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Bringelly Brickworks

Groundwater Management Plan

GLOSSARY AND ABBREVIATIONS

BoM	Australian Bureau of Meteorology
CoA	Conditions of Approval for SSD_5684 MOD 1,
CSR	CSR Limited
DPI&E	Department of Planning Industry & Environment
DPIE Water	Department of Planning, Industry & Environment- Water
EIS	Bringelly Brickworks Quarry Extension Environmental Impact Statement (Golder and Associates 2013)
EMS	Environmental Management Strategy
EP&A Act	Environmental Planning and Assessment Act 1979
EPA	NSW Environment Protection Authority
GDE	Groundwater Dependant Ecosystems
GWMP	Groundwater Management Plan
NOW	NSW Office of Groundwater (Now DPIE Groundwater)
OEH	NSW Office of Environment & Heritage
PIRMP	Pollution Incident Response Management Plan
PGH	PGH Bricks
POEO Act	Protection of the Environment Operations Act 1997
RTS	Bringelly Brickworks Quarry Extension Response to Submissions
Secretary, the	The Secretary of the DP&E
SSD	State Significant Development
TSP	Total Suspended Particulate Matter
VGT	VGT – Environmental Compliance Solutions Pty Ltd – Approved Consultant
WMS	Work method statements
GWMP	Groundwater Management Plan

Document Control

Version	Date	Description of Change
4	Dec 2019	Original approval after consultation
5	Dec 2020	Minor Changes only, format, layout and history update.

CONTENTS

1 INTRODUCTION

1.1 Context

This Groundwater Management Plan (GWMP or Plan) forms part of the Environmental Management Strategy (EMS) for the Bringelly Brickworks (the facility). The Plan has been prepared following the approval of the Bringelly Brickworks Extension Project (SSD_5684) on 3 March 2015 and a Section 96(1A) modification application (MOD1), which was determined on 31 October 2016.

This GWMP has been prepared to address the requirements of the CoA as updated following the determination of MOD1, the mitigation measures listed in the Bringelly Brickworks Quarry Extension Environmental Impact Statement (EIS) and all applicable legislation, licenses and permits.

All relevant environmental plans were prepared and submitted to the DP&E in 2017, this plan represents an updated draft to reflect required amendments and onsite procedures.

1.2 Background

Bringelly Brickworks (the facility) is a clay/shale quarry and brick making facility located at 60 Greendale Road, Bringelly, on Lot 100 in DP 1203966 and comprises an area of approximately 385.55 hectares in the Camden Local Government Area. The facility has been in operation since 1968, and in its original form it had the capacity to process approximately 51,500 tonnes of bricks per annum.

In 1991, Boral Bricks (NSW) Pty Limited undertook to upgrade the facility with new technology and increase production to ensure the continued economic viability of the site due to the age of the manufacturing plant and machinery. The Council of the Municipality of Camden, as the approving authority at the time, approved the Development Application on 13 September 1991 (Council ref. DA 91/1194). From 1991 until 2013, the Bringelly Brickworks facility operated under this approval, which permitted (among other things) quarry extraction up to 200,000 tonnes per annum, the receipt of up to 96,000 tonnes of supplementary materials and brick production up to 160,000 tonnes per annum.

In 2013, Boral Bricks Pty Limited (Boral) prepared an Environmental Impact Statement (EIS) to assess the environmental impacts of an increase in production at the facility and continued extraction of the quarry to meet the anticipated demand for its brick products ('Bringelly Brickworks Extension Project', Application No. SSD_5684). The project was determined to be State Significant Development (SSD) under Part 4, Division 4.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and Clause 8 *State Environmental Planning Policy (State and Regional Development) 2011* (State and Regional Development SEPP).

The EIS was publicly exhibited from 6 November 2013 to 9 December 2013. The then Department of Planning & Environment (DP&E) received 12 submissions during this period, including 11 from public authorities and 1 submission from the general public who objected to the project due to its potential impacts. While none of the government authorities objected to the project, most raised concerns about its potential impacts and/or made recommendations for managing these impacts.

Boral prepared and submitted an initial Response to Submissions (RTS) to the DP&E in February 2014. However, following receipt of the RTS, DP&E received further correspondence from 7 public authorities which necessitated further consultation between Boral, DP&E and the relevant government authorities.

The additional consultation was resolved and in February 2015 DP&E finalised their Environmental Assessment Report and the Bringelly Brickworks Extension Project was approved with conditions on 3 March 2015.

On 1 May 2015, CSR Limited (CSR) and Boral Limited (Boral) formally completed the establishment of a joint venture for operations located in New South Wales, Victoria, Queensland, South Australia, Tasmania and the ACT. Ownership of Bringelly Brickworks (including quarrying activities) was transferred to the joint venture Boral CSR Bricks Pty Ltd (BCB), trading as PGH Bricks & Pavers. PGH Bricks & Pavers (PGH) was the controlling entity of the facility and responsible for implementing the Environmental Management Strategy of the

site. On 31 October 2016 CSR agreed to acquire Boral's interest in BCB, therefore resulting in CSR owning 100% of PGH. BCB no longer exists

Since Project Approval, the type of bricks demanded by the market have changed and Boral Bricks withdrew from the site. These two critical factors necessitated PGH to review its manufacturing requirements to ensure the most efficient use of all the resources available. To manufacture the bricks demanded by the market, the type, composition and

quantity of the raw materials to be imported to Bringelly Brickworks was reconsidered because the type of raw materials required could not be solely extracted from the Bringelly quarry. PGH therefore applied to DP&E to modify SSD_5684 under Section 96(1A) of the *Environmental Planning and Assessment Act 1979* (EP&A Act), to provide for an increased raw material import limit to 321,000 tonnes per annum (referred to as MOD1). MOD1 was approved by DP&E on 31 October 2016.

Bringelly Brick Works continued to operate under DA 91/1194, however approval for State Significant Development (SSD 5684) was issued in March 2015 for the extension of the quarry and to upgrade ancillary infrastructure.

Schedule 2, Condition 9 of SSD 5684 required PGH to surrender DA 91/1194 following commencement of development, as approved in SSD 5684. The SSD was triggered on 24 Feb 2020, and DA 91/1194 was surrendered to Camden Council.

In anticipation of the surrender of DA 91/1194, draft management plans were prepared in accordance with SSD 5684 and submitted to the Department of Planning and Environment (DP&E) on 21 February 2017 for comment. Consultation regarding these plans continues as required and modified plans were submitted for approval by DPI&E in Dec 2019. They were subsequently approved in Dec 2019.

A ground water quality assessment was completed as part of the EIS for the project by specialist water quality consultants, Golder and Associates (2013). This assessment provided a quantitative assessment of potential water quality impacts associated with the project.

The EIS was publicly exhibited from 6 November 2013 to 9 December 2013. The Department of Planning, Industry & Environment (DPIE) received 12 submissions during this period, including 11 from public authorities and 1 submission from the general public who objected to the project due to its potential impacts. While none of the government authorities objected to the project, most raised concerns about its potential impacts and/or made recommendations for managing these impacts.

An initial Response to Submissions (RTS) to the DPIE prepared and submitted in February 2014. However, following receipt of the RTS, DPIE received further correspondence from 7 public authorities which necessitated further consultation between PGH, DPIE and the relevant government authorities.

This plan has been drafted by VGT and PGH Bricks and Pavers Pty Ltd (PGH) and prepared to comply with the requirements of the modified SSD_5684.

1.3 GWMP Approval

This GWMP has been prepared in consultation with the NSW Environment Protection Authority (EPA) who provided comments (refer to Annexure to this report- Water Management Consultation and Correspondence).

This GWMP has also been prepared in consultation with Department of Planning, Industry and Environment-Water (DPIE-Water) who provided comments (refer to Annexure to this report- Water Management Consultation and Correspondence).

The Conditions of Approval relevant to this GWMP and how they are met by this plan are outlined in *Table 3*.

This GWMP must have also been endorsed by the Plant Manager and National Environmental Manager prior to submission to the Secretary of the DPIE.

The GWMP is required to be submitted to the Secretary of the DPIE for approval prior to commencing the development approved in SSD_5684 MOD 1, unless the Secretary agrees otherwise.

1.4 Consultation

Condition 18.b), Schedule 3 of the Project Approval requires that the Groundwater Management Plan be prepared in consultation with the Environment Protection Authority (EPA) and the NSW Department of Planning, Industry and Environment- Water (DPIE Water). A draft copy of this Plan will be provided to each of these agencies for comment prior to submission of a final draft to the Department of Planning for approval. Telephone and Email consultation has been undertaken with representatives from EPA and DPIE Water to support the development of this Plan.

In summary, the EPA stated in their correspondence that they do not approve or endorse the Plan as their role is to set environmental objectives for environmental management, not to be directly involved in the development of strategies to achieve those objectives.

A previous draft plan has been submitted the DPIE post approval and comments were provided (see Annexure to this report- Water Management Consultation and Correspondence). An amended draft plan was submitted in August 2019 and further comments were in turn received from DPIE. The table below summarises these comments relevant to groundwater management of the Site that require actions and where addressed in this report.

Table 1 DPIE Post Approval Environmental Management Plan Comments

Relevant Consent Condition	Comment (from References)	Where Addressed in this Report
A Groundwater Management Plan, which includes:		
• baseline data on groundwater levels, yield and quality in surrounding aquifers;	See Section 5.4 – Please tabulate baseline groundwater quality. Not Satisfied. See Section 6– Reference is made to Tables 5 and 6. These tables do not appear in the document. Please include the data or amend. Not Satisfied.	Section 5.6 Section 5.2
• groundwater assessment and performance criteria, including trigger levels for investigating potentially adverse groundwater impacts;		
• a program to monitor: ○ groundwater inflows to the quarry pit; and	See Section 8 – Please include a program to monitor inflows to the quarry pit (even if they are predicted to be minimal). Not Satisfied.	Section 6
○ impacts of the development on surrounding aquifers;	See Section 8 – Please include a program to monitor impacts on surrounding aquifers (even if impacts are unlikely or predicted to be minimal) Not Satisfied.	Section 6
• an analysis of the monitoring results to determine long-term water levels within the quarry void; and • a plan to respond to any exceedances of the performance criteria.	See Section 9 – Further response beyond investigating the source of pollutant required. Not Satisfied.	Section 8
Other Comments		
Please update all references of “NOW” to “DPIE Water”.		Whole Document
The Department requires clear statements i.e. replace “should” references with “will” etc. Not Satisfied.		Whole Document
Several tables are mislabelled or omitted from the document. Not Satisfied		Tables
Table 13 has been cut off. Please amend. Not Satisfied.		Tables

A draft report was also submitted to Natural Resources Access Regulator (NRAR) and the following comments were provided in correspondence dated 13 November 2018 (see Annexure to this report- Water Management Consultation and Correspondence).

