appendix c

local water management strategy

(RPS Group)

LOCAL WATER MANAGEMENT STRATEGY

Lot 703 Armadale Road, Treeby

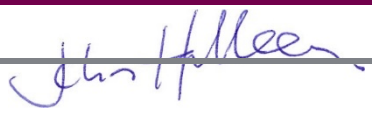
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EXECUTIVE SUMMARY

LWP and the Department of Communities are submitting a Local Structure Plan (LSP) for Lot 703 Armadale Road, Treeby within the City of Cockburn. RPS has prepared this Local Water Management Strategy (LWMS) to support the LSP submission.

The site was previously a sand quarry and is approximately 20.35 hectares (ha) in size. It is relatively flat at approximately 30 m AHD, with elevated ridges on the southern and western edges. The surface geology consists of Bassendean Sand and rainfall infiltration is the dominant hydrological process at the site, with no surface water features present. The majority of the site has been historically cleared of native vegetation, with some native vegetation re-growth occurring. Some remnant vegetation is located on the elevated sand areas on the western and southern boundaries of the site. These existing environmental conditions will guide the development of the site.

The Atwell Drain, a constructed trapezoidal drain runs parallel to the site on the southern side of Armadale Road. There are no wetlands located on the site; the closest mapped wetland is a resource enhancement wetland (UFI 15297) to the south. The average annual maximum groundwater level (AAMGL) ranges from 26.4 m AHD in the south to 27 m AHD in the north, providing approximately 3 m clearance to the water table across most of the site. The site is within a P3* public drinking water source protection area of the Jandakot underground water pollution control area.

This LWMS describes the integrated management of groundwater and surface water that will be implemented at the site, in line with Better Urban Water Management (BUWM) principles. A summary of how the design objectives will be met is provided in Table 1.

Table 1: Water management design objectives and implementation strategies

Design	Strategy
Utilise fit for purpose water sources throughout the development.	The development has a groundwater abstraction licence to abstract groundwater from the Superficial Aquifer for the irrigation of POS and streetscapes, as well as for dust suppression during construction has been submitted to DWER.
Consumption target for water of 100 kL/ person/yr, including not more than 40–60 kL/ person/year scheme water.	Water efficient fixtures and fittings will be installed in households.
Retain and treat stormwater runoff from constructed impervious surfaces from the first 15 mm rainfall	• Lots will have a soakwell to retain and infiltrate lot-generated runoff. • A biofiltration basin installed in the main POS area and a biofiltration roadside swale in the north of the site will retain and treat run-off generated from the 15 mm rainfall event.
Minor roads must remain passable in the 20% AEP event	A pipe and pit drainage system installed in the development will ensure roads will remain passable in the 20% AEP event.
Protection of infrastructure and assets from flooding, with the minimum habitable floor level being at least 0.3 m above the 1% AEP flood levels for the urban drainage system	The 1% AEP TWL in the infiltration basin in the main POS and the roadside swale will be at least 0.3 m below the adjacent finished lot levels.
Provide storage and delineate flow paths for the 1% AEP event	The development will provide flow paths for the major events in the road reserve.
As per City of Cockburn (CoC 2019) requirements, maintain clearance between the finished lot levels and the average annual maximum groundwater level (AAMGL) of at least 1.2 m and 0.5 m from the invert of drainage basins to the AAMGL	• The depth to AAMGL across the site is over 2 m pre-development. • Subsoils will be installed beneath the biofiltration basin in the POS at a minimum 0.5 m below the invert of the basin and discharge to the Atwell Drain. The subsoils will be installed to ensure free draining of the basin and broader POS area, however they will also ensure that the specified groundwater clearance is maintained.
Groundwater quality leaving the site should be the same, or better, than that entering the site.	Fertiliser and pesticide use in the POS and streetscapes will be minimised. Groundwater quality will be monitored post-development to ensure the stormwater quality treatment is functioning as designed.

Design	Strategy
Utilise appropriate structural and non-structural measures to reduce nutrient loads.	The following structural and non-structural controls will be implemented at the site to reduce nutrients: • Vegetation in the treatment train • Stormwater drainage infrastructure maintenance • Street sweeping both during and post-construction • Erosion and dust control during construction • Community education • Post-development monitoring to ensure that water quality targets are being met.

1 INTRODUCTION

This Local Water Management Strategy (LWMS) has been prepared by RPS to support the Structure Plan submission by LWP and Department of Communities Joint Venture for Lot 703 Armadale Road, Treeby on Deposited Plan 413031 (hereafter referred to as "the site"). The site is 20.35 ha in size, and is approximately 18 km south of the Perth CBD, within in the City of Cockburn. The site is located on the northern side of Armadale Road, east of Fraser Road and Calleya Estate. The site location is presented in Figure A.

This LWMS details the integrated total water cycle water management strategies to be implemented for the site and includes

- An assessment of the pre-development environment
- Development of water use sustainability initiatives
- Stormwater management strategy
- Groundwater management strategy
- Plan for implementation of subdivision.

1.1 Planning background

The site has recently undergone a town planning amendment through the Metropolitan Regional Scheme (MRS) from 'Rural-Water Protection' to 'Urban' and through the Town Planning Scheme (TPS) No. 3 from 'Resource' to 'Development'. The site is zoned as "Development Contribution Area 13", "Development Zone" and "Development Area 41" under the City of Cockburn's TPS No.3.

The MRS Amendment for the site was referred to the Environmental Protection Authority (EPA). The EPA assessment determination was "Scheme Not Assessed – Advice Given", with the following advice provided:

- The EPA notes that remnant vegetation along the south western and southern boundaries will be retained as well as the area of remnant vegetation on the eastern side of the site containing the rare Grand Spider Orchid, *Caladenia hueglii.*
- The EPA also notes that the Department of Water has approved the District Water Management Strategy and the proposed Amendment is in accordance with the Draft State Planning Policy No. 2.3 – Jandakot Groundwater Protection.

The EPA also stated that there are 'no environmental issues that cannot be managed' through the planning and development process, therefore a formal assessment is not required.

1.2 Structure plan – proposed development

The proposed development includes

- Approximately 365 residential lots
- 0.2 ha reserved for a childcare site
- 1.68 ha reserved for seniors living
- 0.54 ha of conservation
- 2.28 ha public open space (POS).

The structure plan is provided in Figure B.

1.3 Previous environmental studies

As part of the current scope of works, RPS is also completing a vegetation and flora survey report, black cockatoo habitat survey report, contamination assessment and environmental assessment report.

Other environmental reports that have been completed for the site include:

- Treeby (Banjup) Strategic District Water Management Strategy (JDA 2016)
- Lot 821 Armadale Road, Banjup District Water Management Strategy (hyd2o 2013)
- Lot 821 Armadale Road Banjup, Pre-Development Hydrological Monitoring Programme (hyd2o 2018).

2 DESIGN CRITERIA

2.1 Guidance documents

This report has been prepared in accordance with State Planning Policy 2.9: Water Resources (Government of WA 2007) and with reference to the following guidance documents:

- *Western Australian State Water Plan* (Government of Western Australia 2007)
- Stormwater management manual for Western Australia (Department of Water 2004 – 2007)
- Interim: developing a local water management strategy (DoW 2008)
- Better urban water management (WAPC 2008)
- Liveable neighbourhoods draft (WAPC 2015)
- Water monitoring guidelines for better urban water management strategies and plans (DoW 2012)
- Decision process for stormwater management in WA (DWER 2017)
- Water quality protection note 38: Priority 3* (P3*) areas (DWER 2018).

The Better Urban Water Management framework (WAPC 2008) integrates water management into the land use planning process to ensure planning strategies include total water cycle management and Water Sensitive Urban Design (WSUD).

This LWMS has been prepared to support the structure plan submission for the site and is based on the following objectives:

- New developments should achieve a maximum water consumption target of 100 kL/person/year for residential lots
- At the lot scale (residential) less than 40-60 kL of water consumption should be from scheme water
- Retain and treat stormwater runoff from constructed impervious surfaces generated from the first 15 mm rainfall event as close to source as possible
- Designing stormwater management systems to provide serviceability and amenity for roads during minor (20% AEP) rainfall events
- Protection of infrastructure and assets from flooding and inundation, with minimum habitable floor levels being at least 0.3 m above the 1% AEP flood level for the urban drainage system
- Major arterial roads should remain passable in a 1% AEP event
- Provide storage and delineate flow paths for the 1% AEP event
- The City of Cockburn also have a requirement that drainage basins will be at least 0.5 m above the maximum groundwater level.

3 EXISTING ENVIRONMENT

3.1 Existing and historical land use

The site was previously a sand quarry and has been extensively cleared, although there is some native vegetation re-growth present within the site. Remnant vegetation is located on the western and southern boundaries of the site. The site is surrounded by residential development to the west (Calleya Estate), Bush Forever site 390 to the north, the Boral paving plant to the east and large residential lots to the south of Armadale Road.

3.2 Climate

The climate of the south-western region of Western Australia is characterised by hot dry summers and mild rainy winters. The dominant rainfall mechanisms are caused by cold fronts associated with low-pressure systems that extend across southern Australia between May and October.

The closest weather station is located at Jandakot airport (9172), which has data available since 1972 (BoM 2019). There is significant variation in the annual totals, ranging between 496 mm (2010) and 1,148 mm (1986). The data indicates a decreasing trend in annual and winter rainfall totals. Evaporation is highest between November and March. A comparison of the mean monthly rainfall and evaporation totals demonstrates that the region is water limited between September and April. Between May and August, rainfall exceeds evaporation.

3.3 Topography

The topography of the site consists of elevated areas around the southern (30-42 m AHD) and western (30-36 m AHD) edges, with the rest of the site being relatively flat with a height of around 30 m AHD. Topographical contours are provided in Figure C.

3.4 Geology and soils

3.4.1 Regional mapping

The surface geology of the area is classified by Gozzard (1986) as Bassendean Sand – S8. This defined as quartz sand that is pale grey to white, predominately medium grained, moderately sorted, subangular to subrounded. A layer of friable, limonite-cemented sand occurs throughout most of the area near the water-table (i.e. coffee rock). Surface geological mapping is provided in Figure C.

Davidson (1995) indicates the Superficial Aquifer is underlain by the Kardinya Shale Member which consists of a relatively thick siltstone-shale unit within the Osborne Formation. The Kardinya Shale Member consists of moderately to tightly consolidated inter-bedded siltstones and shales.

3.4.2 Site investigations

Logging of soil profiles during the installation of monitoring bores on site identified the profile as sand with a fine texture, yellow to 4/5 m and then light grey to the end of the hole which ranged from 6 m to 7 m. Lithological logs are included in hyd2o (2018) which is provided in Appendix A.

As part of a due diligence contamination investigation, RPS completed a soil sampling program in July 2019 (RPS 2019a), excavating 49 test pits to 1.0 – 1.3 mbgl. The natural soil profiles encountered may be summarised as:

- Pale yellow/yellow/pale grey/grey, fine to medium-grained sands with low amounts of organic matter (grasses, roots) in some locations.

Fill soils were encountered at 16 of the sampling locations. Fill soils encountered consisted of road base materials containing construction and demolition wastes, brick, rubble, slate and other similar materials (RPS 2019).

A geotechnical investigation was completed for the site by Douglas Partners (2019) which included the excavation of 20 test pits, eight cone penetration tests, six in-situ infiltration tests and laboratory testing of selected samples. The geotechnical investigation encountered the following on site:

- Fill/sand – fine to medium grained, generally dark grey-brown, grey brown and yellow-brown, trace silt and varying gravel content, occasionally trace organics, loose to medium dense encountered at all test pits (except 11), to depths of up to 2.4 m (the extent of the test pit investigation). Where encountered, the loose sand was from the existing surface level to depths of up to generally less than 0.6 m but up to 1.4 m.

- Sand – fine to medium grained, pale yellow, yellow-brown and pale white, trace silt, generally medium dense to dense, from the surface or fill at all test pit locations where natural sand was encountered to the extent of the investigation up to 10 m.

- Estimated in-situ permeability from all test sites were >50 m/day. The geotechnical report is included as Appendix B.

3.5 Contaminated sites

RPS completed a contamination assessment of the site (RPS 2019a). No soil or groundwater contamination was detected which signifies a risk to human health for residential end use.

3.6 Acid sulfate soils

The DWER Acid Sulfate Soil (ASS) risk mapping (DWER 2019a) indicates the entire site has a moderate to low risk of ASS occurring within 3 m of the natural soil surface but a high to moderate risk of ASS beyond 3 m of the natural soil surface. ASS risk mapping is provided in Figure D.

Final fill levels and subsequent excavation will determine whether dewatering is required, and consequently whether an ASS dewatering management plan will be prepared.

3.7 Hydrogeology

The site is located within the Jandakot groundwater area and the following sub-areas (DWER 2019b):

- Superficial Aquifer: Canning Vale sub-area

- Leederville Aquifer: Jandakot confined sub-area

- Yarragadee North Aquifer: Jandakot confined sub-area.

The Superficial Aquifer across the Jandakot Mound has a maximum saturated thickness of ~40 m. The formations are highly permeable with horizontal hydraulic conductivities (K) ranging between ~10 to 50 m/d, although they may reduce to less than 10 m/d where coffee rock is present (Davidson & Yu 2008). Groundwater recharge results directly from rainfall infiltration (annual recharge rates of up to 24%) and there is some leakage into underlying aquifers (Davidson 1995).

The Leederville Aquifer is of Cretaceous age and consists of interbedded sandstone, siltstone and shales made up by the Mariginiup, Wanneroo, Pinjar and Henley Sandstone Members. It is separated from the overlying Superficial Aquifer by the Kardinya Shale, which acts as a confining layer between the two aquifers (Davidson & Yu 2008). The South Perth Shale underlies the Leederville Aquifer and acts as a confining bed between the Leederville and Yarragadee Aquifers (Davidson 1995).

3.8 Drinking water source protection areas

There are 26 production bores (DWER 2018b) within the Jandakot Underground Water Pollution Control Area (UWPCA) that abstract water from the Superficial and Leederville Aquifers and provide public drinking water as part of the Integrated Water Supply Scheme (IWSS) (Water Corporation 2006). The Jandakot UWPCA was proclaimed in 1975 under the *Metropolitan Water Supply Sewerage and Drainage Act 1909* for the purpose of protecting the public drinking water source of the Jandakot Mound (Water Corporation 2006).

The site is currently located within a P3* public drinking water source area (PDWSA). P3* areas are those that were previously P1 or P2 areas and the land has been rezoned within the MRS to 'urban' (DWER 2018). The P3* zoning is a variation of the P3 to address the increased water quality risks resulting from the approved landuse intensification. Water quality protection note 76 (DoW 2006) sets out the planning requirements for PDWSAs and water quality protection note 25 (DoW 2016) sets out the land uses that are compatible with public water source priority areas. DWER assigns priority areas within PDWSAs to guide land use decisions. The *Land use compatibility tables for public drinking water source areas*, Water quality protection note no. 25 DoW (2016) states:

> P3 source protection areas are defined and managed to maintain the quality of the drinking water source for as long as possible with the objective of risk management. P3 areas occur within PDWSAs where the land is zoned for urban and commercial or light industrial uses. Within P3 areas, drinking water sources need to co-exist with higher intensity land uses compared to P1 and P2 areas. Key elements in the protection of P3 areas include the need for deep sewerage and implementing best management practices.

Landuse activities of the area are managed under the *Jandakot land use and water management strategy* (WAPC 1995). A number of landuses should be avoided in P3* areas including airports, amusement parks, aquatic centres, caravan parks, cemeteries, hospitals, golf courses, landfill and waste transfer stations, light and heavy industry, service stations, motor vehicle repair, wash, sales and racing centres, and wastewater treatment plants (DWER 2018).

Additional protection is provided in the immediate vicinity of abstraction points through wellhead protection zones (WPZs). Typically, WPZs are circular, with a radius of 500 m in Priority 1 areas and 300 m in Priority 2 and Priority 3 areas. Figure E shows the location of the nearest Water Corporation Jandakot mound abstraction bores and WPZs. The nearest bore is located approximately 800 m west of the site.

3.9 Groundwater availability

An aquifer allocation report requested from DWER identified that as of May 2019, there was 241,675 kL (or 78%) of the allocated volume available in the Superficial Aquifer. A groundwater licence for irrigation of POS as well as a separate volume for dust suppression during construction was submitted to DWER on 12 August 2019.

3.10 Groundwater levels and flows

3.10.1 Regional groundwater mapping

Regional groundwater mapping from the Perth Groundwater Map (which provides indicative levels only) shows that the historical maximum groundwater levels (MGLs) of the Superficial Aquifer range from 27 m AHD to 28 m AHD across the site (DWER 2019b). Groundwater contours indicate that the flow gradient is relatively flat across the site with a regional flow generally in a south-westerly direction towards Thomsons Lake.

3.10.2 Site specific groundwater monitoring

Pre-development groundwater monitoring at the site was completed by Hyd2o. Five groundwater monitoring bores were installed in May 2016, and the monitoring program was undertaken over an 18-month period from May 2016 to October 2017 capturing two winter peaks. Groundwater levels were measured on a monthly basis from the five bores on site as well as two DWER bores (AWRC no.61610245 (JM26) and AWRC no. 61610335 (JM27)), and water quality monitoring was completed quarterly for the on-site bores.

Hyd2o also obtained DWER long term monitoring data from nearby bores (AWRC no.61610245 (JM26) and AWRC no. 61610335 (JM27)) as well as (AWRC no. 61610247 (JM14) and AWRC no. 61610345 (JM15)) to calculate average annual maximum groundwater levels (AAMGL) and maximum groundwater levels (MGL) over the site. The location of the site monitoring bores as well as the DWER monitoring bores are shown on Figure F. hyd2o monitoring results are included in Appendix A.

3.10.2.1 Groundwater Levels, AAMGLs and MGLs

From the hyd2o site-specific groundwater monitoring, minimum groundwater levels were recorded in May 2016, ranging from 24.97 m AHD at BM2 to 25.58 m AHD at BM1. Maximum groundwater levels for the site were recorded in September 2017 ranging from 26.30 m AHD at BM2 to 26.81 m AHD at BM4 (hyd2o 2018).

The DWER bores show a historical annual variation of approximately 1.0 m to 2.5 m between winter peaks and summer lows. Long term hydrographs show a general decline in groundwater levels between 1970 and ~ 2005, after which groundwater levels appear to be stabilising or increasing (DWER 2019c). This increase is expected to be due to reduction in groundwater abstraction and/or the change in landuse to urban development. DWER long-term hydrographs are included in Appendix C.

Site specific AAMGLs and MGLs were previously calculated by hyd2o by correlating DWER records against site groundwater levels measured in September 2017, which represented the highest groundwater levels recorded during the monitoring period. The calculated AAMGL on the site was estimated to range between 26.6 m AHD in the south to a maximum of 27.1 m AHD in the north (Hyd2o 2018). The depth to AAMGL was reported to range from approximately 2.8 m at BM4 to 3.4 m at BM3. The calculated MGL for the site is estimated to range between 27.5 m AHD at BM2 to 28.0 m AHD at BM4 (Hyd2o 2018).

For this LWMS, a revision of the AAMGLs and MGLs was completed using long-term data from the DWER groundwater monitoring bore AWRC no. 61610177 (JM19). This bore was used as it is closer to the site than the other DWER bores. The AAMGLs incorporating data from this bore ranged from 26.4 m AHD in the south of the site to 27 m AHD in the north, while the MGLs ranged from 27.6 m AHD to 27.9 m AHD, both of which are similar to Hyd2o. Mapping of the site AAMGL contours is illustrated on Figure G. It is anticipated that groundwater will rise with development.

3.11 Groundwater quality

3.11.1 Water Corporation bores

Information presented by Water Corporation (2006) states that the water quality of the Superficial Aquifer in the Jandakot Mound has consistently been good, with the exception of iron and colour, and has generally met the Australian Drinking Water Quality Guideline values (NHMRC 2011). Although there has been no evidence of contaminants reaching the groundwater, many activities including irrigated parks are considered medium management priorities due to their potential to transmit contaminants to groundwater

The Leederville Aquifer underneath the Jandakot Mound is considered to be good quality, with groundwater salinity typically <500 mg/L, while the Yarragadee Aquifer in the area has salinities ranging from 1,000 to 2,000 mg/L (Water Corporation, 2006).

3.11.2 Hyd2o 2016–2017 monitoring

Hyd2o completed six groundwater quality sampling events as part of their monitoring program. Water quality monitoring included in-situ measurements of physical parameters including temperature, electrical conductivity (EC), pH, dissolved oxygen (DO), redox and turbidity. Water samples were collected and sent to a NATA accredited laboratory for analysis of total suspended solids (TSS), nutrients (total nitrogen (TN), total Kjeldahl nitrogen (TKN), ammonium (NH_4-N), nitrogen oxides (NO_x-N), total phosphorus (TP), filterable reactive phosphorus (FRP)) and heavy metals (arsenic, cadmium, chromium, copper, nickel, lead, mercury and zinc). As the site is located within the Jandakot UWPCA, groundwater samples were also analysed for fluoride, *faecal enterococci*, Thermotolerant Coliforms and *E.coli*.

Results were compared to the ANZECC (2000) guidelines for lowland rivers in southwest of Australia. The following provides a summary of the results:

- Groundwater was slightly acidic. Mean pH ranged from 5.42 (BM4) to 6.35 (BM2), which are above the ANZECC guidelines

- Mean EC ranged from 0.11 mS/cm (BM2, BM3 and BM5) to 0.22 mS/cm (BM4), which are within the ANZECC guideline range of 0.12 mS/cm to 0.3 mS/cm

- Mean TN ranged from 2.25 mg/L (BM2) to 8.32 mg/L (BM5), which are above the ANZECC guideline value of 1.2 mg/L.
- Mean TP ranged from 0.025 mg/L (BM1) to 0.058 mg/L (BM5), which are below the ANZECC guideline value of 0.065 mg/L.
- Mean results for metals were below the 99% trigger level for protection of freshwater species, with results for arsenic, cadmium and mercury below the laboratory limit of reporting for all bores.
- All results for fluoride, *faecal enterococci*, Thermotolerant Coliforms and *E. Coli* were below the laboratory limit of reporting.
- While the results for TN are above the ANZECC guideline value, they are representative of typical pre urban groundwater nutrient concentrations from the Swan Coastal Plain (hyd2o 2018). Mean results are presented in Table 2 and are compared to a number of guidelines.

Table 2: Mean water quality results from the hyd2o 2016-2017 pre-development groundwater monitoring program

Sites	Parameters						
	EC (mS/cm)	pH	TN (mg/L)	NH3 (as N) (mg/L)	NO3 (as N) (mg/L)	TP (mg/L)	PO4 (as P) (mg/L)
ANZECC LTIW[1]	-	6.0-8.5	-	-	-	-	0.05
ANZECC FW[2]	-	6.5-8.5	1.2	0.8	-	0.065	0.04
DoH NPUG[3]	-	-	-	-	500	-	-
ADWG[4]	-	-	-	-	50	-	-
BM1	0.134	6.11	2.98	0.015	2.22	0.025	0.005
BM2	0.107	6.65	2.25	0.008	1.83	0.035	0.005
BM3	0.11	6.20	3.20	0.007	2.63	0.048	0.005
BM4	0.22	5.42	2.83	0.077	1.54	0.028	0.005
BM5	0.11	5.71	8.32	0.009	5.68	0.058	0.009

1 – Long-term irrigation water, Table 4.2.10 of *Australian water quality guidelines for fresh and marine water quality* (ANZECC & ARMCANZ 2000)

2 –Lowland rivers in south-west Australia, slightly to moderately disturbed ecosystems, *Australian water quality guidelines for fresh and marine water quality* (ANZECC & ARMCANZ 2000)

3 - Non-potable groundwater use, *Contaminated sites ground and surface water chemical screening guidelines* (DoH 2014)

4 - *Australian drinking water guidelines* (NHMRC & ARMCANZ 2011)

3.11.3 RPS 2019 monitoring

- Additional sampling was completed in June 2019. Groundwater samples were analysed for:
- Metals (As, Cd, Cr, Cu, Hg, Ni, Pb and Zn)
- Total recoverable hydrocarbons (TRH)
- MTBE, benzene, toluene, ethylbenzene, xylene and naphthalene (MBTEXN)
- Polyaromatic hydrocarbons (PAH)
- OC/OP pesticides.
- Nutrients
- Acid Sulfate Soil parameters.

The concentrations of TRH, PAH MBTEXN and OC/OP pesticides were below the limit of reporting for all samples.

Exceedances occurred for pH, metals (dissolved aluminium, chromium, copper and total iron), TN and NH_4-N as detailed below:

- Dissolved aluminium above freshwater guidelines, drinking water guidelines and domestic non-potable use guidelines
- Dissolved chromium and copper above freshwater guidelines
- Total iron above freshwater guidelines, long-term irrigation guidelines, drinking water guidelines and domestic non-potable use guidelines
- TN and NH_4-N above freshwater guidelines
- pH values outside (i.e. below) freshwater guidelines, long-term irrigation guidelines and drinking water guidelines.
- The results are included as Appendix D. As the site will be connected to scheme water and nearby Water Corporation abstraction bores would be screened deeper in the aquifer, the risk to human health is negligible. The results are considered reflective of regional concentrations and are not considered to pose a risk to the ecology on or down-gradient of the site.

3.12 Surface hydrology

There are no surface water features on the site. Rainfall infiltration is the dominant hydrological process at the site due to the predominantly sandy soil present. Furthermore, the relatively flat topography indicates that rainfall water would infiltrate and/or evaporate rather than run-off.

The Atwell Drain is located to the south of the site. The Atwell Drain system is approximately 7 km in length, extending from upstream of Harper Road and eventually discharging to Thomson's Lake, a Conservation Category Wetland (CCW). In relation to the site, the drain runs through Emma Treeby Reserve, west along Armadale Road to REW UFI 15297. The location of the drain and direction of flow relative to the site is shown in Figure H.

Atwell Drain was originally constructed as a trapezoidal channel in the early 1900s to reduce groundwater rise (pdc 2013). Since then sections of the drain west of Tapper Road have been culverted. The drain has an invert level ranging from approximately 26.5 m AHD upstream of Harper Road to 25.6 m AHD at Armadale Road, with an average grade of 1:1250 (pdc 2013). The drain receives groundwater inflow during winter months.

As part of the LWMS for the Banjup quarry redevelopment west of the site, pdc (2013) completed stormwater modelling of the Atwell Drain. The pre-development critical storm event for the Atwell drain was identified to be the 100 yr 24 hr ARI event (equivalent to the 1% AEP). Pdc reported that the Atwell Drain had sufficient capacity to accommodate flows from the Banjup quarry redevelopment site, which resulted in allowable discharge from that development site in events greater than the 5 yr ARI (equivalent to the 20% AEP) via a dn1200 pipe under Armadale Road to Atwell Drain (pdc 2013).

3.13 Wetlands

A search of the Department of Biodiversity, Conservation and Attractions (DBCA) wetland mapping indicates there are no wetlands located on the site. Surrounding the site, the following wetlands include:

- Conservation category dampland, < 1 km south (ID 6782). CCWs support a high level of attributes and functions, and as such are considered "high priority wetlands" by DBCA. Planning objectives should aim to preserve the existing conservation values and as such, no development, clearing, or activity that may lead to further loss or degradation of the wetland is considered appropriate (EPA 2008)

- Resource enhancement sumpland, immediately south of Armadale Rd (ID: 15297). Resource enhancement wetlands support substantial ecological attributes and functions, whilst having been partially modified. Through management, restoration and protection their conservation value may be improved and they have the potential to become CCWs. As such, protection is recommended to restore wetland function, structure and biodiversity (EPA 2008)
- Resource enhancement sumpland, < 0.6 km west (ID: 6878)
- Resource enhancement dampland, < 0.5 km north-east (ID: 13328)
- Multiple use sumpland, < 0.8 km south east (ID: 6789)
- Multiple use dampland, < 0.7 km west (ID: 6652)
- Additionally, Thomson Lake (< 5 km west) and Forrestdale Lake (< 5 km east) are Ramsar classified wetlands of international importance
- DBCA wetland mapping is presented in Figure H.

3.14 Vegetation

Vegetation mapping at the 1:250,000 scale completed by Heddle et al. (1980) identified the site as Bassendean Complex – Central and South. This vegetation complex is described below:

> ***Bassendean Complex – Central and South***: Vegetation ranges from woodland of *Eucalyptus marginata – Allocasuarina fraseriana – Banksia* species on the sand dunes to low woodlands of *Melaleuca* species and sedgelands on the low-lying depressions and swamps.

Most of the site has been cleared since the early 2000s for sand quarrying, with sparse regrowth of vegetation throughout the later years (2012 to present). Although some remnant vegetation is located on the western and southern boundaries of the site.

RPS completed a flora and vegetation review of the site (RPS 2019b). Vegetation description and mapping was conducted using a combination of aerial photo-interpretation, regional vegetation mapping, on-ground confirmation and vegetation structure data. Each vegetation unit was defined by the dominant plant species using the vegetation structure classes established under Bush Forever (WAPC, 2000). Three vegetation units were mapped for the site: Banksia woodland units *BmBaEmLOW* and *BmAfLOW*; and a rehabilitation works unit. Vegetation unit mapping is provided in Figure I. The condition of the vegetation within the site was found to range from “Completely degraded” in the previously cleared area to “Good” to “Very good” throughout the Banksia woodland remnants.

As part of the RPS report (2019b) a search of the DBCA Threatened flora (TF) and Priority Flora (PF) and the DOEE’s Protected Matters was undertaken for known TF and PF records within a 5 km radius of the central coordinates of the site. Seventeen conservation significant species were identified including four TF, two Priority 2, five Priority 3 and six Priority 4 species. The only one of these conservation significant taxa for which there were records within the site was *Caladenia huegelii* (spider orchid) (PGV 2013). DBCA maintain a database of state listed Threatened Ecological Communities (TEC) and Priority Ecological Communities (PEC) and their locations. A search of the NatureMap database was undertaken for known TEC and PEC records within a 5 km radius of the site. Twelve records of three PECs were identified within the search area, however the site lies outside of the PEC buffers.

