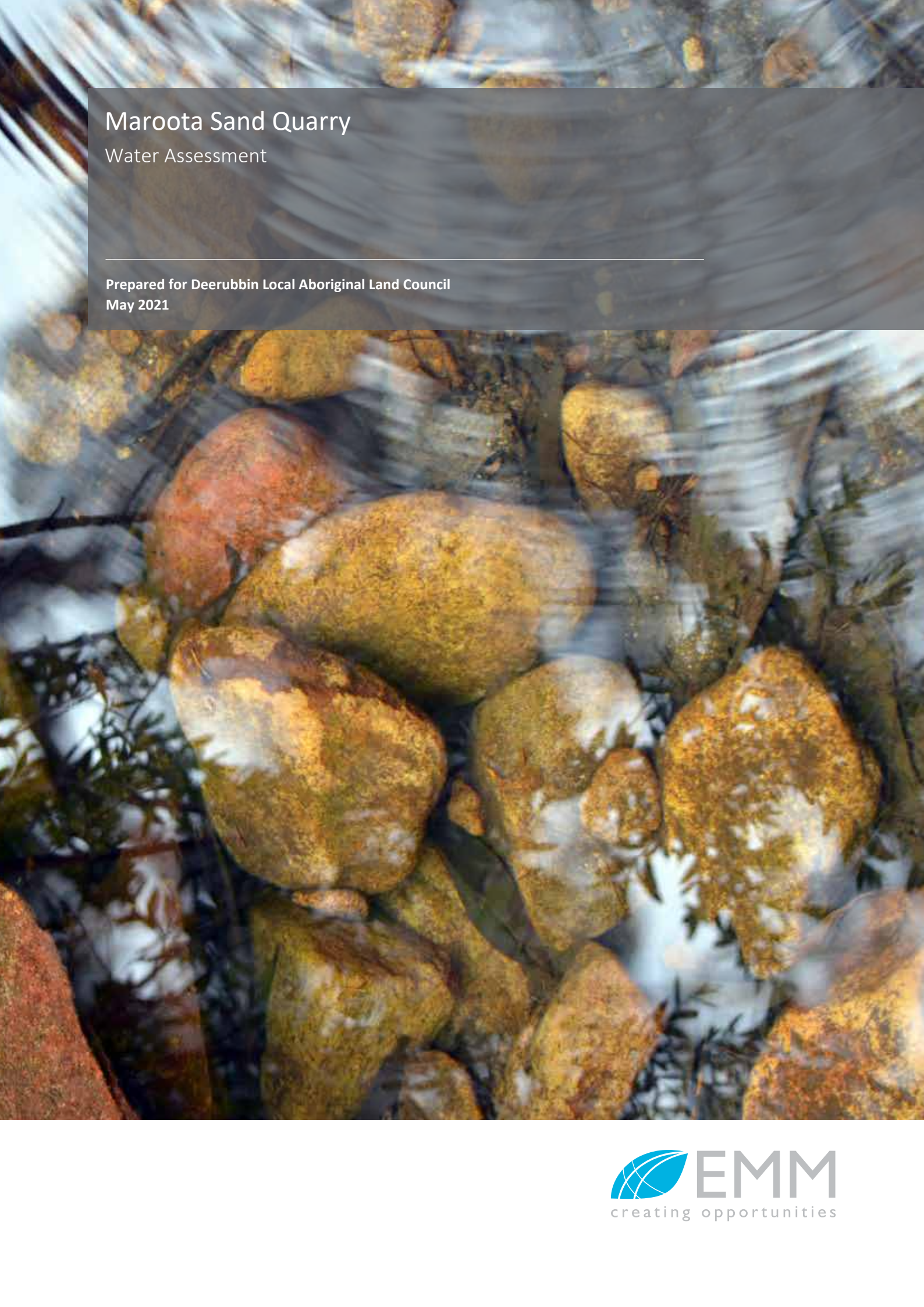




Maroota Sand Quarry

Water Assessment

Prepared for Deerubbin Local Aboriginal Land Council
May 2021



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Maroota Sand Quarry

Water Assessment

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Client

Deerubbin Local Aboriginal Land Council

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17 May 2021

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Executive Summary

ES1 Project context

Deerubbin Local Aboriginal Land Council (DLALC) propose to develop the Maroota Sand Quarry (the project), which is a proposed friable sandstone extraction quarry. The project is located near Maroota NSW, 66 kilometres (km) north-west of Sydney. The quarry is proposed to extract and process up to 500,000 tonnes per annum of material from the Hawkesbury Sandstone deposits as well as shale and clays over a planned life of 28 years.

A State significant development consent under Division 4.7 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) is required to establish the quarry.

This water assessment addresses the Secretary's Environmental Assessment Requirements (SEARs) that relate to both surface and groundwater management and supports the EIS for the project. It characterises the existing environment and is informed by a combination of desktop-based assessments and field investigations. The assessment describes the proposed water management strategy for the project and describes unavoidable residual impacts.

The assessment has been prepared in accordance with the SEARs for the project, issued 18 February 2020, and considers relevant government and industry guidelines.

ES2 Existing environment

The project area (or site) comprises 180.7 ha of land that is currently vegetated with native bushland. The terrain is characterised by a distinct ridgeline that is aligned in a north-west direction and has a relatively flat plateau. Aside from the ridgeline, the terrain is generally rugged and falls steeply into two well defined watercourses that drain to the north-west, into Douglas Creek, which ultimately flows into the Hawkesbury River Estuary.

The proposed quarry pit excavation will occur wholly within the Hawkesbury Sandstone geological unit, which exists along a relatively flat plateau and adjoining ridge line. Maroota Sand and eluvial sand is interpreted to be present in the eastern portion of the project area, outside of the proposed extraction area. An understanding of the groundwater systems within the site is informed by data from 11 local groundwater monitoring bores and regional data. The following groundwater systems have been identified:

1. the shallow aquifer is the saturated zone within the base of the Maroota Sand and within the eluvial/weathered Hawkesbury Sandstone unit. The shallow aquifer is only interpreted to occur in the eastern portion of the site, outside of the proposed extraction area.
2. the deep aquifer is located within the consolidated Hawkesbury Sandstone below the weathered zone and includes the regional water table and all groundwater in the sandstone below it.

The shallow aquifer is interpreted to be perched above the deep aquifer, meaning that the two aquifers are vertically separated by an unsaturated zone. A Maroota Sands Swamp Forest groundwater dependent ecosystem (GDE) is in a watercourse that is located to the north of the extraction area. It is interpreted that this GDE is maintained by groundwater from the shallow aquifer. Refer to Chapter 3 for detailed explanations.

ES3 Water management summary

ES3.1.1 Objectives

A water management strategy for the project is documented in Chapter 5. The key objectives and management approaches that have been applied to the strategy are summarised in Table ES1.

Table ES1 Water management objectives and approach

Objective	Management approach
Avoid aquifer interception.	The pit floor will maintain a 2 m buffer above the wet-weather high regional water table.
Provide surface water controls that are consistent with industry best practice.	• Where practical, clean water will be diverted around disturbed areas. • Dirty water runoff will be managed by erosion and sediment controls that will be designed, constructed and maintained in accordance with the methods recommended in <i>Managing Urban Stormwater: Volume 1</i> (Landcom 2004) and <i>Volume 2E</i> (DECC 2008). • Process water will be managed in a closed loop system that will not discharge into either the dirty water system or offsite. • Water captured in the water management dam will be beneficially used for sand processing and dust suppression to reduce overflow volumes. • Chemical and hydrocarbon products will be stored in bunded areas in accordance with relevant Australian Standards and guidelines.
Apply water efficiency measures to minimise water use	• The sand processing plant will include a filter and plate press system to maximise water recovery and minimise system losses. • Groundwater will be extracted as needed to minimise losses associated with storage.
Establish a secure non-rainfall dependant source of water	• A groundwater supply system that can meet the full project water demand will be established as a non-rainfall dependant water source.

ES3.1.2 Residual impacts

Key residual impacts to the groundwater and surface environment and water users are summarised in Table ES2. Refer to Chapter 6 for detailed explanations.

Table ES2 Residual impacts summary

Activity	Summary of residual impacts
Abstraction of groundwater for quarry water supply	• Drawdown impacts at nearby groundwater works will be less than 2 metres (m). • No impacts to Maroota Sands Swamp Forest GDE are expected.
Excavation of the quarry pit	• No impacts are expected as aquifer interception will be avoided.
Changes to hydrologic regimes in downstream watercourses due to changes in catchment areas and the capture of water in the water management system.	• Some changes to streamflow regimes in immediate receiving waters is expected (see Chapter 6 for details). • No material impacts to 3rd party surface water users is expected.
Overflows from the surface water management system	• Overflow events are expected to occur three times per year. • The water quality of water management system overflows will be progressively monitored. Further measures, such as water treatment could be implemented if monitoring indicates that overflows are resulting in non-trivial degradation of receiving water quality.

ES4 Water licencing

Chapter 7 of this report establishes licensing requirements and pathways for the project.

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1 Introduction

Deerubbin Local Aboriginal Land Council (DLALC) propose to develop the Maroota Sand Quarry (the project), which is a proposed friable sandstone extraction quarry. The project is located in Maroota NSW, 66 kilometres (km) north-west of Sydney, as shown in Figure 1.1. The quarry is proposed to extract and process up to 500,000 tonnes per annum of material from the Hawkesbury Sandstone deposits as well as shale and clays over a planned life of 28 years.

A State significant development (SSD) consent under Division 4.7 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) is required to establish the quarry. On 18 February 2020, the NSW Department of Planning, Industry and Environment (DPIE) issued Secretary's Environmental Assessment Requirements (SEARs) for the environmental impact statement (EIS) for the project. The SSD consent application number is SSD-10410.

This report has been prepared by EMM Consulting Pty Limited (EMM) on behalf of the applicants.

1.1 Project overview

Chapter 3 of the EIS provides a detailed description of the proposed project. Figure 1.2 presents the proposed project layout. Key components of the project include:

- Site establishment works, including clearing of vegetation, removal of overburden, construction of the haul road, processing plant and associated infrastructure.
- Excavated material will be loaded by an excavator into an articulated truck and hauled to a sand processing plant for washing and sorting. Tailings will be thickened and dewatered using a plate and frame press before being progressively stockpiled for combination with overburden and other waste rock into site rehabilitation material.
- The extraction area will be excavated to a floor elevation ranging between 148 metres (m) Australian Height Datum (AHD) and 165 m AHD. No extraction will occur within 2 m of the wet-weather high groundwater levels. The proposed extraction area is presented in Figure 1.2.
- Water required for the sand processing plant and dust suppression activities will be supplied by a water management dam and deep groundwater bore.

1.2 Purpose of the report

This water assessment addresses the SEARs that relate to both surface and groundwater management and supports the EIS for the project. It characterises the existing environment and is informed by a combination of desktop-based assessments and field investigations. The assessment describes the proposed water management strategy for the project and describes unavoidable residual impacts

The specific objectives of this assessment are to:

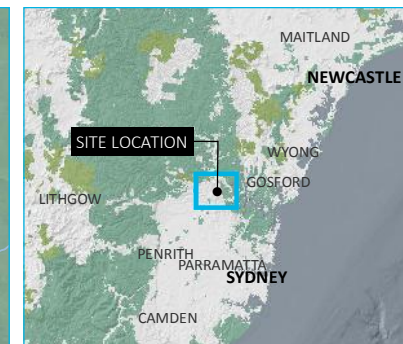
- describe and characterise the existing surface water and groundwater environment;
- describe the proposed water management approach and infrastructure requirements;
- identify and assess impacts to surface water and groundwater during construction and operation of the project;

- identify water licensing requirements; and
- develop management and mitigation measures to minimise the impacts to surface water and groundwater resources associated with the construction and operation of the project.

1.3 Report structure

An overview of the structure of the water assessment is provided below:

- **Executive summary** provides a brief overview of the project and the key findings of the assessment;
- **Chapter 1** introduces the key elements of the project and outlines the objectives of the assessment;
- **Chapter 2** describes the assessment requirements and provides an overview of relevant industry and government guidelines;
- **Chapter 3** provides a characterisation of the existing environment at the project site;
- **Chapter 4** describes the assessment approach;
- **Chapter 5** describes the proposed water management system;
- **Chapter 6** provides an assessment of the impacts of the project on surface water and groundwater resources; and
- **Chapter 7** addresses water licensing requirements.



- KEY
- Site boundary
 - Major road
 - Minor road
 - Named watercourse
 - Named waterbody
 - NPWS reserve
 - State forest (refer inset)

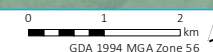
Site locality

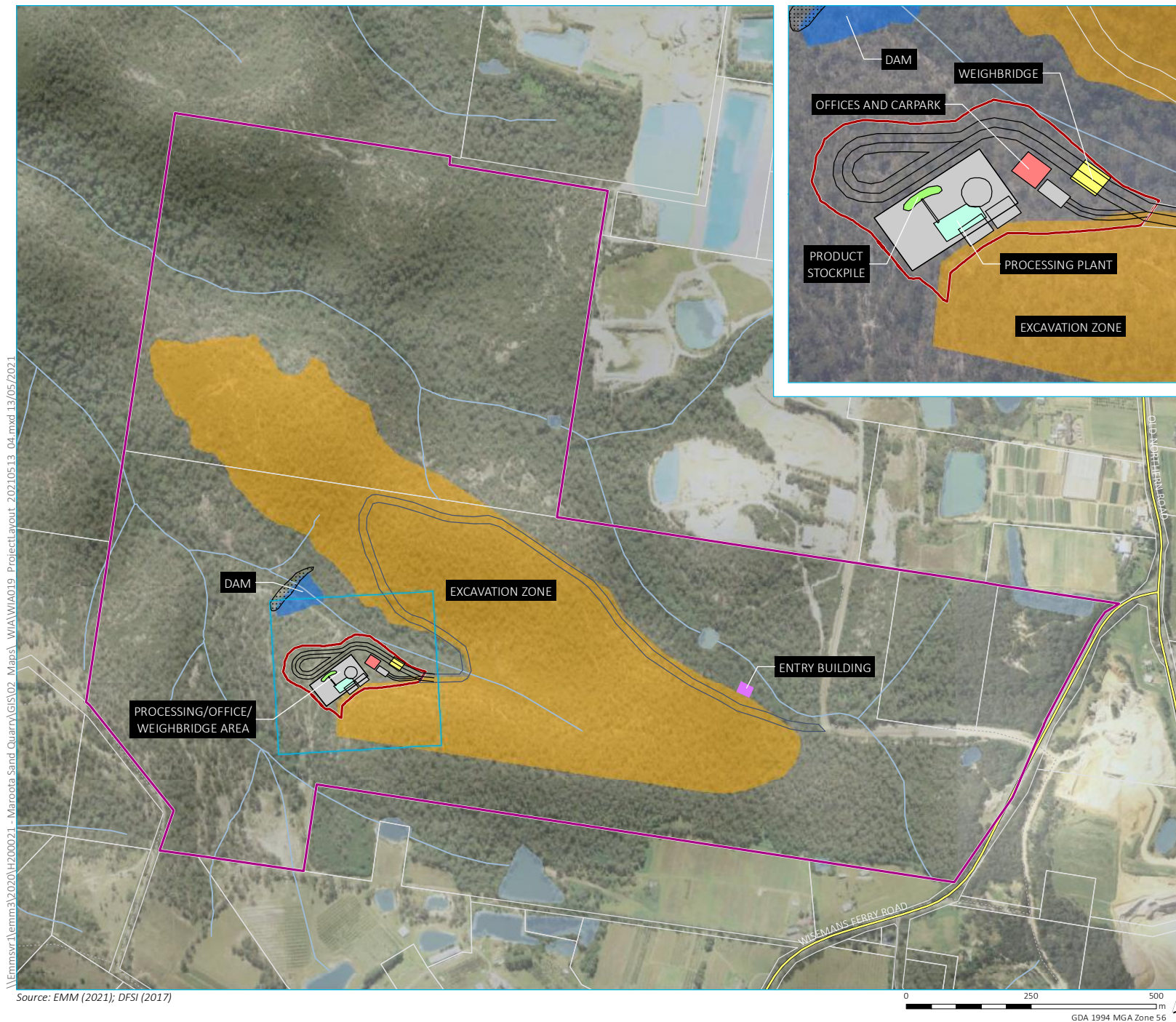
Maroota Sand Quarry
Water impact assessment
Figure 1.1



\\Emmsvr1\emms3\2020\H200021 - Maroota Sand Quarry\GIS\02 Maps\ WIA\WIA001 Project location 20210513 02.mxd 13/05/2021

Source: EMM (2021); DFSI (2017); GA (2011); ASGC (2006)





- KEY**
- Site boundary
 - Major road
 - Minor road
 - Vehicular track
 - Watercourse/drainage line
 - Waterbody
 - Cadastral boundary
 - Proposed quarry layout
 - Site infrastructure
 - Site infrastructure
 - Entry building
 - Offices and carpark
 - Processing plant
 - Weighbridge
 - Product stockpile
 - Cut/fill extent
 - Haul road
 - Dam embankment
 - Dam
 - Excavation zone

Project layout

Maroota Sand Quarry
Water impact assessment
Figure 1.2

2 Assessment framework

2.1 Relevant legislation and policies

2.1.1 *Environmental Planning and Assessment Act 1979*

i Secretary's Environmental Assessment Requirements

This water assessment has been prepared in accordance with the SEARs and relevant government assessment requirements, issued on 18 February 2020. Table 2.1 provides the matters relevant to the assessment and where the requirements have been addressed.

Table 2.1 Relevant matters raised in SEARs

Assessment requirement	Report reference
Identification of any licensing requirements or other approvals under the <i>Water Act 1912</i> and/or <i>Water Management Act 2000</i>	Chapter 7
Demonstration that water for the construction and operation of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan (WSP)	Chapters 6 and 7
A description of the measures proposed to ensure the development can operate in accordance with the requirements of any relevant WSP or water source embargo	Section 5.4 and Chapter 7
A detailed assessment of any need to maintain an adequate buffer between excavations and the highest predicted or recorded regional groundwater table	Section 5.2.3
An assessment of the likely impacts on the quality and quantity of existing surface and groundwater resources, including a detailed assessment of proposed water discharge quantities and quality against receiving water quality and flow objectives	Chapter 6
An assessment of the likely impacts of the development on aquifers, watercourses, riparian land, water-related infrastructure, and other water users	Chapter 6
A detailed description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate surface and groundwater impacts	Chapter 5

ii Approval exemptions

Clause 4.41 (1g) of the EP&A Act exempts an SSD authorised by a development consent from requiring a water use approval under section 89, a water management work approval under section 90, or an activity approval (other than an aquifer interference approval) under section 91 of the WM Act. These exemptions apply to the project as it has been declared a SSD.

2.1.2 *Water Management Act 2000*

The NSW *Water Management Act 2000* (WM Act) is based on the principles of ecologically sustainable development and the need to share and manage water resources for future generations. The WM Act recognises that water management decisions must consider economic, environmental, social, cultural and heritage factors. It recognises that sustainable and efficient use of water delivers economic and social benefits to the state of NSW. The WM Act provides for water sharing between different water users, including environmental, basic landholder rights and licence holders. The licensing provisions of the WM Act apply to those areas where a WSP has commenced.

WSPs are statutory documents that apply to one or more water sources. They define the rules for sharing and managing water resources within water source areas. WSPs describe the basis for water sharing and document the water available and how it is shared between environmental, extractive and other uses. The WSPs outline the water available for extractive uses within different categories, such as local water utilities, domestic and stock, basic landholder rights, irrigation and industrial uses.

The WSPs relevant to the site are:

- *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2011* – the Lower Hawkesbury River Management Zone within the Hawkesbury and Lower Nepean Rivers Water Source applies to the surface water in the vicinity of the site; and
- *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011* – the Sydney Basin Central Groundwater Source applies to groundwater in the Hawkesbury Sandstone and deeper porous rocks in the vicinity of the site.

2.1.3 NSW Aquifer Interference Policy

Projects that intercept groundwater need to consider the NSW *Aquifer Interference Policy* (AIP) (DPI 2012). The AIP defines the regime for protecting and managing the impacts of aquifer interference activities on NSW's water resources. The AIP requires consideration of the potential impacts of an aquifer interference activity in respect to the water table, water pressure and water quality. Proponents must estimate the water take (including incidental take) from each water source and connected water sources. Changes to water table, water pressure and water quality are assessed against minimal impact considerations for each water source.

The AIP defines water sources as being either 'highly productive' or 'less productive' based on levels of salinity and average available yields. The AIP categorises water sources by their lithological character, being one of alluvium, coastal sand, porous rock, or fractured rock, and identifies thresholds for minimal impact considerations. Based on the NSW Government's mapped areas of groundwater productivity in NSW (NOW 2012), the project area is within a 'less productive' porous rock source (applicable to the Hawkesbury Sandstone regional aquifer). Applicable minimal harm considerations for the project have been reproduced in Table 2.2.

If an activity is assessed as being 'minimal impact' or the impacts are no more than the accuracy thresholds of the model, then it is defined as a 'minimal impact'. Where impacts are predicted to be 'greater than minimal impact' but additional studies show that impacts, although greater than 'minimal' do not prevent the long-term viability of the relevant water dependent asset, then the impacts will be defined as 'acceptable'. Where impacts are predicted to be 'greater than minimal impact' and the long-term viability of the water dependent asset is compromised, then the impact is subject to 'make good' provisions.

Table 2.2 Minimal impact criteria for 'less productive' porous rock water source

Water table	Water pressure	Water quality
1. Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, 40 m from any: a) high priority groundwater dependent ecosystem; or b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan. A maximum of a 2 m decline cumulatively at any water supply work.	1. A cumulative pressure head decline of not more than a 2 m 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	1. Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity. 2. If condition 1 is not met then appropriate studies will need to demonstrate to the Minister's

Table 2.2 Minimal impact criteria for ‘less productive’ porous rock water source

Water table	Water pressure	Water quality
2. If more than 10% cumulative variation in the water table, allowing for typical climatic ‘post-water sharing plan’ variations, 40 m from any: a) high priority groundwater dependent ecosystem; or b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan then appropriate studies (including the hydrogeology, ecological condition and cultural function) will need to demonstrate to the Minister’s satisfaction that the variation will not prevent the long-term viability of the dependent ecosystem or significant site. If more than a 2 m decline cumulatively at any water supply work then make good provisions should apply.	demonstrate to the Minister’s satisfaction that the decline will not prevent the long-term viability of the affected water supply works unless make good provisions apply.	satisfaction that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply works.

2.2 Local planning instruments

The Hills Local Environmental Plan 2019 and Development Control Plan 2012 guide planning decisions through zoning and development controls, which include considerations for extractive industries to protect groundwater resources and supplies, provided in Table 2.3 (The Hills Shire Council 2012).

Table 2.3 Development controls required by The Hills Shire Council

Drainage outlets	Employ operational practices capable of maintaining and monitoring drainage outlets at downstream boundaries together with pre-existing groundwater flow and quality conditions
Water flow patterns and water quality	Determine the likely impact upon groundwater and nominate an effective freeboard above wet-weather high groundwater level capable of conserving water flow patterns and water quality on each extraction site
Extraction	Not to occur within 2 m of the wet-weather high groundwater level or otherwise to the requirements of the Office of Environment and Heritage

2.3 Relevant guidelines

2.3.1 Erosion and sediment control guidelines

Managing Urban Stormwater: Soils and Construction – Volume 1 (Landcom 2004) outlines the basic principles for the design, construction and implementation of sediment and erosion control measures to improve stormwater management and mitigate the impacts of land disturbance activities on soils and receiving waters.

Managing Urban Stormwater: Soils and Construction – Volume 2C Unsealed Roads (DECC 2008a) and *Managing Urban Stormwater: Soils and Construction – Volume 2E Mines and Quarries* (DECC 2008b) provide specific guidelines, principles and minimum design standards for good management practice in erosion and sediment control during the construction and operation of unsealed roads and quarries.

2.3.2 Guidelines for waterfront land

The WM Act defines waterfront land as the bed of any river, lake or estuary and any land within 40 m of the riverbanks, lake shore or estuary mean high water mark. Guidelines for controlled activities have been prepared by the NSW Natural Resources Access Regulator (2018). These guidelines provide information on the design and construction of a controlled activity, and other ways to protect waterfront land.

Controlled activity approvals are not required for this project as it is a SSD. Notwithstanding, the guidelines for controlled activities have been considered for any proposed works on waterfront land.

2.3.3 Australian and New Zealand Guidelines for Fresh and Marine Water Quality

The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG 2018) provides guidance on monitoring, assessing and managing ambient water quality in a wide range of water resource types and according to specified environmental values, such as aquatic ecosystems, primary industries, recreation and drinking water. The guidelines provide a framework for:

- establishing water quality objectives;
- assessing and managing water quality for environmental values; and
- establishing protection levels, water quality indicators and trigger values.

Environmental values associated with the waterways and water sources surrounding the site include primary industry, aquatic ecosystems, recreational users, irrigation and stock watering. Water quality monitoring results have been compared to default guideline values (DGVs) recommended by ANZG (2018) for the protection of aquatic ecosystems. Surface water resources in the vicinity of the project are considered to be 'slightly-to-moderately disturbed' systems, due to the impact of disturbance in the catchment associated with past and ongoing agriculture and urban development. The site is also classified as a 'lowland river' as the elevation of the receiving environment is less than 150 m.

DGVs provided by ANZG (2018) for toxicants (including metals) are usually derived from ecotoxicity testing using a species sensitivity distribution of chronic toxicity data. The reliability of the DGVs is classified as very high, high, moderate, low, very low or unknown. Classification is primarily based on the number and type (chronic, acute or a mix of both) of data used to derive the guideline value, as well as the fit of the statistical model (species sensitivity distribution) to the data.

DGVs are provided by ANZG (2018) for 99%, 95%, 90% and 80% species protection. For most toxicants, the level of species protection assigned for slightly-to-moderately disturbed systems is the 95% species protection DGV. For parameters that potentially bioaccumulate, DGVs for 99% species protection are recommended by ANZG (2018) for slightly-to-moderately disturbed systems.

DGVs for slightly-to-moderately disturbed ecosystems recommended by ANZG (2018) are presented in Table 2.4. DGVs for physical and chemical stressors and nutrients provided by ANZECC (2000) have been used as these parameters have not yet been updated by ANZG (2018). DGVs for metals are based on the values recommended for slightly-to-moderately disturbed systems.

Table 2.4 Default guideline values¹ for the assessment of water quality

Parameter	Units	DGV	Additional information
Physical and chemical stressors			
Turbidity	NTU	6-50	DGV for lowland river in south-east Australia (Table 3.3.2; ANZECC 2000)
Electrical conductivity	µS/cm	200–300	DGV for NSW coastal river (Table 3.3.3; ANZECC 2000)
pH	pH units	6.5–8.5	DGV for lowland river in south-east Australia (Table 3.3.2; ANZECC 2000)
Nutrients			
Ammonia	mg N/L	0.02	DGV for lowland river in south-east Australia (Table 3.3.2; ANZECC 2000)
Nitrate + nitrite	mg N/L	0.04	DGV for lowland river in south-east Australia (Table 3.3.2; ANZECC 2000)
Total nitrogen	mg N/L	0.35	DGV for lowland river in south-east Australia (Table 3.3.2; ANZECC 2000)
Reactive phosphorus	mg P/L	0.02	DGV for lowland river in south-east Australia (Table 3.3.2; ANZECC 2000)
Total phosphorus	mg P/L	0.025	DGV for lowland river in south-east Australia (Table 3.3.2; ANZECC 2000)
Dissolved metals			
Arsenic	mg/L	0.013	Moderate reliability DGV for As(V)
Boron	mg/L	0.37	High reliability DGV
Cadmium	mg/L	0.0002	Very high reliability DGV
Chromium	mg/L	0.001	Very high reliability DGV for Cr(VI)
Cobalt	mg/L	0.0014	Unknown reliability DGV
Copper	mg/L	0.0014	High reliability DGV
Lead	mg/L	0.0034	Moderate reliability DGV
Manganese	mg/L	1.9	Moderate reliability DGV
Mercury	mg/L	0.00006	Moderate reliability DGV for 99% species protection level recommended for slightly to moderately disturbed systems due to the potential for bioaccumulation
Nickel	mg/L	0.011	Low reliability DGV
Selenium	mg/L	0.005	Moderate reliability DGV for 99% species protection level recommended for slightly to moderately disturbed systems due to the potential for bioaccumulation
Vanadium	mg/L	0.006	Unknown reliability DGV
Zinc	mg/L	0.008	Very high reliability DGV

1. 95% species protection DGV
mg/L = milligrams per litre

2.3.4 National Water Quality Management Strategy Guidelines for Groundwater Quality Protection in Australia

The *National Water Quality Management Strategy Guidelines for Groundwater Quality Protection in Australia* (NWQMS 2013) provides a risk-based management framework to protect and enhance groundwater quality for the maintenance of specified environmental values. The framework involves the identification of specific beneficial uses and values for the major groundwater systems, and several protection strategies that can emerge to protect each aquifer, including monitoring for all aquifers.

2.3.5 Bunding and spill management guidelines

The following NSW Government guidelines detail best practice storage, handling and spill management procedures for liquid chemicals:

- Liquid Chemical Storage, Handling and Spill Management: Review of Best Practice Regulation (DEC 2005); and
- Storing and Handling Liquids: Environmental Protection: Participant's Manual (DECC 2007).

2.4 NSW water quality and river flow objectives

The *NSW Water Quality and River Flow Objectives* (DECCW 2006) provides environmental values and long-term targets for water quality and river flow in each catchment in NSW. The objectives are intended to be considered in assessing and managing the potential impacts of activities associated with waterways.

The site is located within the Hawkesbury-Nepean catchment. Although there are no specified objectives for this catchment, the typical water quality and river flow objectives for uncontrolled streams in other catchments in NSW are provided in Table 2.5 for reference.

Table 2.5 Water quality and river flow objectives

Environmental value	Objective	Application to proposed project
Water quality objectives		
Aquatic ecosystems	Maintaining or improving the ecological condition of water bodies and their riparian zones over the long term.	There are aquatic ecosystems immediately downstream of the project. This water quality objective is relevant and is assessed in this report.
Visual amenity	Aesthetic qualities of waters.	There may be public and private views to downstream waterways. This water quality objective is relevant and is assessed in this report.
Secondary contact recreation	Maintaining or improving water quality for activities such as boating or wading, where there is a low probability of water being swallowed.	There may be public and private access to downstream waterways. This water quality objective is relevant and is assessed in this report.
Primary contact recreation	Maintaining or improving water quality for activities such as swimming in which there is a high probability of water being swallowed.	There may be public and private access to downstream waterways. This water quality objective is relevant and is assessed in this report.
Livestock water supply	Protecting water quality to maximise the production of healthy livestock.	Some downstream users may extract water from downstream waterways for stock watering purposes. This water quality objective is relevant and is assessed in this report.
Irrigation water supply	Protecting the quality of waters applied to crops or pasture.	There are no known downstream users that extract water for irrigation purposes. Hence, this water quality objective is not assessed in this report.
Homestead water supply	Protecting water quality for domestic use in homesteads, including drinking, cooking and bathing.	It is unlikely that any downstream users extract from downstream waterways for homestead water supply. Hence, this water quality objective is not assessed in this report.

Table 2.5 Water quality and river flow objectives

Environmental value	Objective	Application to proposed project
Drinking water at point of supply – disinfection only	These objectives apply to all current and future licensed offtake points for town water supply and to specific sections of rivers that contribute to drinking water storages or immediately upstream of town water supply offtake points. The objectives also apply to sub-catchments or groundwater used for town water supplies.	Town water supply in the region is provided by Sydney Water. The site is not located within Sydney’s drinking water catchment. Receiving waterways drain to the Hawkesbury-Nepean system downstream of Warragamba Dam. No water is extracted from downstream of the site for town water supply. Hence, this water quality objective is not assessed in this report.
Drinking water at point of supply – clarification and disinfection		
Drinking water at point of supply – groundwater		
Aquatic foods (cooked)	Refers to protecting water quality so that it is suitable for the production of aquatic foods for human consumption and aquaculture activities.	Recreational fishers may use downstream waterways. However, the trigger values for aquatic foods apply to aquaculture not recreational fishing. The required level of protection will be provided by addressing the objective for aquatic ecosystems. Hence, impacts to aquatic foods are not assessed in this report.
River flow objectives		
Protect pools in dry times	Protect natural water levels in pools of creeks and rivers and wetlands during periods of no flows.	The project may result in localised changes to the existing hydrologic regime in downstream watercourses. Hence, these river flow objectives are relevant and are assessed in this report.
Protect natural low flows	Share low flows between the environment and water users and fully protect very low flows.	
Protect important rises in water levels	Protect or restore a proportion of moderate flows and high flows.	
Maintain wetland and floodplain inundation	Maintain or restore the natural inundation patterns and distribution of floodwater supporting natural wetland and floodplain ecosystems.	
Maintain natural flow variability	Maintain or mimic natural flow variability in all streams.	
Manage groundwater for ecosystems	Maintain groundwater within natural levels and variability, critical to surface flows and ecosystems.	
Minimise effects of weirs and other structures	Minimise the impact of instream structures.	A dam is proposed on a second order watercourse. Hence, this objective is relevant and is assessed in the report.

3 Existing environment

3.1 Site description

The site is located on the outskirts of Maroota and comprises 180.7 hectares (ha) of land that is currently vegetated with native bushland. The terrain is characterised by a distinct ridgeline that is aligned in a north-west direction and has a relatively flat plateau. Aside from the ridgeline, the terrain is generally rugged and falls steeply into two well defined gullies that also drain to the north-west. Elevations range from 135 m AHD in the north-west to 200 m AHD in the centre of the site.

Existing land uses in the surrounding area include agriculture (grazing and horticulture), quarries and rural residential. Naturally vegetated landscapes are located to the west and north-west of the site. The following sand and sandstone quarries are located near the site:

- Maroota Sandstone Quarry Australia, located approximately 4.5 km north of the site;
- PF Formation Sand and Concrete quarries:
 - Pit 5 and Pit 15, located approximately 3 km north-east of the site;
 - Pit 4, located approximately 2 km north-east of the site; and
 - Hitchcock Road Sand Extraction Project, located adjacent to north and east of the site.
- Dixon Sand quarries:
 - Old Northern Road Quarry, located approximately 1 km north of the site;
 - Hearses Road Quarry, located approximately 1 km south of the site; and
 - Hodgson Quarries and Plant, Roberts Road Quarry, located approximately 1 km to the east of the site.

3.2 Climate

Patched point climate data was obtained from the Scientific Information for Land Owners (SILO) database hosted by the Science Division of the Queensland Government's Department of Environment and Science. SILO patched point data consist of interpolated estimates based on historically observed data from Bureau of Meteorology (BOM) weather stations. For this assessment, SILO data was obtained for the Maroota (Old Telegraph) Station (BOM station 67014).

Table 3.1 presents key information and statistical data calculated from the SILO patched point data between 1970 and 2019. Figure 3.1 presents the average annual rainfall and evaporation rates on a monthly basis calculated from the SILO data.

Table 3.1 **Key climate statistics**

Key annual statistic	Units	Rainfall	Evaporation
Average	mm/year	932	1,399
Minimum	mm/year	536	1,152
5th percentile	mm/year	589	1,202
10th percentile	mm/year	634	1,234
Median	mm/year	896	1,372
90th percentile	mm/year	1,193	1,568
95th percentile	mm/year	1,426	1,584
Maximum	mm/year	1,637	1,777

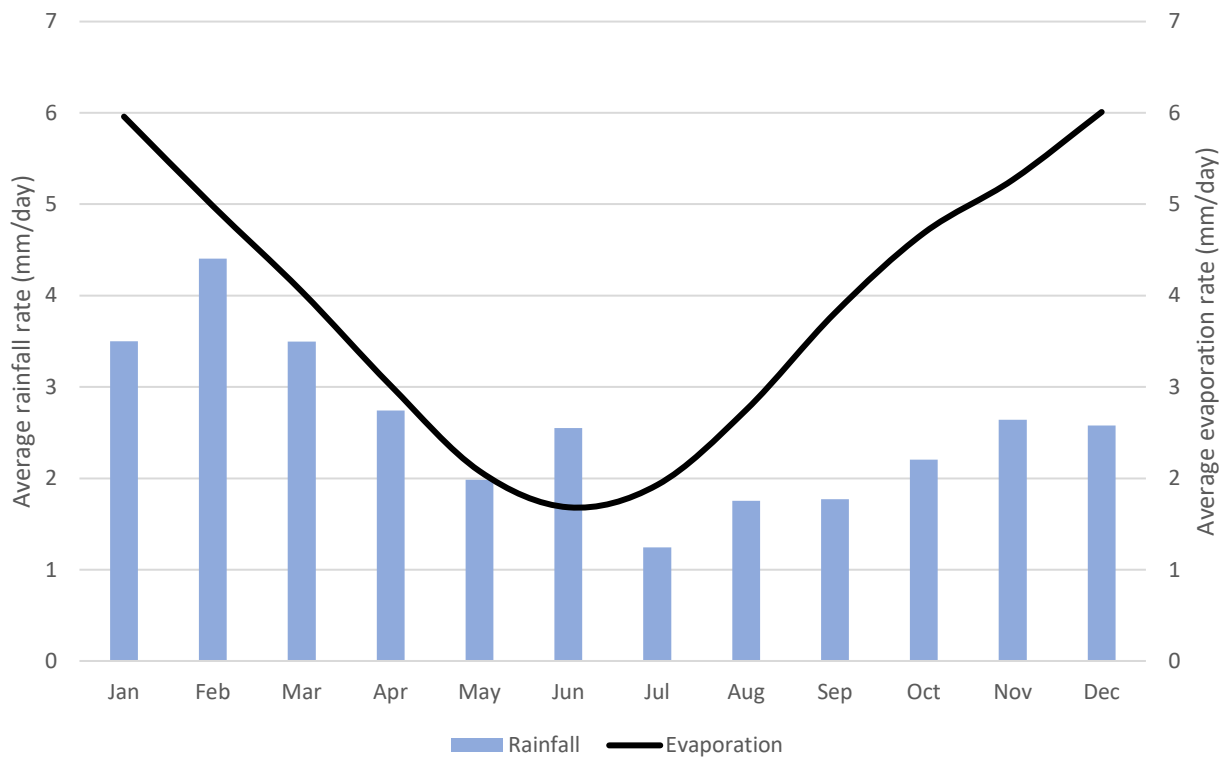


Figure 3.1 **Average daily rainfall and evaporation rates**

Long-term rainfall trends can be characterised using the cumulative rainfall departure (CRD) method (Brendenkamp et al. 1995). CRD shows trends in rainfall relative to the long-term monthly average and provides a historical record of wetter and drier periods. A rising trend in slope in the CRD plot indicates periods of above average rainfall, while a declining slope indicates periods of below average rainfall.

The CRD chart shown on Figure 3.2, shows a near eight-year period of below average rainfall from 1999 to the end of 2007. Following this monthly rainfall was above average, with conditions from mid-2016 onwards again being below average.

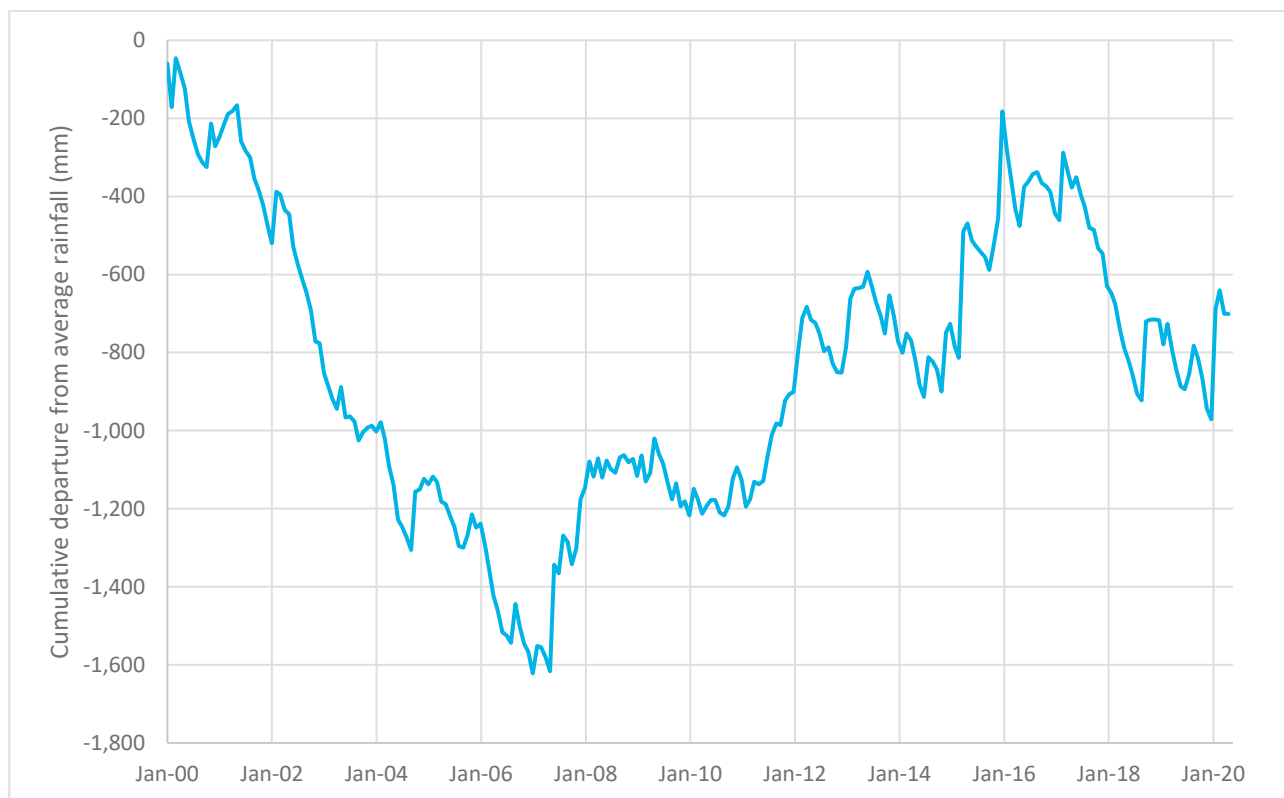


Figure 3.2 Monthly cumulative rainfall departure

3.3 Soils

A soil survey was undertaken as part of the *Land Capability Assessment* (SLR 2020a) for the project. The survey included a number of test pits within the project area to establish soil characteristics. The soils across the site were generally described as dispersive, with a low clay fraction and a strongly acidic nature.

3.4 Geology

3.4.1 Regional geology

The project area is located in the centre of the Permo-Triassic, Sydney Geological Basin. A summary of the geological stratigraphic units occurring in the Maroota area is presented in Table 3.2. A geological outcrop map is shown on Figure 3.3. Geological information has been obtained from Etheridge (1980) and the *Gosford-Lake Macquarie 1:100,000 Geological Map* (Och et al. 2015).

Table 3.2 Geology of the Maroota area

Age	Name of Unit	Lithology	Present in project area
Quaternary	Alluvium	Alluvial and eluvial sand	No
Tertiary	Maroota Sand	Sand, gravel, clayey sand and clay	Yes, but not within the proposed extraction area
Jurassic	Undifferentiated	Basalt	No

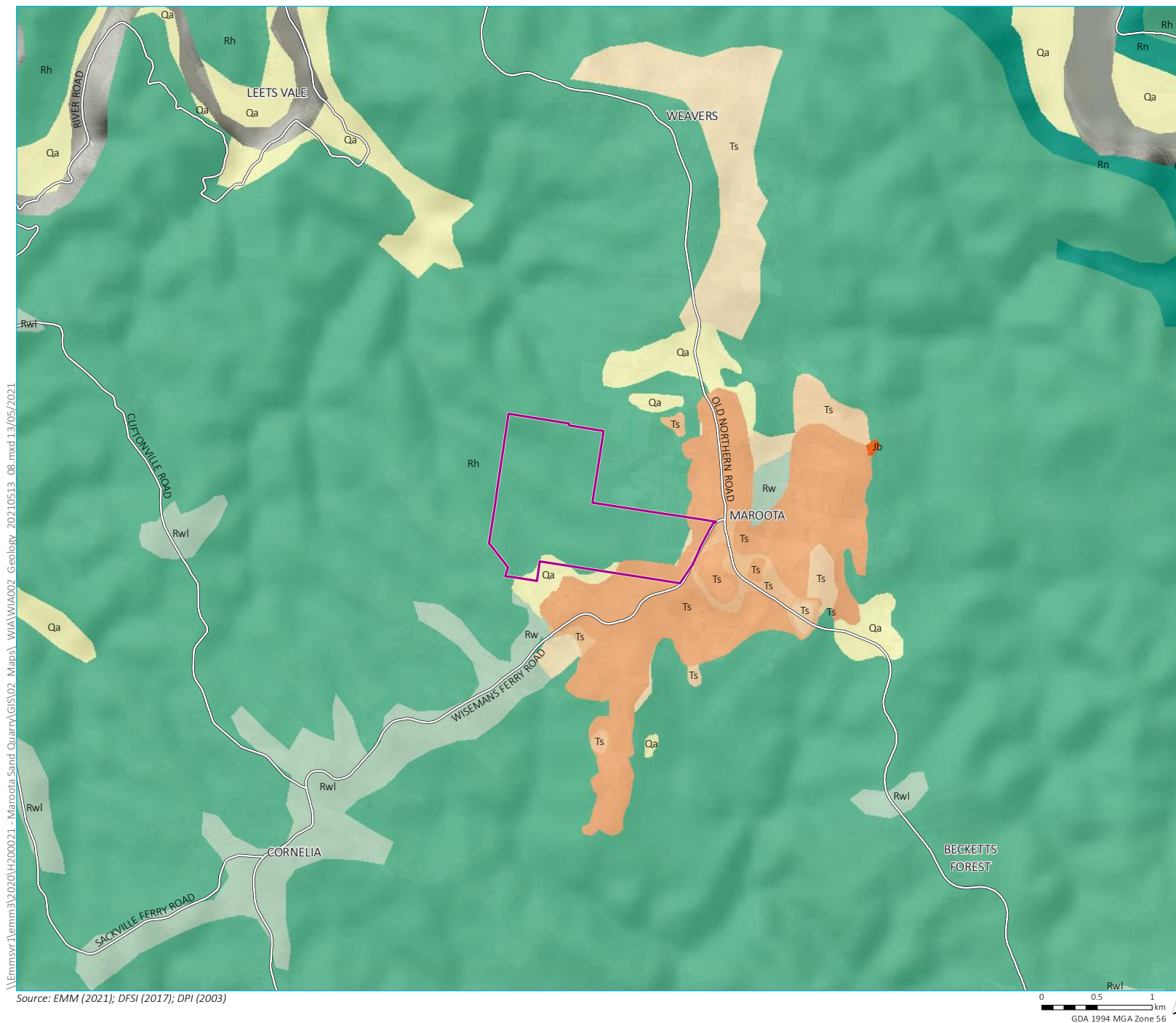
Table 3.2 Geology of the Maroota area

Age	Name of Unit	Lithology	Present in project area
Triassic	Wianamatta Group (Ashfield Shale and Mittagong Formation)	Shale and laminate	Potentially but none mapped
	Hawkesbury Sandstone	Quartzose sandstone with shale lenses (highly weathered sandstone (eluvial) occurs near surface)	Yes
	Narrabeen Group	Sandstone, shale and claystone	Yes, but at depth below the Hawkesbury Sandstone

The geology of the Maroota area is sub-divided into three main geological units after geological mapping (Etheridge 1980):

- the Maroota Sand;
- the eluvial sand of the Hawkesbury Sandstone; and
- the Hawkesbury Sandstone.

The geological units relevant to the extraction area is the Hawkesbury Sandstone. The Maroota sand and eluvial sand occur within the project area but are not within the proposed extraction area.



- KEY**
- Site boundary
 - Major road
 - Surface geology**
 - Quaternary**
 - Undifferentiated (Qa)
 - Tertiary**
 - Undifferentiated (Ts)
 - Maroota Sand - ferruginised sand and silty clay (Ts)
 - Maroota Sand - clay and silty clay (Ts)
 - Maroota Sand - clayey gravel, gravelly sand, clayey sand, pebbly sand and sand (Ts)
 - Jurassic**
 - Basalt (Jb)
 - Triassic**
 - Ashfield Shale - shale and laminate (Rw, Rwl)
 - Hawkesbury Sandstone (Rh)
 - Narrabeen Group (Rn)

Geology of the Maroota area

Maroota Sand Quarry
Water impact assessment
Figure 3.3



3.4.2 Project area geology

The majority of the project area comprises the Hawkesbury Sandstone unit along a relatively flat plateau and adjoining ridge line as shown on Figure 3.3. Along the eastern project boundary the Maroota Sand and eluvial sand is interpreted to be present. The geological drill logs are provided in Appendix A. The Maroota Sand deposit in the eastern part of the site covers approximately 7 ha and is outside of the proposed extraction area.

i Maroota Sand

The Maroota Sand, a poorly sorted, fine to coarse grained unconsolidated to partly consolidated sand with clay lenses and local gravel rich zones. The Tertiary unit accumulated along the former course of the Nepean River (Lee 2017). The Maroota Sand is reported as ranging in thickness from less than 1 m to up to 39 m at the Maroota Trig Station (Etheridge 1980). Randomly occurring discontinuous clay lenses up to 13 m thick have been reported from within the Maroota Sand unit, predominantly in the vicinity of the Maroota Trig Station (Etheridge 1980). The clay lenses may be of large lateral extent (Hopkins and Ross 1996), however they do not occur continuously throughout the deposit. The Maroota Sand occurs on the eastern side of the project area and is not within the proposed extraction area.

ii Eluvial sand

The eluvial sand is described as a weathering product of the Hawkesbury Sandstone basement. Weathering of the irregular erosional surface of the Hawkesbury Sandstone during the late Tertiary and Quaternary has resulted in a soft, friable, easily crushed sediment/rock of highly variable thickness (2 to 15 m in thickness). Where the weathered sandstone occurs above the water table, further decay has produced a loose white sand (Hopkins and Ross 1996). An alternative explanation for the unit is that the eluvial sand may be a remnant basal unit of the Maroota Sand. From geology logs (Graham Lee & Associates 2017) provided in Appendix A, the eluvial sand is interpreted to exist directly below the Maroota Sand on the eastern side of the project area, east of watercourse A (see Section 3.5) and intercepted in DM06. The area is not within the proposed extraction area.

iii Hawkesbury Sandstone

The Hawkesbury Sandstone unit is a massive, flat-lying, mostly homogeneous, medium to coarse grained quartz sandstone. It is 150 to 200 m thick in this part of the Sydney Basin, which is typical for the entire Sydney Geological Basin. Minor interbeds of siltstone and shale can be intercepted within the Hawkesbury Sandstone, often resembling the Ashfield Shale (Department of Minerals and Energy 1991). Block fractures and partings along bedding planes commonly occur throughout the Hawkesbury Sandstone. Weathered Hawkesbury Sandstone can occur as friable, eluvial sandstone near surface.

The Hawkesbury Sandstone is sub-divided into two contrasting sandstone facies, the sheet sandstone facies and massive sandstone facies:

- sheet sandstone facies – medium to coarse sand, granules and small rounded pebbles; and
- massive sandstone facies - much higher amount of clay and much less primary macro-porosity.

3.4.3 Wianamatta Shale

Figure 3.3 shows the Triassic Wianamatta Shale is not present at the site, however Wianamatta Shale outcrops to the immediate south. The transitional unit between the Ashfield Shale and the underlying Hawkesbury Sandstone (Mittagong Formation) has not been mapped. Ridge lines are capped by Ashfield Shale which overlies the Hawkesbury Sandstone, but the occurrence is limited and restricted to areas of higher elevation.

3.5 Surface water

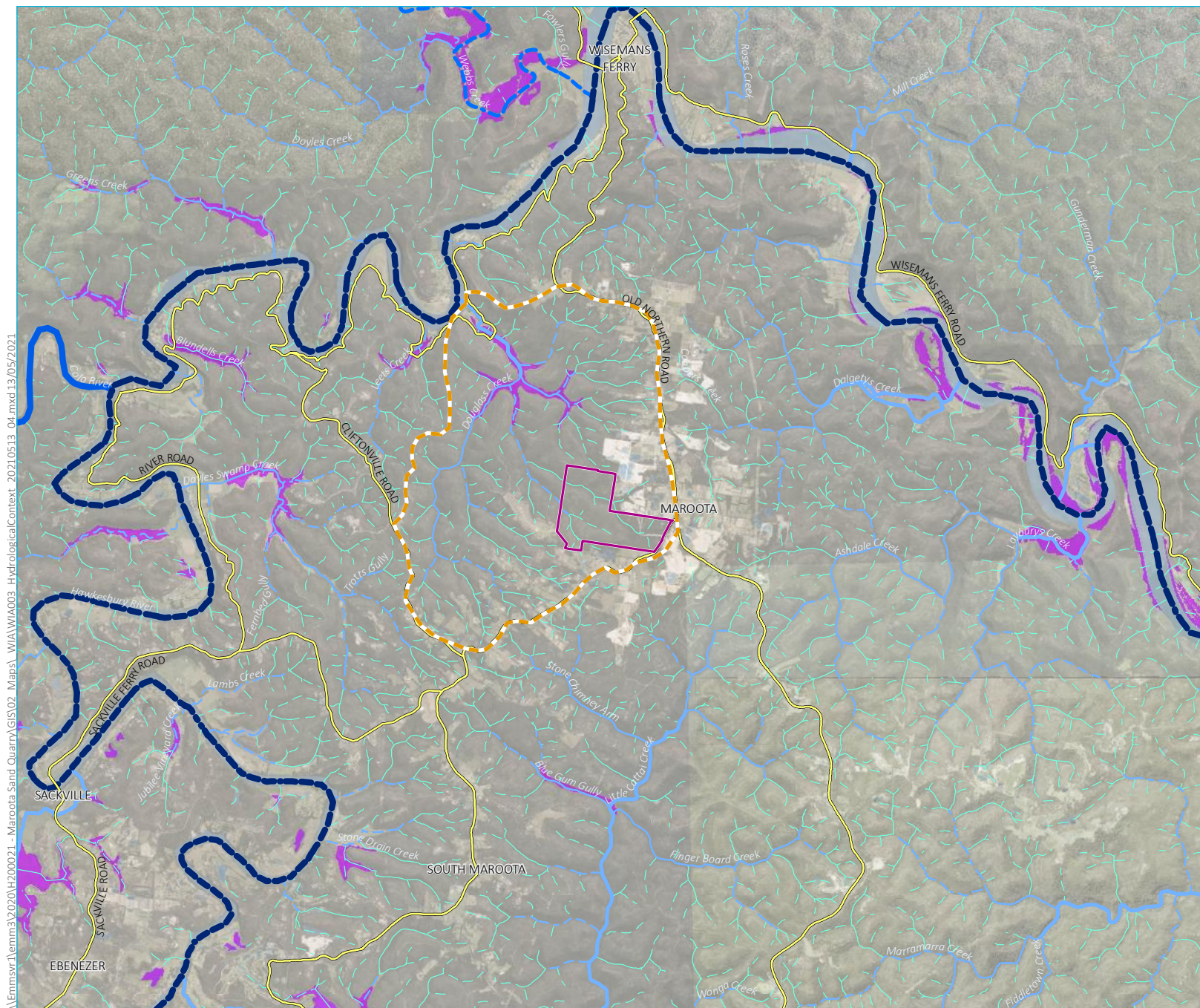
The site is located within the catchment of Douglass Creek, with surface runoff from the site draining to the north-west to the creek approximately 2.5 km downstream of the site. Douglass Creek flows north-west for approximately 2 km to its confluence with the Hawkesbury River estuary at Lower Half Moon Bend and ultimately contributes to Broken Bay. Prior to discharging to the Hawkesbury River estuary, Douglass Creek flows through a large wetland known as Jacksons Swamp. Jacksons Swamp is a freshwater floodplain or reed swamp with some brackish sections and supports wetland species of significance in the Hawkesbury area (Cattai Catchment Management Committee 1998). Douglass Creek has a catchment area of approximately 2,300 ha that contributes to the Hawkesbury River catchment. The regional hydrological context of the site is shown in Figure 3.4.

There are two unnamed watercourses in the vicinity of the proposed disturbance area. As these watercourses are unnamed, they are referred to as Watercourses A and B in this report and are shown in Figure 3.5 and described further below. Five dams are in the eastern portion of the site. These dams are referred to as Dams 1 to 5 and are also shown in Figure 3.5.

Watercourse A is a second order stream that flows in a north-westerly direction. It is interpreted to be groundwater fed (see Section 3.7.1) and has an intermittent flow regime; meaning that, during an average rainfall year, streamflow will occur for most of the year but may cease for weeks or months, typically in late summer or early autumn. Streamflow would also cease for extended periods of time during dry periods. Dam 1 has been established online to Watercourse A.

Watercourse B is a first order stream that flows to the north-west in a well-defined gully. It is interpreted to have an ephemeral flow regime meaning that streamflow only occurs for a short period of time after material rainfall. Watercourse B joins a larger watercourse immediately downstream of the proposed water management dam.

PF Formation Sand and Concrete hold a surface water entitlement to extract up to 32 megalitres per year (ML/year) from Dam 1 (WAL 26168). EMM understands that this water is used by to supply water to a sand quarry to the north of the project site. A search of the *NSW Water Register* (WaterNSW 2020a) indicates that there are no other licensed surface water users that rely on extraction from waterways that flow between the site and the Hawkesbury River.



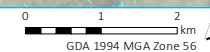
- KEY**
- Site boundary
 - Major road
 - Douglass Creek catchment
 - Coastal wetland
 - Waterbody
- Strahler stream order
- 1st order
 - 2nd order
 - 3rd order
 - 4th order
 - 5th order
 - 6th order
 - 7th order
 - 8th order
 - 9th order

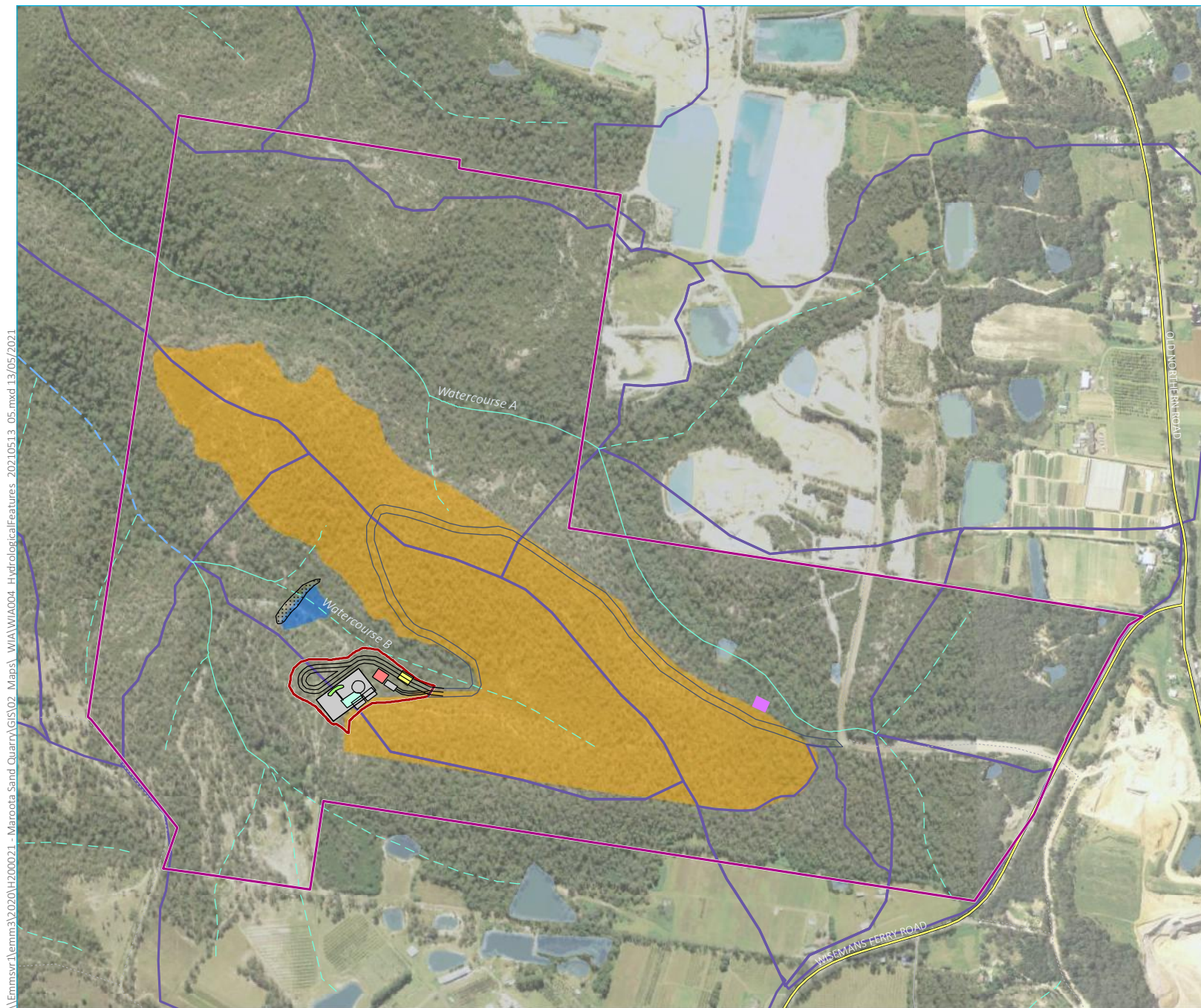
Regional hydrological context

Maroota Sand Quarry
Water impact assessment
Figure 3.4



Source: EMM (2021); DFSI (2017); DPI (2015)





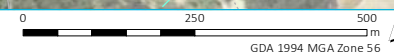
- KEY**
- Site boundary
 - Major road
 - Minor road
 - Vehicular track
 - Catchment area
 - Waterbody
 - Strahler stream order
 - 1st order
 - 2nd order
 - 3rd order
 - Proposed quarry layout
 - Site infrastructure
 - Site infrastructure
 - Entry building
 - Offices and carpark
 - Processing plant
 - Weighbridge
 - Product stockpile
 - Cut/fill extent
 - Haul road
 - Dam embankment
 - Dam
 - Excavation zone

Hydrological features

Maroota Sand Quarry
Water impact assessment
Figure 3.5



Source: EMM (2021); DFSI (2017); DPI (2015)



3.6 Groundwater

3.6.1 Aquifers

The regional Maroota extractive industry groundwater study (EMM 2018) investigated the groundwater resources in the Maroota area. The study used data measured from approximately 60 monitoring bores over the period 17 to 19 April 2018 to produce maps of a groundwater surface for both the shallow and deep aquifers. For the purposes of this assessment, two groundwater systems are presented, which is consistent with the Maroota extractive industry groundwater study. The two groundwater systems present at the project area and surrounds are:

1. the shallow aquifer is the saturated zone within the base of the Maroota Sand and within the eluvial/weathered Hawkesbury Sandstone unit (at the eastern side of the site); and
2. the deep aquifer is located within the consolidated Hawkesbury Sandstone below the weathered zone and includes the regional water table and all groundwater in the sandstone below it.

Groundwater levels between the shallow and deep aquifers generally show distinct vertical separation. Vertical separation can be up to 20 m as shown on Figure 3.6.

i Shallow aquifer

This shallow aquifer is present across the local area (predominantly to the east and south) as an unconfined water table aquifer and combines the Maroota Sand and eluvial sand. The shallow aquifer is located throughout the central Maroota area, while in the project area it only occurs on the eastern half of the site as noted in the geological drill logs of holes east of Watercourse A (Appendix A). It forms a locally significant groundwater resource (Lawson 2018). Springs can occur at the interface between the eluvial sand and the Hawkesbury Sandstone. The shallow aquifer has variable saturation at site. It is unsaturated at the site as measured in DDH02S, while thin saturation occurs at DM06 (Table 3.6). The shallow aquifer is not within the proposed extraction area.

