CONSULTING EARTH SCIENTISTS

SITE WATER BALANCE REPORT
251 ADELAIDE STREET, RAYMOND TERRACE, NEW SOUTH WALES

PREPARED FOR PHEONIX BUILDERS PTY LTD

CES DOCUMENT REFERENCE: CES200502-PHB-AF

Written by: A. Carras

Reviewed by: I.Wong

Authorised by: D. Lowe

Client: Pheonix Builders Pty Ltd
PO BOX 342
Earlwood, NSW, 2206

Date: 07 May 2021

Telephone: 02 8569 2200 • **Fax**: 02 9983 0582

Suite 7, 5 Brunker Road, Broadmeadow • NSW 2292 • Australia • www.consultingearth.com.au

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1. INTRODUCTION

Consulting Earth Scientists Pty Ltd (CES) was commissioned by Pheonix Builders Pty Ltd (the Client) to provide a site water balance for the former quarry (now an inundated disused quarry) and associated land at 251 Adelaide Street, Raymond Terrace in New South Wales (the Site) pursuant to water balance requirements of the Planning Secretary's Environmental Assessment Requirements (SEARs) 1409 as part of assessing the hydrology impacts to support the Environment Impact Statement (EIS). The SEARs 1409 describes the proposed works at the Site to involve 'dewatering and filling in of the onsite dam by disposing approximately 3.5 million tonnes of clean fill of ENM and VENM. It is understood that the filling materials may also contain potential acid sulfate soils (PASS).

2. PREVIOUS WORK

The site has been subject to the previous and recent environmental investigations including:

- Aargus Pty Ltd, 2020, *Preliminary Geotechnical Investigation Report, 251 Adelaide Street, Raymond Terrace, NSW 2324*, 24 January 2020;
- BMT Eastern Australia Pty Ltd (BMT), 2019, *251 Adelaide Street, Raymond Terrace – Earthworks Report, Report Ref: DXW: L.N21195.003.docx*, 5 May 2019;
- Consulting Earth Scientists Pty Ltd (CES), 2020, *Environmental Site Assessment Report, 251 Adelaide Street, Raymond Terrace, NSW 2324, CES Report ID: CES200502-PHB-AE*, 20 November 2020;
- Consulting Earth Scientists Pty Ltd (CES), 2020, *Acid Sulfate Soil Investigation Report for 251 Adelaide Street, Raymond Terrace, NSW 2324, CES Report ID: CES200502-PHB-AG*, 26 November 2020;
- Environmental Resources Management (ERM) (2011), Environmental Due Diligence Report Phase 1 Environmental Site Assessment for 251 Adelaide Street, Raymond Terrace, NSW 2324, Australia, 4 July 2011.

3. OBJECTIVES

The objective of the site water balance is to satisfy the water balance requirements of SEARs 1409 by providing the following information:

- Details of all water extracted, transferred, used and or discharged currently and during planned operation of the site;
- Identify the source of all water collected or stored on the site, including rainfall, stormwater, and groundwater;
- Estimated net water balance on the site for both during filling operations and post-filling scenarios.

4. SCOPE OF WORK

To achieve the objectives and satisfy the aforementioned requirements, CES has completed the following scope of work:

- Desktop review on available information pertaining to the Site;
- Hydrogeology fieldwork involving drilling and installation of five groundwater monitoring wells (i.e. MW01 to MW5) at strategic locations around the perimeter of the inundated disused quarry. The collected bulk soil samples were dispatched to a NATA-accredited laboratory testing facility for particle grading analysis;
- Survey of the installed groundwater monitoring wells and surface water points in coordinates (i.e. Eastings and Northings) and elevation (i.e. mAHD);
- Rising head field permeability tests after the well installation;
- Groundwater level monitoring for the installed wells;
- Retrieval of suitable climate data;
- Developed water balance model and filling assumptions;
- Site water balance modelling to calculate the net water balance volumes for both during site filling operations and post-filling scenarios.

5. DESKTOP REVIEW

5.1 SITE DESCRIPTION

The Site is located at 251 Adelaide Street, Raymond Terrace, NSW and is formally defined as Lot 232 in Deposited Plan (DP) 593512 and covers a total area of 443,600m2 (44.36Ha). The site located within the local government area (LGA) of Port Stephens Council. The approximate coordinates at the centre of the site are (382310.47 E, 6372882.941 N) within the MGA 1994 Zone 56. The site locality map is shown on Figure 1.

The surrounding land use comprised the following:

- **North** – Vacant property with residential properties on Meredith Crescent beyond;
- **East** – Bushland and Raymond Terrace Wastewater Treatment Works with the Pacific Highway beyond;
- **South** – Bushland and Windeyers Creek with the Pacific Highway and the Masonite Road commercial industrial properties beyond; and
- **West** – Adelaide Street with agricultural beyond and the Hunter River at approximately 1.4 km.

5.2 SITE HISTORY

The Site is a former sand quarry, formerly owned by Monier Drilling Pty Ltd and then Rocla Drilling Pty Ltd. It is understood that extractive sand operations started in the 1950s. The quarry reached the end of its economic life and the quarrying activities at the Site ceased in 2010. The quarry void remained since decommissioning and became an inundated disused quarry over time.

5.3 GEOLOGY

A review of the Newcastle 1:100,000 Geological Series Sheet 9232 (Edition 1) 1975 indicated that the Site lies predominantly within Quaternary deposits (Qpb) derived from beach ridges and low-level windblown sand dunes. The remaining portions of the Site lie within the Quaternary deposits (Qps) derived from stable windblown sand sheets and dunes.

The NSW Surface Geology Map indicates the Site is underlain by both Quaternary estuarine deposits (QH_ea) which contain rich organic sediments and Quaternary coastal deposits (QP_bd) which are predominantly sands.

5.4 SUBSURFACE PROFILE

The subsurface profile to approximate depth of 3.7m presented in CES Environmental Site Investigation Report (CES200502-PHB-AE) general consists of the following:

- Fill material containing Silty / clayey SAND, fine to medium grained, medium plasticity, with gravels, organic material, some aggregate, no odours or staining, brown/grey; Sandy CLAY, low plasticity, brown; or SAND, fine grained, beige;

- Natural material containing Silty / clayey SAND, fine to medium grained, with organic material, some siltstone gravels, white/light brown/grey; Silty/ sandy CLAY, high plasticity, with organic material, dark grey; CLAY: moderate plasticity, dark grey; or CLAY, medium plasticity, shale fragments and ironstone gravels, no odours or staining, grey/red/yellow/orange, dry.

5.5 HYDROGEOLOGY

The groundwater aquifer system underlying the Site is known as Tomago Sandbeds, which provides underground water source that runs parallel to the coast between Newcastle and Port Stephens. Tomago Sandbeds aquifer can provide water supply backup to the nearby Grahamstown Dam. The Tomago Sandbeds is a shallow unconfined groundwater aquifer system consisting a moderately permeable formation comprising mixtures of silty and clayey sands.

Previous investigations carried out by CES at the Site indicated that groundwater levels are likely to be present at relatively shallow depths. Within the inundated disused quarry envelope, the depths to water level are generally expected to be less than 2m when measured from the existing surface level around the quarry perimeter but the water levels generally vary according to seasonal changes.

Subsurface and surface water within the study area are expected to discharge either the man-made Grahamstown Drain in the north or the Windeyers Creek in the south, which eventuates to a confluence in the south-west before flowing further to the broader Hunter River system. At approximately 4.4km northeast of the site is the Grahamstown Dam which has a total catchment area 97 km^2.

5.6 QUARRY GEOMETRY INFORMATION

Contour survey of the disused quarry could be referenced from the 2010 Survey Plan (Plan 980351) prepared by Tattersall Lander Pty Ltd, a copy of which appended to this report as **Appendix B**.

The disused quarry is irregular in shape, with a total footprint of approximately 219,579m^2. Reference to the 2010 Survey Plan indicates the deepest point of the quarry to be at RL -0.8m AHD (approximately 11.8m depth) in the central southern portion. However, the recent investigation by CES involving sediment sampling activities encountered quarry depths up to 14m.

By replotting the survey points in AutoCAD and exporting them into the ArcGIS program, the volume of the former quarry void was calculated to be 1,223,463m^3 (refer to Figure 3). Given that the current quarry void depths could be potentially deeper than indicated on the 2010 Survey Plan, the actual volume of the former quarry void can be expected to be greater than 1.25 million cubic metres.

5.7 SUMMARY OF EARTHWORKS FLOOD IMPACT ASSESSMENT (BMT, 2019)

An Earthworks Flood Impact Assessment was undertaken by BMT (2019) for the Site with the objective of providing a conceptual earthworks fill plan for the disused quarry with minimal

impact on the existing flood conditions. BMT conducted hydrologic and hydraulic modelling for the flood impact assessment which assessed the peak flood levels and the flood behaviour at the site for 10% Annual Exceedance Probability (AEP) and 1% AEP design events for existing and post-development scenarios.

A summary of the analysis and results of the flood impact assessment undertaken by BMT is as follows:

- Identification of two flooding mechanisms:
    - Local flooding of Windeyers Creek catchment was assessed as critical condition in terms of assessing the impact of the earthworks. Whilst CES considers that the specific location along Winderyers Creek which was assessed by BMT as critical condition is ambiguous, the northern creek should be correctly referred to as 'Grahamstown Drain', a man-made drain to convey water to the Windeyers Creek catchment in the west; and
    - Backwater inundation from the broader Hunter River system.
- Flood modelling of the Windeyers Creek peak flood levels of 2.0m AHD for 10% AEP and 2.2m AHD for 1% AEP (i.e. flood depths in the order of 0.8m to 1.25m above the modelled lake surface);
- Proposal of earthworks concept fill plan for negligible off-site peak flood level impacts as shown in **Appendix E**. This concept fill plan proposed a high ground (exceeding 2.1m AHD) in the north-west portion, followed by a transition slope (1.1 to 2.1m AHD) and a low-lying ground (1.1m AHD) for flood conveyance in south-east direction for minimal flood impacts.

