HODGSON QUARRY AND PLANT PTY LIMITED

ROBERTS ROAD MAROOTA SAND QUARRY

GROUNDWATER MANAGEMENT PLAN

DUNDON CONSULTING PTY LTD

2 MAY 2018

(RE-ISSUED 30 JULY 2018)

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EXECUTIVE SUMMARY

This document has been prepared to meet the consent requirements of DA 267-11-99 Mod 2 for a Groundwater Water Management Plan for the Maroota Quarry, located at Roberts Road, Maroota.

Maroota is located within the Greater Metropolitan Region Groundwater Sources Water Sharing Plan 2011 (WSP). This Water Sharing Plan defines two groundwater sources, both of which are present beneath the quarry site, namely:

- The Maroota Tertiary Sands Groundwater Source (MTSGS), and
- The Sydney Basin Central Groundwater Source (SBCGS).

The Consent requires that sand and sandstone extraction be limited to not less than 2m above the wet weather high groundwater level for the regional water table in each of these two groundwater sources.

This plan outlines the management and protection measures to be followed by the Maroota Quarry in order to protect the beneficial use values of the two groundwater sources.

The plan needs to be read in conjunction with the Groundwater Monitoring Program, which details the regular groundwater monitoring program, as well as with the Surface Water Management Plan which outlines the surface water monitoring program and the overall site water management measures.

1 INTRODUCTION

1.1 Glossary

Term	Meaning
Alluvium	Unconsolidated geologic formation formed by deposition of clay, silt, sand, gravel and boulders from still or moving water.
AHD – Australian Height Datum	Elevation relative to a height of 0.0 AHD, which was assigned to the mean sea level for 1966 to 1968 at 30 tide gauges around the Australian Mainland coastline (Geoscience Australia, 1971).
ANZECC	Australian and New Zealand Environment and Conservation Council
Aquifer	The classical definition is a soil or rock layer or group of layers that is sufficiently saturated and permeable to yield significant quantities of water. The *Water Management Act 2000* defines an aquifer as a geological structure or formation, or an artificial landfill, that is permeated with water or is capable of being permeated with water.
Aquifer Interference Policy	NSW Government policy for the licensing and assessment of aquifer interference activities
Aquifer interference activity	an activity involving any of the following: (a) the penetration of an aquifer, (b) the interference with water in an aquifer, (c) the obstruction of the flow of water in an aquifer, (d) the taking of water from an aquifer in the course of carrying out mining, or any other activity prescribed by the regulations, (e) the disposal of water taken from an aquifer as referred to in paragraph (d).
Catchment	A valley defined naturally by the watershed line along the tops of the ridges that separate it from a neighbouring catchment. The area within this watershed line is the catchment area from which rainfall flows into a river or reservoir.
Cumulative impact	The sum effect on the environment resulting from the successive or simultaneous effects of several different impacts.
Dewatering	Removal of water from an aquifer as part of the construction phase of a development or part of ongoing mining activities to maintain access, serviceability and/or safe operating conditions.
Ecologically sustainable development	Using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased.
Ecosystem	A functional unit of energy transfer and nutrient cycling in a given place such as a forest or estuary; it includes all the relationships within the biotic community and between the biotic components of the system.
Eluvial	Unconsolidated geological formation or soil that is derived by *in situ* weathering or weathering plus gravitational movement or accumulation.
EPA	Environmental Protection Authority
Erosion	The natural process where wind or water detaches a soil particle and provides energy to move the particle.
Excavation	The act or process of digging out earth during construction.
Groundwater	All waters occurring below the land surface in the saturated zone. The upper surface of the rocks or soils saturated by groundwater in any particular area is called the water table.

Term	Meaning
Habitat	The place where an organism lives; habitats are measurable and can be described by their flora and physical components.
Hydraulic connection	A path or conduit allowing fluids to be connected. The degree to which a groundwater system can respond hydraulically to changes in hydraulic head.
Hydrology	The study of rainfall and surface water runoff processes.
Licence (EPA)	A Pollution Control Licence is issued pursuant to section 17D of the Pollution Control Act 1970 on premises scheduled or prescribed by the legislation. Licensing remains the main instrument for implementing point source pollution control, reduction and remediation programs. A licence is renewable annually and is subject to a fee calculated on the basis of the nature and size of the operation
Local road	A road or street used primarily for access to abutting properties
OEH	Office of Environment and Heritage
pH	A measure of the degree of acidity or alkalinity expressed on a logarithmic scale of 1-14, on which 1 is most acid, 7 is neutral and 14 is most basic.
Recharge	The replenishment of groundwater in an aquifer by infiltration of incident rainfall and/or runoff, or leakage from a surface water body or another aquifer.
Rehabilitation	The restoration of a landscape and especially the vegetation following its disturbance.
Soil	That part of the upper weathered layer of the earth's crust that can support plant growth. Any naturally occurring loose or soft deposit forming part of the earth's crust and resulting from weathering or breakdown of rock formation or from the decay of vegetation.
Stormwater	Rainwater that runs off urban and agricultural catchments, following rain events. This untreated water is carried in stormwater channels and discharges into creeks, rivers, lakes, harbours and oceans.
Study Area	The area to which technical investigations or assessments have been undertaken. Includes areas adjoining or proximal to the site.
Waste	Includes any matter (whether liquid, solid, gaseous or radioactive) that is discharged, emitted or deposited in the environment in such volume, constituency, or manner as to cause an alteration to the environment.
Water body	The collective name for all forms of static and active water features (rivers, creeks, streams, lakes and estuaries).
Wetland	Land either permanently or temporarily covered by water. These areas are usually characterised by vegetation or a moist soil or aquatic type.
Water pollution	Placing in or on, or otherwise introducing into or onto, waters (whether through an act or omission) any matter, whether solid, liquid or gaseous, so that the physical, chemical or biological condition of the waters is changed. (*POEO Act 1997*)

1.2 Site Description

Hodgson Quarry and Plant Pty Ltd's Maroota Quarry is located on Lots 1 and 2 DP 228308 and Lot 2 DP 312327, at Roberts Road near Old Northern Road, Maroota. Maroota is approximately 50 km northwest of Sydney. The site was formerly known as Sun-A-Rise Quarry, where construction of a water supply dam commenced around 1970. Consent was granted in 2000 (DA 267-11-99) for extraction and processing of sand, clay and pebble material.

Hodgson Quarry and Plant Pty Ltd took over operations on the site in 2004.

The main infrastructure features on site are:

- An office building, car shed/workshop and amenities building, located at the entrance to the site. The offices consist of a permanent building whilst the sheds are of corrugated iron and colour bond construction.
- A weighbridge adjacent to the site office.
- A processing plant, located centrally in the quarry. Smaller office buildings and general storage are located in this area.
- Mobile plant including earthmoving equipment located in active areas within the quarry.
- Internal haul roads linking the quarry to the weighbridge and the sand extraction areas. Roads are constructed of gravel.
- Water storage dam, tailings disposal storages, material stockpiles, grass and vegetation.

The quarry project current status and surface contours at June 2016 are shown on **Figure 1**.

1.3 Scope

A Soil and Water Management Plan (SWMP) was developed by Morse McVey and Associates Pty Ltd for the site in 1999 and was submitted with the EIS in the same year. This SWMP contained provisions relating to groundwater, specifically the requirement to ensure that extraction did not proceed below a 2m buffer above the wet weather high groundwater level for the regional water table, and notification requirements if groundwater should be intersected in the excavations.

A new Environmental Assessment (EA) was submitted to the Department of Planning and Environment in May 2015 to extend the life of the quarry. Consent was granted on 18 March 2016.

This report is intended to satisfy part (c) of Condition 42 of the March 2016 consent (NSW Department of Planning and Environment, 2016). It forms part of the overall Water Management Plan, which comprises three components, viz a Site Water Balance, a Surface Water Management Plan, and a Groundwater Management Plan. The Site Water Balance and Surface Water Management Plan have been included in VGT (2018), hereinafter referred to as “SWMP”. This report is the Groundwater Management Plan.

The specific requirements of consent condition 42 are detailed in **Table 1**.

Table 1: Specific Requirements of Consent Condition 42

Consent Condition	Where Addressed
SOIL AND WATER Note: the applicant is required to obtain the necessary water licences for the development under the Water Act 1912 and/or Water Management Act 2000.	SWMP (VGT, 2018)
Water Management Plan 42. The Applicant shall prepare a Water Management Plan for the development to the satisfaction of the Secretary. This plan must be prepared in consultation with the DoI-Water[1] by suitably qualified and experienced persons/s whose appointment has been approved by the Secretary, and be submitted to the Secretary for approval by 31 December 2016. The plan must be updated on an annual basis in consultation with DoI-Water for three years from the date of the approval of Modification 2 and thereafter as agreed with by the Secretary. In addition to the standard requirements for management plans (see condition 65), this plan must include a:	SWMP (VGT, 2018)
a) Site Water Balance that: • Includes details of: o Sources and security of water supply, including contingency planning; o Water use on the site; o Water management on site, including groundwater inflows to the quarry voids and site discharges; and o Audit and reporting procedures, including comparisons of the site water balance each calendar year; and o Describes the measures that would be implemented to minimise clean water use on site and maximise recycling opportunities;	SWMP (VGT, 2018)
b) Surface Water Management Plan that: • A detailed description of the surface water management system of the site, including the: o Clean water diversion systems; o Erosion and sediment controls; o Effluent irrigation system; o Water transfers from the extraction areas; o Water storages; and	SWMP (VGT, 2018)

[1] DoI-Water – Department of Industry Office of Water. Formerly DPI-Water – Department of Primary Industries Office of Water.

Consent Condition	Where Addressed
o Discharge points; • Design objectives and performance criteria for proposed: o Erosion and sediment control structures; o Water storages, including quarry voids; o Site discharges; and o Control of water pollution from rehabilitated areas of the site; • Performance criteria, including trigger levels for investigating any potentially adverse impacts for surface water quality. • A program to monitor: o The effectiveness of the water management system; o Site discharge water quality; and o Surface water level and quality in the process Water Dam, including the quantification of rainfall inflow, groundwater inflow and evaporation; • A plan to respond to any exceedances of the performance criteria, and mitigate and/or offset any adverse surface water impacts of the project; • Long term water quality management objectives and the measures to achieve these objectives; • A plan that ensures surface stormwater runoff from the disturbed areas is directed to the sedimentation dam(s); • A plan that ensures tailgate drainage does not discharge into or onto any adjoining public or Crown road, or other persons land, any Crown land, any rover creek or watercourse, any groundwater aquifer, any native vegetation as described under the native *Vegetation Conservation Act 1997* and any wetlands of environmental significance; • A detailed description of design and construction criteria for the Process Water Dam based on a feasibility study of: o Capacity to construct multiple cells within the overall dam footprint (i.e. a two stage or three stage dam); o Whether the dam floor and walls are able to be effectively lined with compacted clay (especially for multiple cells); o Whether effective hydraulic separation can be achieved between such cells; o Rehabilitating such cells to create a single dam within the final landform; and o The appropriateness of diverting runoff received from off-site around the dam; • A strategy for the decommissioning of water management structures, including storage, sedimentation and leachate	

Consent Condition	Where Addressed
dams once extraction is complete; and • Audit and reporting procedures, including comparisons of the monitoring results each calendar year and quarterly reporting of surface water monitoring results;	
c) Groundwater Management Plan that takes into account the *Web-based Reporting Guideline* (DPE, 2015) and *Groundwater Monitoring and Modelling Plans – Information for Prospective Mining and Petroleum Exploration Activities* (DPI, 2014), and includes: • detailed baseline data on groundwater yield and quality in groundwater bores on privately-owned land, that could be affected by the project;	**Section 44**
• a program to undertake surveyed probe testing of all extracted areas where clay fines have been deposited to: o accurately determine the depth of extraction and depth of clay fines; o identify any ongoing intersection or other interaction between clay fines and the regional groundwater aquifer; o identify any geotechnical characteristics of the emplaced clay fines which may pose risks to workplace safety or implementation of the process water dam design or the final landform; and o identify measures which can be successfully used in rehabilitating these areas;	**Section 3.5, 6**
• a program to monitor potential groundwater quality impacts to the regional aquifer from receiving off-site runoff water in the Process Water Dam;	**Sections 5.2, 6, 7.1**
• groundwater assessment criteria, including trigger levels for investigating any potentially adverse groundwater impacts, in accordance with the *NSW Aquifer Interference Policy*;	**Tables 16, 17, 18, 21; Section 5.4**
• a program to monitor: o the impacts of the project on: - groundwater inflows to water storages; - any groundwater bores on privately-owned land that could be affected by the project; and o seepage from water storages or backfilled voids on site;	**Section 5**
• a plan to respond to any exceedances of the groundwater assessment criteria;	**Sections 5, 6**
• emergency contingency plans for implementation in the event that the groundwater is encountered during excavation; and	**Section 6**
• audit and reporting procedures, including comparisons of the monitoring results each calendar year and quarterly reporting of groundwater monitoring results,	**Section 7.2**

Consent Condition	Where Addressed
The Applicant shall implement the approved management plan as approved from time to time by the Secretary.	

Aspects of Condition 42 that have been addressed in the SWMP (VGT, 2018) are not repeated here.

1.4 Objectives

The principal objectives of the GWMP are.

- To ensure the protection of the groundwater resources in the Maroota Tertiary Sands Groundwater Source (MTSGS) and the Sydney Basin Central Groundwater Source (SBCGS). The MTSGS comprises principally groundwater in the Maroota Sands formation, and the SBCGS comprises groundwater in the Hawkesbury Sandstone formation.
- To establish impact assessment criteria for the groundwater sources, and to develop response plans to be implemented in the event of any exceedances of the assessment criteria.
- To monitor the groundwater levels beneath the quarry site in both the MTSGS and SBCGS, and to identify the groundwater responses to rainfall recharge, natural discharge and any effects of quarrying, sand extraction, irrigation or other causes.
- To provide periodic updates to the Wet Weather High Groundwater Levels on the site, as the basis for the allowable sand extraction depth.
- To monitor for changes in groundwater quality in both groundwater sources.
- To monitor for any seepages into or from the water storages or backfilled voids on the site.
- To identify by a probing survey the depth of historical extraction and the depth of clay fines in backfilled areas of the quarry, to identify if any potential excavation has occurred beneath the base of the MTSGS in past quarrying, and to enable remedial measures to be implemented if necessary.
- To ensure regular (quarterly) reporting of monitoring results, and annual interpretation reporting on the results.
- To identify and implement groundwater improvement measures.

1.5 Consultation

This Groundwater Water Management Plan (GWMP) has been developed in consultation with the Department of Industry – Water (DoI-Water) and the Department of Planning and Environment (DP&E).

The Secretary approved the appointment of Peter Dundon of Dundon Consulting Pty Ltd on 5th April 2016 for the preparation of the GWMP (**Appendix F**). Approval was also received from DoI-Water on 10th May 2016 (**Appendix F**).

A draft Groundwater Monitoring Program (GMP) (Dundon, 2016), which forms a component of the GWMP, was submitted on 16th August 2016.

DoI-Water provided initial advice on the draft GMP by letter dated 26th September 2016. A meeting was held with DoI-Water in their Parramatta offices on 24th October 2016 in relation to this draft GMP, and discussion of further groundwater studies including the

installation of additional monitoring bores. The broad scope of additional studies was agreed to by DoI-Water at that meeting.

An email from the DP&E on 31st October 2016 provided comments on all Management Plans submitted thus far, including the GMP. Locations of the proposed new bores was approved. The draft GMP was approved by DP&E by letter dated 28th November 2016 (**Appendix F**).

Further correspondence resulting from the outcomes of the October 2016 meeting was provided by DoI-Water on 31st October 2016, 22nd November 2016 and 31st March 2017 (**Appendix F**).

The Groundwater Study Report initially submitted on 24th February 2017 is still the subject of ongoing consultation with DoI Water.

A draft of the GWMP was submitted on 21st September 2017. This was followed by a revised version of the GMP on 29th September 2017, and a revised version of the Groundwater Study Report on 4th October 2017.

Comments on all three documents were provided in a letter from DP&E dated 8th February 2018, which included comments from DoI-Water contained in a letter dated 30th January 2018 (**Appendix F**).

Further revisions of the GMP (Dundon, 2018a) and Groundwater Study Report (Dundon 2018b) were submitted to the DP&E and DoI-Water by electronic transfer on 4 May 2018.

Copies of all relevant agency correspondence relating to either the GWMP, the Groundwater Study Report or the GMP are also included in **Appendix F.**

2 DOI-WATER[2] LICENCES

2.1 Licenced or Registered Bores on Site

The quarrying operation holds a number of licences issued under the Water Management Act 2000, for the operation of groundwater bores as well as dams. Location of the bores and dams in the site can be found in **Figure 2**.

According to the DoI-Water groundwater maps available on the Pineena Register, there are a total of eleven registered bores on the site, viz:

- GW075003 and GW075004 - installed by DoI-Water (then known as Department of Water Resources) in 1997;
- GW101674 and GW114208 - current monitoring bores MW1 and MW5;
- GW101675 - former monitoring bore MW2, which is no longer monitored as it is obstructed above the water level, and was replaced by MW5;
- GW101676 and GW114209 - MW3 and MW4 respectively, which are no longer in existence, having been mined out during quarrying activities;
- GW105835 and GW102451 - production bores PB1 and PB2 respectively;
- GW102450 - believed to be an old bore known as 'Excavation Bore', which was granted a licence in 1999 under a departmental amnesty; and
- GW114210 - not able to be reconciled with any known bore on site.

An existing monitoring bore (MW6) installed in January 2015 as a replacement for MW4 is licensed, but is not listed in the DoI-Water Register. It may be the registered bore GW114210 listed above, but the DoI-Water records include no bore completion details, and the location on the DoI-Water plan does not tally with the actual location of MW6.

Three other bores known to have existed on the site are:

- 'Nursery Bore' (believed to have been drilled in the 1970s); and
- 'Roberts Road Bore' (drilled in the 1970s);
- 'House Bore' (drilled in 1981).

The 'House Bore' and 'Nursery Bore' have been destroyed and the 'Roberts Road Bore' was capped in the 1970s. 'Nursery Bore', 'House Bore', 'Roberts Road Bore' and 'Excavation Bore' were granted licences under an amnesty by the then Department of Water Resources in 1999 (see **Appendix F** for correspondence). It appears that only one of these bores ('Excavation Bore') was allocated a registered bore number.

MW1, MW2 and MW3 were licenced under 10BL158808 (URS, 1999). Replacement bore MW4 was drilled under the same licence, as authorised by DNIR (1999).

The location of MW1 (GW 101674) in the DoI-Water database is incorrect.

[2] DoI-Water (Department of Industry Office of Water) Primary Industries – Water) was previously known as Department of Primary Industries – Water (DPI-Water), and earlier had a number of other names with acronyms that include NOW, DWR, DIPNR, DNR, DNIR, DSNR, DLWC.

The original licences for PT84PB1 and PT84PB2 (now known as PB1 and PB2) were converted to Water Access Licences (WAL) in 2011. The licence for the Nursery Dam of 264 ML/a appears to have been incorporated into the WAL approval for PB2, the irrigation bore which is pumped into the Nursery Dam as a water supply for the nursery. The WAL for PB2 is current until 14 June 2025.

In December 2016, seven new bores were installed in and around the site as part of the Groundwater Study required by consent conditions (see **Figure 2**). These were installed under licence no 10BL605799.

The Groundwater Explorer database which is accessible on the Bureau of Meteorology (BOM) website, and is intended to replace the DoI-Water database, is incomplete. It shows only six bores on the site, viz GW101674, GW101675, GW101676, GW102450, GW102451 and GW105835.

The Groundwater Explorer map also shows the two DoI-Water monitoring bores GW075003 and GW075004 to be located on the western side of Old Northern Road, but they are in fact on the eastern side, within the quarry property.

Details of groundwater licences for the property are presented in **Table 2**.

Table 2: Groundwater Bore Licences (table from VGT (2018))

Water Access Licence Number (WAL)	Water Approval No'/ Reference Number	Licence	DoI-Water Registered Bore No	Identification	Purpose	Allocation	Expiry	Bore Status	Comments
24163	10WA114817/ 10AL114816	Was 10BL159748, Now 10PT901430 (converted to WAL 2011)	GW105835	PB1	Sand extraction	45 ML per year	14 June 2025	Converted to WAL	Located on lot 1 DP228308. Installed 6 June 1999. Can extract at a rate of 3 L/s.
24157	10CA114819/ 10AL114818	Was 10BL157595 Now 10PT901431 (converted to WAL 2011)	GW102451	PB2	Irrigation	6 ML per year	14 June 2015	Current. Converted to WAL	Located on Lot 2/228308 Installed 1999. Located adjacent to Dam 4. Possible that the location has been mistaken to be the Nursery Bore in the NOW Register under licence 10BL159150 and is listed as cancelled.
-	10CA104888/ 10AL104887	10SL045324 (converted to WAL 2011)	-	Nursery Dam	Irrigation	264 ML per year	17 February 2016	-	Located on Lot 2/228308.
-	-	10BL15978	GW102450	Excavation Bore	Test Bore	-	-	Cancelled. Destroyed.	Installed 1999. Licence granted under amnesty in 1999.
		-	Not listed on DoI-Water groundwater data base.	Nursery Bore	Test Bore	-	perpetuity	Destroyed.	Located on Lot 2/228308 Installed 1970s? Located between nursery and Dam 4.

Water Access Licence Number (WAL)	Water Approval No'/ Reference Number	Licence	DoI-Water Registered Bore No	Identification	Purpose	Allocation	Expiry	Bore Status	Comments
-	-	-	Not listed on DoI-Water groundwater data base.	House Bore	Test Bore	-	perpetuity		Installed 1981. Located adjacent to House on Lot 2 DP312327.
-	-	-	Not listed on DoI-Water groundwater data base.	Roberts Road Bore	Test Bore	-	perpetuity	Cancelled. Capped in 1970's.	Located on Lot 1/228308 Licence granted under amnesty in 1999. Located near trees adjacent to Roberts Road and site entrance.
-	-	10BL158808	GW101674	MW1	Monitoring	-	perpetuity	Current monitoring bore	Installed 22 October 1998. Located near nursery.
-	-	10BL158808	GW101675	MW2	Monitoring	-	perpetuity	Bore obstructed. Replaced by MW5.	Installed 20 October 1998. Not converted to WAL
-	-	10BL158808	GW101676	MW3	Monitoring	-	perpetuity	Bore Destroyed.	Installed 21 October 1998. Mined out.
-	-	10BL158808	GW114209	MW4	Monitoring	-	perpetuity	Bore Destroyed.	Installed December 2009. Replaced by MW6.
-	-	10BL158808	GW114208	MW5	Monitoring	-	perpetuity	Current monitoring bore	Installed April 2013. Bore replaced MW2. Application for licence under 10BL158808 was made.
-	-	10BL605696	GW114972	MW6	Monitoring		perpetuity	Current monitoring bore	Installed 23 January 2015. To replace MW4
-	-	-	GW075003	-	Monitoring	-	-	DoI-Water monitoring bore	Installed 1997.
-	-	-	GW075004	-	Monitoring	-	-	DoI-Water	Installed 1997.

Water Access Licence Number (WAL)	Water Approval No'/ Reference Number	Licence	Dol-Water Registered Bore No	Identification	Purpose	Allocation	Expiry	Bore Status	Comments
								monitoring bore	
-	-	10BL605799		MW7	Monitoring	-	Perpetuity	Current monitoring bore	Installed 9 December 2016
-	-	10BL605799		MW8	Monitoring	-	Perpetuity	Current monitoring bore	Installed 6 December 2016
-	-	10BL605799		MW9	Monitoring	-	Perpetuity	Current monitoring bore	Installed 19 December 2016
-	-	10BL605799		MW10	Monitoring	-	Perpetuity	Current monitoring bore	Installed 14 December 2016
-	-	10BL605799		MW11	Monitoring	-	Perpetuity	Current monitoring bore	Located on adjoining property (Lot B of DP 356946). Installed 21 December 2016
-	-	10BL605799		MW12	Monitoring	-	Perpetuity	Current monitoring bore	Installed 8 December 2016
-	-	10BL605799		MW13	Monitoring	-	Perpetuity	Current monitoring bore	Installed 7 December 2016

2.2 Registered Bores on Neighbouring Properties

Registered groundwater bores on adjacent properties have also been identified from the DoI-Water database. Registered bores within 500 m of the project site are listed in **Table 3**. Hodgson monitoring bore MW11 is included in **Table 3**, as it is located off-site on the neighbouring property to the north of the quarry.

Table 3: Registered Groundwater Bores Within 500m of Quarry Property

Registered bore number	Distance from quarry property (m)**	Depth (m)	Formation screened	Water level (mbgl)	Water quality	Purpose
GW016348	490	66.0	Hawkesbury Sandstone	30.4	Fresh	Irrigation
GW072037	320	99.0	Hawkesbury Sandstone		Very good	Industrial, irrigation
GW072274	480	168.5	Hawkesbury Sandstone		0-500 ppm	Stock, domestic
GW075001	410	80.0	Hawkesbury Sandstone	Range ~26-35	EC 83-152 µS/cm	Monitoring (DoI-Water)
GW075002-1	490	12.0	Hawkesbury Sandstone	7.0	TDS 207 mg/L	Monitoring (DoI-Water)
GW075002-2	490	27.5	Hawkesbury Sandstone	9.2	TDS 54 mg/L	Monitoring (DoI-Water)
GW075003	0	86.0	Hawkesbury Sandstone	Range 42-50	EC 89-168 µS/cm	Monitoring (DoI-Water)
GW075004	0	60.0	Hawkesbury Sandstone	Range 41-46	EC 96-233 µS/cm	Monitoring (DoI-Water)
GW100230	330	60.0	Hawkesbury Sandstone	29.0	Fresh	Stock, domestic, farming
GW100587	80	42.5	Hawkesbury Sandstone	14.0		Industrial, domestic, stock
GW102005	460	61.0	Hawkesbury Sandstone	18.0	Fresh	Stock, domestic
GW102583	250	102.0	Hawkesbury Sandstone			Domestic
GW104410	530	11.8	Maroota Sands	Range 9-11	TDS 90-460 mg/L	Monitoring (PF 166 MW1)
GW107345	130	150.0	Hawkesbury Sandstone	55.0		Stock, domestic
GW108806	320	35.0	Hawkesbury Sandstone			Monitoring (Arkzeal P/L)
GW108807	550	12.3	Hawkesbury Sandstone			Monitoring (Arkzeal P/L)
GW110198	90	54.0	Hawkesbury Sandstone	28.0		Stock, domestic
GW110585	290	280.0	Hawkesbury Sandstone	74.0		Irrigation
GW110746	260	46.5	?	Range 34-35	TDS 80-250 mg/L	Monitoring (PF Hitch MW1)

Registered bore number	Distance from quarry property (m)**	Depth (m)	Formation screened	Water level (mbgl)	Water quality	Purpose
GW111943	220	66.0	Hawkesbury Sandstone	30.0		Stock, domestic
GW112398	490	102.0	Hawkesbury Sandstone			Stock, domestic
MW11***	220	28.5	Maroota Sands	9.0	TDS 98 mg/L	Monitoring (Hodgson MW11)

* Details taken from DoI-Water database; URS (2006); .

** Distances taken from map in DoI-Water database. Some inaccuracies are likely.

*** Registered number not yet available

The registered bores listed in **Table 3** include 2 screened in Maroota Sands, 18 in Hawkesbury Sandstone, and 2 with no record of lithology. Bore depths range from 4m to 280m. The bore purpose for 8 bores is listed as monitoring, 5 are listed as being for irrigation, 13 for stock and domestic, 4 for domestic, 5 for industrial, and 1 for recreation.

3 EXISTING GROUNDWATER ENVIRONMENT

3.1 Rainfall and Evaporation

The monthly average total rainfalls recorded at the nearest Bureau of Meteorology station Number 67014 (Maroota – Old Telegraph Road) are shown in Table 4.

Table 4: Monthly Rainfall and Evaporation (mm)

Rainfall	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean	98.3	110.6	104.3	87.7	58.3	93.3	45.6	52.5	53.2	64.8	80.4	80.4	929.4
Median	70.9	82.1	82.4	58.5	42.0	57.4	26.4	22.8	41.3	53.6	70.2	75.8	
Highest	146.1	167.1	220.2	183.1	140.7	172.0	161.0	325.0	110.7	83.1	94.4	92.2	
Mean monthly evaporation	183	138	124	90	65	51	56	84	114	146	150	174	

Station 67014, Maroota (Old Telegraph Road) is located opposite the junction with Roberts Road, and is less than 1 km from the quarry. The station has a long record, covering the period from 1925 to 2018.

The nearest evaporation data available on the BoM website are from Richmond UWS Hawkesbury (Station 067021), and covers the period from 1973 to 2018. Station 067021 is approximately 25 km from the quarry.

3.2 Topography and Surface Drainage

The project is located in an incised area of Hawkesbury Sandstone plateau. The topography is therefore quite steeply undulating, with relatively steep valley sides, and steep cliff faces in some places. Within the property on which the quarry is located, the terrain is a moderately undulating valley domain.

The natural drainage of the site was originally in a northerly direction, with the local creek system flowing into Coopers Creek approximately 2 km to the north (Woodward-Clyde, 1999). The original creek line has been disturbed by the quarrying activities, but continues in its original location north of the property from Dam 1. No discharge to the creek from the site has occurred due the water needs of the processing plant.

The site is currently largely internally draining, from the highest elevations adjacent to Old Northern Road along the western/south-western side of the site (elevation range 241 to 225 AHD) towards Dam 1 which is located near the eastern end of the northern site boundary and is the lowest part of the site (ground surface adjacent to Dam 1 is at 188 mAHD).

The deepest excavated depth in the quarry is believed to have been approximately 180 mAHD. The deepest parts of the quarry have now been backfilled with fines settled from either tailings or recycled process water. There are residual silts and clays in the base of Dams 1 and 2 and the unnamed former tailings dam to the north of Dam 2 (**Figure 1**).

The water-filled Process Dam 1 is now the lowest part of the quarry, and the current maximum depth in the quarry is 184.8m, which occurs in a very localised area around the water reclaim pump inlet in Dam 1.

A probing survey conducted in September 2017 established the depth to the top of sediment in Dam 1, finding that the water depth over most of the area of Dam 1 is between 0.1m and 0.7m, with a small localised area of greater water depth around the water recovery pump inlet, where water depth reached a measured maximum of 2.95m. Most of Process Dam 1 has a base elevation in the range 187.1 to 187.6 mAHD, with the deepest measured point near the pump inlet being at 184.8 mAHD.

There are two dams on DP 228308 on the western side of the property (Dams 3 and 4, see **Figure 2**), which capture clean water runoff from upslope areas including a limited area off the quarry property. The water in these dams is used as a water supply source for the nursery located at the north-western corner of the property. Water has at times been pumped from Dam 4 to supplement the quarry water supply. At other times, water has been transferred from the quarry operations into these dams, to ensure continuing available water to the nursery.

Elsewhere on the quarry site, runoff is diverted around the disturbed areas via diversion bunds where possible and where the natural topography assists. A portion of clean water from the undisturbed areas and properties adjacent to the quarry on Roberts Road does enter the main quarry area. Dirty water is collected in the disturbed areas into either the main site dam (Dam 1 on **Figure 2**), or into one of the tailings dams (Dam 2 and the unnamed Dam on **Figure 2**) to allow for settling to occur.

Surface water draining from properties to the east of Roberts Road enters the site via a road culvert just north of the site entrance. This catchment comprising approximately 10 ha is considered clean, and is diverted into Dam 1.

3.3 Geology

The project is located within the Permian to Triassic Sydney Basin. The quarry recovers sands from the Maroota Sands formation, which is of Tertiary age and occupies a paleochannel system incised into the underlying Hawkesbury Sandstone and Ashfield Shale basin sediments. Sand is also recovered from the Hawkesbury Sandstone itself.

The general stratigraphy for the Maroota area is shown in **Table 5**.

Table 5: Stratigraphic Sequence in the Vicinity of Maroota[3] Quarry Project

Age	Unit	Lithology	Comment
Quaternary	Soils	Variable	
Tertiary	Maroota Sands	Sand, gravel, clayey sand and clay	Reworked Hawkesbury Sandstone. Paleochannel sands including clay and ferricrete bands (cemented ironstone). Outcrops at project site and is the target of quarry activities.
Triassic	Ashfield Shale	Shale and laminate	Not present at project site.
	Hawkesbury Sandstone	Quartzose sandstone with shale lenses	Weathered upper profile (eluvial sands) underlain by competent sandstone. Eluvial sands outcrop to north and west of quarry.

3.4 Hydrogeology

Groundwater is present within the Maroota Sands and the underlying Hawkesbury Sandstone. Groundwater in each of these two formations is regionally extensive and forms a regional water table in each. Localised groundwater is also present in perched aquifers on top of or within the Hawkesbury Sandstone above the regional water tables. Thus, localised groundwater may be intersected at a number of elevations above the regional water table levels, in either the Maroota Sands and the Hawkesbury Sandstone.

Since the original consent in 2000, two groundwater policies affecting these aquifers have been introduced, namely:

- The Greater Metropolitan Region Groundwater Sources Water Sharing Plan 2011 (WSP) (NSW Government, 2011); and
- The Aquifer Interference Policy (NSW Office of Water, 2012).

The WSP defines two water sources for the locality –

- the **Maroota Tertiary Sands Groundwater Source** (MTSGS) which includes the total extent of the Maroota Sands paleochannel formation as well as connected Hawkesbury Sandstone eluvium, as defined by a map contained in the WSP; and
- the **Sydney Basin Central Groundwater Source** (SBCGS) which includes the Hawkesbury Sandstone formation over an area defined by a map in the WSP.

Protection measures for both water sources are detailed in the WSP.

The MTSGS is directly recharged by infiltration of rainfall and local runoff, and downward percolation to the water table, or to any perched water table present. The SBCGS is recharged by infiltration of rainfall and runoff in areas where fresh rock outcrops at the ground surface, or through downward leakage from overlying Maroota Sands, alluvium or eluvium. Groundwater levels in both units display fluctuations that relate to episodic

[3] Adapted from (AGT (2015), after Woodward-Clyde (1999) and Etheridge (1980)

recharge associated with the larger rainfall events. The recharge responses are particularly marked in the Maroota Sands.

The upper surface of the Hawkesbury Sandstone has been encountered at varying depths on the site. Some of the earlier drilling did not extend to sufficient depth to fully penetrate the Maroota Sands (MW2, MW3, MW4 and MW5). All bores drilled in the 2016 program MW7 to MW13) were drilled to at least the top of the Hawkesbury Sandstone.

The elevations of the top of Hawkesbury Sandstone are shown on **Figure 3**. Sites where the top was not encountered are marked with the maximum possible elevation, although it is almost certainly somewhat deeper at the above bore sites that were not drilled deep enough. The excavated landform is comprised of exposed Hawkesbury Sandstone in the area to the east of Dam 1. The Hawkesbury Sandstone surface elevations shown at two locations near the bank on the eastern side of Dam 1 are the current surveyed elevations, not the pre-quarrying elevation. The original Hawkesbury Sandstone surface elevations in this area are not known.

Elevations of the top of Maroota Sands and its thickness are plotted on **Figure 4**. The minimum thickness is shown at sites that were not drilled to the base of the Maroota Sands (ie MW2, MW3, MW4 and MW5). At sites where drilling took place within the partly excavated quarry (PB1, MW3 and MW4), the surface elevations at the time of drilling are used. These are not necessarily the original pre-quarry elevations.

The elevations and Maroota Sands thickness have not been contoured on **Figures 3** and **4**, as there is minimal off-site data available to allow sensible contouring which takes account of the regional position.

3.5 Hydraulic Properties

3.5.1 In-situ Formation Properties

In summary, the following approximate hydraulic conductivity ranges are considered to apply to the three main hydrogeological units encountered at the site (Dundon, 2018b):

- Maroota Sands – clean sands and gravels, and clayey sands/gravels – 0.1 to 1.0 m/d
- Maroota Sands – sandy clays, silty clays, and clays – 0.01 to 0.1 m/d
- Hawkesbury Sandstone – 0.001 to 0.05 m/d.

3.5.2 Tailings/Fines Backfill

The fines in the Process Dam 1, Tailings Dam 2 and the unnamed former tailings dam to the north of Dam 2 have a very low hydraulic conductivity. Testing of the in situ conductivity of the settled fines has not been possible due to inaccessibility and safety concerns. However, there is clear evidence of the low conductivity, viz:

- There is no evidence for mounding beneath or downgradient from the site;
- Hydrographs show a declining water level trend in both MW10 and MW6 (up-gradient), and MW11 (down-gradient from Dam 1) – see **Figure 5.**
- There is a clear downstream gradient that appears to be unaffected by the Dam (**Figure 5**).
- All four hydrographs depicted in **Figure 5** are responding primarily to the rainfall pattern, with trends conforming generally with the Maroota RCD curve.

- There is at all times a distinct head difference between the dam water levels and the underlying groundwater levels (see **Figure 5**). The relative water levels measured on 5 April 2018 were:
    - Dam 1 - 187.2 mAHD
    - MW6 (up-gradient) - 183.2 mAHD, and
    - MW11 (down-gradient) - 180.4 mAHD.
- The recession trend in the Dam water level is similar to the recession trends in the up-gradient bores (MW6 and MW10), and less steep than in the down-gradient bore MW11 (**Figure 5**).
- The recession trend in MW11 downstream of Dam 1 is much steeper than the recession trends in both the dam water level itself and the upstream bores (**Figure 5**).

The groundwater bore levels at bores MW10, MW6 and MW11 are at all times several metres lower than the Dam 1 water level. Any leakage from the dam would be expected to result in relatively higher groundwater levels beneath and down-gradient from the dam. However, no such mounding on the water table is apparent, and there is no evidence that the groundwater downstream of the Dam is receiving more recharge than is being received upstream.

Leakage from Dam 1, if it were occurring, would also be expected to result in a gentler downstream recession trend during periods of low rainfall, due to the recharging effect of the leakage from the Dam. However, the down-stream recession trend at MW11 is steeper than the upstream recession trends and the Dam recession trend.

Any downward leakage from the dam would have been reflected in a mounding beneath the dam, and a recharge effect in the downstream bore MW11. Both these effects are absent, suggesting strongly that there is negligible leakage from Dam 1, and therefore the residual clay and silt in the base of the dam has very low permeability. There is likewise no evidence for any significant leakage from either the operating Tailings Dam 2 or the former tailings storage area to the north of Dam 2 (**Figure 2**).

3.6 Groundwater Inflows

Regular inspections across the pit faces and quarry floor has not identified any notable groundwater seepages in the quarry. As noted in the Groundwater Study Report (Dundon Consulting, 2018b) water levels in the 5 site ponds (Process Dam 1, Tailings Dam 2, the unnamed former tailings dam north of Dam 2, and water supply Dams 3 and 4) are higher than groundwater levels in nearby bores within the quarry site, indicating that there is a potential for water to flow from the ponds to the groundwater, but not from the groundwater to the ponds. There is no evidence of any groundwater inflow occurring at the current extraction depth.

The one exception to the above observation is a persistent seepage zone that has been observed in the active quarry about 120m east of Dam 4, at the location marked **"Seepage"** on **Figure 2**. This seepage was observed at an elevation of approximately 195 mAHD, ie about 18m lower than the Dam 4 water level and several metres below the water level in the nearby tailings dam (Dam 2). The location is shown also on the cross-section EE' which is presented in **Figure C5** in **Appendix C**. The seepage was observed to dry up whenever water was pumped for an extended period from Dam 4 causing the water level in Dam 4 to be lowered, indicating a clear connection between the dam and the seepage. This site has now become obscured by sand excavation activity, but is expected to become visible again as the quarry face is advanced to the north-west. It is also now

lower than the water level in Tailings Dam 2, which was lower than the seepage when it was last observed.

This seepage is considered to be a leakage from Dam 4, due to the close correlation between pumping from the Dam 4 and drying up of the seepage, and is not considered to be a true 'groundwater inflow'. It is also at an elevation well above the regional water table level, as depicted on **Figure C5** in **Appendix C**.

3.7 Water Management on Site

The extraction of sand on the site relies on an adequate supply of water for washing and screening of material. The water is drawn primarily from the main process dam (Dam 1), and supplemented when required on infrequent occasions from Dam 3 or Dam 4, or from water supply bore PB2. After processing, the slurry wash water is pumped to the tailings dam to allow settlement of the clay and silt fines, and recovery of water for return by gravity flow to Dam 1 and re-use in the sand recovery process.

The estimated volumes of water held in the dams on the site are listed in **Table 65** (VGT, 2018).

Table 6: Volumes of Site Dams

Dam name	Dam area (m^2)	Estimated average depth (m)	Estimated volume (m^3)
Main Process Dam 1	18,890	ranging from 0.1 to 2.9	13,157
Tailings Dam 2	4,380	2	8,760
Nursery Dam 3	7,494	2	14,988
Nursery Dam 4	14,480	2	28,860
Total volume held			65,765

Note: volumes and areas have been calculated using SURPAC software.

The approximate water storage capacity of the current excavation is approximately 136,000 m^3.

There are residual silts and clays in Dams 1 and 2 and the unnamed former tailings dam.

Most of Process Dam 1 has a base elevation in the range 187.1 to 187.6 mAHD, with the deepest measured point near the pump inlet being at 184.8 mAHD. This compares with the current (April 2018) wet weather high regional groundwater level for the Maroota Sands aquifer of 184.2 to 184.5 mAHD beneath Process Dam 1.

The unnamed former tailings storage area contains only a small volume of superficial water, and is essentially dry most of the time.

The base levels of Dams 3 and 4 are estimated.

3.8 Groundwater Levels

Measured groundwater levels beneath the Maroota sand quarry property range from around 170 mAHD to around 210 mAHD.

The most recent water level measured in each monitoring bore, including the bores that are no longer available, is listed in **Table 7** and are shown on **Figure 6**.

Table 7: Monitoring Bore Water Levels

Bore	Screened interval (m BGL)	Aquifer	Water level		
			Date	m BGL	m AHD
MW1	4.9-9.9	Maroota Sands (perched)	5 April 2018	7.76	205.66
MW5	32-44	Maroota Sands (perched)	20 Sep 2017	34.31	192.69
MW6	24-29	Maroota Sands	5 Apr 2018	19.29	183.18
MW7	30-36	Hawkesbury Sandstone	5 Apr 2018	29.22	183.74
MW8	37-40	Maroota Sands (perched)	5 Apr 2018	34.52	192.49
MW9	44.5-50.5	Hawkesbury Sandstone	5 Apr 2018	38.55	187.03
MW10	44-47	Maroota Sands	5 Apr 2018	33.04	184.08
MW11	24-28.5	Maroota Sands	5 Apr 2018	11.98	180.37
MW12	23-26	Hawkesbury Sandstone	5 Apr 2018	16.03	194.25
MW13	27.5-30.5	Maroota Sands (perched)	5 Apr 2018	26.58	198.92
MW2*	19.5-25.5	Maroota Sands (perched)	*10 Mar 2000*	*23.75*	*203.05*
			9 Jan 2017	>20.7	<206.2
MW3**	14.9-20.9	Maroota Sands (?perched)	*6 Jul 2009*	*18.95*	*183.48*
MW4**	19.5-28.5	Maroota Sands	*19 Jun 2013*	*24.06*	*187.90***
PB1	>28.8	Hawkesbury Sandstone	*19 Aug 1999*	*14.10*	*179.40****
PB2	>53	Hawkesbury Sandstone	*5 Jul 2002*	*42.51*	*173.99****
GW75003	72-75	Hawkesbury Sandstone	*27 Aug 2015*	*46.12*	*179.36*
GW75004	54-57	Hawkesbury Sandstone	9 Jan 2017	40.11	186.84

* Bore obstructed at 20.7 m below ground level. Dry to this depth.

