 99, 102 – 105, 108 – 114	71.2 – 114	Sandstone, siltstone and tuff, variably weathered (completely oxidised to fresh), volcaniclastic, foliated	13
WYMB03	614678	6395043		275.47	60 – 63, 69 – 72,	42 – 84	Siltstone and sandstone, slightly weathered to fresh, brown to grey, foliated	4

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Monitoring bore	Easting	Northing	Ground level (mAHD)	Top of casing (mAHD)	Screen interval (mBGL)	Gravel pack interval (mBGL)	Screened Lithology	Depth to base of alluvium (mBGL)
					78 – 84			
WYMB04	613647	6395148		272.07	72 – 78	30 – 78	Saprolite, quartz and sandstone, volcaniclastic, variably weathered (completely weathered to fresh) green, brown, grey,	23
WYMB06	614360	6392664		268.43	75 – 81, 84 – 90	60 – 90	Quartz, feldspar porphyry, generally fresh, white, khaki, grey, green, brown	3
WYMB10	613258	6396018		272.62	Bore construction details unknown. Bore inferred to be screened in fractured rock. Total hole depth was 150 m.			10.5
GDCMB01	613316	6396040		273.44	Bore construction details unknown. Bore screened in Gundong Creek Alluvium. Total hole depth was 3.5 m.			3.5

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4.2.1 TGO groundwater levels

Quarterly groundwater monitoring is undertaken at deep hard rock monitoring bores (WYMB01, WYMB02, WYMB03, WYMB04, WYMB06 and WYMB10) and the shallow alluvial bore (GDCMP01). Regular monitoring data is available from October 2012; however, data prior to this date is less frequent.

Water level hydrographs from the TGO monitoring bores are plotted on **Figure 4.4** and **Figure 4.5**. A number of distinct trends are apparent from the hydrographs:

- Shallow groundwater levels in Gundong Creek alluvium are relatively stable, with long-term fluctuations of the order of one metre in response to long-term climatic trends. The GDCMB01 hydrograph shows a very close correlation with the CRD curve.
- Hard rock monitoring bores WYMB03, WYMB04 and WYMB10 display relatively stable to slightly increasing trends over the period. These bores are located more than 700 m from mining operations at TGO.
  - WYMB03 shows a gradual and steadily increasing water level from 2008 to 2016, presumably in response to the general rainfall surplus over the period. Since 2017, water levels have been relatively stable.
  - WYMB04 has two spurious data points in late 2007 and early 2008 that are considered likely to be erroneous. Other than these two points water levels are relatively stable.
- Water levels at WYMB02, located adjacent to the Wyoming 1 pit, show a distinct declining trend and response to mining since mid-2016. Prior to 2016 water level were very stable.
- Hard rock monitoring bores WYMB01 and WYMB06 display different responses to the other hard rock monitoring bores, with both monitoring bores responding to a significantly wet period in mid- to late-2016. It is noted that both WYMB01 and WYMB06 are located adjacent to historical workings at the Myalls United gold mine and are screened over depths similar to the old workings. It is also noted, as outlined in the Surface Water Specialist Study, that the locations of WYMB01 and WYMB06 are prone to inundation during even relatively modest (10% AEP) rainfall events due to runoff being impounded behind the Newell Highway.

  The historic workings are known to be linked to the surface, and anecdotally surface water flows have been observed disappearing into the workings during heavy rainfall. It is therefore considered likely that the observed water level responses are the result of surface water ingress to the old buried workings.

  An apparent drawdown and recovery response observed at WYMB01 in 2012 and 2013 may also be associated with extraction of water from the underground workings.
- The difference in groundwater levels at adjacent monitoring bores GDCMB01 and WYMB010 is of the order of 70 m and demonstrates the hydraulic separation of the shallow alluvial aquifer (GDCMB01) and the regional water table (WYMB010).

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Figure 4.4: TGO alluvial monitoring bore (GDCMB01) hydrograph

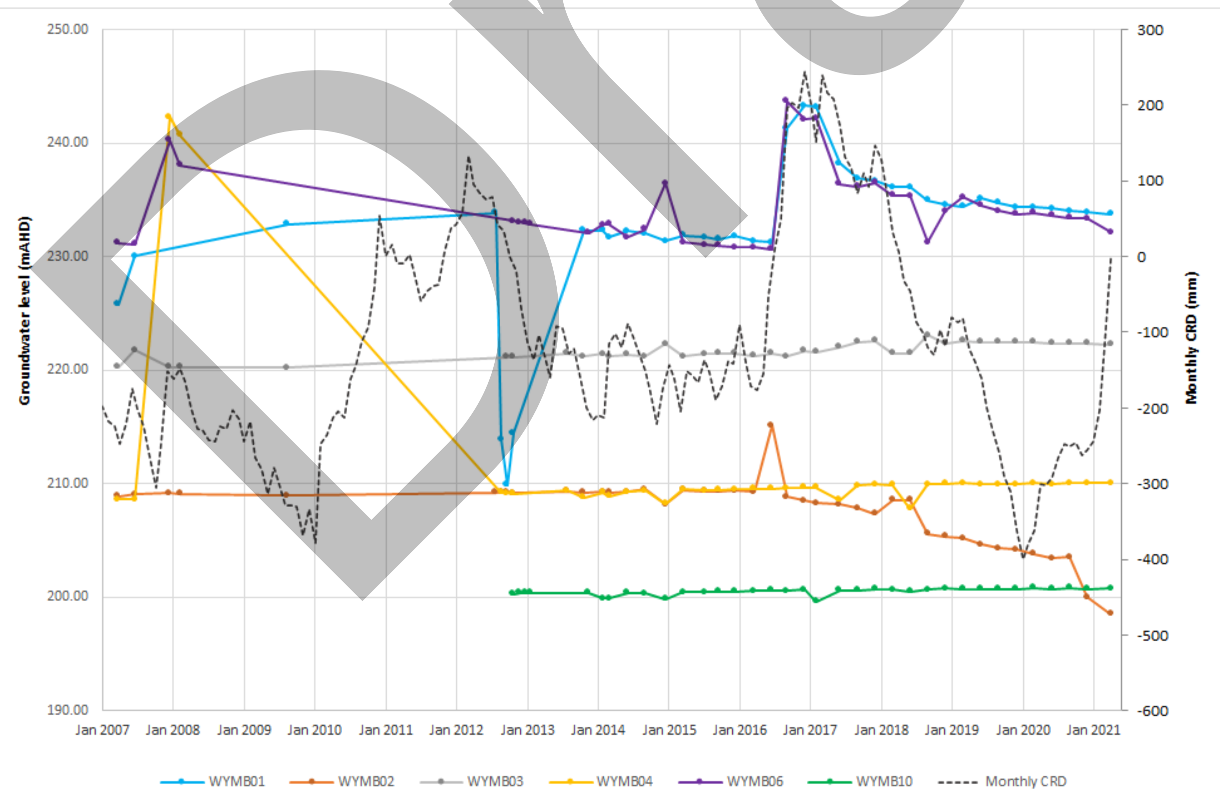

Figure 4.5: TGO hard rock monitoring bore hydrographs

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4.2.2 TGEP groundwater levels

As part of recent investigations, Alkane installed four new monitoring bores at the TGEP, RWWB001, RWWB002, RWWB003 and RWB004. The locations of the monitoring bores are included on **Figure 4.3** and bore details are summarised in **Table 4.1**.

The TGEP monitoring bores are equipped with water level data loggers and available water levels from November 2020 through to March 2021 are presented on **Figure 4.6**. It is noted that RWWB004, screened to a depth of 52 m below ground level is dry and, as such, no water level data is available. For the duration presented on **Figure 4.6**, the monthly CRD does not provide any relevant correlation and instead, daily rainfall is presented.

From **Figure 4.6**, the following observations are made:

- Groundwater level trends at RWWB001 and RWWB003 over the period of observation are relatively stable.

  In mid-March 2021, RWWB003 displayed a minor response following a large rainfall event with a lag of approximately 6 days. Over the same duration, RWWB001 showed erratic fluctuations that are attributed to interference from nearby resource drilling operations.
- Groundwater level trends at RWWB002 demonstrate a very slow recovery following drilling and bore construction. RWWB002 was drilled dry with no indication of groundwater. The prolonged recovery, over a period of approximately 130 days is indicative of the very tight and low permeability of the formation at that location.

It is noted that monitoring bore RWWB004 was screened across the interface between the Cainozoic alluvium and underlying weathered bedrock to assess the potential for a deeper perched aquifer within deeper alluvial deposits. RWWB004 is dry and no deeper perched aquifer was observed; however, this does not preclude the potential presence of saturated alluvium within deeper palaeochannels that may exist below the regional water table.

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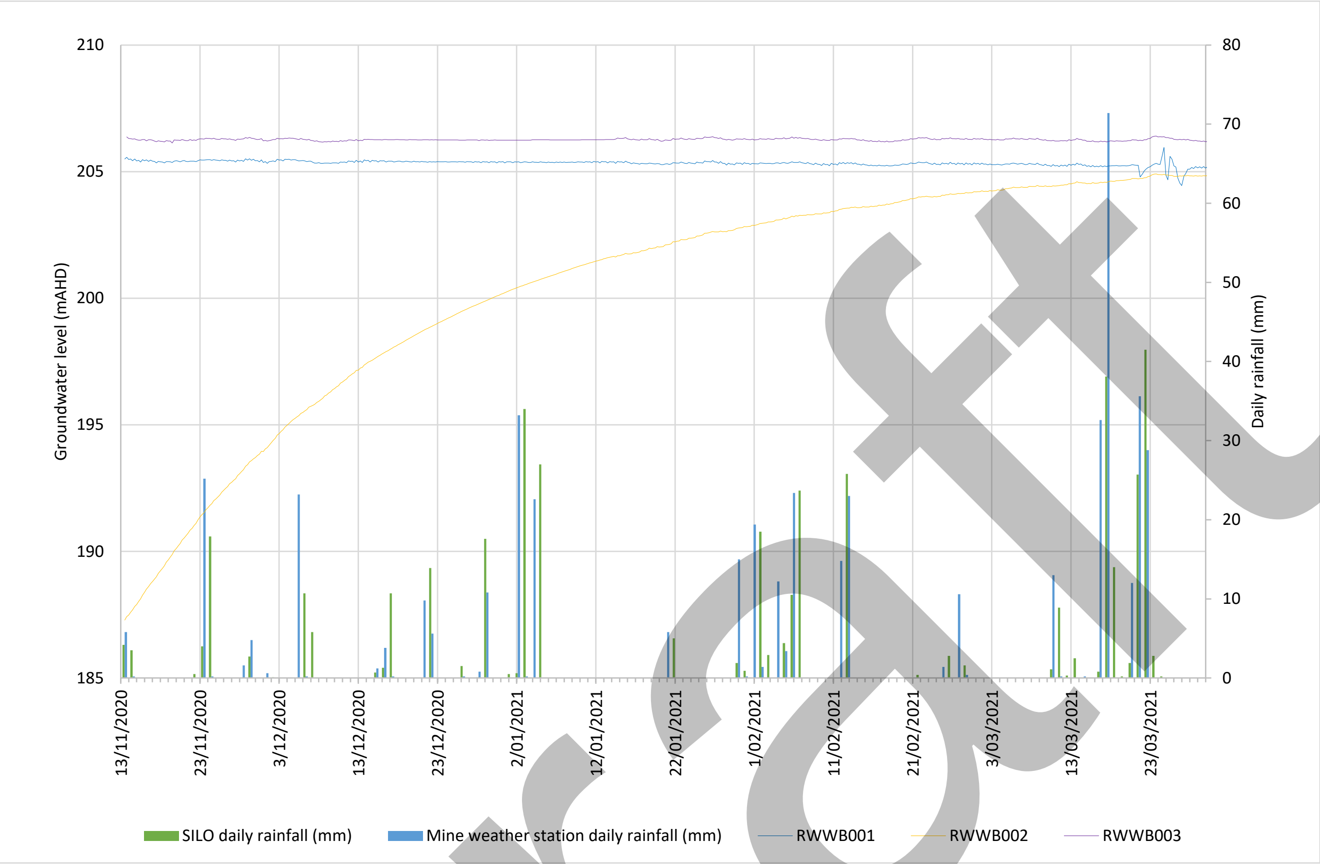

Figure 4.6: TGEP Monitoring bore hydrographs

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4.2.3 Surface water – groundwater interaction

The degree and type of interaction between groundwater and surface water is largely dependent on topography, watercourse geomorphology and the underlying groundwater systems, particularly the depth of groundwater levels relative to watercourse levels.

Surface water – groundwater interaction within the groundwater study area is characterised as follows:

Perched localised alluvial groundwater systems

At a local scale, small perched and discrete alluvial groundwater systems can be expected in the vicinity of some of the larger current or ancient watercourses within the groundwater study area. As these water courses are predominantly ephemeral, groundwater interaction is likely to be dominated by groundwater recharge occurring during times of surface flow, with the watercourses behaving as 'losing' streams.

Registered bores GW037395, GW803148 and GW045135 are located within Gundong Creek alluvium about 3.5 km to 4 km north east of TGO. Bore depths range from 3.7 mbgl to 5.8 mbgl and have reported standing water levels ranging from 0.9 mbgl to 4.4 mbgl. Additionally, project groundwater monitoring bore, GDCMB01, also installed within Gundong Creek alluvium, is about 3.5 m deep and has standing water levels less than 3.5 mbgl.

Despite not being the dominant recharge process, there may be short periods of time along isolated reaches of these ephemeral water courses when the local water table exceeds the stream bed elevation resulting in groundwater baseflow contribution to surface flow.

The localised discrete alluvial groundwater systems are characterised to be physically and hydraulically disconnected from underlying regional groundwater systems. As discussed in **Section 4.2.1**, the water levels observed in the perched Gundong Creek alluvium at GDCMB01, are approximately 70 m above the regional groundwater level at WYMB010.

Regional alluvial and fractured rock groundwater systems

The depth to the water table associated with the regional groundwater system is generally relatively deep compared to the watercourse bed levels near the project. Groundwater depth contours (**Section 3.4.2**) indicate groundwater depths of about 40 mBGL to 60 mBGL in the vicinity of watercourses near the project. Therefore, unless localised discrete perched alluvium groundwater systems are present, regional scale surface water – groundwater interaction in the vicinity of TGO/TGEP is conceptualised to be generally limited and characterised by 'disconnected losing streams'. 'Disconnected losing watercourses' are defined as having watercourse water levels that are above and disconnected from underlying groundwater systems. Indirectly, losing watercourses can interact with the underlying groundwater systems by providing recharge via leakage from the watercourse to the groundwater system.

This characterisation is supported by project drilling and groundwater monitoring bore data (**Sections 4.1**, **4.2.1** and **4.2.2**), which indicates that the alluvium in the vicinity of the project is generally unsaturated. Furthermore, the most significant watercourse in the region of TGO/TGEP, the Bogan River, only has three registered bores near it: GW036833, GW802483 and GW023198. These bores have reported groundwater depths ranging from 12 mBGL to 36.6 mBGL and reported water bearing zones commencing from 25 mBGL to 51 mBGL, one of which is within weathered rock and not alluvium. The low quantity and distribution of registered bores in the groundwater study area also supports the characterisation that regionally significant alluvial aquifers are not present or are uncommon within the groundwater study area.

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4.3 Groundwater quality

Comprehensive groundwater quality sampling has been undertaken on TGO monitoring bores on a quarterly basis, since 2008. Additionally, TGEP monitoring bores RWWB002 and RWWB003 have been sampled on three occasions since late 2020, and RWWB001 sampled on four occasions.

Comprehensive laboratory results for TGO/TGEP monitoring bores are summarised in Appendix B.

Summary statistics for field measured physical parameters, pH and electrical conductivity, and total dissolved solids (TDS), for all monitoring bores are provided in **Table 4.2**.

Table 4.2: Summary of groundwater quality physical parameters, pH and EC, and TDS

Monitoring bore	pH[1]			EC (µS/cm)[1]			TDS (mg/L)[1]		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
RWWB001	6.67	6.58	6.77	28,567	25,600	32,700	19,375	18,700	19,800
RWWB002	6.74	6.63	6.87	20,040	18,400	22,320	15,400	14,300	16,400
RWWB003	6.92	6.86	6.97	19,307	17,800	22,320	12,200	11,700	12,500
WYMB01	7.50	7.08	8.00	11,393	1,241	12,350	7,627	6,400	8,400
WYMB02	7.41	6.80	8.33	20,626	1,877	25,610	14,627	12,800	16,400
WYMB03	7.38	6.70	8.12	19,062	1,817	22,100	13,845	11,500	14,900
WYMB04	7.32	6.89	8.05	24,512	2,124	29,180	18,250	15,800	20,400
WYMB06	7.45	6.83	8.21	12,172	1,174	15,480	8,627	6,830	10,000
WYMB10	7.28	6.72	7.86	25,217	1,967	51,700	16,831	2,190	20,000
GDCMB01	7.19	6.80	8.01	552	345	1137	629	280	1,000

Note: [1] - TGEP data range 2020-2021, 3-4 measurements. TGO data range 2013-2018, 16-20 measurements.

The key points relating to groundwater quality are:

- Average pH for all monitoring bores is typically near neutral, ranging from 6.7 to 7.5.
- Average EC of the regional water table is typically saline, ranging from about 11,393 µS/cm to 28,567 µS/cm.
- RWWB003 is the shallowest of the TGEP monitoring bores and has lower salinity (as both EC and TDS) than RWWB001 and RWWB002. Mean TDS at RWWB003 is 11,700 mg/L and is 7,000 mg/L and 2,600 mg/L lower than at RWWB001 and RWWB002, respectively.
- RWWB002 and RWWB003 are screened at similar depths, but RWWB001 is considerably more saline.
- WYMB01 and WYMB06 have the lowest average salinity of the hardrock monitoring bores. WYMB01 and WYMB06 are located adjacent to historical workings at the Myalls United gold mine and are screened over depths similar to the old workings. The reduced salinity is inferred to be related to the enhanced recharge to the underground workings and dilution of ambient groundwater.

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- EC of the Gundong Creek alluvial aquifer is generally fresh (maximum measured EC of 1,137 µS/cm) and is as expected for a shallow ephemeral alluvial aquifer. The moderately elevated salinity is likely the result of evaporative concentration via evapotranspiration, and evaporation of pooled surface water prior to recharge.

4.3.1 Major Ions

The relative concentrations of the major ions in groundwater samples from all monitoring bores is provided on the Piper Diagram on **Figure 4.7**. Most of the TGO and TGEP hardrock monitoring bores show similar composition and plot as a group as sodium chloride type groundwater. Key differences from this trend are as follows:

- RWWB002 is transitional between sodium chloride type and having no dominant cation, with increased importance of calcium. This is likely the result of reverse ion exchange and/or dissolution of calcium from the formation.
- WYMB06 plots in the sodium-chloride field but is transitional toward having no dominant anion and has elevated sulphate with respect to chloride. This is potentially related to the proximity to the historic underground workings of the Myalls United gold mine and potential oxidation of sulphide minerals. However, the same trend is not observed at WYMB04, also in proximity to the Myalls United gold mine and of similarly reduced salinity. This indicates that the sulphate influence at WYMB06 may be due to localised formation conditions.
- GDCMB01 is associated with the Gundong Creek alluvial aquifer and plots as a sodium dominant water type with significant bicarbonate.

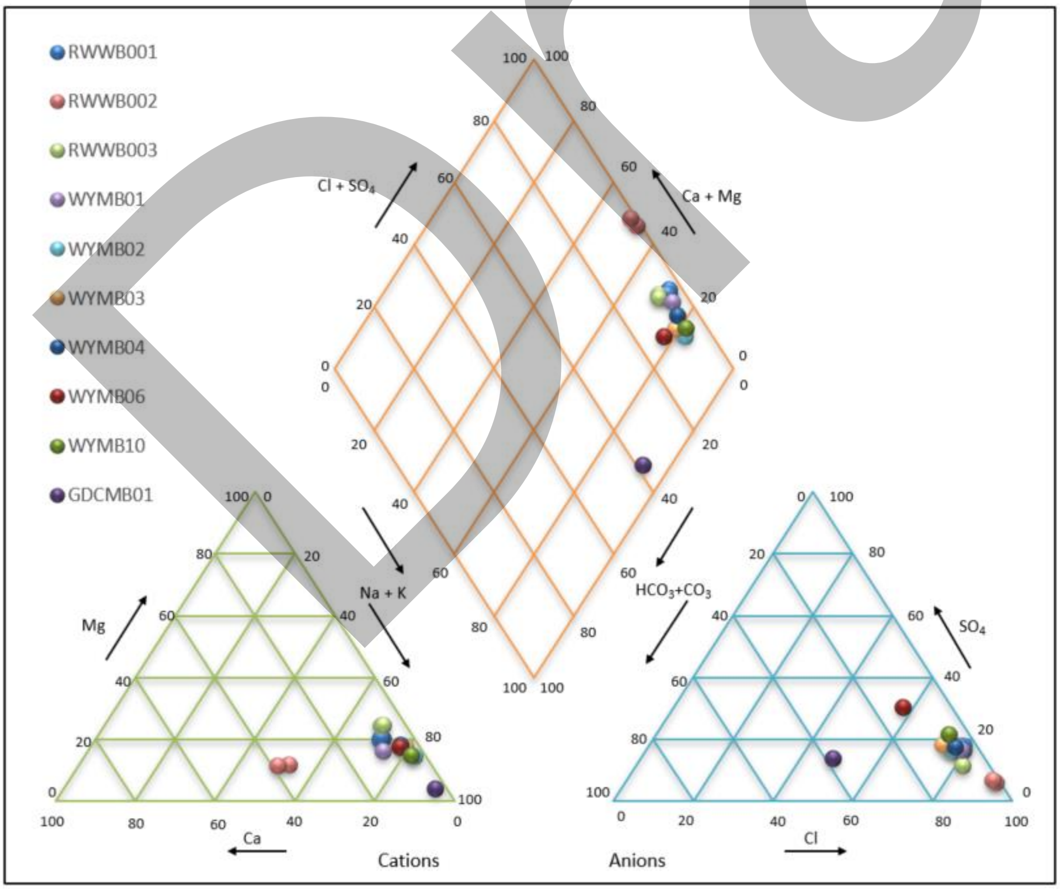

Figure 4.7: Piper plot of major anions and cations

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4.4 Hydraulic Testing

Formation hydraulic conductivity values have been calculated for the TGO and TGEP based on:

- Rising head data from groundwater monitoring bores
- Rising head data from airlifted resource drillholes
- Packer testing within diamond drillholes.

Additionally, airlift yield testing was undertaken at project boreholes to provide a basis to qualitatively assess indicative formation yield and the potential extent of groundwater inflows which may occur to the mine.

4.4.1 Monitoring bores

Indicative values for formation hydraulic conductivity were calculated at TGEP groundwater monitoring bores by Jacobs as part of the current assessment and at TGO groundwater monitoring bores by AGE (2011) and Coffey (2007).

Hydraulic conductivity at the TGEP groundwater monitoring bores RWWB001 and RWWB002 was calculated using water level recovery following airlifting and using delayed water level recovery data following bore construction for RWWB002. RWWB002 displayed no signs of saturation in the monitored zone during drilling or significant water level recovery following bore construction. However, slow water level recovery was observed in this bore in the months after bore construction (**Section 4.2.2** and **Figure 4.6**). Water level recovery data was analysed in the program AQTESOLV (HydroSOLVE, 2007) using the Theis recovery straight line solution (RWWB001) and Hvorslev solution (RWWB002). For both RWWB001 and RWWB002, aquifer thickness was approximated as the saturated formation thickness from the base of hole.

It is noted that RWWB003 was unable to be tested due to jammed equipment in the hole, and RWWB004 was dry.

Hydraulic conductivity at TGO groundwater monitoring bores was calculated by AGE (2011) using airlift water level recovery data from WYMB001, WYMB002 and WYMB003, which was analysed with the Hvorslev solution. Coffey (2007) calculated hydraulic conductivity at WYMB004 and WYMB006 via slug testing. Further details regarding the Coffey (2007) testing are not known. The Coffey (2007) results were taken from a table within GHD (2015) not the original document.

Calculated hydraulic conductivity at the TGEP and TGO groundwater monitoring bores is summarised in **Table 4.3**. Hydraulic conductivity of the fractured rock at the TGEP and TGO groundwater monitoring bores ranged from 2.9×10^{-6} m/d (RWWB002) to 0.11 m/d (WYMB006). The arithmetic and geometric means are approximately 2.7×10^{-2} m/d and 2.1×10^{-3} m/d, respectively. It is noted that bore WYMB006, where the maximum value occurred, is located in close proximity to historical underground workings of the Myalls United mine. It is unclear if the elevated value is related to the workings or associated with structural or weathering influences.

When considering WYMB006 as an outlier, the arithmetic and geometric means are approximately 1.4×10^{-2} m/d and 1.1×10^{-3} m/d, respectively.

Statistics for calculated hydraulic conductivity are summarised in **Section 4.4.5** alongside the results obtained via airlift recovery analysis at open boreholes and packer testing. A qualitative summary of the hydraulic conductivity test values is also provided in **Section 4.4.5**.

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Table 4.3: TGEP/TGO hydraulic conductivity results

Monitoring bore	Gravel pack lithology	Hydraulic conductivity (m/d)
TGEP groundwater monitoring bore		
RWWB001	Monzodiorite, fresh, unoxidised, grey and blue, fine grained, feldspathic	$1.1\text{x}10^{-3}$
RWWB002	Volcaniclastic sandstone, fresh, unoxidised, grey and green, coarse grained, poorly sorted	$2.9\text{x}10^{-6}$
RWWB003	Alluvium, clay, red brown to 56 m. Large (40 mm – 80 mm) gravels from somewhere within alluvium caused hole collapse during drilling. Saprolite from 56 to 70 m; quartz, completely oxidised, brown orange, clayey. At 70 m the saprolite clay transitions to saprolite rock.	testing not completed +
RWWB004	Alluvium, clay and sand layers, poorly sorted, some pebbly layers, variable colour. Transitions to saprolite clay at 40 m.	dry bore
TGO groundwater monitoring bore		
WYMB001	Feldspar phyric volcanic, fresh, fine grained, brown to green	$1.0\text{x}10^{-4}$ #
WYMB002	Sandstone, siltstone and tuff, variably weathered (completely oxidised to fresh), volcaniclastic, foliated	$9.5\text{x}10^{-3}$ #
WYMB003	Siltstone and sandstone, slightly weathered to fresh, brown to grey, foliated	$6.1\text{x}10^{-2}$ #
WYMB004	Saprolite, quartz and sandstone, volcaniclastic, variably weathered (completely weathered to fresh) green, brown, grey,	$9.5\text{x}10^{-3}$ *
WYMB005	Bore construction details unknown. Bore inferred to be screened in weathered or fractured rock because total hole depth was 84 m.	No test data/result available
WYMB006	Quartz, feldspar porphyry, generally fresh, white, khaki, grey, green, brown	0.11 *
WYMB007	Bore construction details unknown. Bore noted to be monitoring fractured rock groundwater system. Total hole depth was 150 m.	No test data/result available
WYMB008	Bore construction details unknown. Bore noted to be monitoring a localised perched alluvial groundwater system. Total hole depth was 9 m.	No test data/result available
WYMB10	Bore construction details unknown. Bore inferred to be screened in fractured rock. Total hole depth was 150 m.	No test data/result available

Notes: # Calculated by AGE (2011), as documented in Appendix 6 of The Impax Group (2011). * Calculated by Coffey, 2007, as documented in GHD (2015).
+ Not estimated – volume displacement slug got jammed in bore and could not be lowered to water table. Hydraulic conductivity in monitored zone inferred to be very low to low as during drilling and immediately following bore construction, the monitored zone did not display signs of saturation.

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4.4.2 Airlift yield testing

Airlift yield testing was completed on 13 RC drill holes and one diamond drill hole.

Airlifting was undertaken via the drill string and typically undertaken for a period of up to 120 minutes. Yields were measured using a timed bucket, with a yield estimation undertaken every 10 minutes.

Details of the airlift yield tested boreholes and the average yield determined from testing are summarised in **Table 4.4**.

The yield values are generally low; however, four locations had relatively elevated yields. RWD048 and RWRC397 recorded average yields of approximately 3 L/s, RWRC399 recorded an average yield of 1.1 L/s, and RWRC422 and RWRC428 recorded average yields of 0.7 L/s and 0.8 L/s. The median and average yield values overall were of the order of 0.2 L/s and 0.7 L/s, respectively. Based on only three out of 13 locations having a yield above 1 L/s, which represents 23% of the test locations, the hydraulic conductivity of the rock mass is inferred to typically be generally low, with some isolated locations where the hydraulic conductivity is low to moderate.

It is noted that only holes with airlift yields below the median value of 0.2 L/s had successful airlift recovery tests completed (**Table 4.5**).

Table 4.4: Summary of airlift yield tested boreholes and airlift yield results

Borehole	Easting	Northing	Ground level (mAHD)	Dip °	Total depth (m)	Total vertical depth (m)	Average yield (L/s)
RWRC387	613758	6389682	266.35	60	264	228.63	0.05
RWRC401	613799	6390284	266.37	58	154	130.60	0.19
RWRC403	613911	6390264	267.07	60	232	200.92	0.11
RWRC418	613739	6389743	265.65	58	190	161.13	0.1
RWD048	614188	6390808	267.89	60	200	173.21	3.32
RWRC389	613811	6390140	266.33	60	232	200.92	0.29
RWRC397	614187	6390850	268.12	58	129	109.40	3.09
RWRC399	614158	6390744	267.74	58	328	278.16	1.13
RWRC405	613732	6390049	266.05	60	210	181.87	0.04
RWRC417	613737	6389811	266.18	58	154	130.60	0.23
RWRC422	613865	6390401	266.78	58	172	145.86	0.7
RWRC427	613863	6389920	267.24	60	172	148.96	0.25
RWRC428	613806	6389782	266.61	60	280	242.49	0.84
RWRC433	613814	6390058	266.34	60	226	195.72	0.09

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4.4.3 Airlift recovery testing

Hydraulic conductivity was estimated at four out of a total of the 14 airlifted boreholes (RWRC387, RWRC401, RWRC403 and RWRC418) using airlift water level recovery data. Hydraulic conductivity was only able to be estimated at these four locations due to lack of water level recovery data at the remaining locations. This was generally due to the dip meter either snagging within the angled holes or falsely signalling on clays within the inner tube.

The testing and analysis method that was employed is summarised as follows:

- Pre-test groundwater level measured by dip meter. In cases where a measurement was not available, the groundwater level was estimated based on available site data
- Airlifting via drill string, typically undertaken for a period of up to120 minutes
- Yield estimation via a timed bucket and stopwatch, with a yield estimation undertaken every 10 minutes
- Water level recovery measurement via dip meter lowered down drill rods. It is noted that difficulty was encountered measuring the water level recovery due to the dip meter falsely signalling due to mud, and due to difficulties encountered lowering the dip meter in the angled boreholes. This led to recovery measurements for only four of the 14 tests
- Angled down-hole measurements were converted to equivalent vertical depths
- Water level recovery data was analysed in the program AQTESOLV (HydroSOLVE, 2007), using the Theis straight line recovery solution or Theis/Hantush type curve recovery solution. Aquifer thickness was estimated using the saturated thickness in the borehole.
- It is noted that given the testing methodology and application in angled drillholes, the resulting hydraulic conductivity values should be indicative or order of magnitude only.

Calculated hydraulic conductivity at the airlifted boreholes is summarised in **Table 4.5** and test locations and yields are shown in **Figure 4.8**. The calculated hydraulic conductivity values range from 4.8×10^{-5} m/d to 1.6×10^{-3} m/d.

Airlift recovery curves and analyses are provided in Appendix C.

As indicated in **Section 4.4.3**, the airlift recovery tests were only able to be successfully undertaken on boreholes that had below median yields (0.2 L/s) and as such the results are not necessarily fully representative of the range of airlift yields observed. In particular the five boreholes with yields of 0.7 L/s or greater would be expected to return relatively elevated hydraulic conductivity values compared to those outlined in **Table 4.5**.

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Table 4.5: Hydraulic conductivity calculated based on airlift water level recovery

Borehole	Easting	Northing	Ground level (mAHD)	Dip °	Total depth (m)	Total vertical depth (m)	Average yield (L/s)	Hydraulic conductivity estimate (m/d)
RWRC387	613758	6389682	266.35	60	264	228.63	0.05	1.1×10^{-4} (based on only four data points)
RWRC401	613799	6390284	266.37	58	154	130.60	0.19	1.6×10^{-3}
RWRC403	613911	6390264	267.07	60	232	200.92	0.11	4.8×10^{-5}
RWRC418	613739	6389743	265.65	58	190	161.13	0.1	5.1×10^{-5}

Statistics for calculated hydraulic conductivity are summarised in **Section 4.4.5** alongside the results obtained from TGEP/TGO groundwater monitoring bores and packer testing. A qualitative summary of the hydraulic conductivity test values is also provided in **Section 4.4.5**.

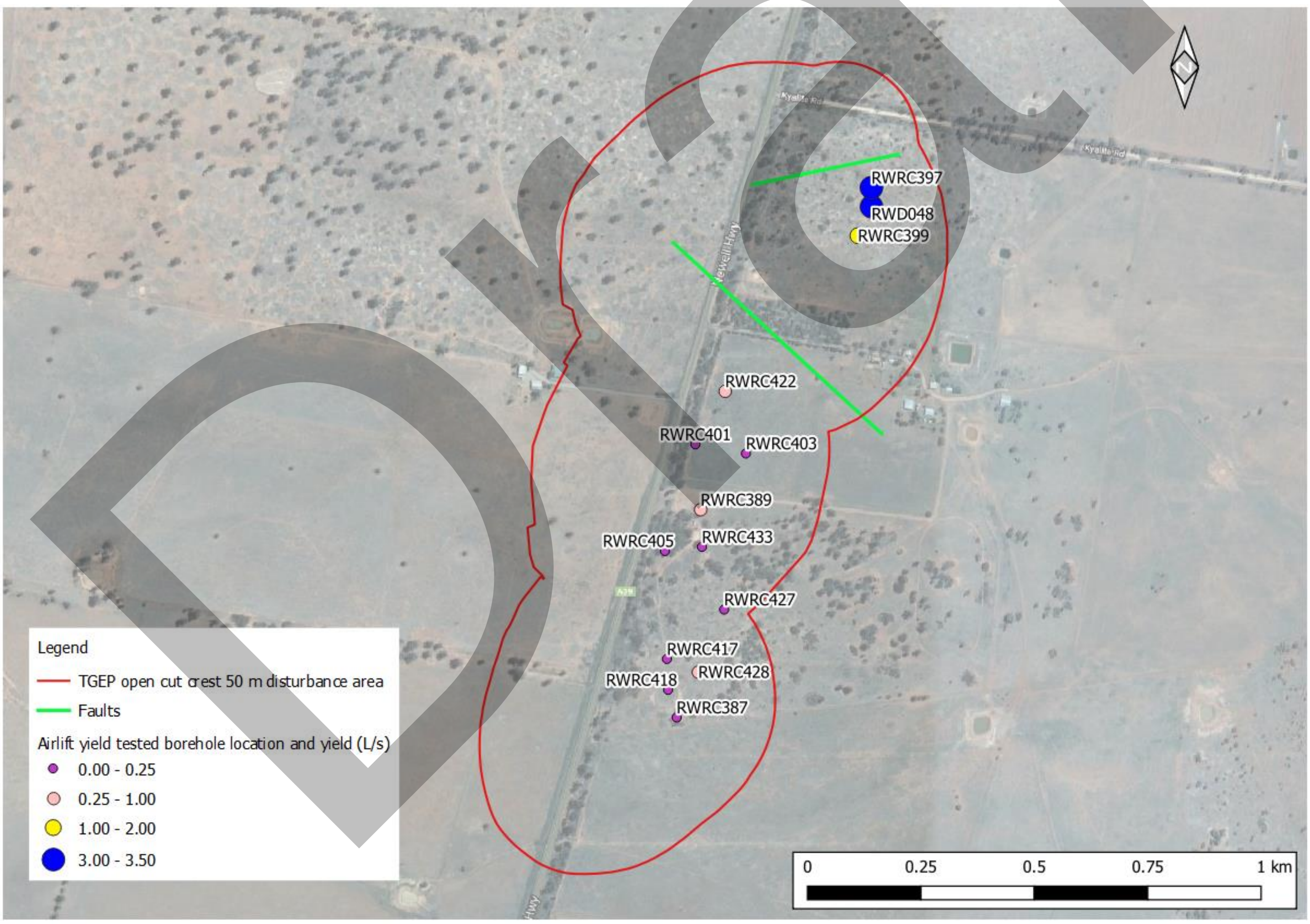

Figure 4.8: Airlift yield test locations and results

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4.4.4 Packer testing

Lugeon, or packer injection testing, was completed on four diamond drill holes in the area of TGEP, RWRC352D, RWDO42, RWD048 and RWMET01.

In general, the field testing and data analysis was completed as follows:

- Pre-test groundwater level measured by dip meter. In cases where a measurement was not available, the groundwater level was estimated based on available site data. Angled measurements were converted to vertical measurements
- Single stage packer testing was undertaken. The testing length interval increasing cumulatively upward by approximately 50 m per test (i.e. minimum test interval occurred near borehole base and then testing intervals increased cumulatively towards ground surface as the packer assembly was gradually withdrawn from the borehole)
- Each test interval typically comprised three five-minute flow intervals at seven pressure stages (i.e. four stages with pressure increasing cumulatively and three stages with pressure decreasing cumulatively)
- Data was analysed in spreadsheet, with consideration given to pressure and flow trends. A lugeon value was calculated for each pressure stage and then a representative lugeon value selected based on Houlsby (1976) and Quinones-Rozo (2010). The representative lugeon value was converted to derive a representative formation hydraulic conductivity value.
- Qualitative classification and description of rock mass discontinuities in accordance with Quinones-Rozo (2010).

Details of the packer tested boreholes and intervals, and test results are summarised in **Table 4.6**. Test analysis summaries are provided in Appendix C. The results are generally indicative of very low to low hydraulic conductivity and a very tight to tight rock mass with respect to discontinuities. Estimates of formation hydraulic conductivity ranged from 4.7×10^{-4} m/d to 6.5×10^{-2} m/d and had a geometric mean and median value of 5.7×10^{-3} m/d and 7.3×10^{-3} m/d, respectively.

There was one test interval result, the maximum of all test results, which occurred at RWD048, where the hydraulic conductivity is classified as 'moderate' and the rock mass classified to have 'a few partly open discontinuities' in accordance with Quinones-Rozo (2010). It is noted that although the hydraulic conductivity is classified as 'moderate' under Quinones-Rozo (2010), the maximum hydraulic conductivity test value of 6.5×10^{-2} m/d is considered relatively low.

It is noted that test results generally show a trend of fracture filling. Fracture filling can result from fractures of limited extent becoming fully pressurised accepting less flow at consecutive steps, or it can also result from the holes not being flushed adequately and drill cuttings physically clogging up the fractures. Notwithstanding, the results are generally indicative of a very tight to tight rock mass.

Statistics for calculated hydraulic conductivity are summarised in **Section 4.4.5** alongside the results obtained from TGEP/TGO groundwater monitoring bores and borehole airlift recovery testing. A qualitative summary of the hydraulic conductivity test values is also provided in **Section 4.4.5**.

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Figure 4.9: Packer tested borehole locations

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Table 4.6: Packer testing results summary

Borehole (and dip/azimuth)	Ground level (mAHD)	Tested declined interval (m)	Tested vertical interval (mBGL)	Tested vertical interval (mAHD)	Lugeon	Hydraulic conductivity, K (m/d)	Qualitative assessment of hydraulic conductivity and rock mass discontinuities	Comment
RWRC352D (dip 60°, azimuth 270°	268.04[1]	400-519	346-449	-78 to -181	0.87	1.09×10^{-2}	Very low hydraulic conductivity, very tight rock mass	▪ Test curve indicates filling of fractures ▪ Average lugeon of pressure Stages 1 to 3 used to calculate K
		451-519	391-449	-123 to -181	NA – no flow conditions	NA – no flow conditions	Very low hydraulic conductivity, very tight rock mass	▪ Negligible to no flow for all pressure stages
		499-519	432-449	-164 to -181	0.04	4.69×10^{-4}	Very low hydraulic conductivity, very tight rock mass	▪ Inconsistent data ▪ Average lugeon value of all pressure stages used to calculate K
RWD042 (dip 60°, azimuth 270°	268.13[1]	150-478	130-414	138 to -146	1.14	1.43×10^{-2}	Low hydraulic conductivity, tight rock mass	▪ Unable to increase pressure beyond 200 kPa. Therefore, only first pressure stage was completed. As such, result is indicative only.
		221-478	191-414	77 to -146	0.27	3.43×10^{-3}	Very low hydraulic conductivity, very tight rock mass	▪ Test curve indicates filling of fractures, possible hydraulic fracturing, or packer bypass at Stage 4 ▪ Average lugeon of pressure Stages 1 to 3 used to calculate K

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Borehole (and dip/azimuth)	Ground level (mAHD)	Tested declined interval (m)	Tested vertical interval (mBGL)	Tested vertical interval (mAHD)	Lugeon	Hydraulic conductivity, K (m/d)	Qualitative assessment of hydraulic conductivity and rock mass discontinuities	Comment
		252-478	218-414	50 to -146	1.04	1.30×10^{-2}	Low hydraulic conductivity, tight rock mass	▪ Highest lugeon (Stage 6) used to calculate K
		300-478	260-414	8 to -146	0.66	8.24×10^{-3}	Very low hydraulic conductivity, very tight rock mass	▪ Test curve indicates filling of fractures ▪ Average lugeon of Stages 1 - 4 used to calculate K
		350-478	303-414	-35 to -146	1.11	1.39×10^{-2}	Low hydraulic conductivity, tight rock mass	▪ Test curve indicates filling of fractures ▪ Average lugeon of Stages 1 – 4 used to calculate K
		400-478	346-414	-78 to -146	2.02	2.53×10^{-2}	Low hydraulic conductivity, tight rock mass	▪ Test curve indicates filling of fractures ▪ Average lugeon of Stages 1 - 3 used to calculate K
		450-478	390-414	-122 to -146	0.73	9.20×10^{-3}	Very low hydraulic conductivity, very tight rock mass	▪ Test curve indicates filling of fractures, partial recovery at Stage 7 ▪ Average lugeon of Stages 1 - 4 used to calculate K
RWD048 (dip 60°,	267.89[2]	200-455	173-394	95 to -126	0.10	1.30×10^{-3}	Very low hydraulic conductivity, very tight rock mass	▪ Average lugeon of Stage 1 - 6 used to calculate K

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Borehole (and dip/azimuth)	Ground level (mAHD)	Tested declined interval (m)	Tested vertical interval (mBGL)	Tested vertical interval (mAHD)	Lugeon	Hydraulic conductivity, K (m/d)	Qualitative assessment of hydraulic conductivity and rock mass discontinuities	Comment
azimuth 270°		245-455	212-394	56 to -126	0.12	$1.46x10^{-3}$	Very low hydraulic conductivity, very tight rock mass	▪ Test curve indicates possible filling of fractures ▪ Lugeon of highest pressure stage used to calculate K
		257-455	223-394	46 to -126	0.16	$2.00x10^{-3}$	Very low hydraulic conductivity, very tight rock mass	▪ Average lugeon of Stage 1 and 2 (only stages completed) used to calculate K
		300-455	260-394	8 to -126	0.13	$1.63x10^{-3}$	Very low hydraulic conductivity, very tight rock mass	▪ Test curve indicates possible filling of fractures ▪ Average lugeon of Stage 2 - 3 used to calculate K
		350-455	303-394	-35 to -126	0.32	$3.96x10^{-3}$	Very low hydraulic conductivity, very tight rock mass	▪ Inconsistent flows ▪ Average lugeon of all stages used to calculate K
		400-455	346-394	-78 to -126	0.54	$6.74x10^{-3}$	Very low hydraulic conductivity, very tight rock mass	▪ Test curve indicates possible filling of fractures ▪ Average lugeon of Stages 1 - 3 used to calculate K
		446-455	386-394	-118 to -126	5.07	$6.35x10^{-2}$	Moderate hydraulic conductivity, few partly open rock mass discontinuities	▪ Only 3 stages completed ▪ Average lugeon of Stages 1 – 3 used to calculate K. Test was

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Borehole (and dip/azimuth)	Ground level (mAHD)	Tested declined interval (m)	Tested vertical interval (mBGL)	Tested vertical interval (mAHD)	Lugeon	Hydraulic conductivity, K (m/d)	Qualitative assessment of hydraulic conductivity and rock mass discontinuities	Comment
								terminated after 5 minutes into Stage 3.
RWMET01 (vertical)	267.03[1]	96-196	96-196	171 to 71	0.51	6.36×10^{-3}	Very low hydraulic conductivity, very tight rock mass	▪ Lowest lugeon value of stages used to calculate K
		144-196	144-196	123 to 71	0.85	1.07×10^{-2}	Very low hydraulic conductivity, very tight rock mass	Possible flushing Highest lugeon value of stages used to calculate K

Notes: [1] Based on borehole collar coordinate projected onto a 5 m LIDAR digital elevation model (Geoscience Australia, 2020). [2] Differential GPS.

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4.4.5 Spatial data trends

Derived values of hydraulic conductivity at groundwater monitoring bores, airlifted boreholes and packer test locations (maximum value shown for packer test locations) are shown in **Figure 4.10**.

It is noted that, except for the groundwater monitoring bores (WYMB and RWWB series bores) and RWMET, the test locations typically have 58 to 60 degree dips and an azimuth of approximately 270 degrees. The borehole locations presented in **Figure 4.10** are the collar locations at ground level.

The hydraulic conductivity test values are relatively elevated in a cluster comprising locations RWD048, RWMET01, RWRC352D and RWD042. This cluster is located between the location of two fault lines that have been mapped by Alkane. Airlift yields were also relatively elevated in this area with the two highest airlift yields of 3.09 and 3.32 L/s recorded in the vicinity of the northern most fault in the Roswell deposit. There is the possibility that hydraulic conductivity may be relatively enhanced in the Roswell deposit in association with proximity to the two fault lines.

It is likely that the mineralisation targeted by mining would have a relatively higher hydraulic conductivity than the surrounding siltstone and shale; however, whilst this is considered reasonably likely, the current data is not considered sufficient to validate this notion.

Packer test interval mid-point depths (mbgl) and calculated hydraulic conductivity for the packer tests are graphed in **Figure 4.11**. It is noted that ground surface elevation variation between the packer tested boreholes is only about 1 m. Thus, whilst **Figure 4.11** displays the data with respect to mbgl, due to the negligible ground surface level variation between the boreholes, the graph is also reflective of hydraulic conductivity trends with respect to relative levels.

Based on **Figure 4.11**, there is no apparent correlation between hydraulic conductivity and test depth or elevation.

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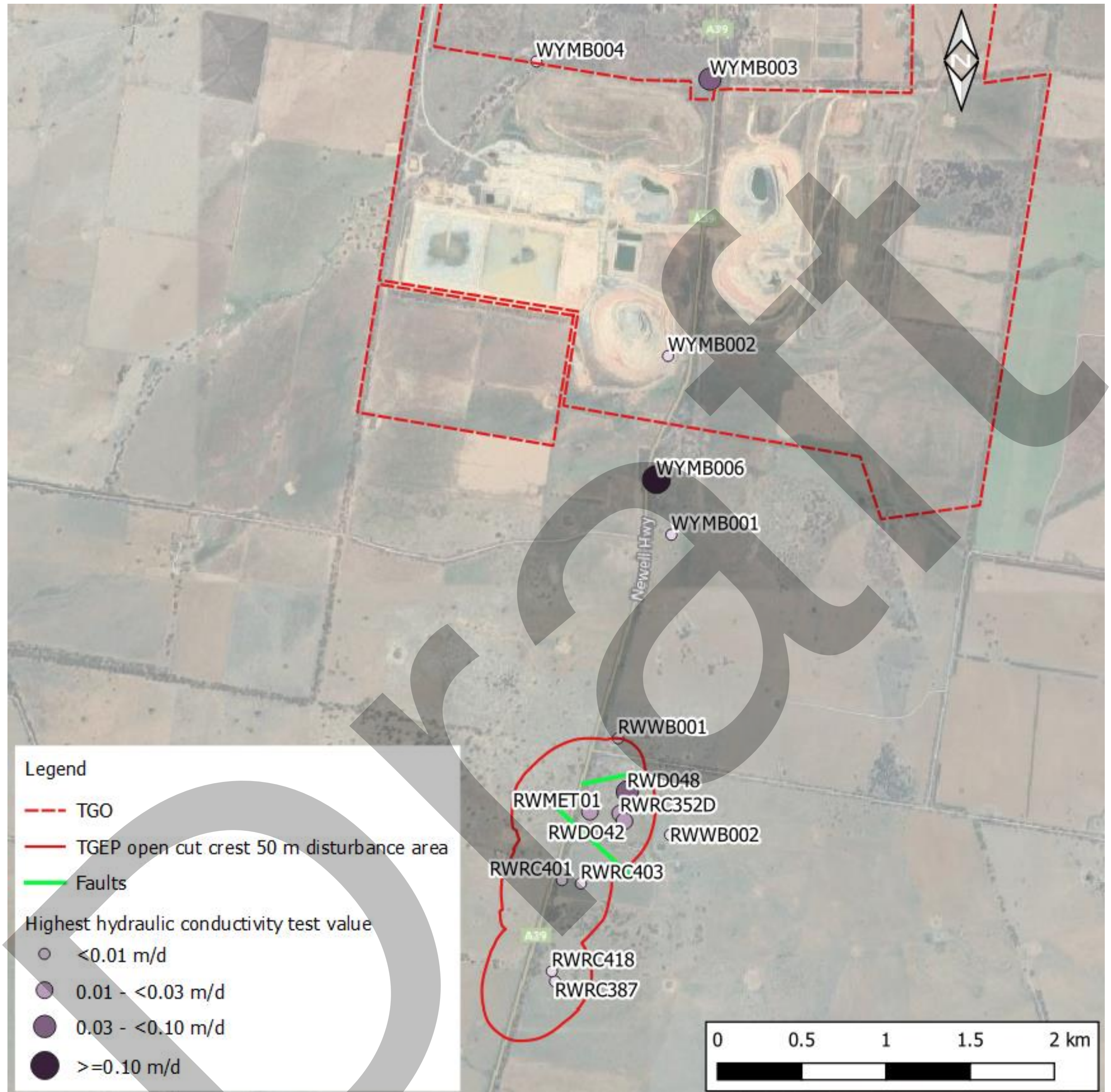

Figure 4.10: Distribution of hydraulic conductivity

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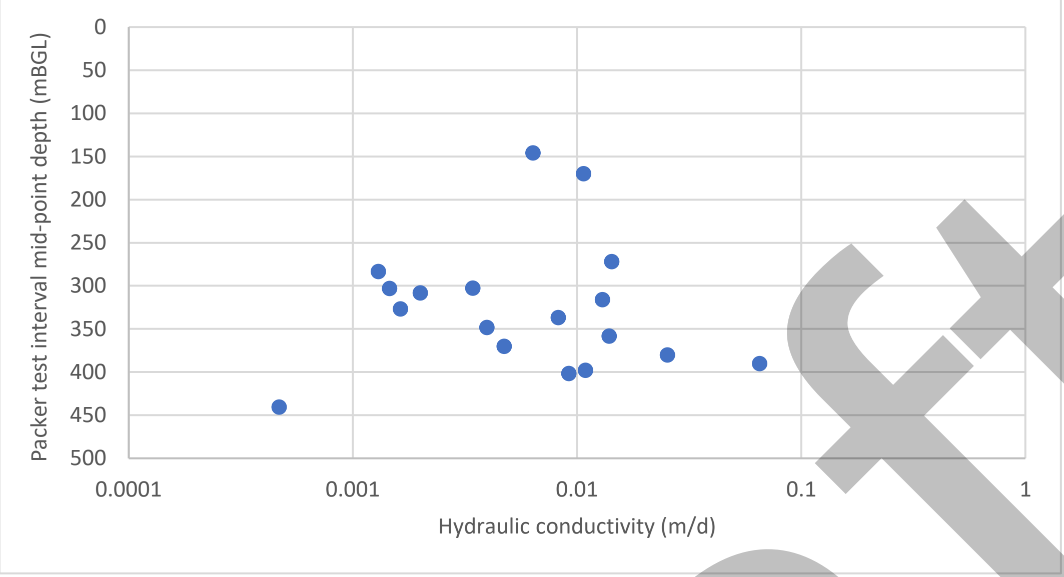

Figure 4.11: Packer test interval mid-point depth (mBGL) and hydraulic conductivity (m/d)

4.4.6 Hydraulic conductivity – statistical summary

A statistical summary of all hydraulic conductivity test results is provided in **Table 4.7**. Out of a total of 29 test values, the minimum and maximum values were 2.90 x 10^{-6} m/d and 0.11 m/d, respectively.

Generally speaking, hydraulic conductivity of aquifer materials varies over many orders of magnitude in nature and has most often been found to be log-normally distributed (Sanchez et al. 1996). Thus, the geometric mean of hydraulic conductivity data is often used to obtain a representative hydraulic conductivity value for a groundwater system (Prudic, 1991).

The geometric mean of all the hydraulic conductivity testing results was 2.71x10^{-3} m/d. This value is classified by Quiñones-Rozo (2010) to be 'very low' and indicative of a 'very tight' rock mass with respect to discontinuities.