6. HYDROGEOLOGY FIELDWORK

6.1

6.1 WELL INSTALLATION

Five groundwater monitoring wells were installed by CES between August to October 2020. The monitoring well survey data are summarised in Table 1.

Table 1: Summary of Monitoring Well Survey

Monitoring Well	Easting	Northing	Ground Elevation (m AHD)	Top of Casing Elevation (m AHD)	Casing Stickup (m agl)	Depth to Base of Well (m)	Base of Well Elevation (m)
MW1	382034	6372757	2.96	3.56	0.60	19.0	-16.04
MW2	381933	6372556	0.78	1.74	0.96	18.5	-17.72

Monitoring Well	Easting	Northing	Ground Elevation (m AHD)	Top of Casing Elevation (m AHD)	Casing Stickup (m agl)	Depth to Base of Well (m)	Base of Well Elevation (m)
MW3	382165	6372962	2.71	3.56	0.85	13.5	-10.79
MW4	382749	6373238	1.80	2.43	0.63	11.0	-9.20
MW5	382679	6372790	1.33	1.96	0.63	14.5	-13.17

The monitoring well survey plan which includes water levels in the creek and the quarry void is provided in **Appendix F**.

The survey undertaken between 16 and 17 December 2020 indicates that water levels within Grahamstown Drain flow downgradient from 0.88m AHD (WL10 located next to MW4 in the northeast of the quarry) to 0.24m AHD (WL6 located next to MW2 in the southwest of the quarry) before flowing to Windeyers Creek in the south and eventually to the broader Hunter River system in the far west.

6.2 GROUNDWATER LEVELS

Following installation of the five groundwater monitoring wells, groundwater level measurements were taken by CES between September to December 2020. The groundwater levels for each well are summarised in Table 2.

Table 2: Summary of Groundwater Levels

Monitoring Well	Date of Groundwater Level Measurement (Day.Month.Year)	Measured Groundwater Level Depth Below Top of Casing (m)	Estimated Groundwater Level Elevation (m HAD)
MW1	01.09.20	3.50	0.06
	29.10.20	2.46	1.1
	13.11.20	2.53	1.03
	16.12.20	2.69	0.87
MW2	08.09.20	0.60	1.14
	29.10.20	0.21	1.53
	16.12.20	1.25	0.49
MW3	08.09.20	2.86	0.7
	29.10.20	2.34	1.22
	16.12.20	2.7	0.86

Monitoring Well	Date of Groundwater Level Measurement (Day.Month.Year)	Measured Groundwater Level Depth Below Top of Casing (m)	Estimated Groundwater Level Elevation (m HAD)
MW4	08.09.20	1.23	1.20
	29.10.20	0.35	2.08
	13.11.20	0.88	1.55
	16.12.20	1.15	1.28
MW5	23.10.20	1.52	0.44
	29.10.20	1.15	0.81
	13.11.20	1.20	0.76
	16.12.20	1.27	0.69

From the data above, the groundwater levels averaged to be at 1.1m AHD in the east (MW4 and MW5) and at 0.89m AHD in the west (MW1 and MW2). This indicates that groundwater flow direction is from east to west.

The installed monitoring well locations including the groundwater levels are provided in Figure 2.

6.3 PERMEABILITY

The subsurface materials encountered during the installation of the groundwater monitoring well locations around the perimeter of the disused quarry generally comprised of Silty or Clayey Sand, which contain mixtures of sand, silt, and clay and assumed to have typical coefficient of permeabilities ranging from 10^{-5} to 10^{-8} m/s (Freeze & Cherry, 1979). The groundwater monitoring well construction logs are provided in **Appendix A**.

Bulk soil samples collected at various depths were dispatched to a NATA-accredited geotechnical testing laboratory facility for material analysis.

CES conducted rising head field permeability tests within the installed groundwater monitoring wells on 29 October 2020 and 13 November 2020.

6.3.1 Hazens Formula

Hazen's formula is an empirical relationship used to correlate indices of grain size distribution with the permeability of granular soils. This formula is commonly used for clean sands with D_{10} ranging from 0.1 to 3.0mm (Holtz et al., 2011).

Hazen's formula

$$k = CD_{10}^2$$

Where:

k = coefficient of permeability (cm/s);

C = constant ranging from 0.4 to 1.2, typically assumed to be 1.0 (assumed below);

D_{10} = grain size corresponding to 10% by weight passing, also referred to as the effective size (mm)

The soil samples were tested for particle size distribution (PSD) analysis at a NATA-accredited laboratory testing facility. The laboratory test certificates are provided in **Appendix C**.

Table 3 below presents the interpreted material permeability using Hazen formula.

Table 3: Interpreted Material Permeability (Hazen Formula)

Monitoring Well	Sample Depth Range (m)	D_{10} (mm)	k (m/s)
MW3	10-15	0.15	2.25E-06
MW5	15-20	0.18	3.24E-06

The interpreted material permeability for sample depths ranging from 10m to 20m lies within the 10^{-5} and 10^{-8} m/s permeability range for typical mixtures of silty and clayey sands (Freeze & Cherry,1979). The material permeability for the first 10m below ground level is expected to have permeability less than 10^{-6} m/s.

6.3.2 Rising Head Tests

The rising head field permeability tests were conducted within the installed groundwater monitoring wells by rapidly dropping the water level and recording the recharge using a water logger. A Grundfos pump was used to drop the water level within the groundwater monitoring wells. The rising head permeability test results were analysed using the AQTESOLV program.

As the groundwater monitoring wells were partially screened within an unconfined aquifer and the water-level response from each water logger was overdamped, the Bouwer and Rice (1976) method of analysis was considered the most appropriate. This involves matching a straight line to water-level displacement data collected over time.

Bouwer and Rice (1976)

$$Ln(H_0) - Ln(H) = \frac{2K_r Lt}{r_{ce}^2 Ln(\frac{R_e}{r_{we}})}$$

$$r_{ce} = \sqrt{(1 - n_e)2_c^2 + n_e r_w^2}$$

$$r_{we} = r_w \sqrt{K_z / K_r}$$

Where:

- H is displacement at time t
- H_0 is initial displacement at t= 0
- K_z is vertical hydraulic conductivity
- L is screen length [L]
- n_e is effective porosity (specific yield) of the filter pack [dimensionless]
- r_c is nominal casing radius
- r_w is well radius
- R_e is external or effective radius of the test
- T is elapsed time since initiation of the test

The Bouwer and Rice (1976) solution assumes the following:

- aquifer has infinite areal extent;
- aquifer is homogeneous and of uniform thickness;
- aquifer potentiometric surface is initially horizontal;
- control well is fully or partially penetrating;
- a volume of water, V, is injected or discharged instantaneously from the control well;
- aquifer is confined or unconfined; and
- flow is steady.

Butler (1998) suggests matching straight-line slug test solutions to data within the recommended normalised head range values between 0.20 and 0.30 for Bouwer and Rice (1976). The AQTESOLV program outputs are provided in **Appendix D**.

Table 4 below presents the rising head permeability test results derived from the Bouwer and Rice (1976) solution.

Table 4: Field Permeability Test Results (Bouwer & Rice, 1976)

Monitoring Well	k (m/s)	Average k (m/s)
MW1	2.288E-05	8.024E-06
MW2	6.304E-06	
MW3	4.146E-06	
MW4	1.464E-06	

Monitoring Well	k (m/s)	Average k (m/s)
MW5	5.328E-06	

The average permeability k value is calculated to be 8.024E-6 m/s which lies within the 10^{-5} and 10^{-8} m/s permeability range for typical mixtures of silty and clayey sands (Freeze & Cherry, 1979).

7. SITE WATER BALANCE MODELLING

7.1 CLIMATE DATA

Climate data was retrieved from the Australian Bureau of Meteorology website, which was accessed on 27 November 2020. Weather records from the Williamtown RAAF (station number 061078) are used to represent weather for the site. Williamtown RAAF is the closest weather station with complete records of rainfall and evaporation. The climate data is shown in Table 5 below.

Table 5: Climatic Data to Year 2020 for Williamtown RAAF Weather Station

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean
Mean Rainfall (mm) (1)	98.3	117.8	120.7	109.8	108.6	124.6	72.6	72.8	60.1	75.9	81.9	77.5	1118.0
Decile 9 monthly rainfall (mm) (1)	202.8	243.8	219.4	228.6	204.8	242.7	141.2	164.1	129.3	159.7	147.8	155.0	1470.2
Mean Monthly Evaporation(mm) (2)	213.9	173.6	155	114	83.7	75	80.6	111.6	141	173.6	189	223.2	1752
Mean Number of Days of Rain >= 1mm (1)	7.1	7.3	8.2	7.5	7.6	8.4	6.4	6.1	5.6	7.2	7.3	7.0	85.7

Notes

(1) BOM, Mean rainfall (mm) for years 1942-2020

(2) BOM, Mean monthly evaporation (mm) for years 1974 to 2016

The annual mean total rainfall for all years at the Site is 1,118 mm which is below the 90th percentile wet year annual mean for all years of 1,470.2 mm. The total annual mean evaporation recorded for the Site for all years is 1,752mm. The total annual mean number of days greater than or equal to 1 mm is 85.7 days.