** Bore lost to sand extraction.

*** Estimated - surface RL not surveyed.

Red Most recent available water level

Five cross-sections have been prepared to illustrate the relationship between the observed groundwater levels in the monitoring bores. Cross-sections BB' and CC' have been extended to include relevant information from the adjacent PF Formation quarry to the west of the Roberts Road quarry.

3.8.1 The cross-sections are presented as Figures C1 to C5 in Appendix C. The locations of the cross-sections are shown on Figure 2. Maroota Sands

Groundwater levels within the Maroota Sands formation range between approximately 180 mAHD (bore MW11) and 206 mAHD (bore MW1).

The deepest reported intersections of Maroota Sands were at MW6, MW10 and MW11, where the top of the Hawkesbury Sandstone is at <173.5 mAHD, 168.1 mAHD and 164 mAHD respectively.

At these locations, the water level in the Maroota Sands on 5 April 2018 was at elevations of 183.2 mAHD, 184.1 mAHD and 180.4 mAHD respectively. All three water levels are lower than the current water level in the main process area dam (Dam 1), which on the same date was 187.2 mAHD. Similar water levels were reported from previous monitoring bores MW3 and MW4 before they were destroyed by the quarry expansion. The water levels in these five bores are believed to be true reflections of the regional water table level within the Maroota Sand aquifer.

Elsewhere on the site, groundwater levels within the Maroota Sands formation are elevated, in the range 192 mAHD to 206 mAHD. In some locations, the perched water levels may be further elevated due to leakage from the various dams on the property, in which the water levels on 5 April 2018 were determined by survey as follows:

- Process dam – Dam 1 187.21 mAHD
- Tailings dam – Dam 2 199.11 mAHD
- Unnamed tailings dam north of Dam 2 200 mAHD (estimated from contours)
- Nursery Dam 3 205.40 mAHD
- Farm Dam 4 212.45 mAHD.

There is localised perched groundwater present at some sites, either in shallow Maroota Sands where the top of the Hawkesbury Sandstone is above the regional water table elevation (such as on the flanks of the paleovalley), or above a clayey aquitard within the Maroota Sands itself.

Examples of perched groundwater above shallow Hawkesbury Sandstone include:

- At bore MW1, which was terminated at 11.8m depth in Maroota Sands, and has continuously reported a water level in the range 205 to 209 mAHD. A new bore drilled in December 2016 at this site (MW7) was completed (screened) in Hawkesbury Sandstone, at around 184-185 mAHD. The top of Hawkesbury Sandstone was encountered at 14m BGL (199 mAHD) in MW7, and drilling revealed the upper part of the Hawkesbury Sandstone to be dry, between at least 199 and 185 mAHD. The groundwater level in MW1 is clearly a perched aquifer above the top of the Hawkesbury Sandstone surface. The relative water levels at this site are shown on a composite bore log on **Figure 7**, and on cross-section AA' (**Figure C1** in **Appendix C**).
- There is a cluster of bores at the site of MW2, MW5 and MW8 (see **Figure 2**), all screened in Maroota Sands. MW2 was drilled to only 26.5m and screened from 19.5-25.5m, and reported a water level in the range 23.7 to 24.7 m BGL (202-203 mAHD), until the bore was found to be obstructed at shallower depth[4]. Bore MW5 was drilled to 44m and was reported to be still in Maroota Sands at that depth. Bore MW8 was drilled in December 2016 to verify whether the water level in MW5 was perched, as MW5 had not reached the Hawkesbury Sandstone. MW8 was drilled to a depth of 49m BGL, and the top of the Hawkesbury Sandstone was interpreted from the drill cuttings to be at approximately 40m. The bore is screened only in Maroota Sands (see log in **Appendix A**). MW5 and MW8, both screened only in Maroota Sands, have a consistent water level at around 192-193 mAHD, about 10m lower than the level previously measured in MW2. The relative water levels at this cluster site are shown on a composite log **Figure 8**, as well as on cross-section BB' (**Figure C2** in **Appendix C**).

[4] The obstruction was measured at 20.7m BGL on 6 December 2016.

- Seepage was noted during drilling of bores MW8, MW9 and MW13 at 10-11m below ground surface, however in all three bores the drilling then revealed dry conditions below the seepage zone (see bore logs in **Appendix A**). Two of these bores (MW8 and MW9) are screened in Maroota Sands, and have standing water levels 10-15m below the seepage zone, confirming that the seepage zone is from a local perched aquifer. The relative groundwater levels at bores MW9 and MW13 are shown on a composite bore log (**Figure 9**) and on cross-section BB' (**Figure C2** in **Appendix C**).

The composite log of MW2, MW5 and MW8, together with the two DoI-Water bores GW75003 and GW75004 (**Figure 9**), shows two distinct standing water levels for the Maroota Sands, as well as the seepages reported during drilling, which are believed to indicate three separate perched groundwater occurrences in the Maroota Sands at this location. All Maroota Sands groundwater levels are well above the deeper water levels in the Hawkesbury Sandstone. GW75004 is not as deep as GW75003, and has a higher water level than GW75003. The higher water level in GW75004 may represent a perched aquifer horizon within the Hawkesbury Sandstone itself, or possibly it may be a composite level between the Hawkesbury Sandstone and the overlying Maroota Sands, as the bore annulus is open to the lowermost 10m of the Maroota Sands, albeit well above the screen interval (see cross-section BB' – **Figure C2** in **Appendix C**).

Taking into account the results of the recent drilling of seven (7) additional monitoring bores in December 2016, and considering the water levels in the dams on the site, it is now considered very likely that at least some of the elevated water levels in the Maroota Sands are affected by leakage from the dams which are all at significantly higher elevation than nearby bore water levels.

None of the occurrences of perched groundwater within Maroota Sands is extensive enough to permit contouring. The reason for perched groundwater within the Maroota Sands arises from the varying lithology of the formation, which is formally described as comprising "clayey gravel, gravelly sand, pebbly sand and sand", but also including other horizons described as "clay and silty clay" and "ferruginised sand and pebbly sand". The "ferruginised sand and pebbly sand" unit appears to be a basal unit, however the "clay and silty clay" unit appears to be gradational and interlayered with the cleaner sands and gravels. Perched groundwater may occur in any location where there is a less permeable Maroota Sands beneath relatively more permeable Maroota Sands, with the less permeable material limiting the downward percolation of water derived from rainfall above, and permitting a zone of saturation to develop within the more permeable material above.

Geological mapping by Etheridge (1980) identified an area of clayey Maroota Sands across the south-western side of the property. This clayey material was drilled as the dominant lithology in bores MW2, MW5, MW8, MW9 and MW13. Elsewhere, horizons of more clayey Maroota Sands were drilled in bores MW3, MW4, MW6, MW7, MW10, MW11 and MW12. The more clayey material would be relatively less permeable than the cleaner lithologies, and would be capable of forming a localised perching layer. In particular, a prominent clay unit close to the base of the paleochannel is reported in the logs of MW3 and MW11, which is believed to form a localised perching layer.

A Quaternary aged eluvial sand was mapped by Etheridge in places overlying the Maroota Sands formation. The eluvial alluvium has been included with the Maroota Sands in the defined MTSGS in the WSP (NSW Government, 2011). However, there is no evidence of any eluvial sands within or near the quarry site.

3.8.2 Hawkesbury Sandstone

Regional groundwater levels within the Hawkesbury Sandstone range between approximately 170 and 195 mAHD.

The regional groundwater level is interpreted to be at 170-180 mAHD (as illustrated by water levels in bores PB2, GW075003 and GW075004). However, like the Maroota Sands, there is perched groundwater within the Hawkesbury Sandstones, either naturally perched above shale bands or possibly artificially elevated by leakage from the site dams. Evidence for the latter is the rising trend seen on the hydrograph for PB2 (**Figure D11** in **Appendix D**).

3.8.3 Groundwater Level Changes with Time

The groundwater levels are presented as hydrographs in **Figures D1** to **D12** in **Appendix D**.

Figure 10 is a composite plot of all available manual monitoring data. **Figures D1** to **D12** present individual hydrographs plotted against the Monthly Rainfall Cumulative Deviation (RCD) curve for the nearest BoM rainfall station – Maroota (Old Telegraph Road), Station 067014. Although there are a number of months where data are missing at the Maroota BoM station, as discussed below at **Section 5.4.3**, the Maroota RCD curve is similar to the curves for the two nearest BoM rainfall stations that have a reliable long-term record, viz Dural and Wiseman's Ferry. Accordingly, the Maroota RCD has been used for the analysis.

Total rainfall is recorded hourly at the quarry site, but data are only available in a spreadsheet format from January 2013 to the present. Therefore, due to the short record, detailed analysis of water level hydrographs using cumulative deviation from long-term average rainfall at the site itself has not been possible.

The rainfall cumulative deviation (RCD) curve is derived by calculating the difference between actual monthly total rainfalls and the long-term average monthly rainfalls for the location. These monthly deviations from the average are then accumulated to develop a cumulative deviation curve. A rising trend on the curve results when monthly rainfalls over a period are above the long-term averages, and a downward trend arises when actual rainfalls are below average. The RCD curve for Maroota is plotted on **Figures D1** to **D12**.

During periods of below average rainfall, the hydrograph of a bore in an aquifer that receives regular recharge shows an overall downward trend, while still showing short-term rises in response to specific rainfall events. In periods of generally above average rainfall, the hydrograph shows an overall rising trend. By comparing the hydrograph with the RCD curve, it is easy to see whether the hydrograph fluctuations are related to rainfall recharge, or other causes, such as an impact from irrigation use or quarry dewatering.

Most hydrographs display a marked fluctuation in response to episodic rainfall recharge and natural discharge. The shallow groundwater responds quite quickly to recharge from larger rainfall events. This is typified by the hydrograph for bore MW1 (**Figure 10** and **Figure D1**), which shows short-term sharp rises in water level following the larger rainfall events, followed by a steady downward recession trend reflecting natural discharge from the shallow perched aquifer. Superimposed on the short-term fluctuations is a longer-term trend, which reflects the overall climatic conditions.

By contrast, the hydrographs for bores in the regional water tables of either the Maroota Sands or the Hawkesbury Sandstone show a much more attenuated response to specific rainfall events. However, even the deeper DoI-Water's Hawkesbury Sandstone bores

GW75003 and GW765004 show a clear similarity between their hydrographs and the RCD curves (**Figure D12**).

There is no evidence from the hydrographs of any trend that could be attributed to any non-climate activity.

At the most recent date of datalogger download (5 April 2018), water levels were at or near historic lows. The Maroota RCD curve has been on an overall downward trend since March 2017, due to mostly below average rainfalls during that time.

3.8.4 Wet Weather High Groundwater Levels

The wet weather high groundwater level (WWHGL) is defined in the Consent as:

> *'The rolling average of all recorded groundwater level measurements at any monitoring location on the site, as first recorded following any rainfall event of at least 50 mm over any 24-hour period, and as contour mapped using this data'.*

For the Roberts Road Maroota site, the WWHGL has been calculated using the water level data from the historical monitoring records for all available monitoring bores on the site, taken immediately after any rainfall exceeding 50mm in any day, as determined using the BoM Maroota (Old Telegraph Road) meteorological station[5].

Separate WWHGLs have been determined for the Maroota Sands and the Hawkesbury Sandstone, using data only from bores interpreted to be screened below the respective regional water tables of the two aquifers. The calculations are presented in **Table 8**.

Contours of the wet weather high groundwater level, updated in April 2018, are depicted for the Maroota Sands and the Hawkesbury Sandstone on **Figures 11** and **12** respectively.

It is interpreted that the Maroota Sands regional water table is only present within the central part of the property, as the top of the Hawkesbury Sandstone rises above this water table level across the western and eastern flanks of the paleovalley. The Hawkesbury Sandstone outcrops along the eastern bank of the Main Process Water Dam 1. The lines marking the limit of saturated Maroota Sands are shown on **Figure 11**. West and east of these lines, there may be groundwater present in perched zones within the Maroota Sands, but the recent drilling program has shown that these zones are both limited in area and of limited saturated thickness.

The contours on **Figure 11** suggest a relatively gentle gradient to the north/north-northeast, down the axis of the paleovalley.

[5] During historical monitoring, water levels have not always been available immediately after a 24-hour rainfall of 50mm or more. Where necessary, the first available water level measurement after the rainfall event has been used in the table.

Table 8: Wet Weather High Groundwater Levels (18 April 2018)

Year	Date	Rainfall	Comment	Peak water level after >50mm/day rainfall (mAHD)												
				MW1	MW2	*MW3	*MW4	MW5	MW6	MW7	MW8	MW9	MW10	MW11	MW12	MW13
Collar Elevation (mAHD)				**213.43**	**226.89**	***202.43**	***212.00**	**227.00**	**202.47**	**212.96**	**227.01**	**225.58**	**217.12**	**192.35**	**210.28**	**225.50**
Screened Interval (mAHD)				***202-208**		***181-187**	***183-192**	**183-195**	**173-178**	**177-183**	**187-190**	**175-181**	**170-173**	**164-168**	**184-187**	**195-198**
1999	24 October	59.0		208.1	203.1	183.6										
2000	9 March	54.0		207.8		182.8										
	17 November	56.0		207.3		182.5										
2001	31 January	53.0		208.0		182.9										
	6 February	50.0		208.0		182.9										
	20-21 March	55.0	2 day total	208.0		182.9										
2002	5 February	60.0		207.4		183.3										
	30 March	56.0		207.4		183.3										
	10 December	55.0		206.8		181.3										
2004	25-26 February	105.0	2 day total	206.6		181.0										
	21-22 October	61.0	2 day total	-		181.0										
2005	2-3 February	50.0	2 day total	-		180.5										
	21 February	60.0		-		180.7										
	23-27 November	55.0	5 day total	-		181.0										
2006	7 September	65.0		206.2		182.1										

Year	Date	Rainfall	Comment	Peak water level after >50mm/day rainfall (mAHD)												
				MW1	MW2	*MW3	*MW4	MW5	MW6	MW7	MW8	MW9	MW10	MW11	MW12	MW13
2007	13 February	52.2		206.2		182.1										
	9 June	172.0		206.2		182.1										
	20 July	136.5		207.7		183.1										
	6 December	50.6		207.7		183.1										
2008	5 June	51.0		207.7		183.1										
2009	2 April	51.0		206.5		183.5										
	22 May	78.0		206.5		183.5										
2010	7 February	75.0		205.6			186.6									
2011	20 August	74.5		206.0			189.3									
2012	18 April	52.0		206.0			189.3									
2013	29 January	118.0		206.8			187.9									
	23 February	72.0	154.4 mm over 2 days (23-24 February 2013)	206.8			187.9									
	24 February	82.4		206.8			187.9									
2014	19 August	52.6		205.7				192.6								
	7 December	55.0		205.9				192.8								
2015	21 April	161.0	279 mm over 2 days (21 to 22 April 2015)	206.5				192.3	183.4							
	22 April	118.0		206.5				192.3	183.4							
	22 December	63.6		207.4				192.6	185.4							
2016	5 January	108.0	221.2 mm over 4 days (4	207.4				192.6	185.4							

Year	Date	Rainfall	Comment	Peak water level after >50mm/day rainfall (mAHD)												
				MW1	MW2	*MW3	*MW4	MW5	MW6	MW7	MW8	MW9	MW10	MW11	MW12	MW13
	6 January	68.0	to 7 January 2016)	207.4				192.6	185.4							
	5 June	69.0	147.4 mm over 3 days (4	207.1				193.1	185.7							
	6 June	68.0	to 6 June 2016)	207.0				193.0	185.8							
2017	18 March	54.8	149.4 mm over 6 days (14 to 19 March 2017)	206.9				192.6	185.0	184.6	192.8	188.8	185.3	183.9	194.7	199.2
	31 March	55.0		206.9				192.6	185.0	184.6	192.8	188.8	185.3	183.9	194.7	199.2
	8 June	36.0*	*111.4 mm over 5 days (7 to 11 June 2017)	207.0				192.6	185.3	184.4	192.8	188.5	185.7	184.3	194.9	199.4
2018	26 February	66.0		205.7					183.4	183.7	192.5	187.2	184.3	180.4	194.4	198.9
Average peak water level after >50mm/day rainfall event				**206.9**	**203.1**	**182.4**	**188.2**	**192.6**	**184.8**	**184.3**	**192.7**	**188.3**	**185.2**	**183.1**	**194.7**	**199.2**

The regional water table (or potentiometric surface) of the Hawkesbury Sandstone has been encountered only in three of the deeper bores on site. The water levels in these bores have been used to construct tentative potentiometric surface contours across part of the site (**Figure 12**). These contours suggest a gradient to the northwest. On the eastern and western parts of the quarry site, the regional Hawkesbury Sandstone potentiometric surface lies below the top of the sandstone, whereas within the central zone occupied by the paleovalley, the potentiometric surface in some places is above the top of the Hawkesbury Sandstone. The potentiometric surface is well below the base of the quarry.

3.9 Groundwater Quality

Historically, there has been limited sampling for comprehensive laboratory analysis of major ionic composition. Monitoring bores MW1 and MW3 were analysed once in 1998, and MW1, MW4 and MW5 on up to four occasions in 2010, 2012 and 2013. Groundwater quality was not monitored between June 2013 and December 2016.

Each of the new monitoring bores MW7 to MW13 were sampled in December-January, and samples submitted to ALS for comprehensive water quality analysis. They were all re-sampled in July 2017, and analysed by VGT Laboratory.

Samples from each of the new monitoring bores MW7 to MW13 were collected in December 2016 – January 2017, and submitted to ALS for comprehensive water quality analysis. All monitoring bores, PB1 and the dams were sampled in July 2017, January 2018 and April 2018 as part of ongoing monitoring.

3.9.1 Laboratory Analysis Results

The results of laboratory analysis for major ion composition are presented in **Table E1** in **Appendix E**. EC and pH trends for all bores and the site dams are shown graphically on **Figures 13** and **14**.

The groundwater in the Maroota Sands is generally low salinity, with lab measurements of EC ranging from 103 µS/cm (at MW6 in July 2017) to 381 µS/cm (at MW3 in October 1998). It is moderately acidic, with laboratory pH values ranging from a low of 3.23 (at MW4 in June 2012) to a high of 6.65 (at MW13 in December 2016).

Groundwater quality in the Hawkesbury Sandstone aquifer system is also low salinity (with EC ranging from 96 to 255 µS/cm), and is less acidic than the Maroota Sands groundwater, with pH moderately low to neutral, ranging from 4.52 to 7.00.

Water quality in the Process Dam and Tailings Dam is similar to the groundwater quality, with measured EC values ranging from 134 to 254 µS/cm and pH ranging from 4.29 to 4.50.

Water quality in the Nursery Dam and Farm Dam is also low salinity, with EC ranging from 116 to 233 µS/cm, and pH is near neutral in the range 6.6 to 8.8.

3.9.2 Monthly Water Quality Monitoring Data

From 1995 until 2013, field measurements of pH, EC and TDS were routinely conducted on samples collected at intervals ranging from monthly to 6-monthly. The results are presented graphically for pH and EC in **Figures 13** and **14**. **Figure 13** shows the full dataset, while **Figure 14** shows the water quality data for the period 2016-2018. Both plots include all available field and lab data.

The pH values range from 3.2 to 10.3, although during 2016-2018, the groundwater samples mostly had pH values in the range 4-7, apart from MW6, which has pH in the

range 7-11. The Process Dam 1 and Tailings Dam 2 had pH in a similar range to the groundwater. However, the surface water samples (Nursery Dam 3 and Farm Dam 4) had pH in the range 6.6-8.8.

EC values range from 46 µS/cm (MW3) to 543 µS/cm (MW2). During 2016-2018, most values were between about 100 and 250 µS/cm. The exceptions are MW1, which has a consistently higher EC that the other groundwater and surface water samples in the range 350-400 µS/cm.

The April 2018 sample from MW6 appears to be anomalous, with pH and EC both higher than past values (10.3 and 406 µS/cm respectively). The quality at the up-gradient bore MW10 remained consistent with previous months (pH 4.4 and EC 190 µS/cm). Likewise the water sampled from the Process Dam 1 on that date reported a pH of 4.4 and EC of 190 µS/cm), hence the change in quality at MW6 was not due to leakage from Dam 1.

3.9.3 Groundwater Quality Characterisation

Major ion chemistry has been analysed using a Piper Trilinear Diagram, which uses the concentrations of the major cations (Ca, Mg, Na and K) and major anions (HCO_3, Cl and SO_4) expressed as milliequivalents per litre (meq/L). The relative concentrations of the cations are plotted on a triangular cation field, and the relative concentrations of the anions on an anion field, and these plotted locations are then projected onto a diamond shaped field that allows the relative ionic concentrations of each sample to be plotted as a unique point.

By comparing the plotted locations of different samples, inferences can be drawn about the sources of different waters, and potential mixing of waters from different sources, as well as proximity to rainfall recharge.

Piper diagrams of all the lab analysis results from the Roberts Rd quarry site are presented as **Figures 15** and **16.** The monitoring bores MW1 to MW13 are plotted in **Figure 15**, while **Figure 16** shows the two production bores PB1 and PB2, and waters sampled from the site dams.

Figures 15 and **16** show only small differences between the Maroota Sands and the Hawkesbury Sandstone groundwaters. All groundwater samples collected from beneath the regional water tables of both aquifers are clustered generally close to the right-hand side of the main field on the Piper diagram, which is characterised by low bicarbonate relative to the other anions, and varying proportions of sodium plus potassium versus calcium plus magnesium among the major cations.

However, there are greater differences between the water chemistry of the regional groundwater and groundwater in perched aquifers.

The perched groundwater in Maroota Sands on this site has more calcium plus magnesium and less sodium plus potassium than the regional Maroota Sands groundwater, but with similar low levels of bicarbonate (**Figure 15**. The perched Hawkesbury Sandstone groundwater differs from the regional Hawkesbury Sandstone groundwater by a higher relative concentration of bicarbonate (15-50% of total anions) than the regional Hawkesbury Sandstone groundwater (less than 5% of total anions).

In summary, the water quality of the Maroota Sands groundwater is characterised by the following:

- Low salinity;
- Acidic pH, in the range 3.5 to 6.5;

- Anionic composition dominated by chloride (generally over 80% of total anions), with very low bicarbonate (less than 10%), and occasional moderately higher concentrations of sulphate (MW4, MW8 and MW12); and
- Cationic composition dominated by sodium + potassium (between 40% and 80%), with low calcium (less than 20%), and magnesium between 10% and 45%.

The Hawkesbury Sandstone groundwater quality from beneath the project site is characterised by the following:

- Low salinity;
- Near neutral pH, in the range 6.1 to 7.0;
- Anionic composition is more variable, with sulphate 5 to 25%, chloride 35 to 70% and bicarbonate less than 5% in regional aquifer and 15 to 50% in perched groundwater; and
- The cations are dominantly sodium + potassium (65 to 90%), with very low magnesium (less than 10%), and low calcium (10 to 30%).

The low EC indicates that both aquifer systems are readily recharged by infiltration of rainfall.

4 Groundwater Monitoring Network

4.1 Monitoring Bores

The monitoring bore network comprises ten (10) currently active monitoring bores (MW1 and MW5 to MW13). Seven are screened to monitor the Maroota Sands aquifer system, and three the Hawkesbury Sandstone. These are supplemented by two DoI-Water bores completed in the Hawkesbury Sandstone (GW75003 and GW75004).

Three previous monitoring bores are no longer available, MW3 and MW4 having been lost to quarry expansion and MW2 having become blocked by an obstruction above the water level in the bore.

MW5 has also been found to be obstructed, some 9m above its original constructed depth but still below the water level in the bore. Hence, it can still be monitored, however as the nature and cause of the obstruction are unknown, and there is less than 1m of water depth above the obstruction, MW5 has been removed from the monitoring network. Comparison of water levels between MW5 and MW8 (**Figure D5**), both of which are screened in the basal part of the Maroota Sands, shows that these two bores have similar absolute water levels and almost identical trends. Hence, MW8 is considered a suitable replacement for MW5.

Seven new bores were installed in December 2016, to provide a broader coverage of the site, and to provide better monitoring of each of the main hydrogeological units, Hawkesbury Sandstone and Maroota Sands (including perched zones).

At three sites, there is now a cluster of bores monitoring at different depths, viz:

- MW1 (Maroota Sands) and MW7 (Hawkesbury Sandstone);
- MW5 (Maroota Sands – partially penetrating), and MW8 (Maroota Sands – fully penetrating); supplemented by two of DoI-Water's bores GW075003 and GW075004 (both in Hawkesbury Sandstone); and
- MW13 (Maroota Sands) and MW9 (Hawkesbury Sandstone).

Locations of these bore clusters are shown on **Figure 2**.

Table 9 lists the main construction and completion details of all monitoring bores that have been installed over the life of the project.

Table 97 also includes details of two water supply production bores, one of which (PB1) has been used to supply process water to the quarrying operations. The other (PB2) is used for water supply at the nursery located at the north-western corner of the property, and does not form part of the quarry operations. The two production bores are significantly deeper than the base of the quarry, and draw water from the underlying Hawkesbury Sandstone rather than the Maroota Sands aquifer.

Also listed in **Table 9** are details of two DoI-Water monitoring bores, which are located within the property close to MW5 and MW8 near the south-western property boundary.

Borehole Logs for bores MW1 to MW13 and PB1 and PB2 are included in **Appendix A**. Logs for the two DoI-Water bores are presented in **Appendix B**.

Table 9: Monitoring Bores – Completion Details

Bore	Date Drilled	Registered Bore No	Location (MGA)		Ground Level	Stick-up	Bore Depth	Base of Bore	Screen Interval		Formation Screened	Salinity TDS	Water Level (5 April 2018)		Current Status
			Easting	Northing	mAHD	m	m	mAHD	mBGL	(mAHD)		mg/L	m BGL	mAHD	
MW1	22 Oct 1998	GW101674	313743	6295740	213.43	0.70	11.9	201.43	4.9-10.9	202.5-208.5	Maroota Sands (perched)	186	7.76	205.66	Active
MW5	Apr 2013	GW114208	313893	6295283	227.00	0.80	44.0 (now 35.2)	183.00 (now 191.8)	32.0-44.0	183-195	Maroota Sands (perched)		*34.31	*192.69	No longer monitored
MW6	23 Jan 2015		314200	6295366	202.47	0.72	29.0	173.47	24-29	173.5-178.5	Maroota Sands		19.29	183.18	Active
MW7	9 Dec 2016		313761	6295741	212.96	0.48	37 (sealed below 36)	176.96	30-36	177-183	Hawkesbury Sandstone		29.22	183.74	Active
MW8	6 Dec 2016		313889	6295287	227.00	0.42	49 (sealed below 40)	187.00	37-40	187-190	Maroota Sands		34.52	192.49	Active
MW9	19 Dec 2016		313916	6295356	225.58	0.53	50.5	175.08	44.5-50.5	175-181	Hawkesbury Sandstone		38.55	187.03	Active
MW10	14 Dec 2016		314122	6295187	217.12	0.48	49 (sealed below 47)	170.12	44-47	170-173	Maroota Sands		33.04	184.08	Active
MW11	21 Dec 2016		314176	6295789	192.35	0.71	29 (sealed below 28.5)	163.85	24-28.5	164-168.5	Maroota Sands		11.98	180.37	Active
MW12	8 Dec 2016		313902	6295584	210.28	0.47	27 (sealed below 26)	184.28	23-26	184-187	Hawkesbury Sandstone		16.03	194.25	Active
MW13	7 Dec 2016		313916	6295358	225.50	0.46	31 (sealed below 30.5)	195.00	27.5-30.5	195-198	Maroota Sands		26.58	198.92	Active
PB1	6 Jul 1999	GW105835	314116	6295574	*~193.5*	0.70	126.1	*~67.4*	Open hole below 28.8	*<164.7*	Hawkesbury Sandstone		*14.1	**~179.4*	Pumping for water supply

Bore	Date Drilled	Registered Bore No	Location (MGA)		Ground Level	Stick-up	Bore Depth	Base of Bore	Screen Interval		Formation Screened	Salinity TDS	Water Level (5 April 2018)		Current Status
			Easting	Northing	mAHD	m	m	mAHD	mBGL	(mAHD)		mg/L	m BGL	mAHD	
PB2	19 Feb 1999	GW102451	313735	6295514	*~212.5*	0.30	156.5	*~56.0*	Open to sandstone below 53	*<202.1*	Hawkesbury Sandstone		*42.8	*~174.0*	Pumping for water supply
	1 Jul 1997	GW075003	313868	6295299	225.48	0.88	109.0	116.48	72-75	150.5-153.5	Hawkesbury Sandstone	90 µS/cm	*46.1	*178.5	DoI-Water monitor bore
	7 Jul 1997	GW075004	313885	6295286	226.95	0.87	60.0	166.95	54-57	170-173	Hawkesbury Sandstone	150 µS/cm	*40.11	*185.94	DoI-Water monitor bore
Former monitoring bores – no longer available															
MW2	20 Oct 1998	GW101675	313896	6295281	226.89	0.80	26.5 (now 20.75)	200.39 (now 206.1)	18.6-24.6	202.3-208.3	Maroota Sands (perched)		*23.75	*203.1	Obstructed at 20.75m. Dry.
MW3	21 Oct 1998	GW101676	**9802.78	**5916.37	202.43	0.90	21.9	180.53	14.9-20.9	181.5-187.5	Maroota Sands (perched)	266	*18.95	*183.5	Mined out
MW4	Dec 2009	GW114209	314121	6295389	*~211.5*	0.85	28.5	*~183*	19.5-28.5	*~183-192*	Maroota Sands		*24.1	*187.9*	Mined out

* Most recent available water levels – MW2 (2000); MW3 (2009); MW4 (2013); MW5 (2017); PB1 (1999); PB2 (2002); GW075003 (2015); GW075004 (2017).

** ISG coordinates.

Italics *Survey information approximate.*

4.2 Historical Monitoring Program

The monitoring program undertaken to date has included:

- Water levels measured in monitoring bores both manually and using dataloggers (1998 to present);
- Water sampling from bores to enable basic water quality parameters to be measured on a regular basis (from 1998 until 2013);
- Intermittent measurements of water levels and water quality from water in the main ponds.

The locations of all monitoring bores and other bores on the site are shown on **Figure 2.**

4.3 Availability of Monitoring Bores

The groundwater monitoring data cover the period 1998 to 2018. Availability of bores through this period of time is detailed in **Table 10**.

Table 10: Historical Availability of Monitoring Bores – 1998 to 2018

Year	MW1	MW2	MW3	MW4	MW5	MW6	MW7	MW8	MW9	MW10	MW11	MW12	MW13	PB1	PB2
1998															
1999															
2000															
2001															
2002															
2003															
2004															
2005															
2006															
2007															
2008															
2009															
2010															
2011															
2012															
2013															
2014															
2015															
2016															
2017															
2018															

Between 2013 and late 2016, only bores MW1, MW5 and MW6 remained operational. MW2 is blocked by an obstruction above the water level, and bores MW3 and MW4 have been mined out by the quarry expansion.

4.4 Baseline Monitoring Data

4.4.1 Groundwater Levels

Groundwater level data are available for the period 1998 to the present. The available groundwater levels are presented in **Appendix C** as hydrographs. Both manual and datalogger measurements are plotted. Data from old bores have been reproduced from past reports prepared by URS[6].

Dataloggers are currently installed in MW1 and MW5. It is proposed to install dataloggers in MW6 and each of the newly installed monitoring bores, as well as each of the five site dams, including those not used by the quarry operations. The dataloggers will be set to record water level at 6 hourly intervals, so that both longer term fluctuations and diurnal fluctuations (if any) can be detected.

A composite hydrograph plot showing all manual water level measurements converted to mAHD is plotted on **Figure 10**. The composite plot includes both the regional aquifer water levels (ie Maroota Sands water table and Hawkesbury Sandstone potentiometric surface), as well as perched groundwater levels from both aquifers. This plot shows that groundwater levels ranged between 165 mAHD and 208 mAHD, although the highest water level confirmed by reliable survey for the Maroota Sands regional groundwater table is 186.01 mAHD.

The baseline data for the regional groundwater levels for the two aquifers are summarised in **Table 11** below.

Table 11: Regional Groundwater Levels from Site Monitoring Bores

Bore	Screened interval (m AHD)	Period of monitoring	Water level range (mAHD)		
			Lowest	Highest	Median
Maroota Sands					
MW6	173.5-178.5	Mar 2015 – present	182.97	186.03	185.17
MW10	170-173	Dec 2016 – present	184.08	185.81	185.51
MW11	164-168.5	Dec 2016 – present	180.37	184.38	183.23
MW3	181.5-187.5	Oct 1998 – Jul 2009	180.66	183.59	182.48
MW4*	~183-192	Dec 2009 – Jun 2013	~186.6	~189.3	~187.2
Hawkesbury Sandstone					
PB1*	<164.7	Aug 1999	~179.4	~179.4	~179.4
PB2*	<202	Aug 1999 – Jul 2002	~165.3	~174.0	~171.3
GW75003	150.5-153.5	Oct 2007 – Aug 2015	176.00	182.96	179.21
GW75004**	170-173	Oct 2007 – Dec 2016	181.42	185.94	184.53

* RLs approximate, estimated from surface topographic contours, not surveyed.

** Possibly perched, above regional water table.

[6] URS was formerly known as Woodward-Clyde, and is now part of the Aecom Group.

The registered bores on neighbouring properties within 500 m of the quarry are listed in **Table 3** (Section 3.2). There are very limited baseline data available from these bores, which are not readily accessible to other parties. The best available baseline data are from monitoring bores on adjacent sand quarrying operations, as well as the DoI-Water monitoring bores, two of which are located on the quarry property (**Table 12**). Data sourced from public records indicates the following water level ranges, for registered bores owned by others within 500m of the quarry.

Table 12: Baseline Groundwater Levels from Monitoring Bores Owned by Others Within 500m of the Quarry Property

Bore	Screened interval		Water level range
	(m BGL)	(m AHD)	(m AHD)
Maroota Sandstone			
None			
Hawkesbury Sandstone			
GW016348	5.3-73.1	142-210*	185*
GW072037	12-99		
GW072274	5.5-168.5		
GW075001 (DoI-Water monitoring bore)	71-74	118.5-121.5	148.1-166.9
GW075002-1 (DoI-Water monitoring bore)	6-9	178.6-181.6	180.6*
GW075002-2 (DoI-Water monitoring bore)	14-17	170.8-173.8	178.6*
GW075003 (DoI-Water monitoring bore)	72-75	150.5-153.5	176.8-183.8
GW075004 (DoI-Water monitoring bore)	54-57	170-173	182.2-186.7
GW100230			
GW100587			
GW102005			
GW102583			
GW107345			
GW108806 (Arkzeal monitoring bore)			
GW110198			
GW110585			
GW110746 (PF monitoring bore Hitch MW1)	31-43	183-195	189-191
GW111943			
GW112398			

* Elevation estimated from surface contours.

Blanks = no data

4.4.2 Groundwater Quality

There are only limited water quality data available from bores owned by others in the project vicinity. As with water levels above, the data available from the public record are limited to monitoring bores on neighbouring sand projects and DoI-Water monitoring bores.

The available baseline groundwater quality data are summarised in **Table 13**.

Table 13: Baseline Groundwater Quality Data from Monitoring Bores Owned by Others Within 500m of the Quarry Property

Bore	EC	TDS	pH
	µS/cm	mg/L	pH units
Maroota Sandstone			
None			
Hawkesbury Sandstone			
GW075001 (DoI-Water monitoring bore)	82-152		
GW075002-1 (DoI-Water monitoring bore)	207*		
GW075002-2 (DoI-Water monitoring bore)	54*		
GW075003 (DoI-Water monitoring bore)	89-168		
GW075004 (DoI-Water monitoring bore)	96-233		
GW110746 (PF monitoring bore Hitch MW1)	160-255**	85-130**	4.0-5.7**

* URS (2006)

** PF Formation AEMR 2015-2016 (South East Environmental, 2016)

The groundwater salinity, whether expressed as EC or TDS, shows significant variation over time, as illustrated by the plots of temporal variations in EC on **Figure 13**17.

The EC data from all three DoI-Water monitoring bores display two periods of markedly higher EC values, viz June-October 2012 and February-August 2015. The PF Formation monitoring bore PFHitchMW1 shows a gradually rising EC since 2011, but a much steeper rise from August 2014.

These rises do not appear to be closely related to the rainfall pattern, as depicted on **Figure 17** by the Maroota monthly rainfall cumulative deviation from long-term average rainfall. Nor are the rises in the DoI-Water monitoring bores coincident with the rise in EC observed at PFHithchMW1, although with only annual data from the PF bore, any correlation with the DoI-Water bores is difficult to gauge.

4.4.3 Meteorological Data

Daily rainfalls are recorded on site, as well as at a number of Bureau of Meteorology (BoM) weather stations in the general area. However, the site data are available in a spreadsheet format only since January 2013, with prior data only accessible in graphical form from earlier monitoring reports by URS. Monthly total rainfalls for the quarry site, and the 067014 Maroota (Old Telegraph Rd) station for the period January 2014 to the present are listed in **Table 14**.

Table 14: Monthly Rainfall – Hodgson Quarry and Maroota BoM Station 067014

Month	Hodgson Quarry				BoM Station 067014 – Maroota (Old Telegraph Rd)			
	2014	2015	2016	2017	2014	2015	2016	2017
January	103.2	102.6	260.4	46.2	32.6	120.2	371.2	44.4
February	115.4	52.8	13.2	80.8	84.2	56.8	15.6	95.0
March	2.6	70.0	31.4	67.6	154.8	75.4	31.6	278.8
April	0*	77.6	8.2	34.0	66.8	409.0	5.6	37.4
May	0*	53.6	1.4	15.4	8.4	77.6	14.6	15.6
June	0	41.0	142.6	87.6	26.4	47.8	192.8	118.2
July	15.0	26.0*	50.0		15.2	30.0	59.3	0.4
August	122.2	29.6	58.4		154.2	38.2	70.2	19.8
September	38.8	33.6	49.6		41.3	41.0	59.2	1.0
October	43.2	31.6	0		47.6	34.2	39.2	61.8
November	28.4*	115.8	61.8		23.6	141.9	71.6	33.8
December	196.2	111.0	57.0		230.2	149.6	63.8	64.6
Year	665.0*	745.2	734.0		885.3	1221.7	994.7	770.8

* Gap in record

Generally, the site rainfall totals are slightly less than the Maroota BoM station totals. Some large discrepancies are noted between the quarry site data and the Maroota BoM station data in a few months, in particular March 2014, April 2015 and March 2017, in all of which the Maroota BoM total rainfall is very much larger than the quarry site total.

The Maroota BoM station is clearly the closest BoM station being less than 1km from the quarry, however during the period of operation of the quarry, the Maroota station has no rainfall data from September 1997 to August 1999, and there are also missing days from other parts of the record which affect the totals for several months, viz:

- 1999 (November)
- 2000 (February, April, May, June, July, October and December)
- 2001 (February to December)
- 2002 (March, June, July and September)
- 2003 (February, May and June)
- 2004 (June, July and August)
- 2005 (July and December)
- 2006 (January, March, May and June)
- 2007 (July and August)
- 2008 (February and November).

However, there are no gaps in the Maroota BoM station data for the period when monthly totals for the quarry are readily available.

There are gaps in the records at most other nearby stations as well, however there is a reasonably complete rainfall record at two other nearby stations, viz:

- 061119 Wiseman's Ferry (Old PO) – 12 km from quarry
- 067086 Dural (Old Northern Rd) – 23 km from quarry.

The nearest BoM station for which pan evaporation data are available is Richmond, approximately 30km from Maroota.

Monthly average rainfalls for the Maroota, Wiseman's Ferry and Dural stations, and monthly average pan evaporation for Richmond, are listed in **Table 15**.

Table 15: Average Monthly Rainfall and Evaporation

Month	Rainfall			Pan Evaporation
	Maroota Old Telegraph Rd (067014)	Wiseman's Ferry Old PO (061119)	Dural Old Northern Rd (067086)	Richmond AMO/MO (067033)
January	99.4	95.5	107.4	195
February	110.9	103.3	135.3	151
March	104.3	101	120.3	136
April	87.7	70.5	98.2	99
May	58.8	66.0	74.5	65
June	93.0	68.8	107.1	54
July	46.2	50.3	50.1	62
August	52.9	49.6	62.1	96
September	53.9	47.9	53.2	162
October	64.9	58.7	70.5	183
November	81.0	75.3	93.8	210
December	80.6	77.1	75.9	133
Year	933.6	864.0	1,048.4	1,546

5 Ongoing Monitoring Requirements

The Mod 2 Consent included the requirement to prepare a Groundwater Monitoring Program (GMP) in consultation with DoI-Water, to be submitted for approval by the Secretary. A draft GMP was submitted in August 2016, and approved by DP&E by letter of 28th November 2016.

Following receipt of Agency comments, a revised GMP was submitted in September 2017. Minor alterations to this plan have been made in response to Agency comments in March-April 2018, and a further revised GMP has been issued (Dundon, 2018a).

Under the Consent Approval, sand extraction within the approved quarry will include predominantly Maroota Sands, but also friable sandstone from the Hawkesbury Sandstone. Accordingly, the Consent Conditions are interpreted to require the monitoring network to include both the Maroota Sands and the underlying Hawkesbury Sandstone.

The Consent requires that extraction not take place below a level 2 metres above the wet weather high groundwater level[7] of the regional aquifer, as measured and mapped on the site. The Consent further requires that the wet weather high groundwater level be updated periodically and reported 6-monthly to DP&E (formerly DoPI) and DoI-Water (formerly DPI-Water).

Contours of the wet weather high groundwater level, updated in April 2018, are depicted for the Maroota Sands and the Hawkesbury Sandstone on **Figures 11** and **12** respectively, and are discussed in **Section 3.8.4** above.

The GMP includes ongoing monitoring of water levels and water quality in each of the current monitoring bores on site. It also requires the monitoring of water levels in each of the five surface water storages on the site. All bores and surface water monitoring points have been installed with automatic water level recorders (dataloggers) set to record water levels at 6 hourly intervals. The Consent also requires the monitoring results to be reported quarterly, and a report comparing monitoring results be conducted annually.