The maximum value of all hydraulic conductivity test results of 0.11 m/d is classified by Quiñones-Rozo (2010) to be 'moderate' and indicative of a rock mass with a 'few partly open discontinuities'. It is noted that although the maximum hydraulic conductivity value is classified as 'moderate' under Quiñones-Rozo (2010), the maximum hydraulic conductivity test value of 0.11 m/d is considered relatively low. The qualitative Quiñones-Rozo (2010) classifications were developed for packer test interpretation and are applicable to rock. Thus, under more broad classifications which consider a wider range of aquifer materials (e.g. sands and gravels), the maximum hydraulic conductivity test value of 0.11 m/d is considered relatively low.

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Table 4.7: Statistical summary of all hydraulic conductivity testing results

Hydraulic conductivity test type	Hydraulic conductivity (m/d) summary statistics				
	Minimum	Arithmetic Mean	Geometric mean	Median	Maximum
TGEP/TGO Groundwater monitoring bores (n=7)	2.90×10^{-6}	2.73×10^{-2}	2.12×10^{-3}	9.50×10^{-3}	0.11
Airlifted boreholes (n=4)	4.80×10^{-5}	4.52×10^{-4}	1.44×10^{-4}	8.05×10^{-5}	1.60×10^{-3}
Packer tested boreholes (n=18)	4.69×10^{-4}	1.09×10^{-2}	5.73×10^{-3}	7.30×10^{-3}	6.53×10^{-2}
All testing types and packer intervals (n=29)	2.90×10^{-6}	1.34×10^{-2}	2.71×10^{-3}	4.73×10^{-3}	0.11

4.5 Storage (groundwater system)

Groundwater system storage properties are physical properties that characterise the capacity of a groundwater system to release groundwater. For water table groundwater systems, storage is discussed in terms of specific yield (Sy), which is also known as drainable porosity. Specific yield, quoted as a ratio, is generally less than or equal to the effective porosity (total connected pore space). Additionally, specific storage (Ss) is the amount of water that a portion of an aquifer releases from storage, per unit mass or volume of aquifer, per unit change in hydraulic head, while remaining fully saturated. Specific storage is a function of the compressibility of the formation and the compressibility of water. Specific storage is also known as elastic storage.

In the vicinity of TGO and TGEP, the Cainozoic deposits are considered to be unconfined, although it is noted that they are also largely unsaturated. The total porosity of these deposits is likely to be relatively large due to the clay and silt content, although the specific yield is likely to be reduced. Indicative values for porosity and specific yield for silty and clayey alluvial deposits is of the order of 5% (Johnson, 1967).

Groundwater system storage within the vicinity TGO/TGEP is inferred to be low for the basement lithologies (volcanics and meta-sediments). Specific yield, where unconfined, is inferred to be in the range of 1 % to 10 %. This specific yield value range aligns with representative specific yield values for fractured igneous and metamorphic rock (1%), shale (2.5%), sandstone (6%) and siltstone (12%) in Bair and Lahm (2006). Specific yield is expected to be at the lower end of the range based on the very tight nature of the rock mass and lack of any significant primary porosity.

An assessment of specific storage has been undertaken based on geotechnical rock strength data. Specific storage is related to formation compressibility, that can be derived from rock strength coefficients of Youngs Modulus and Poissons Ratio, and the compressibility of water. For available project data from five valid strength tests (WSP, 2021) the geometric mean value for specific storage has been estimated at 1.3×10^{-7}, whereas Younger (1993) suggests that typical values of specific storage range from the order of 1×10^{-6} for moderately fractured rock to 7×10^{-7} for unfractured rock.

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5. Conceptualisation

A conceptual hydrogeological model is a descriptive representation of a groundwater system that incorporates an interpretation of the geological and hydrological conditions. A conceptual model consolidates the current understanding of the key processes of the groundwater system, including the influence of stresses, and assists in the understanding of possible future changes.

5.1 Conceptual hydrogeological model

The conceptual hydrogeological model for the TGP is summarised as follows:

- There are three broad groundwater systems apparent in the vicinity of the TGP:
  - Perched aquifer: A shallow and localised perched water table system associated with the larger drainages, particularly Gundong Creek and possibly the Bogan River. These systems are not located close to the TGEP and as such will have no significant interaction from a groundwater perspective.
  - Cainzoic alluvial groundwater system: The Cainzoic alluvial system comprises a relatively thick layer of generally low permeability fluvial sediments. In the vicinity of the TGEP this unit has been shown to be unsaturated and does not locally represent an aquifer. On a regional scale there is potential for saturation, particularly in more deeply incised palaeochannels.
  - Fractured rock groundwater system: Locally, in the vicinity of the TGP, the regional water table is expressed within the basement lithologies. The primary permeability of these basement lithologies is likely to be very low, however there is potential for enhanced permeability associated with structural deformation and discontinuities, zones of mineralisation, and chemical weathering within the transition zone from completely oxidised saprolite to moderately weathered formation.
- Given the depth to groundwater in the vicinity of the TGP, the primary groundwater system of interest with respect to potential groundwater inflows and associated impacts is the fractured rock groundwater system.
- There is potential for preferential groundwater flow along the dominant direction of structural orientation; however, there is no indication of this and the regional groundwater flow direction is typically orthogonal to the structural orientation in the vicinity of the TGP.
- Hydraulic conductivity of the fractured rock groundwater system will typically be very low and of the order of $1x10^{-3}$ to $1x10^{-5}$ m/d. Some localised elevated hydraulic conductivity may be anticipated due to local fracture conditions; however, any such fractures are unlikely to be extensive or interconnected and any associated inflows would be short lived.
- Observed groundwater inflows at TGO open cuts and the underground mine are very low and do not present any issues or require active dewatering. A basic water balance prepared by RW Corkery & Co (2020) for the Wyoming underground at TGO indicated that inflows to the underground could be as much as 1.5 L/s; however, the majority of this was inferred to be seepage or water recycling with the Wyoming One pit sump.
- Rainfall recharge is the dominant recharge process but given the large thickness of unsaturated Cainozoic alluvial deposits, is likely to be relatively low. Rainfall recharge is likely to be more significant along the Harveys Range, contributing to the groundwater throughflow beneath the TGEP.
- Given the large depth to groundwater and ephemeral nature of local water courses there is not anticipated to be a significant groundwater - surface water interaction in the vicinity of the TGP. During times of surface water flow, there may be a component of surface water loss to groundwater (recharge) particularly in the perched groundwater systems. This interaction will not be affected by mine dewatering.
- Within the TGO and TGEP, the dominant mechanism for groundwater discharge is likely to be inflows to mine workings and evaporation from pit walls and sumps. Evapotranspiration may be significant for perched groundwater systems, but due to depth, the regional groundwater system will be beyond the influence of

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evapotranspiration. Groundwater extraction by existing registered bores in the vicinity of the TGEP is considered to be negligible.

- Based on observations from the current extraction areas, groundwater inflows for the Project are anticipated to be low.

5.2 Conceptual hydrogeological slice

A conceptual hydrogeological slice, along the main structural corridor at TGO and TGEP is shown in **Figure 5.1**. The slice view is looking towards the north west.

The slice was developed in geological modelling software, Leapfrog, by importing existing and proposed mine designs, a base of alluvium surface provided by Alkane Resources, TGEP monitoring bores and a derived water table surface for existing conditions.

It is noted that in the south west of the slice, the base of alluvium surface is deeper than in reality. This is clearly demonstrated by monitoring bore RWWB003, as groundwater level monitoring at this bore shows that the alluvium in this location is unsaturated and that the water table is located within the fractured rock beneath the alluvium. Notwithstanding this, the slice is considered suitable for demonstrating conceptual hydrogeology and mine development.

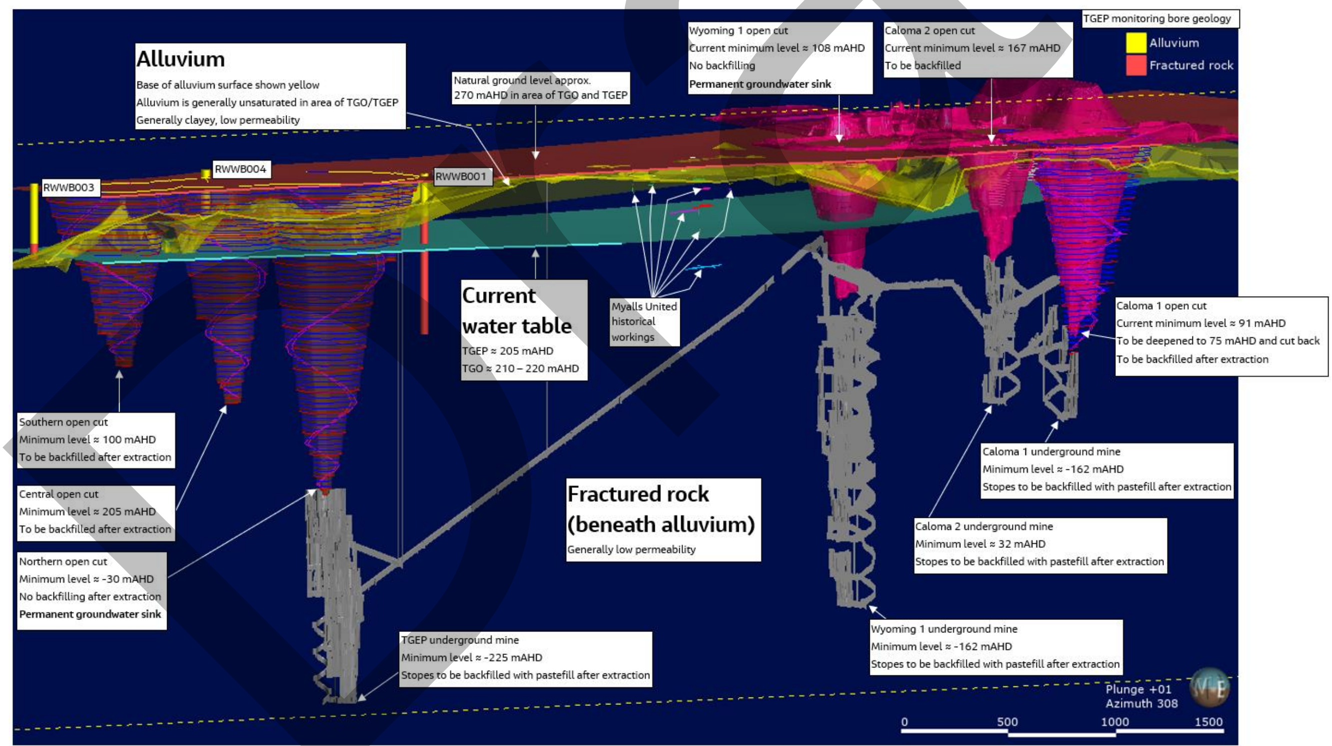

Figure 5.1: Conceptual hydrogeological slice

6. Numerical groundwater flow modelling

6.1 Model objectives

A numerical groundwater flow model (GFM) has been developed for the TGP to inform the groundwater impact assessment. The modelling objectives were as follows:

- Predict future groundwater inflow rates to mining operations, to inform assessment of water licensing entitlement requirements
- Predict associated propagation of groundwater level drawdown, to inform assessment of potential impacts to existing registered bores.

  It is noted that the model does not intend to predict drawdown at potential GDEs or High Priority GDEs. The fractured rock groundwater system that the model represents is conceptualised to not be associated with such GDEs. Therefore, whilst GDE mapping is included in model outputs for transparency/completeness, impacts to GDEs are assessed qualitatively, outside of the GFM. Also, potential impacts to baseflow to watercourses are assessed in this manner for the same core reasons.

6.2 Numerical code

The model has been developed using MODFLOW-USG which was executed in the saturated flow mode. The input and output MODFLOW files were processed using the Groundwater Vistas Graphical User Interface Version 7.15 Build 8.

6.3 Model Assumptions and Limitations

The TGP GFM is a groundwater flow model developed to estimate groundwater inflows to mining operations and the resulting groundwater level drawdown.

The TGP GFM includes the following assumptions and limitations:

- Modelling the subsurface in the model domain as an equivalent porous medium is valid.
- Modelling groundwater in the study area as a single-density fluid is valid.
- Conceptual errors associated with no-flow assumptions across no-flow boundaries along the northern, eastern and southern model exterior are negligible.
- The TGP GFM does not simulate surface water processes, and as such, it does not address issues of surface-water routing and conveyance, or baseflows to watercourses.
- There exists the possibility that specific subsurface features that act as barriers or conduits to groundwater flow have not been explicitly represented in the TGP GFM.
- All model elevations related to model layering and boundary conditions were referenced to the Australian Height Datum (AHD).
- Open cuts and underground mines are represented coarsely, spatially and temporally. Additionally, the model is a simplification of the complex natural system. Therefore, whilst the model is considered suitable to achieve the objectives, there is an inherent degree of uncertainty with results.
- Backfilled open cuts are not represented with altered hydraulic properties. Groundwater level recovery is facilitated by deactivating DRN boundaries.
- Surface water storage within Caloma 1 is not represented in the model.

Additional limitations pertaining to model confidence level classification indicators are discussed in **Section 6.4**.

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6.4 Model Class

In accordance with the Australian Groundwater Modelling Guidelines (Barnett *et al.* 2012), the intended model confidence level classification is Class 2.

Table 6.1 presents a comparison between the characteristics of the model and quantitative indicators for that of a confidence Class 2 model, following the recommendation of Middlemis and Peters (2018). From **Table 6.1**, it can be seen that the TGP GFM meets or exceeds the majority of Class 1 and Class 2 criterion.

Deficiencies in the model, as highlighted by the partially or non-met Class 1 and Class 2 criterion in **Table 6.1** are summarised as follows:

- 'Not much / sparse data coverage' – spatial and temporal head data and hydraulic conductivity data is considered reasonable in the vicinity of TGP, and broader surrounding spatial head data is also considered reasonable. However, it is noted that there is no hydraulic conductivity information for areas within the model domain located further away from TGP. There is also no continuous groundwater level monitoring data for areas located further away from the TGP. Available data for the distal areas consists of individual groundwater level measurements obtained immediately following bore drilling.
- 'Long stress periods' – whilst the calibration and transient prediction model stress period length is one month and is not considered 'long', it is noted that the drain boundaries in the model used to represent mining generally progress at intervals larger than one month. For predictive modelling, the drains used to represent open cuts progress on a six monthly basis. For underground mining, the drains levels progress at coarser intervals, generally ranging from six months to 30 months.
- 'Poor aquifer geometry' – it is noted that the model does not represent specific 'aquifer geometry'. However, this is because aside from shallow perched alluvium, the available data indicates the alluvium in the vicinity of TGP is generally unsaturated. Also, the TGP data does not support the presence of multiple groundwater systems with varying hydraulic properties (i.e. aquifers separated by confining units).
- 'Basic/initial conceptualisation' – the basic conceptualisation adopted is considered to be suitable based on the available data, problem and level of risk.
- 'Validation' – the model has not been validated.
- 'Some high resolution topography &/or some aquifer geometry' – as outlined above, specific aquifer geometry is not represented in the model. There is no high resolution topographic data available for the modelled area. Given that topographic variation in the area is minimal, the use of high resolution topographic data is not considered essential for developing the conceptual and numerical groundwater models.
- 'Some coarse discretisation in key areas (grid or time)' – whilst the grid discretisation is considered adequate and not too coarse in key areas, as outlined above, the drain boundary progression used to simulate mining is considered somewhat coarse. However, this does not hamper model objectives.

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Table 6.1: Model confidence level classification characteristics and indicators

Class	Data	Calibration	Prediction	Quantitative Indicators
1 Simple	Not much / Sparse coverage	Not possible	Timeframe >> Calibration	Model predictive timeframe >10x transient calibration period
	No metered usage	Large error statistic	Long stress periods.	Stresses in predictions >5x higher than calibration
	Low resolution topography	Inadequate data spread	Poor / no validation.	Mass balance error > 1% (or one-off >5%)
	Poor aquifer geometry.	Targets incompatible with model purpose.	Targets incompatible with model purpose.	Properties <> range from expected field values
	Basic / Initial conceptualisation.			No review by Hydrogeologist / Modeller.
2 Impact assessment	Some data / adequate coverage.	Weak seasonal match.	Timeframe > Calibration	Predictive timeframe = 3 to 10x calibration (exceeded for life of mine predictions)
	Some usage data/low volumes.	Long-term trends not replicated in entire model domain.	Long stress periods.	Stresses = 2 to 5 greater than calibration
	Baseflow estimates. Some hydraulic conductivity and storage measurements	Partial performance (e.g. some statistics / part record / model-measure offsets).	Validation. (no validation undertaken at this stage)	Mass balance error< 1%
	Some high resolution topography &/or some aquifer geometry.	Head & Flux targets used to constrain calibration.	Calibration & prediction consistent (transient or steady-state)	Some properties <> range from expected field values.
				Review by Hydrogeologist
	Sound conceptualisation, reviewed & stress-tested.	Non-uniqueness and qualitative uncertainty partially addressed.	Significant new stresses not in calibration.	Some coarse discretisation in key areas (grid or time).
3 Complex simulator	Significant data, good coverage.	Good performance statistics.	Timeframe ~ Calibration	Predictive timeframe = < 3x calibration period (with exception of post mining period)
	Good metered usage information.	Most long term trends matched.	Similar stress periods.	Stresses < 2x
	Local climate data.	Most seasonal matches OK.	Good validation. (no validation although calibration constrained by past mine inflows)	Mass balance error < 0.5%

Class	Data	Calibration	Prediction	Quantitative Indicators
	Aquifer testing data (Kh, Kv & Sy) measurements from range of tests.	Present day head / flux targets, with good model validation.	Transient calibration and prediction.	Properties ~ field measurements.
	High resolution topography in all areas with good aquifer geometry.	Non-uniqueness minimised, qualitative uncertainty justified.	Similar stresses to those in calibration.	No coarse discretisation in key areas (grid or time).
	Detailed conceptualisation.			Review by experienced Modeller.
Legend	Criterion exceeded	Criterion met	Criterion partially met	Criterion not met

6.5 Model Set Up

6.5.1 Model Domain and Boundaries

Figure 6.1 presents the extent of the active model domain, which has maximum extents of approximately 37 km east to west by 27 km north to south. The active model boundary locations are associated with a groundwater flow divide, inferred groundwater flow directions and a down gradient boundary to allow groundwater to exit the model. The boundaries are located at a distance from TGP such that the assessment of mine inflows and resulting drawdown will have negligible influence from any boundary conditions.

External model boundaries adopted for the GFM, include:

- General head boundary
  - The General-Head Boundary package (GHB) is used to simulate head-dependent flux boundaries. The GHB allows flow to enter or leave the model domain based on calculated heads within the model domain, specified heads at a distance outside the model domain and a hydraulic conductance term.
- Specified flux (no flow) boundaries
  - No flow boundaries are specified flux boundaries with flux set at zero.

The areal extent of the active model domain is included in **Figure 6.1** and is defined as follows:

- The north western model boundary is a GHB set orthogonal to the dominant groundwater flow direction.
- Harveys Range is a no flow boundary and is applied to represent a groundwater flow divide conceptualised to occur along the range.
- The northern, southern and eastern extremities are assigned as no flow, with the boundaries set parallel to the dominant groundwater flow direction.

The closest boundary to TGEP and TGO is the northern boundary at approximately 9.9 km and 6.5 km, respectively.

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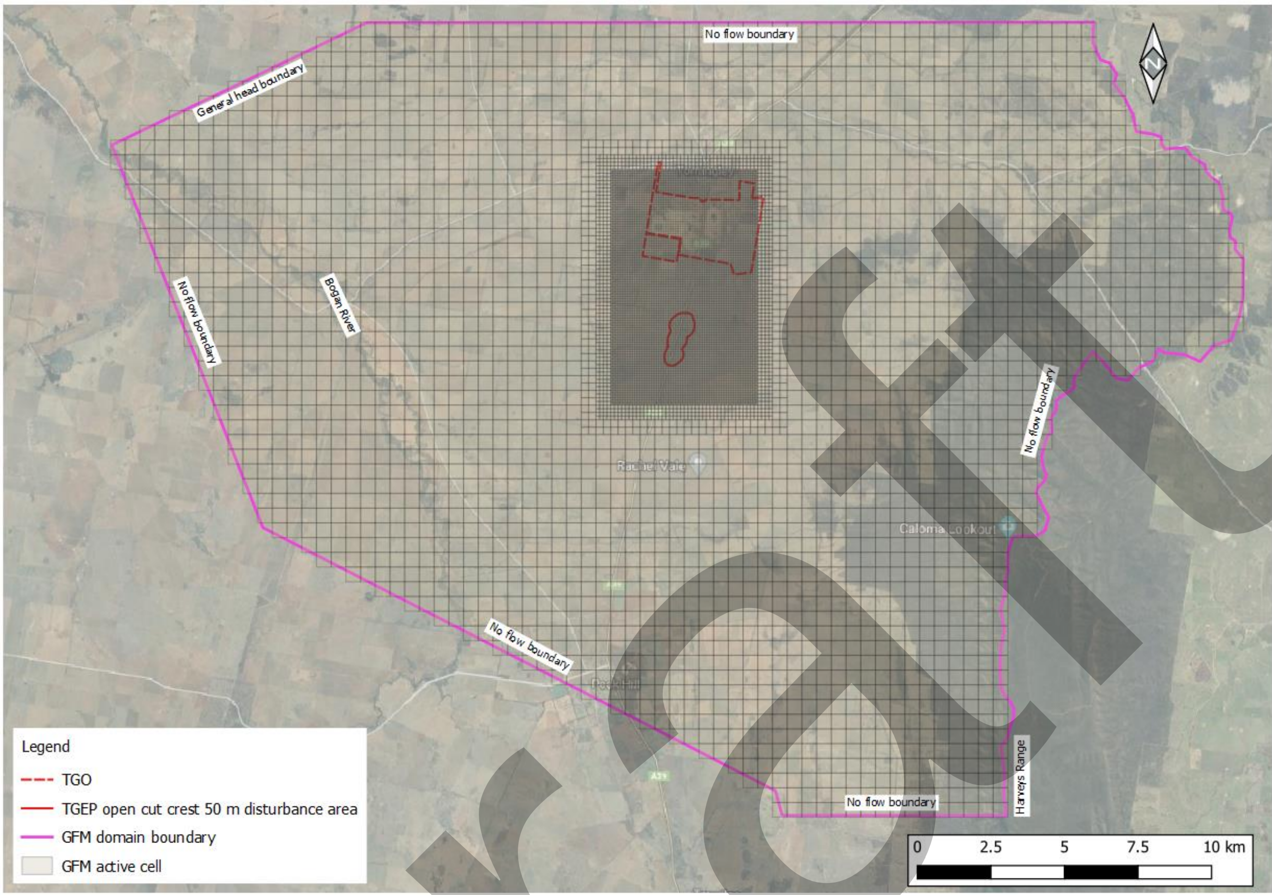

Figure 6.1: GFM active domain boundary and cells

6.5.2 Model Grid

The model grid incorporates quadtree refinement to allow more detail in key areas of interest. The model grid comprises cell sizes ranging from 62.5 m to 500 m, with the finer resolution grid cells being used in the vicinity of mining operations at TGP (**Figure 6.1**). The origin point (0, 0) for the entire model grid (i.e. including inactive cells) is easting 592,000 m and northing 6,374,000 m (Map Grid of Australia 1994, Zone 55). The model grid is not rotated.

The total number of cells, across 6 model layers (vertical) is 93,240, of which 83,634 cells are within the active model domain.

6.5.3 Model Layers

Model layer elevations were assigned based on topography (top of Layer 1) and existing and proposed mining levels, so that various drain boundaries within different layers could adequately represent mining. The bottom model layer was established to enable interaction of mining with the groundwater system below the extent of mining.

Model layer elevations were as follows:

- Layer 1 (top): derived using the hydrologically enforced digital elevation model (1 second SRTM data) (Galant *et al*., 2011).
- Layer 1 (bottom): 170 mAHD, uniform.
- Layer 2 (bottom): 70 mAHD, uniform.

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- Layer 3 (bottom): -35 mAHD, uniform.
- Layer 4 (bottom): -100 mAHD, uniform.
- Layer 5 (bottom): -180 mAHD, uniform.
- Layer 6 (bottom): -300 mAHD, uniform.

The bottom of Layer 6 (-300 mAHD) is about 75 m below the minimum level of proposed mining (i.e. about -225 mAHD for TGEP underground mine). Such a layer thickness is considered adequate to represent interaction of mining with the underlying groundwater system

The uniform model layer elevations are considered appropriate because the TGP data does not support the presence of multiple groundwater flow systems with varying hydraulic properties. Instead, the available data indicates that the rock mass in the vicinity of TGP is generally 'tight' and relatively low hydraulic conductivity, with limited distinct 'aquifers'.

South to north and west to east cross sections through the GFM are shown in **Figure 6.2**.

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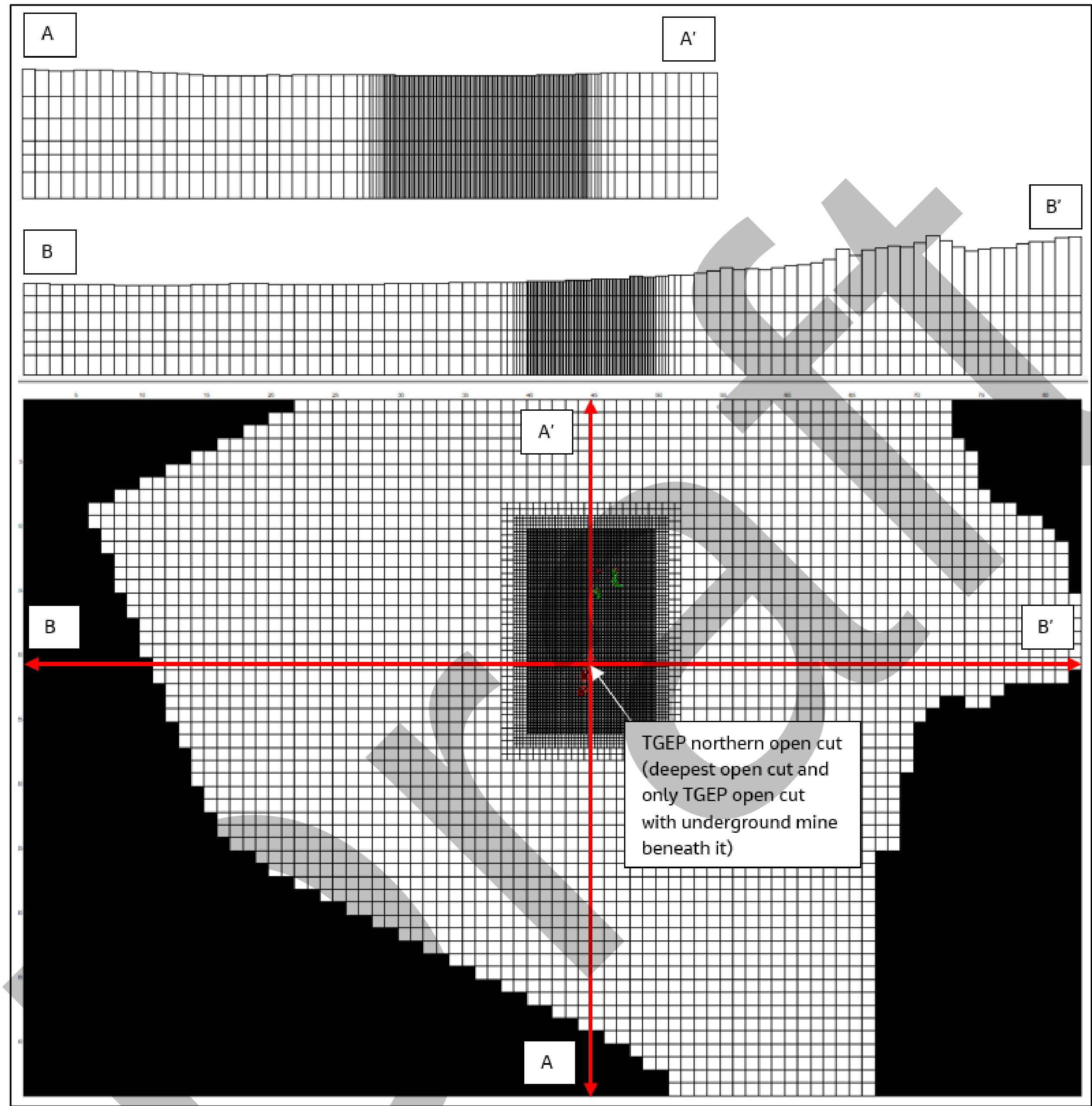

Figure 6.2: Cross sections through GFM

6.5.4 Internal Boundary Conditions

Drains

The Drain (DRN) boundary condition is a head dependant flux boundary that is suitable for simulating seasonal or ephemeral drainages. In the DRN package, if the head in the cell falls below a certain threshold, the flux from the drain to the model cell drops to zero.

Given the depth to groundwater within the fractured rock groundwater system is always below the bottom of simulated watercourses, the simulated groundwater discharge to watercourses (baseflow) is nil.

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DRN boundaries are used in the model to simulate dewatering associated with open cut and underground mining.

DRN cells on areas of open cut were assigned a conductance based on full cell width and length (62.5 m x 62.5 m), drain thickness of 1 m and vertical drain hydraulic conductivity of 100 m/d. The computed uniform conductance rate was 390,625 m^2/d, which effectively results in the model efficiently removing groundwater from the cells if the groundwater head is higher than the DRN stage. DRN stages were set based on minimum mining levels.

DRN cells were applied to envelope areas of underground mining and conductance determined during calibration, through manual trial and error, by approximately matching modelled DRN flows to a water balance based estimate of Wyoming 1 underground mine inflows (RW Corkery & Co, 2020). DRN stages in underground mining areas were also set based on minimum mining levels.

Recharge

Rainfall recharge to the model was represented using the Recharge (RCH) boundary condition. This recharge was informed by rainfall data obtained from the SILO climatic database.

Recharge zones were defined based on the geological information from the Narromine 1:250,000 Metallogenic Series Sheet (Bowman et.al, 1980). The following two recharge zones shown in **Figure 6.3** were defined based on the most eastern transition from outcropping bedrock to alluvium:

- Zone 1 – floodplain and lower slopes
- Zone 2 – foothills and upper slopes

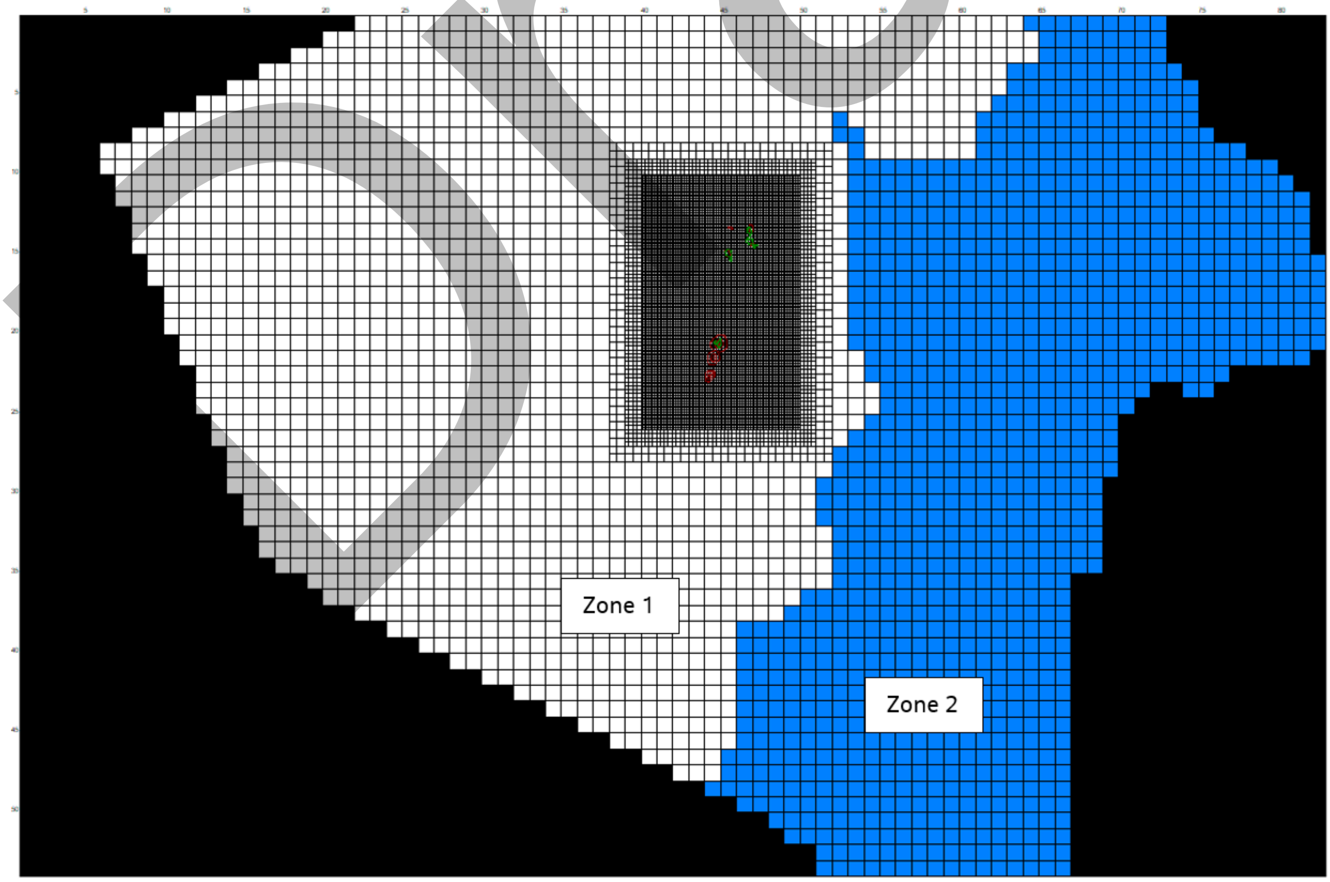

Figure 6.3: GFM recharge zones

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Evapotranspiration

Losses from the model via evapotranspiration (ET) were represented using the Evapotranspiration (EVT) boundary condition. One EVT zone was assigned over the entire model domain to represent ET. The maximum ET rate applied for all stress periods was 3.93 mm/d based on the FAO56 average daily evaporation rate.

The EVT extinction depth was set at a uniform value of 2.0 m. The EVT extinction depth is the depth at which ET approaches zero, and beyond which the EVT boundary cannot remove water from the model.

The use of a single EVT boundary zone for the model is a simple approach and is considered appropriate because losses via the EVT boundary condition do not occur in the vicinity of the mine due to the depth of the regional water table being far below the EVT extinction depth. Therefore, ET is not an important process to model at a high level of detail in order to achieve model objectives.

6.6 Calibration

The TGEP GFM was calibrated to observed groundwater conditions to ensure the model's ability to replicate the behaviour of the natural groundwater system.

The calibration was performed for both steady state and transient groundwater conditions.

6.6.1 Steady state calibration parameters and results

6.6.1.1 Approach

The steady state model was calibrated to the first available (20/03/2007) standing water level measurements at TGP groundwater monitoring bores, WYMB002, WYMB003 and WYMB004, and with a few exceptions, standing water levels at registered bores interpreted to be associated with the fractured rock groundwater system. This resulted in registered bores GW804561, GW802832, GW802834, GW802842 and GW801299 being included as calibration targets. The registered bore standing water level measurements occur in various years, 1993 (one bore), 1997 (three bores) and 2001 (one bore).

Standing water level measurements were available on 20/03/2007 at WYMB001 and WYMB006. However, these locations were not assigned as calibration targets due to water level analysis (**Section 4.2.1**) indicating these bores are likely in hydraulic connection with historical underground workings and at times record markedly different water levels compared to the other TGO bores.

The following registered bores interpreted to be associated with the fractured rock groundwater system were excluded as calibration targets:

- GW027631 – excluded as a calibration target because this bore is very close to GW804561 and there is considerable head difference between the standing water levels (about 28 m). Bore GW804561 was used as a target instead of GW027631 or both GW027631 and GW804561. Bore GW804561 was selected because it had the shallowest standing water level.
- GW802483 – excluded as the relatively shallow standing water level depth (12 m) does not align with the relatively deep water bearing zone depth (centre about 51 m) and there is no aquifer at 12 m depth based on the lithology log. Thus, the reported standing water level is thought to represent perched water table conditions. Furthermore, the reported standing water level in the datum of mAHD is about 225 mAHD and upgradient bore, GW802842, has a standing water level of about 212 mAHD. This is a disparity and not consistent with the demonstrated regional flow direction.

Equal weighting was assigned to observed heads from the registered bores and the TGO monitoring bores.

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Calibration was undertaken via an iterative step-wise process using manual adjustment of input parameters (hydraulic conductivity and recharge) within realistic ranges to achieve an acceptable match between simulated and observed heads (groundwater levels). Calibration success was gauged by qualitatively assessing the match between modelled and observed heads as well as assessing statistical calibration measures. Calibration was considered complete when a reasonably good match between observed and simulated heads was obtained.

6.6.1.2 Calibrated hydraulic conductivity zones and values

Initially, the simplest zonation possible of hydraulic conductivity was trialled, a single zone over the entire model. However, this approach resulted in unfavourable calibration, primarily due to the model not appropriately representing steeper hydraulic gradients in the foothills/upper slopes east of the mine. To address this, firstly, a total of seven hydraulic conductivity zones (**Figure 6.4**) were introduced into the model, largely based on the Narromine 1:250,000 Metallogenic Series Sheet (Bowman et.al, 1980):

- Zone 1 – fractured rock west of Zone 2
- Zone 2 – siltstone and shale
- Zone 3 – fractured rock in area of mine
- Zone 4 – siltstone and sandstone
- Zone 5 – granite
- Zone 6 – Dulladerry Rhyolite
- Zone 7 – Hervey Group (shale, siltstone and sandstone)

Although a total of seven hydraulic conductivity zones were initially incorporated into the model, a successful attempt was made to limit the number of zone values, which effectively resulted in three zones of differing hydraulic conductivity (**Figure 6.5**). This approach was taken to limit unnecessary model complexity. The applied horizontal hydraulic conductivity values were as follows:

- Zone 1 – 0.05 m/d
- Zone 2 and 3 – 0.01 m/d
- Zone 4, 5, 6 and 7 – 0.001 m/d

Vertical hydraulic conductivity was assigned a value one tenth of horizontal hydraulic conductivity for all zones.

The zonation is uniform for all model layers.

The hydraulic conductivity value of 0.01 m/d for the zone enveloping the mine, is similar to the arithmetic mean of packer test values and all test type values.

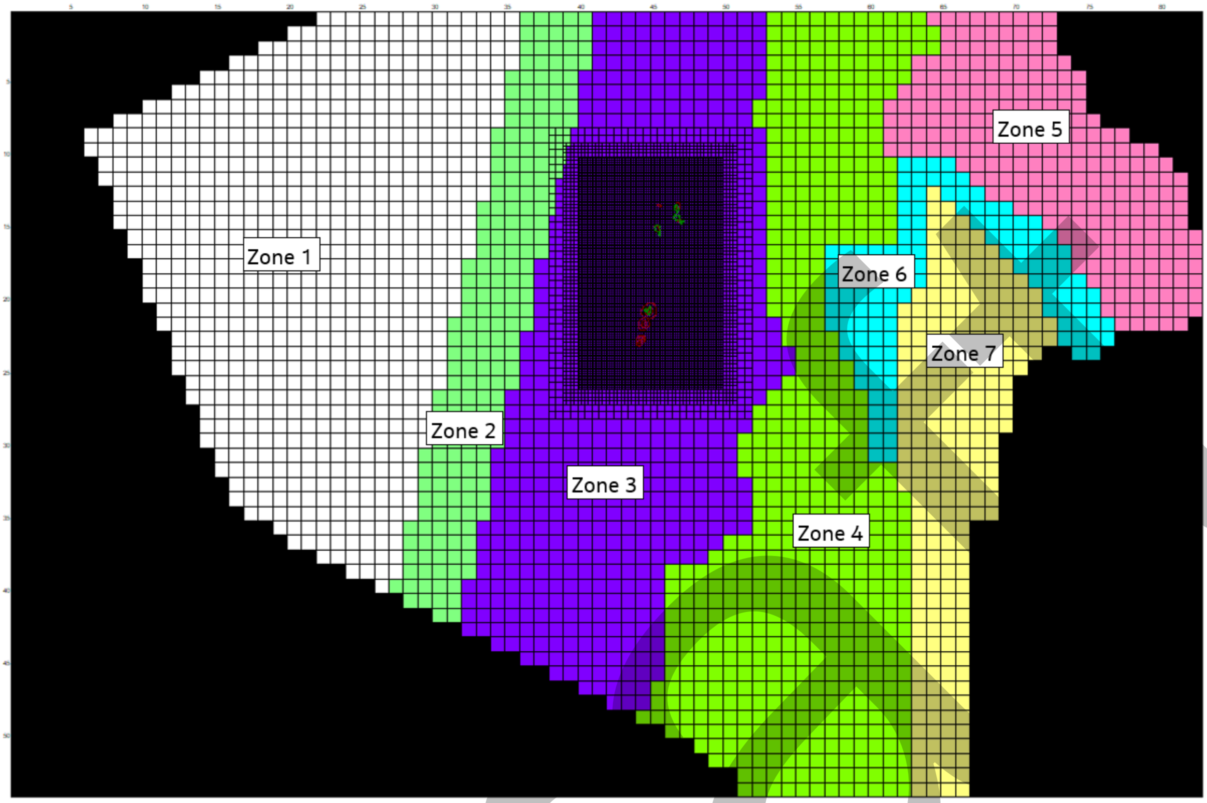

Figure 6.4: Hydraulic conductivity zones (prior to simplification)

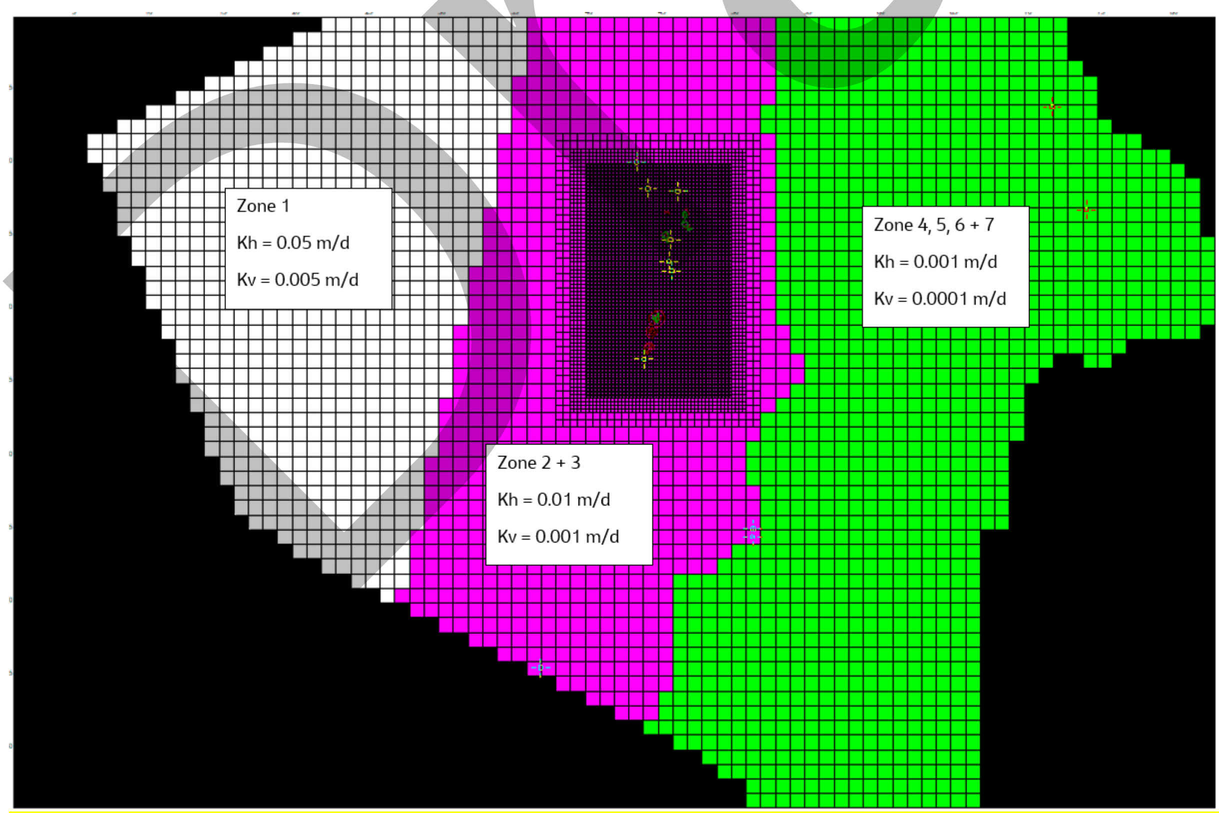

Figure 6.5: Effective and simplified hydraulic conductivity zones and values

6.6.1.3 Calibrated recharge rates

Recharge rates of 0.2 mm/year and 1 mm/year were assigned to recharge Zone 1 and 2, respectively. The recharge rates were determined through trial and error calibration, whilst constraining hydraulic conductivity values for the hydraulic conductivity zone enveloping TGP (representing Zone 2 and 3), to be similar to the arithmetic mean of TGP test values.

The applied recharge rate for both recharge zones is considered low but aligns with the conceptualisation. Relatively higher recharge is expected in the elevated portions of the model where rock outcropping occurs. Relatively lower recharge occurs in areas with thick clayey alluvium cover.

The mean annual rainfall at TGP is about 562 mm/year (**Section 3.1**). Thus, the maximum applied recharge rate of 1 mm/year for Zone 2 is about 0.18 % of average annual rainfall. The relatively low recharge rates as a percentage of average annual rainfall are considered plausible given the hydraulic conductivity values in the area of the mine have been constrained to be similar to the arithmetic mean of test values, and because literature supports low recharge in the area of the model, as does the geology.

CSIRO (2011) broad scale mapping indicates recharge in the area of the GFM is of the order of 1 mm to 5 mm per year. The applied rate for Zone 2 is within this range. The applied rate for Zone 1 is below this range. However, a relatively lower recharge rate is conceivable given the thick clayey alluvium cover. Significantly less recharge is expected to be able to migrate through thick alluvium compared to areas where bedrock is outcropping or subcropping.

6.6.1.4 Calibration results

A comparison of modelled groundwater levels and observed groundwater levels is provided in **Figure 6.6** and **Table 6.2**. Steady state calibration statistics are provided in **Table 6.3**.

Figure 6.6 shows the match between simulated steady state heads and observed heads for all calibration targets. Qualitative assessment of the degree of calibration can be determined by the match between modelled and observed heads that are shown on **Figure 6.6**. This is determined according to how close the plotted points are to the diagonal line from the origin (i.e. along the line y=x that represents perfect calibration). As shown on **Figure 6.6,** there is a good correlation between simulated and observed heads (groundwater levels).

The scaled root mean square (scaled RMS) is one of the statistics often used to quantitatively assess the goodness-of-fit between simulated groundwater levels and actual observed groundwater levels. A scaled RMS error less than ten percent can, depending on the circumstances, is usually a good indicator of a reasonable degree of calibration. The scaled RMS error of 5.4% obtained in the calibrated steady state model indicates the model is reasonably well calibrated to measured heads.

Given the good match between simulated and observed heads in **Figure 6.6** and the acceptable calibration statistics (**Table 6.3**), it was concluded that the steady state model simulates average groundwater levels (heads) with reasonable accuracy.

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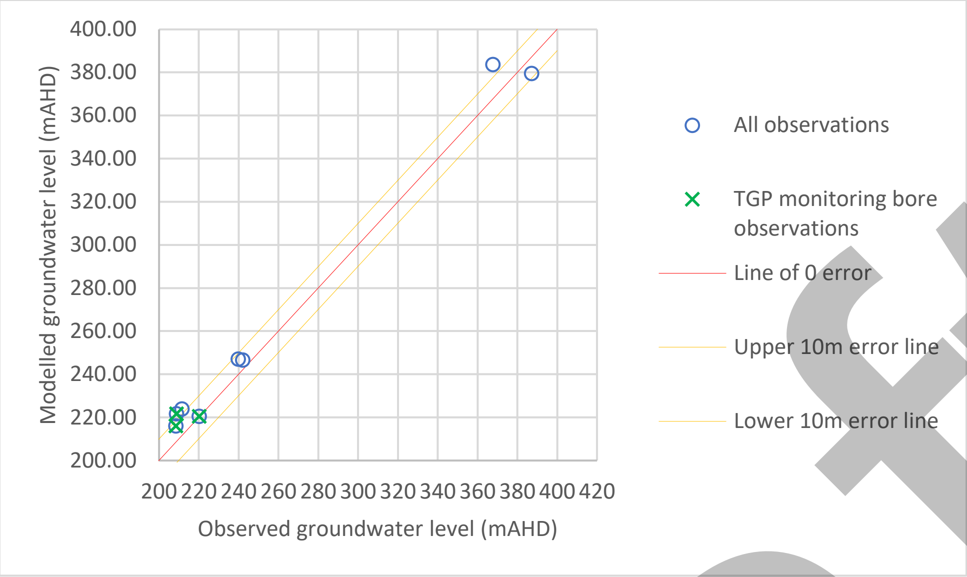

Figure 6.6: Steady state calibration plot

Table 6.2: Steady state calibration summary

Observation point	Observed groundwater level (mAHD)	Modelled groundwater level (mAHD)	Residual (m)
GW804561	367.71	383.63	-15.92
GW802832	211.55	223.83	-12.28
GW802834	242.16	246.50	-4.34
GW802842	239.89	247.07	-7.18
GW801299	387.25	379.51	7.74
WYMB002	208.90	221.63	-12.73
WYMB003	220.27	220.41	-0.14
WYMB004	208.59	215.96	-7.37

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Table 6.3: Steady state calibration statistics

Statistical Parameters	Value
Residual Mean	-6.53
Residual Standard Deviation	7.16
Absolute Residual Mean	8.46
Residual Sum of Squares	751
RMS Error	9.69
Minimum Residual	-15.92
Maximum Residual	7.74
Range of Observation	178.66
Scaled Residual Standard Deviation	0.04
Scaled Absolute Residual Mean	0.05
Scaled RMS	0.054
Number of Observations	8

Calibrated groundwater level contours from the model are shown in **Figure 6.7,** which shows that groundwater levels are elevated in areas of relatively higher topography and decrease in areas with lower elevations, flow is to the west then north west and the hydraulic gradient is steeper in the foot slopes and upper slopes. This aligns with the conceptual model and regional interpolated groundwater level contours (**Figure 3.8**).

The water balance for the steady state model is shown in **Table 6.4**.

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Table 6.4: Steady state water balance

Element	Inflow (kL/d)	Outflow (kL/d)
General head	0	681
Recharge	988	-
ET	-	307
Total	988	988
Percent error	0.04	

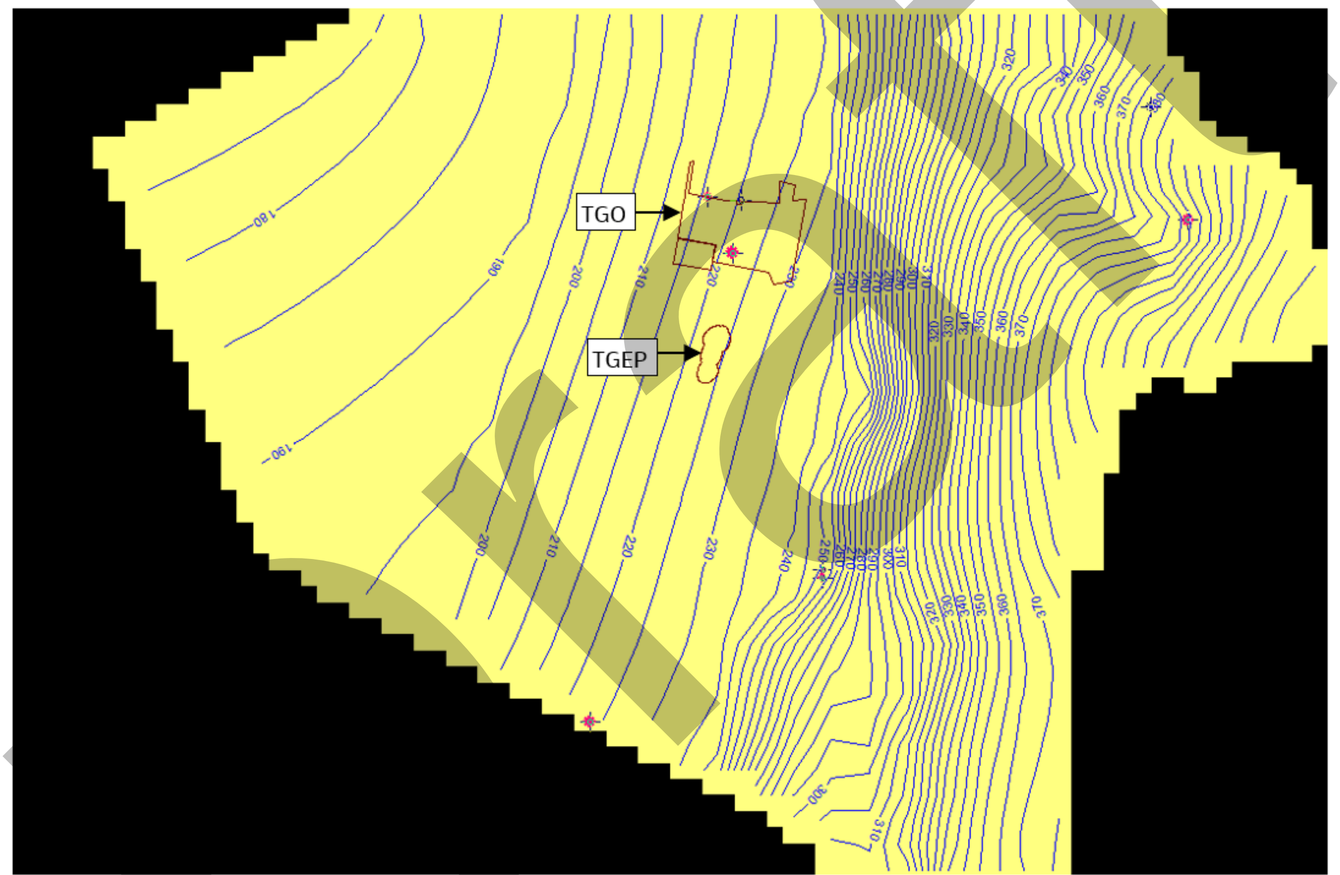

Figure 6.7: Steady state groundwater level contours (5 m interval)

6.6.2 Transient calibration

6.6.2.1 Approach

The transient calibration period comprised 170 monthly stress periods, commencing 01/03/2007 and ending 30/04/2021, with the first period configured as per the steady state model and run in steady state mode. Thus, the calibration period comprises an approximate 6.7 year period prior to commencement of mining and then an approximate 7.5 year period of TGO mining (pre strip at TGO commenced November 2013). The period of TGO mining includes open cut and underground mining.