For the purpose of water balance modelling, climate data such as evapotranspiration, rainfall and temperature from 1970 to 2019 (50 years period) has been retrieved from the same Williamtown

RAAF weather station whereas the solar radiation data was synthetically generated. These climate data were used for the site water balance modelling.

7.2 WATER BALANCE MODEL ASSUMPTIONS

7.2.1 Climatic Components

- Rainfall.
- Evapotranspiration.

7.2.2 Water Extraction/ Demand Components

- Pumping and dewatering of the quarry void.
- Civil earthworks (for site shed and site access).
- Dust suppression (for site access).
- Vehicle washdown.
- Drinking water.

Water extraction from the quarry void will be discharged to the Windeyers Creek and eventually to the broader Hunter River system to the west.

7.2.3 Water Source Components

- Groundwater from Tomago Sandbeds aquifer.
- Rainfall runoff (collected from quarry void).
- Windeyers Creek.
- Stormwater (collected from Grahamstown Drain).

A Guide to Water Sharing Plan (2004) for Tomago groundwater source suggests the following statistics at the start of the Plan:

- Average annual recharge of 35,700 ML/year.
- Environmental water from recharge of 10,700 ML/ year.
- Basic landholder rights of 1,000 ML/year.
- Hunter Water Corporation share components of 25,300 ML/year.
- Other licensed share components of 1,300 ML/ year.
- Extraction limit of 25,000 ML/year.

7.3 FILLING ASSUMPTIONS

7.3.1 General

As the proposed filling earthworks procedure information is limited at this stage, the following key assumptions have been adopted:

- Pumping and dewatering of the quarry void to acceptable levels within the granted groundwater licence. The practice of sump-pump will be employed at strategic locations within the inundated quarry.
- Filling materials will consist of clean fill (ENM and VENM). A sandy clay material has been assumed. Filling materials may contain potential acid sulfate soils (PASS).
- Filling of the disused quarry will be a staged cell construction approach (possibly using an engineered cofferdam solution). The filling would be targeted to achieve a maximum level of 1m AHD, commencing first in the north-east and west portions simultaneously, followed by south-east portion, and progressing toward the central and north-west portions. Following fill placement to 1m AHD across the quarry footprint, the subsequent portions A1 and A2 would be filled further to meet the final landform design. The fill placement and compaction procedure will be undertaken in accordance with AS3798 Guidelines on earthworks for commercial and residential developments.
- A maximum construction period of 12 months, with filling of 3 months duration for each stage.
- The water balance model assumed final landforms comprising high ground of 3m AHD in the north-west portion, followed by a transition slope (1.7m AHD) and a low-lying ground (1.1mAHD) for flood conveyance in south-east direction for minimal flood impacts as per BMT's proposed concept fill plan.
- Sediment and control measures such as temporary earth drains and sediment fencing are in place during filling operations. A site shed, a vehicle washdown area and site access using compacted aggregate have been proposed during the filling operations.
- A nearly impermeable layer (e.g. Bedrock) is present at 5m below the quarry base, ranging from RL -13 to -15m AHD.
- Groundwater inflow into the cells during filling approximated to be 20% of the total cell volume.

7.3.2 Filling Operations Scenario

For during filling operations scenario, the Site is simply divided into cell-construction stages and four filling cell portions. Based on the available information and assumptions, the following has been developed:

Table 6: Staged Filling Operations Scenario up to 1 mAHD

Assumed Construction Cell Stage	Portion	Estimated Area (m^2)	Assumed Average Final Landform Level (m AHD	Assumed Final Landform Gradient / Slope Length	Assumed Average Fill Thickness (m)	Assumed Existing Quarry Base Level (m AHD)

C1a	Northeast	44,637	1	5% / 70m	5	-4
C1b	West	48,672	1	5% / 180m	7	-6
C2	Southeast	31,058	1	5% / 130m	9	-8
C3	Central	95,212	1	5% / 200m	11	-10

A 0.5m thick loamy sand with bare ground is assumed for the filling operations scenario.

7.3.3 Post-Filling Scenario

For post-filling scenario, the Site is divided into three filling portions as per the BMT's concept filling plan. Based on the hydrogeology investigation results and assumptions, the following has been developed:

Table 7: Post-Filling Scenario

Subdivided Portions	Description	Estimated Area (m^2)	Assumed Average Final Landform Level (m AHD	Assumed Final Landform Gradient / Slope Length	Assumed Fill Thickness (m)	Assumed Existing Quarry Base Level (m AHD)
A1	Filled as high as required for flood immunity purposes	67,239	4.0	5% / 200m	12.0	-8
A2	Fill transition slope	36,608	1.7	12% / 60m	11.7	-10
A3	Provide flood conveyance capacity	118,060	1.1	5% / 150m	9.9	-8

A 1m thick revegetation layer with fair stand of grass is assumed for post-filling operations.

7.4 MODELLING METHODOLOGY

The Hydrologic Evaluation of Landfill Performance (HELP) model has been employed for the estimation of net water balance at the Site. The HELP model is a quasi-two-dimensional hydrologic numerical model for conducting water balance analysis, produced by the United States Environmental Protection Agency and later modified by Dr Klaus Berger of the University of Hamburg (HELP 3.95D).

7.5 WATER BALANCE OUTPUTS

7.5.1 Water Balance Summary

Table 8 presents a summary of water balance volumes based on HELP 3.95 modelling and assumptions for both during filling and post filling-operations.

Table 8: Water Balance Summary

Stage	Average Annual Total Precipitation (m^3)	Average Annual Total Runoff (m^3)	Average Annual Total Evapotranspiration(m^3)	Average Annual Estimated Total Net Water Balance (m^3)	Comments
Filling Operations Stage C1a (3 months duration)	49,634	19,454	24,605	295,561* (1,608)	Filling Stage 1a and 1b operations may run concurrently. Continuous pumping and dewatering of the quarry dam throughout the filling operations will be required to lower the water to acceptable levels during filling and must be strictly adhere to the conditions and extraction limits of the granted groundwater licence. Total estimated annual average water balance to be managed using pumping and dewatering is approximately **1.42 million cubic metres (or 1,418 ML)** during filling operations. Runoff will be discharged to the unfilled cells, Grahamstown Drain and Windeyers Creek.
Filling Operations Stage C1b (3 months duration)	54,197	20,715	26,860	148,637* (1,820)	
Filling Operations Stage C2 (3 months duration)	34,566	12,912	17,090	236,111* (1,206)	
Filling Operations Stage C3 (3 months duration)	105,945	38,636	52,289	737,904* (3,826)	
Post-Filling Operations for A1	74,785	4,242	60,098	2,748	Total estimated annual average water balance to be managed is approximately **8,936m^3 (or 8.9 ML)** for post-filling operations.
Post-Filling Operations for A2	40,731	2,358	32,735	1,492	
Post-Filling	131,318	7,940	106,228	4,696	

Operations for A3					

*Total water balance volumes including change in water storage volume, assumed volumes of existing water dam and assumed groundwater inflow. Note that the accuracy of water balance volumes cannot be relied upon and must be reviewed again upon confirmation of proposed dewatering/ filling activities and verification of the assumptions made in this report.

8. RECOMMENDATIONS

Whilst it is not possible to accurately estimate the volumes of water generated and transferred on site, an approximate water balance volume estimate has been generated based on available information and key assumptions. Should there be any change to the proposed development or deviations from the key assumptions made in this report, the water balance must be reviewed and re-assessed accordingly. It is recommended that systems be put in place on site to facilitate accurate monitoring of outflow and inflow water volumes throughout the filling operations. Due to the permeable nature of the quarry void, the Tomago Sandbeds aquifer recharge rates are expected to be high and thus requires a detailed hydrogeology assessment on aquifer impacts from proposed pumping and dewatering activities associated with the project.

The five active groundwater monitoring wells recently installed should continue to be monitored during the project and at post-project completion, with the groundwater level results to be reported based on the groundwater licence requirements. The pumping and dewatering associated with the project should adhere to the conditions of the groundwater licence that is granted based on assessment on the potential aquifer impacts. The project must not involve dewatering activities outside of the limits or conditions of the groundwater licence.

9. REFERENCES

Aargus Pty Ltd, 2020, *Preliminary Geotechnical Investigation Report for 251 Adelaide Street, Raymond Terrace, NSW 2324*, 24 January 2020;

BMT Eastern Australia Pty Ltd, 2019, *251 Adelaide Street, Raymond Terrace - Earthworks Flood Impact Assessment Letter Report, Report Ref: DXW: L.N21195.003.docx*, 5 May 2019;