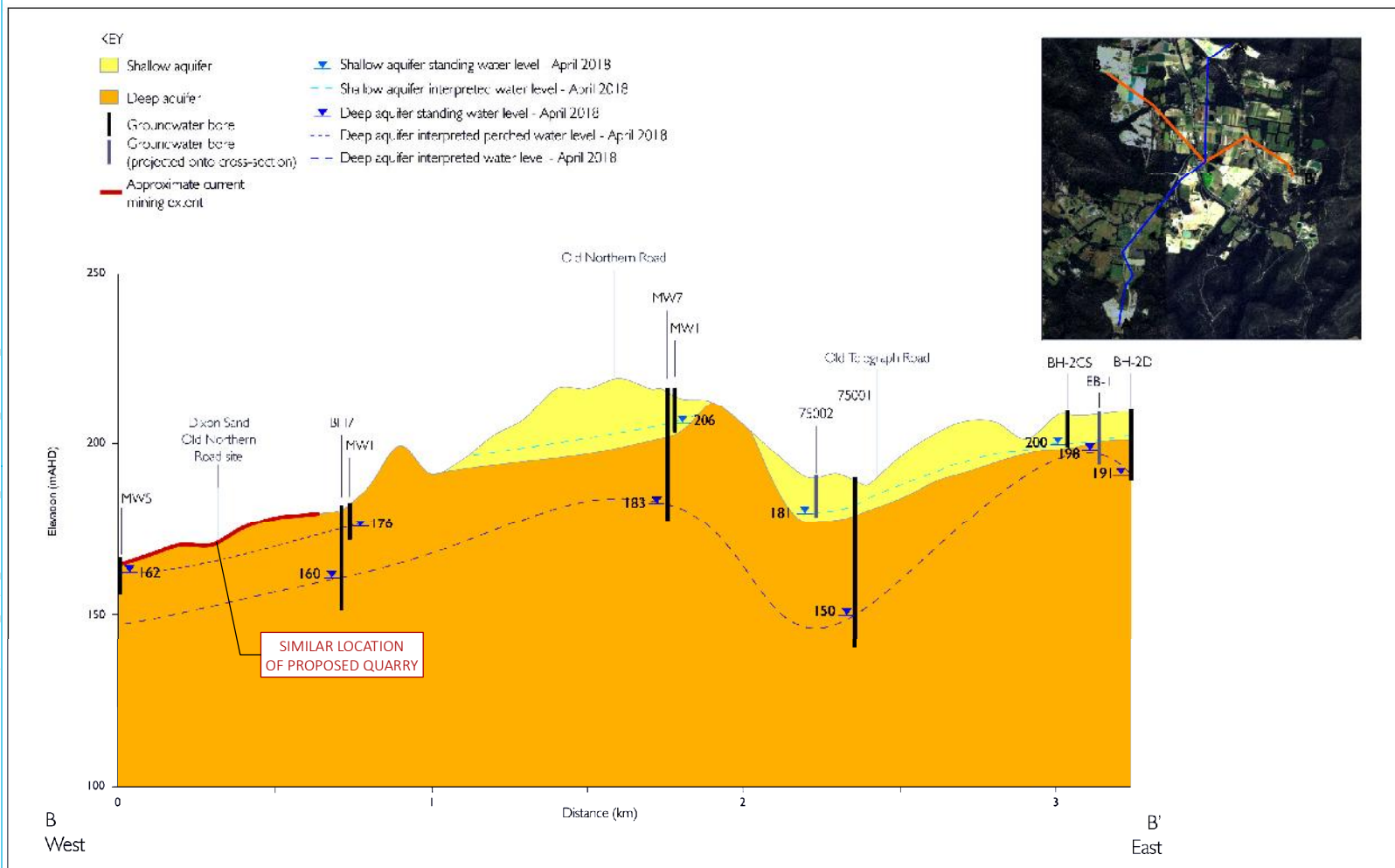
Recharge to this aquifer occurs via direct rainfall recharge, and discharge occurs via springs around the base of the unconsolidated sand outcrop, evapo-transpiration, and leakage to the underlying regional water table in the Hawkesbury Sandstone.

ii Deep aquifer

The deep aquifer is a major, regional aquifer that comprises multiple aquifers and is considered a semi-confined, dual porosity (matrix and fracture) hydrogeological unit in the Hawkesbury Sandstone. Groundwater flow occurs primarily as secondary porosity within fractures and fissures in the host rock matrix rather than in continuous, interconnected pore spaces as in sand and gravel aquifers. Water bearing zones occur at various depths and are commonly laterally extensive, typically occurring within the sheet facies zones, but vertically discrete, restricted by the massive facies, which acts as an aquitard.

Where there are multiple horizons monitored there is a downward hydraulic gradient suggesting recharge from above and a degree of confinement caused by the alternating sheet/massive facies sandstone and/or shale lenses. Recharge to this aquifer occurs via direct rainfall recharge and leakage from the overlying shallow aquifer where present. Recharge rates of around 6% of average annual rainfall have been adopted for planning purposes (NOW 2011) and represents direct rainfall recharge at areas of outcrop, and indirect recharge from the overlying shallow sand aquifer. Discharge occurs via springs lower in the catchment with potentially some evapo-transpiration from the regional water table. During extended dry periods, the large groundwater storage of the deep aquifer is sufficient to maintain supplies to springs and consumptive uses.

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Source: EMM (2021, 2018); DFSI (2017)

Maroota regional cross section (A-A')

Maroota Sand Quarry Water impact assessment Figure 3.6



a Water bearing zones

The summary of observed high yielding groundwater zones, ie greater than 1 litre per second (L/s), from a review of the *Australian Groundwater Explorer* (Bureau of Meteorology 2020) is summarised in Table 3.3. The table shows the depths and yields where water cuts greater than 1 L/s were encountered. The observations are from available information recorded on drillers logs (Form As) and are based on airlift yield estimates at the time of drilling. It is reasonable to assume production pumping yields of 1 to 1.5 L/s could be achievable from deep production bores.

Table 3.3 Summary of high yielding groundwater zones

Registered ID	Screen depth (mbgl)	Screen depth elevation (m AHD)	Target formation	Yield (L/s)
GW110585	171–172	26.5–27.5	Sandstone	1.3
GW110585	152–153	45.5–46.5	Sandstone	1.1
GW105044	127–127.8	41.8–42.6	Sandstone	1.7
GW105047	131–132.8	49.1–47.3	Sandstone	1.6
GW102133	130–132	80.0–78.0	Sandstone, fractured	1.2
GW102450	104–108	91.3–87.3	Sandstone	1.5
GW101527	74–75.5	97.9–99.4	Sandstone	1.3
GW101527	56.5–57.2	116.2–116.9	Sandstone, fractured	1.3
GW059742	–	–	–	1.5
GW075000	–	–	Sandstone*	1.0
GW060051	–	–	Sandstone	1.4

Notes: * assumed to be sandstone based on geological description
 – no information available
 mbgl=metres below ground level
 m AHD = metres above Australian height datum
 L/s = litres per second

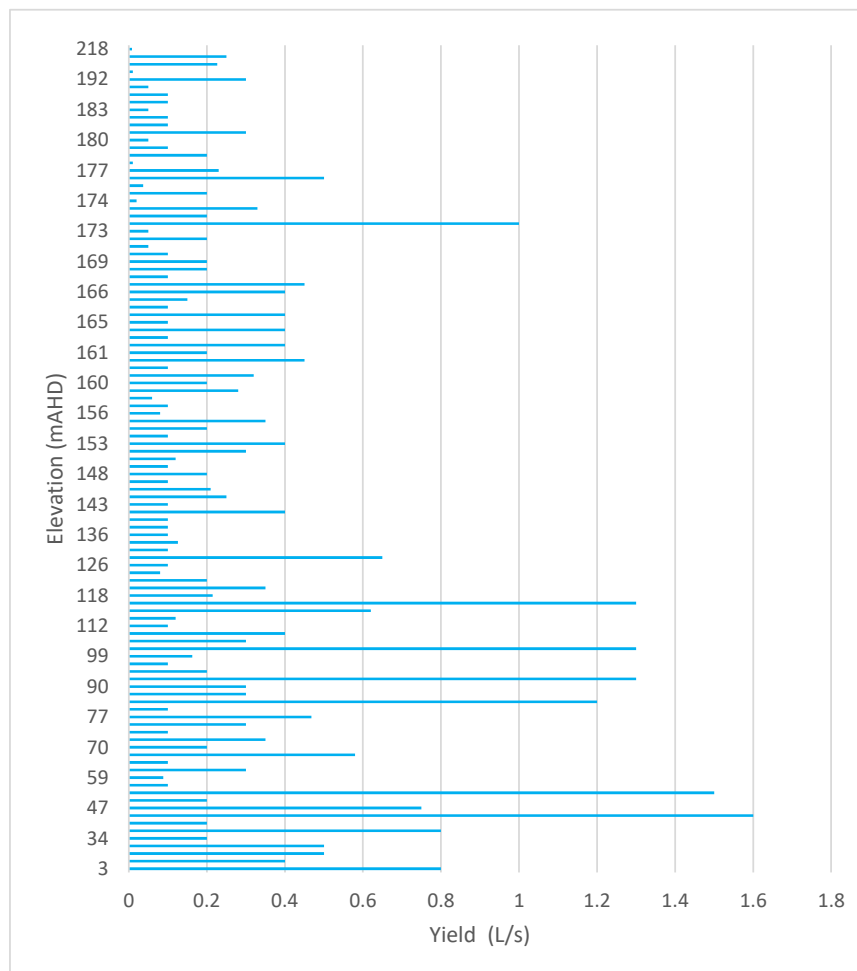
The vertical distribution of water bearing zones is shown on Figure 3.7. The observed yields from drillers logs have been divided into three main zones, upper, middle and lower, based on the available drilling yield observation in the vicinity of the project area. Adopted zone depths are summarised in Table 3.4. Higher yields are typically encountered towards the base of the sequence owing to coarser and more permeable sediments of the formation.

Table 3.4 Distribution of water bearing zones in the Hawkesbury Sandstone

Interval (m AHD)	Interval (mbgl)	Section	Number of intersections	Average yields (L/s)	Maximum yield (L/s)
>155	1–72	Upper	56	0.2	1
100–155	24–103	Middle	23	0.3	1.3
<100	74–198	Lower	30	0.5	1.7

Notes: mbgl = meters below ground level, m AHD = meters Australian Height Datum, L/s = litres per second

The two highest yields, 1.7 L/s and 1.6 L/s, were recorded at comparable depths, between 127 and 133 mbgl, or between 41 and 49 m AHD. At 91.3-87.3 m AHD another high yielding zone (1.5 L/s) was recorded. These water cuts typically span 1 m in length, which supports the conceptual understanding (refer Section 3.8) of being associated with discrete fractures.



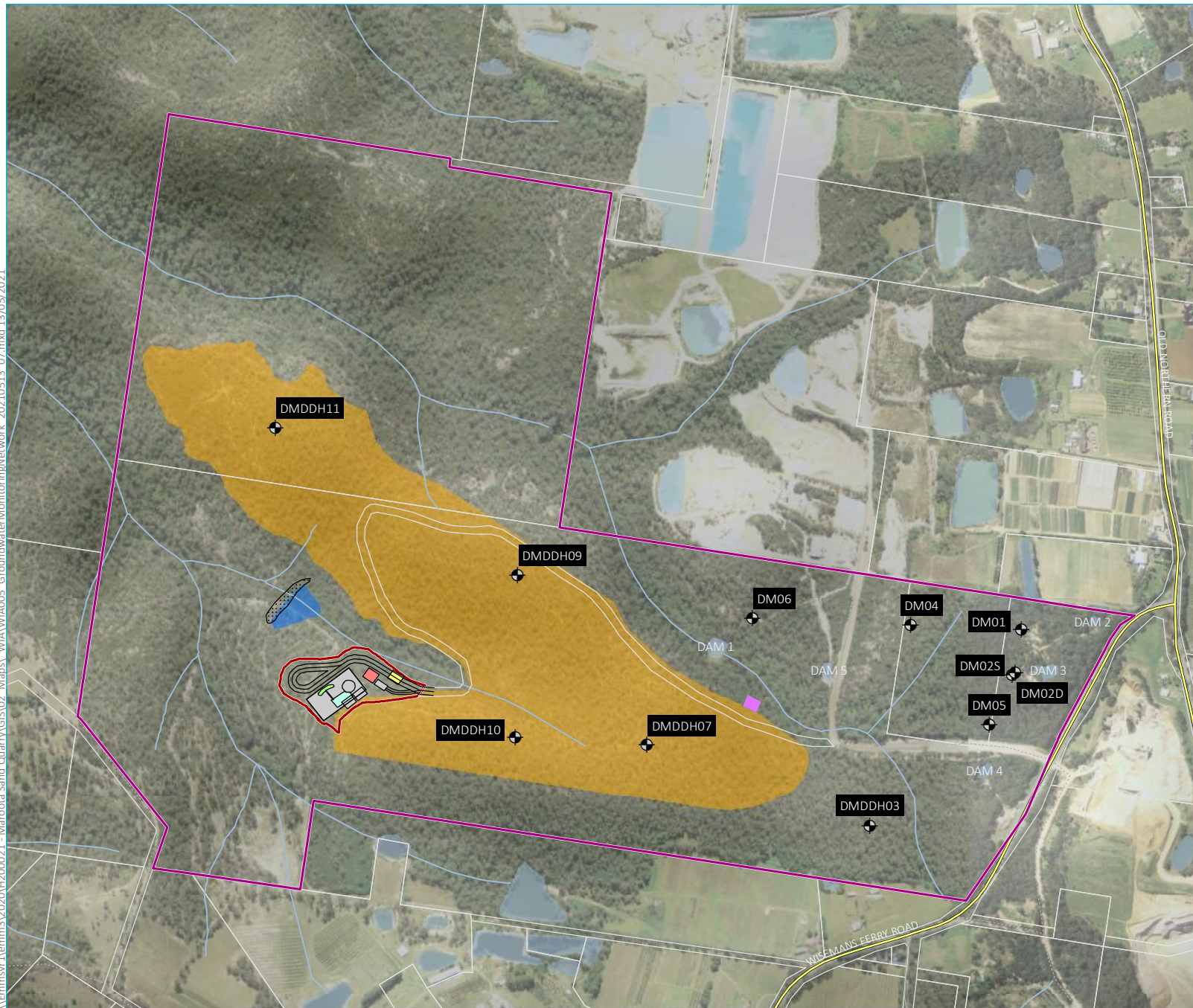
Notes: L/s = litres per second

Figure 3.7 Groundwater drilling yields with depth

3.6.2 Site monitoring network

A groundwater monitoring network was installed in 2017 at the site (Graham Lee & Associates 2017). The network comprises 11 groundwater monitoring bores targeting mostly the upper section of the deep aquifer (Hawkesbury Sandstone) aquifer as shown on Figure 3.8. Monitoring bore construction and the target lithology and stratigraphy is summarised in Table 3.5. There is one nested site, DM02S and DM02D, where a shallow and deep bore are located next to each other to assess potential differences in vertical hydraulic gradients.

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- KEY**
- Monitoring bore location
 - Site boundary
 - Major road
 - Minor road
 - Vehicular track
 - Watercourse/drainage line
 - Waterbody
 - Cadastral boundary
 - Proposed quarry layout
 - Site infrastructure
 - Site infrastructure
 - Entry building
 - Offices and carpark
 - Processing plant
 - Weighbridge
 - Product stockpile
 - Cut/fill extent
 - Haul road
 - Dam embankment
 - Dam
 - Excavation zone

Groundwater monitoring network

Maroota Sand Quarry
Water impact assessment
Figure 3.8



Source: EMM (2021); DFSI (2017)

0 250 500
m
GDA 1994 MGA Zone 56

Table 3.5 Site groundwater monitoring network

Station	Easting	Northing	Groundwater elevation (m AHD)	Total depth (mbgl)	Screened interval (mbgl)	Screened lithology	Aquifer
DM01	313340	6295812	204.5	12	5.8-11.8	clay, silt, sandstone	Shallow
DM02S*	313328	6295727	201.1	10	6.8-9.8	sand	Shallow
DM02D*	313322	6295723	200.1	31	24-30	sandstone	Deep
DMDDH03	313044	6295428	192.7	45.5	39.2-45.2	sandstone	Deep
DM04	313124	6295820	185.5	18	11.9-17.9	sandstone	Deep
DM05	313277	6295625	192	27	21.5-27.5	sandstone	Deep
DM06	312814	6295833	165.1	8	2-8	sand	Shallow
DMDDH07	312608	6295585	193.2	60	54-60	sandstone	Deep
DMDDH09	312355	6295918	187.8	45.5	39.3-45.3	sandstone	Deep
DMDDH10	312351	6295601	173	35.1	29.1-35.1	sandstone	Deep
DMDDH11	311882	6296206	172.2	35	29-35	sandstone	Deep

Notes: * nested site, mbgl = meters below ground level, m AHD = metres Australian Height Datum; Coordinate system GDA 94 zone 56.
Shallow aquifer – Maroota/Eluvial sand, Deep aquifer – Regional Hawkesbury Sandstone

3.6.3 Groundwater levels

i Site groundwater monitoring network

Groundwater levels have been recorded by groundwater level loggers installed at five locations (DM02D, DM02S, DM06, DMDDH07 and DMDDH09) since installation in March 2017. Groundwater level hydrographs covering the period from March 2017 to August 2020 are presented in Figure 3.9. Both manual measurements and continuous level logger are shown. Individual hydrographs are included in Appendix B with an expanded vertical scale to evaluate rainfall recharge trends. The range in observed groundwater levels (minimum, maximum, average) is summarised in Table 3.6.

The following observations from the long term, continuous site monitoring data are made:

- DM02S – targeting the shallow aquifer, shows intermittent presence of groundwater. Groundwater has not been observed since March 2018.
- DM06 – targeting the shallow aquifer, shows a pronounced and immediate response from rainfall and surface water flow. Following a rainfall event on 2 February 2020 totalling 111 mm, the groundwater level rose nearly 2 m.
- Groundwater levels in DM02D, DMDDH07 and DMDDH09, screened in the deep aquifer, shows a small (ie up to 0.15 m) response to rainfall recharge. Groundwater levels in DM02D and DMDDH07 declined by 2–2.5 m over the period August 2017 to January 2020, consistent with below average rainfall. The groundwater level in DMDDH09 also declines over this period but only by 1 m.

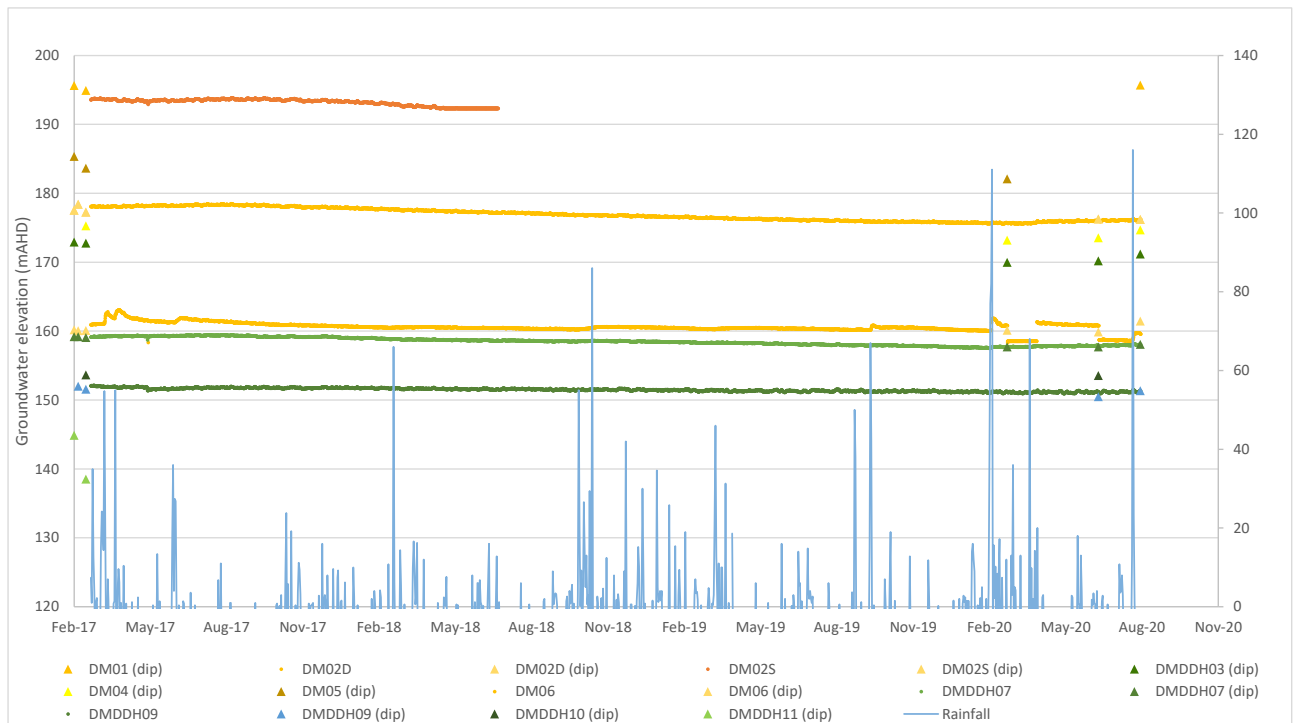


Figure 3.9 Hydrograph for site bores, manual and continuous measurements

Table 3.6 Groundwater level observations

Bore ID	Observed depth to groundwater (mbgl)			Groundwater elevation (m AHD)
	Minimum	Maximum	Average	Maximum
DM01	9.6	11.5	10.4	194.9
DM02S	8.7	10.1	9.1	192.4
DM02D	22.1	25.8	23.6	178.0
DMDDH03	20.6	23.5	22.3	172.1
DM04	10.7	13.0	12.0	174.8
DM05	7.3	10.6	9.3	184.7
DM06	3.5	8.2	5.9	161.6
DMDDH07	34.2	44.8	35.1	159.0
DMDDH09	36.5	43.8	37.8	151.3
DMDDH10	21.5	22.1	21.7	153.0
DMDDH11	28.3	34.7	32.5	143.9

Notes: mbgl – metres below ground level

ii Regional groundwater level trends

Real time monitoring data available from the NSW Government nearby nested monitoring bores (WaterNSW 2020b), GW075001 and GW075002, are located 1.5 km to the west of site and separated by 170 m. Groundwater levels monitoring at these locations has been undertaken (intermittently) since late 1997. Screened lithology are:

- GW075002 – comprises a nested monitoring bore, with two screen intervals in the shallow aquifer; and
- GW075001 – deep aquifer.

The groundwater hydrograph and daily rainfall is presented in Figure 3.10. The groundwater levels show clear and consistent separation of 10 to 20 m in measured groundwater levels between the shallow and deep aquifers. The higher levels in the shallow aquifers confirm a downward flow gradient. This is consistent with the conceptual understanding as presented the Maroota Extractive Industry Groundwater Study and shown on Figure 3.6.

The shallow aquifers respond directly to rainfall recharge, while there is a more gradual response in the deep Hawkesbury Sandstone. Periods of below average rainfall combined with (likely) greater abstraction from the Hawkesbury Sandstone aquifer (GW075001) resulted in a large decline (around 25 m) of groundwater levels in the early 2000s. During the same time there was limited drawdown in the shallow sand aquifers (GW075002) observed.

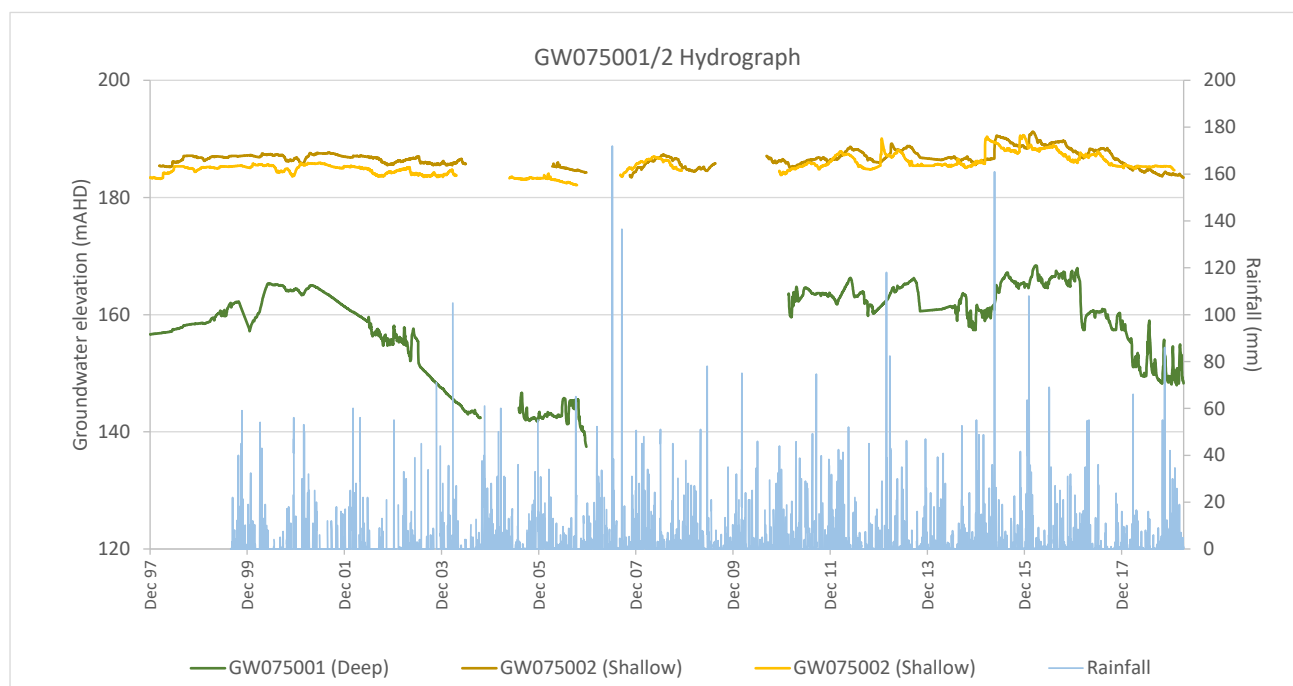


Figure 3.10 Groundwater level hydrograph (GW075001 and GW075002) and rainfall

3.6.4 Hydraulic conductivity

A wide range of hydraulic conductivity measurements are reported for the Hawkesbury Sandstone reflecting the variable nature of the unit and the prevalence of secondary porosity fracture flow. Numerous regional tests have been conducted in the area since, with horizontal hydraulic conductivity ranging from 0.01–0.3 m/day (DLWC 2001). The values recorded at the two site monitoring bores (DMDDH03 and DMDDH10) are consistent with the reported literature values. Hydraulic conductivity from site monitoring bores and other published results for the Hawkesbury Sandstone are provided in Table 3.7.

Table 3.7 **Reported hydraulic conductivity values for Hawkesbury Sandstone**

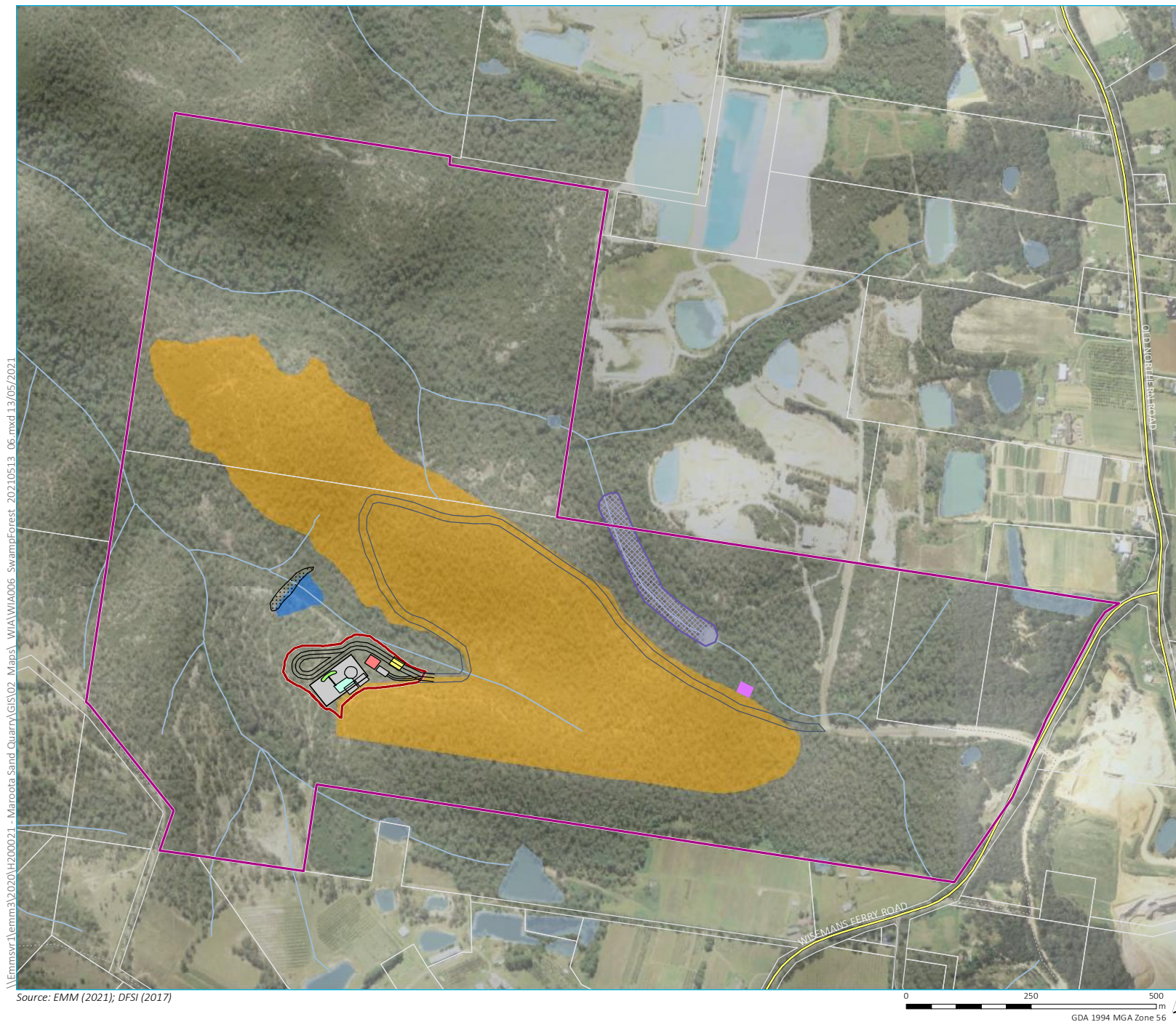
Location / reference	Region	K value (m/day)	Comment	Aquifer
DMDDH03	Project area	0.36	Bouwer-Rice method, slug test undertaken in 2017	Hawkesbury Sandstone (Deep)
DMDDH10	Project area	0.09	Bouwer-Rice method, slug test undertaken in 2017	Hawkesbury Sandstone (Deep)
Russell 2001	Maroota trig station	0.01–0.2	Monitoring bores targeting fracture zones, between 138-150 mbgl	Hawkesbury Sandstone (Deep)
Nexus Environmental	Sand Extraction, Roberts Road Maroota	0.002–0.04	23-50 mbgl upper Hawkesbury Sandstone, monitoring bores with 6 m screens	Hawkesbury Sandstone (Deep)
Alkhatib & Merrick 2007	Mangrove Mountain	0.01–0.5	Calibrated model values from regional numerical model. Represent effective hydraulic conductivity of model layers	Hawkesbury Sandstone (Deep)
Heritage Computing 2013	Calga Sand Quarry	0.005 K_h 0.0001–0.0005 K_v	Calibrated model values from regional numerical model. Represent effective hydraulic conductivity of model layers	Hawkesbury Sandstone (Deep)
Martens 2010	Calga regional area, Hanson's Somersby Quarry Project	0.003–1.6	Range is from shallow monitoring bores	Hawkesbury Sandstone (Deep)
WSP 2007 and Parsons Brinkerhoff 2008	Penrith	0.1–15.7	Wide diameter (7-8") production bores targeting the full sequence of Hawkesbury Sandstone (range of 100–284 m of aquifer thickness)	Hawkesbury Sandstone (Deep)

Notes: K_h – horizontal hydraulic conductivity, K_v – vertical hydraulic conductivity

3.6.5 Groundwater receptors

i Groundwater dependent ecosystems

There is one known groundwater dependent ecosystem (GDE) within the site. The Maroota Sands Swamp Forest GDE, shown in Figure 3.11, is located at the eastern edge of the extraction area and within Watercourse A. Interestingly this GDE is located off the mapped extent of the Maroota Sand deposit and appears to be likely maintained by shallow groundwater beneath Watercourse A. During site investigations, Dam 1 immediately upstream of the GDE was noted to be leaking on the downslope edge of the embankment. This supply of water may also contribute to maintain the GDE health.



- KEY**
- Site boundary
 - Major road
 - Minor road
 - Vehicular track
 - Watercourse/drainage line
 - Waterbody
 - Cadastral boundary
 - Groundwater dependent ecosystem (PCT 923)
 - Proposed quarry layout**
 - Site infrastructure
 - Site infrastructure
 - Entry building
 - Offices and carpark
 - Processing plant
 - Weighbridge
 - Product stockpile
 - Cut/fill extent
 - Haul road
 - Dam embankment
 - Dam
 - Excavation zone

Maroota Sands Swamp Forest

Maroota Sand Quarry
Water impact assessment
Figure 3.11



ii Groundwater users

a Surrounding groundwater works

A search of the *Australian Groundwater Explorer* (Bureau of Meteorology 2020) identified 110 groundwater works within a 3 km radius of the project area. The search results were cross checked with the *NSW Water Register* (WaterNSW 2020a) to find the use type and status which is summarised in Table 3.8. The location of all groundwater works is shown on Figure 3.12. These are located to the north, east and south of the project area. Of these, 57 works are registered with a water supply type; either commercial and industrial, other, stock and domestic, unknown, water supply, or irrigation.

Table 3.8 Surrounding groundwater works

Type	Current	Unknown	Suspended	Total
Commercial and Industrial	8			8
Irrigation	8	3	1	12
Monitoring	16	37		53
Other	2			2
Stock and Domestic	1			1
Unknown	3			3
Water Supply	28	3		31
Total	66	43	1	110

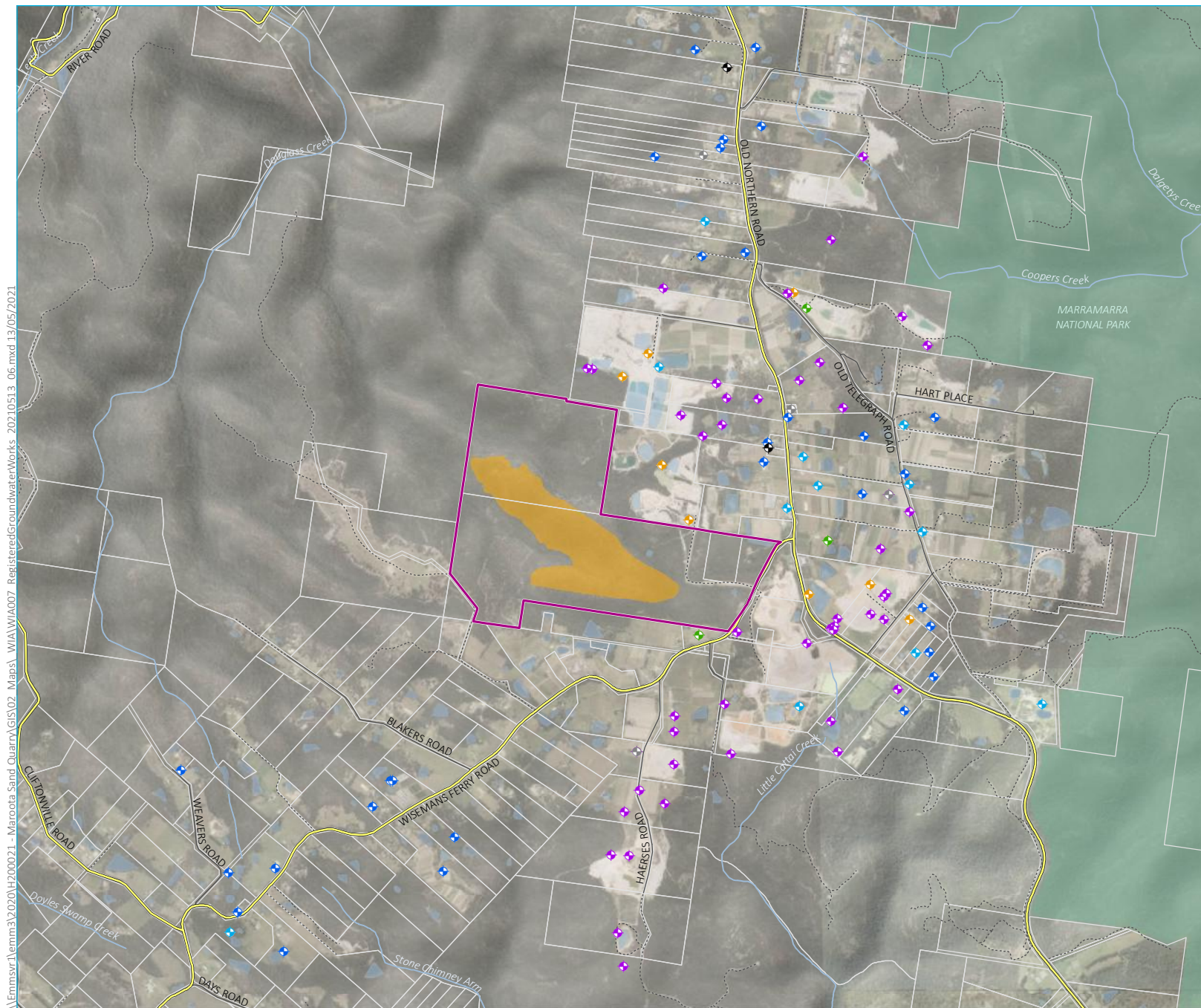
Each groundwater user work summary was investigated and when available the screen interval and lithology was recorded. To assign a geological formation to each user, any groundwater work within the Maroota Sand and eluvial sand geological boundary as shown on Figure 3.3 and with a top of screen less than 30 mbgl was assigned to the shallow aquifer. There are 13 groundwater works assigned to the shallow aquifer. Groundwater works outside the mapped Maroota Sand and eluvial sand geological boundary or with a top of screen greater than 30 m (if inside the boundary) were assigned to the deep aquifer. Groundwater works with no recorded screen interval were also assigned to the deep aquifer. There is a total of 44 groundwater works assigned to the deep aquifer. A list of the nearby groundwater works within 1 km of the extraction boundary and their details is provided in Table 3.9 with all groundwater works within 3 km summarised in Appendix C.

Of the Lot/DPs within 3 km of the extraction area, there are 10 within the Maroota Tertiary Sands Groundwater Source and eight WAL holders in the Sydney Basin Central Groundwater Source.

Table 3.9 **Nearby groundwater works (within 1 km of extraction boundary)**

Registered ID	Easting	Northing	Ground Elevation	Type	Casing depth (m)	Formation	Time of drilling depth to water (mbgl)
GW105044	312572	6296871	169.57	Commercial and Industrial	144.5	Hawkesbury Sandstone	
GW101527	312818	6296319	173.35	Commercial and Industrial	138	Hawkesbury Sandstone	
GW101528	312987	6295975	178.43	Commercial and Industrial	150	Hawkesbury Sandstone	
GW072037	313598	6296047	219.19	Irrigation	99	Hawkesbury Sandstone	
GW102133	313454	6296335	209.97	Water Supply	150.5	Maroota Tertiary Sand	77
GW107345	313853	6295846	212.49	Water Supply	150	Maroota Tertiary Sand	40
GW102451	313735	6295514	220	Commercial and Industrial	156.5	Unknown	
GW100864	313050	6295256	202.99	Unknown	137.16	Unknown	

Note: m AHD – Australian Height Datum, mbgl – metres below ground level



KEY

- ▬ Site boundary
- ▬ Major road
- ▬ Minor road
- ⋯ Vehicular track
- ▬ Named watercourse
- ▬ Waterbody
- ▬ NPWS reserve
- ▬ Cadastral boundary
- ▬ Excavation zone
- Registered bores
 - ◆ Monitoring
 - ◆ Water Supply
 - ◆ Irrigation
 - ◆ Commercial and Industrial
 - ◆ Stock and Domestic
 - ◆ Other
 - ◆ Unknown

Registered groundwater works
in the Maroota area

Maroota Sand Quarry
Water impact assessment
Figure 3.12



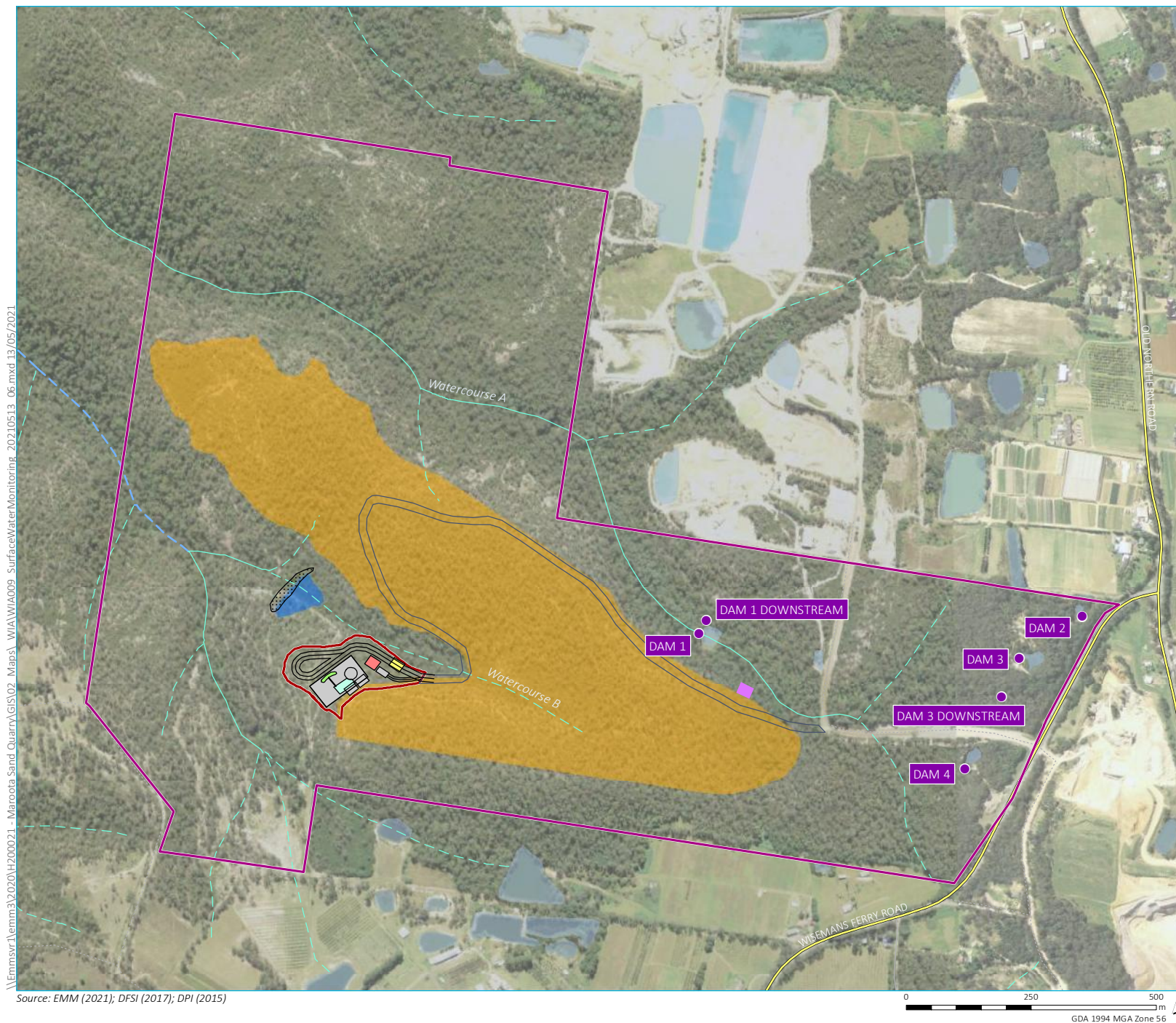
3.7 Water quality

A water quality characterisation program was undertaken to inform this water assessment. The program consisted of sampling on-site on three occasions (referred to as sampling events) at all groundwater monitoring bores (Figure 3.8) that were accessible and surface water locations shown in Figure 3.13. Physicochemical field parameters were measured in situ, with grab samples analysed by Australian Laboratory Services (ALS), a laboratory accredited by the National Association of Testing Authorities, Australia (NATA). All laboratory analytes that were not measured in situ were received by the laboratory within the recommended holding times.

Table 3.10 Water quality sampling events

Sampling event	Date	Rainfall in preceding five days ¹	Comment
Initial	March 2017	0 mm	Initial sampling after monitoring bore installation
Event 1	6 April 2020	20 mm	No access for groundwater sampling. Surface water only
Event 2	16 June 2020	5 mm	Groundwater and surface water
Event 3	5 August 2020	0 mm	Groundwater and surface water

1. SILO data obtained for the Maroota (Old Telegraph) Station (BOM station 67014).



- KEY**
- Surface water quality monitoring location
 - Site boundary
 - Major road
 - Minor road
 - Vehicular track
 - Waterbody
 - Strahler stream order
 - 1st order
 - 2nd order
 - 3rd order
 - Proposed quarry layout
 - Site infrastructure
 - Site infrastructure
 - Entry building
 - Offices and carpark
 - Processing plant
 - Weighbridge
 - Product stockpile
 - Cut/fill extent
 - Haul road
 - Dam embankment
 - Dam
 - Excavation zone

Surface water quality
monitoring locations

Maroota Sand Quarry
Water impact assessment
Figure 3.13

3.7.1 Groundwater quality

Groundwater quality from the site monitoring network has been reviewed to characterise background physiochemical, major ion and dissolved metal concentrations. Groundwater quality has been recorded on three occasions between 2017 and 2020. A summary table and the laboratory reports are included in Appendix D. Average results are provided in Table 3.11. No DGVs have been determined for the regional groundwater quality.

Overall, physiochemical parameters indicate groundwater is mildly acidic at all sampling locations with the exception of DMDDH07. Groundwater salinity is fresh, with a maximum electrical conductivity (EC) measurement of 792 microsiemens per centimetre ($\mu\text{S}/\text{cm}$) (DMDDH09).

The laboratory results indicate the following:

- the shallow groundwater has low salinity (EC is generally less than 200 $\mu\text{S}/\text{cm}$), and pH is mildly acidic (pH is generally less than pH 5.5);
- the groundwater is a Na-Ca-Cl- HCO_3 water type;
- alkalinity is low, the highest total alkalinity result was observed at DMDDH07, 84 milligrams per litre (mg/L);
- major ion results are low, sulfate, chloride and sodium results were above the laboratory limits of reporting (LOR);
- dissolved metal results were typically below the laboratory LOR, with the exception of barium, zinc and manganese. The maximum result was 0.2 mg/L for zinc (DMDDH03);
- nutrients were elevated above the laboratory LOR at all locations with the highest total nitrogen result 15.8 mg/L at DM04 and the highest total phosphorus result of 12.9 mg/L at DMDDH07;
- there was a detection of the light/medium total recoverable hydrocarbons fraction at DMDDH07 in May 2017 with a result of 280 $\mu\text{g}/\text{L}$ for the $>\text{C}_{10}\text{-C}_{16}$ fraction; and
- there were no concentrations above the laboratory LOR for organochlorine pesticides, organophosphorus pesticides, phenolic compounds, polynuclear aromatic hydrocarbons and BTEXN.

Table 3.11 **Groundwater quality results**

Parameter	Units	DM01	DM02S	DM02D	DMDDH03	DM04	DM05	DM06	DMDDH07	DMDDH09	DMDDH10	DMDDH11
Physicochemical parameters												
Dissolved oxygen (DO)	mg/L		4.3	-	2.1	-	2.6	4.4	3.4	4.5	4.8	
EC	µS/cm		298.4	-	187.4	-	206.1	144.8	363.4	792.0	152.3	316.6
pH	pH units		5.4	-	4.3	-	5.2	4.9	8.7	4.4	4.7	4.7
Redox	mV		100.4	-	19.4	-	-183.0	-172.0	-197.0	-90.0	-122.0	
TDS	mg/L		260.6	-	174.8	-	133.9	91.7	224.3	513.5	98.8	205.8
Major ions												
Bicarbonate alkalinity	mg/L	<1	13.7	1.0	5.0	<1	<1	9.5	51.3	<1	2.0	2.0
Carbonate alkalinity	mg/L	<1	5.7	<1	1.5	<1	<1	2.5	24.0	2.0	2.0	3.0
Hydroxide alkalinity	mg/L	<1	<1	<1	<1	<1	<1	<1	15.0	<1	<1	<1
Total alkalinity	mg/L	30.0	46.7	24.0	36.7	57.0	35.0	37.0	60.3	251.3	42.0	90.0
Calcium	mg/L	5.0	3.0	1.0	6.0	3.0	3.0	2.7	1.5	14.3	5.5	5.5
Chloride	mg/L	4.5	5.9	4.9	5.0	4.1	4.9	5.2	7.6	4.1	4.5	4.6
Fluoride	mg/L	<1	1.0	<1	1.0	<1	<1	<1	2.3	1.0	<1	<1
Magnesium	mg/L	20.0	28.3	13.0	22.3	28.0	18.0	20.7	49.7	107.3	25.7	41.5
Potassium	mg/L	<1	4.7	2.0	12.7	6.0	3.0	2.7	9.0	9.3	3.7	7.0
Sodium	mg/L	<1	13.7	1.0	5.0	<1	<1	9.5	56.3	<1	2.0	2.0
Sulfate	mg/L	<1	26.0	<1	24.0	<1	<1	16.5	76.0	64.0	26.0	32.0
Total hardness	mg/L	<1	13.7	1.0	5.0	<1	<1	9.5	51.3	<1	2.0	2.0
Nutrients												
Ammonia	mg/L	<0.01	0.01	<0.01	0.09	-	<0.01	0.05	0.19	0.07	0.02	0.09
Nitrite + nitrate	mg/L	9.36	2.02	0.10	8.19	-	1.49	1.75	4.17	0.38	5.45	0.20
Total Kjeldahl nitrogen	mg/L	<0.01	<0.01	<0.01	<0.01	-	<0.01	<0.01	0.04	0.05	0.01	<0.01

Table 3.11 **Groundwater quality results**

Parameter	Units	DM01	DM02S	DM02D	DMDDH03	DM04	DM05	DM06	DMDDH07	DMDDH09	DMDDH10	DMDDH11
Physicochemical parameters												
Total nitrogen	mg/L	0.30	0.40	<0.01	0.97	-	0.30	0.43	1.17	0.75	0.43	0.85
Reactive phosphorus	mg/L	9.70	2.43	0.10	9.17	-	1.80	2.23	5.33	0.87	5.90	1.05
Total phosphorus	mg/L	<0.01	0.35	<0.01	0.19	-	0.03	0.11	5.17	0.62	0.12	0.34
Dissolved metals (0.45µm filtered)												
Arsenic	mg/L	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001
Barium	mg/L	-	0.02	-	0.03	-	-	0.01	0.04	0.08	0.01	0.03
Beryllium	mg/L	-	<0.001	-	<0.001	-	-	<0.001	<0.001	0.001	<0.001	<0.001
Boron	mg/L	-	<0.05	-	<0.05	-	-	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001
Chromium	mg/L	<0.001	0.001	<0.001	0.002	0.010	0.001	<0.001	0.009	0.002	0.002	<0.001
Cobalt	mg/L	-	0.002	-	0.001	-	-	0.001	<0.001	0.003	0.002	0.001
Copper	mg/L	0.002	0.005	0.001	0.005	0.016	0.015	0.009	0.002	0.004	0.016	0.004
Lead	mg/L	<0.001	<0.001	<0.001	0.001	0.004	<0.001	0.004	<0.001	0.004	0.005	0.001
Manganese	mg/L	-	0.030	-	0.019	-	-	0.031	0.004	0.072	0.023	0.024
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	mg/L	<0.001	0.003	0.002	0.005	0.013	0.016	0.002	0.004	0.003	0.005	0.004
Selenium	mg/L	-	<0.01	-	<0.01	-	-	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	mg/L	-	<0.01	-	<0.01	-	-	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	0.02	0.02	0.06	0.03	0.04	0.10	0.08	0.02	0.04	0.04	0.04

Notes: Average groundwater quality results from up to three sampling event results.

WHST = weathered Hawkesbury Sandstone, HST = Hawkesbury Sandstone, MS = Maroota Sands

TDS = total dissolved solids, Mn = manganese, Total N = total nitrogen, Total P = total phosphorus

* - laboratory results only available

3.7.2 Surface water quality

A summary of the average surface water quality monitoring results is presented in Table 3.12. All monitoring results and laboratory reports are provided in Appendix D. Results that exceed the relevant DGV are highlighted in bold.

Key surface water results are summarised as follows:

- sampled water was generally fresh, with a maximum EC of 768 $\mu\text{S}/\text{cm}$ observed; however, a number of results exceeded the DGV of 300 $\mu\text{S}/\text{cm}$;
- pH was mildly acidic, with all samples below the lower DGV of 6.5;
- nitrogen-based nutrient concentrations were elevated, particularly for ammonia and nitrate which were consistently observed to exceed the relevant DGVs;
- elevated nitrogen concentrations at Dam 3 correlate with groundwater quality results from the shallow aquifer (ie results from DM01, DM02S and DM06) and may be associated with the turf farm located immediately to the north of the site; and
- dissolved metal concentrations were generally below the laboratory LOR, with slight exceedances of the relevant DGVs for cobalt and zinc.

Table 3.12 **Average surface water quality monitoring results**

Parameter	Units	DGV	Dam 1		Dam 1 downstream		Dam 2		Dam 3		Dam 3 downstream		Dam 4	
			Count	Average	Count	Value	Count	Value	Count	Average	Count	Value	Count	Average
Physicochemical parameters														
DO	mg/L		1	2.16	1	3.83	1	5.14	1	2.26	1	5.7	1	1.10
EC	µS/cm	300	3	209	1	166	1	381	3	506	1	260	3	292
pH	pH units	6.5–8.5	3	6.0	1	5.7	1	5.3	3	4.9	1	5.8	3	6.0
TDS	mg/L		3	141	1	124	1	284	3	349	1	196	3	204
Major ions														
Bicarbonate alkalinity	mg/L		3	12	1	13	1	3	3	14	1	31	3	18
Carbonate alkalinity	mg/L		3	<1	1	<1	1	<1	3	<1	1	<1	3	<1
Hydroxide alkalinity	mg/L		3	<1	1	<1	1	<1	3	<1	1	<1	3	<1
Total alkalinity	mg/L		3	12	1	13	1	3	3	14	1	31	3	18
Calcium	mg/L		3	4	1	4	1	15	3	25	1	5	3	10
Chloride	mg/L		3	39	1	32	1	36	3	42	1	42	3	37
Fluoride	mg/L		3	<0.1	1	<0.1	1	<0.1	3	0.1	1	<0.1	3	<0.1
Magnesium	mg/L		3	6	1	4	1	17	3	21	1	10	3	12
Potassium	mg/L		3	2	1	2	1	8	3	9	1	4	3	6
Sodium	mg/L		3	24	1	20	1	23	3	28	1	27	3	24
Sulfate	mg/L		3	17	1	13	1	65	3	81	1	27	3	59
Total hardness	mg/L		3	32	1	26	1	109	3	150	1	54	3	76
Nutrients														
Ammonia	mg N/L	0.02	2	0.12					2	0.05			2	0.14
Nitrate	mg N/L		2	1.82					2	26.9			2	2.04
Nitrite	mg N/L		2	0.02					2	0.02			2	0.02

Table 3.12 **Average surface water quality monitoring results**

Parameter	Units	DGV	Dam 1		Dam 1 downstream		Dam 2		Dam 3		Dam 3 downstream		Dam 4	
			Count	Average	Count	Value	Count	Value	Count	Average	Count	Value	Count	Average
Nitrite + nitrate	mg N/L	0.04	2	1.83					2	26.9			2	2.06
Total Kjeldahl nitrogen	mg N/L		2	0.4					2	3.5			2	0.8
Total nitrogen	mg N/L	0.35	2	2.3					2	30.3			2	2.9
Reactive phosphorus	mg P/L	0.02	2	<0.01					2	<0.01			2	<0.01
Total phosphorus	mg P/L	0.025	2	0.01					2	0.02			2	0.03
Dissolved metals (0.45µm filtered)														
Arsenic	mg/L	0.013	2	<0.001					2	<0.001			2	<0.001
Barium	mg/L		2	0.014					2	0.043			2	0.020
Beryllium	mg/L		2	<0.001					2	<0.001			2	<0.001
Boron	mg/L	0.37	2	<0.05					2	0.06			2	<0.05
Cadmium	mg/L	0.0002	2	<0.0001					2	0.0002			2	<0.0001
Chromium	mg/L	0.001	2	0.001					2	<0.001			2	<0.001
Cobalt	mg/L	0.0014	2	<0.001					2	0.002			2	<0.001
Copper	mg/L	0.0014	2	<0.001					2	<0.001			2	<0.001
Lead	mg/L	0.0034	2	<0.001					2	<0.001			2	<0.001
Manganese	mg/L	1.9	2	0.028					2	0.059			2	0.007
Mercury	mg/L	0.00006	2	<0.0001					2	<0.0001			2	<0.0001
Nickel	mg/L	0.011	2	0.001					2	0.003			2	0.001
Selenium	mg/L	0.005	2	<0.01					2	<0.01			2	<0.01
Vanadium	mg/L	0.006	2	<0.01					2	<0.01			2	<0.01
Zinc	mg/L	0.008 ¹	2	0.005					2	0.074			2	0.015

1. DGV for zinc has been modified for hardness as recommended by Warne et al. (2018) by using the following algorithm: hardness-modified guideline value = toxicity value ÷ (H/30)^{0.85} where the toxicity value is 0.008 mg/L and H = hardness (mg/L). Exceedances of hardness modified guideline values for zinc are shown in bold.

3.8 Conceptual site water model

The conceptual hydrological model includes a descriptive representation of the groundwater systems, surface water systems, flow paths, recharge and discharge mechanisms and the interaction between these various hydrological components and geological units. The conceptual model consolidates the current understanding of the key processes of the groundwater and surface water systems, presented and assists in the understanding of the local environment. The conceptual hydrological model for the site is shown in Figure 3.14 and Figure 3.15.

3.8.1 Groundwater systems

The groundwater regime across the project area is conceptualised as two aquifer systems as presented in the regional Maroota extractive industry groundwater study (EMM 2018). This is based on site specific data and additional data collected by the NSW government departments and private operators across the extraction areas over the last 20 years, but predominantly from the detailed technical studies completed in the late 1990s (Hopkins and Ross 1996 and Salotti et al. 1998) and early 2000s (Russell 2001). The two aquifer systems are:

1. the shallow aquifer is the saturated zone within the base of the Maroota Sand and within the eluvial/weathered Hawkesbury Sandstone unit (at the eastern side of the site); and
2. the deep aquifer is located within the consolidated Hawkesbury Sandstone below the weathered zone and includes the regional water table and all groundwater in the sandstone below it.

3.8.2 Surface water flow

Rainfall onto the land surface is distributed in three main ways:

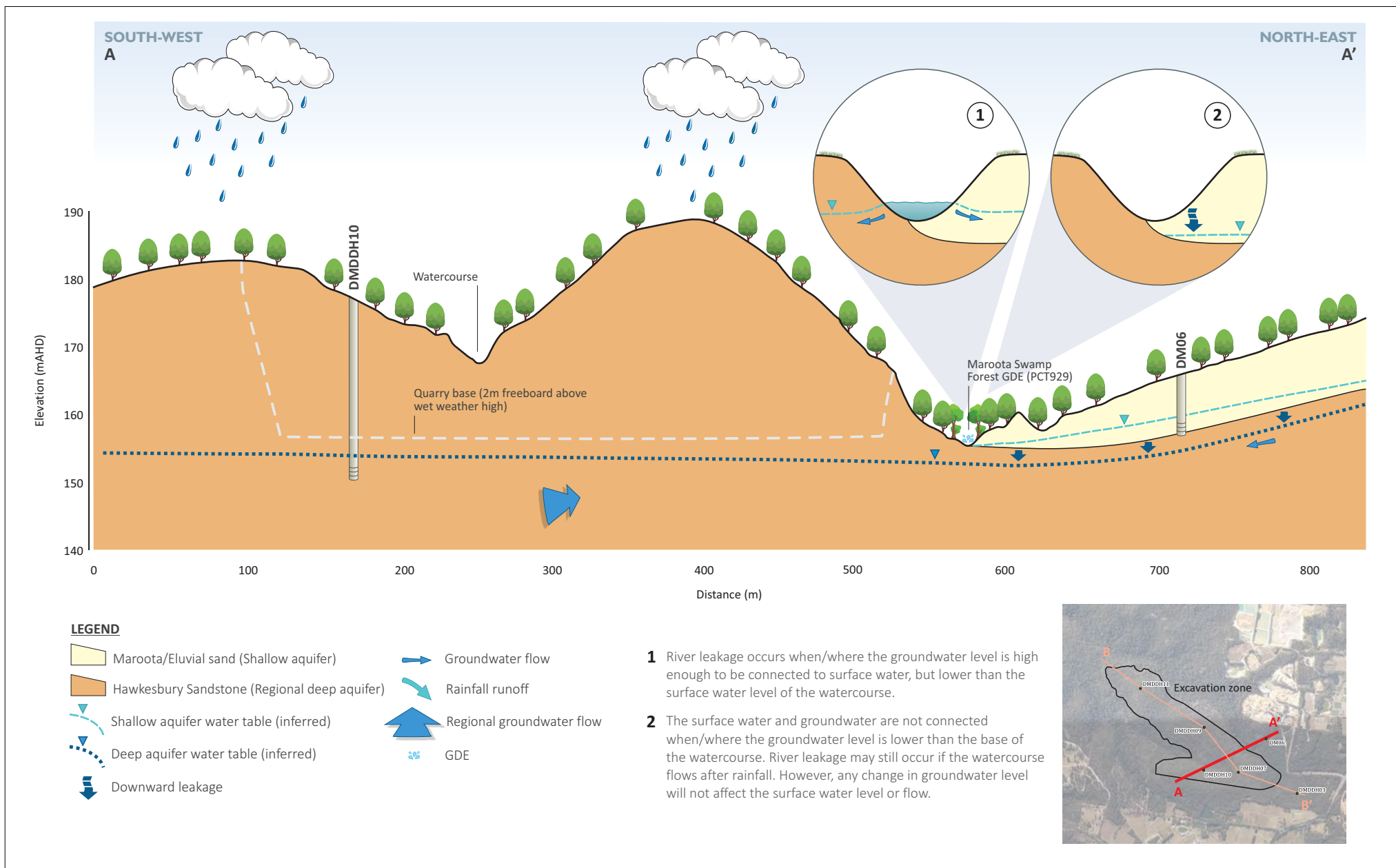
- interception by vegetation, which is then evaporated and transpired into the atmosphere;
- infiltration into the soil, with some recharge to the underlying groundwater system; and
- surface runoff.

3.8.3 Groundwater recharge and discharge

Both the shallow and deep aquifers are recharged via the infiltration of rainfall. The rate of infiltration into the soil is dependent on the rainfall intensity, the initial moisture condition of the soil and the hydraulic characteristics of the soil. Rainfall that exceeds the infiltration capacity of the soil flows overland as surface runoff. The site is considered to have a low to moderate runoff potential, with relatively well drained soils (SLR 2020a).