Aside from the first steady state period, the monthly stress periods were assigned four timesteps.

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The recharge rate applied to the first stress period of the transient model was the same as the rate applied to the steady state model. For the rest of the transient model stress periods, the percentages of daily rainfall assigned as recharge for the zones in the calibrated transient model were the same as applied to the calibrated steady state model. Recharge rates were assigned based on SILO database.

Hydraulic conductivity zones and values applied in the steady state model were maintained in the transient model.

Storage parameters (specific yield and specific storage) were incorporated into the transient model and calibrated via an iterative step-wise process using manual adjustment within realistic ranges to achieve an acceptable match between simulated and observed heads.

DRN boundaries were introduced into the model to represent open cut and underground mining occurring at TGO during the calibration period.

Calibration target locations were as per the steady state model with the addition of:

- TGO monitoring bore, WYMB010 (no measurement is available for this location at the time of steady state model calibration), and TGEP monitoring bores, RWWB001, RWWB002 and RWB003. Groundwater level observations for these TGO/TGEP monitoring bores are included in **Figure 4.5** and **Figure 4.6**. It is noted that for RWB003, only the later groundwater levels were included as targets as groundwater levels measured shortly after bore construction were assumed to be still recovering.
- Groundwater inflow rate targets set as upper limits for the TGO open cuts and a water balance derived groundwater inflow rate for Wyoming 1 underground. The details of these inflow rate targets are discussed alongside results in **Section 6.6.2.4**.

6.6.2.2 Calibrated storage parameters

Specific yield and specific storage values of 7.5% and 1.3×10^{-7} m^{-1}, respectively, were applied to all model cells in the calibrated model.

The adopted specific storage value is the geometric mean of values estimated from rock strength data (**Section 4.5**). This value also aligns with literature values for 'tight' rock (**Section 4.5**).

The adopted specific yield value was largely derived by matching the mining induced drawdown trend at WYMB002, whilst ensuring minimal or no drawdown at other TGP monitoring bores, as WYMB002 is the only bore during the calibration period that is interpreted to be subjected to mining induced drawdown. The adopted value broadly accords with literature (Bair and Lahm, 2006) representative values for sandstone (6%) and siltstone (12%) but is somewhat higher than literature representative values for metamorphic rock (1%) and shale (2.5%). Trial model runs with a lower specific yield value resulted in overstated drawdown and therefore poor calibration.

6.6.2.3 DRN boundaries

A summary of the levels of the DRN boundaries used to simulate open cut and underground TGO mining is provided in **Figure 6.8**. The open cut DRN boundaries were assigned to cells based on the average of the area of the 220 mAHD pit contour (indicative pre mining water table level at TGO) and the area of the minimum pit contour. The underground (Wyoming 1) DRN boundary was applied to envelope the area of underground mining.

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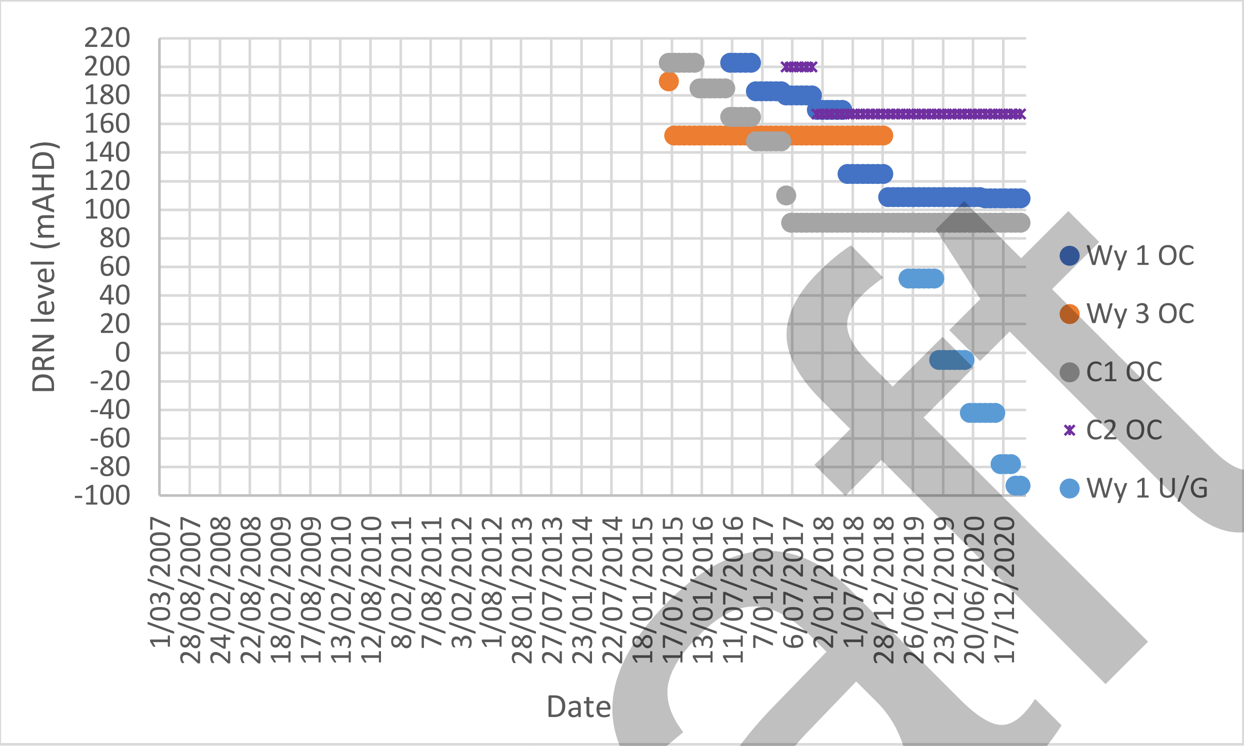

Figure 6.8: Calibration period DRN levels

6.6.2.4 Calibration results

Hydrographs – history matching

Hydrographs comparing observed and modelled heads for TGO and TGEP monitoring bores are shown in **Figure 6.9** and **Figure 6.10**, respectively. Modelled head trends match observed head trends reasonably well and the following is noted:

- The model simulates the mining induced drawdown trend at WYMB002 reasonably well.
- The model hydrographs do not show significant mining induced drawdown at bores other than WYMB002, which corresponds with observed conditions.
- Excepting two non-representative outliers at WYMB004 which are deemed to be likely erroneous data, aside from WYMB002, the model hydrographs show little temporal head variation. This model characteristic corresponds with observed conditions.

The model is generally over predicting heads. Excepting two non-representative outliers at WYMB004 (likely erroneous data points), at TGO bores the maximum error is 13.50 m, which occurs at WYMB010. At TGEP bores the error is larger and an average of about 17.40 m. The overestimation of head is conservative with regards to prediction of groundwater inflow rates.

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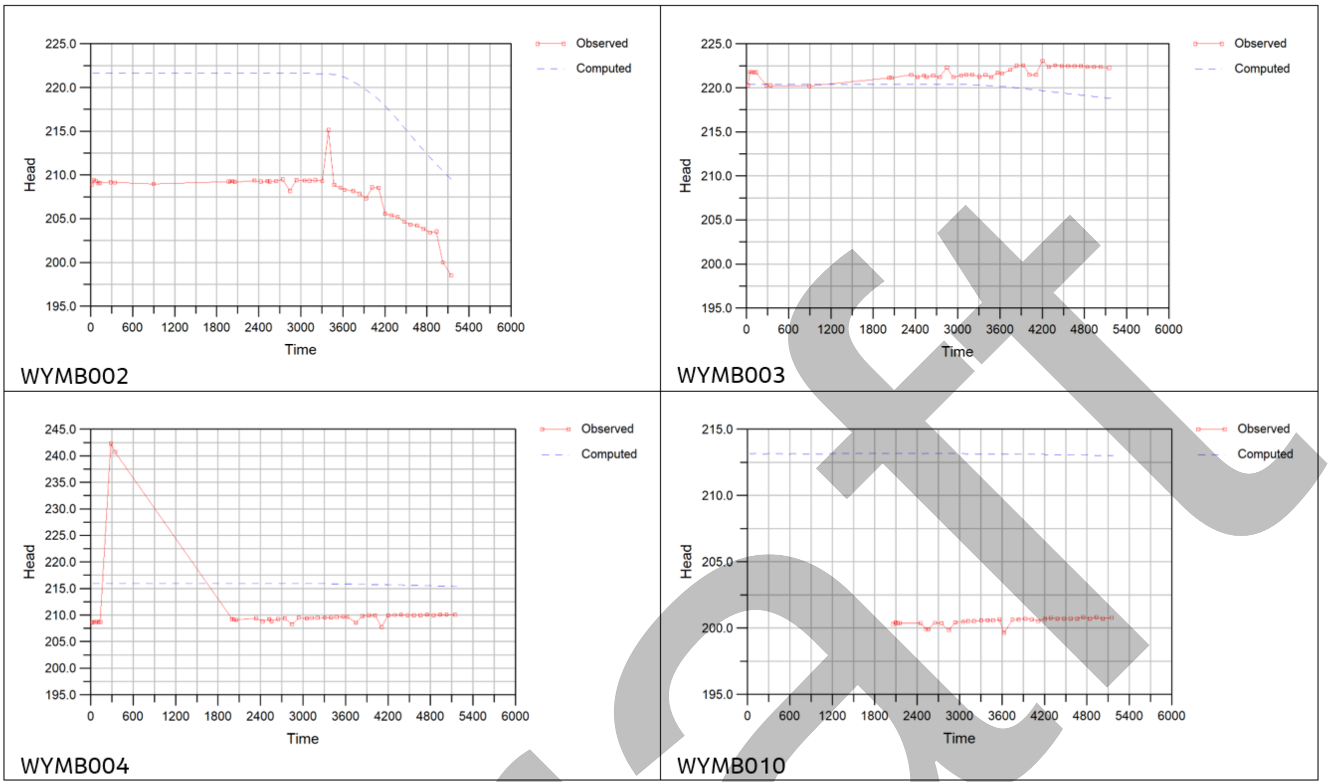

Figure 6.9: Calibration period hydrographs for TGO bores

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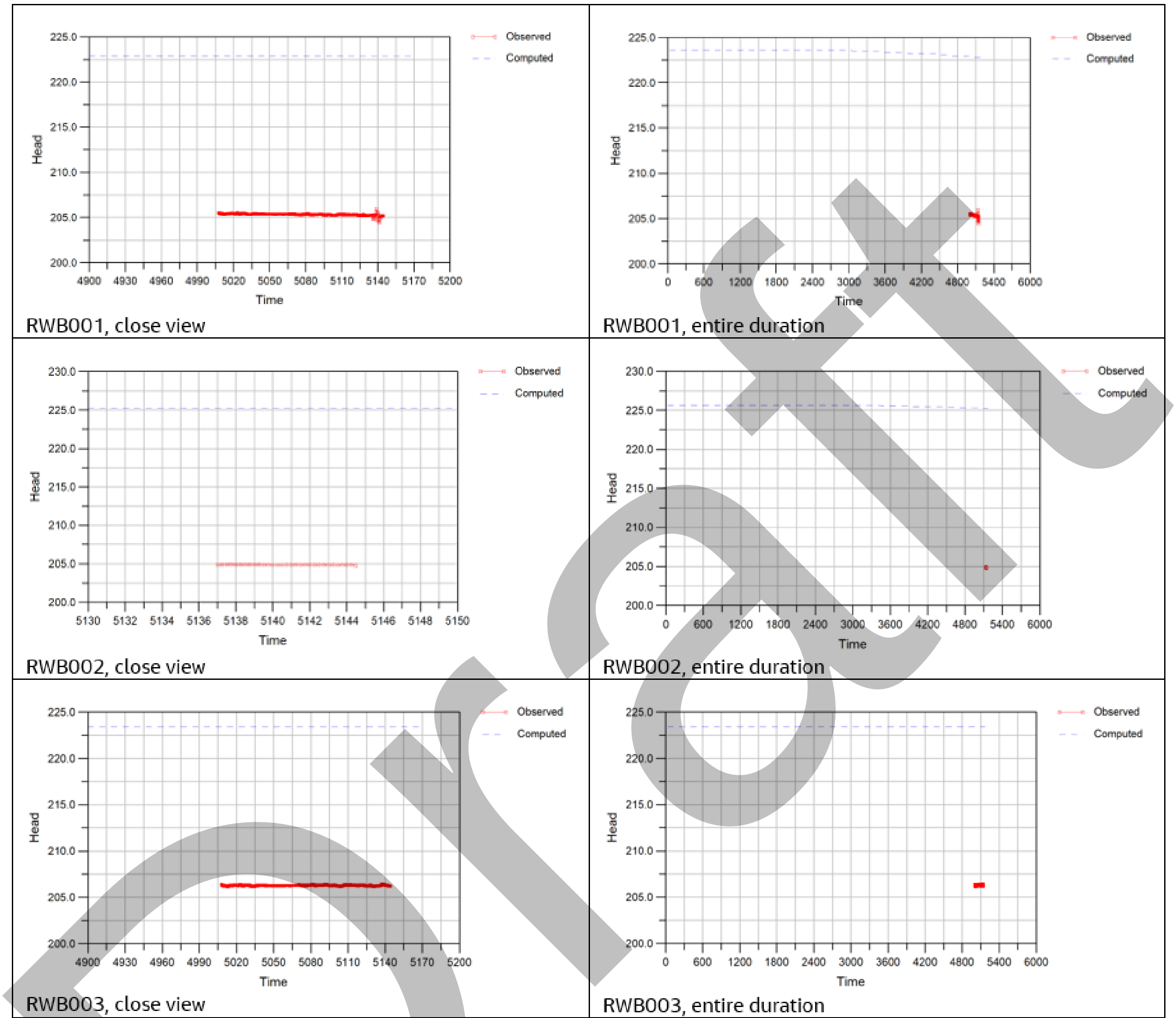

Figure 6.10: Calibration period hydrographs for TGEP bores

Mine Inflows – history matching

Historical inflows to mining operations have been insignificant for both open cuts and underground mining. No active dewatering of groundwater inflows from open cut operations has been undertaken and inflows have not been enough to be of nuisance or interrupt mining. Target inflow rates for calibration are therefore set as an upper limit, with total inflows not to exceed the potential areal evaporation from the pit. The potential areal evaporation was roughly approximated as the pit surface area multiplied by the local annual pan evaporation. As there is no pit lake to account for cooling, and the stilling effect and increased humidity in the pit would likely be countered by the heating of the pit walls, no pan factor was applied. It is noted that the assessment of potential evaporation assumes diffuse seepage over entire area below water table with no focussed inflows. Potential evaporation also assumes saturation at surface and, as such, is likely to be significantly higher than actual evaporation.

The Bureau of Meteorology website indicate that the average annual pan evaporation near TGEP is of the order of 1800 mm, or approximately 4.9 mm/day.

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A simple water balance undertaken for the Wyoming 1 open cut pit and underground (RW Corkery & Co, 2020) for the period 12 November 2019 to 4 February 2020, indicates that maximum potential inflows to the Wyoming 1 underground mine were of the order of 47 ML/yr (128.8 kL/day or 1.5 L/s). However, it was noted that the bulk of these inflows were thought to be due to recirculation from the Wyoming 1 open cut pit sump, located above the underground workings, with inflow noted to increase after rainfall. The Wyoming 1 open cut sump was included during the calibration period and the target upper inflow rate for Wyoming 1 underground mine was 1.5 L/s.

Groundwater inflow rate upper limits/targets and modelled groundwater inflows during transient calibration are presented in **Table 6.5.** From **Table 6.5** it is apparent that modelled mine inflows over the transient calibration period, for all cases except Wyoming 1 underground and Wyoming 3, are within the target criteria. The modelled Wyoming 1 underground inflow exceeds the criteria slightly (6.6%) at the end of stress period 153. The modelled inflow rate for Wyoming 3 exceeds the upper limit by 12.5%. The overstated modelled inflow at Wyoming 3 is interpreted to have occurred because the Wyoming 3 open cut is small relative to the model cells and the open cut is not modelled at a high level of detail. The area of DRN cells applied on Wyoming 3 (only three cells) to represent the area of the open cut below the water table is larger than in reality. Also, the DRN cells for Wyoming 3 do not taper inwards with depth. The overstated Wyoming 3 inflows are not considered problematic in the context of the model's objectives.

Table 6.5: Transient calibration - groundwater inflow targets (upper limit) vs modelled inflow

Pit / Underground	Surface area below water table[1] (m^2)	Potential Areal Evaporation[2,3] (L/s)	Water balance – seepage plus inflow (L/s)	Modelled inflow (L/s)
Wyoming 3	42,700	2.4	-	2.7 [6]
Wyoming 1	120,100	6.8	-	5.7 [5]
Caloma 1	127,600	7.2	-	6.0 [5]
Caloma 2	52,700	3.0	-	2.2 [5]
Wyoming 1 U/G		-	1.5	1.6 [4], 3.2 [5]

Note: [1] – approximated at 220 mAHD
[2] – based on average daily pan evaporation of 4.9 mm.
[3] – Assumes diffuse seepage over entire surface area below water table with no focussed inflows. Potential evaporation also assumes saturation at surface and, as such, is likely to be higher than actual evaporation.
[4] – At end of stress period 153.
[5] – At end of stress period 170, end of calibration period.
[6] – At end of stress period 143, last period before Wyoming 3 open cut DRN is made inactive to simulate recovery.

Statistics, mass balance and groundwater levels

A comparison of modelled groundwater levels and observed groundwater levels for all observations and only TGP monitoring bores is provided in **Figure 6.11** and **Figure 6.12**, respectively. Calibration statistics are provided in **Table 6.6** The figures and calibration statistics indicate the model is reasonably well calibrated to observed heads, particularly at WYMB004 and WYMB003. However, it is noted that the model is generally over predicting head. Excepting two non-representative outliers at WYMB004 (likely erroneous data points), at TGO bores the maximum error is 13.50 m, which occurs at WYMB010. At TGEP bores, the error is larger and an average of about 17.40 m.

The scaled RMS error was 8.8%, indicating the model is reasonably well calibrated to measured heads.

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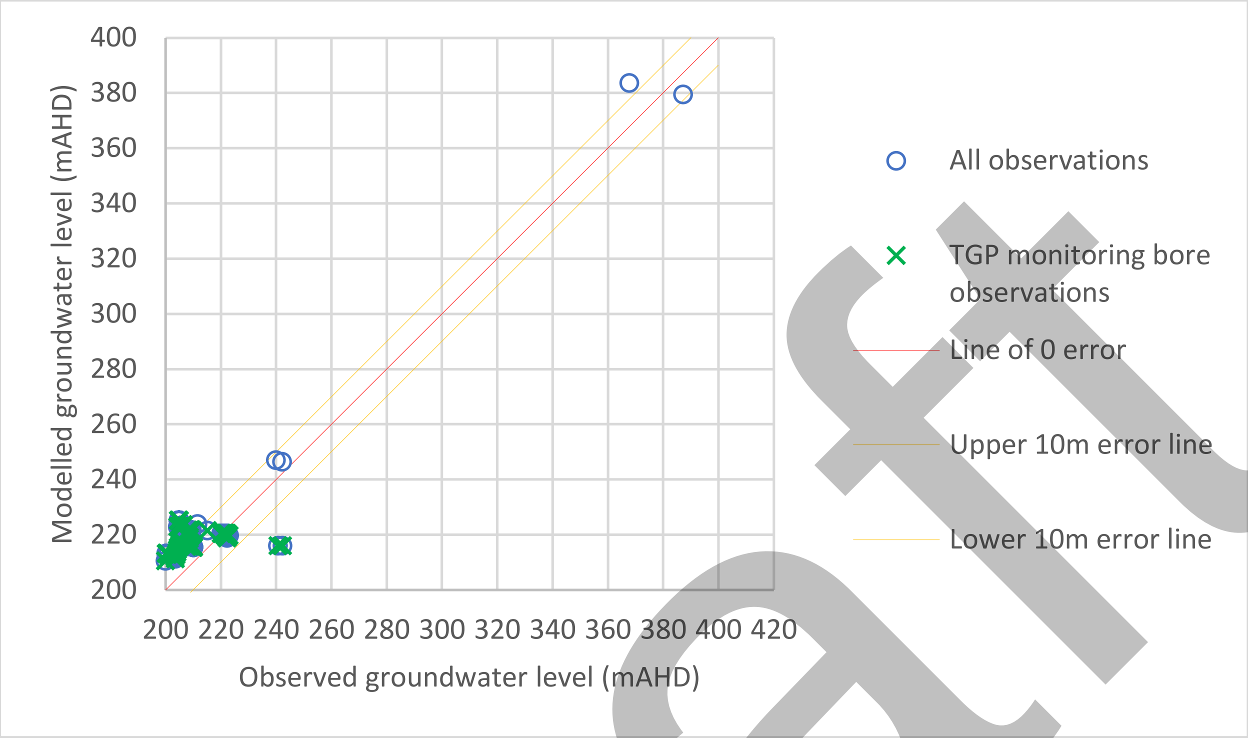

Figure 6.11: Transient calibration plot (all observations)

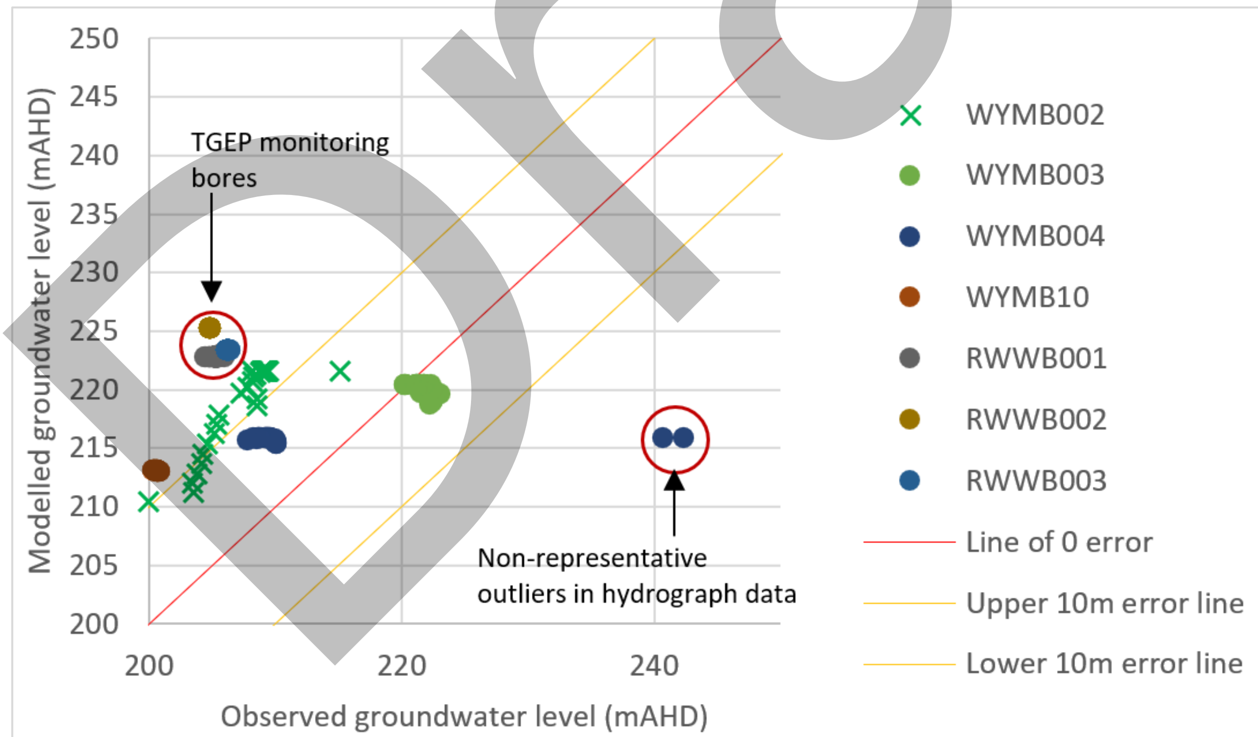

Figure 6.12: Transient calibration plot (TGP monitoring bore observations)

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Table 6.6: Transient calibration statistics

Statistical Parameters	Value
Residual Mean	-16.01
Residual Standard Deviation	4.39
Absolute Residual Mean	16.21
Residual Sum of Squares	356455
RMS Error	16.60
Minimum Residual	-20.46
Maximum Residual	26.37
Range of Observation	188.73
Scaled Residual Standard Deviation	0.02
Scaled Absolute Residual Mean	0.09
Scaled RMS	8.8%
Number of Observations	1294

The average water balance for the transient calibration model is shown in **Table 6.7** and was calculated based on the cumulative water balance divided by the number of days in the transient calibration period.

Groundwater level contours at the end of the transient calibration period are shown in **Figure 6.13**. The contours show mining induced groundwater level reduction, generally constrained to slightly beyond TGO. It is noted that the contours in **Figure 6.13** appropriately convey the groundwater level reduction areal extent at a broad scale but do not accurately convey the detailed groundwater level reduction in the vicinity of mining. This is due to the way the modelling software's contouring function works and its inability to represent closely spaced contours at zoomed out model views. A detailed view of the groundwater level contours in the vicinity of TGO is shown in **Figure 6.14**, which does convey the detailed groundwater level reduction in the vicinity of mining. As shown in **Figure 6.14**, the model predicts minimum groundwater levels at TGO to be 91 mAHD (Caloma 1), 108 mAHD (Wyoming 1), 167 mAHD (Caloma 2) and about 173 mAHD (Wyoming 3). Except for Wyoming 3, the minimum levels accord with the minimum DRN boundary levels applied over the open cuts. Prior to the end of the calibration period, Wyoming 3 DRN is made inactive to represent backfilling and allow groundwater levels to recover at this open cut.

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Table 6.7: Transient calibration model average water balance

Element	Inflow (kL/d)	Outflow (kL/d)
Storage	1,027	331
General head	0	681
Recharge	1,015	-
ET	-	308
Drain		721
Total	2,042	2,041
Percent error	0.02	

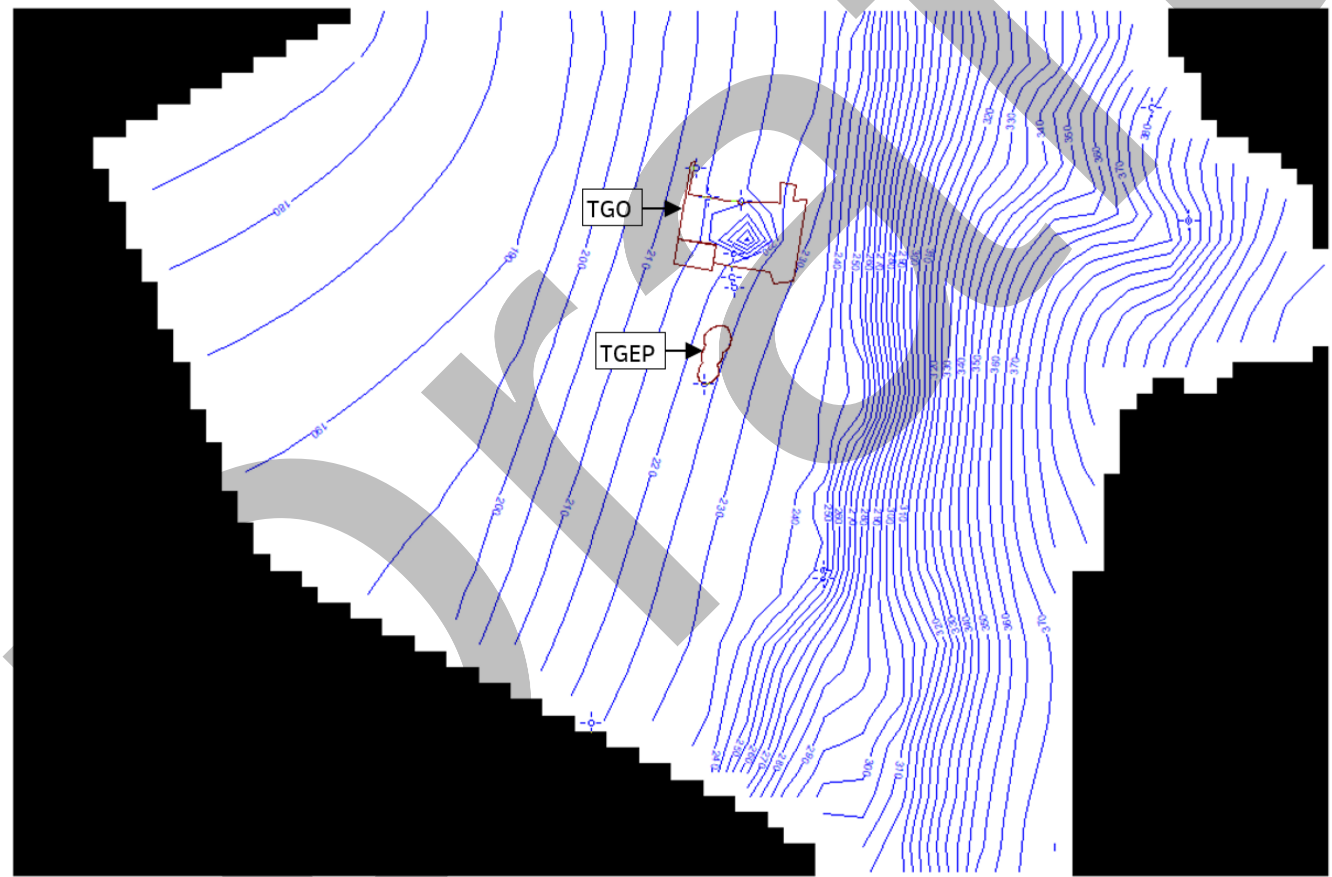

Figure 6.13: Groundwater level contours (5 m interval) at end of transient calibration period (note: closely spaced groundwater levels in vicinity of mining are not represented in the figure)

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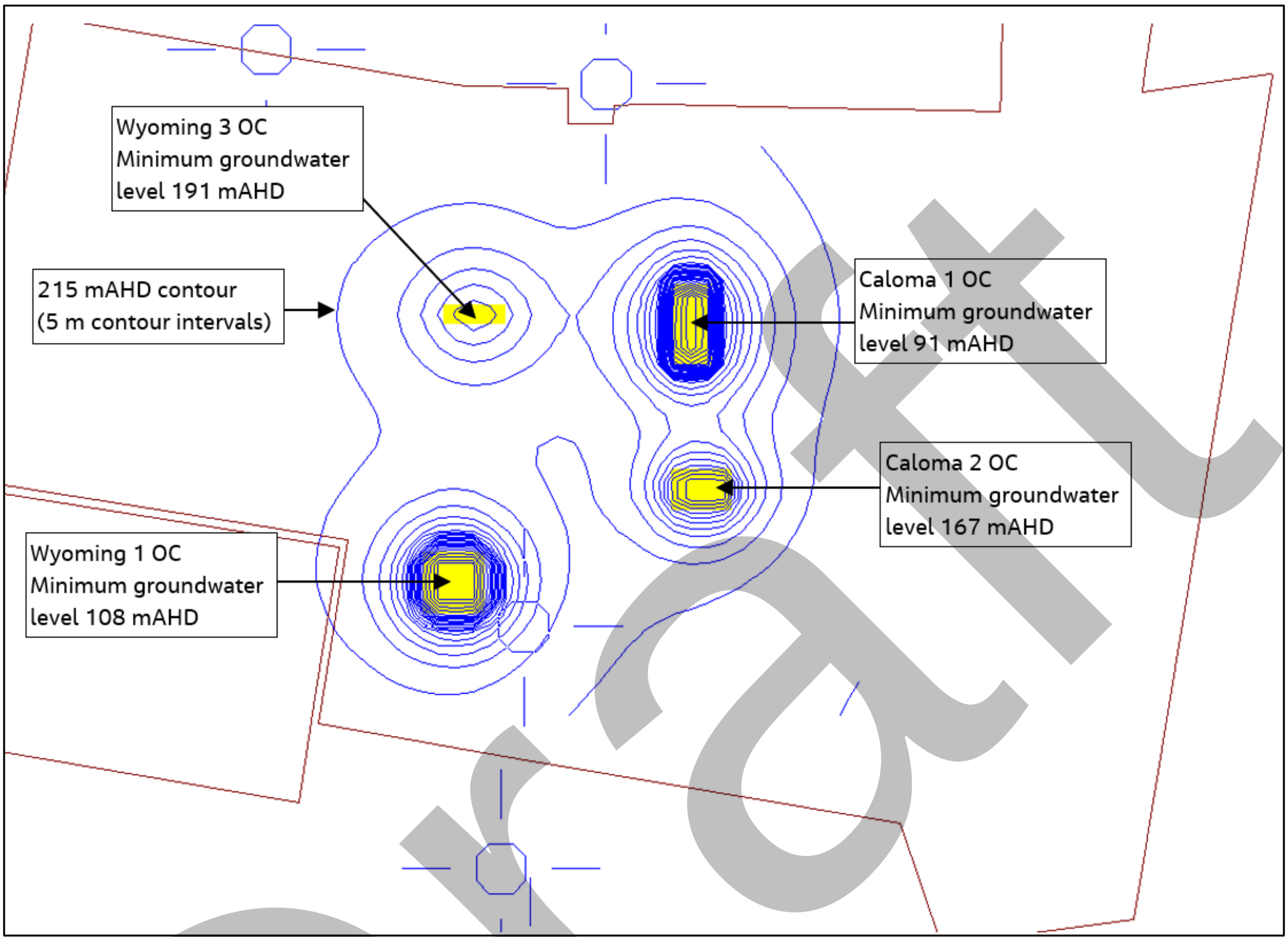

Figure 6.14: Detailed view of groundwater level contours (5 m interval) in vicinity of TGO at end of transient calibration period

Conclusion

Notwithstanding the model generally over predicting head, on balance, the model is considered sufficiently calibrated to achieve model objectives.

6.6.3 Sensitivity analysis

Sensitivity analysis is documented in Appendix D and indicates the model is relatively sensitive to hydraulic conductivity and recharge. The other parameters tested in the sensitivity analysis, EVT, specific storage, specific yield and Wyoming 1 underground DRN conductance were significantly less sensitive.

6.6.4 Final adopted parameters summary

Key final adopted model parameters are summarised in **Table 6.8**.

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Table 6.8: Key final adopted model parameter values

Parameter	Final adopted base case model value
Horizontal hydraulic conductivity (m/d) [1]	▪ Zone 1 – fractured rock west of Zone 2, 0.05 m/d ▪ Zone 2 – siltstone and shale, 0.01 m/d ▪ Zone 3 – fractured rock in area of mine, 0.01 m/d ▪ Zone 4 – siltstone and sandstone, 0.001 m/d ▪ Zone 5 – granite, 0.001 m/d ▪ Zone 6 – Dulladerry Rhyolite, 0.001 m/d ▪ Zone 7 – Hervey Group (shale, siltstone and sandstone), 0.001 m/d
Recharge rate as % of mean annual rainfall	Zone 1: 0.036 Zone 2: 0.177
Evaporation rate (mm/d)	3.93
Storage	Specific storage = 1.3×10^{-7} Specific yield = 0.075
DRN conductance for open cuts (m^2/d)	390,625
DRN conductance for Wyoming 1 (m^2/d)	0.025

Note: [1] Applied vertical hydraulic conductivity = 1/10 x horizontal hydraulic conductivity.

6.7 Prediction model configuration

6.7.1 Approach and time discretisation

The prediction model carried over from the transient calibration period and extended to the end of February 2031, to simulate future mining, then had a final 200 year post-mining period.

Aside from the 200 year post-mining period, time discretisation characteristics were maintained from the transient calibration period (i.e. monthly stress periods, four time steps, time step multiplier of 1.2).

The 200 year post-mining period was represented as a single stress period with four time steps, time step multiplier of 1.2.

The 200 year post-mining period is considered a suitably long planning horizon.

6.7.2 Recharge and ET

The recharge rates from the transient calibration period were maintained but applied to long-term monthly average rainfall for the mining simulation period. For the post-mining period, the recharge rate was applied to average long term rainfall.

The ET rate from the transient calibration period was maintained.

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6.7.3 DRN boundaries

Additional DRN boundaries were incorporated into the model to represent the deepening of Caloma 1 open cut and Wyoming 1 underground mine, underground mining at Caloma 1 and 2 and open cut/underground mining at TGEP.

Except for DRN boundaries associated with the northern portion of the TGEP open cut and the Wyoming 1 open cut, open cut DRN boundaries were made inactive from scheduled backfilling commencement dates provided by Alkane, to simulate potential groundwater level recovery. Underground DRN boundaries were made inactive at the end of scheduled mining for the given underground mines, to simulate potential groundwater level recovery.

DRN boundaries were left active for the northern portion of the TGEP open cut and Wyoming 1 open cut for the post-mining period, as these open cuts will not be backfilled. The levels for these DRNs were assigned based on equilibrium post-mining water levels determined using a spreadsheet water balance model which is documented in Appendix E. The TGEP open cut and Wyoming 1 open cut were assigned DRN levels in the post-mining period of 180 mAHD and 200 mAHD, respectively.

DRN boundary levels are shown for TGO and TGEP in **Figure 6.15** and **Figure 6.16**, respectively.

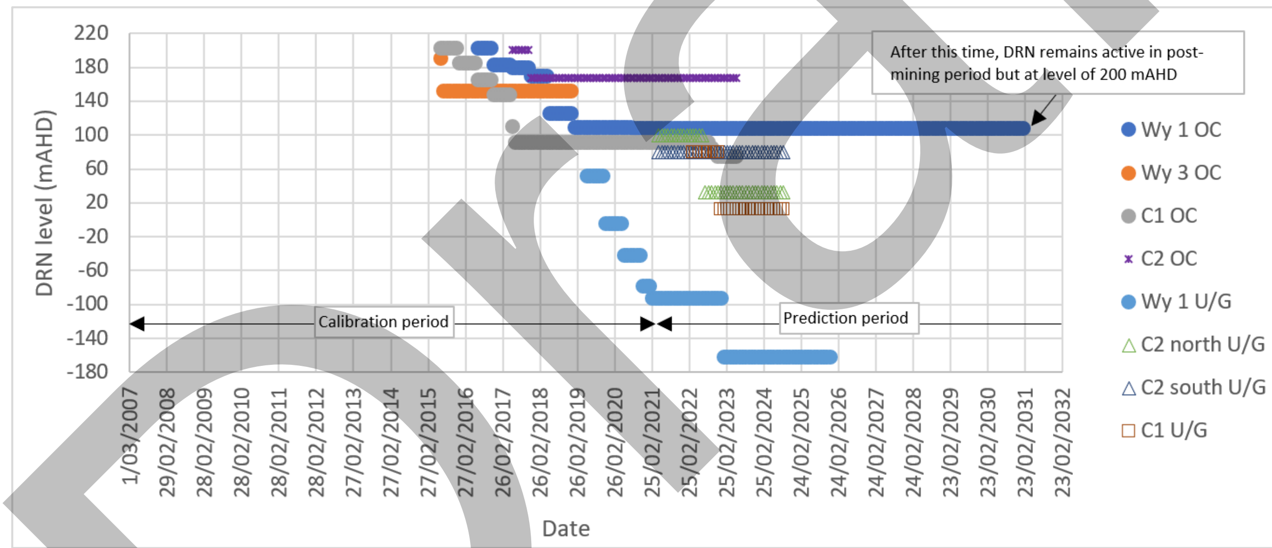

Figure 6.15: TGO DRN boundary levels

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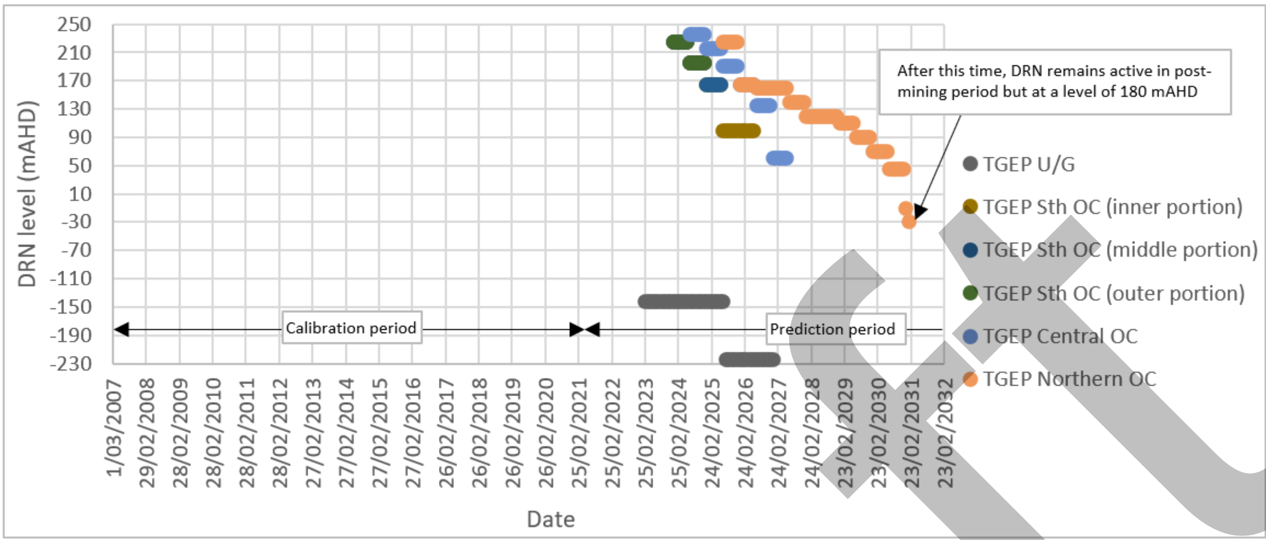

Figure 6.16: TGEP DRN boundary levels

6.8 Results

6.8.1 Inflows

The total drain flow rate at the end of each period for all the open cuts and underground drains is shown in **Figure 6.17** for the mining period. The post-mining total drain flow is not included in **Figure 6.17** because if included, the resolution is poor for the mining period due to the post-mining period being 200 years long. The total post-mining drain flow is about 0.21 ML/d, 0.31 ML/d, 0.31 ML/d and 0.30 ML/d about 37 years, 82 years, 136 years and 200 years after end of mining, respectively. The total post-mining drain flow increases between 37 years and 82 years after end of mining because the DRN level transitions from the minimum open cut levels in the second last model period to the open cut equilibrium water level for the final model period. Thus, as the head recovers higher, the DRN flow increases. In reality, the groundwater inflow rate is anticipated to decrease progressively during the post-mining period.

The total DRN flow rate during mining is typically in the range of 1.25 ML/d to 2.5 ML/d, with a maximum inflow rate of about 3.29 ML/d occurring in January 2027.

The individual DRN flow rates for TGO open cuts, TGO underground mines and TGEP open cut/underground are shown in **Figure 6.18**, **Figure 6.19** and **Figure 6.20**, respectively.

As shown in **Figure 6.20**, for proposed TGEP mining, the central open cut and the northern open cut have the highest rates, with inflow maximum rates of about 2 ML/d to 2.1 ML/d. Flow rates for the southern open cut and the underground mine are significantly less.

Maximum inflow rates for a given DRN level taper off quickly. For example, in the case of the TGEP central open cut, the maximum inflow rate of about 2 ML/d tapers to about 1.4 ML/d within six months.

Groundwater inflow rates which occur in reality are expected to be less than modelled as mining progression would be smoother than modelled. The sudden decreases in DRN levels causes an accompanying sudden increase in inflow rates.

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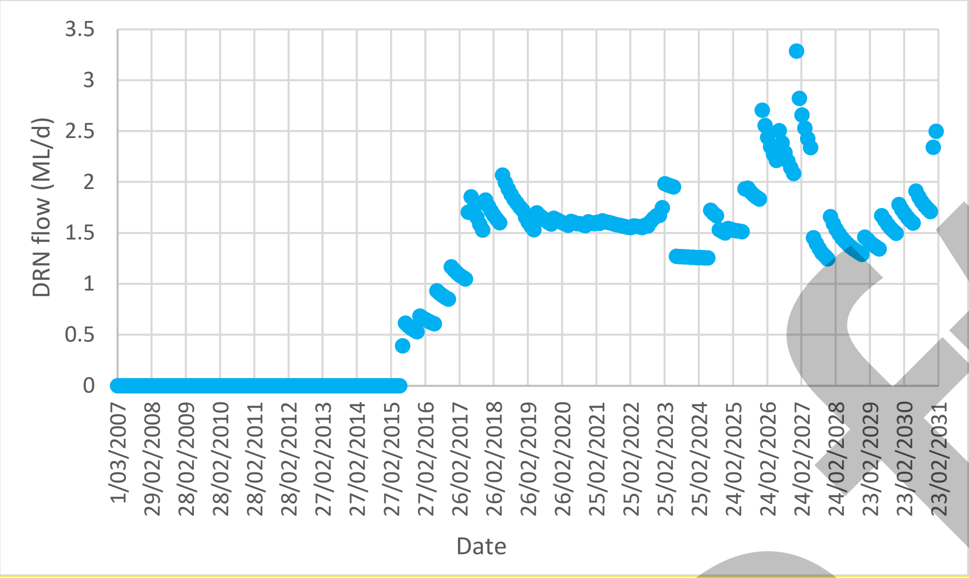

Figure 6.17: Total DRN flow rate (ML/d) during mining

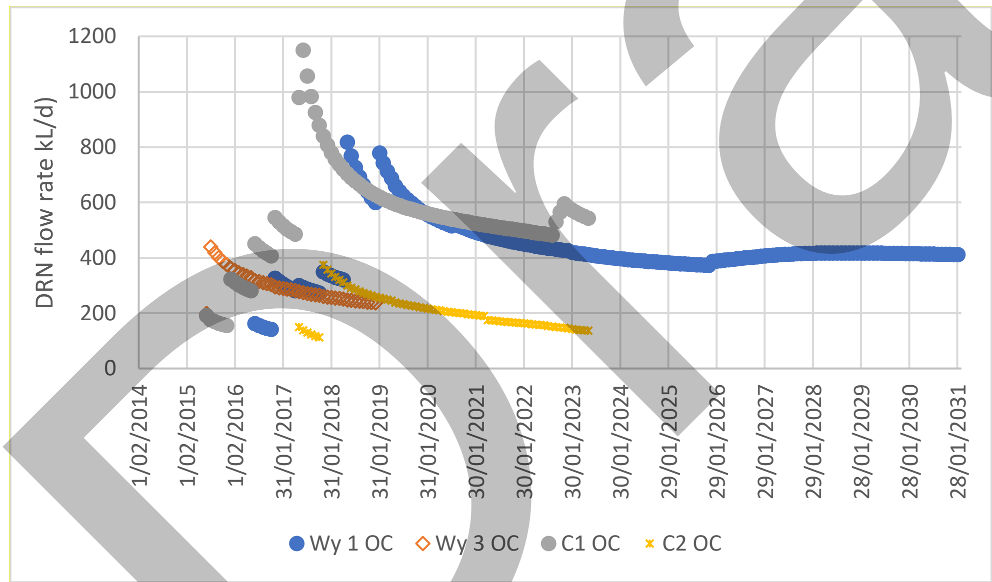

Figure 6.18: DRN flow rate (kL/d) during mining for TGO open cuts

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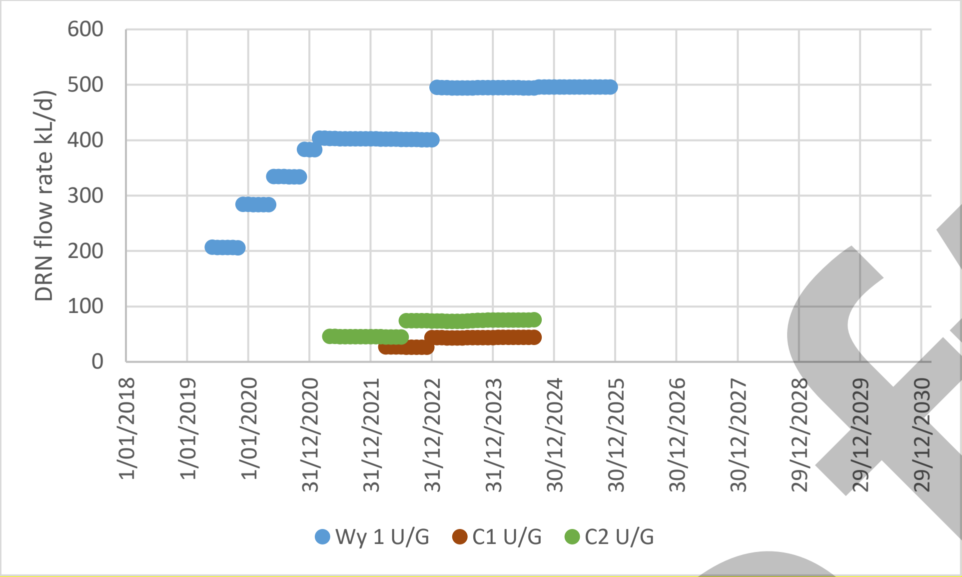

Figure 6.19: DRN flow rate (kL/d) during mining for TGO underground mines

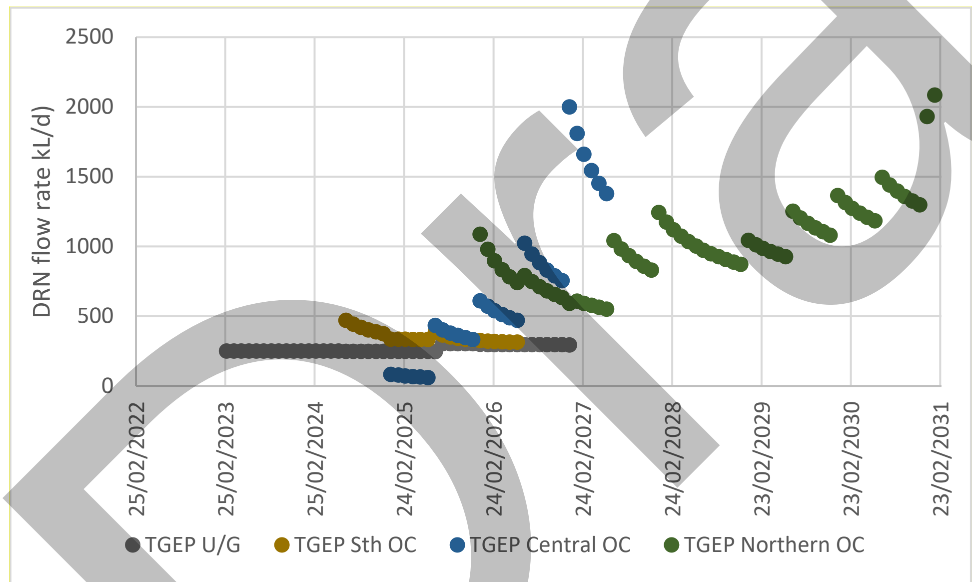

Figure 6.20: DRN flow rate (kL/d) during mining for TGEP open cuts and underground mine

6.8.2 Groundwater level drawdown

Drawdown at end of mining

Base case drawdown at the end of mining is shown in **Figure 6.21**.