Table 2 NRAR Groundwater Management Plan Comments

Comment	Where Addressed in this Report
The Groundwater Management Plan must include all monitoring data gathered to date in summary tabulated form (e.g. minimum, average, maximum, standard deviation) in the body of the document. Raw data collations are to be provided & plotted as appendices or as a supplementary document and accompany the report in electronic form (e.g. MS Excel spreadsheets). Sufficient data to establish baseline conditions and typical fluctuations over several seasons is needed to meet this requirement.	Section 5, Appendix A, Appendix B.
Where monitoring bores have been determined to be 'dry', or otherwise damaged, destroyed or rendered non-functional, the Groundwater Management Plan must set out a program (including nominated drilling depths and a schedule for the completion of the works) to reinstate the installation at each location if required.	Section 7
The Groundwater Management Plan must include an updated project planning diagram, illustrating potential quarrying activities (i.e. development stages and intended extraction activity) and nominating replacement monitoring bore locations where there is a possibility of existing installations being damaged, destroyed or removed by ongoing site operations.	Figure 6
The Groundwater Management Plan must include water level elevations of all water bodies on the site, together with groundwater elevations measured on the same day, and provide a discussion of the relative levels in respect of hydraulic gradients and flow directions in the body of the document. Section diagrams illustrating the relative elevations of the existing (and any proposed) quarry pits and groundwater levels need to be included to support the calculations of groundwater take volumes.	Section 5, Section 7, Figure 4, Figure 5
The Groundwater Management Plan must provide a tabulated summary of all dates (as well as descriptions of the advice received) when consultation with DPIE- Water staff occurred to demonstrate Condition 18(b) has been met.	See Annexure to this report- Water Management Consultation and Correspondence.
The Groundwater Management Plan must clearly describe the trigger levels for investigating potentially adverse groundwater impacts that are to be applied to the groundwater monitoring bores relating to both changes in levels and quality to demonstrate that the relevant part of Condition 18(f) has been met.	Section 8
The Groundwater Management Plan must clearly describe the program to monitor the groundwater inflows to the existing quarry pit and the impacts of the development on surrounding aquifers to demonstrate that the relevant part of Condition 18(f) has been met.	Section 6,Section 7
The Groundwater Management Plan must clearly describe the analysis of the monitoring results to determine long-term water levels within the quarry void to demonstrate that the relevant part of Condition 18(f) has been met.	Section 5, Section 7, Section 10.6

The Groundwater Management Plan will need to include a reconsideration of the response to any exceedances of the performance criteria required under the relevant part of Condition 18(f) to incorporate the analyses of measured site data and specific trigger levels determined for the groundwater monitoring bores.	Section 8, Section 10
The Groundwater Management Plan must clearly set out a quantification of the range of groundwater take under different seasonal conditions (i.e. wet and dry months) and detail the calculations used to derive the volumes to demonstrate compliance with the licensing provisions of the Water Management Act 2000 and the requirements of the NSW Aquifer Interference Policy 2012.	Section 7
The Groundwater Management Plan must clearly set out a strategy for obtaining licensed entitlement from the Sydney Basin Central Groundwater Source to account for the calculated take.	Section 3.4, Section 7
Comment	**Where Addressed in this Report**
The Groundwater Management Plan must include a precise schedule for the revision, reporting and review of the Groundwater Management Plan on a regular basis or as a result of a change in the site operations.	Section 10.6
A suitably credentialed hydrogeological consultant must prepare the revised Groundwater Management Plan and the Water Management Plan in accordance with Condition 18(a).	Appendix C

2 PURPOSE AND OBJECTIVES

2.1 Purpose

The purpose of this Plan is to describe how PGH proposes to manage potential impacts to groundwater generated by the facility. This document has been prepared to satisfy the SSD_5684 MOD1 conditions of consent requiring a Groundwater Management Plan.

2.2 Objectives

The key objective of the GWMP is to ensure that impacts to the downstream environment are minimised. To achieve this objective, PGH will undertake the following:

- Ensure appropriate environmental controls and procedures are implemented to minimise the potential for adverse groundwater quality impacts to identified sensitive receivers and the local community;
- Manage groundwater quality impacts, if they occur, through a systematic analysis of mitigation strategies;
- Ensure environmental management measures identified in *Table 11* are implemented to address the relevant CoA outlined in *Table 3*;
- Ensure appropriate measures are implemented to comply with all relevant legislation and other requirements as described in S*ection 3* of this GWMP: and
- Develop a set of performance criteria and appropriate environmental management measures for the site.

3 ENVIRONMENTAL REQUIREMENTS

3.1 Relevant Legislation and Guidelines

3.1.1 Legislation

Legislation relevant to Groundwater quality management includes:

- Environmental Planning and Assessment Act 1979 (EP&A Act);
- Protection of the Environment Operations Act 1997 (POEO Act);
- Water Act 1912;
- Water Management Act 2000;
- Sydney Water Act 1994;
- Protection of the Environment Operations Regulation 2000; and
- The Water Sharing Plan for the Greater Metropolitan Region Unregulated River Groundwater Sources 2011.

3.1.2 Guidelines and Standards

The main guidelines, specifications and policy documents relevant to this GWMP include:

- Approved Methods for the Sampling and Analysis of Water Pollutants in New South Wales (Gazette no 54 of 12 March 2004 p 1150);
- Managing Urban Stormwater, Volume 2E, Mine and Quarries (Department of Environment and Climate Change, New South Wales, June 2008);
- DECC Managing Urban Stormwater - Soils and Construction V1 (2004); and
- The Australian and New Zealand Environment Conservation Council Guidelines (ANZECC guidelines).

3.2 Minister's Consent Conditions

This document has been prepared to satisfy the SSD_5684 MOD 1 conditions of consent requiring a Groundwater Management Plan. The Conditions of Approval relevant to this GWMP are listed in *Table 3*. A cross reference is also included to indicate where the condition is addressed in this GWMP or other environmental management documents.

Table 3 Conditions of Approval relevant to the GWMP

Condition	Requirement	Where Addressed in this plan
Groundwater Management Plan (Condition 18)	The Applicant shall prepare and implement; (f) a Groundwater Management Plan for the development to the satisfaction of the Secretary, which includes: • baseline data on Groundwater levels, yield and quality in surrounding aquifers; • Groundwater assessment and performance criteria, including trigger levels for investigating potentially adverse Groundwater impacts; • a program to monitor: ○ Groundwater inflows to the quarry pit; and ○ impacts of the development on surrounding aquifers; • an analysis of the monitoring results to determine long-term Groundwater levels within the quarry void; and • A plan to respond to any exceedances of the performance criteria.	GWMP (This plan) Section 5 Section 5.2 Section 7 Section 6 Section 5.2 Section 8

3.3 Licenses and permits

The Environment Protection Authority (EPA) issued the Brickworks with licence number 1808. No groundwater monitoring requirements are listed in the Licence.

3.4 Water Access Licence

The Water Management Act 2000 identifies basic landholder rights and when access licenses are required. The harvestable water right is defined in terms of and equivalent dam capacity, the Maximum Harvestable Right Dam Capacity (MHRDC). Schedule 1 of the Water Management Regulation exempts certain classes of dam including those dams solely for the capture, containment and recirculation of drainage and/or effluent, consistent with best management practice or required by a public authority to prevent the contamination of a water source. Therefore, as the on-site dams are used solely for the capture, containment and reticulation of drainage, consistent with best management practice to prevent impacts to Thompsons Creek, the dams are exempt from the need to obtain a licence under the WM Act.

The site does however have 3 surface water access licences; 1. WAL 26259 = 150 ML

2. WAL 26257 = 6.5 ML

3. WAL 25987 = 152.5 ML

In addition there are 4 groundwater bores (drilled in the EIS) licenced in perpetuity for monitoring under 10BL605770. Only 3 of these are functioning.

Although the site has not currently encountered groundwater, future stages may intercept groundwater and approval is being sought for future take of groundwater prior to extraction below the groundwater level. Predicted inflows to the void from the EIS ranged from 0.1 to 1.0L/s.

4 EXISTING ENVIRONMENT

4.1 Site Location and Overview

The project site is currently used for quarrying, brick production and associated activities. The brickworks and quarry are located on an approximately 385.55 hectare property owned by PGH Limited, which is located at 60 Greendale Road, within the Camden local government area and is approximately 55 km southwest of the Sydney central business district (Refer to *Figure 1*).

The brick making facility along with various administration buildings, a finished brick storage yard, staff car park and internal road network is generally contained within the northern part of the project site (refer to *Figure 2*), and is set back approximately 200 m from Greendale Road.

Existing quarrying activities have substantially altered the natural landform, with various voids and elevated stockpiles present in the active, north-western part of the project site. Other significant landforms on the site include the raw material stockpiles to the south of the brickworks, as well as unusable materials stockpiles along the western boundary of the site. The underlying topography of the operational footprint on the project site is relatively flat, and the land slopes to the south toward Thompsons Creek.

The southern portion of the project site, adjacent to Thompsons Creek, is leased for the agistment of stock and grazing.

5 GROUNDWATER ASSESSMENT

5.1 Background

The project site is located within the 'Hawkesbury Nepean Water Management Area' and within the 'Sydney Basin Central Groundwater Source'. The Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011 applies to the project. The project site sits within the Hawkesbury-Nepean Catchment, which is the largest catchment area in the Sydney area (approximately 21,400 square kilometers).

Bringelly sits in a region of interbedded sedimentary rocks (siltstone, claystone, lam mite and sandstone) known as the Middle Triassic Wianamatta Group. The group is made up of three main formations: Bringelly Shale, Minchinbury Sandstone and Ashfield Shale. The upper unit is the Bringelly Shale, a formation dominated by claystone and siltstone with thin laminate horizons and minor sandstone. This is underlain by Minchinbury Sandstone, a 3–6 metre thick quartz lithic sandstone; followed by the Ashfield Shale which comprises sandstone-siltstone laminate and sideritic claystone.

The Wianamatta Group is underlain by Hawkesbury Sandstone. The project site is underlain by the lower 75 metres to 150 metres of the Bringelly Shale which comprises claystone, siltstone, laminate and sandstone. The base of the sequence in this area is defined by the Cobbity Claystone, a thin (maximum six centimetres) persistent layer of weathered tuff. Alluvium (sands and gravels, fined-grained sand, silt and clay) derived from surrounding rocks are present along streams such as Thompsons Creek and Bardwell Gully.

The quarry is located on the Blacktown landscape is categorised by shallow to podsolic on crests grading to yellow on located on South Creek soil landscape structured plastic clays soil landscape, overlaying Wianamatta Group shales. This soil moderately deep, hardsetting, mottled textured with red and brown lower slopes. The area to the east of the quarry and brickworks consists of layered alluvial soils, structured loams and structured plastic clays.

The quarry area of the site has an elevated topography with the highest point towards the northwest corner at 113 m AHD. A constructed ridge runs along the western boundary north to south of the site which gently slopes downwards towards the east — south east. The lowest point runs along the eastern side of the site and is characterised by Thompson Creek. The general direction of overland flow is towards Thompsons Creek downstream of Dam 6.

The hydrogeology of the project site is mainly controlled by its geology. Hydrostratigraphy units within the Wianamatta Group comprise the Bringelly Shale, Minchinbury Sandstone and Ashfield Shale Units. The Bringelly Shale unit can be characterised as low permeability, majority of groundwater flow via fractures and bedding planes, a layered aquifer system with limited inter-connection between zones, the groundwater potentiometric surface generally follows topography.