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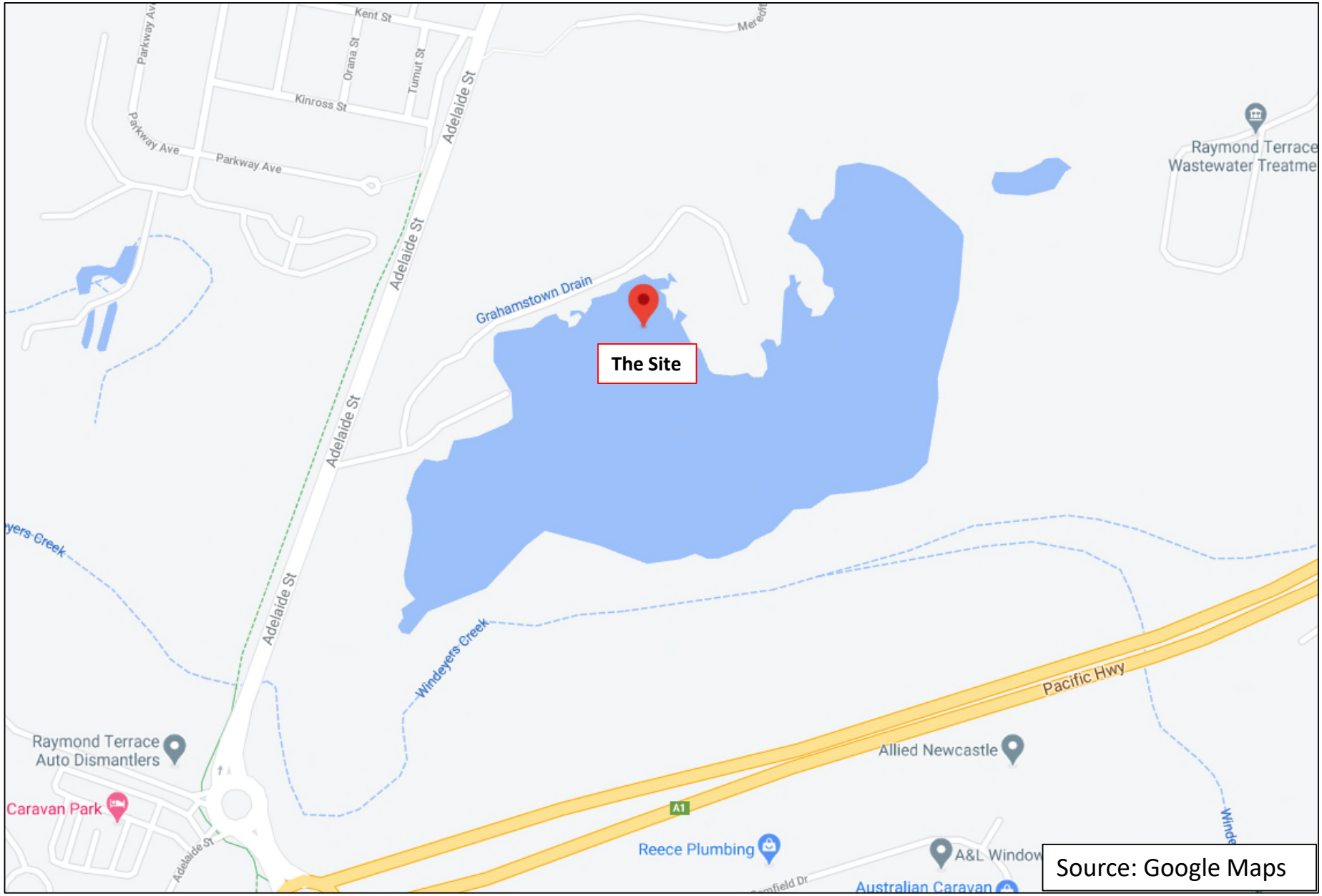
FIGURES



Source: Google Maps

CONSULTING EARTH SCIENTISTS

Suite 3, Level 1
55 Grandview Street, Pymble, NSW, 2073
ph 8569 2200 fax 9983 0582

Figure 1: Site Locality Map

CES Project ID: CES200502-PHB	Date: 15/07/20
Prepared by: A.Carras	Checked by: M.Challoner

Monitoring Well

Inferred Groundwater Flow

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Suite 3, Level 1
55 Grandview Street, Pymble, NSW, 2073
ph 9569 2200 fax 9983 8582

Figure 2: Groundwater Monitoring Wells and Levels

CES Project ID: CES200502-PHB	Date: 15/07/20
Prepared by: A.Carras	Checked by: M.Challoner

Legend

Lot Boundary for 251 Adelaide Street

Elevation (m AHD)

- -1.2 to 0.0
- -2.4 to -1.2
- -3.6 to -2.4
- -4.8 to -3.6
- -6 to -4.8
- -7.2 to -6.0
- -8.4 to -7.2
- -9.6 to -8.4
- -10.8 to -9.6

N

Total Quarry Volume Estimate = 1,223,463 m3

240 120 0 240 Meters

Source: NearMap

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Suite 3, Level 1
55 Grandview Street, Pymble, NSW, 2073
ph 8569 2200 fax 9983 0582

Title

Figure 3: Total Quarry Volume Estimate

CES Project ID:	Date:
CES200502-PHB	09/12/2020
Prepared By: B. Ren	Checked By; I. Wong

APPENDIX A: MONITORING WELL LOGS

CONSULTING EARTH SCIENTISTS

GROUNDWATER WELL MW1

PROJECT NUMBER CES200502-PHB
PROJECT NAME Raymond Terrace
CLIENT Phoenix Builders
ADDRESS 251 Adelaide Street, Raymond Terrace NSW

DRILLING DATE 07/09/20
DRILLIN COMPANY NUMAC
DRILLER Lewis
DRILLING METHOD Casing Advancer
TOTAL DEPTH 19

COORDINATES -32.776776, 151.740395
COORD SYS Latitude/Longtitude

LOGGED BY Andrew Carras
CHECKED BY Mark Challoner

Depth (m)	Samples	Water	Graphic Log	Moisture	Material Description	pH	pH Fox	Well Diagram (0.60m Stickup) MW1	Additional Observations
0				D	FILL: Sandy CLAY: fine grained, brown	5.62	5.31	Grout	
1	MW2/1.0			M	Clayey SAND: fine to medium grained, with organic material, light brown/grey	5.65	5.29	Bentonite	
2									
3		▽		W	Sandy CLAY: high plasticity, dark grey with white fine grained sand				
4					Clayey SAND: fine to medium grained, white with grey clays				
5									
6									
7									
8									
9									
10								Filter Pack	
11									
12									
13									
14									
15									
16									
17									
18								Borehole Collapse	
19					Termination Depth at: 19m				

CONSULTING EARTH SCIENTISTS

GROUNDWATER WELL MW2

PROJECT NUMBER CES200502-PHB
PROJECT NAME Raymond Terrace
CLIENT Phoenix Builders
ADDRESS 251 Adelaide Street, Raymond Terrace NSW

DRILLING DATE 07/09/20
DRILLIN COMPANY NUMAC
DRILLER Lewis
DRILLING METHOD Hollow Flight Augers
TOTAL DEPTH 19

COORDINATES -32.778581, 151.739263
COORD SYS Latitude/Longtitude

LOGGED BY Andrew Carras
CHECKED BY Mark Challoner

Depth (m)	Samples	Water	Graphic Log	Moisture	Material Description	pH	pH FOX	Well Diagram (0.96m Stickup) MW2	Additional Observations
0				D	FILL: Sandy CLAY: moderate plasticity, with silt, foregin materials include aggregate and ceramic tiles, dark brown/grey	6.03	4.40	Grout	
1	MW1/1.0					6.11	4.31		
						5.13	3.60		
2				H					
3		▽		M	Clayey SAND: fine to medium grained, white/grey	4.50	4.10	Bentonite	
				W					
4									
5						5.73	5.01		
6									
7						6.07	4.11		
8									
9						6.67	6.11		
10									
11						7.30	5.91	Filter Pack	
12									
13						7.45	6.35		
14									
15						7.92	6.50		
16					Clayey SAND: fine to medium grained, brown				
17						7.43	7.41		
18									
19					Termination Depth at: 19m			Borehole collapse	

Disclaimer This bore log is intended for environmental not geotechnical purposes.
produced by ESlog.ESdat.net on 17 Nov 2020

CONSULTING EARTH SCIENTISTS

GROUNDWATER WELL MW3

PROJECT NUMBER CES200502-PHB
PROJECT NAME Raymond Terrace
CLIENT Phoenix Builders
ADDRESS 251 Adelaide Street, Raymond Terrace NSW

DRILLING DATE 08/09/20
DRILLIN COMPANY NUMAC
DRILLER Lewis
DRILLING METHOD Hollow Flight Auger
TOTAL DEPTH 19

COORDINATES -32.774930, 151.741825
COORD SYS Latitude/Longtitude

LOGGED BY Andrew Carras
CHECKED BY Mark Challoner

Depth (m)	Samples	Water	Graphic Log	Moisture	Material Description	pH	pH FOX	Well Diagram (0.85m Stickup) MW3	Additional Observations
0				D	FILL: Silty Sandy CLAY: moderate plasticity, with some gravels, organic material, dark brown	8.24	6.69	Grout	
1						8.33	6.32	Bentonite	
2				H					
3	MW3/3.0	▽		M		8.34	5.91		
				W					
4					Clayey SAND: fine to medium grained, white sand with dark grey clay				
5						5.89	4.93		
6									
7						5.86	4.61		
8								Filter Pack	
9						6.10	5.51		
10					increasing clay content				
11						6.35	6.11		
12									
13						6.36	6.02		
14								Borehole collapse	
15					Termination Depth at: 15m Refusal on inferred bedrock				
16									
17									
18									
19									

CONSULTING EARTH SCIENTISTS

GROUNDWATER WELL MW4

PROJECT NUMBER CES200502-PHB
PROJECT NAME Raymond Terrace
CLIENT Phoenix Builders
ADDRESS 251 Adelaide Street, Raymond Terrace NSW

DRILLING DATE 23/10/20
DRILLIN COMPANY STRATACORE
DRILLER Mike
DRILLING METHOD Hollow Flight Auger
TOTAL DEPTH 13.5

COORDINATES -32.772527, 151.748027
COORD SYS Latitude/Longtitude

LOGGED BY Andrew Carras
CHECKED BY Mark Challoner

Depth (m)	Samples	Water	Graphic Log	Moisture	Material Description	pH	pH FOX	Well Diagram (0.63m Stickup) MW4	Additional Observations
0		▽		H	FILL: Silty SAND: fine grained, with organic material, brown	6.3	5.9	Bentonite	
1	MW4/1.0			M	Silty Sandy CLAY: high plasticity, white sand with dark grey clays and silts	5.8	5.2		
2				W					
3						6.2	5.9		
4									
5									
6						6.4	5.8	Filter Pack	
7									
8									
9						6.1	4.9		
10									
11									
12						6.0	5.0	Borehole collapse	
13						6.4	5.9		
14					Termination Depth at: 13.5m Refusal on inferred bedrock				