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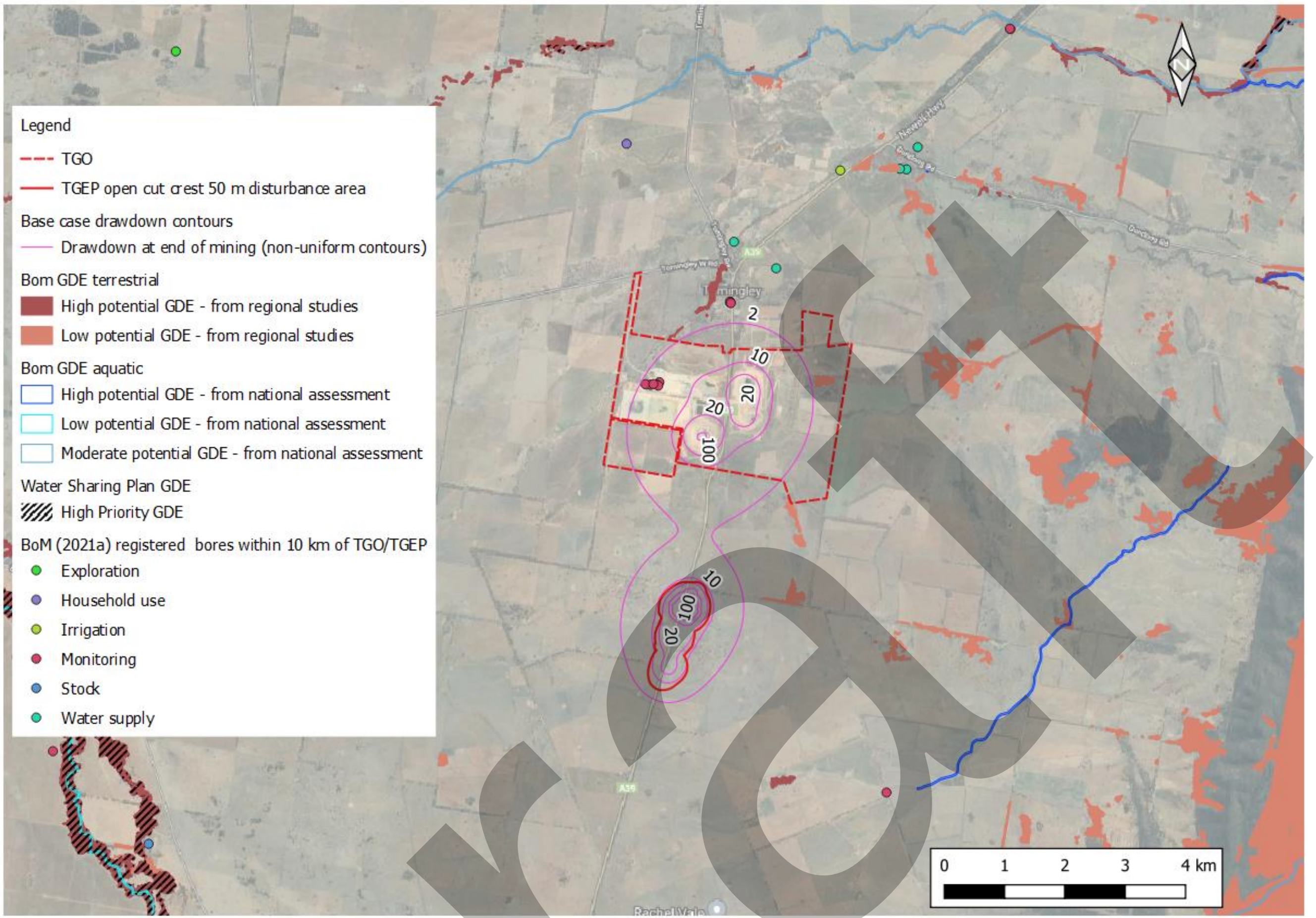

Figure 6.21: Base case drawdown contours (non-uniform) at end of mining

Post-mining period drawdown

Base case groundwater level drawdown approximately 200 years after end of mining is shown in **Figure 6.22.**

Wyoming 1 open cut and the northern portion of the TGEP open cut function as perpetual groundwater sinks because these pits are not proposed to be backfilled and post-mining water level recovery modelling (Appendix E) indicates equilibrium levels about 20 m to 25 m below the pre-mining regional water table level.

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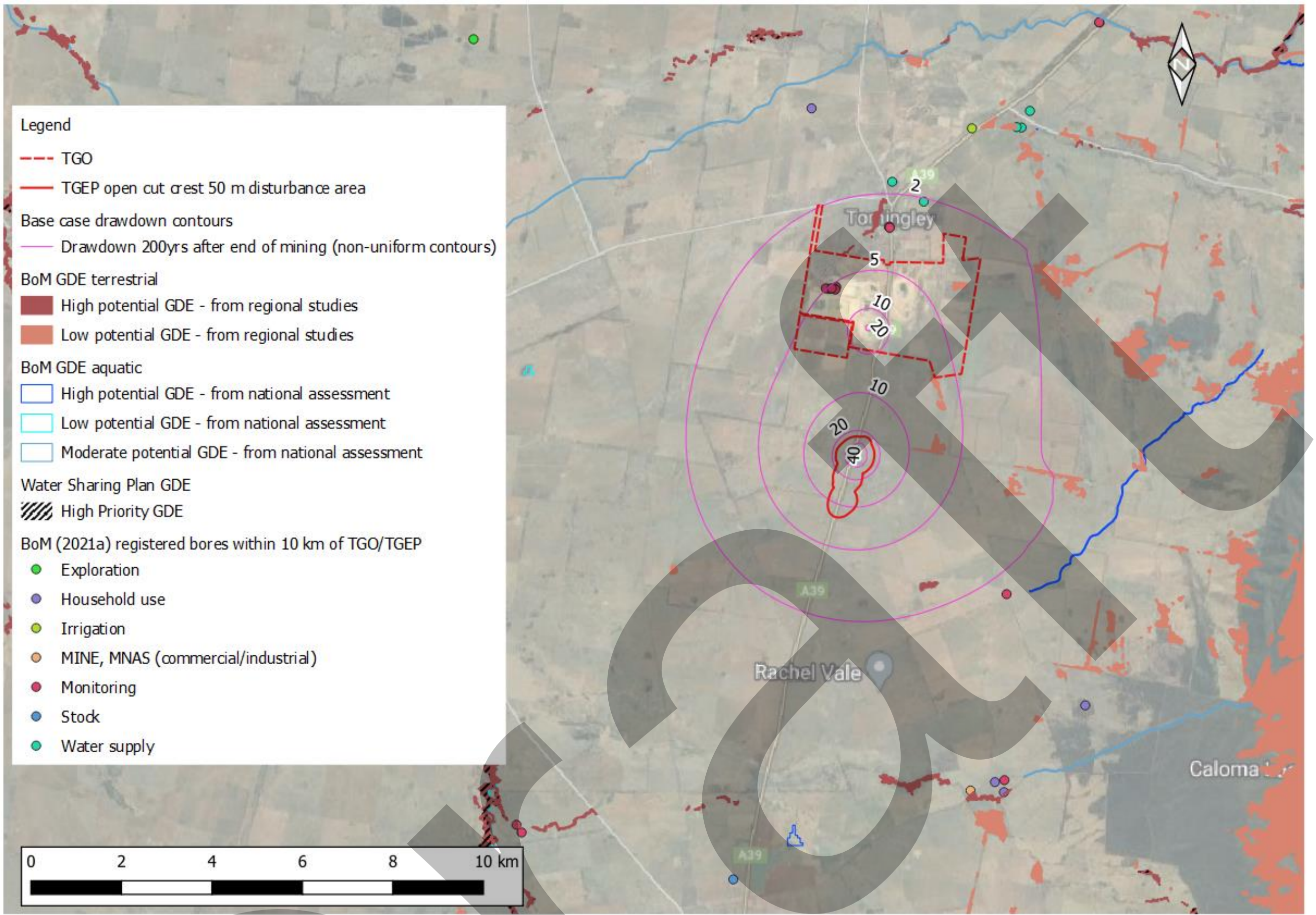

Figure 6.22: Base case drawdown contours (non-uniform) approximately 200 years after end of mining

6.8.3 Uncertainty Analysis

Uncertainty analysis was undertaken to assess the effect of varying model input parameter values on model predictions and is documented in Appendix D.

None of the uncertainty scenario results significantly alter the primary base case assessment findings relating to groundwater level drawdown impacts.

None of the uncertainty scenario results alter the primary base case assessment finding relating to groundwater inflow rates, which is that acquiring entitlement to cover the groundwater take is considered feasible due to the extent of predicted groundwater inflow rates, trading frequency in the applicable water source and percentage of unallocated water in the water source.

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7. Groundwater impact assessment

7.1 Groundwater level drawdown – registered bores

During mining and at the end of mining, the modelled 2 m drawdown contour does not encroach on any existing registered groundwater bores except for a cluster of TGO monitoring bores.

Approximately 200 years after the end of mining, the 2 m drawdown contour encroaches on the following bores in addition to the cluster of TGO monitoring bores:

- A cluster of five bores, north of TGO, all with a purpose of 'monitoring', bores GW803680, GW803679, GW803682, GW803681 and GW803678, where about 4.5 m of drawdown is predicted, and
- GW045137, with a purpose of 'water supply' located north of TGO.

The viability of all non-TGO monitoring bores inside the 2 m drawdown contour from the worst case scenario, drawdown 200 years after mining has ceased, are not anticipated to be impacted by mining. This is because all of the bores within the 2 m drawdown contour are shallow bores. GW045137 has a depth of 12 m and remaining bores have a depth of less than 6 m. These bores tap shallow perched alluvial groundwater systems disconnected from the fractured rock groundwater system that the mine will drawdown. As such, they are assessed as unlikely to be subjected to drawdown.

7.2 Groundwater level drawdown – GDEs

Despite modelled drawdown contours encroaching on areas mapped as potential GDE, GDEs are assessed as unlikely to be impacted by mining. These mapped potential GDEs, if actually associated with groundwater, are conceptualised to be associated with shallow perched alluvial groundwater systems that area disconnected from the fractured rock groundwater system that the mine will drawdown. As such, they are assessed as unlikely to be subjected to drawdown.

7.3 Baseflow reduction

Mining is assessed as unlikely to cause material reductions in baseflow to watercourses. The regional water table in the vicinity of TGO/TGEP is within fractured rock and relatively deep compared to watercourse bed levels. Mining induced groundwater level drawdown is not anticipated to drawdown groundwater levels in perched alluvial groundwater systems, which could at times provide baseflow to watercourses.

7.4 Water licensing

Annual groundwater entitlement is required from the Lachlan Fold Belt MDB Groundwater Source of the Water Sharing Plan for the NSW MDB Fractured Rock Groundwater Sources 2020 (NSW Government, 2020) to cover TGO/TGEP dewatering.

The average modelled groundwater inflow rate for the 18 month long period between 01/01/2026 and 01/06/2027, the period of modelled highest groundwater inflow rates is taken to inform assessment of licensing implications. The average inflow rate over this period is about 2.455 ML/d, which corresponds to a rate of 896 ML/yr. Thus, during the mining period, 676 ML/yr of entitlement (896 ML/yr - 220 ML/year = 676 ML/yr) in addition to the Mine's existing entitlement of 220 ML/year will be required.

Annualised total groundwater inflows during mining are shown in **Figure 7.1**. The flows are annualised by taking the average of the daily groundwater inflow rates that occur at the end of each monthly stress period in a calendar year and then multiplying by 365 days.

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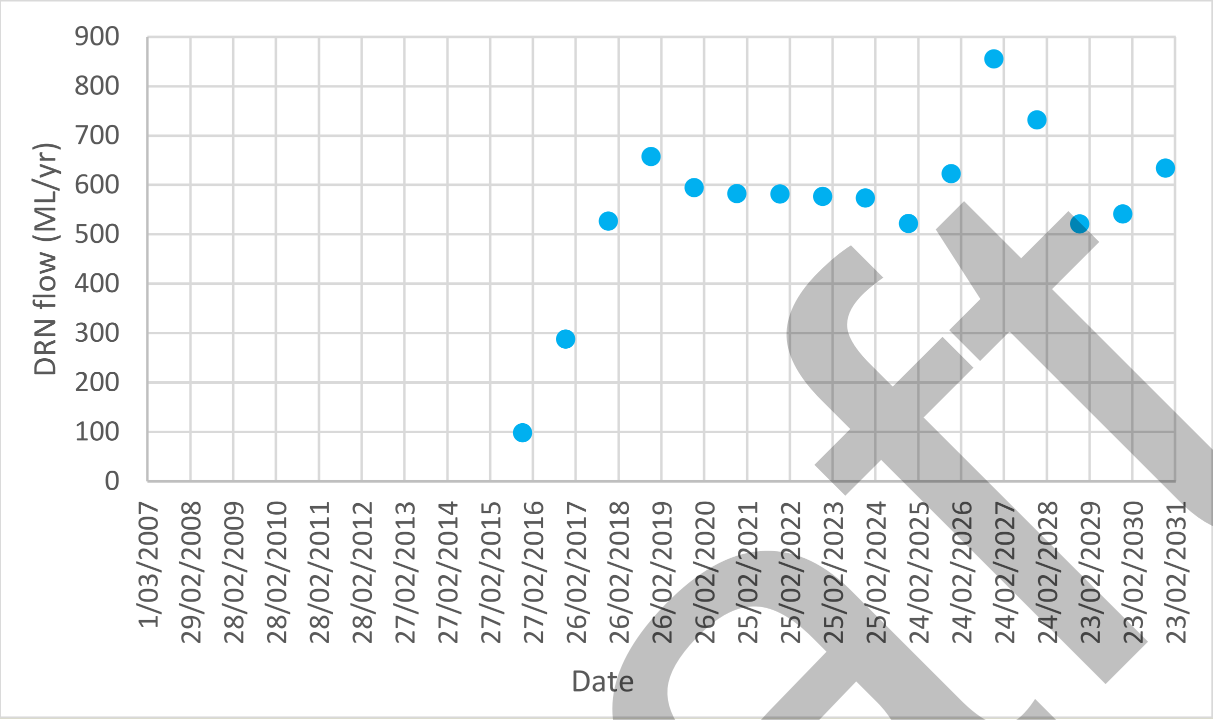

Figure 7.1: Annualised groundwater inflow during mining

Trading is common in the applicable groundwater source and about 70% of the groundwater in this water source is currently unassigned. Therefore, acquiring additional entitlement is considered feasible.

Annual groundwater entitlement will also be required to cover the perpetual groundwater take that will occur after mining has ceased. The modelled post-mining groundwater inflow is about 0.21 ML/d, 0.31 ML/d, 0.31 ML/d and 0.30 ML/d about 37 years, 82 years, 136 years and 200 years after end of mining, respectively. The rate from the final model period of 0.30 ML/d corresponds to a rate of 110 ML/yr. Thus, once near equilibrium conditions occur during the post mining period, 110 ML/year of entitlement will be required to cover the perpetual groundwater take. In the earlier stages of the post mining period, prior to equilibrium conditions occurring, the required entitlement would be higher and progressively decrease with time after mining ceases. Groundwater inflow rate observations, water balance modelling and groundwater modelling could be undertaken at the end of mining or in the very early stages of the post-mining period to estimate the progressively decreasing required entitlement to cover the groundwater take in the early post-mining period prior to equilibrium conditions occurring.

It is noted that the inflow rate is lowest for the time step about 37 years after mining due to the modelling method and groundwater levels in the GFM having not recovered fully in the vicinity of the open cuts at that time. In reality, the inflow rates in early time frames after mining has ceased will likely be relatively high and then progressively decrease with time and the water levels in the open cuts recover.

Acquiring sufficient entitlement to cover groundwater take after mining has ceased is considered feasible due to the trading frequency and percentage of unallocated water in the water source.

It is noted that whilst the model results are considered suitable to inform assessment of licensing implications and feasibility, there is uncertainty with the model results. Therefore, ongoing assessments during mining, including water balance assessments and/or groundwater modelling at a higher resolution with additional inflow rate calibration targets or successful verification of the current groundwater model, could be undertaken to attempt to reduce uncertainty and increase accuracy of required entitlement volumes.

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7.5 Groundwater quality

The Project is assessed as unlikely to lower the groundwater beneficial use category beyond a distance of 40 m of the Project Area, which is an AIP (DPI, 2012) Minimal Impact Consideration criterion.

Although considered low risk, groundwater could become contaminated if accidental spills or leaks of hazardous materials (such as fuels, lubricants and hydraulic oils) occur during extraction.

To date, Alkane have indicated the existing residue storage facility is performing satisfactorily. Drafting note: is this comment ok? There is a potential that increasing the approved Residue Storage Facility 2 capacity by increasing the elevation, will increase seepage. Groundwater quality could be reduced in the vicinity of the residue storage facilities due to seepage of poor quality water.

Potential contamination impacts are assessed as low risk and would be mitigated as discussed in **Section 8.1**.

Groundwater quality in relation to the final void and final void water quality is discussed in **Section 7.6**.

7.6 Final void

The two final voids are expected to behave as sinks, where evaporative loss from the voids will exceed surface water and groundwater inflow. The spreadsheet water balance modelling (Appendix E) developed to simulate water level recovery in the two final voids indicates equilibrium water levels for the TGEP open cut and Wyoming 1 open cut of 180 mAHD and 200 mAHD, respectively.

The majority of water level recovery for the TGEP open cut and Wyoming 1 open cut occurs by 81 years and 42 years after end of mining, respectively.

The final void equilibrium water levels for the TGEP open cut and Wyoming 1 open cut are about 25 m and 20 m below the pre-mining regional water table level. Thus, a perpetual groundwater sink is predicted.

To evaluate the predicted equilibrium levels, as a proxy for the future TGO/TGEP final void behaviour, current water levels, maximum open cut depths and surrounding natural ground levels were reviewed for the main open cut at nearby Peak Hill mine. Peak Hill mine is located about 10 km south of TGEP and the main open cut is comparable area and depth to the TGO Wyoming 1 open cut, in a similar geological setting. The most recent stint of mining at Peak Hill ceased in 2005 and the maximum open cut depth is about 100 m below natural ground levels (Alkane, 2021). The main open cut has limited catchment area. Thus, the open cut's characteristics are similar to the TGO Wyoming 1 open cut and therefore final void conditions at Peak Hill can be used to infer potential final void conditions at TGO/TGEP.

Spot heights of water level elevation within the Peak Hill main open cut are about 253 mAHD and natural ground levels surrounding the open cut range from about 305 mAHD to 336 mAHD. Standing water levels at the three closest registered bores to Peak Hill are approximately 212 mAHD (49 mBGL), 217 mAHD (48 mBGL) and 246 mAHD (35 mBGL) for bores GW802832, GW802833 and GW056594, respectively. The surface elevations of these bores are lower than the natural ground levels at Peak Hill. GW056594 has the closest surface elevation to Peak Hill but is about 24 m to 55 m lower. Cartoscope (2021) reports that the water in Peak Hill open cut is groundwater.

In light of the above, the water levels in the main Peak Hill open cut are interpreted to have come to an equilibrium level that is considerably higher than the minimum open cut level and likely to a level slightly below the regional water table level, due to evaporative loss. This aligns with the final void predicted equilibrium levels for TGEP/TGO.

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As a groundwater sink, the final void water chemistry will gradually degrade, with concentration of salts increasing due to ongoing evaporative loss from the void. Due to the low hydraulic conductivity of the rock mass and the water level in the open cut remaining lower than the regional fractured rock groundwater system water table level, poor quality water will remain within the vicinity of the void and is unlikely to migrate a significant distance from the voids. However, some migration and throughflow could occur.

The spreadsheet water balance modelling (Appendix E) developed to simulate water level recovery also predicted salt concentrations. Salt concentration predictions are as follows:

- TGEP
  - 80 years after end of mining – 16,137 mg/L
  - 200 years after end of mining – 21,916 mg/L
  - 300 years after end of mining – 29,967 mg/L
  - 500 years after end of mining – 46,071 mg/L
- Wyoming 1
  - 100 years after end of mining – 14,089 mg/L
  - 200 years after end of mining – 23,136 mg/L
  - 300 years after end of mining – 32,182 mg/L
  - 500 years after end of mining – 50,276 mg/L

The potentially poor groundwater quality is unlikely to lower the groundwater beneficial use category (industrial) beyond a distance of 40 m from the voids, which is an AIP (DPI, 2012) Minimal Impact Consideration criterion.

The viability of existing registered bores is assessed as unlikely to be impacted under this scenario due to significant separation distances from the open cuts. The nearest registered bores are located greater than 2 km from Wyoming 1 and greater than 4 km from TGEP. Water quality at these bores is unlikely to be impacted by mining.

Potential reduced water quality in the vicinity of the voids is assessed as unlikely to impact GDEs as the regional water table within the fractured rock groundwater system is disconnected from overlying perched alluvial groundwater systems in the vicinity of mining.

7.7 NSW AIP Minimal Impact Considerations Summary

Model predicted groundwater level reductions include some instances where the AIP (DPI, 2012) Minimal Impact Considerations (see **Section 2.3**) are exceeded. However, interpretation of the model results is such that the AIP (DPI, 2012) Minimal Impact Considerations are assessed as being unlikely to be exceeded.

Excluding TGO monitoring bores, a total of six existing registered bores are within the modelled 2 m drawdown contour at the end of the 200 year post-mining period, the worst case scenario. However, none of these bores are assessed as relevant to the modelled drawdown results.

The viability of all non-TGO monitoring bores inside the 2 m drawdown contour from the worst case scenario, drawdown 200 years after mining has ceased, are not anticipated to be impacted by mining. This is because all of the bores within the 2 m drawdown contour are shallow bores. GW045137 has a depth of 12 m and remaining bores have a depth of less than 6 m. These bores tap shallow perched alluvial groundwater systems disconnected from the fractured rock groundwater system that the mine will drawdown. As such, they are assessed as unlikely to be subjected to mining induced drawdown.

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TGO/TGEP is assessed as unlikely to lower the groundwater beneficial use category beyond a distance of 40 m from an activity, which is an AIP (DPI, 2012) Minimal Impact Consideration criterion.

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8. Management and mitigation measures

Management and mitigation measures applicable to groundwater are outlined below in **Sections 8.1**, **8.2** and **8.3**.

8.1 Potential contamination

If accidental spills or leaks occur, potential impacts would be minimised through the implementation of Alkane spill response procedures. These include training and standard practices for the control, containment, and clean-up of any hydrocarbon or chemical spill.

The Project's groundwater monitoring program (**Section 8.3**) would also be used to identify contamination attributable to mining.

8.2 Impacts at existing registered bores

Although not predicted, if unforeseen drawdown impacts occur at an existing registered bore due to mining, in accordance with the AIP (DPI, 2012) Minimal Impact Considerations, then make good previsions would apply. Under these conditions, the impacted bore could potentially be replaced with a deeper bore or bore in a new position.

8.3 Preliminary groundwater monitoring program

It is recommended that ongoing groundwater monitoring is completed during mining at the TGO and TGEP monitoring bores, and that requirements for monitoring after mining has ceased are determined based on assessment of conditions at the end of mining. Also, it is recommended that an up to date groundwater monitoring program is developed and approved following Project approval but prior to commencement of mining at TGEP. The current groundwater management plan (GHD, 2017) is provided in Appendix F and does not include proposed mining at TGEP, nor does it consider the results of the numerical groundwater modelling documented in this report.

The current groundwater management plan (GHD, 2017) is considered generally appropriate for ongoing application at TGO and implementation at TGEP, with the following changes:

- Groundwater level monitoring should be expanded to include TGEP monitoring bores, RWWB001, RWWB002, RWWB003 and RWB004. Groundwater level monitoring should be undertaken at these bores via data logger at a daily frequency. A dedicated barometric logger should be installed in one of the bores and used to enable barometric compensation of the data. If RWWB004 continues to remain dry, then a data logger is not required in this bore. However, groundwater level at RWB004 should still be monitored manually quarterly, to verify the bore is remaining dry on an ongoing basis.
- Groundwater quality monitoring should be expanded to include TGEP monitoring bores, RWWB001, RWWB002, RWWB003 and RWB004 (if not dry at time of sampling). The analysis suite should be the same as that specified in groundwater management plan (GHD, 2017) for the TGO fractured rock monitoring bores.
- The GHD (2017) GDCMB01groundwater level trigger level should be updated to be a groundwater depth of 2.4 m below top of casing or greater for two consecutive quarterly monitoring events.
- The TGO fractured rock monitoring bore groundwater level triggers should be removed. No specific trigger levels are considered necessary for these bores.
- A broad fractured rock groundwater level trigger level should be applied. The trigger should be a complaint from a surrounding landholder regarding groundwater level.

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- The groundwater quality trigger (GHD, 2017) on GDCMB01 should be removed. There is limited potential for mining to cause changes to groundwater quality at this bore.
- A broad fractured rock groundwater quality trigger level should be applied. The trigger should be a complaint from a surrounding landholder regarding groundwater quality.
- An assessment comparing the observed groundwater level drawdown at TGO fractured rock monitoring bores to the drawdown predicted at the end of mining should be made on an annual basis. At this time, comparisons should also be made between observed and modelled groundwater inflow rates. If the observed drawdowns or inflow rates deviate significantly from the model predictions, then an investigation should take place.

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9. Conclusion

A groundwater impact assessment has been undertaken to assess potential impacts to groundwater due to proposed additional or modified TGO operations, and the TGEP.

The groundwater impact assessment included:

- Review of relevant legislation, policy, guidelines and licencing requirements.
- Review of the TGO/TGEP environmental setting, including development of a conceptual hydrogeological model.
- Calculation of groundwater inflows to existing, approved and proposed open cuts and underground mines, and calculation of groundwater level drawdown, using an industry standard numerical groundwater flow model package - MODFLOW.
- Assessment of potential impacts to groundwater due to TGO/TGPEP.
- Development of groundwater related mitigation and management measures.

Interpretation of the groundwater flow model predictions are as follows:

- For TGO and TGEP combined, a total average groundwater inflow rate of 2.455 ML/d occurs for the 18 month long period between 01/01/2026 and 01/06/2017, the period with the highest modelled groundwater inflow rates. This average daily inflow rate corresponds to an annual rate of 896 ML.
- Perpetual groundwater take will occur after mining has ceased due to ongoing evaporative loss within two open cuts where backfilling is not proposed. The predicted total post-mining groundwater inflow rate is about 0.21 ML/d, 0.31 ML/d, 0.31 ML/d and 0.30 ML/d about 37 years, 82 years, 136 years and 200 years after end of mining, respectively. At earlier times, closer to the end of mining, the groundwater inflow rate would likely be higher.
- The modelled groundwater inflow rates do not account for evaporation after the groundwater is removed from the model by the model's numerical boundary used to simulate dewatering. For this reason, due to evaporation, the groundwater inflow rate perceived onsite may be considerably lower than the model results.
- At the end of mining, the modelled 2 m groundwater level drawdown contour extends up to about 1.5 km from a TGO open cut/underground mine and up to about 700 m from the TGEP open cut crest 50 m disturbance area.

  At the end of the 200 year post-mining period, the modelled 2 m groundwater level drawdown contour extends up to about 5 km from an approximate centre point placed between TGO and TGEP.
- GDEs are not anticipated to be impacted by TGO/TGEP.
- Baseflows to watercourses are not anticipated to be impacted by TGO/TGEP.
- Uncertainty analysis was undertaken to assess the effect of varying model input parameter values on model predictions.
  - None of the uncertainty scenario results significantly alter the primary base case assessment findings relating to groundwater level drawdown impacts.
  - None of the uncertainty scenario results alter the primary base case assessment finding relating to groundwater inflow rates, which is that acquiring entitlement to cover the groundwater take is considered feasible due to the extent of predicted groundwater inflow rates, trading frequency in the applicable water source and percentage of unallocated water in the water source.

Conclusions pertaining to groundwater quality are as follows:

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- Groundwater quality is assessed as unlikely to degrade to such point that the groundwater beneficial use category is lowered beyond a distance of 40 m from a TGO/TGEP activity. The salinity of the fractured rock groundwater system water in the vicinity of TGO/TGEP is high and the beneficial use category of the groundwater is limited to industrial use.
- Final void equilibrium water levels for TGEP and TGO are predicted to be 180 mAHD and 200 mAHD, respectively. Thus, a perpetual groundwater sink is predicted to form.
- The final void water chemistry is anticipated to gradually degrade, with concentration of salts increasing due to ongoing evaporative loss from the void. If the water level in the open cuts remains lower than the regional fractured rock groundwater system water table level, poor quality water will likely remain within the vicinity of the void and is unlikely to migrate a significant distance from the voids. However, some migration and throughflow could occur.
- To date, Alkane have indicated the existing residue storage facility is performing satisfactorily. There is a potential that increasing the approved Residue Storage Facility 2 capacity by increasing the elevation, will increase seepage. Groundwater quality could be reduced in the vicinity of the residue storage facilities due to seepage of poor quality water.
- Due to considerable horizontal and vertical separation distances, potential water quality reductions are assessed as unlikely to impact the viability of existing registered bores or potential GDEs.

Potential groundwater impacts due to TGO/TGEP were assessed against the NSW Aquifer Interference Policy's Minimal Impact Considerations. Aside from TGO monitoring bores, the modelled 2 m groundwater level drawdown contour encroaches on 6 existing registered bores at the end of the 200 year post-mining period, the worst case scenario. However, none of these bores are assessed as relevant to the modelled drawdown results. These bores tap shallow perched alluvial groundwater systems disconnected from the fractured rock groundwater system that the mine will drawdown. As such, they are assessed as unlikely to be subjected to mining induced drawdown. TGO/TGEP is assessed as unlikely to lower the groundwater beneficial use category beyond a distance of 40 m from an activity, which is an AIP (DPI, 2012) Minimal Impact Consideration criterion.

Annual groundwater entitlement is required from the Lachlan Fold Belt MDB Groundwater Source of the Water Sharing Plan for the NSW MDB Fractured Rock Groundwater Sources 2020 (NSW Government, 2020) to cover TGO/TGEP dewatering.

The average modelled groundwater inflow rate for the 18 month long period between 01/01/2026 and 01/06/2017, the period of modelled highest groundwater inflow rates is taken to inform assessment of licensing implications. The average inflow rate over this period was about 2.455 ML/d, which corresponds to a rate of 896 ML/yr. Thus, entitlement in addition to the Mine's existing entitlement of 220 ML/year will be required. Trading is common in the applicable groundwater source and about 70% of the groundwater in this water source is currently unassigned. Therefore, acquiring additional entitlement is considered feasible. Annual groundwater entitlement will also be required to cover the perpetual groundwater take that will occur after mining has ceased.

Management and mitigation measures are outlined in the report, including recommendations for ongoing groundwater monitoring.

The Project is considered to constitute a low risk to groundwater systems.

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Appendix A. Registered groundwater works

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Table A.1: Registered groundwater works within 10 km buffer to TGO/TGEP (source: BoM (2021a), and WaterNSW (2021b) for standing water level data)

Bore ID	Bore depth (m)	Drilled date	Purpose	Status	Standing water level depth (m)	Latitude	Longitude
GW012385	44.1	1/10/1959	Exploration	Unknown	7.3	-32.5332	148.1234
GW023198	48.8	1/01/1965	Stock and Domestic	Unknown	36.6	-32.6515	148.1201
GW028886	121.9	1/09/1967	Stock and Domestic	Unknown		-32.7001	148.1867
GW034897	1.8		Water Supply	Unknown		-32.5462	148.2031
GW037395	4.5		Irrigation	Unknown	2.1	-32.5498	148.2409
GW045134	18.3	1/06/1975	Water Supply	Proposed		-32.5607	148.2223
GW045135	3.7	1/06/1975	Water Supply	Proposed	0.9	-32.5496	148.2526
GW045136	5.2	1/06/1975	Water Supply	Proposed		-32.5462	148.2545
GW045137	12.2	1/06/1975	Water Supply	Proposed		-32.5646	148.2298
GW054594	61.6		Water Supply	Functioning		-32.6801	148.2481
GW066562	73	28/04/1990	Monitoring	Proposed		-32.6426	148.2504
GW068651	97	27/04/1990	Commercial and	Proposed		-32.6818	148.2424
GW800177	113.88	18/10/1995	Monitoring	Removed	1	-32.5284	148.2706
GW800178	80	19/10/1995	Monitoring	Removed		-32.5284	148.2706
GW801568	81	30/03/2002	Water Supply	Removed		-32.6646	148.2692
GW802834	77	25/05/1997	Monitoring	Proposed	42	-32.6797	148.2504
GW802842	83	7/08/1997	Water Supply	Functioning	44	-32.6821	148.2503
GW803148	5.8	31/05/2005	Water Supply	Functioning	4.4	-32.5495	148.2514
GW803678	4	12/07/2008	Monitoring	Functioning		-32.5698	148.2219
GW803679	4	12/07/2008	Monitoring	Functioning		-32.5697	148.2217
GW803680	4.5	12/07/2008	Monitoring	Functioning		-32.5696	148.2217
GW803681	3.5	14/07/2008	Monitoring	Functioning		-32.5698	148.2218
GW803682	3.5	14/07/2008	Monitoring	Functioning		-32.5697	148.2218

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GW804130	69	28/05/1998	Monitoring	Abandoned		-32.6328	148.1151
GW804132	61	26/05/1998	Monitoring	Abandoned		-32.6897	148.1355
GW804133	81	26/05/1998	Monitoring	Abandoned		-32.6912	148.1367
GW804136	84	29/05/1998	Monitoring	Abandoned		-32.6378	148.103
GW804137	64	11/06/1998	Monitoring	Removed		-32.5738	148.1033
GW8055261	11	29/06/2015	Monitoring	Functioning		-32.5821	148.2069
GW8055271	11	29/06/2015	Monitoring	Functioning		-32.5821	148.2078
GW8055281	11	30/06/2015	Monitoring	Functioning		-32.582	148.2084
GW8055291	12	30/06/2015	Monitoring	Functioning		-32.5821	148.2089
GW8055301	11	29/06/2015	Monitoring	Functioning		-32.5823	148.2092
GW8055311	11	30/06/2015	Monitoring	Functioning		-32.5817	148.2094

Notes: [1.] Monitoring bore at TGO.

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Appendix B. Groundwater quality results summary

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Metals

Location_Code	Sampled_Date_Time	Reactive Phosphate	Arsenic (Filtered)	Cadmium (Filtered)	Chromium (III+VI) (Filtered)	Copper (Filtered)	Iron (Filtered)	Lead (Filtered)	Magnesium (Filtered)	Manganese (Filtered)	Mercury (Filtered)	Nickel (Filtered)	Zinc (Filtered)
		mg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
EQL		0.01	1	0.1	1	1	0.05	1	1	1	0.1	1	5
ADWG 2018 Health			10	2		2000		10		500	1	20	
ADWG 2018 Aesthetic						1000	0.3			100			3000
ANZG (2018) Freshwater 95% toxicant DGVs				0.2[#3]		1.4[#3]		3.4[#4]		1900[#5]	0.6[#6]	11[#6]	8[#7]
NEPM 2013 Table 1C GILs, Fresh Waters				0.2[#9]		1.4[#9]		3.4[#9]		1900[#10]	0.06[#11]	11[#9]	8[#9]
ANZECC 2000 Irrigation Long-Term			100	10	100	200	0.2	2000		200	2	200	2000
RWWB001	12/10/2020	-	13	<0.1	<1	<1	0.06	<1	669	813	<0.1	19	<5
RWWB001	13/11/2020	-	-	-	-	-	-	-	-	-	-	-	-
RWWB001	13/11/2020	-	6	<0.1	<1	<1	2.74	<1	699	3590	<0.1	20	8
RWWB001	30/03/2021	-	-	-	-	-	-	-	-	-	-	-	-
RWWB001	30/03/2021	<0.01	2	<0.1	<1	<1	0.24	<1	743	3160	<0.1	5	<5
RWWB001	21/05/2021	-	-	-	-	-	-	-	-	-	-	-	-
RWWB001	21/05/2021	-	10	<0.1	<1	<1	5.26	<1	719	1590	<0.1	10	10
RWWB002	13/11/2020	-	-	-	-	-	-	-	-	-	-	-	-
RWWB002	13/11/2020	-	<1	<0.1	<1	4	0.73	<1	266	968	<0.1	2	32
RWWB002	30/03/2021	-	-	-	-	-	-	-	-	-	-	-	-
RWWB002	30/03/2021	<0.01	<1	<0.1	<1	<1	<0.05	<1	297	1190	<0.1	8	19
RWWB002	21/05/2021	-	-	-	-	-	-	-	-	-	-	-	-
RWWB002	21/05/2021	-	<1	<0.1	<1	<1	0.29	<1	280	1100	<0.1	4	8
RWWB003	13/11/2020	-	-	-	-	-	-	-	-	-	-	-	-
RWWB003	13/11/2020	-	<1	<0.1	<1	6	<0.05	<1	530	18	<0.1	6	23
RWWB003	30/03/2021	-	-	-	-	-	-	-	-	-	-	-	-
RWWB003	30/03/2021	0.18	<1	<0.1	<1	1	<0.05	<1	572	51	<0.1	78	<5
RWWB003	21/05/2021	-	-	-	-	-	-	-	-	-	-	-	-
RWWB003	21/05/2021	-	<1	0.1	1	6	<0.05	<1	547	62	<0.1	92	11

Inorganics

Location_Code	Sampled_Date_Time	Soluble Carbonate as CaCO3*	Alkalinity (Hydroxide) as CaCO3	Alkalinity (total) as CaCO3	Ammonia as N	Anions Total	Bicarbonate Alkalinity as CaCO3	Calcium (Filtered)	Cations Total	Chloride	Electrical conductivity (lab)	Fluoride	Ionic Balance	Kjeldahl Nitrogen Total	Nitrate & Nitrite (as N)	Nitrate (as N)	Nitrite (as N)	Nitrogen (Total)
		mg/L	mg/L	mg/L	mg/L	meq/L	mg/L	mg/L	meq/L	mg/L	uS/cm	mg/L	%	mg/L	mg/L	mg/L	mg/L	mg/L
EQL		1	1	1	0.01	0.01	1	1	0.01	1	1	0.1	0.01	0.1	0.01	0.01	0.01	0.1
ADWG 2018 Health												1.5				11.29[#1]	0.91[#2]	
ADWG 2018 Aesthetic										250								
ANZG (2018) Freshwater 95% toxicant DGVs					0.9[#8]													
NEPM 2013 Table 1C GILs, Fresh Waters																		[#12]
ANZECC 2000 Irrigation Long-Term												1						5
RWWB001	12/10/2020	<1	<1	600	0.2	308	600	483	278	8590	27,900	-	5.11	<0.5	0.09	0.09	<0.01	<0.5
RWWB001	13/11/2020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RWWB001	13/11/2020	<1	<1	707	0.36	300	707	450	287	8420	28,100	0.3	2.1	<0.5	0.02	0.02	<0.01	<0.5
RWWB001	30/03/2021	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RWWB001	30/03/2021	<1	<1	754	0.09	285	754	486	302	7810	27,200	0.3	2.98	<0.5	0.02	0.02	<0.01	<0.5
RWWB001	21/05/2021	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RWWB001	21/05/2021	<1	<1	645	0.25	282	645	451	296	7620	26,300	0.3	2.36	0.7	0.04	0.04	<0.01	0.7
RWWB002	13/11/2020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RWWB002	13/11/2020	<1	<1	130	0.32	192	130	1370	192	6340	19,800	0.6	0.09	0.5	0.01	0.01	<0.01	0.5
RWWB002	30/03/2021	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RWWB002	30/03/2021	<1	<1	158	0.23	183	158	1680	217	5970	19,300	0.5	8.45	<0.5	<0.01	<0.01	<0.01	<0.5
RWWB002	21/05/2021	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RWWB002	21/05/2021	<1	<1	151	0.16	183	151	1300	194	5900	18,500	0.5	2.99	<0.2	<0.01	<0.01	<0.01	<0.2
RWWB003	13/11/2020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RWWB003	13/11/2020	<1	<1	724	<0.1	179	724	224	181	5140	18,400	0.9	0.53	1.3	0.05	0.05	<0.01	1.4
RWWB003	30/03/2021	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RWWB003	30/03/2021	<1	<1	776	0.02	178	776	210	193	4760	17,100	0.9	3.83	<0.5	0.07	0.07	<0.01	<0.5
RWWB003	21/05/2021	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RWWB003	21/05/2021	<1	<1	759	<0.01	188	759	199	184	5070	17,200	0.8	1.06	1.4	0.05	0.05	<0.01	1.4

Statistical Summary

Statistic	Reactive Phosphate	Arsenic (Filtered)	Cadmium (Filtered)	Chromium (III+VI) (Filtered)	Copper (Filtered)	Iron (Filtered)	Lead (Filtered)	Magnesium (Filtered)	Manganese (Filtered)	Mercury (Filtered)	Nickel (Filtered)	Zinc (Filtered)
Number of Results	3	10	10	10	10	10	10	10	10	10	10	10
Number of Detects	1	4	1	1	4	6	0	10	10	0	10	7
Minimum Concentration	<0.01	<1	<0.1	<1	<1	<0.05	<1	266	18	<0.1	2	<5
Minimum Detect	0.18	2	0.1	1	1	0.06	ND	266	18	ND	2	8
Maximum Concentration	0.18	13	0.1	1	6	5.26	<1	743	3590	<0.1	92	32
Maximum Detect	0.18	13	0.1	1	6	5.26	ND	743	3590	ND	92	32
Average Concentration	0.063	3.4	0.055	0.55	2	0.94	0.5	532	1254	0.05	24	12
Median Concentration	0.005	0.5	0.05	0.5	0.5	0.15	0.5	559.5	1034	0.05	9	9
Standard Deviation	0.1	4.7	0.016	0.16	2.4	1.7	0	188	1243	0	33	9.9
Number of Guideline Exceedances	0	2	0	0	3	5	0	0	7	10	4	7
Number of Guideline Exceedances(Dete	0	2	0	0	3	5	0	0	7	0	4	7

Statistic	Soluble Carbonate as CaCO3*	Alkalinity (Hydroxide) as CaCO3	Alkalinity (total) as CaCO3	Ammonia as N	Anions Total	Bicarbonate Alkalinity as CaCO3	Calcium (Filtered)	Cations Total	Chloride	Electrical conductivity (lab)	Fluoride	Ionic Balance	Kjeldahl Nitrogen Total	Nitrate & Nitrite (as N)	Nitrate (as N)	Nitrite (as N)	Nitrogen (Total)
Number of Results	10	10	10	10	10	10	10	10	10	10	9	10	10	10	10	10	10
Number of Detects	0	0	10	8	10	10	10	10	10	10	9	10	4	8	8	0	4
Minimum Concentration	<1	<1	130	<0.01	178	130	199	181	4760	17100	0.3	0.09	<0.2	<0.01	<0.01	<0.01	<0.2
Minimum Detect	ND	ND	130	0.02	178	130	199	181	4760	17100	0.3	0.09	0.5	0.01	0.01	ND	0.5
Maximum Concentration	<1	<1	776	0.36	308	776	1680	302	8590	28100	0.9	8.45	1.4	0.09	0.09	<0.01	1.4
Maximum Detect	ND	ND	776	0.36	308	776	1680	302	8590	28100	0.9	8.45	1.4	0.09	0.09	ND	1.4
Average Concentration	0.5	0.5	540	0.17	228	540	685	232	6562	21980	0.57	3	0.53	0.036	0.036	0.005	0.54
Median Concentration	0.5	0.5	676	0.18	190	676	467	205.5	6155	19550	0.5	2.67	0.25	0.03	0.03	0.005	0.25
Standard Deviation	0	0	277	0.12	57	277	548	51	1437	4737	0.25	2.5	0.47	0.029	0.029	0	0.49
Number of Guideline Exceedances	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0
Number of Guideline Exceedances(Dete	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0

Env Stds Comments
#1:Converted from Nitrate as NO3 (50 mg/L)
#2:Converted from Nitrite as NO2 (3 mg/L)
#3:Very high reliability
#4:Moderate reliability
#5:Moderate reliability. DGV may not protect key test species from chronic toxicity (this refers to experimental chronic values or geometric mean for species). Check toxicant DGV technical brief for spread of data and its significance.
#6:Low reliability
#7:High reliability
#8:High reliability. Ammonia as total ammonia, measured as [NH3-N] at pH 8. DGV may not protect key test species from chronic toxicity (this refers to experimental chronic values or geometric mean for species).
#9:Values calculated using hardness of 30 mg/L CaCO3. Refer ANZECC & ARMCANZ (2000) for site specific hardness guidance
#10:Figure may not protect key species from chronic toxicity, refer to ANZECC & ARMCANZ (2000) for further guidance.
#11:Chemical for which possible bioaccumulation and secondary poisoning effects should be considered, refer to ANZECC & ARMCANZ (2000) for further guidance.
#12:refer to guideline

Environmental Standards
NHMRC, NRMMC, August 2018, ADWG 2018 Health
NHMRC, NRMMC, August 2018, ADWG 2018 Aesthetic
ANZECC, October 2000, ANZECC 2000 Irrigation Long-Term
NEPM, April 2013, NEPM 2013 Table 1C GILs, Fresh Waters

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								Field Parameters						Physiochemical parameters
		Potassium (Filtered)	Reactive Phosphorus as P	Sodium (Filtered)	Sulfate as SO4 - Turbidimetric (Filtered)	Total Dissolved Solids	TSS	DO (Field)	DO % (Field)	EC (field)	pH (Field)	Redox (Field)	Temp (Field)	pH (Lab)
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	%	uS/cm	pH Units	mV	oC	pH Units
EQL		1	0.01	1	1	10	5							0.01
ADWG 2018 Health														
ADWG 2018 Aesthetic				180		600					6.5-8.5|6.5-8.5			
ANZG (2018) Freshwater 95% toxicant D														
NEPM 2013 Table 1C GILs, Fresh Waters														
ANZECC 2000 Irrigation Long-Term														
Location_Code	Sampled_Date_Time													
RWWB001	12/10/2020	14	-	4560	2570	19,800	114	-	-	-	-	-	-	7.85
RWWB001	13/11/2020	-	-	-	-	-	-	2.79	35.4	25,600	6.58	24	27.7	-
RWWB001	13/11/2020	14	-	4760	2310	19,400	1710	-	-	-	-	-	-	6.85
RWWB001	30/03/2021	-	-	-	-	-	-	1.58	19.1	27,400	6.77	-104	27.7	-
RWWB001	30/03/2021	15	<0.01	4980	2380	18,700	26	-	-	-	-	-	-	7.02
RWWB001	21/05/2021	-	-	-	-	-	-	2.23	25.2	32,700	6.67	-29	22.6	-
RWWB001	21/05/2021	14	-	4910	2600	19,600	930	-	-	-	-	-	-	6.9
RWWB002	13/11/2020	-	-	-	-	-	-	2.31	28.4	18,400	6.72	159	26.3	-
RWWB002	13/11/2020	11	-	2330	518	16,400	71	-	-	-	-	-	-	6.96
RWWB002	30/03/2021	-	-	-	-	-	-	2.96	34.7	19,400	6.87	-92	27	-
RWWB002	30/03/2021	12	<0.01	2500	571	15,500	114	-	-	-	-	-	-	7.05
RWWB002	21/05/2021	-	-	-	-	-	-	1.91	22	22,320	6.63	-132	22.2	-
RWWB002	21/05/2021	10	-	2430	632	14,300	86	-	-	-	-	-	-	6.93
RWWB003	13/11/2020	-	-	-	-	-	-	5.66	69.3	17,800	6.97	184	25.8	-
RWWB003	13/11/2020	14	-	2890	937	12,400	4090	-	-	-	-	-	-	7.24
RWWB003	30/03/2021	-	-	-	-	-	-	5.23	64	17,800	6.94	176	26	-
RWWB003	30/03/2021	13	0.06	3100	1380	12,500	11,400	-	-	-	-	-	-	7.26
RWWB003	21/05/2021	-	-	-	-	-	-	4.77	55.1	22,320	6.86	123	22.2	-
RWWB003	21/05/2021	13	-	2950	1410	11,700	4610	-	-	-	-	-	-	7.13
Statistical Summary														
Number of Results		10	3	10	10	10	10	9	9	9	9	9	9	10
Number of Detects		10	1	10	10	10	10	9	9	9	9	9	9	10
Minimum Concentration		10	<0.01	2330	518	11700	26	1.58	19.1	17800	6.58	-132	22.2	6.85
Minimum Detect		10	0.06	2330	518	11700	26	1.58	19.1	17800	6.58	ND	22.2	6.85
Maximum Concentration		15	0.06	4980	2600	19800	11400	5.66	69.3	32700	6.97	184	27.7	7.85
Maximum Detect		15	0.06	4980	2600	19800	11400	5.66	69.3	32700	6.97	184	27.7	7.85
Average Concentration		13	0.023	3541	1531	16030	2315	3.3	39	22638	6.8	34	25	7.1
Median Concentration		13.5	0.005	3025	1395	15950	522	2.79	34.7	22320	6.77	24	26	7.035
Standard Deviation		1.6	0.032	1117	863	3219	3624	1.5	19	5101	0.14	129	2.3	0.29
Number of Guideline Exceedances		0	0	10	0	10	0	9	0	0	0	0	9	10
Number of Guideline Exceedances(Detec		0	0	10	0	10	0	9	0	0	0	0	9	10

Env Stds Comments
#1:Converted from Nitrate as NO3 (50 m
#2:Converted from Nitrite as NO2 (3 mg
#3:Very high reliability
#4:Moderate reliability
#5:Moderate reliability. DGV may not pr
#6:Low reliability
#7:High reliability
#8:High reliability. Ammonia as total am
#9:Values calculated using hardness of 3
#10:Figure may not protect key species f
#11:Chemical for which possible bioaccu
#12:refer to guideline

Environmental Standards
NHMRC, NRMMC, August 2018, ADWG 2
NHMRC, NRMMC, August 2018, ADWG 2
ANZECC, October 2000, ANZECC 2000 Ir
NEPM, April 2013, NEPM 2013 Table 1C

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			NA									
			Reactive Phosphate	Weak Acid Dissociable Cyanide	Arsenic	Arsenic (filtered)	Barium (filtered)	Beryllium (filtered)	Boron (filtered)	Cadmium	Cadmium (filtered)	Chromium (III+VI)
			mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
EQL			**0.01**	**0.004**	**1**	**1**	**1**	**1**	**50**	**0.1**	**0.1**	**1**
ADWG 2018 Health					10	10	2,000	60	4,000	2	2	
ADWG 2018 Aesthetic												
ANZECC 2000 Irrigation Long-Term					100	100		100	500	10	10	100
NEPM 2013 Table 1C GILs, Fresh Waters									370#4	0.2#5	0.2#5	
6.5 < pH (Field) (pH Units)												
6.5 < pH (Lab) (pH Units)												
ANZG (2018) Freshwater 95% toxicant DGVs									370#9	0.2#10	0.2#10	
6.5 < pH (Lab) (pH Units)												
Field ID	**Date**	**Lab Report Number**										
SP1	14/10/2019	ES1934009	-	<0.004	-	**8**	**138**	<1	**170**	-	<0.1	-
WCDP3	26/11/2020	ES2042144	-	<0.004	-	**1**	**25**	<1	630	-	<0.1	-
WCDP03	22/02/2021	ES2106358	-	<0.004	-	**3**	**33**	<1	800	-	<0.1	-
WCDP03	26/03/2021	ES2111408	-	<0.004	-	**2**	**30**	<1	670	-	<0.1	-
WCDP04	22/02/2021	ES2106358	-	<0.004	-	**3**	**22**	<1	890	-	<0.1	-
WCDP04	26/03/2021	ES2111408	-	<0.004	-	**3**	**20**	<1	700	-	<0.1	-
WYMB01(EPA9)	27/06/2019	ES1920314	<0.01	<0.004	**6**	-	-	-	-	**0.2**	-	<1
WYMB02(EPA10)	27/06/2019	ES1920314	**0.55**	<0.004	**2**	-	-	-	-	**0.1**	-	**3**
WYMB03(EPA11)	27/06/2019	ES1920314	**0.13**	<0.004	**2**	-	-	-	-	<0.1	-	**1**
WYMB04(EPA12)	27/06/2019	ES1920314	**0.09**	<0.004	**1**	-	-	-	-	<0.1	-	**5**
WYMB06(EPA13)	27/06/2019	ES1920314	**0.44**	**0.019**	**71**	-	-	-	-	**0.1**	-	**3**
WYMB10(EPA14)	27/06/2019	ES1920314	**0.42**	<0.004	<10#16	-	-	-	-	<1.0#16	-	<10#16

Comments

#1 Converted from Nitrate as NO3 (50 mg/L)
#2 Converted from Nitrite as NO2 (3 mg/L)
#3 pH>6.5
#4 Figure may not protect key species from chronic toxicity, refer to ANZECC & ARMCANZ (2000) for further guidance.
#5 Values calculated using hardness of 30 mg/L CaCO3. Refer ANZECC & ARMCANZ (2000) for site specific hardness guidance
#6 Chemical for which possible bioaccumulation and secondary poisoning effects should be considered, refer to ANZECC & ARMCANZ (2000) for further guidance.
#7 refer to guideline
#8 Moderate reliability
#9 High reliability. DGV may not protect key test species from chronic toxicity (this refers to experimental chronic values or geometric mean for species). Check toxicant DGV technical brief for spread of data and its signifi
#10 Very high reliability
#11 Moderate reliability. DGV may not protect key test species from chronic toxicity (this refers to experimental chronic values or geometric mean for species). Check toxicant DGV technical brief for spread of data and its
#12 Low reliability
#13 High reliability
#14 High reliability. Ammonia as total ammonia, measured as [NH3-N] at pH 8. DGV may not protect key test species from chronic toxicity (this refers to experimental chronic values or geometric mean for species).
#15 Result value is an approximate.
#16 Reported Analyte LOR is higher than Requested Analyte LOR

Environmental Standards

NHMRC, NRMMC, August 2018, ADWG 2018 Health
NHMRC, NRMMC, August 2018, ADWG 2018 Aesthetic
ANZECC, October 2000, ANZECC 2000 Irrigation Long-Term
NEPM, April 2013, NEPM 2013 Table 1C GILs, Fresh Waters