Aquifer recharge via infiltration across the area is thought to occur primarily through the unconsolidated Maroota Sand/eluvial sand sequence and occasional losses from streams, local dams and quarry pits. Geological logs (Appendix A) show unconsolidated sand to a depth of around 5-8 m east of Watercourse A. The hydrograph of DM06 shows rapid groundwater level rise during rainfall events, indicating rapid infiltration through the sand.

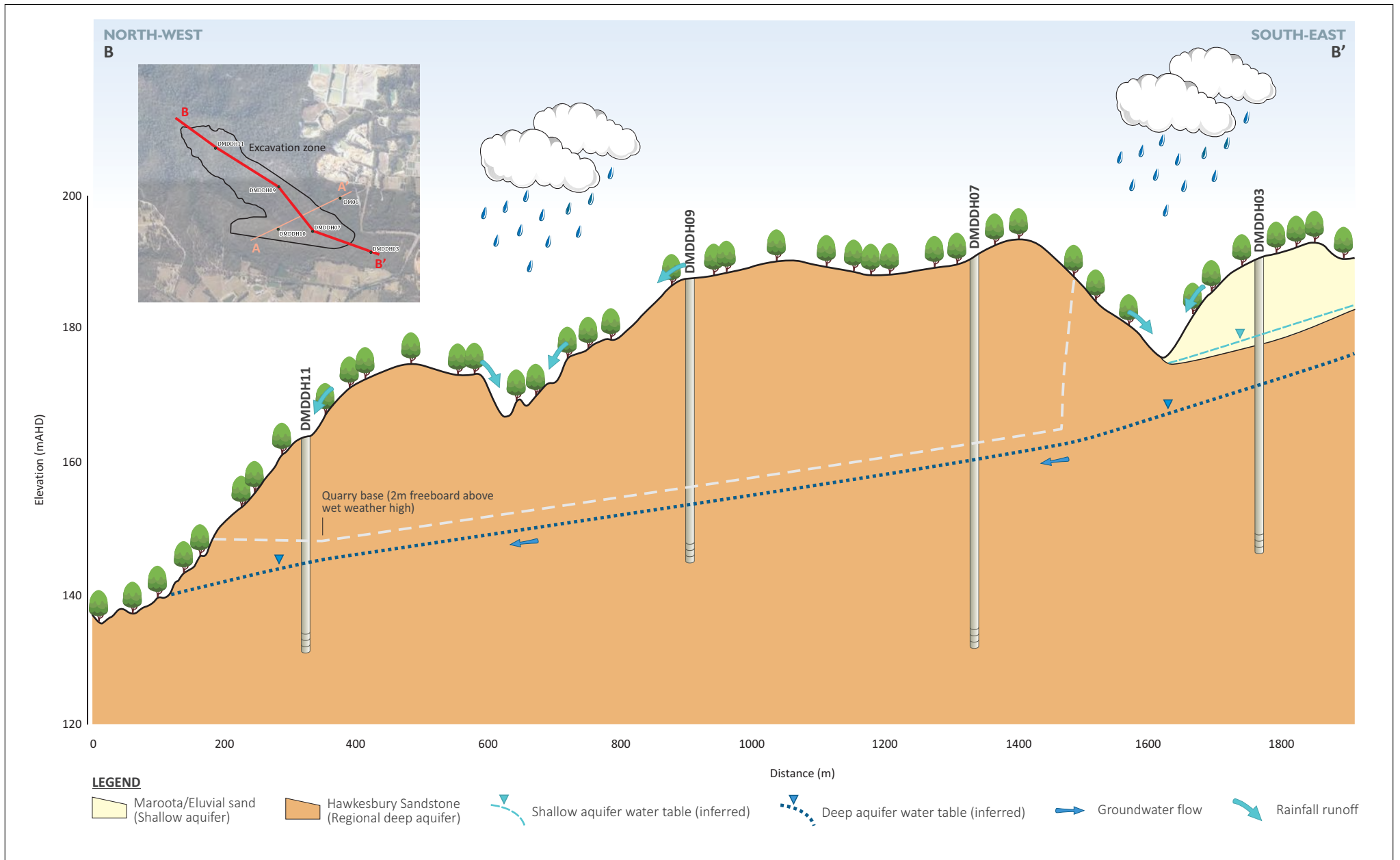
Hawkesbury Sandstone recharge occurs mainly by vertical leakage at the base of the Maroota Sand/eluvial sand sequence and from local rainfall infiltration at outcrop areas. Discharge is likely to primarily occur via evapotranspiration, local groundwater springs, stream baseflow and flow through the aquifer.



Conceptual hydrological model (A-A')

Maroota Sand Quarry
Water Impact Assessment

Figure 3.14



Conceptual hydrological model (B-B')

Maroota Sand Quarry
Water Impact Assessment

Figure 3.15

3.8.4 Surface water-groundwater interaction

Surface water-groundwater interactions occur where aquifers are close to the surface and exchange between surface water and groundwater occurs. The direction of water flow is in constant flux with groundwater either entering the surface water as baseflow contributions (gaining system) or surface water can be recharging shallow groundwater system along topographical low areas (losing system).

Across the project area, the surface water interaction is mostly with the shallow aquifer, during and after periods of rain when shallow aquifer water levels rise beneath Watercourse A.

During site field investigations, the shallow aquifer water table was observed near surface at one location along Watercourse A, near the western extend of the mapped Maroota sands as shown on Figure 3.16. As shown on Photograph 3.1, the surface was cut away with shallow groundwater visually seen to be discharging through the soil. The depth to water was observed at approximately 0.5–1 mbgl. This discharge feature is most likely associated with the shallow aquifer.

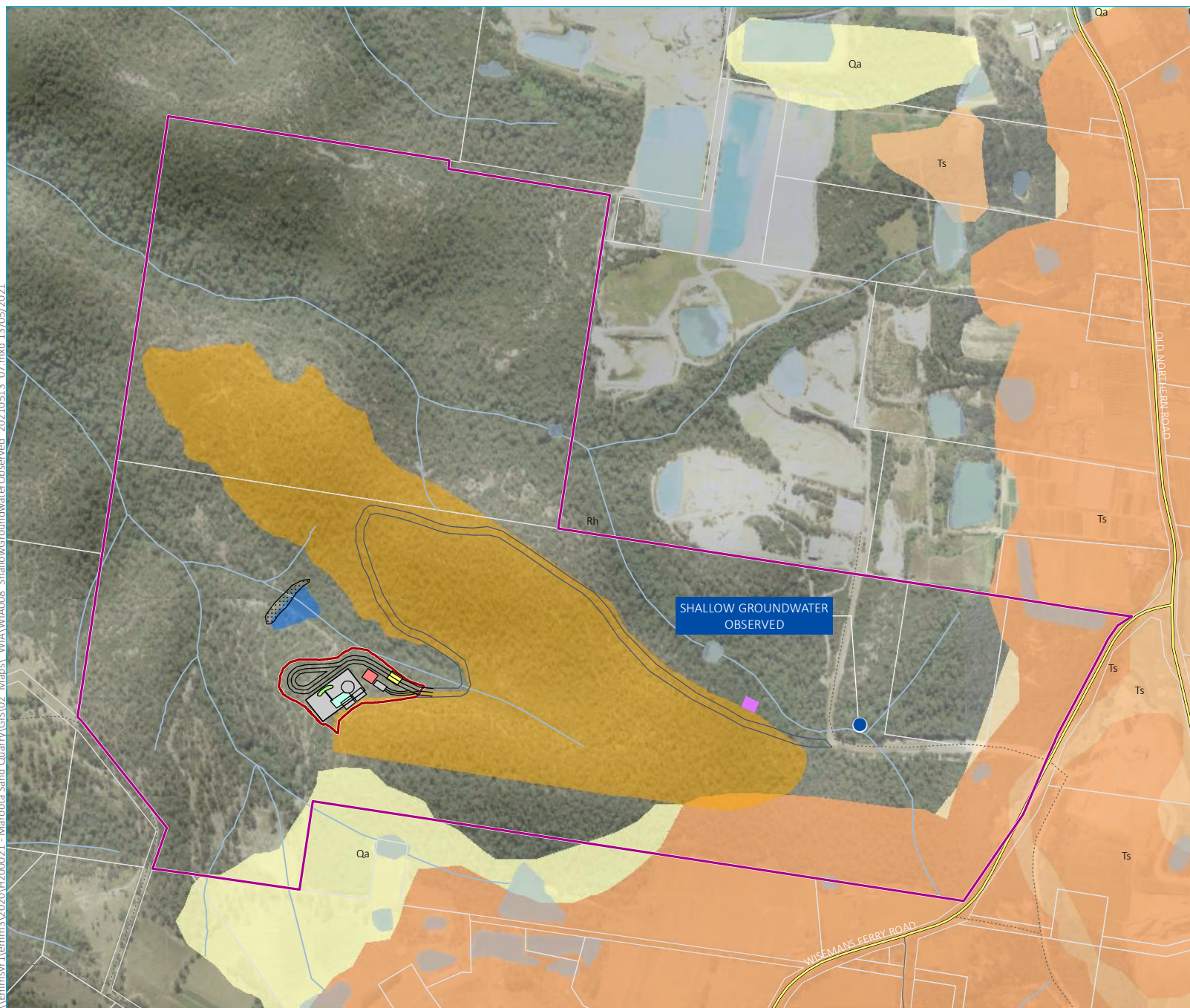
The existing Dam 1 (Figure 3.13), located at the eastern boundary was observed to be cut into the ground and likely intercepts the shallow groundwater below the watercourse. This would maintain baseflow and levels in the dam.

The conceptual understanding for most of the site is that surface water is in connection with the shallow aquifer during times of surface water flow in the Watercourse A and immediately after. Watercourse A is conceptualised to be a gaining stream during time of surface water flow as the water table rises and intercepts the watercourse. The interaction becomes disconnected when surface water flow has ceased and the water table drops below the watercourse base, as shown conceptually on Figure 3.14. The shallow aquifer water table is expected to range from 0–2 m below the watercourse base depending on location and timing of rainfall events. These observations and interactions have been incorporated into the composite site groundwater surface by assigning a depth to water as 0 m along Watercourse A, which on the eastern perimeter of the extraction area.



Photograph 3.1 Shallow groundwater near surface

\\Emmsvr1\emms3\2020\H200021 - Maroota Sand Quarry\GIS\02 Maps\ WIA\WIA008 ShallowGroundwaterObserved 20210513 07.mxd 13/05/2021



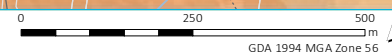
- KEY**
- Shallow groundwater observed
 - Site boundary
 - Major road
 - Minor road
 - Vehicular track
 - Watercourse/drainage line
 - Waterbody
 - Cadastral boundary
 - Surface geology
 - Quaternary
 - Undifferentiated (Qa)
 - Tertiary
 - Maroota Sand - clay and silty clay (Ts)
 - Maroota Sand - clayey gravel, gravelly sand, clayey sand, pebbly sand and sand (Ts)
 - Proposed quarry layout
 - Site infrastructure
 - Site infrastructure
 - Entry building
 - Offices and carpark
 - Processing plant
 - Weighbridge
 - Product stockpile
 - Cut/fill extent
 - Haul road
 - Dam embankment
 - Dam
 - Excavation zone

Locations of observed shallow groundwater near surface

Maroota Sand Quarry
Water impact assessment
Figure 3.16



Source: EMM (2021); DFSI (2017)

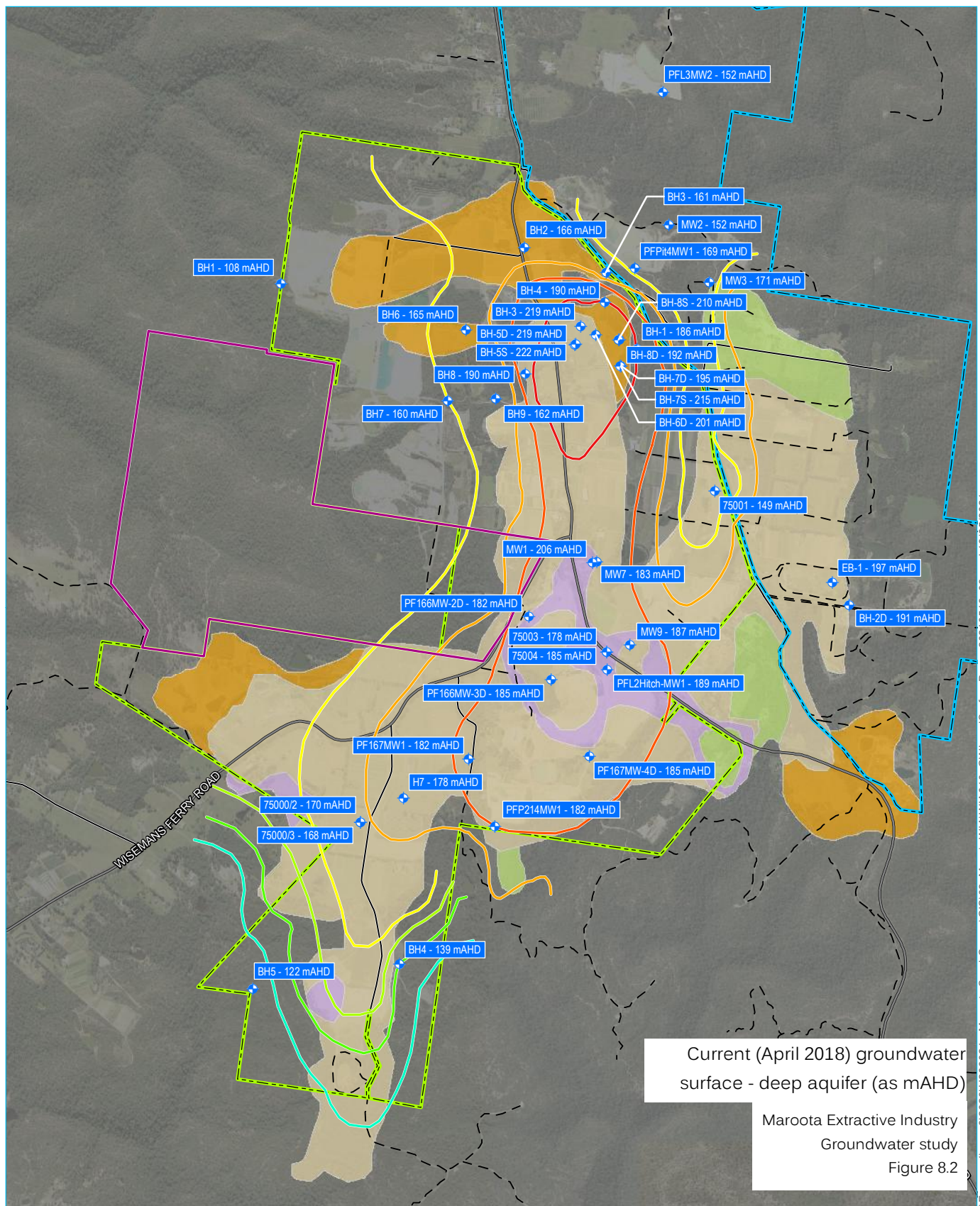


3.8.5 Groundwater flow

The two aquifer systems (shallow and deep) vary in the flow dynamics. Groundwater flow in the shallow (Maroota Sand/eluvial sand) aquifer radiates outward from the elevated centre of the Maroota area, with vertical flow extending only to the top of the underlying, Hawkesbury Sandstone. Lateral groundwater flow occurs at the base of the Maroota and eluvial sands with spring discharge at the edges of the geological extent.

Groundwater flow in the deep aquifer follows a muted reflection of topography, flowing west from the elevated ridge of the proposed extraction area to the gullies below. Where the topographic relief is steep and is incised by massive cliff faces and/or watercourses, regional groundwater may discharge at the surface as springs. Regionally, groundwater flow is towards the west, north and east directions, away from the main surface divide and consistent with topography. The regional deep aquifer groundwater hydraulic head contours are shown on Figure 3.17 (EMM 2018), and show heads declining away from the central Maroota area from an elevation of around 190 m AHD towards the Hawkesbury River at around 3 m AHD.

Locally, across the project area, the groundwater hydraulic head contours based on the mid 2020 water level data for the deep aquifer show that contours are in line with the regional levels. Hydraulic heads are influenced by local topography and continue to decline to the west towards the Hawkesbury River. The local groundwater head contours are shown in Figure 3.18.



KEY

- Site boundary
- SREP9-2 area within The Hills LGA
- SREP9-2 area within Hornsby LGA
- Main road
- Local road
- Vehicular track
- Monitoring bore - deep aquifer

Deep aquifer surface level (m AHD)

- 130
- 140
- 150
- 160
- 170
- 180
- 190

Surface geology

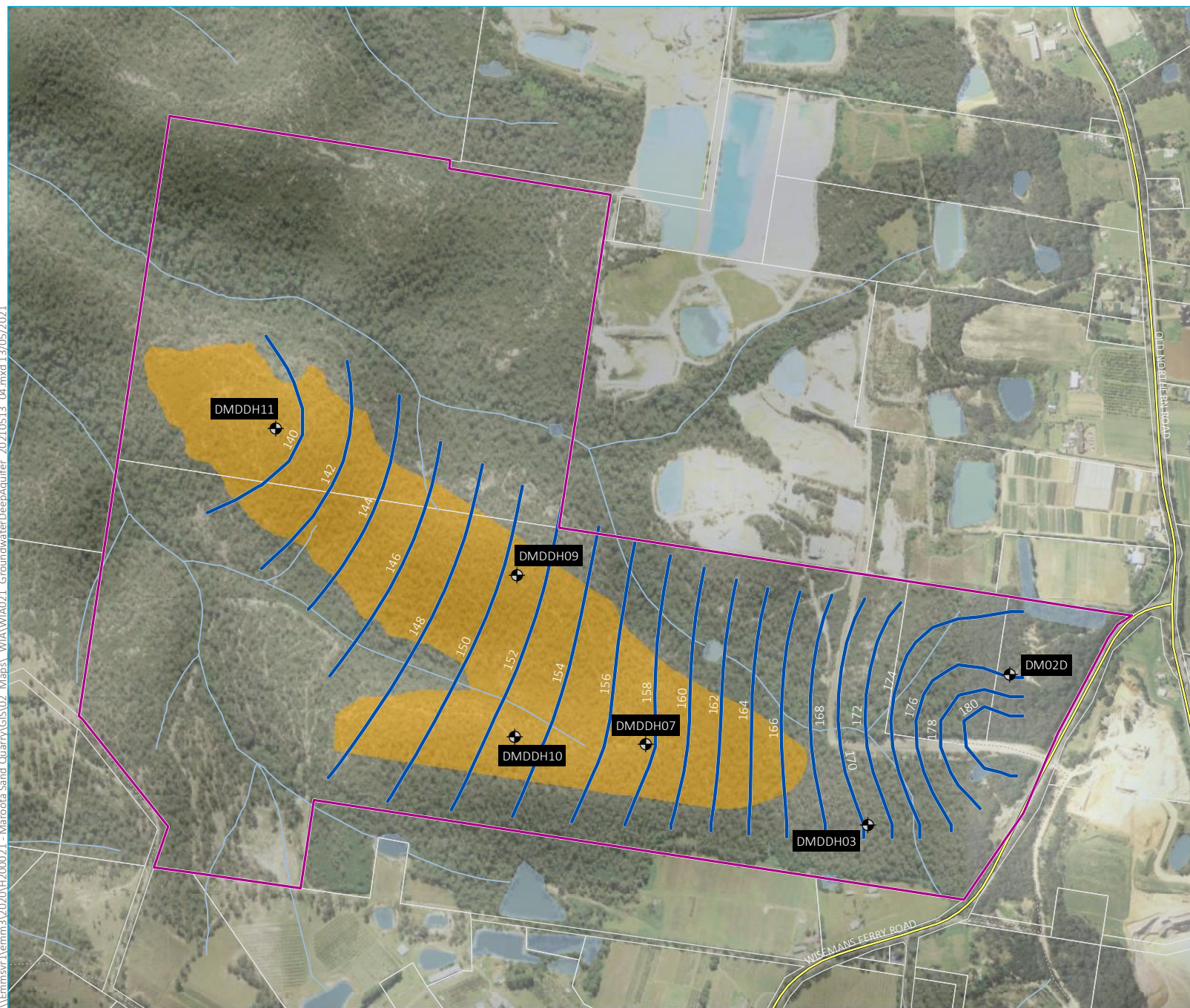
- Holocene
 - Eluvial sand
- Tertiary
 - Maroota Sand - clayey gravel, gravelly sand, clayey sand, pebbly sand and sand
 - Maroota Sand - clay and silty clay
 - Maroota Sand - ferruginised sand and silty clay

Groundwater surface deep Hawkesbury Sandstone aquifer

Maroota Sand Quarry
Water impact assessment
Figure 3.17



\\Emmsvr1\emms3\2020\H200021 - Maroota Sand Quarry\GIS\02 Maps\ WIA\WIA021 GroundwaterDeepAquifer 20210513 04.mxd 13/05/2021



- KEY**
- Monitoring bore location
 - Deep aquifer groundwater elevation (EMM 2020) (mAH)
 - Site boundary
 - Excavation zone
 - Major road
 - Minor road
 - Vehicular track
 - Watercourse/drainage line
 - Waterbody
 - Cadastral boundary

Deep aquifer groundwater elevation
(2020)

Maroota Sand Quarry
Water impact assessment
Figure 3.18



Source: EMM (2021); DFSI (2017)

0 250 500
m
GDA 1994 MGA Zone 56

4 Assessment approach

The aim of the impact assessment is to identify the potential impacts on the existing groundwater and surface water resources due to the quarry development. Management measures are proposed to mitigate identified potential impacts.

The National Water Commission mining risk framework (Moran et al. 2010) has been adopted for the water assessment. The framework applies a source-receptor-pathway analysis that describes how water-affecting activities might impact on sensitive water receptors. For an effect to occur to a sensitive water receptor, an exposure pathway must exist between a water-affecting activity and a receptor. Risks are characterised by making an informed decision as to the potential for adverse effects to arise to sensitive water receptors because of quarry-related activities.

The impact assessment identifies the risk from water-affecting activities and involves assessing the actual consequences arising from the water-affecting activities in terms of direct effects (altered water resource condition) and possible receptor response (such as reduced water access for other users).

4.1 Direct effects

Direct effects are changes to physical and/or quality aspects of groundwater and surface water, or changes to the physical characteristics of water resources because of an activity or change to the existing environment. Examples include changes in water levels, changes in water quality or changes in hydraulic properties of aquifers (Moran et al. 2010). The direct affecting activities identified at Maroota, before any management strategies are put in place are summarised in Table 4.1. A summary of the proposed management measures and residual impacts associated with each effect is provided in Chapter 6.

Table 4.1 Direct water-affecting activities

Impact	Water affecting activity	Potential effect
Water quantity		
Groundwater	Abstraction of groundwater for quarry water supply	• Causes aquifer drawdown
	Excavation of the quarry pit below groundwater surface	• Causes aquifer drawdown. • Can result in the need to discharge to surface water sources due to a requirement to dewater the quarry
Surface water	Disturbance of the existing landscape and the establishment of surface water management controls (ie dams)	• Changes to hydrologic regimes in downstream watercourses
	Quarry pit development leads to changes to catchment areas	• Changes to hydrologic regimes in downstream watercourses
Water quality		
Surface water	Overflows from the water management system	• Changes to the existing water quality regimes in downstream watercourses • The discharge of sediment-laden water can also result in sedimentation impacts

4.2 Indirect effects

Indirect effects of water-affecting activities are those that arise in response to direct effects and typically relate to the potential for impact on sensitive receptors. The indirect effects of the water-affecting activities before any management strategies are put in place are summarised in Table 4.2. A summary of the proposed management measures and residual impacts associated with each effect is provided in Chapter 6.

Table 4.2 Indirect water effects

Impact	Water affecting activity	Potential effect
Impacts to 3 rd party groundwater users.	Abstraction of groundwater for quarry water supply	• Reduction in available water due to groundwater drawdown.
Impacts to 3 rd party surface water users	Disturbance of the existing landscape and the establishment of surface water management controls (ie dams)	• Reduction in available water due to changes in surface water flow regimes.
Impacts to Maroota Sands Swamp Forest GDE	Abstraction of groundwater for quarry water supply	• Reduction in available water due to groundwater drawdown.

5 Water management

This chapter describes the proposed water management system and is structured as follows:

- Section 5.1 introduces terminology used to describe various water categories;
- Section 5.2 describes the water management strategy;
- Section 5.3 documents water balance model results;
- Section 5.4 describes the proposed groundwater supply system in further detail; and
- Section 5.5 outlines proposed monitoring and adaptive management measures.

Residual impacts are discussed separately in Chapter 6.

5.1 Definitions

Surface water and groundwater described in this report has been categorised as follows based on water quality and intended use:

- clean water – surface water runoff from undisturbed or fully rehabilitated catchments;
- dirty water – surface water runoff from disturbed areas, such as the quarry pit, haul road and site infrastructure area, which is likely to contain suspended sediment;
- process water – water that has been used within the sand processing plant;
- groundwater – water removed from below the ground level, either directly via a pumping bore or passive interception at the surface; and
- wastewater – water produced by on-site amenities (ie sewage).

5.2 Water management strategy

5.2.1 Objectives

Table 5.1 describes the water management objectives and approaches that have been applied to establish the proposed water management system.

Table 5.1 Water management objectives and approach

Water management objectives	Approach
1 Avoid aquifer interception.	The pit floor will maintain a 2 m buffer above the wet-weather high regional water table.
2 Provide surface water controls that are consistent with industry best practice.	- Where practical, clean water will be diverted around disturbed areas. - Dirty water runoff will be managed by erosion and sediment controls that will be designed, constructed and maintained in accordance with the methods recommended in <i>Managing Urban Stormwater: Volume 1</i> (Landcom 2004) and <i>Volume 2E</i> (DECC 2008). - Process water will be managed in a closed loop system that will not discharge into either the dirty water system or offsite. - Water captured in the water management dam will be beneficially used for sand processing and dust suppression to reduce overflow volumes. - Chemical and hydrocarbon products will be stored in bunded areas in accordance with relevant Australian Standard AS1940:2004 and guidelines in Section 2.3.5.
3 Apply water efficiency measures to minimise water use	- The sand processing plant will include a filter and plate press system to maximise water recovery and minimise system losses. - Groundwater will be extracted as needed to minimise losses associated with storage.
4 Establish a secure non-rainfall dependant source of water	A groundwater supply system that can meet the full project water demand will be established as a non-rainfall dependant water source.

5.2.2 Water management system overview

This section presents the following figures that describe the layout and functionality of the proposed water management system:

- Figure 5.1 presents a conceptual schematic of the proposed water management system that shows the system functionality.
- Figure 5.2 to Figure 5.4 show the layout of proposed water management system for quarry years 1, 10 and 28 (final year of quarrying) respectively. Each figure shows the catchment extents, the alignment of major drains, site discharge locations and the location of the water management dam and other infrastructure.
- Table 5.2 provides a break-down of the catchment areas for each quarry year.

Key aspects of the water management system is described in further detail in Sections 5.2.3 to 5.2.8.

Table 5.2 Water management area

Catchment	Quarry stage		
	Year 1	Year 10	Year 28
Clean catchment/vegetation	19.1 ha	20.5 ha	12.5 ha
Landform/rehabilitation	0.1 ha	4.5 ha	16.8 ha
Quarry pit	2.7 ha	12.1 ha	29.1 ha

Table 5.2 Water management area

Catchment	Quarry stage		
	Year 1	Year 10	Year 28
Site infrastructure area	2.4 ha	2.4 ha	0.6 ha
Total water management area	24.3 ha	39.5 ha	59.0 ha

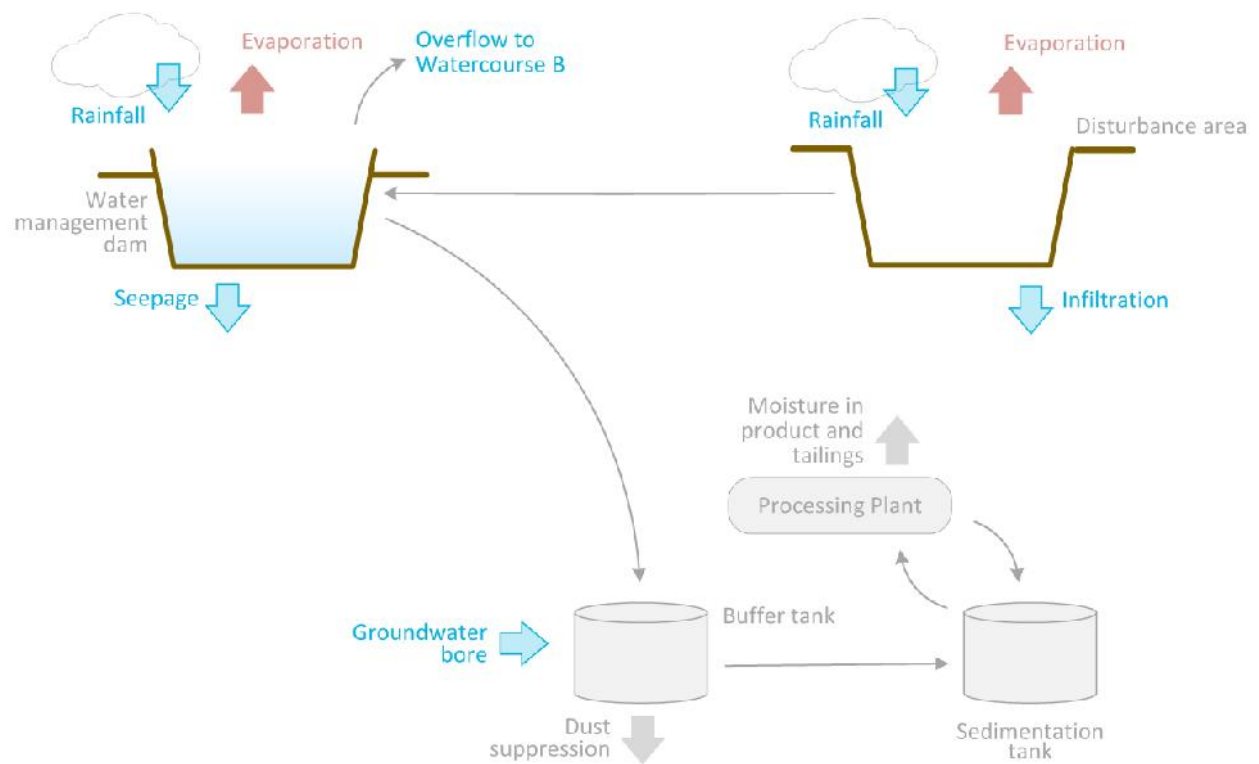
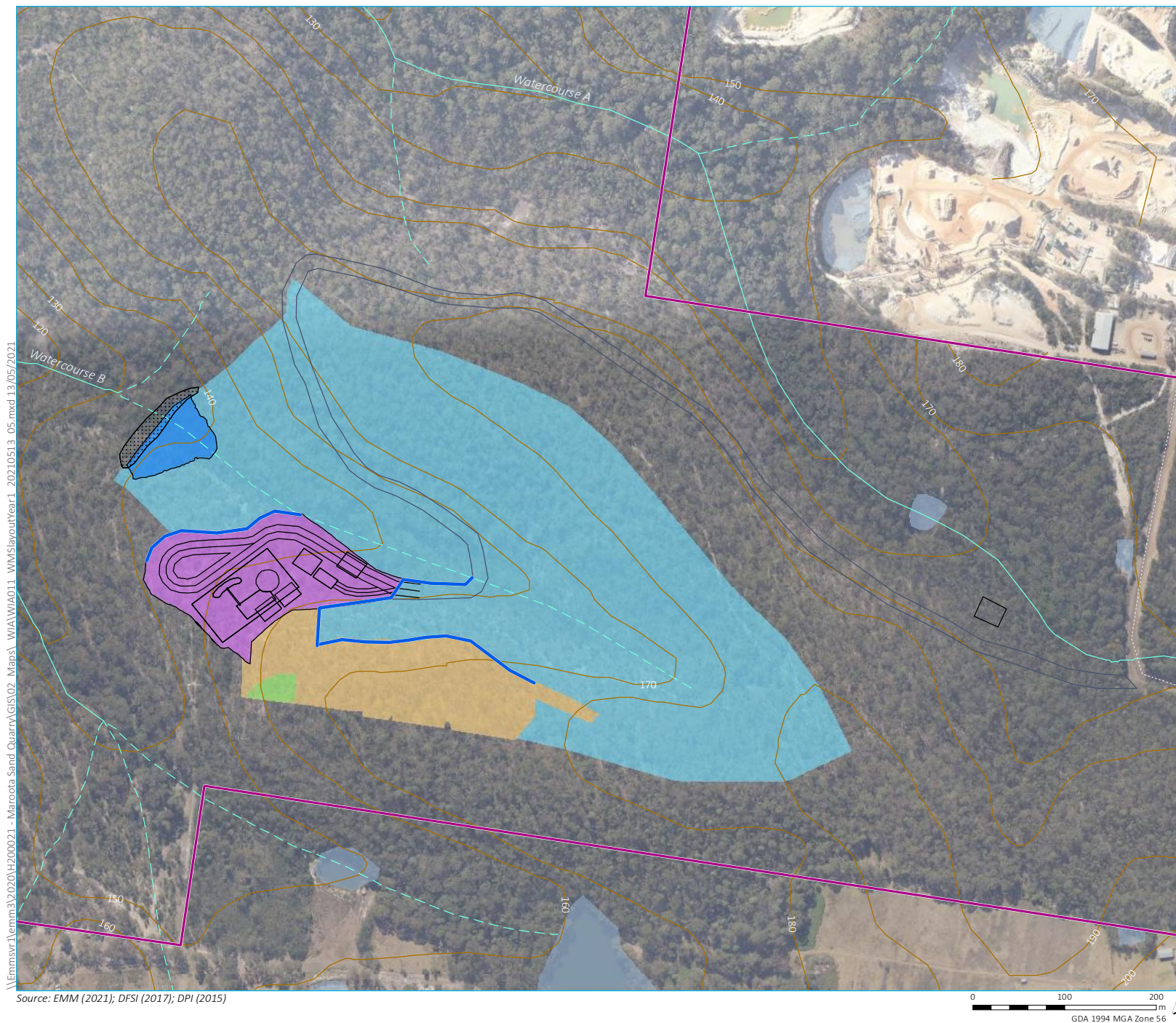


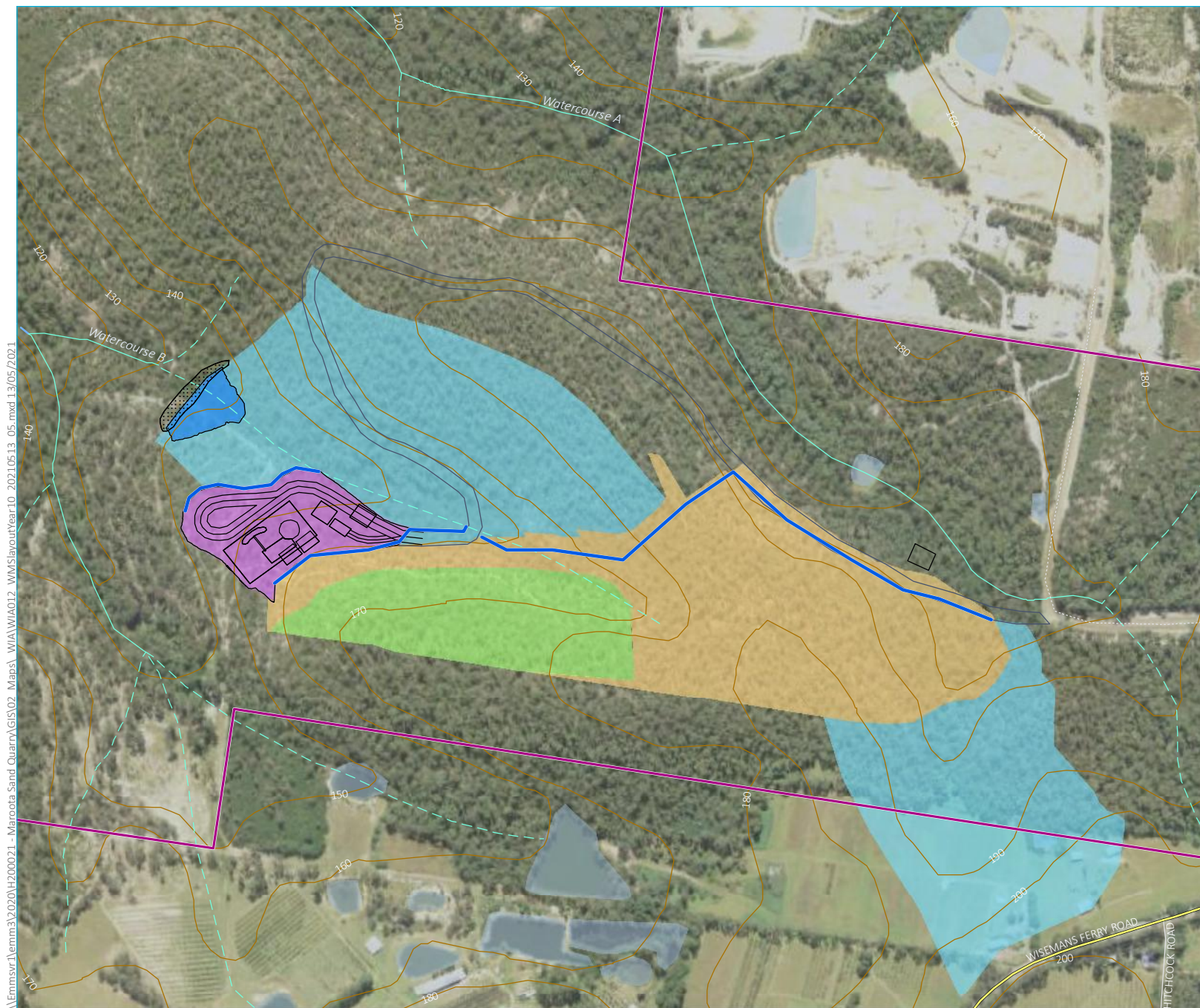
Figure 5.1 Water management strategy



- KEY**
- Site boundary
 - Vehicular track
 - Contour (10 m interval)
 - Waterbody
 - Strahler stream order
 - 1st order
 - 2nd order
 - Water management system layout - year 1
 - Dirty water drainage
 - Project catchments
 - Clean water catchment
 - Landform/rehabilitation
 - Dirty water management areas
 - Quarry pit
 - Site infrastructure area
 - Haul road
 - Proposed quarry layout
 - Site infrastructure
 - Dam embankment
 - Water management dam

Water management system layout
Year 1

Maroota Sand Quarry
Water impact assessment
Figure 5.2



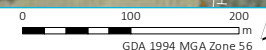
- KEY**
- Site boundary
 - Major road
 - Minor road
 - Vehicular track
 - Contour (10 m interval)
 - Waterbody
 - Strahler stream order
 - 1st order
 - 2nd order
 - 3rd order
 - Water management system layout - year 10
 - Dirty water drainage
 - Project catchments
 - Clean water catchment
 - Landform/rehabilitation
 - Dirty water management areas
 - Quarry pit
 - Site infrastructure area
 - Haul road
 - Proposed quarry layout
 - Site infrastructure
 - Dam embankment
 - Water management dam

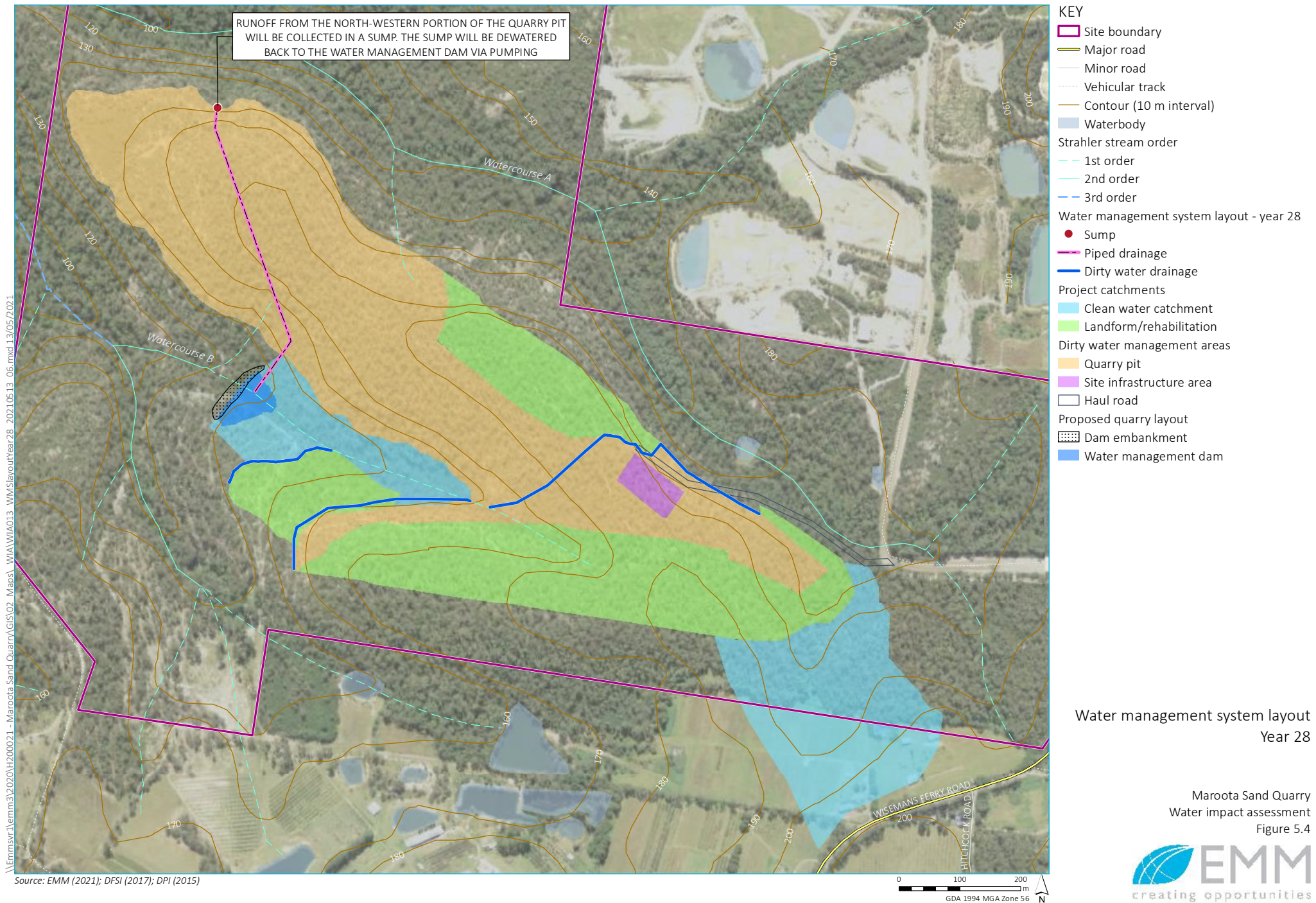
Water management system layout
Year 10

Maroota Sand Quarry
Water impact assessment
Figure 5.3



Source: EMM (2021); DFSI (2017); DPI (2015)





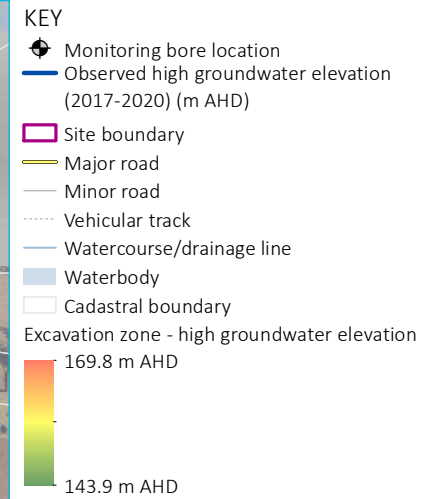
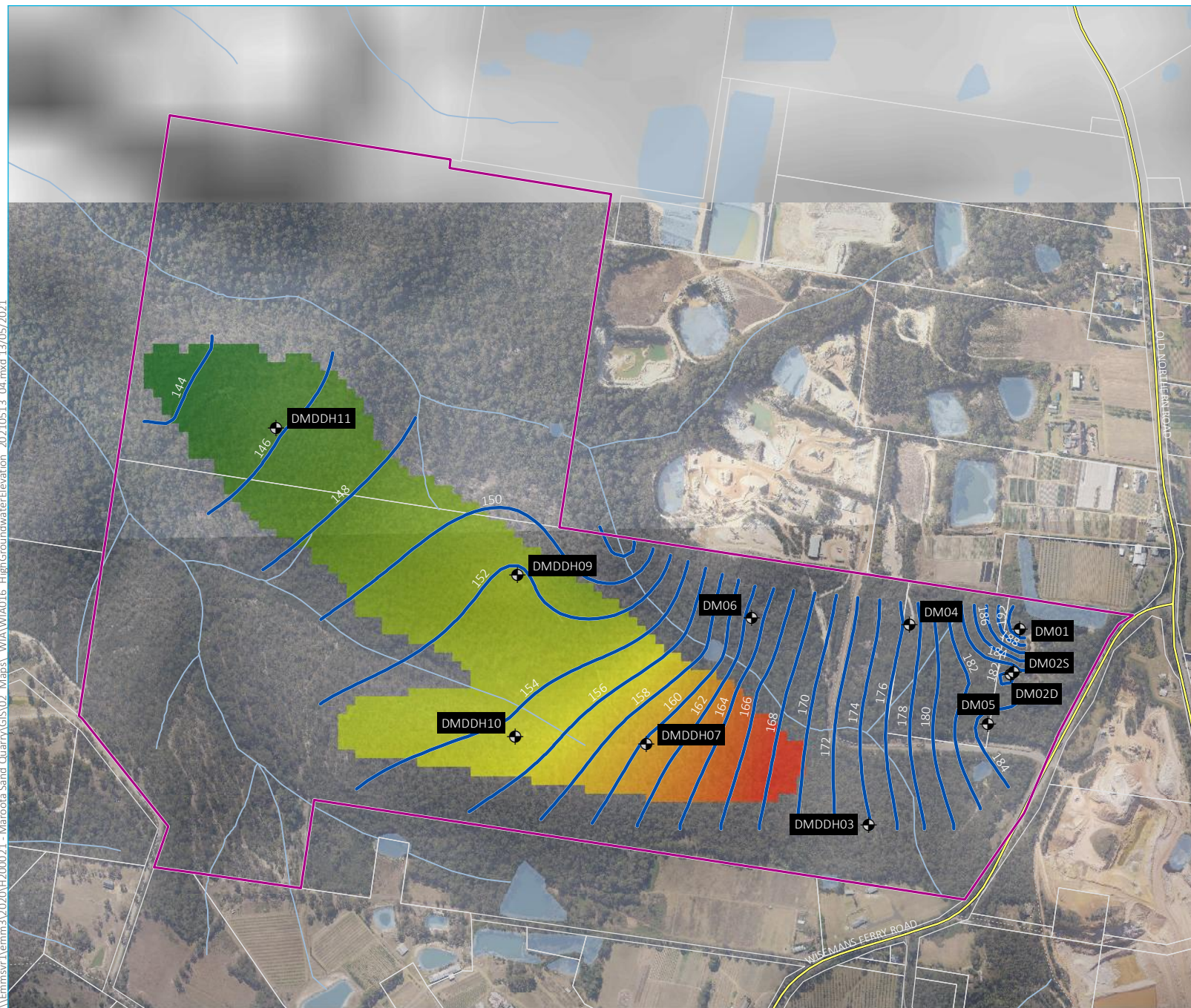
5.2.3 Quarry extraction level

The management strategy to avoid aquifer interception is to limit the extraction depth to 2 m above the observed wet-weather high water table. This objective was applied to the quarry design using available groundwater level data from the 2017–2020 period (Section 3.6.3). A composite wet-weather high groundwater elevation surface includes data from monitoring bores screened in the shallow aquifer (Maroota sand and eluvial sand) and monitoring bores in the deep aquifer (Hawkesbury Sandstone). The groundwater surface was developed using:

- the highest observed groundwater level at each monitoring bore during the 2017–2020 period; and
- accounting for surface water/groundwater interactions – along watercourse A and therefore assuming a 0 m depth to groundwater along the watercourse (see Section 3.8.4).

The quarry extraction depth limit was calculated by adding a 2 m buffer to the composite groundwater elevation surface. The composite groundwater elevation is shown on Figure 5.5. The maximum extraction elevations are presented on Figure 5.6 (extraction elevation limit).

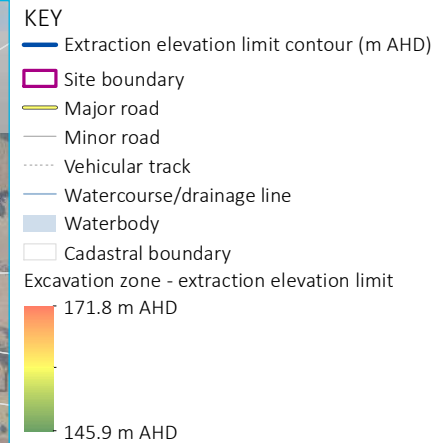
\\Emmsvr1\emms3\2020\H2000021 - Maroota Sand Quarry\GIS\02 Maps\ WIA\WIA016 HighGroundwaterElevation 20210513 04.mxd 13/05/2021



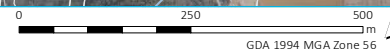
Observed high groundwater elevation (2017-2020)

Maroota Sand Quarry
Water impact assessment
Figure 5.5

\\Emmsvr1\emms3\2020\H200021 - Maroota Sand Quarry\GIS\02 Maps\ WIA\WIA017 ExtractionElevationLimit 20210513 03.mxd 13/05/2021



Source: EMM (2021); DFSI (2017)



Extraction elevation limit

Maroota Sand Quarry
Water impact assessment
Figure 5.6



5.2.4 Dirty water management

All runoff from disturbed areas of the quarry (ie haul roads, the infrastructure area and quarry pit) will be managed in accordance with the methods recommended in *Managing Urban Stormwater: Volume 1* (Landcom 2004) and *Volume 2E* (DECC 2008). The preferred approach is to convey all dirty water runoff to a water management dam located on Watercourse B. This will primarily be achieved using gravity drains. However, as noted in Figure 5.4, runoff from the western portion of the extraction area will be collected in a sump and pumped into the dam. Some runoff from clean water catchment areas will also unavoidably be captured in this dam. The location and extent of the dam and contributing catchment areas are shown in Figure 5.2 to Figure 5.4 for various stages of the project. The dam location and footprint is conceptual and may be adjusted at detailed design.

The water management dam will be designed and constructed in accordance with the methods in *Managing Urban Stormwater: Volume 1* (Landcom 2004) and *Volume 2E* (DECC 2008). The primary function of the dam will be to capture dirty water runoff for future onsite use. When the dam fills, it will overflow into Watercourse B. When overflowing the dam will provide sedimentation treatment, significantly reducing coarse and fine sediment suspended sediment loads in any overflows.

The dam has a minimum conceptual design volume of 15.3 ML, that was calculated using the methods in *Managing Urban Stormwater: Volume 1* (Landcom 2004) and *Volume 2E* (DECC 2008). The following assumptions were applied:

- type D/F sediment basin with sediment zone volume equal to 30% of the settling zone capacity;
- 90th percentile, five-day rainfall depth of 46.7 mm for Wilberforce (Table 6.3; Landcom 2004);
- volumetric runoff coefficient (Cv) of 0.42 for soil hydrologic group B soils with low to moderate runoff potential (Table F2; Landcom 2004); and
- catchment area of 59 ha, based on the maximum water management area that will occur in quarry year 28 (see Table 5.2).

The dam volume will be adjusted at detailed design to accommodate any changes to the water management area.

The dam will be designed and constructed to industry best practice standards to minimise risks and impacts and will include an appropriate spillway and scour protection.

5.2.5 Sand processing plant

The sand processing plant is estimated to use 70 m³/hour of water to wash the excavated material. Following washing, the water/tailings mixture will be directed to a sedimentation tank. A slurry mixture containing concentrated fine material will be pumped from the bottom of the sedimentation tank and will be dewatered using a plate and frame press to produce tailings that will be combined with overburden and other waste rock into site rehabilitation material. Clarified water from the sedimentation tank and water recovered from the plate and frame press will be recirculated to the plant. This process will recover most of the gross water use. Notwithstanding, water losses will occur due to moisture contained in the washed product and tailing. As a result, the sand processing system will require approximately 37.5 ML/year of top-up water. Top-up water will be preferentially sourced from the water management dam (when available) or from groundwater when the water management dam is empty.

No water from the sand processing system will be discharged to the water management dam, which will occasionally overflow when surface water runoff inflows exceed the dam volume.

5.2.6 Project water supply

Project water demand is estimated to be 47 ML/year, comprising of 37.5 ML/year for the sand processing system top-up and 10 ML/year for dust suppression. Water will be preferentially sourced from the water management dam when water is available. A groundwater supply system that can meet the full project water demand will be established as a non-rainfall dependant water source. The groundwater supply system is described further in Section 5.4.

5.2.7 Potable and wastewater

As the project site is not connected to a municipal water supply, drinking water and amenities requirements will be purchased offsite and trucked to the site. Wastewater will be treated in an aerated wastewater treatment system and disposed via irrigation near the infrastructure area.

5.2.8 Fuel storage

A 15,000 L diesel fuel storage tank will be installed in the site infrastructure area. The tank will be a bunded system that meets the requirements of NSW government guidelines (refer Section 2.3.5) and Australian Standard AS1940:2004. Refuelling of plant and equipment will occur within designated bunded areas. Emergency spill response kits will be provided at all refuelling areas.

5.2.9 Rehabilitation strategy

The surface water management concepts described in this chapter have been prepared with consideration of the Rehabilitation Strategy (SLR 2020b). In particular the concepts make allowance for the management of runoff from areas that will be progressively rehabilitated, meaning that no additional surface water management controls are required for areas where rehabilitation is being established.

5.3 Water balance

A water balance model was developed for the proposed water management system. The objectives of the modelling were to estimate:

- volume of water captured by the water management system available for project water use;
- volume of groundwater extraction required to supply water when the water management dam is empty; and
- overflow regimes and volumes from the water management system.

5.3.1 Modelling method

The water balance model was developed in GoldSim version 12.1. The model applies a continuous simulation method that assesses the performance of the modelled water management system under a range of rainfall and evaporation sequences. The model was created by representing the water cycle as a series of elements, each containing pre-set rules and data, that were linked together to simulate the interaction of these elements.

The following aspects of the water management system are represented in the model:

- direct rainfall and evaporation and seepage losses from the water management dam;
- runoff from contributing catchments as a result of rainfall;

- project water uses (ie dust suppression and sand processing plant top-up);
- water management system overflows; and
- groundwater extraction.

5.3.2 Data

i Climatic data

A 50 year simulation period was adopted for the water balance model using historical daily rainfall and evaporation data from the Maroota (Old Telegraph) Station (BOM station 67014) between 1970 and 2020 obtained from SILO, as discussed in Section 3.2.

ii Surface runoff

Surface runoff was estimated using the Australian water balance model (AWBM). The AWBM was developed by Boughton (2004) and is widely used across Australia to estimate runoff. The hydrological model calculates runoff and baseflow components from rainfall after allowing for relevant losses and storage. The AWBM was incorporated into the GoldSim water balance model for the site.

For runoff from vegetated land and the quarry pit, the AWBM was parameterised to achieve long-term average volumetric runoff for group B soil hydrologic group specified by Landcom (2004). Runoff from the site infrastructure area was based on an impervious surface with 5 mm of initial loss.

iii Project water demands

Project water demands are estimated to be 47 ML/year, comprising of 37.5 ML/year for the sand processing system top-up and 10 ML/year for dust suppression on average. These demands were applied at an average daily rate. The water balance model was configured to preferentially source water from the water management dam when water is available and from the groundwater supply system when there is no water available in the water management dam.

iv Water management dam

The water management dam was simulated as a 15.3 ML storage. However, only the upper 11.6 ML was assumed to be available for project water supply as the lower portion of the dam is reserved for sediment storage. Evaporation losses were calculated as a function of the daily pan evaporation rate and dam surface area and seepage losses were calculated as a function of the dam volume assuming a nominal rate. Overflows from the dam are simulated when the stored water volume exceeds 15.3 ML.

5.3.3 Results

The distribution of water across the site estimated by the water balance model for years 1, 10 and 28 of the quarry are presented in Figure 5.7, Figure 5.8 and Figure 5.9 respectively. Results are presented for the average, 10th and 90th percentile values to indicate the likely range of water fluxes due to rainfall variability. Note the 10th and 90th percentile values do not necessarily correspond to the same rainfall series (ie they do not represent a “dry” or “wet” year).

Table 5.3 provides an overview of the average inputs and outputs of the water management system for years 1, 10 and 28 of the quarry.

The results in Table 5.3 show that under average conditions, the largest inflow of water to the water management system is direct rainfall and catchment runoff. There is an increase in runoff captured as the quarry progresses and the water management area increases.

Model results indicate that the water management dam will supply between 57 and 69% of project water requirements during average conditions, with groundwater supplying the balance (31 to 43%). However, the groundwater supply system will provide close to 100% of water requirements during dry conditions.

Evaporation, dust suppression and dam seepage are expected to remain relatively constant between the stages of the quarry. The moisture retained in product sand and tailings is expected to increase from 22.5 ML/year in year 1 of the quarry to 37.5 ML/year for the following years based on the extraction schedule. Off-site discharges due to overflows from the water management dam are expected to increase as the quarry progresses and the water management area increases.