Disclaimer This bore log is intended for environmental not geotechnical purposes.

produced by ESlog.ESdat.net on 17 Nov 2020

CONSULTING EARTH SCIENTISTS

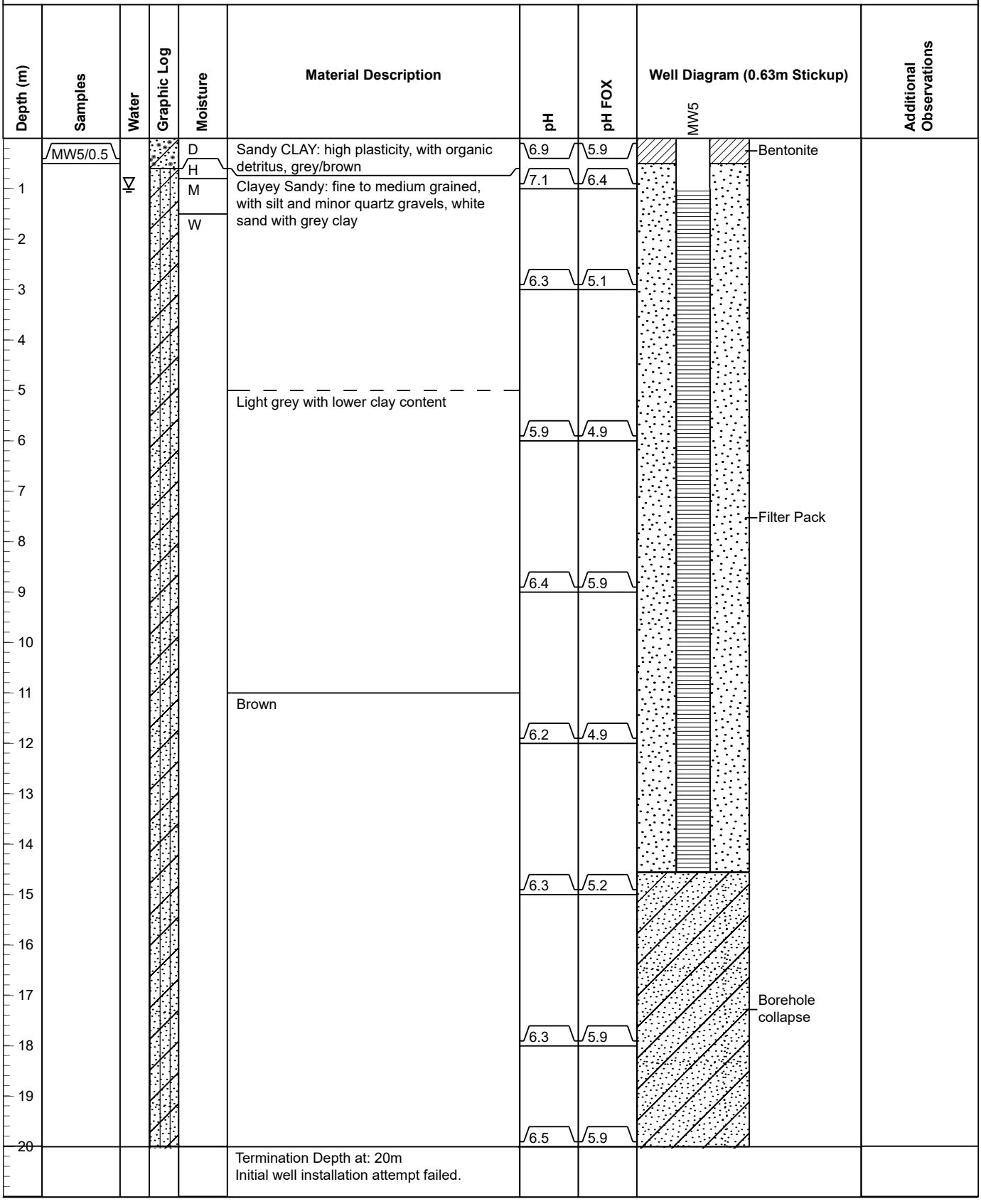
GROUNDWATER WELL MW5

PROJECT NUMBER CES200502-PHB
PROJECT NAME Raymond Terrace
CLIENT Phoenix Builders
ADDRESS 251 Adelaide Street, Raymond Terrace NSW

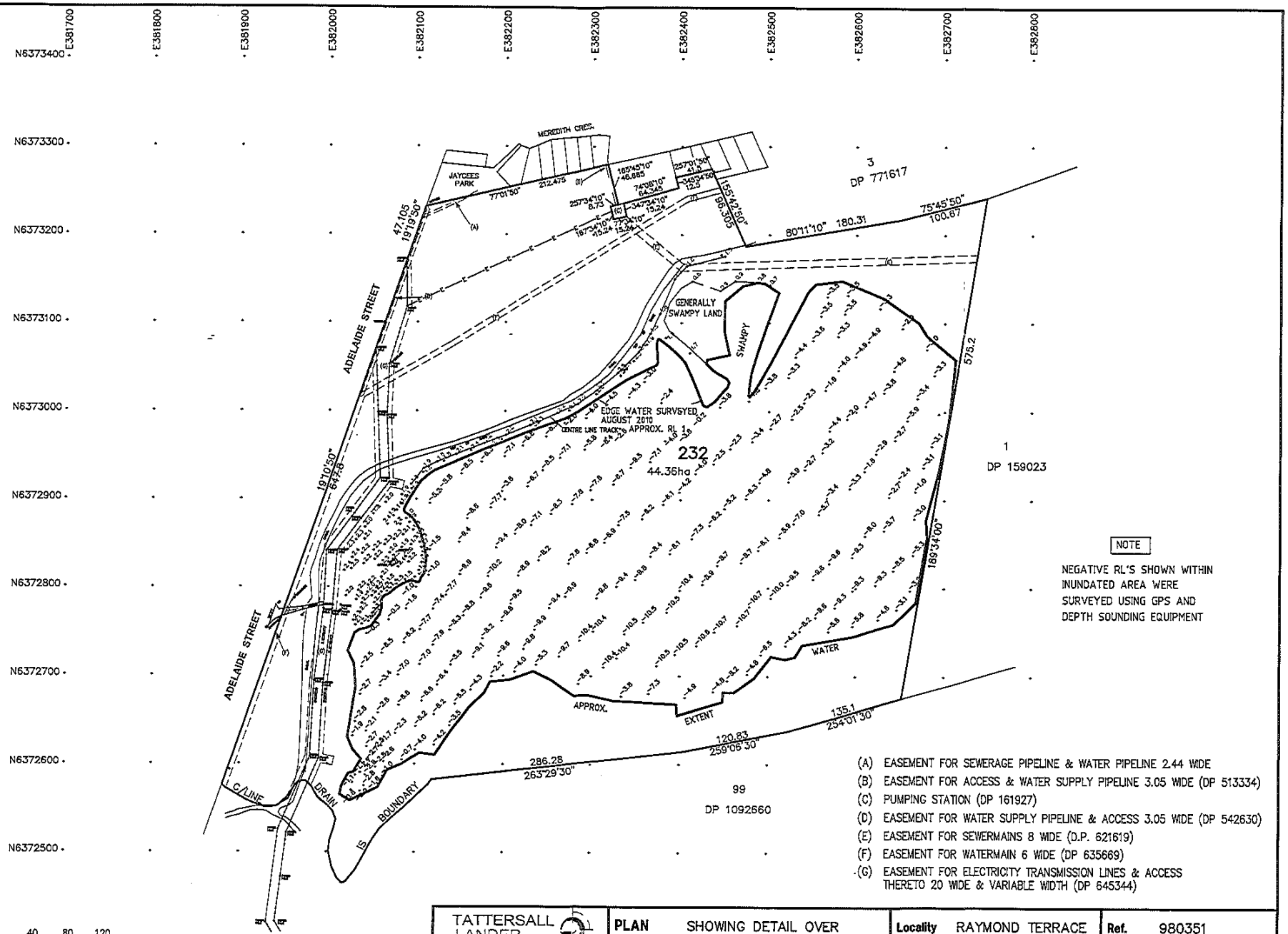
DRILLING DATE 22/10/20
DRILLIN COMPANY STRATACORE
DRILLER Mike
DRILLING METHOD Hollow Flight Auger
TOTAL DEPTH 20

COORDINATES -32.776781, 151.747116
COORD SYS Latitude/Longtitude

LOGGED BY Andrew Carras
CHECKED BY Mark Challoner



APPENDIX B: 2010 SURVEY PLAN
(TATTERSALL LANDER PTY LTD, 2010)



NOTE

NEGATIVE RL'S SHOWN WITHIN INUNDATED AREA WERE SURVEYED USING GPS AND DEPTH SOUNDING EQUIPMENT

(A) EASEMENT FOR SEWERAGE PIPELINE & WATER PIPELINE 2.44 WIDE
(B) EASEMENT FOR ACCESS & WATER SUPPLY PIPELINE 3.05 WIDE (DP 513334)
(C) PUMPING STATION (DP 161927)
(D) EASEMENT FOR WATER SUPPLY PIPELINE & ACCESS 3.05 WIDE (DP 542630)
(E) EASEMENT FOR SEWERMAINS 8 WIDE (D.P. 621619)
(F) EASEMENT FOR WATERMAIN 6 WIDE (DP 635669)
(G) EASEMENT FOR ELECTRICITY TRANSMISSION LINES & ACCESS THERETO 20 WIDE & VARIABLE WIDTH (DP 645344)