Draft

			Metals									
			Chromium (III+VI) (filtered)	Cobalt (filtered)	Copper	Copper (filtered)	Iron	Lead	Lead (filtered)	Magnesium (filtered)	Manganese (filtered)	Mercury
			µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L
EQL			**1**	**1**	**1**	**1**	**50**	**1**	**1**	**1**	**1**	**0.1**
ADWG 2018 Health					2,000	2,000		10	10		500	1
ADWG 2018 Aesthetic					1,000	1,000	300				100	
ANZECC 2000 Irrigation Long-Term			100	50	200	200	200	2,000	2,000		200	2
NEPM 2013 Table 1C GILs, Fresh Waters					1.4[#5]	1.4[#5]		3.4[#5]	3.4[#5]		1,900[#4]	0.06[#6]
6.5 < pH (Field) (pH Units)												
6.5 < pH (Lab) (pH Units)												
ANZG (2018) Freshwater 95% toxicant DGVs					1.4[#10]	1.4[#10]		3.4[#8]	3.4[#8]		1,900[#11]	0.6[#12]
6.5 < pH (Lab) (pH Units)												
Field ID	**Date**	**Lab Report Number**										
SP1	14/10/2019	ES1934009	<1	**2**	-	4	-	-	<1	**78**	**181**	-
WCDP3	26/11/2020	ES2042144	**22**	**2**	-	5	-	-	<1	**45**	**1**	-
WCDP03	22/02/2021	ES2106358	**16**	**2**	-	6	-	-	<1	**53**	**2**	-
WCDP03	26/03/2021	ES2111408	**14**	**2**	-	<1	-	-	<1	**57**	**2**	-
WCDP04	22/02/2021	ES2106358	**5**	**2**	-	6	-	-	<1	**64**	**2**	-
WCDP04	26/03/2021	ES2111408	**5**	**2**	-	2	-	-	<1	**63**	<1	-
WYMB01(EPA9)	27/06/2019	ES1920314	-	-	6	-	**1,020**	6	-	**257**	-	<0.1
WYMB02(EPA10)	27/06/2019	ES1920314	-	-	5	-	**750**	6	-	**464**	-	**0.2**
WYMB03(EPA11)	27/06/2019	ES1920314	-	-	6	-	**120**	10	-	**577**	-	<0.1
WYMB04(EPA12)	27/06/2019	ES1920314	-	-	19	-	**4,820**	4	-	**709**	-	<0.1
WYMB06(EPA13)	27/06/2019	ES1920314	-	-	14	-	**540**	13	-	**266**	-	<0.1
WYMB10(EPA14)	27/06/2019	ES1920314	-	-	<10[#16]	-	**830**	<10[#16]	-	**650**	-	<0.1

Comments

#1 Converted from Nitrate as NO3 (50 mg/L)
#2 Converted from Nitrite as NO2 (3 mg/L)
#3 pH>6.5
#4 Figure may not protect key species from chronic toxicity, refer to ANZECC & ARM
#5 Values calculated using hardness of 30 mg/L CaCO3. Refer ANZECC & ARMCANZ (
#6 Chemical for which possible bioaccumulation and secondary poisoning effects sh
#7 refer to guideline
#8 Moderate reliability
#9 High reliability. DGV may not protect key test species from chronic toxicity (this rcance.
#10 Very high reliability
#11 Moderate reliability. DGV may not protect key test species from chronic toxicitys significance.
#12 Low reliability
#13 High reliability
#14 High reliability. Ammonia as total ammonia, measured as [NH3-N] at pH 8. DGV
#15 Result value is an approximate.
#16 Reported Analyte LOR is higher than Requested Analyte LOR

Environmental Standards

NHMRC, NRMMC, August 2018, ADWG 2018 Health
NHMRC, NRMMC, August 2018, ADWG 2018 Aesthetic
ANZECC, October 2000, ANZECC 2000 Irrigation Long-Term
NEPM, April 2013, NEPM 2013 Table 1C GILs, Fresh Waters

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			Mercury (filtered)	Nickel	Nickel (filtered)	Selenium (filtered)	Vanadium (filtered)	Zinc	Zinc (filtered)	Soluble Carbonate as CaCO3*	Alkalinity (Hydroxide) as CaCO3	Alkalinity (total) as CaCO3
			µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mg/L	mg/L
EQL			**0.1**	**1**	**1**	**10**	**10**	**5**	**5**	**1**	**1**	**1**
ADWG 2018 Health			1	20	20	10						
ADWG 2018 Aesthetic								3,000	3,000			
ANZECC 2000 Irrigation Long-Term			2	200	200	20	100	2,000	2,000			
NEPM 2013 Table 1C GILs, Fresh Waters			0.06#6	11#5	11#5	5#6		8#5	8#5			
6.5 < pH (Field) (pH Units)												
6.5 < pH (Lab) (pH Units)												
ANZG (2018) Freshwater 95% toxicant DGVs			0.6#12	11#12	11#12	11#12		8#13	8#13			
6.5 < pH (Lab) (pH Units)												
Field ID	**Date**	**Lab Report Number**										
SP1	14/10/2019	ES1934009	<0.1	-	**3**	<10	<10	-	<5	<1	<1	**188**
WCDP3	26/11/2020	ES2042144	<0.1	-	<1	**20**	<10	-	**25**	<1	<1	**770**
WCDP03	22/02/2021	ES2106358	<0.1	-	**1**	**40**	<10	-	**14**	<1	<1	**714**
WCDP03	26/03/2021	ES2111408	<0.1	-	<1	**30**	<10	-	<5	<1	<1	**595**
WCDP04	22/02/2021	ES2106358	<0.1	-	**1**	**30**	**20**	-	**21**	<1	<1	**773**
WCDP04	26/03/2021	ES2111408	<0.1	-	<1	**30**	**20**	-	<5	<1	<1	**684**
WYMB01(EPA9)	27/06/2019	ES1920314	-	**3**	-	-	-	**32**	-	<1	<1	**333**
WYMB02(EPA10)	27/06/2019	ES1920314	-	**3**	-	-	-	**10**	-	<1	<1	**982**
WYMB03(EPA11)	27/06/2019	ES1920314	-	**3**	-	-	-	**19**	-	<1	<1	**1,120**
WYMB04(EPA12)	27/06/2019	ES1920314	-	**7**	-	-	-	**62**	-	<1	<1	**942**
WYMB06(EPA13)	27/06/2019	ES1920314	-	**20**	-	-	-	**111**	-	<1	<1	**1,070**
WYMB10(EPA14)	27/06/2019	ES1920314	-	<10#16	-	-	-	<52#16	-	<1	<1	**900**

Comments

#1 Converted from Nitrate as NO3 (50 mg/L)
#2 Converted from Nitrite as NO2 (3 mg/L)
#3 pH>6.5
#4 Figure may not protect key species from chronic toxicity, refer to ANZECC & ARM
#5 Values calculated using hardness of 30 mg/L CaCO3. Refer ANZECC & ARMCANZ (
#6 Chemical for which possible bioaccumulation and secondary poisoning effects sh
#7 refer to guideline
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#9 High reliability. DGV may not protect key test species from chronic toxicity (this re
#10 Very high reliability
#11 Moderate reliability. DGV may not protect key test species from chronic toxicity
#12 Low reliability
#13 High reliability
#14 High reliability. Ammonia as total ammonia, measured as [NH3-N] at pH 8. DGV
#15 Result value is an approximate.
#16 Reported Analyte LOR is higher than Requested Analyte LOR

Environmental Standards

NHMRC, NRMMC, August 2018, ADWG 2018 Health
NHMRC, NRMMC, August 2018, ADWG 2018 Aesthetic
ANZECC, October 2000, ANZECC 2000 Irrigation Long-Term
NEPM, April 2013, NEPM 2013 Table 1C GILs, Fresh Waters

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			Ammonia as N	Anions Total	Bicarbonate Alkalinity as CaCO3	Calcium (filtered)	Cations Total	Chloride	Cyanide (Free)	Cyanide Total	Electrical conductivity (lab)	Fluoride
			mg/L	meq/L	mg/L	mg/L	meq/L	mg/L	mg/L	mg/L	uS/cm	mg/L
EQL			**0.01**	**0.01**	**1**	**1**	**0.01**	**1**	**0.004**	**0.004**	**1**	**0.1**
ADWG 2018 Health										0.08		1.5
ADWG 2018 Aesthetic								250				
ANZECC 2000 Irrigation Long-Term												1
NEPM 2013 Table 1C GILs, Fresh Waters										0.007		
6.5 < pH (Field) (pH Units)												
6.5 < pH (Lab) (pH Units)												
ANZG (2018) Freshwater 95% toxicant DGVs			0.9[#14]									
6.5 < pH (Lab) (pH Units)												
Field ID	**Date**	**Lab Report Number**										
SP1	14/10/2019	ES1934009	**0.07**	**26.7**	**188**	**60**	**26.6**	**660**	<0.004	<0.004	**2,880**	**0.6**
WCDP3	26/11/2020	ES2042144	**0.02**	**58.7**	**770**	**12**	**54.1**	**1,200**	<0.004	<0.004	**5,850**	**1.0**
WCDP03	22/02/2021	ES2106358	<0.01	**59.1**	**714**	**14**	**60.2**	**1,140**	<0.004	<0.004	**5,920**	**1.3**
WCDP03	26/03/2021	ES2111408	**0.06**	**59.0**	**595**	**14**	**66.6**	**1,250**	<0.004	<0.004	**6,240**	**0.9**
WCDP04	22/02/2021	ES2106358	<0.01	**65.4**	**773**	**22**	**66.7**	**1,080**	<0.004	<0.004	**6,320**	**0.8**
WCDP04	26/03/2021	ES2111408	**0.01**	**60.8**	**684**	**23**	**70.6**	**1,120**	<0.004	<0.004	**6,410**	**0.8**
WYMB01(EPA9)	27/06/2019	ES1920314	**0.19**	**119**	**333**	**265**	**128**	**3,310**	<0.004	**0.012**	**12,900**	**0.2**
WYMB02(EPA10)	27/06/2019	ES1920314	<0.01	**230**	**982**	**148**	**253**	**5,820**	<0.004	<0.004	**22,600**	**0.6**
WYMB03(EPA11)	27/06/2019	ES1920314	**0.01**	**231**	**1,120**	**195**	**251**	**5,660**	<0.004	<0.004	**21,900**	**0.6**
WYMB04(EPA12)	27/06/2019	ES1920314	<0.01	**282**	**942**	**291**	**319**	**7,240**	<0.004	<0.004	**27,300**	**1.8**
WYMB06(EPA13)	27/06/2019	ES1920314	<0.01	**111**	**1,070**	**125**	**133**	**1,700**	**0.018**	**0.150**	**11,900**	**0.6**
WYMB10(EPA14)	27/06/2019	ES1920314	<0.01	**290**	**900**	**232**	**330**	**7,320**	<0.004	<0.004	**28,400**	**0.8**

Comments
#1 Converted from Nitrate as NO3 (50 mg/L)
#2 Converted from Nitrite as NO2 (3 mg/L)
#3 pH>6.5
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#5 Values calculated using hardness of 30 mg/L CaCO3. Refer ANZECC & ARMCANZ (
#6 Chemical for which possible bioaccumulation and secondary poisoning effects sh
#7 refer to guideline
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Environmental Standards
NHMRC, NRMMC, August 2018, ADWG 2018 Health
NHMRC, NRMMC, August 2018, ADWG 2018 Aesthetic
ANZECC, October 2000, ANZECC 2000 Irrigation Long-Term
NEPM, April 2013, NEPM 2013 Table 1C GILs, Fresh Waters

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Field ID	Date	Lab Report Number	Ionic Balance	Kjeldahl Nitrogen Total	Nitrate & Nitrite (as N)	Nitrate (as N)	Nitrite (as N)	Nitrogen (Total)	Phosphorus	Potassium (filtered)	Reactive Phosphorus as P	Sodium (filtered)
			Inorganics									
			%	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL			0.01	0.1	0.01	0.01	0.01	0.1	0.01	1	0.01	1
ADWG 2018 Health						11.29#1	0.91#2					
ADWG 2018 Aesthetic												180
ANZECC 2000 Irrigation Long-Term								5 #7	0.05 #7			
NEPM 2013 Table 1C GILs, Fresh Waters												
6.5 < pH (Field) (pH Units)												
6.5 < pH (Lab) (pH Units)												
ANZG (2018) Freshwater 95% toxicant DGVs												
6.5 < pH (Lab) (pH Units)												
SP1	14/10/2019	ES1934009	0.07	0.9	0.04	0.04	<0.01	0.9	0.10	8	<0.01	391
WCDP3	26/11/2020	ES2042144	4.10	2.2	9.82	9.81	0.01	12.0	0.06	9	<0.01	1,140
WCDP03	22/02/2021	ES2106358	0.90	2.2	13.4	13.4	<0.01	15.6	0.14	12	0.02	1,260
WCDP03	26/03/2021	ES2111408	6.05	2.0	13.5	13.5	<0.01	15.5	0.02	11	<0.01	1,400
WCDP04	22/02/2021	ES2106358	0.93	3.0	19.5	19.5	<0.01	22.5	0.08	11	0.04	1,380
WCDP04	26/03/2021	ES2111408	7.40	2.8	18.9	18.9	0.01	21.7	0.04	11	<0.01	1,470
WYMB01(EPA9)	27/06/2019	ES1920314	3.32	-	<0.01	<0.01	<0.01	-	-	6	<0.01	2,140
WYMB02(EPA10)	27/06/2019	ES1920314	4.82	-	0.62	0.62	<0.01	-	-	9	0.18	4,760
WYMB03(EPA11)	27/06/2019	ES1920314	4.15	-	0.37	0.37	<0.01	-	-	16	0.04	4,450
WYMB04(EPA12)	27/06/2019	ES1920314	6.11	-	0.08	0.08	<0.01	-	-	18	0.03	5,640
WYMB06(EPA13)	27/06/2019	ES1920314	8.72	-	0.54	0.54	<0.01	-	-	6	0.14	2,400
WYMB10(EPA14)	27/06/2019	ES1920314	6.49	-	0.43	0.43	<0.01	-	-	21	0.14	6,080

Comments

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NHMRC, NRMMC, August 2018, ADWG 2018 Health
NHMRC, NRMMC, August 2018, ADWG 2018 Aesthetic
ANZECC, October 2000, ANZECC 2000 Irrigation Long-Term
NEPM, April 2013, NEPM 2013 Table 1C GILs, Fresh Waters

Field ID	Date	Lab Report Number	Sodium Absorption Ratio (filtered)	Sulfate as SO4 - Turbidimetric (filtered)	Total Dissolved Solids	Hardness as CaCO3 (filtered)	TSS	Physiochemical parameters: pH (Lab)
			-	mg/L	mg/L	mg/L	mg/L	pH Units
EQL			**0.01**	**1**	**10**	**1**	**5**	**0.01**
ADWG 2018 Health								
ADWG 2018 Aesthetic					600	200		
ANZECC 2000 Irrigation Long-Term								
NEPM 2013 Table 1C GILs, Fresh Waters								
6.5 < pH (Field) (pH Units)								
6.5 < pH (Lab) (pH Units)								
ANZG (2018) Freshwater 95% toxicant DGVs								
6.5 < pH (Lab) (pH Units)								
SP1	14/10/2019	ES1934009	**7.84**	**206**	**1,660**	**471**	**100**	**8.09**
WCDP3	26/11/2020	ES2042144	**33.8**	**457**	**3,420**	**215**	**105**	**8.07**
WCDP03	22/02/2021	ES2106358	**34.4**	**609**	**3,730**	**253**	**100**	**7.95**
WCDP03	26/03/2021	ES2111408	**37.1**	**568**	**3,870**	**270**	**54**	**8.09**
WCDP04	22/02/2021	ES2106358	**33.6**	**938**	**4,140**	**318**	**85**	**7.85**
WCDP04	26/03/2021	ES2111408	**35.9**	**748**	**4,140**	**317**	**58**	**8.04**
WYMB01(EPA9)	27/06/2019	ES1920314	-	**931**	**6,480**	**1,720**	**7**	**7.47**
WYMB02(EPA10)	27/06/2019	ES1920314	-	**2,200**	**14,500**	**2,280**	**33**	**7.51**
WYMB03(EPA11)	27/06/2019	ES1920314	-	**2,360**	**14,600**	**2,860**	<5	**7.41**
WYMB04(EPA12)	27/06/2019	ES1920314	-	**2,830**	**19,300**	**3,650**	**497**	**7.49**
WYMB06(EPA13)	27/06/2019	ES1920314	-	**2,020**	**6,620**	**1,410**	**25**	**7.85**
WYMB10(EPA14)	27/06/2019	ES1920314	-	**3,140**	**19,500**	**3,260**	**23**	**7.47**

Comments
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#2 Converted from Nitrite as NO2 (3 mg/L)
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NHMRC, NRMMC, August 2018, ADWG 2018 Aesthetic
ANZECC, October 2000, ANZECC 2000 Irrigation Long-Term
NEPM, April 2013, NEPM 2013 Table 1C GILs, Fresh Waters

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Appendix C. Hydraulic testing

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Packer Test Data Sheet

Project:	Tomingley			**Project No.:**	TGEP		
Hole No:	RWRC352D	**Test No:**		Date:	21-Sep-20	Operator:	
Collar RL:	268.04	Location:	Easting (m) / Northing (m)	614145 / 6390680		Azimuth:	270

			Value	Notes
a	Declination (°):		60	
b	Depth pit base below hole collar (m)		0	For use when test sections are below pit. (Default = 0).
c	Depth to water below datum (m)	-declined	83.7	Dipper level.
d		-vertical	72.5	c.sin a
e	Height of gauge above datum (m)		1.0	
f	Depth to water below gauge (m)		73.5	d+e
g	Gauge height pressure (Kpa)		735	10f
h	Depth to top of test section (m)	-declined	400	Drill rod depth + 1.03 m
j		-vertical	346.4	h.sin a
k	Length of test section(m)		119	
m	Adopted rock density (specific gravity)		2.6	
n	Geostatic pressure on test section (KPa)		6267	[(j-d).(m-1.0)+(d-b).m].10 [b</=d]
			0	(j-b).(m-1.0).10 [For when b>d only]
p	Hydrostatic pressure on test section (Kpa)		2739	(j-d).10
q	Maximum allowable total test pressure (KPa)		5014	0.8n
r	Maximum allowable gauge test pressure (KPa)		4279	q-g
s	**Target maximum gauge test pressure (KPa)**		**1200**	should be </=1500
t	Target maximum test pressure (KPa)		1935	s+g
u	Target inflation pressure at packer (KPa)		2322	1.2t
v	**Target packer inflation gauge pressure (KPa)**		5061	u+p Press. applied = kPa
	Applied packer inflation gauge pressure (KPa)		6750	

Stage							
1	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1235					
	Time (min)	0	5	10	15		
	Meter reading (L)	19574	19710	19850	19980		
	Flow (L)	0	136	140	130		
	Average Test Flow (L/min)	135.3		**Test Flow (L/min/m)**		1.14	

Stage							
2	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1485					
	Time (min)	0	5	10	15		
	Meter reading (L)	20150	20310	20460	20610		
	Flow (L)		160	150	150		
	Average Test Flow (L/min)	153.3		**Test Flow (L/min/m)**		1.29	

Stage							
3	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1735					
	Time (min)	0	5	10	15		
	Meter reading (L)	20810	20970	21145	21320		
	Flow (L)	0	160	175	175		
	Average Test Flow (L/min)	170.0		**Test Flow (L/min/m)**		1.43	

Stage							
4	Gauge Pressure (KPa):	1250		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1985					
	Time (min)	0	5	10	15		
	Meter reading (L)	21650	21735	21920	22130		
	Flow (L)	0	85	185	210		
	Average Test Flow (L/min)	160.0		**Test Flow (L/min/m)**		1.34	

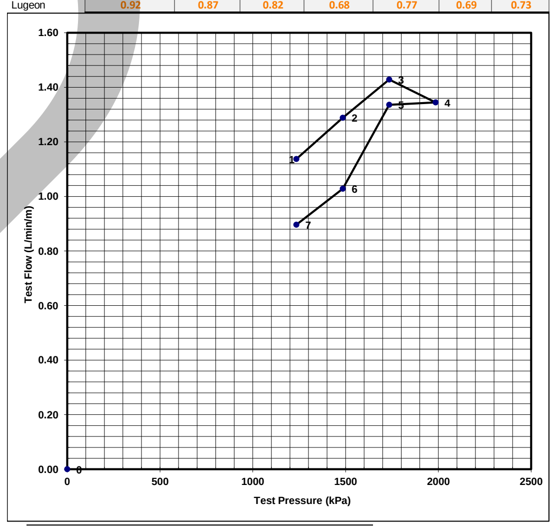
Stage							
5	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1735					
	Time (min)	0	5	10	15		
	Meter reading (L)	22330	22492	22652	22807		
	Flow (L)	0	162	160	155		
	Average Test Flow (L/min)	159.0		**Test Flow (L/min/m)**		1.34	

Stage							
6	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1485					
	Time (min)	0	5	10	15		
	Meter reading (L)	22970	23107	23245	23337		
	Flow (L)	0	137	138	92		
	Average Test Flow (L/min)	122.3		**Test Flow (L/min/m)**		1.03	

Stage							
7	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1235					
	Time (min)	0	5	10	15		
	Meter reading (L)	23500	23600	23710	23820		
	Flow (L)	0	100	110	110		
	Average Test Flow (L/min)	106.7		**Test Flow (L/min/m)**		0.90	

Summary

Test Pressure (Kpa)	1235	1485	1735	1985	1735	1485	1235
Flow Rate (L/min/m)	1.14	1.29	1.43	1.34	1.34	1.03	0.90
Lugeon	0.92	0.87	0.82	0.68	0.77	0.69	0.73



Lugeon units = Test Flow (L/min/m) at 1000kPa = 0.87 (average of Stage 1 - 3)

Permeability (m/day) = 1.09E-02

Permeability (m/s) = 1.26E-07

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Packer Test Data Sheet

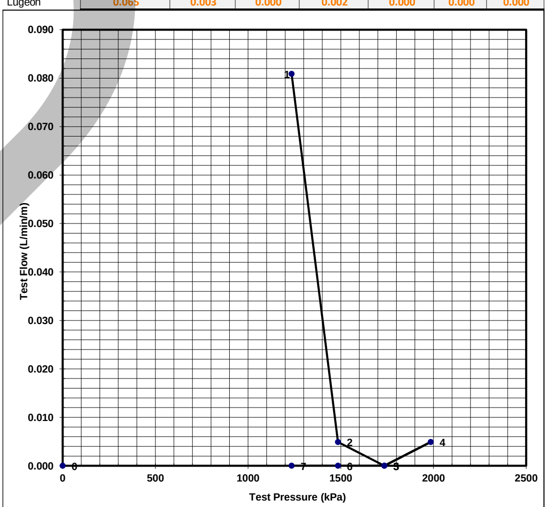
Project:	Tomingley			**Project No.:**	TGEP		
Hole No:	RWRC352D	**Test No:**		Date:	21-Sep-20	Operator:	
Collar RL:	268.04	Location:	Easting (m) / Northing (m)	614145 / 6390680		Azimuth:	270

			Value	Notes
a	Declination (^{0}):		60	
b	Depth pit base below hole collar (m)		0	For use when test sections are below pit. (Default = 0).
c	Depth to water below datum (m)	-declined	83.7	Dipper level.
d		-vertical	72.5	c.sin a
e	Height of gauge above datum (m)		1.0	
f	Depth to water below gauge (m)		73.5	d+e
g	Gauge height pressure (Kpa)		735	10f
h	Depth to top of test section (m)	-declined	451	Drill rod depth + 1.03 m
j		-vertical	390.6	h.sin a
k	Length of test section(m)		68	
m	Adopted rock density (specific gravity)		2.6	
n	Geostatic pressure on test section (KPa)		6974	[(j-d).(m-1.0)+(d-b).m].10 [b</=d]
			0	(j-b).(m-1.0).10 [For when b>d only]
p	Hydrostatic pressure on test section (Kpa)		3181	(j-d).10
q	Maximum allowable total test pressure (KPa)		5579	0.8n
r	Maximum allowable gauge test pressure (KPa)		4844	q-g
s	**Target maximum gauge test pressure (KPa)**		**1200**	should be </=1500
t	Target maximum test pressure (KPa)		1935	s+g
u	Target inflation pressure at packer (KPa)		2322	1.2t
v	**Target packer inflation gauge pressure (KPa)**		5503	u+p Press. applied = kPa
	Applied packer inflation gauge pressure (KPa)		6250	

Test							
1	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1235					
	Time (min)	0	5	10			
	Meter reading (L)	18150	18160	18161			
	Flow (L)	0	10	1			
	Average Test Flow (L/min)	5.5		**Test Flow (L/min/m)**		0.08	
2	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1485					
	Time (min)	0	5	10	15		
	Meter reading (L)	18161	18162	18162	18162		
	Flow (L)		1	0	0		
	Average Test Flow (L/min)	0.3		**Test Flow (L/min/m)**		0.005	
3	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1735					
	Time (min)	0	5	10	15		
	Meter reading (L)	18162	18162	18162	18162		
	Flow (L)	0	0	0	0		
	Average Test Flow (L/min)	0.0		**Test Flow (L/min/m)**		0.00	
4	Gauge Pressure (KPa):	1250		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1985					
	Time (min)	0	5	10	15		
	Meter reading (L)	18162	18163	18163	18163		
	Flow (L)	0	1	0	0		
	Average Test Flow (L/min)	0.3		**Test Flow (L/min/m)**		0.005	
5	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1735					
	Time (min)	0	5	10	15		
	Meter reading (L)	18163	18163	18163	18163		
	Flow (L)	0	0	0	0		
	Average Test Flow (L/min)	0.0		**Test Flow (L/min/m)**		0.00	
6	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1485					
	Time (min)	0	5	10	15		
	Meter reading (L)	18163	18163	18163	18163		
	Flow (L)	0	0	0	0		
	Average Test Flow (L/min)	0.0		**Test Flow (L/min/m)**		0.00	
7	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1235					
	Time (min)	0	5	10	15		
	Meter reading (L)	18163	18163	18163	18163		
	Flow (L)	0	0	0	0		
	Average Test Flow (L/min)	0.0		**Test Flow (L/min/m)**		0.00	

Summary

Test Pressure (Kpa)	1235	1485	1735	1985	1735	1485	1235
Flow Rate (L/min/m)	0.081	0.005	0.000	0.005	0.000	0.000	0.000
Lugeon	0.065	0.003	0.000	0.002	0.000	0.000	0.000



Lugeon units = Test Flow (L/min/m) at 1000kPa =
Permeability (m/day) =
Permeability (m/s) =

No flow conditions. Lugeon and permeability not reported.

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Draft

Packer Test Data Sheet

Project:	Tomingley			**Project No.:**	TGEP		
Hole No:	RWRC352D	**Test No:**		Date:	21-Sep-20	Operator:	
Collar RL:	268.04	Location:	Easting (m) Northing (m)	614145 6390680		Azimuth:	270

a	Declination (°):		60	
b	Depth pit base below hole collar (m)		0	For use when test sections are below pit. (Default = 0).
c	Depth to water below datum (m)	-declined	83.7	Dipper level.
d		-vertical	72.5	c.sin a
e	Height of gauge above datum (m)		1.0	
f	Depth to water below gauge (m)		73.5	d+e
g	Gauge height pressure (Kpa)		735	10f
h	Depth to top of test section (m)	-declined	499	Drill rod depth + 1.03 m
j		-vertical	432.1	h.sin a
k	Length of test section(m)		20	
m	Adopted rock density (specific gravity)		2.6	
n	Geostatic pressure on test section (KPa)		7639	[(j-d).(m-1.0)+(d-b).m].10 [b</=d]
			0	(j-b).(m-1.0).10 [For when b>d only]
p	Hydrostatic pressure on test section (Kpa)		3597	(j-d).10
q	Maximum allowable total test pressure (KPa)		6111	0.8n
r	Maximum allowable gauge test pressure (KPa)		5377	q-g
s	**Target maximum gauge test pressure (KPa)**		**1200**	should be </=1500
t	Target maximum test pressure (KPa)		1935	s+g
u	Target inflation pressure at packer (KPa)		2322	1.2t
v	**Target packer inflation gauge pressure (KPa)**		5918	u+p Press. applied = kPa
	Applied packer inflation gauge pressure (KPa)		6750	

1

Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
Gauge Height Pressure (Kpa):	735					
Total Test Pressure (Kpa):	1235					
Time (min)	0	5	10			
Meter reading (L)	1784	1785	1786			
Flow (L)	0	1	1			
Average Test Flow (L/min)	1.0		**Test Flow (L/min/m)**		0.05	

2

Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
Gauge Height Pressure (Kpa):	735					
Total Test Pressure (Kpa):	1485					
Time (min)	0	5	10	15		
Meter reading (L)	1786	1788	1789	1791		
Flow (L)		2	1	2		
Average Test Flow (L/min)	1.7		**Test Flow (L/min/m)**		0.08	

3

Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
Gauge Height Pressure (Kpa):	735					
Total Test Pressure (Kpa):	1735					
Time (min)	0	5	10	15		
Meter reading (L)	1791	1792	1793	1794		
Flow (L)	0	1	1	1		
Average Test Flow (L/min)	1.0		**Test Flow (L/min/m)**		0.05	

4

Gauge Pressure (KPa):	1250		Gland packer leakage (L/min)			0
Gauge Height Pressure (Kpa):	735					
Total Test Pressure (Kpa):	1985					
Time (min)	0	5	10	15		
Meter reading (L)	1794	1795	1796	1798		
Flow (L)	0	1	1	2		
Average Test Flow (L/min)	1.3		**Test Flow (L/min/m)**		0.07	

5

Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
Gauge Height Pressure (Kpa):	735					
Total Test Pressure (Kpa):	1735					
Time (min)	0	5	10	15		
Meter reading (L)	1798	1799	1800	1801		
Flow (L)	0	1	1	1		
Average Test Flow (L/min)	1.0		**Test Flow (L/min/m)**		0.05	

6

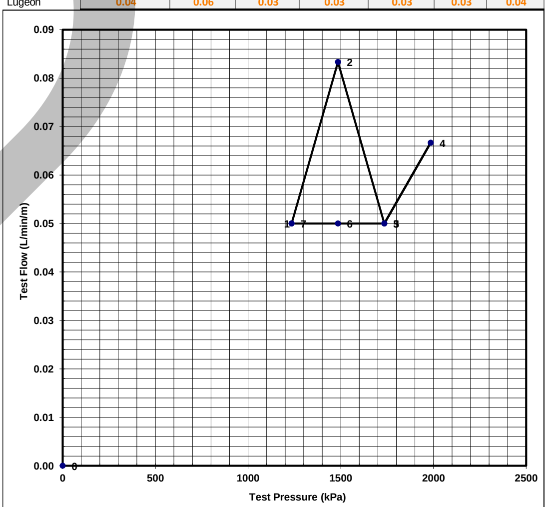
Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
Gauge Height Pressure (Kpa):	735					
Total Test Pressure (Kpa):	1485					
Time (min)	0	5	10	15		
Meter reading (L)	1801	1802	1803	1804		
Flow (L)	0	1	1	1		
Average Test Flow (L/min)	1.0		**Test Flow (L/min/m)**		0.05	

7

Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
Gauge Height Pressure (Kpa):	735					
Total Test Pressure (Kpa):	1235					
Time (min)	0	5	10	15		
Meter reading (L)	1804	1805	1806	1807		
Flow (L)	0	1	1	1		
Average Test Flow (L/min)	1.0		**Test Flow (L/min/m)**		0.05	

Summary

Test Pressure (Kpa)	1235	1485	1735	1985	1735	1485	1235
Flow Rate (L/min/m)	0.05	0.08	0.05	0.07	0.05	0.05	0.05
Lugeon	0.04	0.06	0.03	0.03	0.03	0.03	0.04



Lugeon units = Test Flow (L/min/m) at 1000kPa = 0.04 (average lugeon for stages)

Permeability (m/day) = 4.69E-04

Permeability (m/s) = 5.43E-09

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Draft

Packer Test Data Sheet

Project:	Tomingley			**Project No.:**	TGEP		
Hole No:	RWD042	**Test No:**		Date:	26-Sep-20	Operator:	
Collar RL:	268.13	Location:	Easting (m) Northing (m)	614175 6390630		Azimuth:	270

a	Declination (°):		60	
b	Depth pit base below hole collar (m)		0	For use when test sections are below pit. (Default = 0).
c	Depth to water below datum (m)	-declined	97.4	Dipper level.
d		-vertical	84.4	c.sin a
e	Height of gauge above datum (m)		1.0	
f	Depth to water below gauge (m)		85.4	d+e
g	Gauge height pressure (Kpa)		854	10f
h	Depth to top of test section (m)	-declined	150	Drill rod depth + 1.03 m
j		-vertical	129.9	h.sin a
k	Length of test section(m)		328	
m	Adopted rock density (specific gravity)		2.6	
n	Geostatic pressure on test section (KPa)		2922	[(j-d).(m-1.0)+(d-b).m].10 [b</=d]
			0	(j-b).(m-1.0).10 [For when b>d only]
p	Hydrostatic pressure on test section (Kpa)		456	(j-d).10
q	Maximum allowable total test pressure (KPa)		2338	0.8n
r	Maximum allowable gauge test pressure (KPa)		1484	q-g
s	**Target maximum gauge test pressure (KPa)**		**1200**	should be </=1500
t	Target maximum test pressure (KPa)		2054	s+g
u	Target inflation pressure at packer (KPa)		2464	1.2t
v	**Target packer inflation gauge pressure (KPa)**		2920	u+p Press. applied = kPa
	Applied packer inflation gauge pressure (KPa)		3250	

1	Gauge Pressure (KPa):	200		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1054					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	41658	42045	42442	42843		
	Flow (L)	0	387	397	401		
	Average Test Flow (L/min)	395.0		**Test Flow (L/min/m)**		1.20	

2	Gauge Pressure (KPa):			Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	854					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)						
	Flow (L)		0	0	0	0	0
	Average Test Flow (L/min)	0.0		**Test Flow (L/min/m)**		0.00	

3	Gauge Pressure (KPa):			Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	854					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)						
	Flow (L)	0	0	0	0	0	0
	Average Test Flow (L/min)	0.0		**Test Flow (L/min/m)**		0.00	

4	Gauge Pressure (KPa):			Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	854					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)						
	Flow (L)	0	0	0	0	0	0
	Average Test Flow (L/min)	0.0		**Test Flow (L/min/m)**		0.00	

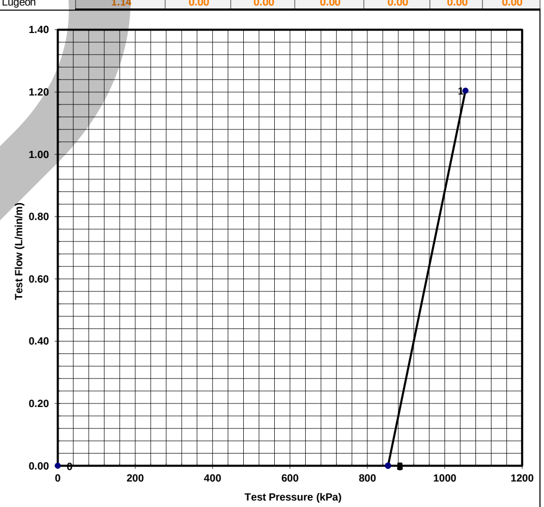
5	Gauge Pressure (KPa):			Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	854					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)						
	Flow (L)	0	0	0	0	0	0
	Average Test Flow (L/min)	0.0		**Test Flow (L/min/m)**		0.00	

6	Gauge Pressure (KPa):			Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	854					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)						
	Flow (L)	0	0	0	0	0	0
	Average Test Flow (L/min)	0.0		**Test Flow (L/min/m)**		0.00	

7	Gauge Pressure (KPa):			Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	854					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)						
	Flow (L)	0	0	0	0	0	0
	Average Test Flow (L/min)	0.0		**Test Flow (L/min/m)**		0.00	

Summary

Test Pressure (Kpa)	1054	854	854	854	854	854	854
Flow Rate (L/min/m)	1.20	0.00	0.00	0.00	0.00	0.00	0.00
Lugeon	1.14	0.00	0.00	0.00	0.00	0.00	0.00



Lugeon units = Test Flow (L/min/m) at 1000kPa =	1.14	(Stage 1)
Permeability (m/day) =	**1.43E-02**	
Permeability (m/s) =	**1.65E-07**	

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Draft

Packer Test Data Sheet

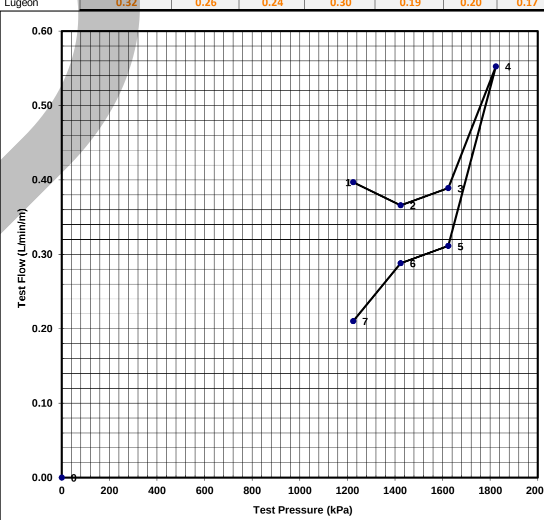
Project:	Tomingley			**Project No.:**	TGEP		
Hole No:	RWD042	**Test No:**	1	Date:	16-Sep-20	Operator:	
Collar RL:	268.13	Location:	Easting (m)	614175		Azimuth:	270
			Northing (m)	6390630			

a	Declination (°):		60	
b	Depth pit base below hole collar (m)		0	For use when test sections are below pit. (Default = 0).
c	Depth to water below datum (m)	-declined	94.0	Dipper level.
d		-vertical	81.4	c.sin a
e	Height of gauge above datum (m)		1.0	
f	Depth to water below gauge (m)		82.4	d+e
g	Gauge height pressure (Kpa)		824	10f
h	Depth to top of test section (m)	-declined	221	Drill rod depth + 1.03 m
j		-vertical	191.4	h.sin a
k	Length of test section(m)		257	
m	Adopted rock density (specific gravity)		2.6	
n	Geostatic pressure on test section (KPa)		3876	[(j-d).(m-1.0)+(d-b).m].10 [b</=d]
			0	(j-b).(m-1.0).10 [For when b>d only]
p	Hydrostatic pressure on test section (Kpa)		1100	(j-d).10
q	Maximum allowable total test pressure (KPa)		3101	0.8n
r	Maximum allowable gauge test pressure (KPa)		2277	q-g
s	**Target maximum gauge test pressure (KPa)**		**1200**	should be </=1500
t	Target maximum test pressure (KPa)		2024	s+g
u	Target inflation pressure at packer (KPa)		2429	1.2t
v	**Target packer inflation gauge pressure (Kpa)**		3529	u+p Press. applied = kPa

Stage							
1	Gauge Pressure (KPa):	400		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	824					
	Total Test Pressure (Kpa):	1224					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	490	600	710	810	910	1000
	Flow (L)	0	110	110	100	100	90
	Average Test Flow (L/min)	102.0		**Test Flow (L/min/m)**		0.40	
2	Gauge Pressure (KPa):	600		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	824					
	Total Test Pressure (Kpa):	1424					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	1130	1230	1330	1420	1510	1600
	Flow (L)		100	100	90	90	90
	Average Test Flow (L/min)	94.0		**Test Flow (L/min/m)**		0.37	
3	Gauge Pressure (KPa):	800		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	824					
	Total Test Pressure (Kpa):	1624					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	1750	1860	1960	2060	2160	2250
	Flow (L)	0	110	100	100	100	90
	Average Test Flow (L/min)	100.0		**Test Flow (L/min/m)**		0.39	
4	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	824					
	Total Test Pressure (Kpa):	1824					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	2310	2460	2610	2740	2890	3020
	Flow (L)	0	150	150	130	150	130
	Average Test Flow (L/min)	142.0		**Test Flow (L/min/m)**		0.55	
5	Gauge Pressure (KPa):	800		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	824					
	Total Test Pressure (Kpa):	1624					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	3110	3190	3270	3350	3430	3510
	Flow (L)	0	80	80	80	80	80
	Average Test Flow (L/min)	80.0		**Test Flow (L/min/m)**		0.31	
6	Gauge Pressure (KPa):	600		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	824					
	Total Test Pressure (Kpa):	1424					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	3580	3650	3720	3790	3870	3950
	Flow (L)	0	70	70	70	80	80
	Average Test Flow (L/min)	74.0		**Test Flow (L/min/m)**		0.29	
7	Gauge Pressure (KPa):	400		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	824					
	Total Test Pressure (Kpa):	1224					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	3980	4010	4070	4130	4190	4250
	Flow (L)	0	30	60	60	60	60
	Average Test Flow (L/min)	54.0		**Test Flow (L/min/m)**		0.21	

Summary

Test Pressure	1224	1424	1624	1824	1624	1424	1224
Flow Rate (L/min/m)	0.40	0.37	0.39	0.55	0.31	0.29	0.21
Lugeon	0.32	0.26	0.24	0.30	0.19	0.20	0.17



Lugeon units = Test Flow (L/min/m) at 1000kPa = 0.27 (average of Stage 1 - 3)

Permeability (m/day) = 3.43E-03

Permeability (m/s) = 3.97E-08

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Draft

Packer Test Data Sheet

Project:	Tomingley			**Project No.:**	TGEP		
Hole No:	RWD042	**Test No:**	2	Date:	17-Sep-20	Operator:	
Collar RL:	268.3	Location:	Easting (m) / Northing (m)	614175 / 6390630		Azimuth:	270

a	Declination (°):		60	
b	Depth pit base below hole collar (m)		0	For use when test sections are below pit. (Default = 0).
c	Depth to water below datum (m)	-declined	94.0	Dipper level.
d		-vertical	81.4	c.sin a
e	Height of gauge above datum (m)		1.0	
f	Depth to water below gauge (m)		82.4	d+e
g	Gauge height pressure (Kpa)		824	10f
h	Depth to top of test section (m)	-declined	252	Drill rod depth + 1.03 m
j		-vertical	218.2	h.sin a
k	Length of test section(m)		226	
m	Adopted rock density (specific gravity)		2.6	
n	Geostatic pressure on test section (KPa)		4306	[(j-d).(m-1.0)+(d-b).m].10 [b</=d]
			0	(j-b).(m-1.0).10 [For when b>d only]
p	Hydrostatic pressure on test section (Kpa)		1368	(j-d).10
q	Maximum allowable total test pressure (KPa)		3445	0.8n
r	Maximum allowable gauge test pressure (KPa)		2621	q-g
s	**Target maximum gauge test pressure (KPa)**		**1200**	should be </=1500
t	Target maximum test pressure (KPa)		2024	s+g
u	Target inflation pressure at packer (KPa)		2429	1.2t
v	**Target packer inflation gauge pressure (KPa)**		3797	u+p Press. applied = kPa
	Applied packer inflation gauge pressure (KPa)		4000	

Stage							
1	Gauge Pressure (KPa):	400		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	824					
	Total Test Pressure (Kpa):	1224					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	6300	6480	6680	6870	7030	7210
	Flow (L)	0	180	200	190	160	180
	Average Test Flow (L/min)	182.0		**Test Flow (L/min/m)**		0.81	

Stage							
2	Gauge Pressure (KPa):	600		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	824					
	Total Test Pressure (Kpa):	1424					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	7450	7650	7850	8040	8220	8420
	Flow (L)		200	200	190	180	200
	Average Test Flow (L/min)	194.0		**Test Flow (L/min/m)**		0.86	

Stage							
3	Gauge Pressure (KPa):	800		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	824					
	Total Test Pressure (Kpa):	1624					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	8640	8880	9120	9360	9590	9840
	Flow (L)	0	240	240	240	230	250
	Average Test Flow (L/min)	240.0		**Test Flow (L/min/m)**		1.06	

Stage							
4	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	824					
	Total Test Pressure (Kpa):	1824					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	10200	10510	10830	11150	11490	11860
	Flow (L)	0	310	320	320	340	370
	Average Test Flow (L/min)	332.0		**Test Flow (L/min/m)**		1.47	

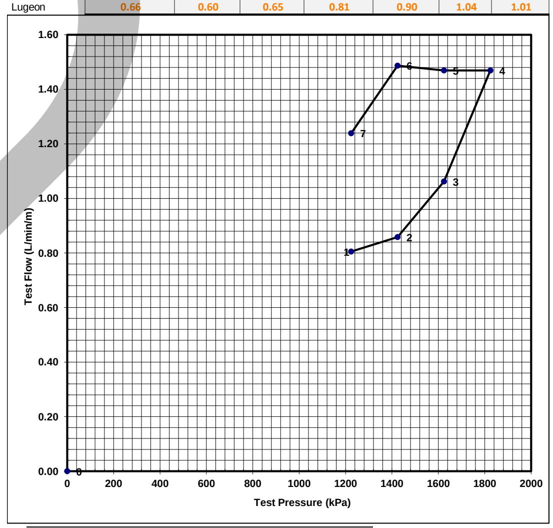
Stage							
5	Gauge Pressure (KPa):	800		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	824					
	Total Test Pressure (Kpa):	1624					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	12140	12480	12780	13080	13400	13800
	Flow (L)	0	340	300	300	320	400
	Average Test Flow (L/min)	332.0		**Test Flow (L/min/m)**		1.47	

Stage							
6	Gauge Pressure (KPa):	600		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	824					
	Total Test Pressure (Kpa):	1424					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	14100	14440	14780	15120	15440	15780
	Flow (L)	0	340	340	340	320	340
	Average Test Flow (L/min)	336.0		**Test Flow (L/min/m)**		1.49	

Stage							
7	Gauge Pressure (KPa):	400		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	824					
	Total Test Pressure (Kpa):	1224					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	16040	16320	16610	16900	17170	17440
	Flow (L)	0	280	290	290	270	270
	Average Test Flow (L/min)	280.0		**Test Flow (L/min/m)**		1.24	

Summary

Test Pressure (Kpa)	1224	1424	1624	1824	1624	1424	1224
Flow Rate (L/min/m)	0.81	0.86	1.06	1.47	1.47	1.49	1.24
Lugeon	0.66	0.60	0.65	0.81	0.90	1.04	1.01



Lugeon units = Test Flow (L/min/m) at 1000kPa =	1.04	(Stage 6)
Permeability (m/day) =	**1.30E-02**	
Permeability (m/s) =	**1.51E-07**	

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Draft

Packer Test Data Sheet

Project:	Tomingley			**Project No.:**	TGEP	
Hole No:	RWD042	**Test No:**		Date:	26-Sep-20	Operator:
Collar RL:	268.13	Location:	Easting (m) Northing (m)	614175 6390630	Azimuth:	270

a	Declination (°):		60	
b	Depth pit base below hole collar (m)		0	For use when test sections are below pit. (Default = 0).
c	Depth to water below datum (m)	-declined	97.4	Dipper level.
d		-vertical	84.4	c.sin a
e	Height of gauge above datum (m)		1.0	
f	Depth to water below gauge (m)		85.4	d+e
g	Gauge height pressure (Kpa)		854	10f
h	Depth to top of test section (m)	-declined	300	Drill rod depth + 1.03 m
j		-vertical	259.8	h.sin a
k	Length of test section(m)		178	
m	Adopted rock density (specific gravity)		2.6	
n	Geostatic pressure on test section (KPa)		5000	[(j-d).(m-1.0)+(d-b).m].10 [b</=d]
			0	(j-b).(m-1.0).10 [For when b>d only]
p	Hydrostatic pressure on test section (Kpa)		1755	(j-d).10
q	Maximum allowable total test pressure (KPa)		4000	0.8n
r	Maximum allowable gauge test pressure (KPa)		3147	q-g
s	**Target maximum gauge test pressure (KPa)**		**1200**	should be </=1500
t	Target maximum test pressure (KPa)		2054	s+g
u	Target inflation pressure at packer (KPa)		2464	1.2t
v	**Target packer inflation gauge pressure (KPa)**		4219	u+p Press. applied = kPa
	Applied packer inflation gauge pressure (KPa)		4750	

Stage							
1	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1354					
	Time (min)	0	5	10	15		
	Meter reading (L)	35920	36131	36298	36445		
	Flow (L)	0	211	167	147		
	Average Test Flow (L/min)	175.0		**Test Flow (L/min/m)**		0.98	

Stage							
2	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1604					
	Time (min)	0	5	10	15		
	Meter reading (L)	36497	36712	36884	37042		
	Flow (L)		215	172	158		
	Average Test Flow (L/min)	181.7		**Test Flow (L/min/m)**		1.02	

Stage							
3	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1854					
	Time (min)	0	5	10	15		
	Meter reading (L)	37090	37325	37522	37706		
	Flow (L)	0	235	197	184		
	Average Test Flow (L/min)	205.3		**Test Flow (L/min/m)**		1.15	

Stage							
4	Gauge Pressure (KPa):	1250		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	2104					
	Time (min)	0	5	10	15		
	Meter reading (L)	37745	38025	38247	38470		
	Flow (L)	0	280	222	223		
	Average Test Flow (L/min)	241.7		**Test Flow (L/min/m)**		1.36	

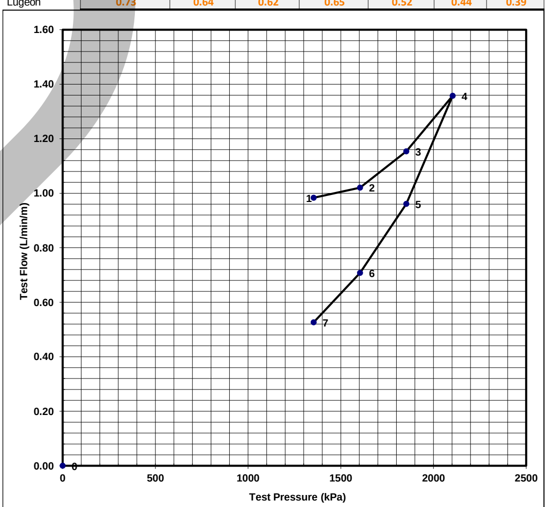
Stage							
5	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1854					
	Time (min)	0	5	10	15		
	Meter reading (L)	38484	38664	38825	38997		
	Flow (L)	0	180	161	172		
	Average Test Flow (L/min)	171.0		**Test Flow (L/min/m)**		0.96	

Stage							
6	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1604					
	Time (min)	0	5	10	15		
	Meter reading (L)	39000	39111	39242	39378		
	Flow (L)	0	111	131	136		
	Average Test Flow (L/min)	126.0		**Test Flow (L/min/m)**		0.71	

Stage							
7	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1354					
	Time (min)	0	5	10	15		
	Meter reading (L)	39380	39460	39554	39661		
	Flow (L)	0	80	94	107		
	Average Test Flow (L/min)	93.7		**Test Flow (L/min/m)**		0.53	

Summary

Test Pressure (Kpa)	1354	1604	1854	2104	1854	1604	1354
Flow Rate (L/min/m)	0.98	1.02	1.15	1.36	0.96	0.71	0.53
Lugeon	0.73	0.64	0.62	0.65	0.52	0.44	0.39



Lugeon units = Test Flow (L/min/m) at 1000kPa = 0.66 (average Stage 1 - 4)
Permeability (m/day) = 8.24E-03
Permeability (m/s) = 9.54E-08

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Draft

Packer Test Data Sheet

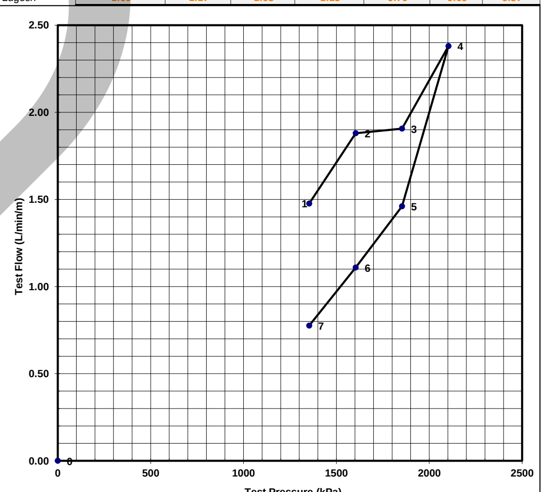
Project:	Tomingley			**Project No.:**	TGEP		
Hole No:	RWD042	**Test No:**		Date:	26-Sep-20	Operator:	
Collar RL:	268.13	Location:	Easting (m) / Northing (m)	614175 / 6390630		Azimuth:	270

a	Declination (°):		60	
b	Depth pit base below hole collar (m)		0	For use when test sections are below pit. (Default = 0).
c	Depth to water below datum (m)	-declined	97.4	Dipper level.
d		-vertical	84.4	c.sin a
e	Height of gauge above datum (m)		1.0	
f	Depth to water below gauge (m)		85.4	d+e
g	Gauge height pressure (Kpa)		854	10f
h	Depth to top of test section (m)	-declined	350	Drill rod depth + 1.03 m
j		-vertical	303.1	h.sin a
k	Length of test section(m)		128	
m	Adopted rock density (specific gravity)		2.6	
n	Geostatic pressure on test section (KPa)		5693	[(j-d).(m-1.0)+(d-b).m].10 [b</=d]
			0	(j-b).(m-1.0).10 [For when b>d only]
p	Hydrostatic pressure on test section (Kpa)		2188	(j-d).10
q	Maximum allowable total test pressure (KPa)		4555	0.8n
r	Maximum allowable gauge test pressure (KPa)		3701	q-g
s	**Target maximum gauge test pressure (KPa)**		**1200**	should be </=1500
t	Target maximum test pressure (KPa)		2054	s+g
u	Target inflation pressure at packer (KPa)		2464	1.2t
v	**Target packer inflation gauge pressure (KPa)**		4652	u+p Press. applied = kPa
	Applied packer inflation gauge pressure (KPa)		5250	