5.1 Monitoring Program

The monitoring program is described in detail in the document Groundwater Monitoring Program (Dundon Consulting, 2018a), and is summarised in **Table 16.**

[7] The Development Consent defines the *'Wet weather high groundwater level'* as *'The rolling average of all recorded groundwater level measurements at any monitoring location on the site, as first recorded following any rainfall event of at least 50 mm over any 24-hour period, and as contour mapped using this data'.*

Table 16: Monitoring Regime

Monitoring Bores and Ponds	Purpose	Continuous	Weekly	Three-Monthly	Annually
MW1, MW6, MW7, MW8, MW9, MW10, MW11, MW12 and MW13. Process area pond (Dam 1), tailings dam (Dam 2), nursery dam (Dam 3) and farm dam (Dam 4).	Ensure base level of quarry does not exceed 2m above regional wet weather high groundwater levels	Automatic piezometers with datalogger		Manual water level to confirm and calibrate datalogger	
	Ensure water quality of MTSGS and SBCGS are not adversely impacted			Field measure-ments of EC, TDS, pH	Lab analysis of oil and grease
	Ensure no seepage inflows (other than perched groundwater)	Daily observation to detect any seepage	If observed, sample for water quality. If measurable, monitor volume of seepage inflows		
Bores MW9, MW12 and MW13, and future Stage bores as detailed in Consent.	Establish baseline levels of regional water in future quarry stages	Automatic piezometer with datalogger		Manual water level to confirm and calibrate datalogger	

Approaches will be made to neighbouring landholders to seek approval to include periodic monitoring of groundwater levels and quality in bores on nearby properties.

Impact Assessment Criteria are detailed in **Table 17**.

Table 17: Impact Assessment Criteria

Potential Impact	Impact Observed	Criteria for Response Action	Response Action – Investigation by Authorised Hydrogeologist
Groundwater inflows to quarry	Observed seepage from the quarry walls or floor	Any observed seepage.	Investigate source to determine whether perched or regional groundwater, or seepage from site dams.
Groundwater levels	Cumulative change in regional groundwater levels greater than the natural pre-quarrying climatic variation	Cumulative change in groundwater levels more than 10% greater than natural climatic variation through the period of monitoring.	Investigate to confirm the quarry as the cause of impact. Develop a mitigation strategy and consult with DoI-Water for approval.
Groundwater quality	Change in water quality	Observed water quality that changes the beneficial use value of a water sample, exhibited by a salinity more than 20% above the long-term maximum salinity value, or pH more than 10% above or below the historical range, in two consecutive monitoring events.	Investigate to confirm the quarry as the cause of impact. Develop a mitigation strategy and consult with DoI-Water for approval.
Other groundwater users	Reported decrease in yield or groundwater level, or water quality	Reported loss of more than 10% of pre-quarrying yield; observed water quality parameter	Investigate to confirm the quarry as the cause of impact. Develop a mitigation strategy and consult with DoI-Water for approval.

Hodgson Quarry and Plant Pty Ltd will monitor the environmental performance of the quarry operations against the requirements of the consent in terms of groundwater level and quality impacts.

Both groundwater levels and groundwater quality are subject to natural variability, and therefore assessment of performance will be assisted by the use of trigger levels which are designed to distinguish impacts from natural variations, as described below.

5.2 Groundwater Quality Monitoring – Trigger Values

Groundwater drawn from both the MTSGS and the SBCGS is used in the Maroota area for irrigation, stock and domestic and some industrial purposes. The quarry operations therefore need to ensure that the groundwater remains available and suitable for continued use in these use categories.

The ANZECC guidelines for Fresh and Marine Water Quality (ANZECC, 2000) apply to the quality of both surface waters and groundwaters since they have been developed to

protect environmental values relating to above-ground uses such as irrigation and stock and domestic use. The quality of groundwater should also be maintained so that in the event it reaches the surface it will not detrimentally impact the environmental values or water quality objectives of the surrounding ecosystem.

The potential for the quarrying operations to impact on the groundwater would be related to either direct interception of the regional aquifers of the MTSGS and the SBCGS, interception of perched aquifers, or seepage from the operational areas of the site (washing plant, stockpile areas, active sand extraction areas, haul roads and access roads, workshop areas, and other site infrastructure areas) to the underlying groundwater.

The consent conditions are designed to ensure that the regional aquifers are not intercepted, and to prevent any adverse off-site impacts from interception of perched groundwater.

Impacts on groundwater quality arising from any contaminants included in water seepage from the Process Dam 1 or Tailings Dam 2 are expected to be minimised by the low permeability fines at the base of both dams, and the former tailings area north of Dam 2. As the water used in processing is derived either form rainfall runoff, or from Hawkesbury Sandstone via production bore PB1 (see **Figure 2**), both of which have a quality similar to or better than the regional Maroota Sands groundwater, any leakage that might occur is expected to be benign and non-contaminating.

The fines infilling the dams are expected to be benign as well, as the sand processing on site involves only washing, and the only potential contaminants would be from possible oil/fuel leaks from vehicles, electric motors and pumping equipment. The proposed monitoring program includes annual testing for oil and grease. To date no oil and grease has been detected in any samples; if detected in future testing, follow-up more specific testing may be undertaken if necessary.

ANZECC (2000) recommends that wherever possible site-specific data is used to define trigger values for physical and chemical factors which can adversely impact the environment.

Baseline groundwater monitoring results indicate that baseline values for pH and possibly electrical conductivity in the vicinity of the Maroota quarry can be outside of the ANZECC (2000) default trigger values shown in **Table 18**. Therefore site specific trigger levels have been developed.

Table 18: Default Trigger Values for Key Water Quality Parameters

Water Quality Parameter	Default Trigger Value(s)
pH	**6.0 – 8.5**
Electrical Conductivity (µS/cm)	**125 - 2200**

Source: ANZECC (2000)

The Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources does not specifically designate beneficial use categories for groundwater within the Maroota Tertiary Sands Groundwater Source or the Sydney Basin Central Groundwater Source. The WSP does state that no high environmental value areas have been identified in the Maroota Tertiary Sands Groundwater Source.

Notwithstanding, Hodgson Quarry and Plant Pty Ltd will endeavour to maintain the existing ambient water quality in terms of physical parameters (EC and pH) to preserve the current

beneficial use value afforded to both groundwater sources by the current users, and the natural environment.

Site specific trigger values for EC and pH based on long-term monitoring data from each of the site monitoring bores are detailed in **Table 19**. The EC trigger for a bore is a value 20% above the maximum historical value, and the pH trigger is 10% above or below the historical maximum and minimum for that bore, as specified in **Table 16** above. The trigger values nave been updated to 5 April 2018, the date of the most recent water quality monitoring on site.

Table 19: EC and pH Investigation Trigger Values

Bore	No of monitoring events	Max EC value from monitoring data (µS/cm)	EC trigger value (µS/cm)	pH range from monitoring data	pH trigger values
MW1	23	430	>516	3.51-5.18	<3.2 or >5.7
MW6	3	103-110*	>132	7.09-10.3	<6.3 or >11.4
MW7	4	266	>319	5.3-7.00	<4.8 or >7.7
MW8	3	183	>220	4.66-5.68	<4.2 or >6.2
MW9	4	175	>210	4.6-6.71	<4.1or >7.4
MW10	4	190	>228	4.4-5.45	<4.0 or >6.0
MW11	4	169	>203	4.7-6.34	<4.2 or >7.0
MW12	4	156	>187	5.2-6.12	<4.7 or >6.7
MW13	3	204	>245	4.52-6.56	<4.1 or >7.2

* Anomalous EC value from 5 April 2018 has been excluded.

All current monitoring bores have now been monitored on at least 3 occasions, spanning the period January 2017 to April 2018. The investigation trigger values listed in **Table 19** have been updated based on the available data to April 2018. The above trigger values will now remain in place, unless future monitoring indicates that the trigger values are not appropriate.

Additional monitoring will be undertaken to detect any possible contamination of the groundwater resources by activities associated with the quarry operations. These would most likely involve hydrocarbons derived from accidental spillages (of fuel or other chemicals that may be stored or used on site), or from routine maintenance of plant and equipment.

Annual laboratory testing for oil and grease will be undertaken on water samples from all monitoring bores on site.

Suspended solids resulting from the quarry operations are likely to have minimal impact on the groundwater, and monitoring of suspended solids is not proposed.

5.3 Water Testing

The monitoring regime outlined in the Groundwater Monitoring Program (Dundon, 2017) and summarised above in **Table 16** would include 6-monthly sampling for analysis of physical parameters:

- pH
- Electrical conductivity (EC)

- Total dissolved solids (TDS).

Should the EC in any sample be observed to exceed a value more than 20% higher than the previous highest maximum value recorded (see triggers described in **Table 19**), further testing will be conducted of the major ions as listed below to determine whether there has been any fundamental change in the chemical character of the groundwater, as a basis for determining if any further action is required.

- Calcium
- Magnesium
- Sodium
- Potassium
- Chloride
- Nitrate
- Sulphate
- Bicarbonate alkalinity.

Annual sampling of each monitoring bore will be undertaken to allow laboratory analysis of oil and grease. The purpose of this sampling is to detect any potential groundwater contamination from the quarrying operations. As these parameters have not previously been analysed, trigger levels will be determined on the basis of ongoing sampling.

5.4 Groundwater Level Trigger Values

Groundwater levels are monitored routinely at 9 bores within the quarry property and one bore on the adjoining property downstream to the northeast. The two DoI-Water monitoring bores located within the quarry property are also monitored by DoI-Water.

As the groundwater levels are in a dynamic relationship with the natural recharge and discharge processes, there is no absolute water level value that would be suitable as an trigger. Rather, the evidence for a quarry-related impact would be a change from the natural dynamic trends on the water levels at each bore.

Accordingly, it is proposed that the groundwater investigation protocol would be initiated if the monitored groundwater level in any bore exceeded either the highest or lowest values of the baseline water level range for that bore, as detailed below in **Table 20**. As 7 of the 10 monitoring bores have only a relatively short period of monitoring, the trigger values in **Table 20** will be periodically updated as more data is collected.

Table 20: Groundwater Level Baseline Ranges (mAHD)

Monitoring bore	Water levels baseline range of monitored values	
	mBGL	mAHD
MW1	5.05 – 8.50	205.63 – 209.08
MW6	17.16 – 20.22	182.97 – 186.03
MW7	16.82 – 29.71	183.73 – 196.62
MW8	34.27 – 34.95	192.48 – 193.16
MW9	36.00 – 39.08	187.03 – 190.11
MW10	31.79 – 33.52	184.08 – 185.81
MW11	8.68 – 12.69	180.37 – 184.38
MW12	15.81 – 16.50	194.25 – 194.94
MW13	26.13 – 27.06	198.20 – 199.83

6 Performance Criteria

Groundwater performance criteria, including triggers and response actions, are summarised in **Table 19**.

Table 21: Trigger Action Response Plan

Objective	Performance Criteria	Potential Adverse Outcome	Trigger Level	Response Action	Evidence of Response Effectiveness
Prevent interference with regional groundwater (MTSGS and SBCGS)	Maintain extraction at least 2m above wet weather high groundwater level	Depletion of MTSGS groundwater	Visible seepage in quarry face/floor	Initiate investigation within 14 days to determine if perched or regional groundwater. If regional groundwater, revise extraction plans accordingly.	Ongoing observation/ monitoring. Lack of persistence of seepage. Quarterly reporting of monitoring data. Six-monthly updates of wet weather high GW level contours.
	Silt depth in Main Process Dam 1 not >2m below wet weather high groundwater level	Depletion of MTSGS groundwater	Probe of silt depths reveals excess past depth of excavation[8]	Backfill any remaining void space above 2m above wet weather high GW level.[9]	Confirmatory probing survey of water/silt depths post-backfilling.
	Six-monthly update of wet weather high GW level contour	Depletion of MTSGS groundwater	Extraction depth found to be below 2m above revised wet weather high GW	Immediately cease extraction below the permitted depth.	Six-monthly reporting. Report to include

[8] Subject to personal safety concerns.
[9] Not practically achievable, as the Process Dam is the project's only reliable water storage.

Objective	Performance Criteria	Potential Adverse Outcome	Trigger Level	Response Action	Evidence of Response Effectiveness
	plans. Compare with current extraction depths in quarry.		level	Revise extraction plans. Backfill any excess excavation if necessary. Drill additional monitoring bores in future extraction areas to provide advance confirmation of groundwater levels. Investigate necessity to replace any monitoring bore lost to future extraction, and replace if deemed necessary.	updated wet weather high GW level contours. Report on any new monitoring bores.
Maintain groundwater quality beneficial use values	Ensure no excessive change to either EC or pH	Deterioration of quality may have adverse impact on other user or environment.	Exceedance of EC or pH trigger value in 2 successive 3-monthly sampling events.	Within 30 days, initiate investigation to determine cause of quality change. If changes not due to natural factors, develop response strategy in consultation with DoI-Water.	Reporting to DoI-Water and DP&E. Lab analysis reports.

Objective	Performance Criteria	Potential Adverse Outcome	Trigger Level	Response Action	Evidence of Response Effectiveness
Prevent pollution of groundwater by quarry operations	No detection of oil and grease above trigger values.	Contamination of groundwater could have adverse impact on other users or environment.	Exceedance of trigger values in two consecutive sampling events. Trigger levels to be determined on basis of sampling in first year after completion of this GWMP.	Response as per SWMP (Table 36, page 49). Review site practices, including vehicle wash-down, fuel/chemical storage, equipment maintenance, etc.	Reporting to DoI-Water and DP&E. Lab analysis reports.
No impact on neighbours' groundwater supply	No complaint lodged claiming loss of yield or quality	Interruption to other users' water supply	Complaint from neighbour. Excess drawdown in downstream monitoring bore MW11, more than 2m below lowest recorded level. Excess rise in EC, or rise/fall in pH, more than 10% outside historical monitored range at bore MW11.	Within 30 days, commission investigation to confirm the quarry as the cause of loss of yield or adverse change in quality. Make good provision - if quarry causes a loss of yield or adverse change in quality in a neighbour's water supply, provide a replacement water supply, either direct supply by quarry or provision of a new bore, or other agreed alternative.	Post-response monitoring to demonstrate return to ambient water quality. Reporting to DoI-Water and DP&E.

7 Monitoring and Maintenance

7.1 Groundwater Monitoring

Groundwater monitoring will be undertaken as outlined in detail in the GMP document, and as summarised below. Results will be reviewed every six months.

- Automatic data loggers to monitor the bore water levels in all site monitoring bores, and 3-monthly manual checks to ensure accurate datalogger calibrations. Monitoring bore locations shown on **Figure 2**.
- Automatic data loggers to monitor the dam water levels for comparison to bore water levels, to assess the degree of hydraulic interconnection between the dams and the groundwater.
- All bores to be sampled and water quality tested quarterly for parameters listed in **Section 5.3**.

7.2 Reporting

In accordance with consent condition 44, the results of the groundwater monitoring program will be reported to DP&E and DoI-Water, using contour plans depicting the surface topography, updated contour maps of the wet weather high groundwater levels of the regional aquifers (both MTSGS and SBCGS), and proposed depth of extraction for each extraction Phase.

Reporting will occur six-monthly for the duration of extraction, and throughout rehabilitation of the site. Unless otherwise agreed with the Secretary.

7.3 Responsibility

- Plant Manager - for maintenance of the monitoring program as required, and implementing responses to groundwater quality or level triggers should they arise.
- All staff - for noting any occurrence of face or floor seepages and notifying the Plant Manager.

8 FUTURE SAND EXTRACTION AND POST-CLOSURE REHABILITATION

The staged extraction plan as presented in the EA is shown on **Figure 18**. As at April 2018, extraction is occurring mostly in the Phase 1A, 1B and 2A areas. Future sand extraction will progress through Phases 2B; 3A and 3B; 4A, 4B and 4C; 5A and 5B; and finally 6A and 6B.

The final depth of extraction will be as dictated by the maximum depth of extraction allowed by the Consent, which is not less than 2m above the Wet Weather High Groundwater Levels (WWHGWLs) for the Maroota Sands and the Hawkesbury Sandstone. The quarry floor will comprise Maroota Sands in the central/north-eastern part, and Hawkesbury Sandstone in the south-western part, and in the north-eastern corner. For consistency, the same extraction depth has been applied to both the Hawkesbury Sandstone and the Maroota Sands, although a deeper extraction of the Hawkesbury Sandstone would be permitted under the Consent, due to the deeper WWHGWL for the Hawkesbury Sandstone relative to the Maroota Sands.

The currently proposed contours of final depth of extraction are shown in **Figure 19**, and range between 187 and 188mAHD. The final extraction depth may ultimately be higher in parts of the quarry, if substantial areas of clayey Maroota Sands, or other material which may be uneconomic, are revealed during future excavation.

The conceptual post-extraction rehabilitation plan has been prepared in draft form by VGT (2018). In summary,

- the existing nursery infrastructure in the north-western corner of the site will be retained;
- the Process Dam will be maintained as a permanent water storage;
- the landform will slope gently away from the tree screens along Old Northern Road towards the dam in the north-eastern corner of the site; and
- the final extracted land surface will be revegetated with locally-occurring native species.

The rehabilitated landform will overall have essentially the same shape as the final extraction landform depicted in **Figure 19**.

The water quality monitoring to date suggests that the quarry operations will continue to be benign with respect to the groundwater quality, both through the remaining quarry life and also post-rehabilitation.

Post-rehabilitation, the groundwater in both the Maroota Sands and the Hawkesbury Sandstone are predicted to be unaffected by either the quarry operations or the final landform. There may be a very small downward component of leakage from the water storage occupying the remnant Process Dam that may cause a slight mounding effect on the Maroota Sands water table. However, as the fines backfilling the deepest parts of the Process Dam are apparently of such low permeability as to be effectively preventing any significant leakage from the current Process Dam, it is anticipated that any leakage from the final dam will be very low, and less than the potential losses from the existing Nursery Dam 3 and Farm Dam 4.

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APPENDIX A

BORE LOGS – SITE MONITORING BORES AND PRODUCTION BORES

Groundwater Monitoring Bore FIELD LOG

Woodward-Clyde

Borehole No: **PT84MW1**

Sheet: 1 of 1

CLIENT:	Nexus Environmental Planning Pty Ltd	JOB NUMBER:	A8602019/1
PROJECT:	Proposed Extractive Industry, PT84	DATE COMMENCED:	22/10/98
LOCATION:	cnr Old Northern Rd & Roberts Rd, Maroota	DATE COMPLETED:	22/10/98
DRILL CONTRACTOR:	Intertech	LOGGED BY:	SRR

Drill Model:	Intertech 750	Hole Angle:	90 deg.	Bore Size:	150mm	RL:	213.43 m AHD
Drilling Fluid:	Biogel	Orientation:	deg.	Co-ords: E	9422.49	N	6132.88 ISG

Drilling Info.					Material Properties					Field Records/Construction Information				
Method	Casing	Rig resistance/ Penetration rate/fast	Water	Depth (m)	Graphic Log	Classification	Material Description type, plasticity/particle size, colour, secondary/minor components	Moisture Condition	Consistency Rel. Density	Scale	Sampling	Testing PID (ppm)	Comments/Construction	Well Diagram
Air Drilling	170mm			0		CL	silty SAND/sandy SILT, topsoil, low plasticity, brown							
				1			silty CLAY, medium plasticity, orange brown - some gravel fragments (rounded to sub-angular)							
				2			- 1.7m, light grey and red-brown iron-oxidised bands						Backfill	
				3									50mm PVC Casing	
				4									bentonite seal	
				5			- 4.5m, mainly light grey, clayey gravel/gravelly clay , with quartz silica sub-rounded gravel							
Rotary Mud Drilling			WL at 5.34m on 28/10/98	6		GC CH	sandy GRAVEL, fine to medium grained quartz gravel,brown/orange brown, iron-oxidised, sub-rounded in sandy matrix						2mm gravel backfill	
				7			CLAY, medium plasticity, light grey with some gravel (3-4mm) sub-rounded							
				8										
				9									50mm PVC Class 18, Machine Slotted	
				10			SANDSTONE, extremely weathered, light grey, fine to medium grained - increasing in strength with depth - slow progress with blade bit from 10.5m							
				11										
				12			Borehole Discontinued at 12.0m (limit of investigation)						sump TD 11.8m	
				13										
				14										
				15										

Produced By: SRR

Checked By:

Document No: s:/A86/A8602019/1/logs/MW1.log

Groundwater Monitoring Bore
FIELD LOG

Woodward-Clyde

Borehole No: **PT84MW2**

Sheet: 1 of 2

CLIENT:	Nexus Environmental Planning Pty Ltd	JOB NUMBER:	A8602019/1
PROJECT:	Proposed Extractive Industry, PT84	DATE COMMENCED:	20/10/98
LOCATION:	cnr Old Northern Rd & Roberts Rd, Maroota	DATE COMPLETED:	20/10/98
DRILL CONTRACTOR:	Intertech	LOGGED BY:	SRR

Drill Model:	Intertech 750	Hole Angle:	90	deg.	Bore Size:	150mm	RL: 226.8	m AHD
Drilling Fluid:	Biogel	Orientation:		deg.	Co-ords: E	9637.10	N 5698.78	ISG

Drilling Info.				Material Properties						Field Records/Construction Information				
Method	Casing	Penetration (no resistance)	Water	Depth (m)	Graphic Log	Classification	Material Description type, plasticity/particle size, colour, secondary/minor components	Moisture Condition	Consistency Rel. Density	Scale	Sampling	Testing PID (ppm)	Comments/Construction	Well Diagram
Air Drilling	170mm			0		CL	silty SAND/sandy SILT, topsoil, low plasticity, brown							
				1			silty CLAY, low plasticity, brown							
				2		SW	SAND, medium grained, red-brown iron-oxidised							
				3										
				4										
				5			SAND, medium grained, yellow brown with some iron-oxidised bands						Backfill	
				6		CH	SAND, medium grained, light brown and light grey, with some quartz gravel fragments (2–4mm)							
				7		CH	CLAY, medium to high plasticity, light grey and red-brown							
Casing Advancer							SAND, fine grained, light grey							
				8			CLAY, medium to high plasticity, light grey with some red-brown bands							
				9										
				10										
				11										
				12										
				13										
				14									50mm PVC Casing	
				15										

Produced By: SRR
Checked By:

Document No: s:/A86/A8602019/1/logs/MW2.log

Groundwater Monitoring Bore FIELD LOG

Woodward-Clyde

Borehole No: PT84MW2

Sheet: 2 of 2

CLIENT:	Nexus Environmental Planning Pty Ltd	JOB NUMBER:	A8602019/1
PROJECT:	Proposed Extractive Industry, PT84	DATE COMMENCED:	20/10/98
LOCATION:	cnr Old Northern Rd & Roberts Rd, Maroota	DATE COMPLETED:	20/10/98
DRILL CONTRACTOR:	Intertech	LOGGED BY:	SRR

Drill Model:	Intertech 750	Hole Angle: 90	deg.	Bore Size:	150mm	RL: 226.8	m AHD
Drilling Fluid:	Biogel	Orientation:	deg.	Co-ords: E	9637.10	N 5698.76	ISG

Drilling Info. | Material Properties | Field Records/Construction Information

Method: Casing Advancer

Casing

Rig resistance/ Penetration rate/ Recovery

Water: WL at 24.52m on 29/10/98

Depth (m)

Graphic Log | Classification

Material Description — type, plasticity/particle size, colour, secondary/minor components

Moisture Condition | Consistency Rel. Density

Scale | Sampling | Testing | PID (ppm)

Comments/Construction | Well Diagram

Depth (m)	Classification	Material Description	Comments/Construction
16	SW	SAND, fine to medium grained, light grey	
17			
18		– medium to coarse grained from 17.5m (coarser with depth)	bentonite seal
19			
20			
21			2mm gravel backfill
22	GP	GRAVEL, fine to medium grained quartz gravel,brown and grey, sub-rounded	
23			
24			50mm PVC Class 18, Machine Slotted
25			
26			sump
			TD 26.50m
27		Borehole Discontinued at 26.5m (limit of investigation)	
28			
29			
30			

Produced By: SRR

Checked By:

Document No: s:/A86/A8602019/f/logs/MW2.log

Groundwater Monitoring Bore
FIELD LOG

Woodward-Clyde

Borehole No: PT84MW3

Sheet: 1 of 2

CLIENT:	Nexus Environmental Planning Pty Ltd	JOB NUMBER:	A8802019/1
PROJECT:	Proposed Extractive Industry, PT84	DATE COMMENCED:	21/10/98
LOCATION:	cnr Old Northern Rd & Roberts Rd, Maroota	DATE COMPLETED:	21/10/98
DRILL CONTRACTOR:	Intertech	LOGGED BY:	SRR

Drill Model:	Intertech 750	Hole Angle:	90 deg.	Bore Size:	150mm	RL:	202.43 m AHD
Drilling Fluid:	Biogel	Orientation:	deg.	Co-ords: E	8802.78	N	5916.37 ISG

Drilling Info.					Material Properties					Field Records/Construction Information				
Method	Casing	Ipo resistance/ Penetration (rate/ref)	Water	Depth (m)	Graphic Log	Classification	Material Description type, plasticity/particle size, colour, secondary/minor components	Moisture Condition	Consistency Rel. Density	Scale	Sampling	Testing PID (ppm)	Comments/Construction	Well Diagram
Air Drilling	170mm			1		CL	silty SAND/sandy SILT, topsoil, low plasticity, brown							
							silty CLAY, low plasticity, orange brown - increasing stiffness with depth							
				2			- some quartz silica gravel bands (2-4mm)							
				3										
							gravelly CLAY, low plasticity, yellow brown with rounded to sub-angular quartz gravel - some red-brown banding - increasing gravel content with depth						Backfill	
				4										
				5										
				6										
				7		GC	clayey GRAVEL, medium grained quartz silica gravel (3-4mm), brown silty clay matrix							
						SW	SAND, coarse grained, light grey, silica sand, sub-rounded - grading to medium grained with depth							
				8										
				9		SC	clayey SAND, medium grained, yellow-brown						50mm PVC Casing	
Rotary Mud Drilling						SW	SAND, coarse grained, light grey with quartz gravel fragments, sub-rounded							
				10										
				11			- from 11.5m, fine grained							
				12			- from 12.0m, medium to coarse grained with some quartz gravel sub-rounded (3-4mm)						bentonite seal	
				13										
				14										
				15										

Produced By: SRR
Checked By:

Document No: s:/AB6/AB6020I9/I/logs/MW3.log

Groundwater Monitoring Bore FIELD LOG

Woodward-Clyde

Borehole No: PT84MW3

Sheet: 2 of 2

CLIENT:	Nexus Environmental Planning Pty Ltd	JOB NUMBER:	AB602018/1
PROJECT:	Proposed Extractive Industry, PT84	DATE COMMENCED:	21/10/98
LOCATION:	cnr Old Northern Rd & Roberts Rd, Maroota	DATE COMPLETED:	21/10/98
DRILL CONTRACTOR:	Intertech	LOGGED BY:	SRR

Drill Model:	Intertech 750	Hole Angle:	90	deg.	Bore Size:	150mm	RL: 202.43 m AHD
Drilling Fluid:	Biogel	Orientation:		deg.	Co-ords: E	9802.78	N 5818.37 ISG

Drilling Info.					Material Properties						Field Records/Construction Information				
Method	Casing	Pen. resistance/ Penetration rate/Recl	Water	Depth (m)	Graphic Log	Classification	Material Description type, plasticity/particle size, colour, secondary/minor components	Moisture Condition	Consistency Rel. Density		Scale	Sampling	Testing PID (ppm)	Comments/Construction	Well Diagram
Rotary Mud Drilling			WL at 18.84m on 29/10/98	16		SR	~ 15.5~15.7m, medium plasticity, light grey clay band								
				17			~ from 16.5m, coarse grained							2mm gravel backfill	
				18											
				19										50mm PVC Class 18, Machine Slotted	
				20											
				21		GW CH	GRAVEL, fine to medium grained, red-brown iron-oxidsed/cemented CLAY, medium to high plasticity, red-brown and grey								
				22		GW	GRAVEL, fine to medium grained quartz gravel, brown and grey, sub-rounded (3~4mm)							sump TD 21.90m	
				23			Borehole Discontinued at 23.2m (limit of investigation)								
				24											
				25											
				26											
				27											
				28											
				29											
				30											

Produced By: SRR

Checked By:

Document No: s:/AB6/AB602018/1/logs/NW3.log

URS

PROJECT :	HB Maroota Monitoring Bore	JOB NO.:	43167795
LOCATION:	Roberts Road, Maroota	DATE STARTED:	21/12/2009
SUPERVISOR	F.Carosone	DATE COMPLETED:	22/12/2009

DRILLED BY:	Intertech Drilling Services	METHOD:	Mud rotary	DIAMETER:	140 mm
RIG:	Intertech 850	TOTAL DEPTH :	28.5 m	R.L. CONCRETE:	mAHD
DATUM:	0.57 m above concrete/ground	SWL:	m b.datum	R.L.STEEL PLATE:	mAHD
EASTING:	314121	NORTHING:	6295389	R.L. SWL :	

WELL NUMBER: PT84MW4

Lithological Log		Remarks	Depth (m)	Bore Construction
				Datum 152 mm monument Concrete pad
0 - 0.5	SOIL: brown, sandy.			
0.5 - 6	SAND: orange/brown, fine, clayey, sorted subrounded quartz grains becoming lighter colour below 3 m.		1 2 3 4 5	sand backfill 200 mm HFA hole 152 mm diam. steel casing Rigid foam seal
6 - 6.9	SAND: orange, gravelly medium/coarse subangular quartz grains		6	
6.9 - 8	SAND: grey, gravelly, medium/coarse subangular quartz grains.		7	PVC Blank Casing, 60mm OD, 50mm ID cl 18
8 - 9	SAND: orange, gravelly medium/coarse subangular quartz grains.		8	8
9 - 10	CLAY: grey, soft, sandy.		9	bentonite pellets seal
10 - 12	CLAY: grey and orange.		10 11	10
12 - 14	GRAVEL: grey, sandy, with some clay, fine, subrounded, clear and white quartz grains.		12 13	backfill 140 mm diam.hole
14 - 15	CLAY: grey and red, layered, some sand.		14	
15 - 17	CLAY: grey and white, soft, some sand.		15 16	
17 - 20	GRAVEL: grey and white with some white clay, 2 -5 mm quartz grains.		17 18 19	2 mm washed sand gravel pack
20 - 25.5	SAND: red, gravelly medium/coarse subangular quartz grains.		20 21 22 23 24 25	19.5 PVC screens 60mm OD, 50mm ID cl 18, 0.45 mm slot
25.5 - 27.5	SAND: grey, gravelly, angular to subangular quarts grains		26 27	
27.5 - 28.5	Ironstone, red with dark red clay, very hard.		28	
28.5	Bottom of the hole		29	28.5 bottom cap bottom of the hole

Checked by:.. FC

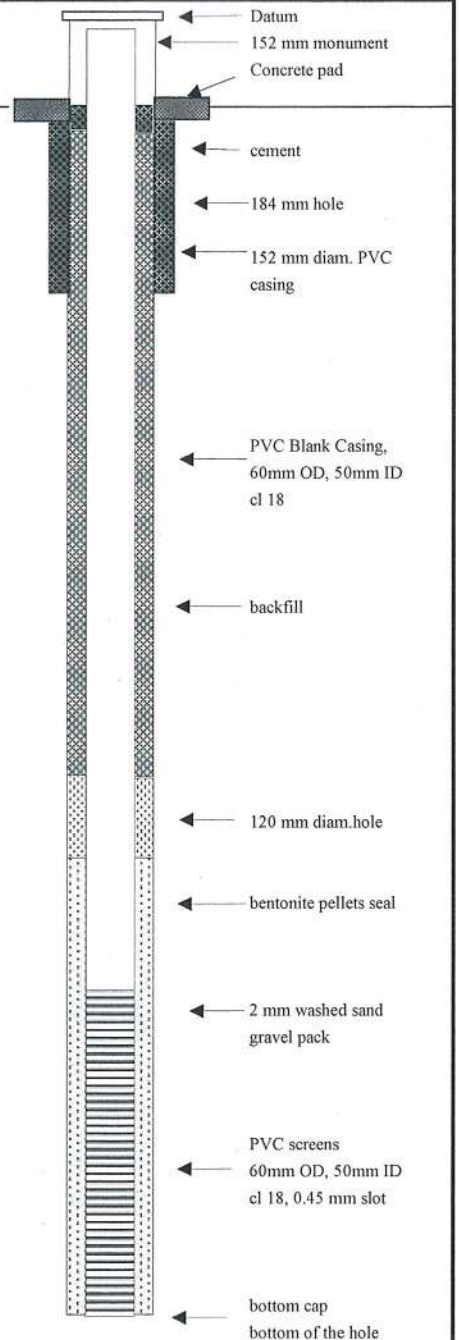
URS

PROJECT :	Hodgson Quarries and Plant	JOB NO.:	43167954
LOCATION:	Roberts Road, Maroota	DATE STARTED:	11/04/2013
SUPERVISOR	F.Carosone	DATE COMPLETED:	11/04/2013

DRILLED BY:	Ultra Drilling	METHOD:	Air rotary	DIAMETER:	120mm
RIG:	Mayhew 1000	TOTAL DEPTH :	44 m	R.L. CONCRETE:	mAHD
DATUM:	0.73 m above concrete/ground	SWL:	34.6m b.datum	R.L.STEEL PLATE:	mAHD
EASTING:	313896	NORTHING:	6295313	R.L. SWL :	

WELL NUMBER: PT84MW5

Lithological Log		Remarks	Depth (m)	Bore Construction
0 - 4	SAND: red/orange,fine to medium rounded quartyz grains, clayey		1	
			2	
			3	
4 - 8	SAND + CLAY: grey and brown, fine gtrained with grey clay		4	
			5	
			6	
			7	
8-13	CLAY: grey, brown and dark red, stiff, dry		8	
			9	
			10	
			11	
			12	
13 -15	SAND: red, dark red, iron stained, fine, sorted, subrounded to rounded quartz grains		13	
			14	
15- 17	SAND: grey, light grey and buff coloured, fine, sorted, subrounded to rounded quartz grains		15	
			16	
17 - 21	SAND: orange to dark orange, fine to medium, sorted, subrounded quartz grains		17	
			18	
			19	
			20	
21 - 30	GRAVEL: orange, Fe stained, medium to coarse, subrounded, with white poorly sorted quartz grains. Becoming fine @ 26 m		21	
			22	
			23	
			24	
			25	
			26	
			27	
			28	
			29	
			30	
30 - 44	SAND: gray/ brown, fine to medium, subrounded to subangular some clear quartz grains. Traces of grey clay.		31	
			32	
			33	
			34	
			35	
			36	
			37	
			38	
			39	
			40	
			41	
			42	
			43	
44	Bottom of the hole		44	



Checked by:.. FC

Dundon Consulting Pty Ltd

BORE: MW6

Logging Sheet

			Project No:	**16-0318**
Client:	Bore:	Elevation (GL):	Elevation (TOC):	Stickup:
Hodgson Quarry Products Pty Ltd	**MW6**	**202.468 mAHD**	**203.17 mAHD**	**0.70m**
Location:				
Roberts Rd Maroota Quarry				
	Drilling Contractor:	Date Started:	Date Finished:	Supervised By:
	Ultra Drilling		23-Jan-15	?? Driller
			Hole depths:	
			As shown	

Description (Driller's log on Form A)	Depth (metres)	Well Construction Details:
	0	MW6
Sand / clay	5, 10, 15, 20, 25	**Marroota Sands**
Clay	30, 35, 40, 45, 50	

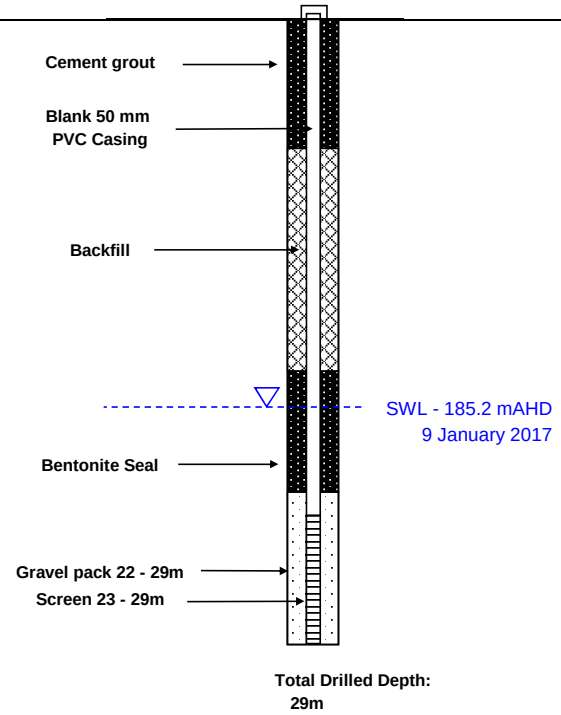


Figure xx: Bore Log - MW6

BOREHOLE LOG

Name of Hole: MW7

Project Number: 2801
Client: Hodgson Quarry Products and Plant
Project: Drilling Operations/ Groundwater Study
Location: Off Roberts Road, Maroota, NSW
Logged by: MA

MAROOTA

Date Commenced: 09/12/2016
Date Completed: 09/12/2016
Surface RL: 212.9m AHD
Collar Height: 0.48m
Coordinates: 313761 6295740
Drilling Contractor: Ultra Drilling Waterbores

vgt Environmental Compliance Solutions

Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
Blade Bit	212	0				Topsoil/Clayey Sand- orange to borwn, fine to coarse grained, sub-rounded to rounded grains	
	211	1				Sandy Clay- orange to red, coarse grained sand, sub rounded to rounded	1.5m colour change
	210	2				Clay- Pink to cream	
	209	3				Clay- orange to cream	
	208	4				Clay- Cream	Some sand
	207	5				Clay- Cream	
	206	6				Silty Clay- Pink to Purple	
	205	7				Clayey Sand- pink to light orange, fine grained, sub rounded to rounded grains	7.2m Colour change
	204	8				Clayey Sand- cream, fine grained, subrounded to rounded grains	Water injected
Hammer Bit	203	9				Clayey Sand- cream, fine grained, subrounded to rounded grains	
	202	10					
	201	11					
	200	12				Sand- creamto light brown, fine to medium grained, sub rounded to rounded grains	
	199	13					
	198	14				Sandstone- Orange, red to brown, fine to medium grained, subroounded to rounded grains	Feruginised Chips at top of sequence
	197	15				Sandstone- orange, fine to medium grained, subrounded to rounded grains	
	196	16				Sandstone- light orange, fine to coarse grained, ssubrounded to rounded grains	
	195	17	<			Sandstone-orange, fine grained, subrounded to rounded grains	
	194	18					
	193	19					
	192	20					

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and litholgical analysis.

Logged By: MA	Checked By: GT (12/1/2017)	Version: 2801_HMA_DO_LOG_MW7_V2

BOREHOLE LOG

Name of Hole: MW7

Project Number: 2801
Client: Hodgson Quarry Products and Plant
Project: Drilling Operations/ Groundwater Study
Location: Off Roberts Road, Maroota, NSW
Logged by: MA

MAROOTA

Date Commenced: 09/12/2016
Date Completed: 09/12/2016
Surface RL: 212.9m AHD
Collar Height: 0.48m
Coordinates: 313761 6295740
Drilling Contractor: Ultra Drilling Waterbores

vgt Environmental Compliance Solutions

Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
Hammer Bit	191	21				Sandstone-orange, fine grained, subrounded to rounded grains	
	190	22					
	189	23					
	188	24					
	187	25					
	186	26				Sandstone- dark orange, fine to medium grained, subrounded to rounded grains	
	185	27					
	184	28					
	183	29					
	182	30					
	181	31					
	180	32					
	179	33					
	178	34				Sandstone- orange, fine to coarse grained, subrounded to rounded grains	
	177	35					
	176	36					
	175	37				Hole Terminated in Hawkebury Sandstone	
	174	38					

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and litholoIgical analysis.

Logged By: MA	Checked By: GT (12/1/2017)	Version: 2801_HMA_DO_LOG_MW7_V2

BOREHOLE LOG

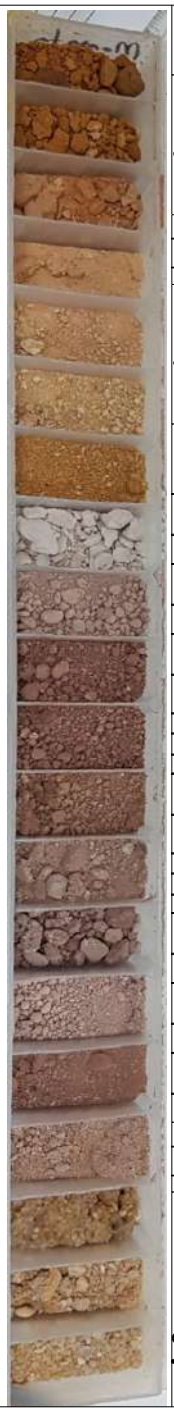
Name of Hole: MW8

Project Number: 2801
Client: Hodgson Quarry Products and Plant
Project: Drilling Operations/ Groundwater Study
Location: Off Roberts Road, Maroota, NSW
Logged by: MA

MAROOTA

Date Commenced: 5/12/2016
Date Completed: 6/12/2016
Surface RL: 227.005m
Collar Height: 0.42m
Coordinates: 313889 6295287
Drilling Contractor: Ultra Drilling Waterbores

vgt Environmental Compliance Solutions



Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Graphic Log	Description	Additional Information
Hammer Bit	227	0			Silty Sand- orange to light brown, fine to medium grained, subrounded to rounded grains	Feruginised fragments and some clay
	226	1			Silty Sand- orange, fine to medium grained, subrounded to rounded grains	Feruginised fragments and some clay
	225	2				
	224	3			Clayey Sand- orange to light orange, fine grained, subrounded to rounded	
	223	4			Silty Sand- light orange to orange, fine to coarse grained subrounded to rounded	Hammer bit not firing
	222	5				
	221	6			Silty Sand- orange, fine to coarse grained, subrounded to rounded grains	Hammer bit not firing
	220	7			Clay- white to light brown	Hammer bit not firing
	219	8			Clay- purple to pink	
	218	9			Clay- Deep purple	
	217	10				
	216	11			Clay-Purple to light brown	Water seepage @ 13m
	215	12				
	214	13			Clay- Deep purple	Hammer bit not firing
	213	14			Clay- light brown to purple	Hammer bit not firing
	212	15			Clay- dark brown to red	Hammer bit not firing
	211	16			Clayey Sand- cream to orange, fine grained, subrounded to rounded grains	Hammer bit not firing
	210	17				
	209	18				
	208	19				
	207	20				

Other Information:GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and litholoIgical analysis.

Logged By: MA	Checked By: GT (12/01/2017)	2801_HMA_DO_LOG_MW8_V2

BOREHOLE LOG

Name of Hole: MW8

Project Number: 2801
Client: Hodgson Quarry Products and Plant
Project: Drilling Operations/ Groundwater Study
Location: Off Roberts Road, Maroota, NSW
Logged by: MA

MAROOTA

Date Commenced: 5/12/2016
Date Completed: 6/12/2016
Surface RL: 227.005m
Collar Height: 0.42m
Coordinates: 313889 6295287
Drilling Contractor: Ultra Drilling Waterbores

vgt Environmental Compliance Solutions

Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
Hammer Bit	206	21				Pebbly Sand - orange to light brown, coarse to very coarse, rounded to subrounded	Hammer bit not firing to 20.5m, some clay
	205	22					
	204	23					
	203	24					
	202	25					
	201	26					
	200	27					
	199	28				Pebbly Sand- light brown, fine grained, subrounded to rounded grains	Some clay
	198	29					
	197	30				Sand- white to light brown, fine grained, subrounded to rounded	Some clay
	196	31				Sandy Clay- brown to light purple, fine grained, subrounded to rounded	Water injected
	195	32				Clayey Sand- brown to light brown, fine grained, subrounded to rounded	
	194	33					
	193	34				Pebbly Sand- brown to pink, very coarse to fine , subrounded to rounded	Feruginised fragments
	192	35					
	191	36					
	190	37					
	189	38				Clayey Sand- brown to purple, medium grained, subrounded to rounded grains	Hardness increasing
	188	39					
	187	40					

Other Information:GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and litholoIgical analysis.