3.14.1 Bush Forever

Bush Forever identifies areas of regional conservation value on the Swan Coastal Plain (SCP) portion of the Perth Metropolitan Region with the aim to protect a comprehensive representation of the biological diversity on the SCP (Government of Western Australia 2000). The site is situated immediately adjacent to Bush Forever Site No. 390 – Fraser Road Bushland, Banjup. This Bush Forever site contains plant communities representative of the Bassendean Complex and Southern River Complex, and rare flora species including Spider Orchids (*Caladenia huegelii)*.

Previous floristic surveys have inferred two floristic community types within this Bush Forever site:

- Seasonal Wetlands
  - FCT 4 – Melaleuca preissiana damplands
- Uplands Centred on Bassendean Dunes and Dandaragan Plateau
  - FCT 23a – Central Banksia attenuata – B. menziesii woodlands.

3.15 Heritage

A search of the Department of Planning, Lands and Heritage, Aboriginal Heritage Inquiry System (DPLH 2019) identified that there are no Registered Aboriginal Sites located on site, and none found within a 1 km radius.

The Aboriginal Heritage Inquiry System search revealed one "Other Heritage Place" within or next to the site area:

- Readymix Sandpit 1, artefacts/scatter (ID 4108), around the south-west corner.

"Other Heritage Places" within 1 km of the site include:

- Banjup: Calsil, Artefacts/scatter, camp (ID 3301), < 0.5 km east
- Readymix Sandpit 2, artefacts/scatter, camp (ID 3300), < 0.5 km west.

The location of these "Other Heritage Places" are shown on Figure J.

A search of the Heritage Council State Register of Heritage Places (*Heritage of Western Australia Act 1990*) InHerit portal (Heritage Council of Western Australia 2019) confirmed the site is not listed on the state's heritage list. A search of the area identified one heritage area within a 1 km radius of the site, as follows:

- Armadale/Fremantle Rail, Armadale Road to Cockburn, immediately adjacent to the site.

A search of the Department of the Environment and Energy Australian Heritage Database (DoEE 2019) identified no areas of heritage significance.

3.16 Summary of environmental constraints and opportunities from the existing environment

Based on the description of the pre-development site characteristics, the following key constraints and opportunities have been identified to inform water management at the site:

- The sandy soils underlying the site should allow good infiltration of stormwater runoff from the site.
- There is at least ~3 m clearance to the pre-development AAMGL. It is expected that pre-development groundwater levels will rise due to the change in landuse, however they are not expected to rise to problematic levels.
- The site is located within a P3* public drinking water source protection area which requires particular management practices for urban development to occur.
- There are elevated nitrogen concentrations and some heavy metal exceedances in groundwater which will need to be considered in terms of urban water management.

4 WATER SERVICING

4.1 Potable water supply

All lots within the development will be connected and supplied with potable water from the Water Corporation Integrated Water Supply Scheme (IWSS). Water Corporation has indicated that a DN375 water main extension from the existing DN760 water distribution main south of Armadale Road will be constructed (Wood & Grieve Engineers 2016).

4.2 Wastewater servicing

Lots will be connected to the Water Corporation reticulated gravity fed sewer network which will gravitate to one of two wastewater pump stations.

4.3 Non-potable water supply – irrigation of POS

A groundwater licence (GWL203459(1)) for 18,975 kL/year for the irrigation of POS as well as 28,000 kL/yr for dust suppression during construction to be abstracted from the Superficial Aquifer has been issued by DWER. A copy of the licence is included as Appendix E.

5 WATER CONSERVATION STRATEGY

5.1 Proposed strategy

The State Water Plan (2007b) is a strategic policy and planning framework to meet the state's water demands to the year 2030. One of the key targets is to reduce potable water consumption to less than 100 kL per person per year. In order to meet this target, several water saving initiatives to reduce potable water use will be investigated and implemented where practical within the development.

Methods that will be utilised to achieve the potable water consumption target include:

- Water efficient fixtures and fittings to be installed in households and new homeowners will be encouraged to take up other Waterwise practices
- Irrigation of POS with groundwater
- Landscaping design will incorporate Waterwise native plants to reduce irrigation demand and turf will be limited to areas of active recreation.

5.2 Household water conservation

The Building code of Australia sets minimum standards of efficiency for water using fixtures and fittings in homes. These include:

- All tap fittings, except bath outlets, garden taps and toilets must be a minimum 4-star WELS rated.
- All showerheads must be a minimum of 3-star WELS rated.
- An outdoor private swimming pool or spa associated with a Class 1 building must be supplied with a cover or blanket.
- All internal hot water outlets (such as taps, showers and washing machine water supply fittings) must be connected to a hot water system or a re-circulating hot water system with pipes installed and insulated in accordance with AS/NZS 3500.

5.3 Landscape concept

The landscaping design will incorporate waterwise concepts to minimise the long-term irrigation requirements and create a Waterwise urban development including:

- Minimising turf areas to active areas
- Hydro-zoning plants based on irrigation availability
- Maximising native plants used, with species being selected based on intended use i.e. plants with a high uptake of nutrients being planted in the biofiltration area.

There is an area of unmanaged conservation POS of 0.54 ha and areas of managed POS including drainage of 2.28 ha. are three areas of POS totalling 2.39 ha, as well as a private open space area of 0.231 ha. The landscape masterplan, landscape concept plan for the central POS, drainage layout, and cross sections of the POS drainage areas is provided at the rear of the report in Appendix H.

6 STORMWATER MANAGEMENT

6.1 Drainage strategy

The preliminary drainage design has been developed by the project engineers Cossill & Webley. The site will effectively manage stormwater by incorporating WSUD principles and best management practices (BMPs). Key design criteria for the site are outlined in Table 3, which have been established consistent with the design objectives specified in Section 2.1. The drainage plan will be subject to further design and engineering specifications during the detailed design phase, with this information to be documented in subsequent UWMP(s). The engineering plans provided by Cossill & Webley are included in Appendix F.

Table 3: Design criteria to meet the water management objectives

Stormwater	
Flood Protection (1% AEP)	• Overland flow paths for the major events will be provided for in the road reserve within the development area. • Protection of infrastructure and assets from flooding, with the minimum habitable floor level being at least 0.3 m above the 1% AEP flood levels for the urban drainage system. • There are no flood ways or flood zones within the development.
Serviceability (20% AEP)	The installation of the pit and pipe drainage system will ensure the roads will remain passable up to and including the 20% AEP event.
Treatment and retention of the 15 mm event	• Lots greater than 300m² will have a soakwell to retain and infiltrate lot-generated runoff. A biofiltration basin in the main POS area, and a biofiltration roadside swale in the north of the site, will retain and treat runoff generated from the 15 mm rainfall event.
Groundwater	
Sufficient Clearance to groundwater levels	• The depth to AAMGLs across the site is over 2 m pre-development and bulk earthworks will ensure that the clearance between the finished lot levels and the pre-development AAMGL will be at least 1.2 m as specified by the City of Cockburn. • Subsoils are proposed to be installed beneath the basin in the POS at 0.5 m below the invert of the basin. The subsoils will be installed to ensure free draining of the basin, however they will also ensure that the specified groundwater clearance of 0.5 m is maintained from the invert of the basin to groundwater.
Groundwater Quality	The treatment measures for runoff from the 15 mm rainfall event aim to maintain post-development groundwater quality relative to pre-development and if possible improved.

6.2 Minor drainage events

One of the main purposes of the minor drainage system is to retain, treat and infiltrate run-off from the first 15 mm of rainfall as close to source as possible.

6.2.1 Lot drainage

Lots greater than 300 m² will have soakwells within the lot boundary to infiltrate lot generated runoff from the 15mm rainfall event. With the proposed earthworks, the lots will have at least 1.2 m clearance to the pre-development AAMGL. The site is also underlain by Bassendean Sands which have a high permeability and so the site will be suitable for the use of soakwells within lots.

6.2.2 Road reserve

A pipe and pit system within the internal road network will be used to convey stormwater up to and including the 20% AEP events generated from impervious road surfaces and lots <300 m². The stormwater will be directed to either a biofiltration basin located in the central POS or a biofiltration roadside swale located in the north of the site, with gross pollutant traps installed prior to the discharge to the basin and swale. The site has been divided into four catchments; catchment a and b direct stormwater to the basin in the central POS, and catchments c and d direct stormwater to the roadside swale in the north of the site. The catchment plan which shows the direction of stormwater flow is illustrated in Figure K and the Preliminary Earthworks Plan (6234-LWP-SK06) is included in Appendix F.

6.2.3 Basin design

Runoff from the 15 mm rainfall event will be treated via bio-filtration in order to remove nutrients and other pollutants. The biofiltration areas have been sized to at least 2% of the connected impervious catchment areas (2% for catchments a and b and 6% of catchments c and d) and the biofiltration section of the basin in the central POS restricts 5.5% of the total POS area.

The bio-retention basin and swale will be planted with reeds, sedges and other plant species that will be selected based on their ability to uptake nutrients and planted in accordance with *Vegetated guidelines for stormwater biofilters in the south-west of Western Australia* (Monash 2014). The biofiltration areas will also contain soil amendment to retain nutrients and will be designed in accordance with *Adoption Guidelines for Stormwater Biofiltration Systems* (Payne et al. 2015). The biofiltration basin will incorporate the following soil amendment:

- Filter layer
- Transition layer of fine gravel or crushed rock
- Drainage layer including the subsoil drain.

The basin in the central POS will incorporate two tiers. Runoff from the 15 mm event and the 20% AEP will be detained within a lower tier, with an invert at 28.20 m AHD, with events greater than this up to and including the 1% AEP being detained within a basin with an invert set at 29.15 m AHD (Drainage Basin Plan 6234-LWP-SK08 in Appendix F). The TWLs for the 15 mm event, 20% AEP and 1% AEP are shown on the Drainage Basin Plan (6234-LWP-SK08) and on Drainage Basin Long Sections (6234-LWP-SK09) in Appendix F and provided in Table 4. The adjacent finished lot levels are at a minimum of 29.9 m AHD. The criteria for minimum 300 mm freeboard from the TWL of the maximum design depth of 1.15 m (29.35 m AHD) in the basin would be achieved, with a clearance of 550 mm.

Table 4: Top water levels for the 15 mm, 20% AEP and 1% AEP events

	TWL (m AHD)	
	Main POS basin	Roadside swale
15 mm	28.7	29.39
20% AEP	29.15	29.52
1% AEP	29.35	29.79

The basin in the central POS is proposed to be underlain with a subsoil drainage system to ensure that the basin is free draining. The subsoil under the basin will have an RL of 27.70 m AHD, providing 0.5 m clearance to the invert of the basin. The subsoil drains will also underlie the whole of the central POS. A survey has been completed of the Atwell Drain of the section that runs parallel to the site and identified the RL in this section ranges from 25.92 m AHD in the east to 25.66 m AHD in the west. This elevation will allow sufficient grade for the subsoil drain to outlet to the Atwell Drain under Armadale Road. The subsoil underneath the basin will discharge to the Atwell Drain under Armadale Road at 25.80 m AHD which will allow a free draining being at least 0.1 m above the base of the drain. The proposed subsoil drainage plan (6234-LSP-SK07) is included in Appendix F.

- The roadside swale will have an invert of 29.3 m AHD and a maximum depth of 0.29 m. The adjacent lots have a minimum finished lot level of 30.34 m AHD which will also provide more than the minimum 300 mm clearance to the TWL of 29.8 m AHD. Due to the additional clearance to groundwater from the invert of the swale, subsoil drains are not proposed under the roadside swale

6.3 Major drainage events

Stormwater run-off generated from events greater than the 20% AEP event up to and including the 1% AEP event will be conveyed via overland flow paths along the road and road reserve to either the basin located in the central POS or the roadside swale located in the north of the site.

No permanent water bodies are proposed for the site and the stormwater drainage system will be designed to ensure that stormwater will be infiltrated within 96 hours following the peak critical storm event to prevent mosquito and midge breeding conditions.

6.4 Drainage modelling

The overall drainage design was modelled using xpswmm to quantify the storage volumes required for the site. The modelled volumes, TWLs and inundation areas are provided in Table 5.

Table 5: Flood storage details

	Max volume (m^3)	Area of inundation (m^2)	TWL (m)
Main POS Basin			
15 mm event	786	1,720	0.5
20% AEP	1,370	1.900	0.8
1% AEP	3,580	6,170	1.15
Roadside swale			
15 mm event	77	705	0.09
20% AEP	220	1,382	0.22
1% AEP	743	2,549	0.49

6.5 Water quality treatment

Water quality objectives will be met through the stormwater management strategies that will be implemented on site. The development will utilise structural and non-structural controls for water quality treatment including:

- Infiltrating run-off from the 15 mm rainfall event as close to source as possible
- Bio-filtration areas with amended soils with a PRI value of at least 10 to assist in retaining phosphorus
- Stormwater drainage infrastructure maintenance
- Street sweeping during and post-construction
- Erosion and dust control during construction
- Post-development monitoring to ensure that water quality targets are being met.

6.5.1 UNDO results

The UNDO tool has been run and the results are included in Appendix G. The modelled nutrient export load for the site is 1.45 kg/ha/yr for nitrogen and 0.19 kg/ha/yr for phosphorus, or 28.74 kg/yr for nitrogen and 3.70 kg/yr for phosphorus. While there are no nutrient load criteria for the Atwell Drain, as a comparison the median load target for phosphorus in the Serpentine River is 21 tonnes per year.

7 GROUNDWATER MANAGEMENT

Strategies that will be applied to ensure minimal impact to groundwater resources include:

- All lots will be connected to reticulated sewer
- Implementation of WSUD principles including at-source infiltration of up to and including 15 mm rainfall events using biofiltration, with plant species selected based on their ability to remove nutrients and contaminants from the soil profile
- The use of soil amendment in biofiltration areas
- The use of gross pollutant traps at stormwater drainage pipe discharge points, to minimise pollutants entering biofiltration areas
- Minimising and controlling fertilizer and pesticide application rates applied to the site through appropriate plant selection, and operation and maintenance procedures during and post-development
- Encouraging home purchasers to use native plants for landscaping to reduce fertilizer and pesticide use
- Monitoring groundwater quality leaving the site to verify that pre-development water quality is at a minimum maintained or improved
- Regular street sweeping during and post-construction.

Due to being in a P3* area, DWER requires additional water quality management measures to ensure that the proposed development will not impact on existing or future water supply (DWER 2018). Many of the requirements relate to wellhead protection zones (WPZs), which are not relevant to this site as there are no WPZs within the site boundary. Other P3* management measures include:

- As discussed in Section 3.8, exclusion of high risk land uses from the development area (e.g. service stations)
- Water quality monitoring program during and post-construction, including for pathogens. The sampling and analysis plan completed at subdivision stage (UWMP) will identify contingency actions, triggers and timeframes
- Any monitoring bores need to be appropriately constructed and decommissioned when no longer used to prevent contamination of the PDWSA
- If temporary sewage pumping arrangements are required, they should be located as far away as possible from Water Corporation production bores and outside of WPZs. Automated telemetry of sewerage levels needs to be in place to prevent overflows
- If sewage pump stations cannot be located outside the PDWSA, they are to at least be located outside of WPZs. They should be sized and used for the development only (i.e. not to service a larger catchment area)
- POS designed to reduce fertiliser and pesticide use. Fertiliser application rates and irrigation will be matched to local soils and plant requirements to reduce leaching
- Recycled water is generally not supported
- Use of clean fill that doesn't introduce contaminants
- Retention of existing native vegetation as much as possible
- Adequate erosion control during development
- Education and awareness programs targeted at community, land sales personnel, purchasers and builders.

Due to the depth to groundwater, groundwater levels will not require management through subsoil drains. Subsoil drains will be installed underneath the main POS basin to assist in infiltration. Final lot levels and clearance to groundwater will be provided in the UWMP for the site following refinement of the earthwork and engineering design.

8 MONITORING REQUIREMENTS

8.1 Pre-development monitoring

As discussed in Section 3.7.6, pre-development groundwater monitoring was completed for the site by hyd2o in order to determine baseline conditions for the site and to guide the engineering drainage design. Additional monitoring was completed by RPS in 2019 to obtain additional baseline data for pesticides.

8.2 Post-development monitoring

Post-development groundwater monitoring will be undertaken for a minimum of two years, following completion of the development. The monitoring program is proposed to include:

- Measuring groundwater levels
- Field physico-chemical parameters (temperature, electrical conductivity, pH, dissolved oxygen, redox and turbidity)
- Collecting water samples to be sent to a NATA accredited laboratory for analysis of nutrients (TP, reactive phosphorus, TN, TKN, NH_4-N and NO_x-N) and pathogens (due to being located in a P3* area)
- It is proposed that quality and level monitoring would be undertaken on a quarterly basis.

The groundwater monitoring locations will be from the on-site bores shown on Figure F. If any of these bores are damaged or destroyed, replacement bores will be installed as close as possible to ensure consistency in the monitoring program.

8.3 Reporting

Results from the post-development monitoring program will be presented in a post-development monitoring report which will be submitted to the City of Cockburn and DWER at the end of the monitoring program. The report will provide details of any variation the development has had on the hydrological conditions and any contingency actions proposed or undertaken.

8.4 Trigger values and contingency plans

The results from the groundwater quality monitoring will be compared to the pre-development baseline results obtained (mean + 20%), as well as the guidelines specified in Table 2 including the long-term irrigation water guidelines (ANZECC & ARMCANZ 2000), guidelines for slightly to moderately disturbed freshwater ecosystems in southwest Australia (ANZECC & ARMCANZ 2000), non-potable groundwater use (DoH 2014) and Australian drinking water guidelines (NHMRC & ARMCANZ 2011). The trigger values are presented in Table 6.

Table 6: Proposed post-development water quality monitoring trigger values

Sites	Parameters						
	EC (mS/cm)	pH	TN (mg/L)	NH_4 (as N) (mg/L)	NO_3 (as N) (mg/L)	TP (mg/L)	PO_4 (as P) (mg/L)
ANZECC LTIW[1]	-	6.0-8.5	-	-	-	-	0.05
ANZECC FW[2]	-	6.5-8.5	1.2	0.8	-	0.065	0.04
DoH NPUG[3]	-	-	-	-	500	-	-
ADWG[4]	-	-	-	-	50	-	-
BM1 + 20%	0.16	7.3	3.6	0.02	2.7	0.03	0.006
BM2 + 20%	0.13	8.0	2.7	0.01	2.2	0.04	0.006
BM3 + 20%	0.13	7.4	3.8	0.01	3.2	0.06	0.006

Sites	Parameters						
	EC (mS/cm)	pH	TN (mg/L)	NH_4 (as N) (mg/L)	NO_3 (as N) (mg/L)	TP (mg/L)	PO_4 (as P) (mg/L)
BM4 + 20%	0.26	6.5	3.4	0.09	1.8	0.03	0.006
BM5 + 20%	0.13	6.8	10.0	0.01	6.8	0.07	0.011

1 – Long-term irrigation water, Table 4.2.10 of *Australian water quality guidelines for fresh and marine water quality* (ANZECC & ARMCANZ 2000)

2 – Lowland rivers in south-west Australia slightly to moderately disturbed ecosystems, *Australian water quality guidelines for fresh and marine water quality* (ANZECC & ARMCANZ 2000)

3 - Non-potable groundwater use, *Contaminated sites ground and surface water chemical screening guidelines* (DoH 2014)

4 - *Australian drinking water guidelines* (NHMRC & ARMCANZ 2011)

In the event that future trigger values are breached on two consecutive events, further investigation will be undertaken to determine the cause of these exceedances and appropriate remedial actions will be taken.

Contingency plans may include:

- Notifying Water Corporation and DWER if water quality is considered a potential risk to the Jandakot water supply scheme
- Assess the spatial extent of the occurrence
- Determine if it is due to residential development or other factors
- Identification and removal of pollution source, if possible
- Review operational and maintenance practices
- Further soil amendment in infiltration areas (in relation to quality) or engineering to facilitate infiltration (in relation to levels)
- Increased planting of nutrient stripping vegetation in infiltration areas
- Education and public awareness program
- Confirm that the POS operating and maintenance strategy is being implemented.

Additional detail of the post-development monitoring plan including finalised trigger values will be provided in future UWMPs for the site.

9 IMPLEMENTATION

9.1 Preliminary implementation plan

An LWMS checklist is provided in Appendix I. The proposed roles and responsibilities for the development's water management are presented in Table 7, which will be appropriately refined at the UWMP stage.

Table 7: Roles and responsibilities

Principles	Role	Responsibility	Time scale
UWMP	Preparation of UWMP	The proponent	When required as condition of subdivision approval
Post-development monitoring program	Groundwater	The proponent	Quarterly water levels and quality monitoring for two years following practical completion of the development
Public open space	Fertiliser application	The proponent	As required during revegetation and ongoing maintenance until handover to CoC
	Plant establishment (planting and irrigation regime)	The proponent	For two years after planting or as agreed with the CoC.
	Irrigation scheduling	The proponent	As required following planting until handover to CoC
Drainage infrastructure	Maintenance of drainage infrastructure	The proponent	As required for two years after completion of the development until handover to the CoC. The extent of the maintenance commitment will be confirmed with the CoC at the UWMP stage of the development.
Subsoil drains	Maintenance of subsoils	The proponent	Subsoils will be inspected prior to handover and flushed as required.
Subdivision management	Construction and site works management	The proponent	As required during construction until handover to CoC
	Erosion and sediment control including street sweeping	The proponent	As required during construction
	Waste and pollution management	The proponent	As required during construction until handover to CoC
Reporting	Report on monitoring results	The proponent	Following the two year post-development monitoring program.

9.2 Further information to be provided at UWMP stage

Consistent with processes defined in WAPC (2008), an Urban Water Management Plan/s (UWMPs) will be developed and submitted to support subdivision applications for the site. A UWMP will address:

- Demonstrated compliance with this LWMS criteria and objectives to the satisfaction of the CoC and DWER
- Agreed/approved measures to achieve water conservation and efficiencies of water use
- Management of groundwater levels including proposed finished lot levels, fill levels and subsoil drainage inverts
- Landscaping plans and POS details
- Detailed stormwater drainage design including the location and sizing of drainage infrastructure and required storage as well as drainage control points, and integrated major and minor flood management capability

- Management of subdivision works including development of a strategy for sediment control during construction as well as ASS and dewatering management
- Specific post-development monitoring and reporting to be undertaken consistent with the monitoring program defined in the LWMS
- Finalised implementation plan including roles and responsibilities of all parties involved
- Contingency plans (where necessary).

More detail of POS and drainage integration will be provided during the development of the UWMP and in consultation with the City of Cockburn, including preparation of detailed landscaping plans (species selection and treatments), and detailed design drawings.

10 REFERENCES

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FIGURES



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Figure A

Site location

GDA 1994 MGA Zone 50

0 50 100 200 m

Job Number: EWP17096.001
Doc Number: 001
Date: 05.08.19
Scale: Map 1:5,000 Overview 1:500,000 @ A4
Created by: RA
Source: Imagery - Landgate



Figure B

Development plan

0 25 50 75 100 m

Job Number: EWP17096-001
Doc Number: 002
Date: 25.11.19
Scale: 1:2500 @ A3
Created by: RA
Source: Treeby Structure Plan (LWPTRE RD1 018 RevA) - Roberts Day, 28.11.19

LEGEND

Contour (mAHD)

Site boundary

Geology (DMP, 50K Mapsheets)

Cps - PEATY CLAY - dark grey and black, soft, variable organic content, some quartz sand in places, of lacustrine origin

S10 - SAND - as S8 as relatively thin veneer over strong, blocky, brown silts and clays

S8 - SAND - very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted, of eolian origin

Sp1 - PEATY SAND - grey to black, fine to medium-grained, moderately sorted quartz sand, slightly peaty, of lacustrine origin

S8

S8

Cps

S10

Cps

Cps

S10

Sp1

Figure C

Topography and geology

GDA 1994 MGA Zone 50

0 50 100 200 m

Job Number: EWP17096.001
Doc Number: 003
Date: 05.08.19
Scale: 1:4,000 @ A3
Created by: RA
Source: Orthophoto - Landgate, 2019

Document Path: G:\Jobs\L_Jobs\L17096 - LWP Treeby DD\Figures EWP17096.001 - LWMS\EWP17096_001_G_003_FigC Topography and geology_190805.mxd

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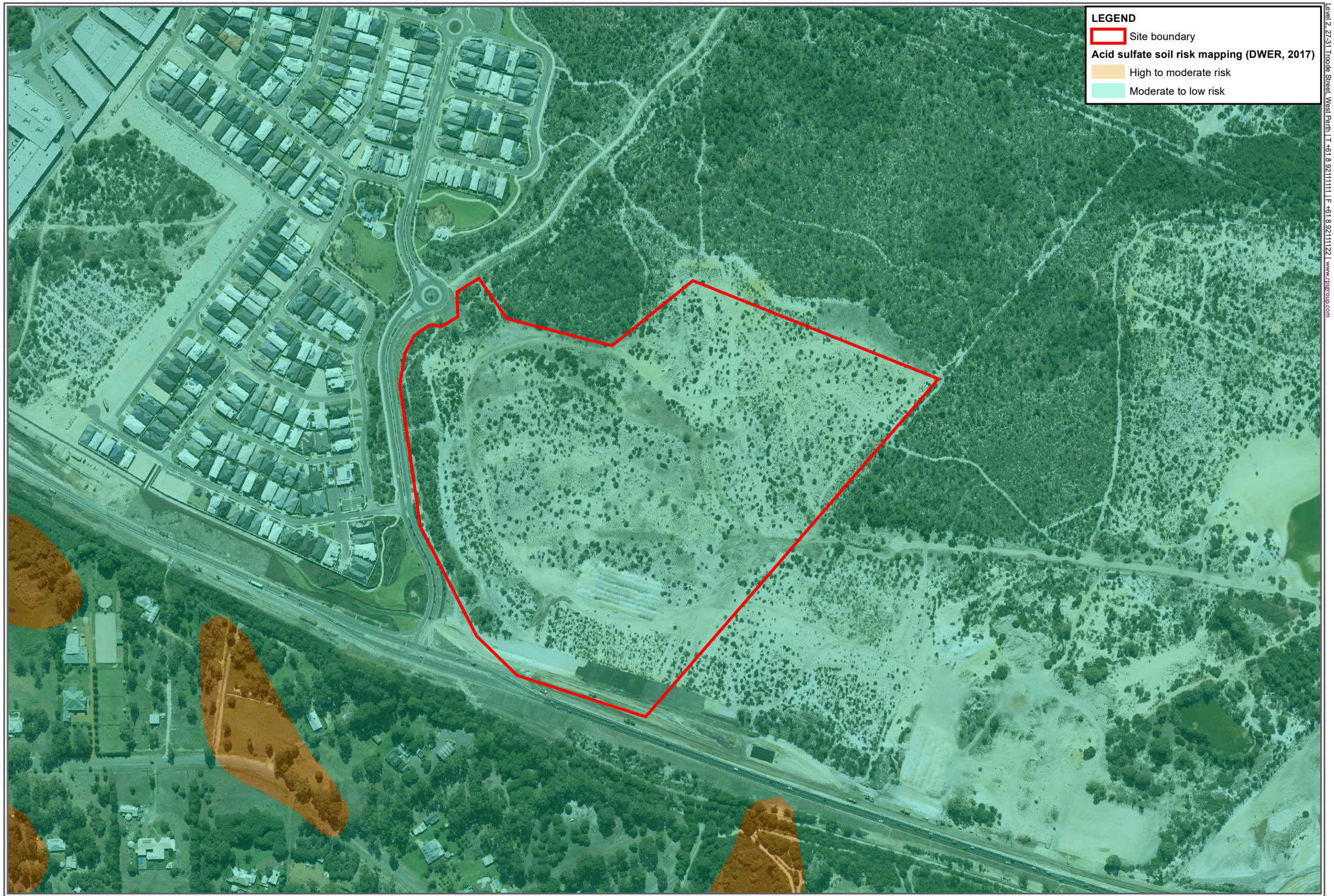