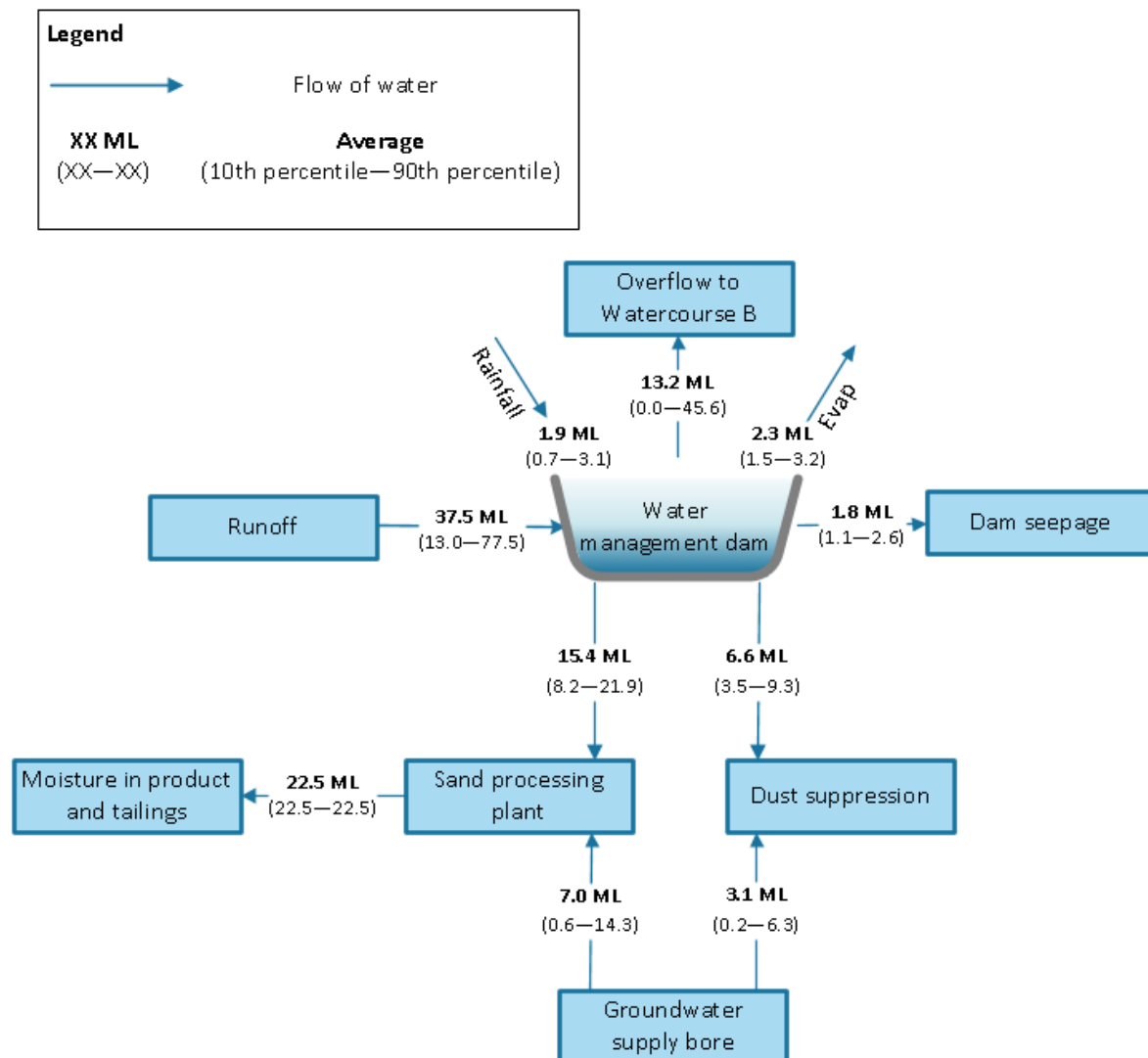


Figure 5.7 **Water balance results – Year 1**

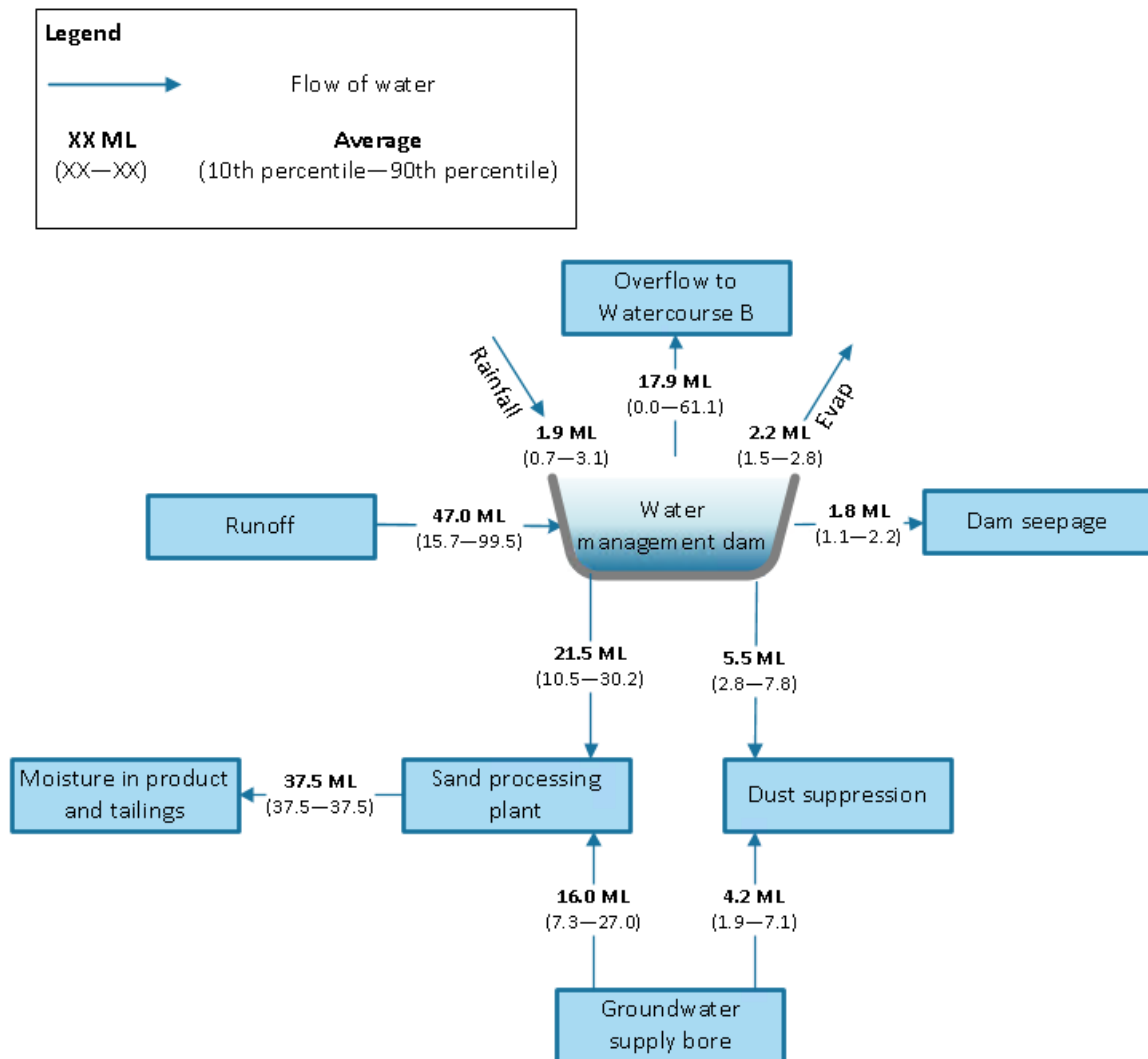


Figure 5.8 **Water balance results – Year 10**

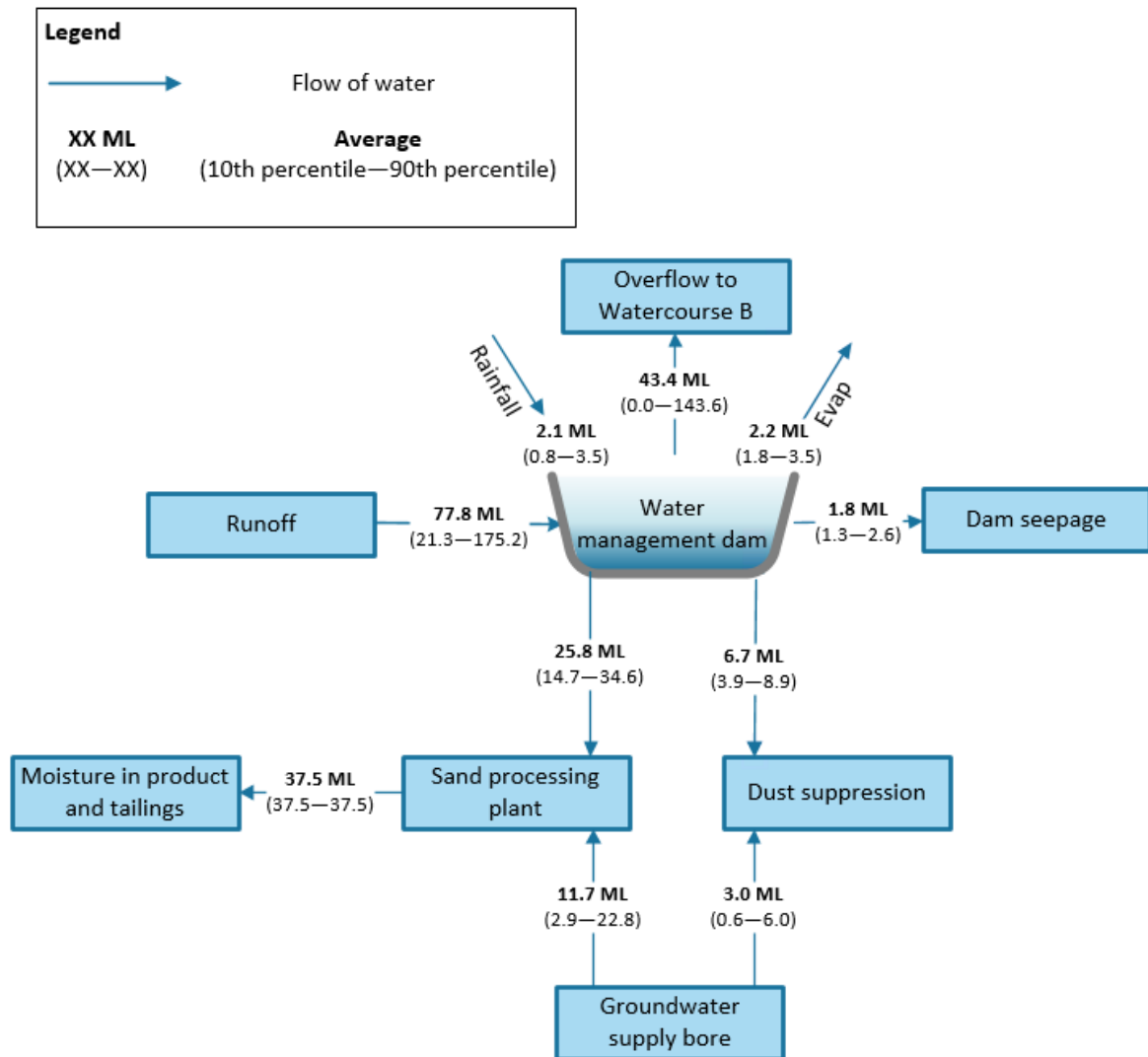


Figure 5.9 Water balance results – Year 28

Table 5.3 **Summary of average annual water balance results**

	Year 1	Year 10	Year 28
	ML/year	ML/year	ML/year
INPUTS			
Rainfall and runoff	39.4	48.9	79.9
Groundwater bore supply	10.1	20.2	14.7
Total inputs	49.5	69.1	94.6
OUTPUTS			
Evaporation	2.3	2.2	2.2
Moisture of product and tailings	22.5	37.5	37.5
Dust suppression	9.7	9.7	9.7
Water management dam seepage	1.8	1.8	1.8
System overflows	13.2	17.9	43.4
Total outputs	49.5	69.1	94.6
BALANCE	0	0	0

i **Groundwater supply**

Figure 5.10 presents the simulated daily groundwater extraction volumes for year 1, 10 and 28 of the quarry plan. Results indicate that the groundwater supply system will need to meet the total operational water demand approximately 35 to 40% of the time. It is expected that groundwater supply will mostly be required to provide water in between rainfall events and continuously for extended periods of time during dry conditions. The project water requirement is approximately 33 ML/year or 0.09 ML/day in Year 1 and 47 ML/year or 0.13 ML/day for all other quarry years.

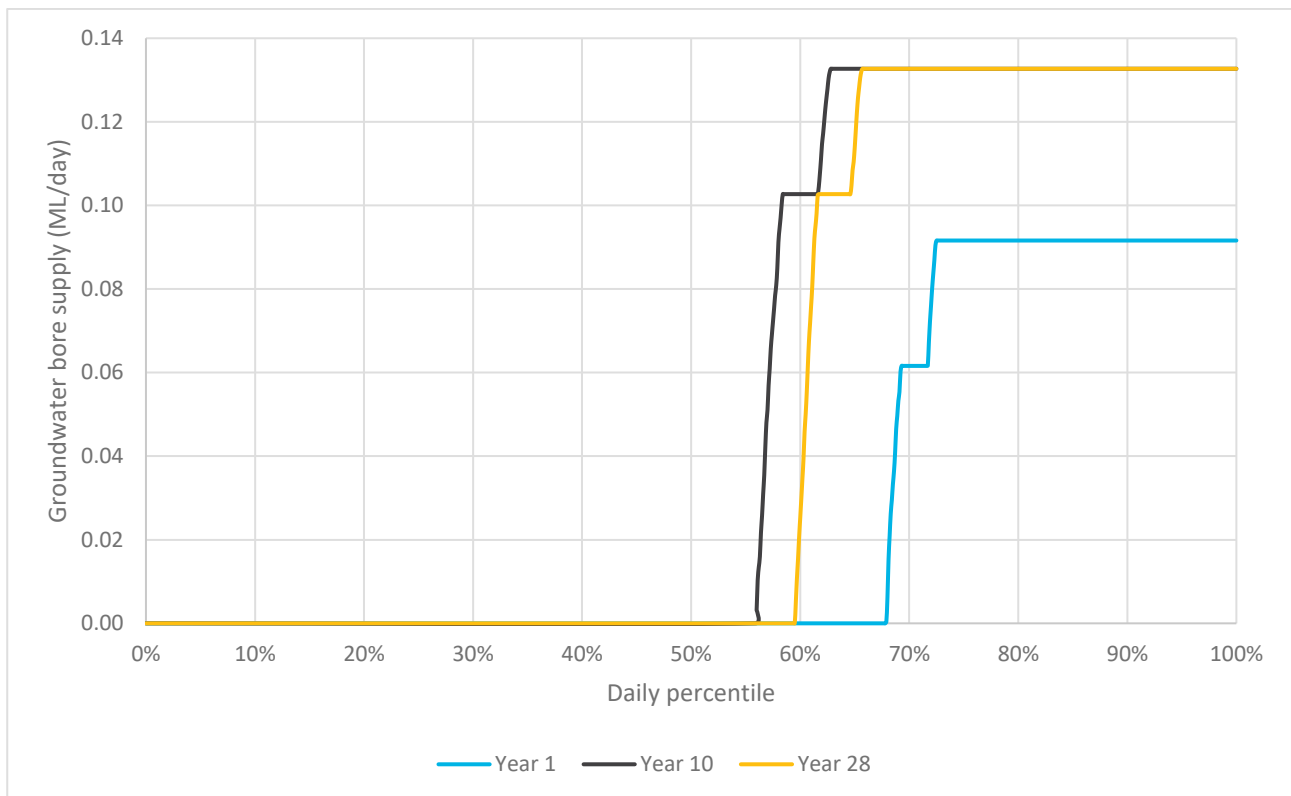


Figure 5.10 Modelled daily groundwater bore supply

ii System overflows

System overflows will occur via the water management dam spillway when the water management dam is full. Figure 5.11 presents overflow statistics for year 1, 10 and 28 of the quarry over the 50 year historical rainfall record modelled. For clarity, the results are shown with a logarithmic vertical axis. Note that values of 0 ML/day are not plotted.

Overflows are predicted to occur on less than 2% of days modelled. Overflows will typically occur intermittently over several days during wet weather periods that may comprise several days of material rainfall. On average overflow events (ie overflows that occur for several days) will occur three times per year. Overflows are expected to cease shortly after the wet weather conditions end and runoff subsides. Importantly, overflows are only expected to occur when streamflow in receiving watercourses is naturally elevated.

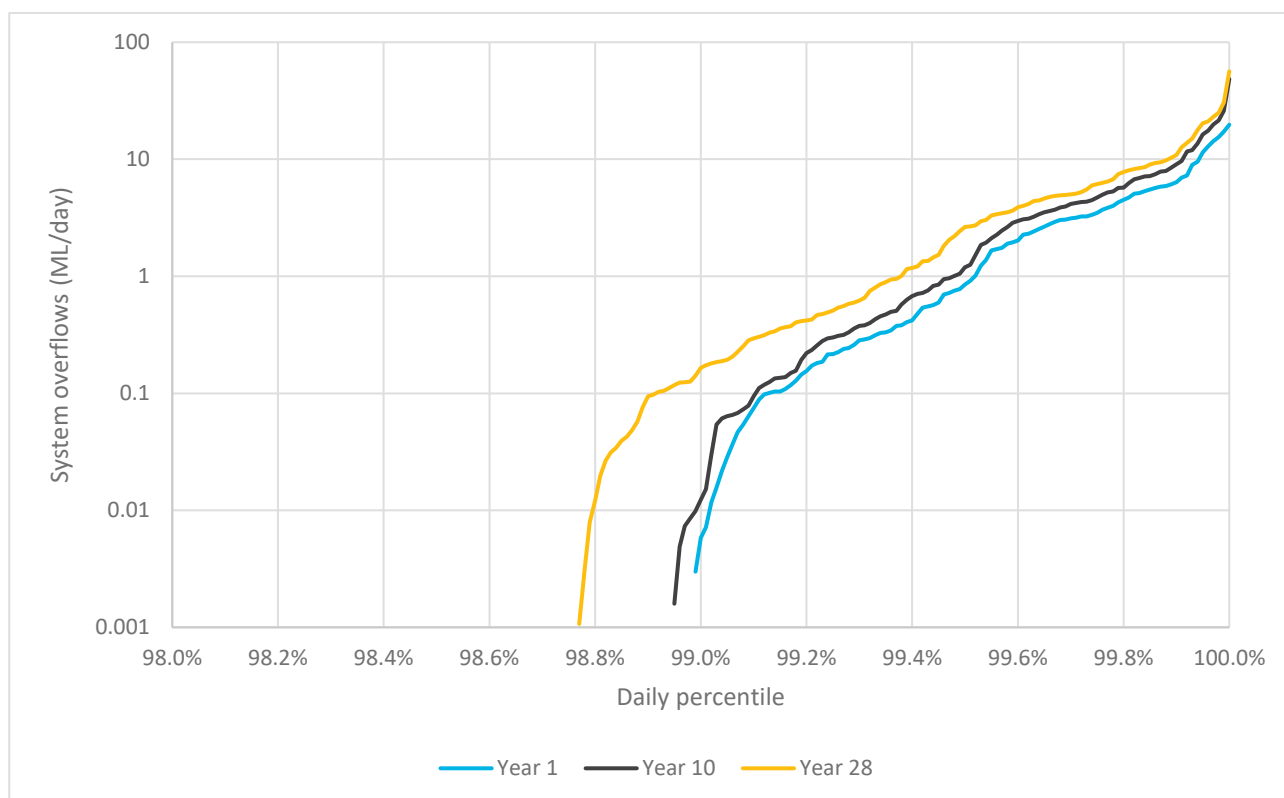


Figure 5.11 Modelled daily system overflows

5.4 Groundwater supply

As described earlier in this chapter, a groundwater supply system is required as a secondary rainfall independent water source. The groundwater supply will target the deep Hawkesbury Sandstone aquifer. Based on historical drilling records and as discussed in Section 3.6.1ii, it is reasonable to assume production pumping yields of 1-1.5 L/s would be achievable. Drilling should continue into the Hawkesbury Sandstone until an airlift yield of around 2 L/s is obtained.

Proposed drilling depths are: 120m minimum depth; 150m probable depth; and 200m maximum depth. Drilling should not continue past the base of the Hawkesbury Sandstone into the Narrabeen Formation. If insufficient water is obtained from one production bore, then a second nearby production bore should be considered. Spacing of production bores should be at least 100 m.

Several areas within the site have been identified as being suitable for a water supply. These areas have been developed with consideration of the rules for the Sydney Basin Central Groundwater Source in the *Greater Metropolitan Region Groundwater Sources 2011 WSP*, which is applicable to the local Hawkesbury Sandstone aquifer. The rules relating to water supply bore sighting and design and are described in Table 5.4.

Table 5.4 Water supply rules for the Sydney Basin Central Groundwater Source

WSP rule	Distance (m)
Distance restriction from an approved water supply work nominated by another access licence	400
Distance restriction from an approved water supply work for basic landholder rights only	100
Distance restriction from the property boundary	50
Distance restriction from an approved water supply work nominated by a local water utility or major utility access licence	1,000
Distance restriction from a Department observation bore	200

The following restrictions relative to the project boundary were identified:

- Four commercial and two water supply bores with nominated WALs within 400 m of the northern project boundary (associated with the existing PF Quarry) and one commercial water supply bore with nominated WALs within 400 m of the eastern project boundary.
- One stock and domestic (basic landholder) bore within 100 m of the southern project boundary.

There are no known restrictions relating to NSW Government observation bores and local or major utility access licences.

Three potential areas within the site have been identified as being suitable for a water supply bore. These areas are summarised in Table 5.5 and shown on Figure 5.12. The preference is to locate the bore(s) as close as possible to the infrastructure area (ie within area 1). The alternative areas (ie areas 2 and 3) can be utilised as a contingency (for example if low yields are achieved from bores in area 1).

Table 5.5 Proposed water supply bore locations

Preference	Area	Pros	Cons
1	1 - South/south-west	• Near plant/infrastructure areas • Away from GDE • No licence distance restrictions	
2	2 - North-west	• Away from GDE	• Furthest away from plant/infrastructure areas, requires access
3	3 - South-eastern corner	• Away from GDE	• Higher elevation • Away from plant/infrastructure areas, requires access • Less flexibility with space due to license distance restrictions

\\Emmsvr1\emms3\2020\H2000021 - Maroota Sand Quarry\GIS\02 Maps\ WIA\WIA015 PreferredWaterSupplyBoreLocations 20210513 07.mxd 13/05/2021



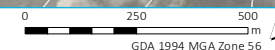
- KEY**
- Site boundary
 - Major road
 - Minor road
 - Vehicular track
 - Watercourse/drainage line
 - Waterbody
 - NPWS reserve
 - Cadastral boundary
 - Groundwater dependent ecosystem (PCT 923)
 - Proposed quarry layout
 - Site infrastructure
 - Site infrastructure
 - Entry building
 - Offices and carpark
 - Processing plant
 - Weighbridge
 - Product stockpile
 - Cut/fill extent
 - Haul road
 - Dam embankment
 - Dam
 - Excavation zone
 - Registered bores
 - Irrigation
 - Commercial and Industrial
 - Stock and Domestic
 - Distance restriction buffers
 - Distance restriction for approved water supply work for basic landholder rights only
 - Distance restriction for approved water supply work nominated by another access licence
 - Distance restriction for the property boundary
 - Distance restriction for GDE
 - Proposed water supply bore location
 - Area 1
 - Area 2
 - Area 3

Preferred water supply
bore locations

Maroota Sand Quarry
Water impact assessment
Figure 5.13



Source: EMM (2021); BoM (2020); DFSI (2017)



5.4.1 Drilling

Drilling and water supply bore construction will be undertaken by a Class 4 water bore driller. Ideally all drilling should be undertaken using air hammer techniques using air rotary percussion, also known as down-hole hammer. A casing advance system (such as overburden drilling excentric or tubex) may be employed through the sand and weathered rock if required. This is a system that advances casing with the drill bit during drilling, avoiding the collapse of the unconsolidated sediments and is cased off allowing the bore to be deepened into the underlying fresh sandstone. Drilling should not introduce any drilling fluid additives other than water. Air hammer drilling methods ensure that water quality and indicative yields can be accurately recorded throughout the drilling process.

5.4.2 Casing design and construction

A nominal casing design schematic for a fully cased and slotted screened production bore is included in Figure 5.13 showing casing material, indicative depths, indicative screen intervals, and diameters. The final design will depend on the geological and hydrogeological conditions encountered.

A summary of the casings and construction method is provided. The following conditions will be followed with respect to casing design and installation, in accordance with *Minimum construction requirements for water bores in Australia* (NUDLC 2020).

5.4.3 Surface casing

A primary surface casing should be set into the competent formation to prevent washouts and erosion of the uppermost weathered rock during subsequent drilling. The annulus of the surface casing will be sealed using a cement-grout mixture. This has three general purposes:

1. zone isolation and segregation;
2. corrosion control; and
3. formation stability and casing strength improvement.

This casing will be constructed using class 12, nominal diameter 200 mm flush threaded PVC to approximately 40 m depth to stabilise the weathered zone and to exclude the ingress of shallow groundwater.

i Production casing

An internal production casing with slotted screened lengths may not be required if the Hawkesbury Sandstone is competent from 40 m to total depth. If the sandstone is unstable at depth, the casing should be cased to at least the depth of the likely pump intake and preferably to total depth.

If required, the production casing will use class 12, 150 mm flush threaded PVC, installed into the Hawkesbury Sandstone to a minimum depth of 90 mbgl. Machine slotted screen lengths should be used over water bearing zones in zones below 50 m. If the bore is cased to total depth, then the bottom 6 m of the casing should be blank to allow for a sump.

ii Gravel pack

A gravel pack will not be required if the Hawkesbury Sandstone is competent and no production casing is installed.

If production casing is installed to total depth then a washed, well-rounded, gravel pack will be placed in a controlled manner in the annulus of the bore (between the bore wall and casing) across all the slotted screen intervals of the production casing. The gravel pack will be placed from the base of the drillhole to a minimum of 2 m above the top of the top slotted screen interval. The size of the gravel pack will be approximately 3 to 6 mm diameter.

iii Bentonite seal

If required a seal comprising coated bentonite pellets will be placed in a controlled manner immediately above the gravel pack to isolate the target water bearing zone. The bentonite seal will have a minimum thickness of 3 m.

iv Secondary gravel pack

If required a washed, well-rounded, gravel pack will be placed in a controlled manner in the annulus of the bore above the bentonite. The gravel pack will be placed above the top of the bentonite to 5 m below the surface.

v Grout backfill

If required, the top 5 m of the bore annulus will be grouted using a cement-bentonite mix.

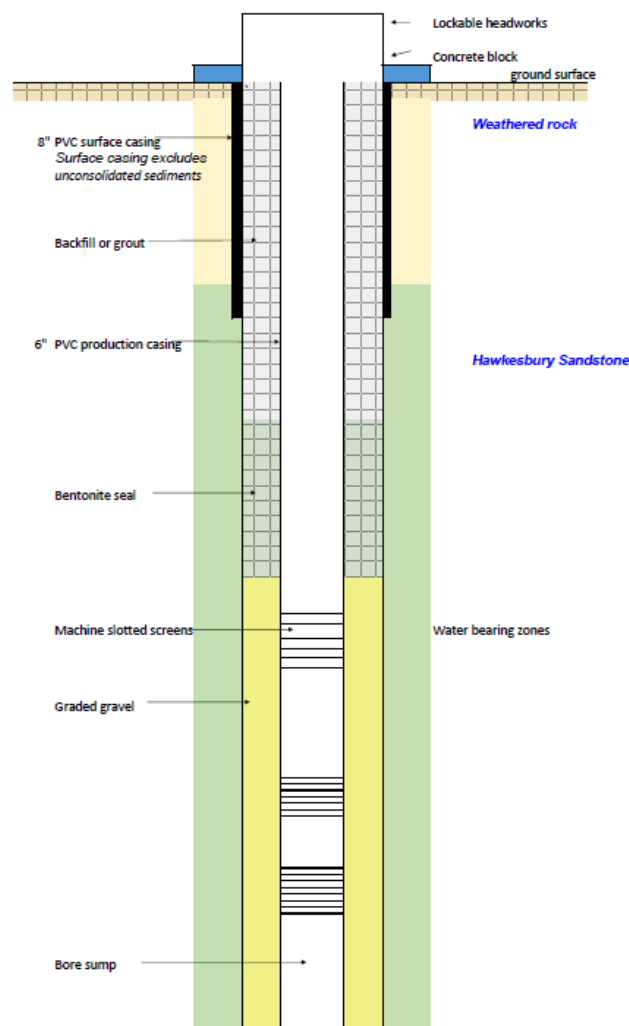


Figure 5.13 **Nominal fully cased water supply bore schematic**

5.5 Monitoring and adaptive management

5.5.1 Management plans

The following monitoring and management plans will be prepared post approval:

- Water monitoring and response plan. This plan will establish:
 - an ongoing groundwater monitoring program (both level and quality);
 - an ongoing surface water monitoring program (both quantity and quality); and
 - trigger action response plans that will provide a framework for identifying issues and implementing additional controls or alternative management measures to rectify issues.

- Water management plan. This plan will:
 - describe how water will be managed to achieve compliance with consent and EPL licence conditions; and
 - establish responsibilities and reporting requirements.

All plans will be developed in consultation with relevant agencies and will be progressively reviewed and updated.

5.5.2 Contingency options

Table 5.6 describes a range of contingency measures that could be implemented.

Table 5.6 Contingency options

Trigger	Contingency measure
Additional monitoring (prior to extensive development of the pit) identifies the need for adjustments to the composite wet-weather high groundwater elevation surface (see Section 5.2.3)	• Review the pit design to minimise the potential for groundwater inflows.
Project water requirements are greater than expected	• Review the potential for increased groundwater abstraction. • Review water supply options and identify further sustainable options. • Acquire appropriate licence entitlements if required.
Groundwater abstraction rates in Area 1 (Figure 5.12) are lower than expected.	• Establish additional groundwater supply bores in Area 2 or 3 (Figure 5.1).
Monitoring identifies that water management system overflows are resulting in the non-trivial degradation of receiving water quality	• Review water management system to identify opportunities for improved source controls. • Review the potential for water treatment to improve water quality.

6 Water impact assessment

This chapter describes the project's water impacts and is structured as follows:

- Section 6.1 assesses impacts due to proposed groundwater abstraction;
- Section 6.2 describes the project's residual impacts;
- Section 6.3 addresses the AIP policy framework; and
- Section 6.4 addresses the water quality and river flow objectives.

6.1 Groundwater abstraction for water supply – drawdown assessment

6.1.1 Overview

As described in Chapter 5, a groundwater supply system is proposed as a non-rainfall dependant water source for the project. The system is expected to meet the total operational water demand approximately 40% of the time (see water balance model results in Section 5.3).

A groundwater impact assessment has been prepared to assess the drawdown potential:

1. at nearby groundwater works in the regional deep aquifer; and
2. the nearby shallow aquifer and the Maroota Sands Swamp Forest GDE.

This section describes the groundwater impact assessment and makes frequent reference to Chapter 3 which describes the deep and shallow aquifer characteristics and the Maroota Sands Swamp Forest GDE. Water licencing considerations are discussed separately in Chapter 7.

6.1.2 Theis analytical model

i Model approach

The Theis method is an analytic solution for the drawdown for non-steady groundwater flow and assumes radial flow towards an abstraction point. Drawdown at any point at a given time is directly proportional to the pumping rate and inversely proportional to aquifer transmissivity and aquifer storativity. The model represents a simplification of the aquifer system, with the following key (and generally conservative) assumptions applied to the model:

- groundwater abstraction is simulated to occur at continuous rate for the entire 28 year operational period. Two abstraction scenarios were assessed. These are discussed further below;
- the groundwater bore is located near the infrastructure area and is screened in the deep sandstone aquifer (see Section 5.4);
- the deep sandstone aquifer is confined within the deep aquifer water bearing zones, which are assumed to be vertically connected and act as one single aquifer unit;
- there is no groundwater gradient;

- the aquifers are approximated as linear;
- the aquifer has infinite areal extent;
- the aquifer is homogeneous, isotropic and uniform thickness;
- the water removed from storage is discharges instantaneously with decline in head;
- the pumping bore is fully penetrating; therefore, flow is horizontal;
- each of the existing private bores is fully penetrating; and
- no rainfall recharge is considered.

ii Abstraction scenarios

The groundwater supply system will need to meet the total operational water demand approximately 40% of the time (see water balance model results in Section 5.3). This is equivalent to a long-term average abstraction rate of 20 ML/year. However, higher abstraction rates (up to the total project water requirement of 47 ML /year) may be required during dry periods when there is minimal surface water available. Accordingly, the following abstraction scenarios have been assessed:

- **Expected scenario** – This scenario applies a 20 ML/year (0.6 L/s) abstraction rate which is equivalent to groundwater supplying 40% of the total operational water demand over an extended period (see water balance results in Section 5.3).
- **Conservative scenario** - 50 ML/year (1.5 L/s) - this is a conservative scenario that assumes no water is sourced from the water management dam. This scenario is representative of the functionality of the water management system during drought conditions (when minimal surface water would be available) but is not representative of long-term conditions that would comprise a range of dry, average and wet years.

It is noted that DLALC are in the process of acquiring a 50 ML/year WAL via a controlled allocation. This will ensure entitlements for the maximum annual water take are held. Water licencing is addressed in Chapter 7.

iii Adopted model parameters

Hydraulic properties assigned to the analytical model are based on previous studies of the Hawkesbury Sandstone in the Maroota area (DLWC 2001) and information available from work summaries (WaterNSW 2020b). The adopted values are also consistent with the site-specific testing (see Table 3.7). Adopted parameter values are described in Table 6.1.

Table 6.1 Model parameter values

Parameter	Adopted value	Source
Hydraulic conductivity	0.1 m/day	Maroota groundwater study – Technical status report (DLWC 2001)
Storativity	0.0045	Maroota groundwater study – Technical status report (DLWC 2001)
Aquifer thickness	150 m	Groundwater elevation at proposed location (shown on Figure 5.12). Assume drilling to 0 m AHD for this assessment.

Table 6.1 **Model parameter values**

Parameter	Adopted value	Source
Pumping rate	• 20 ML/year (expected scenario) • 50 ML/year (conservative scenario)	• Expected scenario – long-term average abstraction (water balance results Section 5.3) • Conservative scenario – short term maximum abstraction rate during a dry period.
Duration of abstraction	Continuously for 28 years	Quarry planning (Section 1.1)

6.1.3 Model results and discussion

i Drawdown at nearby groundwater works

There are 43 groundwater users screened in the deep aquifer (this includes those with unknown screen intervals) as described in Section 3.6.5ii and summarised in Table 3.8 and Appendix C. The results of the modelled drawdown for the six closest groundwater works are shown on Figure 6.1 and Figure 6.2 for the 20 and 50 ML/year abstraction scenarios respectively. The predicted drawdown at all groundwater works within 3 km of the extraction area is provided in Appendix G.

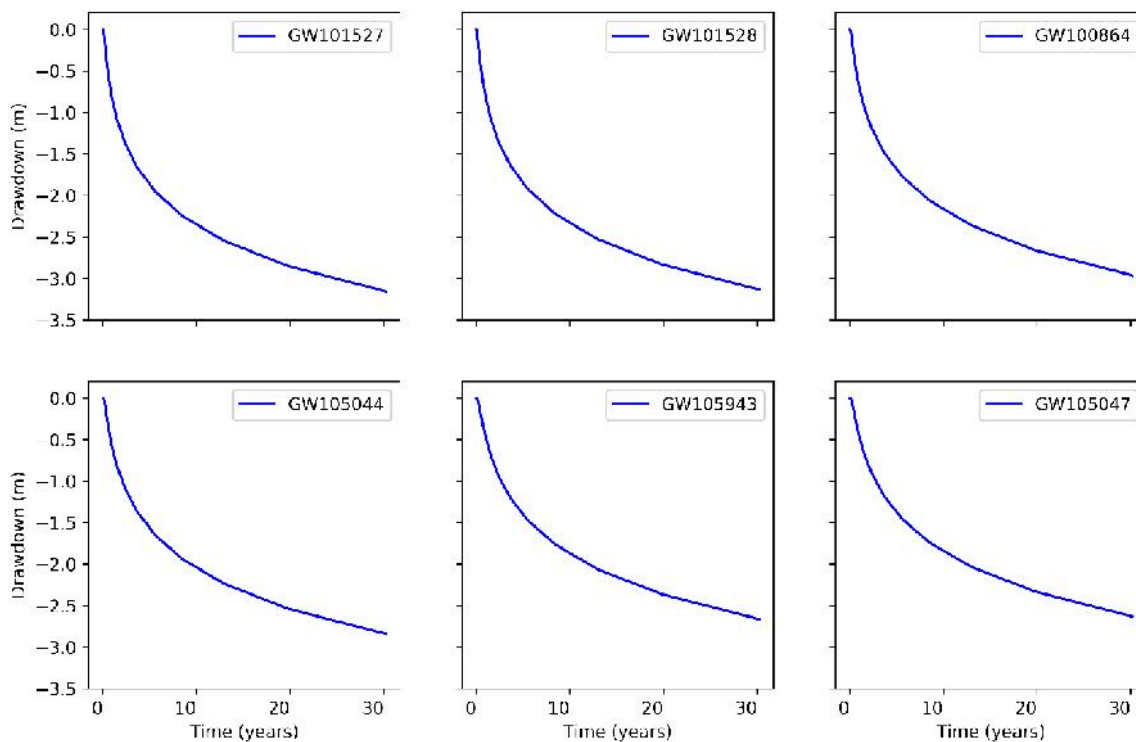


Figure 6.1 Model drawdown at closest groundwater works – 50 ML/yr

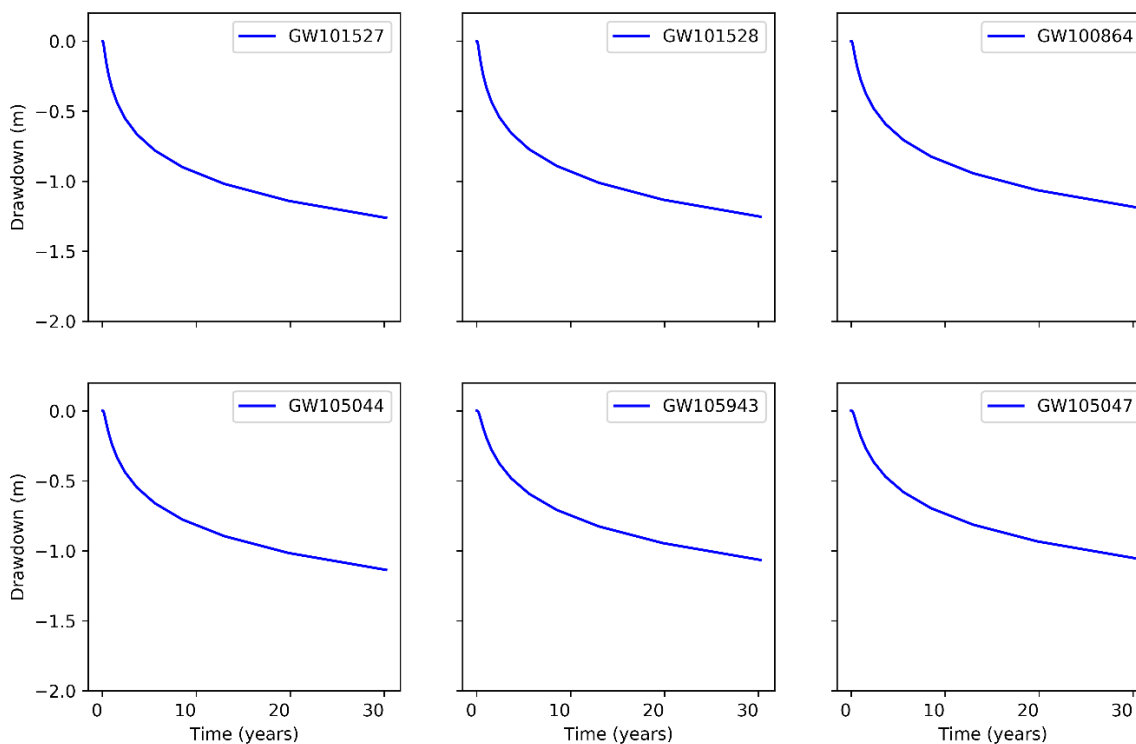


Figure 6.2 Model drawdown at closest groundwater works – 20 ML/yr

Table 6.2 summarises the total drawdown and time taken to reach 2 m drawdown at each of the deep aquifer groundwater users.

Table 6.2 Drawdown at existing groundwater works

Registered ID	Distance from pumping bore (m)	Years to >2 m drawdown (50 ML)	Final drawdown (m) - 50 ML	Final drawdown (m) - 20 ML	Registered ID	Distance from pumping bore (m)	Years to >2 m drawdown	Final drawdown (m) - 50 ML	Final drawdown (m) - 20 ML
GW101527	1041	6.2	-3.1	-1.2	GW107004	2362	-	-1.9	-0.8
GW101528	1056	6.2	-3.1	-1.2	GW038147	2391	-	-1.9	-0.8
GW100864	1189	7.9	-2.9	-1.2	GW059742	2431	-	-1.9	-0.8
GW105044	1295	9.3	-2.8	-1.1	GW059118	2445	-	-1.9	-0.8
GW105943	1465	11.9	-2.6	-1.0	GW109326	2473	-	-1.9	-0.7
GW105047	1498	12.4	-2.6	-1.0	GW110585	2489	-	-1.9	-0.7
GW057460	1606	14.4	-2.5	-1.0	GW033197	2509	-	-1.8	-0.7
GW072780	1612	14.4	-2.5	-1.0	GW053898	2511	-	-1.8	-0.7
GW108133	1676	15.6	-2.4	-1.0	GW103570	2639	-	-1.8	-0.7
GW034628	1683	15.8	-2.4	-1.0	GW102587	2685	-	-1.8	-0.7
GW105067	1786	17.8	-2.3	-0.9	GW101839	2754	-	-1.7	-0.7
GW102451	1788	17.8	-2.3	-0.9	GW102634	2833	-	-1.7	-0.7
GW072980	1807	18.1	-2.3	-0.9	GW108136	2845	-	-1.7	-0.7
GW048741	1866	19.5	-2.3	-0.9	GW100185	2868	-	-1.7	-0.7
GW016348	1888	19.8	-2.2	-0.9	GW104105	2898	-	-1.6	-0.7
GW106261	1910	20.4	-2.2	-0.9	GW037738	2961	-	-1.6	-0.6
GW109927	2010	22.3	-2.2	-0.9	GW101212	3079	-	-1.6	-0.6
GW072274	2146	25.7	-2.1	-0.8	GW071883	3317	-	-1.5	-0.6
GW060051	2192	26.6	-2.0	-0.8	GW104348	3348	-	-1.5	-0.6
GW104460	2254	-	-2.0	-0.8	GW060147	3351	-	-1.5	-0.6
GW055962	2354	-	-1.9	-0.8	GW015051	3503	-	-1.4	-0.6
GW113253	2357	-	-1.9	-0.8					

In conclusion, model results indicate that groundwater abstraction at the expected rate of 20 ML/year will not result in drawdown impacts of more than 2 m at nearby groundwater works. As this is the expected scenario it is applied to describe the project's impacts. Results from the conservative scenario (50 ML/year abstraction) indicate that a maximum drawdown of 3.2 m at the closest groundwater work could occur, however, more than 6 years of continuous pumping at 50 ML /year would be required before a drawdown impact of greater than 2 m occurs. As a typical dry period will last 2-3 years, this analysis demonstrates that short-term abstraction at rates of up to 50 ML/year can occur without resulting in a drawdown impact of greater than 2 m at nearby groundwater works.

ii Impacts to shallow aquifer (Maroota Sand) and Maroota Sands Swamp Forest GDE

The shallow aquifer (Maroota and eluvial sand) is located east of the proposed groundwater supply bore location. While drawdown in the shallow aquifer has not been modelled, it is unlikely to occur as the shallow aquifer is interpreted to be perched above the deep aquifer, meaning that the two aquifers are vertically separated by an unsaturated zone (see Section 3.8 for further information).

The long-term groundwater level monitoring data presented in Figure 3.10 supports this conclusion, showing that shallow aquifer groundwater levels measured at GW075002 have remained stable since monitoring began in 1997, despite significant (up to 25 m) fluctuations in the deep aquifer (GW075001) over the same period.

A Maroota Sands Swamp Forest GDE is located within Watercourse A, to the north-east of the extraction area. As described in Section 3.8, the GDE is maintained by shallow groundwater beneath Watercourse A, which is interpreted to be the shallow aquifer. As described above, groundwater abstraction from the deep aquifer is not expected to impact the shallow aquifer. Hence, no impacts to the GDE are expected.

6.2 Residual impacts

The National Water Commission mining risk framework (Moran et al. 2010) was applied to establish potential direct and indirect water-effect associated with the project (Chapter 4). The proposed management measures and residual impacts associated with each effect are described in Table 6.3. The effects are itemised for referencing purposes.

Table 6.3 **Summary of residual impacts**

Item	Activity	Potential effect	Management approach	Residual impact
Direct effects to groundwater regimes				
1.1	Abstraction of groundwater for quarry water supply	Causes aquifer drawdown which can reduce groundwater availability for existing users (landowners, GDEs) and baseflow in watercourses	The following measures will be implemented to minimise abstraction volumes: - the sand processing plant and frame press system will maximise the recovery of water, reducing system losses and the project's water requirements; and - groundwater abstraction will only be used when surface water from the water management dams is unavailable (approximately 40% of the time). The following measures will be implemented to minimise the impacts of abstraction: - the groundwater bore will be located away from potential receptors and will be designed to limit inflow from the upper part of the Hawkesbury Sandstone aquifer; and - groundwater levels will be progressively monitored, and a TARP will be prepared that establishes an adaptive management framework.	The groundwater abstraction impact assessment (Section 6.1) concluded that long-term abstraction at the expected rate of 20 ML/year or short-term abstraction at rates up to 50 ML/year will not - result in drawdown impacts of more than 2 m at nearby groundwater works; or - impact the shallow aquifer.
1.2	Excavation of the quarry pit	Any pit excavations that intercept the groundwater table can result in: - aquifer drawdown which can reduce groundwater availability for existing users (landowners, GDEs) and baseflow in watercourses; and - groundwater inflows into the quarry's water management system. Any material inflows will increase the frequency and magnitude of discharges from the water management system.	A quarry pit extraction elevation limit was established by applying a 2 m buffer to a wet-weather high groundwater surface.	No impacts are expected as aquifer interception will be avoided.

Table 6.3 **Summary of residual impacts**

Item	Activity	Potential effect	Management approach	Residual impact
Direct effects to surface water regimes				
2.1	Disturbance of the existing landscape and the establishment of surface water management controls (ie dams)	Changes to hydrologic regimes in downstream watercourses	Runoff from the quarry's water management system will be collected in a water management dam that will be located on Watercourse B. Water collected in the dam will be used within the operation to minimise the frequency and magnitude of overflows.	Watercourse A – During operations (from year 5), the project will reduce the contributing catchment area to Dam 1 (located on Watercourse A, but not part of the project) by 13.7 ha, this is equivalent to 24% of the existing catchment and will result in a commensurate reduction in streamflow that originates from surface water runoff. It is noted that baseflow in Watercourse A is interpreted to occur from discharges from the shallow aquifer which is not expected to be impacted by the project (see item 1.1). Watercourse B – During operations runoff from the Watercourse B catchment will be captured in the water management dam, which will occasionally overflow. It is expected that the streamflow regime in the 200 m long watercourse reach downstream of the dam will be materially impacted. Approximately 200 m downstream of the dam, Watercourse B joins a larger 2nd order watercourse. The water management dam will impact approximately 21% of the contributing catchment area of this larger watercourse. Further downstream this ratio will diminish as the catchment area increases.
2.2	Quarry pit development leads to changes to catchment areas	Changes to hydrologic regimes in downstream watercourses	The final landform seeks to minimise changes to the existing catchment boundaries and runoff regimes (see SLR 2020b).	

Table 6.3 **Summary of residual impacts**

Item	Activity	Potential effect	Management approach	Residual impact
Direct effects to receiving water quality				
3	Overflows from the surface water management system	Changes to the existing water quality regimes in downstream watercourses. The discharge of sediment-laden water can result in sedimentation impacts.	The following measures will be implemented to minimise abstraction volumes: No water from the sand processing system will be discharged into the water management dam. This avoids this potential contamination pathway. Disturbed areas will be progressively rehabilitated to reduce the overall disturbance area at any point in time (SLR 2020b). Where practical, all runoff from areas disturbed by the project will be managed in accordance with the methods recommended in Managing Urban Stormwater: Volume 1 (Landcom 2004) and Volume 2E (DECC 2008). The primary control is a 15.3 ML water management dam that will be located on Watercourse B. Runoff captured in the dam will be preferentially used for operational water. Surface water quality will be progressively monitored, and a TARP will be prepared that establishes an adaptive management framework.	The proposed erosion and sediment controls will effectively manage coarse and fine sediment entrained in dirty water runoff. Hence, sedimentation impacts in downstream watercourses is not expected. Overflows from the water management system will typically occur intermittently over several days during wet weather periods that may comprise several days of material rainfall. On average overflow events (ie overflows that occur for several days) will occur three times per year (Section 5.3.3). Overflows are expected to cease shortly after the wet weather conditions end and runoff subsides. Importantly, overflows are only expected to occur when streamflow in receiving watercourses is naturally elevated. The water quality of water management system overflows will be progressively monitored. Further measures, such as water treatment could be implemented if monitoring indicates that overflows are resulting in non-trivial degradation of receiving water quality (see Section 5.5).
Indirect effects				
4 - Impacts to 3 rd party groundwater users.	Abstraction of groundwater for quarry water supply	Reduction in available water due to groundwater drawdown.	See item 1.1	The groundwater abstraction impact assessment (Section 6.1) concluded that long-term abstraction at the expected rate of 20 ML/year or short-term abstraction at rates up to 50 ML/year will not result in drawdown impacts of more than 2 m at nearby groundwater works.

Table 6.3 **Summary of residual impacts**

Item	Activity	Potential effect	Management approach	Residual impact
5 - Impacts to 3 rd party surface water users	Disturbance of the existing landscape and the establishment of surface water management controls (ie dams)	Reduction in available water due to changes in surface water flow regimes.	See item 2.1 and 2.2	PF Formation Sand and Concrete hold a surface water entitlement to extract up to 32 ML/year from Dam 1 (Section 3.5). During operations (from year 5), the project will reduce the contributing catchment area to Dam 1 by 13.7 ha. This is equivalent to 24% of the existing catchment and will result in a commensurate reduction in streamflow when surface water runoff is occurring (see Item 2). This reduction in runoff volume is not expected to materially reduce water availability as Dam 1 is a small storage (ie it cannot hold much runoff) and the dam level is maintained by baseflow that is interpreted to discharge from the shallow aquifer, which is not predicted to be impacted by the project (Section 6.1).
6 - Impacts to Maroota Sands Swamp Forest GDE	Abstraction of groundwater for quarry water supply	Reduction in available water due to groundwater drawdown.	See item 1.1	The groundwater abstraction impact assessment (Section 6.1) concluded that abstraction from the deep aquifer will not impact the shallow aquifer or the Maroota Sands Swamp Forest GDE.

6.3 Assessment against aquifer interference policy

The AIP outlines requirements for obtaining water licences for aquifer interference activities and the minimal impact considerations for assessing groundwater impacts in NSW. This section compares the expected impacts against the requirements of the AIP and discusses compliance with the policy.

i Minimal impact considerations

The minimal impact considerations are a series of thresholds that define minimal impacts from aquifer interference activities. There are two levels of minimal impact considerations specified in the AIP, being Level 1 and Level 2. If the predicted impacts are less than the threshold level specified by the Level 1, then these impacts are acceptable under the AIP. Where the predicted impacts are greater than the Level 1 minimal impact considerations, then additional studies are required to fully assess and manage these predicted impacts. If this assessment shows that the predicted impacts do not prevent the long-term viability of the relevant water-dependent asset, then the impacts will be considered acceptable.

Table 6.4 compares the project impacts to the minimal impact considerations for less productive porous and fractured rock water sources. The assessment is based on the proposed impacts in the regional deep aquifer. The localised shallow aquifer is not assessed as it is not expected to be impacted by the project (Section 6.1).

Table 6.4 Minimal impact considerations – less productive porous and fractured rock water sources

Water sharing plan: Greater Metropolitan Region Groundwater Sources Water Sharing Plan 2011

Aquifer	Sydney Basin Central Groundwater Sources
Category	Less productive
Level 1: Minimal Impact Considerations	Assessment
Water table Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic “post water sharing plan” variations, 40 m from any: (a) high priority groundwater dependent ecosystem; or (b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan or A maximum of a 2 m decline cumulatively at any water supply work.	At the time of writing, there was no culturally significant sites or high priority GDEs¹ located within the study area. The Maroota Sand Swamp Forest GDE is not a high priority GDE but is located within the project area and is maintained by perched groundwater from the shallow aquifer. It will not be impacted by drawdown in the deep regional aquifer. The groundwater abstraction impact assessment (Section 6.1) concluded that long-term abstraction at the expected rate of 20 ML/year or short-term abstraction at rates up to 50 ML/year will not result in drawdown impacts of more than 2 m at nearby groundwater works. No impacts are expected due to the excavation of the quarry pit as aquifer interception will be avoided (Section 5.2.3) Conclusion: does not exceed Level 1 minimal impact consideration thresholds
Water pressure A cumulative pressure head decline of not more than a 2 m decline, at any water supply work	The groundwater abstraction impact assessment (Section 6.1) concluded that long-term abstraction at the expected rate of 20 ML/year or short-term abstraction at rates up to 50 ML/year will not result in drawdown impacts of more than 2 m at nearby groundwater works. No impacts are expected due to the excavation of the quarry pit as aquifer interception will be avoided (Section 5.2.3) Conclusion: does not exceed Level 1 minimal impact consideration thresholds

Table 6.4 Minimal impact considerations – less productive porous and fractured rock water sources

Water sharing plan: Greater Metropolitan Region Groundwater Sources Water Sharing Plan 2011

Aquifer	Sydney Basin Central Groundwater Sources
Category	Less productive
Level 1: Minimal Impact Considerations	Assessment
Water quality Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity	The quarry floor extraction limit is designed to be 2 m above the wet-weather high groundwater level. As no aquifer interception will occur there is no potential to concentrate salts and the beneficial use category is not predicted to be affected, nor is groundwater salinity expected to increase. Conclusion: does not exceed Level 1 minimal impact consideration thresholds

1. A high priority GDE refers to a GDE listed in the WSP.

6.4 Assessment against NSW water quality and river flow objectives

Water quality and river flow objectives were established for receiving waters in Table 2.5. Potential impacts to the objectives due to the project are described in Table 6.5.

Table 6.5 Assessment of water quality and river flow objectives

Environmental value	Objective	Application to project
Water quality objectives		
Aquatic ecosystems	Maintaining or improving the ecological condition of water bodies and their riparian zones over the long term.	Overflows from the water management system will typically occur intermittently over several days during wet weather periods that may comprise several days of material rainfall. On average overflow events (ie overflows that occur for several days) will occur three times per year (Section 5.3). Overflows are expected to cease shortly after the wet weather conditions end and runoff subsides. Importantly, overflows are only expected to occur when streamflow in receiving watercourses is naturally elevated. The water quality of water management system overflows will be progressively monitored (see Section 5.5). Further measures, such as water treatment could be implemented if monitoring indicates that overflows are resulting in non-trivial degradation of receiving water quality.
Visual amenity	Aesthetic qualities of waters.	No material impacts to the visual amenity of receiving waters is expected as: - water management system overflows will occur occasionally for short periods of time; and - overflows are not expected to have elevated concentrations of oils, petrol chemicals or floating debris which can impact the visual amenity of water (ANZECC 2000).

Table 6.5 Assessment of water quality and river flow objectives

Environmental value	Objective	Application to project
Secondary contact recreation	Maintaining or improving water quality for activities such as boating or wading, where there is a low probability of water being swallowed.	No material impacts the potential for secondary and primary contact recreation in receiving waters is expected as: water management system overflows will occur occasionally for short periods of time; and
Primary contact recreation	Maintaining or improving water quality for activities such as swimming in which there is a high probability of water being swallowed.	overflows are not expected to have elevated nutrients or concentrations of coliforms, enterococci or protozoans as there is no source of these pollutants in the surface water management system.
Livestock water supply	Protecting water quality to maximise the production of healthy livestock.	The water quality of water management system overflows is expected to be suitable for both livestock consumption and irrigation.
Irrigation water supply	Protecting the quality of waters applied to crops or pasture.	
Homestead water supply	Protecting water quality for domestic use in homesteads, including drinking, cooking and bathing.	It is unlikely that any downstream users extract from downstream waterways for homestead water supply. Hence, this water quality objective is not assessed in this report.
Drinking water at point of supply – disinfection only	These objectives apply to all current and future licensed offtake points for town water supply and to specific sections of rivers that contribute to drinking water storages or immediately upstream of town water supply offtake points. The objectives also apply to sub-catchments or groundwater used for town water supplies.	Town water supply in the region is provided by Sydney Water. The site is not located within Sydney's drinking water catchment. Receiving waterways drain to the Hawkesbury-Nepean system downstream of Warragamba Dam. No water is extracted from downstream of the site for town water supply. Hence, this water quality objective is not assessed in this report.
Drinking water at point of supply – clarification and disinfection		
Drinking water at point of supply – groundwater		
Aquatic foods (cooked)	Refers to protecting water quality so that it is suitable for the production of aquatic foods for human consumption and aquaculture activities.	Recreational fishers may use downstream waterways. However, the trigger values for aquatic foods apply to aquaculture not recreational fishing. The required level of protection will be provided by addressing the objective for aquatic ecosystems. Hence, impacts to aquatic foods are not assessed in this report.
River flow objectives		
Protect pools in dry times	Protect natural water levels in pools of creeks and rivers and wetlands during periods of no flows.	Changes to hydrologic regimes in downstream watercourses are described in Table 6.3 (see item 2).
Protect natural low flows	Share low flows between the environment and water users and fully protect very low flows.	
Protect important rises in water levels	Protect or restore a proportion of moderate flows and high flows.	
Maintain wetland and floodplain inundation	Maintain or restore the natural inundation patterns and distribution of floodwater supporting natural wetland and floodplain ecosystems.	

Table 6.5 **Assessment of water quality and river flow objectives**

Environmental value	Objective	Application to project
Maintain natural flow variability	Maintain or mimic natural flow variability in all streams.	
Manage groundwater for ecosystems	Maintain groundwater within natural levels and variability, critical to surface flows and ecosystems.	
Minimise effects of weirs and other structures	Minimise the impact of instream structures.	A 15.3 ML dam is proposed on Watercourse B. The dam will be designed and constructed to industry best practice standards to minimise risks and impacts.

7 Water licensing

7.1 Approvals

As discussed in Section 2.1.1ii, the project is an SSD and as such, there is no requirement to obtain approvals under the WM Act, including water use, water management work or controlled activity approvals, in accordance with Section 4.41 of the EP&A Act. However, the quarry operations must hold WALs to account for any surface water and groundwater take during the quarry operations.

7.2 Groundwater

The groundwater supply system is expected to meet the total operational water demand approximately 40% of the time (see water balance model results in Section 5.3). This is equivalent to a long-term average abstraction rate of 20 ML/year. However, higher abstraction rates (up to the total project water requirement of 47 ML /year) may be required during dry periods when there is minimal surface water available.

A WAL will need to be purchased either by a Controlled Allocation (when the NSW Government releases water to the market) or from a current holder of water in the same groundwater source.

Table 7.1 presents the pathway proposed to secure the required groundwater allocation for the project. A Registration of Interest (RoI) for a groundwater allocation from the Sydney Basin Central Groundwater Source has been submitted via the 2020 Controlled allocation order for a 50 ML/year water entitlement. This exceeds the above-mentioned theoretical maximum groundwater abstraction rate of 47 ML/year. The receipt for the RoI is provided in Appendix F.

Table 7.1 Water allocation sought

Type	Licence number	Water Source	Entitlement sought (units)	Maximum groundwater take (ML/year)
Groundwater	Expression of interest 2020 Controlled allocation order	Sydney Basin Central Groundwater Sources	50 units	50

Note: Unit volume for a WAL is set in the WSP and is generally 1 ML per unit

7.3 Surface water

7.3.1 Water take

Dams that are solely for the capture, containment or recirculation of drainage, consistent with best management practice to prevent the contamination of a water source, that are located on a minor stream are considered to be excluded works under Schedule 1, item 3 of the NSW Water Management (General) Regulation 2018. The water management dam is an excluded work under this definition as the primary use of the dam is for water quality control by capturing sediment-laden runoff and retaining sediment to prevent pollution of the downstream receiving environment. Additionally, the dam is located on a first order watercourse which is a minor stream.

Water stored within the water management dam is proposed to be reused for dust suppression activities and to supply the sand processing plant. The take of water from the water management dam is exempt from requiring a licence under Schedule 4, item 12 of the NSW Water Management (General) Regulation 2018.

7.3.2 Harvestable rights

Under Section 53 of the WM Act, owners or occupiers of a landholding are entitled to collect a proportion of the runoff from their property in one or more dams located on a minor stream or unmapped stream and use the water without the need for a licence or water supply work or water use approvals. Harvestable Rights Orders are published in the NSW Government Gazette and specify the rules relating to harvestable rights.

In the Central and Eastern Divisions of NSW (where the project is located), landholders may capture, store and use up to 10% of the average regional runoff for their property. Dams that are solely for the capture, containment or recirculation of drainage, consistent with best management practice to prevent the contamination of a water source, that are located on a minor stream are not included in harvestable rights calculations.

DLALC's current landholding that is within or adjacent to the project site is 1,296 ha. This area excludes the parcel of land in the north-eastern corner of the project site that is subject to a permissive occupancy. The Maximum Harvestable Right Calculator provided by WaterNSW was used to determine the maximum harvestable right for the site of 103 ML (Appendix I).

There is an existing small farm dam that is located within DLALC's landholding to the north of the project site. This dam is estimated to have a capacity of less than 1 ML. The proposed water management dam is not included within the harvestable rights calculations as it fulfills the definition of a dam that is solely for the capture, containment or recirculation of drainage, consistent with best management practice to prevent the contamination of a water source, that are located on a minor stream. Therefore, the remaining harvestable rights for the project is 102 ML.

The predicted maximum volume of clean catchment runoff captured by the water management dam in an average year is 26 ML/year. This occurs in year 10 of the quarry schedule when the clean water catchment area is greatest (see Table 5.2). As this volume is within the calculated maximum harvestable rights, there is no licensing required for the capture or use of clean runoff at the site.

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Abbreviations

AHD	Australian Height Datum
AIP	Aquifer Interference Policy
ALS	Australian Laboratory Services
AWBM	Australian Water Balance Model
BOM	Bureau of Meteorology
CRD	cumulative rainfall departure
Cv	runoff coefficient
DGV	default guideline value
DLALC	Deerubbin Local Aboriginal Land Council
DO	dissolved oxygen
DPIE	NSW Department of Planning, Industry and Environment
EC	electrical conductivity
EMM	EMM Consulting Pty Limited
EP&A Act	<i>Environmental Planning and Assessment Act 1979</i>
GDE	groundwater dependent ecosystem
K	hydraulic conductivity
LOR	limit of reporting
L/s	litre per second
m/day	metres per day
mbgl	metres below ground level
mg/L	milligrams per litre
ML	megalitre
ML/day	megalitre per day
ML/year	megalitre per year
mV	millivolt
NATA	National Association of Testing Authorities
Redox	oxygen reduction potential
RoI	registration of interest
S	storativity
SEARs	Secretary's Environmental Assessment Requirements
SILO	Scientific Information for Land Owners
SSD	State significant development
T	transmissivity
TDS	total dissolved solids
μS/cm	microsiemens per centimetre

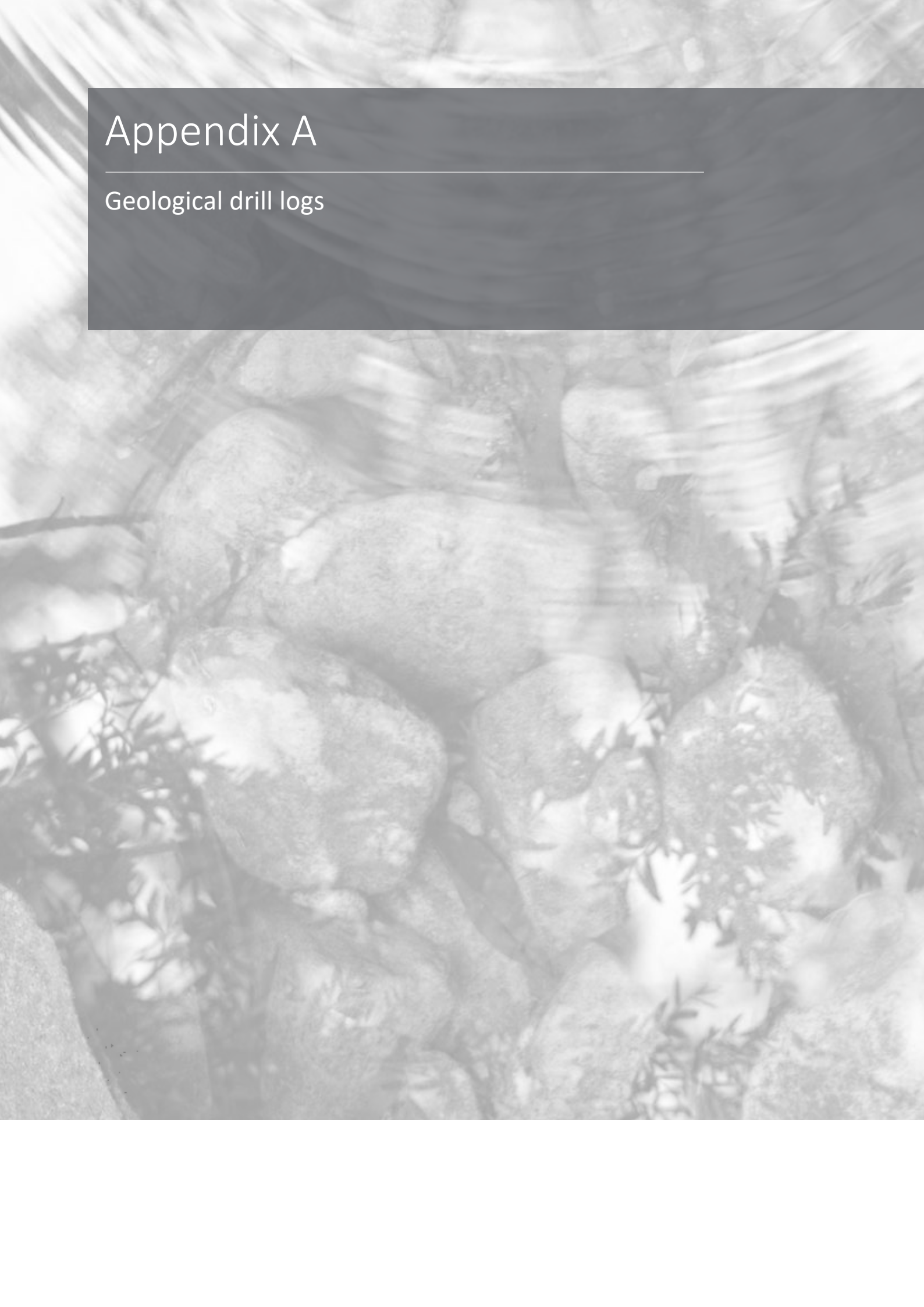
WAL	water access licence
WM Act	<i>NSW Water Management Act 2000</i>
WSP	water sharing plan

Glossary

- **Shallow aquifer** - which occurs as the saturated zone within the Maroota Sand and the eluvial sand (at the eastern side of the site); and
- **Deep aquifer** - is located within the consolidated Hawkesbury Sandstone below the weathered zone and includes the regional water table and all groundwater below in the sandstone below it.
- **Maroota sand** - A Tertiary sedimentary geological unit accumulated along the former course of the Nepean River and made up of a poorly sorted, fine to coarse grained unconsolidated to partly consolidated sand with clay lenses and local gravel rich zones. Randomly occurring discontinuous clay lenses up to 13 m thick have been reported from within the Maroota Sand unit.
- **Eluvial sand** - Weathering of the irregular erosional surface of the Hawkesbury Sandstone during the late Tertiary and Quaternary has resulted in a soft, friable, easily crushed sediment/rock of highly variable thickness (2 to 15 m in thickness).
- **Hawkesbury Sandstone** – a flat-lying medium to coarse grained, quartz sandstone, sub-divided into two contrasting sandstone facies, the sheet sandstone facies: medium to coarse sand, granules and small rounded pebbles; and massive sandstone facies: much higher amount of clay and much less primary macro-porosity.
- **Maroota Sands Swamp Forest groundwater dependent ecosystem (GDE)** – Located at the eastern edge of the extraction area and within Watercourse A that flows east to west through the centre of the site. Interestingly this GDE is located off the mapped extent of the Maroota Sand deposit and appears to be likely maintained by shallow groundwater beneath Watercourse A.
- **Theis equation** - An analytic solution for the drawdown for non-steady groundwater flow and assumes radial flow towards an abstraction point. Drawdown at any point at a given time is directly proportional to the pumping rate and inversely proportional to aquifer transmissivity and aquifer storativity.