Logged By: MA	Checked By: GT (12/01/2017)	2801_HMA_DO_LOG_MW8_V2

BOREHOLE LOG

Name of Hole: MW8

Project Number: 2801
Client: Hodgson Quarry Products and Plant
Project: Drilling Operations/ Groundwater Study
Location: Off Roberts Road, Maroota, NSW
Logged by: MA

MAROOTA

Date Commenced: 5/12/2016
Date Completed: 6/12/2016
Surface RL: 227.005m
Collar Height: 0.42m
Coordinates: 313889 6295287
Drilling Contractor: Ultra Drilling Waterbores

vgt Environmental Compliance Solutions

Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
Hammer Bit	186	41				Sandstone - orange	Interbedded shale laminations
	185	42					
	184	43					
	183	44					
	182	45					
	181	46					
	180	47					
	179	48					
	178	49					
						Hole Terminated in Hawkesbury Sandstone	
	177	50					
	176	51					
	175	52					

Other Information: **GPS Coordinates sourced from handheld devices. Survey conducted post exploration.**
Stratum contacts determined by hardness, colour, sample recovery and litholoIgical analysis.

Logged By: MA	Checked By: GT (12/01/2017)	2801_HMA_DO_LOG_MW8_V2

BOREHOLE LOG

Name of Hole: MW9

Project Number: 2801

Client: Hodgson Quarry Products and Plant

Project: Drilling Operations/ Groundwater Study

Location: Off Roberts Road, Maroota, NSW

Logged by: MA

MAROOTA

Date Commenced: 19/12/2016

Date Completed: 19/12/2016

Surface RL:225.577 m

Collar Height: 0.52m

Coordinates: 313916 6295355

Drilling Contractor: Ultra Drilling Waterbores

vgt Environmental Compliance Solutions

Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Graphic Log	Description	Additional Information
Auger	225	0			Clayey Sand- orange to brown, fine to coarse grained, subrounded to rounded grains	Topsoil 0 - 0.3m
Blade Bit	224	1			Clayey sand- light brown to red, coarse grained, subrounded to rounded grains	Feruginised chips
	223	2			Clayey Sand- red to light orange, fine to coarse grained, subrounded to rounded grains	
	222	3			Clayey Sand- red to light brown, fine to coarse grained, rounded to subrounded grains	Feruginised Chips
	221	4			Clay- Pink to red	Some cream clay
	220	5			Clay- Pink to red	Some silt
	219	6				
	218	7				
	217	8				
	216	9			Clay- Cream to pink- silty	Water seapage @12m
	215	10				
	214	11				
	213	12				
Hammer Bit	212	13			Clay- Red, no sand	
	211	14				
	210	15			Pebbly Sand- light orange, fine to very coarse grained, subrounded to rounded grains	
	209	16				
	208	17			Pebbly Sand- orange to light orange, fine to very coarse grained, subrounded to rounded grains	
	207	18				
	206	19				
		20				

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and litholoIgical analysis.

Logged By: MA	Checked By GT (12/01/2017)	Version: 2801_HMA_DO_LOG_MW9

BOREHOLE LOG

Name of Hole: MW9

Project Number: 2801

Client: Hodgson Quarry Products and Plant

Project: Drilling Operations/ Groundwater Study

Location: Off Roberts Road, Maroota, NSW

Logged by: MA

MAROOTA

Date Commenced: 19/12/2016

Date Completed: 19/12/2016

Surface RL:225.577 m

Collar Height: 0.52m

Coordinates: 313916 6295355

Drilling Contractor: Ultra Drilling Waterbores

vgt Environmental Compliance Solutions

Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
Hammer Bit	205	21					
	204	22				Sand- orange to pink, fine to coarse grained, subrounded/subangular to rounded grains	
	203	23				Sand- light brown, fine to coarse grained, subrounded/subangular to rounded grains	Feruginised chips
	202	24					
	201	25					
	200	26				Sand- brown to orange, fine grained	Feruginised chips
	199	27					
	198	28					
	197	29					
	196	30					
	195	31				Sandstone- brown to light orange	Hardness progressively increasing
	194	32					
	193	33					
	192	34					
	191	35					
	190	36					
	189	37					
	188	38					
	187	39				Sandstone- light orange to red	
	186	40					

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and litholoIgical analysis.

Logged By: MA	Checked By GT (12/01/2017)	Version: 2801_HMA_DO_LOG_MW9

BOREHOLE LOG

Name of Hole: MW9

Project Number: 2801

Client: Hodgson Quarry Products and Plant

Project: Drilling Operations/ Groundwater Study

Location: Off Roberts Road, Maroota, NSW

Logged by: MA

MAROOTA

Date Commenced: 19/12/2016

Date Completed: 19/12/2016

Surface RL:225.577 m

Collar Height: 0.52m

Coordinates: 313916 6295355

Drilling Contractor: Ultra Drilling Waterbores

Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
Hammer Bit	185	41				Sandstone- light brown	Water injeted @49m
	184	42					
	183	43					
	182	44					
	181	45					
	180	46					
	179	47					
	178	48					
	177	49					
	176	50					
	175	51				Hole Terminated in Hawkesbury Sandstone	
	174	52					

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and litholoIgical analysis.

Logged By: MA	Checked By GT (12/01/2017)	Version: 2801_HMA_DO_LOG_MW9

BOREHOLE LOG

Name of Hole: MW10

Project Number: 2801

Client: Hodgson Quarry Products and Plant

Project: Drilling Operations/ Groundwater Study

Location: Off Roberts Road, Maroota, NSW

Logged by: MA

MAROOTA

Date Commenced: 12/12/2016

Date Completed: 14/12/2016

Surface RL: 217.124m

Collar Height: 0.49m

Coordinates: 314122 6295186

Drilling Contractor: Ultra Drilling Waterbores

vgt Environmental Compliance Solutions

Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
Auger	217	0				Silty Clay - Orange to grey	Topsoil 0-0.2m
	216	1					
	215	2				Clay- red to cream, no sand	
	214	3				Clay- red, no sand	Some Silt
	213	4					
	212	5				Clay- cream to red, no sand	Some Silt
	211	6					
	210	7				Clay- red to orange, no sand	
Blade Bit	209	8				Clay- pink to cream, no sand	
	208	9				Clay- pink to purple, no sand	Some Silt
	207	10				Sand- light orange, fine grained, subrounded to rounded grains	Some Clay
	206	11					
	205	12					
	204	13					
	203	14					
	202	15				Sand- dark orange, fine to very coarse, grained, subrounded/subangular to rounded grains	Not hammering @ 18m
	201	16					
	200	17					
	199	18					
Hammer Bit	198	19					
	197	20					

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and litholoIgical analysis.

Logged By: MA	Checked By: GT (12/01/2017)	Date: 2801_HMA_DO_LOG_MW10_V2

BOREHOLE LOG

Name of Hole: MW10

Project Number: 2801

Client: Hodgson Quarry Products and Plant

Project: Drilling Operations/ Groundwater Study

Location: Off Roberts Road, Maroota, NSW

Logged by: MA

MAROOTA

Date Commenced: 12/12/2016

Date Completed: 14/12/2016

Surface RL: 217.124m

Collar Height: 0.49m

Coordinates: 314122 6295186

Drilling Contractor: Ultra Drilling Waterbores

vgt Environmental Compliance Solutions

Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
Hammer Bit	196	21				Pebbly Sand- orange to red, coarse to very coarse, subrounded to rounded grains	Not hammering
	195	22					
	194	23				Sand- cream to light orange, fine to medium grained, subrounded/subangular to rounded grains	Not hammering
	193	24					
	192	25				Sand- orange, fine to coarse grained, subrounded/subangular to rounded	Not hammering
	191	26					
	190	27				Pebbly Sand- pink to orange, fine to very coarse grained, subangular to rounded grains	Not hammering, minor clay bands
	189	28				Pebbly Sand- pink to cream, coarse to very coarse, subrounded to rounded grains	Not hammering, minor clay bands
	188	29					
	187	30				Pebbly Sand- Pink to light brown, coarse to very coarse grained, subrounded to rounded grains	Hammering
	186	31				Pebbly Sand- pink to red, coarse to very coarse grained, subangular/subrounded to rounded grains	
	185	32	<				
	184	33				Pebbly Sand- pink to red, coarse to very coarse grained, subangular/subrounded to rounded grains	Water seepage
	183	34					
	182	35					
	181	36					
	180	37					
	179	38					
	178	39					
	177	40					

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and litholoIgical analysis.

Logged By: MA	Checked By: GT (12/01/2017)	Date: 2801_HMA_DO_LOG_MW10_V2

BOREHOLE LOG

Name of Hole: MW10

Project Number: 2801
Client: Hodgson Quarry Products and Plant
Project: Drilling Operations/ Groundwater Study
Location: Off Roberts Road, Maroota, NSW
Logged by: MA

MAROOTA

Date Commenced: 12/12/2016
Date Completed: 14/12/2016
Surface RL: 217.124m
Collar Height: 0.49m
Coordinates: 314122 6295186
Drilling Contractor: Ultra Drilling Waterbores

Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
Hammer Bit	176	41				Pebbly Sand- brown, coarse to very coarse grained, subrounded to rounded grains	
	175	42					
	174	43					
	173	44					
	172	45					
	171	46				Pebbly Sand- red, coarse to very coarse grained, subangular/subrounded to rounded grains	
	170	47					
	169	48				Pebbly Sand- pink to orange, some very coarse to coarse grains, subrounded to rounded	
	168	49					
	167	50				Hole Terminated in Hawkesbury Sandstone as determined by drill penetration rates and colour change in drill water. No sample retained	
	166	51					
	165	52					

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and litholoIgical analysis.

Logged By: MA	Checked By: GT (12/01/2017)	Date: 2801_HMA_DO_LOG_MW10_V2

BOREHOLE LOG

Name of Hole: MW11

Project Number: 2801

Client: Hodgson Quarry Products

Project: Drilling Operations/ Groundwater Study

Location: Off Roberts Road, Maroota, NSW

Logged by: MA

MAROOTA

Date Commenced: 20/12/2016

Date Completed: 21/12/2016

Surface RL: 192.349m

Collar Height: 0.7m

Coordinates: 314176 6295788

Drilling Contractor: Ultra Drilling Waterbores

vgt Environmental Compliance Solutions

Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
Blade Bit	192	0				Sand- light brown to grey, fine to very coarse grained,	
	191	1				Sand- brown to orange, fine to very coarse grained, subrounded to rounded grains	
	190	2					
	189	3				Sand- orange, fine to very coarse grained, subrounded to rounded grains	
	188	4					
Hammer Bit	187	5				Pebbly Sand- orange to brown, fine to very coarse, rounded to subrounded	
	186	6					
	185	7				Pebbly Sand- red, coarse to very coarse grained, subrounded to rounded grains	
	184	8					
	183	9	<			Pebbly Sand- orange, coarse to very coarse grained, subrounded to rounded grains	
	182	10					
	181	11					
	180	12				Sand- red, coarse to very coarse grained, subrounded to rounded grains	
	179	13					
	178	14				Sand- orange, coarse to very coarse grained, subrounded to rounded grains	
	177	15					
	176	16					
	175	17				Sand- orange, coarse to very coarse grained, subrounded to rounded grains	
	174	18					
	173	19				Clay- White, some medium to fine grained sand	
		20					

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and litholoIgical analysis.

Logged By: MA	Checked By: GT (12/01/2017)	Version: 2801_HMA_DO_LOG_MW11_V2

BOREHOLE LOG

Name of Hole: MW11

Project Number: 2801

Client: Hodgson Quarry Products

Project: Drilling Operations/ Groundwater Study

Location: Off Roberts Road, Maroota, NSW

Logged by: MA

MAROOTA

Date Commenced: 20/12/2016

Date Completed: 21/12/2016

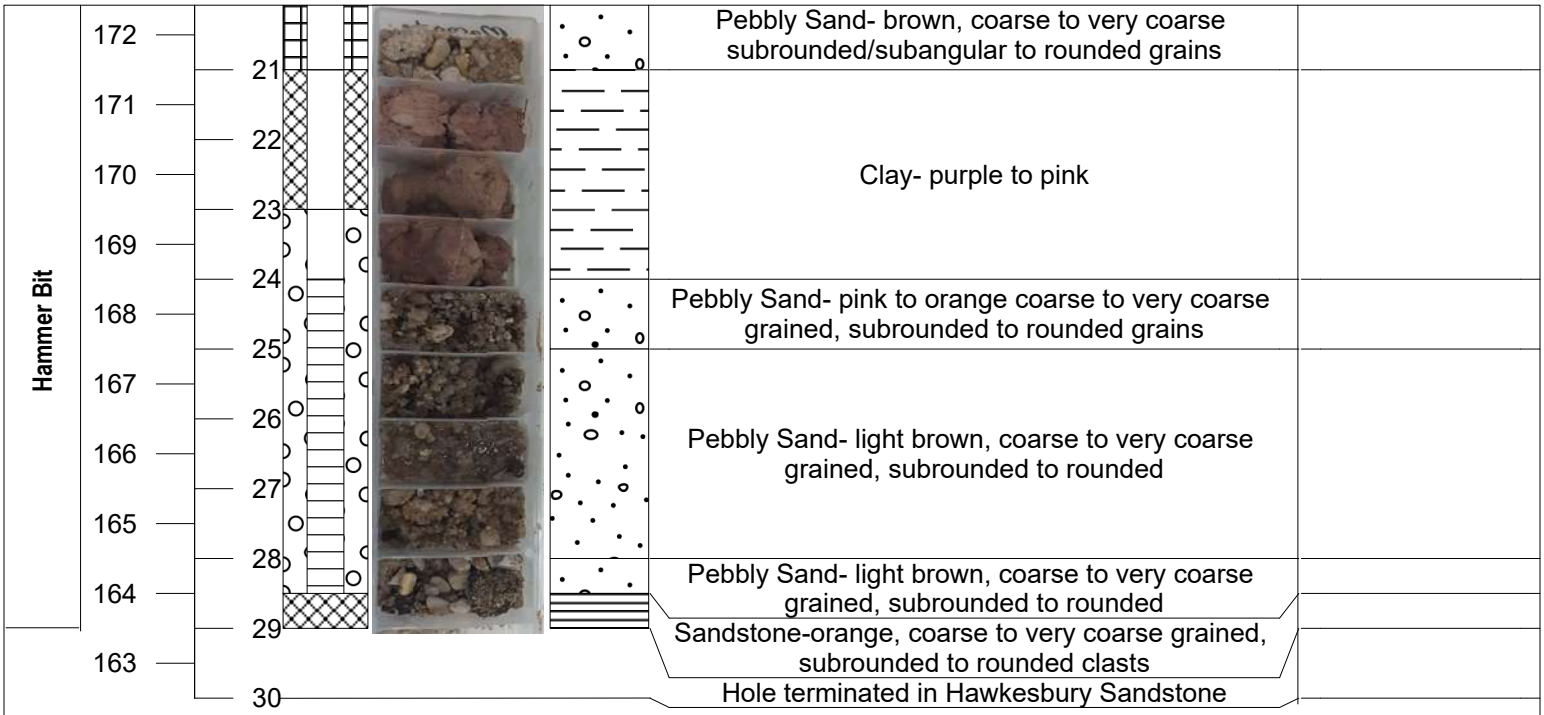
Surface RL: 192.349m

Collar Height: 0.7m

Coordinates: 314176 6295788

Drilling Contractor: Ultra Drilling Waterbores

Environmental Compliance Solutions



Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and litholoIgical analysis.

Logged By: MA	Checked By: GT (12/01/2017)	Version: 2801_HMA_DO_LOG_MW11_V2

BOREHOLE LOG

Name of Hole:MW12

Project Number: 2801

Client: Hodgson Quarry Products and Plant

Project: Drilling Operations/ Groundwater Study

Location: Off Roberts Road, Maroota, NSW

Logged by: MA

MAROOTA

Date Commenced: 08/12/2016

Date Completed: 08/12/2016

Surface RL: 210.275m

Collar Height: 0.48m

Coordinates: 313902 6295583

Drilling Contractor: Ultra Drilling Waterbores

vgt Environmental Compliance Solutions

Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
Blade	210	0				Sand- orange to dark orange coarse to very coarse grained, subrounded to rounded grains	
	209	1				Sand- dark orange, fine to coarse grained, subrounded to rounded grains	Feruginised chips, some clay bands
	208	2				Sand- orange to red, fine to coarse grained, subrounded to rounded	Feruginised chips
	207	3				Sand- red to cream, fine to medium grained, subrounded to rounded grains	Feruginised chips
	206	4				Silty Sand- cream to light orange, fine to medium grained, subrounded to rounded grains	
	205	5					
	204	6				Sand- cream, fine to medium grained, rounded to subrounded grains	
	203	7					
	202	8					
	201	9					
	200	10				Sand- cream to pink fine to medium grained, subrounded to rounded grains	Water seepage
Hammer Bit	199	11				Sand- pink to light brown, fine grained, subrounded to rounded grains	
	198	12				Sand- cream to light brown, very coarse to coarse grained, subrounded to rounded grains	
	197	13					
	196	14					
	195	15					
	194	16	<				
	193	17				Sand- cream to light brown, coarse to very coarse, rounded to subrounded grains	
	192	18					
	191	19					
	190	20					

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and litholgical analysis.

Logged By: MA	Checked By GT (12/01/2017)	Version: 2801_HMA_DO_LOG_MW12_V2

BOREHOLE LOG

Name of Hole:MW12

Project Number: 2801

Client: Hodgson Quarry Products and Plant

Project: Drilling Operations/ Groundwater Study

Location: Off Roberts Road, Maroota, NSW

Logged by: MA

MAROOTA

Date Commenced: 08/12/2016

Date Completed: 08/12/2016

Surface RL: 210.275m

Collar Height: 0.48m

Coordinates: 313902 6295583

Drilling Contractor: Ultra Drilling Waterbores

Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
Hammer Bit	189	21				Sand- brown to light brown, fine to coarse, subrounded to rounded	Not Hammering
	188	22					
	187	23					
	186	24				Sandstone- grey to brown, fine to medium grained, subrounded to rounded grains	Shale laminations, hard
	185	25					
	184	26					
	183	27					
	182	28				Hole Terminated in Hawkesbury Sandstone	

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and litholgical analysis.

Logged By: MA	Checked By GT (12/01/2017)	Version: 2801_HMA_DO_LOG_MW12_V2

BOREHOLE LOG

Name of Hole:MW13

Project Number: 2801

Client: Hodgson Quarry Products and Plant

Project: Drilling Operations/ Groundwater Study

Location: Off Roberts Road, Maroota, NSW

Logged by: MA

MAROOTA

Date Commenced: 07/12/2016

Date Completed: 07/12/2016

Surface RL: 225.497 m

Collar Height: 0.46m

Coordinates: 313915 6295358

Drilling Contractor: Ultra Drilling Waterbores

vgt Environmental Compliance Solutions

Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
Hammer Bit	212	0				Silty Sand- orange to light orange, medium to coarse grained, round to subrounded grains	
	211	1				Silty Sand- red to orange , medium to coarse grained, round to subrounded grains	Some Feruginised chips
	210	2				Silty Sand- deep red to red, fine to medium grained, rounded to subrounded	
	209	3				Clayey Sand- red to light brown, fine to very coarse grained, rounded to subrounded grains	
	208	4				Clay- white, some fine grain sand	
	207	5				Clay- cream to pink	Some silt
	206	6				Clay- purple to pink	Some Feruginised chips
	205	7					
	204	8					
	203	9					
	202	10					
	201	11					
	200	12					
	199	13				Clay-pink to cream	
	198	14				Silty Clay- red to purple	
	197	15				Sand- orange, coarse to very coarse grained, rounded to subrounded grains	Sand @15.2
	196	16				Pebbly Sand- orange, coarse to very coarse, rounded to subrounded	
	195	17				Sand- white to light orange, medium grained, subrounded to rounded	
	194	18				Sand- white to light orange, coarse to very coarse, rounded to subrounded	
	193	19					
	192	20					

Other Information:GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and litholoIgical analysis.

Logged By: MA	Checked By	Version: 2801_HMA_DO_LOG_MW13_V2

BOREHOLE LOG

Name of Hole:MW13

Project Number: 2801

Client: Hodgson Quarry Products and Plant

Project: Drilling Operations/ Groundwater Study

Location: Off Roberts Road, Maroota, NSW

Logged by: MA

MAROOTA

Date Commenced: 07/12/2016

Date Completed: 07/12/2016

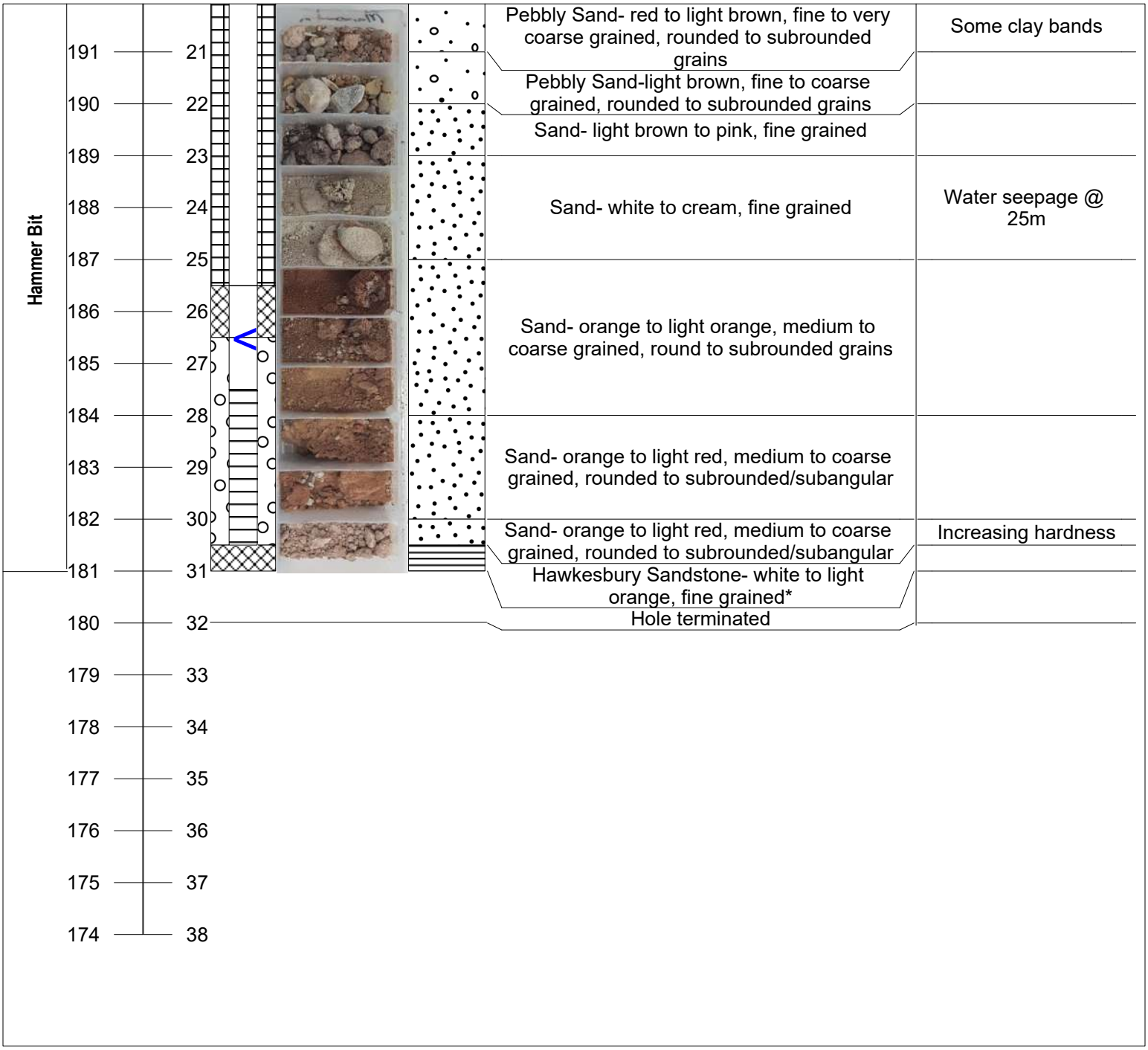
Surface RL: 225.497 m

Collar Height: 0.46m

Coordinates: 313915 6295358

Drilling Contractor: Ultra Drilling Waterbores

Environmental Compliance Solutions



Other Information:GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and litholoIgical analysis.

Logged By: MA	Checked By	Version: 2801_HMA_DO_LOG_MW13_V2

WOODWARD - CLYDE

PROJECT : Dr.Martin EIS, Process Water Supply
LOCATION: Roberts Road, Maroota, NSW.
SUPERVISOR: Fabio Carosone

JOB NO.: A8602019.2
DATE STARTED: 28.6.1999
DATE COMPLETED: 6.7.1999

INSTALLED BY: Intertech Drilling Services
RIG: Intertech 750
DATUM m.above concrete/ground
EASTING:

METHOD: air/mud
TOTAL DEPTH : 126 m
SWL: 14.8m b.g.
NORTHING:

DIAMETER: 158 mm
R.L. GROUND: m
R.L.DATUM: m
R.L. SWL : m

WELL NUMBER: PT84PB1

Lithological Log		Remarks	Depth (m)	Bore Construction
				158 mm Steel Casing; Concrete pad
0-1.5	SAND: brown, medium to coarse, subangular quartz grains. Some minor layers of red fine sand and gravel.			
1.5-3	GRAVEL: white, coarse, pebbly, some minor sand,subang. qtz grains	blade bit	5	
3-8	SAND: white-cream, med/coarse, subang.to subrd. Sorted qtz grains some purple bands,soft, becoming coarse, brown. Some clay.			Backfill
4.8-7	CLAY: light grey, some sand, dry becoming light brown and gold in colour at base. Some red-brown sand at 6-6.2 m.		10	200mm dia.hole
7-9	GRAVEL: white and red, rd,crse qtz pebbles and some sand. @7.5m, light red/pink, and some purple and grey clay.		15	Steel casing, 158mm ID 168 mm OD Welded joints
9-11.3	SAND: dark red/purple, med./coarse, sorted, subrd, qtz grains @10 m finer and darker, minor clay @10.5m lighter, pink and some purple clay @11m darker with dark red pebbles(2-3mm), some stiff purple clay		20	
11.3-11.5	FERRICRETE: dark red, hard			
11.5-17.3	CLAY: grey mottled purple and brown, moist, plastic @12m grey brown		25	
17.3-18	CLAY: red-brown, high sand content			28.5 base of 200 mm hole
18-20	CLAY: grey-red and orange, moist, plastic, with some brown red sand		30	28.85 Base of casing
20-23.5	CLAY: grey, light grey, plastic	D.H.Hammer		
23.5-24	CLAY: light brown, yellow and mottled purple. Some grit at 24m			
24-24.2	FERRICRETE: dark brown/red, hard		35	
24.2-26.1	CLAY: as @ 23.5-24			
26.1-34	SANDSTONE: grey, fine/med qtz grains, weathered, clayey @27 m white grey, @27.5m harder		40	158 mm hole D.H.Hammer
34-34.1	FERRICRETE: dark brown/red, hard			
34.1-41	SANDSTONE: grey white, fine to med., subang./subrd, sorted qtz grains			
41-42	CLAY: light grey and purple		45	
42-46	SANDSTONE: as @ 34.1-41			
46-48	FERRICRETE: brown, in several thinner bands			open hole
48-51	SANDSTONE: as above		50	
51-58	SANDSTONE: brown, and orange, fine grained, med hard @53m grey white @56m yellow brown, iron-rich bands, fine/med.		55	
58-58.5	SILTSTONE: grey/black, harder than above, fine grained			
58.5-59.5	SANDSTONE: grey, medium grained			
59.5-62.5	SILTSTONE: dark grey, shaley, fine grained, hard		60	
62.5-66	SANDSTONE: orange, fine to medium grains			
			65	
66-68	SANDSTONE: grey, white, fine to medium			
68-74	SANDSTONE: yellow, iron-rich, medium		70	
74-78	SANDSTONE:yellow, iron-rich,white and brown		75	
78-84	SANDSTONE: dark grey, hard @79.5m light orange/brown		80	

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Prepared by: FC
Checked by:

WOODWARD - CLYDE

PROJECT : Dr.Martin EIS, Process Water Supply		JOB NO.:	A8602019.2
LOCATION: Roberts Road, Maroota, NSW		DATE STARTED:	28.6.1999
SUPERVISOR: Fabio Carosone		DATE COMPLETED:	6.7.1999
INSTALLED BY: Intertech Drilling Services	METHOD: air/mud	DIAMETER:	158 mm
RIG: Intertech 750	TOTAL DEPTH : 126.1 m	R.L. GROUND:	m
DATUM m.above concrete/ground	SWL: m b.d.	R.L.DATUM:	m
EASTING:	NORTHING:	R.L. SWL :	m

WELL NUMBER: PT84PB1

Lithological Log	Remarks	Depth (m)	Bore Construction
84-102 SANDSTONE: grey, hard/medium hard @86m iron-rich bands @90m some grey clay @96m minor iron rich bands		85 90 95 100	
102-126.1 SANDSTONE: grey and brown, med. grains, coarser than above firmer. @104m milky whitegravel pebbles (2 mm) @112m some coarse qtz pebbles @115m some coarse qtz pebbles		105 110 115 120 125	open hole 158 mm hole D.H.Hammer
126.1 Bottom of the hole		130 135 140 145 150 155 160	126.1 Bottom of the hole

Prepared by: FC
Checked by:...

WOODWARD - CLYDE

PROJECT : Dr.Martin EIS, Process Water Supply		JOB NO.:	A8602019.2
LOCATION: Roberts Road, Maroota, NSW		DATE STARTED:	6.7.1999
SUPERVISOR: Fabio Carosone		DATE COMPLETED:	9.7.1999
INSTALLED BY: Intertech Drilling Services	METHOD: air	DIAMETER:	158 mm
RIG: Intertech 750	TOTAL DEPTH : 156.5m	R.L. GROUND:	m
DATUM m.above concrete/ground	SWL: 50.9m b.g.	R.L.DATUM:	m
EASTING:	NORTHING:	R.L. SWL :	m

WELL NUMBER: PT84PB2

Lithological Log		Remarks	Depth (m)	Bore Construction
				158 mm Steel Casing; Concrete pad
0-0.5	TOPSOIL: sandy loam, red brown			
0.5-1.5	CLAY: red, sandy, some ferricrete			
1.5-2	CLAY: grey/white, stiff		5	200mm dia.hole
	SAND: red, weakly cemented, hard band	blade bit		Steel casing, 158mm ID 168 mm OD welded joints
2.5-2.7	CLAY: white/grey, stiff		10	
2.7-4	SAND: red/orange, fine to medium, sorted qtz grains. Some clay			
4-4.1	CLAY: grey/white, stiff, dry			10.4 base of 200mm casing
4.1-5	SAND: as above with thin iron cemented bands	D.H.Hammer	15	
5-5.5	CLAY: grey/white			
5.5-9	SAND: orange, med/fine, sorted, subrnd qtz grains			
9-10.2	CLAY: yellow/orange, stiff, with thin layers of gravel @10.2m hard		20	Backfill
10.2-15.5	SANDSTONE: grey/white, clayey, fine grained, soft			
15.5-18	SANDSTONE: yellow/brown, firm, some orange clay @17m some ferricrete bands		25	
18-25	SANDSTONE: grey with coarse qtz pebbles and iron cement @19.5m ferricrete, 5 cm layers			
25-31	SANDSTONE: much as above, with very coarse qtz gravel pebbles with iron stains and cement. Weakly cemented, soft		30	
31-32	CLAY: grey, soft, plastic			
32-36.5	CLAY: dark red and yellow matrix, gravelly		35	
36.5-41.5	some grey clay and ferricrete, poor sample, unconsolidated.soft			158 mm hole D.H.Hammer
			40	
	SANDSTONE: grey/dark grey, harder and ferricrete bands @42m red purple colour			
43-45	CLAY: grey and purple, stiff @43.5m ferricrete bands		45	
45-49.5	CLAY: red/orange @48.5m ferricrete bands			125 mm PVC casing spigot/socket glued
49.5-54	SANDSTONE: grey, fine grained, some light yellow colour @53.5m ferricrete bands		50	
54-60.5	SANDSTONE: grey and yellow, medium, sorted, subrnd qtz grains. gravelly bands, minor ferricrete bands			53 shade cloth seal
			55	
			60	59.5 base of PVC casing
60.5-63.5	SILTSTONE: grey/dark grey, sublaminar and hard			
63.5-66	SANDSTONE: yellow/grey, harder		65	
66-66.5	SANDSTONE: red, with ferricrete bands, medium grained			
66.5-70	SANDSTONE: grey/yellow, as above			
70-75.5	SILTSTONE: grey/dark grey, laminar		70	
			75	158 mm hole D.H.Hammer
75.5-78.5	SANDSTONE: grey/white, medium grained			
78.5-83	SILTSTONE: grey/dark grey, as above		80	

Prepared by: FC
Checked by:

S:\A8602019.2\PT84PB2\10/11/99\FC

Dundon Consulting Pty Ltd

BORE: PB2

Logging Sheet

Project No: **16-0318**

Client:	Bore:	Elevation (GL):	Elevation (TOC):	Stickup:
Hodgson Quarry and Plant Pty Ltd	**PB2 (PT84PB2)**	**approx 216.5 mAHD**	**approx 217.2 mAHD**	**0.70m**
Location:				
Roberts Rd Maroota Quarry				

Drilling Contractor:	Date Started:	Date Finished:	Supervised By:
Intertech Drilling	**06-Jul-99**	**09-Jul-99**	**F Carosone**

Hole depths: **As shown**

Description (Driller's log on Form A)	Depth (metres)	Well Construction Details:
		PB2
Topsoil	0	Maroota Sands
Clay, red-grey / white, with sandy loam interbed		Concrete pad
Sand / gravel, red, some clay	10	Blank 168 mm steel casing; Drilled 210 mm hole 0-10.4 m
Sandstone, white / yellow, med grained		
Ironstone	20	Drilled 158 mm hole 10.4-90.2 m
Sand / clay, yellow, quartz fractured		Backfill
	30	Blank 140 mm PVC casing
Sandstone, yellow soft		
	40	SWL - 170.0 mAHD 5 July 2002
Ironstone		
Sandstone, white soft	50	Shadecloth seal
Ironstone		
Sandstone, yellow with quartz	60	
Ironstone		
Sandstone, white with silt bands	70	Open hole 59 - 156.5m
		Hawkesbury Sandstone
Sandstone, white-grey, med grained	80	
	90	
Sandstone, white-grey, with iron		Drilled 120 mm hole 90.2-156.5 m
	100	
	110	
	120	
Sandstone, white with quartz bands		
	130	
	140	
Siltstone		
	150	
Sandstone, white with quartz bands		
	160	Total Drilled Depth: 156.5m
	170	
	180	

Figure xx: Bore Log - PT84PB2

APPENDIX B

BORE LOGS – DoI-WATER MONITORING BORES

NSW Office of Water
Work Summary

GW075003

Licence: | **Licence Status:**

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore
Work Status: Instrumented
Construct.Method: Rotary
Owner Type: NSW Office of Water

Commenced Date:
Completion Date: 01/07/1997
Final Depth: 109.00 m
Drilled Depth: 109.00 m

Contractor Name: JH ISELT PTY LTD
Driller: John Hans Iselt
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description: Fresh
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:			
Licensed:	CUMBERLAND	MAROOTA	LT2 DP228308

Region: 10 - Sydney South Coast
River Basin: 212 - HAWKESBURY RIVER
Area/District:
CMA Map: 9031-2S
Grid Zone:
Scale:

Elevation: 225.34 m (A.H.D.)
Elevation Source: R.L. at W.L.M.Pt.
Northing: 6295298.400
Easting: 313869.800
Latitude: 33°27'56.2"S
Longitude: 150°59'49.5"E

GS Map: -
MGA Zone: 56
Coordinate Source: PR.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	3.00	200			Rotary Air
1		Hole	Hole	3.00	24.00	160			Rotary Air
1		Backfill	Backfill	0.00	24.00				
2		Hole	Hole	0.00	3.00	200			Rotary
2		Hole	Hole	3.00	109.00	160			Rotary
2		Backfill	Backfill	3.00	68.50				
2		Annulus	Waterworn/Rounded	70.00	86.00	160			Graded
2		Backfill	Backfill	86.00	109.00				
2	1	Casing	P.V.C.	-0.75	84.50	90	80		Seated on Bottom, Screwed and Glued
2	1	Opening	Screen	72.00	75.00	90		1	PVC Class 12, , A: 0.50mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
55.00	55.50	0.50	Unknown	50.00	60.00	0.05	60.00		
72.50	74.00	1.50	Unknown	45.00	80.00	0.45	80.00		
82.00	83.00	1.00	Unknown	47.80	109.00	0.25	109.00	01:00:00	

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.20	0.20	Topsoil	Topsoil	
0.20	3.30	3.10	Sandy Clay	Clay	
3.30	6.40	3.10	Clay White	Clay	
6.40	14.60	8.20	Clay Red	Clay	
14.60	23.70	9.10	Sand Coarse	Sand	
23.70	55.00	31.30	Sandstone Yellow	Sandstone	
55.00	55.50	0.50	Sandstone Yellow WB	Sandstone	
55.50	70.00	14.50	Sandstone Yellow	Sandstone	
70.00	72.50	2.50	Mudstone Grey	Mudstone	
72.50	74.00	1.50	Sandstone Grey WB	Sandstone	
74.00	82.00	8.00	Sandstone Yellow	Sandstone	
82.00	83.00	1.00	Sandstone Yellow WB	Sandstone	
83.00	93.70	10.70	Sandstone Yellow	Sandstone	
93.70	95.50	1.80	Shale/Mudstone	Mudstone	
95.50	100.50	5.00	Sandstone Grey	Sandstone	
100.50	104.00	3.50	Mudstone Grey	Mudstone	
104.00	109.00	5.00	Sandstone Yellow	Sandstone	

Remarks

01/07/1997: Form A Remarks:
Rem: Backfilled from 109m to 86m, Bento Plug from 86m to 84.5m, Gravel pack from 84.5m to 70m, Bento Plug from 70m to 68.5m, Backfilled to 3m, Bento Plug from 3m to 1m.
Hole 1 Abandoned due to loss of circulation through gravel layers.
01/08/1997: Hole 1 Abandoned due to loss of circulation through gravel layers.
11/02/1998: Drilled depth 109 m. Slotted depth 72 - 75 m.
11/02/1998: Top of PVC casing 226.339 metres AHD RL Ground = 225.459m
Top of PVC casing used as zero reference point.
11/02/1998: New equipment installed.
Dataflow model 392 datalogger in, s/n 42236
Dataflow 3 metre capacitance sensor in, s/n unknown.
26/02/1999: Sensor calibrated.
Calibrated slope -3005
Calibrated offset 10961.5
26/02/1999: Sensor o-ring set to 45.7 m. below PVC casing.
20/03/2001: Logging interval changed to 12 hours.
29/05/2002: Datalogger/sensor replaced.
Dataflow model 392 datalogger out, s/n 42236
Dataflow 3 metre capacitance sensor out, s/n unknown
Diver TD sensor/datalogger in, s/n 29122
29/05/2002: Sensor tip set to 48.14 m. below PVC casing.
29/05/2004: 0.1 m. data resolution from this point.
22/09/2004: Access too site restricted by dumping of quarry spoil 75004.jpg
22/09/2004: Data collection
07/05/2005: data collection
08/03/2006: Loggers removed for cal check
14/03/2006: Logger re installed post cal check
13/07/2006: Combo lock installed (7232)
13/07/2006: GW075003 - From Parramatta take Windsor Rd too BaulkHam Hills
Turn right into OLD Northern RD at Bull & Bush Hotel
Follow Old Northern Rd, through Castle Hill,Dural,Glenorie & Sth Maroota continue towards Maroota
At Roberts Rd go approx 20m further along Old Northern Rd and turn right into second gate near cottage.
Turn left and follow along fence line for approx 20m
Bore (yellow standpipe) is located near fence line.

Access to this site requires the completion of "Site Induction/sign in-out" from the Sand Mine operator located in Roberts Rd,Maroota.

HB Maroota Pty Ltd
C/- Ralph Betts
P O Box 1778
GOSFORD NSW 2250

Ph 4368-4357
Mobile 0409-912536
Email hbresources@bigpond.com
13/07/2006: Access to this site requires the completion of "Site Induction" from Sand Mining company located in Roberts Rd,Maroota
27/11/2006: Conc pad too steel flange plate 0.585m Conc pad too PVC 8.885
27/11/2006: Download 02
19/10/2007: D/L #3; Dip SWL=49.49 (to PVC); EC=89; Temp=18.7
12/08/2008: Downloaded; Dip SWL=45.33m(to PVC); EC=97; Temp=18.7
12/08/2008: Sensor level set to 51.32m below PVC
22/01/2009: Downloaded; Dip SWL=45.06m(to PVC); EC=98; Temp=18.9
24/07/2009: Downloaded; Dip SWL=44.83m(to PVC); EC=99; Temp=18.7
24/01/2011: Site visited - Upon arrival Water Level = 46.84m EC = 99m/S Temp = 19.2 deg

Instrument changed OUT: Baro S/N A5792 IN: Diver S/N 29123. Actual depth of sensor measured = 51.27m
07/04/2011: Site visited - Upon arrival Water Level = 47.57m EC = 95u/S Temp = 18.7 deg

Instrument changed OUT: Baro S/N A5792 IN: Solinst S/N 63425.
01/06/2011: Site visited - Water level = 47.52m EC = 98U/m Temp = 18.6Deg

Instrument swapped - OUT = Baro S/N 63425 IN = Solinst S/N 63830
02/08/2011: Site visited - Upon arrival Water Level = 46.011m EC = 99u/S Temp = 18.9 deg
21/09/2011: Site visited - Upon arrival Water Level = 46.718m EC = 99u/S Temp = 18.9 deg

Logger Swapped as it gave a range of 0 - 4.096m? Tried to change the range to 0cm - 1000cm but failed to stick.