Stage							
1	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1354					
	Time (min)	0	5	10	15		
	Meter reading (L)	30940	31117	31340	31507		
	Flow (L)	0	177	223	167		
	Average Test Flow (L/min)	189.0		**Test Flow (L/min/m)**		1.48	
2	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1604					
	Time (min)	0	5	10	15		
	Meter reading (L)	31512	31872	32071	32234		
	Flow (L)		360	199	163		
	Average Test Flow (L/min)	240.7		**Test Flow (L/min/m)**		1.88	
3	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1854					
	Time (min)	0	5	10	15		
	Meter reading (L)	32289	32562	32783	33021		
	Flow (L)	0	273	221	238		
	Average Test Flow (L/min)	244.0		**Test Flow (L/min/m)**		1.91	
4	Gauge Pressure (KPa):	1250		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	2104					
	Time (min)	0	5	10	15		
	Meter reading (L)	33069	33440	33729	33983		
	Flow (L)	0	371	289	254		
	Average Test Flow (L/min)	304.7		**Test Flow (L/min/m)**		2.38	
5	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1854					
	Time (min)	0	5	10	15		
	Meter reading (L)	34009	34186	34374	34570		
	Flow (L)	0	177	188	196		
	Average Test Flow (L/min)	187.0		**Test Flow (L/min/m)**		1.46	
6	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1604					
	Time (min)	0	5	10	15		
	Meter reading (L)	34578	34708	34856	35004		
	Flow (L)	0	130	148	148		
	Average Test Flow (L/min)	142.0		**Test Flow (L/min/m)**		1.11	
7	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1354					
	Time (min)	0	5	10	15		
	Meter reading (L)	35008	35097	35198	35306		
	Flow (L)	0	89	101	108		
	Average Test Flow (L/min)	99.3		**Test Flow (L/min/m)**		0.78	

Summary

Test Pressure (Kpa)	1354	1604	1854	2104	1854	1604	1354
Flow Rate (L/min/m)	1.48	1.88	1.91	2.38	1.46	1.11	0.78
Lugeon	1.09	1.17	1.03	1.13	0.79	0.69	0.57



Lugeon units = Test Flow (L/min/m) at 1000kPa =	1.11	(average Stage 1 - 4)
Permeability (m/day) =	**1.39E-02**	
Permeability (m/s) =	**1.60E-07**	

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Draft

Packer Test Data Sheet

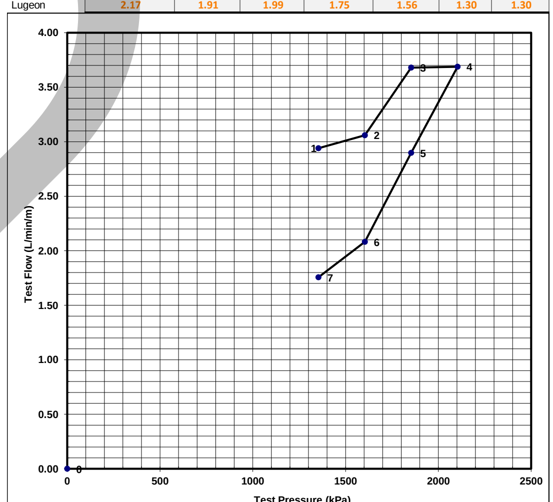
Project:	Tomingley			**Project No.:**	TGEP		
Hole No:	RWD042	**Test No:**		Date:	25-Sep-20	Operator:	
Collar RL:	268.13	Location:	Easting (m) / Northing (m)	614175 / 6390630		Azimuth:	270

a	Declination (°):		60	
b	Depth pit base below hole collar (m)		0	For use when test sections are below pit. (Default = 0).
c	Depth to water below datum (m)	-declined	97.4	Dipper level.
d		-vertical	84.4	c.sin a
e	Height of gauge above datum (m)		1.0	
f	Depth to water below gauge (m)		85.4	d+e
g	Gauge height pressure (Kpa)		854	10f
h	Depth to top of test section (m)	-declined	400	Drill rod depth + 1.03 m
j		-vertical	346.4	h.sin a
k	Length of test section(m)		78	
m	Adopted rock density (specific gravity)		2.6	
n	Geostatic pressure on test section (KPa)		6386	[(j-d).(m-1.0)+(d-b).m].10 [b</=d]
			0	(j-b).(m-1.0).10 [For when b>d only]
p	Hydrostatic pressure on test section (Kpa)		2621	(j-d).10
q	Maximum allowable total test pressure (KPa)		5109	0.8n
r	Maximum allowable gauge test pressure (KPa)		4255	q-g
s	**Target maximum gauge test pressure (KPa)**		**1200**	should be </=1500
t	Target maximum test pressure (KPa)		2054	s+g
u	Target inflation pressure at packer (KPa)		2464	1.2t
v	**Target packer inflation gauge pressure (KPa)**		5085	u+p Press. applied = kPa
	Applied packer inflation gauge pressure (KPa)		5750	

Stage							
1	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1354					
	Time (min)	0	5	10	15		
	Meter reading (L)	25158	25458	25655	25846		
	Flow (L)	0	300	197	191		
	Average Test Flow (L/min)	229.3		**Test Flow (L/min/m)**		2.94	
2	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1604					
	Time (min)	0	5	10	15		
	Meter reading (L)	25897	26156	26379	26613		
	Flow (L)		259	223	234		
	Average Test Flow (L/min)	238.7		**Test Flow (L/min/m)**		3.06	
3	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1854					
	Time (min)	0	5	10	15		
	Meter reading (L)	26643	26982	27260	27504		
	Flow (L)	0	339	278	244		
	Average Test Flow (L/min)	287.0		**Test Flow (L/min/m)**		3.68	
4	Gauge Pressure (KPa):	1250		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	2104					
	Time (min)	0	5	10	15		
	Meter reading (L)	27541	27844	28124	28404		
	Flow (L)	0	303	280	280		
	Average Test Flow (L/min)	287.7		**Test Flow (L/min/m)**		3.69	
5	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1854					
	Time (min)	0	5	10	15		
	Meter reading (L)	28436	28650	28894	29114		
	Flow (L)	0	214	244	220		
	Average Test Flow (L/min)	226.0		**Test Flow (L/min/m)**		2.90	
6	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1604					
	Time (min)	0	5	10	15		
	Meter reading (L)	29138	29262	29450	29625		
	Flow (L)	0	124	188	175		
	Average Test Flow (L/min)	162.3		**Test Flow (L/min/m)**		2.08	
7	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1354					
	Time (min)	0	5	10	15		
	Meter reading (L)	29641	29794	29906	30052		
	Flow (L)	0	153	112	146		
	Average Test Flow (L/min)	137.0		**Test Flow (L/min/m)**		1.76	

Summary

Test Pressure (Kpa)	1354	1604	1854	2104	1854	1604	1354
Flow Rate (L/min/m)	2.94	3.06	3.68	3.69	2.90	2.08	1.76
Lugeon	2.17	1.91	1.99	1.75	1.56	1.30	1.30



Lugeon units = Test Flow (L/min/m) at 1000kPa = 2.02 (average Stage 1 - 3)

Permeability (m/day) = 2.53E-02

Permeability (m/s) = 2.93E-07

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Draft

Packer Test Data Sheet

Project:	Tomingley			**Project No.:**	TGEP		
Hole No:	RWD042	**Test No:**		Date:	25-Sep-20	Operator:	
Collar RL:	268.13	Location:	Easting (m) Northing (m)	614175 6390630		Azimuth:	270

a	Declination (^{0}):		60	
b	Depth pit base below hole collar (m)		0	For use when test sections are below pit. (Default = 0).
c	Depth to water below datum (m)	-declined	97.4	Dipper level.
d		-vertical	84.4	c.sin a
e	Height of gauge above datum (m)		1.0	
f	Depth to water below gauge (m)		85.4	d+e
g	Gauge height pressure (Kpa)		854	10f
h	Depth to top of test section (m)	-declined	450	Drill rod depth + 1.03 m
j		-vertical	389.7	h.sin a
k	Length of test section(m)		28	
m	Adopted rock density (specific gravity)		2.6	
n	Geostatic pressure on test section (KPa)		7079	[(j-d).(m-1.0)+(d-b).m].10 [b</=d]
			0	(j-b).(m-1.0).10 [For when b>d only]
p	Hydrostatic pressure on test section (Kpa)		3054	(j-d).10
q	Maximum allowable total test pressure (KPa)		5663	0.8n
r	Maximum allowable gauge test pressure (KPa)		4810	q-g
s	**Target maximum gauge test pressure (KPa)**		**1200**	should be </=1500
t	Target maximum test pressure (KPa)		2054	s+g
u	Target inflation pressure at packer (KPa)		2464	1.2t
v	**Target packer inflation gauge pressure (KPa)**		5518	u+p Press. applied = kPa
	Applied packer inflation gauge pressure (KPa)		6250	

Stage							
1	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1354					
	Time (min)	0	5	10	15		
	Meter reading (L)	24145	24175	24203	24232		
	Flow (L)	0	30	28	29		
	Average Test Flow (L/min)	29.0		**Test Flow (L/min/m)**		1.04	

Stage							
2	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1604					
	Time (min)	0	5	10	15		
	Meter reading (L)	24237	24274	24307	24343		
	Flow (L)		37	33	36		
	Average Test Flow (L/min)	35.3		**Test Flow (L/min/m)**		1.26	

Stage							
3	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1854					
	Time (min)	0	5	10	15		
	Meter reading (L)	24347	24385	24441	24457		
	Flow (L)	0	38	56	16		
	Average Test Flow (L/min)	36.7		**Test Flow (L/min/m)**		1.31	

Stage							
4	Gauge Pressure (KPa):	1250		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	2104					
	Time (min)	0	5	10	15		
	Meter reading (L)	24463	24502	24538	24583		
	Flow (L)	0	39	36	45		
	Average Test Flow (L/min)	40.0		**Test Flow (L/min/m)**		1.43	

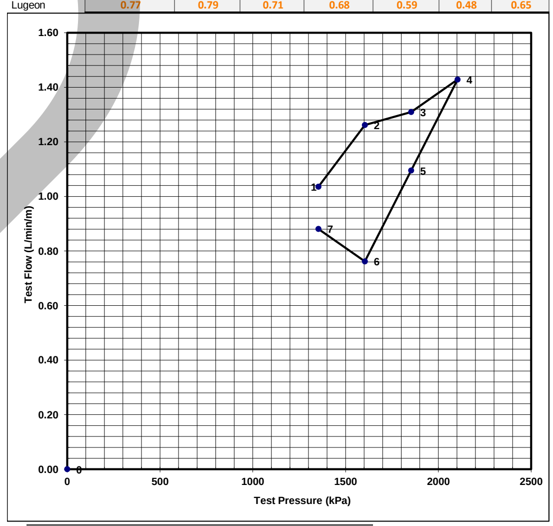
Stage							
5	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1854					
	Time (min)	0	5	10	15		
	Meter reading (L)	24587	24621	24649	24679		
	Flow (L)	0	34	28	30		
	Average Test Flow (L/min)	30.7		**Test Flow (L/min/m)**		1.10	

Stage							
6	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1604					
	Time (min)	0	5	10	15		
	Meter reading (L)	24682	24713	24741	24746		
	Flow (L)	0	31	28	5		
	Average Test Flow (L/min)	21.3		**Test Flow (L/min/m)**		0.76	

Stage							
7	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	854					
	Total Test Pressure (Kpa):	1354					
	Time (min)	0	5	10	15		
	Meter reading (L)	24746	24772	24796	24820		
	Flow (L)	0	26	24	24		
	Average Test Flow (L/min)	24.7		**Test Flow (L/min/m)**		0.88	

Summary

Test Pressure (Kpa)	1354	1604	1854	2104	1854	1604	1354
Flow Rate (L/min/m)	1.04	1.26	1.31	1.43	1.10	0.76	0.88
Lugeon	0.77	0.79	0.71	0.68	0.59	0.48	0.65



Lugeon units = Test Flow (L/min/m) at 1000kPa =	0.73	(average Stage 1 - 4)
Permeability (m/day) =	**9.20E-03**	
Permeability (m/s) =	**1.07E-07**	

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Draft

Packer Test Data Sheet

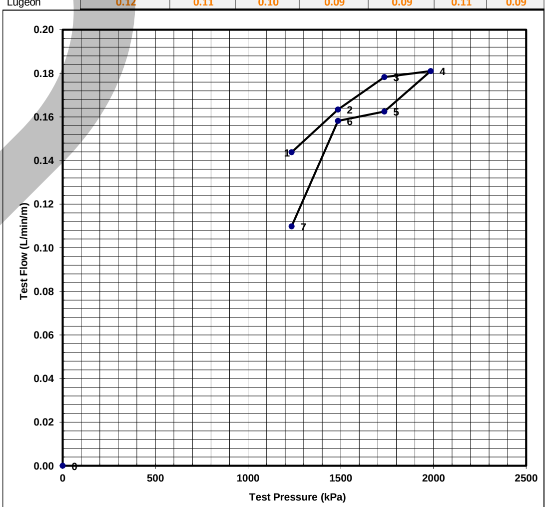
Project: Tomingley				**Project No.:** TGEP			
Hole No:	RWD048	**Test No:**		Date:	29-Sep-20	Operator:	
Collar RL:	267.89	Location:	Easting (m) / Northing (m)	614188 / 6390808		Azimuth:	270

a	Declination (°):		60	
b	Depth pit base below hole collar (m)		0	For use when test sections are below pit. (Default = 0).
c	Depth to water below datum (m)	-declined	83.7	Dipper level.
d		-vertical	72.5	c.sin a
e	Height of gauge above datum (m)		1.0	
f	Depth to water below gauge (m)		73.5	d+e
g	Gauge height pressure (Kpa)		735	10f
h	Depth to top of test section (m)	-declined	200	Drill rod depth + 1.03 m
j		-vertical	173.2	h.sin a
k	Length of test section(m)		255	
m	Adopted rock density (specific gravity)		2.6	
n	Geostatic pressure on test section (KPa)		3496	[(j-d).(m-1.0)+(d-b).m].10 [b</=d]
			0	(j-b).(m-1.0).10 [For when b>d only]
p	Hydrostatic pressure on test section (Kpa)		1007	(j-d).10
q	Maximum allowable total test pressure (KPa)		2797	0.8n
r	Maximum allowable gauge test pressure (KPa)		2062	q-g
s	**Target maximum gauge test pressure (KPa)**		**1200**	should be </=1500
t	Target maximum test pressure (KPa)		1935	s+g
u	Target inflation pressure at packer (KPa)		2322	1.2t
v	**Target packer inflation gauge pressure (KPa)**		3329	u+p Press. applied = kPa
	Applied packer inflation gauge pressure (KPa)		4000	

Stage							
1	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1235					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	51991	52029	52066	52101		
	Flow (L)	0	38	37	35		
	Average Test Flow (L/min)	36.7		**Test Flow (L/min/m)**		0.14	
2	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1485					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	52155	52199	52241	52280		
	Flow (L)		44	42	39		
	Average Test Flow (L/min)	41.7		**Test Flow (L/min/m)**		0.16	
3	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			3.2
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1735					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	52349	52400	52446	52495		
	Flow (L)	0	51	46	49		
	Average Test Flow (L/min)	45.5		**Test Flow (L/min/m)**		0.18	
4	Gauge Pressure (KPa):	1250		Gland packer leakage (L/min)			3.5
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1985					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	52579	52627	52677	52728		
	Flow (L)	0	48	50	51		
	Average Test Flow (L/min)	46.2		**Test Flow (L/min/m)**		0.18	
5	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			2.9
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1735					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	52798	52842	52887	52931		
	Flow (L)	0	44	45	44		
	Average Test Flow (L/min)	41.4		**Test Flow (L/min/m)**		0.16	
6	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1485					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	52978	53016	53052	53099		
	Flow (L)	0	38	36	47		
	Average Test Flow (L/min)	40.3		**Test Flow (L/min/m)**		0.16	
7	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1235					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	53120	53149	53178	53204		
	Flow (L)	0	29	29	26		
	Average Test Flow (L/min)	28.0		**Test Flow (L/min/m)**		0.11	

Summary

Test Pressure (Kpa)	1235	1485	1735	1985	1735	1485	1235
Flow Rate (L/min/m)	0.14	0.16	0.18	0.18	0.16	0.16	0.11
Lugeon	0.12	0.11	0.10	0.09	0.09	0.11	0.09



Lugeon units = Test Flow (L/min/m) at 1000kPa = 0.10 (average Stage 1 - 6)

Permeability (m/day) = 1.30E-03

Permeability (m/s) = 1.50E-08

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Draft

Packer Test Data Sheet

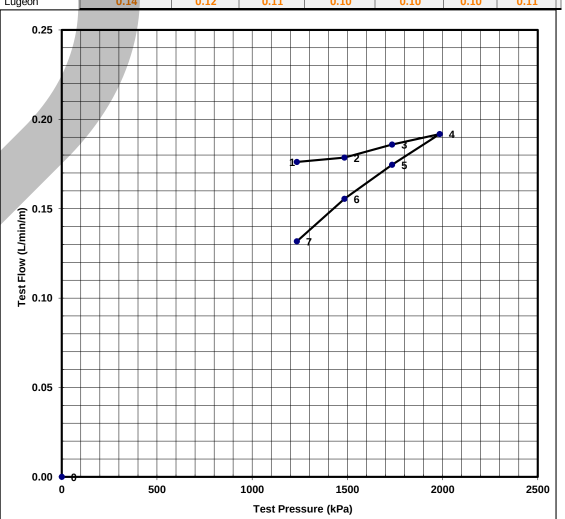
Project:	Tomingley				**Project No.:**	TGEP		
Hole No:	RWD048	**Test No:**			Date:	29-Sep-20	Operator:	
Collar RL:	267.89	Location:	Easting (m) / Northing (m)		614188 / 6390808		Azimuth:	270

a	Declination (°):		60	
b	Depth pit base below hole collar (m)		0	For use when test sections are below pit. (Default = 0).
c	Depth to water below datum (m)	-declined	83.7	Dipper level.
d		-vertical	72.5	c.sin a
e	Height of gauge above datum (m)		1.0	
f	Depth to water below gauge (m)		73.5	d+e
g	Gauge height pressure (Kpa)		735	10f
h	Depth to top of test section (m)	-declined	245	Drill rod depth + 1.03 m
j		-vertical	212.2	h.sin a
k	Length of test section(m)		210	
m	Adopted rock density (specific gravity)		2.6	
n	Geostatic pressure on test section (KPa)		4120	[(j-d).(m-1.0)+(d-b).m].10 [b</=d]
			0	(j-b).(m-1.0).10 [For when b>d only]
p	Hydrostatic pressure on test section (Kpa)		1397	(j-d).10
q	Maximum allowable total test pressure (KPa)		3296	0.8n
r	Maximum allowable gauge test pressure (KPa)		2561	q-g
s	**Target maximum gauge test pressure (KPa)**		**1200**	should be </=1500
t	Target maximum test pressure (KPa)		1935	s+g
u	Target inflation pressure at packer (KPa)		2322	1.2t
v	**Target packer inflation gauge pressure (Kpa)**		3719	u+p Press. applied = kPa
	Applied packer inflation gauge pressure (KPa)		4200	

Stage							
1	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1235					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	50601	50641	50678	50712		
	Flow (L)	0	40	37	34		
	Average Test Flow (L/min)	37.0		**Test Flow (L/min/m)**		0.18	
2	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0.5
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1485					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	50717	50757	50794	50831		
	Flow (L)		40	37	37		
	Average Test Flow (L/min)	37.5		**Test Flow (L/min/m)**		0.18	
3	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			1.3
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1735					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	50838	50880	50919	50959		
	Flow (L)	0	42	39	40		
	Average Test Flow (L/min)	39.0		**Test Flow (L/min/m)**		0.19	
4	Gauge Pressure (KPa):	1250		Gland packer leakage (L/min)			1.4
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1985					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	50962	51005	51046	51087		
	Flow (L)	0	43	41	41		
	Average Test Flow (L/min)	40.3		**Test Flow (L/min/m)**		0.19	
5	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1735					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	51090	51127	51164	51200		
	Flow (L)	0	37	37	36		
	Average Test Flow (L/min)	36.7		**Test Flow (L/min/m)**		0.17	
6	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1485					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	51203	51235	51268	51301		
	Flow (L)	0	32	33	33		
	Average Test Flow (L/min)	32.7		**Test Flow (L/min/m)**		0.16	
7	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1235					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	51303	51331	51358	51386		
	Flow (L)	0	28	27	28		
	Average Test Flow (L/min)	27.7		**Test Flow (L/min/m)**		0.13	

Summary

Test Pressure	1235	1485	1735	1985	1735	1485	1235
Flow Rate (L/min/m)	0.18	0.18	0.19	0.19	0.17	0.16	0.13
Lugeon	0.14	0.12	0.11	0.10	0.10	0.10	0.11



Lugeon units = Test Flow (L/min/m) at 1000kPa = 0.12 (average Stage 1 - 4)
Permeability (m/day) = 1.46E-03
Permeability (m/s) = 1.69E-08

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Draft

Packer Test Data Sheet

Project:	Tomingley			**Project No.:**	TGEP	
Hole No:	RWD048	**Test No:**		Date:	29-Sep-20	Operator:
Collar RL:	267.89	Location:	Easting (m) / Northing (m)	614188 / 6390808	Azimuth:	270

a	Declination (°):		60	
b	Depth pit base below hole collar (m)		0	For use when test sections are below pit. (Default = 0).
c	Depth to water below datum (m)	-declined	83.7	Dipper level.
d		-vertical	72.5	c.sin a
e	Height of gauge above datum (m)		1.0	
f	Depth to water below gauge (m)		73.5	d+e
g	Gauge height pressure (Kpa)		735	10f
h	Depth to top of test section (m)	-declined	257	Drill rod depth + 1.03 m
j		-vertical	222.6	h.sin a
k	Length of test section(m)		198	
m	Adopted rock density (specific gravity)		2.6	
n	Geostatic pressure on test section (KPa)		4286	[(j-d).(m-1.0)+(d-b).m].10 [b</=d]
			0	(j-b).(m-1.0).10 [For when b>d only]
p	Hydrostatic pressure on test section (Kpa)		1501	(j-d).10
q	Maximum allowable total test pressure (KPa)		3429	0.8n
r	Maximum allowable gauge test pressure (KPa)		2694	q-g
s	**Target maximum gauge test pressure (KPa)**		**1200**	should be </=1500
t	Target maximum test pressure (KPa)		1935	s+g
u	Target inflation pressure at packer (KPa)		2322	1.2t
v	**Target packer inflation gauge pressure (KPa)**		3823	u+p Press. applied = kPa
	Applied packer inflation gauge pressure (KPa)		4320	

Stage	Parameter						
1	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			3.25
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1235					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	49999	50044	50085	50126		
	Flow (L)	0	45	41	41		
	Average Test Flow (L/min)	39.1		**Test Flow (L/min/m)**		0.20	

Stage	Parameter						
2	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1485					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)	50132	50179				
	Flow (L)		47				
	Average Test Flow (L/min)	47.0		**Test Flow (L/min/m)**		0.24	

Stage	Parameter						
3	Gauge Pressure (KPa):			Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	735					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)						
	Flow (L)	0	0	0	0	0	0
	Average Test Flow (L/min)	0.0		**Test Flow (L/min/m)**		0.00	

Stage	Parameter						
4	Gauge Pressure (KPa):			Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	735					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)						
	Flow (L)	0	0	0	0	0	0
	Average Test Flow (L/min)	0.0		**Test Flow (L/min/m)**		0.00	

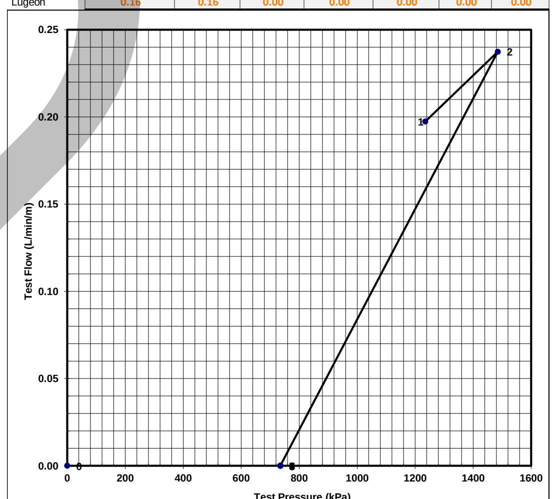
Stage	Parameter						
5	Gauge Pressure (KPa):			Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	735					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)						
	Flow (L)	0	0	0	0	0	0
	Average Test Flow (L/min)	0.0		**Test Flow (L/min/m)**		0.00	

Stage	Parameter						
6	Gauge Pressure (KPa):			Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	735					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)						
	Flow (L)	0	0	0	0	0	0
	Average Test Flow (L/min)	0.0		**Test Flow (L/min/m)**		0.00	

Stage	Parameter						
7	Gauge Pressure (KPa):			Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	735					
	Time (min)	0	5	10	15	20	25
	Meter reading (L)						
	Flow (L)	0	0	0	0	0	0
	Average Test Flow (L/min)	0.0		**Test Flow (L/min/m)**		0.00	

Summary

Test Pressure (Kpa)	1235	1485	735	735	735	735	735
Flow Rate (L/min/m)	0.20	0.24	0.00	0.00	0.00	0.00	0.00
Lugeon	0.16	0.16	0.00	0.00	0.00	0.00	0.00



Lugeon units = Test Flow (L/min/m) at 1000kPa = 0.16 (average of Stage 1 and 2)

Permeability (m/day) = 2.00E-03

Permeability (m/s) = 2.32E-08

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Draft

Packer Test Data Sheet

Project:	Tomingley			**Project No.:**	TGEP		
Hole No:	RWD048	**Test No:**		Date:	29-Sep-20	Operator:	
Collar RL:	267.89	Location:	Easting (m) / Northing (m)	614188 / 6390808		Azimuth:	270

a	Declination (°):		60	
b	Depth pit base below hole collar (m)		0	For use when test sections are below pit. (Default = 0).
c	Depth to water below datum (m)	-declined	83.7	Dipper level.
d		-vertical	72.5	c.sin a
e	Height of gauge above datum (m)		1.0	
f	Depth to water below gauge (m)		73.5	d+e
g	Gauge height pressure (Kpa)		735	10f
h	Depth to top of test section (m)	-declined	300	Drill rod depth + 1.03 m
j		-vertical	259.8	h.sin a
k	Length of test section(m)		155	
m	Adopted rock density (specific gravity)		2.6	
n	Geostatic pressure on test section (KPa)		4882	[(j-d).(m-1.0)+(d-b).m].10 [b</=d]
			0	(j-b).(m-1.0).10 [For when b>d only]
p	Hydrostatic pressure on test section (Kpa)		1873	(j-d).10
q	Maximum allowable total test pressure (KPa)		3905	0.8n
r	Maximum allowable gauge test pressure (KPa)		3171	q-g
s	**Target maximum gauge test pressure (KPa)**		**1200**	should be </=1500
t	Target maximum test pressure (KPa)		1935	s+g
u	Target inflation pressure at packer (KPa)		2322	1.2t
v	**Target packer inflation gauge pressure (KPa)**		4195	u+p Press. applied = kPa
	Applied packer inflation gauge pressure (KPa)		4750	

Stage							
1	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			3.25
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1235					
	Time (min)	0	5	10	15		
	Meter reading (L)	48634	48673	48707	48740		
	Flow (L)	0	39	34	33		
	Average Test Flow (L/min)	32.1		**Test Flow (L/min/m)**		0.21	

Stage							
2	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			3.25
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1485					
	Time (min)	0	5	10	15		
	Meter reading (L)	48746	48783	48817	48849		
	Flow (L)		37	34	32		
	Average Test Flow (L/min)	31.1		**Test Flow (L/min/m)**		0.20	

Stage							
3	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1735					
	Time (min)	0	5	10	15		
	Meter reading (L)	48854	48889	48922	48955		
	Flow (L)	0	35	33	33		
	Average Test Flow (L/min)	33.7		**Test Flow (L/min/m)**		0.22	

Stage							
4	Gauge Pressure (KPa):	1250		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1985					
	Time (min)	0	5	10	15		
	Meter reading (L)	48958	48991	49025	49056		
	Flow (L)	0	33	34	31		
	Average Test Flow (L/min)	32.7		**Test Flow (L/min/m)**		0.21	

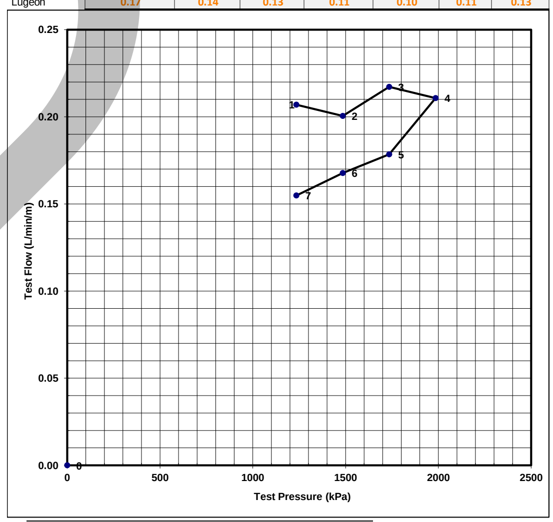
Stage							
5	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1735					
	Time (min)	0	5	10	15		
	Meter reading (L)	49059	49087	49114	49142		
	Flow (L)	0	28	27	28		
	Average Test Flow (L/min)	27.7		**Test Flow (L/min/m)**		0.18	

Stage							
6	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1485					
	Time (min)	0	5	10	15		
	Meter reading (L)	49144	49170	49196	49222		
	Flow (L)	0	26	26	26		
	Average Test Flow (L/min)	26.0		**Test Flow (L/min/m)**		0.17	

Stage							
7	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1235					
	Time (min)	0	5	10	15		
	Meter reading (L)	49226	49250	49274	49298		
	Flow (L)	0	24	24	24		
	Average Test Flow (L/min)	24.0		**Test Flow (L/min/m)**		0.15	

Summary

Test Pressure (Kpa)	1235	1485	1735	1985	1735	1485	1235
Flow Rate (L/min/m)	0.21	0.20	0.22	0.21	0.18	0.17	0.15
Lugeon	0.17	0.14	0.13	0.11	0.10	0.11	0.13



Lugeon units = Test Flow (L/min/m) at 1000kPa = 0.13 (average Stage 2 - 3)

Permeability (m/day) = 1.63E-03

Permeability (m/s) = 1.89E-08

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Draft

Packer Test Data Sheet

Project:	Tomingley			**Project No.:**	TGEP		
Hole No:	RWD048	**Test No:**		Date:	28-Sep-20	Operator:	
Collar RL:	267.89	Location:	Easting (m) / Northing (m)	614188 / 6390808		Azimuth:	270

a	Declination (°):		60	
b	Depth pit base below hole collar (m)		0	For use when test sections are below pit. (Default = 0).
c	Depth to water below datum (m)	-declined	83.7	Dipper level.
d		-vertical	72.5	c.sin a
e	Height of gauge above datum (m)		1.0	
f	Depth to water below gauge (m)		73.5	d+e
g	Gauge height pressure (Kpa)		735	10f
h	Depth to top of test section (m)	-declined	350	Drill rod depth + 1.03 m
j		-vertical	303.1	h.sin a
k	Length of test section(m)		105	
m	Adopted rock density (specific gravity)		2.6	
n	Geostatic pressure on test section (KPa)		5575	[(j-d).(m-1.0)+(d-b).m].10 [b</=d]
			0	(j-b).(m-1.0).10 [For when b>d only]
p	Hydrostatic pressure on test section (Kpa)		2306	(j-d).10
q	Maximum allowable total test pressure (KPa)		4460	0.8n
r	Maximum allowable gauge test pressure (KPa)		3725	q-g
s	**Target maximum gauge test pressure (KPa)**		**1200**	should be </=1500
t	Target maximum test pressure (KPa)		1935	s+g
u	Target inflation pressure at packer (KPa)		2322	1.2t
v	**Target packer inflation gauge pressure (KPa)**		4628	u+p Press. applied = kPa
	Applied packer inflation gauge pressure (KPa)			

1						
Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
Gauge Height Pressure (Kpa):	735					
Total Test Pressure (Kpa):	1235					
Time (min)	0	5	10	15		
Meter reading (L)	46370	46431	46491	46550		
Flow (L)	0	61	60	59		
Average Test Flow (L/min)	60.0		**Test Flow (L/min/m)**		0.57	

2						
Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
Gauge Height Pressure (Kpa):	735					
Total Test Pressure (Kpa):	1485					
Time (min)	0	5	10	15		
Meter reading (L)	46630	46663	46691	46716		
Flow (L)		33	28	25		
Average Test Flow (L/min)	28.7		**Test Flow (L/min/m)**		0.27	

3						
Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
Gauge Height Pressure (Kpa):	735					
Total Test Pressure (Kpa):	1735					
Time (min)	0	5	10	15		
Meter reading (L)	46767	46813	46838	46910		
Flow (L)	0	46	25	72		
Average Test Flow (L/min)	47.7		**Test Flow (L/min/m)**		0.45	

4						
Gauge Pressure (KPa):	1250		Gland packer leakage (L/min)			0
Gauge Height Pressure (Kpa):	735					
Total Test Pressure (Kpa):	1985					
Time (min)	0	5	10	15		
Meter reading (L)	47005	47089	47176	47251		
Flow (L)	0	84	87	75		
Average Test Flow (L/min)	82.0		**Test Flow (L/min/m)**		0.78	

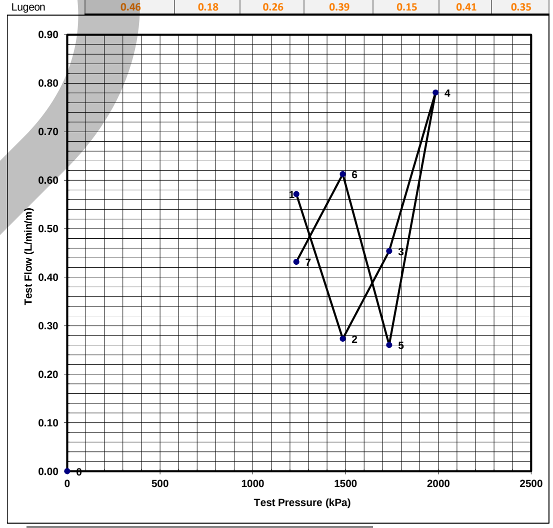
5						
Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
Gauge Height Pressure (Kpa):	735					
Total Test Pressure (Kpa):	1735					
Time (min)	0	5	10	15		
Meter reading (L)	47341	47390	47401	47423		
Flow (L)	0	49	11	22		
Average Test Flow (L/min)	27.3		**Test Flow (L/min/m)**		0.26	

6						
Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
Gauge Height Pressure (Kpa):	735					
Total Test Pressure (Kpa):	1485					
Time (min)	0	5	10	15		
Meter reading (L)	47501	47568	47631	47694		
Flow (L)	0	67	63	63		
Average Test Flow (L/min)	64.3		**Test Flow (L/min/m)**		0.61	

7						
Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
Gauge Height Pressure (Kpa):	735					
Total Test Pressure (Kpa):	1235					
Time (min)	0	5	10	15		
Meter reading (L)	47748	47789	47838	47884		
Flow (L)	0	41	49	46		
Average Test Flow (L/min)	45.3		**Test Flow (L/min/m)**		0.43	

Summary

Test Pressure (Kpa)	1235	1485	1735	1985	1735	1485	1235
Flow Rate (L/min/m)	0.57	0.27	0.45	0.78	0.26	0.61	0.43
Lugeon	0.46	0.18	0.26	0.39	0.15	0.41	0.35



Lugeon units = Test Flow (L/min/m) at 1000kPa =	0.32	(average of all stages)
Permeability (m/day) =	**3.96E-03**	
Permeability (m/s) =	**4.59E-08**	

\\Jacobs.com\ANZ\IE\Projects\05_Northern\IH191000\06_Technical\Groundwater\Packer testing\[Packer Test_RWD048.xls]350-455

Draft

Packer Test Data Sheet

Project: Tomingley				**Project No.:** TGEP		
Hole No:	RWD048	**Test No:**		Date:	28-Sep-20	Operator:
Collar RL:	267.89	Location:	Easting (m) / Northing (m)	614188 / 6390808	Azimuth:	270

a	Declination (°):		60	
b	Depth pit base below hole collar (m)		0	For use when test sections are below pit. (Default = 0).
c	Depth to water below datum (m)	-declined	83.7	Dipper level.
d		-vertical	72.5	c.sin a
e	Height of gauge above datum (m)		1.0	
f	Depth to water below gauge (m)		73.5	d+e
g	Gauge height pressure (Kpa)		735	10f
h	Depth to top of test section (m)	-declined	400	Drill rod depth + 1.03 m
j		-vertical	346.4	h.sin a
k	Length of test section(m)		55	
m	Adopted rock density (specific gravity)		2.6	
n	Geostatic pressure on test section (KPa)		6267	[(j-d).(m-1.0)+(d-b).m].10 [b</=d]
			0	(j-b).(m-1.0).10 [For when b>d only]
p	Hydrostatic pressure on test section (Kpa)		2739	(j-d).10
q	Maximum allowable total test pressure (KPa)		5014	0.8n
r	Maximum allowable gauge test pressure (KPa)		4279	q-g
s	**Target maximum gauge test pressure (KPa)**		**1200**	should be </=1500
t	Target maximum test pressure (KPa)		1935	s+g
u	Target inflation pressure at packer (KPa)		2322	1.2t
v	**Target packer inflation gauge pressure (KPa)**		5061	u+p Press. applied = kPa
	Applied packer inflation gauge pressure (KPa)			

Stage							
1	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			3.25
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1235					
	Time (min)	0	5	10	15		
	Meter reading (L)	44908	44953	44990	45038		
	Flow (L)	0	45	37	48		
	Average Test Flow (L/min)	40.1		**Test Flow (L/min/m)**		0.73	

Stage							
2	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1485					
	Time (min)	0	5	10	15		
	Meter reading (L)	45098	45144	45189	45234		
	Flow (L)		46	45	45		
	Average Test Flow (L/min)	45.3		**Test Flow (L/min/m)**		0.82	

Stage							
3	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1735					
	Time (min)	0	5	10	15		
	Meter reading (L)	45300	45346	45391	45434		
	Flow (L)	0	46	45	43		
	Average Test Flow (L/min)	44.7		**Test Flow (L/min/m)**		0.81	

Stage							
4	Gauge Pressure (KPa):	1250		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1985					
	Time (min)	0	5	10	15		
	Meter reading (L)	45491	45537	45579	45619		
	Flow (L)	0	46	42	40		
	Average Test Flow (L/min)	42.7		**Test Flow (L/min/m)**		0.78	

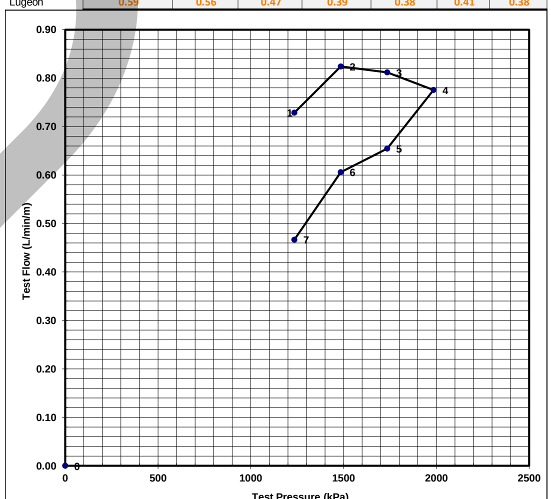
Stage							
5	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1735					
	Time (min)	0	5	10	15		
	Meter reading (L)	45660	45697	45732	45768		
	Flow (L)	0	37	35	36		
	Average Test Flow (L/min)	36.0		**Test Flow (L/min/m)**		0.65	

Stage							
6	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1485					
	Time (min)	0	5	10	15		
	Meter reading (L)	45803	45837	45871	45903		
	Flow (L)	0	34	34	32		
	Average Test Flow (L/min)	33.3		**Test Flow (L/min/m)**		0.61	

Stage							
7	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1235					
	Time (min)	0	5	10	15		
	Meter reading (L)	45932	45958	45983	46009		
	Flow (L)	0	26	25	26		
	Average Test Flow (L/min)	25.7		**Test Flow (L/min/m)**		0.47	

Summary

Test Pressure (Kpa)	1235	1485	1735	1985	1735	1485	1235
Flow Rate (L/min/m)	0.73	0.82	0.81	0.78	0.65	0.61	0.47
Lugeon	0.59	0.56	0.47	0.39	0.38	0.41	0.38



Lugeon units = Test Flow (L/min/m) at 1000kPa =	0.54	(average Stage 1 - 3)
Permeability (m/day) =	**6.74E-03**	
Permeability (m/s) =	**7.80E-08**	

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Draft

Packer Test Data Sheet

Project:	Tomingley			**Project No.:**	TGEP		
Hole No:	RWD048	**Test No:**		Date:	28-Sep-20	Operator:	
Collar RL:	267.89	Location:	Easting (m) / Northing (m)	614188 / 6390808		Azimuth:	270

a	Declination (°):		60	
b	Depth pit base below hole collar (m)		0	For use when test sections are below pit. (Default = 0).
c	Depth to water below datum (m)	-declined	83.7	Dipper level.
d		-vertical	72.5	c.sin a
e	Height of gauge above datum (m)		1.0	
f	Depth to water below gauge (m)		73.5	d+e
g	Gauge height pressure (Kpa)		735	10f
h	Depth to top of test section (m)	-declined	446	Drill rod depth + 1.03 m
j		-vertical	386.2	h.sin a
k	Length of test section(m)		9	
m	Adopted rock density (specific gravity)		2.6	
n	Geostatic pressure on test section (KPa)		6905	[(j-d).(m-1.0)+(d-b).m].10 [b</=d]
			0	(j-b).(m-1.0).10 [For when b>d only]
p	Hydrostatic pressure on test section (Kpa)		3138	(j-d).10
q	Maximum allowable total test pressure (KPa)		5524	0.8n
r	Maximum allowable gauge test pressure (KPa)		4789	q-g
s	**Target maximum gauge test pressure (KPa)**		**1200**	should be </=1500
t	Target maximum test pressure (KPa)		1935	s+g
u	Target inflation pressure at packer (KPa)		2322	1.2t
v	**Target packer inflation gauge pressure (KPa)**		5459	u+p Press. applied = kPa
	Applied packer inflation gauge pressure (KPa)		6250	

1	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1235					
	Time (min)	0	5	10	15		
	Meter reading (L)	43796	43861	43920	43978		
	Flow (L)	0	65	59	58		
	Average Test Flow (L/min)	60.7		**Test Flow (L/min/m)**		6.74	

2	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1485					
	Time (min)	0	5	10	15		
	Meter reading (L)	43986	44054	44121	44187		
	Flow (L)		68	67	66		
	Average Test Flow (L/min)	67.0		**Test Flow (L/min/m)**		7.44	

3	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1735					
	Time (min)	0	5	10	15		
	Meter reading (L)	44192	44266				
	Flow (L)	0	74				
	Average Test Flow (L/min)	74.0		**Test Flow (L/min/m)**		8.22	

4	Gauge Pressure (KPa):	1250		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1985					
	Time (min)	0	5	10	15		
	Meter reading (L)						
	Flow (L)	0	0	0	0		
	Average Test Flow (L/min)	0.0		**Test Flow (L/min/m)**		0.00	

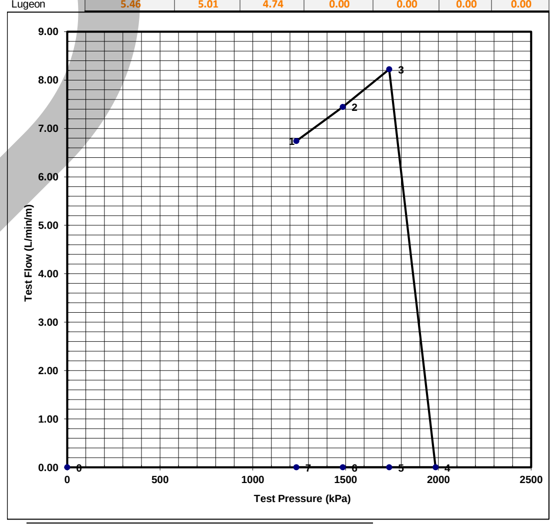
5	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1735					
	Time (min)	0	5	10	15		
	Meter reading (L)						
	Flow (L)	0	0	0	0		
	Average Test Flow (L/min)	0.0		**Test Flow (L/min/m)**		0.00	

6	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1485					
	Time (min)	0	5	10	15		
	Meter reading (L)						
	Flow (L)	0	0	0	0		
	Average Test Flow (L/min)	0.0		**Test Flow (L/min/m)**		0.00	

7	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	735					
	Total Test Pressure (Kpa):	1235					
	Time (min)	0	5	10	15		
	Meter reading (L)						
	Flow (L)	0	0	0	0		
	Average Test Flow (L/min)	0.0		**Test Flow (L/min/m)**		0.00	

Summary

Test Pressure (Kpa)	1235	1485	1735	1985	1735	1485	1235
Flow Rate (L/min/m)	6.74	7.44	8.22	0.00	0.00	0.00	0.00
Lugeon	5.46	5.01	4.74	0.00	0.00	0.00	0.00



Lugeon units = Test Flow (L/min/m) at 1000kPa =	5.07	(average Stage 1 - 3)
Permeability (m/day) =	**6.35E-02**	
Permeability (m/s) =	**7.35E-07**	

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Draft

Packer Test Data Sheet

Project: Tomingley				**Project No.:** TGEP		
Hole No:	RWMET01	**Test No:**		Date:	29-Sep-20	Operator:
Collar RL:	267.03	Location:	Easting (m) / Northing (m)	613965 / 6390690	Azimuth:	

a	Declination (°):		90	
b	Depth pit base below hole collar (m)		0	For use when test sections are below pit. (Default = 0).
c	Depth to water below datum (m)	-declined	75.0	Dipper level.
d		-vertical	75.0	c.sin a
e	Height of gauge above datum (m)		1.0	
f	Depth to water below gauge (m)		76.0	d+e
g	Gauge height pressure (Kpa)		760	10f
h	Depth to top of test section (m)	-declined	96	Drill rod depth + 1.03 m
j		-vertical	96.0	h.sin a
k	Length of test section(m)		100	
m	Adopted rock density (specific gravity)		2.6	
n	Geostatic pressure on test section (KPa)		2286	[(j-d).(m-1.0)+(d-b).m].10 [b</=d]
			0	(j-b).(m-1.0).10 [For when b>d only]
p	Hydrostatic pressure on test section (Kpa)		210	(j-d).10
q	Maximum allowable total test pressure (KPa)		1829	0.8n
r	Maximum allowable gauge test pressure (KPa)		1069	q-g
s	**Target maximum gauge test pressure (KPa)**		**1200**	should be </=1500
t	Target maximum test pressure (KPa)		1960	s+g
u	Target inflation pressure at packer (KPa)		2352	1.2t
v	**Target packer inflation gauge pressure (KPa)**		2562	u+p Press. applied = kPa
	Applied packer inflation gauge pressure (KPa)			

1						
Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
Gauge Height Pressure (Kpa):	760					
Total Test Pressure (Kpa):	1260					
Time (min)	0	5	10	15	20	25
Meter reading (L)	3380	3443	3507	3572		
Flow (L)	0	63	64	65		
Average Test Flow (L/min)	64.0		**Test Flow (L/min/m)**		0.64	

2						
Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
Gauge Height Pressure (Kpa):	760					
Total Test Pressure (Kpa):	1510					
Time (min)	0	5	10	15	20	25
Meter reading (L)	3664	3745	3832	3914		
Flow (L)		81	87	82		
Average Test Flow (L/min)	83.3		**Test Flow (L/min/m)**		0.83	

3						
Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
Gauge Height Pressure (Kpa):	760					
Total Test Pressure (Kpa):	1760					
Time (min)	0	5	10	15	20	25
Meter reading (L)	4037	4148	4257	4366		
Flow (L)	0	111	109	109		
Average Test Flow (L/min)	109.7		**Test Flow (L/min/m)**		1.10	

4						
Gauge Pressure (KPa):	1250		Gland packer leakage (L/min)			0
Gauge Height Pressure (Kpa):	760					
Total Test Pressure (Kpa):	2010					
Time (min)	0	5	10	15	20	25
Meter reading (L)	4508	4648	4771	4900		
Flow (L)	0	140	123	129		
Average Test Flow (L/min)	130.7		**Test Flow (L/min/m)**		1.31	

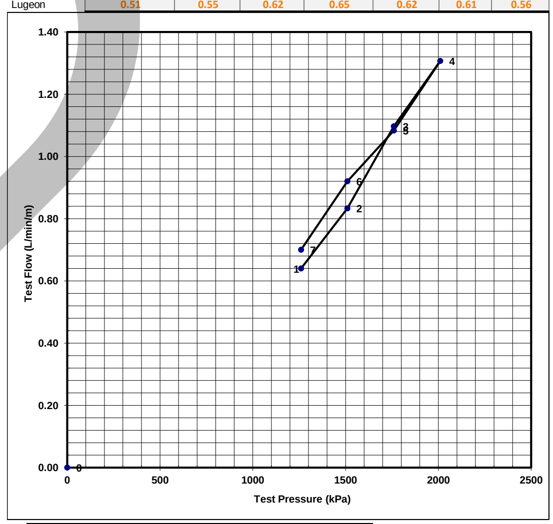
5						
Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
Gauge Height Pressure (Kpa):	760					
Total Test Pressure (Kpa):	1760					
Time (min)	0	5	10	15	20	25
Meter reading (L)	5041	5148	5253	5366		
Flow (L)	0	107	105	113		
Average Test Flow (L/min)	108.3		**Test Flow (L/min/m)**		1.08	

6						
Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
Gauge Height Pressure (Kpa):	760					
Total Test Pressure (Kpa):	1510					
Time (min)	0	5	10	15	20	25
Meter reading (L)	5480	5578	5675	5756		
Flow (L)	0	98	97	81		
Average Test Flow (L/min)	92.0		**Test Flow (L/min/m)**		0.92	

7						
Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
Gauge Height Pressure (Kpa):	760					
Total Test Pressure (Kpa):	1260					
Time (min)	0	5	10	15	20	25
Meter reading (L)	5842	5913	5984	6052		
Flow (L)	0	71	71	68		
Average Test Flow (L/min)	70.0		**Test Flow (L/min/m)**		0.70	

Summary

Test Pressure (Kpa)	1260	1510	1760	2010	1760	1510	1260
Flow Rate (L/min/m)	0.64	0.83	1.10	1.31	1.08	0.92	0.70
Lugeon	0.51	0.55	0.62	0.65	0.62	0.61	0.56



Lugeon units = Test Flow (L/min/m) at 1000kPa = 0.51 (Stage 1, lowest lugeon for a stage)

Permeability (m/day) = 6.36E-03

Permeability (m/s) = 7.37E-08

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k m/s	6.60317E-08	7.1744E-08	8.1004E-08	8.45108E-08	8.0019E-08	7.92E-08	7.222E-08
k m/d	0.005705143	0.00619868	0.00699873	0.007301731	0.00691364	0.006843	0.00624

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Packer Test Data Sheet

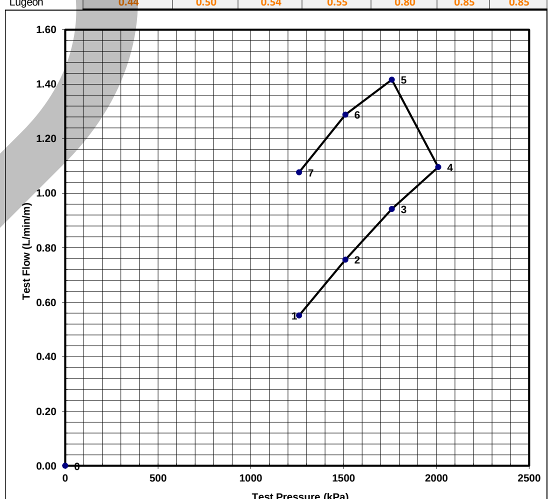
Project:	Tomingley		**Project No.:**	TGEP	
Hole No:	RWMET01	**Test No:**		Date: 29-Sep-20	Operator:
Collar RL:	267.03	Location:	Easting (m) 613965 / Northing (m) 6390690		Azimuth:

			Value	Notes
a	Declination (°):		90	
b	Depth pit base below hole collar (m)		0	For use when test sections are below pit. (Default = 0).
c	Depth to water below datum (m)	-declined	75.0	Dipper level.
d		-vertical	75.0	c.sin a
e	Height of gauge above datum (m)		1.0	
f	Depth to water below gauge (m)		76.0	d+e
g	Gauge height pressure (Kpa)		760	10f
h	Depth to top of test section (m)	-declined	144	Drill rod depth + 1.03 m
j		-vertical	144.0	h.sin a
k	Length of test section(m)		52	
m	Adopted rock density (specific gravity)		2.6	
n	Geostatic pressure on test section (KPa)		3054	[(j-d).(m-1.0)+(d-b).m].10 [b</=d]
			0	(j-b).(m-1.0).10 [For when b>d only]
p	Hydrostatic pressure on test section (Kpa)		690	(j-d).10
q	Maximum allowable total test pressure (KPa)		2443	0.8n
r	Maximum allowable gauge test pressure (KPa)		1683	q-g
s	**Target maximum gauge test pressure (KPa)**		**1200**	should be </=1500
t	Target maximum test pressure (KPa)		1960	s+g
u	Target inflation pressure at packer (KPa)		2352	1.2t
v	**Target packer inflation gauge pressure (KPa)**		3042	u+p Press. applied = kPa
	Applied packer inflation gauge pressure (KPa)			