Appendix A

Geological drill logs



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REPORT No GLA2017-01

APPENDICES

INVESTIGATION OF SAND & SANDSTONE RESOURCES

MAROOTA

NSW

Report Prepared For Deerubbin Local Aboriginal Land Council

Graham Lee
BSc, FAusIMM, CP (Geo)

April 2017

APPENDIX 1

DRILL HOLE COLLAR SURVEY INFORMATION

DLALC - MAROOTA SAND DRILL HOLE COLLARS

Hole ID	MGA Zone 56 mE	MGA Zone 56 mN	Elev AHD	Total Depth
DM01-AC	313340	6295812	204.6	12.0
DM02S-AC	313328	6295727	201.1	10.0
DM02D-RCP	313322	6295723	200.1	31.0
DMDDH03	313044	6295428	192.7	45.5
DM04-RCP	313124	6295820	185.6	18.0
DM05-AC	313278	6295626	192.0	7.0
DMDDH05	313277	6295625	192.0	27.0
DM06-AC	312814	6295833	165.0	8.0
DMDDH07	312608	6295585	193.2	60.0
DMDDH09	312355	6295918	187.9	42.5
DMDDH10	312368	6295606	173.8	35.1
DMDDH11	311882	6296206	172.3	35.1

DLALC - MAROOTA SAND SURVEY

Hole ID	Azimuth	Dip	Total Depth
DM01-AC	360	90	12.0
DM02S-AC	360	90	10.0
DM02D-RCP	360	90	31.0
DMDDH03	360	90	45.5
DM04-RCP	360	90	18.0
DM05-AC	360	90	7.0
DMDDH05	360	90	27.0
DM06-AC	360	90	8.0
DMDDH07	360	90	60.0
DMDDH09	360	90	42.5
DMDDH10	360	90	35.1
DMDDH11	360	90	35.1

APPENDIX 2

COMPILATION OF DRILL HOLE DATA

**Open Hole Graphic Logs, Chip Photographs, and Lithological Logs
DDH Graphic Logs, Core Photographs, and Lithological Logs**

Drill Holes Included:

DM01-AC

DM02S-AC

DM02D-RCP

DMDDH03

DM04-RCP

DM05-AC

DMDDH05

DM06-AC

DMDDH07

DMDDH09

DMDDH10

DMDDH11

Legend:

	CY	Clay
	SLT	Silt
	SD	Sand
	SS	Sandstone
	CGT	Conglomerate
	Fe	Iron Stone
	NS	Core Loss

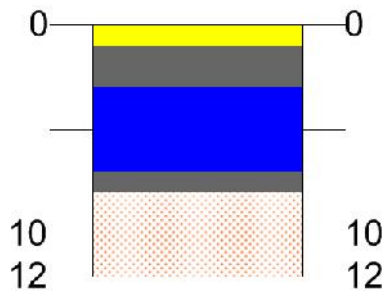
DM01-AC

Graphic Log

Chip tray photograph

Lithological log

Log for DM01-AC





DMOI - 2011

DLALC MAROOTA SAND PROJECT - JANUARY 2017 AC and RCP DRILL HOLES

Hole ID	From (m)	To (m)	Major Lithology	Maj Grain Size	Maj Sorting	Colour	Minor Lithology	Min Grain Size	Min Sorting	Colour	Comments	Sample No
DM01-AC	0	1	SAND	Medium	Well	Cream+red	Clay			Cream+Red	Fe stone red. Base of Tertiary sand	77340
DM01-AC	1	2	SILT			Cream+red	Clay			Cream+Red	Fe stone red. Tertiary clay	77341
DM01-AC	2	3	SILT			Red + White	Clay			Red + White	Tertiary Clay	77342
DM01-AC	3	4	CLAY			White + P brn	Silt			White + P brn	Tertiary Clay	77343
DM01-AC	4	5	CLAY			White + cream	Silt			P brn	Tertiary Clay	77344
DM01-AC	5	6	CLAY			P brn	Silt			P brn	Tertiary Clay	77345
DM01-AC	6	7	CLAY			P brn	Silt			P brn	Tertiary Clay	77346
DM01-AC	7	8	SILT			P brn	Clay			P brn	Tertiary Clay with fine sand.	77347
DM01-AC	8	9	SANDSTONE	V fine-fine	Moderate	P brn	Clay + silt			P brn	Top of Hawkesbury Sandstone.	77348
DM01-AC	9	10	SANDSTONE	V fine-fine	Moderate	P brn	Clay + silt			P brn		77349
DM01-AC	10	11	SANDSTONE	Fine	Moderate	P brn	Clay			P brn	With thin brown Fe stone layers	77350
DM01-AC	11	12	SANDSTONE	V fine-fine	Moderate	P brn	Clay			P brn	With lots of cyclone scale contamination in sample DO NOT TEST. EOH 12.0m	77351

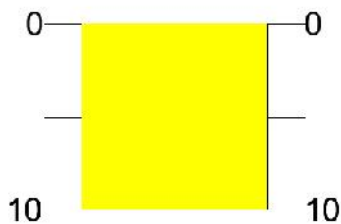
DM02S-AC

Graphic Log

Chip tray photograph

Lithological log

Log for DM02S-AC





1107-2017

DLALC MAROOTA SAND PROJECT - JANUARY 2017 AC and RCP DRILL HOLES

Hole ID	From (m)	To (m)	Major Lithology	Maj Grain Size	Maj Sorting	Colour	Minor Lithology	Min Grain Size	Min Sorting	Colour	Comments	Sample No
DM02S-AC	0	1	SAND	Medium	Moderate	Grey + brn	Fe stone	Lumps		Brown	With minor pebbles & clay	77301
DM02S-AC	1	2	SAND	Fine-med	Moderate	Grey + red	Fe stone	Lumps		Brown	Plus clay, & 2 hard Fe stone layers	77302
DM02S-AC	2	3	SAND	Fine-med	Moderate	Red + cream	Fe stone	Lumps		Brown	Plus clay	77303
DM02S-AC	3	4	SAND	Fine-med	Moderate	Red + cream	Fe stone	Fine		Brown	Plus clay	77304
DM02S-AC	4	5	SAND	Fine-med	Moderate	Cream + orang	Fe stone	Fine		Brown	Plus clay	77305
DM02S-AC	5	6	SAND	Medium	Well	Cream+pink	Clay			Cream+pink	Good sand	77306
DM02S-AC	6	7	SAND	Medium	Well	Brn-orange	Clay			Brn-orange	Good sand	77307
DM02S-AC	7	8	SAND	Fine-med	Moderate	Cream + grey	Silt			P grey	Clay	77308
DM02S-AC	8	9	SAND	Fine-med	Moderate	Cream	Silt			Cream	Clay	77309
DM02S-AC	9	10	SAND	Fine-med	Moderate	P brn	Clay			P brn	EOH 10.0m	77310

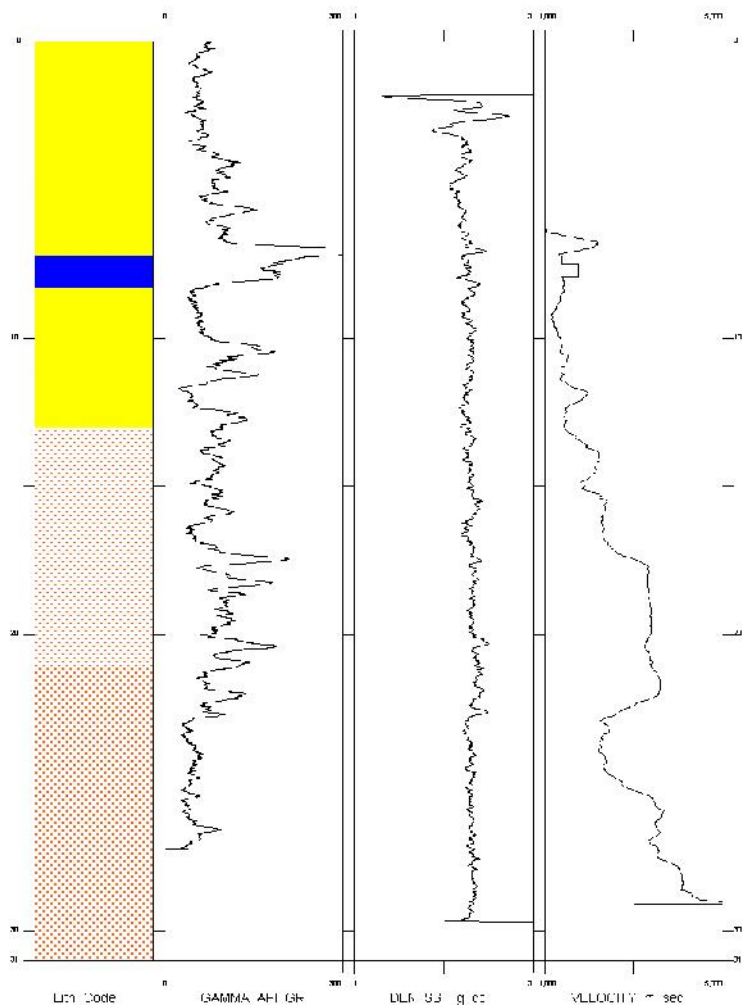
DM02D-RCP

Graphic Log with geophysical plots

Chip tray photograph

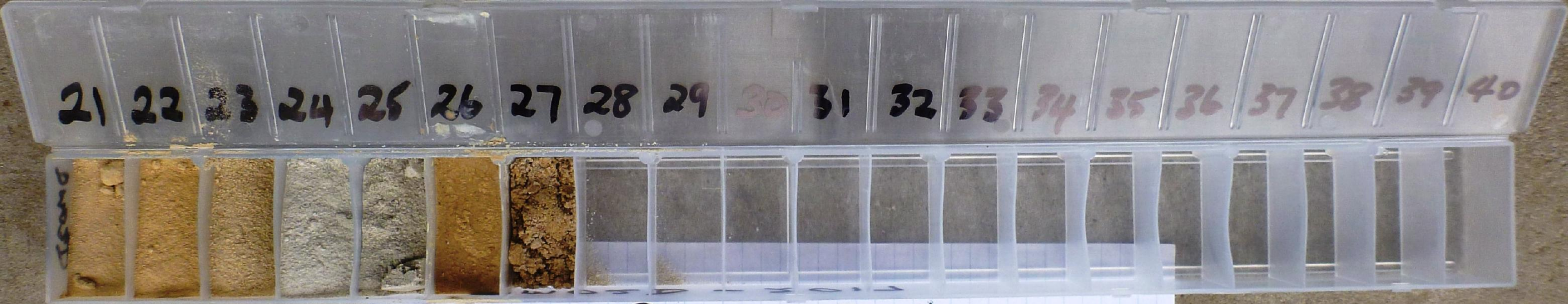
Lithological log

Log for DM02D-RCP





DMO 2 D - 2017



Dm02D-2017

DLALC MAROOTA SAND PROJECT - JANUARY 2017 AC and RCP DRILL HOLES

Hole ID	From (m)	To (m)	Major Lithology	Maj Grain Size	Maj Sorting	Colour	Minor Lithology	Min Grain Size	Min Sorting	Colour	Comments	Sample No
DM02D-RCP	0	1	SAND	Fine-med	Mod-well	Orange	Clay			Orange		77311
DM02D-RCP	1	2	SAND	Medium	Mod	red	Fe Stone	Lumps		Red + White	Plus clay	77313
DM02D-RCP	2	3	SAND	Medium	Moderate	Orange-brn	Fe Stone			Brown	Hard Fe stone stopped penetartion. Hammered to 3.0m& cased off.	77314
	3	4	SAND	Medium	Moderate	Cream	Fe Stone			Red + White	Fe stone at top & bottom of sample.	77315
DM02D-RCP	4	5	SAND	Medium	Moderate	P pink	Clay			P pink	Through Fe stone. Cased at 3.0m	77316
DM02D-RCP	5	6	SAND	Fine	Moderate	Cream	Fe Stone	Lumps		Brown	Small sample after casing. Some foam pack in sample.	77317
DM02D-RCP	6	7	SAND	Fine	Moderate	P brown	Clay			P brown	Sand to 7.2m	77318
DM02D-RCP	7	7.2	SAND	Fine	Moderate	P brown	Clay			P brown		77319
DM02D-RCP	7.2	8	CLAY	Fine	Moderate	Cream	Silt			Cream		
DM02D-RCP	8	8.3	CLAY	Fine	Moderate	Cream	Silt			Cream		77320
DM02D-RCP	8.3	9	SAND	Fine	Moderate	P brown	Clay+silt			P brown		
DM02D-RCP	9	10	SAND	Fine	Moderate	Cream	V clay			Cream		77321
DM02D-RCP	10	11	SAND	V fine-fine	Well	Cream	V clay			Cream		77322
DM02D-RCP	11	12	SAND	Fine	Well	Cream	Clay+silt			Cream		77323
DM02D-RCP	12	13	SAND	Fine	Well	Cream	Clay+silt			Cream	Air core refusal at 12.0m. Samll sample. Hammer drilled to EOH.	77324
DM02D-RCP	13	14	SANDSTONE	Fine	Well	Cream	V clay+silt			Cream	Good sample	77325
DM02D-RCP	14	15	SANDSTONE	Fine-med	Moderate	White	Clay			White	Good sample	77326
DM02D-RCP	15	16	SANDSTONE	Medium	Moderate	White	Clay			White	Good sampple	77327
DM02D-RCP	16	17	SANDSTONE	Medium	Moderate	White	Clay			White	Smaller sample	77328
DM02D-RCP	17	18	SANDSTONE	Fine	Moderate	Cream	Clay			Cream	Smaller sample	77329
DM02D-RCP	18	19	SANDSTONE	Fine-med	Moderate	Cream	Clay			Cream	Smaller sample. Moist at rod change.	77330
DM02D-RCP	19	20	SANDSTONE	Fine-med	Moderate	Cream+p brn	Clay			Cream+p brn	Moderate sized sample.	77331
DM02D-RCP	20	21	SANDSTONE	Fine-med	Moderate	P brown	Clay			P brown	Small sample with unbroken SS lumps.	77332
DM02D-RCP	21	22	SANDSTONE	Fine-med	Moderate	P brown	Clay			P brown	Small sample with unbroken SS lumps.	77333
DM02D-RCP	22	23	SANDSTONE	Fine-med	Moderate	P brown	Clay			P brown	Dry	77334
DM02D-RCP	23	24	SANDSTONE	Fine-med	Moderate	White	Clay			White	Dry	77335
DM02D-RCP	24	25	SANDSTONE	Fine-med	Moderate	White	Clay			White	Dry	77336
DM02D-RCP	25	26	SANDSTONE	Fine-med	Moderate	P brown	Clay			P brown	Water at rod change. Wet sample	77337
DM02D-RCP	26	27	SANDSTONE	Medium	Moderate	Cream	Clay			Cream	No bagged sample - Chip tray sample	77338
DM02D-RCP	27	28	SANDSTONE								No samples - wet	
DM02D-RCP	28	29	SANDSTONE								No samples - wet	
DM02D-RCP	29	30	SANDSTONE								No samples - wet	
DM02D-RCP	30	31	SANDSTONE								No samples - wet. EOH 32.0m	

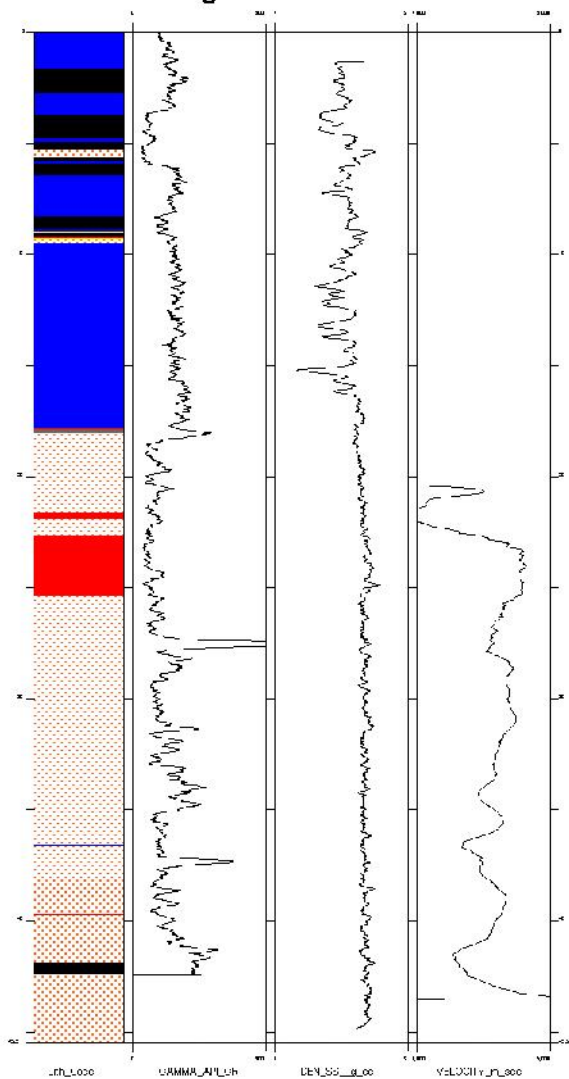
DMDDH03

Graphic Log with geophysical plots

Core tray photograph

Lithological log

Log for DMDDH03





DLALC - MAROOTA PROJECT 2017 DIAMOND DRILLING LITHOLOGICAL LOGS

Hole ID	From	To	Int	Lith Code	Lithology	Grain size	Colour	Drill Depth	Drilled Int (m)	Core Rec (m)	Comment
DMDDH03	0.000	0.930	0.930		CLAY		Orange-brn				Fine sand & silt.
DMDDH03	0.930	1.630	0.700		CLAY		Orange				With cream & red mottle. Sand & silt. Broken core.
DMDDH03	1.630	2.750	1.120		CORE LOSS			3.0	3.0	1.7	Sand??
DMDDH03	2.750	3.500	0.750		CLAY		Orange	3.50	0.5	0.7	
DMDDH03	3.500	3.700	0.200		CLAY		P brown				Soft, plastic.
DMDDH03	3.700	4.800	1.100		CORE LOSS			4.80	1.3	0.2	Sand??
DMDDH03	4.800	4.920	0.120		CLAY		P brown				
DMDDH03	4.920	5.320	0.400		CORE LOSS						Sand??
DMDDH03	5.320	5.400	0.080		SANDSTONE		Red	5.40	0.6	0.2	Granule conglomerate. Soft plastic clay matrix at top; hard red Fe cement at bottom.
DMDDH03	5.400	5.640	0.240		SANDSTONE						As above.
DMDDH03	5.640	5.800	0.160		CORE LOSS						Friable Sand??
DMDDH03	5.800	5.910	0.110		CLAY		P grey + red	6.90	1.1	0.2	
DMDDH03	5.910	6.470	0.560		CORE LOSS						Sand??
DMDDH03	6.470	7.370	0.900		CLAY		P grey	7.40	0.5	0.9	Red mottle near top. Some beds with qtz granules in clay matrix.
DMDDH03	7.370	7.900	0.530		CLAY		P grey	7.90	0.5	0.5	As above.
DMDDH03	7.900	8.310	0.410		CLAY		Grey	8.30	0.4	0.4	With qtz granule beds. Some red mottle.
DMDDH03	8.310	8.910	0.600		CORE LOSS						Sand??
DMDDH03	8.910	9.000	0.090		CLAY		Grey	9.00	0.7	0.1	Sand??
DMDDH03	9.000	9.060	0.060		SAND		Pink				Med-coarse, poor sorting. Clay matrix.
DMDDH03	9.060	9.210	0.150		CORE LOSS						Sand??
DMDDH03	9.210	9.270	0.060		Fe STONE		Red+Brown	9.30	0.3	0.1	
DMDDH03	9.270	9.310	0.040		Fe STONE		Red+Brown				
DMDDH03	9.310	9.340	0.030		SAND	Co-V coarse	Red-brn				Unconsolidated.
DMDDH03	9.340	9.490	0.150		SANDSTONE	Coarse	Red-brn				With small pebbles in clay matrix.
DMDDH03	9.490	10.040	0.550		CLAY		P grey + red	9.90	0.6	0.6	With coarse sand in some layers.
DMDDH03	10.040	10.580	0.540		CLAY		P grey + red	10.50	0.6	0.5	
DMDDH03	10.580	11.610	1.030		CLAY		P grey	11.50	1.0	1.0	Minor red mottle. (No sand)
DMDDH03	11.610	11.610	0.000		CLAY			12.40	0.9	0	Core slipped out of tube - picked up next run.
DMDDH03	11.610	12.810	1.200		CLAY		P grey	12.70	0.3	1.2	With some red mottle. V minor sandy layers with clay matrix.
DMDDH03	12.810	13.560	0.750		CLAY		P grey				As above.
DMDDH03	13.560	13.960	0.400		CLAY		Orange+grey	13.8	1.1	1.1	
DMDDH03	13.960	15.640	1.680		CLAY		Grey	15.4	1.6	1.7	With red mottle.
DMDDH03	15.640	17.830	2.190		CLAY		Grey				As above. With minor layer coarse sand in clay matrix. BASE TERTIARY
DMDDH03	17.830	17.880	0.050		Fe STONE		Brown				Soft clayey. Highly weathered. TOP HAWKESBURY SS
DMDDH03	17.880	18.070	0.190		SILTSTONE		Orange+cream				V clayey, soft, with medium grained sand.
DMDDH03	18.070	18.080	0.010		Fe STONE		Brown				
DMDDH03	18.080	18.310	0.230		SANDSTONE	Fine	Cream+orange				With clay matrix. Highly weathered. Soft. Some red.
DMDDH03	18.310	18.530	0.220		SANDSTONE	F-medium	P brown	18.30	2.9	2.9	Hard. Bedded, dip 10°.
DMDDH03	18.530	21.550	3.020		SANDSTONE	Medium	White+p brn				With D brn Fe spots (oxidised pyrite blebs).
DMDDH03	21.550	21.680	0.130		SANDSTONE	Medium	Brown				
DMDDH03	21.680	21.910	0.230		Fe STONE		D brn + orange				Moderate Fe cement. (Probably too hard to yield much sand) So coarse grained SS near bottom.
DMDDH03	21.910	22.060	0.150		SANDSTONE	Co-V coarse	Cream				Some qtz granules.
DMDDH03	22.060	22.290	0.230		SANDSTONE	Medium	Cream				
DMDDH03	22.290	22.640	0.350		SANDSTONE	Medium	Orange				Fe cement & orange clay matrix
DMDDH03	22.640	24.630	1.990		Fe STONE	Medium	Orange+brn	24.40	3.0	3.0	Medium grained sandstone with some coarser layers. D brown Fe cement on bedding & as sub vertical veins. (Yield probably low).
DMDDH03	24.630	25.360	0.730		Fe STONE	Medium	Orange+brn				As above.
DMDDH03	25.360	25.770	0.410		SANDSTONE	Medium	Orange+pink				Competent core with faint bedding.
DMDDH03	25.770	27.630	1.860		SANDSTONE	Medium	P pink	27.40	3.0	3.0	Faint bedding, dip 10°.
DMDDH03	27.630	29.750	2.120		SANDSTONE	Medium	Cream+orange				As above.
DMDDH03	29.750	29.950	0.200		SANDSTONE	Medium	Brown				Increasing Fe cement with depth.
DMDDH03	29.950	29.960	0.010		Fe STONE		D brown				
DMDDH03	29.960	30.010	0.050		SANDSTONE	Medium	Brown				With Fe cement

DLALC - MAROOTA PROJECT 2017 DIAMOND DRILLING LITHOLOGICAL LOGS

Hole ID	From	To	Int	Lith Code	Lithology	Grain size	Colour	Drill Depth	Drilled Int (m)	Core Rec (m)	Comment
DMDDH03	30.010	30.640	0.630		SANDSTONE	Medium	Cream	30.40	3.0	3.0	Graphite on bedding.
DMDDH03	30.640	31.570	0.930		SANDSTONE	Medium	Cream				As above.
DMDDH03	31.570	31.580	0.010		CLAY		Cream				Soft, plastic.
DMDDH03	31.580	32.140	0.560		SANDSTONE	Med-coarse	Cream+p or				White clayey matrix.
DMDDH03	32.140	32.860	0.720		SANDSTONE	Med-coarse	Orange+p or				Partly friable. Possible water flow unit.
DMDDH03	32.860	32.890	0.030		SANDSTONE	Fine	White				Soft white clay matrix.
DMDDH03	32.890	33.270	0.380		SANDSTONE	Co-V coarse	Orange				Some claystone clasts to 10mm across. Poorly sorted. Washed out clay clasts at end of unit - cavities. Possible water flow unit.
DMDDH03	33.270	33.580	0.310		SANDSTONE	F-medium	White	33.40	3.0	3.0	Well sorted. Graphite on bedding.
DMDDH03	33.580	33.800	0.220		SANDSTONE	F-medium	White				As above.
DMDDH03	33.800	33.810	0.010		CLAY		Grey				Soft, plastic.
DMDDH03	33.810	34.370	0.560		SANDSTONE	F-medium	White				Well sorted. Graphite on bedding.
DMDDH03	34.370	34.390	0.020		SANDSTONE	Medium	Orange				Medium grained. Fe cement.
DMDDH03	34.390	34.420	0.030		Fe STONE		D brown+or				Partly friable.
DMDDH03	34.420	36.230	1.810		SANDSTONE	Medium	P pink				With large washed out clay clast cavity, & some smaller clay clasts.
DMDDH03	36.230	36.290	0.060		SANDSTONE	F-medium	Cream+brn				Well sorted. Soft friable.
DMDDH03	36.290	36.510	0.220		SANDSTONE	Medium	White	36.40	3.0	3.0	Well sorted. Fe spots ex pyrite. Fe laminae at top with Fe lens.
DMDDH03	36.510	36.590	0.080		SANDSTONE	Medium	White				As above.
DMDDH03	36.590	36.610	0.020		CLAY		White+brn				Brown Fe, soft & sandy.
DMDDH03	36.610	37.220	0.610		SANDSTONE	Medium	White				Well sorted. Fe spots ex pyrite. Partly friable.
DMDDH03	37.220	37.390	0.170		SANDSTONE	Medium	Cream+red				Fe stained. Friable. Clayey in part.
DMDDH03	37.390	37.870	0.480		SANDSTONE	Medium	White				Bedded & jointed. Partly friable.
DMDDH03	37.870	38.040	0.170		SANDSTONE	Medium	Brown+white				Soft clayey matrix, & friable.
DMDDH03	38.040	39.390	1.350		SANDSTONE	F-medium	Cream	39.38	3.0	2.9	Orange towards base. Some graphite on bedding. Weakly bedded.
DMDDH03	39.390	39.760	0.370		SANDSTONE	F-medium	Cream+orange				Fe laminae near bottom.
DMDDH03	39.760	39.770	0.010		Fe STONE		Brown				
DMDDH03	39.770	40.220	0.450		SANDSTONE	F-medium	Cream				Well sorted. Graphite on bedding.
DMDDH03	40.220	40.390	0.170		SANDSTONE	Med-coarse	Cream+orange				With qtz granules. Well bedded.
DMDDH03	40.390	40.960	0.570		SANDSTONE	F-medium	Cream				
DMDDH03	40.960	41.380	0.420		SANDSTONE	F-medium	Orange				With Fe stone laminae.(Not hard Fe stone).
DMDDH03	41.380	41.520	0.140		SANDSTONE	F-medium	Cream+p pink				
DMDDH03	41.520	41.550	0.030		SANDSTONE	Fine	Red				With brown Fe stone laminae, broken; not hard.
DMDDH03	41.550	41.640	0.090		SANDSTONE	F-medium	Orange				
DMDDH03	41.640	41.910	0.270		SANDSTONE	F-medium	White				Partly friable.
DMDDH03	41.910	42.410	0.500		CORE LOSS			42.40	3.0	2.6	
DMDDH03	42.410	45.500	3.090		SANDSTONE	Medium	P org+cream	45.50	3.0	3.0	Graphite on bedding. Mostly massive. Some Fe banding. EOH 45.5m

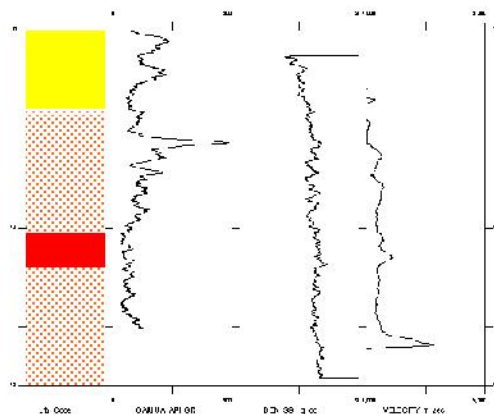
DM04-RCP

Graphic Log with geophysical plots

Chip tray photograph

Lithological log

Log for DM04-RCP





DM04 - 2017

DLALC MAROOTA SAND PROJECT - JANUARY 2017 AC and RCP DRILL HOLES

Hole ID	From (m)	To (m)	Major Lithology	Maj Grain Size	Maj Sorting	Colour	Minor Lithology	Min Grain Size	Min Sorting	Colour	Comments	Sample No
DM04-RCP	0	1	SAND	Fine-med	Well	Brown	Clay			Brown	Good sample - Air core	77359
DM04-RCP	1	2	SAND	Fine-med	Well	White	Clay			White	Good sample - Air core	77360
DM04-RCP	2	3	SAND	Fine	Well	Cream	Clay			Cream	Good sample - Air core	77361
DM04-RCP	3	4	SAND	Fine	Moderate	White	Clay			White	Hard at 4.5m. Moved site and hammer drilled to EOH.	77363
DM04-RCP	4	5	SANDSTONE	Fine	Moderate	Cream	Clay			Cream		77364
DM04-RCP	5	6	SANDSTONE	Fine	Moderate	P brown	Clay			P brown		77365
DM04-RCP	6	7	SANDSTONE	Fine	Moderate	White	Clay			White		77366
DM04-RCP	7	8	SANDSTONE	V fine	Moderate	White	Clay			White		77367
DM04-RCP	8	9	SANDSTONE	Fine	Moderate	White	Clay			White	Sandstone lumps.	77368
DM04-RCP	9	10	SANDSTONE	Fine-med	Moderate	White	Clay			White		77369
DM04-RCP	10	10.3	SANDSTONE	Fine-med	Moderate	White	Clay			White		77370
DM04-RCP	10.3	11	Fe STONE	Fine-med	Moderate	Brown	Clay			Brown	Fe stone chips. Sandy.	
DM04-RCP	11	12	Fe STONE	Medium	Moderate	Red-brn	Clay			Red-brn	Fe stone chips. Sandy.	77371
DM04-RCP	12	13	SANDSTONE	Medium	Poor	Brn+amber	Clay			Amber	Water at 13m Small damp sample.	77372
DM04-RCP	13	14	SANDSTONE	Medium	Poor	Amber	Clay			Amber	Small sample	77373
DM04-RCP	14	15	SANDSTONE	Medium-coarse	Poor	Amber	Clay			Amber	V small sample. End of sampling	77374
DM04-RCP	15	16	SANDSTONE								No sample	
DM04-RCP	16	17	SANDSTONE								No sample	
DM04-RCP	17	18	SANDSTONE								EOH 18.0m in water.	

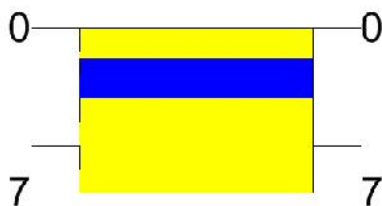
DM05-AC

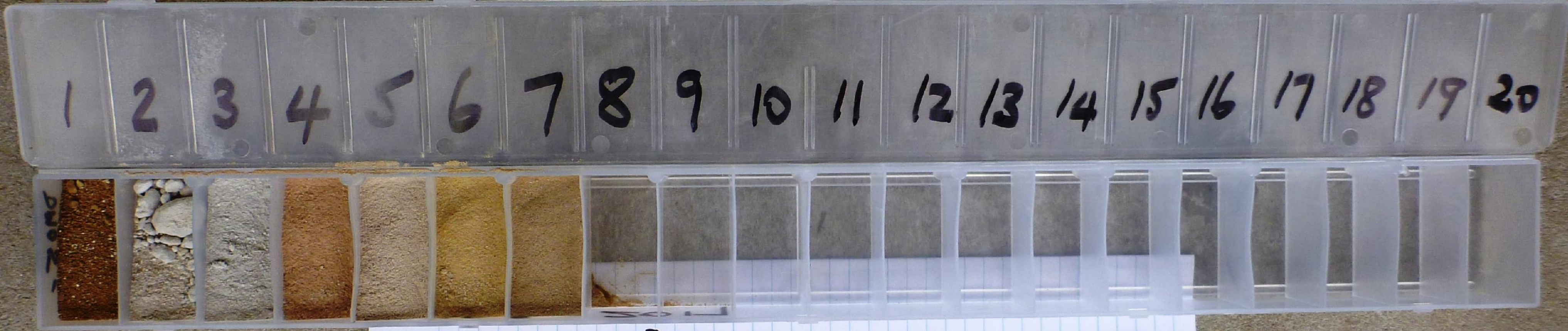
Graphic Log

Chip tray photograph

Lithological log

Log for DM05-AC





DM05-2017

DLALC MAROOTTA SAND PROJECT - JANUARY 2017 AC and RCP DRILL HOLES

Hole ID	From (m)	To (m)	Major Lithology	Maj Grain Size	Maj Sorting	Colour	Minor Lithology	Min Grain Size	Min Sorting	Colour	Comments	Sample No
DM05-AC	0	1	SAND	Fine-med	Mod-well	Brown	Clay			Brown	Slope wash, less clay than most samples.	77352
DM05-AC	1	1.3	SAND	Fine-med	Mod-well	Cream	Clay			White		77353
DM05-AC	1.3	2	CLAY			White	Silt			White		
DM05-AC	2	3	CLAY			White	Silt			White	Just into sand at 3.0m	77354
DM05-AC	3	4	SAND	Fine	Moderate	Orange	Clay			White	Thin clayey layers	77355
DM05-AC	4	5	SAND	Fine	Moderate	Orange	Clay			White	Thin clayey layers	77356
DM05-AC	5	6	SAND	Fine	Moderate	P brn	Clay			P brn	Thin white layers. Water at 6.0m	77357
DM05-AC	6	7	SAND	Fine	Moderate	P brn	Clay			P brn	V hard no penetration below 6.7m. EOH 6.7m	77358

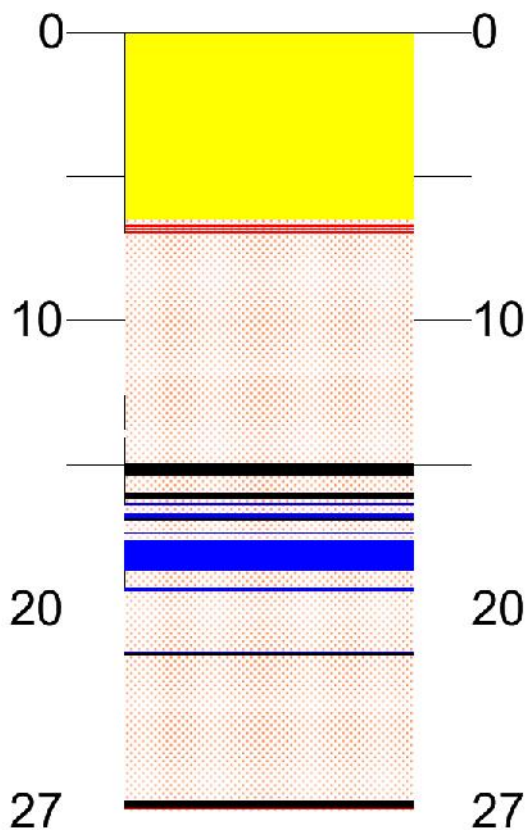
DMDDH05

Graphic Log

Core tray photograph

Lithological log

Log for DMDDH05





DLALC - MAROOTA PROJECT 2017 DIAMOND DRILLING LITHOLOGICAL LOGS

Hole ID	From	To	Int	Lith Code	Lithology	Grain size	Colour	Drill Depth	Drilled Int (m)	Core Rec (m)	Comment
DMDDH05	0.000	6.500	6.500		SAND+CLAY		P brown				Open hole to bottom of air cored hole. See logs for DM05-AC for detail.
DMDDH05	6.500	6.700	0.200		SANDSTONE	F-medium	White				with orange staining, clay matrix. Some qtz granules to 5mm dia between 6.60 to 6.66m.
DMDDH05	6.700	6.770	0.070		Fe STONE		D brown				With qtz granules to 5mm in bottom 1/2. Some f-med grained orange sandstone interbedded.
DMDDH05	6.770	6.835	0.065		SANDSTONE	F-medium	Orange				
DMDDH05	6.835	6.850	0.015		Fe STONE		D brown				
DMDDH05	6.850	6.920	0.070		SANDSTONE	F-medium	Orange				Fe stone laminae
DMDDH05	6.920	7.010	0.090		Fe STONE	Fine	D brown				With some pods orange sandstone.
DMDDH05	7.010	7.180	0.170		SANDSTONE	F-medium	Red				with scattered qtz granules. Brown at top.
DMDDH05	7.180	7.450	0.270		SANDSTONE	F-medium	Orange				V clayey. Top grades into overlying red sandstone.
DMDDH05	7.450	8.480	1.030		SANDSTONE	F-medium	White				Well bedded, with pale coloured laminae on bedding. Dip <5°.
DMDDH05	8.480	9.260	0.780		SANDSTONE	F-medium	P pink + P Or				As above. Some small scale X beds dip approx 10°.
DMDDH05	9.260	9.425	0.165		SANDSTONE	F-medium	Orange	9.4	2.9	2.95	V clayey.
DMDDH05	9.425	9.840	0.415		SANDSTONE	F-medium	Orange				With some thin M-coarse beds & scattered granules. V clayey. Some weak Fe cemented laminae.
DMDDH05	9.840	9.990	0.150		SANDSTONE	F-medium	Orange				V clayey, with Fe laminae.
DMDDH05	9.990	10.360	0.370		SANDSTONE	F-medium	Orange				V clayey.
DMDDH05	10.360	10.750	0.390		SANDSTONE	F-medium	Or + P pink				V clayey.
DMDDH05	10.750	12.220	1.470		SANDSTONE	F-medium	P Or + pink				Colour banded. Mostly thinly bedded.
DMDDH05	12.220	12.340	0.120		SANDSTONE	F-medium	Orange+red	12.5	3.0	2.95	V clayey. Some Fe coloured beds (not Fe stone).
DMDDH05	12.340	12.570	0.230		SANDSTONE	F-medium	Orange				
DMDDH05	12.570	12.585	0.015		Fe STONE		Brown				
DMDDH05	12.585	13.765	1.180		SANDSTONE	F-medium	P Orange+P brn				Well bedded. Cross bedding dip ranges from 10° to 35°
DMDDH05	13.765	13.785	0.020		Fe STONE		Brown				
DMDDH05	13.785	14.075	0.290		SANDSTONE	F-medium	P brown				
DMDDH05	14.075	14.090	0.015		Fe STONE		Brown				
DMDDH05	14.090	14.610	0.520		SANDSTONE	F-medium	Cream + P Or				
DMDDH05	14.610	14.690	0.080		SANDSTONE	F-medium	P brown				With brown Fe enriched laminae.
DMDDH05	14.690	14.950	0.260		SANDSTONE	F-medium	Cream + P Or				Friable at bottom of unit.
DMDDH05	14.950	15.400	0.450		CORE LOSS			15.4	3.0	2.6	
DMDDH05	15.400	15.960	0.560		SANDSTONE	F-medium	Cream				Grade to brown at bottom. Over cored core with loss.
DMDDH05	15.960	16.200	0.240		CORE LOSS						
DMDDH05	16.200	16.300	0.100		SANDSTONE	F-medium	D brown	16.3	0.7	0.7	With Fe stone laminae & layering.
DMDDH05	16.300	16.400	0.100		SHALE		D grey				Laminite, shale & paler grey siltstone. 20° dip on bottom of unit.
DMDDH05	16.400	16.670	0.270		SANDSTONE	F-medium	P grey				Massive SS. Rippled bottom contact.
DMDDH05	16.670	16.850	0.180		SHALE		D grey				Laminite, shale & paler grey siltstone. Slickenside bottom contact dip 50°.
DMDDH05	16.850	16.930	0.080		CORE LOSS						
DMDDH05	16.930	17.320	0.390		SANDSTONE	F-medium	P grey				Massive SS.
DMDDH05	17.320	17.380	0.060		SHALE		D grey				Laminite, shale & paler grey siltstone.
DMDDH05	17.380	17.610	0.230		SANDSTONE	F-medium	P grey				Massive SS.
DMDDH05	17.610	18.400	0.790		SHALE		D grey	18.4	2.1	2.1	Laminite, shale & paler grey siltstone.
DMDDH05	18.400	18.650	0.250		SHALE		D grey				Laminite, shale & paler grey siltstone.
DMDDH05	18.650	18.710	0.060		SANDSTONE	Fine	P grey				Silty. With thin darker grey shaly wisps.
DMDDH05	18.710	18.880	0.170		SANDSTONE	Medium	Orange				With scattered qtz granules. Some brown Fe enriched laminae.
DMDDH05	18.880	18.895	0.015		Fe STONE		Brown				Dip 25°.
DMDDH05	18.895	19.025	0.130		SANDSTONE	Medium	Orange				With small d grey shale rip up clasts.
DMDDH05	19.025	19.035	0.010		Fe STONE		Brown				
DMDDH05	19.035	19.160	0.125		SANDSTONE	Medium	Orange				With interbedded grey shale lenses at bottom.
DMDDH05	19.160	19.270	0.110		SANDSTONE	F-medium	P pink				
DMDDH05	19.270	19.390	0.120		SHALE		D grey				With minor thin Fe stained beds.
DMDDH05	19.390	19.850	0.460		SANDSTONE	F-medium	P pink				Mostly well bedded with mica & graphite on bedding planes. Bedding dip 10°.
DMDDH05	19.850	19.950	0.100		SANDSTONE	F-medium	Grey				with orange & brn Fe staining.

DLALC - MAROOTA PROJECT 2017 DIAMOND DRILLING LITHOLOGICAL LOGS

Hole ID	From	To	Int	Lith Code	Lithology	Grain size	Colour	Drill Depth	Drilled Int (m)	Core Rec (m)	Comment
DMDDH05	19.950	19.990	0.040		SANDSTONE		P brown				Fe cemented SS. (Not hard Fe Stone)
DMDDH05	19.990	20.050	0.060		SANDSTONE	F-medium	Orange+ cream				Fe cemented.
DMDDH05	20.050	20.070	0.020		SANDSTONE		Brown				Fe cemented SS. (Not hard Fe Stone)
DMDDH05	20.070	20.390	0.320		SANDSTONE	Medium	Brn+Or+cream				Bedded, dip 20°. Some thin coarser thin beds.
DMDDH05	20.390	20.460	0.070		SANDSTONE	Med-coarse	Cream				
DMDDH05	20.460	21.460	1.000		SANDSTONE	F-medium	Cream	21.4	3.0	3.1	With orange laminae. Well bedded, dip 20°. Clay on bedding.
DMDDH05	21.460	21.510	0.050		CLAYSTONE		Cream				Soft, plastic.
DMDDH05	21.510	21.585	0.075		CORE LOSS						
DMDDH05	21.585	22.775	1.190		SANDSTONE	Medium	Cream				With some coarser beds.
DMDDH05	22.775	22.800	0.025		Fe STONE		Brown	22.8	1.4	1.3	
DMDDH05	22.800	23.340	0.540		SANDSTONE	Fine	Cream				Mostly well bedded.
DMDDH05	23.340	24.390	1.050		SANDSTONE	F-medium	Orange	24.4	1.6	1.6	
DMDDH05	24.390	24.570	0.180		SANDSTONE	F-medium	P orange				
DMDDH05	24.570	24.840	0.270		SANDSTONE	Fine	Cream+p grey				Clayey.
DMDDH05	24.840	25.565	0.725		SANDSTONE	Med-coarse	P grey				
DMDDH05	25.565	26.205	0.640		SANDSTONE	Med-coarse	P orange				With some scattered qtz granules.
DMDDH05	26.205	26.220	0.015		Fe STONE		Brown				
DMDDH05	26.220	26.650	0.430		SANDSTONE	Medium	Orange				Some ground core faces.
DMDDH05	26.650	26.910	0.260		CORE LOSS						
DMDDH05	26.910	26.930	0.020		Fe STONE		Brown				
DMDDH05	26.930	27.000	0.070		SANDSTONE	Medium	Orange	27.0	2.6	2.6	EOH 27.0m

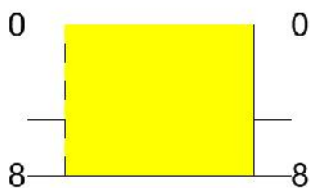
DM06-AC

Graphic Log

Chip tray photograph

Lithological log

Log for DM06-AC





DM 06-2017

DLALC MAROOTA SAND PROJECT - JANUARY 2017 AC and RCP DRILL HOLES

Hole ID	From (m)	To (m)	Major Lithology	Maj Grain Size	Maj Sorting	Colour	Minor Lithology	Min Grain Size	Min Sorting	Colour	Comments	Sample No
DM06-AC	0	1	SAND	Fine-med	Moderate	P brn+grey	Clay			P brn		77375
DM06-AC	1	2	SAND	Fine	Moderate	P brown	Clay			P brn	Some soft layers	77376
DM06-AC	2	3	SAND	V fine-fine	Moderate	Cream	Clay			Cream	Some soft layers	77377
DM06-AC	3	4	SAND	Fine-med	Moderate	Cream+brn	Clay			Cream+brn	Small sample	77378
DM06-AC	4	5	SAND	Fine-med	Moderate	P brown	Clay			P brn	Small sample. Some harder layers	77379
DM06-AC	5	6	SAND	Fine	Moderate	Cream	Clay			Cream	Water at 5.7m at rod change.	77380
DM06-AC	6	7	SAND	Fine	Moderate	Cream	Clay			Cream	Large sample	77381
DM06-AC	7	8	SAND	Fine-med	Moderate	P grey+red	Fe stone			Red	Hard at 8.0m EOH 8.0m	77382

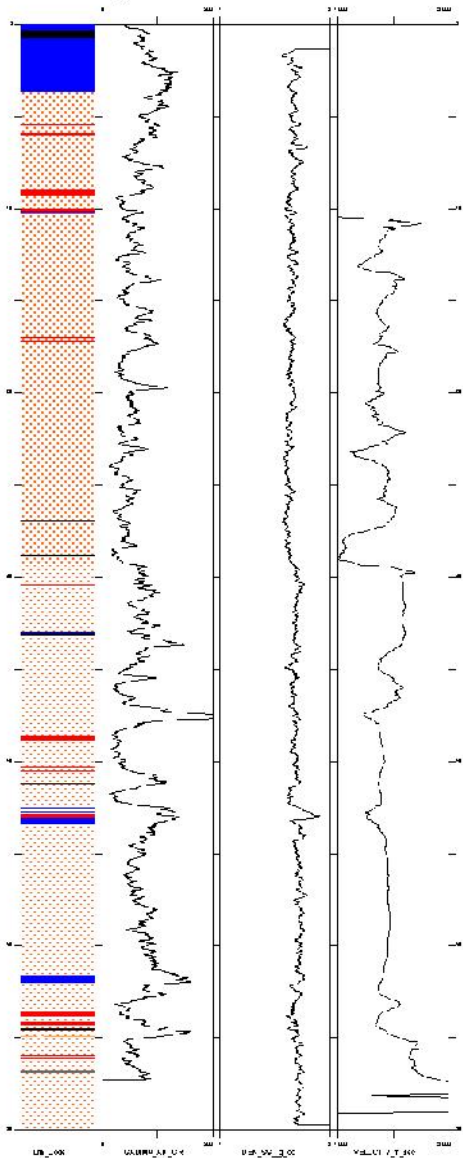
DMDDH07

Graphic Log with geophysical plots

Core tray photograph

Lithological log

Log for DMDDH07





DMDDH07-2017 BOXES 1 to 16

DLALC - MAROOTA PROJECT 2017 DIAMOND DRILLING LITHOLOGICAL LOGS

Hole ID	From	To	Int	Lith Code	Lithology	Grain size	Colour	Drill Depth	Drilled Int (m)	Core Rec (m)	Comment
DMDDH07	0.000	0.330	0.330		CLAY		Brown+grey				Soil
DMDDH07	0.330	0.780	0.450		CORE LOSS						
DMDDH07	0.780	2.490	1.710		CLAY		Cream+orange				With red-brown Fe stone bands, up to 0.21m thick. ALL OVERBURDEN
DMDDH07	2.490	3.000	0.510		SHALE		Grey	3.0	3.0	2.6	Laminite. Interbedded shale with pale grey-cream siltstone. Includes some D brown Fe stone.
DMDDH07	3.000	3.730	0.730		SHALE		Grey				As above. Base of Wianamatta Shale
DMDDH07	3.730	4.430	0.700		SANDSTONE	V fine	Cream				Silty & clayey, with orange banding. Some more clayey layers.
DMDDH07	4.430	5.450	1.020		SANDSTONE	Fine	White+orange				Clayey.
DMDDH07	5.450	5.500	0.050		Fe STONE		Brown				Hard. Bedded, dip 10o.
DMDDH07	5.500	5.910	0.410		SANDSTONE	Fine	Cream				Clayey. Friable at top of unit.
DMDDH07	5.910	6.070	0.160		Fe STONE		Brown	6.2	3.2	3.1	Sandy, Friable in parts.
DMDDH07	6.070	6.660	0.590		SANDSTONE	Fine	Orange				Clayey.
DMDDH07	6.660	6.700	0.040		Fe STONE		Red				Hard.
DMDDH07	6.700	6.950	0.250		SANDSTONE	Fine	Brown+or				
DMDDH07	6.950	8.980	2.030		SANDSTONE	F-medium	Cream				With some med-coarse layers. P orange at top. Some d grey carbonaceous wisps & fine laminations on bedding. Dip 5°.
DMDDH07	8.980	9.190	0.210		Fe STONE	Medium	Brown+red	9.3	3.1	3.1	Sandy. 50% to product.
DMDDH07	9.190	9.310	0.120		Fe STONE	Medium	Brown+red				As above. Top over cored.
DMDDH07	9.310	10.040	0.730		SANDSTONE	Medium	Orange				Banded cream & reddish orange on bedding. Dip 25°.
DMDDH07	10.040	10.180	0.140		Fe STONE	Medium	Brown+red				Sandy. 50% to product.
DMDDH07	10.180	10.230	0.050		SHALE		Grey				Broken & soft. Bedded 0°.
DMDDH07	10.230	10.265	0.035		Fe STONE		Red				Hard.
DMDDH07	10.265	11.100	0.835		SANDSTONE	Medium	Orange				
DMDDH07	11.100	12.310	1.210		SANDSTONE	Medium	Cream+pink+or	12.4	3.1	3.1	
DMDDH07	12.310	12.950	0.640		SANDSTONE	Medium	Cream+pink+or				
DMDDH07	12.950	12.960	0.010		Fe STONE		Brown				
DMDDH07	12.960	14.580	1.620		SANDSTONE	Medium	P orange				Minor Fe enriched (redder). Some paler & white layers.
DMDDH07	14.580	15.360	0.780		SANDSTONE	Medium	White	15.6	3.1	3.1	
DMDDH07	15.360	17.010	1.650		SANDSTONE	Medium	White				
DMDDH07	17.010	17.020	0.010		CLAY		White				Soft
DMDDH07	17.020	17.040	0.020		Fe STONE		Brown				Part Fe rich soft clay, part hard Fe stone
DMDDH07	17.040	17.060	0.020		SANDSTONE	Medium	Red				
DMDDH07	17.060	17.230	0.170		SANDSTONE	Medium	Cream				
DMDDH07	17.230	17.270	0.040		Fe STONE		Brown				Hard. Broken at top.
DMDDH07	17.270	18.440	1.170		SANDSTONE	Medium	Cream	18.5	3.0	3.0	Minor orange banding. Thin (10mm) bands of fine grained sandstone layers more cemented throughout, separating coarser & thicker less cemented sandstone.
DMDDH07	18.440	19.920	1.480		SANDSTONE	Medium	Cream				As above.
DMDDH07	19.920	19.950	0.030		SANDSTONE	Medium	Cream				With red Fe weak cement
DMDDH07	19.950	20.260	0.310		SANDSTONE	Medium	Cream				Minor orange banding. Thin (10mm) bands of fine grained sandstone layers more cemented throughout, separating coarser & thicker less cemented sandstone.
DMDDH07	20.260	20.380	0.120		SANDSTONE	Medium	Cream				With red Fe weak cement
DMDDH07	20.380	20.720	0.340		SANDSTONE	Medium	Cream				Minor orange banding. Thin (10mm) bands of fine grained sandstone layers more cemented throughout, separating coarser & thicker less cemented sandstone.
DMDDH07	20.720	20.740	0.020		Fe STONE		Brown				Hard
DMDDH07	20.740	20.990	0.250		SANDSTONE	Medium	P brown				
DMDDH07	20.990	20.995	0.005		CLAY		Cream				Soft plastic.
DMDDH07	20.995	21.000	0.005		Fe STONE	Medium	Red				Sandstone heavily cemented.
DMDDH07	21.000	21.360	0.360		SANDSTONE	Medium	P brn-cream				
DMDDH07	21.360	21.365	0.005		Fe STONE		D brown				
DMDDH07	21.365	21.435	0.070		SANDSTONE	Medium	Orange	21.5	3.0	3.0	
DMDDH07	21.435	21.585	0.150		SANDSTONE	Med-coarse	P brn-cream				
DMDDH07	21.585	21.595	0.010		Fe STONE		Red				Wavy surfaces
DMDDH07	21.595	24.420	2.825		SANDSTONE	Medium	Cream	24.5	3.0	3.0	With some red Fe cement bands. Scattered qtz granules. Some ex pyrite Fe spotting from 23.3m

DLALC - MAROOTA PROJECT 2017 DIAMOND DRILLING LITHOLOGICAL LOGS

Hole ID	From	To	Int	Lith Code	Lithology	Grain size	Colour	Drill Depth	Drilled Int (m)	Core Rec (m)	Comment
DMDDH07	24.420	26.680	2.260		SANDSTONE	Medium	Cream				As above with no Fe spots.
DMDDH07	26.680	26.920	0.240		SANDSTONE	Coarse	White				
DMDDH07	26.920	27.020	0.100		CORE LOSS						
DMDDH07	27.020	27.490	0.470		SANDSTONE	Medium	White	27.5	3.0	3.0	With qtz granules throughout
DMDDH07	27.490	27.940	0.450		SANDSTONE	Med-coarse	White				
DMDDH07	27.940	28.160	0.220		SANDSTONE	Co-V coarse	Cream+p brn				
DMDDH07	28.160	28.820	0.660		SANDSTONE	Medium	Cream+p pink				With qtz granules
DMDDH07	28.820	28.920	0.100		CORE LOSS						
DMDDH07	28.920	29.455	0.535		SANDSTONE	Med-coarse	P pink+brn				
DMDDH07	29.455	29.460	0.005		CLAY	White					With v thin red Fe stone laminae.
DMDDH07	29.460	30.400	0.940		SANDSTONE	Medium	Orange				Graphite flakes throughout. With p brown, red, cream banding.
DMDDH07	30.400	30.490	0.090		Fe STONE		Red	30.5	3.0	3.0	Hard. With soft cream sandy clay interbedded.
DMDDH07	30.490	30.500	0.010		SANDSTONE	F-medium	Cream				Soft
DMDDH07	30.500	30.770	0.270		SANDSTONE	Medium	Red				Massive. Banded deep & pale red.
DMDDH07	30.770	32.230	1.460		SANDSTONE	Medium	Orange				
DMDDH07	32.230	32.260	0.030		SANDSTONE	Medium	Cream+orange				Soft, plastic, clayey.
DMDDH07	32.260	33.050	0.790		SANDSTONE	Medium	P Orange				Massive
DMDDH07	33.050	33.060	0.010		Clay		Orange				Soft, plastic.
DMDDH07	33.060	33.160	0.100		CORE LOSS						
DMDDH07	33.160	33.500	0.340		SANDSTONE	Medium	Cream	33.5	3.0	3.0	
DMDDH07	33.500	34.260	0.760		SANDSTONE	Medium	Cream				
DMDDH07	34.260	34.360	0.100		SANDSTONE	Medium	Cream+red				Soft & friable In part. Red Fe cement in laminae. Graphite rich layers.
DMDDH07	34.360	34.640	0.280		SANDSTONE	Medium	Cream				Minor red Fe laminae. Soft & friable in places.
DMDDH07	34.640	34.720	0.080		SANDSTONE	Medium	P red				Soft & friable.
DMDDH07	34.720	36.510	1.790		SANDSTONE	V coarse	Cream	36.5	3.0	2.9	With V small pebbles to 10mm & granules. With minor red & brown bands.
DMDDH07	36.510	36.710	0.200		SANDSTONE	V coarse	Cream				As above. Broken, core loss??
DMDDH07	36.710	38.190	1.480		SANDSTONE	Medium	Cream				With scattered Fe spots ex pyrite.
DMDDH07	38.190	38.550	0.360		SANDSTONE	Coarse	Red				Fe cement.
DMDDH07	38.550	38.560	0.010		Fe STONE		Red				Hard. With coarse sandstone. Lensoidal band.
DMDDH07	38.560	38.600	0.040		SANDSTONE	Coarse	P grey				With red Fe spots
DMDDH07	38.600	38.920	0.320		Fe STONE		Red+brown				Lenses throughout sandstone 50% yield.
DMDDH07	38.920	39.470	0.550		SANDSTONE	Coarse	White	39.5	3.0	3.0	With red Fe spots ex pyrite.
DMDDH07	39.470	39.520	0.050		SANDSTONE	Coarse	White				As above.
DMDDH07	39.520	39.530	0.010		CLAY		Cream				V soft
DMDDH07	39.530	39.670	0.140		SANDSTONE	Coarse	Brown				
DMDDH07	39.670	39.680	0.010		Fe STONE		Red				Lensoidal band.
DMDDH07	39.680	39.720	0.040		SANDSTONE	Coarse	Brown				
DMDDH07	39.720	40.330	0.610		SANDSTONE	Coarse	Cream+orange				
DMDDH07	40.330	40.355	0.025		Fe STONE		Brown, hard				With fine grained sandstone.
DMDDH07	40.355	40.530	0.175		SANDSTONE	M-coarse	Orange				
DMDDH07	40.530	40.570	0.040		Fe STONE		Brown+D brn				Hard. Lenses.
DMDDH07	40.570	41.210	0.640		SANDSTONE	Medium	Orange+P red				Massive, well sorted.
DMDDH07	41.210	41.290	0.080		CORE LOSS						
DMDDH07	41.290	42.390	1.100		SANDSTONE	Coarse	Cream				Brown at top. With scattered small pebbles. At bottom coarser with red Fe stone laminae.
DMDDH07	42.390	42.420	0.030		CLAYSTONE		Grey				
DMDDH07	42.420	42.500	0.080		SANDSTONE	V coarse	Cream+orange	42.5	3.0	3.0	With claystone clasts & some washed out clasts. Water flow.
DMDDH07	42.500	42.580	0.080		CLAYSTONE		Grey				With coarse sandstone & Fe stone lenses (Could be large rip up clasts.)
DMDDH07	42.580	42.600	0.020		Fe STONE		Red				With coarse sand & granules.
DMDDH07	42.600	42.690	0.090		SANDSTONE	Medium	P grey				With large claystone clasts.
DMDDH07	42.690	42.740	0.050		SANDSTONE	Coarse	Red				With claystone clasts, some washed out. Fe Cement. Water flow.
DMDDH07	42.740	42.750	0.010		Fe STONE		Red				Hard
DMDDH07	42.750	42.770	0.020		CLAY		Ochre				Soft
DMDDH07	42.770	42.830	0.060		Fe STONE		Red				Hard

DLALC - MAROOTA PROJECT 2017 DIAMOND DRILLING LITHOLOGICAL LOGS

Hole ID	From	To	Int	Lith Code	Lithology	Grain size	Colour	Drill Depth	Drilled Int (m)	Core Rec (m)	Comment
DMDDH07	42.830	42.860	0.030		SANDSTONE	V coarse	Ochre				Granules
DMDDH07	42.860	42.890	0.030		CLAY		Ochre				Soft
DMDDH07	42.890	43.100	0.210		Fe STONE		Red+brown				Hard. Broken at bottom. Water flow.
DMDDH07	43.100	43.380	0.280		SHALE		D grey				Laminite, d grey shale interbedded with p grey siltstone.
DMDDH07	43.380	43.930	0.550		SANDSTONE	V fine-Fine	Grey				With black carbonaceous deposits on bedding. Horizontal bedding.
DMDDH07	43.930	45.500	1.570		SANDSTONE	Medium	P grey	45.5	3.0	3.0	Fine grained at top. Black carbonaceous deposits on bedding & wisps throughout.
DMDDH07	45.500	48.490	2.990		SANDSTONE	Medium	P grey	48.5	3.0	3.0	As above.
DMDDH07	48.490	49.100	0.610		SANDSTONE	Medium	P grey				As above.
DMDDH07	49.100	49.170	0.070		SANDSTONE	Medium	P grey				With D grey rounded pebbles to 20mm across.
DMDDH07	49.170	51.530	2.360		SANDSTONE	Medium	P grey	51.5	3.0	3.0	With carbonaceous deposits on bedding & wisps throughout. Massive. Large brown pebbles 30mm dia at 50.80m.
DMDDH07	51.530	51.660	0.130		SANDSTONE	Medium	P grey				As above.
DMDDH07	51.660	52.040	0.380		SHALE		D grey				Laminite with p grey siltstone. Slump at bottom.
DMDDH07	52.040	52.520	0.480		SANDSTONE	Medium	P grey				With carbonaceous deposits on bedding & wisps throughout. Massive.
DMDDH07	52.520	52.700	0.180		SANDSTONE	Medium	P grey				With D grey shale rip up clasts.
DMDDH07	52.700	52.705	0.005		Fe STONE		Red				Hard.
DMDDH07	52.705	52.895	0.190		SANDSTONE	Med-coarse	Orange				With scattered qtz granules.
DMDDH07	52.895	52.915	0.020		Fe STONE		Brown				Hard
DMDDH07	52.915	53.625	0.710		SANDSTONE	Medium	Orange				With thin Fe laminae & qtz granules.
DMDDH07	53.625	53.905	0.280		Fe STONE		Brown				Sub vertical veins in medium-coarse orange sandstone. 60% yield.
DMDDH07	53.905	54.175	0.270		SANDSTONE	Medium	Orange+cream				Partly friable.
DMDDH07	54.175	54.335	0.160		Fe STONE		Brown				In medium orange sandstone. 80% yield.
DMDDH07	54.335	54.415	0.080		SANDSTONE	Medium	Cream				With large claystone wash out cavities. Water flow.
DMDDH07	54.415	54.425	0.010		Fe STONE		Brown				Hard.
DMDDH07	54.425	54.445	0.020		SANDSTONE	Med-coarse	Orange				With washed out claystone cavities. Water flow.
DMDDH07	54.445	54.515	0.070		SANDSTONE	Medium	Cream	54.5	3.0	3.0	
DMDDH07	54.515	54.605	0.090		CORE LOSS						
DMDDH07	54.605	54.625	0.020		SANDSTONE	Coarse	Cream				With washed out claystone cavities. Water flow.
DMDDH07	54.625	54.935	0.310		SANDSTONE	Medium	Orange				With qtz granules.
DMDDH07	54.935	54.985	0.050		CONGLOMERATE	Medium	Orange				Qtz & dark shale clasts in sandstone. Some washed out clast cavities. Water flow.
DMDDH07	54.985	55.385	0.400		SANDSTONE	Medium	Orange				One Fe stone laminae. Coarse graphite on some bedding.
DMDDH07	55.385	55.400	0.015		Fe STONE		Brown				Hard.
DMDDH07	55.400	56.000	0.600		SANDSTONE	Medium	Orange				With abundant graphite on some bedding.
DMDDH07	56.000	56.020	0.020		Fe STONE		Brown				Sandy. 90% yield
DMDDH07	56.020	56.090	0.070		SANDSTONE						
DMDDH07	56.090	56.180	0.090		Fe STONE		Brown				Sandy. 80% yield.
DMDDH07	56.180	56.280	0.100		SANDSTONE	Medium	Orange				
DMDDH07	56.280	56.300	0.020		Fe STONE		Brown				Sandy. 50% yield.
DMDDH07	56.300	56.330	0.030		Fe STONE		Brown				Hard.
DMDDH07	56.330	56.420	0.090		SANDSTONE	Medium	Orange				
DMDDH07	56.420	56.450	0.030		Fe STONE		Brown				Hard.
DMDDH07	56.450	56.820	0.370		SANDSTONE	Medium	P grey				Massive.
DMDDH07	56.820	56.910	0.090		SILTSTONE		Grey				With d grey shale & black carbonaceous laminae, plus coal laminae.
DMDDH07	56.910	57.550	0.640		SANDSTONE	Medium	P grey	57.5	1.2	1.2	Massive. Oxidises to look like 'Yellow Block'.
DMDDH07	57.550	60.000	2.450		SANDSTONE	Medium	P grey	60.0	1.5	1.5	Massive. Oxidises to look like 'Yellow Block'. EOH 60.0m