100 80 60 40 20 0 40 80 120 METRES
SCALE

DATUM OF LEVELS : AUSTRALIAN HEIGHT DATUM (AHD)
R.L. ADOPTED : SSM 91322 3.826m AHD

FILE: S:\Clients\1998\980351\Dwg\980351_site22102010.dwg

TATTERSALL LANDER PTY LTD
DEVELOPMENT CONSULTANTS
2 Bourke St. P.O.Box 580
RAYMOND TERRACE 2324
Ph: 49871500 Fax: 49871733

PLAN SHOWING DETAIL OVER LOT 232 IN DP 593512

Client ROCLA QUARRY PRODUCTS

Locality RAYMOND TERRACE
Council PORT STEPHENS
Purchase No. Q218763

Ref. 980351
Date of Survey SEPT 2010
Scale 1:4000 **Sheet Size** A3

APPENDIX C: LABORATORY TEST CERTIFICATES

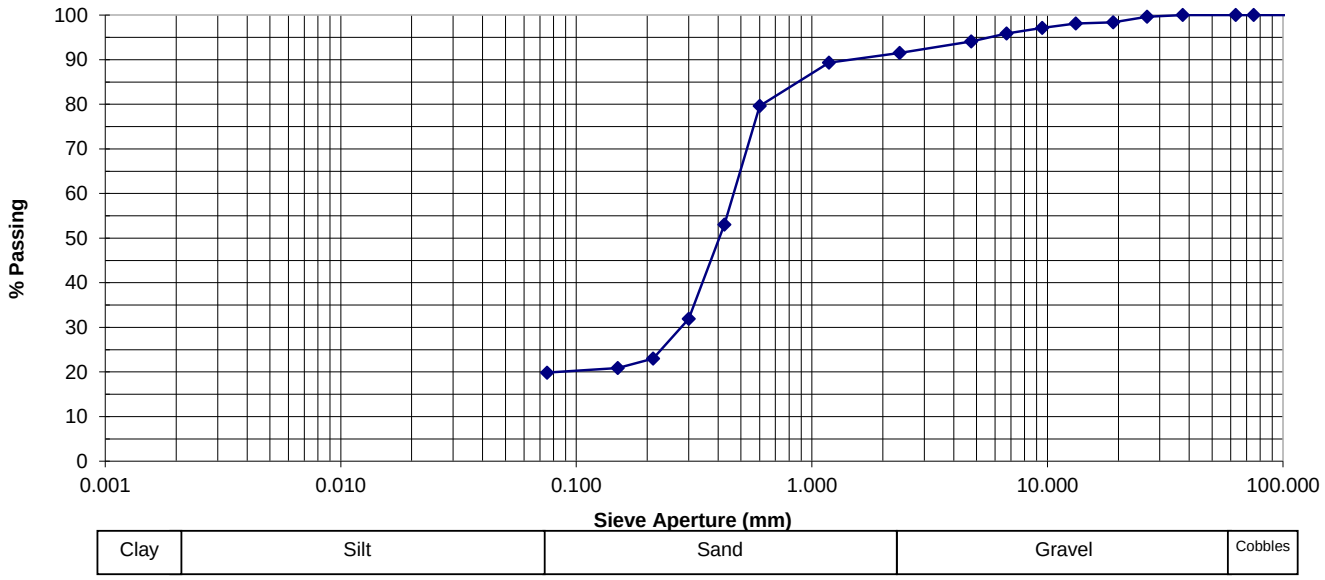
Particle Size Distribution Report

Client	Consulting Earth Scientists	**Source**	MW1-0-5
Address	Suite 3, Level 1, 55, Grandview Street, Pymble, NSW, 2073	**Sample Description**	Silty SAND trace of Gravel.
Project	CES200502	**Report No**	S64342-PSD
Job No	S20489-1	**Lab No**	S64342

Test Procedure AS 1289.3.6.1 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of analysis by sieving

Sampling Sampled by Client - results apply to the sample as received **Date Sampled** 22-23/10/20

Preparation Prepared in accordance with the test method **Date Tested** 9/11/2020



Sieve Aperture: (mm)	% Passing	Specification (..) Envelope	Sieve Aperture: (mm)	% Passing	Specification (..) Envelope
200	100		4.75	94	
75	100		2.36	92	
63	100		1.18	89	
37.5	100		0.600	80	
26.5	100		0.425	53	
19	98		0.300	32	
13.2	98		0.212	23	
9.5	97		0.150	21	
6.7	96		0.075	20	

Notes

NATA

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. This document shall not be reproduced, except in full.

NATA Accredited Laboratory Number: 14874

Authorised Signatory: Date:

10/11/2020

Chris Lloyd

MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

Particle Size Distribution Report

Client	Consulting Earth Scientists	**Source**	MW2-5-10
Address	Suite 3, Level 1, 55, Grandview Street, Pymble, NSW, 2073	**Sample Description**	Sandy Silty CLAY trace of Gravel.
Project	CES200502	**Report No**	S64343-PSD
Job No	S20489-1	**Lab No**	S64343

Test Procedure AS 1289.3.6.1 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of analysis by sieving

Sampling Sampled by Client - results apply to the sample as received **Date Sampled** 22-23/10/20

Preparation Prepared in accordance with the test method **Date Tested** 9/11/2020

Sieve Aperture: (mm)	% Passing	Specification (..) Envelope	Sieve Aperture: (mm)	% Passing	Specification (..) Envelope
200	100		4.75	99	
75	100		2.36	99	
63	100		1.18	98	
37.5	100		0.600	94	
26.5	100		0.425	78	
19	100		0.300	59	
13.2	100		0.212	51	
9.5	99		0.150	50	
6.7	99		0.075	49	

Notes

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MACQUARIE GEOTECH

Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

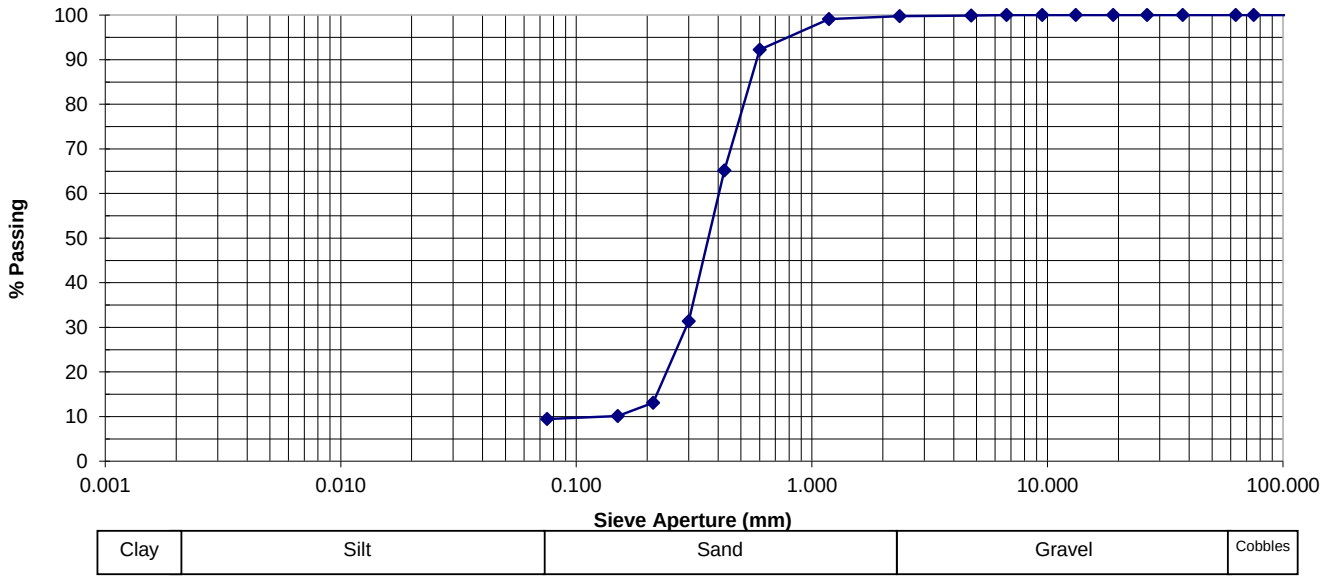
Particle Size Distribution Report

Client	Consulting Earth Scientists	**Source**	MW3-10-15
Address	Suite 3, Level 1, 55, Grandview Street, Pymble, NSW, 2073	**Sample Description**	SAND with Silt.
Project	CES200502	**Report No**	S64344-PSD
Job No	S20489-1	**Lab No**	S64344

Test Procedure AS 1289.3.6.1 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of analysis by sieving

Sampling Sampled by Client - results apply to the sample as received **Date Sampled** 22-23/10/20

Preparation Prepared in accordance with the test method **Date Tested** 9/11/2020



Sieve Aperture: (mm)	% Passing	Specification (..) Envelope	Sieve Aperture: (mm)	% Passing	Specification (..) Envelope
200	100		4.75	100	
75	100		2.36	100	
63	100		1.18	99	
37.5	100		0.600	92	
26.5	100		0.425	65	
19	100		0.300	31	
13.2	100		0.212	13	
9.5	100		0.150	10	
6.7	100		0.075	9	

Notes

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Authorised Signatory: Date:

10/11/2020

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Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