Stage							
1	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	760					
	Total Test Pressure (Kpa):	1260					
	Time (min)	0	5	10	15		
	Meter reading (L)	1173	1200	1231	1259		
	Flow (L)	0	27	31	28		
	Average Test Flow (L/min)	28.7		**Test Flow (L/min/m)**		0.55	
2	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	760					
	Total Test Pressure (Kpa):	1510					
	Time (min)	0	5	10	15		
	Meter reading (L)	1328	1362	1403	1446		
	Flow (L)		34	41	43		
	Average Test Flow (L/min)	39.3		**Test Flow (L/min/m)**		0.76	
3	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	760					
	Total Test Pressure (Kpa):	1760					
	Time (min)	0	5	10	15		
	Meter reading (L)	1521	1569	1617	1668		
	Flow (L)	0	48	48	51		
	Average Test Flow (L/min)	49.0		**Test Flow (L/min/m)**		0.94	
4	Gauge Pressure (KPa):	1250		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	760					
	Total Test Pressure (Kpa):	2010					
	Time (min)	0	5	10	15		
	Meter reading (L)	1733	1789	1843	1904		
	Flow (L)	0	56	54	61		
	Average Test Flow (L/min)	57.0		**Test Flow (L/min/m)**		1.10	
5	Gauge Pressure (KPa):	1000		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	760					
	Total Test Pressure (Kpa):	1760					
	Time (min)	0	5	10	15		
	Meter reading (L)	1989	2058	2132	2210		
	Flow (L)	0	69	74	78		
	Average Test Flow (L/min)	73.7		**Test Flow (L/min/m)**		1.42	
6	Gauge Pressure (KPa):	750		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	760					
	Total Test Pressure (Kpa):	1510					
	Time (min)	0	5	10	15		
	Meter reading (L)	2300	2362	2435	2501		
	Flow (L)	0	62	73	66		
	Average Test Flow (L/min)	67.0		**Test Flow (L/min/m)**		1.29	
7	Gauge Pressure (KPa):	500		Gland packer leakage (L/min)			0
	Gauge Height Pressure (Kpa):	760					
	Total Test Pressure (Kpa):	1260					
	Time (min)	0	5	10	15		
	Meter reading (L)	2574	2631	2684	2742		
	Flow (L)	0	57	53	58		
	Average Test Flow (L/min)	56.0		**Test Flow (L/min/m)**		1.08	

Summary

Test Pressure (Kpa)	1260	1510	1760	2010	1760	1510	1260
Flow Rate (L/min/m)	0.55	0.76	0.94	1.10	1.42	1.29	1.08
Lugeon	0.44	0.50	0.54	0.55	0.80	0.85	0.85



Lugeon units = Test Flow (L/min/m) at 1000kPa =	0.85	(Stage 7)
Permeability (m/day) =	**1.07E-02**	
Permeability (m/s) =	**1.24E-07**	

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Airlift yield recovery analysis sheets (4 sheets)

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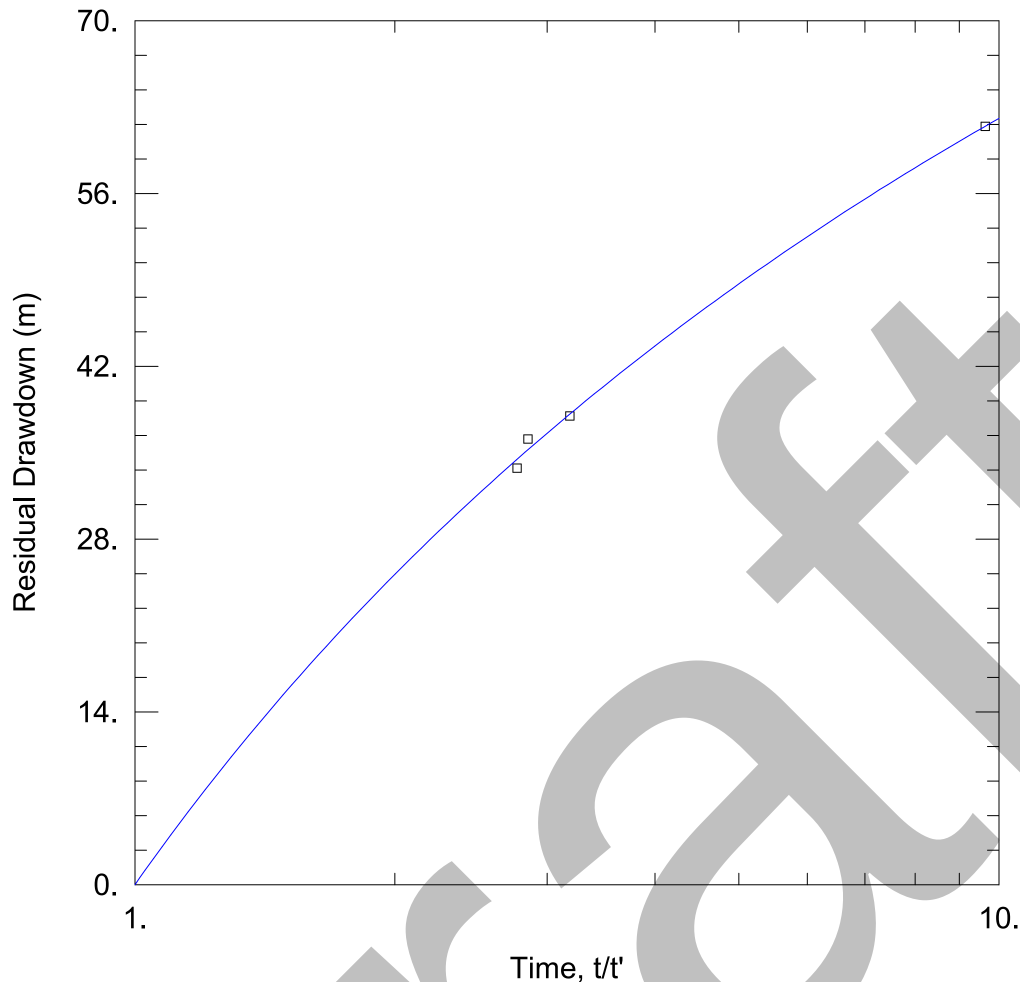

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RWRC387 AIRLIFT RECOVERY

Data Set: \...\RWRC387.aqt
Date: 01/15/21 Time: 13:01:54

PROJECT INFORMATION

Company: Jacobs
Client: R.W Corkery & Co
Project: IH191000
Location: TGEP
Test Well: RWRC387

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
RWRC387	613760	613760

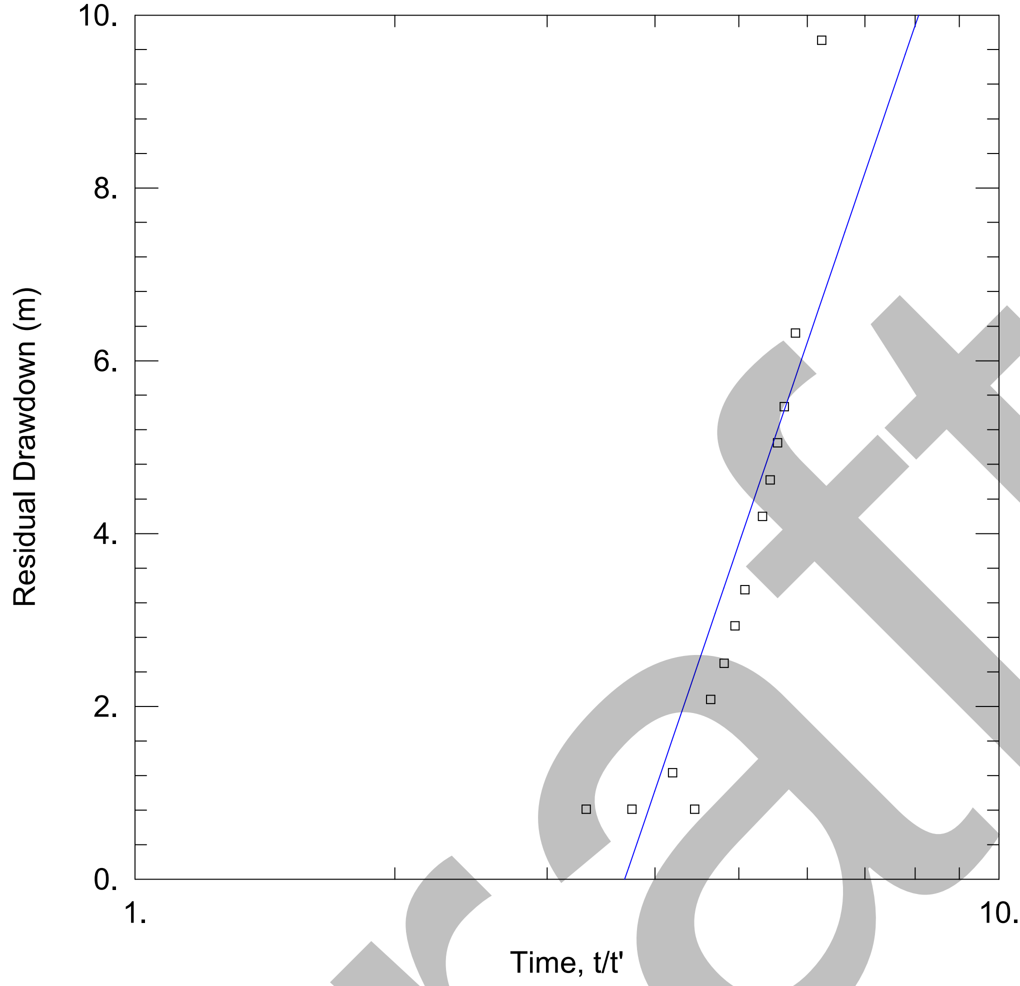
Observation Wells

Well Name	X (m)	Y (m

SOLUTION

Aquifer Model: Confined
Solution Method: Theis

T = 0.01786 m^2/day
Kz/Kr = 1.
S = 0.02217
b = 161. m



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RWRC401 AIRLIFT RECOVERY

Data Set:
Date: 01/15/21 Time: 14:21:21

PROJECT INFORMATION

Company: Jacobs
Client: R.W Corkery & Co
Project: IH191000
Location: TGEP
Test Well: RWRC401

AQUIFER DATA

Saturated Thickness: 65. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
RWRC401	613805	6390290

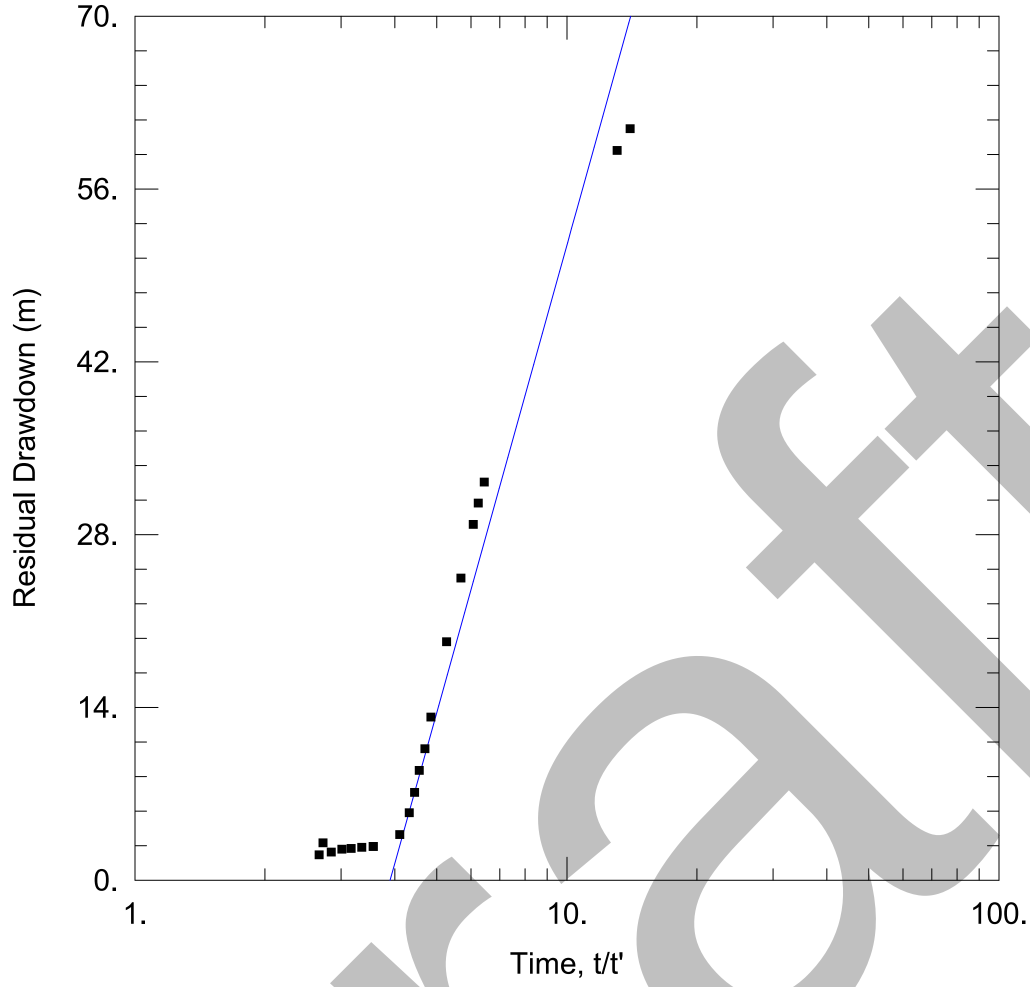
Observation Wells

Well Name	X (m)	Y (m)

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 0.1058 m^2/day S/S' = 3.69



Draft

RWRC403

Data Set: \...\RWRC403.aqt
Date: 01/15/21 Time: 15:12:24

PROJECT INFORMATION

Company: Jacobs
Client: R.W Corkery & Co
Project: IH191000
Location: TGEP
Test Well: RWRC401

AQUIFER DATA

Saturated Thickness: 131. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
RWRC403	613811	6390140

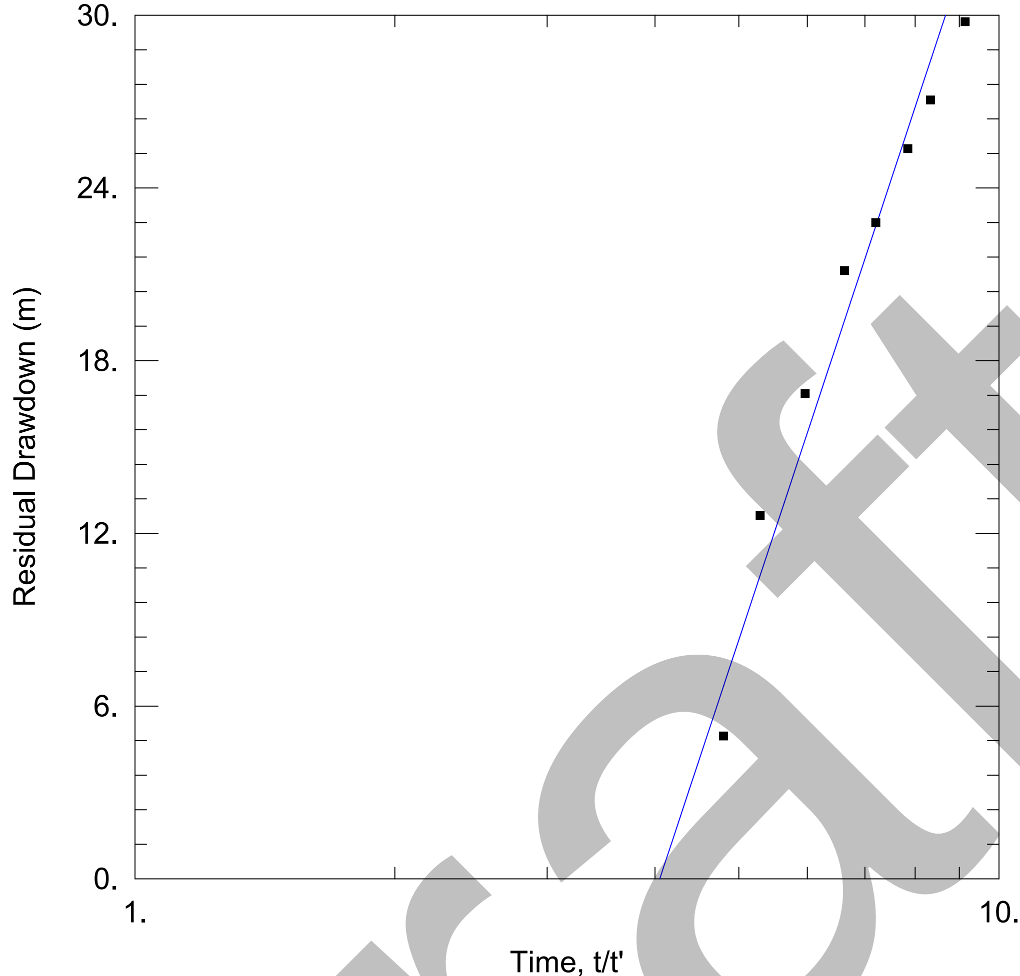
Observation Wells

Well Name	X (m)	Y (m)

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 0.006325 m^2/day S/S' = 3.898



RWRC418 AIRLIFT RECOVERY

Data Set: \...\RWRC418.aqt
Date: 01/15/21 Time: 16:30:47

PROJECT INFORMATION

Company: Jacobs
Client: R.W Corkery & Co
Project: IH191000
Location: TGEP
Test Well: RWRC418

AQUIFER DATA

Saturated Thickness: 94. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
RWRC418	613738	6389812

Observation Wells

Well Name	X (m)	Y (m)

SOLUTION

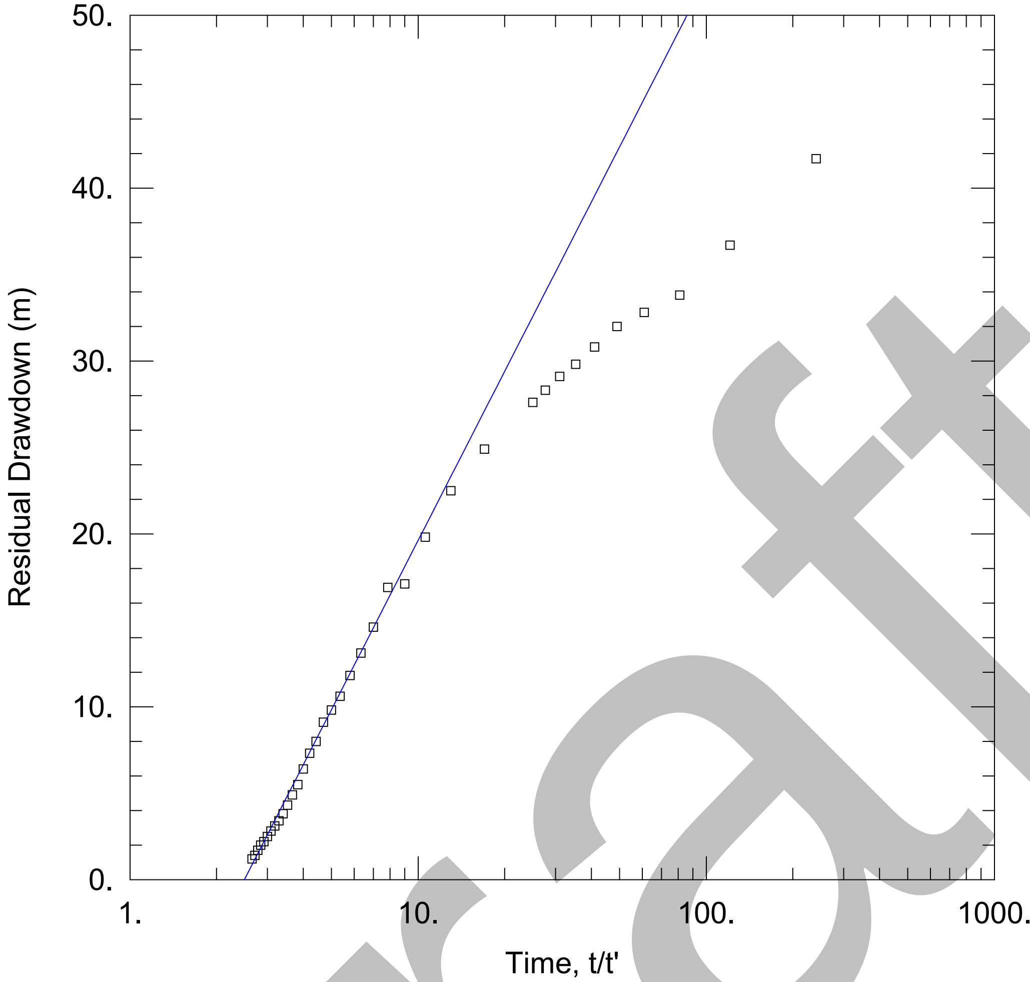
Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 0.004765 m^2/day S/S' = 4.051

Draft

TGEP groundwater monitoring bore hydraulic test analysis sheets (2 sheets)

Draft



RWWB001 AIRLIFT RECOVERY TEST

Data Set: \...\RWWB001.aqt
Date: 01/18/21 Time: 11:20:14

PROJECT INFORMATION

Company: Jacobs
Client: R.W Corkery & Co
Project: IH191000
Location: TGEP
Test Well: RWWB001
Test Date: 12.10.2020

AQUIFER DATA

Saturated Thickness: 86. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
RWWB001	614132	6391126

Observation Wells

Well Name	X (m)	Y (m)
□ RWWB001	614132	6391126

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 0.09729 m^2/day S/S' = 2.496

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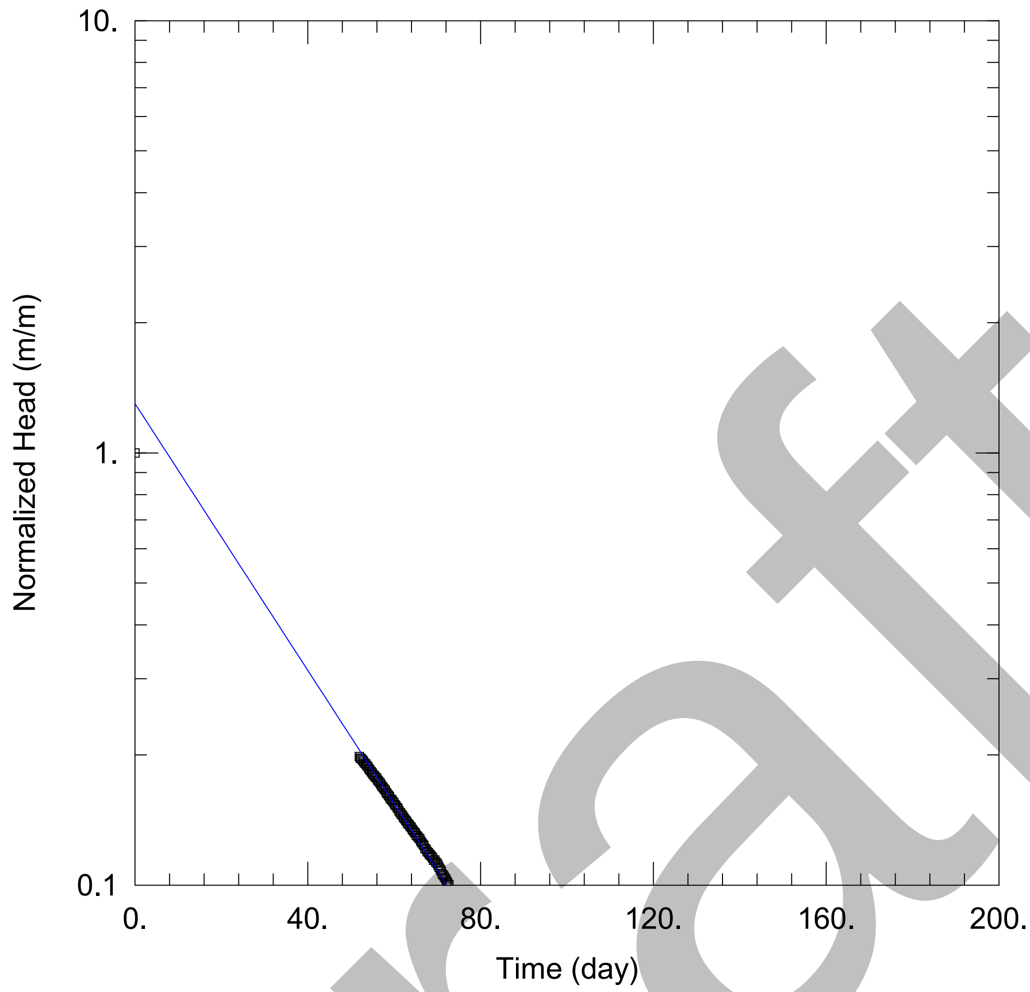

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RWWB002 POST-DRILLING WATER LEVEL RECOVERY

Data Set: \...\RWWB002_slug test solution.aqt
Date: 01/19/21 Time: 12:24:09

PROJECT INFORMATION

Company: Jacobs
Client: R.W Corkery & Co
Project: IH191000
Location: TGEP
Test Well: RWWB002

AQUIFER DATA

Saturated Thickness: 79.2 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (RWWB002)

Initial Displacement: 79.2 m Static Water Column Height: 79.2 m
Total Well Penetration Depth: 150.2 m Screen Length: 30. m
Casing Radius: 0.025 m Well Radius: 0.025 m

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev
K = 2.881E-6 m/day y0 = 103. m

Appendix D. GFM sensitivity and uncertainty analysis

Sensitivity analysis

A sensitivity analysis was conducted on the transient calibration model for the following parameters:

- Hydraulic conductivity
- Recharge
- ET
- Specific storage
- Specific yield
- DRN conductance for Wyoming 1 U/G

The adopted final calibrated parameter values were subjected to multipliers of 0.75 and 1.25 to generate revised model parameters. The model was then run separately for each revised parameter value. The multipliers and parameter values are shown in **Table D.1**.

The results are shown in **Table D.2**, which tabulates the sum of squared residuals (of the head targets) for each model run. The results indicate that the model is relatively sensitive to hydraulic conductivity and recharge. The other parameters tested in the sensitivity analysis, EVT, specific storage, specific yield and Wyoming 1 underground DRN conductance were significantly less sensitive.

The results show that the model's sum of squared residuals is reduced when hydraulic conductivity is increased, or when recharge is reduced. This occurs because these changes lower the head and the base case calibration head is overstated in the vicinity of TGO/TGP, where the majority of head observations are located.

Table D.1: Transient calibration period sensitivity analysis parameter multipliers and values

Parameter	Base value parameter multiplier		
	0.75	**1 (i.e. base value)**	**1.25**
Horizontal hydraulic conductivity (m/d) [1]	Zone 1: 0.0375 Zone 2 and 3: 0.0075 Zone 4 -7: 0.0008	Zone 1: 0.05 Zone 2 and 3: 0.01 Zone 4 -7: 0.001	Zone 1: 0.0625 Zone 2 and 3: 0.0125 Zone 4 -7: 0.0013
Recharge rate as % of mean annual rainfall	Zone 1: 0.1334 Zone 2: 0.0267	Zone 1: 0.1779 Zone 2: 0.0356	Zone 1: 0.2224 Zone 2: 0.0445
ET (mm/d)	2.95	3.93	4.91
Specific storage	9.8×10^{-8}	1.3×10^{-7}	1.6×10^{-7}
Specific yield (%)	5.6	7.5	9.4
DRN conductance for Wyoming 1 U/G	0.019	0.025	0.031

Notes: [1] Applied vertical hydraulic conductivity = 1/10 x horizontal hydraulic conductivity.

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Table D.2: Transient calibration period sensitivity analysis results

Parameter	Base value parameter multiplier		
	0.75	**1 (i.e. base value)**	**1.25**
	Sum of squared residuals [% deviation from base]		
Horizontal hydraulic conductivity	6.97×10^5 [96]	3.56×10^5	2.05×10^5 [-42]
Recharge	1.50×10^5 [-58]	3.56×10^5	5.58×10^5 [57]
ET	3.58×10^5 [0.57]	3.56×10^5	3.58×10^5 [0.57]
Specific storage	3.56×10^5 [0.01]	3.56×10^5	3.56×10^5 [0.01]
Specific yield	3.55×10^5 [-0.27]	3.56×10^5	3.58×10^5 [0.57]
DRN conductance for Wyoming 1 U/G	3.58×10^5 [0.57]	3.56×10^5	3.55×10^5 [-0.27]

Uncertainty analysis

An uncertainty analysis was conducted using four variants of the transient prediction model, with each variant representing a specific uncertainty scenario. The modelled uncertainty scenarios were as follows:

- Increased hydraulic conductivity and recharge – base case values increased by 1.5 multiplier
- Decreased hydraulic conductivity and recharge – base case values decreased by 0.5 multiplier
- Increased storage – base case specific storage and specific yield values increased by one order of magnitude and 1.5 multiplier, respectively.
- Decreased storage – base case specific storage and specific yield values decreased by one order of magnitude and 0.5 multiplier, respectively.

Total DRN flow rate at the end of mining and the 2 m drawdown contour at the end of mining were compared to assess the results. Drawdown for each of the uncertainty scenarios was calculated using results from a corresponding null case model run for which all the DRNs were deleted.

The base case and uncertainty scenario individual parameter values are shown in **Table D.3**.

The base case and uncertainty scenario total DRN flow rates at the end of mining are shown in **Table D.4**. The largest increase (82%) from the base case flow rate occurs under the increased storage scenario. The largest decrease (53%) from the base case flow rate occurs under the decreased hydraulic conductivity and recharge scenario. Based on all the uncertainty scenario DRN flow rates, none of the uncertainty scenarios alter the primary base case assessment finding, which is that acquiring entitlement to cover the groundwater take is considered feasible due to the extent of predicted groundwater inflow rates, trading frequency in the water source and percentage of unallocated water in the water source.

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Table D.3: Base case and uncertainty scenario individual parameter values

Parameter	Base value parameter multiplier		
	0.5 (0.1 for specific storage)	**1 (i.e. base value)**	**1.5 (10 for specific storage)**
Horizontal hydraulic conductivity (m/d) [1]	Zone 1: 0.025 Zone 2 and 3: 0.005 Zone 4 -7: 0.0005	Zone 1: 0.05 Zone 2 and 3: 0.01 Zone 4 -7: 0.001	Zone 1: 0.075 Zone 2 and 3: 0.015 Zone 4 -7: 0.0015
Recharge rate as % of mean annual rainfall	Zone 1: 0.0890 Zone 2: 0.0178	Zone 1: 0.1779 Zone 2: 0.0356	Zone 1: 0.2669 Zone 2: 0.0095
Specific storage	$1.3x10^{-8}$	$1.3x10^{-7}$	$1.3x10^{-6}$
Specific yield (%)	3.75	7.5	11.25

Notes: [1] Applied vertical hydraulic conductivity = 1/10 x horizontal hydraulic conductivity.

Table D.4: Base case and uncertainty scenario total DRN flow rate at end of mining

Uncertainty scenario	Total DRN flow rate at end of mining (kL/d) [% increase from base case]
Base case	2,496
Increased hydraulic conductivity and recharge	3,328 [33]
Decreased hydraulic conductivity and recharge	1,569 [-53]
Increased storage	2,854 [82]
Decreased storage	2,048 [-28]

The 2 m drawdown contour at the end of mining is shown for all four uncertainty scenarios in **Figure D.1**. Based on all the uncertainty scenario 2 m drawdown contours at the end of mining, none of the uncertainty scenarios are considered likely to significantly alter the primary base case assessment findings relating to groundwater level drawdown impacts.

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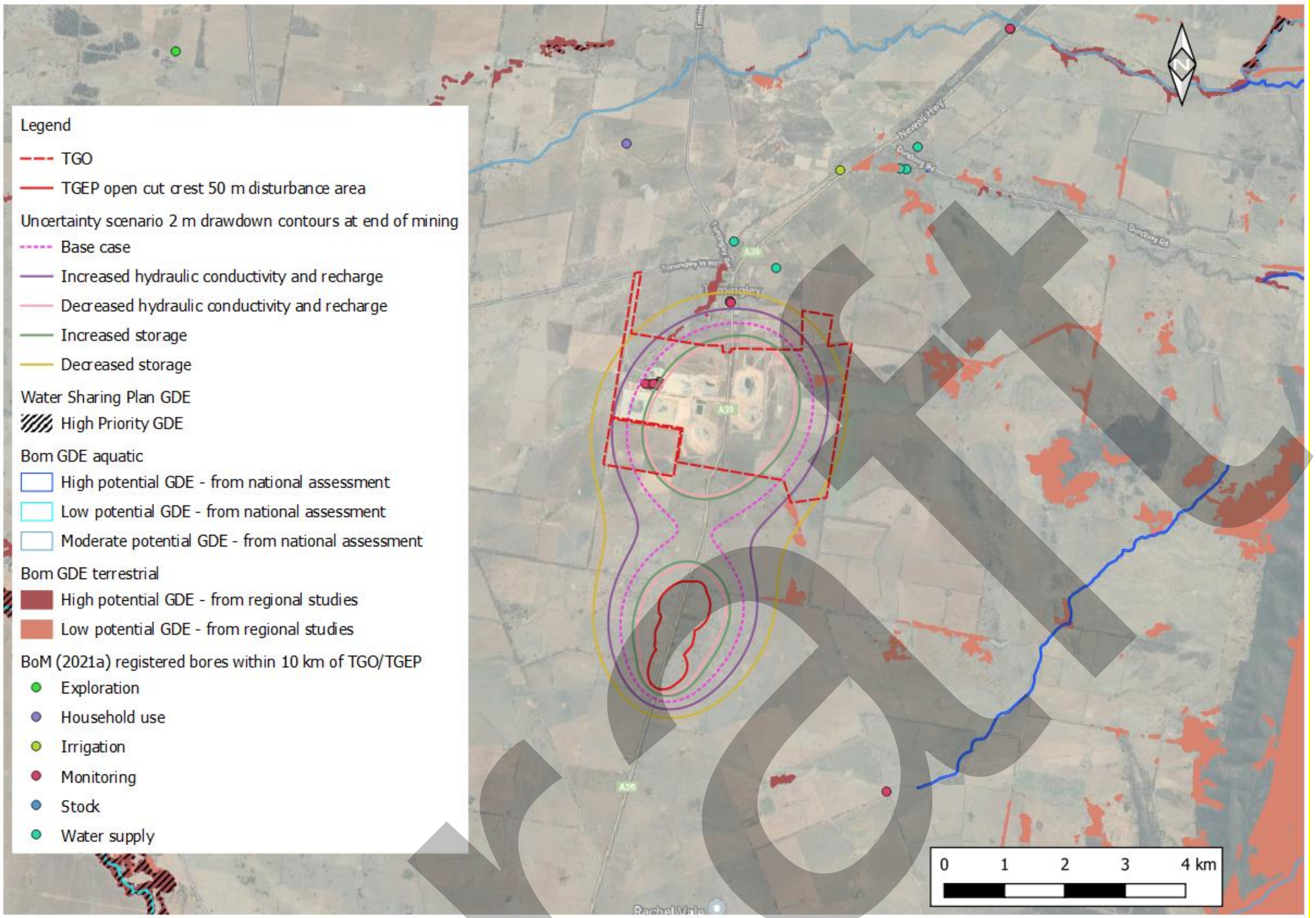

Figure D.1: Uncertainty scenario 2 m drawdown contours at end of mining

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Appendix E. Final void water level recovery modelling

Purpose

Water balance models were developed to simulate post-mining water level recovery in the two voids which will not be backfilled, the northern portion of the TGEP open cut and the Wyoming 1 open cut at TGO. The objectives were to:

- Determine approximate equilibrium water levels, to inform groundwater modelling of the post-mining period, and to inform impact assessment, and
- Determine salt concentrations of the void water.

Methodology

Simple individual water balance models were developed to simulate post-mining water level recovery in the northern portion of the TGEP open cut and the Wyoming 1 open cut at TGO. The models were created using a spreadsheet program.

Aside from void volumes of TGEP being represented using the formula for a cone and void volumes for Wyoming 1 being represented using the formula for a truncated cone, the general method used in the TGEP and Wyoming 1 models was the same.

The models apportioned the total void volume into multiple slices based on elevation at increments of about 10 m to 15 m. Starting from a dry pit, the time for each void slice to fill was calculated. Inflow sources comprised direct rainfall, runoff from the dry area of the void and groundwater inflow. Run off from external catchment area was not considered as the external catchment area is negligible. Outflow was limited to evaporation.

Pit lake equilibrium level is determined to be the pit lake water level applicable for the void slice which has a net flux closest to zero.

Groundwater inflow rates were determined using the GFM by completing multiple model runs, each with different DRN level heights, to enable creation of pit lake level and groundwater inflow graphs. The line equations from the graphs were used to populate groundwater inflow rate for the different pit lake water level elevations.

Rainfall and runoff were applied daily based on long-term mean daily rainfall from SILO, with a runoff coefficient of 0.45 applied. Groundwater inflow was applied daily. For levels above the pre-mining water table, groundwater inflow rate was zero. Evaporation was applied daily based on long-term mean daily evaporation from SILO and a pan factor of 0.70. The SILO climate data is summarised in Section 3.1 of the main report.

Groundwater salinity was assigned based on monitoring bore data. Runoff and direct rainfall were assigned a salinity of 30 mg/L and 10 mg/L, respectively.

Further insight into the model parameters and structure is covered in the results section below.

Results

TGEP

TGEP water balance inputs and results are shown in Figure E.1. Net flux approaches zero for the slice which has a pit lake level of 180 mAHD (row highlighted green), meaning pit lake water level equilibrium occurs at approximately 180 mAHD.

Long-term pit lake salinity is 16,137 mg/L, 21,916 mg/L, 29,967 mg/L and 46,071 mg/L for 80 years, 200 years, 300 years and 500 years after end of mining, respectively.

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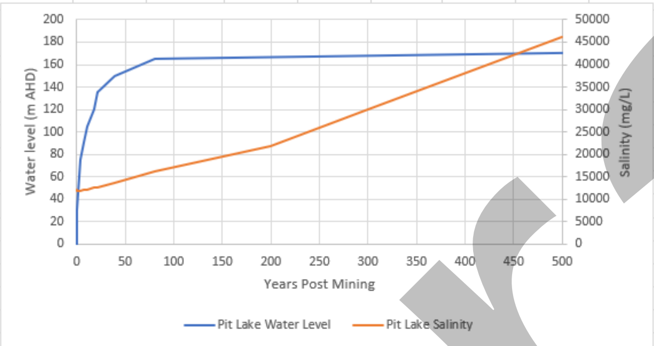
TGEP Mine Void - Water and Salt Balance

Mean Daily Rainfall	1.54 mm/d	In Pit runoff coeff.	0.45	Groundwater salinity	15400 mg/L — Mean of RWWB002 monitoring bore
Mean Daily Evaporation	5.02 mm/d	Ex Pit runoff coeff	0.35	Surface water salinity	30 mg/L
Minimum pit level (mAHD)	-27 mAHD	Pan Factor	0.70	Rainfall salinity	10 mg/L
Upstream Catchment	0 m2				

Pit Lake Water Depth (m)	Pit Lake Water Level Elevation (mAHD)	Dry Pit Area (m2)	Pit Lake Surface Area (m2)	Pit Lake Surface Area Radius (m)	Pit Lake Volume (m3)	Pit Lake Slice Volume (m3)	Direct Rainfall - IN (m3/d)	In Pit Runoff - IN (m3/d)
0	-27	435,916	0	0	0			
12	-15	434,840	1,075	18.50	4,301	4,301	1.7	301.3
27	0	431,498	4,418	37.50	39,761	35,460	6.8	299.0
42	15	427,018	8,898	53.22	124,567	84,806	13.7	295.9
57	30	420,725	15,191	69.54	288,631	164,064	23.4	291.6
72	45	412,756	23,160	85.86	555,828	267,197	35.7	286.0
87	60	403,113	32,803	102.18	951,283	395,455	50.5	279.4
102	75	391,794	44,121	118.51	1,500,120	548,837	67.9	271.5
117	90	378,801	57,114	134.83	2,227,462	727,342	88.0	262.5
132	105	364,133	71,783	151.16	3,158,435	930,973	110.5	252.3
147	120	347,790	88,126	167.49	4,318,161	1,159,727	135.7	241.0
162	135	344,715	91,201	170.38	4,924,836	606,675	140.4	238.9
177	150	319,471	116,445	192.52	6,870,232	1,945,396	179.3	221.4
192	165	291,215	144,700	214.61	9,260,817	2,390,585	222.8	201.8
207	180	259,948	175,968	236.67	12,141,767	2,880,950	271.0	180.1
222	195	225,669	210,247	258.70	15,558,258	3,416,491	323.8	156.4
231	204	203,656	232,260	271.90	17,884,005	2,325,747	357.7	141.1
232	205	201,143	234,773	273.37	18,155,750	271,745	361.5	139.4
237	210	188,378	247,538	280.70	19,555,465	1,399,715	381.2	130.5
252	225	148,076	287,840	302.69	24,178,564	4,623,099	443.3	102.6
267	240	104,761	331,154	324.67	29,472,731	5,294,167	510.0	72.6
282	255	58,435	377,480	346.63	35,483,141	6,010,410	581.3	40.5
292	265	0	435,916	372.50	42,429,120	6,945,979	671.3	0.0

Pit Lake Water Depth (m)	Ex Pit runoff - IN (m3/d)	GW Inflow - IN (m3/d)	Pit Lake Evap - OUT (m3/d)	Net Flux (m3/d)	Time to fill (days)	Cumulative Time (days)	Cumulative Time (Years)	Salt Flux (kg/d)	Incremental Salt Load (kg)	Cumulative Salt Load (kg)	Pit Lake Salinity (mg/L)
0											
12	0	1050.524	3.8	1349.7	3	3	0.01	16181	51,560	51,560	11988
27	0	983.07	15.5	1273.4	28	31	0.09	15142	421,671	473,231	11902
42	0	915.6165	31.3	1194.0	71	102	0.28	14104	1,001,752	1,474,983	11841
57	0	848.163	53.4	1109.7	148	250	0.68	13065	1,931,513	3,406,496	11802
72	0	780.7095	81.4	1021.0	262	512	1.40	12026	3,147,161	6,553,656	11791
87	0	713.256	115.3	927.9	426	938	2.57	10987	4,682,857	11,236,514	11812
102	0	645.8025	155.0	830.2	661	1,599	4.38	9949	6,576,852	17,813,365	11875
117	0	578.349	200.7	728.1	999	2,598	7.12	8910	8,900,633	26,713,998	11993
132	0	510.8955	252.2	621.5	1,498	4,096	11.22	7871	11,790,175	38,504,174	12191
147	0	443.442	309.7	510.5	2,272	6,367	17.44	6833	15,522,328	54,026,501	12511
162	0	375.9885	320.5	434.8	1,395	7,763	21.27	5794	8,083,517	62,110,018	12612
177	0	308.535	409.2	300.1	6,483	14,246	39.03	4755	30,830,560	92,940,578	13528
192	0	241.0815	508.5	157.3	15,202	29,448	80.68	3717	56,504,064	149,444,642	16137
207	0	173.628	618.4	6.4	449,318	478,766	1311.69	2678	1,203,446,035	1,352,890,678	111425
222	0	106.1745	738.8	-152.5	-22408.5	456,357	1,250	1,640	-36747464.3	1,316,143,213	84,595
231	0	65.7024	816.2	-251.6	-9242.2	447,115	1,225	1,017	-9397491.2	1,306,745,722	73,068
232	0	0	825.0	-324.0	-838.6	446,277	1,223	5	-4200.9	1,306,741,521	71,974
237	0	0	869.8	-358.1	-3908.8	442,368	1,212	5	-20003.4	1,306,721,518	66,821
252	0	0	1011.5	-465.6	-9929.8	432,438	1,185	5	-54205.6	1,306,667,312	54,042
267	0	0	1163.7	-581.1	-9110.6	423,327	1,160	6	-53076.3	1,306,614,236	44,333
282	0	0	1326.5	-704.7	-8529.6	414,798	1,136	6	-53038.6	1,306,561,197	36,822
292	0	0	1531.8	-860.5	-8072.1	406,726	1,114	7	-54188.5	1,306,507,009	30,793



Longterm Salinity Years	Cumulative Salt Load kg	Pit Lake Salinity mg/L
200	266,094,396	21,916
300	363,855,359	29,967
500	559,377,284	46,071

Figure E.1: TGEP water balance inputs and results

Wyoming 1

Wyoming 1 water balance inputs and results are shown in Figure E.2. Net flux approaches zero for the slice which has a pit lake level of 200 mAHD (row highlighted green), meaning pit lake water level equilibrium occurs at approximately 200 mAHD.

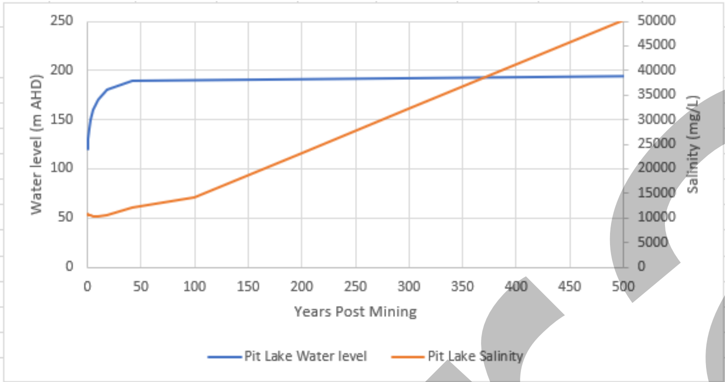
Long-term pit lake salinity is 14,089 mg/L, 23,136 mg/L, 32,182 mg/L and 50,276 mg/L for 100 years, 200 years, 300 years and 500 years after end of mining, respectively.

Draft

TGO Wyoming 1 Mine Void - Water and Salt Balance

Mean Daily Rainfall	1.54	mm/d	In Pit runoff coeff.	0.45	Groundwater salinity	14627	mg/L	Mean of WYMB02 monitoring bore
Mean Daily Evaporation	5.02	mm/d	Ex Pit runoff coeff	0.35	Surface water salinity	30	mg/L	
Minimum pit level (mAHD)	109	mAHD	Pan Factor	0.70	Rainfall salinity	10	mg/L	
Upstream Catchment	0	m2						

Pit Lake Water Depth m	Pit Lake Water Level Elevation mAHD	Dry Pit Area m2	Pit Lake Surface Area m2	Pit Lake Surface Area Radius m	Pit Lake Volume m3	Pit Lake Slice Volume m3	Direct Rainfall - IN m3/d	In Pit Runoff - IN m3/d	Ex Pit runoff - IN m3/d	GW Inflow - IN m3/d	Pit Lake Evap - OUT m3/d	Net Flux m3/d	Time to fill days	Cumulative Time days	Cumulative Time Years	Salt Flux kg/d	Incremental Salt Load kg	Cumulative Salt Load kg	Pit Lake Salinity mg/L
0	109	193,032	3,318	32.5	0														
11	120	191,572	4,778	39.00	44,288	44,288	7.4	132.8	0	340.384	16.8	463.7	96	96	0.26	4980	475,652	475,652	10740
21	130	189,988	6,362	45.00	99,922	55,634	9.8	131.7	0	294.026	22.4	413.1	135	230	0.63	4302	579,345	1,054,996	10558
31	140	179,608	16,742	73.00	284,304	184,382	25.8	124.5	0	250.308	58.8	341.7	540	770	2.11	3663	1,976,261	3,031,257	10662
41	150	183,256	13,094	64.56	314,392	30,088	20.2	127.0	0	209.23	46.0	310.4	97	867	2.37	3062	296,816	3,328,073	10586
51	160	175,911	20,439	80.66	543,887	229,495	31.5	121.9	0	170.792	71.8	252.4	909	1,776	4.87	2500	2,273,311	5,601,384	10299
61	170	166,889	29,461	96.84	867,565	323,678	45.4	115.7	0	134.994	103.5	192.5	1,682	3,458	9.47	1976	3,322,971	8,924,355	10287
71	180	156,190	40,160	113.06	1,302,192	434,627	61.8	108.2	0	101.836	141.1	130.8	3,323	6,780	18.58	1491	4,955,193	13,879,549	10659
81	190	143,815	52,535	129.32	1,864,532	562,341	80.9	99.7	0	71.318	184.6	67.3	8358.5	15139.0	41.5	1045	8734462.1	22614010.8	12128.5
91	200	129,763	66,587	145.59	2,571,354	706,821	102.5	89.9	0	43.44	234.0	1.9	367557.7	382696.7	1048.5	637	234252444.6	256866455.4	99895.4
101	210	114,034	82,316	161.87	3,439,421	868,068	126.8	79.0	0	18.202	289.3	-65.3	-13301.1	369395.6	1012.0	268	-3568660.2	253297795.2	73645.5
111	220	96,629	99,721	178.16	4,485,502	1,046,081	153.6	67.0	0	0	350.4	-129.9	-8053.9	361341.7	990.0	2	-17761.6	253280033.6	56466.4
121	230	77,547	118,803	194.46	5,726,363	1,240,860	183.0	53.7	0	0	417.5	-180.8	-6864.1	354477.6	971.2	2	-16247.0	253263786.6	44227.7
131	240	56,789	139,561	210.77	7,178,769	1,452,407	214.9	39.4	0	0	490.4	-236.1	-6150.6	348327.0	954.3	3	-15639.8	253248146.8	35277.4
141	250	34,354	161,996	227.08	8,859,488	1,680,719	249.5	23.8	0	0	569.3	-296.0	-5678.6	342648.3	938.8	3	-15518.6	253232628.2	28583.2
151	260	10,242	186,108	243.39	10,785,287	1,925,798	286.6	7.1	0	0	654.0	-360.3	-5345.3	337303.1	924.1	3	-15699.3	253216928.9	23478.0
161	270	0	196,350	250.00	12,085,399	1,300,113	302.4	0.0	0	0	690.0	-387.6	-3354.3	333948.7	914.9	3	-10142.7	253206786.1	20951.5



Longterm Salinity Years	Cumulative Salt Load kg	Pit Lake Salinity mg/L
100	36,227,838	14,089
200	59,490,076	23,136
300	82,752,314	32,182
500	129,276,789	50,276

Figure E.2: Wyoming 1 water balance inputs and results

Draft

Appendix F. GHD (2017) Groundwater management plan

Draft

Draft

Alkane Resources Pty Ltd

Tomingley Gold Operations
Groundwater management plan

November 2017

Table of contents

Table index

Figure index

Draft

Appendices

Draft

1. Introduction

1.1 Overview

Tomingley Gold Mine is owned and operated by Tomingley Gold Operations Pty Ltd (TGO), a wholly owned subsidiary of Alkane Resources Ltd. TGO is a medium-sized gold project with approximately 921,000 ounces of gold in the current defined resource, with an aim to produce approximately 50,000 to 60,000 ounces of gold per year. TGO is located at Tomingley in central western NSW, south of Dubbo and north of Peak Hill (refer to Figure 1-1).

Project approval was granted in July 2012 with the mining lease issued in February 2013. Mining commenced in January 2014 with three open cut mines (Wyoming One, Wyoming Three and Caloma One). The project includes a processing plant with associated residue storage facility (RSF). The original approval has been modified three times. A summary of the site history at TGO is included in Table 1-1.

Table 1-1 Site history

Year	Month	Activity
2012	July	Project approval.
2013	February	Mining lease granted.
		Construction of key processing infrastructure complete including RSF, additional surface water management features constructed and in use.
	November	Mining of overburden commenced only necessary surface water management features constructed.
		Modification 1 approved.
2014	May	Water Management Plan Revision 1 prepared.
2015	April	Modification 2 approved.
	July	Additional Groundwater Bores installed around Raw Water and Process Water Dam.
	October	Commencement of Wyoming One Pit.
		Modifications to surface water management system around Caloma One Pit.
	December	Expansion of Sediment Basin 5 capacity.
2016	February	Water Management Plan Revision 2 prepared.
	May	Modification 3 approved.
	July	Commencement of Caloma Two Pit.
2017	March	Expansion of Sediment Basin 4 and alteration of clean water diversion.
	November	Water Management Plan Revision 3 prepared.

TGO is currently operating the mine in accordance with the following approvals:

- Project Approval 09_0155 (as modified).
- Environment Protection Licence (EPL) 20169 (licence version date 20 March 2017).
- Mining Lease (ML) 1684.

This water management plan (WMP) covers all operations at TGO and includes the approved mining operations and associated infrastructure within the site boundary (refer to Figure 1-2).

Land use within and surrounding TGO includes:

- Residential and rural residential.

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- Agriculture.
- Transportation infrastructure (Newell Highway).
- Commercial (Tomingley Township).
- Recreation and community facilities.
- Former mining operations, north of Tomingley (Myalls United Gold Mine).