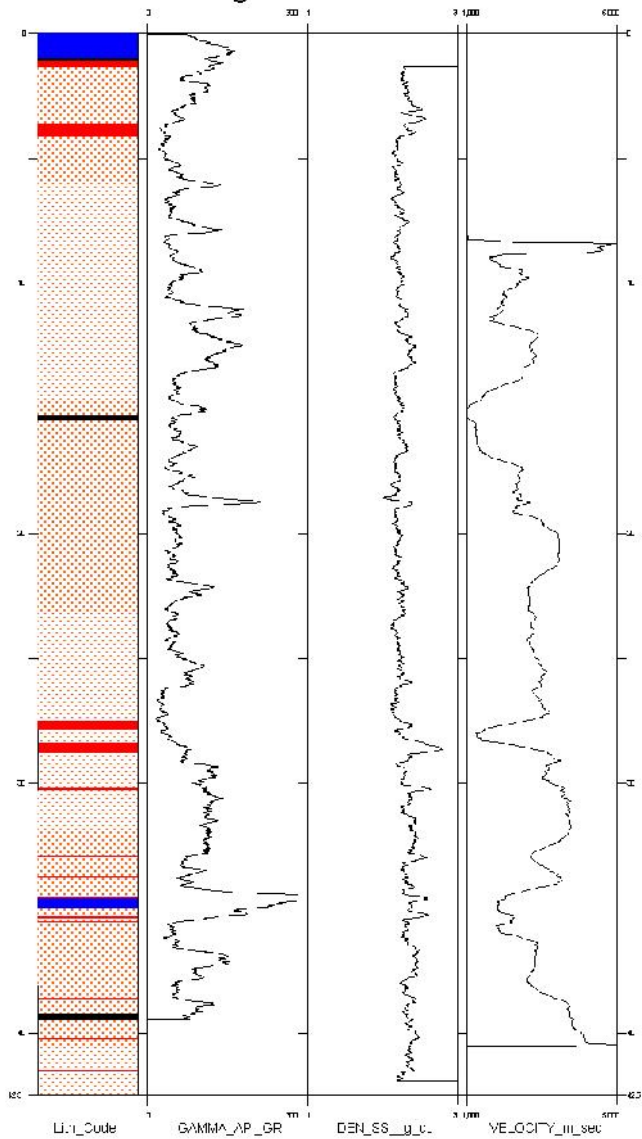
DMDDH09

Graphic Log with geophysical plots

Core tray photograph

Lithological log

Log for DMDDH09





DLALC - MARootA PROJECT 2017 DIAMOND DRILLING LITHOLOGICAL LOGS

Hole ID	From	To	Int	Lith Code	Lithology	Grain size	Colour	Drill Depth	Drilled Int (m)	Core Rec (m)	Comment
DMDDH09	0.000	0.200	0.200		CLAY		Grey				Soil
DMDDH09	0.200	0.990	0.790		CLAY		Cream				With orange mottle
DMDDH09	0.990	1.090	0.100		CORE LOSS						
DMDDH09	1.090	1.320	0.230		Fe STONE		Brown				Base of TERTIARY
DMDDH09	1.320	1.500	0.180		SANDSTONE	Fine	Cream				Top of Hawkesbury SS
DMDDH09	1.500	1.550	0.050		SANDSTONE	Fine	Red				Some hard Fe cemented.
DMDDH09	1.550	1.690	0.140		SANDSTONE	Fine	Cream				Mostly hard.
DMDDH09	1.690	2.090	0.400		SANDSTONE	F-medium	Red+Brown				Some Fe cement, hard.
DMDDH09	2.090	2.460	0.370		SANDSTONE	Fine	Cream				
DMDDH09	2.460	3.100	0.640		SANDSTONE	F-medium	Red+Brown	3.10	3.1	3.0	Some hard Fe cemented
DMDDH09	3.100	3.580	0.480		SANDSTONE	F-medium	Red+Brown				As above.
DMDDH09	3.580	4.060	0.480		Fe STONE	Med-coarse	Brown+red	4.10	1.0	0.9	With minor less cemented layers.
DMDDH09	4.060	4.105	0.045		SANDSTONE	Med-coarse	Orange				With qtz granules. Hard.
DMDDH09	4.105	4.145	0.040		Fe STONE	F-medium	Brown +red				Hard. Bedded, dip 10°.
DMDDH09	4.145	4.640	0.495		SANDSTONE	Medium	Cream+brn				Some qtz granules. Well bedded, dip 15°.
DMDDH09	4.640	5.030	0.390		SANDSTONE	Medium	Cream+pink	5.00	0.9	1.0	As above.
DMDDH09	5.030	6.580	1.550		SANDSTONE	Medium	Cream+pink	6.50	1.5	1.5	As above. Well bedded, dip 20°.
DMDDH09	6.580	6.910	0.330		SANDSTONE	Medium	Cream+pink	6.90	0.4	0.4	As above.
DMDDH09	6.910	7.620	0.710		SANDSTONE	Medium	Cream+pink				As above. With some coarser layers.
DMDDH09	7.620	7.680	0.060		SANDSTONE	Coarse	Cream				With red specks, partly friable.
DMDDH09	7.680	9.510	1.830		SANDSTONE	Medium	Cream+pink	9.50	2.6	2.6	With some coarser layers.
DMDDH09	9.510	12.460	2.950		SANDSTONE	F-medium	Cream	12.50	3.0	3.0	With scattered qtz granules. Faintly bedded.
DMDDH09	12.460	12.480	0.020		CLAY		Grey				Soft
DMDDH09	12.480	12.630	0.150		SANDSTONE	Vf-fine	Cream				With clay matrix & thin (0.002mm) red Fe stone in middle of unit.
DMDDH09	12.630	14.450	1.820		SANDSTONE	Medium	Cream				Grades to fine grained at top. Poorly bedded.
DMDDH09	14.450	14.520	0.070		SANDSTONE	Medium	Red+cream				Fe cement.
DMDDH09	14.520	15.300	0.780		SANDSTONE	Medium	Cream				Bedded, & friable at bottom. Dip 20°.
DMDDH09	15.300	15.500	0.200		CORE LOSS			15.50	3.0	2.9	
DMDDH09	15.500	15.900	0.400		SANDSTONE	Medium	Cream				As above.
DMDDH09	15.900	15.910	0.010		Fe STONE		Red				Lensoidal, (part missing).
DMDDH09	15.910	16.170	0.260		SANDSTONE	Med-V coarse	Cream				Poorly sorted.
DMDDH09	16.170	16.180	0.010		SANDSTONE	Clay	Brown				Soft.
DMDDH09	16.180	18.530	2.350		SANDSTONE	Medium	Cream	18.50	3.0	3.0	Massive. Scattered brn Fe blebs (ex pyrite). Random qtz granules.
DMDDH09	18.530	21.050	2.520		SANDSTONE	Medium	Cream				Weakly bedded. Scattered thin coarser grained layers.
DMDDH09	21.050	21.060	0.010		Fe STONE		Red				
DMDDH09	21.060	21.260	0.200		SANDSTONE	Medium	Red+cream	21.40	2.9	2.6	Banded.
DMDDH09	21.260	21.640	0.380		SANDSTONE	Medium	Red+cream				As above.
DMDDH09	21.640	22.730	1.090		SANDSTONE	Medium	Cream	22.70	1.3	1.4	With pink + orange banding. Well bedded at bottom. Dip20°.
DMDDH09	22.730	23.890	1.160		SANDSTONE	Medium	Cream				As above.
DMDDH09	23.890	24.640	0.750		SANDSTONE	Medium	Red+pink	24.50	1.8	1.9	Weakly Fe cemented. Massive.
DMDDH09	24.640	24.740	0.100		SANDSTONE	Medium	Red+pink				As above.
DMDDH09	24.740	25.340	0.600		SANDSTONE	Medium	Cream				Orange bands.
DMDDH09	25.340	25.710	0.370		SANDSTONE	Medium	Red+pink				Weak Fe cement
DMDDH09	25.710	25.720	0.010		Fe STONE		Red				
DMDDH09	25.720	27.330	1.610		SANDSTONE	Medium	Cream				Poorly bedded.
DMDDH09	27.330	27.500	0.170		SANDSTONE	Medium	Orange	27.50	3.0	3.0	With 1 thin Fe stone laminae.
DMDDH09	27.500	27.890	0.390		Fe STONE	Med-coarse	Orange+brn				Fe stone bands, lenses & veining. 25% hard Fe stone.
DMDDH09	27.890	28.270	0.380		SANDSTONE	Med-coarse	Cream				Partly friable.
DMDDH09	28.270	28.390	0.120		SANDSTONE	Med-coarse	Red				Minor Fe cement.
DMDDH09	28.390	28.780	0.390		Fe STONE	Med-coarse	Orange+brn				Fe stone bands, lenses & veining. 50% hard Fe stone.
DMDDH09	28.780	28.830	0.050		Fe STONE		Brown				V hard.
DMDDH09	28.830	29.040	0.210		SANDSTONE	Medium	Orange				Finely bedded.
DMDDH09	29.040	29.050	0.010		Fe STONE		Brown				Hard. Wavy banding.
DMDDH09	29.050	29.350	0.300		SANDSTONE	Medium	Orange				With some Fe cement.

DLALC - MAROOTA PROJECT 2017 DIAMOND DRILLING LITHOLOGICAL LOGS

Hole ID	From	To	Int	Lith Code	Lithology	Grain size	Colour	Drill Depth	Drilled Int (m)	Core Rec (m)	Comment
DMDDH09	29.350	29.360	0.010		Fe STONE		Brown				Hard.
DMDDH09	29.360	29.710	0.350		SANDSTONE	Medium	Cream				With orange + pink banding
DMDDH09	29.710	29.715	0.005		Fe STONE		Brown				Hard
DMDDH09	29.715	30.080	0.365		SANDSTONE	Medium	Cream				With black organic traces.
DMDDH09	30.080	30.180	0.100		SANDSTONE	Med-coarse	Brown	30.50	3.0	2.7	With black organic traces.
DMDDH09	30.180	30.260	0.080		Fe STONE		D brown +brn				Hard
DMDDH09	30.260	30.600	0.340		SANDSTONE	Medium	P orange				Massive
DMDDH09	30.600	30.850	0.250		SANDSTONE	Medium	P grey				Massive
DMDDH09	30.850	31.400	0.550		SANDSTONE	Medium	Orange				
DMDDH09	31.400	32.920	1.520		SANDSTONE	F-medium	P grey				Fine at bottom, coarser at top. Horizontal bedding at bottom, massive at top. Black carbonaceous layers on bedding, & flecks throughout.
DMDDH09	32.920	32.960	0.040		Fe STONE		D brn + orange				Hard
DMDDH09	32.960	33.190	0.230		SANDSTONE	Medium	Orange	33.20	2.7	3.0	With Fe bands & veins. 50% hard Fe stone.
DMDDH09	33.190	33.750	0.560		SANDSTONE	Medium	Orange+cream				Banded.
DMDDH09	33.750	33.770	0.020		Fe STONE		Brown				Hard
DMDDH09	33.770	34.140	0.370		SANDSTONE	Medium	Orange				
DMDDH09	34.140	34.150	0.010		Fe STONE		Brown				Hard
DMDDH09	34.150	34.540	0.390		SANDSTONE	Medium	Orange				
DMDDH09	34.540	34.620	0.080		Fe STONE		Brown				Hard
DMDDH09	34.620	35.060	0.440		SHALE		D grey				With minor sandstone layers
DMDDH09	35.060	35.260	0.200		SANDSTONE	Medium	Cream				With D grey shale rip up clasts. Minor red Fe cement.
DMDDH09	35.260	35.290	0.030		Fe STONE		Red+brown				Hard
DMDDH09	35.290	35.340	0.050		SANDSTONE	Medium	Cream+orange				
DMDDH09	35.340	35.410	0.070		Fe STONE		D brown +brn				Hard
DMDDH09	35.410	35.450	0.040		SANDSTONE	Medium	Orange				
DMDDH09	35.450	35.460	0.010		Fe STONE		Brown				Hard. Lensoidal
DMDDH09	35.460	35.560	0.100		SANDSTONE	Coarse	Orange+pink				
DMDDH09	35.560	35.570	0.010		Fe STONE		Brown				Hard. Lensoidal
DMDDH09	35.570	35.770	0.200		SANDSTONE	Medium	Orange+pink				Coarse at top.
DMDDH09	35.770	35.780	0.010		Fe STONE		D brown				Hard
DMDDH09	35.780	36.400	0.620		SANDSTONE	Medium	P pink + Or	36.50	3.3	3.2	Bedded.
DMDDH09	36.400	36.620	0.220		SANDSTONE	Medium	Orange+pink				Bedded.
DMDDH09	36.620	36.625	0.005		Fe STONE		D brown				Hard. Separate core disc
DMDDH09	36.625	37.605	0.980		SANDSTONE	Medium	Cream				Massive. Some Fe grains ex pyrite.
DMDDH09	37.605	37.610	0.005		Fe STONE		D brown				Hard
DMDDH09	37.610	37.650	0.040		SANDSTONE	Medium	D orange				Fe cemented.
DMDDH09	37.650	38.110	0.460		SANDSTONE	Medium	Orange				Banded.
DMDDH09	38.110	38.120	0.010		Fe STONE		D brown				Hard
DMDDH09	38.120	38.190	0.070		SANDSTONE	Coarse	Brown				Some Fe cement.
DMDDH09	38.190	38.530	0.340		SANDSTONE	Medium	Cream+orange				With scattered qtz granules.
DMDDH09	38.530	38.550	0.020		Fe STONE		D brown				Hard
DMDDH09	38.550	38.630	0.080		SANDSTONE	F-medium	Orange				Well sorted
DMDDH09	38.630	38.640	0.010		Fe STONE		D brown				Hard
DMDDH09	38.640	38.740	0.100		SANDSTONE	F-medium	Orange				Well sorted.
DMDDH09	38.740	39.230	0.490		SANDSTONE	Medium	White				Some over core & broken core. Graphite on some bedding.
DMDDH09	39.230	39.500	0.270		CORE LOSS			39.50	3.0	3.0	
DMDDH09	39.500	40.240	0.740		SANDSTONE	Medium	White				Minor orange banding. Graphite on some bedding.
DMDDH09	40.240	40.265	0.025		Fe STONE		D brown				Hard
DMDDH09	40.265	40.885	0.620		SANDSTONE	Medium	Orange				Minor coarser layers. Some brn Fe cement.
DMDDH09	40.885	41.495	0.610		SANDSTONE	Medium	White				Orange banding in top part of unit.
DMDDH09	41.495	41.540	0.045		Fe STONE		D brown				Hard
DMDDH09	41.540	41.610	0.070		SANDSTONE	Med-coarse	Pink				
DMDDH09	41.610	42.500	0.890		SANDSTONE	Med-coarse	Cream	42.50	3.0	3.0	With some orange banding. EOH 42.50m

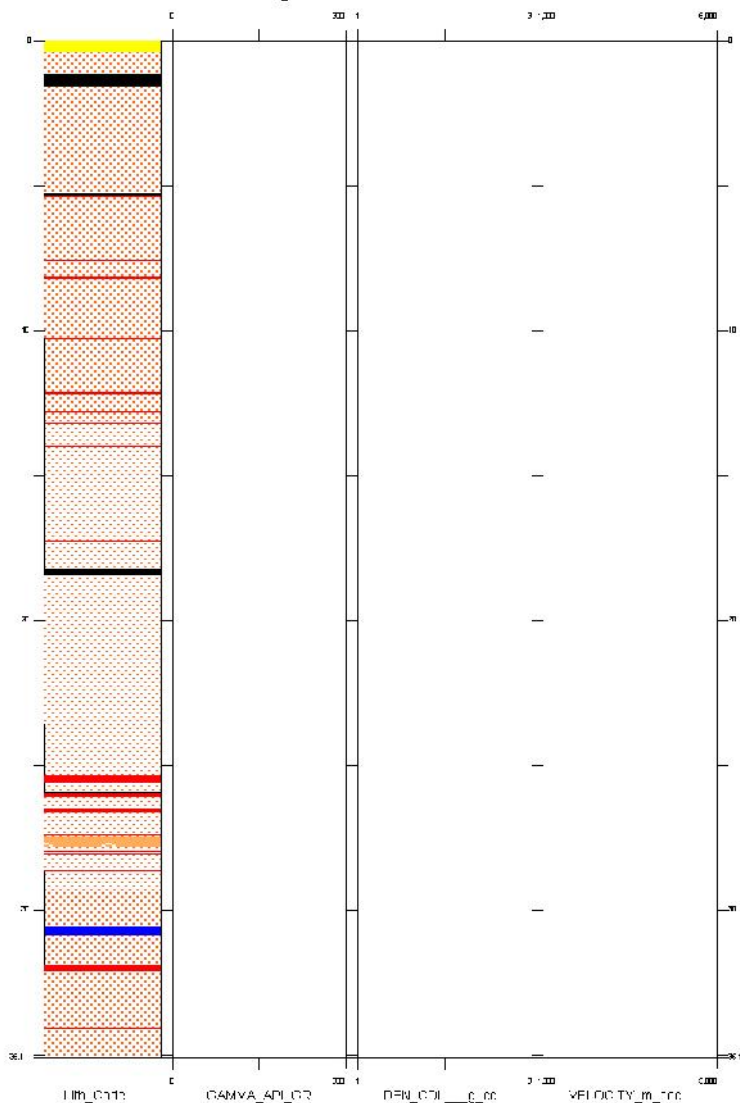
DMDDH10

Graphic Log

Core tray photograph

Lithological log

Log for DMDDH10





DLALC - MAROOTA PROJECT 2017 DIAMOND DRILLING LITHOLOGICAL LOGS

Hole ID	From	To	Int	Lith Code	Lithology	Grain size	Colour	Drill Depth	Drilled Int (m)	Core Rec (m)	Comment
DMDDH10	0.000	0.400	0.400		SAND		Brown				With clay. Soil.
DMDDH10	0.400	0.740	0.340		SANDSTONE	Fine-medium	Cream				Highly weathered. Friable.
DMDDH10	0.740	0.790	0.050		SANDSTONE	Fine-medium	Red				Fe cemented.
DMDDH10	0.790	1.020	0.230		SANDSTONE	Medium	Cream				Friable.
DMDDH10	1.020	1.150	0.130		SANDSTONE	Medium	Red				Fe cemented.
DMDDH10	1.150	1.590	0.440		CORE LOSS						
DMDDH10	1.590	3.100	1.510		SANDSTONE	Medium	Cream	3.10	3.0	3.0	Partly friable.
DMDDH10	3.100	5.290	2.190		SANDSTONE	Medium	Cream				As above.
DMDDH10	5.290	5.390	0.100		Core loss						
DMDDH10	5.390	5.400	0.010		Fe STONE		Brown				Hard
DMDDH10	5.400	6.070	0.670		SANDSTONE	Medium	Cream	6.20	3.1	3.1	Coarse grained in bottom 0.05m.
DMDDH10	6.070	7.570	1.500		SANDSTONE	Medium	Cream				As above.
DMDDH10	7.570	7.580	0.010		Fe STONE		Brown				Hard lens.
DMDDH10	7.580	8.170	0.590		SANDSTONE	Medium	Cream				
DMDDH10	8.170	8.220	0.050		Fe STONE		Brown				Sandy cream medium grained sand interbedded. 50% yield.
DMDDH10	8.220	8.410	0.190		SANDSTONE	Medium	Cream				
DMDDH10	8.410	8.415	0.005		Fe STONE		Brown				Hard.
DMDDH10	8.415	8.785	0.370		SANDSTONE	Medium	Cream				
DMDDH10	8.785	8.835	0.050		Fe STONE		D brown				Hard. With orange sandstone interbedded. 70% yield.
DMDDH10	8.835	8.995	0.160		SANDSTONE	Medium	Cream				
DMDDH10	8.995	9.045	0.050		SANDSTONE	Med-coarse	Orange				
DMDDH10	9.045	9.070	0.025		Fe STONE		D brown				Hard
DMDDH10	9.070	9.130	0.060		SANDSTONE	Medium	Cream	9.20	3.0	3.0	
DMDDH10	9.130	10.290	1.160		SANDSTONE	Medium	Cream				
DMDDH10	10.290	10.310	0.020		Fe STONE		Brown				Hard.
DMDDH10	10.310	12.100	1.790		SANDSTONE	Medium	Cream				Massive.
DMDDH10	12.100	12.190	0.090		Fe STONE		Brown				Hard. With medium grained sandstone interbedded. Yield 0%.
DMDDH10	12.190	12.780	0.590		SANDSTONE	Medium	Cream				
DMDDH10	12.780	12.830	0.050		Fe STONE		Brown				Hard. With orange medium grained sandstone interbedded, Fe cemented on top.
DMDDH10	12.830	13.210	0.380		SANDSTONE	Medium	Cream				
DMDDH10	13.210	13.235	0.025		Fe STONE		Brown				Hard
DMDDH10	13.235	13.975	0.740		SANDSTONE	Medium	Cream				Orange at bottom.
DMDDH10	13.975	14.025	0.050		Fe STONE	Medium	Brown+orange				Interbedded sandstone. 50% yield.
DMDDH10	14.025	15.150	1.125		SANDSTONE	Fine-medium	White	15.30	3.0	3.1	Massive.
DMDDH10	15.150	16.340	1.190		SANDSTONE	Fine-medium	White				As above.
DMDDH10	16.340	17.060	0.720		SANDSTONE	Medium	Orange				Massive. Colour banded, paler & darker.
DMDDH10	17.060	17.260	0.200		SANDSTONE	Fine-medium	White				Well bedded at bottom.
DMDDH10	17.260	17.310	0.050		Fe STONE		Red+brown				
DMDDH10	17.310	18.230	0.920		SANDSTONE	Medium	Orange+cream	18.40	3.1	3.1	Bedded, with band of <5mm thick Fe stone at 18.0m.
DMDDH10	18.230	18.430	0.200		CORE LOSS						
DMDDH10	18.430	19.720	1.290		SANDSTONE	Medium	Cream				Well cross bedded.
DMDDH10	19.720	21.040	1.320		SANDSTONE	Med-coarse	White				With qtz granules.
DMDDH10	21.040	21.510	0.470		SANDSTONE	Medium	White	21.50	3.1	3.1	
DMDDH10	21.510	23.560	2.050		SANDSTONE	Med-coarse	White				With some coarse grained layers & scattered granules.
DMDDH10	23.560	23.600	0.040		CLAYSTONE		Grey				Dip 10° on top & bottom.
DMDDH10	23.600	24.460	0.860		SANDSTONE	Medium	Cream	24.50	3.0	3.1	With fine p orange banding
DMDDH10	24.460	25.230	0.770		SANDSTONE	Medium	Cream				As above.
DMDDH10	25.230	25.350	0.120		SANDSTONE	Medium	Orange				With scattered qtz granules & some washed out claystone cavities.
DMDDH10	25.350	25.610	0.260		Fe STONE		D brown				With coarse orange sandstone interbedded. 80% yield.
DMDDH10	25.610	25.920	0.310		SANDSTONE	Medium	Cream				With white clay. Coarse grained at bottom. Water flow at bottom.
DMDDH10	25.920	25.970	0.050		CORE LOSS						
DMDDH10	25.970	26.070	0.100		Fe STONE		D brown				Thin laminae in orange med-coarse sandstone. Yield 85%
DMDDH10	26.070	26.255	0.185		SANDSTONE	Med-coarse	Orange				
DMDDH10	26.255	26.260	0.005		Fe STONE		D brown				Hard.

DLALC - MARootA PROJECT 2017 DIAMOND DRILLING LITHOLOGICAL LOGS

Hole ID	From	To	Int	Lith Code	Lithology	Grain size	Colour	Drill Depth	Drilled Int (m)	Core Rec (m)	Comment
DMDDH10	26.260	26.310	0.050		SANDSTONE	Med-coarse	Orange				
DMDDH10	26.310	26.325	0.015		Fe STONE		D brown				Hard.
DMDDH10	26.325	26.375	0.050		SANDSTONE	Medium	Orange				
DMDDH10	26.375	26.385	0.010		Fe STONE		D brown				
DMDDH10	26.385	26.495	0.110		SANDSTONE	Medium	Orange				With large grey claystone clasts, & abundant qtz granules.
DMDDH10	26.495	26.600	0.105		Fe STONE		D brown+red				Hard, sandy.
DMDDH10	26.600	26.700	0.100		SANDSTONE	Medium	Orange				Some Fe cement.
DMDDH10	26.700	27.380	0.680		SANDSTONE	Medium	P grey				With abundant qtz granules & D grey claystone rip up clasts to 60mm across.
DMDDH10	27.380	27.430	0.050		Fe STONE		Brown+red				
DMDDH10	27.430	27.480	0.050		SANDSTONE	Medium	P grey	27.50	3.0	3.0	With abundant qtz granules & D grey claystone rip up clasts to 60mm across.
DMDDH10	27.480	27.810	0.330		CONGLOMERATE	Granule	P grey				Qtz rich with D grey shale rip up clasts.
DMDDH10	27.810	27.980	0.170		SANDSTONE	Medium	P grey				
DMDDH10	27.980	27.990	0.010		Fe STONE		Brown				Hard.
DMDDH10	27.990	28.030	0.040		SANDSTONE	Medium	Orange				
DMDDH10	28.030	28.070	0.040		Fe STONE		Brown				Hard.
DMDDH10	28.070	28.610	0.540		SANDSTONE	Medium	Orange				
DMDDH10	28.610	28.660	0.050		Fe STONE		Brown				Hard. Open along bedding planes.
DMDDH10	28.660	28.890	0.230		SANDSTONE	Medium	Grey				Massive at top, finely bedded at bottom.
DMDDH10	28.890	29.810	0.920		SANDSTONE	Med-coarse	Grey				With small flat shale clasts & minor granules. Partly friable.
DMDDH10	29.810	30.460	0.650		SANDSTONE	Medium	Grey	30.50	3.0	3.0	With abundant large D grey shale rip up clasts
DMDDH10	30.460	30.580	0.120		SANDSTONE	Medium	Grey				As above.
DMDDH10	30.580	30.880	0.300		SHALE		D grey				With P grey siltstone laminae. Bedding dip 20°.
DMDDH10	30.880	31.610	0.730		SANDSTONE	Medium	Grey				With abundant large D grey shale rip up clasts
DMDDH10	31.610	31.650	0.040		Fe STONE		Red				Hard.
DMDDH10	31.650	31.920	0.270		SANDSTONE	Medium	Orange				
DMDDH10	31.920	31.930	0.010		Fe STONE		Red				Hard.
DMDDH10	31.930	32.080	0.150		Fe STONE	Medium	Orange				Strong Fe cement. Yield 0%
DMDDH10	32.080	32.090	0.010		Fe STONE		Red				Hard.
DMDDH10	32.090	32.445	0.355		SANDSTONE	Medium	Cream+Orange				
DMDDH10	32.445	32.450	0.005		Fe STONE		Red				Hard.
DMDDH10	32.450	33.460	1.010		SANDSTONE	Medium	Orange	33.50	3.0	3.0	Massive, with weak colour banding. Washed out claystone clasts at 33.42m. Water flow.
DMDDH10	33.460	34.070	0.610		SANDSTONE	Med-coarse	Orange+brn				With coarser layers. Many cavities from washed out claystone clasts at bottom. Water flow.
DMDDH10	34.070	34.090	0.020		Fe STONE		Brown				Hard
DMDDH10	34.090	34.200	0.110		SANDSTONE	Medium	Orange				
DMDDH10	34.200	35.100	0.900		SANDSTONE	Medium	White+cream	35.10	1.6	1.6	With cavities from washed out claystone clasts. Water flow. EOH 35.10m

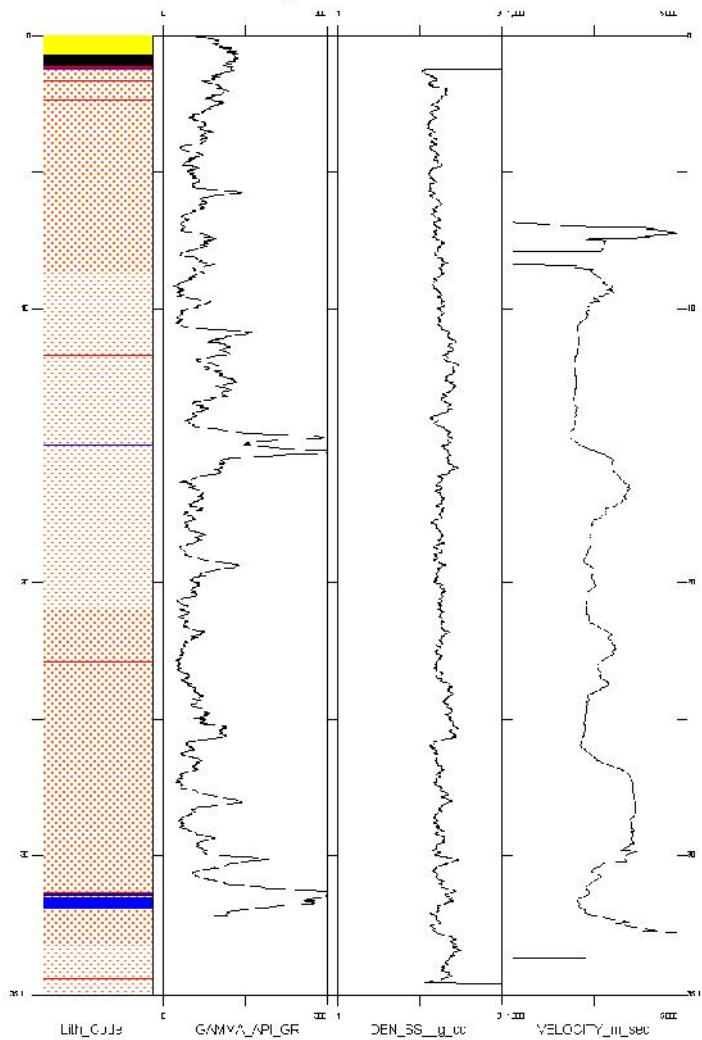
DMDDH11

Graphic Log with geophysical plots

Core tray photograph

Lithological log

Log for DMDDH11





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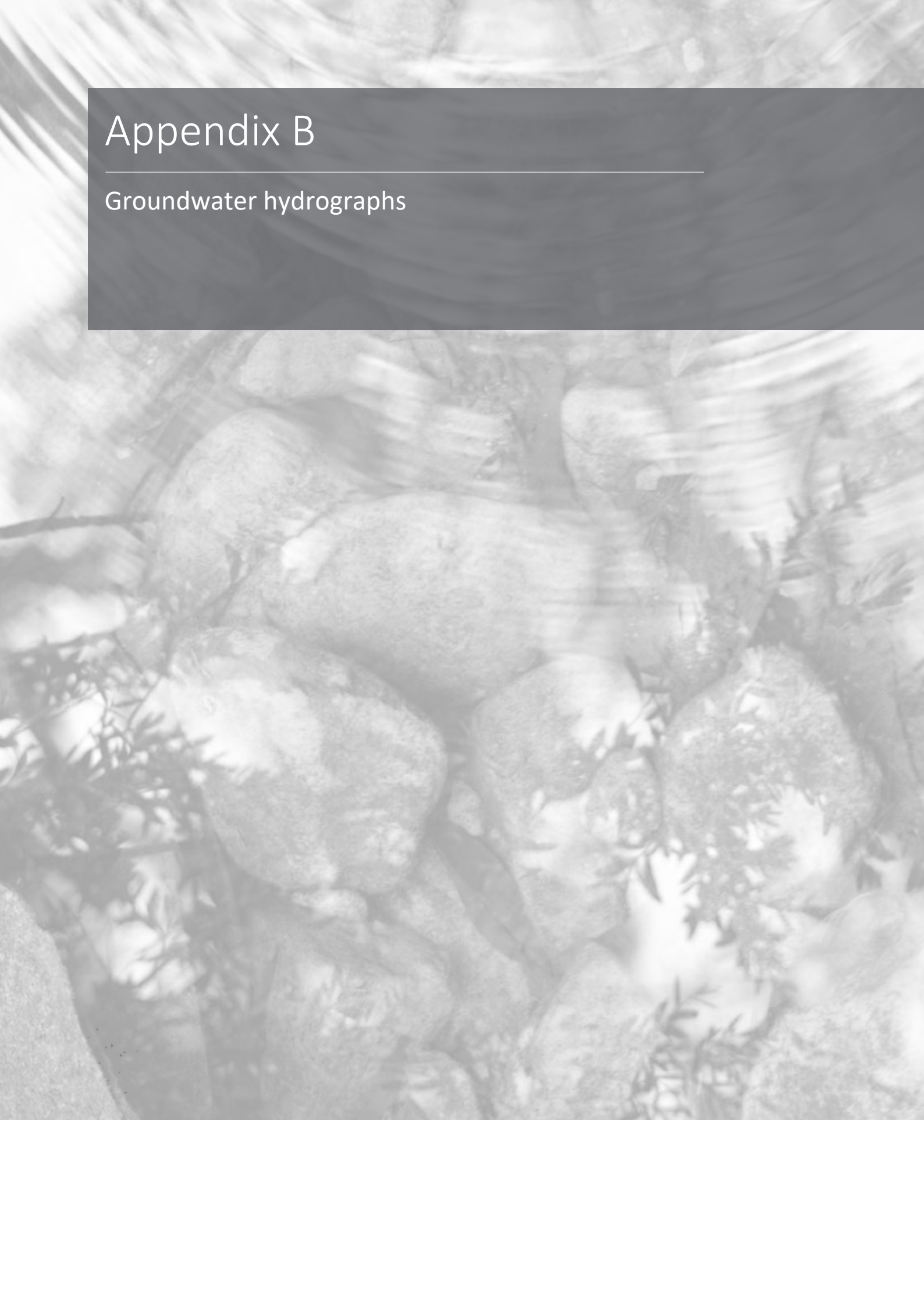
Hole ID	From	To	Int	Lith Code	Lithology	Grain size	Colour	Drill Depth	Drilled Int (m)	Core Rec (m)	Comment
DMDDH11	0.000	0.150	0.150		SAND		Brown				Clayey. Soil
DMDDH11	0.150	0.700	0.550		SAND		Orange				Clayey. With red sandstone fragments. V clayey at bottom
DMDDH11	0.700	1.100	0.400		CORE LOSS			1.10	1.1	0.7	
DMDDH11	1.100	1.120	0.020		CLAY		Orange+red				
DMDDH11	1.120	1.160	0.040		Fe STONE		Red				Hard
DMDDH11	1.160	1.220	0.060		CLAY		Cream+or				With qtz granules.
DMDDH11	1.220	1.260	0.040		Fe STONE		Red				Hard
DMDDH11	1.260	1.630	0.370		SANDSTONE	Medium	Cream+or	1.70	0.6	0.6	Red at top & bottom of unit.
DMDDH11	1.630	1.670	0.040		Fe STONE		Red				Hard. Broken nodule.
DMDDH11	1.670	1.700	0.030		SANDSTONE	Fine	Orange				
DMDDH11	1.700	1.715	0.015		Fe STONE	Fine-medium	Brown				Sandy
DMDDH11	1.715	2.180	0.465		SANDSTONE	Fine-medium	Orange+brn				
DMDDH11	2.180	2.190	0.010		Fe STONE	Fine	Brown				Sandy
DMDDH11	2.190	2.205	0.015		CLAY		Cream				
DMDDH11	2.205	2.215	0.010		Fe STONE		Brown				Sandy
DMDDH11	2.215	2.355	0.140		SANDSTONE	Medium	Red+brown				Some Fe cement
DMDDH11	2.355	2.390	0.035		Fe STONE		Brown				Hard. With cream clay soft laminae.
DMDDH11	2.390	2.510	0.120		SANDSTONE	Fine-medium	Red				
DMDDH11	2.510	2.520	0.010		Fe STONE		Red				Hard
DMDDH11	2.520	2.960	0.440		SANDSTONE	Medium	Cream+brn				Coarser at bottom. With Qtz granules throughout. Weakly banded.
DMDDH11	2.960	3.190	0.230		SANDSTONE	Medium	Cream+white				
DMDDH11	3.190	3.230	0.040		SANDSTONE	Coarse	White				
DMDDH11	3.230	3.450	0.220		SANDSTONE	Medium	P orange	3.50	1.8	1.8	
DMDDH11	3.450	6.560	3.110		SANDSTONE	Medium	White	6.50	3.0	3.1	Random qtz granules & small pebbles. Tr graphite. Week bedding, dip 20°.
DMDDH11	6.560	9.690	3.130		SANDSTONE	Medium	White	9.50	3.0	3.0	AS above.
DMDDH11	9.690	10.930	1.240		SANDSTONE	Medium	White				As above.
DMDDH11	10.930	11.120	0.190		SANDSTONE	Medium	White				As above, with orange banding.
DMDDH11	11.120	11.140	0.020		SILTSTONE		P grey				With v fine sand & graphite.
DMDDH11	11.140	11.710	0.570		SANDSTONE	Medium	Orange				Banded.
DMDDH11	11.710	11.725	0.015		Fe STONE		Brown				Fine sand & silt.
DMDDH11	11.725	12.235	0.510		SANDSTONE	Medium	Orange				Banded.
DMDDH11	12.235	12.620	0.385		SANDSTONE	Medium	P grey	12.50	3.0	3.0	With minor orange colouration.
DMDDH11	12.620	13.300	0.680		SANDSTONE	Medium	P grey				As above.
DMDDH11	13.300	13.810	0.510		SANDSTONE	Medium	Orange				With cream banding. Bedding dip 20°.
DMDDH11	13.810	13.820	0.010		Fe STONE		Red				Hard. With medium grained sand.
DMDDH11	13.820	14.850	1.030		SANDSTONE	Medium	Orange				With cream banding. Bedding dip 20°.
DMDDH11	14.850	14.970	0.120		SANDSTONE	Fine	P grey				
DMDDH11	14.970	15.030	0.060		SHALE		Grey				Silty
DMDDH11	15.030	15.620	0.590		SANDSTONE	Fine-medium	White	15.50	3.0	3.0	
DMDDH11	15.620	16.100	0.480		SANDSTONE	Fine-medium	White				
DMDDH11	16.100	16.230	0.130		SANDSTONE	Fine-medium	White				With orange & brown banding.
DMDDH11	16.230	16.520	0.290		SANDSTONE	Medium	White+orange				With Fe stone banding from laminae to 10mm thick. Mostly not too hard with sand in Fe stone.
DMDDH11	16.520	18.740	2.220		SANDSTONE	Medium	White	18.50	3.0	3.0	Minor scattered granules. With minor pale coloured layers.
DMDDH11	18.740	18.970	0.230		SANDSTONE	M-coarse	White				
DMDDH11	18.970	18.975	0.005		Fe STONE		Red				
DMDDH11	18.975	21.530	2.555		SANDSTONE	M-coarse	White	21.50	3.0	3.0	Scattered qtz granules
DMDDH11	21.530	22.420	0.890		SANDSTONE	M-coarse	White				Bedding dip 20°.
DMDDH11	22.420	22.465	0.045		Fe STONE		Red				Med grained sandy. Hard.
DMDDH11	22.465	22.875	0.410		SANDSTONE	Medium	White				
DMDDH11	22.875	22.880	0.005		Fe STONE		Red				Sandy. Hard.
DMDDH11	22.880	22.925	0.045		SANDSTONE	M-coarse	White				
DMDDH11	22.925	22.960	0.035		Fe STONE		Red				Sandy. Hard.
DMDDH11	22.960	24.330	1.370		SANDSTONE	Co-V coarse	White				Porous. Some washed out ?shale?. Water permeable.

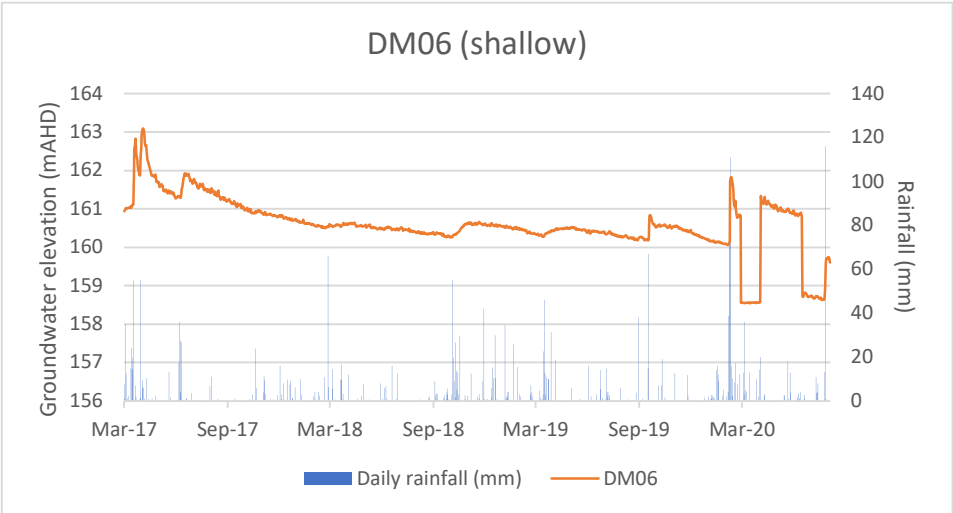
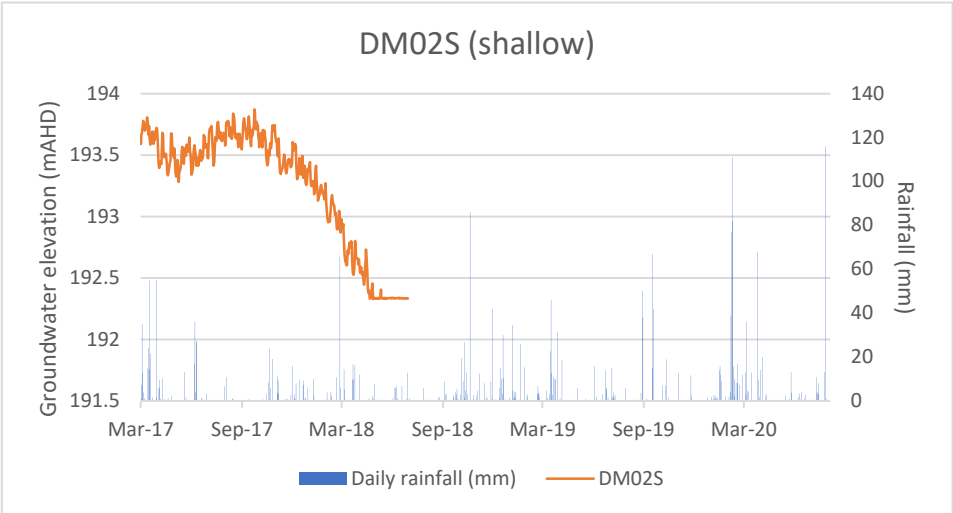
DLALC - MARootA PROJECT 2017 DIAMOND DRILLING LITHOLOGICAL LOGS

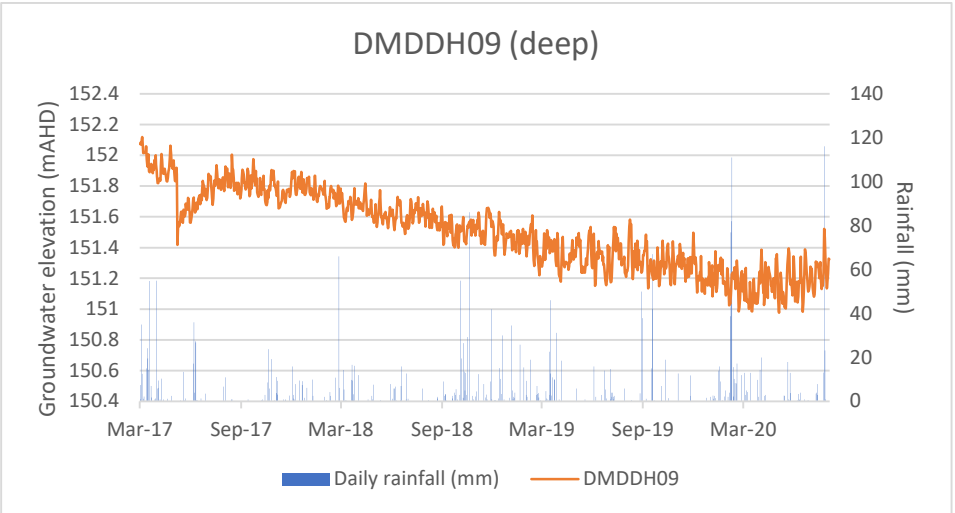
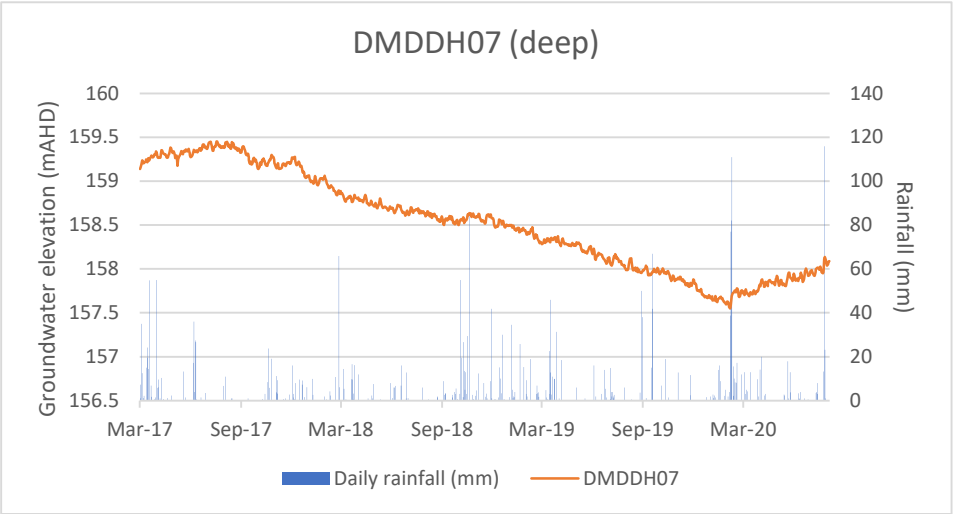
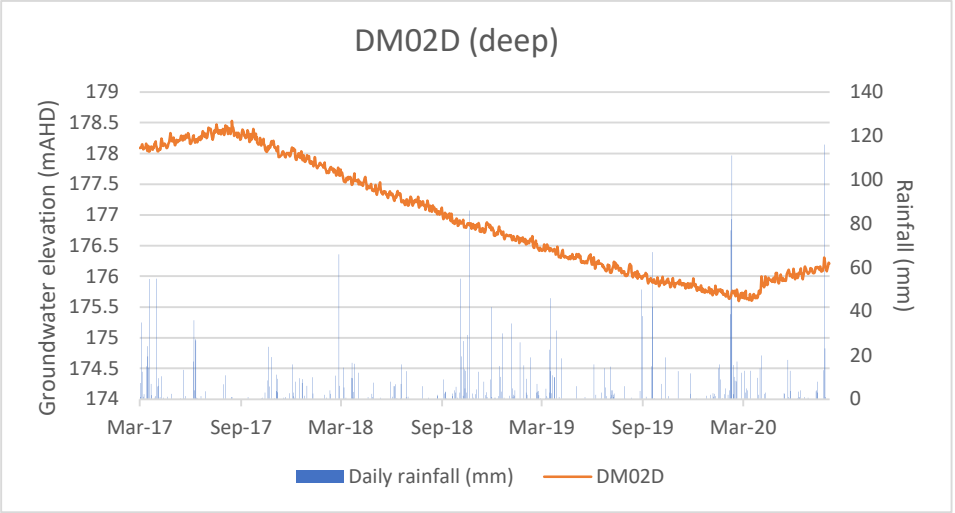
Hole ID	From	To	Int	Lith Code	Lithology	Grain size	Colour	Drill Depth	Drilled Int (m)	Core Rec (m)	Comment
DMDDH11	24.330	24.570	0.240		SANDSTONE	Medium	White	24.50	3.0	3.0	Clayey
DMDDH11	24.570	27.540	2.970		SANDSTONE	Medium	White-cream	27.50	3.0	3.0	Some washed out shale?. Permeable.
DMDDH11	27.540	29.380	1.840		SANDSTONE	Medium	White-cream				As above. Permeable.
DMDDH11	29.380	29.770	0.390		SANDSTONE	Medium	Brown+P brn				Fe cemented.
DMDDH11	29.770	30.210	0.440		SANDSTONE	Medium	Orange				Banded.
DMDDH11	30.210	30.260	0.050		SANDSTONE	Fine	Cream				V clayey. Clay parting on top of unit. Top dip 15°, bottom dip 5° (true).
DMDDH11	30.260	30.510	0.250		SANDSTONE	Medium	Cream	30.50	3.0	3.0	
DMDDH11	30.510	31.310	0.800		SANDSTONE	Medium	Orange				Banded.
DMDDH11	31.310	31.315	0.005		Fe STONE		Brown				
DMDDH11	31.315	31.335	0.020		SANDSTONE	Fine	White				Lensoidal.
DMDDH11	31.335	31.370	0.035		Fe STONE		Brown				With coarse sand.
DMDDH11	31.370	31.450	0.080		CLAY		P grey				Soft, Plastic.
DMDDH11	31.450	31.470	0.020		CORE LOSS						
DMDDH11	31.470	31.550	0.080		SANDSTONE		Cream	31.90	1.4	1	With clay rip up clasts.
DMDDH11	31.550	31.930	0.380		CLAYSTONE		P grey				Massive - not bedded.
DMDDH11	31.930	33.500	1.570		SANDSTONE	F-medium	White	33.50	1.6	2	Mostly massive. Graphite on bedding.
DMDDH11	33.500	34.500	1.000		SANDSTONE	F-medium	White				As above.
DMDDH11	34.500	34.540	0.040		Fe STONE	medium	Brown				Hard. With sand. Undulose top surface.
DMDDH11	34.540	34.570	0.030		SANDSTONE	medium	Brown				With Fe cement.
DMDDH11	34.570	34.580	0.010		Fe STONE		Brown				Two 0.005m bands. Coalescing and lenticular.
DMDDH11	34.580	34.670	0.090		SANDSTONE	Medium	Orange				Coarser at bottom.
DMDDH11	34.670	35.100	0.430		SANDSTONE	Medium	Cream+or	35.10	1.6	1.6	Coarser at bottom & darker orange. EOH 35.1m

Appendix B

Groundwater hydrographs







Appendix C

Groundwater works within 3 km

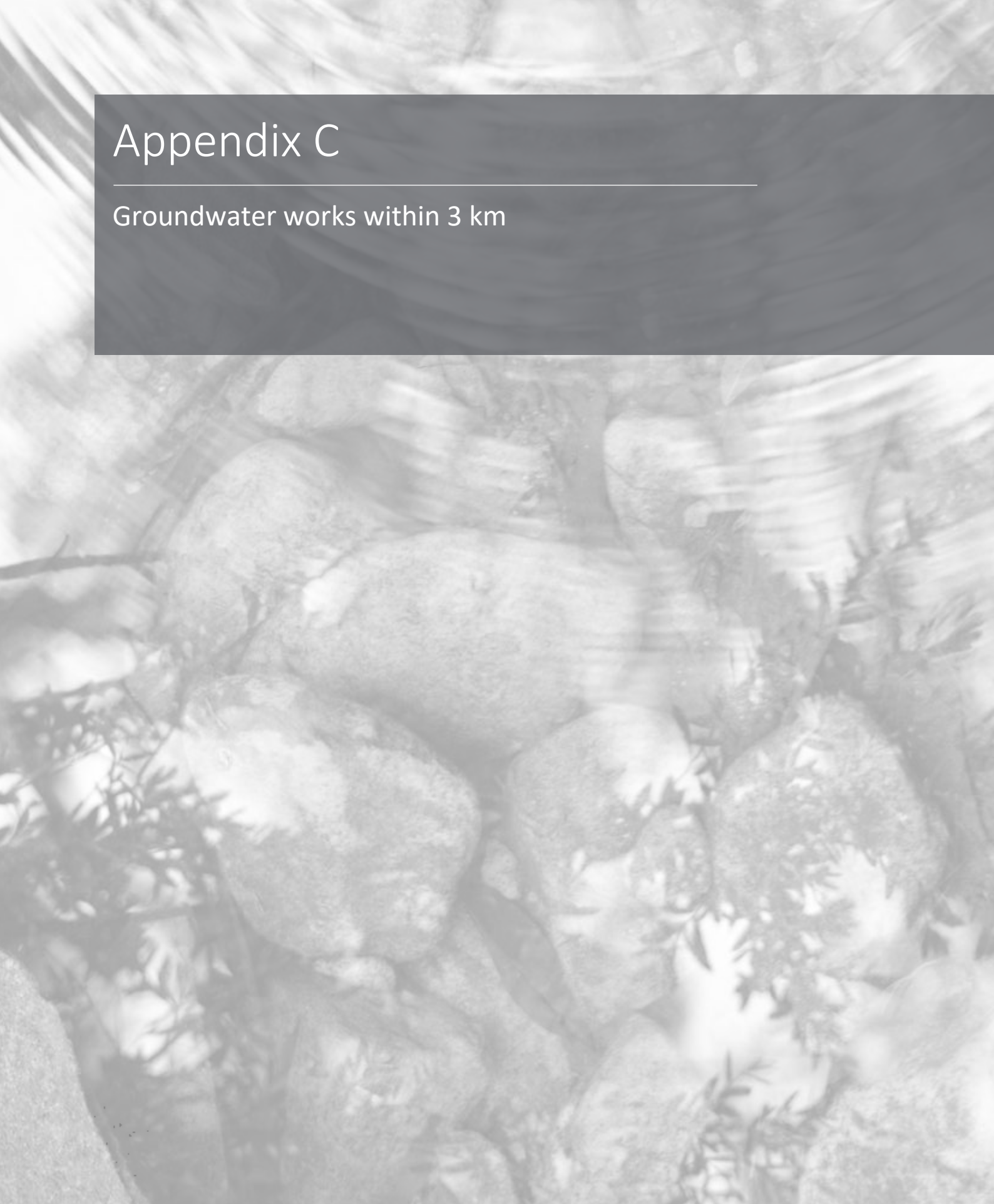


Table C.1 **Nearby groundwater works (within 1 km)**

Registered ID	Easting	Northing	Ground Elevation (m AHD)	Type	Casing depth (m)	Formation	Time of drilling depth to water (mbgl)
GW109326	310409	6293804	140.11	Water Supply	180	Hawkesbury Sandstone	
GW102587	310120	6293774	136.55	Water Supply	174.5	Hawkesbury Sandstone	
GW109927	311457	6293784	142.98	Water Supply	162	Hawkesbury Sandstone	
GW102634	310177	6293528	154.13	Water Supply	61	Hawkesbury Sandstone	
GW105067	311528	6293997	138.81	Water Supply	30.48	Hawkesbury Sandstone	
GW105943	312802	6296929	179.56	Irrigation	5	Hawkesbury Sandstone	
GW105044	312572	6296871	169.57	Commercial and Industrial	144.5	Hawkesbury Sandstone	
GW105047	312734	6297012	180.08	Commercial and Industrial	156.8	Hawkesbury Sandstone	
GW104460	314078	6296500	192.99	Water Supply	96	Hawkesbury Sandstone	
GW104105	313205	6298347	223.44	Water Supply	91.44	Hawkesbury Sandstone	
GW101527	312818	6296319	173.35	Commercial and Industrial	138	Hawkesbury Sandstone	
GW101212	313439	6298430	210.91	Water Supply	60	Hawkesbury Sandstone	
GW101528	312987	6295975	178.43	Commercial and Industrial	150	Hawkesbury Sandstone	
GW107004	313639	6297392	197.68	Commercial and Industrial	204.4	Hawkesbury Sandstone	
GW108136	313184	6298298	220.08	Water Supply	66	Hawkesbury Sandstone	18
GW060051	313067	6297622	220.78	Water Supply	172.2	Hawkesbury Sandstone	
GW113253	313338	6297642	0	Water Supply	120	Hawkesbury Sandstone	
GW100185	310462	6293284	142.91	Water Supply	73.2	Hawkesbury Sandstone	
GW101839	313075	6298248	201.61	Unknown	0	Hawkesbury Sandstone	
GW104348	313027	6298903	206.92	Water Supply	132	Hawkesbury Sandstone	

Table C.1 **Nearby groundwater works (within 1 km)**

Registered ID	Easting	Northing	Ground Elevation (m AHD)	Type	Casing depth (m)	Formation	Time of drilling depth to water (mbgl)
GW103570	312776	6298240	173.39	Water Supply	57.91	Hawkesbury Sandstone	
GW072980	311016	6294189		Water Supply	151	Hawkesbury Sandstone	
GW072037	313598	6296047	219.19	Irrigation	99	Hawkesbury Sandstone	
GW105835	314116	6295574	194.11	Commercial and Industrial	126	Maroota Tertiary Sand	
GW112398	314329	6294786	0	Water Supply	102	Maroota Tertiary Sand	
GW103148	314520	6296617	196.66	Water Supply	60	Maroota Tertiary Sand	
GW104614	313676	6294811	189.32	Irrigation	4	Maroota Tertiary Sand	
GW105192	313698	6296366	222.8	Irrigation	234	Maroota Tertiary Sand	
GW102133	313454	6296335	209.97	Water Supply	150.5	Maroota Tertiary Sand	77
GW100587	314362	6295353	205.6	Commercial and Industrial	42.5	Maroota Tertiary Sand	14
GW100230	314402	6295147	213.84	Irrigation	60	Maroota Tertiary Sand	29
GW102583	314484	6295153	209.38	Water Supply	102	Maroota Tertiary Sand	
GW102005	314512	6294999	215.56	Water Supply	61	Maroota Tertiary Sand	18
GW111943	314493	6295313		Water Supply	66	Maroota Tertiary Sand	30
GW110198	314442	6295428		Water Supply	54	Maroota Tertiary Sand	
GW107345	313853	6295846	212.49	Water Supply	150	Maroota Tertiary Sand	40
GW016348	313792	6296187	219.85	Irrigation	73.1	Unknown	
GW072274	314067	6296137	195.44	Water Supply	168.5	Unknown	
GW059118	314360	6296198	188.6	Irrigation	6	Unknown	
GW059742	314333	6296259	187.44	Water Supply	23.2	Unknown	
GW053898	314327	6296567	184.41	Irrigation	31	Unknown	6
GW108133	313484	6296427	213.57	Other	150.6	Unknown	
GW037738	310127	6293404	144.62	Irrigation	94.4	Unknown	
GW060147	315187	6294827	190.03	Irrigation	46	Unknown	

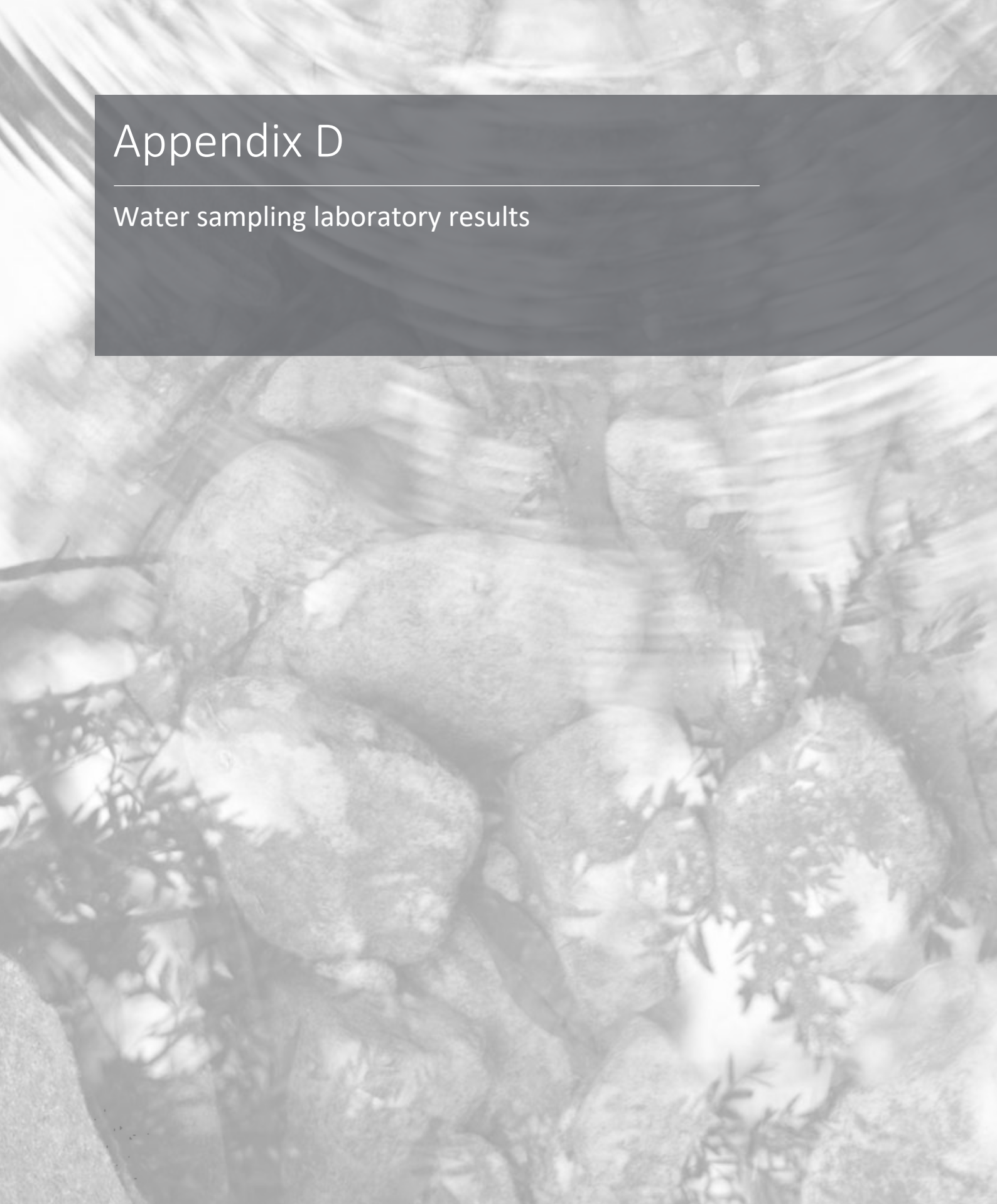
Table C.1 **Nearby groundwater works (within 1 km)**