OUT: solinst logger S/N 63830

IN: Diver logger S/N D3891
29/11/2011: Site visited - Upon arrival Water Level = 46.880m EC = 102u/S Temp = 18.9 deg
24/01/2012: Site visited - Upon arrival Water Level = 42.525m EC = 102u/S Temp = 18.7 deg
02/05/2012: Site visited - Upon arrival Water Level = 44.090m EC = 107u/S Temp = 18.7 deg
26/06/2012: Site visited - Upon arrival Water Level = 45.784m EC = 168u/S Temp = 18.5 deg
14/08/2012: Site visited - Upon arrival Water Level = 45.132m EC = 162u/S Temp = 18.6 deg
26/09/2012: Primary Client changed from GWSE to GWA on 26/09/2012.
24/10/2012: Site visited - Upon arrival Water Level = 46.202m EC = 161u/S Temp = 18.5 deg LOGGEr FAILED to DOWNLOAD

Diver Baro logger removed S/No. = D3891

Troll logger installed S/No. = 320670
12/12/2012: Routine Site visit - Upon arrival Water Level = 45.823m EC = 117u/s Temp = 18.7 deg
14/03/2013: Routine Site visit - Upon arrival Water Level = 45.747m EC = 115u/s Temp = 18.9 deg
23/04/2013: Routine Site visit - Upon arrival Water Level = 46.023m EC = 115u/s Temp = 18.7 deg
06/08/2013: Routine Site visit - Upon arrival Water Level = 45.471m EC = 106u/s Temp = 18.7 deg
Last logger level = 46.081m, Last logged Temp = 17.9 deg
09/10/2013: Routine Site visit - Upon arrival Water Level = 46.266m EC = 95u/s Temp = 18.7 deg
Last logger level = 45.400m, Last logged Temp = 18.4 deg
20/03/2014: Routine Site visit: SWL = 47.585 m
EC = 92u/s Temp = 18.8 deg
Last logger level = 46.162m, Last logged Temp = 18.4 deg
15/05/2014: Routine Site visit: SWL = 47.448 m
EC = 93 u/s Temp = 18.7 deg
Last logger level = 47.608 m, Last logged Temp = 19.9 deg
27/05/2014: Routine Site visit: SWL = 47.405 m
EC = 98 u/s Temp = 18.9 deg
Last logger level = N/A m, Last logged Temp = N/A deg
Cable extended 6m to approx 51m
22/07/2014: Routine Site visit: SWL = 47.535 m
EC = 96 u/s Temp = 18.6 deg
Last logger level = 47.403 m, Last logged Temp = 18.4 deg
09/10/2014: Regular site visit: SWL = 47.490 m
Measured EC = 96 us/cm Measured Temp = 18.7 deg
Last logged level= 47.526 m Last logged temp = 18.4 deg.
Logger time 1 hour fast. Adjusted in editing.
04/02/2015: Regular site visit: SWL = 48.900 m
Measured EC = 125 us/cm Measured Temp = 18.7 deg
Last logged level= 47.940 m Last logged temp = 18.4 deg.
Logger time 1 hour behind. Adjusted in editing.
20/08/2015: Regular site visit: SWL = 46.970 m
Measured EC = 156 us/cm Measured Temp = 18.6 deg

***** End of GW075003 *****

NSW Office of Water
Work Summary

GW075004

Licence: | **Licence Status:**

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore
Work Status: Instrumented
Construct.Method: Rotary
Owner Type: NSW Office of Water

Commenced Date:
Completion Date: 07/07/1997
Final Depth: 60.00 m
Drilled Depth: 60.00 m

Contractor Name: JH ISELT PTY LTD
Driller: John Hans Iselt
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description: Fresh
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:			
Licensed:	CUMBERLAND	MAROOTA	LT2 DP228308

Region: 10 - Sydney South Coast
River Basin: 212 - HAWKESBURY RIVER
Area/District:
CMA Map: 9031-2S
Grid Zone:
Scale:

Elevation: 227.76 m (A.H.D.)
Elevation Source: R.L. at W.L.M.Pt.
Northing: 6295287.700
Easting: 313890.200
Latitude: 33°27'56.6"S
Longitude: 150°59'50.3"E

GS Map: -
MGA Zone: 56
Coordinate Source: PR.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	24.00	200			Rotary
1		Hole	Hole	24.00	60.00	160			Rotary
1		Backfill	Backfill	3.00	28.00				
1		Annulus	Waterworn/Rounded	30.00	60.00				Graded
1	1	Casing	P.V.C.	-0.75	60.00	90	80		Seated on Bottom, Screwed and Glued
1	1	Opening	Screen	54.00	57.00	90		1	PVC Class 12, , A: 0.50mm

Water Bearing Zones

			WBZ Type						

From (m)	To (m)	Thickness (m)		S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
53.00	54.00	1.00	Unknown	44.80	60.00	0.20	60.00	01:00:00	

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.40	0.40	Topsoil	Topsoil	
0.40	7.50	7.10	Sand Coarse	Sand	
7.50	9.00	1.50	Clay Red/White	Clay	
9.00	15.50	6.50	Gravel Fine	Gravel	
15.50	19.70	4.20	Clay Red	Clay	
19.70	24.70	5.00	Gravel Fine	Gravel	
24.70	28.00	3.30	Sand Coarse	Sand	
28.00	32.50	4.50	Sandstone White	Sandstone	
32.50	37.90	5.40	Ironstone	Ironstone	
37.90	38.50	0.60	Clay Red/White	Clay	
38.50	53.00	14.50	Sandstone Yellow	Sandstone	
53.00	54.00	1.00	Sandstone Yellow WB	Sandstone	
54.00	60.00	6.00	Sandstone Yellow	Sandstone	

Remarks

07/07/1997: Form A Remarks:
Rem: Gravel pack from 30m to 60m, Bento plug from 30m to 28m, Backfill from 38m to 3m, Bento Plug from 3m to 1m
03/12/1997: Drilled depth 60 m. Slotted depth 54 - 57 m.
03/12/1997: Top of PVC casing = 227.764 metres AHD RL Ground = 226.894m
Top of PVC casing used as zero reference point.
04/02/1998: New equipment installed.
Dataflow model 392 datalogger in, s/n 42226
Dataflow 3 metre capacitance sensor in, s/n unknown
26/02/1999: Sensor calibrated.
Calibrated slope -2807
Calibrated offset 9654.299
26/02/1999: Sensor o-ring set to 43.11 m. below PVC casing.
03/05/2000: Logging interval set to 3 hours.
20/03/2001: Datalogger replaced.
Dataflow model 392 datalogger out, s/n 42226
Dataflow model 392 datalogger in, s/n 43231
20/03/2001: Logging interval changed to 12 hours.
29/05/2002: Datalogger/sensor replaced.
Dataflow model 392 datalogger out, s/n 43231
Dataflow 3 metre capacitance sensor out, s/n unknown
Diver TD sensor/datalogger in, s/n 29093
Diver Barometric sensor/datalogger in, 27720
29/05/2002: Sensort tip set to 46.13 m. below PVC casing.
29/05/2004: 0.1 m. data resolution from this point.
22/09/2004: data collection
07/05/2005: data collection
08/03/2006: Logger removed for cal check
14/03/2006: loggers re installed post cal check
13/07/2006: new set level for sensor 51.30m
13/07/2006: GW075004 - From Parramatta take Windsor Rd too BaulkHam Hills
Turn right into OLD Northern RD at Bull & Bush Hotel
Follow Old Northern Rd, through Castle Hill,Dural,Glenorie & Sth Maroota continue towards Maroota
At Roberts Rd go approx 20m further along Old Northern Rd and turn right into second gate near cottage.
Turn left and follow along fence line for approx 20m
Bore (yellow standpipe) is located near fence line.

Access to this site requires the completion of "Site Induction/sign in-out" from the Sand Mine operator located in Roberts Rd,Maroota.

HB Maroota Pty Ltd
C/- Ralph Betts
P O Box 1778
GOSFORD NSW 2250
Ph 4368-4357
Mobile 0409-912536
Email hbresources@bigpond.com
13/07/2006: Access to this site requires the completion of "Site Induction" from Sand Mining company located in Roberts Rd,Maroota
13/07/2006: Combo lock installed (7232)
27/11/2006: cONC PAD TOO STEEL FLANGE PALTE 0.565m Conc Pad too PVC 0.855m
27/11/2006: Download 02
19/10/2007: D/L #3; Dip SWL=44.16 m (to pVC); EC=150; Temp =18.7
12/08/2008: Downloaded; Dip SWL=42.45m (to PVC); EC=166; Temp =18.7

22/01/2009: Downloaded; Dip SWL=42.10m (to PVC); EC=159; Temp =18.7
24/07/2009: Downloaded; Dip SWL=42.23m (to PVC); EC=147; Temp =18.7
24/01/2011: Site visited - Upon arrival Water Level = 42.65m EC = 152m/S Temp = 18.9 deg

Actual depth of sensor measured = 51.8m
07/04/2011: Site visited - Upon arrival Water Level = 42.94m EC = 140u/S Temp = 19.0 deg

Instrument changed OUT: Diver S/N 60246 IN: Solinst S/N 66752.
01/06/2011: Site visited - Water level = 42.90m EC = 142U/m Temp = 18.7Deg
02/08/2011: Site visited - Upon arrival Water Level = 42.883m EC = 145u/S Temp = 18.7 deg
20/09/2011: Site visited - Upon arrival Water Level = 42.418m EC = 141u/S Temp = 18.9 deg
29/11/2011: Site visited - Upon arrival Water Level = 42.528m EC = 146u/S Temp = 19.1 deg
24/01/2012: Site visited - Upon arrival Water Level = 42.437m EC = 143u/S Temp = 18.7 deg
02/05/2012: Site visited - Upon arrival Water Level = 41.317m EC = 153u/S Temp = 18.7 deg
26/06/2012: Logger lost - cable broken logger fell into bore. No logger replacement available.
14/08/2012: Site visited - Upon arrival Water Level = 41.377m EC = 233u/S Temp = 18.7 deg

New logger installed - Solinst Serial No. = 1022337
26/09/2012: Primary Client changed from GWSE to GWA on 26/09/2012.
24/10/2012: Site visited - Upon arrival Water Level = 41.745m EC = 229u/S Temp = 18.7 deg

Solinst logger removed S/No. = 22337

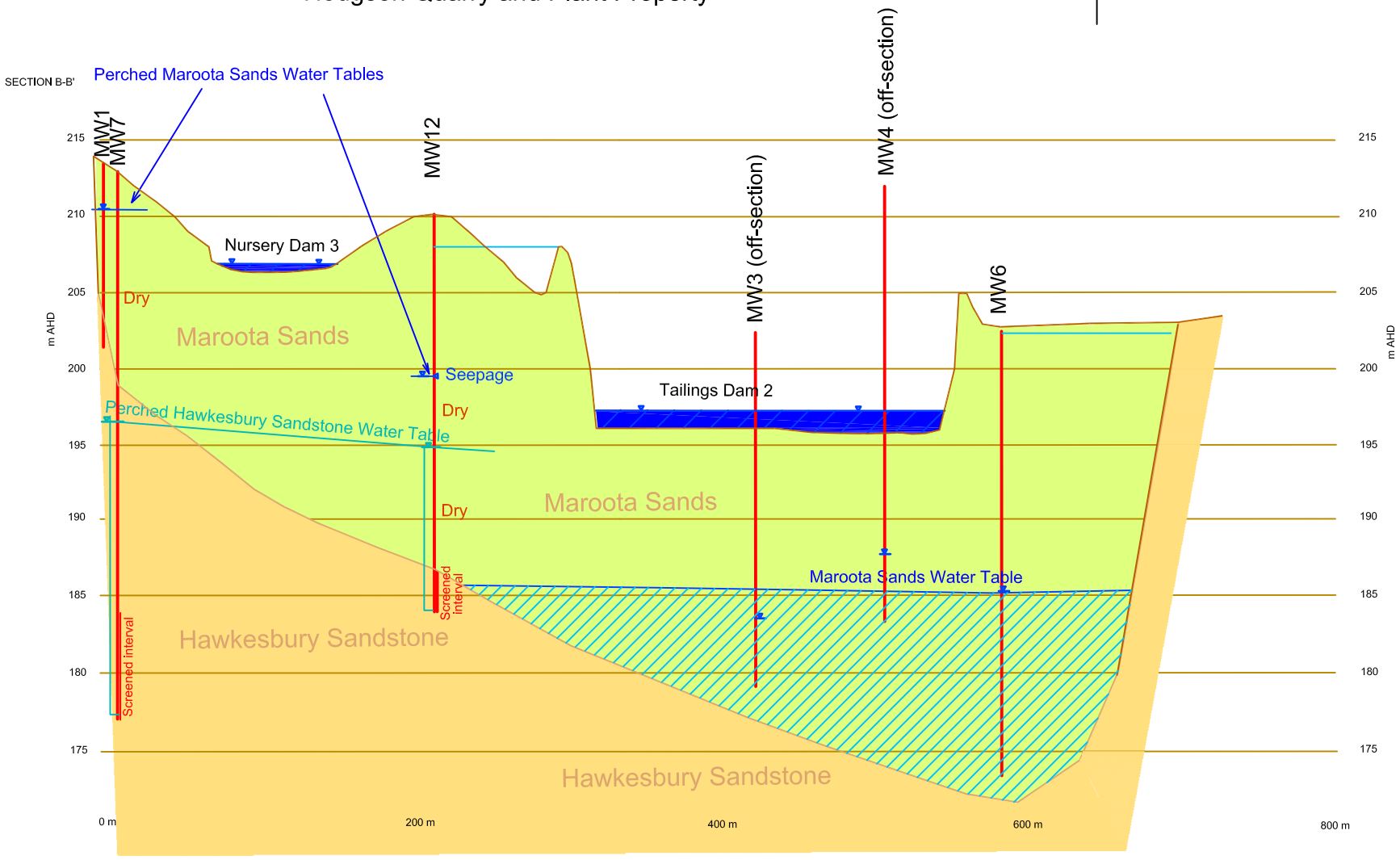
Troll logger installed S/No. = 320538
12/12/2012: Routine Site visit - Upon arrival Water Level = 42.003m EC = 162u/s Temp = 18.7 deg
14/03/2013: Routine Site visit - Upon arrival Water Level = 41.959m EC = 162u/s Temp = 18.7 deg
23/04/2013: Routine Site visit - Upon arrival Water Level = 41.988m EC = 155u/s Temp = 18.7 deg
06/08/2013: Routine Site visit - Upon arrival Water Level = 42.195m EC = 140u/s Temp = 18.7 deg
Last logger level = 41.996m, Last logged Temp = 18.4 deg
09/10/2013: Routine Site visit - Upon arrival Water Level = 45.527m EC = 128u/s Temp = 18.7 deg
Last logger level = 42.122m, Last logged Temp = 18.4 deg
20/03/2014: Routine Site visit: SWL = 43.318 m
EC = 126u/s Temp = 18.7 deg
Last logger level = 42.424m, Last logged Temp = 18.4 deg
15/05/2014: Routine Site visit: SWL = 42.737 m
EC = 123 u/s Temp = 18.7 deg
Last logger level = 43.292 m, Last logged Temp = 18.4 deg
27/05/2014: Routine Site visit: SWL = 42.575 m
EC = 132 u/s Temp = 18.8 deg
Last logger level = N/A m, Last logged Temp = N/A deg
Cable extended 4m to approx 46m
22/07/2014: Routine Site visit: SWL = 42.535 m
EC = 96 u/s Temp = 18.6 deg
Last logger level = 42.446 m, Last logged Temp = 18.3 deg
09/10/2014: Regular site visit: SWL = 42.345 m
Measured EC = 133 us/cm Measured Temp = 18.7 deg
Last logged level= 42.361 m Last logged temp = 18.4 deg.
Logger time 1 hour fast. Adjusted in editing.
04/02/2015: Regular site visit: SWL = 42.447 m
Measured EC = 166 us/cm Measured Temp = 18.7 deg
Last logged level= 42.498 m Last logged temp = 18.4 deg.
Logger time 1 hour behind. Adjusted in editing.
20/08/2015: Regular site visit: SWL = 41.845 m
Measured EC = 192 us/cm Measured Temp = 18.6 deg

***** End of GW075004 *****

APPENDIX C

CROSS-SECTIONS

Hodgson Quarry and Plant Property



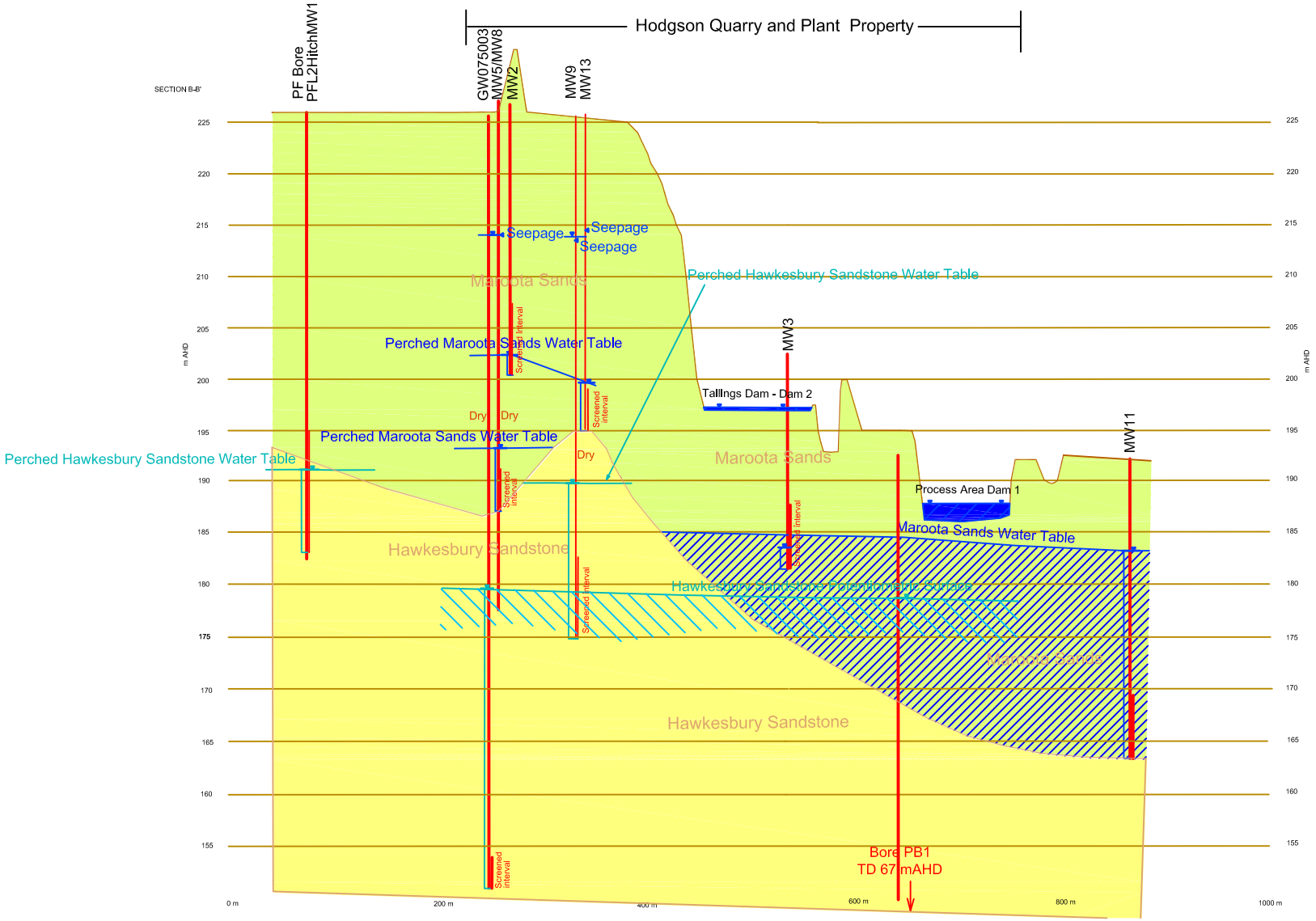
DATE:	19 September 2017	SCALE:	N/A
AUTHOR: PD	CHECKED: PD	PROJECT NO:	16-318
DRAWING NO:	0318-008c	REVISION:	C

Dundon Consulting Pty Ltd

Hodgson Quarry and Plant Pty Ltd

ROBERTS ROAD MAROOTA SAND QUARRY
CROSS-SECTION A-A'
(through piezometers MW1, MW7, MW12, MW3, MW4 and MW6)

Figure C1



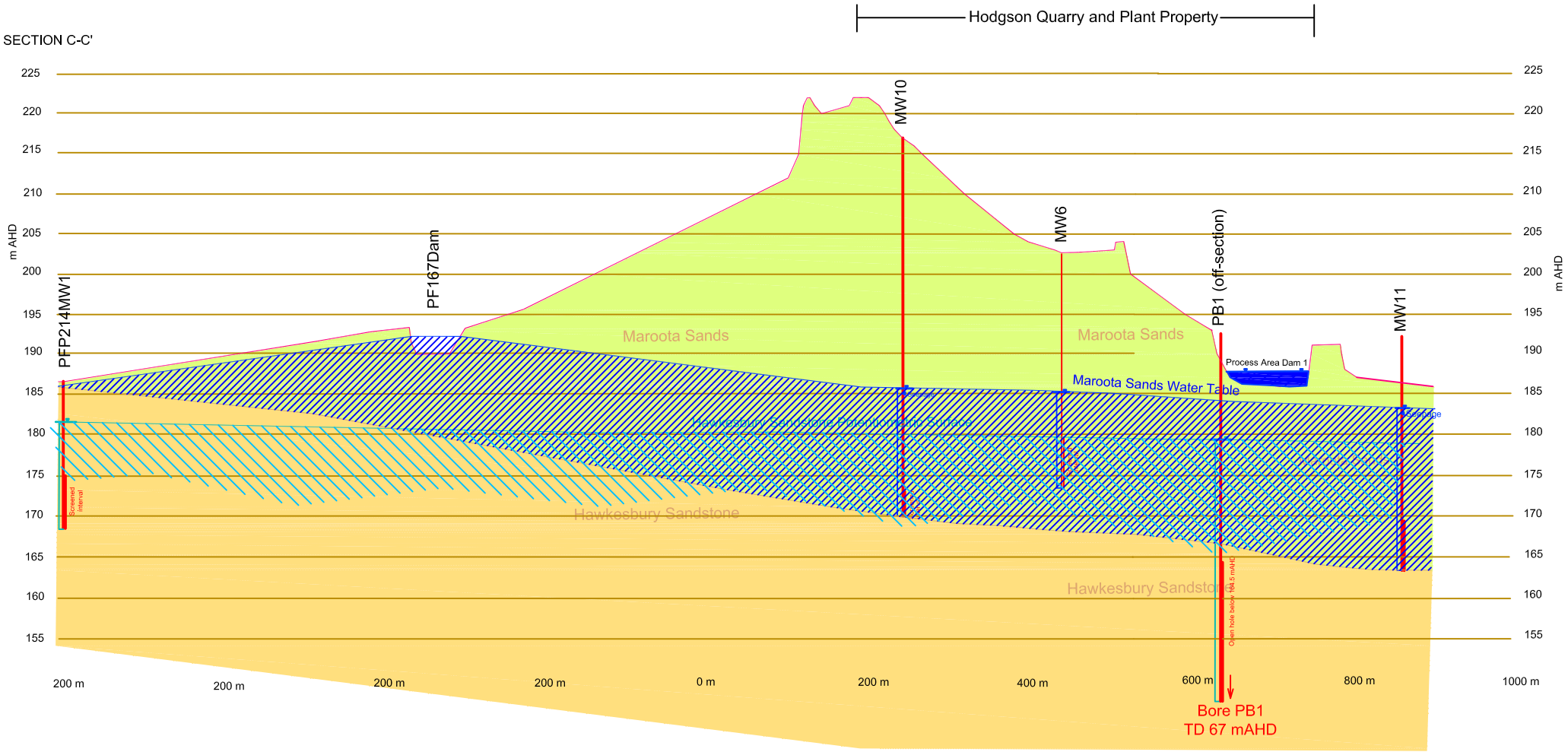
DATE:	22 September 2017	SCALE:	N/A
AUTHOR: PD	CHECKED: PD	PROJECT NO:	16-318
DRAWING NO:	0318-015b	REVISION:	B

Dundon Consulting Pty Ltd

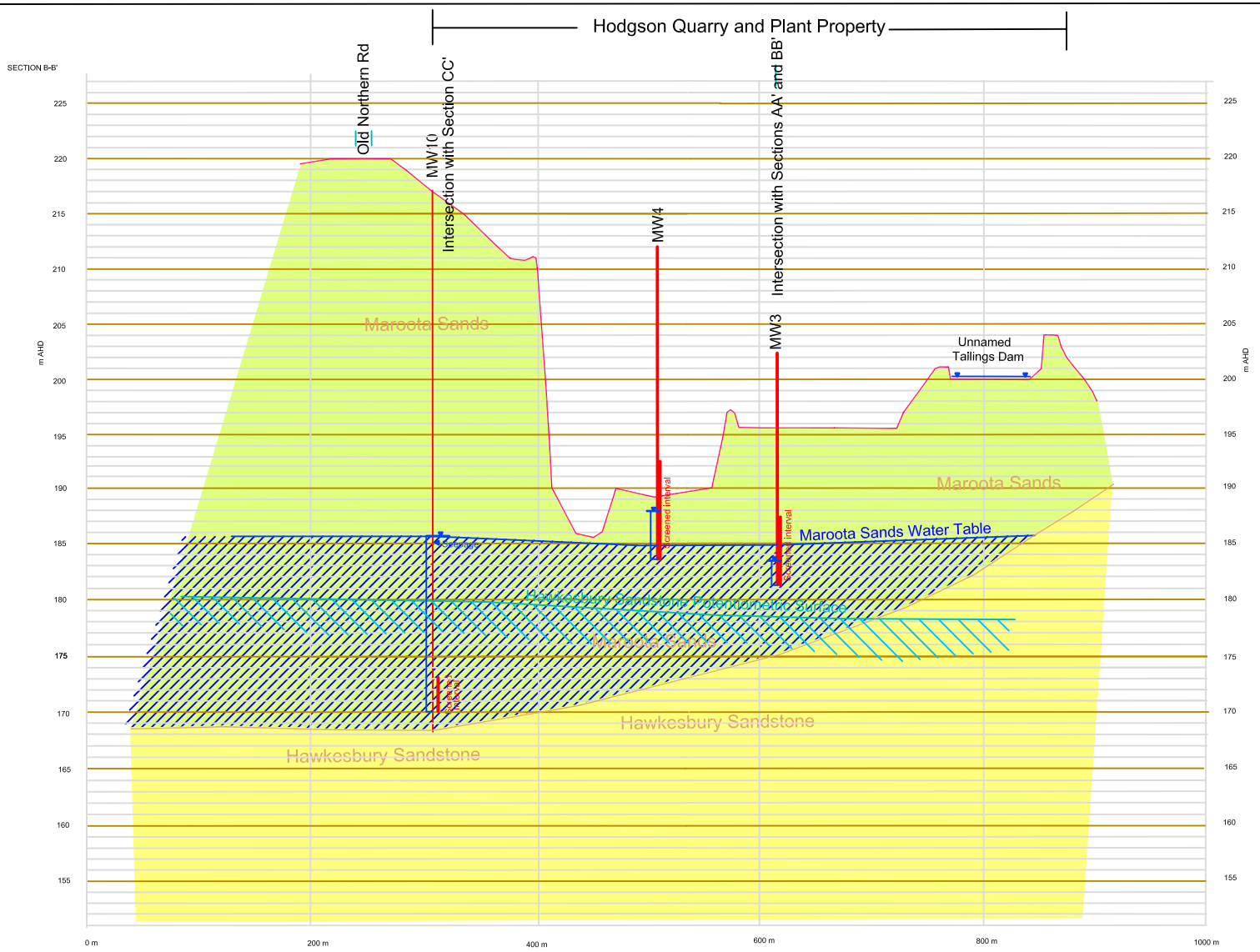
Hodgson Quarry and Plant Pty Ltd

ROBERTS ROAD MAROOTA SAND QUARRY
CROSS-SECTION B-B'
(through piezometers PFHitchMW1, MW5, MW8, MW9, MW13, MW3 and MW11)

Figure C2



DATE: 22 September 2017		SCALE: N/A	**Hodgson Quarry and Plant Pty Ltd**
AUTHOR: PD	CHECKED: PD	PROJECT NO: 16-318	**ROBERTS ROAD MAROOTA SAND QUARRY CROSS-SECTION C-C' (through piezometers PF214MW1, PF166Dam, MW10, MW6 and MW12)**
DRAWING NO: 0318-010b		REVISION: B	
Dundon Consulting Pty Ltd			**Figure C3**



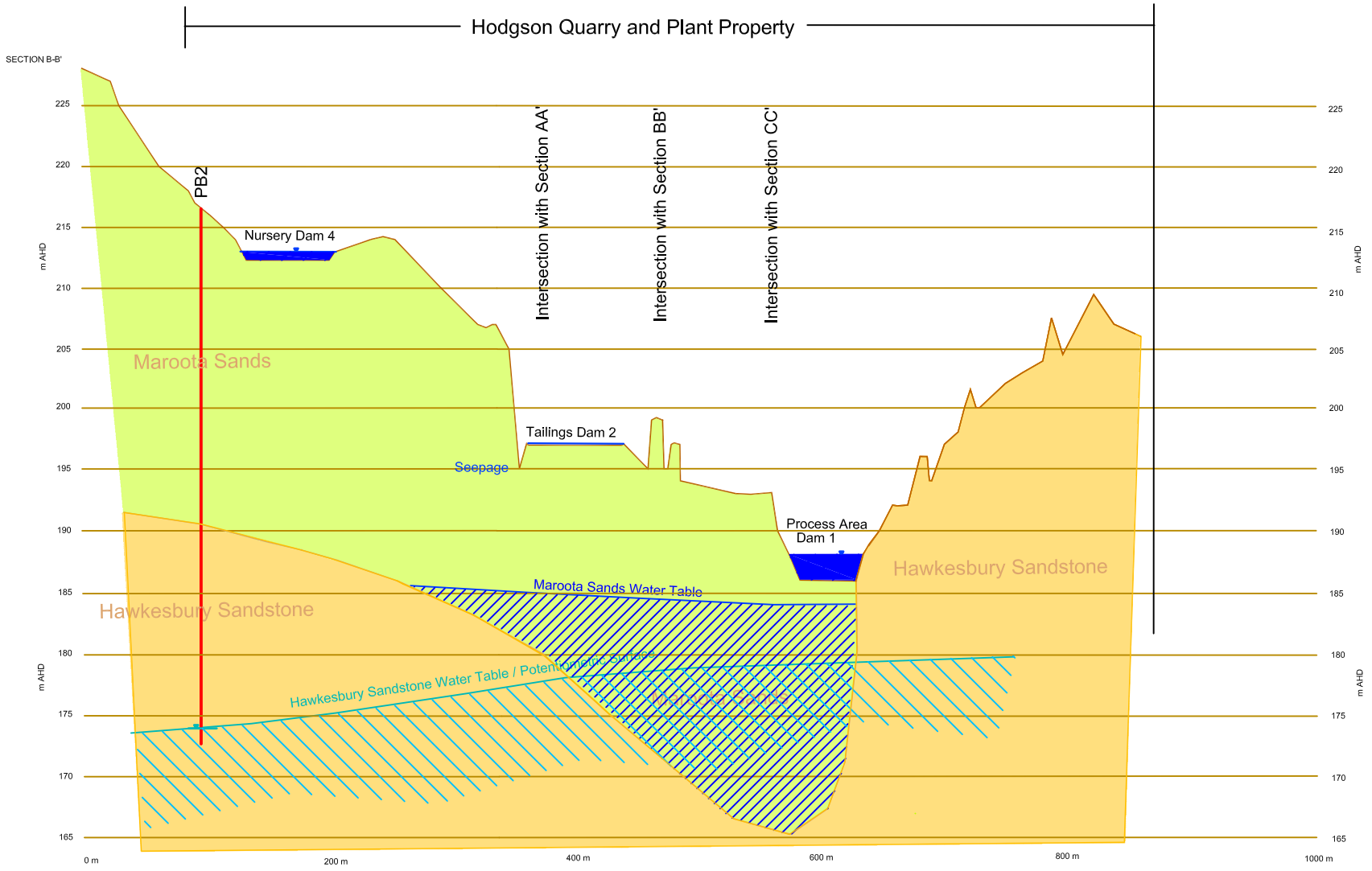
DATE:	21 September 2017	SCALE:	N/A
AUTHOR: PD	CHECKED: PD	PROJECT NO:	16-318
DRAWING NO:	0318-010b	REVISION:	B

Dundon Consulting Pty Ltd

Hodgson Quarry and Plant Pty Ltd

ROBERTS ROAD MAROOTA SAND QUARRY
CROSS-SECTION D-D'
(through piezometers MW3, MW4 and MW10)

FIgure C4



DATE:	19 September 2017	SCALE:	N/A
AUTHOR: PD	CHECKED: PD	PROJECT NO:	16-318
DRAWING NO:	0318-011c	REVISION:	C

Dundon Consulting Pty Ltd

Hodgson Quarry and Plant Pty Ltd

ROBERTS ROAD MAROOTA SAND QUARRY
CROSS-SECTION EE'
(through bore PB1, seepage, tailings dam and main dam)