There are no high priority GDEs springs or national parks located within the project site. South Creek is categorized as a GDE category 'Reliant on surface expression of groundwater (rivers, springs, wetlands) and the zone along the creek is rated as area of 'high' vulnerability rating based on the vulnerability mapping from NSW Atlas. South Creek is located approximately 2.5 kilometres to the east of the project site. Results of the search for groundwater dependent ecosystems from the National Atlas of GDEs indicated the following GDEs (Category 'Reliant on subsurface groundwater – vegetation') within the project site: Cumberland Shale Hills Woodland, Cumberland Shale Plains Woodland and Cumberland River Flat Forest[1].

5.2 Initial Groundwater Assessment

Once the monitoring bores were installed and developed, water level and in-situ physio-chemical parameters were measured and recorded. Samples were collected for laboratory analysis after these initial parameters were recorded. Both data sets are tabulated in *Appendix A.*

Sampling was conducted at each monitoring bore within the scope of this project using disposable bailers and samples were retained in approved sampling bottles for shipping to the selected laboratory. Best practice is to purge 3 well volumes prior to sampling to ensure that the water being sampled is truly representative of that produced by the aquifer. In the case of GWO3 and GWO4 the ingress of groundwater was very slow so to ensure that adequate purging could be carried out, Boral site staff commenced the purging process using dedicated bailers prior to Golder mobilising to site for the water quality sampling event. Records of purged water volumes were

kept. The well volumes were calculated in advance of the purging process, using standard formulas for litre volumes of water per linear metre of 50mm monitoring bore casing and screen in HQ boreholes. The volumes that were required to be purged are calculated in *Table 4* below.

Table 4 Volume of Groundwater to be purged from the EIS

Table 2: Volume of groundwater to be purged based on three well volumes

Borehole	SWL[1] (mbtoc)	Date Measured	TDB[2] (mbgs)	Sump length (m)	Screen length (m)	Height of water column in well (m)	Well volume (litres)	Volume to be purged* (litres)	Actual purged volume (litres)
GW01	11.2	24/04/2013	40	3	18	29.36	89.32	267.96	207
GW02	10.76	24/04/2013	40	3	18	29.86	90.32	270.96	270
GW03	32.24	24/04/2013	40	1	15	8.36	29.232	87.696	87
GW04	39.81	24/04/2013	42	3	18	2.79	5.58	16.74	34.5

[1] – Static Water Level

[2] – Total Depth of Borehole

* Based on 3.7 litres per linear metre of screen and 2 litres per linear metre of casing.

Golder staff completed the remainder of the purging process while on site for the sampling event. A calibrated water quality meter was used to observe the field parameters during the purging process and purging was carried out until stability was observed in the parameters. A decontaminated sampling bucket was used to collect the bore water during sampling. Field records of the water quality sampling event including recorded insitu water quality parameters and SWLs can be found in the Golders report (see *Appendix A*).

As a QNQC on the water quality sampling methodology field blank samples were also taken and trip blanks provided by the laboratory were kept with the samples during transportation and storage. Duplicate samples were taken at GWO2 to act as a QAJQC on the laboratory procedures. Samples were stored in cooler boxes with ice bricks to preserve the samples and transported to the ALS laboratory within the allowable handling times for the selected parameters. The results of the water quality sampling are presented in Appendix A.

Results indicate that GWO4 is a dry hole, and GWO3 has partial saturation within the screened zone. Hydraulic conductivity values for GWO3 and GWO4 were found to be 1.915×10^{-9} m/s and 2.55×10^{-10} m/s, respectively, consistent with marine clays and shales1. GWO1 and GWO2 demonstrate hydraulic conductivities, k, of 2.628×10^{-7}m/s and 2.288x1 10^{-7} m/s, respectively. These values are consistent with sandstone formations. All bores had elevated levels of Zinc. The groundwater quality analysis results establish baseline readings for the long-term monitoring of groundwater characteristics.

5.3 Groundwater Levels

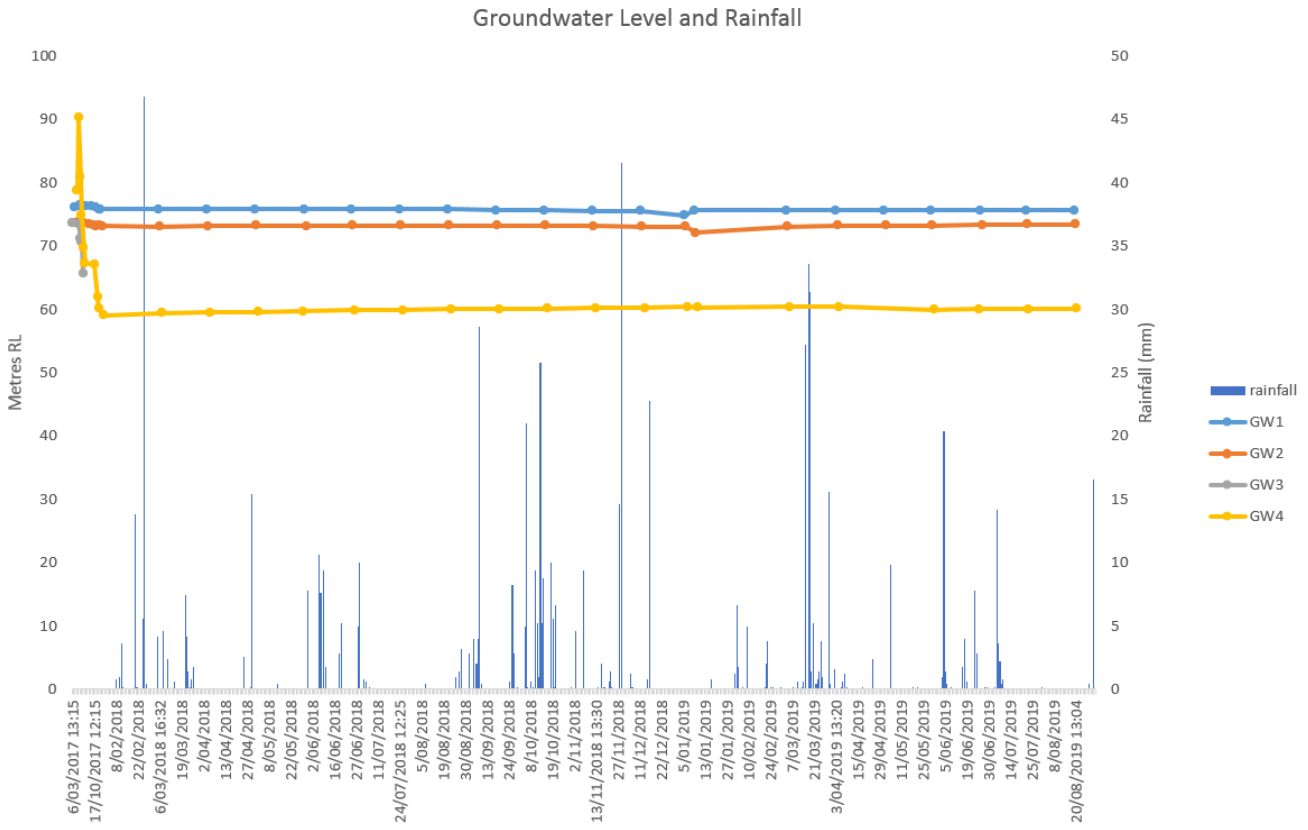
Groundwater levels varied from 60 to 76 metres AHD in the area. A weathered unit overlies the Bringelly Shale and perched shallow groundwater can occur within this layer at places. Groundwater depths (metres below ground surface) on site range between 11 to 40 metres. *Figure 3* shows the locations of the bores.

Table 5 Surveyed co-ordinates and elevations for groundwater monitoring bores

Bore Location ID	Easting	Northing	Elevation(mAHD)	Depth (metres below ground surface)
GW01	289202	6242112.1	88	11
GW02	289502.1	6242101.8	83.55	10.07
GW03	289628.5	6241630.2	87	26.19
GW04	289214.9	6241594.5	99	39.53

Note: GW3 is not functioning and GW4 groundwater levels are generally very low or even dry.
Monitoring has been undertaken since the installation of the bores and the levels appear to be fairly consistent as shown in the graph below.

Graph 1: Groundwater Levels



Rainfall appears to have little impact on the levels in the bores. To date there has been no regular measurement of water levels within the Main Pit although the most recent survey suggest that the pit water level is at approximately 69m RL. Notwithstanding this lack of measurement, there have been periods where the Main Pit has been dewatered and this does not appear to impact the bore levels indicating there is little linkage between the pit water and the surrounding groundwater.

From the cross-sectional plots of the bores and the Main Pit it (see *Figure 4*) appears that groundwater is lowest in the south and below the Main Pit level, and rises to the north (see *Figure 5*). In an eastward direction the levels appear to gradually decrease. This is consistent with the hydraulic gradient discussed in the EIS of flows from the north toward the south east, towards the South Creek locality to the east of the site. It is evident that the Main Pit has not progressed to the groundwater level and no groundwater seepage has been noted to date, therefore groundwater inflow measurements cannot be undertaken at this stage.

5.4 Groundwater Yields

As the Bringelly Shale formation within the project area is very low yielding and of low quality and does not have high environmental values. The Bringelly Shale groundwater is not considered to be 'high productive' water source based on the NSW Aquifer Interference Policy criteria.

Groundwater inflows to the pit were estimated in the EIS for a low hydraulic conductivity scenario and a high hydraulic conductivity scenario. The flows ranged from 0.1 to 1.0L/s with an annual estimated inflow of 1.5ML/year for the low hydraulic conductivity scenario at the final stage of the pit extraction. The pit has not currently extended below the groundwater level and no inflows or seepage have been observed on the site.

5.5 Groundwater Quantity

The Bringelly brick making facility utilises approximately **15,000KL per annum** of Potable water. The site also has a capacity of over 400,000m^3 of dam storage onsite in order to utilise harvested stormwater for processing and dust control. No Groundwater is expected to be extracted by the project for use in the brickmaking process.

5.6 Groundwater Quality

Baseline groundwater quality samples were initially analysed against trigger values for toxicants in freshwater for the protection of 95% of species in the column 'ANZECC 2000 Freshwater 95% and reported in the EIS by Golder and Associates (2013) and reproduced in the table below. The water quality results also indicate levels of zinc exceeding the ANZECC 2000 Trigger Values for the Protection of Freshwater Aquatic Ecosystems (95% Level of Protection).

Table 6 Groundwater Quality from the EIS

Table 6.