Registered ID	Easting	Northing	Ground Elevation (m AHD)	Type	Casing depth (m)	Formation	Time of drilling depth to water (mbgl)
GW102451	313735	6295514	220	Commercial and Industrial	156.5	Unknown	
GW110585	314443	6295902	198.53	Irrigation	280	Unknown	
GW048741	313603	6296615	225.76	Water Supply	30	Unknown	6.2
GW034628	313477	6296458	213.7	Water Supply	91.4	Unknown	5.4
GW106261	313624	6296667	228.04	Unknown	0	Unknown	
GW038147	313089	6297838	207.88	Irrigation	121.9	Unknown	17
GW055962	313719	6297295	192.3	Stock and Domestic	22	Unknown	4
GW033197	309823	6294415	123.52	Water Supply	76.2	Unknown	
GW015051	313404	6298922	232.1	Water Supply	85.3	Unknown	
GW057460	311142	6294348	147.76	Water Supply	76	Unknown	
GW072780	311127	6294350	147.76	Water Supply	180.5	Unknown	
GW100864	313050	6295256	202.99	Unknown	137.16	Unknown	
GW071883	313225	6298796		Other		Unknown	

Note: mAHD – Australian Height Datum, mbgl – metres below ground level

Appendix D

Water sampling laboratory results



D.1 Groundwater results

Parameter	Units	9/05/2017											16/06/2020						5/08/2020							
		DM01	DM02 S	DM02 D	DMDDH 03	DM04	DM05	DM06	DMDDH 07	DMDDH 09	DMDDH 10	DMDDH 11	DM02 D	DMDDH 03	DM04	DM06	DMD DH07	DMDDH 09	DMDDH 10	DM02 D	DMDDH 03	DM04	DMDDH 07	DMDDH 09	DMDDH 10	DMDDH 11
Physicochemcial parameters (field)																										
Electrical Conductivity	µS/cm												401.5	140.8	268.7	206.1	344.9	794	85.6	195.2	148.7	106	381.8	790	219	316.6
Total Dissolved Solids	mg/L												260.6	91.65	174.8	133.9	224.25	513.5	55.6							
pH	pH												5.76	4.76	4.13	5.18	7.86	3.74	4.77	4.96	4.95	4.53	9.57	5.01	4.54	4.7
Redox	mV												100.4	-172	19.4	-183	-197	-90	-122							
Dissolved oxygen % sat	%												42	47	22	25	36	38	50							
Dissolved oxygen	mg/L												4.3	4.4	2.1	2.6	3.4	4.5	4.8							
Physicochemical parameters (lab)																										
pH	pH	4.48	4.9	5.74	4.34	4.49	4.1	4.91	6.71	3.7	4.01	3.9	5.76	5.31	5.06		6.91	3.92	4.57	6.13	6.01	5.51	9.04	4.67	5.01	5.27
Electrical Conductivity @ 25°C	µS/cm	196	102	237	173	276	243	156	349	941	344	372	214	157	290		382	854	81	222	166	107	440	941	235	340
Total Dissolved Solids (Calc.)	mg/L	132	71	139	102	163	147	122	364	422	178	214	139	102	188		248	555	53	144	108	70	286	612	153	221
Total Hardness as CaCO3	mg/L												27	13	35		64	65	<1	25	20	13	88	63	26	32
Hydroxide Alkalinity as CaCO3	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1	<1	<1	<1	<1	15	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	mg/L	<1	1	16	<1	<1	<1	<1	84	<1	<1	<1	12	4	5		35	<1	<1	13	15	5	35	<1	2	2
Total Alkalinity as CaCO3	mg/L	<1	1	16	<1	<1	<1	<1	84	<1	<1	<1	12	4	5		35	<1	<1	13	15	5	50	<1	2	2
Major ions																										
Fluoride	mg/L												<0.1	<0.1	<0.1		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sulfate as SO4 - Turbidimetric	mg/L	<1	2	8	1	15	6	3	19	9	1	6	3	4	16		4	9	6	3	3	7	4	10	4	8
Chloride	mg/L	30	24	46	38	44	57	35	34	293	63	101	50	37	50		77	207	18	44	36	16	70	254	45	79
Calcium	mg/L	<1	<1	6	<1	<1	<1	<1	16	<1	<1	<1	6	2	1		24	<1	<1	5	3	2	32	2	2	3
Magnesium	mg/L	5	1	3	3	8	3	3	<1	15	6	5	3	2	8		1	14	<1	3	3	2	2	14	5	6
Sodium	mg/L	20	13	32	21	26	28	18	60	113	36	41	27	20	29		44	105	13	26	21	12	45	104	28	42
Potassium	mg/L	<1	<1	1	<1	<1	<1	<1	3	1	<1	<1	<1	<1	<1		2	1	<1	<1	<1	1	2	1	<1	<1
Dissolved metals																										
Arsenic	mg/L	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Beryllium	mg/L												<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	
Barium	mg/L												0.024	0.012	0.034		0.044	0.082	0.002	0.021	0.017	0.017	0.043	0.081	0.026	0.027
Cadmium	mg/L	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.0001	<0.0001	<0.001	<0.0001	<0.001		<0.001	<0.0001	<0.0001	<0.001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001
Chromium	mg/L	<0.001	<0.001	0.001	<0.001	0.001	0.01	0.001	0.005	<0.001	0.003	<0.001	1	<0.001	0.001		0.011	0.002	0.001	1	<0.001	0.003	0.01	<0.001	<0.001	<0.001
Cobalt	mg/L												0.002	0.001	0.001		<0.001	0.003	<0.001	0.002	0.001	1	<0.001	0.003	0.002	0.001
Copper	mg/L	0.002	0.001	0.005	0.016	0.006	0.016	0.015	0.001	0.006	0.016	0.004	1	0.001	0.003		0.003	0.004	<0.001	1	<0.001	1	<0.001	0.001	<0.001	<0.001
Lead	mg/L	<0.001	<0.001	<0.001	0.004	<0.001	0.004	1	<0.001	0.005	0.005	0.001	<0.001	<0.001	0.001		<0.001	0.004	<0.001	1	<0.001	1	<0.001	0.003	<0.001	<0.001
Manganese	mg/L												0.03	0.029	0.029		0.004	0.071	0.004	0.029	0.033	0.008	<0.001	0.072	0.041	0.024
Nickel	mg/L	<0.001	0.002	0.005	0.002	0.009	0.013	0.016	0.002	0.002	0.011	0.002	0.002	0.003	0.004		0.005	0.004	0.001	0.001	0.002	0.001	<0.001	0.004	0.002	0.005
Selenium	mg/L												<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
Vanadium	mg/L												<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
Zinc	mg/L	0.022	0.059	0.043	0.023	0.038	0.036	0.1	0.015	0.016	0.027	0.033	0.019	0.19	0.033		0.026	0.053	0.038	0.012	0.039	0.022	<0.005	0.058	0.041	0.052

Parameter	Units	9/05/2017											16/06/2020						5/08/2020									
			DM02	DM02	DMDDH					DMDDH	DMDDH	DMDDH	DMDDH	DM02	DMDDH			DMD	DMDDH	DMDDH	DM02	DMDDH			DMDDH	DMDDH	DMDDH	DMDDH
		DM01	S	D	03	DM04	DM05	DM06	07	09	10	11	D	03	DM04	DM06	DH07	09	10	D	03	DM04	07	09	10	11		
Boron	mg/L												<0.05	<0.05	<0.05		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05		
Mercury	mg/L	<0.00	<0.00	<0.00		<0.00	<0.00	<0.00					<0.00		<0.00		<0.00		<0.00		<0.00							
		01	01	01	<0.0001	01	01	01	<0.0001	<0.0001	<0.0001	<0.0001	01	<0.0001	01		01	<0.0001	<0.0001	01	<0.0001	01	<0.0001	<0.0001	<0.0001	<0.0001		
Nutrients																												
Ammonia as N	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.47	0.05	0.02	0.12	<0.01	0.06	0.06		0.03	0.08	<0.01	0.01	0.04	0.12	0.08	0.07	<0.01	0.05		
Nitrite as N	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.27	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	0.02	<0.01	0.02	<0.01	<0.01	0.02	0.02		
Nitrate as N	mg/L	9.36	0.1	1.88	2.05	7.91	<0.01	1.49	1.32	0.1	9.91	0.09	1.86	1.86	14.6		5.48	0.22	0.27	2.31	1.35	2.03	5.43	0.81	6.14	0.28		
Nitrite + Nitrate as N	mg/L	9.36	0.1	1.88	2.05	7.91	<0.01	1.49	1.59	0.1	9.91	0.09	1.86	1.86	14.6		5.48	0.22	0.27	2.33	1.35	2.05	5.43	0.81	6.16	0.3		
Total Kjeldahl Nitrogen as N	mg/L	0.3	<0.1	0.1	0.3	0.6	<0.1	0.3	2	<0.1	0.4	0.1	0.6	0.4	1.2		0.8	1.3	0.1	0.5	0.6	1.1	0.7	0.2	0.8	1.6		
Total Nitrogen as N	mg/L	9.7	0.1	2	2.4	8.5	<0.1	1.8	3.6	0.1	10.3	0.2	2.5	2.3	15.8		6.3	1.5	0.4	2.8	2	3.2	6.1	1	7	1.9		
Total Phosphorus as P	mg/L	<0.01	<0.01	<0.01	0.08	<0.01	<0.01	0.03	12.9	0.18	0.06	<0.01	0.49	0.06	0.21		1.68	1.45	0.04	0.2	0.18	0.17	0.92	0.24	0.27	0.34		
Reactive Phosphorus as P	mg/L												<0.01	<0.01	<0.01		0.05	0.07	0.01	<0.01	<0.01	<0.01	0.02	0.03	<0.01	<0.01		
Organochlorine Pesticides																												
alpha-BHC	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
Hexachlorobenzene (HCB)	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
beta-BHC	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
gamma-BHC	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
delta-BHC	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
Heptachlor	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
Aldrin	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
Heptachlor epoxide	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
trans-Chlordane	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
alpha-Endosulfan	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
cis-Chlordane	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
Dieldrin	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
4,4`-DDE	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
Endrin	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
beta-Endosulfan	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
4,4`-DDD	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
Endrin aldehyde	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
Endosulfan sulfate	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
4,4`-DDT	µg/L	----	<2.0	<2.0	<2.0	----	----	<2.0	<2.0	----	----	----																
Endrin ketone	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
Methoxychlor	µg/L	----	<2.0	<2.0	<2.0	----	----	<2.0	<2.0	----	----	----																
Total Chlordane (sum)	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
Sum of DDD + DDE + DDT	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
Sum of Aldrin + Dieldrin	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
Organophosphorus Pesticides																												
Dichlorvos	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
Demeton-S-methyl	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
Monocrotophos	µg/L	----	<2.0	<2.0	<2.0	----	----	<2.0	<2.0	----	----	----																
Dimethoate	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
Diazinon	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
Chlorpyrifos-methyl	µg/L	----	<0.5	<0.5	<0.5	----	----	<0.5	<0.5	----	----	----																
Parathion-methyl	µg/L	----	<2.0	<2.0	<2.0	----	----	<2.0	<2.0	----	----	----																

Parameter	Units	9/05/2017											16/06/2020						5/08/2020							
		DM01	DM02 S	DM02 D	DMDDH 03	DM04	DM05	DM06	DMDDH 07	DMDDH 09	DMDDH 10	DMDDH 11	DM02 D	DMDDH 03	DM04	DM06	DMD DH07	DMDDH 09	DMDDH 10	DM02 D	DMDDH 03	DM04	DMDDH 07	DMDDH 09	DMDDH 10	DMDDH 11
Total Petroleum Hydrocarbons																										
C6 - C9 Fraction	µg/L	----	<20	<20	<20	----	----	<20	<20	----	----	----														
C10 - C14 Fraction	µg/L	----	<50	<50	<50	----	----	50	230	----	----	----														
C15 - C28 Fraction	µg/L	----	<100	<100	<100	----	----	<100	150	----	----	----														
C29 - C36 Fraction	µg/L	----	<50	<50	<50	----	----	<50	<50	----	----	----														
C10 - C36 Fraction (sum)	µg/L	----	<50	<50	<50	----	----	50	380	----	----	----														
Total Recoverable Hydrocarbons - NEPM 2013 Fractions																										
C6 - C10 Fraction	µg/L	----	<20	<20	<20	----	----	<20	<20	----	----	----														
C6 - C10 Fraction minus BTEX (F1)	µg/L	----	<20	<20	<20	----	----	<20	<20	----	----	----														
>C10 - C16 Fraction	µg/L	----	<100	<100	<100	----	----	<100	280	----	----	----														
>C16 - C34 Fraction	µg/L	----	<100	<100	<100	----	----	<100	<100	----	----	----														
>C34 - C40 Fraction	µg/L	----	<100	<100	<100	----	----	<100	<100	----	----	----														
>C10 - C40 Fraction (sum)	µg/L	----	<100	<100	<100	----	----	<100	280	----	----	----														
>C10 - C16 Fraction minus Naphthalene (F2)	µg/L	----	<100	<100	<100	----	----	<100	280	----	----	----														
BTEXN																										
Benzene	µg/L	----	<1	<1	<1	----	----	<1	<1	----	----	----														
Toluene	µg/L	----	<2	<2	<2	----	----	<2	<2	----	----	----														
Ethylbenzene	µg/L	----	<2	<2	<2	----	----	<2	<2	----	----	----														
meta- & para-Xylene	µg/L	----	<2	<2	<2	----	----	<2	<2	----	----	----														
ortho-Xylene	µg/L	----	<2	<2	<2	----	----	<2	<2	----	----	----														
Total Xylenes	µg/L	----	<2	<2	<2	----	----	<2	<2	----	----	----														
Sum of BTEX	µg/L	----	<1	<1	<1	----	----	<1	<1	----	----	----														
Naphthalene	µg/L	----	<5	<5	<5	----	----	<5	<5	----	----	----														

D.2 Surface water results

Table D.1 Surface water quality monitoring results

Parameter	Units	DGV	Event 1 – 6 April 2020						Event 2 – 16 June 2020			Event 3 – 5 August 2020		
			Dam 1	Dam 1 downstream	Dam 2	Dam 3	Dam 3 downstream	Dam 4	Dam 1	Dam 3	Dam 4	Dam 1	Dam 3	Dam 4
Physicochemical parameters														
DO	mg/L		2.16	3.83	5.14	2.26	5.7	1.1						
EC	µS/cm	300	162	166	381	300	260	65	230	768	437	234	451	374
pH	pH units	6.5–8.5	5.67	5.74	5.26	5.52	5.75	5.77	6.15	4.95	6.44	6.23	4.24	5.87
TDS	mg/L		122	124	284	222	196	48	150	499	284	152	326	280
Major ions														
Bicarbonate alkalinity	mg/L		14	13	3	37	31	5	16	3	26	7	<1	22
Carbonate alkalinity	mg/L		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Hydroxide alkalinity	mg/L		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<
Total alkalinity	mg/L		14	13	3	37	31	5	16	3	26	7	<1	22
Calcium	mg/L		4	4	15	7	5	1	2	43	14	5	25	15
Chloride	mg/L		32	32	36	38	42	10	52	53	58	34	36	44
Fluoride	mg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1
Magnesium	mg/L		4	4	17	9	10	2	6	35	18	7	20	17
Potassium	mg/L		2	2	8	6	4	4	1	12	7	2	9	6
Sodium	mg/L		20	20	23	24	27	6	29	36	36	23	23	30
Sulfate	mg/L		13	13	65	26	27	1	6	132	82	31	84	94
Total hardness	mg/L		26	26	109	54	54	11	30	250	109	41	145	107
Nutrients														
Ammonia	mg N/L	0.02							0.12	0.04	0.25	0.11	0.06	0.02
Nitrate	mg N/L								1.57	33.4	1.35	2.07	20.3	2.72

Table D.1 **Surface water quality monitoring results**

Parameter	Units	DGV	Event 1 – 6 April 2020						Event 2 – 16 June 2020			Event 3 – 5 August 2020		
			Dam 1	Dam 1 downstream	Dam 2	Dam 3	Dam 3 downstream	Dam 4	Dam 1	Dam 3	Dam 4	Dam 1	Dam 3	Dam 4
Nitrite	mg N/L								0.02	<0.01	0.02	<0.01	0.03	0.02
Nitrite + nitrate	mg N/L	0.04							1.59	33.4	1.37	2.07	20.3	2.74
Total Kjeldahl nitrogen	mg N/L								0.3	5.1	0.9	0.5	1.8	0.7
Total nitrogen	mg N/L	0.5							1.9	38.5	2.3	2.6	22.1	3.4
Reactive phosphorus	mg P/L	0.02							<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total phosphorus	mg P/L	0.05							<0.01	0.02	0.03	0.01	0.02	0.02
Dissolved metals														
Arsenic	mg/L	0.013							<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	mg/L								0.014	0.054	0.020	0.014	0.031	0.019
Beryllium	mg/L								<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.37							<0.05	0.06	<0.05	<0.05	<0.05	<0.05
Cadmium	mg/L	0.0002							<0.0001	0.0002	<0.0001	<0.0001	0.0002	<0.0001
Chromium	mg/L	0.001							<0.001	<0.001	<0.001	0.001	<0.001	<0.001
Cobalt	mg/L	0.0014							<0.001	0.002	<0.001	<0.001	0.002	<0.001
Copper	mg/L	0.0014							<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	mg/L	0.0034							<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	1.9							0.038	0.068	0.008	0.017	0.050	0.006
Mercury	mg/L	0.00006							<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	mg/L	0.011							0.001	0.003	<0.001	<0.001	0.002	0.001
Selenium	mg/L	0.005							<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	mg/L	0.006							<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	0.008 ¹							0.005	0.073	0.014	<0.005	0.074	0.016

CERTIFICATE OF ANALYSIS

Work Order	: ES1705324	Page	: 1 of 19
Amendment	: 1		
Client	: AUST GROUNDWATER & ENVIRO CONSULTANTS	Laboratory	: Environmental Division Sydney
Contact	: COSTANTE CONTE	Contact	: Customer Services ES
Address	: 4 HUDSON STREET HAMILTON NSW 2303	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: +61 02 4962 2091	Telephone	: +61-2-8784 8555
Project	: G1859- MAROOTA SANDS	Date Samples Received	: 10-Mar-2017 09:34
Order number	: ----	Date Analysis Commenced	: 11-May-2017
C-O-C number	: ----	Issue Date	: 23-May-2017 18:02
Sampler	: THOMAS WALTERS		
Site	: ----		
Quote number	: SY/224/17		
No. of samples received	: 12		
No. of samples analysed	: 12		



Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Edwandy Fadjar	Organic Coordinator	Sydney Organics, Smithfield, NSW
Raymond Commodore	Instrument Chemist	Sydney Inorganics, Smithfield, NSW
Sanjeshni Jyoti	Senior Chemist Volatiles	Sydney Organics, Smithfield, NSW



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- TDS by method EA-015 may bias high for various samples due to the presence of fine particulate matter, which may pass through the prescribed GF/C paper.
- EK055G: It has been noted that Ammonia is greater than TKN for sample No 11, however this difference is within the limits of experimental variation.
- Ionic Balance out of acceptable limits for sample 9 due to analytes not quantified in this report.
- Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenzo(a,h)anthracene (1.0), Benzo(g,h,i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero.



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	DM01	DM02D	DM02S	DMDDH03	DM04
Client sampling date / time					09-May-2017 09:55	09-May-2017 08:11	09-May-2017 09:15	09-May-2017 13:43	09-May-2017 14:48
Compound	CAS Number	LOR	Unit		ES1705324-001	ES1705324-002	ES1705324-003	ES1705324-004	ES1705324-005
					Result	Result	Result	Result	Result
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		4.48	5.74	4.90	4.34	4.49
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		196	237	102	173	276
EA015: Total Dissolved Solids dried at 180 ± 5 °C									
Total Dissolved Solids @180°C	----	10	mg/L		132	139	71	102	163
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		<1	16	1	<1	<1
Total Alkalinity as CaCO3	----	1	mg/L		<1	16	1	<1	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		<1	8	2	1	15
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		30	46	24	38	44
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		<1	6	<1	<1	<1
Magnesium	7439-95-4	1	mg/L		5	3	1	3	8
Sodium	7440-23-5	1	mg/L		20	32	13	21	26
Potassium	7440-09-7	1	mg/L		<1	1	<1	<1	<1
EG020F: Dissolved Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L		<0.001	<0.001	0.002	<0.001	<0.001
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L		<0.001	0.001	<0.001	<0.001	0.001
Copper	7440-50-8	0.001	mg/L		0.002	0.005	0.001	0.016	0.006
Nickel	7440-02-0	0.001	mg/L		<0.001	0.005	0.002	0.002	0.009
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	<0.001	0.004	<0.001
Zinc	7440-66-6	0.005	mg/L		0.022	0.043	0.059	0.023	0.038
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	DM01	DM02D	DM02S	DMDDH03	DM04
Client sampling date / time					09-May-2017 09:55	09-May-2017 08:11	09-May-2017 09:15	09-May-2017 13:43	09-May-2017 14:48
Compound	CAS Number	LOR	Unit		ES1705324-001	ES1705324-002	ES1705324-003	ES1705324-004	ES1705324-005
					Result	Result	Result	Result	Result
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		9.36	1.88	0.10	2.05	7.91
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		9.36	1.88	0.10	2.05	7.91
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		0.3	0.1	<0.1	0.3	0.6
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		9.7	2.0	0.1	2.4	8.5
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		<0.01	<0.01	<0.01	0.08	<0.01
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		0.85	1.78	0.74	1.09	1.55
Total Cations	----	0.01	meq/L		1.28	1.96	0.65	1.16	1.79
EP068A: Organochlorine Pesticides (OC)									
alpha-BHC	319-84-6	0.5	µg/L		----	<0.5	<0.5	<0.5	----
Hexachlorobenzene (HCB)	118-74-1	0.5	µg/L		----	<0.5	<0.5	<0.5	----
beta-BHC	319-85-7	0.5	µg/L		----	<0.5	<0.5	<0.5	----
gamma-BHC	58-89-9	0.5	µg/L		----	<0.5	<0.5	<0.5	----
delta-BHC	319-86-8	0.5	µg/L		----	<0.5	<0.5	<0.5	----
Heptachlor	76-44-8	0.5	µg/L		----	<0.5	<0.5	<0.5	----
Aldrin	309-00-2	0.5	µg/L		----	<0.5	<0.5	<0.5	----
Heptachlor epoxide	1024-57-3	0.5	µg/L		----	<0.5	<0.5	<0.5	----
trans-Chlordane	5103-74-2	0.5	µg/L		----	<0.5	<0.5	<0.5	----
alpha-Endosulfan	959-98-8	0.5	µg/L		----	<0.5	<0.5	<0.5	----
cis-Chlordane	5103-71-9	0.5	µg/L		----	<0.5	<0.5	<0.5	----
Dieldrin	60-57-1	0.5	µg/L		----	<0.5	<0.5	<0.5	----
4,4'-DDE	72-55-9	0.5	µg/L		----	<0.5	<0.5	<0.5	----
Endrin	72-20-8	0.5	µg/L		----	<0.5	<0.5	<0.5	----
beta-Endosulfan	33213-65-9	0.5	µg/L		----	<0.5	<0.5	<0.5	----
4,4'-DDD	72-54-8	0.5	µg/L		----	<0.5	<0.5	<0.5	----
Endrin aldehyde	7421-93-4	0.5	µg/L		----	<0.5	<0.5	<0.5	----
Endosulfan sulfate	1031-07-8	0.5	µg/L		----	<0.5	<0.5	<0.5	----
4,4'-DDT	50-29-3	2	µg/L		----	<2.0	<2.0	<2.0	----
Endrin ketone	53494-70-5	0.5	µg/L		----	<0.5	<0.5	<0.5	----
Methoxychlor	72-43-5	2	µg/L		----	<2.0	<2.0	<2.0	----



Analytical Results

Sub-Matrix: WATER
 (Matrix: WATER)

Client sample ID

				DM01	DM02D	DM02S	DMDDH03	DM04
Client sampling date / time				09-May-2017 09:55	09-May-2017 08:11	09-May-2017 09:15	09-May-2017 13:43	09-May-2017 14:48
Compound	CAS Number	LOR	Unit	ES1705324-001	ES1705324-002	ES1705324-003	ES1705324-004	ES1705324-005
				Result	Result	Result	Result	Result
EP068A: Organochlorine Pesticides (OC) - Continued								
^ Total Chlordane (sum)	----	0.5	µg/L	----	<0.5	<0.5	<0.5	----
^ Sum of DDD + DDE + DDT	72-54-8/72-55-9/5 0-2	0.5	µg/L	----	<0.5	<0.5	<0.5	----
^ Sum of Aldrin + Dieldrin	309-00-2/60-57-1	0.5	µg/L	----	<0.5	<0.5	<0.5	----
EP068B: Organophosphorus Pesticides (OP)								
Dichlorvos	62-73-7	0.5	µg/L	----	<0.5	<0.5	<0.5	----
Demeton-S-methyl	919-86-8	0.5	µg/L	----	<0.5	<0.5	<0.5	----
Monocrotophos	6923-22-4	2	µg/L	----	<2.0	<2.0	<2.0	----
Dimethoate	60-51-5	0.5	µg/L	----	<0.5	<0.5	<0.5	----
Diazinon	333-41-5	0.5	µg/L	----	<0.5	<0.5	<0.5	----
Chlorpyrifos-methyl	5598-13-0	0.5	µg/L	----	<0.5	<0.5	<0.5	----
Parathion-methyl	298-00-0	2	µg/L	----	<2.0	<2.0	<2.0	----
Malathion	121-75-5	0.5	µg/L	----	<0.5	<0.5	<0.5	----
Fenthion	55-38-9	0.5	µg/L	----	<0.5	<0.5	<0.5	----
Chlorpyrifos	2921-88-2	0.5	µg/L	----	<0.5	<0.5	<0.5	----
Parathion	56-38-2	2	µg/L	----	<2.0	<2.0	<2.0	----
Pirimphos-ethyl	23505-41-1	0.5	µg/L	----	<0.5	<0.5	<0.5	----
Chlorfenvinphos	470-90-6	0.5	µg/L	----	<0.5	<0.5	<0.5	----
Bromophos-ethyl	4824-78-6	0.5	µg/L	----	<0.5	<0.5	<0.5	----
Fenamiphos	22224-92-6	0.5	µg/L	----	<0.5	<0.5	<0.5	----
Prothiofos	34643-46-4	0.5	µg/L	----	<0.5	<0.5	<0.5	----
Ethion	563-12-2	0.5	µg/L	----	<0.5	<0.5	<0.5	----
Carbophenothion	786-19-6	0.5	µg/L	----	<0.5	<0.5	<0.5	----
Azinphos Methyl	86-50-0	0.5	µg/L	----	<0.5	<0.5	<0.5	----
EP075(SIM)A: Phenolic Compounds								
Phenol	108-95-2	1	µg/L	----	<1.0	<1.0	<1.0	----
2-Chlorophenol	95-57-8	1	µg/L	----	<1.0	<1.0	<1.0	----
2-Methylphenol	95-48-7	1	µg/L	----	<1.0	<1.0	<1.0	----
3- & 4-Methylphenol	1319-77-3	2	µg/L	----	<2.0	<2.0	<2.0	----
2-Nitrophenol	88-75-5	1	µg/L	----	<1.0	<1.0	<1.0	----
2,4-Dimethylphenol	105-67-9	1	µg/L	----	<1.0	<1.0	<1.0	----
2,4-Dichlorophenol	120-83-2	1	µg/L	----	<1.0	<1.0	<1.0	----
2,6-Dichlorophenol	87-65-0	1	µg/L	----	<1.0	<1.0	<1.0	----
4-Chloro-3-methylphenol	59-50-7	1	µg/L	----	<1.0	<1.0	<1.0	----
2,4,6-Trichlorophenol	88-06-2	1	µg/L	----	<1.0	<1.0	<1.0	----



Analytical Results

Sub-Matrix: WATER
 (Matrix: WATER)

Client sample ID

				DM01	DM02D	DM02S	DMDDH03	DM04
Client sampling date / time				09-May-2017 09:55	09-May-2017 08:11	09-May-2017 09:15	09-May-2017 13:43	09-May-2017 14:48
Compound	CAS Number	LOR	Unit	ES1705324-001	ES1705324-002	ES1705324-003	ES1705324-004	ES1705324-005
				Result	Result	Result	Result	Result
EP075(SIM)A: Phenolic Compounds - Continued								
2,4,5-Trichlorophenol	95-95-4	1	µg/L	----	<1.0	<1.0	<1.0	----
Pentachlorophenol	87-86-5	2	µg/L	----	<2.0	<2.0	<2.0	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1	µg/L	----	<1.0	<1.0	<1.0	----
Acenaphthylene	208-96-8	1	µg/L	----	<1.0	<1.0	<1.0	----
Acenaphthene	83-32-9	1	µg/L	----	<1.0	<1.0	<1.0	----
Fluorene	86-73-7	1	µg/L	----	<1.0	<1.0	<1.0	----
Phenanthrene	85-01-8	1	µg/L	----	<1.0	<1.0	<1.0	----
Anthracene	120-12-7	1	µg/L	----	<1.0	<1.0	<1.0	----
Fluoranthene	206-44-0	1	µg/L	----	<1.0	<1.0	<1.0	----
Pyrene	129-00-0	1	µg/L	----	<1.0	<1.0	<1.0	----
Benz(a)anthracene	56-55-3	1	µg/L	----	<1.0	<1.0	<1.0	----
Chrysene	218-01-9	1	µg/L	----	<1.0	<1.0	<1.0	----
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1	µg/L	----	<1.0	<1.0	<1.0	----
Benzo(k)fluoranthene	207-08-9	1	µg/L	----	<1.0	<1.0	<1.0	----
Benzo(a)pyrene	50-32-8	0.5	µg/L	----	<0.5	<0.5	<0.5	----
Indeno(1,2,3.cd)pyrene	193-39-5	1	µg/L	----	<1.0	<1.0	<1.0	----
Dibenz(a,h)anthracene	53-70-3	1	µg/L	----	<1.0	<1.0	<1.0	----
Benzo(g,h,i)perylene	191-24-2	1	µg/L	----	<1.0	<1.0	<1.0	----
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L	----	<0.5	<0.5	<0.5	----
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L	----	<0.5	<0.5	<0.5	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	----	<20	<20	<20	----
C10 - C14 Fraction	----	50	µg/L	----	<50	<50	<50	----
C15 - C28 Fraction	----	100	µg/L	----	<100	<100	<100	----
C29 - C36 Fraction	----	50	µg/L	----	<50	<50	<50	----
^ C10 - C36 Fraction (sum)	----	50	µg/L	----	<50	<50	<50	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	----	<20	<20	<20	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	----	<20	<20	<20	----
>C10 - C16 Fraction	----	100	µg/L	----	<100	<100	<100	----
>C16 - C34 Fraction	----	100	µg/L	----	<100	<100	<100	----
>C34 - C40 Fraction	----	100	µg/L	----	<100	<100	<100	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	DM01	DM02D	DM02S	DMDDH03	DM04
Client sampling date / time					09-May-2017 09:55	09-May-2017 08:11	09-May-2017 09:15	09-May-2017 13:43	09-May-2017 14:48
Compound	CAS Number	LOR	Unit		ES1705324-001	ES1705324-002	ES1705324-003	ES1705324-004	ES1705324-005
					Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued									
^ >C10 - C40 Fraction (sum)	----	100	µg/L		----	<100	<100	<100	----
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L		----	<100	<100	<100	----
EP080: BTEXN									
Benzene	71-43-2	1	µg/L		----	<1	<1	<1	----
Toluene	108-88-3	2	µg/L		----	<2	<2	<2	----
Ethylbenzene	100-41-4	2	µg/L		----	<2	<2	<2	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L		----	<2	<2	<2	----
ortho-Xylene	95-47-6	2	µg/L		----	<2	<2	<2	----
^ Total Xylenes	1330-20-7	2	µg/L		----	<2	<2	<2	----
^ Sum of BTEX	----	1	µg/L		----	<1	<1	<1	----
Naphthalene	91-20-3	5	µg/L		----	<5	<5	<5	----
EP068S: Organochlorine Pesticide Surrogate									
Dibromo-DDE	21655-73-2	0.5	%		----	90.6	99.1	98.4	----
EP068T: Organophosphorus Pesticide Surrogate									
DEF	78-48-8	0.5	%		----	82.2	88.0	96.8	----
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	1	%		----	21.4	26.1	18.4	----
2-Chlorophenol-D4	93951-73-6	1	%		----	40.8	56.1	38.0	----
2,4,6-Tribromophenol	118-79-6	1	%		----	54.9	55.8	78.6	----
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	1	%		----	57.2	69.0	51.1	----
Anthracene-d10	1719-06-8	1	%		----	77.1	88.4	75.4	----
4-Terphenyl-d14	1718-51-0	1	%		----	79.5	85.8	87.0	----
EP080S: TPH(V)/BTEX Surrogates									
1,2-Dichloroethane-D4	17060-07-0	2	%		----	109	108	106	----
Toluene-D8	2037-26-5	2	%		----	115	108	107	----
4-Bromofluorobenzene	460-00-4	2	%		----	112	106	106	----



Analytical Results

Sub-Matrix: WATER
 (Matrix: WATER)

Client sample ID

				DM05	DM06	DMDDH07	DMDDH09	DMDDH10
Client sampling date / time				09-May-2017 12:25	09-May-2017 11:14	09-May-2017 12:25	09-May-2017 14:00	09-May-2017 13:20
Compound	CAS Number	LOR	Unit	ES1705324-006	ES1705324-007	ES1705324-008	ES1705324-009	ES1705324-010
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	4.10	4.91	6.71	3.70	4.01
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	243	156	349	941	344
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	147	122	364	422	178
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	<1	84	<1	<1
Total Alkalinity as CaCO3	----	1	mg/L	<1	<1	84	<1	<1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	6	3	19	9	1
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	57	35	34	293	63
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	<1	<1	16	<1	<1
Magnesium	7439-95-4	1	mg/L	3	3	<1	15	6
Sodium	7440-23-5	1	mg/L	28	18	60	113	36
Potassium	7440-09-7	1	mg/L	<1	<1	3	1	<1
EG020F: Dissolved Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.003	<0.001	<0.001
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	0.010	0.001	0.005	<0.001	0.003
Copper	7440-50-8	0.001	mg/L	0.016	0.015	0.001	0.006	0.016
Nickel	7440-02-0	0.001	mg/L	0.013	0.016	0.002	0.002	0.011
Lead	7439-92-1	0.001	mg/L	0.004	<0.001	<0.001	0.005	0.005
Zinc	7440-66-6	0.005	mg/L	0.036	0.100	0.015	0.016	0.027
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	<0.01	<0.01	0.47	0.05	0.02
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.27	<0.01	<0.01



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	DM05	DM06	DMDDH07	DMDDH09	DMDDH10
Client sampling date / time					09-May-2017 12:25	09-May-2017 11:14	09-May-2017 12:25	09-May-2017 14:00	09-May-2017 13:20
Compound	CAS Number	LOR	Unit		ES1705324-006	ES1705324-007	ES1705324-008	ES1705324-009	ES1705324-010
					Result	Result	Result	Result	Result
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		<0.01	1.49	1.32	0.10	9.91
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		<0.01	1.49	1.59	0.10	9.91
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		<0.1	0.3	2.0	<0.1	0.4
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		<0.1	1.8	3.6	0.1	10.3
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		<0.01	0.03	12.9	0.18	0.06
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		----	----	3.13	----	----
Total Anions	----	0.01	meq/L		1.73	1.05	----	8.45	1.80
Total Cations	----	0.01	meq/L		----	----	----	7.18	----
Total Cations	----	0.01	meq/L		1.46	1.03	3.48	----	2.06
Ionic Balance	----	0.01	%		----	----	5.38	8.14	----
EP068A: Organochlorine Pesticides (OC)									
alpha-BHC	319-84-6	0.5	µg/L		----	<0.5	<0.5	----	----
Hexachlorobenzene (HCB)	118-74-1	0.5	µg/L		----	<0.5	<0.5	----	----
beta-BHC	319-85-7	0.5	µg/L		----	<0.5	<0.5	----	----
gamma-BHC	58-89-9	0.5	µg/L		----	<0.5	<0.5	----	----
delta-BHC	319-86-8	0.5	µg/L		----	<0.5	<0.5	----	----
Heptachlor	76-44-8	0.5	µg/L		----	<0.5	<0.5	----	----
Aldrin	309-00-2	0.5	µg/L		----	<0.5	<0.5	----	----
Heptachlor epoxide	1024-57-3	0.5	µg/L		----	<0.5	<0.5	----	----
trans-Chlordane	5103-74-2	0.5	µg/L		----	<0.5	<0.5	----	----
alpha-Endosulfan	959-98-8	0.5	µg/L		----	<0.5	<0.5	----	----
cis-Chlordane	5103-71-9	0.5	µg/L		----	<0.5	<0.5	----	----
Dieldrin	60-57-1	0.5	µg/L		----	<0.5	<0.5	----	----
4,4'-DDE	72-55-9	0.5	µg/L		----	<0.5	<0.5	----	----
Endrin	72-20-8	0.5	µg/L		----	<0.5	<0.5	----	----
beta-Endosulfan	33213-65-9	0.5	µg/L		----	<0.5	<0.5	----	----
4,4'-DDD	72-54-8	0.5	µg/L		----	<0.5	<0.5	----	----
Endrin aldehyde	7421-93-4	0.5	µg/L		----	<0.5	<0.5	----	----
Endosulfan sulfate	1031-07-8	0.5	µg/L		----	<0.5	<0.5	----	----



Analytical Results

Sub-Matrix: WATER
 (Matrix: WATER)

Client sample ID

				DM05	DM06	DMDDH07	DMDDH09	DMDDH10
Client sampling date / time				09-May-2017 12:25	09-May-2017 11:14	09-May-2017 12:25	09-May-2017 14:00	09-May-2017 13:20
Compound	CAS Number	LOR	Unit	ES1705324-006	ES1705324-007	ES1705324-008	ES1705324-009	ES1705324-010
				Result	Result	Result	Result	Result
EP068A: Organochlorine Pesticides (OC) - Continued								
4,4'-DDT	50-29-3	2	µg/L	----	<2.0	<2.0	----	----
Endrin ketone	53494-70-5	0.5	µg/L	----	<0.5	<0.5	----	----
Methoxychlor	72-43-5	2	µg/L	----	<2.0	<2.0	----	----
^ Total Chlordane (sum)	----	0.5	µg/L	----	<0.5	<0.5	----	----
^ Sum of DDD + DDE + DDT	72-54-8/72-55-9/5 0-2	0.5	µg/L	----	<0.5	<0.5	----	----
^ Sum of Aldrin + Dieldrin	309-00-2/60-57-1	0.5	µg/L	----	<0.5	<0.5	----	----
EP068B: Organophosphorus Pesticides (OP)								
Dichlorvos	62-73-7	0.5	µg/L	----	<0.5	<0.5	----	----
Demeton-S-methyl	919-86-8	0.5	µg/L	----	<0.5	<0.5	----	----
Monocrotophos	6923-22-4	2	µg/L	----	<2.0	<2.0	----	----
Dimethoate	60-51-5	0.5	µg/L	----	<0.5	<0.5	----	----
Diazinon	333-41-5	0.5	µg/L	----	<0.5	<0.5	----	----
Chlorpyrifos-methyl	5598-13-0	0.5	µg/L	----	<0.5	<0.5	----	----
Parathion-methyl	298-00-0	2	µg/L	----	<2.0	<2.0	----	----
Malathion	121-75-5	0.5	µg/L	----	<0.5	<0.5	----	----
Fenthion	55-38-9	0.5	µg/L	----	<0.5	<0.5	----	----
Chlorpyrifos	2921-88-2	0.5	µg/L	----	<0.5	<0.5	----	----
Parathion	56-38-2	2	µg/L	----	<2.0	<2.0	----	----
Pirimphos-ethyl	23505-41-1	0.5	µg/L	----	<0.5	<0.5	----	----
Chlorfenvinphos	470-90-6	0.5	µg/L	----	<0.5	<0.5	----	----
Bromophos-ethyl	4824-78-6	0.5	µg/L	----	<0.5	<0.5	----	----
Fenamiphos	22224-92-6	0.5	µg/L	----	<0.5	<0.5	----	----
Prothiofos	34643-46-4	0.5	µg/L	----	<0.5	<0.5	----	----
Ethion	563-12-2	0.5	µg/L	----	<0.5	<0.5	----	----
Carbophenothion	786-19-6	0.5	µg/L	----	<0.5	<0.5	----	----
Azinphos Methyl	86-50-0	0.5	µg/L	----	<0.5	<0.5	----	----
EP071 SG: Total Petroleum Hydrocarbons - Silica gel cleanup								
C10 - C14 Fraction	----	50	µg/L	----	<50	<50	----	----
C15 - C28 Fraction	----	100	µg/L	----	<100	<100	----	----
C29 - C36 Fraction	----	50	µg/L	----	<50	<50	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L	----	<50	<50	----	----
EP071 SG: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Silica gel cleanup								
>C10 - C16 Fraction	----	100	µg/L	----	<100	<100	----	----



Analytical Results

Sub-Matrix: WATER
 (Matrix: WATER)

Client sample ID

				DM05	DM06	DMDDH07	DMDDH09	DMDDH10
Client sampling date / time				09-May-2017 12:25	09-May-2017 11:14	09-May-2017 12:25	09-May-2017 14:00	09-May-2017 13:20
Compound	CAS Number	LOR	Unit	ES1705324-006	ES1705324-007	ES1705324-008	ES1705324-009	ES1705324-010
				Result	Result	Result	Result	Result
EP071 SG: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Silica gel cleanup - Continued								
>C16 - C34 Fraction	----	100	µg/L	----	<100	<100	----	----
>C34 - C40 Fraction	----	100	µg/L	----	<100	<100	----	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L	----	<100	<100	----	----
>C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	----	<100	<100	----	----
EP075(SIM)A: Phenolic Compounds								
Phenol	108-95-2	1	µg/L	----	<1.0	<1.0	----	----
2-Chlorophenol	95-57-8	1	µg/L	----	<1.0	<1.0	----	----
2-Methylphenol	95-48-7	1	µg/L	----	<1.0	<1.0	----	----
3- & 4-Methylphenol	1319-77-3	2	µg/L	----	<2.0	<2.0	----	----
2-Nitrophenol	88-75-5	1	µg/L	----	<1.0	<1.0	----	----
2,4-Dimethylphenol	105-67-9	1	µg/L	----	<1.0	<1.0	----	----
2,4-Dichlorophenol	120-83-2	1	µg/L	----	<1.0	<1.0	----	----
2,6-Dichlorophenol	87-65-0	1	µg/L	----	<1.0	<1.0	----	----
4-Chloro-3-methylphenol	59-50-7	1	µg/L	----	<1.0	<1.0	----	----
2,4,6-Trichlorophenol	88-06-2	1	µg/L	----	<1.0	<1.0	----	----
2,4,5-Trichlorophenol	95-95-4	1	µg/L	----	<1.0	<1.0	----	----
Pentachlorophenol	87-86-5	2	µg/L	----	<2.0	<2.0	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1	µg/L	----	<1.0	<1.0	----	----
Acenaphthylene	208-96-8	1	µg/L	----	<1.0	<1.0	----	----
Acenaphthene	83-32-9	1	µg/L	----	<1.0	<1.0	----	----
Fluorene	86-73-7	1	µg/L	----	<1.0	<1.0	----	----
Phenanthrene	85-01-8	1	µg/L	----	<1.0	<1.0	----	----
Anthracene	120-12-7	1	µg/L	----	<1.0	<1.0	----	----
Fluoranthene	206-44-0	1	µg/L	----	<1.0	<1.0	----	----
Pyrene	129-00-0	1	µg/L	----	<1.0	<1.0	----	----
Benzo(a)anthracene	56-55-3	1	µg/L	----	<1.0	<1.0	----	----
Chrysene	218-01-9	1	µg/L	----	<1.0	<1.0	----	----
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1	µg/L	----	<1.0	<1.0	----	----
Benzo(k)fluoranthene	207-08-9	1	µg/L	----	<1.0	<1.0	----	----
Benzo(a)pyrene	50-32-8	0.5	µg/L	----	<0.5	<0.5	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	1	µg/L	----	<1.0	<1.0	----	----
Dibenz(a.h)anthracene	53-70-3	1	µg/L	----	<1.0	<1.0	----	----
Benzo(g.h.i)perylene	191-24-2	1	µg/L	----	<1.0	<1.0	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID				
Client sampling date / time				DM05	DM06	DMDDH07	DMDDH09	DMDDH10
Compound				CAS Number	LOR	Unit		
				ES1705324-006	ES1705324-007	ES1705324-008	ES1705324-009	ES1705324-010
				Result	Result	Result	Result	Result
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons - Continued								
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L	----	<0.5	<0.5	----	----
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L	----	<0.5	<0.5	----	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	----	<20	<20	----	----
C10 - C14 Fraction	----	50	µg/L	----	50	230	----	----
C15 - C28 Fraction	----	100	µg/L	----	<100	150	----	----
C29 - C36 Fraction	----	50	µg/L	----	<50	<50	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L	----	50	380	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	----	<20	<20	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	----	<20	<20	----	----
>C10 - C16 Fraction	----	100	µg/L	----	<100	280	----	----
>C16 - C34 Fraction	----	100	µg/L	----	<100	<100	----	----
>C34 - C40 Fraction	----	100	µg/L	----	<100	<100	----	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L	----	<100	280	----	----
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	----	<100	280	----	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	----	<1	<1	----	----
Toluene	108-88-3	2	µg/L	----	<2	<2	----	----
Ethylbenzene	100-41-4	2	µg/L	----	<2	<2	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	----	<2	<2	----	----
ortho-Xylene	95-47-6	2	µg/L	----	<2	<2	----	----
^ Total Xylenes	1330-20-7	2	µg/L	----	<2	<2	----	----
^ Sum of BTEX	----	1	µg/L	----	<1	<1	----	----
Naphthalene	91-20-3	5	µg/L	----	<5	<5	----	----
EP068S: Organochlorine Pesticide Surrogate								
Dibromo-DDE	21655-73-2	0.5	%	----	95.6	92.8	----	----
EP068T: Organophosphorus Pesticide Surrogate								
DEF	78-48-8	0.5	%	----	84.7	82.2	----	----
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	1	%	----	29.0	25.6	----	----
2-Chlorophenol-D4	93951-73-6	1	%	----	56.9	51.4	----	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				DM05	DM06	DMDDH07	DMDDH09	DMDDH10
Client sampling date / time				09-May-2017 12:25	09-May-2017 11:14	09-May-2017 12:25	09-May-2017 14:00	09-May-2017 13:20
Compound	CAS Number	LOR	Unit	ES1705324-006	ES1705324-007	ES1705324-008	ES1705324-009	ES1705324-010
				Result	Result	Result	Result	Result
EP075(SIM)S: Phenolic Compound Surrogates - Continued								
2,4,6-Tribromophenol	118-79-6	1	%	----	57.8	67.9	----	----
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	1	%	----	76.0	75.4	----	----
Anthracene-d10	1719-06-8	1	%	----	85.0	80.7	----	----
4-Terphenyl-d14	1718-51-0	1	%	----	83.8	80.2	----	----
EP080S: TPH(V)/BTEX Surrogates								
1,2-Dichloroethane-D4	17060-07-0	2	%	----	108	108	----	----
Toluene-D8	2037-26-5	2	%	----	111	118	----	----
4-Bromofluorobenzene	460-00-4	2	%	----	107	113	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	DMDDH11	DM02D DUPLICATE	----	----	----
Client sampling date / time					09-May-2017 14:40	09-May-2017 08:11	----	----	----
Compound	CAS Number	LOR	Unit		ES1705324-011	ES1705324-012	-----	-----	-----
				Result	Result		----	----	----
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		3.90	5.73	----	----	----
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		372	236	----	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C									
Total Dissolved Solids @180°C	----	10	mg/L		214	139	----	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		<1	15	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L		<1	15	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		6	8	----	----	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		101	48	----	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		<1	7	----	----	----
Magnesium	7439-95-4	1	mg/L		5	3	----	----	----
Sodium	7440-23-5	1	mg/L		41	30	----	----	----
Potassium	7440-09-7	1	mg/L		<1	1	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L		<0.001	<0.001	----	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	----	----	----
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L		0.004	0.005	----	----	----
Nickel	7440-02-0	0.001	mg/L		0.002	0.005	----	----	----
Lead	7439-92-1	0.001	mg/L		0.001	<0.001	----	----	----
Zinc	7440-66-6	0.005	mg/L		0.033	0.039	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	----	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		0.12	0.01	----	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	DMDDH11	DM02D DUPLICATE	----	----	----
Client sampling date / time					09-May-2017 14:40	09-May-2017 08:11	----	----	----
Compound	CAS Number	LOR	Unit		ES1705324-011	ES1705324-012	-----	-----	-----
					Result	Result	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		0.09	1.92	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		0.09	1.92	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		0.1	0.4	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		0.2	2.3	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		<0.01	<0.01	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		2.97	1.82	----	----	----
Total Cations	----	0.01	meq/L		2.19	1.93	----	----	----
EP068A: Organochlorine Pesticides (OC)									
alpha-BHC	319-84-6	0.5	µg/L		----	<0.5	----	----	----
Hexachlorobenzene (HCB)	118-74-1	0.5	µg/L		----	<0.5	----	----	----
beta-BHC	319-85-7	0.5	µg/L		----	<0.5	----	----	----
gamma-BHC	58-89-9	0.5	µg/L		----	<0.5	----	----	----
delta-BHC	319-86-8	0.5	µg/L		----	<0.5	----	----	----
Heptachlor	76-44-8	0.5	µg/L		----	<0.5	----	----	----
Aldrin	309-00-2	0.5	µg/L		----	<0.5	----	----	----
Heptachlor epoxide	1024-57-3	0.5	µg/L		----	<0.5	----	----	----
trans-Chlordane	5103-74-2	0.5	µg/L		----	<0.5	----	----	----
alpha-Endosulfan	959-98-8	0.5	µg/L		----	<0.5	----	----	----
cis-Chlordane	5103-71-9	0.5	µg/L		----	<0.5	----	----	----
Dieldrin	60-57-1	0.5	µg/L		----	<0.5	----	----	----
4,4'-DDE	72-55-9	0.5	µg/L		----	<0.5	----	----	----
Endrin	72-20-8	0.5	µg/L		----	<0.5	----	----	----
beta-Endosulfan	33213-65-9	0.5	µg/L		----	<0.5	----	----	----
4,4'-DDD	72-54-8	0.5	µg/L		----	<0.5	----	----	----
Endrin aldehyde	7421-93-4	0.5	µg/L		----	<0.5	----	----	----
Endosulfan sulfate	1031-07-8	0.5	µg/L		----	<0.5	----	----	----
4,4'-DDT	50-29-3	2	µg/L		----	<2.0	----	----	----
Endrin ketone	53494-70-5	0.5	µg/L		----	<0.5	----	----	----
Methoxychlor	72-43-5	2	µg/L		----	<2.0	----	----	----



Analytical Results

Sub-Matrix: WATER
 (Matrix: WATER)

Client sample ID

				DMDDH11	DM02D DUPLICATE	----	----	----
Client sampling date / time				09-May-2017 14:40	09-May-2017 08:11	----	----	----
Compound	CAS Number	LOR	Unit	ES1705324-011	ES1705324-012	-----	-----	-----
				Result	Result	----	----	----

EP068A: Organochlorine Pesticides (OC) - Continued

^ Total Chlordane (sum)	----	0.5	µg/L	----	<0.5	----	----	----
^ Sum of DDD + DDE + DDT	72-54-8/72-55-9/5 0-2	0.5	µg/L	----	<0.5	----	----	----
^ Sum of Aldrin + Dieldrin	309-00-2/60-57-1	0.5	µg/L	----	<0.5	----	----	----

EP068B: Organophosphorus Pesticides (OP)

Dichlorvos	62-73-7	0.5	µg/L	----	<0.5	----	----	----
Demeton-S-methyl	919-86-8	0.5	µg/L	----	<0.5	----	----	----
Monocrotophos	6923-22-4	2	µg/L	----	<2.0	----	----	----
Dimethoate	60-51-5	0.5	µg/L	----	<0.5	----	----	----
Diazinon	333-41-5	0.5	µg/L	----	<0.5	----	----	----
Chlorpyrifos-methyl	5598-13-0	0.5	µg/L	----	<0.5	----	----	----
Parathion-methyl	298-00-0	2	µg/L	----	<2.0	----	----	----
Malathion	121-75-5	0.5	µg/L	----	<0.5	----	----	----
Fenthion	55-38-9	0.5	µg/L	----	<0.5	----	----	----
Chlorpyrifos	2921-88-2	0.5	µg/L	----	<0.5	----	----	----
Parathion	56-38-2	2	µg/L	----	<2.0	----	----	----
Pirimphos-ethyl	23505-41-1	0.5	µg/L	----	<0.5	----	----	----
Chlorfenvinphos	470-90-6	0.5	µg/L	----	<0.5	----	----	----
Bromophos-ethyl	4824-78-6	0.5	µg/L	----	<0.5	----	----	----
Fenamiphos	22224-92-6	0.5	µg/L	----	<0.5	----	----	----
Prothiofos	34643-46-4	0.5	µg/L	----	<0.5	----	----	----
Ethion	563-12-2	0.5	µg/L	----	<0.5	----	----	----
Carbophenothion	786-19-6	0.5	µg/L	----	<0.5	----	----	----
Azinphos Methyl	86-50-0	0.5	µg/L	----	<0.5	----	----	----

EP075(SIM)A: Phenolic Compounds

Phenol	108-95-2	1	µg/L	----	<1.0	----	----	----
2-Chlorophenol	95-57-8	1	µg/L	----	<1.0	----	----	----
2-Methylphenol	95-48-7	1	µg/L	----	<1.0	----	----	----
3- & 4-Methylphenol	1319-77-3	2	µg/L	----	<2.0	----	----	----
2-Nitrophenol	88-75-5	1	µg/L	----	<1.0	----	----	----
2,4-Dimethylphenol	105-67-9	1	µg/L	----	<1.0	----	----	----
2,4-Dichlorophenol	120-83-2	1	µg/L	----	<1.0	----	----	----
2,6-Dichlorophenol	87-65-0	1	µg/L	----	<1.0	----	----	----
4-Chloro-3-methylphenol	59-50-7	1	µg/L	----	<1.0	----	----	----
2,4,6-Trichlorophenol	88-06-2	1	µg/L	----	<1.0	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	DMDDH11	DM02D DUPLICATE	----	----	----
Client sampling date / time					09-May-2017 14:40	09-May-2017 08:11	----	----	----
Compound	CAS Number	LOR	Unit		ES1705324-011	ES1705324-012	-----	-----	-----
					Result	Result	----	----	----
EP075(SIM)A: Phenolic Compounds - Continued									
2,4,5-Trichlorophenol	95-95-4	1	µg/L		----	<1.0	----	----	----
Pentachlorophenol	87-86-5	2	µg/L		----	<2.0	----	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	1	µg/L		----	<1.0	----	----	----
Acenaphthylene	208-96-8	1	µg/L		----	<1.0	----	----	----
Acenaphthene	83-32-9	1	µg/L		----	<1.0	----	----	----
Fluorene	86-73-7	1	µg/L		----	<1.0	----	----	----
Phenanthrene	85-01-8	1	µg/L		----	<1.0	----	----	----
Anthracene	120-12-7	1	µg/L		----	<1.0	----	----	----
Fluoranthene	206-44-0	1	µg/L		----	<1.0	----	----	----
Pyrene	129-00-0	1	µg/L		----	<1.0	----	----	----
Benz(a)anthracene	56-55-3	1	µg/L		----	<1.0	----	----	----
Chrysene	218-01-9	1	µg/L		----	<1.0	----	----	----
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1	µg/L		----	<1.0	----	----	----
Benzo(k)fluoranthene	207-08-9	1	µg/L		----	<1.0	----	----	----
Benzo(a)pyrene	50-32-8	0.5	µg/L		----	<0.5	----	----	----
Indeno(1,2,3.cd)pyrene	193-39-5	1	µg/L		----	<1.0	----	----	----
Dibenz(a,h)anthracene	53-70-3	1	µg/L		----	<1.0	----	----	----
Benzo(g,h,i)perylene	191-24-2	1	µg/L		----	<1.0	----	----	----
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L		----	<0.5	----	----	----
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L		----	<0.5	----	----	----
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	20	µg/L		----	<20	----	----	----
C10 - C14 Fraction	----	50	µg/L		----	<50	----	----	----
C15 - C28 Fraction	----	100	µg/L		----	<100	----	----	----
C29 - C36 Fraction	----	50	µg/L		----	<50	----	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L		----	<50	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
C6 - C10 Fraction	C6_C10	20	µg/L		----	<20	----	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L		----	<20	----	----	----
>C10 - C16 Fraction	----	100	µg/L		----	<100	----	----	----
>C16 - C34 Fraction	----	100	µg/L		----	<100	----	----	----
>C34 - C40 Fraction	----	100	µg/L		----	<100	----	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	DMDDH11	DM02D DUPLICATE	----	----	----
Client sampling date / time					09-May-2017 14:40	09-May-2017 08:11	----	----	----
Compound	CAS Number	LOR	Unit		ES1705324-011	ES1705324-012	-----	-----	-----
					Result	Result	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued									
^ >C10 - C40 Fraction (sum)	----	100	µg/L		----	<100	----	----	----
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L		----	<100	----	----	----
EP080: BTEXN									
Benzene	71-43-2	1	µg/L		----	<1	----	----	----
Toluene	108-88-3	2	µg/L		----	<2	----	----	----
Ethylbenzene	100-41-4	2	µg/L		----	<2	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L		----	<2	----	----	----
ortho-Xylene	95-47-6	2	µg/L		----	<2	----	----	----
^ Total Xylenes	1330-20-7	2	µg/L		----	<2	----	----	----
^ Sum of BTEX	----	1	µg/L		----	<1	----	----	----
Naphthalene	91-20-3	5	µg/L		----	<5	----	----	----
EP068S: Organochlorine Pesticide Surrogate									
Dibromo-DDE	21655-73-2	0.5	%		----	84.1	----	----	----
EP068T: Organophosphorus Pesticide Surrogate									
DEF	78-48-8	0.5	%		----	75.2	----	----	----
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	1	%		----	22.6	----	----	----
2-Chlorophenol-D4	93951-73-6	1	%		----	48.9	----	----	----
2,4,6-Tribromophenol	118-79-6	1	%		----	53.3	----	----	----
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	1	%		----	67.8	----	----	----
Anthracene-d10	1719-06-8	1	%		----	76.0	----	----	----
4-Terphenyl-d14	1718-51-0	1	%		----	77.3	----	----	----
EP080S: TPH(V)/BTEX Surrogates									
1,2-Dichloroethane-D4	17060-07-0	2	%		----	112	----	----	----
Toluene-D8	2037-26-5	2	%		----	114	----	----	----
4-Bromofluorobenzene	460-00-4	2	%		----	109	----	----	----



Surrogate Control Limits

Sub-Matrix: WATER		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP068S: Organochlorine Pesticide Surrogate			
Dibromo-DDE	21655-73-2	30	120
EP068T: Organophosphorus Pesticide Surrogate			
DEF	78-48-8	27	129
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10	44
2-Chlorophenol-D4	93951-73-6	14	94
2,4,6-Tribromophenol	118-79-6	17	125
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	20	104
Anthracene-d10	1719-06-8	27	113
4-Terphenyl-d14	1718-51-0	32	112
EP080S: TPH(V)/BTEX Surrogates			
1,2-Dichloroethane-D4	17060-07-0	71	137
Toluene-D8	2037-26-5	79	131
4-Bromofluorobenzene	460-00-4	70	128

CERTIFICATE OF ANALYSIS

Work Order : **ES2011835**
Client : **EMM CONSULTING PTY LTD**
Contact : **THOMAS WALTERS**
Address : 6/146 Hunter Street
 Newcastle 2300
Telephone : ----
Project : H200021 Maroota
Order number : H20021
C-O-C number : ----
Sampler : Thomas Walters
Site : ----
Quote number : EN/112/18 - Primary work only
No. of samples received : 8
No. of samples analysed : 8

Page : 1 of 5
Laboratory : Environmental Division Sydney
Contact : Customer Services ES
Address : 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone : +61-2-8784 8555
Date Samples Received : 06-Apr-2020 16:05
Date Analysis Commenced : 06-Apr-2020
Issue Date : 15-Apr-2020 15:57



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ashesh Patel	Senior Chemist	Sydney Inorganics, Smithfield, NSW
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Neil Martin	Team Leader - Chemistry	Chemistry, Newcastle West, NSW



General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- Ionic Balance out of acceptable limits for sample 3 due to analytes not quantified in this report.
- EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				DAM03	DAM03 downstream	DAM02	DAM04	Upstream DAM01
Client sampling date / time				06-Apr-2020 09:10	06-Apr-2020 09:45	06-Apr-2020 10:05	06-Apr-2020 10:35	06-Apr-2020 11:10
Compound	CAS Number	LOR	Unit	ES2011835-001	ES2011835-002	ES2011835-003	ES2011835-004	ES2011835-005
				Result	Result	Result	Result	Result
EA005: pH								
pH Value	----	0.01	pH Unit	6.51	6.35	5.44	6.10	6.02
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	289	291	419	72	210
EA016: Calculated TDS (from Electrical Conductivity)								
Total Dissolved Solids (Calc.)	----	1	mg/L	188	189	272	47	136
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	54	54	109	11	28
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	37	31	3	10	5
Total Alkalinity as CaCO3	----	1	mg/L	37	31	3	10	5
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	26	27	65	1	15
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	38	42	36	10	36
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	7	5	15	1	3
Magnesium	7439-95-4	1	mg/L	9	10	17	2	5
Sodium	7440-23-5	1	mg/L	24	27	23	6	23
Potassium	7440-09-7	1	mg/L	6	4	8	4	2
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
EN055: Ionic Balance								
∅ Total Anions	----	0.01	meq/L	2.35	2.37	2.43	0.50	1.43
∅ Total Cations	----	0.01	meq/L	2.29	2.35	3.35	0.58	1.61
∅ Ionic Balance	----	0.01	%	----	----	16.0	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Downstream DAM01	DAM01	GW-Seep-01	----	----
Client sampling date / time					06-Apr-2020 11:35	06-Apr-2020 11:50	06-Apr-2020 13:20	----	----
Compound	CAS Number	LOR	Unit		ES2011835-006	ES2011835-007	ES2011835-008	-----	-----
					Result	Result	Result	----	----
EA005: pH									
pH Value	----	0.01	pH Unit		6.30	6.31	6.03	----	----
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		193	193	214	----	----
EA016: Calculated TDS (from Electrical Conductivity)									
Total Dissolved Solids (Calc.)	----	1	mg/L		125	125	139	----	----
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L		26	26	42	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		13	14	29	----	----
Total Alkalinity as CaCO3	----	1	mg/L		13	14	29	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		13	13	7	----	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		32	32	36	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		4	4	7	----	----
Magnesium	7439-95-4	1	mg/L		4	4	6	----	----
Sodium	7440-23-5	1	mg/L		20	20	18	----	----
Potassium	7440-09-7	1	mg/L		2	2	2	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		<0.1	<0.1	<0.1	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		----	----	0.02	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		----	----	<0.01	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		----	----	<0.01	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		----	----	<0.01	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		----	----	<0.01	----	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				Downstream DAM01	DAM01	GW-Seep-01	----	----
Client sampling date / time				06-Apr-2020 11:35	06-Apr-2020 11:50	06-Apr-2020 13:20	----	----
Compound	CAS Number	LOR	Unit	ES2011835-006	ES2011835-007	ES2011835-008	-----	-----
				Result	Result	Result	----	----
EN055: Ionic Balance								
∅ Total Anions	----	0.01	meq/L	1.43	1.45	1.74	----	----
∅ Total Cations	----	0.01	meq/L	1.45	1.45	1.68	----	----

CERTIFICATE OF ANALYSIS

Work Order : **ES2020898**
Client : **EMM CONSULTING PTY LTD**
Contact : Tim Wilkinson
Address : 6/146 Hunter Street
 Newcastle 2300
Telephone : ----
Project : H200021 Maroota
Order number : H200021
C-O-C number : ----
Sampler : Claire Corthier
Site : ----
Quote number : EN/112/18 - Primary work only
No. of samples received : 10
No. of samples analysed : 10

Page : 1 of 6
Laboratory : Environmental Division Sydney
Contact : Customer Services ES
Address : 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone : +61-2-8784 8555
Date Samples Received : 17-Jun-2020 12:20
Date Analysis Commenced : 17-Jun-2020
Issue Date : 25-Jun-2020 11:06



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

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<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ashesh Patel	Senior Chemist	Sydney Inorganics, Smithfield, NSW
Hoa Nguyen	Senior Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW



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Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	DM04	SW3	SW2	DM02D	SW1
Client sampling date / time					16-Jun-2020 09:15	16-Jun-2020 11:40	16-Jun-2020 10:50	16-Jun-2020 12:00	16-Jun-2020 13:00
Compound	CAS Number	LOR	Unit		ES2020898-001	ES2020898-002	ES2020898-003	ES2020898-004	ES2020898-005
					Result	Result	Result	Result	Result
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		5.06	6.44	4.95	5.76	6.15
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		290	437	768	214	230
EA016: Calculated TDS (from Electrical Conductivity)									
Total Dissolved Solids (Calc.)	----	1	mg/L		188	284	499	139	150
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L		35	109	250	27	30
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		5	26	3	12	16
Total Alkalinity as CaCO3	----	1	mg/L		5	26	3	12	16
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		16	82	132	3	6
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		50	58	53	50	52
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		1	14	43	6	2
Magnesium	7439-95-4	1	mg/L		8	18	35	3	6
Sodium	7440-23-5	1	mg/L		29	36	36	27	29
Potassium	7440-09-7	1	mg/L		<1	7	12	<1	1
EG020F: Dissolved Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Boron	7440-42-8	0.05	mg/L		<0.05	<0.05	0.06	<0.05	<0.05
Barium	7440-39-3	0.001	mg/L		0.034	0.020	0.054	0.024	0.014
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	0.0002	<0.0001	<0.0001
Cobalt	7440-48-4	0.001	mg/L		0.001	<0.001	0.002	0.002	<0.001
Chromium	7440-47-3	0.001	mg/L		0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L		0.003	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L		0.029	0.008	0.068	0.030	0.038
Nickel	7440-02-0	0.001	mg/L		0.004	<0.001	0.003	0.002	0.001
Lead	7439-92-1	0.001	mg/L		0.001	<0.001	<0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	DM04	SW3	SW2	DM02D	SW1
Client sampling date / time					16-Jun-2020 09:15	16-Jun-2020 11:40	16-Jun-2020 10:50	16-Jun-2020 12:00	16-Jun-2020 13:00
Compound	CAS Number	LOR	Unit		ES2020898-001	ES2020898-002	ES2020898-003	ES2020898-004	ES2020898-005
					Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued									
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L		0.033	0.014	0.073	0.019	0.005
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		<0.1	<0.1	0.1	<0.1	<0.1
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		0.06	0.25	0.04	<0.01	0.12
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	0.02	<0.01	<0.01	0.02
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		14.6	1.35	33.4	1.86	1.57
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		14.6	1.37	33.4	1.86	1.59
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		1.2	0.9	5.1	0.6	0.3
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		15.8	2.3	38.5	2.5	1.9
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		0.21	0.03	0.02	0.49	<0.01
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
EN055: Ionic Balance									
∅ Total Anions	----	0.01	meq/L		----	----	6.69	----	----
∅ Total Anions	----	0.01	meq/L		1.84	3.86	----	1.71	1.91
∅ Total Cations	----	0.01	meq/L		1.97	3.92	6.90	1.72	1.88
∅ Ionic Balance	----	0.01	%		----	----	1.58	----	----
∅ Ionic Balance	----	0.01	%		----	0.80	----	----	----



Analytical Results

Sub-Matrix: WATER
 (Matrix: WATER)

Client sample ID

				DMDDH03	DMDDH07	DMDDH09	DMDDH10	QA1
Client sampling date / time				16-Jun-2020 14:30	16-Jun-2020 15:20	16-Jun-2020 16:00	16-Jun-2020 16:30	16-Jun-2020 00:00
Compound	CAS Number	LOR	Unit	ES2020898-006	ES2020898-007	ES2020898-008	ES2020898-009	ES2020898-010
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	5.31	6.91	3.92	4.57	6.44
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	157	382	854	81	436
EA016: Calculated TDS (from Electrical Conductivity)								
Total Dissolved Solids (Calc.)	----	1	mg/L	102	248	555	53	283
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	13	64	65	<1	116
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	4	35	<1	<1	24
Total Alkalinity as CaCO3	----	1	mg/L	4	35	<1	<1	24
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	4	4	9	6	86
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	37	77	207	18	58
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	2	24	<1	<1	15
Magnesium	7439-95-4	1	mg/L	2	1	14	<1	19
Sodium	7440-23-5	1	mg/L	20	44	105	13	36
Potassium	7440-09-7	1	mg/L	<1	2	1	<1	7
EG020F: Dissolved Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Barium	7440-39-3	0.001	mg/L	0.012	0.044	0.082	0.002	0.020
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	7440-48-4	0.001	mg/L	0.001	<0.001	0.003	<0.001	<0.001
Chromium	7440-47-3	0.001	mg/L	<0.001	0.011	0.002	0.001	<0.001
Copper	7440-50-8	0.001	mg/L	0.001	0.003	0.004	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	0.029	0.004	0.071	0.004	0.009
Nickel	7440-02-0	0.001	mg/L	0.003	0.005	0.004	0.001	0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.004	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	DMDDH03	DMDDH07	DMDDH09	DMDDH10	QA1
Client sampling date / time					16-Jun-2020 14:30	16-Jun-2020 15:20	16-Jun-2020 16:00	16-Jun-2020 16:30	16-Jun-2020 00:00
Compound	CAS Number	LOR	Unit		ES2020898-006	ES2020898-007	ES2020898-008	ES2020898-009	ES2020898-010
					Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued									
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L		0.190	0.026	0.053	0.038	0.029
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		<0.1	<0.1	<0.1	<0.1	<0.1
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		0.06	0.03	0.08	<0.01	0.17
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	0.02
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		1.86	5.48	0.22	0.27	1.39
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		1.86	5.48	0.22	0.27	1.41
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		0.4	0.8	1.3	0.1	1.1
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		2.3	6.3	1.5	0.4	2.5
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		0.06	1.68	1.45	0.04	0.03
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	0.05	0.07	0.01	<0.01
EN055: Ionic Balance									
∅ Total Anions	----	0.01	meq/L		1.21	2.95	6.03	0.63	3.91
∅ Total Cations	----	0.01	meq/L		1.13	3.24	5.74	0.56	4.06
∅ Ionic Balance	----	0.01	%		----	4.68	2.39	----	1.90

CERTIFICATE OF ANALYSIS

Work Order : **ES2027234**
Client : **EMM CONSULTING PTY LTD**
Contact : Tim Wilkinson
Address : 6/146 Hunter Street
 Newcastle 2300
Telephone : ----
Project : H200021 Maroota
Order number : H200021
C-O-C number : ----
Sampler : Claire Corthier
Site : ----
Quote number : EN/112/18 - Primary work only
No. of samples received : 13
No. of samples analysed : 13

Page : 1 of 8
Laboratory : Environmental Division Sydney
Contact : Customer Services ES
Address : 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone : +61-2-8784 8555
Date Samples Received : 06-Aug-2020 11:00
Date Analysis Commenced : 06-Aug-2020
Issue Date : 13-Aug-2020 16:50



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW



General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- EN055: Ionic Balance out of acceptable limits for sample ES2027234-#003 due to analytes not quantified in this report.
- EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.