Figure D

Acid sulfate soils risk mapping

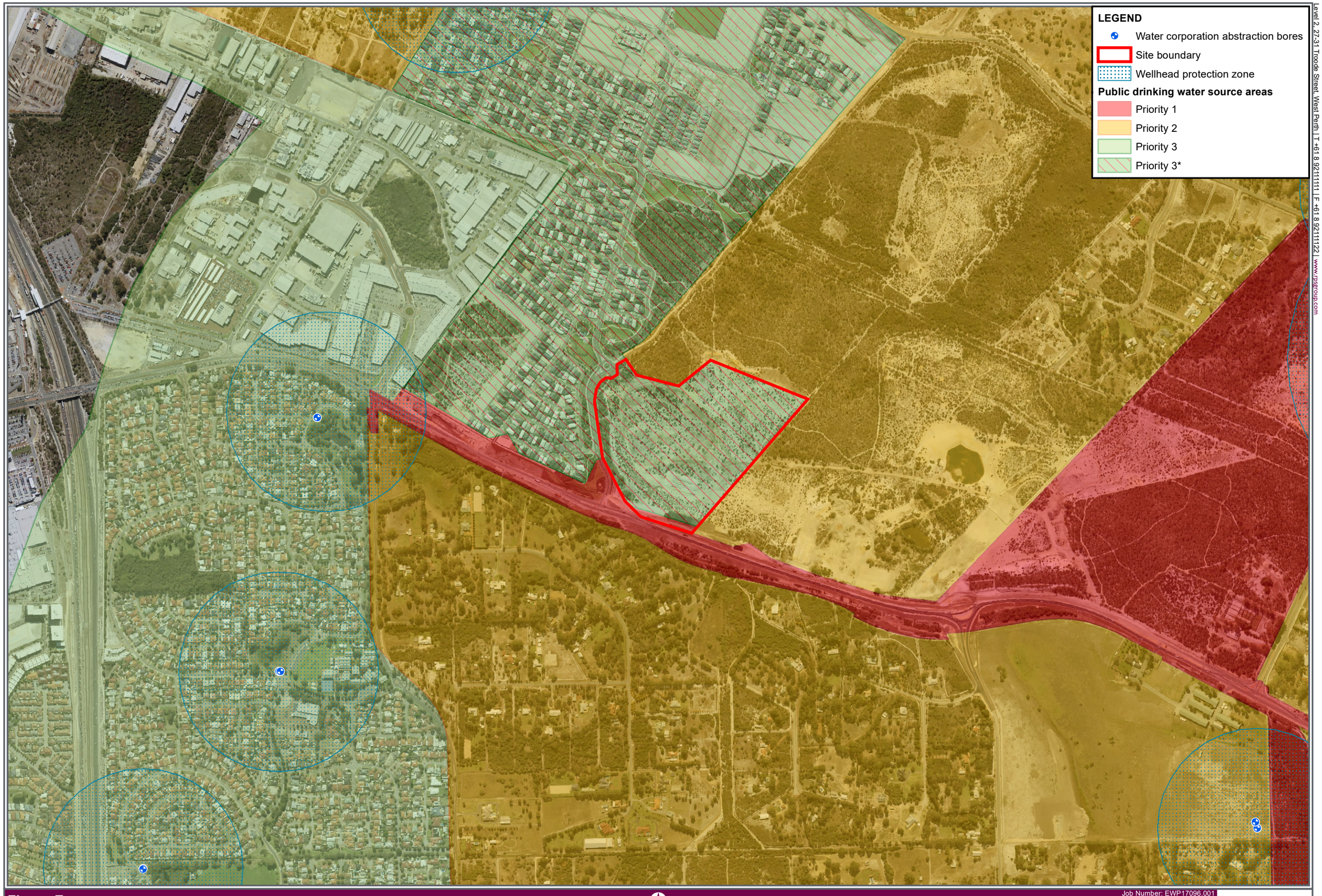
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0 50 100 200 m

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Doc Number: 004
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Source: Orthophoto - Landgate, 2019

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Figure E

Water Corporation abstraction bores and well head protection zones

GDA 1994 MGA Zone 50

0 125 250 500 m

Job Number: EWP17096.001
Doc Number: 005
Date: 05.08.19
Scale: 1:10,000 @ A3
Created by: RA
Source: Orthophoto - Landgate, 2019

Document Path: G:\Jobs\L_Jobs\L17096 - LWP Treeby DD\Figures EWP17096.001 - LWMS\EWP17096_001_G_005_FigE Water Corp abstraction bores and well head protection_190805.mxd



Figure F

Groundwater monitoring bore locations

GDA 1994 MGA Zone 50

0 125 250 500 m

Job Number: EWP17096.001
Doc Number: 006
Date: 05.08.19
Scale: 1:14,000 @ A3
Created by: RA
Source: Orthophoto - Landgate, 2019

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Figure G

AAMGL contours

GDA 1994 MGA Zone 50

0 50 100 200 m

Job Number: EWP17096.001
Doc Number: 007
Date: 05.08.19
Scale: 1:3,000 @ A3
Created by: RA
Source: Orthophoto - Landgate, 2019

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Document Path: G:\Jobs\L_Jobs\L17096 - LWP Treeby DD\Figures EWP17096.001 - LWMS\EWP17096_001_G_007_FigG AAMGL contours _190805.mxd

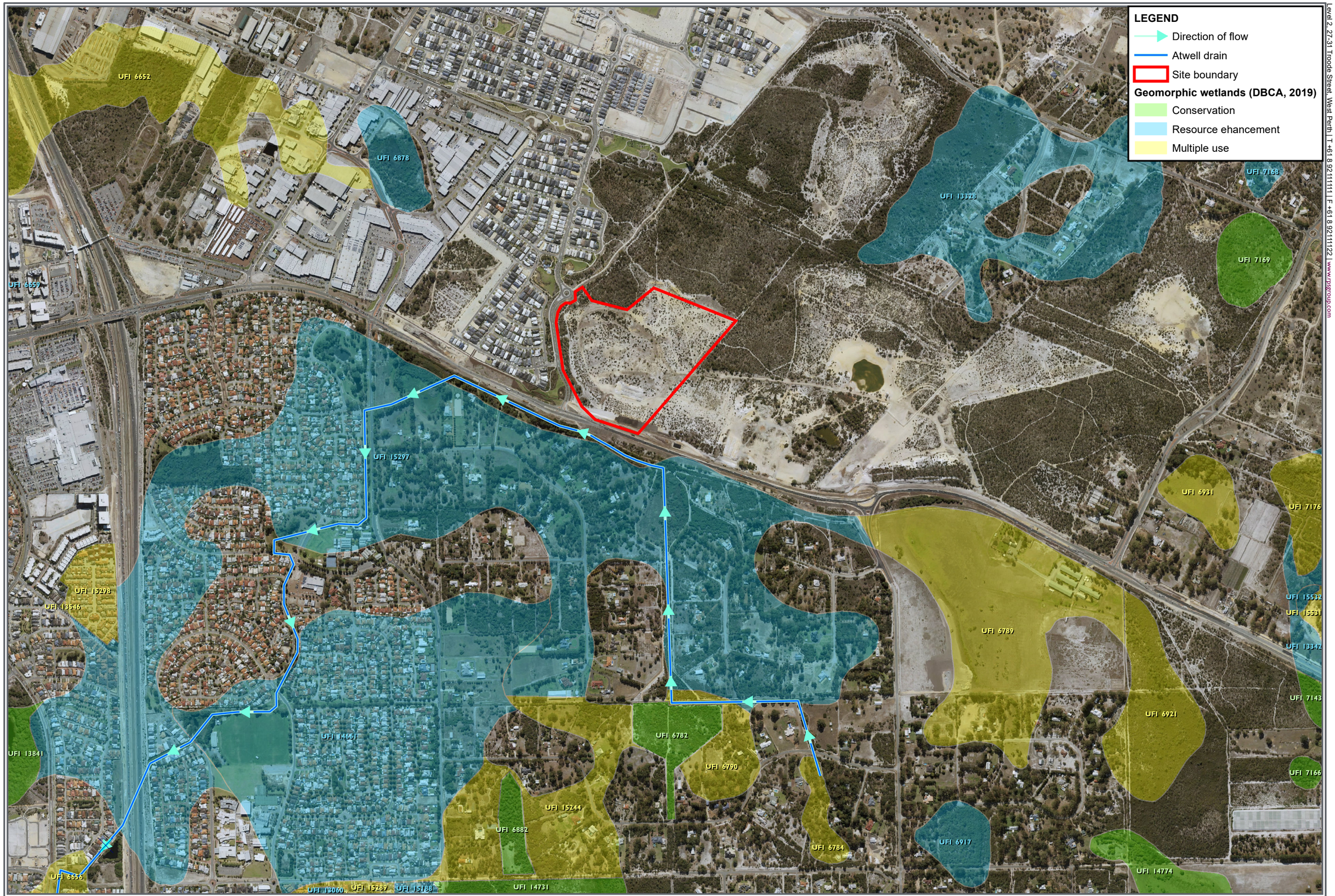


Figure H

Geomorphic wetland mapping

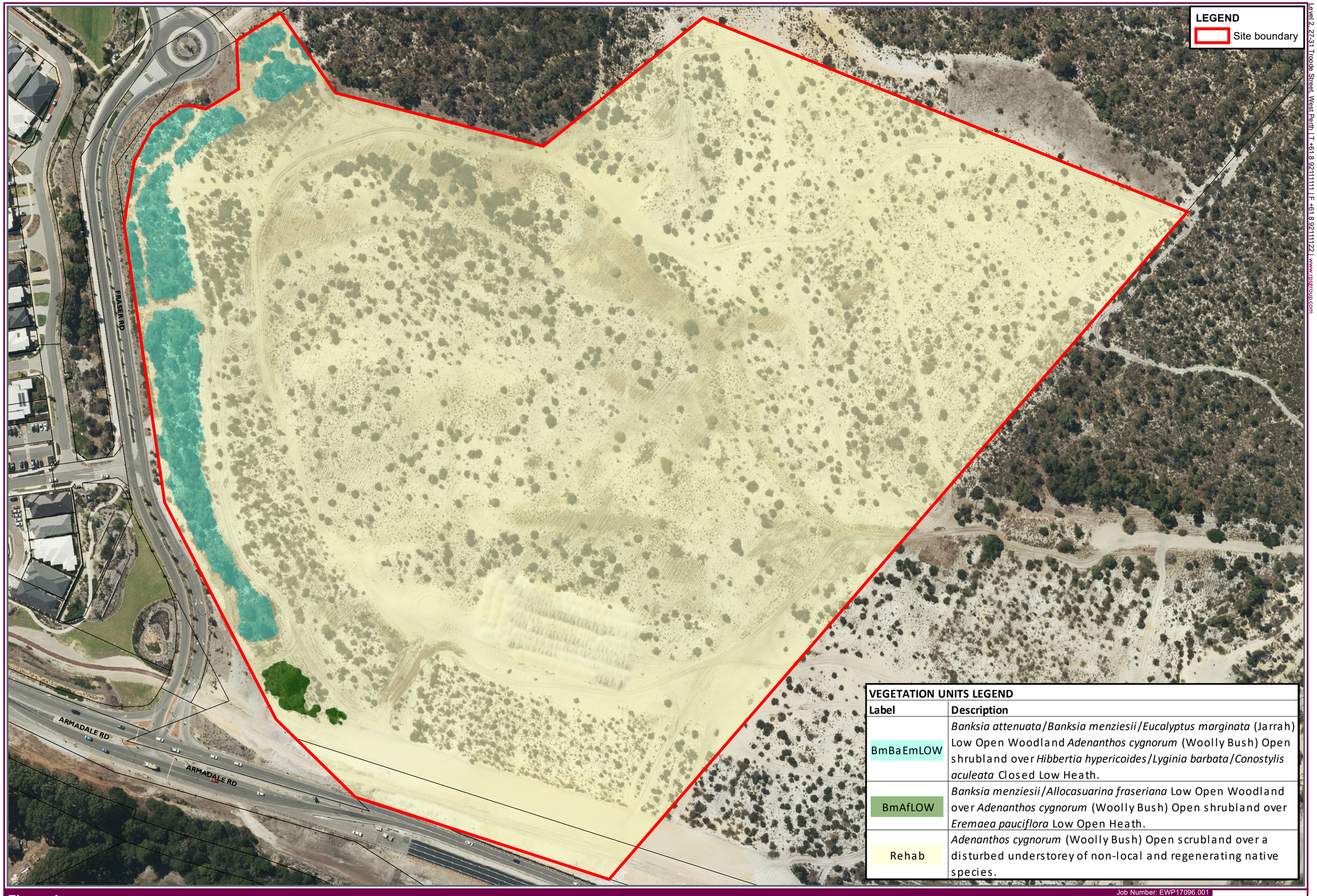
GDA 1994 MGA Zone 50

0 125 250 500 m

Job Number: EWP17096.001
Doc Number: 008
Date: 05.08.19
Scale: 1:12,000 @ A3
Created by: RA
Source: Orthophoto - Landgate, 2019

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VEGETATION UNITS LEGEND	
Label	**Description**
BmBaEmLOW	*Banksia attenuata/Banksia menziesii/Eucalyptus marginata* (Jarrah) Low Open Woodland *Adenanthos cygnorum* (Woolly Bush) Open shrubland over *Hibbertia hypericoides/Lyginia barbata/Conostylis aculeata* Closed Low Heath.
BmAfLOW	*Banksia menziesii/Allocasuarina fraseriana* Low Open Woodland over *Adenanthos cygnorum* (Woolly Bush) Open shrubland over *Eremaea pauciflora* Low Open Heath.
Rehab	*Adenanthos cygnorum* (Woolly Bush) Open scrubland over a disturbed understorey of non-local and regenerating native species.

Figure I

Vegetation units

GDA 1994 MGA Zone 50

0 25 50 100 m

Job Number: EWP17096.001
Doc Number: 009
Date: 05.08.19
Scale: 1:2,000 @ A3
Created by: MA
Source: Cadastre - Landgate, 2019 Orthophoto - Landgate, Aug 2018

Document Path: G:\Jobs\L_Jobs\L17096 - LWP Treeby DD\Figures EWP17096.001 - LWMS\EWP17096_001_G_009_FigI_Vegetation Units_190805.mxd

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Figure J

Aboriginal heritage sites

GDA 1994 MGA Zone 50

0 75 150 300 m

Job Number: EWP17096.001
Doc Number: 010
Date: 05.08.19
Scale: 1:6,000 @ A3
Created by: RA
Source: Orthophoto - Landgate, 2019

Document Path: G:\Jobs\L_Jobs\L17096 - LWP Treeby DD\Figures EWP17096.001 - LWMS\EWP17096_001_G_010_FigJ Aboriginal Heritage Sites_190805.mxd



Figure K

Drainage catchments and flow paths

GDA 1994 Perth Coastal Grid 1994

0 25 50 100 m

Job Number: EWP17096.001
Doc Number: 011
Date: 16.10.19
Scale: 1:2,200 @ A3
Created by: RA

Source: Orthophoto - Landgate, 2019 Treeby Structure Plan (LWP TRE RD1 017 RevA.1)-Roberts Day, 01.11.19

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Appendix A

Hyd2o monitoring report

29 January 2018

Your Ref:
Our Ref: H16013Cv1

Department of Communities
Locked Bag 22,
East Perth WA 6892
ATTENTION: Beth Ferialdi

Dear Beth,

RE: LOT 821 ARMADALE ROAD BANJUP
PRE DEVELOPMENT HYDROLOGICAL MONITORING PROGRAMME

Hyd2o was commissioned by the Housing Authority in 2016 to undertake the pre development hydrological monitoring programme for Lot 821 Armadale Road Banjup (the site). The site is bound by Armadale Rd, to the south, a commercial site to the east, a Bush Forever site to the north, and the Cayella residential development to the west.

This report details the installation of the site bores (including bore logs), the method of the programme, and results of the programme. Mapping of annual average maximum groundwater contours (AAMGL) is also provided.

The programme was designed to satisfy the requirements of the Department of Water and Environmental Regulation (DWER) for predevelopment hydrological monitoring as outlined in 'Water Monitoring Guidelines for Better Urban Water Management Strategies and Plans' (Department of Water, 2012).

Results will be used to inform the future local water management strategy for the site.

1. MONITORING PROGRAMME

1.1. BORE INSTALLATION

Five groundwater monitoring bores were installed at the site on 3rd May 2016 (Figure 1).

The locations of the bores were based on site inspection and a desktop assessment of suitable locations based on other available information including bores installed for adjacent development areas, the DWER online Perth Groundwater Atlas and Water Information Reporting websites, and service clearances based on the Dial Before You Dig service. The driller, Direct Push Probing, assisted in determining final locations on the day of installation based on accessibility.

The bores were installed by Direct Push Probing via a drill rig, overseen by Hyd2o. The bores were constructed suitable for water level and water quality monitoring.

Logging of soil profiles and survey to Australian Height Datum was completed for each bore installed, with logs included as Attachment 1. The profile of all bores was sand with a fine texture, yellow to 4m-5m and then light grey to the end of hole which ranged from 6m to 7m.

1.2. MONITORING PROGRAMME

The monitoring programme was undertaken over an 18 month period, commencing in May 2016, with the final monitoring occasion in October 2017 – capturing two winters (Table 1).

Water level monitoring was undertaken monthly at the onsite bores and an additional two nearby DWER bores (JM26 and JM27) (Figure 1). The monitoring of long term DWER bores allowed for onsite groundwater measurements to be referenced to long term local groundwater records for consistency and the calculation of an average annual maximum groundwater level (AAMGL) and maximum groundwater level (MGL) for the site (refer Section 2).

Water quality monitoring at the five onsite bores was undertaken quarterly (totalling six occasions), and was consistent with DWER requirements.

Both groundwater samples were measured in situ for physical parameters (temperature, electrical conductivity, pH, dissolved oxygen, oxidation reduction and turbidity), with samples sent to a NATA approved laboratory for analysis of total suspended solids nutrients, and heavy metals. The following parameters were analysed: total nitrogen, total Kjeldahl nitrogen, ammonia, nitrate, nitrite, total phosphorus, filterable reactive phosphorus, and heavy metals (arsenic, cadmium, chromium, copper, nickel, lead, mercury, and zinc). As the site is within the Jandakot Groundwater Protection Area, DWER requested that samples also be tested for Fluoride, Faecal Enterococci, Thermotolerant Coliforms, and E. coli.

Table 1: Pre Development Monitoring Programme

Monitoring	Parameter	Location	Method	Frequency and Timing
Groundwater	Water Level (mAHD)	5 bores within site and 2 nearby DoW bores	Water level meter or similar	Monthly (18 occasions)
	Water Quality	5 bores within site	Low flow pump	Quarterly (6 occasions)

2. MONITORING RESULTS

2.1. GROUNDWATER LEVELS

Groundwater levels for the site were monitored monthly from May 2016 through to November 2017 at the five site bores and DWER bores JM26 and JM27.

Table 2 and Attachment 2 show all recorded groundwater levels for the site bores. Minimum groundwater levels for the site bores were recorded in May 2016 and ranged from 24.97 mAHD at BM2 to 25.58 mAHD at BM1.

Maximum groundwater levels over the monitoring period were recorded in September 2017 ranging from 26.30 mAHD at BM2 to 26.81 mAHD at BM4.

The recorded groundwater levels were broadly consistent with the Perth Groundwater Atlas. The online DWER Perth Groundwater Atlas shows May 2003 groundwater levels across the site ranging from 24.9 mAHD to 26 mAHD, which represent a typical minimum groundwater level at the end of summer. The Atlas also provides groundwater contours showing the historical maximum groundwater levels across the site being between 26.9 mAHD and 28 mAHD, approximately 2 m above the May 2003 levels.

Table 2 and Attachment 2 also show all DWER bore groundwater levels recorded from JM26 and JM27 as part of the monitoring programme. Two additional DWER bores, JM14 and JM15 (Figure 1), were also analysed using data available on Water Information Reporting (DWER 2018) to assist in determining the AAMGL for the site. The DWER bores show a historical annual variation of approximately 1.0m to 2.5m between winter and summer levels with long-term hydrographs showing a general decline in groundwater levels since the 1970s. DWER long-term hydrographs are included in Attachment 2.

Table 3 and Table 4 detail the calculation of the average annual maximum groundwater levels (AAMGL) and maximum groundwater levels (MGL) for the site based on long term DWER records correlated against readings from the September 2017 peak groundwater levels which represented the highest groundwater levels recorded within the site during the monitoring period.

AAMGL mapping is provided in Figure 2.

The AAMGL on the site is estimated to range between a maximum of 27.13 mAHD in the north of the site, to 26.50 mAHD in the southern corner of the site. Depth to AAMGL from natural surface ranges from approximately 2.82m at BM4 to 3.39m at BM3.

The MGL for the site is estimated to range between 28.05mAHD at BM4 and 27.54mAHD at BM2.

Table 2: Groundwater Levels – Site Bores & DWER Bores

	Groundwater Bore						
	BM1	**BM2**	**BM3**	**BM4**	**BM5**	**JM26**	**JM27**
Easting	394073	394292	394435	394260	394584	395200	396909
Northing	6444766	6444533	6444651	6444843	6444809	6443765	6443397
TOC (mAHD)	30.57	30.44	30.69	30.51	30.45	30.66	30.46
NS (mAHD)	29.95	29.82	30.11	29.95	29.81	30.05	29.86
	Groundwater Levels (mAHD)						
13/05/2016	25.58	24.97	25.14	25.55	25.20	26.05	23.86
15/06/2016	25.81	25.23	25.35	25.73	25.32	26.46	24.40
29/07/2016	26.14	25.65	25.73	26.08	25.64	26.84	24.80
22/08/2016	26.24	25.77	25.85	26.19	25.80	26.25	24.92
27/09/2016	26.55	26.13	26.24	26.58	26.25	25.92	25.06
20/10/2016	26.59	26.17	26.31	26.62	26.32	26.28	25.05
21/11/2016	26.44	26.01	26.16	26.48	26.18	25.93	24.60
20/12/2016	26.31	25.83	26.04	26.34	26.05	25.97	24.44
23/01/2017	26.15	25.59	25.82	26.14	25.84	25.56	23.98
27/02/2017	26.49	25.64	25.84	26.22	25.84	25.86	24.36
22/03/2017	26.13	25.52	25.84	26.10	25.73	25.92	24.41
12/04/2017	26.07	25.47	25.65	26.04	25.69	25.79	24.22
24/05/2017	25.94	25.37	25.53	25.92	25.56	25.74	24.42
26/06/2017	25.94	25.41	25.51	25.88	25.54	25.79	24.45
17/07/2017	26.17	25.70	25.78	26.12	25.72	26.15	24.73
18/08/2017	26.60	26.20	26.29	26.59	26.12	26.63	25.27
29/09/2017	26.65	26.30	26.40	26.81	26.41	26.56	25.16
30/10/2017	26.58	26.24	26.38	26.66	26.38	26.46	25.00

Table 3: AAMGL and MGL – DWER Bores

Bore	Period of Record	Groundwater Level 29/09/17	Groundwater Level 02/10/17*	AAMGL (mAHD)	Correction Factor (m)	MGL (mAHD)	Correction Factor (m)
JM26	1975-2017	26.56	-	26.96	0.40	27.56	1.00
JM27	1975-2017	25.16	-	25.32	0.16	26.22	1.06
JM14	1975-2017	-	25.67	26.19	0.52	27.45	1.78
JM15	1975-2017	-	26.43	26.61	0.18	27.54	1.11
Correction Factors for Site Bores					**+0.32**		**+1.24**

***Data from Water Information Reporting (DWER 2018)**

Table 4: AAMGL and MGL - Site Bores

Bore	Natural Surface (mAHD)	Groundwater Level (mAHD) 29/09/17	Applied Correction Factor (m)	AAMGL (mAHD)	Depth Below Natural Surface (m)	Applied Correction Factor (m)	MGL (mAHD)	Depth Below Natural Surface (m)
BM1	29.95	26.65	+0.32	26.97	2.98	+1.24	27.89	2.06
BM2	29.82	26.30	+0.32	26.62	3.20	+1.24	27.54	2.28
BM3	30.11	26.40	+0.32	26.72	3.39	+1.24	27.64	2.47
BM4	29.95	26.81	+0.32	27.13	2.82	+1.24	28.05	1.90
BM5	29.81	26.41	+0.32	26.73	3.08	+1.24	27.65	2.16

2.2. GROUNDWATER QUALITY

Groundwater quality samples were taken from all site bores quarterly, commencing in May 2016 with the last sample set taken in August 2017. A total of six groundwater sampling occasion were undertaken. Detailed groundwater quality results are included in Attachment 3, with laboratory reports in Attachment 4.

Groundwater quality results are summarised in Table 5 and below, with comparison to ANZECC (2000) guidelines for lowland rivers in the southwest of Australia.

- Mean pH at bores across the site ranged from 5.42 at BM4 to 6.35 at BM2, outside ANZECC guideline range of 6.5 to 8.0 pH and indicating slightly acidic groundwater.
- Mean EC at the site bores ranged from 0.11 mS/cm at BM2, BM3 and BM5 to 0.22 mS/cm at BM4, comparative to the ANZECC guideline range of 0.12 mS/cm to 0.300 mS/cm.
- Mean TN at bores across the site ranged from 2.25 mg/L at BM2 to 8.32 at BM5, above the ANZECC guideline of 1.2 mg/L.
- Mean TP at the site bores ranged from 0.025 mg/L at BM1 to 0.058 mg/L at BM5, within the ANZECC guideline value of 0.065 mg/L.

Whilst the TN values are above the ANZECC guidelines, they are representative of typical pre urban development groundwater nutrient values found on the Swan Coastal Plain.

Across all bores, the mean results for all metals were within the 99% trigger level of protection for freshwater species, with results for Arsenic, Cadmium, and Mercury below the laboratory detectable limit in all samples at all bores (refer Attachment 3).

Results for all samples at all bores for Fluoride, Faecal Enterococci, Thermotolerant Coliforms, and E. coli were below the laboratory detectable limit.

Table 5: Mean Groundwater Quality Result Summary

Parameter	ANZECC	BM1	BM2	BM3	BM4	BM5
EC (mS/cm)	0.12 – 0.30	0.13	0.11	0.11	0.22	0.11
pH	6.5 – 8.0	5.85	6.35	6.20	5.42	5.71
TN (mg/L)	1.2	2.98	2.25	3.20	2.83	8.32
TP (mg/L)	0.065	0.025	0.035	0.048	0.028	0.058
Ammonia (mg/L)	0.08	0.015	0.008	0.007	0.077	0.009
Nitrite as N (mg/L)	-	0.010	0.005	0.005	>0.005	>0.005
Nitrate as N (mg/L)	-	2.22	1.83	2.63	1.54	5.68

3. REFERENCES

Australian and New Zealand Environment and Conservation Council (ANZECC), 2000. National Water Quality Management Strategy: Australian and New Zealand Guidelines for Fresh and Marine Water Quality, October 2000.

Department of Water, 2012. Water Monitoring Guidelines for Better Urban Water Management Strategies and Plans.

Western Australian Planning Commission, 2008. Better Urban Water Management, October 2008.

Should you have any queries regarding this report, please do not hesitate to contact Renee Blandin or Sasha Martens of this office.