Figure C5

APPENDIX D

BORE WATER LEVEL HYDROGRAPHS

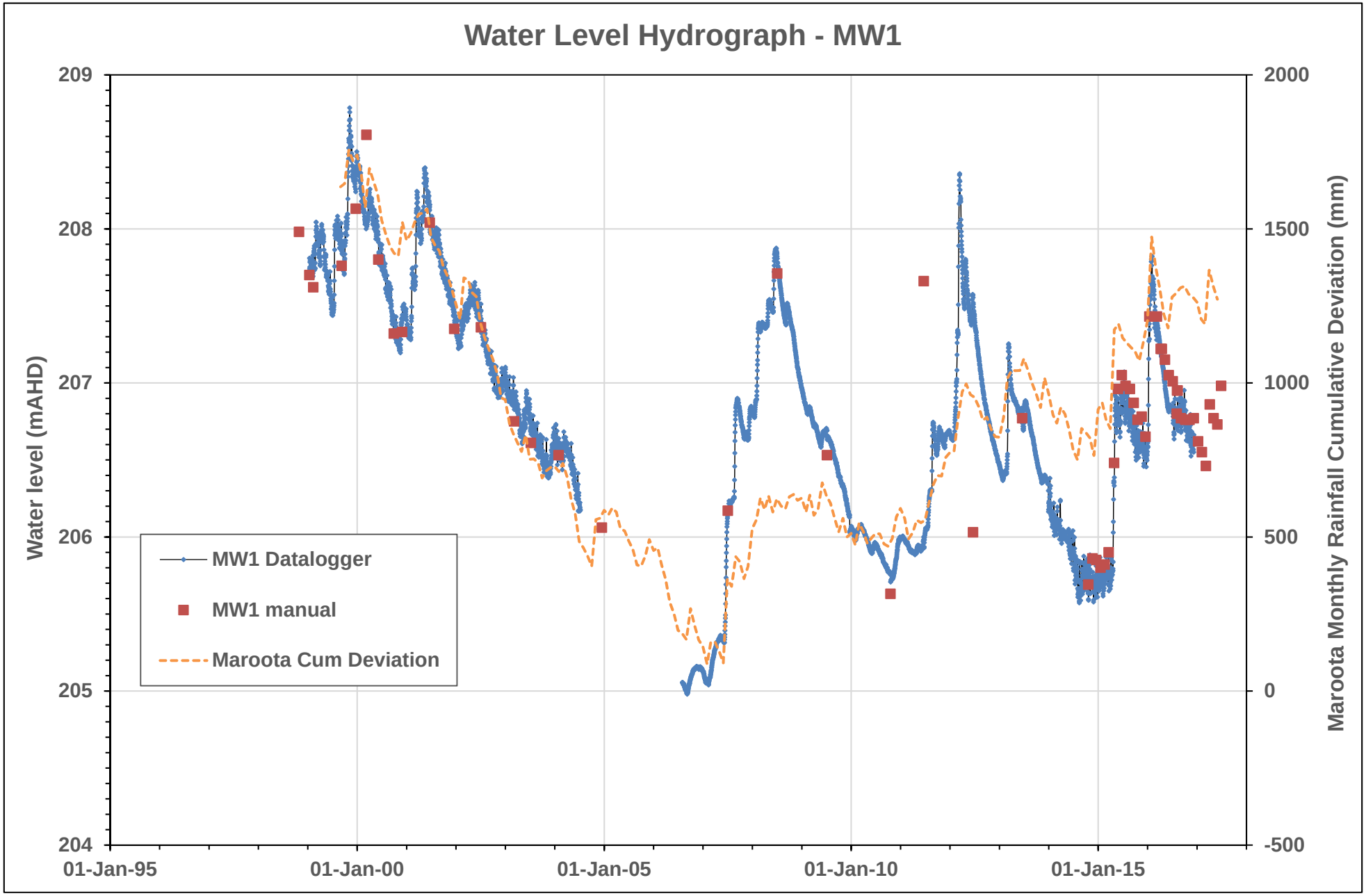


Figure D1: Water Level Hydrograph - MW1

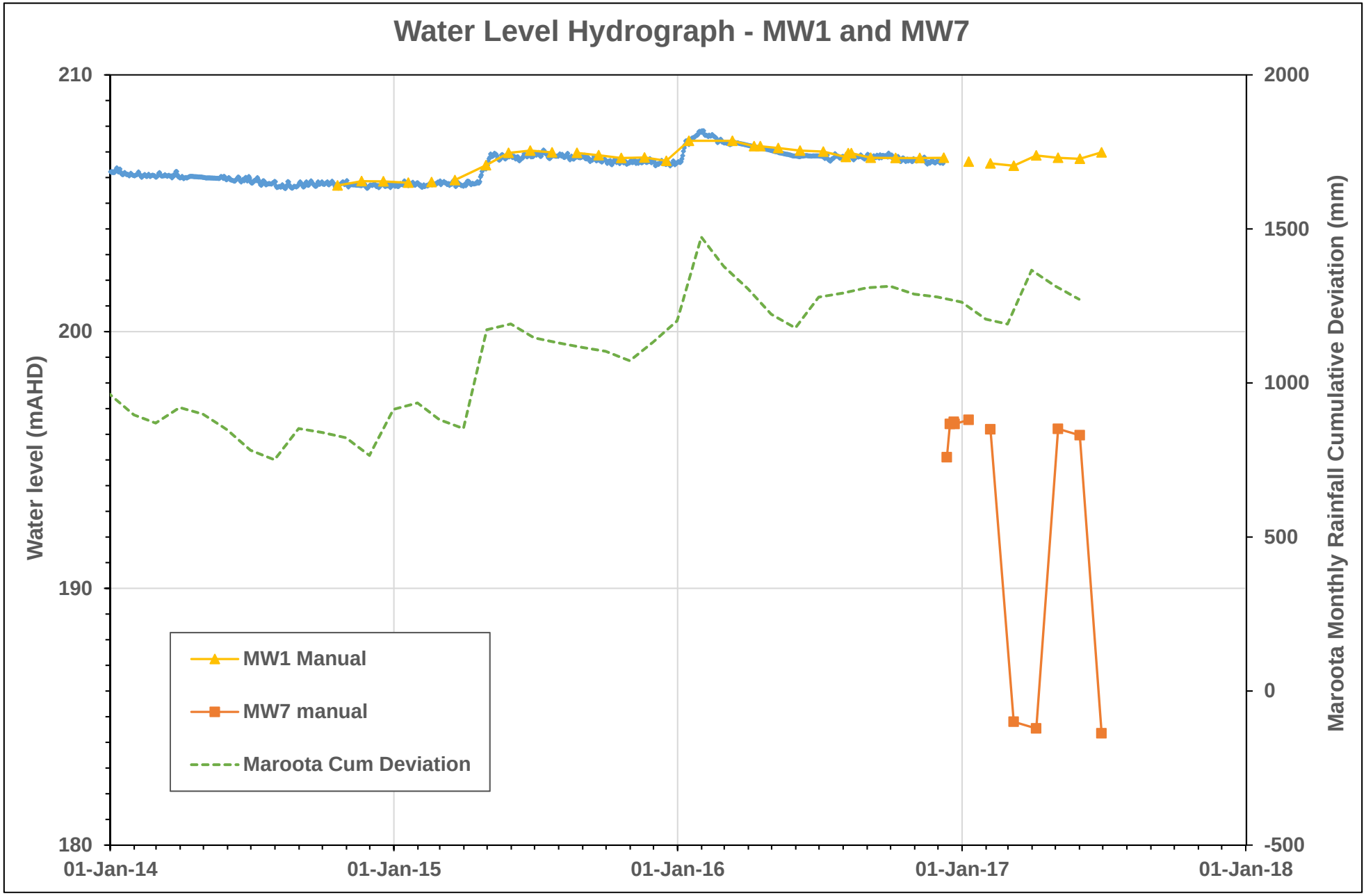


Figure D2: Water Level Hydrographs - MW1 and MW7

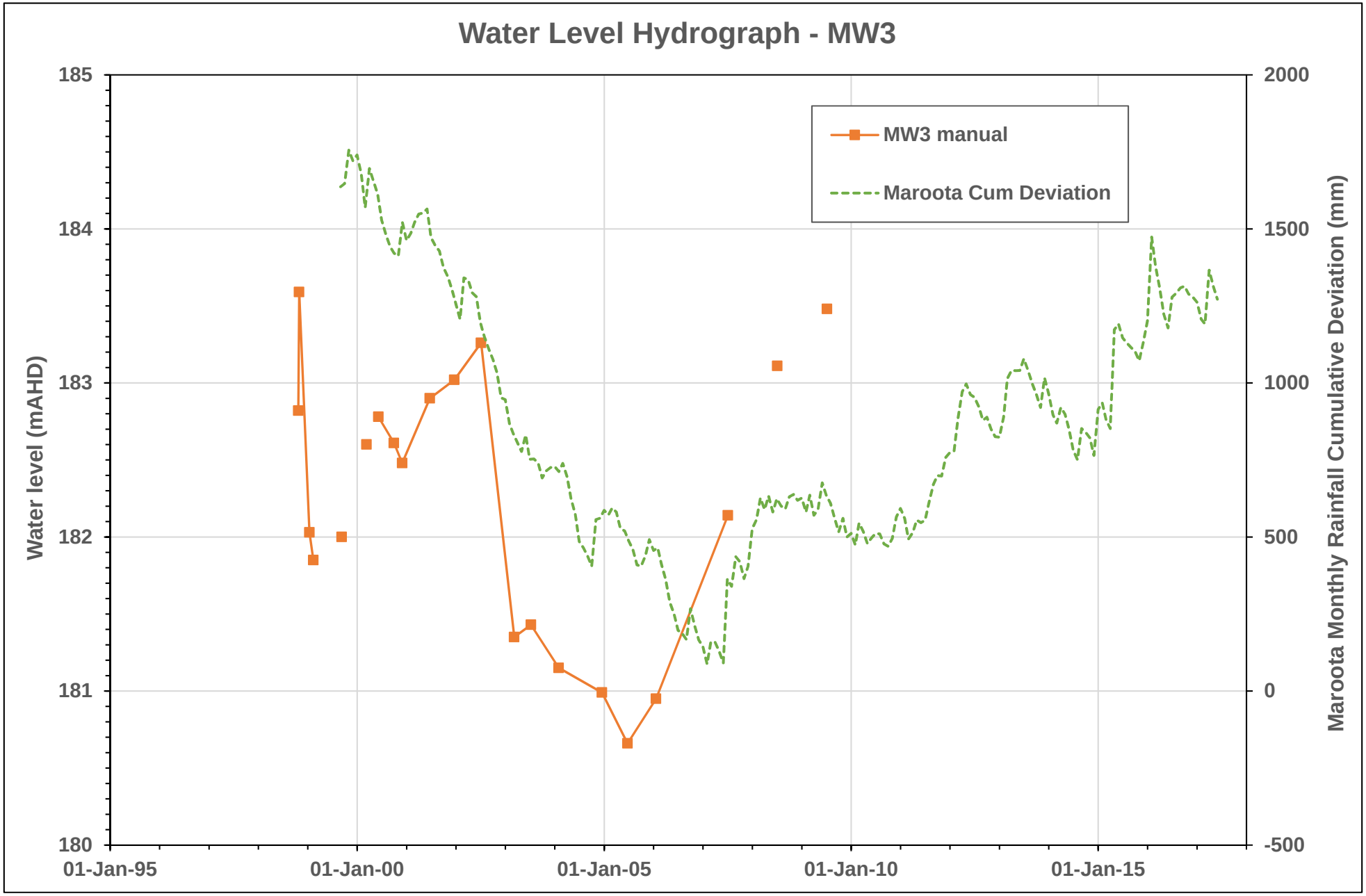


Figure D3: Water Level Hydrograph - MW3

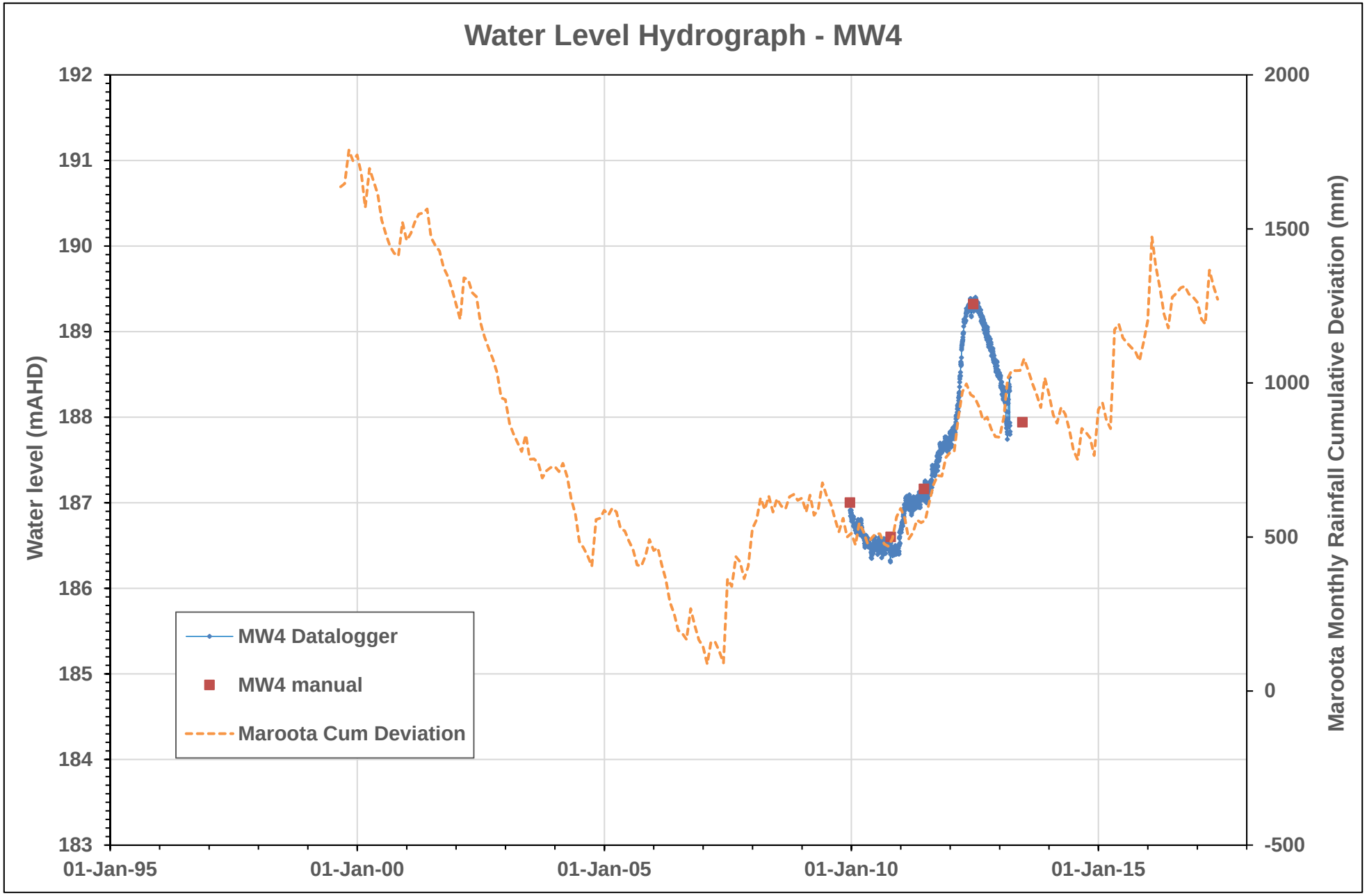


Figure D4: Water Level Hydrograph - MW4

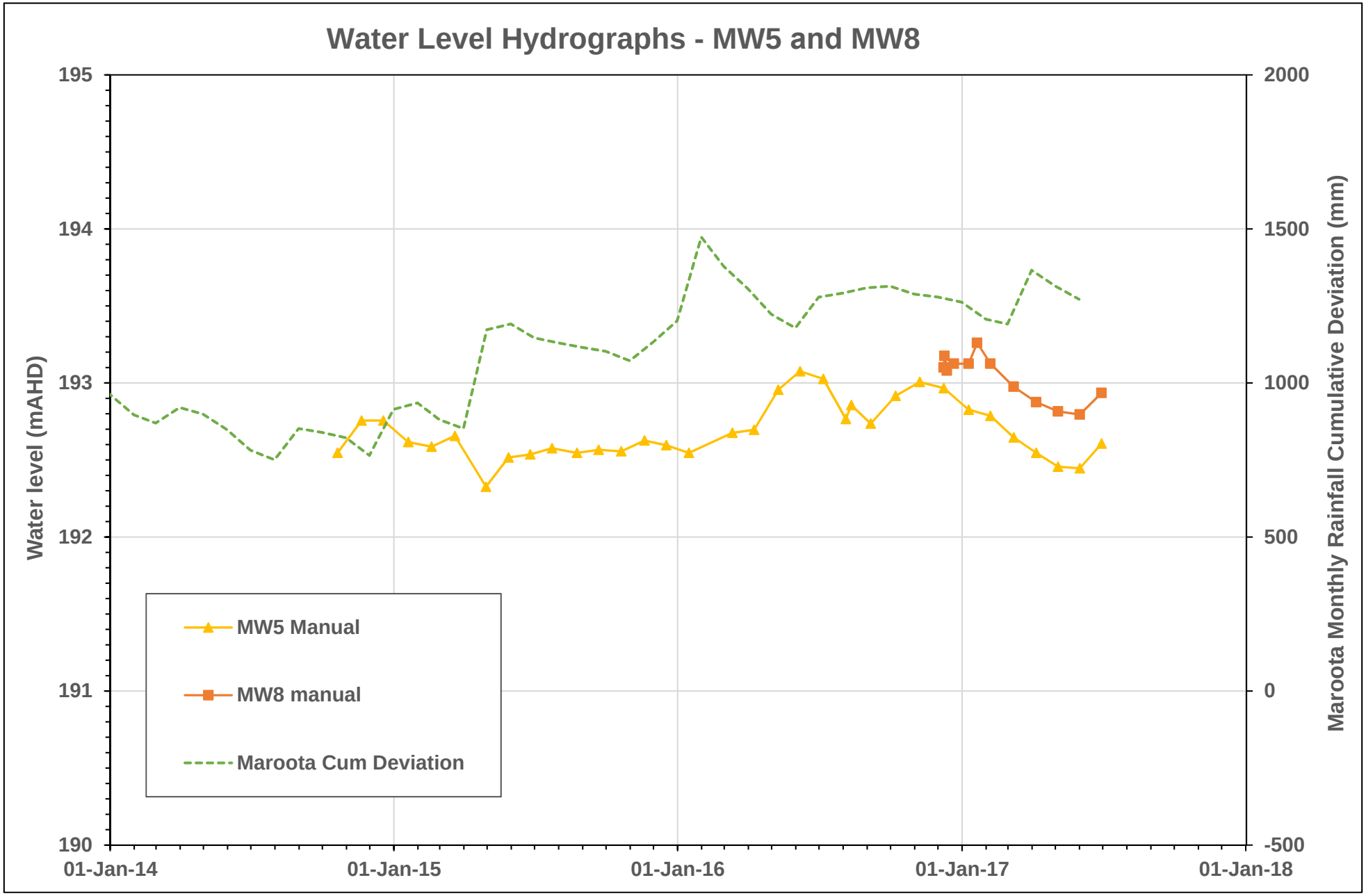


Figure D5: Water Level Hydrographs - MW5 and MW8

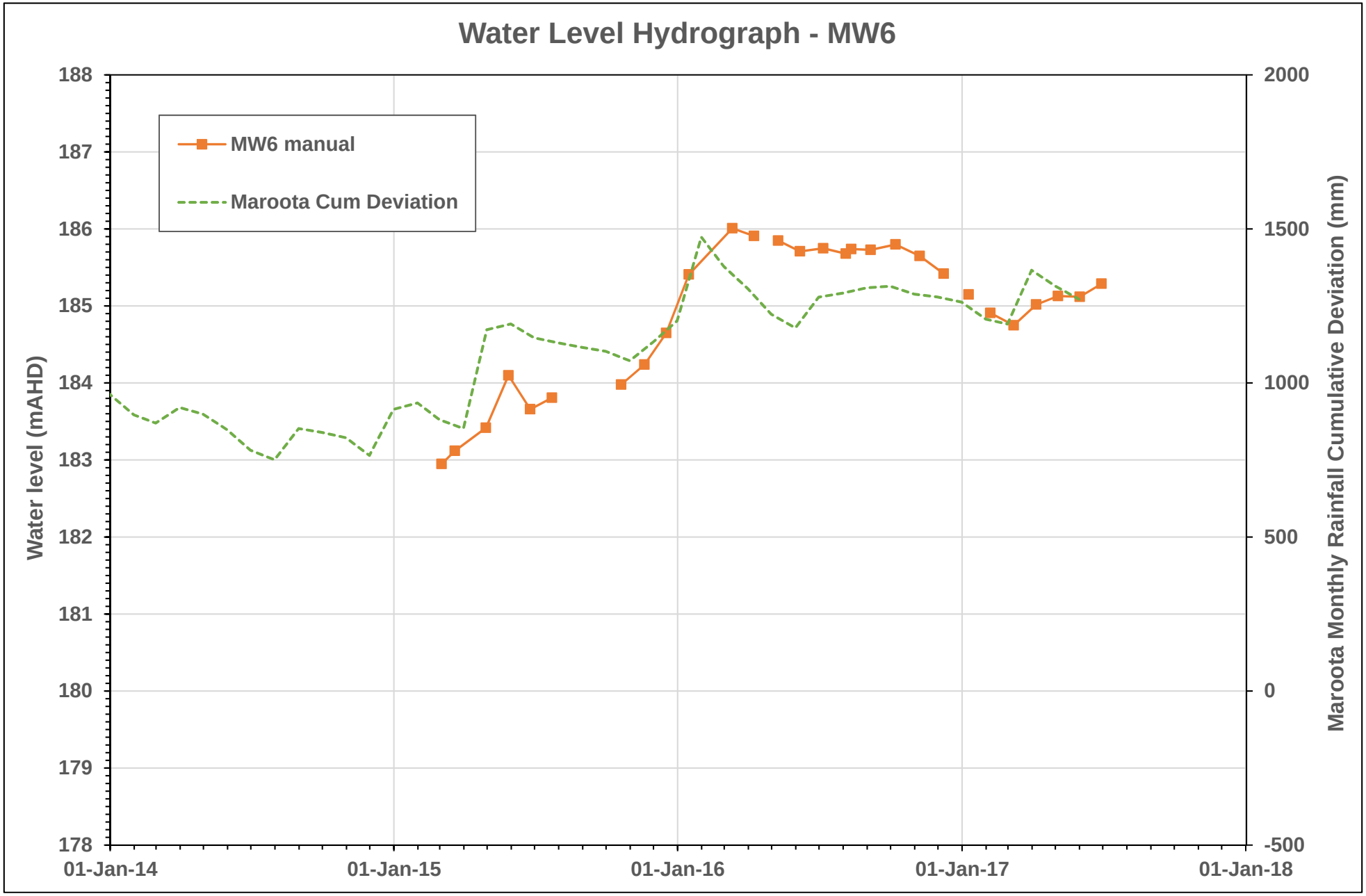


Figure D6: Water Level Hydrograph - MW6

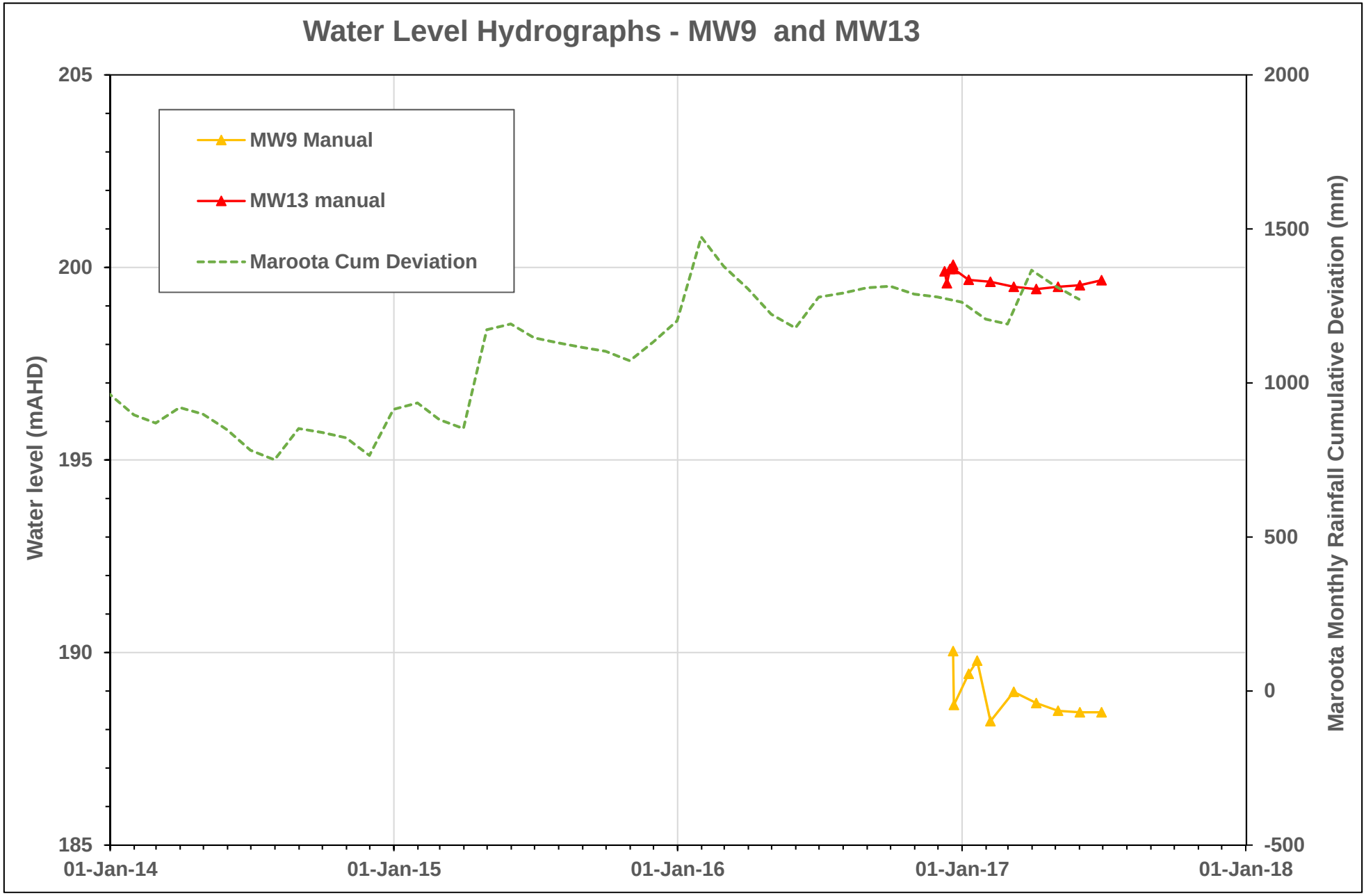


Figure D7: Water Level Hydrographs - MW9 and MW13

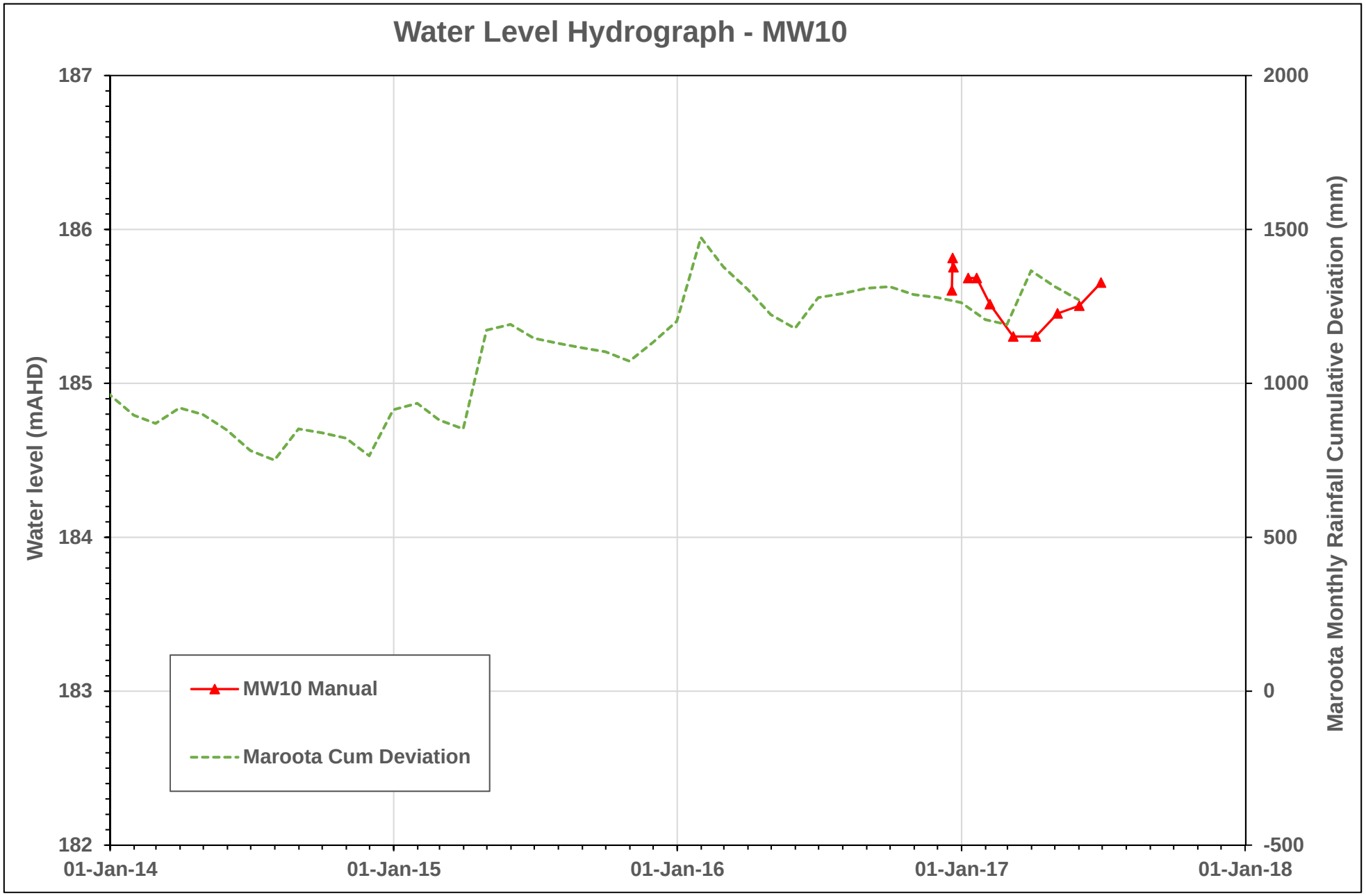


Figure D8: Water Level Hydrograph - MW10

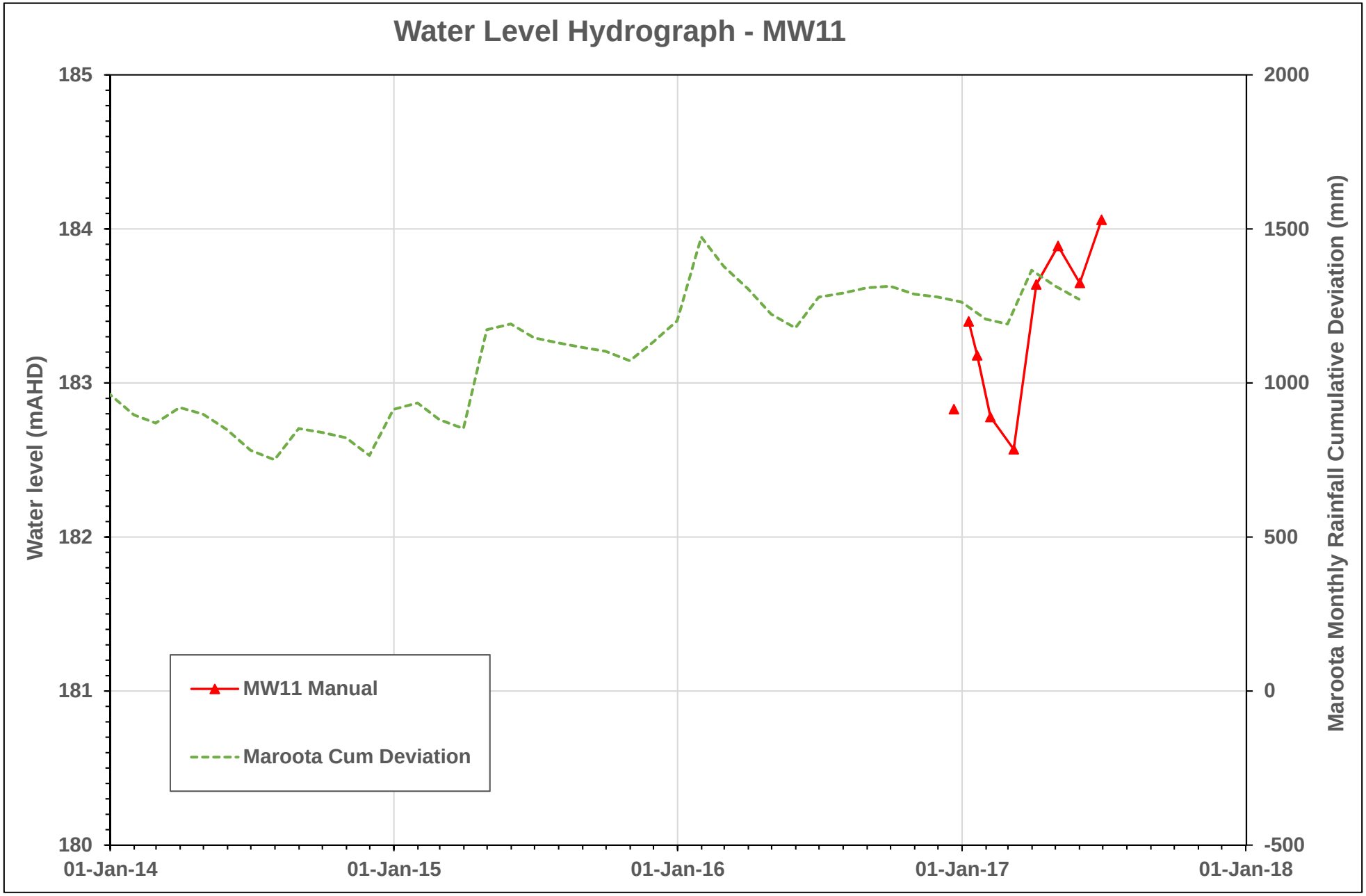


Figure 9: Water Level Hydrograph - MW11

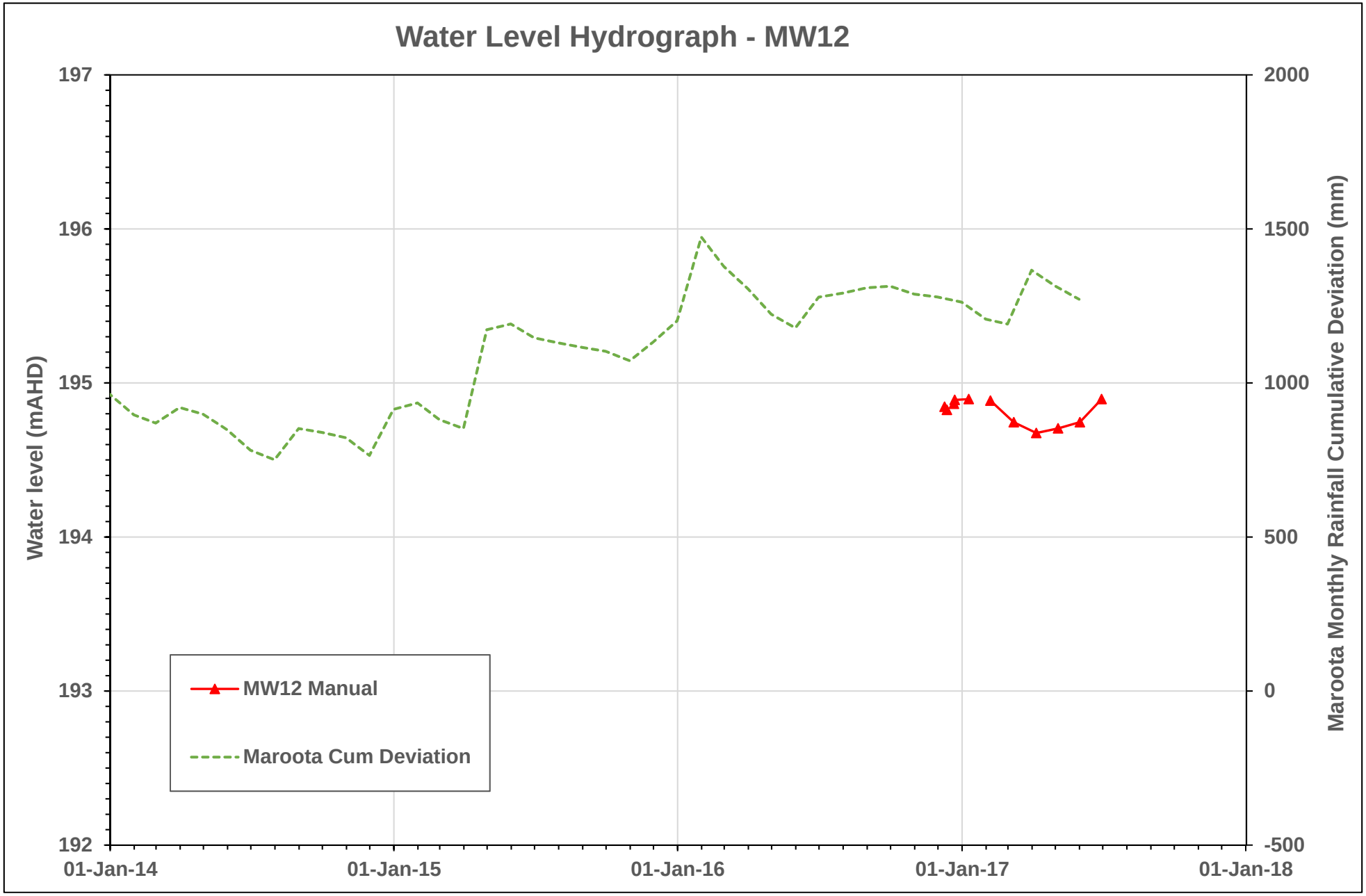


Figure D10: Water Level Hydrograph - MW12

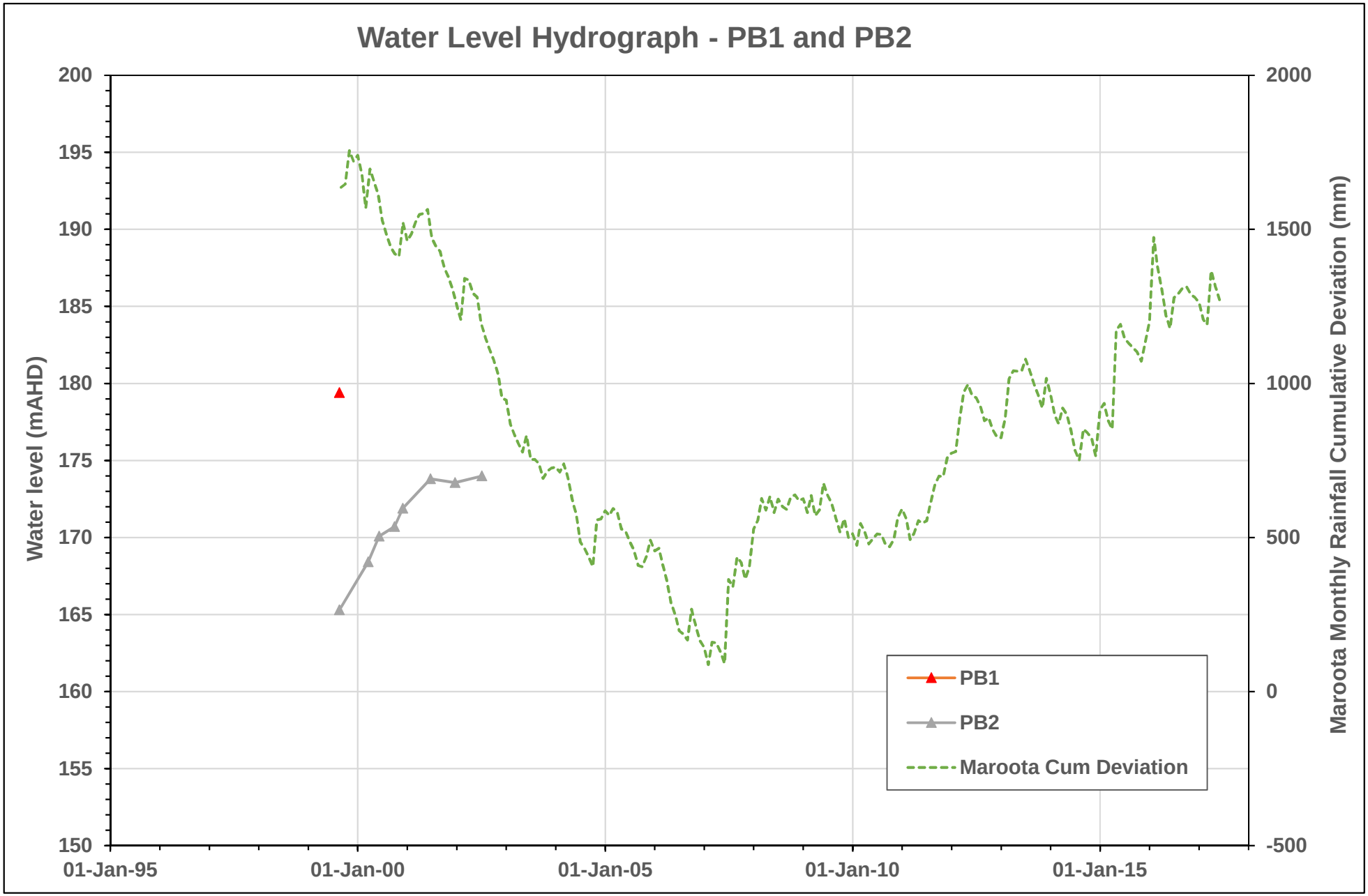


Figure D11: Water Level Hydrographs - PB1 and PB2

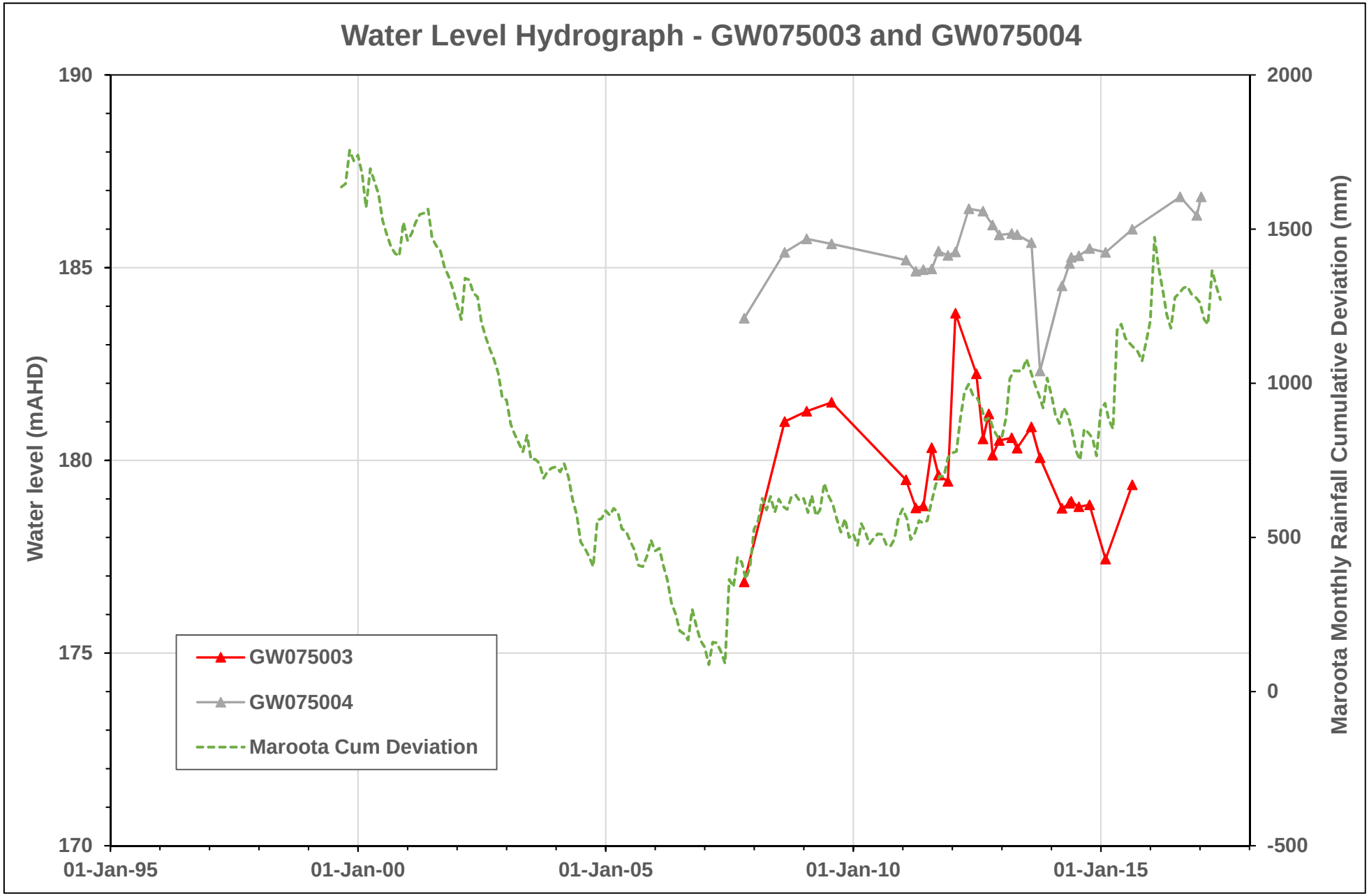


Figure D12: Water Level Hydrographs - GW075003 and GW075004

APPENDIX E

GROUNDWATER QUALITY – LABORATORY WATER QUALITY ANALYSIS RESULTS

Table E1: Laboratory Water Quality Analysis Results

Bore	Aquifer	Date sampled	pH	EC @ 25°C	TDS @ 180°C	OH alkalinity	CO_3 alkalinity	HCO_3 alkalinity	SO_4	Cl	Ca	Mg	Na	K	Total anions	Total cations
Units			pH units	µS/cm	mg/L	mg/L $CaCO_3$	mg/L $CaCO_3$	mg/L $CaCO_3$	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/L	meq/L
MW1	Maroota Sands	23 Oct 98	4.96	246	186	<1	<1	4	3	50	3	3	27	3		
		19 Oct 10	4.24	174	150	<1	<1	3.6	4	30	1	6	12	2		
		22 Jun 11	5.18	122	169	<1	<1	4.8	8	143	5	5	19	2		
		20 Jun 12	4.87	174	320	<1	<1	<1	8	31	1	5	13	6		
		19 Jun 13	4.93	312	820	<1	<1	<1	8	59	6	12	22	6	1.83	2.40
		27 Jul 17	4.1	355	247			<5	4	47	5	14	25	4		
MW3	Maroota Sands	23 Oct 98	5.88	381	266	<1	<1	4	3	50	3	9	27	3		
MW4	Maroota Sands	19 Oct 10	4.58	138	100	<1	<1	2.4	1	29	<1	3	16	<1		
		22 Jun 11	3.23	151	99	<1	<1	2.4	2	33	<1	3	17	1		
		20 Jun 12	4.45	141	123	<1	<1	<1	22	26	<1	4	14	1		
		19 Jun 13	4.49	152	95	<1	<1	<1	<1	36	<1	4	16	1	1.02	1.05
MW5	Maroota Sands	19 Jun 13	4.13	140	158	<1	<1	<1	1	34	<1	2	15	<1		
		27 Jul 17	5.1	113	61			5	2	22	1	1	13	2		
MW6	Maroota Sands	27 Jul 17	9.3	103	55			19	<1	18	2	1	12	5		
MW7	Hawkesbury Sandstone	22 Dec 16	7.00	255	282	<1	<1	50	17	27	4	1	46	<1	2.11	2.28
		27 Jul 17	5.3	192	215			12	9	29	<0.5	<0.5	59	<0.5		
MW8	Maroota Sands	20 Jan 17	5.68	161	114	<1	<1	5	1	36	3	3	26	<1	1.14	1.53
		27 Jul 17	5.1	178	118			8	2	37	4	3	26	<0.5		
MW9	Hawkesbury Sandstone	20 Jan 17	6.71	175	134	<1	<1	18	4	32	8	2	25	<1	1.34	1.34
		27 Jul 17	4.9	148	96			<5	2	24	3	2	16	0.8		
MW10	Maroota Sands	20 Jan 17	5.45	184	104	<1	<1	2	<1	42	1	4	30	<1	1.22	1.22
		27 Jul 17	4.7	180	108			<5	<1	39	0.6	4	27	0.6		
MW11	Maroota Sands	20 Jan 17	6.34	169	98	<1	<1	5	7	34	4	2	24	3	1.20	1.20
		27 Jul 17	4.7	154	90			<5	<1	32	<0.5	2	19	1		

Table E1: Laboratory Water Quality Analysis Results

Bore	Aquifer	Date sampled	pH	EC @ 25°C	TDS @ 180°C	OH alkalinity	CO_3 alkalinity	HCO_3 alkalinity	SO_4	Cl	Ca	Mg	Na	K	Total anions	Total cations
MW12	Hawkesbury Sandstone	22 Dec 16	6.12	156	110	<1	<1	8	12	21	2	<1	23	3	1.00	1.18
		27 Jul 17	5.3	96	72			11	7	13	2	0.9	12	<0.5		
MW13	Maroota Sands	16 Dec 16	6.65	204	105	<1	<1	17	5	34	4	2	26	3	1.40	1.57
		27 Jul 17	4.9	134	92			<5	1	27	2	2	16	<0.5		
PB1	Hawkesbury Sandstone	27 Jul 17	4.6	148	88			<5	<1	30	<0.5	3	19	0.7		
PB2	Hawkesbury Sandstone	12 Sep 05	4.52	113	77			<1	<1	34	<1	3	17	<1		
Process Dam 1	-	27 Jul 17	4.5	134	90			<5	4	25	<0.5	2	16	2		
Tailings Dam 2	-	27 Jul 17	4.5	139	75			<5	4	25	<0.5	2	17	3		
Nursery Dam 3	-	27 Jul 17	6.6	133	77			13	9	20	3	3	13	4		
Nursery Dam 4	-	27 Jul 17	6.6	116	63			15	3	20	2	3	13	2		
Former Tailings Dam	-	27 Jul 17	4.9	77	49			<5	2	15	<0.5	1	11	1		

Table E1: Laboratory Water Quality Analysis Results

Bore	Aquifer	Date sampled	pH	EC @ 25°C	TDS @ 180°C	OH alkalinity	CO_3 alkalinity	HCO_3 alkalinity	SO_4	Cl	Ca	Mg	Na	K	Total anions	Total cations	Oil and grease
Units			pH units	µS/cm	mg/L	mg/L $CaCO_3$	mg/L $CaCO_3$	mg/L $CaCO_3$	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/L	meq/L	mg/L
MW1	Maroota Sands	23 Oct 98	4.96	246	186	<1	<1	4	3	50	3	3	27	3			
		19 Oct 10	4.24	174	150	<1	<1	3.6	4	30	1	6	12	2			
		22 Jun 11	5.18	122	169	<1	<1	4.8	8	143	5	5	19	2			
		20 Jun 12	4.87	174	320	<1	<1	<1	8	31	1	5	13	6			
		19 Jun 13	4.93	312	820	<1	<1	<1	8	59	6	12	22	6	1.83	2.40	
		27 Jul 17	4.1	355	247			<5	4	47	5	14	25	4			
		11 Jan 18	4.14	396	247*												<5
		5 April 18	4.2	385													
MW3	Maroota Sands	23 Oct 98	5.88	381	266	<1	<1	4	3	50	3	9	27	3			
MW4	Maroota Sands	19 Oct 10	4.58	138	100	<1	<1	2.4	1	29	<1	3	16	<1			
		22 Jun 11	3.23	151	99	<1	<1	2.4	2	33	<1	3	17	1			
		20 Jun 12	4.45	141	123	<1	<1	<1	22	26	<1	4	14	1			
		19 Jun 13	4.49	152	95	<1	<1	<1	<1	36	<1	4	16	1	1.02	1.05	
MW5	Maroota Sands	19 Jun 13	4.13	140	158	<1	<1	<1	1	34	<1	2	15	<1			
		27 Jul 17	5.1	113	61			5	2	22	1	1	13	2			
MW6	Maroota Sands	27 Jul 17	9.3	103	55			19	<1	18	2	1	12	5			
		11 Jan 18	7.09	110	69*												<5
		5 April 18	10.3	406													
MW7	Hawkesbury Sandstone	22 Dec 16	7.00	255	282	<1	<1	50	17	27	4	1	46	<1	2.11	2.28	
		27 Jul 17	5.3	192	215			12	9	29	<0.5	<0.5	59	<0.5			
		11 Jan 18	5.45	170	106*												<5
		5 April 18	5.8	237													

Table E1: Laboratory Water Quality Analysis Results

Bore	Aquifer	Date sampled	pH	EC @ 25°C	TDS @ 180°C	OH alkalinity	CO_3 alkalinity	HCO_3 alkalinity	SO_4	Cl	Ca	Mg	Na	K	Total anions	Total cations	Oil and grease
MW8	Maroota Sands	20 Jan 17	5.68	161	114	<1	<1	5	1	36	3	3	26	<1	1.14	1.53	
		27 Jul 17	5.1	178	118			8	2	37	4	3	26	<0.5			
		11 Jan 18	4.66	183	114*												<5
MW9	Hawkesbury Sandstone	20 Jan 17	6.71	175	134	<1	<1	18	4	32	8	2	25	<1	1.34	1.34	
		27 Jul 17	4.9	148	96			<5	2	24	3	2	16	0.8			
		11 Jan 18	4.64	183	73*												<5
		5 April 18	4.6	148													
MW10	Maroota Sands	20 Jan 17	5.45	184	104	<1	<1	2	<1	42	1	4	30	<1	1.22	1.22	
		27 Jul 17	4.7	180	108			<5	<1	39	0.6	4	27	0.6			
		11 Jan 18	4.53	186	116*												<5
		5 April 18	4.4	190													
MW11	Maroota Sands	20 Jan 17	6.34	169	98	<1	<1	5	7	34	4	2	24	3	1.20	1.20	
		27 Jul 17	4.7	154	90			<5	<1	32	<0.5	2	19	1			
		11 Jan 18	4.69	158	99*												<5
		5 April 18	4.6	151													
MW12	Hawkesbury Sandstone	22 Dec 16	6.12	156	110	<1	<1	8	12	21	2	<1	23	3	1.00	1.18	
		27 Jul 17	5.3	96	72			11	7	13	2	0.9	12	<0.5			
		11 Jan 18	5.46	103	64*												<5
		5 April 18	5.2	102													
MW13	Maroota Sands	16 Dec 16	6.65	204	105	<1	<1	17	5	34	4	2	26	3	1.40	1.57	
		27 Jul 17	4.9	134	92			<5	1	27	2	2	16	<0.5			
		11 Jan 18	4.52	142	88*												<5
PB1	Hawkesbury Sandstone	27 Jul 17	4.6	148	88			<5	<1	30	<0.5	3	19	0.7			
PB2	Hawkesbury Sandstone	12 Sep 05	4.52	113	77			<1	<1	34	<1	3	17	<1			

Table E1: Laboratory Water Quality Analysis Results

Bore	Aquifer	Date sampled	pH	EC @ 25°C	TDS @ 180°C	OH alkalinity	CO_3 alkalinity	HCO_3 alkalinity	SO_4	Cl	Ca	Mg	Na	K	Total anions	Total cations	Oil and grease
Process Dam 1	-	27 Jul 17	4.5	134	90			<5	4	25	<0.5	2	16	2			
		5 April 18	4.4	229													
Tailings Dam 2	-	27 Jul 17	4.5	139	75			<5	4	25	<0.5	2	17	3			
		11 Jan 18	4.29	254	159*												<5
		5 April 18	4.3	249													
Nursery Dam 3	-	27 Jul 17	6.61	133	77			13	9	20	3	3	13	4			
		11 Jan 18	7.09	177	111*												<5
		5 April 18	7.8	223													
Farm Dam 4	-	27 Jul 17	6.6	116	63			15	3	20	2	3	13	2			
		11 Jan 18	6.87	165	103*												<5
		5 April 18	8.8	188													
Former Tailings Dam	-	27 Jul 17	4.9	77	49			<5	2	15	<0.5	1	11	1			

APPENDIX F

RELEVANT CORRESPONDENCE WITH DP&E AND DoI-WATER

NSW GOVERNMENT | Planning & Environment

Planning Services
Resource Assessments
Name: Jessie Evans
Phone: 9228 6419
Email: jessie.evans@planning.nsw.gov.au

Mr Neil Kennan
Nexus Environmental Planning Pty Ltd
PO Box 212
CONCORD NSW 2137

Dear Mr Neil Kennan

Roberts Road Sand Quarry (DA 267-11-99)
Approval of Expert

I refer to your letter dated 1 April 2016, seeking the Secretary's approval of a suitably qualified and experienced expert to undertake a comprehensive groundwater study of the quarry site, in accordance with condition 39(a) of Schedule 2 of the development consent.