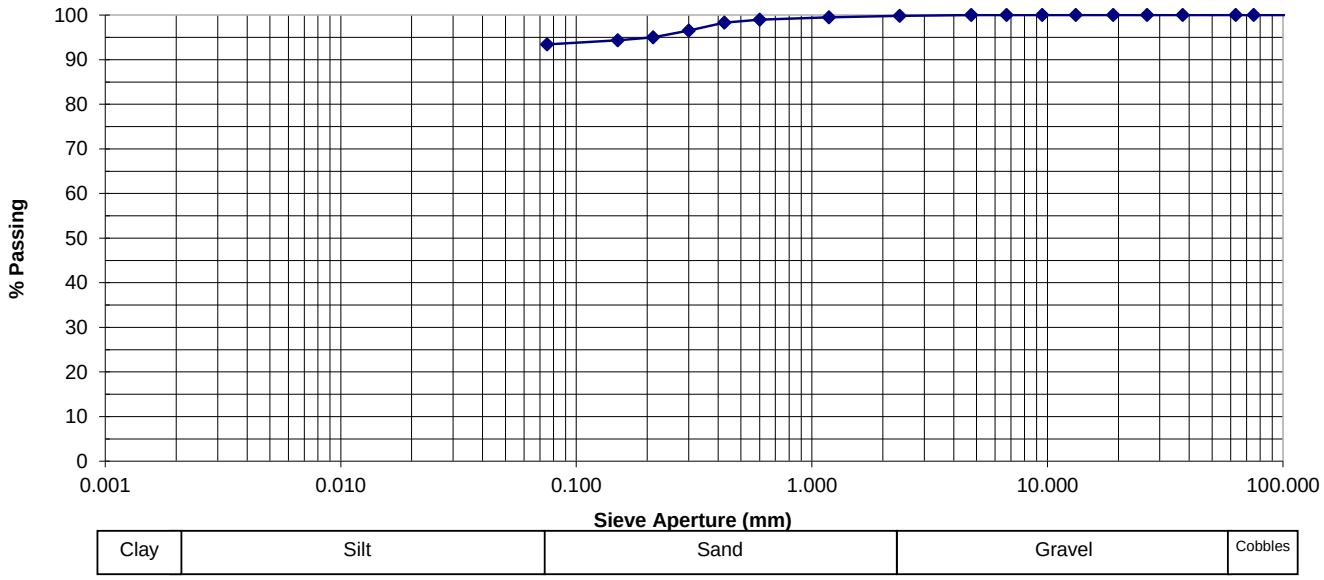
Particle Size Distribution Report

Client	Consulting Earth Scientists	**Source**	MW4-10-15
Address	Suite 3, Level 1, 55, Grandview Street, Pymble, NSW, 2073	**Sample Description**	Silty CLAY trace of Sand.
Project	CES200502	**Report No**	S64345-PSD
Job No	S20489-1	**Lab No**	S64345

Test Procedure AS 1289.3.6.1 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of analysis by sieving

Sampling Sampled by Client - results apply to the sample as received **Date Sampled** 22-23/10/20

Preparation Prepared in accordance with the test method **Date Tested** 9/11/2020



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75	100		2.36	100	
63	100		1.18	99	
37.5	100		0.600	99	
26.5	100		0.425	98	
19	100		0.300	97	
13.2	100		0.212	95	
9.5	100		0.150	94	
6.7	100		0.075	93	

Notes

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Macquarie Geotechnical
U7/8 10 Bradford Street
Alexandria NSW 2015

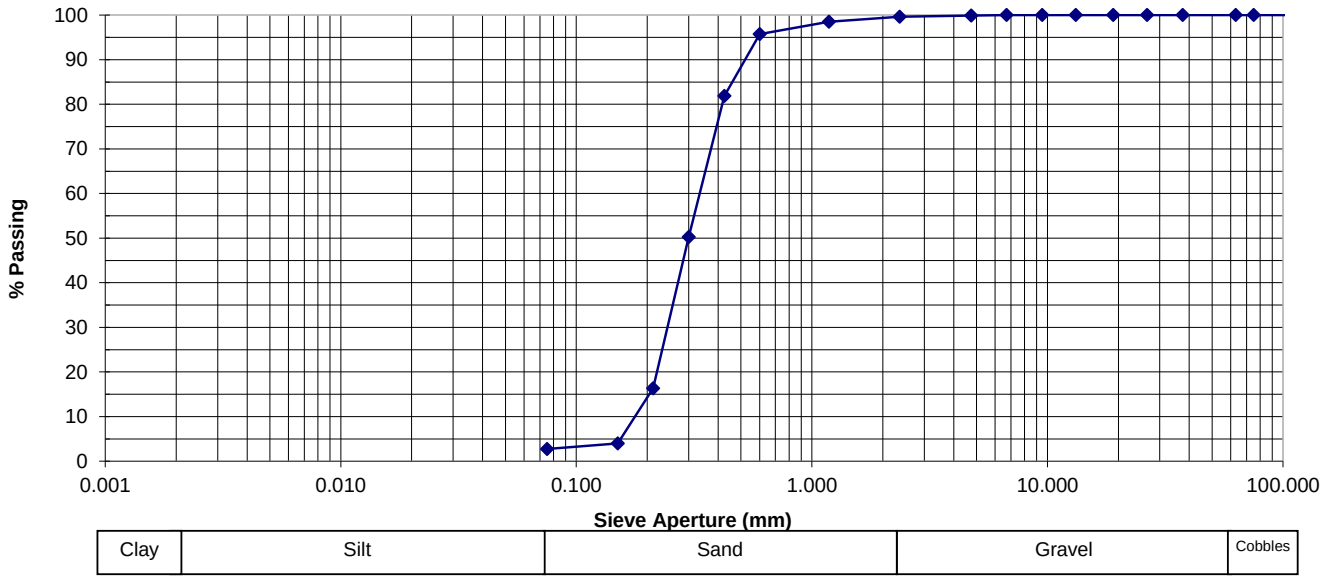
Particle Size Distribution Report

Client	Consulting Earth Scientists	**Source**	MW5-15-20
Address	Suite 3, Level 1, 55, Grandview Street, Pymble, NSW, 2073	**Sample Description**	SAND trace of Silt.
Project	CES200502	**Report No**	S64346-PSD
Job No	S20489-1	**Lab No**	S64346

Test Procedure AS 1289.3.6.1 Soil classification tests - Determination of the particle size distribution of a soil - Standard method of analysis by sieving

Sampling Sampled by Client - results apply to the sample as received **Date Sampled** 22-23/10/20

Preparation Prepared in accordance with the test method **Date Tested** 9/11/2020



Sieve Aperture: (mm)	% Passing	Specification (..) Envelope	Sieve Aperture: (mm)	% Passing	Specification (..) Envelope
200	100		4.75	100	
75	100		2.36	100	
63	100		1.18	99	
37.5	100		0.600	96	
26.5	100		0.425	82	
19	100		0.300	50	
13.2	100		0.212	16	
9.5	100		0.150	4	
6.7	100		0.075	3	

Notes

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NATA Accredited Laboratory Number: 14874

Authorised Signatory: Date:

10/11/2020

Chris Lloyd

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U7/8 10 Bradford Street
Alexandria NSW 2015

APPENDIX D: AQTESOLV OUTPUTS

CONSULTING
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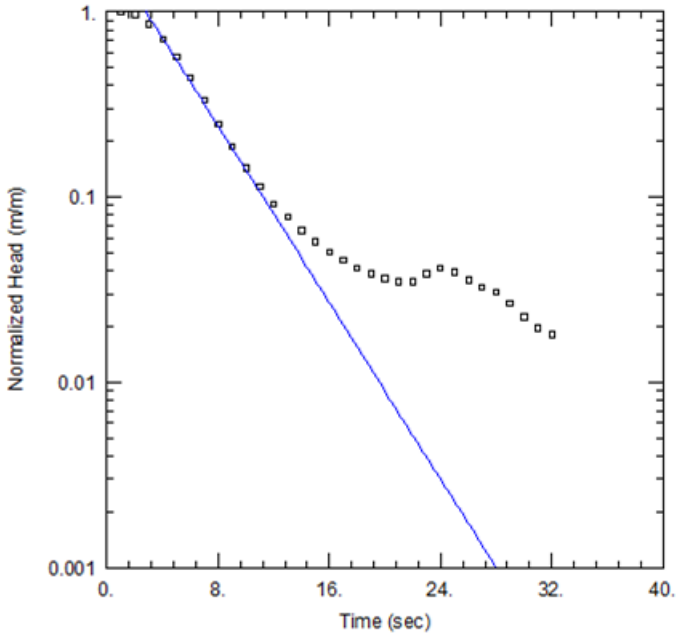
SCIENTISTS



WELL TEST ANALYSIS

Data Set:
Date: 11/30/20 Time: 16:46:58

PROJECT INFORMATION

Test Well: MW1

AQUIFER DATA

Saturated Thickness: 16.97 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (New Well)