Yours sincerely,



Renee Blandin

Environmental Hydrologist

Attachments

Figure 1: Monitoring Locations

Figure 2: Groundwater Map

Attachment 1: Lithological Logs

Attachment 2: Water Level Monitoring Data

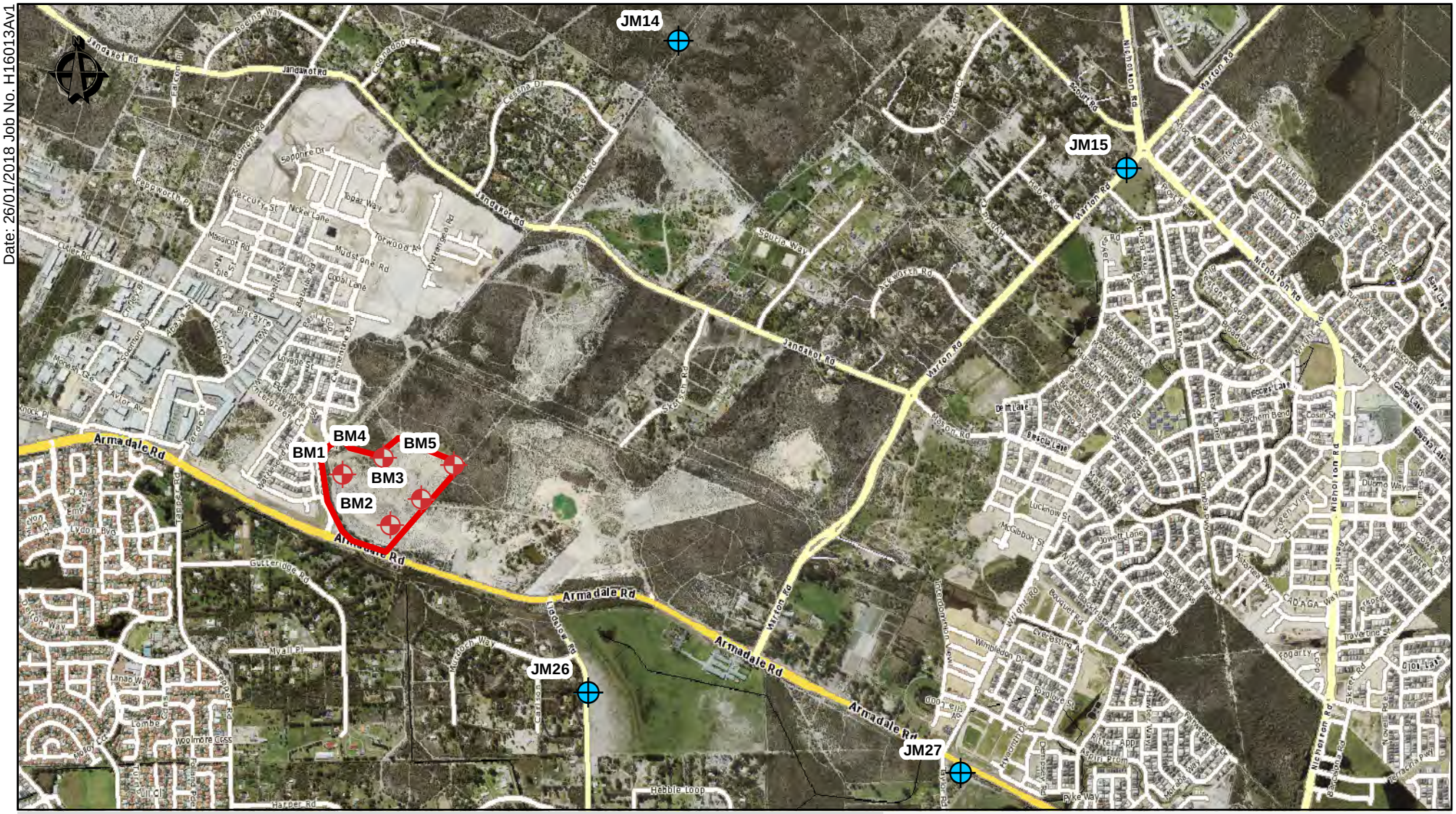
Attachment 3: Water Quality Monitoring Data

Attachment 4: Laboratory Reports

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FIGURES

Date: 26/01/2018 Job No. H16013Av1



Site

DWER Groundwater Monitoring Bores

Site Groundwater Monitoring Bores

hyd2o

Lot 821 Armadale Road Banjup Hydrological Monitoring Report

Groundwater Monitoring Bores

Figure 1

Date: 26/01/2018 Job No. H16013Av1



Site

AAMGL Contour (mAHD)

Groundwater Monitoirng Bore (AAMGL mAHD)

hyd2o

Lot 821 Armadale Road Banjup Hydrological Monitoring Report

Groundwater Map

Figure 2

ATTACHMENT 1
LITHOLOGICAL LOGS

Hyd2o
Suite 6B 103 Rokeby Rd
Subiaco, WA 6008

PO Box 1055
Subiaco WA 6904

BM5

LITHOLOGICAL LOG

Client: Housing Authority		Job No:H16013	
Project: Lot 821 Armadale Road Banjup		Hole commenced: 10.00	
Bore location: 394586 mEasting, 6444805 mNorthing		Hole completed: 11.00	
Datum:	MGA Zone 50, GDA 94	Logged by: R. Blandin	
Bore Name:	BM5	Total Depth:	
Drill type:	Drill Rig Hollow Auger	R.L. TOC:	
Hole diameter:	50 mm	Natural Surface:	

support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
PVC (Class 9)		▽		1.0 m	Light Brown	Fine	Sand	Low	Slightly Moist	
				2.0 m	Medium Grey					
				3.0 m	Light Grey Medium Brown Mottled					
				4.0 m	Light Grey					
				5.0 m	Light Grey Medium Brown Mottled				Moist	
				6.0 m	Light Grey				Saturated	
				7.0 m						
				8.0 m						
				9.0 m						
				10.0 m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dar Brown, Red, Orange, Yellow, Grey, Blue
Mec Brown, Red, Orange, Yellow, Grey, Blue
Ligl Brown, Red, Orange, Yellow, Grey, Blue

Tones : solid colour, blemish or mottle

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 03/05/16

WL below TOC: 5.20 m

Stickup above NS:

WL: below NS

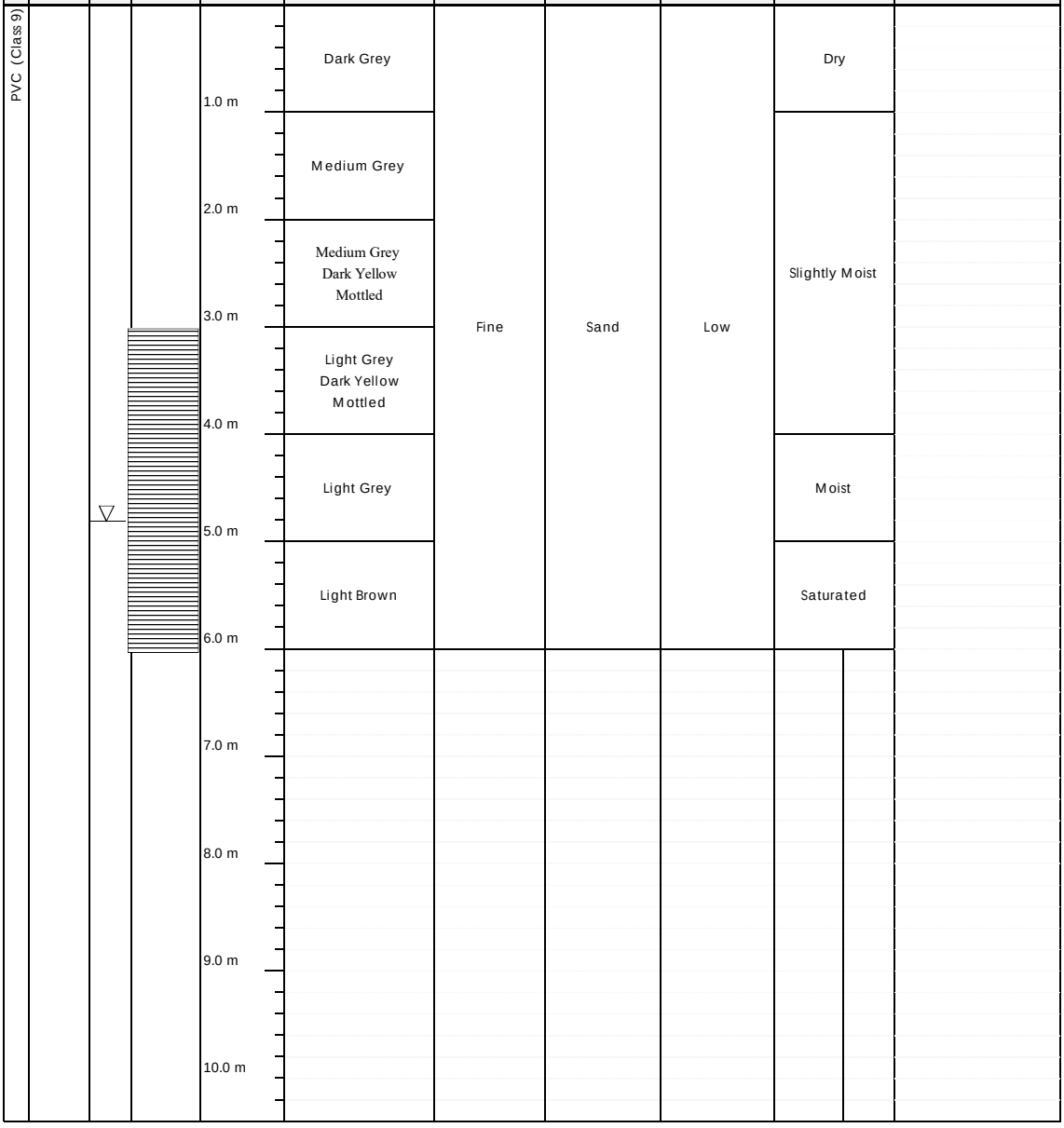
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Subiaco, WA 6008

PO Box 1055
Subiaco WA 6904

BM4

LITHOLOGICAL LOG

Client: Housing Authority		Job No:H16013	
Project: Lot 821 Armadale Road Banjup		Hole commenced: 11:30	
Bore location: 394263 mEasting, 6444845 mNorthing		Hole completed: 12:30	
Datum:	MGA Zone 50, GDA 94	Logged by: R. Blandin	
Bore Name:	BM4	Total Depth:	
Drill type:	Drill Rig Hollow Auger	R.L. TOC:	
Hole diameter:	50 mm	Natural Surface:	



NOTES ON BORELOG

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Mec Brown, Red, Orange, Yellow, Grey, Blue
Ligl Brown, Red, Orange, Yellow, Grey, Blue

Tones : solid colour, blemish or mottle

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 03/05/2016

WL below TOC: 5.52 m

Stickup above NS:

WL: below NS

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BM3

LITHOLOGICAL LOG

Client: Housing Authority		Job No:H16013	
Project: Lot 821 Armadale Road Banjup		Hole commenced: 9.00	
Bore location: 394435 mEasting, 6444651 mNorthing		Hole completed: 10.00	
Datum:	MGA Zone 50, GDA 94	Logged by: R. Blandin	
Bore Name:	BM3	Total Depth:	
Drill type:	Drill Rig Hollow Auger	R.L. TOC:	
Hole diameter:	50 mm	Natural Surface:	

support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
					COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
PVC (Class 9)		▽		1.0 m	Medium Yellow	Medium	Sand	Low	Slightly Moist	
				2.0 m	Light Brown	Fine				
				3.0 m						
				4.0 m	Light Yellow					
				5.0 m	Medium Brown				Moist	
				6.0 m	Light Grey				Saturated	
				7.0 m						
				8.0 m						
				9.0 m						
				10.0 m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dar Brown, Red, Orange, Yellow, Grey, Blue — Tones : solid colour, blemish or mottle
Mec Brown, Red, Orange, Yellow, Grey, Blue
Ligl Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 03/05/16

WL below TOC:5.53 m

Stickup above NS:

WL: below NS

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Subiaco WA 6904

BM2

LITHOLOGICAL LOG

Client: Housing Authority		Job No:H16013	
Project: Lot 821 Armadale Road Banjup		Hole commenced: 7.50	
Bore location: 394292 mEasting, 6444534 mNorthing		Hole completed: 8.50	
Datum:	MGA Zone 50, GDA 94	Logged by: R. Blandin	
Bore Name:	BM2	Total Depth:	
Drill type:	Drill Rig Hollow Auger	R.L. TOC:	
Hole diameter:	50 mm	Natural Surface:	

support	backfill	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
					COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
PVC (Class 9)				1.0 m	Medium Yellow	Fine	Sand	Low	Slightly Moist	
				2.0 m	Medium Yellow					
				3.0 m	Medium Yellow					
				4.0 m	Medium Yellow					
		▽		5.0 m	Brown/Yellow Mottled					
				6.0 m	Light Grey Light Yellow				Saturated	
				7.0 m						
				8.0 m						
				9.0 m						
				10.0 m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
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SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 03/05/2016

WL below TOC: 5.45m

Stickup above NS:

WL:

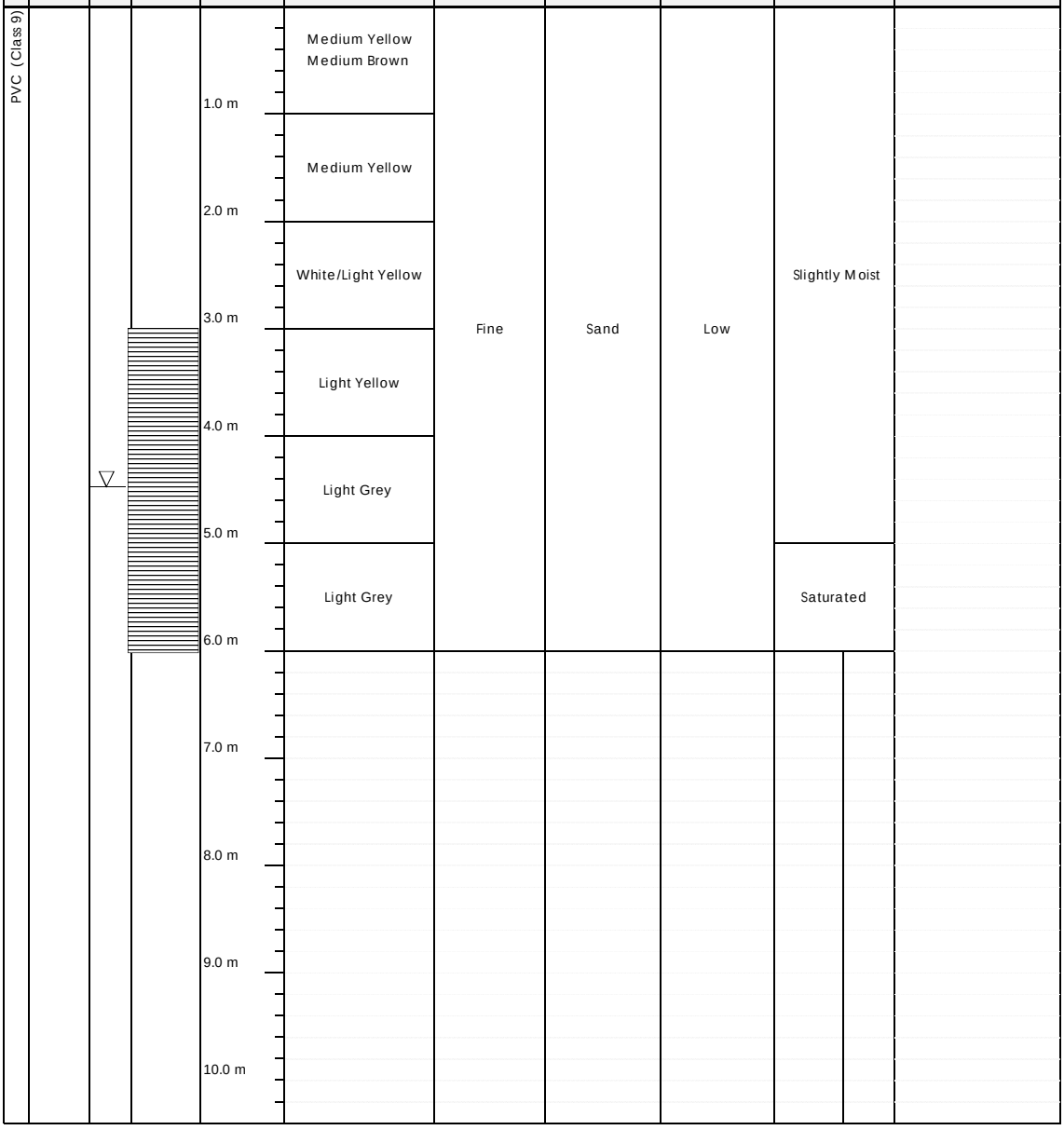
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Suite 6B 103 Rokeby Rd
Subiaco, WA 6008

PO Box 1055
Subiaco WA 6904

BM1

LITHOLOGICAL LOG

Client: Housing Authority		Job No:H16013	
Project: Lot 821 Armadale Road Banjup		Hole commenced: 12:30	
Bore location: 394075 mEasting, 6444767 mNorthing		Hole completed: 13:30	
Datum:	MGA Zone 50, GDA 94	Logged by: R. Blandin	
Bore Name:	BM1	Total Depth:	
Drill type:	Drill Rig Hollow Auger	R.L. TOC:	
Hole diameter:	50 mm	Natural Surface:	



NOTES ON BORELOG

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SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: 03/05/16

WL below TOC: 4.96 m

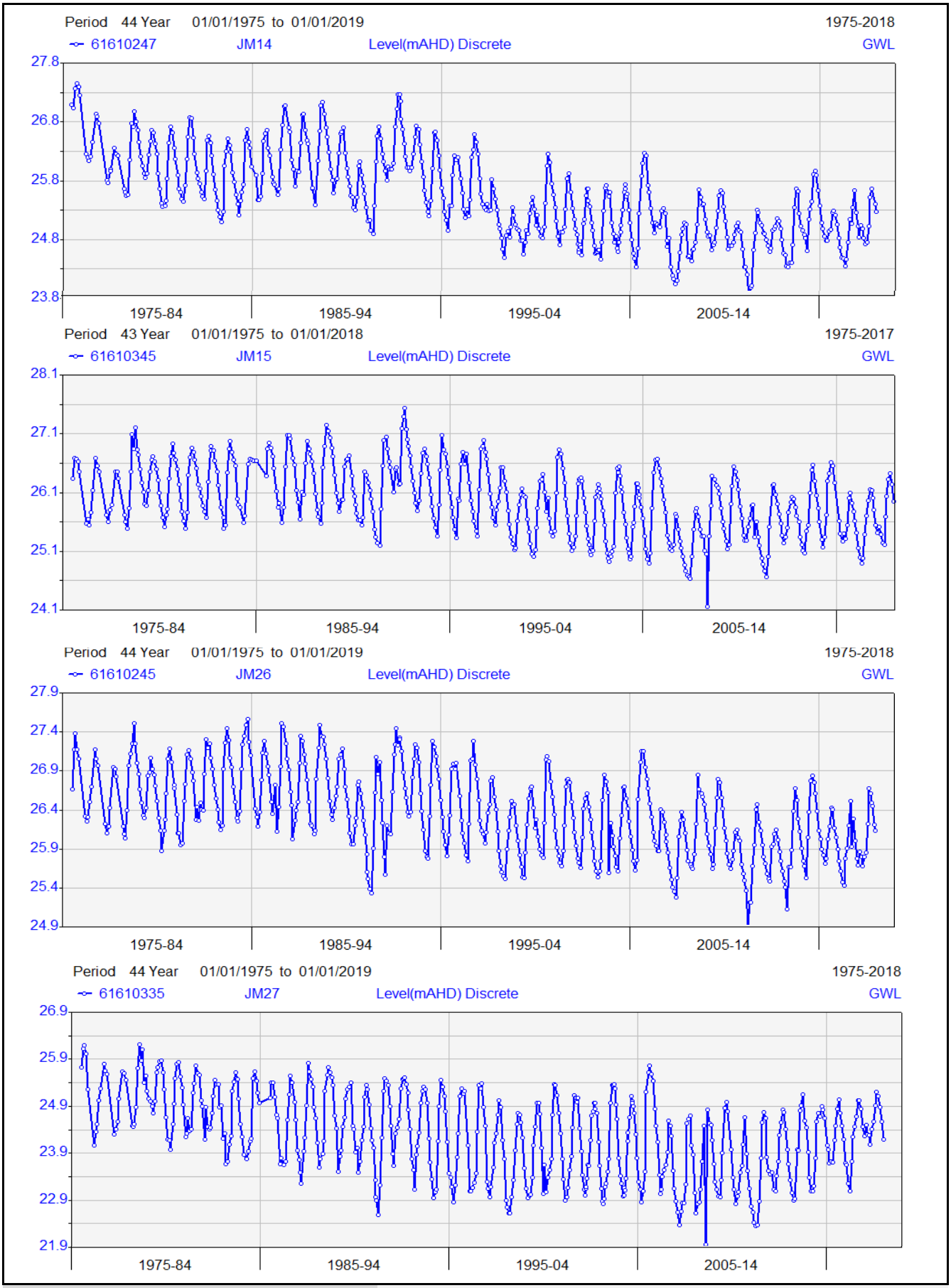
Stickup above NS:

WL: below NS

ATTACHMENT 2
WATER LEVEL MONITORING DATA

H16013
Lot 821 Armadale Road Banjup
Groundwater Levels

Bore Name	**BM1**		**BM2**		**BM3**		**BM4**		**BM5**		**JM26**		**JM27**	
Top of Casing	30.57		30.44		30.69		30.51		30.45		30.66		30.46	
Monitoring Date	Groundwater Levels (meters below top of casing and meters Australian height datum)													
	mBTOC	mAHD	mBTOC	mAHD	mBTOC	mAHD	mBTOC	mAHD	mBTOC	mAHD	mBTOC	mAHD	mBTOC	mAHD
13/05/2016	4.99	25.58	5.47	24.97	5.55	25.14	4.96	25.55	5.25	25.20	4.61	26.05	6.60	23.86
15/06/2016	4.76	25.81	5.21	25.23	5.34	25.35	4.78	25.73	5.13	25.32	4.20	26.46	6.06	24.40
29/07/2016	4.43	26.14	4.79	25.65	4.96	25.73	4.43	26.08	4.81	25.64	3.82	26.84	5.66	24.80
22/08/2016	4.33	26.24	4.67	25.77	4.84	25.85	4.32	26.19	4.65	25.80	4.41	26.25	5.54	24.92
27/09/2016	4.02	26.55	4.31	26.13	4.45	26.24	3.93	26.58	4.20	26.25	4.74	25.92	5.40	25.06
20/10/2016	3.98	26.59	4.27	26.17	4.38	26.31	3.89	26.62	4.13	26.32	4.38	26.28	5.41	25.05
21/11/2016	4.13	26.44	4.43	26.01	4.53	26.16	4.03	26.48	4.27	26.18	4.73	25.93	5.86	24.60
20/12/2016	4.26	26.31	4.61	25.83	4.65	26.04	4.17	26.34	4.40	26.05	4.69	25.97	6.02	24.44
23/01/2017	4.42	26.15	4.85	25.59	4.87	25.82	4.37	26.14	4.61	25.84	5.10	25.56	6.48	23.98
27/02/2017	4.08	26.49	4.80	25.64	4.85	25.84	4.29	26.22	4.61	25.84	4.80	25.86	6.10	24.36
22/03/2017	4.44	26.13	4.92	25.52	4.85	25.84	4.41	26.10	4.72	25.73	4.74	25.92	6.05	24.41
12/04/2017	4.50	26.07	4.97	25.47	5.04	25.65	4.47	26.04	4.76	25.69	4.87	25.79	6.24	24.22
24/05/2017	4.63	25.94	5.07	25.37	5.16	25.53	4.59	25.92	4.89	25.56	4.92	25.74	6.04	24.42
26/06/2017	4.63	25.94	5.03	25.41	5.18	25.51	4.63	25.88	4.91	25.54	4.87	25.79	6.01	24.45
17/07/2017	4.40	26.17	4.74	25.70	4.91	25.78	4.39	26.12	4.73	25.72	4.51	26.15	5.73	24.73
18/08/2017	3.97	26.60	4.24	26.20	4.40	26.29	3.92	26.59	4.33	26.12	4.03	26.63	5.19	25.27
29/09/2017	3.92	26.65	4.14	26.30	4.29	26.40	3.70	26.81	4.04	26.41	4.10	26.56	5.30	25.16
30/10/2017	3.99	26.58	4.20	26.24	4.31	26.38	3.85	26.66	4.07	26.38	4.20	26.46	5.46	25.00



Source: Department of Water (2018)

ATTACHMENT 3
WATER QUALITY MONITORING DATA

H16013
Lot 821 Armadale Road Banjup
Groundwater Monitoring

BM1									mg/L																			
	WL mBTOC	Temp (*C)	pH	EC (mS/cm)	DO (mg/L)	DO (%)	Redox (mV)	Turbidity (NTU)	TSS	Flouride	TN	TKN	Ammonia	Nitrate	Nitrite	TP	FRP	Arsenic	Cadmium	Chromium	Copper	Nickel	Lead	Mercury	Zinc	F. Enter	Th.Co	E.coli
13/05/2016	4.99	22.48	5.42	0.090	2.63	31.9	102	1622	390	0.1	1.5	0.7	0.056	0.83	0.006	0.01	0.005	0.001	0.0001	0.001	0.003	0.001	0.001	0.00005	0.015	-	-	-
22/08/2016	4.33	18.11	5.69	0.000	4.94	52.9	136	354	130	0.1	1.9	-	0.011	1.3	0.005	0.02	0.005	0.001	0.0001	0.001	0.001	0.001	0.001	0.00005	0.002	10	10	10
21/11/2016	4.13	20.10	6.00	0.166	2.40	26.1	162	45	16	0.1	2.3	0.4	0.005	1.9	0.005	0.01	0.005	0.001	0.0001	0.001	0.003	0.001	0.001	0.00005	0.004	10	10	10
27/02/2017	4.08	22.69	5.29	0.260	4.31	41.7	50	113	91	0.1	4.6	1	0.005	3.7	0.005	0.03	0.005	0.001	0.0001	0.001	0.001	0.001	0.001	0.00005	0.005	10	10	10
24/05/2017	4.63	21.00	7.84	0.067	2.65	30.3	132	112	86	0.1	3.7	1	0.010	2.7	0.005	0.04	0.005	0.001	0.0001	0.001	0.001	0.002	0.001	0.00005	0.003	10	10	10
18/08/2017	3.97	19.10	6.39	0.222	3.32	35.8	184	132	110	0.1	3.9	1	0.005	2.9	0.032	0.04	0.005	0.001	0.0001	0.001	0.001	0.001	0.001	0.00005	0.001	10	10	10
Mean	n/a	20.58	6.11	0.134	3.38	36.5	128	396	137	0.1	3.0	0.82	0.015	2.2	0.010	0.025	0.005	0.001	0.0001	0.001	0.0017	0.0012	0.001	0.00005	0.0050	10	10	10
Median	n/a	20.55	5.85	0.128	2.99	33.9	134	123	101	0.1	3.0	1	0.008	2.3	0.005	0.025	0.005	0.001	0.0001	0.001	0.0010	0.0010	0.001	0.00005	0.0035	10	10	10
BM2									mg/L																			
	WL mBTOC	Temp (*C)	pH	EC (mS/cm)	DO (mg/L)	DO (%)	Redox (mV)	Turbidity (NTU)	TSS	Flouride	TN	TKN	Ammonia	Nitrate	Nitrite	TP	FRP	Arsenic	Cadmium	Chromium	Copper	Nickel	Lead	Mercury	Zinc	F. Enter	Th.Co	E.coli
13/05/2016	5.47	22.05	5.92	0.118	4.99	58.1	125	2000	420	0.1	2.7	0.6	0.022	2.1	0.005	0.03	0.005	0.001	0.0001	0.001	0.002	0.001	0.001	0.00005	0.013	-	-	-
22/08/2016	4.67	18.05	6.29	0.000	6.70	71.7	103	277	310	0.1	2.1	-	0.005	1.8	0.005	0.03	0.005	0.001	0.0001	0.001	0.002	0.001	0.001	0.00005	0.003	10	10	10
21/11/2016	4.43	20.91	6.40	0.000	4.36	48.4	145	138	58	0.1	1.9	0.4	0.005	1.6	0.005	0.01	0.005	0.001	0.0001	0.001	0.002	0.001	0.001	0.00005	0.003	10	10	10
27/02/2017	4.8	22.11	6.22	0.159	5.15	58.5	56	254	320	0.1	2.5	0.5	0.005	2	0.005	0.04	0.005	0.001	0.0001	0.001	0.001	0.001	0.001	0.00005	0.002	10	10	10
24/05/2017	5.07	20.64	8.42	0.207	5.26	58.1	71	1075	370	0.1	2.2	0.4	0.005	1.8	0.005	0.05	0.005	0.001	0.0001	0.001	0.001	0.001	0.001	0.00005	0.002	10	10	10
18/08/2017	4.24	19.40	6.62	0.158	7.55	82.0	217	370	670	0.1	2.1	0.4	0.005	1.7	0.005	0.05	0.005	0.001	0.0001	0.001	0.001	0.001	0.001	0.00005	0.001	10	10	10
Mean	n/a	20.53	6.65	0.107	5.67	62.8	120	686	358	0.1	2.3	0.46	0.008	1.8	0.005	0.035	0.005	0.001	0.0001	0.001	0.0015	0.0010	0.001	0.00005	0.0040	10	10	10
Median	n/a	20.78	6.35	0.138	5.21	58.3	114	324	345	0.1	2.2	0.4	0.005	1.8	0.005	0.035	0.005	0.001	0.0001	0.001	0.0015	0.0010	0.001	0.00005	0.0025	10	10	10
BM3									mg/L																			
	WL mBTOC	Temp (*C)	pH	EC (mS/cm)	DO (mg/L)	DO (%)	Redox (mV)	Turbidity (NTU)	TSS	Flouride	TN	TKN	Ammonia	Nitrate	Nitrite	TP	FRP	Arsenic	Cadmium	Chromium	Copper	Nickel	Lead	Mercury	Zinc	F. Enter	Th.Co	E.coli
13/05/2016	5.55	21.82	5.74	0.165	6.24	71.0	109	1738	370	0.1	3.7	0.5	0.015	3.2	0.005	0.02	0.005	0.001	0.0001	0.001	0.001	0.001	0.001	0.00005	0.014	-	-	-
22/08/2016	4.84	17.35	6.04	0.049	6.42	67.4	114	121	90	0.1	2.1	-	0.005	1.9	0.005	0.01	0.005	0.001	0.0001	0.001	0.001	0.001	0.001	0.00005	0.003	10	10	10
21/11/2016	4.53	19.10	7.40	0.111	5.77	61.9	249	47	17	0.1	1.8	0.1	0.005	1.7	0.005	0.01	0.005	0.001	0.0001	0.001	0.004	0.001	0.001	0.00005	0.019	10	10	10
27/02/2016	4.85	21.26	6.15	0.034	7.91	85.3	92	728	410	0.1	5.1	1.4	0.005	3.7	0.005	0.14	0.005	0.001	0.0001	0.001	0.001	0.001	0.001	0.00005	0.001	10	10	10
24/05/2017	5.16	19.65	6.93	0.118	6.08	65.4	122	565	220	0.1	4.4	0.8	0.009	3.6	0.007	0.10	0.005	0.001	0.0001	0.001	0.001	0.001	0.001	0.00005	0.002	10	10	10
18/08/2017	4.4	18.80	6.24	0.156	7.76	83.3	246	19	30	0.1	2.1	0.4	0.005	1.7	0.005	0.01	0.005	0.001	0.0001	0.001	0.001	0.001	0.001	0.00005	0.001	10	10	10
Mean	n/a	19.66	6.42	0.106	6.70	72.4	155	536	190	0.1	3.2	0.64	0.007	2.6	0.005	0.048	0.005	0.001	0.0001	0.001	0.0015	0.0010	0.001	0.00005	0.0067	10	10	10
Median	n/a	19.38	6.20	0.115	6.33	69.2	118	343	155	0.1	2.9	0.5	0.005	2.6	0.005	0.015	0.005	0.001	0.0001	0.001	0.0010	0.0010	0.001	0.00005	0.0025	10	10	10
BM4									mg/L																			
	WL mBTOC	Temp (*C)	pH	EC (mS/cm)	DO (mg/L)	DO (%)	Redox (mV)	Turbidity (NTU)	TSS	Flouride	TN	TKN	Ammonia	Nitrate	Nitrite	TP	FRP	Arsenic	Cadmium	Chromium	Copper	Nickel	Lead	Mercury	Zinc	F. Enter	Th.Co	E.coli
13/05/2016	4.96	22.39	5.45	0.373	2.04	23.4	116	2000	140	0.1	2.2	2.1	0.180	0.067	0.005	0.01	0.005	0.001	0.0001	0.003	0.022	0.002	0.003	0.00005	0.039	-	-	-
22/08/2016	4.32	17.45	5.55	0.000	2.71	28.3	153	974	300	0.1	3.8	-	0.060	2.6	0.005	0.03	0.005	0.001	0.0001	0.001	0.003	0.001	0.001	0.00005	0.004	10	10	10
21/11/2016	4.03	20.16	6.15	0.267	1.79	19.8	233	67	19	0.1	1.9	0.6	0.044	1.4	0.005	0.01	0.005	0.001	0.0001	0.002	0.007	0.001	0.001	0.00005	0.011	10	10	10
27/02/2017	4.29	20.64	4.56	0.388	3.13	28.5	106	246	130	0.1	5.3	1.2	0.058	4.1	0.005	0.02	0.005	0.001	0.0001	0.002	0.001	0.001	0.001	0.00005	0.003	10	10	10
24/05/2017	4.59	19.84	5.80	0.000	2.73	28.9	147	105	68	0.1	1	0.8	0.086	0.24	0.005	0.01	0.005	0.001	0.0001	0.003	0.002	0.002	0.001	0.00005	0.005	10	10	10
18/08/2017	3.92	19.10	5.00	0.310	3.51	37.8	276	627	760	0.1	2.8	2	0.032	0.85	0.005	0.09	0.005	0.001	0.0001	0.003	0.001	0.002	0.001	0.00005	0.002	10	10	10
Mean	n/a	19.93	5.42	0.223	2.65	27.8	172	670	236	0.1	2.8	1.34	0.077	1.5	0.005	0.028	0.005	0.001	0.0001	0.0023	0.0060	0.0015	0.00133	0.00005	0.0107	10	10	10
Median	n/a	20.00	5.50	0.289	2.72	28.4	150	436	135	0.1	2.5	1.2	0.059	1.1	0.005	0.015	0.005	0.001	0.0001	0.0025	0.0025	0.0015	0.001	0.00005	0.0045	10	10	10
BM5									mg/L																			
	WL mBTOC	Temp (*C)	pH	EC (mS/cm)	DO (mg/L)	DO (%)	Redox (mV)	Turbidity (NTU)	TSS	Flouride	TN	TKN	Ammonia	Nitrate	Nitrite	TP	FRP	Arsenic	Cadmium	Chromium	Copper	Nickel	Lead	Mercury	Zinc	F. Enter	Th.Co	E.coli
13/05/2016	5.25	21.75	5.36	0.130	5.04	57.3	152	1884	280	0.1	11	5.3	0.024	5.8	0.005	0.01	0.005	0.001	0.0001	0.001	0.001	0.001	0.001	0.00005	0.018	-	-	-
22/08/2016	4.65	17.91	6.65	0.088	4.96	52.0	103	2000	1900	0.1	11	-	0.005	6.9	0.005	0.11	0.005	0.001	0.0001	0.001	0.005	0.002	0.001	0.00005	0.007	10	10	10
21/11/2016	4.27	20.74	6.10	0.000	4.11	45.8	204	246	46	0.1	7.5	1.3	0.005	6.3	0.005	0.03	0.029	0.001	0.0001	0.001	0.001	0.001	0.001	0.00005	0.006	10	10	10
27/02/2017	4.61	21.35	4.77	0.164	5.67	65.6	96	851	230	0.1	6.4	1.8	0.005	4.6	0.005	0.1	0.005	0.001	0.0001	0.001	0.001	0.001	0.001	0.00005	0.003	10	10	10
24/05/2017	4.89	19.09	6.42	0.140	4.05	45.8	155	141	47	0.1	7.4	1.8	0.005	5.6	0.005	0.04	0.005	0.001	0.0001	0.001	0.001	0.002	0.001	0.00005	0.004	10	10	10
18/08/2017	4.33	18.40	4.95	0.143	6.13	65.2	268	299	440	0.1	6.6	1.8	0.009	4.9	0.005	0.06	0.006	0.001	0.0001	0.001	0.001	0.001	0.001	0.00005	0.004	10	10	10
Mean	n/a	19.87	5.71	0.111	4.99	55.3	163	903	491	0.1	8.3	2.4	0.009	5.7	0.005	0.058	0.0092	0.001	0.0001	0.001	0.0017	0.0013	0.001	0.00005	0.0070	10	10	10
Median	n/a	19.92	5.73	0.135	5.00	54.7	154	575	255	0.1	7.5	1.8	0.005	5.7	0.005	0.050	0.005	0.001	0.0001	0.001	0.0010	0.0010	0.001	0.00005	0.0050	10	10	10

Below detectable limit

ATTACHMENT 4
LABORATORY REPORTS

16-18 Hayden Court, Myaree, Western Australia 6154
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email: lab@mpl.com.au
envirolab.com.au
Envirolab Services (WA) Pty Ltd trading as
MPL Laboratories | ABN 53 140 099 207

CERTIFICATE OF ANALYSIS 180768

Client:
Hyd2O
Suite 6B, 103 Rokeby Rd
Subiaco
WA 6008

Attention: Renee Blandin

Sample log in details:

Your Reference:	**H16013 Lot 821 Armadale Rd, Banjup Mon.**
No. of samples:	5 Water
Date samples received:	16/05/2016
Date completed instructions received:	16/05/2016
Location:	

Analysis Details:
Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last pages of this report for any comments relating to the results.