The Department has considered the information supplied concerning the qualification and experience of Mr Peter Dundon of Dundon Consulting Pty Ltd and would like to advise you that the Secretary has approved his appointment.

If you have any enquiries about this matter, please contact Jessie Evans.

Yours sincerely

Howard Reed 5.4.16
Howard Reed
Director
Resource Assessments
As nominee of the Secretary

Department of Primary Industries
Water

Contact: Janne Grose
Phone: 02 8838 7505
Email: janne.grose@dpi.nsw.gov.au

Our ref: V15/3875#23
File No:
Your Ref:

10 May 2016

Mr Neil Kennan
Nexus Environmental Planning Pty Ltd
PO Box 212
CONCORD NSW 2137

Dear Mr Kennan

Re: Roberts Road Sand Quarry, Maroota (Mod 2 to DA 267-11-99) – consultant endorsement

Thank you for your email of 5 April 2016 seeking DPI Water's endorsement to appoint the consultant, Mr Peter Dundon to undertake a comprehensive groundwater study of the Roberts Road Sand Quarry site, in accordance with Condition 39(a) of Schedule 2 of the development consent.

With respect to the undertaking of a comprehensive groundwater study of the Sand Extraction at Roberts Road Maroota, DPI Water are satisfied that the consultant Peter Dundon is adequate to undertake the work on, based on the qualifications and experience provided.

Yours sincerely

Wayne Conners
Senior Water Regulation Officer, Hunter, Sydney and South Coast (Parramatta)

Department of Primary Industries
Water

Contact: Janne Grose
Phone: 02 8838 7505
Email: janne.grose@dpi.nsw.gov.au

Our ref: V15/4528#23
File No:
Your Ref:

26 September 2016

Peter Dundon
Dundon Consulting Pty Ltd
PO Box 6219
PYMBLE NSW 2073

pjdundon@ozemail.com.au

Dear Mr Dundon

Re: Roberts Road Sand Quarry, Maroota (MOD 2 to DA 267-11-99) – draft Groundwater Monitoring Program

I refer to your email of 23 August 2016 seeking comments on the draft Groundwater Monitoring Program (GMP). DPI Water has reviewed the GMP which was read in conjunction with the document Hodgson Quarry Groundwater Assessment, Roberts Road, Maroota AGT 1355-14-NAN V03 issued 18/09/2016 and provides the following recommendations and comments in Attachment A:

Recommendations

Prior to approval:

1. Provide detailed cross-sections through the site in a north-south and east-west orientation and along the longest groundwater pathway as guided by the regional groundwater contours for the site.
2. Provide a clearer surface topography contour map in A3 format.
3. Provide a map of the extent and thickness of the Maroota Sands paleochannel on site including the top and bottom elevations.
4. Provide a map of the extent and thickness of the:
   a. Maroota Sands paleochannel on site including the top and bottom elevations;
   b. clay confining layer identified on site at elevation ~183 mAHD (including the top and bottom elevations); and
   c. Hawkesbury eluvium identified on site (including the top and bottom elevations).
5. Provide a map of the extent and surface topography of the underlying Hawkesbury Sandstone.
6. Provide all borelogs and surveyed locations for all existing boreholes on site, including historical bores since destroyed by mining.
7. Provide groundwater contour maps for the:
   a. perched aquifer within the Maroota Sands Aquifer above the confining clay layer.
   b. aquifer within the Maroota Sands and Hawkesbury Eluvium Aquifers beneath the confining clay layer.
   c. Fractured Hawkesbury Sandstone Aquifer.

These maps may be derived by the use of a groundwater model suitable for the task and provided after drilling.

8 Provision of, and analysis of, historical pumping records from bores PT84PB1 and PT84PB2.

9 All proposed boreholes to be drilled by a suitably qualified driller.

10 All bores to be logged and monitoring bores on site to be designed by a suitably qualified and experienced groundwater consultant.

11 DPI Water considers that there are an insufficient number of clustered bores targeting multiple aquifers. The Proponent should consider this recommendation and discuss this with DPI Water.

12 Consultation with DPI Water hydrogeologists to ensure a sufficient groundwater monitoring program is in place for the site for ongoing monitoring until 2025.

13 Provide a detailed analysis of evapotranspiration and recharge on site.

14 Provide a complete water balance for the site that considers the water volumes in the dams, run off and any water supplementation from bores or other water supply sources.

15 Monitoring of water levels in the dams.

16 Proponents Groundwater Consultant to liaise with DPI Water Hydrogeologists who will be made available for a meeting to discuss the existing issues and recommendations.

Recommendations 1 – 8 are provided to ensure that uncertainty with regards to a clay layer encountered on site is understood. If the clay layer is extensive across the site and confining a water table then there is clarity as to the water in dams observed on aerial photographs as originating from surface water runoff or upper Maroota sands aquifer and not the regional Hawkesbury Sandstone Aquifer or the Eluvium Aquifer (if distinct from the underlying fractured rock aquifer). Without the hydrogeological and geological conceptual models, it is not possible to properly site, design or construct monitoring bores that are a requirement of the consent conditions.

Recommendations 9 – 12 are to ensure that the proponent has access to groundwater infrastructure (that may include also DPI Water bores) and that is suitable for monitoring.

Recommendations 13-15 plus earlier recommendations are to ensure that earlier mining did not exceed beyond the wet weather high groundwater level of the regional aquifer. They will also allow finalisation of the wet weather high groundwater level of the regional aquifer and allow maximum exploitation of the resource in a safe manner. The Proponent may have penetrated the confining clay layer on site historically and the water in the dams may be regional aquifer water continually evaporating and this needs to be confirmed.

Furthermore all recommendations as provided by DPI Water lend support towards fulfilling other Soil and Water consent conditions. Should you require further information please do not hesitate to contact Janne Grose on (02) 8838 7505.

Yours sincerely

Irene Zinger
A/Regional Manager – Metro
Water Regulation Operations
26-09-2016

ATTACHMENT A

Roberts Road Quarry MOD 2 (DA 267-11-00) – Hodgson Quarry Products Pty Ltd

Department of Primary Industries, Water (DPI Water) provides the following comments on the draft Groundwater Monitoring Program (GMP). The GMP was read in conjunction with the document Hodgson Quarry Groundwater Assessment, Roberts Road, Maroota AGT 1355-14-NAN V03 issued 18/09/2016.

DPI Water recommended in the aforementioned report that a groundwater level of 184.08 mAHD be adopted across the site as the wet weather high groundwater level of the regional aquifer with a maximum extraction depth of 186.06 mAHD for sand mining. The latest consent condition was 182 mAHD in the footprint of the Process Water Dam and below a depth of 186.1 mAHD in all other areas. However, in their latest submission, the Proponent has proposed a more conservative value of 185.3 mAHD to be adopted across the site as the wet weather high groundwater level of the regional aquifer until further data becomes available from the new bores proposed.

The Proponent states that the lowest point in the quarry is currently at about 186 mAHD however prior reports have stated that quarrying has historically reached 180 mAHD on site and was at 183 mAHD at the time of application for Modification 2. Considering that mining has historically reached 180 mAHD and regional water levels are above this level, it is uncertain to DPI Water if the water observed in the dams on site is being recharged also by the regional groundwater table and therefore breaching consent conditions.

There is also uncertainty with regards to the three dimensional conceptual hydrogeology of the site. The submitted document could benefit from further clarification by the provision of detailed hydrogeological cross-sections and a discussion of the hydrogeology and existing data. This supplementary information would support the design, location and construction details for the proposed monitoring bores that the Proponent is seeking to drill on site and allow DPI Water to recommend approval of an updated GMP.

The current GMP cannot however be recommended for approval as fulfilling consent conditions without the provision of the requested supplementary information and suggested further consultation with DPI Water prior to drilling is suggested.

Assessment

Modification 2 Consent Requirement	Proponent Response	DPI Water Comment
43. The Applicant shall prepare a Groundwater Monitoring Program for the development to the satisfaction of the Secretary. This program must:	Draft Groundwater Monitoring Program – 20 August 2016. Dundon Consulting Pty Ltd	Draft received. Further details required
(a) Be prepared in consultation with DPI-Water and be submitted to the Secretary for approval within four months of the date of approval of Modification 2;	Modification (Mod 2) was approved on 18 March 2016.	Uncertainty about degree of consultation undertaken and whether GMP was submitted within four months.
(b) Include proposed construction of a network of at least five active monitoring bores around the south-eastern, southern, western and north-western boundaries of the extraction area (but outside of the overall extraction footprint) in proximity to extraction Phases 1 to 6 as identified in Modification 2, to collect groundwater level monitoring data from the regional aquifer;	Bores PBH2 to PBH4 are the bores required to satisfy Consent Condition 43 (b).	DPI Water recommends that the initial active monitoring network will include PT84MW6, all existing bores (that might be destroyed but should be monitored until they are); both pumping bores plus the proposed new bore locations. Consultation with DPI will result in finalisation of the no. of bore sites to be drilled.
(c) Include proposed construction to deepen (or replace) PT84MW1 in order that a bore in that general area monitors the regional aquifer; and	Bore PBH1 is the bore required to satisfy Consent Condition 43 (c). An additional bore PBH5 is proposed for the adjacent property to the north of the quarry it will provide valuable off-site information on	Satisfied pending suitable and appropriate construction.

Modification 2 Consent Requirement	Proponent Response	DPI Water Comment
	the regional groundwater level within the Maroota Sands.	
(d) Include potential construction of active monitoring bores within the largest components of at least the two forthcoming extraction Phases (on a rolling basis), each to collect at least 2 years of continuous baseline groundwater monitoring data prior to extraction commencing in that Phase.	Bores PBH6 to PBH8 are the bores required to satisfy Consent Condition 43 (d).	Satisfactory response.
44. The results of the Groundwater Monitoring Program shall be reported (to) the Department and DPI-Water, using contour plans depicting the surface topography, updated contour maps of the wet weather high groundwater level of the regional aquifer and proposed depth of extraction for each extraction Phase. Reporting is to occur on a six monthly basis for the duration of extractive operations, and throughout rehabilitation of the site, unless otherwise agreed with the Secretary. The Applicant shall implement the Groundwater Monitoring Program as approved from time to time by the Secretary."	Proponent provided figures 1 and 2 depicting current and proposed bores and included contour maps of the recent surface topography. Proponent mentioned that inadequate data existed to present groundwater contour maps. Proponent proposed that the data resulting from the proposed monitoring bores still to be drilled would help in providing relevant contour maps.	Groundwater contour maps not provided. Proponent presented a reasonable justification for not providing the maps as there were further bores to be drilled to obtain sufficient data. Proponent did not provide surface topography maps for future extraction phases. Proponent did however provide hydrographs of bore data and a comprehensive analysis of the existing data. Not satisfied as Proponent is still to provide contour maps in future.

End Attachment A

AGENDA

Draft Groundwater Monitoring Program

Roberts Rd, Maroota Sand Quarry

October 24, 2016
14:00 – 15:00

Meeting called by Janne Grose

Attendees:	DPI Water Representatives Project Representatives: Peter Dundon, (Hydrogeologist, Dundon Consulting Pty Ltd), Greg Thomson, (Geologist, VGT Pty Ltd), Lisa Thomson (Environmental Consultant, VGT Pty Ltd)

Background:

A draft Groundwater Monitoring Program was submitted to the Department of Primary Industries – Water for comment on 23/8/2016. A letter dated 26th September (reference: V15/4528#23) was received with 16 recommendations and attached comments. Recommendation number 16 of the letter was:

- Proponents Groundwater Consultant to liaise with DPI Water Hydrogeologists who will be made available for a meeting to discuss the existing issues and recommendations

Outline of proposed groundwater monitoring plan	Peter Dundon
Outline of known geology of the site	Greg Thomson
Outline of current and previous site monitoring data	Lisa Thomson
Outline of issues with proposed groundwater monitoring	DPI Water Hydrogeologists

Department of Primary Industries
Water

Contact: Janne Grose
Phone: 02 8838 7505
Email: janne.grose@dpi.nsw.gov.au

Our ref: V15/3875#23 and V15/4528#23
File No: OUT16/40532
Your Ref:

31 October 2016

Peter Dundon
Dundon Consulting Pty Ltd
PO Box 6219
PYMBLE NSW 2073

pjdundon@ozemail.com.au

Dear Mr Dundon

Re: Roberts Road Sand Quarry, Maroota (MOD 2 to DA 267-11-99) – draft Groundwater Monitoring Program

I refer to the meeting of 24 October 2016 attended by DPI Water, VGT Pty Ltd and your-self to discuss DPI Water's submission of 26 September 2016 on the draft Groundwater Monitoring Program (GMP). Reference is also made to your letter of 26 October, which provides an outline of outcomes from the meeting.

DPI Water's submission included 16 Recommendations, which were discussed at the meeting.

Key actions/outcomes from the meeting are asfollows.

1. DPI Water confirms it has no objection to the groundwater drilling program commencing at the Roberts Road Sand Quarry site in order to obtain data to finalise the Groundwater Monitoring Program (GMP).

2. DPI Water is not in the position to approve the existing draft GMP and accepts that it is currently a working document. The GMP will need to be updated and finalised post drilling.

3. DPI Water requires that a continuous water level logger needs to be placed on each of the dams at the site to determine if the water in the dams is originating from the Maroota sands aquifer. Peter Dundon is to determine the best way to do this.

4. In relation to DPI Water's recommendations the following was agreed:
    i. Recommendations 1-3: VGT Pty Ltd provided DPI Water with a hard copy of all existing historical data, which they presented at the meeting, and have subsequently emailed an electronic copy to DPI Water to address Recommendations 1-3.

    ii. VGT Pty Ltd advised Recommendations 1-8 can be addressed once the groundwater drilling has been undertaken.

iii. Recommendation 6: Peter Dundon advised a record of historical bore logs and data is not available for the site due to a change in ownership.

iv. Recommendation 7: VGT Pty Ltd agreed to provide the groundwater contour maps to DPI Water.

v. Recommendation 8: VGT Pty Ltd advised the historical pumping records are not available but agreed to discuss with the landowner as to whether the bores can be metered.

vi. Recommendation 9: it was confirmed that the proposed monitoring boreholes will be drilled by suitably qualified drillers.

vii. Recommendation 10: Peter Dundon agreed that all bores will be logged.

viii. Recommendation 11: DPI Water requires that at least one clustered bore needs to be installed at the site to target multiple aquifers. Peter Dundon agreed that at least 1 clustered bore shall be installed at the site near MW5.

ix. Recommendation 12: DPI Water agreed that Recommendation 12 can be deferred and dealt with once the bores have been drilled.

x. Recommendation 13: DPI Water confirmed it requires a detailed analysis of evaporation on the site (rather than evapo-transpiration).

xi. Recommendations 13-15: VGT Pty Ltd confirmed Recommendations 13-15 will be addressed in the Groundwater Management Plan.

5. DPI Water confirms that all available DPI Water bore data relevant to the site is available on the public record.

6. Peter Dundon requested that DPI Water provides background detail/the source document to the '*wet weather high groundwater level' which is referred to in the Conditions of Development Consent.*

   DPI Water advises extractive industries in the Baulkham Hills Shire Council local government area were subject to the conditions of a development control plan (DCP) issued in 1997 for such activities (Baulkham Hills Shire Council Extractive Industries Development Control Plan No 500). That plan was subsequently incorporated into a consolidated DCP in 2007 – Part D Section 6 was relevant to extractive industries. The DCP was updated in 2012 and the requirement on extractive industries was retained, however relocated into a different section. The Hills Shire Council DCP, Part B Section 1 'Rural' Appendix B[1], subsection B.2.4 relates and requires *inter alia* the following:

   > "*Extraction should not occur within 2 metres of the wet weather high groundwater level or otherwise to the requirements of the Office of Environment and Heritage*".

   Previous versions of this condition referred to the Department of Land and Water Conservation (DLWC) or the Department of Natural Resources – therefore the appropriate agency is now DPI Water (as the successor to those identified organisations), not the Office of Environment and Heritage. It is understood that the 2 m freeboard requirement has been adopted for all of the current extractive industries

[1] The Hills Shire Council 2012. The Hills Development Control Plan (DCP) 2012. Viewed 15 October 2015, http://www.thehills.nsw.gov.au/Building/Planning-Guidelines/The-Hills-Development-Control-Plan.

projects in the Maroota area in accordance with the requirements of the Hills Shire Council DCP (The Hills DCP).

Yours sincerely

Irene Zinger
A/ Regional Manager – Metro
Water Regulation Operations

Planning Services
Resource Assessments
Contact: Genevieve Seed
Phone: (02) 9274 6489
Email: genevieve.seed@planning.nsw.gov.au

Lisa Thomson
Principal Environmental Consultant
Vgt Environmental Compliance Solutions
PO Box 2335
GREENHILLS NSW 2323

Dear Ms Thomson

Roberts Road Sand Quarry (DA 267-11-99)
Groundwater Monitoring Program

I refer to your email dated 14 November 2016 submitting a revised Groundwater Monitoring Program for the Roberts Road Sand Quarry, in accordance with condition 43 of Schedule 2 of the above development consent.

The Secretary has approved this monitoring program.

However, following the completion of the drilling program this monitoring program must be updated to reflect the actual locations of boreholes and to provide accurate contour plans depicting the surface topography, the wet weather high groundwater level of the regional aquifer and the proposed depth of extraction for each extraction phase.

If you have any enquiries about this matter, please contact Genevieve Seed.

Yours sincerely

Howard Reed

Howard Reed 28·11·16
Director
Resource Assessments
As nominee of the Secretary

Department of Primary Industries
Water

Contact: Janne Grose
Phone: 02 8838 7505
Email: janne.grose@dpi.nsw.gov.au

Our ref: V15/3875#23, OUT16/45897

22 November 2016

Lisa Thompson
VGT Pty Ltd
PO Box 2335
GREEN HILLS NSW 2323

Lisa@vgt.com.au

Dear Ms Thompson

Re: Roberts Road Sand Quarry, Maroota – draft Groundwater Study Progress Report for DA 267-11-99

Thank you for your email of 31 October 2016 to DPI Water seeking comments on the Groundwater Study Progress Report for DA 267-11-99.

In a submission of 26 September 2016, DPI Water provided the Proponent with a number of recommendations in relation to the Groundwater Monitoring Program for the site. The recommendations were discussed with Peter Dundon Consulting and VGT Pty Ltd at a meeting held on 24 October 2016 and actions/outcomes from the meeting were outlined in DPI Water's subsequent letter of 31 October 2016.

The Proponent is obligated to provide DPI Water with the following documents within time frames specified by conditions of consent:

- Groundwater Study
- Groundwater Management Improvement Program
- Groundwater Monitoring Program
- Water Management Plan.

The implementation of DPI Water's recommendations is required to provide input into the above documents. The documents rely on information that will result from completing the recommendations. The documents therefore cannot be reviewed until the recommendations (including additional drilling) are fulfilled.

DPI Water recommends the proponent completes the work associated with the recommendations outlined in the attached DPI Water letters of 26 September 2016 and 31 October 2016. The proponent should then submit the above-mentioned documents as a package to DPI Water for review.

Yours sincerely

Irene Zinger
A/ Regional Manager – Metro
Water Regulation

Department of Primary Industries
Water

Contact: Janne Grose
Phone: 02 8838 7505
Email: janne.grose@dpi.nsw.gov.au

Our ref: V15/3875#23, OUT17/13594
File No:
Your Ref:

31 March 2017

Lisa Thompson
VGT
PO Box 2335
GREENHILLS NSW 2323

Lisa@vgt.com.au

Dear Ms Thompson

Re: Roberts Road Quarry Maroota (DA 267-11-99 Mod 2) – Groundwater Study report

Thank you for emailing a copy of the Groundwater Study Report (dated 24 February 2017 - 16-0318-R02). DPI Water has reviewed the Groundwater Study Report and provides the following recommendations and more detailed comments in Attachment A.

Recommendations

DPI Water recommends that the following recommendations are provided to the Proponent.

1 Additional detailed cross-sections through the site should be provided to DPI Water, and improvement of existing cross-sections is required to clearly show lithological differences, and a complete set of bore logging sheets need to be provided, as depicted on Figures 9, 10 and 11.

2 The Proponent should provide a map of the resources proposed as targets of mining from present day onwards. Detailed information about the lithology, extents, depths and thickness of the target resource is to be provided for the entire site and stages of mining are to be discussed. Contour maps of the surface topography of proposed maximum mining depth everywhere on site as well as post-mining rehabilitated topography are also to be provided.

3 Consultation with DPI Water Hydrogeologists is required to ensure a sufficient groundwater monitoring program is in place for the site for ongoing monitoring until 2025.

4 Monitoring of water levels in the dams using loggers.

5 The Proponents Groundwater Consultant should liaise with DPI Water Hydrogeologists who will be made available for a meeting to discuss the site conceptual hydrogeology and recommendations.

For further information please contact Janne Grose, Water Regulation Officer at DPI Water (Parramatta office) on **t:** (02) 8838 7505; **e:** janne.grose@dpi.nsw.gov.au

Yours sincerely

Irene Zinger
Regional Manager - Metro,
Water Regulation

ATTACHMENT A

Roberts Road Quarry Maroota (DA 267-11-99 Mod 2) – Groundwater Study Report

DPI Water has reviewed the Groundwater Study Report and provides these detailed comments in Attachment A.

There is still uncertainty with regards to the conceptual hydrogeology. The latest information provided does not provide certainty as to the pre-mining, present day and post mining wet weather high water table to enable a proper assessment of the conditions on site.

- The Proponent appears to reference all water above the Hawkesbury Sandstone Basement as “perched groundwater”. This diminishes the significance of a regional groundwater table in the Maroota Tertiary Sands Groundwater Source, for the establishment of maximum mining depths (which is to extend no deeper than within two metres of the wet weather high groundwater level at any location). The wet weather water table is variable across the site and what the Proponent terms as a “perched Maroota sands water table in a desaturated zone” is regarded by DPI Water to be a regional Maroota Sands aquifer water table that has already been significantly lowered by mining activities relative to baseline conditions that existed pre-mining. MW2 water levels (203 m AHD) suggest a much higher baseline regional water level than the present water level at MW5 and MW8 (193 m AHD).

- The Proponent suggests that the extent of the saturated Maroota Sands is limited towards the west by the depiction of a red line on Figure 19. However multiple Maroota Sand screened bores show a standing water level reading in the western “desaturated zone”. DPI Water would like some clarification justifying the suggestion and clarity about whether this desaturation was present pre-mining and to address the contradiction.

- The submitted document could benefit from further clarification by the provision of further detailed hydrogeological cross-sections in other orientations. Seepages in Maroota sands were noted at elevations immediately to the west of the main dam that were higher than current dam water levels. Historical data suggests that Maroota Sands water levels were significantly higher than existing water levels. The drawdown could be attributed to water supply dewatering, evaporation from the capillary zone or evaporation from open water on the dams.

DPI Water finds the report inadequate towards determining the location of the wet weather high groundwater table on site and requires further information.

End of Attachment A

Planning Services
Resource Assessments
Contact: Jack Murphy
Phone: (02) 8217 2016
Email: jack.murphy@planning.nsw.gov.au

Ms Lisa Thomson
Principal Environmental Consultant
VGT – Environmental Compliance Solutions
PO Box 2335
Greenhills NSW 2323

Email: Lisa@vgt.com.au

Dear Ms Thomson

Roberts Road Quarry – Modification 2 (DA 267-11-99 MOD 2)
Environmental Management Plans

I refer to your email dated 15 November 2017 submitting revised management plans for the Roberts Road Quarry (DA 267-11-99) including the:

- Groundwater Study, dated October 2017 (condition 39 of Schedule 2);
- Water Management Plan, dated November 2017 (condition 42, Schedule 2); and
- Groundwater Monitoring Program, dated November 2017 (condition 43, Schedule 2).

I also refer to your email dated 29 June 2017 submitting the Landscape and Rehabilitation Management Plan, dated June 2017 (condition 60, Schedule 2).

The Department considers that these documents have not adequately addressed the relevant conditions of consent. The Department's comments on these documents are enclosed in **Attachment A**.

The Department notes that the Department of Industry – Water has also provided comments in relation to the water management plans. Please ensure these comments are satisfactorily addressed prior to resubmitting these plans.

The Department requests that these documents are revised and re-submitted no later than **23 March 2018**.

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

Yours sincerely,

Howard Reed 8.2.18

Howard Reed
Director
Resource Assessments
As nominee of the Secretary

Attachment A

Roberts Road Sand Quarry – Management Plan 2017 Reviews

Groundwater Study and Remediation Works – DA 267-11-99 MOD 2 – Condition 39 Schedule 2	**Satisfactory (Yes/No/Partial)**	**Comment**	**Action Required**
Within six weeks of the date of approval of Modification 2, the Applicant shall commission a comprehensive groundwater study of the site. This study must:			
(a) be prepared by suitably qualified and experienced person/s whose appointment has been endorsed by the Secretary and DPI-Water;	Yes		Nil actions required, other than those set out in the Comments and General Comments below.
(b) consult with DPI-Water;	Partial	Refer to DoI's comments.	
(c) examine all existing records of groundwater levels at the site;	Partial	Refer to DoI's comments.	
(d) develop an interim contour map of the wet weather high groundwater level of the regional aquifer, based on all available records (see also Condition 44); and	Partial	Refer to DoI's comments.	
(e) provide advice and recommendations on the Groundwater Monitoring Program as set out in Condition 43.	Partial	Refer to DoI's comments.	
General comments:			

OUT18/14628

Lisa Thomson
VGT Pty Ltd
PO Box 2335
GREENHILLS NSW 2323

Lisa@vgt.com.au

Dear Ms Thomson

Roberts Road Maroota Sand Quarry - draft Groundwater Management Plan, Groundwater Monitoring Program, Groundwater Study Report and Surface Water Management Plan

Thank you for providing copies of the following draft reports to the Department of Industry – Water (DoI Water) – formerly DPI Water - to review:

- Groundwater Management Plan (dated 21 September 2017)
- Groundwater Monitoring Program (dated 29 September 2017)
- Groundwater Study Report (dated 4 October 2017)
- Surface Water Management Plan (dated 11 October 2017).

DPI Water has previously reviewed the draft Groundwater Study Report (our letter dated 31 March 2017); Surface Water Management Plan (our letter dated 4 April 2017) and Groundwater Monitoring Program (our letters dated 26 September 2016 and 31 October 2016).

DoI Water has reviewed the current draft reports and provides the following recommendations below and detailed comments in Attachment A.

Prior to approval

Groundwater Management Plan

DoI Water recommends that before approval of the Groundwater Management Plan (GMP), the proponent is to submit a further updated version of the GMP:

1. Including an explanation of how the EC and pH trigger values in Table 17 were derived.

2. Include definitive time frames within the Trigger Action Response Plan (Table 19) for the “Response Action” and “Evidence of Responsive Effectiveness” categories.
3. Clarification is required of the geotechnical qualities (particularly the permeability / porosity in terms of prevention of water ingress to infill areas) of the clay fines and infill material.
4. Any hazards presented by the clay fines are to be identified and discussed in relation to ongoing operations.
5. Measures of rehabilitation need to be identified and the rehabilitation plan outlined.
6. Provide previously requested information / figures, as follows.
    a. A diagrammatic plan of the regional elevations for the Hawkesbury Sandstone palaeo-topography.
    b. A diagrammatic (contour) plan of the thickness (isopach) and regional elevations for the top surface of the Maroota Tertiary Sands palaeochannels.
    c. A diagrammatic (contour) plan of the regional elevations for the perched water tables.
    d. A diagrammatic (contour) plan of the thickness (isopach) and regional elevations for the top surface of occurrences of the confining clay aquitard.
    e. A diagrammatic (contour) plan of the thickness (isopach) and regional elevations for the top surface of occurrences of the Hawkesbury Sandstone eluvium.

For expediency in reviewing and to meet due diligence obligations, it is recommended that the proponent includes the required information in an updated document and provides the revised version to DoI Water.

<u>Groundwater Monitoring Program</u>

DoI Water recommends that before approval of the Groundwater Monitoring Program the proponent is to provide:

1. a copy of Figure 16 (not included in the current Groundwater Monitoring Program report – Figure 15 was included twice), and
2. a production schedule plan showing monitoring bore locations, wet weather high groundwater levels (Maroota Sands and Hawkesbury Sandstone – eluvium regional groundwater table), perched groundwater levels, and flow contours.

<u>Groundwater Study Report</u>

DoI Water recommends that the Groundwater Study Report be revised in conjunction with the Groundwater Management Plan and the two be reconciled concurrently. The Groundwater Study Report needs to include the following information.

1. A detailed discussion of the hydrogeological / geological units intersected in drilling and mining operations on site.
2. Hydrogeology discussion to be bolstered by the inclusion of previously requested information / figures, as listed below.
    a. A diagrammatic contour plan of the regional elevations for the Hawkesbury Sandstone palaeo-topography.
    b. A diagrammatic contour plan of the thickness (isopach) and regional elevations for the top surface of the Maroota Tertiary Sands palaeochannels.

c. A diagrammatic contour plan of the regional elevations for the perched water tables.
d. A diagrammatic contour plan of the thickness (isopach) and regional elevations for the top surface of occurrences of the confining clay aquitard.
e. A diagrammatic plan of the thickness (isopach) and regional elevations for the top surface of occurrences of the Hawkesbury Sandstone eluvium.

3. A discussion on the wet weather high water table and how it is being derived across the site. DoI Water note that there is a brief discussion on this matter in the Groundwater Management Plan but similar comments are not included in the Groundwater Study Report. The two reports need to be reconciled concurrently, updated and revised versions resubmitted to DoI Water.
4. A discussion of the resources for mining from present day onwards, detailing information about the lithology, extents, depths and thickness of the target resource across the entire site and stages of mining in context to the identified water tables (both regional and perched), including appropriate maps or diagrammatic plans such as:
    a. A contour map of the surface topography of proposed maximum mining depth across the quarry site.
    b. A contour plan of the proposed post-mining rehabilitated topography.
5. Short relevant discussions in relation to the geotechnical properties of, and any hazards presented by the clay fines / infill material identified, and discussed in relation to ongoing operations, back filling operations and effectiveness as a water ingress seal.
6. Measures of rehabilitation need to be identified and rehabilitation plan briefly outlined.
7. A brief discussion on the predicted impact upon groundwater level by the proposed closure and rehabilitation of the quarry site as currently planned.

For expediency in reviewing and to meet due diligence obligations, it is recommended that the proponent include the required information in an updated document and provide the revised version to DoI Water.

A timeframe of three month is proposed for the updated version of the Groundwater Study. The requirements on information noted above have been requested several times by now and must be addressed.

The update of the groundwater study will be concurrent to a regional hydrogeological study of the Maroota area proposed by DoI Water in the next three months. The aim of the regional study is to provide a uniform hydrogeological conceptualisation across the area that would be referred to by all proponents. Data collected and complied by Hodgson Quarry will assist in the regional assessment. Contacts will be made with Hodgson Quarry to discuss data.

Not required prior to approval

DoI Water encourages the proponent to increase their knowledge of joints, fractures and any faults which occur throughout their operational area within the underlying Hawkesbury Sandstone aquifer.

DoI Water notes that detailed information of the water levels and pumping records for PT84PB1 and PT84PB2 were requested by DPI Water. DoI Water considers that the detailed pumping records should be provided and discussed as a component of the Site Water Balance, itself a component of the Water Management Plan. The Water Management Plan is expected to be provided for review in the near future.

Surface Water Management Plan

- The SWMP is updated to reflect the DoI Water's most recent name change
- Figure 10 should identify which dams are the sediment dams
- The SWMP should clarify if water loggers have been installed in each of the dams on the site, and if not it should explain why this has not occurred.
- Ongoing monitoring of water levels in dams must be a component of the SWMP to inform the Site Water Balance
- The proponent should contact WaterNSW for the proposed transfer of the required allocation of the current water licence on Lot 2 DP228308 for 'irrigation' to Lot 1 DP228308 (where Dam 1 is located), as WAL dealings are dealt with by WaterNSW.
- The SWMP should explain what the quarry intends to do during periods when there isn't enough water and clarify if the quarry proposes to stop processing during these periods.
- erosion and sediment control monitoring is also undertaken within 24 hours of expected rainfall and within 18 hours of a rainfall event of sufficient intensity and duration to cause runoff on-site
- the water quality of all on-site dams is sampled over 12 months -2 years on a 3 monthly basis to pick up any seasonal variation within the dam water to determine if there is any relationship to groundwater

In relation to groundwater related issues, a DoI Water hydrogeologist can be made available should a meeting or further discussion be required.

For further information please contact Irene Zinger on **e:** irene.zinger@dpi.nsw.gov.au while Janne Grose is away on a 12 month secondment.

Yours sincerely

Irene Zinger
Manager
Regulatory Operations – Metro
Water Regulation

30 January 2018

Attachment A

Roberts Road Maroota Sand Quarry - draft Groundwater Management Plan, Groundwater Monitoring Program, Groundwater Study Report and Surface Water Management Plan

The Department of Industry – Water (DoI Water) – formerly DPI Water has reviewed the following draft reports:

- Groundwater Management Plan (dated 21 September 2017)
- Groundwater Monitoring Program (dated 29 September 2017)
- Groundwater Study Report (dated 4 October 2017)
- Surface Water Management Plan (dated 11 October 2017)

and provides the following comments:.

Groundwater Management Plan and Groundwater Monitoring Program

Conceptual Hydrogeology

Clarification of the three dimensional conceptual hydrogeology of the site has been provided in the form of the requested hydrogeological cross-sections and a discussion of the hydrogeology and existing data. This supplementary information supports the design, location and construction details for the proposed monitoring bores that the Proponent has installed.

Report Formatting

Some minor formatting and figure reference sequencing issues were noted (including the submission of a second Figure 15 instead of the referenced Figure 16) in the documents.

Statement of Approval

Provisional approval of the updated Groundwater Monitoring Program can be considered, provided several diagrams are submitted to L&W promptly.

However, the updated Groundwater Management Plan requires further clarification and provision of outstanding information previously requested.

Outstanding Matters

Groundwater Monitoring Program

DPI Water previously provided comments on the draft Groundwater Monitoring Program, Modification 2 (OUT16/46966, Sept. 2016) in which further information was requested to be provided by the proponent. Some of this requested information is mis-referenced in the document or remains outstanding.

The Groundwater Monitoring Program references a ‘Figure 16’, however there are two ‘Figure 15’s in the document and ‘Figure 16’ is missing.

Although a production schedule plan has been presented in the Groundwater Management Plan, it has not been presented in the context of plotted monitoring bore wet weather high groundwater levels (including perched levels) and flow contours in the Groundwater Monitoring Program document. Prompt provision of such a plot would greatly assist in understanding the production plan and potential groundwater interactions and monitoring as the quarry progresses.

A number of maps or plans of the thickness and regional elevations for; the perched water tables, confining clay aquitard and Hawkesbury Sandstone eluvium, have previously been requested by DPI Water (OUT16/46966, Sept. 2016). These have not been presented in the Groundwater Monitoring Program; however presentation of some of the information relating to these has been included in the encompassing updated Groundwater Management Plan.

Groundwater Management Plan

The Groundwater Management Plan requires further clarification regarding the derivation of electrical conductivity (EC) and pH trigger values in Table 17. A detailed discussion is needed to demonstrate their applicability and provide confidence that any adverse impacts of the quarrying will be recognised and responded to.

Further, the Trigger Action Response Plan (Table 19) would benefit from the inclusion of definitive time frames for the "Response Action" and "Evidence of Responsive Effectiveness" categories. These timeframes should be meaningful so that the responses can be implemented in a timely fashion, on-site impacts are appropriately managed and off-site impacts are prevented.

The proponent is to provide the above requested information as listed in the following recommendations as a further updated Groundwater Management Plan, within 3 months.

DoI Water response to the proponent response on the Conditions of Approval

CoA **SCHEDULE 2, SOIL AND WATER**	**Proponent Response**	**DoI Water Comment**
(c) Groundwater Management Plan that takes into account the Web-based Reporting Guideline (DPE 2015) and Groundwater Monitoring and Modelling Plans – Information for Prospective Mining and Petroleum Exploration Activities (DPI 2014), and includes:		
• *detailed baseline data on groundwater yield and quality in groundwater bores on privately-owned land, that could be affected by the project;*	Section 5.4; Table 10, Table 11,associated discussion.	Satisfactory.
• *a program to undertake surveyed probe testing of all extracted areas where clay fines have been deposited to:*	Section 4.5, 7.	Satisfactory.
o accurately determine the depth of extraction and depth of clay fines;	"A probing survey conducted in September 2017 established the depth of to the top of sediment in Process Dam 1, finding that the water depth over most of the area of Dam 1 is between 0.1m and 0.7m, with a small localised area of greater water depth around the water supply pump inlet, where water depth reached a measured maximum of 2.935m."	Satisfactory. Process Dam 1 survey acknowledged, water level survey acknowledged for other dams - no other information on survey or survey of depth of fill in other dams was presented.

CoA SCHEDULE 2, SOIL AND WATER	Proponent Response	DoI Water Comment
o identify any ongoing intersection or other interaction between clay fines and the regional groundwater aquifer;	"Most of Process Dam 1 has a base elevation in the range 187.1 to 187.6 mAHD, with the deepest measured point near the pump inlet being at 184.8 mAHD. This compares with the current (September 2017) wet weather high regional groundwater level for the Maroota Sands aquifer of 184.6 to 184.7 mAHD beneath Process Dam 1." " The unnamed former tailings storage area contains only a small volume of superficial water, and is essentially dry most of the time."	Satisfactory. Process Dam 1 survey acknowledged, water level survey acknowledged for other dams - no other information on survey or survey of depth of fill in other dams was presented.
o identify any geotechnical characteristics of the emplaced clay fines which may pose risks to workplace safety or implementation of the process water dam design or the final landform; and	"The results of laboratory analysis for major ion composition are presented in Table E1 in Appendix E. EC and pH trends for all bores and the site dams are shown graphically on Figure 10." Section 4, 5, 6, 7.	Unsatisfactory. No geotechnical qualities of clay fines discussed or hazards identified. Clarification of this aspect of the operation is required.
o identify measures which can be successfully used in rehabilitating these areas;		Unsatisfactory. No measures of rehabilitation identified or rehabilitation discussed. Further detail needs to be provided.
• a program to monitor potential groundwater quality impacts to the regional aquifer from receiving off-site runoff water in the Process Water Dam;	Sections 6.2, 7, 8.1.	Unsatisfactory. A discussion of how the EC and pH trigger values were derived needs to be provided.
• groundwater assessment criteria, including trigger levels for investigating any potentially adverse groundwater impacts, in accordance with the NSW Aquifer Interference Policy;	Tables 14, 15, 16, 19; Section 6.4.	Satisfactory.
• a program to monitor:	Section 6.	Satisfactory.
o the impacts of the project on:		
- groundwater inflows to water storages;		
- any groundwater bores on privately-owned land that could be affected by the project; and		
o seepage from water storages or backfilled voids on site;		
• a plan to respond to any exceedances of the groundwater assessment criteria;	Sections 6, 7.	Unsatisfactory. Specified timeframes for the “Action Response” need to be provided as part of the TARP.

CoA SCHEDULE 2, SOIL AND WATER	Proponent Response	DoI Water Comment
• *emergency contingency plans for implementation in the event that the groundwater is encountered during excavation; and*	Section 7.	Unsatisfactory. Specified timeframes for the "Action Response" need to be provided as part of the TARP.
• *audit and reporting procedures, including comparisons of the monitoring results each calendar year and quarterly reporting of groundwater monitoring results,*	Section 8 - restates criteria.	Satisfactory.
The Applicant shall implement the approved management plan as approved from time to time by the Secretary.		