Analyte	Unit	ANZECC 2000 Stock Water Guideline	ANZECC 2000 Freshwater 95%	GW01	GW02	GW02 Duplicate	GW03	GW04
pH				8.49	8.04	8.02	7.62	8.04
Electrical Conductivity @ 25°C	µS/cm			15200	22000	22200	15200	2020
Total Dissolved Solids @180°C	mg/L	4000		8880	13600	13300	9220	2350
Redox Potential	mV			51	92.5	120	75.7	32
Dissolved Oxygen	mg/L			7.4	7.4	7.2	4.2	1.9
Turbidity	NTU			48.5	68.6	61.4	451	12400
Alkalinity								
Hydroxide Alkalinity as $CaCO_3$	mg/L			<1	<1	<1	<1	<1
Carbonate Alkalinity as $CaCO_3$	mg/L			29	<1	<1	<1	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L			219	393	388	274	327
Total Alkalinity as $CaCO_3$	mg/L			248	393	388	274	327
Dissolved Major Anions								
Chloride	mg/L			4740	7600	7620	4720	412
Sulfate as $SO4^{2-}$	mg/L	1000		6	<1	<1	10	31
Dissolved Major Cations								
Calcium	mg/L	1000		143	284	306	207	12
Magnesium	mg/L			138	238	255	77	2
Sodium	mg/L			2700	4680	4710	2850	433
Potassium	mg/L			57	54	57	57	9
Reactive Phosphorus as P	mg/L			0.02	0.04	0.04	0.04	<0.01
Nitrite as N	mg/L			<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L		0.7	0.01	0.01	<0.01	<0.01	<0.01
Nitrite and Nitrate as N (NOx)	mg/L			0.01	0.01	<0.01	<0.01	<0.01
Dissolved Metals								
Arsenic	mg/L	0.5	0.013	0.004	0.001	0.001	0.005	0.005
Cadmium	mg/L	0.01	0.0002	<0.0001	0.0001	<0.0001	<0.0001	0.0005
Chromium	mg/L	1	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	1	0.0014	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	mg/L	0.1	0.0034	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury	mg/L	0.002	0.0006	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	mg/L	1	0.011	0.001	0.001	<0.001	0.002	0.003
Zinc	mg/L	20	0.008	0.013	0.085	0.1	0.05	0.166
Ionic Balance								
Total Anions	meq/L		139	222	223	139	18.8	139
Total Cations	meq/L		137	239	242	142	19.8	137
Ionic Balance			0.52	3.56	4.26	1.15	2.62	0.52

Monitoring data to date has been summarised in the tables below and is reproduced in full in Appendix A.

Table 7 GW1 Groundwater Quality Summary

Analyte	Units	Average	Minimum	Maximum	Standard Deviation
pH	pH units	7.1	6.9	7.4	0.12
Conductivity	µS/cm	21,100	17,000	23,300	1,270
Chloride	mg/L	7,480	6,100	8,700	745
Sulphate	mg/L	26	5	130	44
Total Alkalinity	mg/L	473	330	570	75
Sodium	mg/L	5,120	4,200	6,300	724
Potassium	mg/L	60	44	75	11
Calcium	mg/L	282	220	330	36
Magnesium	mg/L	284	220	320	36
Dissolved Oxygen	mg/L	1.6	0.5	3.8	0.8
TDS (by calculation)	mg/L	13,000	10,600	14,600	887
Redox Potential	mV	191	103	269	37
Total Nitrogen	mg/L	9.5	7.4	11.0	1.0
Nitrate	mg/L	0.001	<0.001	0.056	0.018
Nitrite	mg/L	0.002	<0.001	0.018	0.006
Ammonia	mg/L	8.0	6.1	9.3	1.2
Fluoride	mg/L	0.1	0.1	0.2	0
Total Phosphorus	mg/L	0.3	<0.05	0.8	0.5
Reactive Phosphorus	mg/L	0.047	0.007	0.085	0.024
Arsenic	mg/L	0.001	<0.001	0.005	0.002
Barium	mg/L	28	2	58	19
Beryllium	mg/L	<0.0005	<0.0005	<0.0005	0
Cadmium	mg/L	<0.0001	<0.0001	0.0001	0.00003
Chromium	mg/L	<0.001	<0.001	<0.001	0
Cobalt	mg/L	<0.001	<0.001	0.001	0.0004
Copper	mg/L	<0.001	<0.001	0.003	0.001
Manganese	mg/L	0.14	0.10	0.20	0.04
Nickle	mg/L	0.001	<0.001	0.003	0.001
Lead	mg/L	<0.001	<0.001	<0.001	0
Vanadium	mg/L	<0.001	<0.001	<0.001	0
Zinc	mg/L	0.035	0.002	0.061	0.021
Iron	mg/L	2.7	1.1	4.3	1.5
Benzene	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
Toluene	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
Ethyl Benzene	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
Xylene	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (C6-C9)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (C10-C14)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (C15-C28)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (C29-C36)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (C6-C10)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (>C10-C16)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (>C16-C34)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (>C34-C40)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
PAH	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
Total Phenolics	µg/L	Not Detected	Not Detected	Not Detected	Not Detected

Table 8 GW2 Groundwater Quality Summary

Analyte	Units	Average	Minimum	Maximum	Standard Deviation
pH	pH units	7.0	6.9	7.7	0.16
Conductivity	µS/cm	19,400	1,730	22,200	3,550
Chloride	mg/L	7,230	6,600	8,100	548
Sulphate	mg/L	<1	<1	<1	0
Total Alkalinity	mg/L	474	430	510	25
Sodium	mg/L	5,170	4,300	6,000	700
Potassium	mg/L	54	38	64	9
Calcium	mg/L	574	230	290	23
Magnesium	mg/L	223	160	260	32
Dissolved Oxygen	mg/L	1.5	0.6	4.5	0.9
TDS (by calculation)	mg/L	11,700	1,080	13,600	3,000
Redox Potential	mV	202	100	302	43
Total Nitrogen	mg/L	8.6	6.8	11.0	1.4
Nitrate	mg/L	0.003	<0.001	0.020	0.007
Nitrite	mg/L	0.002	<0.001	0.015	0.005
Ammonia	mg/L	7.5	6.1	11.0	1.5
Fluoride	mg/L	0.1	0.1	0.2	0.1
Total Phosphorus	mg/L	0.1	<0.1	0.2	0.1
Reactive Phosphorus	mg/L	0.085	<0.001	0.160	0.043
Arsenic	mg/L	0.002	<0.001	0.010	0.004
Barium	mg/L	63	54	72	6.0
Beryllium	mg/L	<0.0005	<0.0005	<0.0005	0
Cadmium	mg/L	<0.0001	<0.0001	0.0001	0.00003
Chromium	mg/L	<0.001	<0.001	<0.001	0
Cobalt	mg/L	<0.001	<0.001	0.002	0.001
Copper	mg/L	<0.001	<0.001	<0.001	0
Manganese	mg/L	0.08	0.03	0.22	0.07
Nickle	mg/L	<0.001	<0.001	0.001	0.0003
Lead	mg/L	<0.001	<0.001	<0.001	0
Vanadium	mg/L	<0.001	<0.001	<0.001	0
Zinc	mg/L	0.047	0.017	0.089	0.022
Iron	mg/L	2.0	0.8	5.5	2.0
Benzene	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
Toluene	µg/L	1	<1	6	2.0
Ethyl Benzene	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
Xylene	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (C6-C9)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (C10-C14)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (C15-C28)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (C29-C36)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (C6-C10)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (>C10-C16)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (>C16-C34)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (>C34-C40)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
PAH	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
Total Phenolics	µg/L	Not Detected	Not Detected	Not Detected	Not Detected

Table 9 GW3 Groundwater Quality Summary

Analyte	Units	Average	Minimum	Maximum	Standard Deviation
pH	pH units	7.3	7.0	7.6	0.25
Conductivity	µS/cm	16,400	12,400	17,800	2,680
Chloride	mg/L	5,150	3,900	6,400	1,770
Sulphate	mg/L	14	14	14	0
Total Alkalinity	mg/L	225	200	250	35
Sodium	mg/L	4,200	3,500	4,900	990
Potassium	mg/L	58	50	66	11
Calcium	mg/L	215	170	260	64
Magnesium	mg/L	81	64	98	24
Dissolved Oxygen	mg/L	2.8	1.8	4.3	1.1
TDS (by calculation)	mg/L	10,300	7,730	11,200	1,690
Redox Potential	mV	178	143	222	33
Total Nitrogen	mg/L	8.9	8.4	9.3	0.6
Nitrate	mg/L	0.010	<0.001	0.020	0.014
Nitrite	mg/L	0.003	<0.001	0.006	0.004
Ammonia	mg/L	8.0	7.3	8.7	1.0
Fluoride	mg/L	<0.1	<0.1	<0.1	0
Total Phosphorus	mg/L	0.2	0.2	0.2	0
Reactive Phosphorus	mg/L	0.19	0.10	0.27	0.12
Arsenic	mg/L	0.003	0.002	0.004	0.001
Barium	mg/L	44	29	58	20.5
Beryllium	mg/L	<0.0005	<0.0005	<0.0005	0
Cadmium	mg/L	<0.0001	<0.0001	0.0001	0
Chromium	mg/L	<0.001	<0.001	<0.001	0
Cobalt	mg/L	0.004	0.003	0.005	0.001
Copper	mg/L	<0.001	<0.001	<0.001	0
Manganese	mg/L	0.57	0.37	0.77	0.28
Nickle	mg/L	0.001	<0.001	0.002	0.001
Lead	mg/L	<0.001	<0.001	<0.001	0
Vanadium	mg/L	<0.001	<0.001	<0.001	0
Zinc	mg/L	0.024	0.019	0.029	0.007
Iron	mg/L	2.0	1.3	2.6	0.9
Benzene	µg/L	4	<1	7	4.9
Toluene	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
Ethyl Benzene	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
Xylene	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (C6-C9)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (C10-C14)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (C15-C28)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (C29-C36)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (C6-C10)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (>C10-C16)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (>C16-C34)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (>C34-C40)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
PAH	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
Total Phenolics	µg/L	Not Detected	Not Detected	Not Detected	Not Detected

Table 10 GW4 Groundwater Quality Summary

Analyte	Units	Average	Minimum	Maximum	Standard Deviation
pH	pH units	7.5	7.1	7.9	0.26
Conductivity	µS/cm	10,200	475	38,700	13,000
Chloride	mg/L	513	21	860	438
Sulphate	mg/L	14	11	17	3
Total Alkalinity	mg/L	367	220	440	127
Sodium	mg/L	607	93	950	454
Potassium	mg/L	9	8	10	1
Calcium	mg/L	13	4	26	12
Magnesium	mg/L	5	2	9	4
Dissolved Oxygen	mg/L	1.9	0.9	4.5	1.2
TDS (by calculation)	mg/L	6,400	297	24,200	8,100
Redox Potential	mV	204	74	313	76
Total Nitrogen	mg/L	2.4	1.5	3.4	1.0
Nitrate	mg/L	<0.001	<0.001	<0.001	0
Nitrite	mg/L	<0.001	<0.001	<0.001	0
Ammonia	mg/L	1.10	0.007	1.90	0.981
Fluoride	mg/L	-	-	-	-
Total Phosphorus	mg/L	0.6	0.6	0.6	0
Reactive Phosphorus	mg/L	0.16	0.09	0.22	0.07
Arsenic	mg/L	0.005	0.002	0.009	0.004
Barium	mg/L	0.81	0.34	1.50	0.61
Beryllium	mg/L	<0.0005	<0.0005	<0.0005	0
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	0
Chromium	mg/L	<0.001	<0.001	<0.001	0
Cobalt	mg/L	<0.001	<0.001	<0.001	0
Copper	mg/L	0.003	<0.001	0.009	0.005
Manganese	mg/L	0.097	0.006	0.250	0.133
Nickle	mg/L	0.001	<0.001	0.003	0.002
Lead	mg/L	<0.001	<0.001	<0.001	0
Vanadium	mg/L	<0.001	<0.001	<0.001	0
Zinc	mg/L	0.005	0.003	0.007	0.002
Iron	mg/L	0.23	0.13	0.34	0.11
Benzene	µg/L	3	<1	6	3.1
Toluene	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
Ethyl Benzene	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
Xylene	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (C6-C9)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (C10-C14)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (C15-C28)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (C29-C36)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (C6-C10)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (>C10-C16)	µg/L	<50	<50	50	29
TPH (>C16-C34)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
TPH (>C34-C40)	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
PAH	µg/L	Not Detected	Not Detected	Not Detected	Not Detected
Total Phenolics	µg/L	Not Detected	Not Detected	Not Detected	Not Detected

Monitoring for GW1 and GW2 has been undertaken for a number of years however data for GW3 and GW4 is limited due to the destruction of GW3 and the low yields of groundwater available for testing in GW4.