Report Details:

Date results requested by:	20/05/16
Date of Preliminary Report:	Not issued
Issue Date:	20/05/16

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Results Approved By:

Joshua Lim
Operations Manager

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Miscellaneous Inorganics						
Our Reference:	UNITS	180768-1	180768-2	180768-3	180768-4	180768-5
Your Reference	----------	BM1	BM2	BM3	BM4	BM5
Date Sampled	----------	13/05/2016	13/05/2016	13/05/2016	13/05/2016	13/05/2016
Type of sample		Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Date prepared	-	17/05/2016	17/05/2016	17/05/2016	17/05/2016	17/05/2016
Date analysed	-	17/05/2016	17/05/2016	17/05/2016	17/05/2016	17/05/2016
Total Suspended Solids	mg/L	390	420	370	140	280
Fluoride	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1

Nutrients in Water						
Our Reference:	UNITS	180768-1	180768-2	180768-3	180768-4	180768-5
Your Reference	----------	BM1	BM2	BM3	BM4	BM5
Date Sampled	----------	13/05/2016	13/05/2016	13/05/2016	13/05/2016	13/05/2016
Type of sample		Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Date prepared	-	18/05/2016	18/05/2016	18/05/2016	18/05/2016	18/05/2016
Date analysed	-	18/05/2016	18/05/2016	18/05/2016	18/05/2016	18/05/2016
Total Nitrogen	mg/L	1.5	2.7	3.7	2.2	11
TKN by Discrete Analyser	mg/L	0.7	0.6	0.5	2.1	5.3
Ammonia as N	mg/L	0.056	0.022	0.015	0.18	0.024
Nitrate as N	mg/L	0.83	2.1	3.2	0.067	5.8
Nitrite as N	mg/L	0.006	<0.005	<0.005	<0.005	<0.005
Total Phosphorus	mg/L	<0.01	0.03	<0.02	<0.01	<0.01
Phosphate as P	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005

Metals in Water - Low Level						
Our Reference:	UNITS	180768-1	180768-2	180768-3	180768-4	180768-5
Your Reference	----------	BM1	BM2	BM3	BM4	BM5
Date Sampled	----------	13/05/2016	13/05/2016	13/05/2016	13/05/2016	13/05/2016
Type of sample		Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Date prepared	-	17/05/2016	17/05/2016	17/05/2016	17/05/2016	17/05/2016
Date analysed	-	17/05/2016	17/05/2016	17/05/2016	17/05/2016	17/05/2016
Arsenic-Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium-Dissolved	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium-Dissolved	mg/L	0.001	<0.001	<0.001	0.003	<0.001
Copper-Dissolved	mg/L	0.003	0.002	0.001	0.022	0.001
Lead-Dissolved	mg/L	<0.001	<0.001	<0.001	0.003	<0.001
Mercury-Dissolved	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Nickel-Dissolved	mg/L	0.001	0.001	<0.001	0.002	<0.001
Zinc-Dissolved	mg/L	0.015	0.013	0.014	0.039	0.018

Method ID	Methodology Summary
INORG-019	Suspended Solids - determined gravimetrically by filtration of the sample. The samples are dried at 104+/-5oC.
INORG-081	Anions - a range of anions are determined by Ion Chromatography based on APHA latest edition Method 4110 -B. Soils and other sample types reported from a water extract unless otherwise specified (standard soil extract ratio 1:5).
INORG-055	Total Nitrogen by colourimetric analysis based on APHA 4500-P J, 4500-NO3 F.
INORG-062	TKN by calculation fromTotal Nitrogen and NOx using APHA methodology.
INORG-057	Ammonia by colourimetric analysis based on APHA latest edition 4500-NH3 F.
INORG-055	Nitrate - determined colourimetrically. Soils are analysed from a water extract.
INORG-055	Nitrite - determined colourimetrically. Soils are analysed from a water extract.
INORG-060	Phosphate- determined colourimetrically. Soils are analysed from a water extract.
Metals-022	Determination of various metals by ICP-MS.
Metals-021	Determination of Mercury by Cold Vapour AAS.

QUALITY CONTROL Miscellaneous Inorganics	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			17/05/2016	180768-1	17/05/2016 || 17/05/2016	LCS-1	17/05/2016
Date analysed	-			17/05/2016	180768-1	17/05/2016 || 17/05/2016	LCS-1	17/05/2016
Total Suspended Solids	mg/L	5	INORG-019	<5	180768-1	390 || [N/T]	LCS-1	92%
Fluoride	mg/L	0.1	INORG-081	<0.1	180768-1	<0.1 || <0.1	LCS-1	99%
QUALITY CONTROL Nutrients in Water	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			18/05/2016	180768-1	18/05/2016 || 18/05/2016	LCS-1	18/05/2016
Date analysed	-			18/05/2016	180768-1	18/05/2016 || 18/05/2016	LCS-1	18/05/2016
Total Nitrogen	mg/L	0.1	INORG-055	<0.1	180768-1	1.5 || 1.3 || RPD: 14	LCS-1	100%
TKN by Discrete Analyser	mg/L	0.1	INORG-062	<0.1	180768-1	0.7 || 0.5 || RPD: 33	[NR]	[NR]
Ammonia as N	mg/L	0.005	INORG-057	<0.005	180768-1	0.056 || 0.055 || RPD: 2	LCS-1	93%
Nitrate as N	mg/L	0.005	INORG-055	<0.005	180768-1	0.83 || 0.87 || RPD: 5	LCS-1	109%
Nitrite as N	mg/L	0.005	INORG-055	<0.005	180768-1	0.006 || 0.006 || RPD: 0	LCS-1	107%
Total Phosphorus	mg/L	0.01	INORG-055	<0.01	180768-1	<0.01 || <0.01	LCS-1	107%
Phosphate as P	mg/L	0.005	INORG-060	<0.005	180768-1	<0.005 || [N/T]	LCS-1	98%
QUALITY CONTROL Metals in Water - Low Level	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			17/05/2016	180768-5	17/05/2016 || 17/05/2016	LCS-1	17/05/2016
Date analysed	-			17/05/2016	180768-5	17/05/2016 || 17/05/2016	LCS-1	17/05/2016
Arsenic-Dissolved	mg/L	0.001	Metals-022	<0.001	180768-5	<0.001 || <0.001	LCS-1	104%
Cadmium-Dissolved	mg/L	0.0001	Metals-022	<0.0001	180768-5	<0.0001 || <0.0001	LCS-1	103%
Chromium-Dissolved	mg/L	0.001	Metals-022	<0.001	180768-5	<0.001 || <0.001	LCS-1	104%
Copper-Dissolved	mg/L	0.001	Metals-022	<0.001	180768-5	0.001 || 0.001 || RPD: 0	LCS-1	115%
Lead-Dissolved	mg/L	0.001	Metals-022	<0.001	180768-5	<0.001 || <0.001	LCS-1	99%
Mercury-Dissolved	mg/L	0.00005	Metals-021	<0.00005	180768-5	<0.00005 || [N/T]	LCS-1	108%
Nickel-Dissolved	mg/L	0.001	Metals-022	<0.001	180768-5	<0.001 || <0.001	LCS-1	109%
Zinc-Dissolved	mg/L	0.001	Metals-022	<0.001	180768-5	0.018 || 0.017 || RPD: 6	LCS-1	109%

QUALITY CONTROL Miscellaneous Inorganics	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	[NT]	[NT]	180768-2	17/05/2016
Date analysed	-	[NT]	[NT]	180768-2	17/05/2016
Total Suspended Solids	mg/L	[NT]	[NT]	[NR]	[NR]
Fluoride	mg/L	[NT]	[NT]	180768-2	103%

Report Comments:

Definitions:

NT: Not tested NA: Test not required INS: Insufficient sample for this test PQL: Practical Quantitation Limit
<: Less than >: Greater than RPD: Relative Percent Difference LCS: Laboratory Control Sample
NS: Not Specified NEPM: National Environmental Protection Measure NR: Not Reported

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

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Envirolab Services (WA) Pty Ltd trading as
MPL Laboratories | ABN 53 140 099 207

CERTIFICATE OF ANALYSIS 184745

Client:
Hyd2O
Suite 6B, 103 Rokeby Rd
Subiaco
WA 6008

Attention: Renee Blandin

Sample log in details:

Your Reference:	**H16013 Lot 821 Armadale Rd Banjup**
No. of samples:	5 Water
Date samples received:	22/08/2016
Date completed instructions received:	22/08/2016
Location:	

Analysis Details:
Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last pages of this report for any comments relating to the results.

Report Details:

Date results requested by:	26/08/16
Date of Preliminary Report:	Not issued
Issue Date:	26/08/16

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Results Approved By:

Joshua Lim
Operations Manager

Jessica Miller
Micro Team Leader

NATA
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COMPETENCE

Miscellaneous Inorganics						
Our Reference:	UNITS	184745-1	184745-2	184745-3	184745-4	184745-5
Your Reference	----------	BM1	BM2	BM3	BM4	BM5
Date Sampled	----------	22/08/2016	22/08/2016	22/08/2016	22/08/2016	22/08/2016
Type of sample		Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Date prepared	-	23/08/2016	23/08/2016	23/08/2016	23/08/2016	23/08/2016
Date analysed	-	23/08/2016	23/08/2016	23/08/2016	23/08/2016	23/08/2016
Total Suspended Solids	mg/L	130	310	90	300	1,900
Total Nitrogen	mg/L	1.9	2.1	2.1	3.8	11
Total Phosphorus	mg/L	0.02	0.03	0.01	0.03	0.11
Nitrate as N	mg/L	1.3	1.8	1.9	2.6	6.9
Nitrite as N	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005
Ammonia as N	mg/L	0.011	<0.005	<0.005	0.060	<0.005
Phosphate as P	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005
Fluoride	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1

Metals in Water - Low Level						
Our Reference:	UNITS	184745-1	184745-2	184745-3	184745-4	184745-5
Your Reference	----------	BM1	BM2	BM3	BM4	BM5
Date Sampled	----------	22/08/2016	22/08/2016	22/08/2016	22/08/2016	22/08/2016
Type of sample		Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Date prepared	-	24/08/2016	24/08/2016	24/08/2016	24/08/2016	24/08/2016
Date analysed	-	24/08/2016	24/08/2016	24/08/2016	24/08/2016	24/08/2016
Arsenic-Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium-Dissolved	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium-Dissolved	mg/L	<0.001	<0.001	<0.001	0.002	<0.001
Copper-Dissolved	mg/L	0.001	0.002	<0.001	0.003	0.005
Lead-Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury-Dissolved	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Nickel-Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	0.002
Zinc-Dissolved	mg/L	0.002	0.003	0.003	0.004	0.007

Microbiological Testing						
Our Reference:	UNITS	184745-1	184745-2	184745-3	184745-4	184745-5
Your Reference	----------	BM1	BM2	BM3	BM4	BM5
Date Sampled	----------	22/08/2016	22/08/2016	22/08/2016	22/08/2016	22/08/2016
Type of sample		Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Date testing started	-	22/08/2016	22/08/2016	22/08/2016	22/08/2016	22/08/2016
Date testing completed	-	24/08/2016	24/08/2016	24/08/2016	24/08/2016	24/08/2016
Faecal Enterococci	cfu/100mL	<10	<10	<10	<10	<10
Thermotolerant Coliforms	cfu/100mL	<10	<10	<10	<10	<10
E.coli	cfu/100mL	<10	<10	<10	<10	<10

Method ID	Methodology Summary
INORG-019	Suspended Solids - determined gravimetrically by filtration of the sample. The samples are dried at 104+/-5oC.
INORG-055	Total Nitrogen by colourimetric analysis based on APHA 4500-P J, 4500-NO3 F.
INORG-055	Nitrate - determined colourimetrically. Soils are analysed from a water extract.
INORG-055	Nitrite - determined colourimetrically. Soils are analysed from a water extract.
INORG-057	Ammonia by colourimetric analysis based on APHA latest edition 4500-NH3 F.
INORG-060	Phosphate- determined colourimetrically. Soils are analysed from a water extract.
INORG-081	Anions - a range of anions are determined by Ion Chromatography based on APHA latest edition Method 4110 -B. Soils and other sample types reported from a water extract unless otherwise specified (standard soil extract ratio 1:5).
Metals-022	Determination of various metals by ICP-MS.
Metals-021	Determination of Mercury by Cold Vapour AAS.
MICRO-001	Faecal Enterococci: Microbial Water Analysis - in accordance with MICRO-001 (ISO 7899-2:2000).
MICRO-001	Thermotolerant Coliforms: Microbial Water Analysis - in accordance with MICRO-001 (AS4276.7-2007). Recommended maximums based on NHMRC and ARMC Australian Drinking Water Guidelines.
MICRO-001	E. Coli: Microbial Water Analysis - in accordance with MICRO-001 (AS4276.7-2007). Recommended maximums based on NHMRC and ARMC Australian Drinking Water Guidelines.

QUALITY CONTROL Miscellaneous Inorganics	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			23/08/2016	184745-1	23/08/2016 || 23/08/2016	LCS-1	23/08/2016
Date analysed	-			23/08/2016	184745-1	23/08/2016 || 23/08/2016	LCS-1	23/08/2016
Total Suspended Solids	mg/L	5	INORG-019	<5	184745-1	130 || [N/T]	LCS-1	93%
Total Nitrogen	mg/L	0.1	INORG-055	<0.1	184745-1	1.9 || [N/T]	LCS-1	101%
Total Phosphorus	mg/L	0.01	INORG-055	<0.01	184745-1	0.02 || [N/T]	LCS-1	90%
Nitrate as N	mg/L	0.005	INORG-055	<0.005	184745-1	1.3 || [N/T]	LCS-1	104%
Nitrite as N	mg/L	0.005	INORG-055	<0.005	184745-1	<0.005 || [N/T]	LCS-1	109%
Ammonia as N	mg/L	0.005	INORG-057	<0.005	184745-1	0.011 || [N/T]	LCS-1	93%
Phosphate as P	mg/L	0.005	INORG-060	<0.005	184745-1	<0.005 || [N/T]	LCS-1	104%
Fluoride	mg/L	0.1	INORG-081	<0.1	184745-1	<0.1 || <0.1	LCS-1	104%

QUALITY CONTROL Metals in Water - Low Level	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			24/08/2016	[NT]	[NT]	LCS-1	24/08/2016
Date analysed	-			24/08/2016	[NT]	[NT]	LCS-1	24/08/2016
Arsenic-Dissolved	mg/L	0.001	Metals-022	<0.001	[NT]	[NT]	LCS-1	101%
Cadmium-Dissolved	mg/L	0.0001	Metals-022	<0.0001	[NT]	[NT]	LCS-1	104%
Chromium-Dissolved	mg/L	0.001	Metals-022	<0.001	[NT]	[NT]	LCS-1	100%
Copper-Dissolved	mg/L	0.001	Metals-022	<0.001	[NT]	[NT]	LCS-1	103%
Lead-Dissolved	mg/L	0.001	Metals-022	<0.001	[NT]	[NT]	LCS-1	104%
Mercury-Dissolved	mg/L	0.00005	Metals-021	<0.00005	[NT]	[NT]	LCS-1	102%
Nickel-Dissolved	mg/L	0.001	Metals-022	<0.001	[NT]	[NT]	LCS-1	102%
Zinc-Dissolved	mg/L	0.001	Metals-022	<0.001	[NT]	[NT]	LCS-1	103%

QUALITY CONTROL Microbiological Testing	UNITS	PQL	METHOD	Blank
Date testing started	-			22/08/2016
Date testing completed	-			24/08/2016
Faecal Enterococci	cfu/100mL	1	MICRO-001	<1
Thermotolerant Coliforms	cfu/100mL	1	MICRO-001	<1
E.coli	cfu/100mL	1	MICRO-001	<1

QUALITY CONTROL Miscellaneous Inorganics	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	[NT]	[NT]	184745-2	23/08/2016
Date analysed	-	[NT]	[NT]	184745-2	23/08/2016
Total Suspended Solids	mg/L	[NT]	[NT]	[NR]	[NR]
Total Nitrogen	mg/L	[NT]	[NT]	[NR]	[NR]
Total Phosphorus	mg/L	[NT]	[NT]	[NR]	[NR]
Nitrate as N	mg/L	[NT]	[NT]	[NR]	[NR]
Nitrite as N	mg/L	[NT]	[NT]	[NR]	[NR]
Ammonia as N	mg/L	[NT]	[NT]	[NR]	[NR]
Phosphate as P	mg/L	[NT]	[NT]	[NR]	[NR]
Fluoride	mg/L	[NT]	[NT]	184745-2	100%

Report Comments:

Definitions:

NT: Not tested NA: Test not required INS: Insufficient sample for this test PQL: Practical Quantitation Limit
<: Less than >: Greater than RPD: Relative Percent Difference LCS: Laboratory Control Sample
NS: Not Specified NEPM: National Environmental Protection Measure NR: Not Reported

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

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Envirolab Services (WA) Pty Ltd trading as
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CERTIFICATE OF ANALYSIS 188816

Client:
Hyd2O
Suite 6B, 103 Rokeby Rd
Subiaco
WA 6008

Attention: Renee Blandin

Sample log in details:

Your Reference:	**H16013 Lot 821 Armadale Rd Banjup**
No. of samples:	5 Water
Date samples received:	21/11/2016
Date completed instructions received:	21/11/2016
Location:	

Analysis Details:
Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last pages of this report for any comments relating to the results.

Report Details:

Date results requested by:	25/11/16
Date of Preliminary Report:	Not issued
Issue Date:	25/11/16

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Tests not covered by NATA are denoted with *.

Results Approved By:

Joshua Lim
Operations Manager

Jessica Jones
Micro Team Leader

ACCREDITED FOR TECHNICAL COMPETENCE

Miscellaneous Inorganics						
Our Reference:	UNITS	188816-1	188816-2	188816-3	188816-4	188816-5
Your Reference	----------	BM1	BM2	BM3	BM4	BM5
Date Sampled	----------	21/11/2016	21/11/2016	21/11/2016	21/11/2016	21/11/2016
Type of sample		Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Date prepared	-	21/11/2016	21/11/2016	21/11/2016	21/11/2016	21/11/2016
Date analysed	-	21/11/2016	21/11/2016	21/11/2016	21/11/2016	21/11/2016
Total Suspended Solids	mg/L	16	58	17	19	46
Fluoride	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1

Nutrients in Water						
Our Reference:	UNITS	188816-1	188816-2	188816-3	188816-4	188816-5
Your Reference	----------	BM1	BM2	BM3	BM4	BM5
Date Sampled	----------	21/11/2016	21/11/2016	21/11/2016	21/11/2016	21/11/2016
Type of sample		Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Date prepared	-	21/11/2016	21/11/2016	21/11/2016	21/11/2016	21/11/2016
Date analysed	-	21/11/2016	21/11/2016	21/11/2016	21/11/2016	21/11/2016
Total Nitrogen	mg/L	2.3	1.9	1.8	1.9	7.5
TKN by Discrete Analyser	mg/L	0.4	0.4	<0.1	0.6	1.3
Nitrate as N	mg/L	1.9	1.6	1.7	1.4	6.3
Nitrite as N	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005
Ammonia as N	mg/L	0.005	<0.005	<0.005	0.044	<0.005
Total Phosphorus	mg/L	0.01	0.01	<0.01	<0.01	0.03
Phosphate as P	mg/L	<0.005	<0.005	<0.005	<0.005	0.029

Metals in Water - Low Level						
Our Reference:	UNITS	188816-1	188816-2	188816-3	188816-4	188816-5
Your Reference	----------	BM1	BM2	BM3	BM4	BM5
Date Sampled	----------	21/11/2016	21/11/2016	21/11/2016	21/11/2016	21/11/2016
Type of sample		Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Date prepared	-	22/11/2016	22/11/2016	22/11/2016	22/11/2016	22/11/2016
Date analysed	-	22/11/2016	22/11/2016	22/11/2016	22/11/2016	22/11/2016
Arsenic-Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium-Dissolved	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium-Dissolved	mg/L	<0.001	<0.001	<0.001	0.002	<0.001
Copper-Dissolved	mg/L	0.003	0.002	0.004	0.007	0.001
Lead-Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury-Dissolved	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Nickel-Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc-Dissolved	mg/L	0.004	0.003	0.019	0.011	0.006

Microbiological Testing						
Our Reference:	UNITS	188816-1	188816-2	188816-3	188816-4	188816-5
Your Reference	----------	BM1	BM2	BM3	BM4	BM5
Date Sampled	----------	21/11/2016	21/11/2016	21/11/2016	21/11/2016	21/11/2016
Type of sample		Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Date testing started	-	21/11/2016	21/11/2016	21/11/2016	21/11/2016	21/11/2016
Date testing completed	-	23/11/2016	23/11/2016	23/11/2016	23/11/2016	23/11/2016
Faecal Enterococci	cfu/100mL	<10	<10	<10	<10	<10
Thermotolerant Coliforms	cfu/100mL	<10	<10	<10	<10	<10
E.coli	cfu/100mL	<10	<10	<10	<10	<10

Method ID	Methodology Summary
INORG-019	Suspended Solids - determined gravimetrically by filtration of the sample. The samples are dried at 104+/-5oC.
INORG-081	Anions - a range of anions are determined by Ion Chromatography based on APHA latest edition Method 4110 -B. Soils and other sample types reported from a water extract unless otherwise specified (standard soil extract ratio 1:5).
INORG-055	Total Nitrogen by colourimetric analysis based on APHA 4500-P J, 4500-NO3 F.
INORG-062	TKN by calculation fromTotal Nitrogen and NOx using APHA methodology.
INORG-055	Nitrate - determined colourimetrically. Soils are analysed from a water extract.
INORG-055	Nitrite - determined colourimetrically. Soils are analysed from a water extract.
INORG-057	Ammonia by colourimetric analysis based on APHA latest edition 4500-NH3 F.
INORG-060	Phosphate- determined colourimetrically. Soils are analysed from a water extract.
Metals-022	Determination of various metals by ICP-MS.
Metals-021	Determination of Mercury by Cold Vapour AAS.
MICRO-001	Faecal Enterococci: Microbial Water Analysis - in accordance with MICRO-001 (ISO 7899-2:2000).
MICRO-001	Thermotolerant Coliforms: Microbial Water Analysis - in accordance with MICRO-001 (AS4276.7-2007). Recommended maximums based on NHMRC and ARMC Australian Drinking Water Guidelines.
MICRO-001	E. Coli: Microbial Water Analysis - in accordance with MICRO-001 (AS4276.7-2007). Recommended maximums based on NHMRC and ARMC Australian Drinking Water Guidelines.

QUALITY CONTROL Miscellaneous Inorganics	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			21/11/2016	188816-1	21/11/2016 || 21/11/2016	LCS-1	21/11/2016
Date analysed	-			21/11/2016	188816-1	21/11/2016 || 21/11/2016	LCS-1	21/11/2016
Total Suspended Solids	mg/L	5	INORG-019	<5	188816-1	16 || [N/T]	LCS-1	91%
Fluoride	mg/L	0.1	INORG-081	<0.1	188816-1	<0.1 || <0.1	LCS-1	102%
QUALITY CONTROL Nutrients in Water	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			22/11/2016	[NT]	[NT]	LCS-1	22/11/2016
Date analysed	-			22/11/2016	[NT]	[NT]	LCS-1	22/11/2016
Total Nitrogen	mg/L	0.1	INORG-055	<0.1	[NT]	[NT]	LCS-1	98%
TKN by Discrete Analyser	mg/L	0.1	INORG-062	<0.1	[NT]	[NT]	[NR]	[NR]
Nitrate as N	mg/L	0.005	INORG-055	<0.005	[NT]	[NT]	LCS-1	104%
Nitrite as N	mg/L	0.005	INORG-055	<0.005	[NT]	[NT]	LCS-1	102%
Ammonia as N	mg/L	0.005	INORG-057	<0.005	[NT]	[NT]	LCS-1	89%
Total Phosphorus	mg/L	0.01	INORG-055	<0.01	[NT]	[NT]	LCS-1	102%
Phosphate as P	mg/L	0.005	INORG-060	<0.005	[NT]	[NT]	LCS-1	115%
QUALITY CONTROL Metals in Water - Low Level	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			22/11/2016	188816-1	22/11/2016 || 22/11/2016	LCS-1	22/11/2016
Date analysed	-			22/11/2016	188816-1	22/11/2016 || 22/11/2016	LCS-1	22/11/2016
Arsenic-Dissolved	mg/L	0.001	Metals-022	<0.001	188816-1	<0.001 || <0.001	LCS-1	101%
Cadmium-Dissolved	mg/L	0.0001	Metals-022	<0.0001	188816-1	<0.0001 || <0.0001	LCS-1	102%
Chromium-Dissolved	mg/L	0.001	Metals-022	<0.001	188816-1	<0.001 || <0.001	LCS-1	104%
Copper-Dissolved	mg/L	0.001	Metals-022	<0.001	188816-1	0.003 || 0.003 || RPD: 0	LCS-1	107%
Lead-Dissolved	mg/L	0.001	Metals-022	<0.001	188816-1	<0.001 || <0.001	LCS-1	103%
Mercury-Dissolved	mg/L	0.00005	Metals-021	<0.00005	188816-1	<0.00005 || <0.00005	LCS-1	114.00000%
Nickel-Dissolved	mg/L	0.001	Metals-022	<0.001	188816-1	<0.001 || <0.001	LCS-1	106%
Zinc-Dissolved	mg/L	0.001	Metals-022	<0.001	188816-1	0.004 || 0.003 || RPD: 29	LCS-1	103%

QUALITY CONTROL Microbiological Testing	UNITS	PQL	METHOD	Blank
Date testing started	-			21/11/2016
Date testing completed	-			23/11/2016
Faecal Enterococci	cfu/100mL	1	MICRO-001	<1
Thermotolerant Coliforms	cfu/100mL	1	MICRO-001	<1
E.coli	cfu/100mL	1	MICRO-001	<1

QUALITY CONTROL Miscellaneous Inorganics	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	[NT]	[NT]	188816-2	21/11/2016
Date analysed	-	[NT]	[NT]	188816-2	21/11/2016
Total Suspended Solids	mg/L	[NT]	[NT]	[NR]	[NR]
Fluoride	mg/L	[NT]	[NT]	188816-2	107%

QUALITY CONTROL Metals in Water - Low Level	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	[NT]	[NT]	188816-2	22/11/2016
Date analysed	-	[NT]	[NT]	188816-2	22/11/2016
Arsenic-Dissolved	mg/L	[NT]	[NT]	188816-2	106%
Cadmium-Dissolved	mg/L	[NT]	[NT]	188816-2	107%
Chromium-Dissolved	mg/L	[NT]	[NT]	188816-2	99%
Copper-Dissolved	mg/L	[NT]	[NT]	188816-2	101%
Lead-Dissolved	mg/L	[NT]	[NT]	188816-2	96%
Mercury-Dissolved	mg/L	[NT]	[NT]	188816-2	125.00000%
Nickel-Dissolved	mg/L	[NT]	[NT]	188816-2	99%
Zinc-Dissolved	mg/L	[NT]	[NT]	188816-2	111%

Report Comments:

Definitions:

NT: Not tested NA: Test not required INS: Insufficient sample for this test PQL: Practical Quantitation Limit
<: Less than >: Greater than RPD: Relative Percent Difference LCS: Laboratory Control Sample
NS: Not Specified NEPM: National Environmental Protection Measure NR: Not Reported

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

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Envirolab Services (WA) Pty Ltd trading as
MPL Laboratories | ABN 53 140 099 207

CERTIFICATE OF ANALYSIS 192594

Client:
Hyd2O
Suite 6B, 103 Rokeby Rd
Subiaco
WA 6008

Attention: Renee Blandin

Sample log in details:

Your Reference:	**H16013 Lot 821 Armadale Rd Banjup**
No. of samples:	5 Water
Date/Time samples received:	27/02/2017 / 12:00
Date completed instructions received:	27/02/2017
Location:	

Analysis Details:
Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last pages of this report for any comments relating to the results.