1.2 Purpose

This groundwater management plan (GWMP) addresses the specific water components of the conditions of the Project Approval 09_0155 and outstanding statement of commitments as part of the Project.

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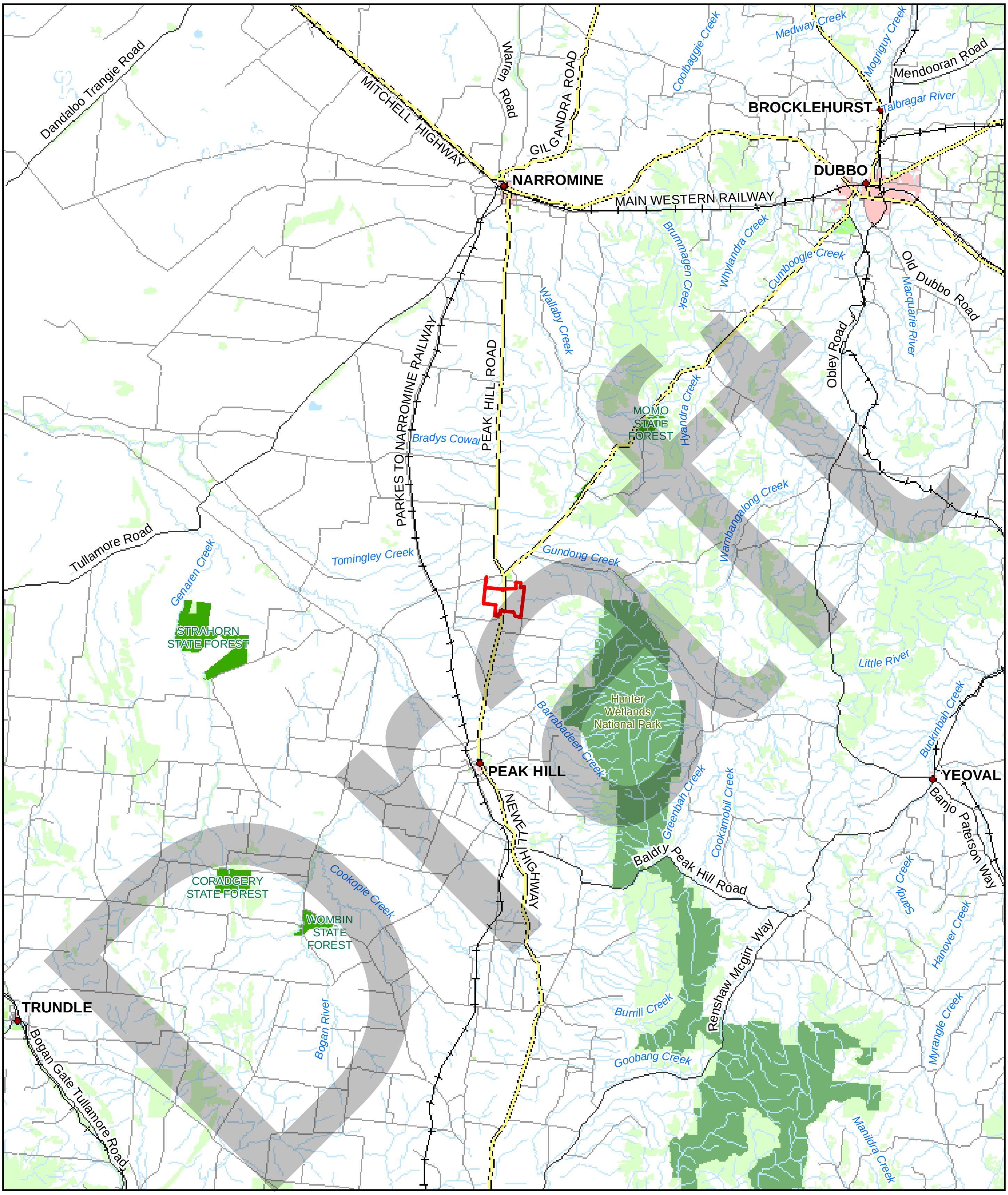

LEGEND

- Site boundary
- Railway
- Principal Road
- Secondary Road
- Minor Road
- Watercourse
- Built Up Area
- Recreation Area
- National Park
- State Forest
- Forest Or Shrub

Paper Size A4

0 1.5 3 6 9 12 15

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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ALKANE

Tomingley Gold Operations
Groundwater Management Plan

Job Number	21-26505
Revision	0
Date	13 Nov 2017

Locality plan

Figure 1-1

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

\\ghdnet\ghd\AU\Newcastle\Projects\21\26505\GIS\Maps\Deliverables\GWMP\2126505_GWMP005_Locality_0.mxd

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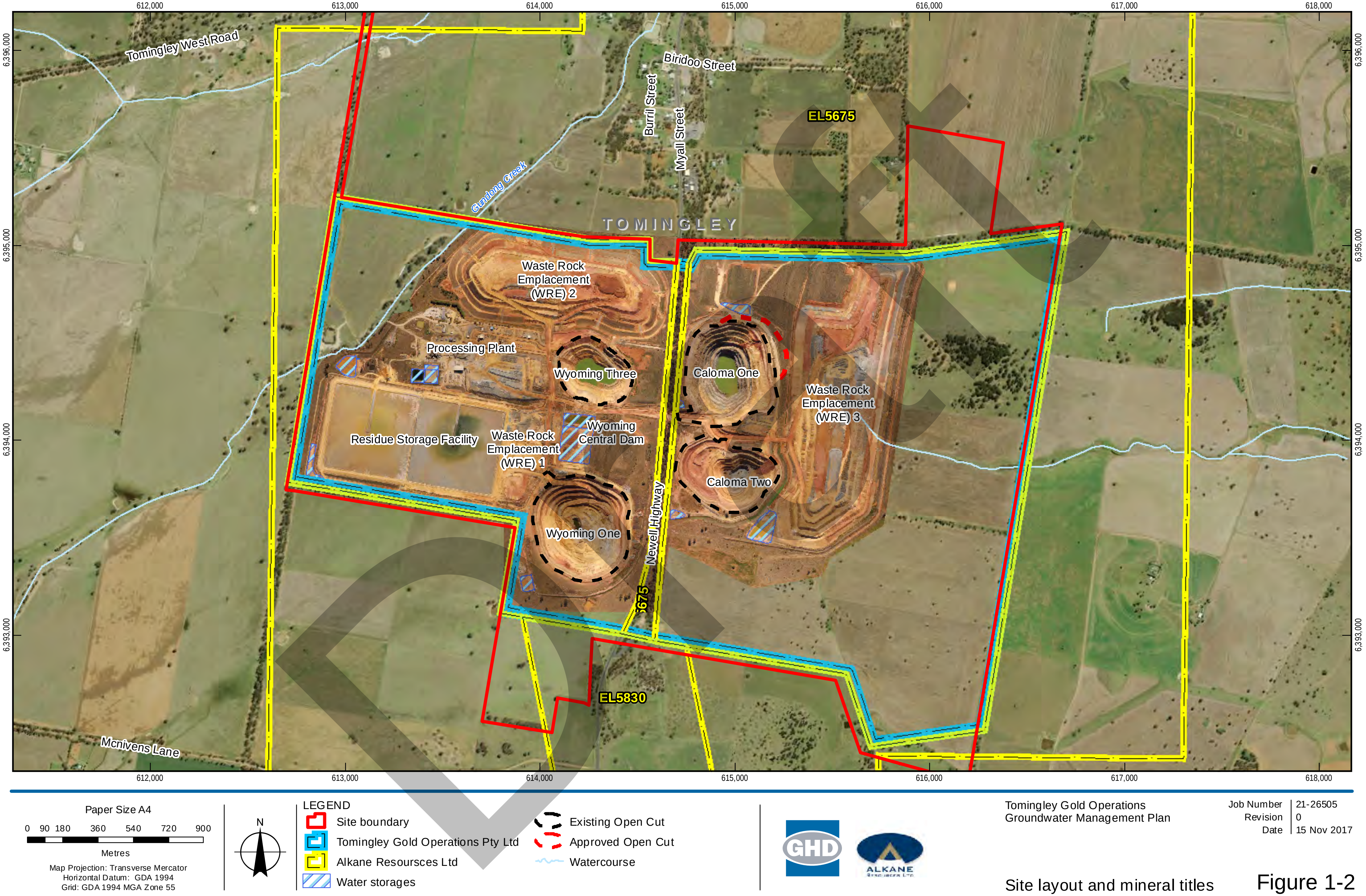
Data source: Geoscience Australia: 250k Topographic Series 3, 2006; LPI: DTDB, 2012. Created by: gmcdiarmid



Tomingley Gold Operations
Groundwater Management Plan

Job Number	21-26505
Revision	0
Date	15 Nov 2017

Site layout and mineral titles

Figure 1-2

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Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

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Data source: NSW DT&I R&E: Mine titles; Tomingley Gold Operations: Imagery, 2015. LPI: DTDB, 2012; LPI, imagery, 2017. Created by: gmcdiarmid

2. Data

2.1 Climate

2.1.1 Rainfall

Daily rainfall data was obtained as SILO Patched Point Data from the Queensland Climate Change Centre of Excellence. SILO Patched Point Data is based on historical data from a particular Bureau of Meteorology (BOM) station with missing data 'patched in' by interpolating with data from nearby stations. For this assessment, SILO data was obtained for the Peak Hill Post Office Station (station number 50031), which is located approximately 14 km south of the site. This station was chosen based on the length and quality of the data record and proximity to the mine site.

The period of rainfall data used for this assessment extended from January 1900 to July 2015 and is summarised as annual totals in Figure 2-1. The statistics for this rainfall data set are:

- Minimum annual rainfall – 233 mm in 1944.
- Average annual rainfall – 561 mm.
- Median annual rainfall – 545 mm.
- Maximum annual rainfall – 1217 mm in 1950.

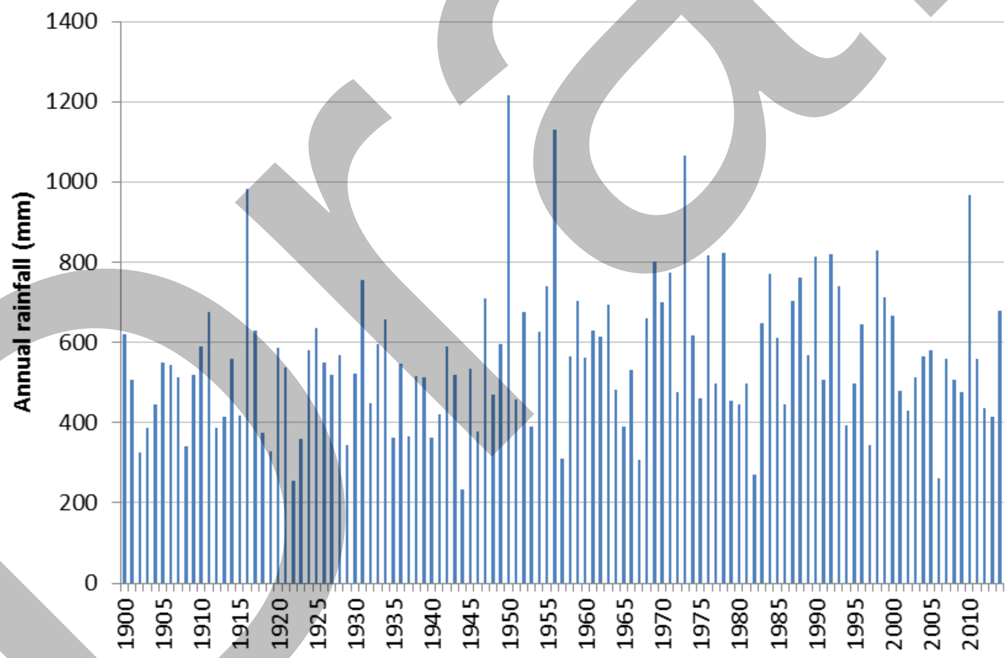

Figure 2-1 Annual rainfall recorded at Peak Hill Post Office station

The SILO dataset was used to generate a Cumulative Rainfall Departure (CRD) curve. CRD is the monthly accumulation of the difference between the observed monthly rainfall and the long-term average monthly rainfall.

The CRD over the period 1900 to 2015 is shown in Figure 2-2. Any increase in the CRD reflects above average rainfall while a decrease in CRD reflects below average rainfall. The CRD curve only deviates from zero due to atypical (above and below average) rainfall.

Figure 2-2 CRD curve for Peak Hill Post Office station

As shown in Figure 2-2, the CRD curve indicates that in recent years average rainfall has had periods both below average (2005 to 2010) and above average (2010 to 2014).

2.2 Geology and soils

Tomingley is located on the Junee-Narromine volcanic belt, part of the Palaeozoic Lachlan Orogen composition of sedimentary, volcanic and intrusive rock formations of early Cambrian to early Devonian age. The Ordo-Silurian sequences that comprise the Wyoming/Caloma deposits, are tight to isoclinal folding, strong axial planar cleavage with green schist metamorphic assemblages.

The area is dominated by alluvial sequences of clays, sands and gravel of Quaternary to Tertiary age, up to 50 m thick. The alluvial material dissipates to the south and north with basement outcropping. There is a well-developed weathering profile which can extend down to 70 m below ground level (The Impax Group, 2011).

Soil erodibility values (K factors) for the site are moderate to high at 0.04 to 0.05 (SEEC, 2011). Typically, the worst soils are located to the east of the Newell Highway in the sodic Gilgaied Dermosol soils (SEEC; 2011).

As part of the site Mining Operations Plan (MOP), topsoils are approximately 30 cm below natural surface with the most ideal for stripping and stockpiling being the red Dermasol. Subsoils were defined from 30 cm to 70 cm below natural surface with sodic tendencies. The typical emersion value for the subsoil material has been reported to be Class 1.

2.3 Hydrogeology

There are three distinct groundwater systems within the vicinity of TGO's mining leases, as identified by The Impax Group (2011):

- Shallow alluvium – discrete, shallow alluvium (less than 10-20 m deep) dissects the plains surrounding the mine site along creek flow paths. These aquifers are believed to be recharged from rainfall infiltration. Groundwater within these systems is of relatively good quality; however, yields are relatively low and dependent on rainfall.

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- Deep alluvium – up to 100 m deep and located approximately 10 km to the northwest and west of TGO. Groundwater yields are believed to be low and of poor quality. These systems may have some interaction with underlying bedrock however are believed to be primarily recharged from rainfall.
- Fractured rock – the area surrounding Tomingley is typically underlain by shale, siltstone and chert with several fractured rock aquifers in the vicinity of the mine. Groundwater yields range from 0-3 L/s, generally less than 1.5 L/s, and water quality is poor with high salinity.

Perched groundwater occurs within the shallow alluvium; however, it is generally not continuous across the mine site. Shallow groundwater appears to be more permanent along Gundong Creek to the northeast of the Wyoming 3 pit.

The hydraulic conductivity of the shallow alluvial clay is generally low to very low. Falling head tests on clayey strata between 1.55 and 42.5 m bgl at the RSF area (to the southwest of the Wyoming 3 pit) indicate hydraulic conductivities of 0.0002 to 0.002 m/d or 2.3×10^{-8} to 10^{-9} m/s (DE Cooper & Associates, 2011). In addition, overburden clay from the Wyoming 1 pit was tested for its potential use in the RSF embankment and found to have a compacted hydraulic conductivity of less than 10^{-10} m/s (8.6×10^{-6} m/day) (DE Cooper & Associates, 2011).

A deeper confined groundwater system occurs within the fractured sandstone and siltstone. The water bearing zone most likely occurs at a depth of greater than 100 m bgl in the vicinity of the Wyoming 3 pit, as indicated by the lack of groundwater inflow into the pit. During exploration drilling at the Wyoming 3 pit site, there was no record of water flows into the drill hole at less than 50 m bgl. At 50 to 100 m depth there was some water recorded during rod changes but no flow during drilling. At greater than 100 m depth, some weak flow during drilling was recorded. Therefore, the Wyoming 3 pit is predominantly within the unsaturated zone above the confined water bearing zone. Based on the information available there is no mention of potential hydraulic connectivity from the Wyoming 3 pit to the proposed underground mine 500 m to the south of the pit.

Based on groundwater monitoring data, the hydraulic gradient of the deep groundwater system is approximately 0.01 to the north. Adopting a hydraulic conductivity of 0.07 m/day, the deep groundwater moves to the north at a rate of approximately 0.0007 m/day or 0.3 m/year.

2.3.1 Groundwater bore search

A search of the NSW Groundwater Bore Database (DPIW, 2015) was undertaken to identify registered bores within a 10 km radius of TGO and within a 5 km radius of the production borefield. The search identified 22 bores within a 10 km radius of TGO. Licences for a number of these 22 bores were reported as cancelled, lapsed or abandoned. Of the 22 bores the majority (11) were licensed as a test bore or monitoring bore. Of the remaining bores; four were intended for public/municipal water supply, three were registered as stock and domestic, and one bore was registered as groundwater exploration, mining, irrigation and town water supply.

The search of the NSW Groundwater Bore Database identified 67 bores within a 5 km radius of the production borefield. A number of the identified bores were reported as cancelled or lapsed. Of the 67 bores identified the majority (48) were licensed for stock, domestic or irrigation use. Of the remaining bores; 10 were licensed as monitoring bores, three as groundwater exploration, two as industrial, two as test bores and two bores had an unknown licensed purpose.

Licensed groundwater bores in the vicinity of TGO are shown in Figure 2-3 and licensed bores in the vicinity of the production bore are shown in Figure 2-4. Details regarding licensed groundwater bores are summarised in Appendix A.

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2.3.1 Groundwater dependant ecosystems

The closest high priority GDEs listed in the NSW Murray Darling Fractured Rock Groundwater Sources WSP are Dilladerry Spring located approximately 18.5 km east of TGO and Hyandra Hill Spring located approximately 28 km north east of TGO. Various tributaries of the Bogan River that lie to the north of the site are potential GDEs. The piper plot in Appendix B and the discussion of water quality in Section 3.2.5 indicates that the groundwater of the deeper fractured rock aquifer is saline and of sodium chloride type while the groundwater of the Gundong Creek alluvial aquifer is fresh to brackish and of sodium-chloride/bicarbonate type. The differing water chemistry indicates a low degree of connectivity between the alluvial and fractured rock aquifers. Therefore, it is likely that groundwater drawdown in the fractured rock aquifer will have negligible impact on the alluvial aquifer of Gundong Creek or of the various watercourses near TGO.

Near the extraction bore potential GDEs include isolated areas of eucalyptus forest and the Macquarie River. It is considered that as with areas of vegetation near TGO, these areas of eucalyptus forest are unlikely to be solely dependent on groundwater.

Draft

LEGEND

- Site boundary
- Cadastre
- Groundwater bore
- Watercourse

Paper Size A4

0 375 750 1,500 2,250 3,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Tomingley Gold Operations
Groundwater Management Plan

NSW groundwater bore search - TGO

Job Number	21-26505
Revision	0
Date	13 Nov 2017

Figure 2-3

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Data source: LPI: DTDB\DCDB, 2012. LPI: Imagery, 2015: DPI: Groundwater Bores, 2015. Created by: gmcdiarmid

LEGEND

- Site boundary
- Groundwater bore
- Roads
- Watercourse

Paper Size A4

0 200 400 800 1,200 1,600 2,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

Tomingley Gold Operations
Groundwater Management Plan

Job Number	21-26505
Revision	0
Date	13 Nov 2017

NSW groundwater bore search - production borefield

Figure 2-4

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

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Data source: LPI: DTDB\DCDB, 2012. LPI: Imagery, 2015; DPI: Groundwater Bores, 2015. Created by: gmcdiarmid

3. Groundwater management

3.1 Groundwater monitoring network

The existing groundwater monitoring network has been progressively established at TGO since 2006. TGO undertakes quarterly groundwater monitoring of deep bores (WYMB01, WYMB02, WYMB03, WYMB04 and WYMB06) and shallow alluvial bore GDCMP01 in accordance with EPL 20169. In addition, TGO undertakes monthly monitoring of shallow bores in the vicinity of the RSF (RSFMP01, RSFMP02, RSFMP03, RSFMP04, RSFMP05, RSFMP06, RSFMP07, RSFMP08, RSFMP09, RSFMP10 and RSFMP11), PWD (PWMP01 and PWMP02) and WCD – South (WCD-P1, WCD-P2, WCD-P3, WCD-P4, WCD-P5, WCD-P6, WCD-P7, WCD-P8). Six additional shallow monitoring bores were installed to monitor potential impact from the PWD and associated process water pipelines (PWMP03, PWMP04, PWMP05, PWMP06, PWMP07 and PWMP08).

Details of groundwater bores are summarised in Table 3-1. Monitoring bore locations are shown in Figure 3-1.

Table 3-1 Groundwater monitoring bore details

Bore	Depth (m)	Top of Casing (TOC) Elevation (m AHD)	Monitoring Period	Lithology
WYMB001	90	270.424[(a)]	April 2007 – present	Unknown
WYMB002	114	268.515[(a)]	April 2007 – present	Unknown
WYMB003	84	275.472[(a)]	April 2007 – present	Unknown
WYMB004	78	272.07[(a)]	April 2007 – present	Unknown
WYMB006	90	268.43[(a)]	April 2007 – present	Unknown
WYMB10	150	272.62[(b)]	November 2012 – present	Unknown
GDCMB01	3.5	273.44[(b)]	November 2012 – present	Gundong Creek Alluvium
RSFMP01	10.95	268.9[(c)]	March 2014 – present (dry since installation)	Shallow strata
RSFMP02	10.58	268.3[(c)]	March 2014 – present (dry since installation)	Shallow strata
RSFMP03	11.88	267.25[(c)]	March 2014 – present	Shallow strata
RSFMP04	5.28	266.1[(c)]	March 2014 – present	Shallow strata
RSFMP05	13	265.8[(c)]	March 2014 – present	Shallow strata
RSFMP06	4.08	264.85[(c)]	March 2014 – present	Shallow strata
RSFMP07	5.5	265.15[(c)]	March 2014 – present	Shallow strata
RSFMP08	4.43	265.9[(c)]	March 2014 – present (dry since installation)	Shallow strata
RSFMP09	5	266.65[(c)]	March 2014 – present (dry since May 2014)	Shallow strata
RSFMP10	5.5	267.75[(c)]	March 2014 – present (dry since August 2014)	Shallow strata
RSFMP11	5.74	269[(c)]	March 2014 – present (dry since installation)	Shallow strata
PWMP01	11.49	267.85[(c)]	January 2015 – present	Shallow strata
PWMP02	12	267.95[(c)]	January 2015 – present	Shallow Strata
PWMP03	12	To be surveyed	July 2015 – present	Shallow Strata
PWMP04	11.56	To be surveyed	July 2015 – present	Shallow Strata
PWMP05	11.59	To be surveyed	July 2015 – present	Shallow Strata
PWMP06	12.91	To be surveyed	July 2015 – present	Shallow Strata

Bore	Depth (m)	Top of Casing (TOC) Elevation (m AHD)	Monitoring Period	Lithology
PWMP07	11.82	To be surveyed	July 2015 – present	Shallow Strata
PWMP08	9.56	To be surveyed	July 2015 – present	Shallow Strata
WCD-P1	TBC	TBC	Following upgrade of WCD - South	Shallow Strata
WCD-P2	TBC	TBC		Shallow Strata
WCD-P3	TBC	TBC		Shallow Strata
WCD-P4	TBC	TBC		Shallow Strata
WCD-P5	TBC	TBC		Shallow Strata
WCD-P6	TBC	TBC		Shallow Strata
WCD-P7	TBC	TBC		Shallow Strata

(a) Casing surveyed.
(b) Casing elevation estimated using natural surface survey and measuring stand up of casing.
(c) Level estimated using natural surface survey.

3.1.1 Background groundwater levels

Fractured rock monitoring bores

Hydrographs of all fractured rock groundwater monitoring bores have been plotted and compared with the CRD and are shown in Figure 2-2.

The groundwater hydrographs presented in Appendix C show that pre-mining groundwater levels at WYMB001 were generally rising over the period of monitoring while levels at WYMB002 and WYMB003 were generally constant. The observed variation of pre-mining groundwater levels at WYMB002 and WYMB003 is likely due to natural variation in groundwater levels.

The groundwater hydrographs in Appendix C for WYMB004 and WYMB006 indicate that groundwater levels at these monitoring locations are generally constant with the exception of a spike in groundwater levels in early 2008. Coffey (2008) found this observed rise in groundwater levels at WYMB004 and WYMB006 followed a significant month of above average rainfall of approximately 150 mm in December 2007. WYMB004 and WYMB006 are located near McPhail's historical workings and Coffey (2008) concluded that the response in groundwater levels following rainfall might be related to filling of McPhail's historical workings.

Groundwater hydrographs for WYMB004 and WYMB006 in Appendix C indicate that the rise in groundwater levels in early 2008 does follow a period of heavy rainfall. However, there is no similarly strong response in groundwater levels at WYMB004 following wet periods in early 2014 and December 2014. Similarly, the response in groundwater levels at WYMB006 to wet periods in early 2014 and December 2014 is not as strong as the response to rainfall observed in early 2008.

Baseline and operational groundwater levels are summarised in Table 3-2.

Table 3-2 Groundwater level summary

Location	Baseline (pre-January 2014) groundwater level (m AHD)		Operational groundwater level (m AHD)	
	Minimum	Maximum	Minimum	Maximum
WYMB001	209.97	233.82	230.79	232.25
WYMB002	208.91	209.37	208.17	209.49
WYMB003	220.19	221.74	221.20	222.29

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Location	Baseline (pre-January 2014) groundwater level (m AHD)		Operational groundwater level (m AHD)	
	Minimum	Maximum	Minimum	Maximum
WYMB004	208.62	242.32	208.23	209.48
WYMB006	231.13	240.31	231.06	236.42
WYMB10	200.30	200.42	196.85	200.47

During the operational phase at TGO groundwater levels have typically remained within pre-mining minimum and maximum groundwater levels. The hydrographs for WYMB002, WYMB003, WYMB006 and WYMB010 shown in Appendix C indicate some variation in groundwater levels for the December 2014 monitoring round; however groundwater levels returned to typical levels by the following March 2015 monitoring round.

Shallow bores

There is limited background data for shallow groundwater monitoring bores. As outlined in Table 3-1 monitoring commenced at GDCMB01 in November 2011. Monitoring of bores associated with the RSF and the processing area did not begin until after commencement of operations at TGO.

Of the RSF monitoring locations, RSFMP01, RSFMP02, RSFMP08 and RSFMP11 have been dry since installation; RSFMP09 has been dry since May 2014 and RSFMP10 has been dry since August 2014. Of the PWD monitoring locations PWMP03 to PWMP08 were only recently installed and therefore typically water level has been gauged only once at these locations.

At alluvial monitoring locations where sufficient groundwater level data exists, groundwater level have been plotted and compared to the CRD curve. These hydrographs are shown in Appendix C. The recorded groundwater elevations (m AHD) for each alluvial monitoring bore are shown in black. It should be noted that groundwater levels at TGO have been manually recorded and that the limit of reading of the measuring tape is considered to be 10 mm. When considering the accuracy achievable by the field technician, the limit of accuracy of an individual measurement may be up to ± 50 mm. Therefore, groundwater monitoring is unlikely to detect changes in groundwater level of less than 10 mm at a particular bore from one monthly monitoring round to the next. Further, groundwater bore top of casing (TOC) elevations have not been surveyed for shallow groundwater monitoring locations and groundwater elevations have been estimated using natural surface survey and measuring the height of the top of casing above the natural surface.

HARTT (Hydrograph Analysis: Rainfall and Time Trends) analysis has been undertaken for each dataset to establish the relationship between groundwater levels and rainfall to determine underlying trends in groundwater level that are independent of rainfall. The best fit HARTT regression line is shown in red in each hydrograph. The HARTT statistical output for each alluvial hydrograph is shown in Table 3-3.

Table 3-3 HARTT analysis results for monitoring bores

Bore	R^2	Rainfall Coeff. *a* (m/mm)	P rain	Time Coeff. *b* (m/mth)	P Time	*c* (m)
RSFMP03	0.661	0.008	0.454	0.327	0.000	257.77
RSFMP04	0.406	0	0.221	0.008	0.068	260.72
RSFMP05	0.759	0.007	0.010	0.100	0.000	257.60
RSFMP06	0.265	0.005	0.059	0.026	0.095	261.60
RSFMP07	0.873	0	0.666	0.071	0.002	259.75
RSFMP10	0.148	0.007	0.731	-0.049	0.564	263.53

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Bore	R^2	Rainfall Coeff. *a* (m/mm)	P rain	Time Coeff. *b* (m/mth)	P Time	*c* (m)
PWMP01	0.957	0.004	0.355	0.224	0.004	257.09
PWMP02	0.315	0.056	0.329	0.073	0.888	263.97
GDCMB01	0.566	0	0.859	-0.022	0.012	271.747

The R^2 value of the HARTT regression line gives a measure of the quality of fit of the non-linear regression line to the observed hydrograph. This value was greater than 50% for five of the nine alluvial hydrographs analysed, indicating that over half of the hydrographs can be reasonably modelled by the HARTT variables (CRD and linear time trends) alone. A lower R^2 value indicates that the bore is situated at a location where the hydrograph cannot be adequately modelled by the HARTT variables and that other factors are affecting groundwater levels.

The p-value for the rainfall variable *a* is less than 0.05 for RSFMP05 only indicating that there is a strong relationship between groundwater level and CRD at this location. The p-value for the time variable is less than 0.05 for RSFMP03, RSFMP05, RSFMP07, PWMP01 and GDCMB01 indicating statistically significant linear time trends (independent of rainfall) in groundwater levels at these locations. Where the p-value is greater than 0.05, time trends are statistically insignificant and the time coefficient *b* cannot be relied upon to describe historical trends or predict future groundwater levels.

All the monitoring locations that identified a statistically significant rising time trend in groundwater level (RSFMP03, RSFMP05, RSFMP07 and PWMP01) are located near the western end of the RSF. The rising trend in groundwater levels at these monitoring locations may be due to recovery in shallow groundwater levels following the completion of construction of the surface facilities area and/or seepage to groundwater from a process water pipeline in the vicinity of PWMP02 (GHD, 2015). Monitoring bores PWMP03, PWMP04, PWMP05, PWMP06, PWMP07 and PWMP08 were installed to monitor this rising trend in groundwater.

WCD – South was enlarge and upgraded to a process water storage in later 2017. Monitoring of bores around the storage will commence when the upgrade is completed.

Production borefield

There are a number of DPIW monitoring bores located in the vicinity of the production borefield. The DPIW monitoring bores are located in the Macquarie River Alluvium; the same aquifer that the production borefield is extracting from. Monitoring data from the DPIW bores GW096079-1 and GW096080-2 is publically available and has been analysed using HARTT Analysis. Hydrographs for these DPIW monitoring bores are shown in Appendix C and the HARTT statistical output for these bores is shown in Table 3-4.

Table 3-4 HARTT analysis results for DPIW monitoring bores

Bore	R^2	Rainfall Coeff. *a* (m/mm)	P rain	Time Coeff. *b* (m/mth)	P Time
GW096079-1	0.514	0.008	0.000	-0.022	0.000
GW096080-2	0.606	0.006	0.074	-0.116	0.000

The R^2 value of the HARTT regression line gives a measure of the quality of fit of the non-linear regression line to the observed hydrograph. This value was greater than 50% for both the alluvial hydrographs analysed, indicating that both hydrographs can be reasonably modelled by the HARTT variables (CRD and linear time trends) alone.

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The p-value for the rainfall variable *a* is less than 0.05 for GW096079-1 only indicating that there is a strong relationship between groundwater level and CRD at this location. At GW096079-1 groundwater levels respond by approximately 8 mm per mm of CRD (or atypical rainfall). Where the p-value is greater than 0.05, CRD trends are statistically insignificant and the rainfall coefficient *a* cannot be relied upon to describe historical trends or predict future groundwater levels.

The p-value for the time variable is less than 0.05 for both hydrographs analysed indicating statistically significant linear time trends (independent of rainfall) in groundwater levels at these locations. Both monitoring locations indicate a statistically significant falling time trend in groundwater levels (independent of rainfall). The falling time trend in groundwater level may be attributable to groundwater extraction from the alluvial aquifer.

3.2 Monitoring

The purpose of this Groundwater Monitoring Program is to provide a framework for monitoring and management of groundwater quality and levels. The aim of groundwater monitoring is to ensure groundwater drawdown is within the predictions of the groundwater modelling undertaken as part of the EIS for the Project (Impax Group, 2008), monitoring for any leachate from the RSF and to detect any potential impact on surrounding groundwater users and to ensure that requirements of the NSW Aquifer Interference Policy are met. The Groundwater Monitoring Program outlines the locations, parameter, frequency and methodology of monitoring.

3.2.1 Monitoring methodology

As specified by DIPNR (2003) (to be adopted as a minimum standard), groundwater monitoring should be undertaken in general accordance with ‘A Practical Guide to Groundwater Sampling’ (Jiwan and Gates, 1992). It is recommended that low flow sampling techniques be used for purging and sampling (rather than bailers or submersible pumps) to minimise aquifer disturbance and reduce the volume of groundwater extracted during sampling.

In general, the groundwater monitoring methodology should include the following:

- Gauging of groundwater levels prior to purging.
- Purging of monitoring bores using a low flow peristaltic pump. To limit the disturbance of possible sediments in the base of each bore, the sample tubing at each bore should be lowered to approximately the middle of the screened interval for purging and sample collection.
- Measurement of groundwater field parameters (pH, EC) using a calibrated water quality meter and a flow cell during purging. The pH and EC readings should be recorded in the field once they have stabilised.
- If groundwater samples are to be collected, they are to be transferred into suitably preserved laboratory supplied sample containers once field parameters have stabilised. Samples to be analysed for dissolved metals are to be filtered in the field using 0.45 µm filters. All sample containers are to be clearly labelled with sample number, sample location, sample depth and sample date. The sample containers are to be transferred to a chilled esky for sample preservation prior to and during shipment to the testing laboratory. A Chain-of-Custody form should be forwarded with the samples to the testing laboratory.
- Decontamination of all non-dedicated sampling equipment between monitoring locations.

Where contractor specific sampling protocols exist, the adoption of the more stringent monitoring methodologies should be considered.

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3.2.2 Groundwater monitoring network

The TGO groundwater monitoring network is shown in Figure 3-1. Details regarding monitoring bores are provided in Table 3-1.

3.2.3 Groundwater transfer metering

To monitor and assess groundwater make at TGO, dewatering volumes from all open cut pits require to be metered. Volumetric metering must continue as long as dewatering continues.

Once dewatering from each open cut pit has ceased monitoring of water level in each pit is required. Monitoring of water levels should continue until water levels stabilise and equilibrium of groundwater levels has occurred.

Water quality samples from each of the open cut pits and underground workings should be collected on a monthly basis when water is present.

3.2.4 Monitoring parameters and frequency

The monitoring of groundwater levels and quality and dewatering volumes is to continue as part of the Project. The frequency and parameters to be monitored have been provided in Table 3-5.

It is also recommended that groundwater level data at DPIW monitoring bores GW096079-1 and GW096080-2 is reviewed on an annual basis. This data is publically available from DPIW website; http://www.water.nsw.gov.au/realtime-data/groundwater.

Table 3-5 Groundwater monitoring parameters and frequency

Location	Frequency	Parameter
WYMB01, WYMB02, WYMB03, WYMB04, WYMB06, WYMB10, GDCMB01	Quarterly	Water Level
WYMB01, WYMB02, WYMB03, WYMB04, WYMB06, WYMB10, GDCMB01	Quarterly	Alkalinity (as calcium carbonate), ammonia, arsenic, bicarbonate, cadmium, calcium (dissolved), carbonate, chloride, chromium, copper, cyanide (free), cyanide (total), cyanide (weak acid dissociable), EC, hardness (as calcium carbonate), lead, magnesium (dissolved), mercury, nickel, nitrate, pH, phosphate, potassium (dissolved), sodium (dissolved), sulphate, TDS, iron (total), TSS, zinc.
RSFMP01, RSFMP02, RSFMP03, RSFMP04, RSFMP05, RSFMP06, RSFMP07, RSFMP08, RSFMP09, RSFMP10, RSFMP11, PWMP01, PWMP02, PWMP03, PWMP04, PWMP05, PWMP06	Monthly	Water Level
RSFMP01, RSFMP02 RSFMP03, RSFMP04 RSFMP05, RSFMP06 RSFMP07, RSFMP08 RSFMP09, RSFMP10 RSFMP11, PWMP01 PWMP02, PWMP03 PWMP04, PWMP05 PWMP06	Monthly	pH, EC, TDS, TSS, alkalinity, ammonia, nitrate, sulphate, chloride, calcium (dissolved), magnesium (dissolved), sodium (dissolved), potassium (dissolved), aluminium, arsenic, cadmium, chromium, copper, nickel, lead, selenium, zinc, iron, mercury, cyanide (free), cyanide (total), cyanide (weak acid dissociable).

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Location	Frequency	Parameter
WCD-P1, WCD-P2, WCD-P3, WCD-P4, WCD-P5, WCD-P6, WCD-P7, WCD-P8	Monthly	Water level
Open cut pits and underground workings	Daily	Dewatering volumes
Open cut pits and underground workings	Monthly when water is present	pH, EC, arsenic, copper, nickel, zinc, cyanide and ammonia, calcium, magnesium, sodium, potassium.
Open cut pits	Monthly once extraction is complete	Water level

3.2.5 Groundwater quality

Background water quality data is available at deeper bores WYMB01, WYMB02, WYMB03, WYMB04, WYMB06 and WYMB10; and at alluvial monitoring bore GDCMB01. Groundwater quality plots are presented in Appendix D.

Background groundwater quality indicates that pH was generally between 7 and 8.5 for all sites indicating that all sites are slightly basic. Background Electrical Conductivity (EC) at WYMB02, WYMB03, WYMB04 and WYMB10 was over 20,000 µS/cm indicating very saline water. Background EC at WYMB01 and WYMB06 was lower however still very saline at typically 12,000 to 13,000 µS/cm.

Piper diagram has been developed for all groundwater monitoring locations and is shown in Appendix B. The piper diagram allows comparison of water chemistry between monitoring locations. The piper diagram indicates that the groundwater at all deeper monitoring locations within the fractured and porous rock aquifer is of similar chemistry of sodium chloride type. The groundwater at the Wyoming three sump and the Caloma one sump is of similar chemistry to the fractured and porous groundwater monitoring locations indicating that the open cut pits are intercepting groundwater from the fractured and porous rock aquifer.

The piper diagram indicates that groundwater in the Gundong Creek alluvial aquifer is of differing chemistry to the deeper fractured and porous aquifer. The differing chemistry indicates a low degree of connectivity between the alluvial aquifer and the fractured and porous rock aquifer.

Water quality parameters at GDCMB01 have been compared to Default Trigger Values (DTVs) for 95% species protection recommended by ANZECC and ARMCANZ (2000a) due to its location within the alluvium. Water quality at GDCMB01 has been plotted against DTVs with quality graphs shown in Appendix D. Water quality at GDCMB01 is below DTVs for arsenic, cadmium, mercury, and ammonia. EC at GDCMB01 is typically just above the DTV. GDCMB01 has also exceeded DTVs for pH, TSS, chromium, copper, lead, nickel, zinc and dissolved iron on one or more occasions.

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Paper Size A4

0 200 400 600 800 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Site boundary
- EPL 20169
- Groundwater monitoring bore
- Watercourse

GHD

ALKANE

Tomingley Gold Operations
Groundwater Management Plan

Job Number 21-26505
Revision 0
Date 15 Nov 2017

Groundwater monitoring points

Figure 3-1

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Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

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Data source: Tomingley Gold Operations: Imagery, 2015; LPI: DTDB\Imagery, 2012, 2015. Created by: gmcdiarmid

3.3 Groundwater trigger values

The NSW Aquifer Interference Policy requires that potential impacts on groundwater sources, including users and GDEs, be assessed against minimal impact considerations, outlined in Table 1 of the policy. If the predicted impacts are less than the Level 1 minimal impact considerations, then these impacts will be considered as acceptable. The Level 1 minimal impact considerations for Less Productive Fractured Groundwater Sources have been adopted for the TGO pit top. The Level 1 minimal impact considerations for Highly Productive Alluvial Groundwater Sources have been adopted for the production borefield. The Level 1 minimal impact considerations are as follows:

- A cumulative pressure head decline of not more than a 2 m, at any water supply work.
- If the predicted pressure head decline is greater than the requirement above, then appropriate studies are required to demonstrate that the decline will not prevent the long-term viability of the affected water source unless make good provisions apply.
- If the above condition is not met then appropriate studies will need to demonstrate that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply works.

3.3.1 Groundwater levels

The majority of shallow bores have been located to provide early detection of leaks from the RSF and processing areas. Therefore, trigger values for shallow monitoring bores are recommended to be based on a rise in groundwater level. For all shallow monitoring bores (except GDCMBP01) a Stage 1 trigger would be exceeded if groundwater levels rise over three consecutive months. A Stage 1 trigger would result in an investigation to determine if the rise in groundwater level is attributable to mining related activities.

The stage 1 investigation will include an analysis of groundwater quality monitoring data to identify whether the increases in groundwater levels are attributable to mining related activities. If it is likely that the rise in groundwater levels is the result of mining related activities, temporary modifications to the responsible mining activities will be made until groundwater levels return to normal levels. The modifications may include reduction in the placement of tailings and process water within the RSFs.

A Stage 2 trigger would be exceeded if groundwater levels rise over six consecutive months. The subsequent investigation will also include an analysis of groundwater quality monitoring data to determine whether the increases are the result of mining related activities. If mining related activities are likely to be responsible for the changes to shallow groundwater levels, longer term changes to water management on site will be implemented. These changes may include cessation of tailings placement and process water storage within the RSFs.

Groundwater level triggers for deeper groundwater monitoring bores have been developed to monitor drawdown in the fractured rock aquifer. All deeper groundwater monitoring bores are within the radius of groundwater drawdown predicted by the Impax Group (2011) as discussed in Section 4.1. Due to the lack of a numerical groundwater model, the extent of drawdown at each of the monitoring bores has not been predicted. It is recommended that groundwater level drawdown triggers are based on historical groundwater levels and from any complaints from a surrounding land holder.

The proposed groundwater level Stage 1 trigger is a drop in groundwater level more than 2 m below minimum pre-mining groundwater level or a complaint from a surrounding landholder. The proposed groundwater level Stage 2 trigger is a drop in groundwater level more than 4 m below the pre-mining groundwater level or two complaints from surrounding landholders within a three-month period.

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Similar to groundwater monitoring bores in the fractured rock, the groundwater level trigger for GDCMP01 is recommended to be based upon historical groundwater levels. The stage 1 trigger value for groundwater level at GDCMP01 is proposed to be a groundwater level of 1 m below minimum historical groundwater level. The stage 2 trigger value for groundwater level at GDCMP01 is proposed to be a groundwater level of 2 m below minimum historical groundwater level.

Groundwater monitoring bores WYMB001 and WYMB006 are located outside of the modelled drawdown area. The potential impact to groundwater levels at these locations due to mining operations at TGO is therefore expected to be negligible.

Groundwater level trigger values are summarised in Table 3-6.

If the deeper groundwater levels are drawn down to either the stage 1 and stage 2 trigger level, an investigation will be undertaken to ascertain whether the falling groundwater levels are the result of mining related activities, and the result of external factors (eg over-use of the groundwater source by other licensed water users or extended period of drought). If the investigation identifies that the fall in groundwater levels is the result of mining related activities, compensatory water supplies will be provided to the affected landowners.

Table 3-6 Groundwater level trigger values

Bore	Stage 1 Trigger (m AHD)	Stage 2 Trigger (m AHD)
WYMB001	207.97	205.97
WYMB002	206.91	204.91
WYMB003	218.19	216.19
WYMB004	206.62	204.62
WYMB006	229.13	227.13
WYMB10	198.30	196.30
GDCMB01	269.64	268.64

Production borefield

Triggers for the production borefield have been defined in order to identify potential drawdown in the Macquarie River alluvium. Groundwater level trigger values are based on groundwater levels at DPIW monitoring bores, since these have been largest historical dataset. Trigger values are also based on complaints from adjacent landholders regarding groundwater level or quality.

Trigger values have been defined for the DPIW monitoring bores in order to identify drawdown occurring at surrounding landholder's groundwater extraction locations. The two closest surrounding landholder's stock and domestic groundwater extraction bores are GW805125 and GW028348 located approximately 650 m to the north and 700 m to the east south-east from the production bore respectively as shown in Figure 2-4.

DPIW monitoring bores within the vicinity of the production borefield include GW096080 located within 100 m of the production bore and GW273056 located 900 m to the north west of the production bore. GW273056 is also located at least 600 m from all other extraction bores.

Trigger levels are proposed to indicate a potential exceedance of Level 1 minimal impact considerations defined by the NSW AIP (i.e a fall in groundwater level of more than 2 m at any water supply work). The Stage 1 trigger for the production borefield is defined as a fall below the minimum groundwater level at GW273056-2 shown in Table 3-7; or a complaint from a surrounding landholder regarding groundwater level or quality. The Stage 2 trigger is defined as a fall in groundwater level of more than 2 m below minimum groundwater level at GW273056-2, shown in Table 3-7. It is recommended that TGO monitors groundwater levels at GW096080-2.

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GW096080-2 is located within 100 m of the production bore and groundwater levels at this bore can be used to verify that extraction from the production bore is impacting on the Macquarie River alluvial aquifer. DPIW monitoring bore data is available from http://www.water.nsw.gov.au/realtime-data/groundwater.

Exceedance of trigger values at DPIW monitoring bores may not be directly attributable to extraction from the production borefield as there are a number of other bores extracting from the Macquarie River alluvium. Any exceedance of triggers at the production borefield is recommended to trigger further investigation into the cause of the fall in groundwater levels.

Table 3-7 Trigger values – DPIW monitoring bores

Bore	Minimum groundwater elevation (m AHD)	Stage 1 trigger (m AHD)	Stage 2 trigger (m AHD)
GW273056-2	220.01	220.01	218.01
GW096080-2	217.42	-	-

3.3.2 Groundwater quality triggers

The NSW Aquifer Interference Policy the impact on groundwater quality from TGO operations should not reduce the beneficial use category beyond 40 m from the activity.

The review of historical groundwater quality data indicates that EC at deeper groundwater monitoring bores is typically of a value around 20,000 µS/cm at WYMB02, WYMB03, WYMB04 and WYMB10. Background EC is approximately 12,000 to 13,000 µS/cm for WYMB01 and WYMB06. The very high EC at these locations limits the usefulness of deep groundwater within the porous and fractured groundwater source to industrial use only. The search for registered groundwater works indicates that there are only two monitoring bores registered as stock or domestic within 10 km of TGO. Both of these bores are over 8 km from TGO.

Considering the lack of nearby registered groundwater bores, high groundwater EC, and uneconomically low water yield, it is recommended that the trigger for groundwater quality for deep monitoring bores are based on complaints from surrounding landholders. It is recommended that a Stage 1 trigger for groundwater quality for the deep groundwater aquifer is a complaint from a surrounding landholder regarding groundwater quality.

It is recommended that groundwater quality triggers for deep groundwater monitoring bores are considered for revision in a revised WMP following approval of the in pit waste rock disposal.

Analysis of water quality data at GDCMP01 compared groundwater quality to DTVs. Groundwater quality at GDCMP01 exceeds DTVs for a number of water quality parameters. Recommended trigger values at GDCMP01 are recommended to be a combination of DTVs and historical water quality. It is proposed that the trigger value is proposed to be the DTV except where historical data exceeds the DTV. Where historical data exceeds the DTV then the trigger value is proposed to be the maximum historical concentration. Recommended trigger values are shown in Table 3-8.

Table 3-8 Recommended trigger values GDCMB01 (EPA 5)

Parameter	Trigger Value	Units	Source
pH	6.0 – 8.5	pH units	DTV
EC	706	µS/cm	Max. historical concentration
Arsenic	0.024	mg/L	DTV
Cadmium	0.0002	mg/L	DTV
Chromium	0.025	mg/L	Max. historical concentration

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Parameter	Trigger Value	Units	Source
Copper	0.002	mg/L	Max. historical concentration
Lead	0.015	mg/L	Max. historical concentration
Mercury	0.0006	mg/L	DTV
Nickel	0.015	mg/L	Max. historical concentration
Zinc	0.071	mg/L	Max. historical concentration
Iron (dissolved)	2.5	mg/L	Max. historical concentration
Iron (total)	21.1	mg/L	Max. historical concentration
Cyanide (Total, Free and WAD)	0.004	mg/L	Max. historical concentration
Ammonia	0.9	mg/L	DTV

Limited groundwater quality data is available at shallow groundwater monitoring locations associated with the RSF and the PWD. This lack of data is due to a number of these locations being dry or almost dry for the majority of monitoring periods. The lack of water quality data is also due to these monitoring bores only being installed in the last two years.

In order to identify any impacts from the RSF or the PWD; it is proposed that the water quality trigger triggers for GDCMB01 are adopted for shallow groundwater monitoring locations associated with the RSF and the processing plant. The exception to this is RSFMP03 which appears to be influenced by the deeper porous and fractured rock aquifer as indicated by the piper plot shown in Appendix B.

The stage 1 trigger for all shallow groundwater monitoring locations (except RSFMP03) is proposed to be an exceedance of a trigger value for any water quality parameter listed in Table 3-8. The stage 1 trigger for all shallow groundwater monitoring bores is also proposed to be a continuous upward trend in any of the parameters listed in Table 3-8 for three consecutive months. The stage 2 trigger value is proposed to be an exceedance of a trigger value listed in Table 3-8 for three consecutive months for any water quality parameter. The stage 2 trigger for all shallow groundwater monitoring bores is also proposed to be a continuous upward trend in any of the parameters listed in Table 3-8 for six consecutive months.

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4. Potential risks

A number of mining related activities have the potential to impact groundwater levels and quality. Open cut mining pits, waste rock dumps and reject storage facilities all have the ability to affect groundwater levels and quality.

4.1 Open cut and underground mining

Open cut and underground mining may result in groundwater level drawdown as mining intercepts aquifers that are pumped out of the workings. Any open cut or underground mining in Caloma Open Cut, Wyoming One, Wyoming One Underground Extension and Wyoming Three pits will potentially result in groundwater drawdown in the vicinity of the workings. Drawdown will continue as long as open cut areas continue to be dewatered. As dewatering ceases it is anticipated groundwater levels will slowly re-stabilise.

Observed groundwater make is approximately 0.2 ML/day for each pit.

Groundwater drawdown for each of the open cut pits and the underground workings was estimated by the Impax Group (2011) using the analytical equations and approach developed by Marinelli and Niccoli (2000). The analytical equations developed by Marinelli and Niccoli (2000) provide a method of estimating steady state or long term average inflows into a mine pit. The analysis was updated as part of the assessment process for Modification 3 (GHD 2015). The updated radius of drawdown was generally less than initially estimated by Impax Group (2011), which is consistent with groundwater observations. The updated radius of drawdown for each of the open cut pits and areas of underground mining is summarised in Table 4-1.

Table 4-1 Predicted radius of drawdown (GHD 2015)

Mining Area	Radius of Drawdown (m)
Caloma Open Cut	2,130
Wyoming One	2,130
Wyoming One Underground Extension	2,500
Wyoming Three	660
Caloma Two	810
Caloma Two Underground	2,400

The Marinelli and Niccoli (2000) method considers each area of mining individually and not the cumulative effect of all mining areas being mined either concurrently or consecutively.

4.2 Residue storage facilities

RSF decant water is saline and moderately alkaline, with elevated concentrations of arsenic, copper, nickel, cyanide and ammonia. The infiltration of RSF water into the local groundwater (or overflow into the surrounding surface water environment) therefore has the potential to result in the contamination of the local groundwater supply.

In accordance with the Statement of Commitments the RSF has been constructed over naturally occurring clays that have a permeability of less than 1 x 10^{-9} m/s of depth 900 mm or greater. The very low permeability, combined with adequate progressive dewatering of tailings, is intended to minimise the potential interaction of water from the RSF with the local groundwater resource.

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4.3 Water supply borefield

The Woodlands Borefield consists of a number of water supply bores that extract from the Lower Macquarie River alluvium. Drilling of bores within the water Woodlands Borefield indicates that the alluvial material extends to a depth of at least 45 m bgl (Impax Group, 2008). The Woodlands Borefield is potentially extracting from the deeper alluvial sediments of the Macquarie River paleochannel.

GW801047 safe pumping yield is reported to be between 23.5 L/s and 30.8 L/s (or 741 ML/year to 971 ML/year) and Test bore 4 safe pumping yield is reported to be between 28.9 L/s and 39.7 L/s (or 911 ML/year to 1251 ML/year) (Impax Group, 2008).

4.4 Final void management

There will be four final voids (Caloma One, Caloma Two, Wyoming One Pit and the partially filled Wyoming Three) as part of the post-mining landscape. The rehabilitation objectives for the mine are identified in the Mining Operations Plan (MOP). Rehabilitation of the voids would include the following activities:

- 12 months prior to mining completion of a pit, an assessment of geotechnical stability will be undertaken.
- Where possible, the upper benches of Caloma One Pit will be laid back to encourage revegetation.
- No revegetation of the lower benches will be undertaken on any of the Pits.
- Access to each pit will be prevented through construction of berms and security fencing.

The final voids will be allowed to fill because of the post-mining landscape and this WMP will be updated to reflect the work completed as part of site rehabilitation.

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