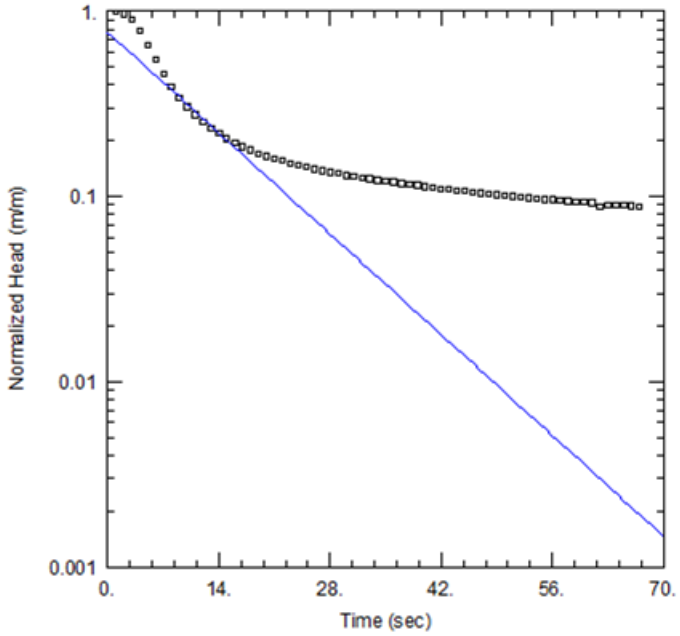
Initial Displacement: -0.97 m
Total Well Penetration Depth: 16.97 m
Casing Radius: 0.025 m
Static Water Column Height: 16.97 m
Screen Length: 14.5 m
Well Radius: 0.11 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 2.288E-5 m/sec y0 = -2.1 m

CONSULTING
EARTH
SCIENTISTS



WELL TEST ANALYSIS

Data Set:
Date: 11/30/20 Time: 16:42:11

PROJECT INFORMATION

Test Well: MW2

AQUIFER DATA

Saturated Thickness: 18.64 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (New Well)

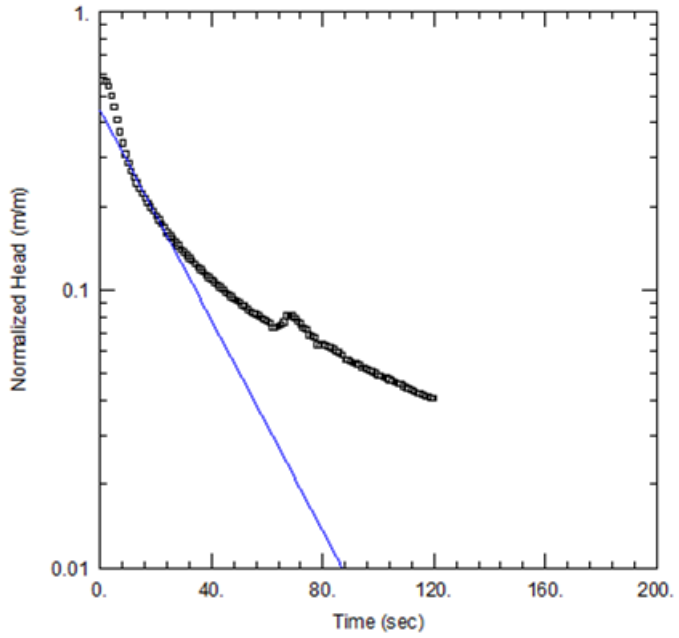
Initial Displacement: -0.73 m
Total Well Penetration Depth: 18.09 m
Casing Radius: 0.025 m
Static Water Column Height: 18.64 m
Screen Length: 17. m
Well Radius: 0.11 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 6.304E-6 m/sec y0 = -0.56 m

CONSULTING
EARTH
SCIENTISTS



WELL TEST ANALYSIS	
Data Set: Date: 11/30/20	Time: 17:00:07
PROJECT INFORMATION	
Test Well: MW3	
AQUIFER DATA	
Saturated Thickness: 12.26 m	Anisotropy Ratio (Kz/Kr): 1.
WELL DATA (New Well)	
Initial Displacement: -1.36 m Total Well Penetration Depth: 12.76 m Casing Radius: 0.025 m	Static Water Column Height: 12.26 m Screen Length: 12. m Well Radius: 0.11 m
SOLUTION	
Aquifer Model: Unconfined K = 4.146E-6 m/sec	Solution Method: Bouwer-Rice y0 = -0.6026 m

CONSULTING
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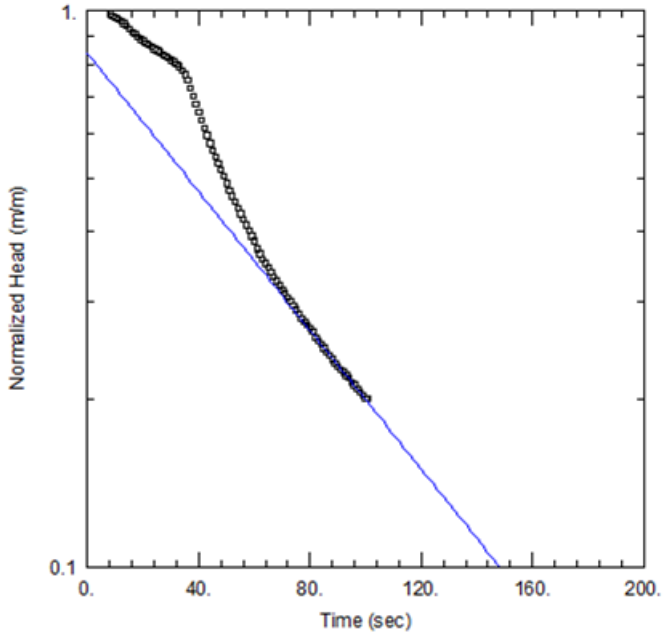


WELL TEST ANALYSIS

Data Set:
Date: 11/30/20 Time: 16:51:18

PROJECT INFORMATION

Test Well: MW4

AQUIFER DATA

Saturated Thickness: 11.75 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (New Well)

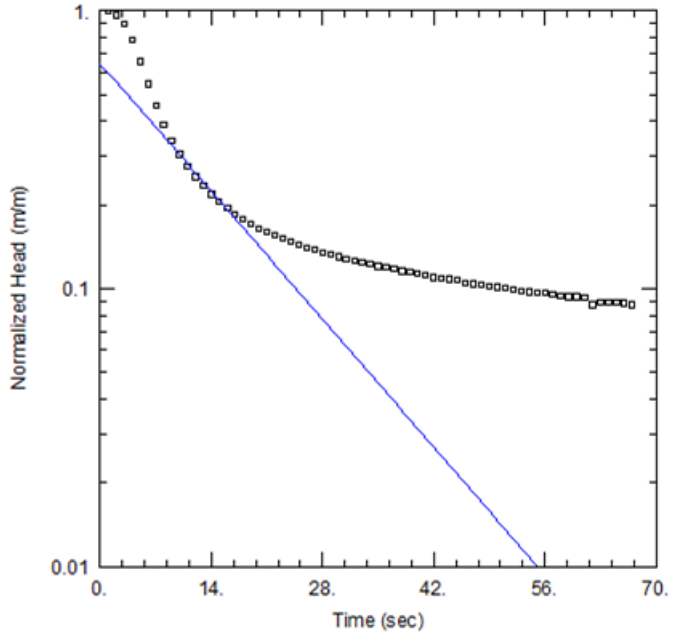
Initial Displacement: -0.56 m
Total Well Penetration Depth: 11.75 m
Casing Radius: 0.025 m
Static Water Column Height: 11.75 m
Screen Length: 11. m
Well Radius: 0.11 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 1.464E-6 m/sec y0 = -0.47 m

CONSULTING
EARTH
SCIENTISTS



WELL TEST ANALYSIS

Data Set:
Date: 11/30/20 Time: 16:37:13

PROJECT INFORMATION

Test Well: MW5

AQUIFER DATA

Saturated Thickness: 18.64 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (New Well)

Initial Displacement: -0.73 m
Total Well Penetration Depth: 18.09 m
Casing Radius: 0.025 m
Static Water Column Height: 18.64 m
Screen Length: 17. m
Well Radius: 0.11 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 5.328E-6 m/sec y0 = -0.47 m

APPENDIX E: PROPOSED CONCEPT FILL PLAN (BMT, 2019)

Title:
Concept Fill Plan

Figure:	Rev:
4	A

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 100 200m

Approx. Scale

BMT
www.bmt.org

Filepath: K:\N21195_Adelaide_St_Golf_Course_FIA\MapInfo\Workspaces\FIG_004_Fill_Plan.wor

APPENDIX F: MONITORING WELL SURVEY (2020)

DIAL BEFORE YOU DIG
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GENERAL NOTE:

1. THIS PLAN IS CURRENT AS AT DATE OF SURVEY.
2. BACKGROUND AERIAL IMAGERY IS TO BE USED AS A REFERENCE GUIDE ONLY AND APPROXIMATE POSITION ONLY.
3. COORDINATES SPECIFIED ON THIS PLAN ARE BASED ON MGA GDA94 & AHD71.

DALY.SMITH
EXPERIENCE YOU CAN TRUST

A: 3/48 Newcastle Street, Morisset NSW 2264
A: 4/9 Lambton Road, Broadmeadow NSW 2292
T: (02) 4973 2745 | F: (02) 4970 5366
E: mail@dalysmith.com.au DALYSMITH.COM.AU

DRAWING TITLE
MONITORING LEVELS

ADDRESS
GRAHAMSTOWN DRAIN,
RAYMOND TERRACE

CLIENT
CONSULTING EARTH SCIENTISTS

SURVEY DATE	DATUM	CONTOURS
17/12/2020	AHD	N/A

ORIGIN OF LEVELS: SSM 110567 RL 5.537m AHD

125 0 125
SCALE @ A3 1:5000

ISSUE	DATE	PURPOSE
0	17/12/2020	ISSUE TO CLIENT

SURVEYED	DRAWN	CHECKED
KH/SL	MM	MM

35002 T01

LEGEND

○ MW	MONITORING WELL LEVEL
× WL	WATER LEVEL

Matthew McMaster
Registered Surveyor 9012
17/12/2020 Ref: 35002 T01

FILENAME C:\12dS\data\DS-FP\35002S - Grahamstown Drain, Raymond Terrace_17103\4.0 Drawings\35002 T01.dwg