Report Details:

Date results requested by:	3/03/17
Date of Preliminary Report:	Not issued
Issue Date:	3/03/17

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Results Approved By:

Joshua Lim
Operations Manager

Jessica Jones
Micro Team Leader

NATA
ACCREDITED FOR
TECHNICAL
COMPETENCE

Miscellaneous Inorganics						
Our Reference:	UNITS	192594-1	192594-2	192594-3	192594-4	192594-5
Your Reference	----------	BM1	BM2	BM3	BM4	BM5
Date Sampled	----------	27/02/2017	27/02/2017	27/02/2017	27/02/2017	27/02/2017
Type of sample		Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Date prepared	-	28/02/2017	28/02/2017	28/02/2017	28/02/2017	28/02/2017
Date analysed	-	28/02/2017	28/02/2017	28/02/2017	28/02/2017	28/02/2017
Total Suspended Solids	mg/L	91	320	410	130	230
Fluoride	mg/L	<0.1	<0.1	0.1	0.1	0.1

Nutrients in Water						
Our Reference:	UNITS	192594-1	192594-2	192594-3	192594-4	192594-5
Your Reference	----------	BM1	BM2	BM3	BM4	BM5
Date Sampled	----------	27/02/2017	27/02/2017	27/02/2017	27/02/2017	27/02/2017
Type of sample		Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Date prepared	-	01/03/2017	28/02/2017	28/02/2017	28/02/2017	28/02/2017
Date analysed	-	01/03/2017	28/02/2017	28/02/2017	28/02/2017	28/02/2017
Total Nitrogen	mg/L	4.6	2.5	5.1	5.3	6.4
TKN by Discrete Analyser	mg/L	1	0.5	1.4	1.2	1.8
Nitrate as N	mg/L	3.7	2.0	3.7	4.1	4.6
Nitrite as N	mg/L	0.005	<0.005	<0.005	<0.005	<0.005
Ammonia as N	mg/L	<0.005	<0.005	<0.005	0.058	<0.005
Total Phosphorus	mg/L	0.03	0.04	0.14	0.02	0.10
Phosphate as P	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005

Metals in Water - Low Level						
Our Reference:	UNITS	192594-1	192594-2	192594-3	192594-4	192594-5
Your Reference	----------	BM1	BM2	BM3	BM4	BM5
Date Sampled	----------	27/02/2017	27/02/2017	27/02/2017	27/02/2017	27/02/2017
Type of sample		Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Date prepared	-	03/03/2017	03/03/2017	03/03/2017	03/03/2017	03/03/2017
Date analysed	-	03/03/2017	03/03/2017	03/03/2017	03/03/2017	03/03/2017
Arsenic-Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium-Dissolved	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium-Dissolved	mg/L	<0.001	<0.001	<0.001	0.002	<0.001
Copper-Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	<0.001
Lead-Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury-Dissolved	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Nickel-Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc-Dissolved	mg/L	0.005	0.002	0.001	0.003	0.003

Microbiological Testing						
Our Reference:	UNITS	192594-1	192594-2	192594-3	192594-4	192594-5
Your Reference	----------	BM1	BM2	BM3	BM4	BM5
Date Sampled	----------	27/02/2017	27/02/2017	27/02/2017	27/02/2017	27/02/2017
Type of sample		Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Date testing started	-	28/02/2017	28/02/2017	28/02/2017	28/02/2017	28/02/2017
Date testing completed	-	02/03/2017	02/03/2017	02/03/2017	02/03/2017	02/03/2017
Faecal Enterococci	cfu/100mL	<10	<10	<10	<10	<10
Thermotolerant Coliforms	cfu/100mL	<10	<10	<10**	<10	<10**
E.coli	cfu/100mL	<10	<10	<10**	<10	<10**

Method ID	Methodology Summary
INORG-019	Suspended Solids - determined gravimetrically by filtration of the sample. The samples are dried at 104+/-5oC.
INORG-081	Anions - a range of anions are determined by Ion Chromatography based on APHA latest edition Method 4110 -B. Soils and other sample types reported from a water extract unless otherwise specified (standard soil extract ratio 1:5).
INORG-055	Total Nitrogen by colourimetric analysis based on APHA 4500-P J, 4500-NO3 F.
INORG-062	TKN by calculation fromTotal Nitrogen and NOx using APHA methodology.
INORG-055	Nitrate - determined colourimetrically. Soils are analysed from a water extract.
INORG-055	Nitrite - determined colourimetrically. Soils are analysed from a water extract.
INORG-057	Ammonia by colourimetric analysis based on APHA latest edition 4500-NH3 F.
INORG-060	Phosphate- determined colourimetrically. Soils are analysed from a water extract.
METALS-022	Determination of various metals by ICP-MS.
METALS-021	Determination of Mercury by Cold Vapour AAS.
MICRO-001	Faecal Enterococci: Microbial Water Analysis - in accordance with MICRO-001 (ISO 7899-2:2000).
MICRO-001	Thermotolerant Coliforms: Microbial Water Analysis - in accordance with MICRO-001 (AS4276.7-2007). Recommended maximums based on NHMRC and ARMC Australian Drinking Water Guidelines.
MICRO-001	E. Coli: Microbial Water Analysis - in accordance with MICRO-001 (AS4276.7-2007). Recommended maximums based on NHMRC and ARMC Australian Drinking Water Guidelines.

QUALITY CONTROL Miscellaneous Inorganics	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			28/02/2017	[NT]	[NT]	LCS-1	28/02/2017
Date analysed	-			28/02/2017	[NT]	[NT]	LCS-1	28/02/2017
Total Suspended Solids	mg/L	5	INORG-019	<5	[NT]	[NT]	LCS-1	83%
Fluoride	mg/L	0.1	INORG-081	<0.1	[NT]	[NT]	LCS-1	97%
QUALITY CONTROL Nutrients in Water	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			28/02/2017	[NT]	[NT]	LCS-1	28/02/2017
Date analysed	-			28/02/2017	[NT]	[NT]	LCS-1	28/02/2017
Total Nitrogen	mg/L	0.1	INORG-055	<0.1	[NT]	[NT]	LCS-1	100%
TKN by Discrete Analyser	mg/L	0.1	INORG-062	<0.1	[NT]	[NT]	LCS-1	103%
Nitrate as N	mg/L	0.005	INORG-055	<0.005	[NT]	[NT]	LCS-1	103%
Nitrite as N	mg/L	0.005	INORG-055	<0.005	[NT]	[NT]	LCS-1	106%
Ammonia as N	mg/L	0.005	INORG-057	<0.005	[NT]	[NT]	LCS-1	91%
Total Phosphorus	mg/L	0.01	INORG-055	<0.01	[NT]	[NT]	LCS-1	103%
Phosphate as P	mg/L	0.005	INORG-060	<0.005	[NT]	[NT]	LCS-1	113%
QUALITY CONTROL Metals in Water - Low Level	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			03/03/2017	192594-1	03/03/2017 || 03/03/2017	LCS-1	03/03/2017
Date analysed	-			03/03/2017	192594-1	03/03/2017 || 03/03/2017	LCS-1	03/03/2017
Arsenic-Dissolved	mg/L	0.001	METALS-022	<0.001	192594-1	<0.001 || <0.001	LCS-1	97%
Cadmium-Dissolved	mg/L	0.0001	METALS-022	<0.0001	192594-1	<0.0001 || <0.0001	LCS-1	99%
Chromium-Dissolved	mg/L	0.001	METALS-022	<0.001	192594-1	<0.001 || <0.001	LCS-1	95%
Copper-Dissolved	mg/L	0.001	METALS-022	<0.001	192594-1	0.001 || 0.001 || RPD: 0	LCS-1	96%
Lead-Dissolved	mg/L	0.001	METALS-022	<0.001	192594-1	<0.001 || <0.001	LCS-1	99%
Mercury-Dissolved	mg/L	0.00005	METALS-021	<0.00005	192594-1	<0.00005 || [N/T]	LCS-1	102%
Nickel-Dissolved	mg/L	0.001	METALS-022	<0.001	192594-1	<0.001 || <0.001	LCS-1	96%
Zinc-Dissolved	mg/L	0.001	METALS-022	<0.001	192594-1	0.005 || 0.005 || RPD: 0	LCS-1	96%

QUALITY CONTROL Microbiological Testing	UNITS	PQL	METHOD	Blank
Date testing started	-			28/02/2017
Date testing completed	-			02/03/2017
Faecal Enterococci	cfu/100mL	1	MICRO-001	<1
Thermotolerant Coliforms	cfu/100mL	1	MICRO-001	<1
E.coli	cfu/100mL	1	MICRO-001	<1

QUALITY CONTROL Metals in Water - Low Level	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	[NT]	[NT]	192594-2	03/03/2017
Date analysed	-	[NT]	[NT]	192594-2	03/03/2017
Arsenic-Dissolved	mg/L	[NT]	[NT]	192594-2	96%
Cadmium-Dissolved	mg/L	[NT]	[NT]	192594-2	98%
Chromium-Dissolved	mg/L	[NT]	[NT]	192594-2	90%
Copper-Dissolved	mg/L	[NT]	[NT]	192594-2	90%
Lead-Dissolved	mg/L	[NT]	[NT]	192594-2	99%
Mercury-Dissolved	mg/L	[NT]	[NT]	[NR]	[NR]
Nickel-Dissolved	mg/L	[NT]	[NT]	192594-2	89%
Zinc-Dissolved	mg/L	[NT]	[NT]	192594-2	101%

Report Comments:

** - High background growth of non-coliform bacteria may underestimate the Thermotolerant Coliform and E.coli Count.

Definitions:

NT: Not tested NA: Test not required INS: Insufficient sample for this test PQL: Practical Quantitation Limit
<: Less than >: Greater than RPD: Relative Percent Difference LCS: Laboratory Control Sample
NS: Not Specified NEPM: National Environmental Protection Measure NR: Not Reported

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

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Envirolab Services (WA) Pty Ltd trading as
MPL Laboratories | ABN 53 140 099 207

CERTIFICATE OF ANALYSIS 196138

Client:
Hyd2O
Suite 6B, 103 Rokeby Rd
Subiaco
WA 6008

Attention: Renee Blandin

Sample log in details:

Your Reference:	**H16013 Lot 821 Armadale Rd Banjup**
No. of samples:	5 Water
Date/Time samples received:	24/05/2017 / 16:30
Date completed instructions received:	24/05/2017
Location:	

Analysis Details:
Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last pages of this report for any comments relating to the results.

Report Details:

Date results requested by:	30/05/17
Date of Preliminary Report:	Not issued
Issue Date:	30/05/17

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Tests not covered by NATA are denoted with *.

Results Approved By:

Joshua Lim
Operations Manager

Jessica Jones
Micro Team Leader

ACCREDITED FOR TECHNICAL COMPETENCE

Miscellaneous Inorganics						
Our Reference:	UNITS	196138-1	196138-2	196138-3	196138-4	196138-5
Your Reference	----------	BM1	BM2	BM3	BM4	BM5
Date Sampled	----------	24/05/2017	24/05/2017	24/05/2017	24/05/2017	24/05/2017
Type of sample		Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Date prepared	-	25/05/2017	25/05/2017	25/05/2017	25/05/2017	25/05/2017
Date analysed	-	25/05/2017	25/05/2017	25/05/2017	25/05/2017	25/05/2017
Total Suspended Solids	mg/L	86	370	220	68	47
Fluoride	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1

Nutrients in Water						
Our Reference:	UNITS	196138-1	196138-2	196138-3	196138-4	196138-5
Your Reference	----------	BM1	BM2	BM3	BM4	BM5
Date Sampled	----------	24/05/2017	24/05/2017	24/05/2017	24/05/2017	24/05/2017
Type of sample		Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Date prepared	-	25/05/2017	25/05/2017	25/05/2017	25/05/2017	25/05/2017
Date analysed	-	25/05/2017	25/05/2017	25/05/2017	25/05/2017	25/05/2017
Total Nitrogen	mg/L	3.7	2.2	4.4	1.0	7.4
TKN by Discrete Analyser	mg/L	1	0.4	0.8	0.8	1.8
Nitrate as N	mg/L	2.7	1.8	3.6	0.24	5.6
Nitrite as N	mg/L	<0.005	<0.005	0.007	<0.005	<0.005
Ammonia as N	mg/L	0.010	<0.005	0.009	0.086	<0.005
Total Phosphorus	mg/L	0.04	0.05	0.10	0.01	0.04
Phosphate as P	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005

Metals in Water - Low Level						
Our Reference:	UNITS	196138-1	196138-2	196138-3	196138-4	196138-5
Your Reference	----------	BM1	BM2	BM3	BM4	BM5
Date Sampled	----------	24/05/2017	24/05/2017	24/05/2017	24/05/2017	24/05/2017
Type of sample		Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Date prepared	-	25/05/2017	25/05/2017	25/05/2017	25/05/2017	25/05/2017
Date analysed	-	25/05/2017	25/05/2017	25/05/2017	25/05/2017	25/05/2017
Arsenic-Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium-Dissolved	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium-Dissolved	mg/L	<0.001	<0.001	<0.001	0.003	<0.001
Copper-Dissolved	mg/L	<0.001	<0.001	<0.001	0.002	0.001
Lead-Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury-Dissolved	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Nickel-Dissolved	mg/L	0.002	<0.001	0.001	0.002	0.002
Zinc-Dissolved	mg/L	0.003	0.002	0.002	0.005	0.004

Microbiological Testing						
Our Reference:	UNITS	196138-1	196138-2	196138-3	196138-4	196138-5
Your Reference	----------	BM1	BM2	BM3	BM4	BM5
Date Sampled	----------	24/05/2017	24/05/2017	24/05/2017	24/05/2017	24/05/2017
Type of sample		Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Date testing started	-	25/05/2017	25/05/2017	25/05/2017	25/05/2017	25/05/2017
Date testing completed	-	27/05/2017	27/05/2017	27/05/2017	27/05/2017	27/05/2017
Faecal Enterococci	cfu/100mL	20	<10	<10	<10	<10
Thermotolerant Coliforms	cfu/100mL	<10	<10	<10	<10	<10
E.coli	cfu/100mL	<10	<10	<10	<10	<10

Method ID	Methodology Summary
INORG-019	Suspended Solids - determined gravimetrically by filtration of the sample. The samples are dried at 104+/-5oC.
INORG-081	Anions - a range of anions are determined by Ion Chromatography based on APHA latest edition Method 4110 -B. Soils and other sample types reported from a water extract unless otherwise specified (standard soil extract ratio 1:5).
INORG-055	Total Nitrogen by colourimetric analysis based on APHA 4500-P J, 4500-NO3 F.
INORG-062	TKN by calculation fromTotal Nitrogen and NOx using APHA methodology.
INORG-055	Nitrate - determined colourimetrically. Soils are analysed from a water extract.
INORG-055	Nitrite - determined colourimetrically. Soils are analysed from a water extract.
INORG-057	Ammonia by colourimetric analysis based on APHA latest edition 4500-NH3 F.
INORG-060	Phosphate- determined colourimetrically. Soils are analysed from a water extract.
METALS-022	Determination of various metals by ICP-MS.
METALS-021	Determination of Mercury by Cold Vapour AAS.
MICRO-001	Faecal Enterococci: Microbial Water Analysis - in accordance with MICRO-001 (ISO 7899-2:2000).
MICRO-001	Thermotolerant Coliforms: Microbial Water Analysis - in accordance with MICRO-001 (AS4276.7-2007). Recommended maximums based on NHMRC and ARMC Australian Drinking Water Guidelines.
MICRO-001	E. Coli: Microbial Water Analysis - in accordance with MICRO-001 (AS4276.7-2007). Recommended maximums based on NHMRC and ARMC Australian Drinking Water Guidelines.

QUALITY CONTROL Miscellaneous Inorganics	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			25/05/2017	196138-1	25/05/2017 || 25/05/2017	LCS-1	25/05/2017
Date analysed	-			25/05/2017	196138-1	25/05/2017 || 25/05/2017	LCS-1	25/05/2017
Total Suspended Solids	mg/L	5	INORG-019	<5	196138-1	86 || [N/T]	LCS-1	88%
Fluoride	mg/L	0.1	INORG-081	<0.1	196138-1	<0.1 || <0.1	LCS-1	109%
QUALITY CONTROL Nutrients in Water	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			25/05/2017	[NT]	[NT]	LCS-1	25/05/2017
Date analysed	-			25/05/2017	[NT]	[NT]	LCS-1	25/05/2017
Total Nitrogen	mg/L	0.1	INORG-055	<0.1	[NT]	[NT]	LCS-1	101%
TKN by Discrete Analyser	mg/L	0.1	INORG-062	<0.1	[NT]	[NT]	[NR]	[NR]
Nitrate as N	mg/L	0.005	INORG-055	<0.005	[NT]	[NT]	LCS-1	105%
Nitrite as N	mg/L	0.005	INORG-055	<0.005	[NT]	[NT]	LCS-1	108%
Ammonia as N	mg/L	0.005	INORG-057	<0.005	[NT]	[NT]	LCS-1	94%
Total Phosphorus	mg/L	0.01	INORG-055	<0.01	[NT]	[NT]	LCS-1	112%
Phosphate as P	mg/L	0.005	INORG-060	<0.005	[NT]	[NT]	LCS-1	110%
QUALITY CONTROL Metals in Water - Low Level	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			25/05/2017	[NT]	[NT]	LCS-1	25/05/2017
Date analysed	-			25/05/2017	[NT]	[NT]	LCS-1	25/05/2017
Arsenic-Dissolved	mg/L	0.001	METALS-022	<0.001	[NT]	[NT]	LCS-1	91%
Cadmium-Dissolved	mg/L	0.0001	METALS-022	<0.0001	[NT]	[NT]	LCS-1	86%
Chromium-Dissolved	mg/L	0.001	METALS-022	<0.001	[NT]	[NT]	LCS-1	90%
Copper-Dissolved	mg/L	0.001	METALS-022	<0.001	[NT]	[NT]	LCS-1	91%
Lead-Dissolved	mg/L	0.001	METALS-022	<0.001	[NT]	[NT]	LCS-1	90%
Mercury-Dissolved	mg/L	0.00005	METALS-021	<0.00005	[NT]	[NT]	LCS-1	107%
Nickel-Dissolved	mg/L	0.001	METALS-022	<0.001	[NT]	[NT]	LCS-1	90%
Zinc-Dissolved	mg/L	0.001	METALS-022	<0.001	[NT]	[NT]	LCS-1	91%

QUALITY CONTROL Microbiological Testing	UNITS	PQL	METHOD	Blank
Date testing started	-			25/05/2017
Date testing completed	-			27/05/2017
Faecal Enterococci	cfu/100mL	1	MICRO-001	<1
Thermotolerant Coliforms	cfu/100mL	1	MICRO-001	<1
E.coli	cfu/100mL	1	MICRO-001	<1

Report Comments:

Definitions:

NT: Not tested NA: Test not required INS: Insufficient sample for this test PQL: Practical Quantitation Limit
<: Less than >: Greater than RPD: Relative Percent Difference LCS: Laboratory Control Sample
NS: Not Specified NEPM: National Environmental Protection Measure NR: Not Reported

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

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Measurement Uncertainty estimates are available for most tests upon request.

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+61 8 9317 2505

lab@mpl.com.au
envirolab.com.au

Envirolab Services (WA) Pty Ltd trading as
MPL Laboratories | ABN 53 140 099 207

CERTIFICATE OF ANALYSIS 199590

Client:
Hyd2O
Suite 6B, 103 Rokeby Rd
Subiaco
WA 6008

Attention: Renee Blandin

Sample log in details:

Your Reference:	**H16013 Lot 821 Armadale Rd Banjup Monito**
No. of samples:	5 Water
Date/Time samples received:	18/08/2017 / 15:35
Date completed instructions received:	18/08/2017
Location:	

Analysis Details:
Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last pages of this report for any comments relating to the results.

Report Details:

Date results requested by:	25/08/17
Date of Preliminary Report:	Not issued
Issue Date:	25/08/17

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Accredited for compliance with ISO/IEC 17025 - Testing
Tests not covered by NATA are denoted with *.

Results Approved By:

Todd Lee
Laboratory Manager

Jessica Jones
Micro Team Leader

ACCREDITED FOR TECHNICAL COMPETENCE

Miscellaneous Inorganics						
Our Reference:	UNITS	199590-1	199590-2	199590-3	199590-4	199590-5
Your Reference	----------	BM1	BM2	BM3	BM4	BM5
Date Sampled	----------	18/08/2017	18/08/2017	18/08/2017	18/08/2017	18/08/2017
Type of sample		Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Date prepared	-	21/08/2017	21/08/2017	21/08/2017	21/08/2017	21/08/2017
Date analysed	-	21/08/2017	21/08/2017	21/08/2017	21/08/2017	21/08/2017
Total Suspended Solids	mg/L	110	670	30	760	440
Fluoride	mg/L	0.1	0.1	0.1	0.1	0.1

Nutrients in Water						
Our Reference:	UNITS	199590-1	199590-2	199590-3	199590-4	199590-5
Your Reference	----------	BM1	BM2	BM3	BM4	BM5
Date Sampled	----------	18/08/2017	18/08/2017	18/08/2017	18/08/2017	18/08/2017
Type of sample		Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Date prepared	-	21/08/2017	21/08/2017	21/08/2017	21/08/2017	21/08/2017
Date analysed	-	21/08/2017	21/08/2017	21/08/2017	21/08/2017	21/08/2017
Total Nitrogen	mg/L	3.9	2.1	2.1	2.8	6.6
TKN by Discrete Analyser	mg/L	1	0.4	0.4	2.0	1.8
Nitrate as N	mg/L	2.9	1.7	1.7	0.85	4.9
Nitrite as N	mg/L	0.032	<0.005	<0.005	<0.005	<0.005
Ammonia as N	mg/L	<0.005	<0.005	<0.005	0.032	0.009
Phosphate as P	mg/L	<0.005	<0.005	<0.005	<0.005	0.006
Total Phosphorus	mg/L	0.04	0.05	0.01	0.09	0.06

Metals in Water - Low Level						
Our Reference:	UNITS	199590-1	199590-2	199590-3	199590-4	199590-5
Your Reference	----------	BM1	BM2	BM3	BM4	BM5
Date Sampled	----------	18/08/2017	18/08/2017	18/08/2017	18/08/2017	18/08/2017
Type of sample		Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Date prepared	-	24/08/2017	24/08/2017	24/08/2017	24/08/2017	24/08/2017
Date analysed	-	24/08/2017	24/08/2017	24/08/2017	24/08/2017	24/08/2017
Arsenic-Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium-Dissolved	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium-Dissolved	mg/L	<0.001	<0.001	<0.001	0.003	<0.001
Copper-Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lead-Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury-Dissolved	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Nickel-Dissolved	mg/L	<0.001	<0.001	<0.001	0.002	<0.001
Zinc-Dissolved	mg/L	0.001	0.001	<0.001	0.002	0.004

Microbiological Testing						
Our Reference:	UNITS	199590-1	199590-2	199590-3	199590-4	199590-5
Your Reference	----------	BM1	BM2	BM3	BM4	BM5
Date Sampled	----------	18/08/2017	18/08/2017	18/08/2017	18/08/2017	18/08/2017
Type of sample		Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Date testing started	-	18/08/2017	18/08/2017	18/08/2017	18/08/2017	18/08/2017
Date testing completed	-	21/08/2017	21/08/2017	21/08/2017	21/08/2017	21/08/2017
Faecal Enterococci	cfu/100mL	<10	<10	<10	<10	<10
Thermotolerant Coliforms	cfu/100mL	<10	<10	<10	<10	<10
E.coli	cfu/100mL	<10	<10	<10	<10	<10

Method ID	Methodology Summary
INORG-019	Suspended Solids - determined gravimetrically by filtration of the sample. The samples are dried at 104+/-5oC.
INORG-081	Anions - a range of anions are determined by Ion Chromatography based on APHA latest edition Method 4110 -B. Soils and other sample types reported from a water extract unless otherwise specified (standard soil extract ratio 1:5).
INORG-055	Total Nitrogen by colourimetric analysis based on APHA 4500-P J, 4500-NO3 F.
INORG-062	TKN by calculation fromTotal Nitrogen and NOx using APHA methodology.
INORG-055	Nitrate - determined colourimetrically. Soils are analysed from a water extract.
INORG-055	Nitrite - determined colourimetrically. Soils are analysed from a water extract.
INORG-057	Ammonia by colourimetric analysis based on APHA latest edition 4500-NH3 F.
INORG-060	Phosphate- determined colourimetrically. Soils are analysed from a water extract.
METALS-022	Determination of various metals by ICP-MS.
METALS-021	Determination of Mercury by Cold Vapour AAS.
MICRO-001	Faecal Enterococci: Microbial Water Analysis - in accordance with MICRO-001 (ISO 7899-2:2000).
MICRO-001	Thermotolerant Coliforms: Microbial Water Analysis - in accordance with MICRO-001 (AS4276.7-2007). Recommended maximums based on NHMRC and ARMC Australian Drinking Water Guidelines.
MICRO-001	E. Coli: Microbial Water Analysis - in accordance with MICRO-001 (AS4276.7-2007). Recommended maximums based on NHMRC and ARMC Australian Drinking Water Guidelines.