Analytical Results

Sub-Matrix: WATER
 (Matrix: WATER)

Client sample ID

				DMDDH03	DMDDH07	DMDDH09	DMDDH11	DMDDH10
Client sampling date / time				05-Aug-2020 09:10	05-Aug-2020 10:10	05-Aug-2020 11:00	05-Aug-2020 11:30	05-Aug-2020 12:15
Compound	CAS Number	LOR	Unit	ES2027234-001	ES2027234-002	ES2027234-003	ES2027234-004	ES2027234-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	6.01	9.04	4.67	5.27	5.01
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	166	440	941	340	235
EA016: Calculated TDS (from Electrical Conductivity)								
Total Dissolved Solids (Calc.)	----	1	mg/L	108	286	612	221	153
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	20	88	63	32	26
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	15	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	15	35	<1	2	2
Total Alkalinity as CaCO3	----	1	mg/L	15	50	<1	2	2
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	3	4	10	8	4
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	36	70	254	79	45
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	3	32	2	3	2
Magnesium	7439-95-4	1	mg/L	3	2	14	6	5
Sodium	7440-23-5	1	mg/L	21	45	104	42	28
Potassium	7440-09-7	1	mg/L	<1	2	1	<1	<1
EG020F: Dissolved Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Barium	7440-39-3	0.001	mg/L	0.017	0.043	0.081	0.027	0.026
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.001	<0.001	<0.001
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.0001	<0.0001	<0.0001
Cobalt	7440-48-4	0.001	mg/L	0.001	<0.001	0.003	0.001	0.002
Chromium	7440-47-3	0.001	mg/L	<0.001	0.010	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	0.033	<0.001	0.072	0.024	0.041
Nickel	7440-02-0	0.001	mg/L	0.002	<0.001	0.004	0.005	0.002
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.003	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	DMDDH03	DMDDH07	DMDDH09	DMDDH11	DMDDH10
Client sampling date / time					05-Aug-2020 09:10	05-Aug-2020 10:10	05-Aug-2020 11:00	05-Aug-2020 11:30	05-Aug-2020 12:15
Compound	CAS Number	LOR	Unit		ES2027234-001	ES2027234-002	ES2027234-003	ES2027234-004	ES2027234-005
					Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued									
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L		0.039	<0.005	0.058	0.052	0.041
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		<0.1	<0.1	<0.1	<0.1	<0.1
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		0.04	0.08	0.07	0.05	<0.01
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	<0.01	0.02	0.02
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		1.35	5.43	0.81	0.28	6.14
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		1.35	5.43	0.81	0.30	6.16
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		0.6	0.7	0.2	1.6	0.8
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		2.0	6.1	1.0	1.9	7.0
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		0.18	0.92	0.24	0.34	0.27
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	0.02	0.03	<0.01	<0.01
EN055: Ionic Balance									
∅ Total Anions	----	0.01	meq/L		----	3.45	----	----	1.83
∅ Total Anions	----	0.01	meq/L		1.38	----	7.37	2.44	----
∅ Total Cations	----	0.01	meq/L		1.31	3.77	5.80	2.47	1.73
∅ Ionic Balance	----	0.01	%		----	4.49	----	----	----
∅ Ionic Balance	----	0.01	%		----	----	11.9	----	----



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				SW2	DM02D	SW3	DM04	SW1
Client sampling date / time				05-Aug-2020 13:00	05-Aug-2020 14:15	05-Aug-2020 14:20	05-Aug-2020 14:50	05-Aug-2020 00:00
Compound	CAS Number	LOR	Unit	ES2027234-006	ES2027234-007	ES2027234-008	ES2027234-009	ES2027234-010
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	4.83	6.13	6.67	5.51	6.23
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	502	222	430	107	234
EA016: Calculated TDS (from Electrical Conductivity)								
Total Dissolved Solids (Calc.)	----	1	mg/L	326	144	280	70	152
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	145	25	107	13	41
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	13	22	5	7
Total Alkalinity as CaCO3	----	1	mg/L	<1	13	22	5	7
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	84	3	94	7	31
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	36	44	44	16	34
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	25	5	15	2	5
Magnesium	7439-95-4	1	mg/L	20	3	17	2	7
Sodium	7440-23-5	1	mg/L	23	26	30	12	23
Potassium	7440-09-7	1	mg/L	9	<1	6	1	2
EG020F: Dissolved Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Barium	7440-39-3	0.001	mg/L	0.031	0.021	0.019	0.017	0.014
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	7440-43-9	0.0001	mg/L	0.0002	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	7440-48-4	0.001	mg/L	0.002	0.002	<0.001	<0.001	<0.001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	0.003	0.001
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	0.050	0.029	0.006	0.008	0.017
Nickel	7440-02-0	0.001	mg/L	0.002	0.001	0.001	0.001	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	SW2	DM02D	SW3	DM04	SW1
Client sampling date / time					05-Aug-2020 13:00	05-Aug-2020 14:15	05-Aug-2020 14:20	05-Aug-2020 14:50	05-Aug-2020 00:00
Compound	CAS Number	LOR	Unit		ES2027234-006	ES2027234-007	ES2027234-008	ES2027234-009	ES2027234-010
					Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued									
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L		0.074	0.012	0.016	0.022	<0.005
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		<0.1	<0.1	<0.1	<0.1	<0.1
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		0.06	0.01	0.02	0.12	0.11
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		0.03	0.02	0.02	0.02	<0.01
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		20.3	2.31	2.72	2.03	2.07
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		20.3	2.33	2.74	2.05	2.07
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		1.8	0.5	0.7	1.1	0.5
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		22.1	2.8	3.4	3.2	2.6
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		0.02	0.20	0.02	0.17	0.01
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
EN055: Ionic Balance									
∅ Total Anions	----	0.01	meq/L		4.21	----	----	----	----
∅ Total Anions	----	0.01	meq/L		----	1.56	3.64	0.70	1.74
∅ Total Cations	----	0.01	meq/L		4.12	1.63	3.61	0.81	1.88
∅ Ionic Balance	----	0.01	%		1.08	----	----	----	----
∅ Ionic Balance	----	0.01	%		----	----	0.44	----	----



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	GDE	SPRING	QA1	----	----
Client sampling date / time					05-Aug-2020 16:00	05-Aug-2020 16:30	05-Aug-2020 00:00	----	----
Compound	CAS Number	LOR	Unit		ES2027234-011	ES2027234-012	ES2027234-013	-----	-----
					Result	Result	Result	----	----
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		6.10	6.33	5.12	----	----
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		210	190	504	----	----
EA016: Calculated TDS (from Electrical Conductivity)									
Total Dissolved Solids (Calc.)	----	1	mg/L		136	124	328	----	----
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L		37	38	145	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		6	23	<1	----	----
Total Alkalinity as CaCO3	----	1	mg/L		6	23	<1	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		31	15	86	----	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		29	31	35	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		5	7	25	----	----
Magnesium	7439-95-4	1	mg/L		6	5	20	----	----
Sodium	7440-23-5	1	mg/L		19	18	22	----	----
Potassium	7440-09-7	1	mg/L		2	2	9	----	----
EG020F: Dissolved Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Boron	7440-42-8	0.05	mg/L		<0.05	<0.05	<0.05	----	----
Barium	7440-39-3	0.001	mg/L		0.013	0.009	0.030	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	0.0002	----	----
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.001	0.002	----	----
Chromium	7440-47-3	0.001	mg/L		0.001	<0.001	<0.001	----	----
Copper	7440-50-8	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Manganese	7439-96-5	0.001	mg/L		0.014	0.003	0.049	----	----
Nickel	7440-02-0	0.001	mg/L		0.001	<0.001	0.002	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	----	----



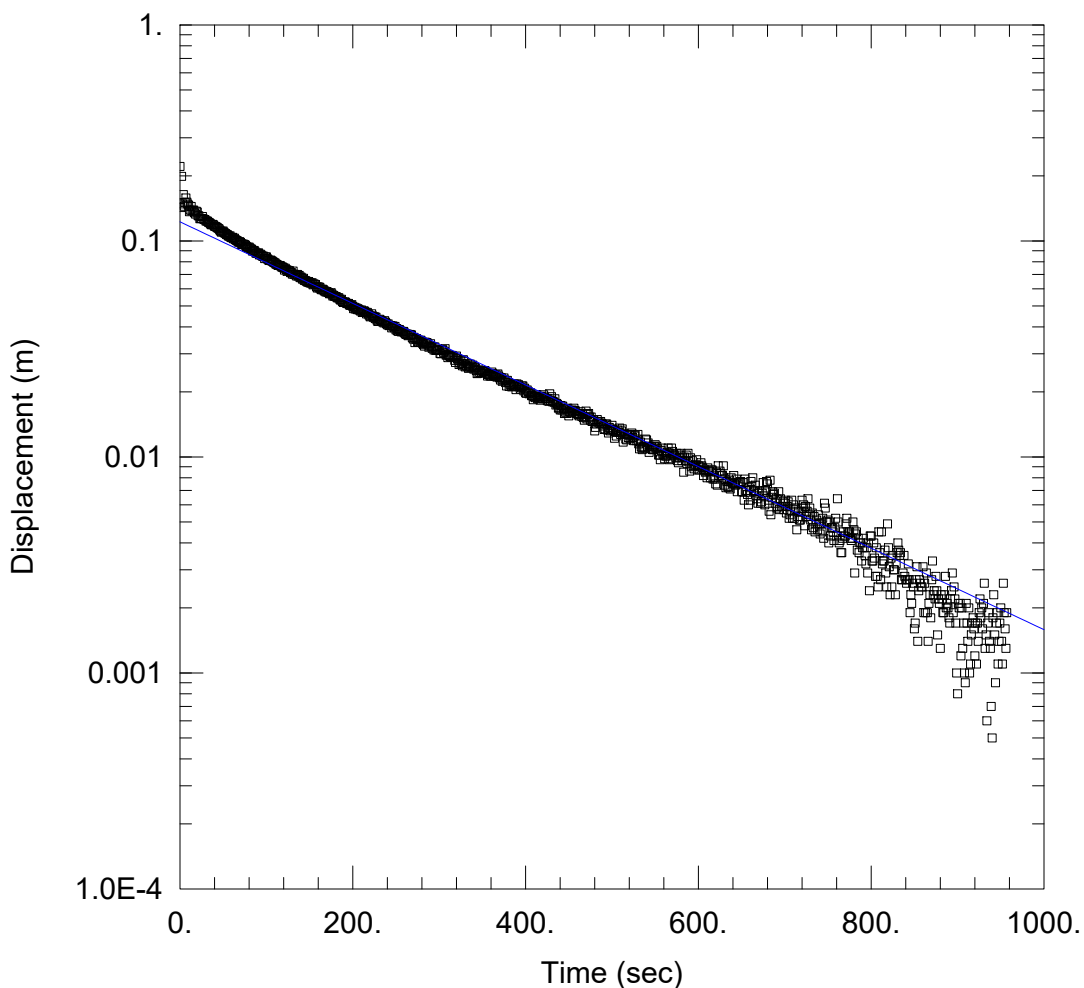
Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	GDE	SPRING	QA1	----	----
Client sampling date / time					05-Aug-2020 16:00	05-Aug-2020 16:30	05-Aug-2020 00:00	----	----
Compound	CAS Number	LOR	Unit		ES2027234-011	ES2027234-012	ES2027234-013	-----	-----
					Result	Result	Result	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	----	----
Zinc	7440-66-6	0.005	mg/L		0.010	<0.005	0.073	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		<0.1	<0.1	<0.1	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		0.03	0.02	0.08	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		0.03	0.02	0.02	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		1.92	0.14	20.2	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		1.95	0.16	20.2	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		0.5	0.5	1.8	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		2.4	0.7	22.0	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		0.04	0.06	0.01	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	<0.01	<0.01	----	----
EN055: Ionic Balance									
∅ Total Anions	----	0.01	meq/L		----	----	4.22	----	----
∅ Total Anions	----	0.01	meq/L		1.58	1.65	----	----	----
∅ Total Cations	----	0.01	meq/L		1.62	1.59	4.08	----	----
∅ Ionic Balance	----	0.01	%		----	----	1.96	----	----

Appendix E

Slug test analysis





WELL TEST ANALYSIS

Data Set: \...\DMDDH10_Bower-Rice_Slug test.aqt

Date: 07/02/20

Time: 09:49:25

PROJECT INFORMATION

Company: EMM Consulting

Project: H200021

Location: Maroota

Test Well: DMDDH10

Test Date: 01/03/2017

AQUIFER DATA

Saturated Thickness: 20.27 m

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (DMDDH10)

Initial Displacement: 0.2212 m

Static Water Column Height: 14.73 m

Total Well Penetration Depth: 14.84 m

Screen Length: 6. m

Casing Radius: 0.025 m

Well Radius: 0.025 m

Gravel Pack Porosity: 0.

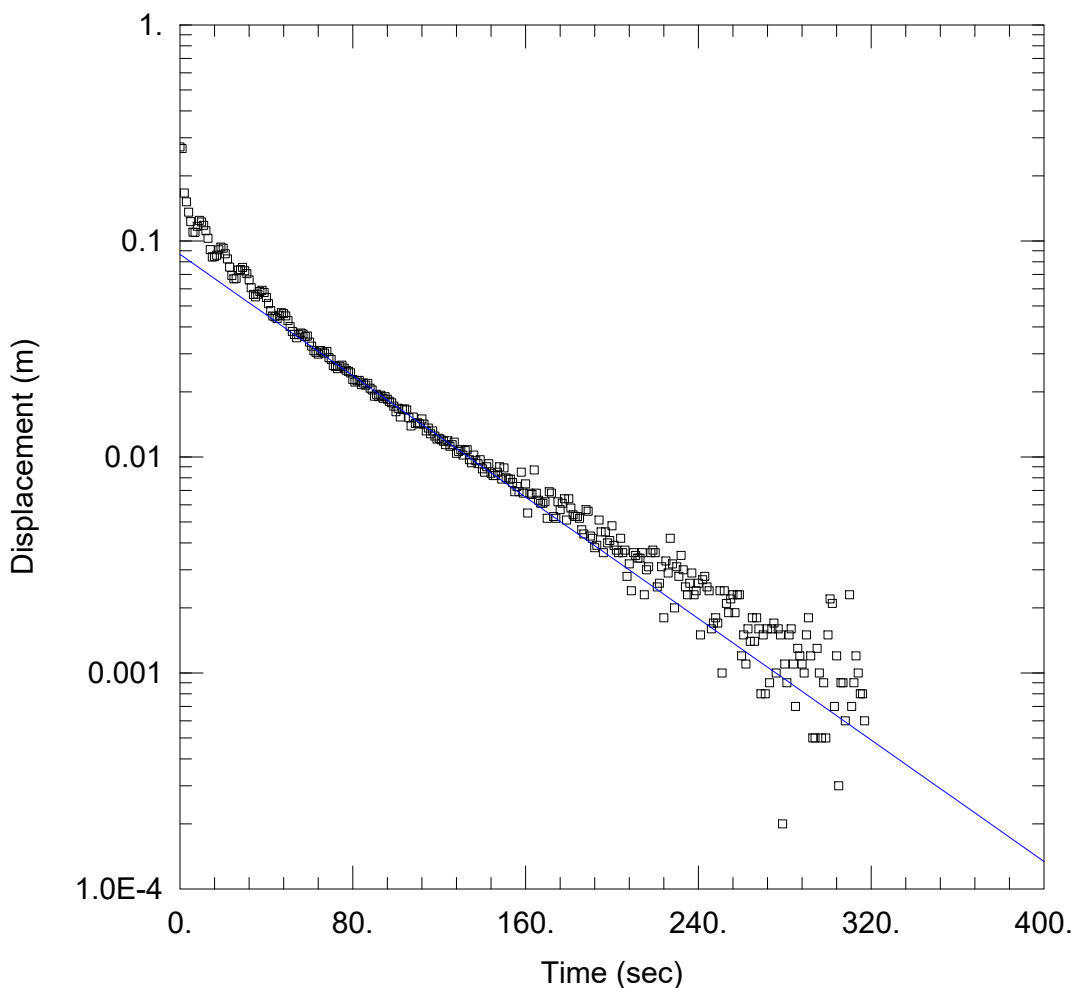
SOLUTION

Aquifer Model: Unconfined

Solution Method: Bouwer-Rice

$K = 0.08543$ m/day

$y_0 = 0.1226$ m



WELL TEST ANALYSIS

Data Set: \...\DMDDH03_Bower-Rice_Slug test.aqt

Date: 07/02/20

Time: 09:58:45

PROJECT INFORMATION

Company: EMM Consulting

Project: H200021

Location: Maroota

Test Well: DMDDH03

Test Date: 01/03/2017

AQUIFER DATA

Saturated Thickness: 26.35 m

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (DMDDH03)

Initial Displacement: 0.2723 m

Static Water Column Height: 26.35 m

Total Well Penetration Depth: 26.01 m

Screen Length: 6. m

Casing Radius: 0.025 m

Well Radius: 0.025 m

Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Unconfined

Solution Method: Bouwer-Rice

$K = 0.3642$ m/day

$y_0 = 0.08674$ m

Appendix F

Registration of interest to purchase groundwater



Controlled Allocation 2020

Registration of Interest | Application form



E3 - For ROI applications made by a Company/Corporation/Trust

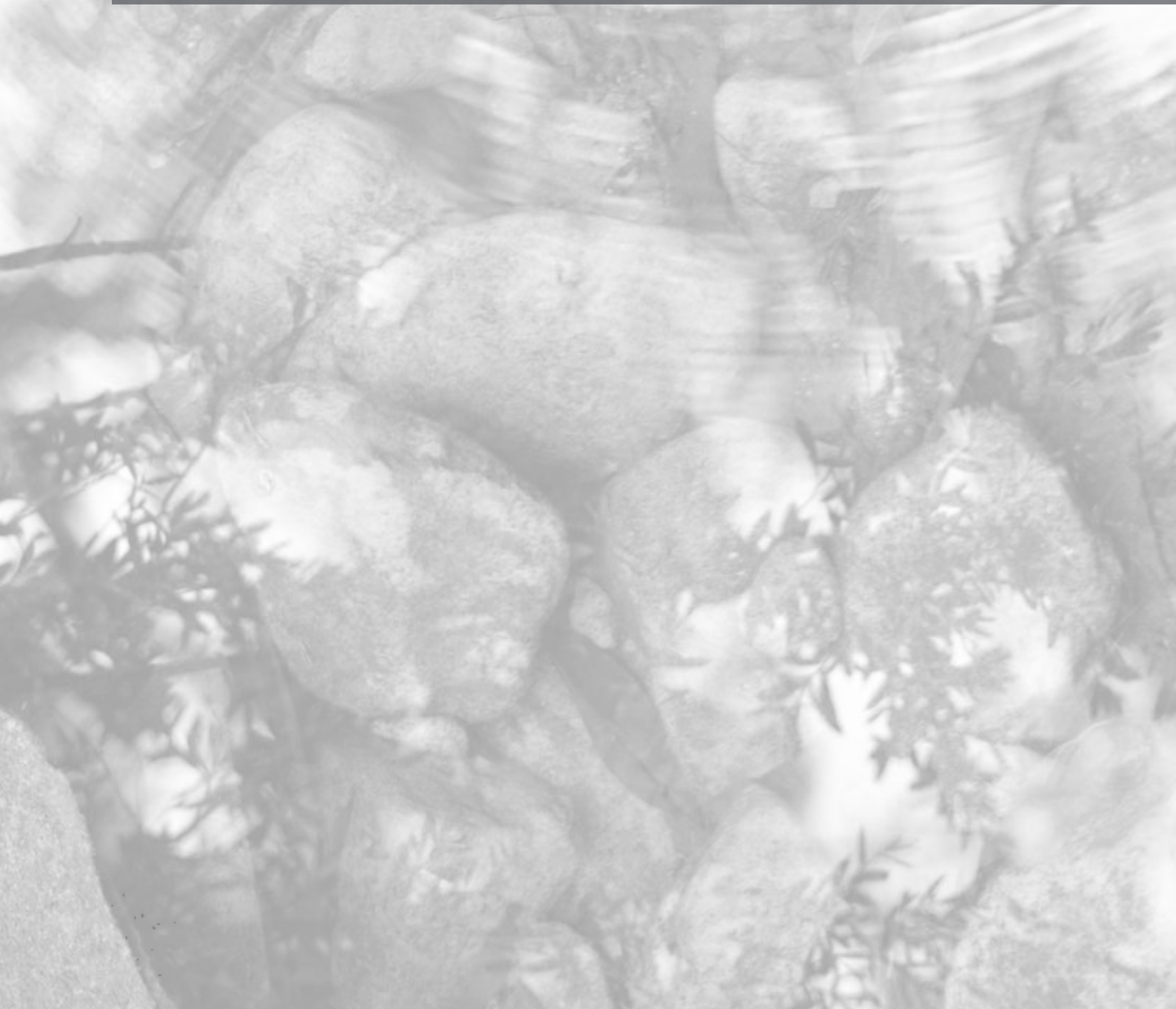
Executed on behalf of the applicant in accordance with section 127 of the *Corporations Act 2001* (Cth) (if a company) or by its duly authorised officer or power of attorney (for other types of corporation):

Authorised signatory

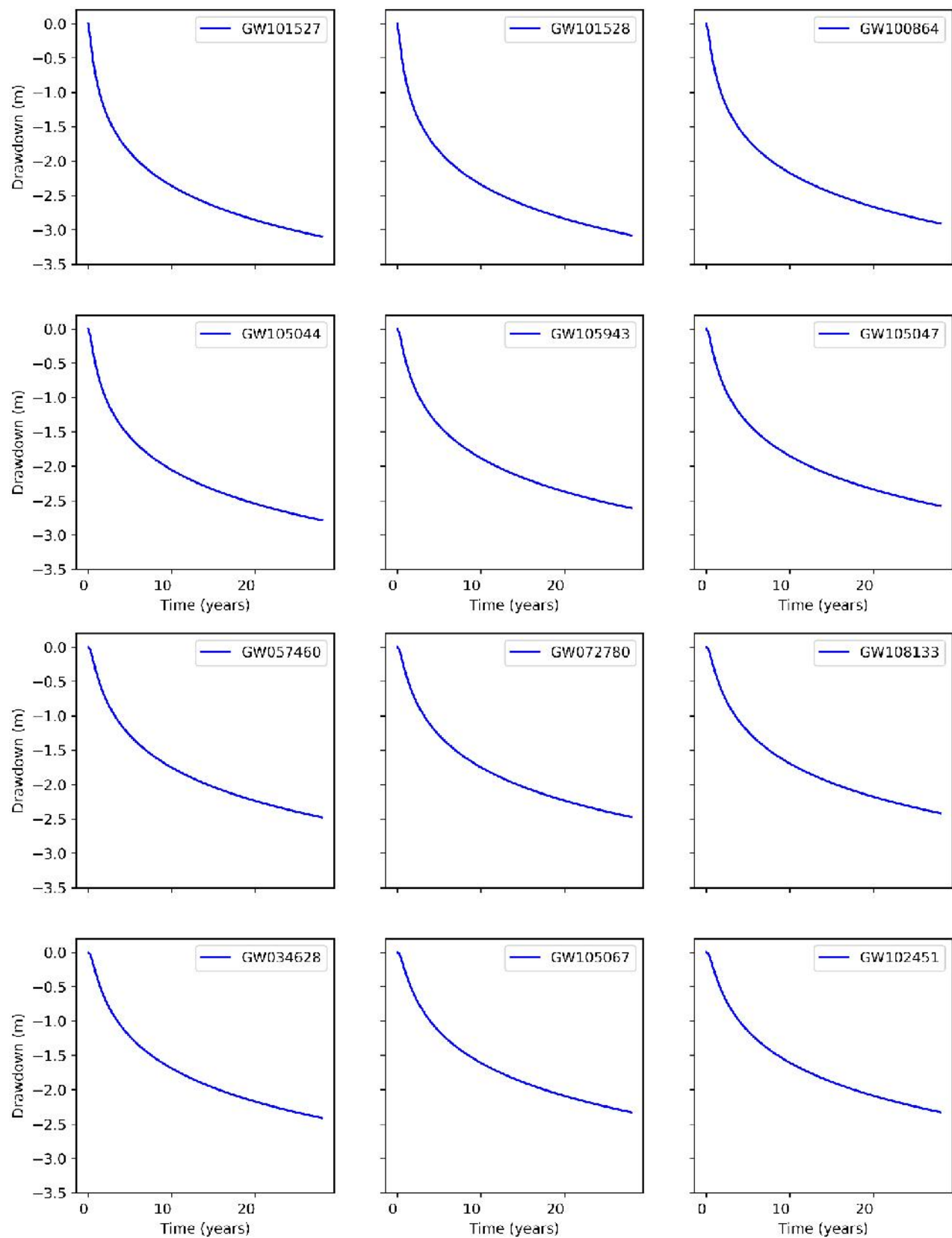
By entering into this Agreement the signatory warrants that the signatory is duly authorised/power of attorney to execute this Agreement on behalf of Deerubbin Local Aboriginal Land Council Ltd Name of Company/Corporation/Trustee	
☒ Duly Authorised Officer (Tick this box if you are the Duly authorised officer and provide supporting evidence)	☐ Power of Attorney (Tick this box if you have power of attorney and provide supporting evidence.)
Name of authorised signatory:	Name of authorised signatory:
Signature of authorised signatory:	Signature of authorised signatory:
Date:	Date:

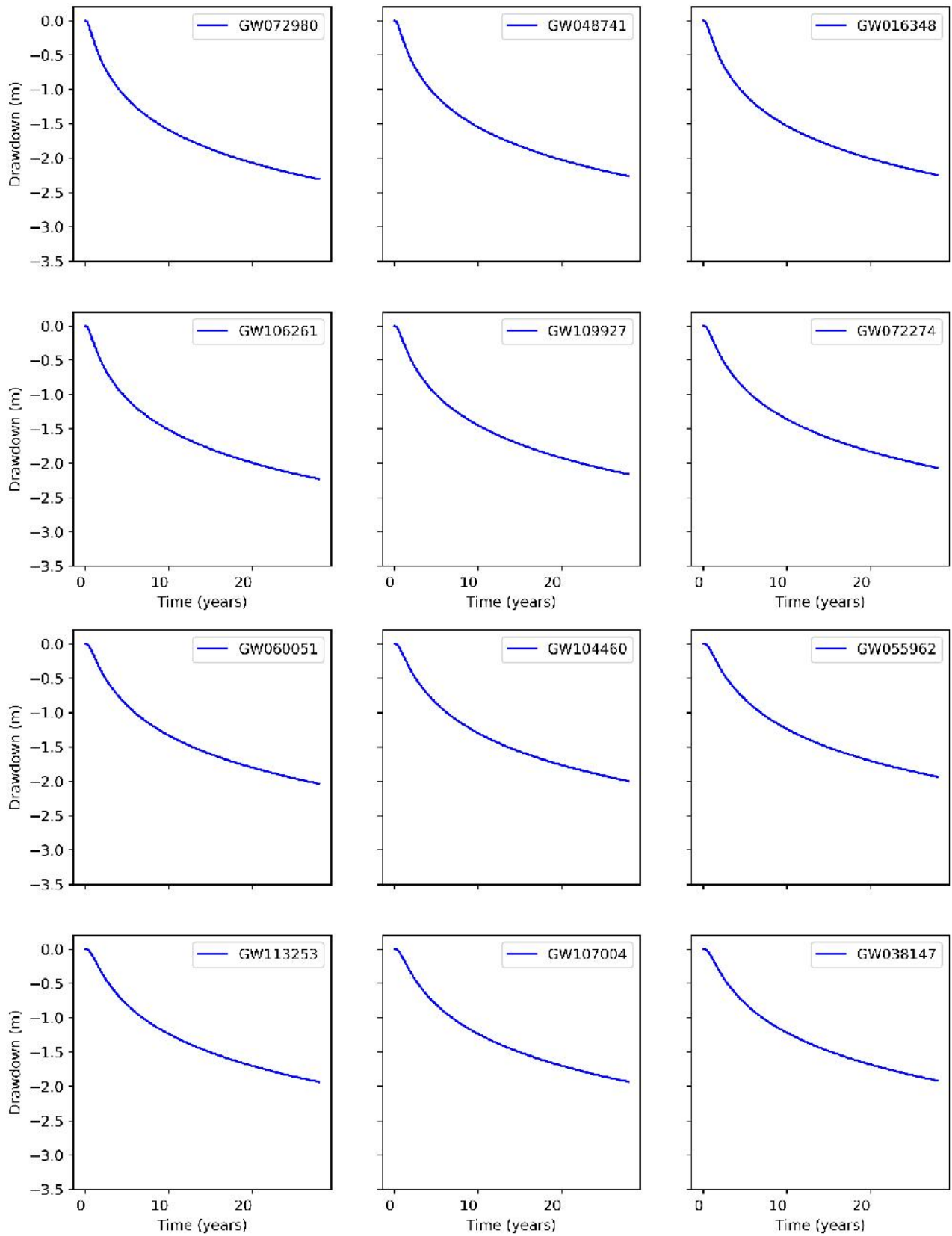
Appendix G

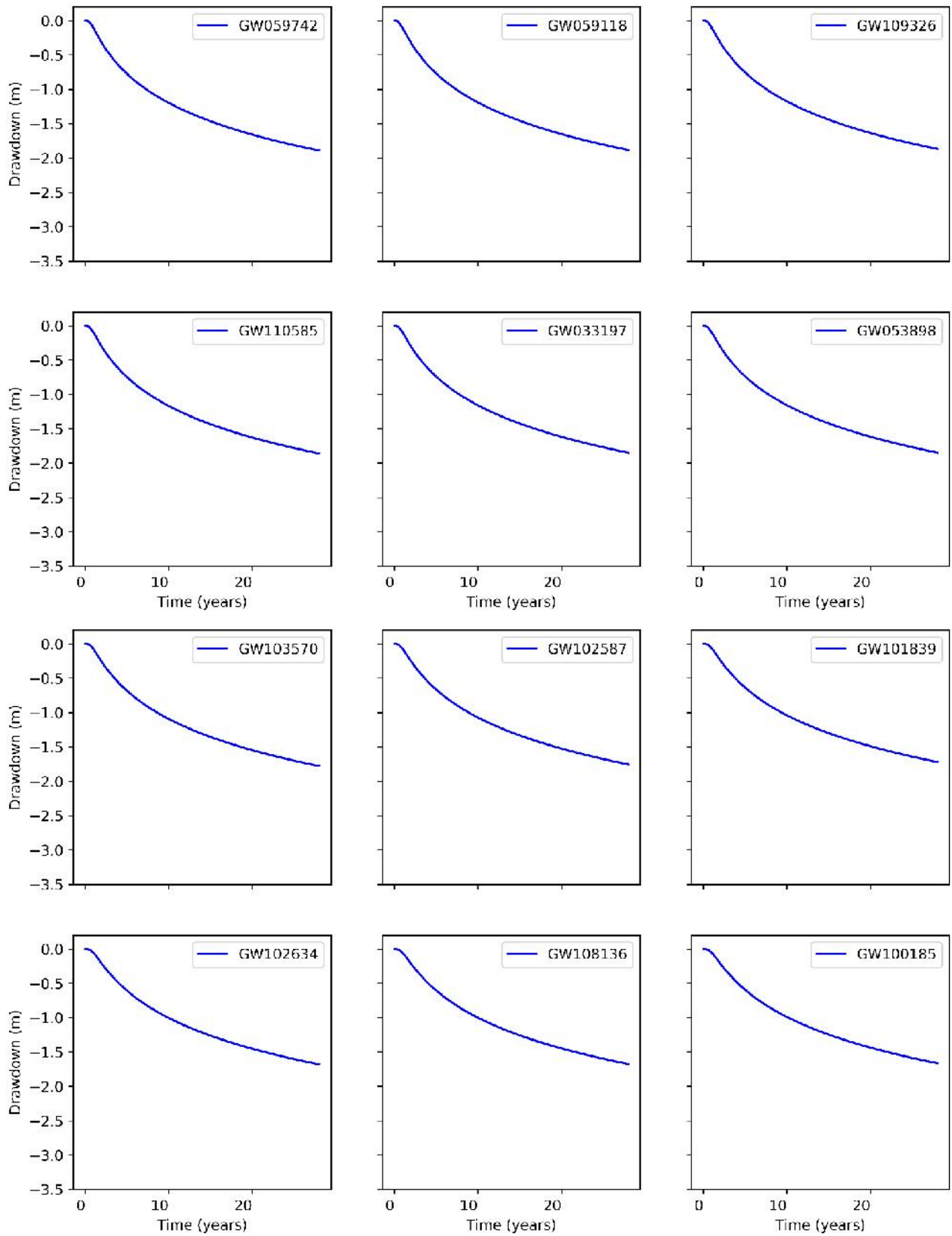
Groundwater drawdown model results

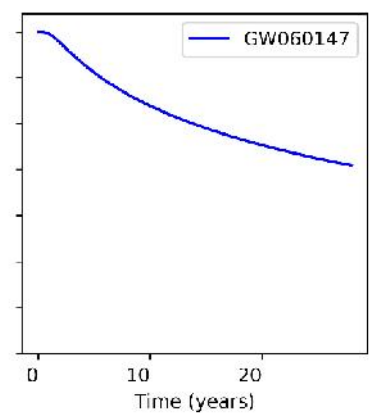
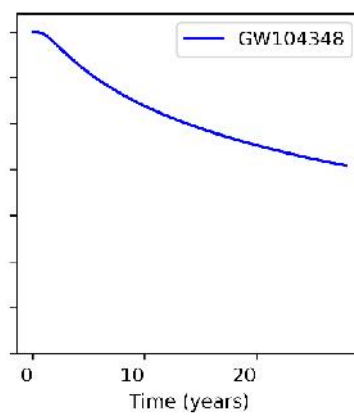
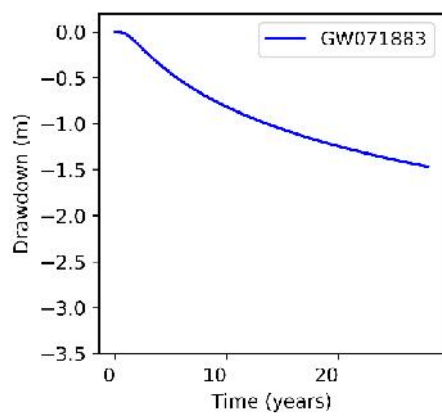
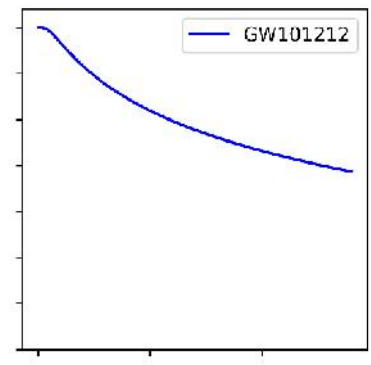
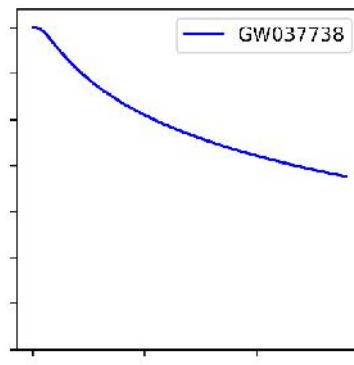
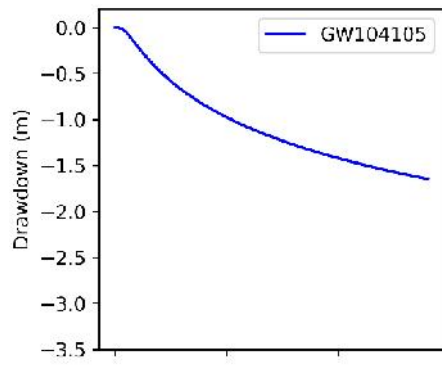


G.1 Drawdown charts – 50 ML/year

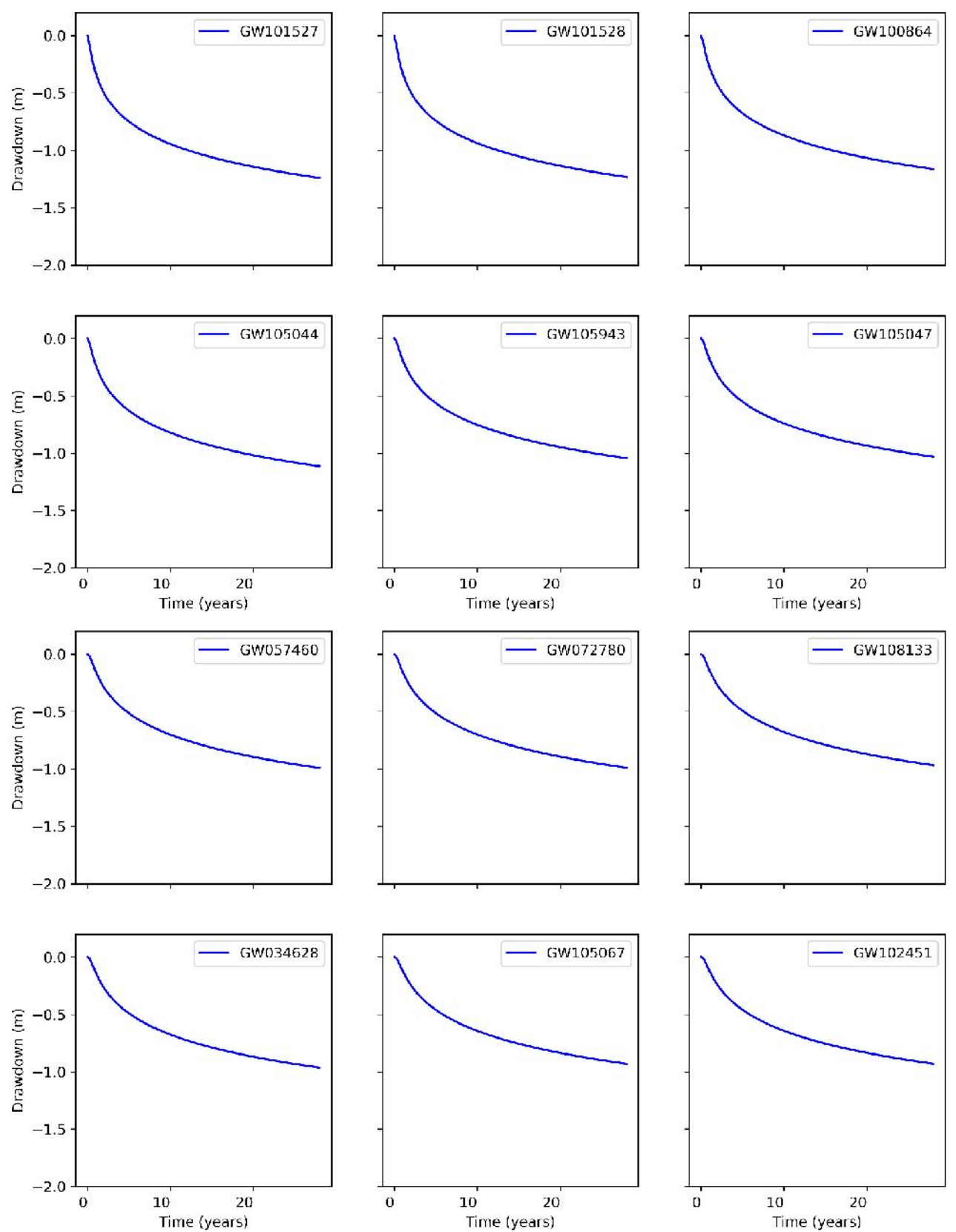


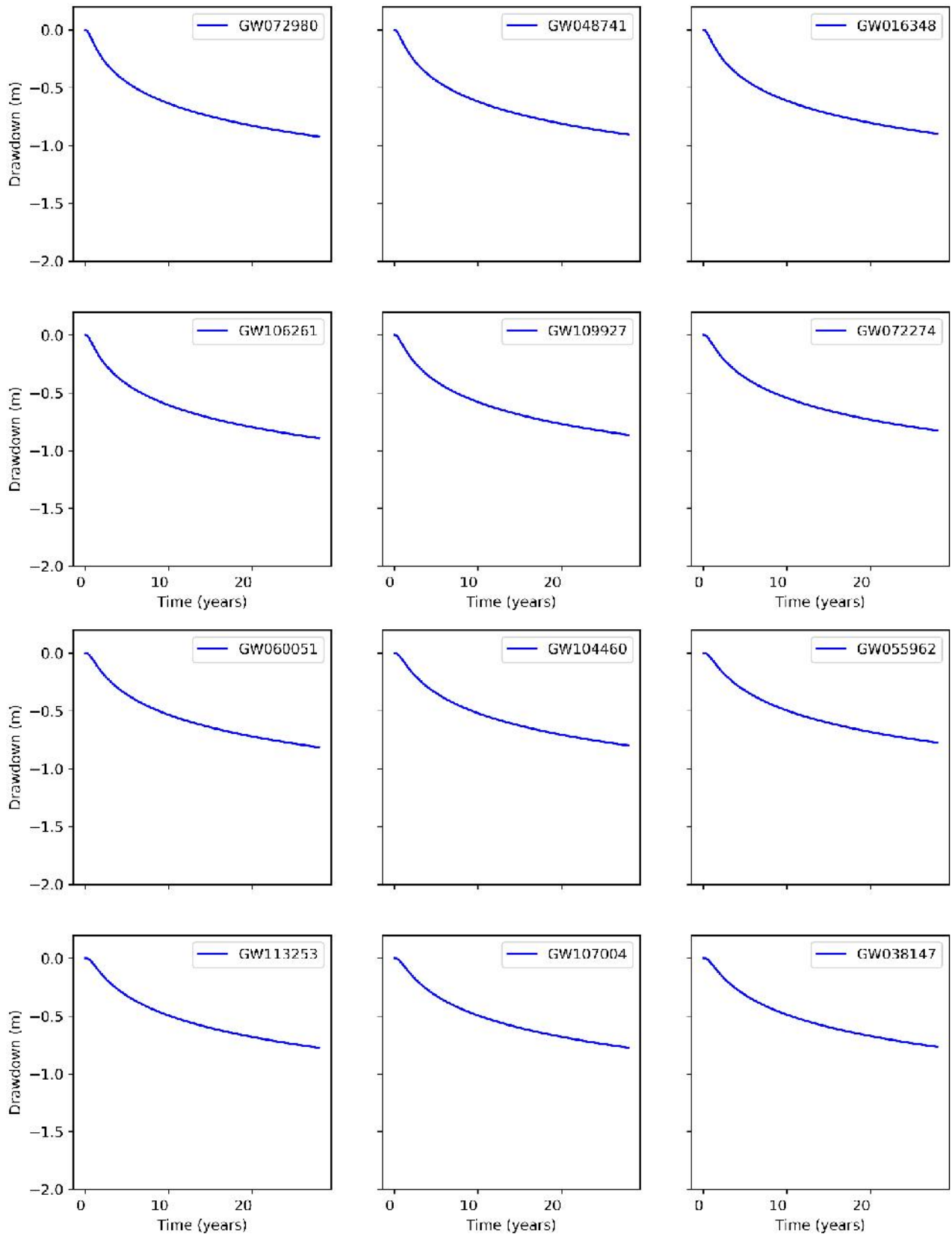


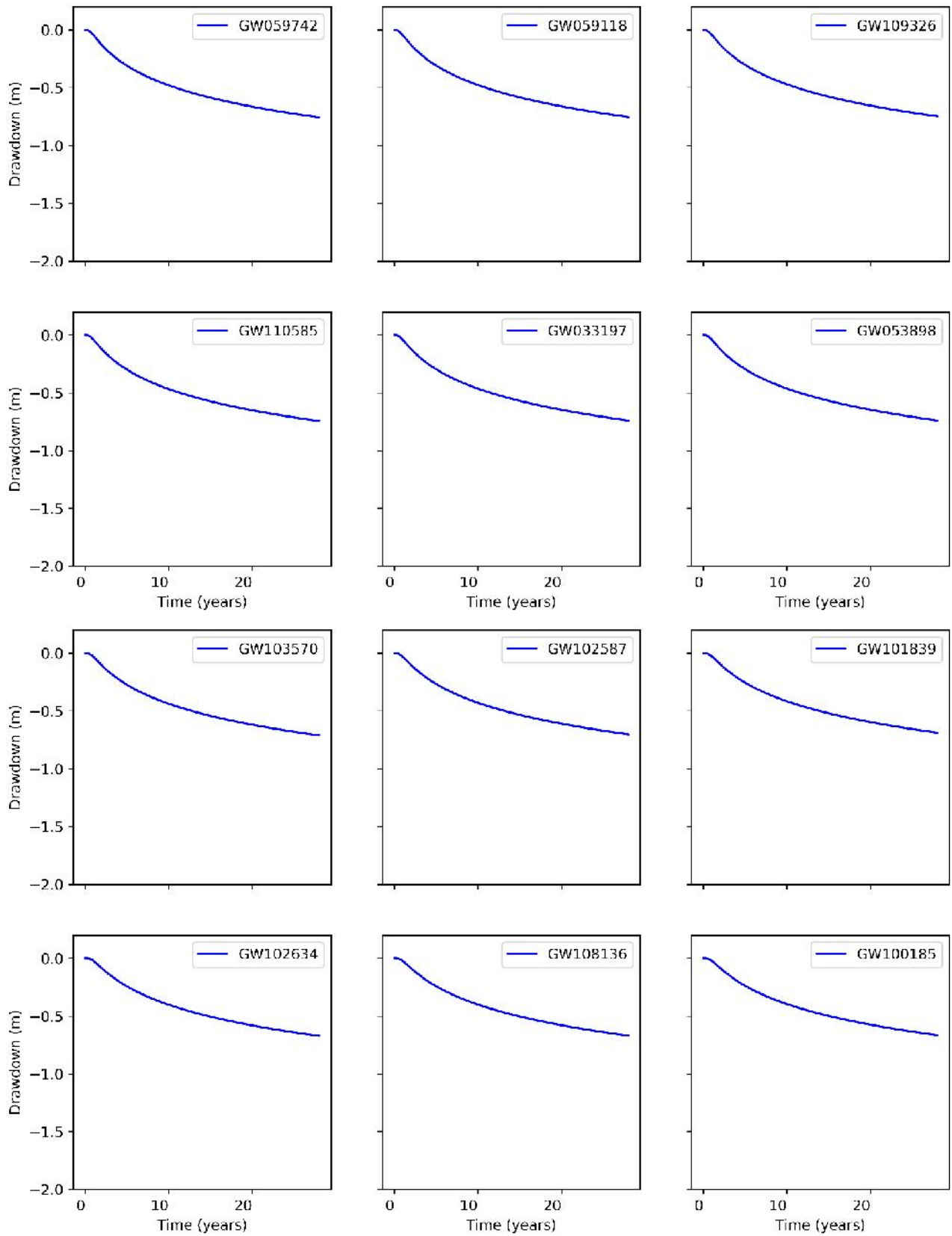


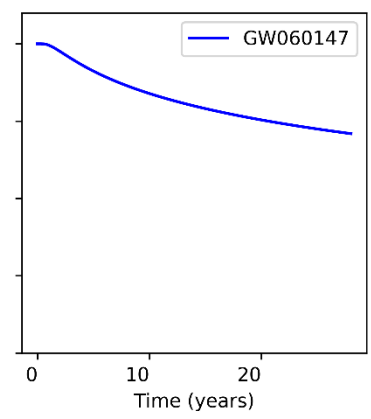
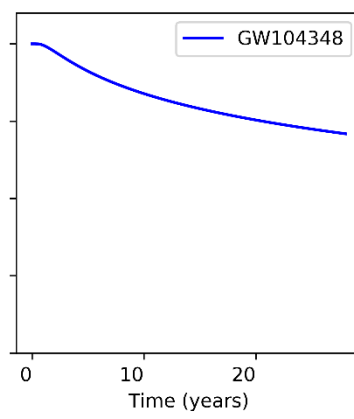
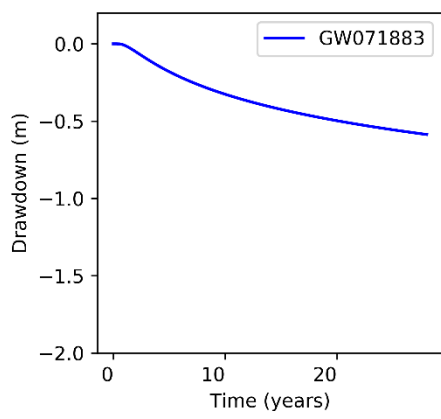
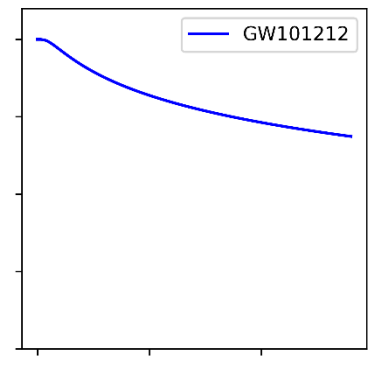
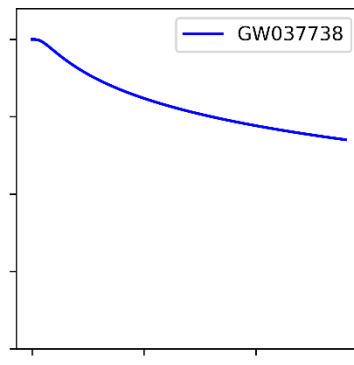
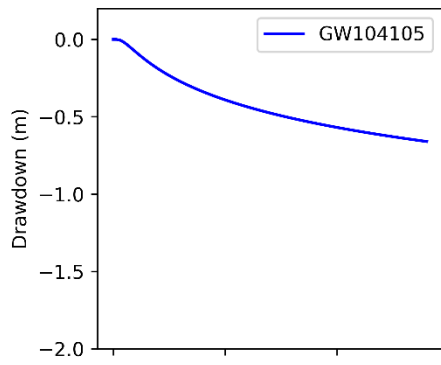


G.2 Drawdown charts – 20 ML/year











Appendix H

Groundwater model equations

H.1 Theis equation (confined aquifer)

$$Q = \frac{4\pi Ts}{W(u)} \quad u = \frac{r^2 S}{4Tt}$$

Q – Discharge (L/T)

T = Transmissivity (L²/T)

S = Storativity

r = Radius from discharge well (L)

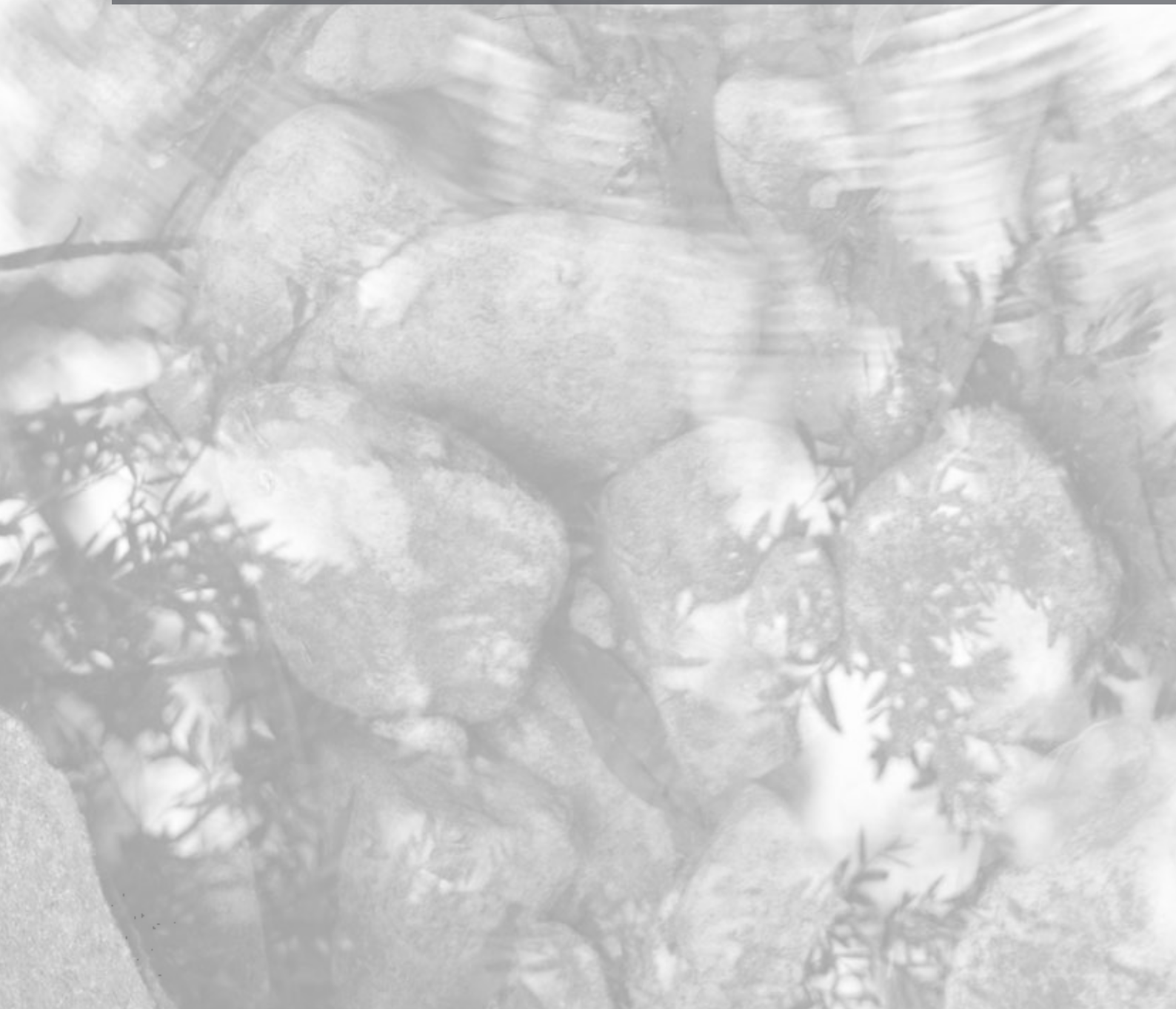
t = Time (T)

u = Dimensionless time parameter

W(u) = Well function

Appendix I

Maximum harvestable right dam capacity





Maximum Harvestable Right Dam Capacity

Information provided by the user

1. The location of the proposed dam is:

- Latitude: **-33.46145**
- Longitude: **150.97977**

2. Total property area to use for calculating the size of the dam is **1296 Hectares**

Result

The maximum Harvestable right dam capacity for your property is **103.68** ML (Megalitres)

Date

01/10/2020

Name

Maroota Sand Quarry

Limitations of the calculator

a) Where to site a dam

You can only construct a harvestable rights dam where the Harvestable Rights Orders apply, refer to [NSW Government Gazette 40 dated 31 March 2006](#) (pages 1628 to 1631).

b) First and Second order streams

The maximum harvestable right calculator does not verify that the location of the proposed dam sits on a first or second order stream. A factsheet : "[Where can they be built without a licence?](#)" is available on WaterNSW website to help you work out the stream orders.

You will need to use the legislated topographic map for your area to identify the stream order. This map is the gazetted map as per [NSW Government Gazette 37 dated 24 March 2006](#) (pages 1500-1509).

c) Size of property and dam

The calculator does not take into account other dams already on your property. If you have existing harvestable rights dams on your property, you must take the capacity of these dams into account when constructing a new dam. In the Eastern and Central Divisions other dams must also be taken into account, as described in the [NSW Government Gazette 40 dated 31 March 2006](#) (pages 1628 to 1631).

d) Protected wetlands

The Harvestable Rights Orders specify that you are not allowed to build a dam on or within 3 km of a RAMSAR wetland site. There are 12 RAMSAR wetlands in NSW. Further information on the location of those [12 RAMSAR sites in NSW](#) can be found on the NSW Environment and Heritage government website.