There is minimal variation in the quality of groundwater to date from GW1 and GW2. Early detection of Toluene in GW2 (August 2017) has not been repeated in subsequent sampling rounds and may be due to the installation of the bore. Benzene was also detected in an early sampling round in August 2017, however the bore was subsequently destroyed. It is suspected that it is also a consequence of the installation process. GW4 indicated the presence of Total Petroleum Hydrocarbons (>C10-C16 fraction) in November 2017 but due to the low recharge rate it has not been possible to sample since that time. Similarly it is likely a consequence of the bore installation process. No PAH or Phenolic compounds have been detected in any of the bores.

Monitoring of the bores will continue in order to establish baseline data. This data will be used to establish baseline data and compared to groundwater monitoring conducted once the MOD1 extension development commences.

5.7 Surrounding Aquifers

The regional groundwater system is recharged by rainfall recharge and discharge via evaporation, evapotranspiration and discharge to creeks to the creeks to the east of the project site and to the Hawkesbury-Nepean system to the north. There are no existing registered groundwater bores within the project site based on search results of the NSW Office of Water groundwater bore database and NSW Natural Resource Atlas and NSW Groundwater Database (Water Data Transfer Format and Hydstra)

5.8 Groundwater Management on Site

The project sites groundwater management site plan is shown in *Figure 3.*

6 GROUNDWATER IMPACTS

6.1 Potential Impacts

The impact of the project on groundwater levels is expected to be localised, and limited mainly to the vicinity of the quarry pit. There will be no impact to groundwater flow system when the excavation depth of the quarry pit extension is above the groundwater levels. The predictive modelling results indicated a negligible change in groundwater regional flow direction as a result of the proposed activities. It is not envisaged that the groundwater seepage into the open cut quarry areas could potentially induce groundwater flow from neighbouring strata (from the underlying sandstone aquifers).

The modelled total groundwater inflow to the final quarry pit is estimated to be 0.1-1 litres per second with a likely inflow of 0.1 litres per second (assuming a low hydraulic conductivity). If there is water ponding in the pit during the time quarrying ceases then groundwater may actually be recharged during this time and groundwater withdrawn during quarrying is recharged during the time the pit is allowed to fill. It is envisaged that the actual groundwater loss per year during the quarry expansion is less than the estimated annual inflows based on a conservative modelling approach.

There is no measureable groundwater impact expected on Thompsons Creek, Bardwell Gully and South Creek as a result of the quarry pit extension. Thompsons Creek is fed from rural, residential and urban drainage and demonstrates poor water quality. Bardwell Gully, a drainage channel on the site's northern boundary, flows north under Greendale Road and into Thompsons Creek.

The depth to groundwater level is generally observed at being 10 to 26 metres below ground surface. It is inferred that the groundwater does not provide base flow to these creeks. It is envisaged that the pit dewatering will not have impact on Thompsons Creek and Bardwell Gully.

The groundwater vulnerability mapping indicated that South Creek is a GDE category 'Reliant on surface expression of groundwater' (NSW Natural Resource Atlas, accessed June 2013) and it is inferred that the base flow condition occurs at South Creek. Increased salinity close to watercourses and drainage lines has been observed, probably reflecting discharge of deep groundwater from the Bringelly Shale. The modelled drawdown does not extend to the South Creek in Scenario A and is less than 0.2 metres at South Creek in Scenario B; therefore, the impact on this receptor is considered to be low.

6.1.1 Potential impact on groundwater quality

There is the potential for spills and contamination by metals and hydrocarbons from the machinery, waste disposal, waste oil used in maintenance of equipment and fuel storage areas; however, adequate bunding and immediate clean-up of spills which is standard practice and/or a legislated requirement at the project site should prevent contamination of shallow strata and subsequent leakage to the groundwater system. The site has a very low hydraulic conductivity and any spills would not be expected to spread.

6.1.2 Potential impacts on registered bores

There are 4 registered groundwater bores within the project site. Based on the extent of the predicted drawdown in the Bringelly Shale formation associated with the project, no private groundwater users have been identified as being affected or potentially affected by the project.

6.1.3 Impact on groundwater dependent ecosystems

There are no identified 'high priority' GDEs within or surrounding the project area. Within the project site, there are no river base flows, no karst or cave ecosystems, no known springs that are fed by groundwater around which groundwater dependent ecosystems have developed. No GDEs category 'Subterranean' were identified within the project site based on information from the Australian National Atlas of GDEs. Results of the search for groundwater dependent ecosystems from the National Atlas of GDEs indicated the following GDEs Category 'Reliant on subsurface groundwater – vegetation': Cumberland Shale Hills Woodland, Cumberland Shale Plains Woodland and Cumberland River Flat Forest. These woodlands are likely to be supported by localised perched water near the surface or rainfall. The likelihood of this receptor being impacted because of the loss of quantity of deeper groundwater in Bringelly Shale (10 to 26 metres below ground surface) due to quarry operations is low as the drawdown caused by the project is limited and that the slight lowering in groundwater table is not likely to stress

the woodland. Where terrestrial ecosystems (vegetation) are rainfall dependant and not connected to the groundwater system, the quarrying and associated dewatering would have no impact on this receptor. It is envisaged that the baseflow in South Creek will not be affected by the potential groundwater drawdown at the quarry pit extension; therefore, any GDE that may occurs in the South Creek will not be impacted by the project.

6.1.4 Post-operation recovery of groundwater levels

During the post-operation stage, the groundwater will slowly enter the open pit and eventually an equilibrium water level will be reached over time. It is anticipated that the surface water runoff will fill the open pit at the cessation of operations and the pit water may represent a source of fresh water recharging the local groundwater if the pit water level is higher than the groundwater level. It is likely that no long term impact on post operation groundwater levels would be observed at any significant distance from the pit.

7 MONITORING AND MAINTENANCE

7.1 Groundwater Quality

Groundwater will be sampled monthly at the licenced Groundwater Bore locations. Samples will be analysed monthly for depth to water level, temperature, pH, conductivity, dissolved oxygen and redox potential. Quarterly monitoring of the bores will also include the parameters listed in *Section 5.6* and include nutrients, major cations and anions, metals, BTEX, PAH, Phenolics and Fluoride.

The levels in the perimeter bores will be monitored along with rainfall and pit water levels in order to determine and changes that may indicate an impact to surrounding aquifers i.e. a change of more than 30% to the previously recorded levels.

Where appropriate, trends in groundwater quality and levels will be graphically represented. All sampling data is recorded and reported on the PGH website and in the EPL Annual return.

The results of all monitoring will assist in the compilation of the Annual Rehabilitation Report (ARR) to the DPIE-Resources and Geoscience and to the DPIE in the Annual Report.

7.2 Groundwater Inflows

Any visible flows observed during excavation activities will be measured by capturing a measured volume over a known time period; for example, the time taken for a 25L bucket to be filled. If the seepage is too small to be collected, it shall be recorded using photography and GPS location. The dates and period of time for which the flow is observed will also be recorded. If the flow rate changes during the time period observed, the rate will be measured again. Measurements will be undertaken monthly across a range of seasonal variations i.e wet and dry months.

This data coupled with rainfall and evaporation from the preceding 12 months will be used to update the Site Water Balance (as described in the Soil and Water Management Plan). Any differences between the predicted model and the actual results would also be used to estimate the groundwater inflows.

Any calculations undertaken to estimate the groundwater take will be included in any reports to DPIE as outlined in *Section 10.6*. The reports will demonstrate compliance with the Water Management Act 2000 and the requirements of the NSW Aquifer Interference Policy 2012, in particular compliance with any WAL obtained for groundwater take.

7.3 Groundwater Bore Maintenance

Bores will be inspected each month for damage or any other fault that may render the bore inoperable. The area around the bore will be kept clear of vegetation and objects that may interfere with access. Missing caps will be replaced and the bores will be painted in highly visible paint or otherwise visible identified so as to minimise accidental destruction by vehicle impact.

If a bore is identified as ‘dry’ (e.g. not deep enough to strike groundwater) or otherwise damaged, destroyed or rendered non-functional, the bore will be assessed as to the relevance to the groundwater monitoring program. The bore may be replaced or relocated if the assessment determines that data is required from that point to continue the monitoring and assessment program. Bore abandonment may be appropriate in some instances such as encroachment of mining. If appropriate, replacement/relocation of such bore will be completed prior to commencement of mining within that area.

Drilling depths of the bores is determined by the expected groundwater levels within the target location. As the depth of the void increases, there may be localised changes to the groundwater levels, particularly as mining progresses below the current groundwater table. The bores should be of sufficient depth to encounter groundwater and this would be confirmed by the contract drillers at the time of installation.

In the case of GW3 where the bore has been destroyed, it has been determined that whilst background data is still being monitored, that the bore will not be re-established at this stage. Prior to the MOD1 development proceeding and mining progresses within the extension areas, the re-installment of the bore will be reviewed. GW4 is very slow to recharge and does not provide sufficient volumes for analytical testing but it still provides useful data regarding the depth of the groundwater. It will also be reviewed once the MOD1 extension commences.

7.4 Mine Staging and Groundwater Bore Location

Prior to the opening of a new Cell, monitoring bore locations will be reviewed and new bores will be installed at appropriate locations. Bores will be located in order to provide up gradient and down gradient profiles of the groundwater around the active cells. Background monitoring of existing and new bores will be conducted for a minimum of 1 year prior to the opening up of any new Cells.