QUALITY CONTROL Miscellaneous Inorganics	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			21/08/2017	199590-1	21/08/2017 || 21/08/2017	LCS-1	21/08/2017
Date analysed	-			21/08/2017	199590-1	21/08/2017 || 21/08/2017	LCS-1	21/08/2017
Total Suspended Solids	mg/L	5	INORG-019	<5	199590-1	110 || [N/T]	LCS-1	102%
Fluoride	mg/L	0.1	INORG-081	<0.1	199590-1	0.1 || 0.1 || RPD: 0	LCS-1	101%
QUALITY CONTROL Nutrients in Water	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			21/08/2017	199590-1	21/08/2017 || 21/08/2017	LCS-1	21/08/2017
Date analysed	-			21/08/2017	199590-1	21/08/2017 || 21/08/2017	LCS-1	21/08/2017
Total Nitrogen	mg/L	0.1	INORG-055	<0.1	199590-1	3.9 || 3.9 || RPD: 0	LCS-1	103%
TKN by Discrete Analyser	mg/L	0.1	INORG-062	<0.1	199590-1	1 || 1 || RPD: 0	[NR]	[NR]
Nitrate as N	mg/L	0.005	INORG-055	<0.005	199590-1	2.9 || 3.0 || RPD: 3	LCS-1	100%
Nitrite as N	mg/L	0.005	INORG-055	<0.005	199590-1	0.032 || 0.032 || RPD: 0	LCS-1	105%
Ammonia as N	mg/L	0.005	INORG-057	<0.005	199590-1	<0.005 || <0.005	LCS-1	98%
Phosphate as P	mg/L	0.005	INORG-060	<0.005	199590-1	<0.005 || <0.005	LCS-1	98%
Total Phosphorus	mg/L	0.01	INORG-055	<0.01	199590-1	0.04 || 0.04 || RPD: 0	LCS-1	106%
QUALITY CONTROL Metals in Water - Low Level	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			24/08/2017	199590-1	24/08/2017 || 24/08/2017	LCS-1	24/08/2017
Date analysed	-			24/08/2017	199590-1	24/08/2017 || 24/08/2017	LCS-1	24/08/2017
Arsenic-Dissolved	mg/L	0.001	METALS-022	<0.001	199590-1	<0.001 || <0.001	LCS-1	102%
Cadmium-Dissolved	mg/L	0.0001	METALS-022	<0.0001	199590-1	<0.0001 || <0.0001	LCS-1	107%
Chromium-Dissolved	mg/L	0.001	METALS-022	<0.001	199590-1	<0.001 || <0.001	LCS-1	97%
Copper-Dissolved	mg/L	0.001	METALS-022	<0.001	199590-1	<0.001 || <0.001	LCS-1	103%
Lead-Dissolved	mg/L	0.001	METALS-022	<0.001	199590-1	<0.001 || <0.001	LCS-1	94%
Mercury-Dissolved	mg/L	0.00005	METALS-021	<0.00005	199590-1	<0.00005 || <0.00005	LCS-1	97%
Nickel-Dissolved	mg/L	0.001	METALS-022	<0.001	199590-1	<0.001 || <0.001	LCS-1	104%
Zinc-Dissolved	mg/L	0.001	METALS-022	<0.001	199590-1	0.001 || 0.001 || RPD: 0	LCS-1	105%

QUALITY CONTROL Microbiological Testing	UNITS	PQL	METHOD	Blank
Date testing started	-			18/08/2017
Date testing completed	-			19/08/2017
Faecal Enterococci	cfu/100mL	1	MICRO-001	<1
Thermotolerant Coliforms	cfu/100mL	1	MICRO-001	<1
E.coli	cfu/100mL	1	MICRO-001	<1

QUALITY CONTROL Nutrients in Water	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	[NT]	[NT]	199590-2	23/08/2017
Date analysed	-	[NT]	[NT]	199590-2	23/08/2017
Total Nitrogen	mg/L	[NT]	[NT]	199590-2	99%
TKN by Discrete Analyser	mg/L	[NT]	[NT]	[NR]	[NR]
Nitrate as N	mg/L	[NT]	[NT]	199590-2	102%
Nitrite as N	mg/L	[NT]	[NT]	199590-2	111%
Ammonia as N	mg/L	[NT]	[NT]	199590-2	106%
Phosphate as P	mg/L	[NT]	[NT]	199590-2	101%
Total Phosphorus	mg/L	[NT]	[NT]	199590-2	103%

Report Comments:

Definitions:

NT: Not tested NA: Test not required INS: Insufficient sample for this test PQL: Practical Quantitation Limit
<: Less than >: Greater than RPD: Relative Percent Difference LCS: Laboratory Control Sample
NS: Not Specified NEPM: National Environmental Protection Measure NR: Not Reported

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Appendix B

Geotechnical investigation

Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on
Geotechnical Investigation

Proposed Residential Development
Lot 821 Armadale Road, Banjup, WA

Prepared for
Anstey Road Developments

Project 96594
September 2019



Douglas Partners
Geotechnics / Environment / Groundwater

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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author		13 SEPTEMBER 2019
Reviewer		13 September 2019

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Appendix A: About This Report
Drawing

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Appendix B: Results of Field Work

Appendix C: Results of Laboratory Testing

Report on Geotechnical Investigation
Proposed Residential Development
Lot 821 Armadale Road, Banjup, WA

1. Introduction

This report presents the results of a geotechnical investigation undertaken for a proposed residential development at Lot 821 Armadale Road, Banjup, WA. The investigation was commissioned on 15 July 2019 by Kelli Howell of Anstey Road Developments and was undertaken in accordance with Douglas Partners' proposal PER190281 dated 10 July 2019.

It is understood that the proposed development comprises a residential subdivision and associated internal access roads and public open space. Finished surface levels across the site, following earthworks, will range between approximately RL 29.5 m and RL 32 m AHD.

The aim of the geotechnical investigation is to assess the subsurface conditions at the site and provide comments on:

- The sub-soil conditions including identification of areas of problematic soils, loose zones and uncontrolled fill if encountered, with suitable earthworks remediation strategies provided.
- Topsoil condition and thickness and comments on suitable topsoil blending ratios to produce structural fill suitable for the proposed development.
- The geotechnical suitability of the south-west bund soils and stockpiled materials for re-use in cut to fill operations.
- Provide recommendations on re-use options of all materials encountered during the investigation, with the aim of minimising off-site disposal costs during earthworks.
- Site preparation, excavatability, compaction control criteria and other earthworks requirements to suitably prepare the ground for the proposed development.
- Appropriate site classification in accordance with the requirements of AS 2870-2011.
- Geotechnical parameters for soil retention (assuming limestone block mass-gravity retaining walls) and safe batter slopes.
- Pavement design parameters and any other comments pertinent to pavement subgrade preparation.
- The depth to groundwater, if encountered.
- The suitability of the in situ soils for stormwater disposal by soakage, particularly within the proposed central public open space.

The investigation included the excavation of 20 test pits, the supervision of eight cone penetration tests, six in situ infiltration tests and laboratory testing of selected samples. The details of the field work are presented in this report, together with comments and recommendations on the issues listed above.

2. Site Description

The site is located approximately 2.5 km east of Cockburn. It is bounded by Armadale Road to the south, by Ghostgum Avenue to the West and by undeveloped bushland elsewhere.

At the time of the investigation, the site comprised a generally open and flat area. It had previously been cleared of significant vegetation, although regrowth of grass, shrubs and bushes, which are thick in some areas, had occurred. The exposed soils indicated some evidence of prior disturbance, with some crushed brick and concrete materials of unknown thickness spread over the surface in some areas. A number of stockpiles of predominantly sand material, though incorporating some material assessed to be topsoil, were observed in the southern part of the site. Historical aerial photographs indicate that the first major disturbance of the site occurred around 2004 to 2005, with clearing, excavation and removal of sand, and possibly some placement of materials occurring until approximately 2009. In general, no further activity appears to have occurred within in the site since 2009, except for the placement of the stockpiles noted above in 2018.

A typical view of the site are presented in Figure 1 below, and a view of the stockpiles mentioned above in Figure 2 (next page).



Figure 1: General View of the Site Near Test Location 10



Figure 2: General View of Stockpiles on the Site

The site generally grades from approximately RL 36 m AHD on the western boundary to RL 30m AHD on the eastern boundary with a bund running along the southern boundary with a maximum height of RL 43 m AHD. A survey of the site provided by the client (6234-LWP-SK01 Rev a indicates two low points of approximately RL 26 m AHD in the southern part of the site and RL 27 m AHD in the north west. Both areas are shown to be several metres below the surrounding areas. Neither low point were visually apparent on site during the field work, nor on aerial photographs, nor in the publicly available LiDAR data. The LiDAR data has been used as it conforms more closely to observed site conditions.

The 1:50 000 Fremantle Environmental Geology map indicates that the soil beneath the site comprises Bassendean Sand.

The Perth Groundwater Atlas (2004) indicates that regional aquifer was between RL 25 m AHD and RL 26 m AHD in May 2003.

3. Field Work Methods

Field work was carried out on 30 August and 2 September 2019 and comprised:

- 20 test pits;
- Eight cone penetration tests;
- A Perth sand penetrometer (PSP) test at each test pit location; and
- Six infiltration tests.

The test pits (test locations1 to 20) were excavated using an 8 tonne excavator with a 800 mm wide bucket to depths of between approximately 1.7 m and 2.8 m, at which depths they collapsed.

The cone penetration tests (21 to 28) were carried out using a 36 mm diameter instrumented cone with a following 130 mm long friction sleeve attached to rods of the same diameter, pushed continuously at a rate of 20 mm/sec into the soil by hydraulic thrust from a ballasted 12 tonne tracked rig. Strain gauges in the cone and sleeve measure resistance to penetration and this data allows assessment of the type and condition of the materials penetrated. The cone penetration tests were undertaken to depths of between approximately 4 m and 10 m.

Ground conditions were logged in general accordance with AS1726-2017 by a suitably experienced geotechnical engineer from Douglas Partners. Soil samples were recovered for subsequent geotechnical laboratory testing.

Perth sand penetrometer testing was carried out in accordance with AS 1289.6.3.3 adjacent to each test pit to assess the in situ density of the shallow soils to depths of generally approximately 1 m, or prior refusal. The results of these Perth sand penetrometer tests are presented on the borehole log sheets in Appendix B.

The field infiltration tests were performed using the falling head method, at depths of between approximately 0.7 m and 0.95 m below the existing surface level at test locations 30 to 34.

Test locations were determined with reference to existing site features, and are presented on Drawing 1 in Appendix A. Surface elevations at each test location were interpolated from publicly available LiDAR data.

4. Field Work Results

4.1 Ground Conditions

Detailed logs of the ground conditions are presented in Appendix B, and should be read in conjunction with the notes defining descriptive terms and classification methods provided in Appendix A.

The subsurface conditions encountered comprised:

- **FILL/SAND SP:** fine to medium grained, generally dark grey-brown, grey-brown and yellow-brown, trace silt and varying gravel content, occasionally trace organics, loose to medium dense, encountered all test pit locations except test location 11, to depths of up to 2.4 m (the extent of the test pit investigation), and interpreted at most cone penetration test locations, to depths of up to 3.2 m. Where encountered, the loose sand was from the existing surface level to depths of up to generally less than 0.6 m but locally up to 1.4 m.
- **SAND SP:** fine to medium grained, pale yellow, yellow-brown, and pale white, trace silt, generally medium dense to dense, from the surface or underlying the fill at all test locations where natural sand was encountered (i.e. except at test pit locations where the test pit terminated in fill) to the extent of the investigation of up to 10 m.

4.2 Groundwater

Groundwater was encountered at test locations 24 and 27 at depths of 3.2 m and 6.9 m below existing ground level (approximately RL 26.8 m AHD and RL 26.9 m AHD) respectively during the field work undertaken on 2 September 2019. Groundwater was not observed at the other test locations, though collapse of the cone penetration test holes prior to dipping for groundwater may have prevented measurement of groundwater level at other test locations.

The boreholes were immediately backfilled following the investigation, which precluded longer-term monitoring of groundwater levels at those locations.

The Perth Groundwater Atlas (2004) indicates that the level of the regional aquifer was between RL 25 m AHD and RL 26 m AHD in May 2003.

It should be noted that groundwater levels are affected by climatic conditions and soil permeability, and will therefore vary with time.

4.3 Results of Infiltration Testing

Six in situ infiltration tests were carried out using the falling head method at test locations 29 to 34 at depths of between approximately 0.7 m and 0.95 m below existing ground level. An estimated permeability value has been derived from the in situ permeability test data using Hvorslev (1951).

Permeability can also be estimated from particle size distribution test results from samples taken from the same depths at infiltration test locations, using Hazen's formula. Hazen's formula provides an indication of the permeability for clean sand in loose conditions, and thus the result derived using this approach should be considered with caution.

Table 1 below summarises the permeability results.

Table 1: Summary of Permeability Analysis

Test Location	Depth (m)	Measured Permeability[1]		Derived Permeability (m/s) [2]		In situ Conditions of Tested Material
		(m/s)	(m/day)	(m/s)	(m/day)	
29	0.95	1.8×10^{-3}	>50	-	-	Loose Sand, trace silt
30	0.70	1.0×10^{-3}	50			Loose Sand, trace silt
31	0.75	1.8×10^{-3}	>50	0.7×10^{-3}	>50	Loose Sand, trace silt
32	0.70	1.5×10^{-3}	>50			Medium Dense Sand, trace silt
33	0.705	0.7×10^{-3}	>50			Medium Dense Sand, trace silt
34	0.70	1.8×10^{-3}	>50	0.6×10^{-3}	>50	Medium Dense Sand, trace silt

Notes: [1]: In situ permeability (Hvorslev).
[2]: Hazen's formula (assumes sand in loose condition).

5. Laboratory Testing

A geotechnical laboratory testing programme has been scheduled with a NATA registered laboratory and comprises the determination of:

- the particle size distribution of six samples; and
- the organic content of four samples.

The detailed test certificates are be presented in Appendix C, with the results summarised in Table 2 (next page).

Table 2: Summary of Laboratory Testing Results

Test Location	Depth (m)	Fines (%)	Sand (%)	Gravel (%)	Organic (%)	Material
2	1.9-1.2	1	99	0	0.3	FILL/SAND, trace silt
12	0.6-0.7	0	100	0	0.1	SAND
14	0.2-0.3	3	68	29	-	FILL/SAND, with gravel
31	0.6-0.7	1	98	1	-	SAND, trace silt
34	0.6-0.7	0	100	0	1.7	SAND
Topsoil Stockpile – Sample 1	-	-	-	-	3.1	SAND, trace silt, trace organics
Topsoil Stockpile – Sample 2	-	3	97	0	1.5	SAND, trace silt, trace organics

Notes on Table : The % fines is the amount of particles smaller than 75 µm.
The % sand is the amount of particles smaller than 2.36 mm and larger than 75 µm.
The % gravel is the amount of particles smaller than 63 mm and larger than 2.36 mm.
See Drawing 1 for location of topsoil stockpile

6. Proposed Development

It is understood that the proposed development comprises a residential subdivision and associated internal access roads and public open space. Finished surface levels across the site, following earthworks, will range between approximately RL 29.5 m and RL 32 m AHD.

7. Comments

7.1 Site Suitability

Results of the investigation indicate that the site is underlain by generally loose to medium dense sand fill overlying medium dense to dense natural sand. The loose fill is near the existing surface, generally to depths of less than 0.6 m, though locally encountered up to 1.4 m deep. Stockpiles of material placed in the southern part of the site (see Drawing 1, Appendix A) contain sand and topsoil materials, comprising sand with a trace of silt and organics.

Groundwater was encountered at two test locations during the field work on 30 August and 2 September 2019, at depths of 3.2 m and 6.9 m (approximately RL 26.8 m AHD and RL 26.9 m AHD). Desktop information indicates that the level of the regional aquifer was between RL 25 m AHD and RL 26 m AHD in May 2003, when groundwater was near its low seasonal level.

From a geotechnical standpoint, the land is physically capable of development for the proposed development, provided that the provisions outlined in the subsequent subsections of the report are taken into consideration, and recommendations are implemented.

7.2 Site Classification

The site is generally underlain by loose to medium dense sand fill overlying medium dense to dense natural sand.

Fill was encountered at most test locations across the site. A surface layer of loose fill was present in many test locations. In the absence of documentation to confirm the fill on the site was controlled and placed under engineering supervision, it should be considered as "uncontrolled".

The site classification of the site in its current condition is "Class P" in accordance AS2870-2011 because of the presence of uncontrolled fill and the presence of loose sand in some locations.

However, based on encountered conditions, a site classification of "Class A" in accordance AS2870-2011 can be achieved provided the site preparation recommendations in Section 7.5 are carried out.

It should be noted that AS 2870-2011 applies to single houses, townhouses and the like classified as Class 1 and 10a under the Building Code of Australia. It also applies to light industrial and commercial buildings if they are similar in size, loading and superstructure flexibility to those designs included in AS 2870-2011.

7.3 Excavation Conditions

The encountered ground conditions comprise medium dense to dense sand, with a layer of near surface loose sand, to the extent of the investigation.

Conventional earthmoving equipment should be generally suitable for excavations across the site within the surficial sand.

As discussed in Section 4.2, groundwater was encountered at two test locations at approximately RL 26.8 m AHD and RL 26.9 m AHD, though collapse to the cone penetration test hole prior to dipping for groundwater may have prevented identification of groundwater at other test locations. Higher groundwater levels may be anticipated following particularly wet periods. Desktop information indicates that the level of the regional aquifer was between RL 25 m AHD and RL 26 m AHD in May 2003. Therefore, excavations below, say, RL 27.5 m AHD may be affected by groundwater, particularly in the winter months. It is recommended that monitoring wells are installed during detailed investigations to allow monitoring of groundwater levels at the site.

7.4 Geotechnical Suitability for Re-Use of In Situ Materials

7.4.1 Re-Use of Stockpiles

An area of stockpiles is located in the southern part of the site, as indicated on Drawing 1, Appendix A. Inspection of the stockpiles indicated that they are partly composed of clean sand, particularly around the perimeter of the stockpile area, and partly by sandy topsoil material. Laboratory testing indicates that the organic content of the topsoil material is below 5%, though the possible presence of material with higher organic content within the stockpile cannot be precluded.

The sand stockpiles are geotechnically suitable for reuse as structural fill material provided it is free from organic matter and particles greater than 150 mm in size.

The topsoil stockpiles are considered generally suitable for re-use as structural fill and particles greater than 150 mm in size. However, as a precaution against possible variability in the organic content of this material, it is recommended that it is blended with clean sand on a ratio of 2 (clean sand):1 (topsoil stockpile). Further testing of the stockpile material during detailed investigations or during construction should be undertaken to refine this suggested blending ratio.

It should be noted that this study has not assessed whether unacceptable levels of contaminants exist within the filling material as this was outside the scope of the investigation. Such levels, if they occur, may limit or prevent the use of this material. Douglas Partners would be pleased to assist with this matter if required.

7.4.2 Re-Use of Existing Fill

The encountered existing fill on the site comprised sand with a trace of silt and various gravel content.

The encountered fill across the site is considered geotechnically suitable for reuse as structural fill material provided it is free from organic matter and particles greater than 150 mm in size.

As noted above, this study has not assessed whether unacceptable levels of contaminants exist within the filling material as this was outside the scope of the investigation. Such levels, if they occur, may limit or prevent the use of this material.

7.4.3 Re-Use of Natural Sand

The fill across the site is underlain by natural sand with a trace of silt.

The encountered natural sand is considered geotechnically suitable for reuse as structural fill material provided it is free from organic matter and particles greater than 150 mm in size.

7.4.4 Topsoil

The investigation did not encounter topsoil, which historical aerial photographs indicate has been previously stripped from the site.

7.5 Site Preparation

7.5.1 Site Stripping

As noted above, the investigation did not encounter topsoil. However, revegetation of the site has occurred since then. All deleterious material, including (if encountered) waste, debris, unsuitable fill and vegetation should be stripped from the proposed development areas of the site.

Any tree roots remaining from clearing operations within the proposed development area should be completely removed to a depth of 0.6 m, and the excavation backfilled with material of similar geotechnical properties to the surrounding ground and suitably compacted.

The granular fill encountered during the investigation is considered likely suitable to be left in place. It should be noted that areas of unsuitable fill not encountered by this investigation cannot be entirely precluded, therefore inspections of the site following clearing and stripping should be conducted by a geotechnical engineer, to identify any possible areas which required further treatment.

7.5.2 Proof Rolling and Compaction

A surface layer of loose fill was encountered across much of the site. The thickness of the encountered loose layer was generally less than 0.6 m, though it was locally up to 1.4 m thick. Some of the loose material may be removed during earthworks in part of the site, but may remain in place in other areas.

Therefore, following removal of unsuitable material, if any, and excavation to formation level (in areas of cut) it is recommended that the exposed ground beneath be proof rolled with a heavy smooth drum roller (say minimum 18 tonnes deadweight) in vibrating mode.

Any areas that show signs of excessive deformation during compaction should be compacted until deformation ceases or, alternatively, the poor quality material should be excavated and replaced with suitable structural filling and compacted.

Following proof rolling to confirm suitable foundation material, footing locations should be tested to a depth of 1.0 m below footing formation level, or shallower refusal, by a suitably experienced geotechnical engineer.

The above measure should generally be sufficient. However, if loose material remains after proof rolling, which may occur in areas of thicker loose material, it is recommended that some surface material be excavated to allow compaction of the underlying material, and subsequently replaced and compacted.

Compaction control of sand could be carried out using a Perth sand penetrometer (PSP) test in accordance with test method AS 1289.6.3.3. All areas within the proposed building envelope should be compacted to achieve a minimum blow count of 8 blows per 300 mm penetration to a depth of not less than 0.5 m below foundation level.

Earthworks should be supervised by a Geotechnical Engineer.

7.5.3 Imported Filling

If required, imported filling should comprise free draining, cohesionless, well graded sand that:

- contains less than 5% by weight of particles less than 75 microns in size;
- contains no particles greater than 150 mm in size; and
- is free of organic and other deleterious materials.

It is recommended that test certificates are reviewed and approved by the geotechnical engineer prior to importing material to site.

Other materials could be considered, provided they are granular and non-reactive, and following review by a geotechnical engineer.

7.5.4 Fill Placement

Any fill should be placed in layers not exceeding 300 mm loose thickness and compacted near optimum moisture content with a roller of say 12 tonne deadweight. It is recommended that earthworks be carried out with regular inspections by a geotechnical engineer.

7.5.5 Compaction Testing

Compaction control of the sand filling could be carried out using a Perth sand penetrometer (PSP) test in accordance with test method AS 1289.6.3.3. All areas within the proposed building envelopes should be compacted to achieve a minimum blow count of 8 blows per 300 mm penetration to a depth of not less than 1.0 m below foundation level.

The top 300 mm in the base of any excavation should be re-compacted using a vibratory plate compactor prior to construction of any footings. Inspection of footing excavations by a geotechnical engineer is also recommended.

7.5.6 Geotechnical Inspection

Owing to the presence of fill across the site, it is recommended that earthworks are inspected by a geotechnical engineer.

7.6 Design Parameters for Excavations and Retaining Systems

It is recommended that batter slopes not steeper than 1.5H:1V (horizontal : vertical) be adopted for temporary excavations not deeper than 3 m in sand material. For deeper excavations, average batter slopes not steeper than 2H:1V should be adopted, with horizontal benches at least 1 m wide at 5 m intervals in height. These recommended batter angles should be re-assessed if loads are to be applied near the top of the batter or if there is a possibility of substantial overland water flow. Permanent batter slopes should not be steeper than 2H:1V.

Design of temporary and permanent retaining structures in sand can be based on the design parameters listed in Table 3 below. In addition, retaining structures should be designed to support lateral pressure from external loads such as such as live loads from the surrounding developments and construction activities.

Table 3: Suggested Soil Parameters for Retaining Wall Design

Soil Type	Unit Weight (kN/m^3)	Shear Strength		Pressure Coefficients		
		Φ ′ (°)	c’ (kPa)	Ka	Kp	K0
Sand (natural and fill) – Loose	18	30	0	0.33	3.0	0.5
Sand (natural and fill) – Medium Dense or Denser	20	34	0	0.28	3.5	0.5

7.7 Pavement Design Parameters

Based on observation of the sandy soils underlying the site, and Douglas Partners’ experience, and assuming the recommendations in Section 7.4 are implemented, a subgrade California bearing ratio (CBR) of 12% is suggested for pavement design for subgrades in the natural sand, provided the subgrade is compacted to not less than 95% of modified maximum dry density to a depth of at least 0.5 m below subgrade level.

7.8 Stormwater Disposal and Drainage

The shallow ground conditions comprise generally medium dense sand, with a surface layer of loose fill. It is assumed that the density of the loose fill will be increased to at least medium dense during earthworks, or the loose material removed if in areas of cut. As discussed in Section 4.2, groundwater was encountered at two test locations at approximately RL 26.8 m AHD and RL 26.9 m AHD, though collapse to the cone penetration test hole prior to dipping for groundwater may have prevented identification of groundwater at other test locations. Higher groundwater levels may be anticipated following particularly wet periods.

Six in situ falling head infiltration tests were undertaken in loose or medium dense sand at depths of between approximately 0.7 m and 0.95 m at test locations 29 to 34, as described in Section 4.3 above. The estimated permeability values arising from the tests was greater than 50 m/day.

A further assessment of permeability at the test location was carried out by applying Hazen's formula to the particle size distribution result from samples taken from the test locations at the infiltration test depths. It should be noted that Hazen's formula applies to 'clean' sand in a loose state and that values derived using this approach should be considered with caution. The result of this assessment also suggests permeability values greater than 50 m/day. The permeability results reflect the low fines content of the sand at the test locations.

Given possible variability in situ permeability, the possible extensive earthworks and an anticipated reduction of permeability following compaction operations, a permeability value of 1×10^{-4} m/s (approximately 8 m/day) is suggested for the in situ sand in a dense condition.

On-site stormwater disposal using soakwells, sumps and drainage basins is considered suitable for this site. The infiltration capability commonly reduces over time due to silt build up at the base of soakwells and therefore the soakwells must be cleaned and maintained on a regular basis. Soakwells should preferably be positioned at a distance from all buildings, retaining walls and boundaries by not less than 2 m.

8. References

1. Australian Standard AS2870-2011, 'Residential Slabs and Footings', April 2011, Standards Australia
2. Australian Standard AS 1289-2000, Methods of Testing Soils for Engineering Purposes.
3. Australian Standard AS 1289.6.3.3-1999, Soil Strength and Consolidation Tests- Determination of the Penetration Resistance of a Soil – Perth Sand Penetrometer Test.
4. Australian Standard AS 1726-2017, Geotechnical Site Investigation.
5. Australian Standard AS 3798-2007, Guidelines on Earthworks for Commercial and Residential Developments.
6. Department of Environment, Perth Groundwater Atlas, Second Edition, December 2004
7. Hvorslev M. J., 1951, Time lag and soil permeability in groundwater observations, US Army Corps of Engineers Waterways Experiment Observation Station, Bulletin 36, Vicksburg, Mississippi
8. Hazen A, 1930, "Water Supply", in American Civil Engineers Handbook, Wiley, New York.

9. Limitations

Douglas Partners (DP) has prepared this report for this project at Lot 821 Armadale Road, Banjup, WA in accordance with DP's proposal dated 10 July 2019 and acceptance received from Kelli Howell of Anstey Road Developments dated 15 July 2019. The work was carried out under DP's Conditions of Engagement . This report is provided for the exclusive use of Anstey Road Developments for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The scope for work for this investigation/report did not include the assessment of surface or sub-surface materials or groundwater for contaminants, within or adjacent to the site. Should evidence of filling of unknown origin be noted in the report, and in particular the presence of building demolition materials, it should be recognised that there may be some risk that such filling may contain contaminants and hazardous building materials.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the geotechnical components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix A

About This Report
Drawing

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Sampling Methods

Douglas Partners

Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as:

  15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Cone Penetration Tests

Douglas Partners

Introduction

The Cone Penetration Test (CPT) is a sophisticated soil profiling test carried out in-situ. A special cone shaped probe is used which is connected to a digital data acquisition system. The cone and adjoining sleeve section contain a series of strain gauges and other transducers which continuously monitor and record various soil parameters as the cone penetrates the soils.

The soil parameters measured depend on the type of cone being used, however they always include the following basic measurements

- Cone tip resistance q_c
- Sleeve friction f_s
- Inclination (from vertical) i
- Depth below ground z

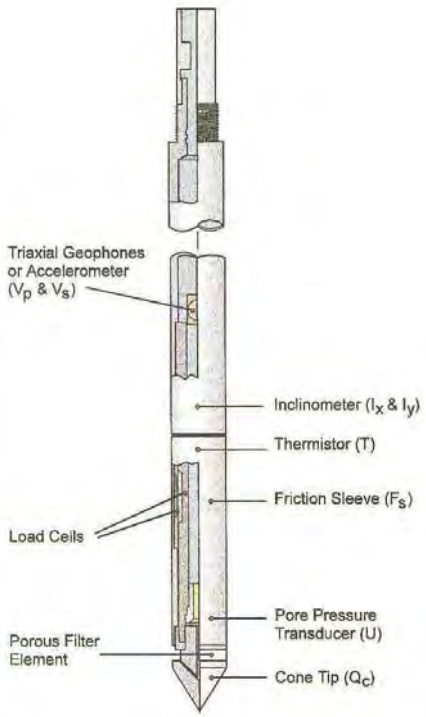


Figure 1: Cone Diagram

The inclinometer in the cone enables the verticality of the test to be confirmed and, if required, the vertical depth can be corrected.

The cone is thrust into the ground at a steady rate of about 20 mm/sec, usually using the hydraulic rams of a purpose built CPT rig, or a drilling rig. The testing is carried out in accordance with the Australian Standard AS1289 Test 6.5.1.



Figure 2: Purpose built CPT rig

The CPT can penetrate most soil types and is particularly suited to alluvial soils, being able to detect fine layering and strength variations. With sufficient thrust the cone can often penetrate a short distance into weathered rock. The cone will usually reach refusal in coarse filling, medium to coarse gravel and on very low strength or better rock. Tests have been successfully completed to more than 60 m.

Types of CPTs

Douglas Partners (and its subsidiary GroundTest) owns and operates the following types of CPT cones:

Type	Measures
Standard	Basic parameters (q_c, f_s, i & z)
Piezocone	Dynamic pore pressure (u) plus basic parameters. Dissipation tests estimate consolidation parameters
Conductivity	Bulk soil electrical conductivity (σ) plus basic parameters
Seismic	Shear wave velocity (V_s), compression wave velocity (V_p), plus basic parameters

Strata Interpretation

The CPT parameters can be used to infer the Soil Behaviour Type (SBT), based on normalised values of cone resistance (Qt) and friction ratio (Fr). These are used in conjunction with soil classification charts, such as the one below (after Robertson 1990)

Cone Penetration Tests

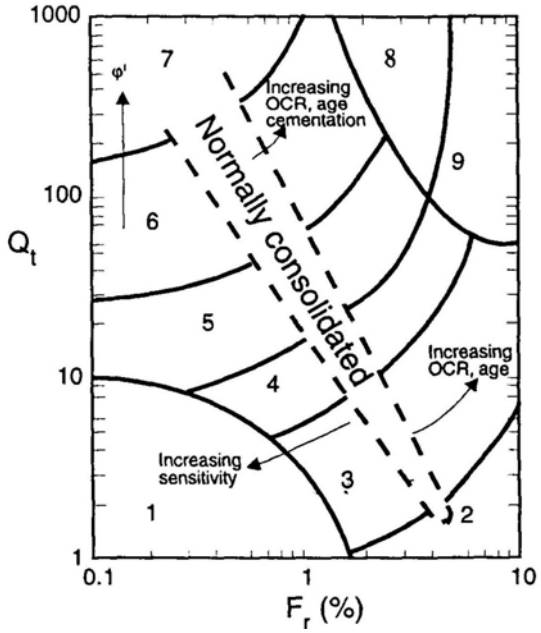


Figure 3: Soil Classification Chart

DP's in-house CPT software provides computer aided interpretation of soil strata, generating soil descriptions and strengths for each layer. The software can also produce plots of estimated soil parameters, including modulus, friction angle, relative density, shear strength and over consolidation ratio.