Groundwater Monitoring		
43. The Applicant shall prepare a Groundwater Monitoring Program for the development to the satisfaction of the Secretary. This program must:	This plan.	Satisfactory.
(a) be prepared in consultation with DPI-Water and be submitted to the Secretary for approval within four months of the date of approval of Modification 2;	Previous draft Monitoring Program, comments supplied by DPI Water.	Satisfactory.
(b) include proposed construction of a network of at least five active monitoring bores around the south-eastern, southern, western and north-western boundaries of the extraction area (but outside of the overall extraction footprint) in proximity to extraction Phases 1 to 6 as identified in Modification 2, to collect continuous groundwater level monitoring data from the regional aquifer;	Section 3. Current: 9 monitoring bores. Placement shown on figures provided, Table 4, Figure 2.	Satisfactory.
(c) include proposed construction to deepen (or replace) PT84MW1 in order that a bore in that general location monitors the regional aquifer; and	Section 3. Table 4, Figure 2. MW7 installed adjacent to monitor regional groundwater level in Hawkesbury Sandstone.	Satisfactory.
(d) include proposed construction of active monitoring bores within the largest components of at least the two forthcoming extraction Phases (on a rolling basis), each to collect at least 2 years of continuous baseline groundwater monitoring data prior to extraction commencing with that Phase.	Sections 3, 4,and 5.	Unsatisfactory. Difficult to judge as no groundwater data was presented overlaid on the production schedule plan. A production schedule plan showing monitoring bore location and wet weather high groundwater level needs to be provided.

CoA SCHEDULE 2, SOIL AND WATER	Proponent Response	DoI Water Comment
44. The results of the Groundwater Monitoring Program shall be reported the Department and DPI-Water, using contour plans depicting the surface topography, updated contour maps of the wet weather high groundwater level of the regional aquifer and proposed depth of extraction for each extraction Phase. Reporting is to occur on a six monthly basis for the duration of extractive operations, and throughout rehabilitation of the site, unless otherwise agreed with the Secretary.	Section 6 Reporting, reiterates criteria.	Satisfactory.
The Applicant shall implement the Groundwater Monitoring Program as approved from time to time by the Secretary.		

Proponent Responses to DPI Water comment

DPI Water Response	Proponent Response to DPI Water comment	DoI Water Comment
Prior to approval:		
1 Detailed cross-sections through the site in a north-south and east-west orientation and along the longest groundwater pathway as guided by the regional groundwater contours for the site.	Appendix C Cross-sections. "Five cross-sections have been prepared to illustrate the relationship between the observed groundwater levels in the monitoring bores. Cross-sections BB' and CC' have been extended to include relevant information from the adjacent PF Formation quarry to the west of the Roberts Road quarry."	Satisfactory.
2 Provide a clearer surface topography contour map in A3 format.	Figure 1 and 2 - Surface Contours and Quarry Status at June 2016 and Bore locations respectively.	Satisfactory. The surface contour maps provided are clear and of sufficient detail to enable enlargement without loss of clarity in the PDF format provided. Sufficient for purpose.

DPI Water Response	Proponent Response to DPI Water comment	DoI Water Comment
3 Provide a map of the extent and thickness of the Maroota Sands palaeochannel on site including the top and bottom elevations.	Palaeochannel extent shown on wet weather high groundwater level plans.	Satisfactory. The requested plan has not been presented as such. However the data has been presented in cross sections and the wet weather groundwater level plans. From the data presented in the sections it is evident that not all drill holes are fully penetrating and therefore the control on the lower bound of the Maroota Sands is less than desired. The information presented is sufficient for its purpose.
4 Provide a map of the extent and thickness of the:		
a. Maroota Sands palaeochannel on site including the top and bottom elevations.	as above	Satisfactory. The requested plan has not been presented as such. However the data has been presented in cross sections and the wet weather groundwater level plans. From the data presented in the sections it is evident that not all drill holes are fully penetrating and therefore the control on the lower bound of the Maroota Sands is less than desired. The information presented is sufficient for its purpose.
b. clay confining layer identified on site at elevation ~183m AHD (including the top and bottom elevations).	Confining clay layer extent has not been shown on any plans or cross sections. Location of some perched water tables is indicted on a number of sections.	Satisfactory. The requested plan has not been presented as such. However related perched water table level data has been presented on a number of cross sections. From the data presented in the sections and the drill logs it is evident that not all of the limited number of drill holes penetrate the clay aquitard and therefore the control on the positioning of the clay aquitard is less than desired. The information presented is sufficient for its purpose.
c. Hawkesbury eluvium identified on site (including the top and bottom elevations).		Unsatisfactory. Information pertaining to the Hawkesbury eluvium has not been presented. This information needs to be provided.
5 Provide a map of the extent and surface topography of the underlying Hawkesbury Sandstone.		Unsatisfactory. No map of the palaeo-topography for the Hawkesbury Sandstone has been presented. This information needs to be provided.

DPI Water Response	Proponent Response to DPI Water comment	DoI Water Comment
6 Provision of all borelogs and surveyed locations for all existing boreholes on site including historical bores since destroyed by mining.	APPENDIX A BORE LOGS – SITE MONITORING BORES AND PRODUCTION BORES	Satisfactory.
7 Provision of groundwater contour maps for the:		
a. perched aquifer within the Maroota Sands Aquifer above the confining clay layer.		Satisfactory. Not presented. This data has been presented in cross sections. The information is sufficient for its purpose. However clarity on this matter would be better achieved by provision of the requested contour plot.
b. aquifer within the Maroota Sands and Hawkesbury Eluvium Aquifers beneath the confining clay layer.	"Wet weather High Groundwater Level Hawkesbury Sandstone" plan - Figure 8 and "Wet Weather Groundwater level Maroota Sands" plan - Figure 7	Satisfactory.
c. fractured Hawkesbury Sandstone Aquifer.	APPENDIX A BORE LOGS – SITE MONITORING BORES AND PRODUCTION BORES	Bore logs provided indicated the drill method was insufficient to enable the collection of fracture information within the sandstone. Hence L&W recognise that this information is not readily available. L&W encourage the proponent to increase their knowledge of this aspect of the aquifer.
These maps may be derived by the use of a groundwater model suitable for the task and provided after drilling.		
8 Provision of and analysis of historical pumping records from bores PT84PB1 and PT84PB2.	Water levels within PT84PB1 and PT84PB2 discussed - Hawkesbury Sandstone regional aquifer.	Unsatisfactory. This information was not provided. Water levels within PT84PB1 and PT84PB2 discussed - Hawkesbury Sandstone regional aquifer. (NOTE: pumping records should be provided and discussed as a component of the Site Water Balance).
9 All proposed boreholes to be drilled by a suitably qualified driller.	Ultra Drilling Waterbores.	Satisfactory.
10 All bores to be logged and monitoring bores on site to be designed by a suitably qualified and experienced groundwater consultant.	"The Secretary approved the appointment of Peter Dundon of Dundon Consulting Pty Ltd on 5th April 2016 for the preparation of the GWMP." "Approval was also received from DPI-Water on 10th May 2016."	Satisfactory.

DPI Water Response	Proponent Response to DPI Water comment	DoI Water Comment
11 DPI Water considers that there are an insufficient number of clustered bores targeting multiple aquifers. The Proponent should consider this recommendation and discuss this with DPI Water.	DPI-Water provided initial advice on the draft of a Groundwater Monitoring Program (GMP) which forms a component of the GWMP, by letter dated 26th September 2016. A meeting was held with DPI-Water in their Parramatta offices on 24th October 2016 in relation to this draft GMP, and discussion of further groundwater studies including the installation of additional monitoring bores. The broad scope of additional studies was agreed to by DPI Water at that meeting. Further correspondence resulting from the outcomes of this meeting was provided by DPI-Water on 31st October 2016, 22nd November 2016 and 31st March 2017. Consultation in relation to the Groundwater study Report is ongoing.	Satisfactory.
12 Consultation with DPI Water Hydrogeologists to ensure a sufficient groundwater monitoring program is in place for the site for ongoing monitoring until 2025.	An email from the DP&E on 14th October 2016 provided comments on all Management Plans submitted thus far, including the GMP. Locations of the proposed new bores were approved. The draft Groundwater Monitoring Program (Dundon, 2016) submitted on 16 August 2016 was approved by DP&E by letter dated 28 November 2016 (see Appendix F). The Groundwater Study Report (Dundon, 2017) submitted on 24 February 2017 is still the subject of ongoing consultation with DPI Water. Copies of other relevant agency correspondence relating to either the Groundwater Study Report or the Groundwater Monitoring Program are also included in Appendix F.	

DPI Water Response	Proponent Response to DPI Water comment	DoI Water Comment
13 Provide a detailed analysis of evapotranspiration and recharge on site.	Sections 4.6 and 5.4.3.	Satisfactory. Ongoing monitoring of rainfall/ recharge and evapotranspiration on site must be a component of the surface water management plan to inform the Site Water Balance.
14 Provide a complete water balance for the site that considers the water volumes in the dams, run off and any water supplementation from bores or other water supply sources.	"This report is intended to satisfy part (c) of Condition 42 of the March 2016 consent (NSW Department of Planning and Environment, 2016). It forms part of the overall Water Management Plan, which comprises three components, viz a Site Water Balance, a Surface Water Management Plan, and a Groundwater Management Plan. The Site Water Balance and Surface Water Management Plan have been included in VGT (2017), hereinafter referred to as “SWMP”. This report is the Groundwater Management Plan."	Satisfactory.
15 Monitoring of water levels in the dams.	Survey during September 2017.	Satisfactory. Ongoing monitoring of water levels in dams must be a component of the surface water management plan to inform the Site Water Balance.
16 Proponents Groundwater Consultant to liaise with DPI Water Hydrogeologists who will be made available for a meeting to discuss the existing issues and recommendations.	As per points 11 and 12.	Satisfactory.

Groundwater Study Report

The draft Groundwater Study Report (dated 24 Feb 2017) was previously reviewed by DPI Water. The previous groundwater advice within the DPI Water submission (dated 31 March 2017) made a number of recommendations for the proponent to follow up on. Some, but not all, of these recommendations have been satisfactorily included in the revised current version of the Groundwater Study Report (dated 4 Oct 2017).

DoI Water find the Groundwater Study Report to be limited in content and it does not demonstrate a clear understanding of the hydrogeology at Hodgson Quarry and Plant Pty Limited Roberts Road sand quarry operations. Further recommendations to improve the Groundwater Study Report are provided in the covering letter.

DPI Water Recommendations	Proponent Response to DPI Water	DoI Water Comment
1. Additional detailed cross-sections through the site should be provided to DPI Water, and improvement of existing cross-sections is required to clearly show lithological differences, and a complete set of bore logging sheets need to be provided, as depicted on Figures 9, 10 and 11.	"Five cross-sections have been prepared to illustrate the relationship between the observed groundwater levels in the monitoring bores." "Bore logs are presented for all bores in Appendix A. Logs for the DPI-Water bores are presented in Appendix B."	Satisfactory. Major lithologies are identified on sections - minor critical clay lithologies are not identified at scale of diagrams. Notable seepage and groundwater table levels have been identified.
2. The Proponent should provide a map of the resources proposed as targets of mining from present day onwards. Detailed information about the lithology, extents, depths and thickness of the target resource is to be provided for the entire site and stages of mining are to be discussed. Contour maps of the surface topography of proposed maximum mining depth everywhere on site as well as post-mining rehabilitated topography are also to be provided.		Unsatisfactory. The requested maps have not been provided. The planned ongoing development is to be discussed in terms of the interaction with the various identified water tables, including the 'perched' water tables. The proponent is to provide the requested diagram in a revision of a further updated Groundwater Study Report and a copy of an updated Groundwater Management Plan.
3. Consultation with DPI Water Hydrogeologists is required to ensure a sufficient groundwater monitoring program is in place for the site for ongoing monitoring until 2025.	Groundwater Monitoring Plan.	Satisfactory. A DoI Water Hydrogeologist will be made available for a meeting or discussion of the site conceptual hydrogeology and recommendations if requested.
4. Monitoring of water levels in the dams using loggers.	"Dataloggers have now been installed in all monitored bores as well as on the Process Water Dam 1, Tailings Dam, Nursery Dam 3 and Farm Dam 4. The dataloggers have all been set to record water level at hourly intervals, so that both longer term fluctuations and diurnal	Satisfactory.

DPI Water Recommendations	Proponent Response to DPI Water	DoI Water Comment
	fluctuations (if any) can be detected, as well as any relationship between the fluctuating water levels in the Process Dam and Tailings Dam, and the nearby monitoring bores."	
5. The Proponents Groundwater Consultant should liaise with DPI Water Hydrogeologists who will be made available for a meeting to discuss the site conceptual hydrogeology and recommendations.		Satisfactory. A meeting was held between the parties, 24 October 2016. A DoI Water Hydrogeologist will be made available for a meeting or discussion of the site conceptual hydrogeology and recommendations if requested.
There is still uncertainty with regards to the conceptual hydrogeology. - The latest information provided does not provide certainty as to the pre-mining, present day and post mining wet weather high water table to enable a proper assessment of the conditions on site.		Unsatisfactory. There is no discussion on the wet weather high water table or how it is derived in the Groundwater Study Report. There is more discussion on this matter in the Groundwater Management Report than found in the Groundwater Study Report. The two reports need to be reconciled concurrently, updated and revised versions resubmitted to DoI Water.
- The Proponent appears to reference all water above the Hawkesbury Sandstone Basement as “perched groundwater”. This diminishes the significance of a regional groundwater table in the Maroota Tertiary Sands Groundwater Source, for the establishment of maximum mining depths (which is to extend no deeper than within two metres of the wet weather high groundwater level at any location).	"Groundwater is present within the Maroota Sands and the underlying Hawkesbury Sandstone. Groundwater in each of these two formations is regionally extensive and forms a regional water table in each. Localised groundwater is also present in perched aquifers within the Maroota Sands, as well as on top of or within the Hawkesbury Sandstone, above the regional water tables. Thus, localised groundwater may be intersected at a number of elevations above the regional water table levels."	Satisfactory.
- The wet weather water table is variable across the site and what the Proponent terms as a “perched Maroota sands water table in a desaturated zone” is regarded by DPI Water to be a regional Maroota Sands aquifer water table	"Groundwater levels in both units (Maroota Sands and Hawkesbury Sandstone) display fluctuations that relate to episodic recharge associated with major rainfall events. The recharge response are particularly marked in the Maroota Sands." " MW2 became blocked in early 2000	Satisfactory. The proponent response is duly noted and is valid to the data presented. DoI Water recognise that the measurements are limited to sporadic data over an extended time for the region and locality, this hampers the recognition of pre-mining groundwater levels

DPI Water Recommendations	Proponent Response to DPI Water	DoI Water Comment
that has already been significantly lowered by mining activities relative to baseline conditions that existed pre-mining. MW2 water levels (203 m AHD) suggest a much higher baseline regional water level than the present water level at MW5 and MW8 (193 m AHD).	by an obstruction above the water level in the bore, and was not able to be monitored thereafter." Hence MW2 is considered unreliable. "The deepest reported intersections of Maroota Sands were at MW6, MW10 and MW11, where the top of the Hawkesbury Sandstone was encountered at <173.5 mAHD, 168.1 mAHD and 164 mAHD respectively. At these locations, the water level in the Maroota Sands on 24 August 2017 was at elevations of 185.3 mAHD, 185.7 mAHD and 184.0 mAHD respectively. All three water levels are lower than the current water level in the main process area dam (Dam 1), where the water level on the same date was 188.1 mAHD. Similar water levels were reported from previous monitoring bores MW3 and MW4 before they were destroyed by the quarry expansion. These water levels in these five bores are believed to be true reflections of the regional water table level within the Maroota Sand aquifer. Elsewhere on the site, groundwater levels within the Maroota Sands formation are elevated, in the range 192 mAHD to 206 mAHD. In some locations, the perched water levels may be further elevated due to leakage from the various dams on the property."	and or any lowering of regional groundwater table. Recognition of groundwater levels for both regional (within the Maroota Sands and Hawkesbury Sandstone), and those of a 'perched' nature is reflecting the current situation as seen at the time of writing.
- The Proponent suggests that the extent of the saturated Maroota Sands is limited towards the west by the depiction of a red line on Figure 19. However multiple Maroota Sand screened bores show a standing water level reading in the western “desaturated zone”. DPI Water would like some clarification justifying the suggestion and clarity about whether this desaturation was	Topographically and palaeo-topographically the bores both to the west and south of the depicted saturated Maroota Sands zone are significantly elevated to those within the saturated Maroota Sands zone. Standing water level in the bores to the west and south of the saturated Maroota Sands zone indicate discrete perched aquifers (with dry intervals between as indicated on cross sections) at levels above the regional Maroota Sands groundwater table.	Satisfactory.

DPI Water Recommendations	Proponent Response to DPI Water	DoI Water Comment
present pre-mining and to address the contradiction.		
- The submitted document could benefit from further clarification by the provision of further detailed hydrogeological cross-sections in other orientations. Seepages in Maroota sands were noted at elevations immediately to the west of the main dam that were higher than current dam water levels. Historical data suggests that Maroota Sands water levels were significantly higher than existing water levels. The drawdown could be attributed to water supply dewatering, evaporation from the capillary zone or evaporation from open water on the dams.	"Five cross-sections have been prepared to illustrate the relationship between the observed groundwater levels in the monitoring bores." "There is evidence for seepage from at least one of the site dams. All dam water levels are higher than the nearby groundwater, and seepage from the dams may account for some of the observed perched groundwater within the site." "A persistent seepage zone has been observed in the active quarry about 120m east of Dam 4 (Farm Dam), at the location marked “Seepage” on Figure 2, close to the edge of Tailings Dam 2. This seepage is observed at an elevation of approximately 195 mAHD, ie about 18m lower than the Dam 4 water level and about 7m higher than the water level in Dam 2. The seepage has been observed to dry up whenever water is pumped for an extended period from Dam 4 causing the water level in Dam 4 to be lowered, indicating a clear connection between the dam and the seepage."	Satisfactory.
DPI Water finds the report inadequate towards determining the location of the wet weather high groundwater table on site and requires further information.		Unsatisfactory. There is no discussion on the wet weather high water table or how it is derived in the Groundwater Study Report. There is more discussion on this matter in the Groundwater Management Report than found in the Groundwater Study Report. The two reports need to be reconciled concurrently, updated and revised versions resubmitted to DoI Water.

Surface Water Management Plan

DPI Water Comment	Proponent Response to DPI Water	DoI Water Comment
Section 1 of the SWMP indicates a portion of clean water from the undisturbed areas and properties adjacent to the quarry enters the main quarry area. Clean water runoff should be diverted away from the quarry area. The SWMP should clarify if it is possible to divert this clean water around the site so it does not enter the quarry.	Section 2.4.6 Section 4.1 and Section 7.4	Section 4.1 confirms it is not physically possible to divert the clean water around the site due to the topography.
It is suggested the heading for Section 2.3.2 'National Office of Water (NOW)' is amended to 'DPI Water'.	Whole Document	It is noted the whole management plan has been amended to refer to DPI Water. DPI Water has since become DoI Water. It is suggested the SWMP is updated to reflect the department's most recent name change.
It is recommended Section 2.3.2 includes licensing details on all the dams on the site.	Section 2.4.6	Noted.
It is noted there are aspects of groundwater monitoring in the SWMP. Aspects of the hydrogeology on the site are yet to be finalised.	Groundwater aspects have been removed from this report and are covered in the GWMP	Noted.
The SWMP needs to include a figure which shows the location of the bores listed in Table 2 including the location of the groundwater bore (GW102451). It is unclear where this bore is located.	Groundwater aspects have been removed from this report and are covered in the GWMP	Noted.
Table 2 indicates the WAL for 10CA114819 and 10CA104888 expired in February 2016. The SWMP needs to clarify if current approvals are held.	Table 5 Groundwater aspects have been removed from this report and are covered in the GWMP	Noted
Section 2.5 makes reference to email correspondence from the DPI on the '14 October 2016'. This needs to be amended to the '10 October 2016 (see page 13).	Reference deleted Groundwater aspects have been removed from this report and are covered in the GWMP. No reference to SWMP in correspondence	Noted

DPI Water Comment	Proponent Response to DPI Water	DoI Water Comment
Section 4.1 notes surface water collected over properties east of Roberts Road enters the site via a road culvert. It indicates this catchment is approximately 10 Ha and is considered clean and is diverted into Dam 1. As water from Dam 1 is used for processing a Water Access Licence (WAL) is required.	Section 2.4.6 Section 4.1 and Section 7.4	As clean water is diverted into Dam 1 and it is used in the quarry processing, a WAL will be required for the use of this water.
The collection of dirty water in dams or sediment ponds for a water supply is exempt from requiring a licence under the Water Management (General) Regulation 2011. The collection of clean water from undisturbed areas in dams to provide a water supply is not exempt and is not supported by DPI Water unless it is in accordance with an appropriate WAL and a nominated work. If clean water is being collected, then the proponent must liaise with DPI Water to ensure appropriate licences are held.	Section 2.4.6 Section 4.1 and Section 7.4	Section 2.4.6 confirms that Dam 1 receives clean water from the property next door and the dam is used to feed the processing plant. The SWMP indicates the proponent intends to investigate the transfer of the required allocation of the current water licence on Lot 2 DP228308 for 'irrigation' held by Mr Leonard Martin (the landowner) to Lot 1 DP228308 (where Dam 1 is located) for works where Mr Martin is also the landowner. The proponent is advised to contact WaterNSW on this issue, as WAL dealings are dealt with by WaterNSW.
Groundwater Inflows. The pumping bores need to be metered.	Groundwater aspects have been removed from this report and are covered in the GWMP.	Noted

DPI Water Comment	Proponent Response to DPI Water	DoI Water Comment
The SWMP needs to clarify if the quarry discharges water off site. Section 4.5 states “no discharge off-site has occurred recently” but this is not consistent with: • Section 4.6 which states “at present the site does not discharge water off site” • Section 7.6.5 which states “no discharge of water off-site has occurred to date” It is suggested the SWMP clarifies if any off-site discharge has occurred. It would appear from Section 7.6.5 that no offsite discharge has occurred. If off site discharge has occurred, Section 4.5 needs to include details such as when off-site discharge occurred and whether surface water quality monitoring was undertaken at this time.	Section 4.5. No discharge off-site occurs and none is planned.	Section 2.4.5 also addresses this issue
Section 4.5 notes that should discharge be required surface water monitoring would be undertaken. The SWMP needs to provide details on where the surface water quality sampling points are located.	Section 4.5 No discharge off-site occurs and none is planned	Sections 2.4.5 and 4.4 also address this issue.
DPI Water supports a nil discharge approach for dirty/sediment laden water. Clean surface runoff, however should be diverted away from development and diverted to downstream catchments for the environment and other users (unless the water is captured under a WAL.	Section 2.4.6, Section 4.1, Section 4.5 and Section 7.4. No discharge off-site occurs and none is planned	The SWMP confirms it is not physically possible to divert the clean water around the site due to the topography.
Discharge Points. The SWMP should identify where the discharge points are located.	Section 4.5 No discharge off-site occurs and none is planned	Noted

DPI Water Comment	Proponent Response to DPI Water	DoI Water Comment
Water Use on site. Section 5.3 notes that after processing liberated water is drained into a 'holding dam'. The SWMP needs to clarify which dam is the holding dam and include a figure which locates it.	Section 4, Section 5.3, Section 7 and Figure Ten	Sections 5.2 and 5.3 confirm that Dam 2 is currently the holding dam and its location is shown on Figure 10.
Recycling of Water. Section 5.4 refers to collecting water in the sediment dams for reuse. The SWMP needs to clarify which dams are the sediment dams and include details on the capacity of these dams. A figure needs to be included in the SWMP which shows the location of the sediment dams.	Section 4, Section 5.4, Section 7 and Figure Ten	Figure 10 should identify which dams are the sediment dams.
Modelling Assumptions. The modelling provides a ball park figure understanding but it does not represent reality.	Section 5. Water balance has been updated	Ongoing monitoring of water levels in dams must be a component of the SWMP to inform the Site Water Balance.
Projected Future Water Usage. Section 5.6.2 notes water levels within the dam will be recorded annually and that to assist with this, loggers will be installed in key dams. DPI Water advised in its submission of 31 October 2016 that it requires a continuous water level logger to be placed on each of the dams at the site to determine if the water in the dams is originating from the Maroota sands aquifer. The SWMP needs to be amended to reflect this.	Section 5.6.2, Section 11.2	DPI Water advised that it requires a continuous water level logger to be placed on each of the dams at the site to determine if the water in the dams is originating from the Maroota sands aquifer. Section 5.6.2 indicates that a water logger has recently been installed in Dam 1. The SWMP should clarify if loggers have been installed in each of the dams at the site and if not it should explain why this has not occurred.
Clean Water Management. Section 7.1 notes clean water is diverted around the site via a series of earthen bunds and it refers to Figure 3. Figure 3 needs to be amended to show the location of the bunds. As the SWMP indicates clean water from undisturbed areas enters the quarry area, Section 7.1 should include details on this.	Figure Two, Figure Three, Figure Four, Figure 5, Figure Six, Figure Seven and Figure Eight	The amendments made to Section 7.1 and the figures provide greater clarity.

DPI Water Comment	Proponent Response to DPI Water	DoI Water Comment
Final Stage catchment Section 7.2.5 notes the potential volume of the final dam on the site would be 945 300 m^3, which equates to 945 ML. The proponent would need to purchase WAL(s) to account for the volume of water held by the dam. The SWMP assumes the final dam would have an average depth of 7m. A groundwater WAL may also be required if the dam intercepts groundwater. It is recommended the proponent commences investigating the purchase of WAL(s)	Section 7.2.5, Section 7.4 and Section 8	It is noted that the estimated volume of the final dam has been reduced from 945 ML which was included in the previous draft SWMP to 570 ML and that the site currently holds a water licence for 264 ML (Section 7.2.5, page 50) Section 7.4 notes the landholder holds a WAL for the two nursery dams (Dams 3 and 4) on the site which will be transferred to the dam in the final landform (page 52). Transferring the WAL for the 2 nursery dams will not be sufficient, as the WAL for dams 3 and 4 only amounts to 264 ML. The proponent will need to purchase a WAL for the additional 306 ML. Alternatively the final void could be constructed so that it is only large enough to account for the 264 ML
The NSW Dams Safety Committee should be consulted in relation to this dam.	Section 8.2	Noted
Transfer of Water to Offsite Dam. Section 7.6.2 indicates excess surface water from Dam 1 is to be transferred from the site to the neighbouring land owned by Mr Tony Portelli. The SWMP indicates the water is to be used for stock water and irrigation. The SWMP needs to clarify whether Mr Portelli has the correct approvals under the Water Management Act 2000. Details are required on the location of Mr Portelli's property and the location of his dam(s). Clarification is required as to how the water is to be transferred, and whether it is to be transferred via a pipeline to his property.	Section 4.5 No Discharge off-site occurs and none is planned	Noted
<u>Performance Criteria</u> Once the proponent clarifies the remaining groundwater issues, this section will be subject to change.	Section 10	Section 10 of the previous draft SWMP included an objective in Table 36 for "no impacts to groundwater quality and quantity'. It is noted the revised SWMP has deleted this objective from Table 35.

Additional Comments

Deficit in water supply

Sections 5.2 and 5.6.1.4 note there may be some periods in the life of the quarry where there will be a deficit in water supply. The SWMP should explain what the quarry intends to do during periods when there isn't enough water and clarify if it is proposed to stop processing during these periods.

9.3 Erosion Control

The SWMP notes lands planted recently will be watered regularly until an effective cover has established (page 62). The SWMP should also require follow up watering, in addition to the application of follow up seed and fertiliser, where minor erosion and inadequate vegetative protection occurs.

Section 10

An 'action to be implemented' for the onsite dams and earth embankments should include:

- vegetation on the earth embankments should regularly be watered especially during dry weather conditions

This will assist to ensure the embankments remain adequately vegetated.

11.1 Erosion and Sediment Monitoring

It is noted monitoring of the soil erosion, sediment and water control is undertaken monthly (page 66). It is recommended erosion and sediment control monitoring is also undertaken:

- Within 24 hours of expected rainfall
- Within 18 hours of a rainfall event of sufficient intensity and duration to cause runoff on-site

11.2 Surface Water Monitoring

Section 11.2 indicates that the surface water monitoring will include automatic data loggers to monitor the dam levels (page 66). The SWMP needs to clarify which dams will have automatic data loggers installed. Ongoing monitoring of water levels in dams must be a component of the SWMP to inform the Site Water Balance.

The quarry also proposes to sample and test the water quality of all on-site dams on "a once only basis" to determine if there is a relationship to groundwater. It is recommended water quality sampling of the dams is undertaken over 12 months -2 years on a 3 monthly basis to pick up any seasonal variation within the dam water to determine if there is any relationship to groundwater.

End of Attachment A

Water Management Plan – DA 267-11-99 MOD 2 – Condition 42 Schedule 2	**Satisfactory (Yes/No/Partial)**	**Comment**	**Action Required**
The Applicant shall prepare a Water Management Plan for the development to the satisfaction of the Secretary. This plan must be prepared in consultation with DPI-Water by suitably qualified and experienced person/s whose appointment has been approved by the Secretary, and be submitted to the Secretary for approval by 31 December 2016. The plan must be updated on an annual basis in consultation with DPI-Water for three years from the date of approval of Modification 2 and thereafter as agreed with by the Secretary. In addition to the standard requirements for management plans (see Condition 61), this plan must include a:			
(a) Site Water Balance that: • includes details of: ○ sources and security of water supply, including contingency planning; ○ water use on site; ○ water management on site, including groundwater inflows to the quarry voids and site discharges; and ○ audit and reporting procedures, including comparisons of the site water balance each calendar year; and ○ describes the measures that would be implemented to minimise clean water use on site and maximise recycling opportunities;	Partial	○ See Section 5.2 – please include details of contingency planning. ○ Satisfied – See Section 5.3. ○ See Section 7 – Please include a discussion of how groundwater inflows to quarry voids will be managed. ○ Satisfied - See Section 11.4 and Table 35. ○ See Section 7– Refer to DoI Water's Comments regarding a Water Access Licence.	Nil actions required, other than those set out in the Comments and General Comments below.
(b) Surface Water Management Plan, that includes: • a detailed description of the surface water management system on site, including the: ○ clean water diversion systems; ○ erosion and sediment controls; ○ effluent irrigation system; ○ water transfers from the extraction areas; ○ water storages; and ○ discharge points; • design objectives and performance criteria for proposed:	Partial	• Changes required for the surface water management system on site: ○ Satisfied – See Section 7.1, Section 5.2 and Figure 2. ○ See Section 9.3 – Please clarify how natural grasslands are managed. ○ Satisfied – See Section 4.5, no discharges are to occur offsite. ○ Satisfied – See Section 4.2 and Chart 1. ○ Satisfied – See Section 7 ○ Satisfied – See Section 4.5, no discharges are to occur offsite. • Design objectives and performance criteria require changes: ○ See Table 35:	

Water Management Plan – DA 267-11-99 MOD 2 – Condition 42 Schedule 2	**Satisfactory (Yes/No/Partial)**	**Comment**	**Action Required**
○ erosion and sediment control structures; ○ water storages, including quarry voids; ○ site discharges; and ○ control of water pollution from rehabilitated areas of the site; • performance criteria, including trigger levels for investigating any potentially adverse impacts for surface water quality; • a program to monitor: ○ the effectiveness of the water management system; ○ site discharge water quality; and ○ surface water level and quality in the Process Water Dam, including the quantification of rainfall inflow, groundwater inflow and evaporation; • a plan to respond to any exceedances of the performance criteria, and mitigate and/or offset any adverse surface water impacts of the project; • long term water quality management objectives and the measures to achieve these objectives; • a plan that ensures surface stormwater runoff from the disturbed areas is directed to the sedimentation dam(s); • a plan that ensures tailgate drainage does not discharge into or onto any adjoining public or Crown road, any other persons land, any Crown land, any river, creek or watercourse, any groundwater aquifer, any native vegetation as described under the Native Vegetation Conservation Act 1997 and any wetlands of environmental significance; • a detailed description of design and construction criteria for the Process Water Dam based on a feasibility study of:		– Row 5 – Please remove 'dam wall failure' as a performance trigger. The proposed triggers should allow for early identification of instability to prevent dam wall failure. – Please include performance and completion criteria relating to quarry voids. – Please include performance and completion criteria for water quality in water storages, including a plan to respond to any exceedances of the criteria. • See Section 11 – The proposed once only monitoring of onsite dams is not acceptable to meet this condition. A program must be in place to monitor water quality in water storages. The Department recommends quarterly monitoring by an accredited lab for a two-year period. Following this period, monitoring frequency can be reviewed. • Satisfied – Table 35 – Refer to comment above for additional inclusions in Table 35. • Satisfied – See Section 7.5. • Satisfied – See Section 4. • Satisfied – See Section 7.6. • Please include a detailed design and construction criteria for the Process Water Dam.	

Water Management Plan – DA 267-11-99 MOD 2 – Condition 42 Schedule 2	**Satisfactory (Yes/No/Partial)**	**Comment**	**Action Required**
○ capacity to construct multiple cells within the overall dam footprint (ie a two stage or three stage dam); ○ whether the dam floor and walls are able to be effectively lined with compacted clay (especially for multiple cells); ○ whether effective hydraulic separation can be achieved between such cells; ○ rehabilitating such cells to create a single dam within the final landform; and ○ the appropriateness of diverting runoff received from off-site around the dam; • a strategy for the decommissioning of water management structures, including storage, sedimentation and leachate dams once extraction is complete; and • audit and reporting procedures, including comparisons of the monitoring results each calendar year and quarterly reporting of surface water monitoring results;		• Satisfied – See Section 7.4 and Section 7.9. • Satisfied See Section 11.4.	
(c) Groundwater Management Plan that takes into account the Web-based Reporting Guideline (DPE 2015) and Groundwater Monitoring and Modelling Plans – Information for Prospective Mining and Petroleum Exploration Activities (DPI 2014), and includes: • detailed baseline data on groundwater yield and quality in groundwater bores on privately owned land, that could be affected by the project; • a program to undertake surveyed probe testing of all extracted areas where clay fines have been deposited to: ○ accurately determine the depth of extraction and depth of clay fines;	Partial	• Satisfied – See Section 5.4, Appendix C and Figure 9. Available baseline data presented. • Further details required – Refer to DoI's comments.	

Water Management Plan – DA 267-11-99 MOD 2 – Condition 42 Schedule 2	**Satisfactory (Yes/No/Partial)**	**Comment**	**Action Required**
○ identify any ongoing intersection or other interaction between clay fines and the regional groundwater aquifer; ○ identify any geotechnical characteristics of the emplaced clay fines which may pose risks to workplace safety or implementation of the process water dam design or the final landform; and ○ identify measures which can be successfully used in rehabilitating these areas; • a program to monitor potential groundwater quality impacts to the regional aquifer from receiving off-site runoff water in the Process Water Dam; • groundwater assessment criteria, including trigger levels for investigating any potentially adverse groundwater impacts, in accordance with the NSW Aquifer Interference Policy; • a program to monitor: ○ the impacts of the project on: - groundwater inflows to water storages; - any groundwater bores on privately-owned land that could be affected by the project; and ○ seepage from water storages or backfilled voids on site; • a plan to respond to any exceedances of the groundwater assessment criteria; • emergency contingency plans for implementation in the event that the groundwater is encountered during excavation; and • audit and reporting procedures, including comparisons of the monitoring results each		• Refer to DoI's comments • Refer to DoI's comments. • Satisfied – See Section 6. • See Section 7 – Refer to DoI's comments. • See Section 7 – Refer to DoI's comments. • Satisfied – See Section 8.	

Water Management Plan – DA 267-11-99 MOD 2 – Condition 42 Schedule 2	**Satisfactory (Yes/No/Partial)**	**Comment**	**Action Required**
calendar year and quarterly reporting of groundwater monitoring results			
The Applicant shall implement the approved management plan as approved from time to time by the Secretary.	-		
General comments:			
1. Section 5.6.1 SWMP the phrase “the site would not overtop” is used, does this mean discharge or is it just describing a dam spilling? Please rephrase for clarity. 2. Section 9.3 SWMP “should” is used several times, replace with “will”. 3. SWMP – Please include an introductory paragraph that clarifies the scope of the project. Please discuss the scope of activities in the management plan in relation to the most recent approved MOD. Will the dam be separated with temporary walls? 4. Ensure the DoI Water's comments are adequately addressed.			

Groundwater Monitoring – DA 267-11-99 MOD 2 – Condition 43 Schedule 2	**Satisfactory (Yes/No/Partial)**	**Comment**	**Action Required**
The Applicant shall prepare a Groundwater Monitoring Program for the development to the satisfaction of the Secretary. This program must:			
(a) be prepared in consultation with DPI-Water and be submitted to the Secretary for approval within four months of the date of approval of Modification 2;	Yes	Evidence provided.	Nil actions required, other than those set out in the Comments and General Comments below.
(b) include proposed construction of a network of at least five active monitoring bores around the south-eastern, southern, western and north-western boundaries of the extraction area (but outside of the overall extraction footprint) in proximity to extraction Phases 1 to 6 as identified in Modification 2, to collect continuous groundwater level monitoring data from the regional aquifer;	Yes	Satisfied – See Section 3.	
(c) include proposed construction to deepen (or replace) PT84MW1 in order that a bore in that general location monitors the regional aquifer; and	Yes	Satisfied – See Figure 1 (MW1 replaced by MW7).	
(d) include proposed construction of active monitoring bores within the largest components of at least the two forthcoming extraction Phases (on a rolling basis), each to collect at least 2 years of continuous baseline groundwater monitoring data prior to extraction commencing with that Phase.	No	Refer to DoI's comments.	
General comments:			
1. Figure 15 repeated, no Figure 16 please amend. 2. Ensure the DoI Water's comments are adequately addressed.			

Landscape and Rehabilitation Management Plan – condition 60, Schedule 2	**Satisfactory (Yes/No)**	**Comment**	**Action Required**
The Applicant shall prepare a Landscape and Rehabilitation Management Plan for the development to the satisfaction of the Secretary. This plan must:			
a) be submitted to the Secretary for approval by 30 June 2017, unless otherwise agreed by the Secretary;	Yes	-	Nil actions required, other than those set out in the Comments and General Comments below.
b) provide details of the conceptual final landform and associated land uses for the site;	No	The conceptual final landform is reliant on the agree wet weather high groundwater level. This has not yet been approved.	
c) describe the short, medium and long-term measures that would be implemented to ensure compliance with the rehabilitation objectives and progressive rehabilitation obligations in this consent;	Yes	Sections 4.4 and 4.5.	
d) a detailed description of the measures that would be implemented over the next 3 years (to be updated for each 3 year period following the 3 years covered by the initial approval of the plan) including the procedures to be implemented for:			
• maximising the salvage of environmental resources within the approved disturbance area for beneficial reuse;	Yes		Nil actions required, other than those set out in the Comments and General Comments below.
• protecting vegetation and fauna habitat outside the approved disturbance area on-site;	Yes		
• minimising the impacts on native fauna;	Yes		
• landscaping the site to minimise visual and lighting impacts;	Partial	What is the timeframe for screening to be fully established?	
• reviewing improved pasture species and application rates;	Yes	Section 5.5	
• controlling weeds and feral pests;	Partial	Section 6.2.4 notes that 'regular' weed removal shall be conducted. Please specify the frequency of weed and pest inspections to determine if action is required.	
• controlling erosion;	Yes		
• controlling access; and	Yes		
• bushfire management;	Yes		
e) include a program to monitor and report on the effectiveness of these measures, and progress against the performance and completion criteria;	Yes		
f) include a mass balance calculation to ensure that appropriate volumes of material are available to implement the final landform as described in this plan;	Yes		
g) provide for the construction and maintenance of the process water dam in accordance with the approved design and construction criteria (see Condition 42(b));	No	Construction methodology of the process dam not provided.	
h) identify the potential risks to the successful rehabilitation of the site, and include a description of the contingency	Yes	Section 6.2	

measures that would be implemented to mitigate these risks; and			
i) include details of who would be responsible for monitoring, reviewing, and implementing the plan.	Yes	Section 11	
Other Comments			

"Wayne Conners" <Wayne.Conners@dnr.nsw.gov.au>

To: <Fabio_Carosone@URSCorp.com>
cc:
Subject: Re: Monitoring bore replacement at Maroota

27/11/2009 11:13 a.m.

Fabio,

I can confirm that a replacement monitoring bore can be drilled under groundwater licence 10BL158808.

Please forward the bore log to me upon completion together with a site plan.

Wayne Conners
Natural Resource Project Officer
NSW Office of Water
Level 11, 10 Valentine Ave Parramatta 2150 PO Box 3720 Parramatta 2124

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Department of Environment, Climate Change and Water

>>> <Fabio_Carosone@URSCorp.com> 19/11/2009 9:38 am >>>

Wayne,

thank you for your advice this morning on the replacement monitoring at the H.B.Maroota site, Maroota. As indicated by you, the replacement bore can be drilled under the same licence number issued for the three monitoring bores on the property. The licence number is 10BL158808, Lot1, DP228308. As requested, I attach copy of the bore log PT84MW3 (which includes the surveyed coordinates) and a site plan showing the current bores location. I have not marked the proposed new location for the bore, but it will be a short distance south along the fence between Lot 1 and Lot 2 , on Lot 1. Thank you for your assistance on this matter.

(See attached file: HB Maroota PT84MW3.pdf)

Regards

Fabio Carosone
Senior Associate Hydrogeologist

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Our Ref: V15/3875#23 & OUT18/10820

Hodgson Quarry Products PTY LTD
PO Box 1778
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Via email:
info@hodgsonquarryproducts.com.au

Dear Sir/Madam

RE: Hodgson Quarry Roberts Road Maroota, NSW
Water Management Plan Review (WMP)

The Natural Resources Access Regulator (NRAR) – previously DPI Water - has had the opportunity to review of the supporting water management plan documents for the Hodgon Quarry Roberts Road Sand Quarry. The documents assessed were:

- Groundwater Management Plan (GMaP), Roberts Road Maroota Sand Quarry, Revision 16-0318-RO2B, prepared by Dundon Consulting Pty Ltd, for Hodgson Quarry and Plant PTY LTD and dated 16 April 2018
- Groundwater Study Report (GWSR), Roberts Road Maroota Sand Quarry, Revision 16-0318-RO3F, prepared by Dundon Consulting Pty Ltd, for Hodgson Quarry and Plant PTY LTD and dated 2 May 2018
- Groundwater Monitoring Program (GMP), Roberts Road Maroota Sand Quarry, Revision 16-0318-RO1C, prepared by Dundon Consulting Pty Ltd, for Hodgson Quarry and Plant PTY LTD and dated 15 April 2018
- Surface Water Management Plan (SWMP), Maroota Quarry Via Maroota, Revision 2801_MA_EMP_SWMP_2018_F4 and dated 20 March 2018.

NRAR is satisfied with the Groundwater Study reports and Surface Water Management Plan for Hodgson Quarry Roberts Road Sand Quarry.

However NRAR would like to request the following amendments to the Groundwater Management and Monitoring Plan.

- A “Make Good Provision” be included. Should there be a significant impact on neighbouring groundwater supply a make good provision will apply. This may include providing water to the impacted neighbouring bore or groundwater work affected.
- In addition if the Process/Tailings dam water is found to be leaking into the underlying aquifer and groundwater, it is expected the pH would be managed to remain between 6.5 and 8.5.

The Department requests further detailed information of the water levels and pumping records for PT84PB1 and PT84PB2 to be included in future monitoring and management reporting for the site.

Please contact Annika Lawrence, Water Regulation Officer (Newcastle) on (02) 4904 2516 or annika.lawrence@nrar.nsw.gov.au if you have further enquiries regarding this matter.

Yours sincerely

Irene Zinger
Manager Regional Water Regulation Branch (East)
Natural Resources Access Regulator

15/07/2018