As shown in *Figure 6*, the existing bores are located around the perimeter of the current void. GW1 and GW2 are outside the mining extension area in the north (Cell D) and are unlikely to require relocation. GW3 may require relocation prior to mining commencing within Cell G and GW4 will require relocation prior to mining in Cell F. Conceptual locations of future bores are also shown on *Figure 6.*

8 PERFORMANCE CRITERIA

Table 11 Performance Criteria and Trigger Action Response Plan

Objective	Performance Indicator	Potential Adverse Outcome	Trigger Level	Actions to be Implemented	Evidence/ Reference
Groundwater levels at the site are consistent with the baseline hydrological conditions of the surrounding environment	Monitored Groundwater levels from the site to be as close as possible to the natural levels expected pre-development.	Significant changes to or loss of aquifers harms GDEs downstream.	Significant drop (>30%) in measured Groundwater Levels.	Review Groundwater management procedures and continue monitoring. Review of data and site by qualified hydrologist. Assess impact to GDE's by ecologist and investigate remediation measures if required.	Annual review report
Groundwater quality at the site is consistent with the baseline hydrological conditions of the surrounding environment	Monitored Groundwater quality from the site to be as close as possible to the natural levels expected pre-development.	Significant changes to the water quality of the groundwater harms GDE's downstream.	Electrical conductivity (Ec) of the bores changes by more than 30% from the historical average value. Metal levels change greater than 30% when compared to previous recordings. Petroleum Hydrocarbons are greater than 10 mg/L or change of greater than 30% over background readings	Review Groundwater management procedures and continue monitoring. Review of data and site by qualified hydrologist. Assess impact to GDE's by ecologist and investigate remediation measures if required.	Annual review report

Objective	Performance Indicator	Potential Adverse Outcome	Trigger Level	Actions to be Implemented	Evidence/ Reference
	Fuel and oil storage is bunded and spill kits are accessible. No spills of hydrocarbons occur.	Releases of hydrocarbons changes quality of Groundwater and harms ecological communities downstream.	Hydrocarbon spill of sufficient volume occurs that has not been contained and contaminants observed to enter the Groundwater management system.	All hydrocarbon spills are to be cleaned up. • Procedures for handling hydrocarbons to be revised and updated if required. • Staff and contractors to be re-trained in the handling of hydrocarbons. • Groundwater bores are to be sampled and tested for the presence of Hydrocarbons. • Groundwater/contamination expert advice to be sought if hydrocarbons present in groundwater. • PIRMP to be activated	PIRMP Spill Response Training Annual review report & photographic evidence/ Managing Urban Storm Groundwater- Soils and Construction- Volume 2E Mines and Quarries & SWMP & GWMP
Constructed Groundwater Bores are installed and functional.	Constructed Groundwater Bores blocked.	Inability to monitor Groundwater	Groundwater Bore observed to be blocked during inspection or sampling.	Clean / repair blocked or damaged bores where possible. Investigate installation of a new bore if restoration not possible.	Annual review report & photographic evidence

Objective	Performance Indicator	Potential Adverse Outcome	Trigger Level	Actions to be Implemented	Evidence/ Reference
Surface water (mixed with groundwater inflows from the mine void) discharged from the site is consistent with the baseline ecological and geomorphic conditions of the surrounding environment. Note: Minor groundwater inflows will only occur as extraction proceeds below the groundwater level. No groundwater is discharged directly nor is it discharged through the bores.	Water quality monitoring of the water to be discharged does not meet the EPL criteria.	Significant changes to quality of water to be discharged, particularly elevated conductivity due to Groundwater influx, harms ecological communities downstream.	Water to be discharged does not meet the EPL criteria quality parameters outside the EPL criteria of pH between 6.5 and 8.5, Conductivity <1450µS/cm.	• Cease discharge offsite if occurring. • Consult with groundwater expert and surface water expert to determine measures to be implemented to meet EPL discharge guidelines. • Consult with ecologist to investigate remediation measure to downstream environment if required.	PIRMP Annual review report & photographic evidence/ Managing Urban Storm Groundwater- Soils and Construction- Volume 2E Mines and Quarries & SWMP & GWMP, EPL

9 ENVIRONMENTAL MANAGEMENT MEASURES

Specific Groundwater management measures identified in the EIS and CoA have been interpreted and generally reproduced in *Table 12*. The management measures identified in this table are to be implemented to mitigate or manage impacts identified. Relevant responsibility and references for each have been identified in the corresponding columns below.

Table 12 Environmental Management Measures

#	Management Measure	Responsibility	Frequency	Reference
General				
G1	An environmental consultant with appropriate qualifications for the task will be engaged to help review the Groundwater Management Plan and measures for the Project.	Environmental Consultant Environmental Manager Operations Manager	As required	Appropriately Qualified Consultant Correspondence
G2	All relevant individuals will read the GWMP with any engineering plans and any other plans or written instructions issued in relation to development at the project site.	Operations Manager Site Engineers Contractors	As required	GWMP (This Plan)
G3	Implement Groundwater Management Procedures and regularly review to ensure relevance and compliance with internal and external requirements.	Operations Manager Site Engineers Contractors	At least annually	Groundwater Management Procedures
G4	Inform all subcontractors of their responsibilities in minimising the potential for any groundwater quality impacts, spills etc. through site induction and toolbox talks.	Environmental Manager Operations Manager	At least annually	Induction
G5	Annual Review of this plan and relevant procedures	Operations Manager Environmental Manager	At least annually	GWMP (This Plan)

#	Management Measure	Responsibility	Frequency	Reference
Groundwater Management				
GW1	Undertake Groundwater quality, flow and consumption monitoring as per the requirements of the EPL and this Plan	Environmental Manager Site Engineer Site Staff & Contractors	Monthly	EPL, GWMP (This Plan) ENVIZY
GW2	Routine maintenance and inspection of Bores, including water level checks. Blocked or damaged bores may need to be repaired where required.	Operations Manager Site Engineer Site Staff & Contractors	As required	GWMP (This Plan)
GW3	Activities with the potential to reduce or contaminate local Groundwater quality (including refuelling, vehicle servicing, concrete washout, storage of fuels and hazardous materials,) will be undertaken within appropriately bunded areas.	Operations Manager Site Engineer Site Staff & Contractors	As required	Groundwater Management Procedures / PIRMP
GW4	All Fuel and oil storage will be appropriately bunded with spill kits are accessible. All hydrocarbon spills are to be cleaned up and reported as per PIRMP. Procedures for handling hydrocarbons and spills to be revised and updated if required.	Environmental Manager Operations Manager Site Engineer Site Staff & Contractors	As required	GWMP (This Plan)
GW5	Staff and contractors to be trained in the handling of hydrocarbons, spills and PIRMP annually.	Environmental Manager Operations Manager Site Engineer Site Staff & Contractors	Annually	GWMP (This Plan)/Induction/ Spill Training

10 COMPLINACE MANAGEMENT

10.1 Inspections

Monthly inspections and daily visual observations by the Plant Manager (or delegate) of Groundwater quality conditions and controls will occur throughout the operational lifetime of the facility.

10.2 Training

All employees and contractors working on site will undergo site induction training, which will cover issues relating to Groundwater quality management, including:

- Existence and requirements of this Plan;
- Relevant legislation;
- Bringelly Brickworks operational hours;
- Location of Spill kits;
- All other Groundwater quality management measures that need to be implemented to minimise impact to and ground Groundwater;
- Location of Groundwater monitoring bores; and
- Incident and Complaints reporting.

10.3 Complaints & Enquiries Procedure

All community inquiries and complaints related to the facility's activities will be referred to a community information line (02 4774 8751). A postal address, PGH Bricks, Locked Bag 1345, North Ryde BC NSW 1670) and email address has been provided for receipt of complaints and enquiries. Information to be recorded will include location of complainant, time of occurrence of alleged complaint, perceived source, prevailing weather conditions and similar details that could be utilised to assist in the investigation of the complaint.

An initial response acknowledging a complaint will be provided within 24 hours of a complaint being received. A further detailed response, including steps taken to resolve the issue(s) that led to the complaint, will be provided within 10 days. All reasonable endeavours will be made to resolve and close off complaints. The complainants will be kept informed of when they will receive a response.

Information on all complaints received, including how they were addressed, whether resolution was reached and whether mediation was required or used will be included in a complaint register.

Complaints and the subsequent action(s) taken by PGH will be reported at each subsequent Community Consultative Committee meeting.

10.4 Incident Management

PGH will immediately notify the Secretary and any relevant agencies when an incident has occurred. More specifically, where the following conditions are not met a Groundwater incident shall be raised and reported accordingly:

1. On review of Groundwater quality monitoring data, an exceedance is recorded above the criteria stipulated in *Section 8*; and
2. Within seven days of the declaration of an incident, a report documenting the facts of

the incident must be submitted to the Secretary. This report is to document the findings of the incident investigation, attempt to identify the cause and nature of the exceedance.

Note, the trigger levels stipulated in *Section 8* will be further refined as more background data becomes available.

10.5 Audit

Audits (both internal and external) and reporting will be undertaken to assess the effectiveness of environmental controls, compliance with this GWMP, CoA and other relevant approvals, licenses and guidelines.

10.6 Reporting

The effectiveness of the Groundwater management system will be assessed in an annual review and audits as required by consent conditions. Additional reviews will be undertaken in the form of an Annual Rehabilitation Report (ARR) as required by the Mine Lease conditions and an Annual Review submitted to DPIE- Resources and Geoscience and DPIE respectively. In addition Groundwater usage and quality data will be provided in the EPL Annual Return (if required), DPIE- Water through any WAL licensing requirements and internally through ENVIZY.

These reviews will report on the progress towards performance criteria as outlined in *Table 11*. Where an action response has been implemented, details of the action and any results obtained will be included in the ARR. The ARR's will be submitted to the DPIE-RG until the Mining Lease has been relinquished.

The annual reviews and Audits (routinely conducted every 3 years after the initial 12 monthly audit) will be submitted to the Secretary.

As part of the measurement of the effectiveness of the Groundwater management system, PGH will assess the following:

- Groundwater imported, Groundwater use, volumes stored and any discharges from the site and report results or changes to the balance;
- Groundwater quality results for compliance and trends;
- Identifying non-compliances and actions taken to ensure compliance;
- Discrepancies between the predicted and actual impacts of the development; and
- Measures that may be undertaken to improve the environmental performance of the development.

11 REVIEW AND IMPROVEMENT

Continuous improvement of this GWMP will be achieved through the ongoing evaluation of environmental management performance against environmental policies, objectives and targets.

The continuous improvement process is designed to:

- Identify areas of opportunity for improvement of environmental management and performance;
- Determine the cause or causes of non-conformances and deficiencies;
- Develop and implement a plan of corrective and preventative action to address any non- conformances and deficiencies;
- Verify the effectiveness of the corrective and preventative actions;
- Document any changes in procedures resulting from process improvement; and
- Make comparisons with objectives and targets.

Inspections, monitoring, auditing and management reviews may result in the need to update or revise this GWMP.

12 REFERENCES

1. Golder and Associates - Groundwater impact assessment (2013)
2. Hyder Consulting - Bringelly Brickworks and Quarry Expansion ENVIRONMENTAL IMPACT STATEMENT Volumes 1 & 2 -5 September 2013
3. Kleinfelder Groundwater Management Plan PGH Bricks & Pavers Bringelly - 28 October 2016
4. DECC, 2008, the Blue Book – Volume 2D.
5. Landcom, 2004, Managing Urban Storm Groundwater: Soils and Construction – Volume 1 and 2 (4th edition).
6. Western Sydney Regional Organisation of Councils, 2004, Draft Salinity Code of Practice.
7. DPIE-Water Guidelines for Controlled Activities.
8. ANZECC Guidelines for Fresh and Marine Groundwater Quality.
9. ANZECC Guidelines for Groundwater Quality Monitoring and Reporting.
10. Groundwater Management Act 2000.

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Figure 1 Site Location

Plan of:	Bringelly Clay Mine Groundwater Management Plan - Site Location	**Location:**	Bringelly Clay Mine Off Greendale Road, Bringelly, NSW	**Source:**	nearmap - Image Date 12/01/2019 & Google Maps 2019	**Our Ref:**	8006_BR_GMP_C001_V0_F1.cdr
Figure:	ONE	**Council:**	Camden Council	**Survey:**	N/A	**Plan By:**	JD
Sheet:	1 of 1	**Tenure:**	ML 1731	**Projection:**	N/A	**Project Manager:**	TO
Version/Date:	V0 10/09/2019	**Client:**	PGH Bricks & Pavers Pty Ltd	**Contour Interval:**	N/A	**Office:**	Thornton

This figure may be based on third party data which has not been verified by vgt and may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and vgt does not warrant its accuracy.

vgt Environmental Compliance Solutions Pty Ltd

Legend

- Cadastral Boundary
- Project Approval Boundary
- Authority Boundary *(ML 1731)*

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Figure 2 Site Layout

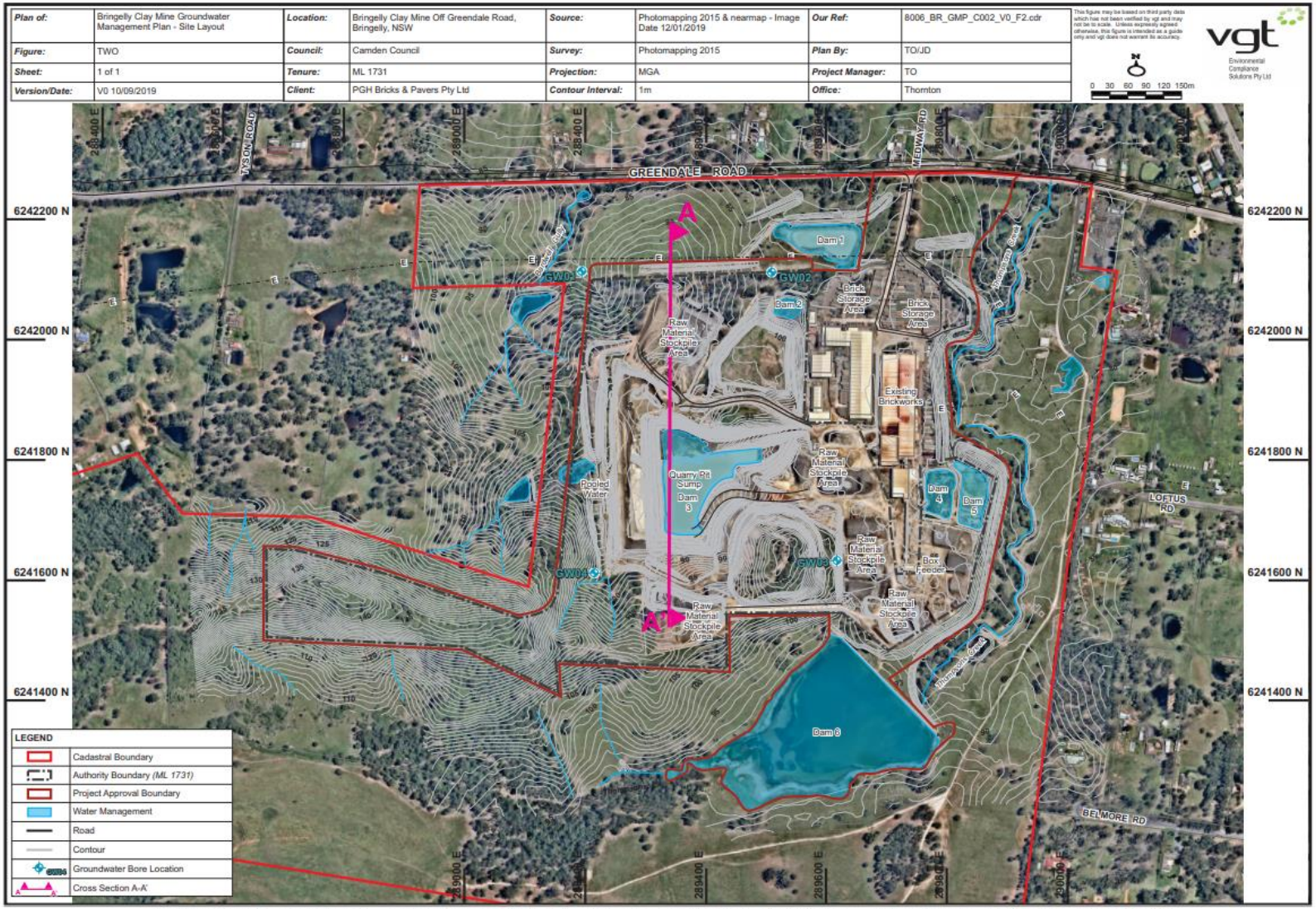

Figure 3 Existing Water Management

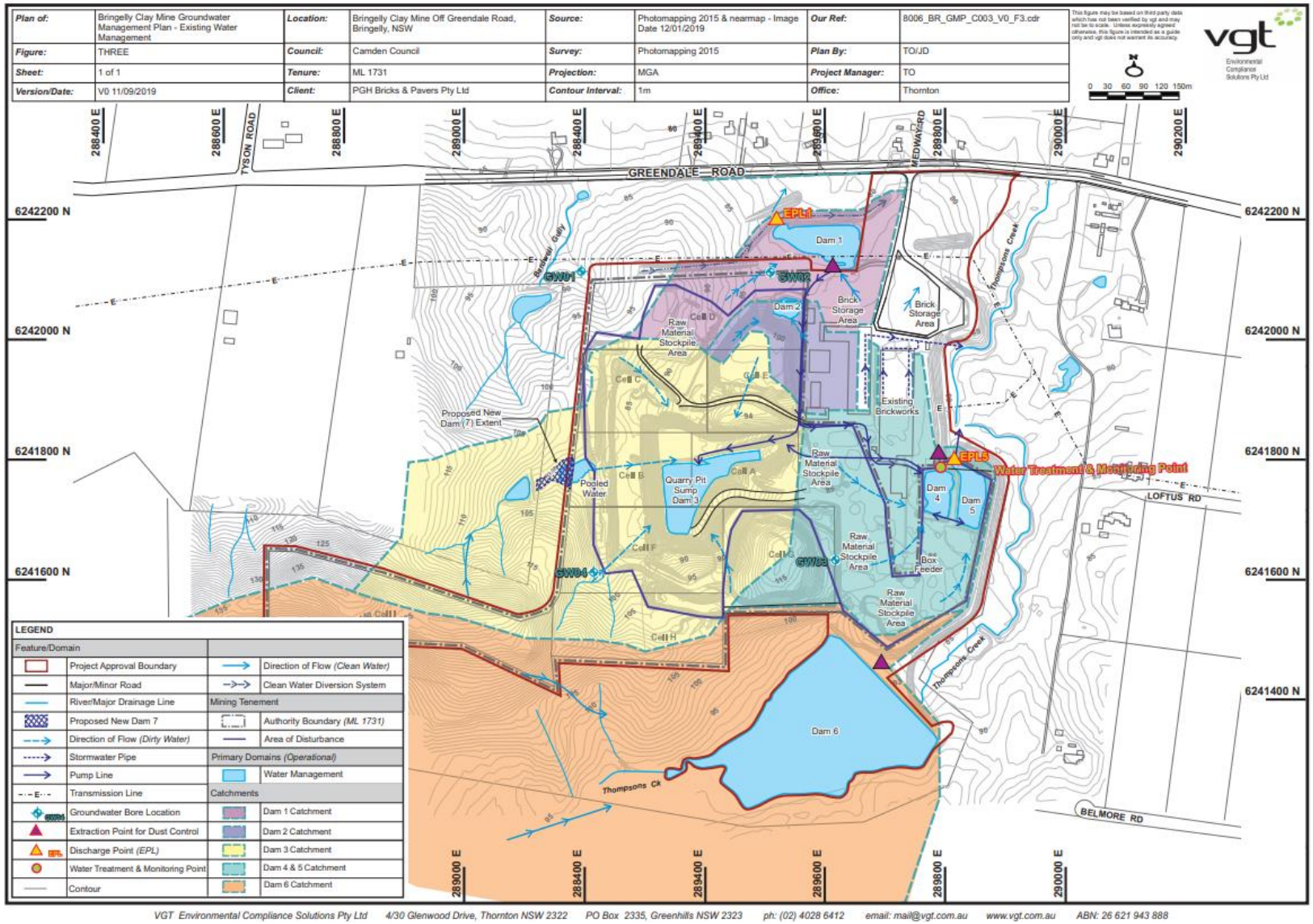

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Figure 4 Cross Section

Plan of:	Bringelly Clay Mine Groundwater Management Plan - Cross Section	**Location:**	Bringelly Clay Mine Off Greendale Road, Bringelly, NSW	**Source:**	Photomapping 2015 & Landair 2017	**Our Ref:**	8006_BR_GMP_C002_V0_F2.cdr
Figure:	FOUR	**Council:**	Camden Council	**Survey:**	Photomapping 2015 & Landair 2017	**Plan By:**	SK/JD
Sheet:	1 of 1	**Tenure:**	ML 1731	**Projection:**	MGA	**Project Manager:**	TO
Version/Date:	V0 10/09/2019	**Client:**	PGH Bricks & Pavers Pty Ltd	**Contour Interval:**	N/A	**Office:**	Thornton

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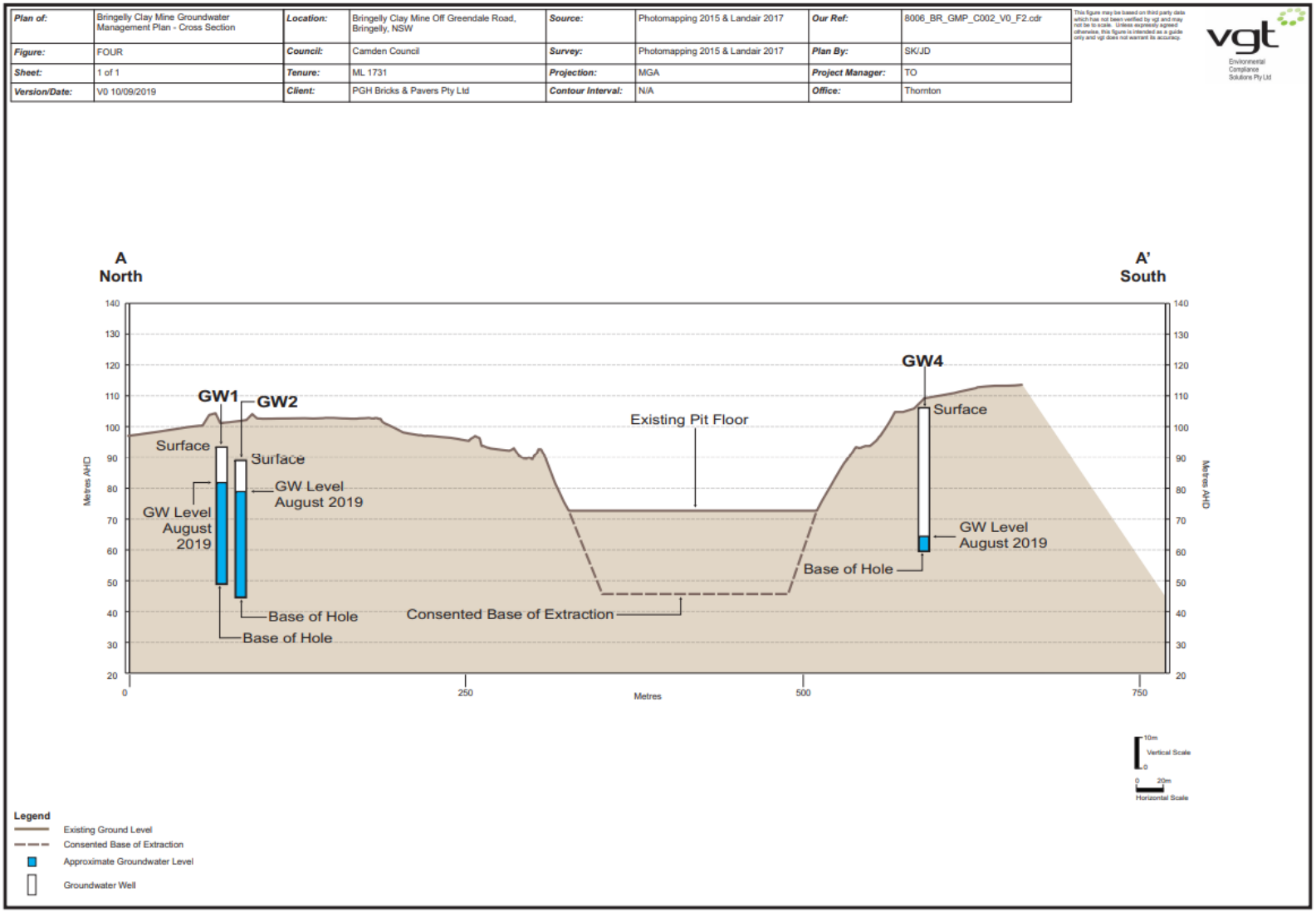

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Figure 5 Groundwater Contours

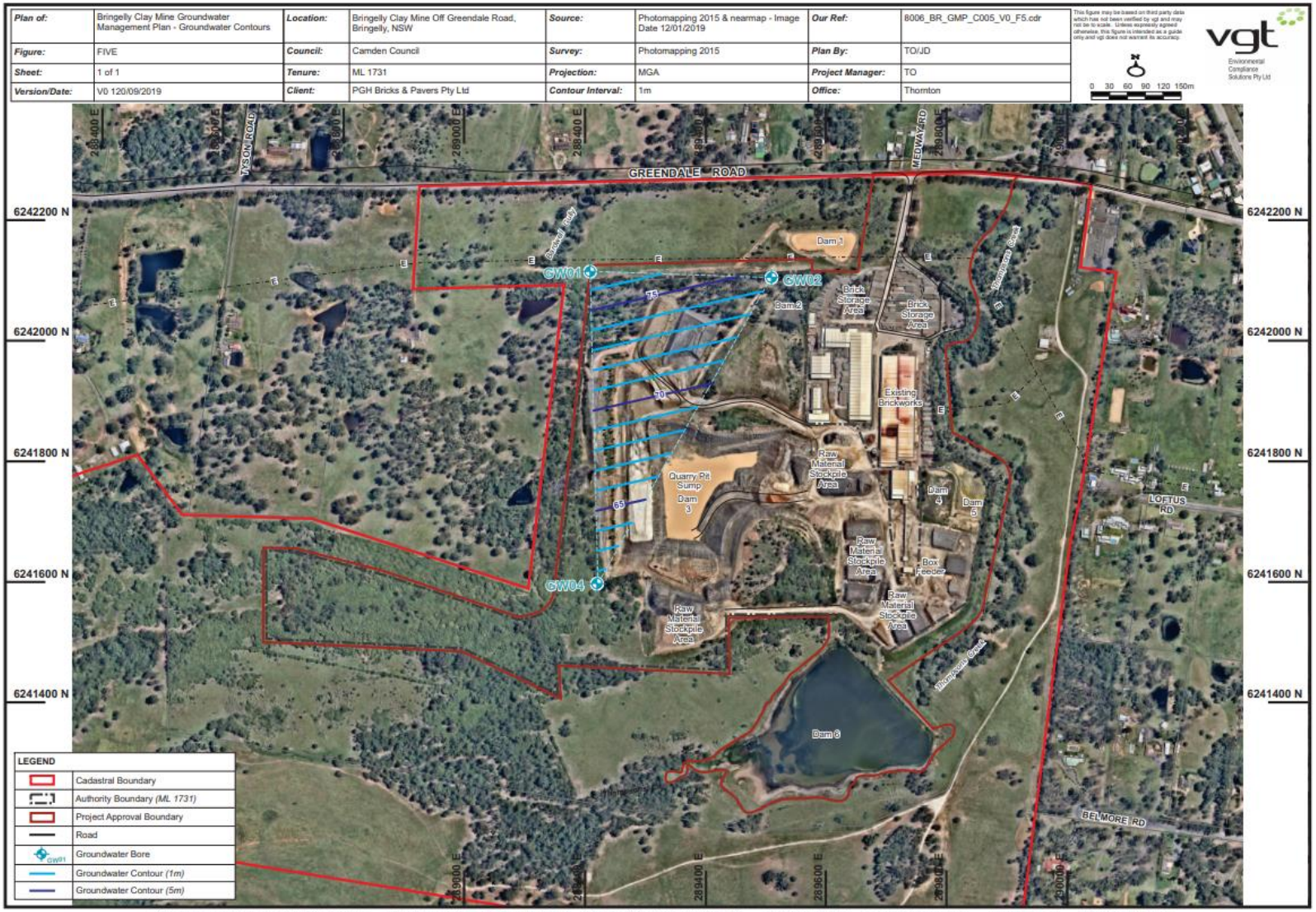
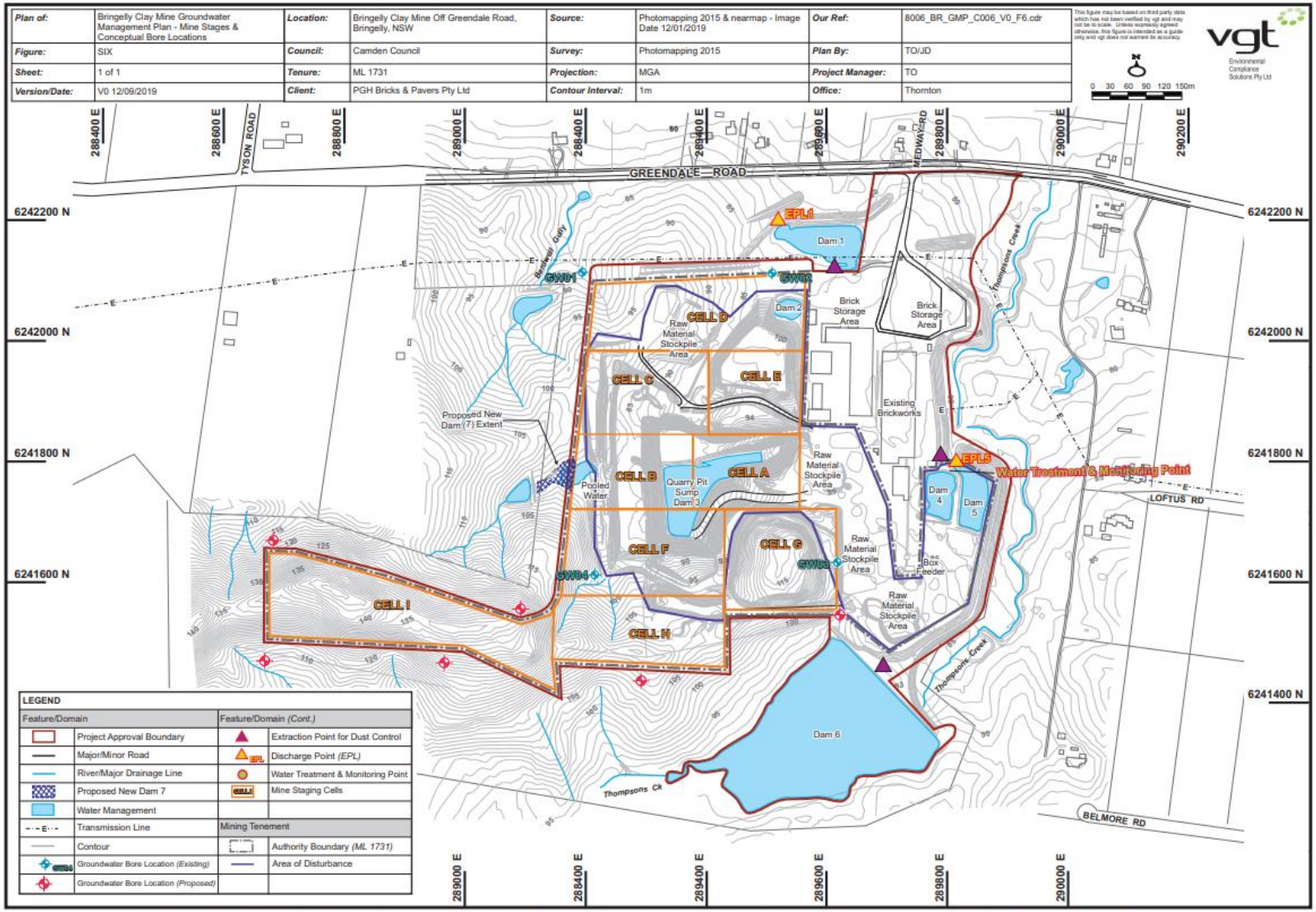


Figure 6 Mine Stages and Concetual Bore Locations



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APPENDIX A GROUNDWATER ASSESSMENT FIELDWORK FACTUAL REPORT

APPENDIX B GROUNDWATER MONITORING

APPENDIX C CONSULTANT APPROVAL

NSW GOVERNMENT | Planning, Industry & Environment

Planning and Assessment
Energy and Resource Assessments
Contact: Jack Murphy
Phone: 8217 2016
Email: jack.murphy@planning.nsw.gov.au

Mr Greg Thomson
Director
VGT Environmental Compliance Solutions Pty Ltd
PO Box 2334
Greenhills NSW 2323

Dear Mr Thomson,

Bringelly Brickworks Extension (SSD 5684)
Appointment of a Suitably Qualified and Experienced Person

I refer to your letter dated 2 September 2019 requesting the Secretary's endorsement of a suitably qualified and experienced person to prepare the Water Management Plan for the Bringelly Brickworks Extension (SSD 5684).

The Department has reviewed the credentials of Ms Tara O'Brien of VGT Environmental Compliance Solutions Pty Ltd and agrees she is a suitably qualified person. In accordance with condition 18 of Schedule 3 of SSD 5684, the Secretary endorses Ms Tara O'Brien to prepare the above document.

Should you have any enquiries in relation to this matter, please contact Jack Murphy.

Yours sincerely,

Howard Reed 2.9.19
Howard Reed
Director Resource Assessments
as the Secretary's nominee