DP's CPT software helps our engineers quickly evaluate the critical soil layers and then focus on developing practical solutions for the client's project.

Engineering Applications

There are many uses for CPT data. The main applications are briefly introduced below:

Settlement

CPT provides a continuous profile of soil type and strength, providing an excellent basis for settlement analysis. Soil compressibility can be estimated from cone derived moduli, or known consolidation parameters for the critical layers (eg. from laboratory testing). Further, if pore pressure dissipation tests are undertaken using a piezocone, in-situ consolidation coefficients can be estimated to aid analysis.

Pile Capacity

The cone is, in effect, a small scale pile and, therefore, ideal for direct estimation of pile capacity. DP's in-house program ConePile can analyse most pile types and produces pile capacity versus depth plots. The analysis methods are based on proven static theory and empirical studies, taking account of scale effects, pile materials and method of installation. The results are expressed in limit state format, consistent with the Piling Code AS2159.

Dynamic or Earthquake Analysis

CPT and, in particular, Seismic CPT are suitable for dynamic foundation studies and earthquake response analyses, by profiling the low strain shear modulus G_0. Techniques have also been developed relating CPT results to the risk of soil liquefaction.

Other Applications

Other applications of CPT include ground improvement monitoring (testing before and after works), salinity and contaminant plume mapping (conductivity cone), preloading studies and verification of strength gain.

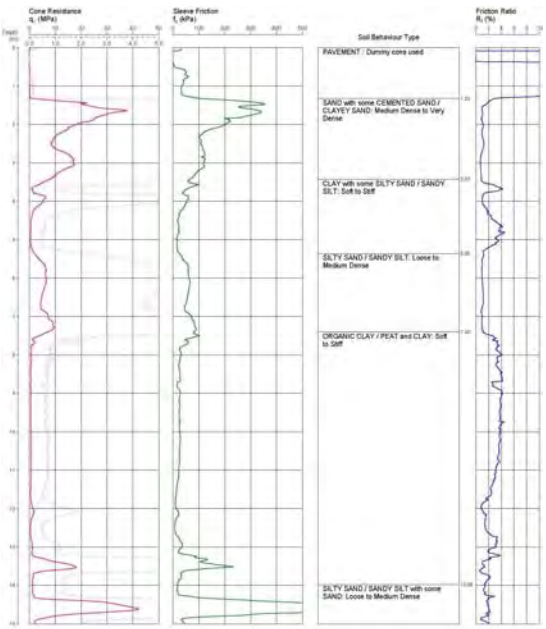


Figure 4: Sample Cone Plot

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are generally based on Australian Standard AS1726:2017, Geotechnical Site Investigations. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	19 - 63
Medium gravel	6.7 - 19
Fine gravel	2.36 – 6.7
Coarse sand	0.6 - 2.36
Medium sand	0.21 - 0.6
Fine sand	0.075 - 0.21

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

The proportions of secondary constituents of soils are described as follows:

In fine grained soils (>35% fines)

Term	Proportion of sand or gravel	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	>30%	Sandy Clay
With	15 – 30%	Clay with sand
Trace	0 - 15%	Clay with trace sand

In coarse grained soils (>65% coarse)
- with clays or silts

Term	Proportion of fines	Example
And	Specify	Sand (70%) and Clay (30%)
Adjective	>12%	Clayey Sand
With	5 - 12%	Sand with clay
Trace	0 - 5%	Sand with trace clay

In coarse grained soils (>65% coarse)
- with coarser fraction

Term	Proportion of coarser fraction	Example
And	Specify	Sand (60%) and Gravel (40%)
Adjective	>30%	Gravelly Sand
With	15 - 30%	Sand with gravel
Trace	0 - 15%	Sand with trace gravel

The presence of cobbles and boulders shall be specifically noted by beginning the description with ‘Mix of Soil and Cobbles/Boulders’ with the word order indicating the dominant first and the proportion of cobbles and boulders described together.

Soil Descriptions

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	VS	<12
Soft	S	12 - 25
Firm	F	25 - 50
Stiff	St	50 - 100
Very stiff	VSt	100 - 200
Hard	H	>200
Friable	Fr	-

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	Density Index (%)
Very loose	VL	<15
Loose	L	15-35
Medium dense	MD	35-65
Dense	D	65-85
Very dense	VD	>85

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Extremely weathered material – formed from in-situ weathering of geological formations. Has soil strength but retains the structure or fabric of the parent rock;
- Alluvial soil – deposited by streams and rivers;
- Estuarine soil – deposited in coastal estuaries;
- Marine soil – deposited in a marine environment;
- Lacustrine soil – deposited in freshwater lakes;
- Aeolian soil – carried and deposited by wind;
- Colluvial soil – soil and rock debris transported down slopes by gravity;
- Topsoil – mantle of surface soil, often with high levels of organic material.
- Fill – any material which has been moved by man.

Moisture Condition – Coarse Grained Soils

For coarse grained soils the moisture condition should be described by appearance and feel using the following terms:

- Dry (D) — Non-cohesive and free-running.
- Moist (M) — Soil feels cool, darkened in colour.
  Soil tends to stick together.
  Sand forms weak ball but breaks easily.
- Wet (W) — Soil feels cool, darkened in colour.
  Soil tends to stick together, free water forms when handling.

Moisture Condition – Fine Grained Soils

For fine grained soils the assessment of moisture content is relative to their plastic limit or liquid limit, as follows:

- ‘Moist, dry of plastic limit’ or ‘w <PL’ (i.e. hard and friable or powdery).
- ‘Moist, near plastic limit’ or ‘w ≈ PL (i.e. soil can be moulded at moisture content approximately equal to the plastic limit).
- ‘Moist, wet of plastic limit’ or ‘w >PL’ (i.e. soils usually weakened and free water forms on the hands when handling).
- ‘Wet’ or ‘w ≈LL’ (i.e. near the liquid limit).
- ‘Wet’ or ‘w >LL’ (i.e. wet of the liquid limit).

Symbols & Abbreviations

Douglas Partners

Introduction

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

Drilling or Excavation Methods

C	Core drilling
R	Rotary drilling
SFA	Spiral flight augers
NMLC	Diamond core - 52 mm dia
NQ	Diamond core - 47 mm dia
HQ	Diamond core - 63 mm dia
PQ	Diamond core - 81 mm dia

Water

▷	Water seep
▽	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
E	Environmental sample
U_{50}	Undisturbed tube sample (50mm)
W	Water sample
pp	Pocket penetrometer (kPa)
PID	Photo ionisation detector
PL	Point load strength Is(50) MPa
S	Standard Penetration Test
V	Shear vane (kPa)

Description of Defects in Rock

The abbreviated descriptions of the defects should be in the following order: Depth, Type, Orientation, Coating, Shape, Roughness and Other. Drilling and handling breaks are not usually included on the logs.

Defect Type

B	Bedding plane
Cs	Clay seam
Cv	Cleavage
Cz	Crushed zone
Ds	Decomposed seam
F	Fault
J	Joint
Lam	Lamination
Pt	Parting
Sz	Sheared Zone
V	Vein

Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

h	horizontal
v	vertical
sh	sub-horizontal
sv	sub-vertical

Coating or Infilling Term

cln	clean
co	coating
he	healed
inf	infilled
stn	stained
ti	tight
vn	veneer

Coating Descriptor

ca	calcite
cbs	carbonaceous
cly	clay
fe	iron oxide
mn	manganese
slt	silty

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

Other

fg	fragmented
bnd	band
qtz	quartz

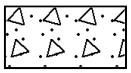
Symbols & Abbreviations

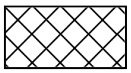
Graphic Symbols for Soil and Rock

General

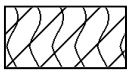

Asphalt

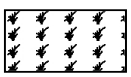

Road base

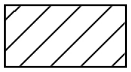

Concrete

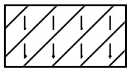

Filling

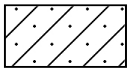
Soils


Topsoil

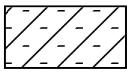

Peat

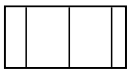

Clay

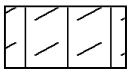

Silty clay

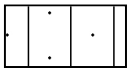

Sandy clay

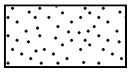

Gravelly clay

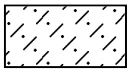

Shaly clay

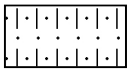

Silt


Clayey silt


Sandy silt


Sand

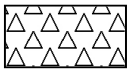

Clayey sand


Silty sand


Gravel

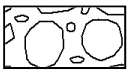

Sandy gravel


Cobbles, boulders

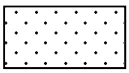

Talus

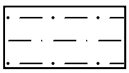
Sedimentary Rocks

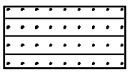

Boulder conglomerate

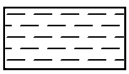

Conglomerate


Conglomeratic sandstone

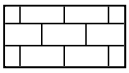

Sandstone


Siltstone

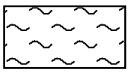

Laminite

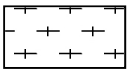

Mudstone, claystone, shale

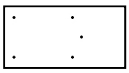

Coal


Limestone

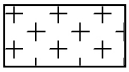
Metamorphic Rocks

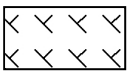

Slate, phyllite, schist

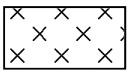

Gneiss

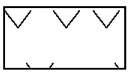

Quartzite

Igneous Rocks

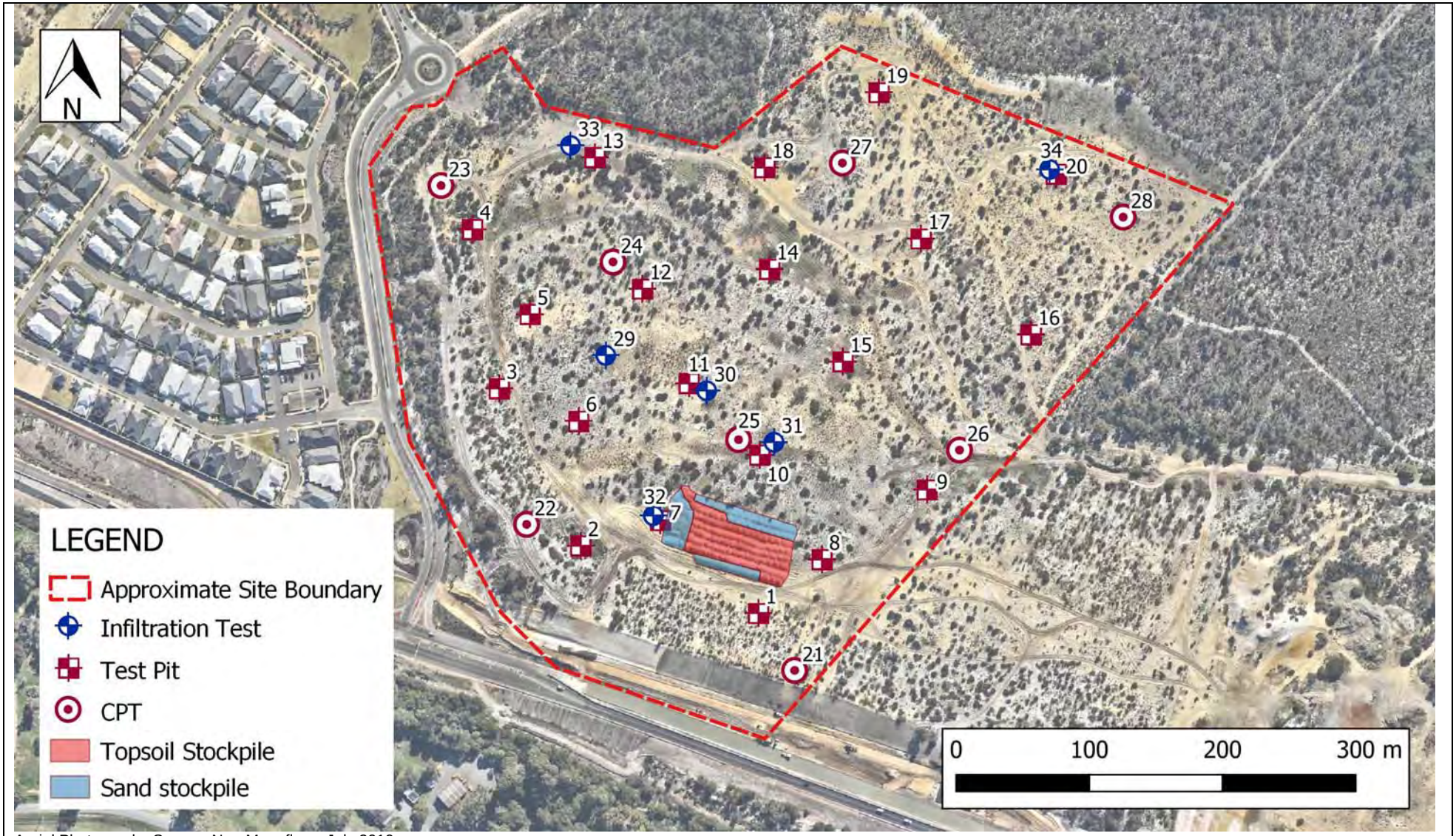

Granite


Dolerite, basalt, andesite


Dacite, epidote


Tuff, breccia


Porphyry



Aerial Photography Source: NearMap, flown July 2019.

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT:	Anstey Road Developments Pty Ltd	**Test Location Plan**	PROJECT No:	96594
	OFFICE:	Perth	**Proposed Residential Development**	DRAWING No:	1
	DATE:	2-9-2019	**Lot 821 Armadale Road, Banjup**	REVISION:	0

Appendix B

Results of Field Work

TEST PIT LOG

CLIENT: Anstey Road Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lot 821 Armadale Road, Banjup

SURFACE LEVEL: 31 m AHD*
EASTING: 394266
NORTHING: 6444506

PIT No: 1
PROJECT No: 96594
DATE: 30/8/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
31	0.1	FILL/SAND SP - fine to medium grained, grey, trace silt, trace organics, moist.		D	0.0 0.1				
		FILL/SAND SP - fine to medium grained, yellow-brown mottled grey, trace silt, moist, medium dense. Rootlets present to 0.2 m.							
30	1								1
				D	1.9 2.0				
29	2								2
	2.1	Pit discontinued at 2.1m (collapse)							



RIG: 8T Excavator with 800 mm wide bucket

LOGGED: PJ

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS: *surface levels interpolated from publicly available LiDAR and field observation

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

TEST PIT LOG

CLIENT: Anstey Road Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lot 821 Armadale Road, Banjup

SURFACE LEVEL: 31 m AHD*
EASTING: 394133
NORTHING: 6444556

PIT No: 2
PROJECT No: 96594
DATE: 30/8/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
31		FILL/SAND SP - fine to medium grained, dark grey-grey, trace silt, moist, loose.							
		- becoming brown-grey, medium dense from 0.6 m depth.							
30	1								1
				D	1.9				
29	2 2.0	Pit discontinued at 2.0m (collapse)			2.0				2



RIG: 8T Excavator with 800 mm wide bucket

LOGGED: PJ

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS: *surface levels interpolated from publicly available LiDAR and field observation

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Anstey Road Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lot 821 Armadale Road, Banjup

SURFACE LEVEL: 30.5 m AHD*
EASTING: 394072
NORTHING: 6444674

PIT No: 3
PROJECT No: 96594
DATE: 30/8/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
30	0	FILL/SAND SP - fine to medium grained, grey-brown, trace silt, trace organics, moist, loose. Rootlets to 0.2 m.							5 10 15 20
	1								1
29	1.2	SAND SP - fine to medium grained, pale yellow, trace silt, moist, loose. - becoming medium dense from 1.35 m depth.							
	1.6	Pit discontinued at 1.6m (collapse)							
	2								
28									



RIG: 8T Excavator with 800 mm wide bucket

LOGGED: PJ

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS: *surface levels interpolated from publicly available LiDAR and field observation

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics | Environment | Groundwater

TEST PIT LOG

CLIENT: Anstey Road Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lot 821 Armadale Road, Banjup

SURFACE LEVEL: 30.5 m AHD*
EASTING: 394052
NORTHING: 6444794

PIT No: 4
PROJECT No: 96594
DATE: 30/8/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
30	0.3	FILL/SAND SP - fine to medium grained, grey/brown, trace silt, with rootlets, moist, loose.							
		SAND SP - fine to medium grained, yellow-brown, trace silt, moist, medium dense. - becoming pale yellow from 0.7 m depth.							
29	1.7	Pit discontinued at 1.7m (collapse)							
28									



RIG: 8T Excavator with 800 mm wide bucket

LOGGED: PJ

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS: *surface levels interpolated from publicly available LiDAR and field observation

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics | Environment | Groundwater

TEST PIT LOG

CLIENT: Anstey Road Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lot 821 Armadale Road, Banjup

SURFACE LEVEL: 30 m AHD*
EASTING: 394095
NORTHING: 6444730

PIT No: 5
PROJECT No: 96594
DATE: 30/8/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
30	0.0	FILL/SAND SP - fine to medium grained, grey/brown, trace silt, with rootlets, moist, loose.		D	0.0 0.1				
	0.3	SAND SP - fine to medium grained, pale yellow, trace silt, moist, medium dense.							
29	1								1
	1.9	Pit discontinued at 1.9m (collapse)							
28	2								

5 10 15 20



RIG: 8T Excavator with 800 mm wide bucket

LOGGED: PJ

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS: *surface levels interpolated from publicly available LiDAR

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Anstey Road Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lot 821 Armadale Road, Banjup

SURFACE LEVEL: 30 m AHD*
EASTING: 394131
NORTHING: 6444650

PIT No: 6
PROJECT No: 96594
DATE: 30/8/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
30		FILL/SAND SP - fine to medium grained, grey-brown, trace silt, trace organics, moist, loose. Rootlets to 0.2 m.							
		- becoming dense from 0.45 m depth.							
	0.6	SAND SP - fine to medium grained, pale yellow, trace silt, moist, dense.		D	0.8 0.9				
29	1	- becoming pale white from 0.9 m depth.							1
28	2	2.0 Pit discontinued at 2.0m (collapse)							2

5 10 15 20



RIG: 8T Excavator with 800 mm wide bucket

LOGGED: PJ

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS: *surface levels interpolated from publicly available LiDAR

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Anstey Road Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lot 821 Armadale Road, Banjup

SURFACE LEVEL: 30 m AHD*
EASTING: 394193
NORTHING: 6444575

PIT No: 7
PROJECT No: 96594
DATE: 30/8/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
30	0.1	FILL/GRAVELLY SAND SW - fine to medium grained, brown, moist. Gravel comprises granite, brick, crushed rock.		D	0.0 0.1				
		FILL/SAND SP-SW - fine to medium grained, dark grey, with gravel, moist, loose.							
	0.55	SAND SP - fine to medium grained, pale yellow, trace silt, moist.							
29	1	- becoming medium dense.							1
		- becoming pale white from 1.4 m depth.							
	1.8	Pit discontinued at 1.8m (collapse)							
28	2								



RIG: 8T Excavator with 800 mm wide bucket

LOGGED: PJ

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS: *surface levels interpolated from publicly available LiDAR

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Anstey Road Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lot 821 Armadale Road, Banjup

SURFACE LEVEL: 30 m AHD*
EASTING: 394314
NORTHING: 6444546

PIT No: 8
PROJECT No: 96594
DATE: 30/8/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
30		FILL/SAND SP - fine to medium grained, grey-white, trace silt, with rootlets, moist, loose. Rubber hose and glass found at surface.							
		- becoming dense from 0.45 m depth.							
		- becoming yellow-brown mottled grey from 0.6 m depth.							
29	1			D	1.2 1.3				1
		- becoming brown with gravel sized pieces of coffee rock. Occasional cobbles of coffee rock.							
28	2			D	2.0 2.1				2
	2.4	Pit discontinued at 2.4m (collapse)							



RIG: 8T Excavator with 800 mm wide bucket

LOGGED: PJ

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS: *surface levels interpolated from publicly available LiDAR

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Anstey Road Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lot 821 Armadale Road, Banjup

SURFACE LEVEL: 30 m AHD*
EASTING: 394393
NORTHING: 6444598

PIT No: 9
PROJECT No: 96594
DATE: 30/8/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
30		FILL/GRAVELLY SAND SW - fine to medium grained, pale brown-grey, moist, medium dense. Gravel comprises granite, brick, crushed rock.		D	0.2 0.3				
	0.55	FILL/SAND SP - fine to medium grained, dark grey mottled yellow-brown, trace gravel, moist, medium dense.							
	0.75	SAND SP - fine to medium grained, pale grey, trace silt, moist, desne.							
29	1			D	1.1 1.2				1
	1.6	Pit discontinued at 1.6m (collapse)							
28	2								



RIG: 8T Excavator with 800 mm wide bucket

LOGGED: PJ

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS: *surface levels interpolated from publicly available LiDAR

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Anstey Road Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lot 821 Armadale Road, Banjup

SURFACE LEVEL: 30 m AHD*
EASTING: 394267
NORTHING: 6444624

PIT No: 10
PROJECT No: 96594
DATE: 30/8/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
30		FILL/GRAVELLY SAND SW - fine to medium grained, brown, loose. Gravel comprises granite, brick, crushed rock.		D	0.3 0.4				
		- becoming medium dense from 0.6 m depth.							
	0.8	FILL/SAND SP - fine to medium grained, dark grey,trace silt, moist, medium dense to dense.		D	1.0 1.1				
29	1								1
28	2								2
	2.2	Pit discontinued at 2.2m (collapse)							



RIG: 8T Excavator with 800 mm wide bucket

LOGGED: PJ

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS: *surface levels interpolated from publicly available LiDAR

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Anstey Road Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lot 821 Armadale Road, Banjup

SURFACE LEVEL: 30 m AHD*
EASTING: 394214
NORTHING: 6444678

PIT No: 11
PROJECT No: 96594
DATE: 30/8/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
30		SAND SP-SM - fine to medium grained, dark grey, with silt, trace rootlets, moist, medium dense.		D	0.0 0.1				
	0.35	SAND SP - fine to medium grained, pale white, trace silt, moist, medium dense.							
29	1	- becoming dense from 0.6 m depth.		D	0.5 0.6				
	1.9	Pit discontinued at 1.9m (collapse)							
28	2								



RIG: 8T Excavator with 800 mm wide bucket

LOGGED: PJ

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS: *surface levels interpolated from publicly available LiDAR

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Anstey Road Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lot 821 Armadale Road, Banjup

SURFACE LEVEL: 30 m AHD*
EASTING: 394179
NORTHING: 6444749

PIT No: 12
PROJECT No: 96594
DATE: 30/8/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
30	0.3	FILL/SAND SP - fine to medium grained, grey-brown, trace silt, trace gravel, moist, loose.		D	0.2 0.3				
29	1	SAND SP - fine to medium grained, yellow, trace silt, moist, medium dense. - becoming dense from 0.75 m depth.		D	0.6 0.7				
28	1.7 2	Pit discontinued at 1.7m (collapse)							



RIG: 8T Excavator with 800 mm wide bucket

LOGGED: PJ

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS: *surface levels interpolated from publicly available LiDAR

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Anstey Road Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lot 821 Armadale Road, Banjup

SURFACE LEVEL: 30 m AHD*
EASTING: 394144
NORTHING: 6444848

PIT No: 13
PROJECT No: 96594
DATE: 30/8/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
30	0.0	FILL/GRAVELLY SAND SW - fine to medium grained, pale brown-grey, moist, loose. Gravel comprises granite, brick, crushed rock.		D	0.1 0.2				
	0.5	FILL/SAND SP - fine to medium grained, yellow-grey, trace silt, trace organics, moist, loose. - becoming dense from 0.6 m depth.		D	0.6 0.7				
29	1								1
	1.3	SAND SP - fine to medium grained, pale yellow, trace silt, moist.		D	1.4 1.5				
28	1.9	Pit discontinued at 1.9m (collapse)							
	2								

5 10 15 20



RIG: 8T Excavator with 800 mm wide bucket

LOGGED: PJ

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS: *surface levels interpolated from publicly available LiDAR

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Anstey Road Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lot 821 Armadale Road, Banjup

SURFACE LEVEL: 30 m AHD*
EASTING: 394275
NORTHING: 6444764

PIT No: 14
PROJECT No: 96594
DATE: 30/8/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
30		FILL/SAND SP-W - fine to medium grained, brown, with gravel, moist, loose. Gravel comprises granite, brick, crushed rock.		D	0.2 0.3				
	0.5	SAND SP - fine to medium grained, pale grey, trace silt, moist, dense.							
29	1								1
		- becoming yellow-brown from 1.7 m depth.		D	1.8 1.9				
28	2	2.0 Pit discontinued at 2.0m (collapse)							2



RIG: 8T Excavator with 800 mm wide bucket

LOGGED: PJ

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS: *surface levels interpolated from publicly available LiDAR

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Anstey Road Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lot 821 Armadale Road, Banjup

SURFACE LEVEL: 30 m AHD*
EASTING: 394330
NORTHING: 6444694

PIT No: 15
PROJECT No: 96594
DATE: 30/8/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
30		FILL/SAND SP - fine to medium grained, grey/brown, trace silt, trace rootlets, moist. Gravel (brick, granite, crushed rock) on surface.							
		- becoming dense from 0.45 m depth.							
	0.65	SAND SP - fine to medium grained, pale grey mottled pale brown, trace silt, moist, dense. Possible fill.							
29	1			D	1.5 1.6				1
	1.8	Pit discontinued at 1.8m (collapse)							
28	2								



RIG: 8T Excavator with 800 mm wide bucket

LOGGED: PJ

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS: *surface levels interpolated from publicly available LiDAR

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Anstey Road Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lot 821 Armadale Road, Banjup

SURFACE LEVEL: 30 m AHD*
EASTING: 394471
NORTHING: 6444715

PIT No: 16
PROJECT No: 96594
DATE: 30/8/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
30		FILL/SAND SP - fine to medium grained, brown mottled grey, trace silt, moist, dense. Rootlets to 0.4 m depth.							
		- becoming yellow-brown mottled grey from 0.3 m depth.							
29	1			D	0.9 1.0				1
28	2								2
	2.5	SAND SP - fine to medium grained, orange-brown, trace silt, moist.		D	2.5				
	2.6	Pit discontinued at 2.6m (collapse)			2.6				



RIG: 8T Excavator with 800 mm wide bucket

LOGGED: PJ

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS: *surface levels interpolated from publicly available LiDAR

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Anstey Road Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lot 821 Armadale Road, Banjup

SURFACE LEVEL: 30 m AHD*
EASTING: 394388
NORTHING: 6444787

PIT No: 17
PROJECT No: 96594
DATE: 30/8/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
30		FILL/SAND SP - fine to medium grained, brown, trace silt, moist, loose to medium dense. Roots (10-20 mm thick) to 0.3 m depth.							
		- becoming dense from 0.45 m depth.							
		- becoming grey-brown from 0.6 m depth.							
29	1			D	1.0 1.1				1
28	2								2
	2.4	SAND SP - fine to medium grained, yellow, trace silt, moist.							
	2.6	Pit discontinued at 2.6m (collapse)							

Dynamic Penetrometer Test (blows per 150mm): 5 10 15 20



RIG: 8T Excavator with 800 mm wide bucket

LOGGED: PJ

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS: *surface levels interpolated from publicly available LiDAR

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Anstey Road Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lot 821 Armadale Road, Banjup

SURFACE LEVEL: 30 m AHD*
EASTING: 394271
NORTHING: 6444840

PIT No: 18
PROJECT No: 96594
DATE: 30/8/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
30		FILL/SAND SP - fine to medium grained, yellow-grey, trace silt, trace organics, moist, medium dense.							
		- becoming dark grey-yellow from 0.5 m depth.							
		- becoming dense from 0.6 m depth.							
29	1			D	0.9 1.0				1
		- old rubber pipe at approximately 1.1 m depth.							
28	2	2.0 Pit discontinued at 2.0m (collapse)							2



RIG: 8T Excavator with 800 mm wide bucket

LOGGED: PJ

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS: *surface levels interpolated from publicly available LiDAR

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Anstey Road Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lot 821 Armadale Road, Banjup

SURFACE LEVEL: 30 m AHD*
EASTING: 394357
NORTHING: 6444896

PIT No: 19
PROJECT No: 96594
DATE: 30/8/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
30		FILL/SAND SP - fine to medium grained, grey mottled yellow-brown, trace silt, moist, medium dense.		D	0.45 0.5				
29	1	- becoming dense from 0.6 m depth.							1
28	2								2
	2.4	SAND SP - fine to medium grained, pale yellow, trace silt, moist.		D	2.4 2.5				
	2.5	Pit discontinued at 2.5m (collapse)							



RIG: 8T Excavator with 800 mm wide bucket

LOGGED: PJ

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS: *surface levels interpolated from publicly available LiDAR

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Anstey Road Developments Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: Lot 821 Armadale Road, Banjup

SURFACE LEVEL: 30 m AHD*
EASTING: 394490
NORTHING: 6444835

PIT No: 20
PROJECT No: 96594
DATE: 30/8/2019
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
30		FILL/SAND SP - fine to medium grained, brown mottled dark grey, trace silt, moist, medium dense to dense.							
29	1								
28	2								
	2.4	Pit discontinued at 2.4m (collapse)							



RIG: 8T Excavator with 800 mm wide bucket

LOGGED: PJ

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No Free Groundwater Observed

REMARKS: *surface levels interpolated from publicly available LiDAR

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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CONE PENETRATION TEST

CLIENT: Anstey Road Developments Pty Ltd

PROJECT: Proposed Residential Development

LOCATION: Lot 821 Armadale Road

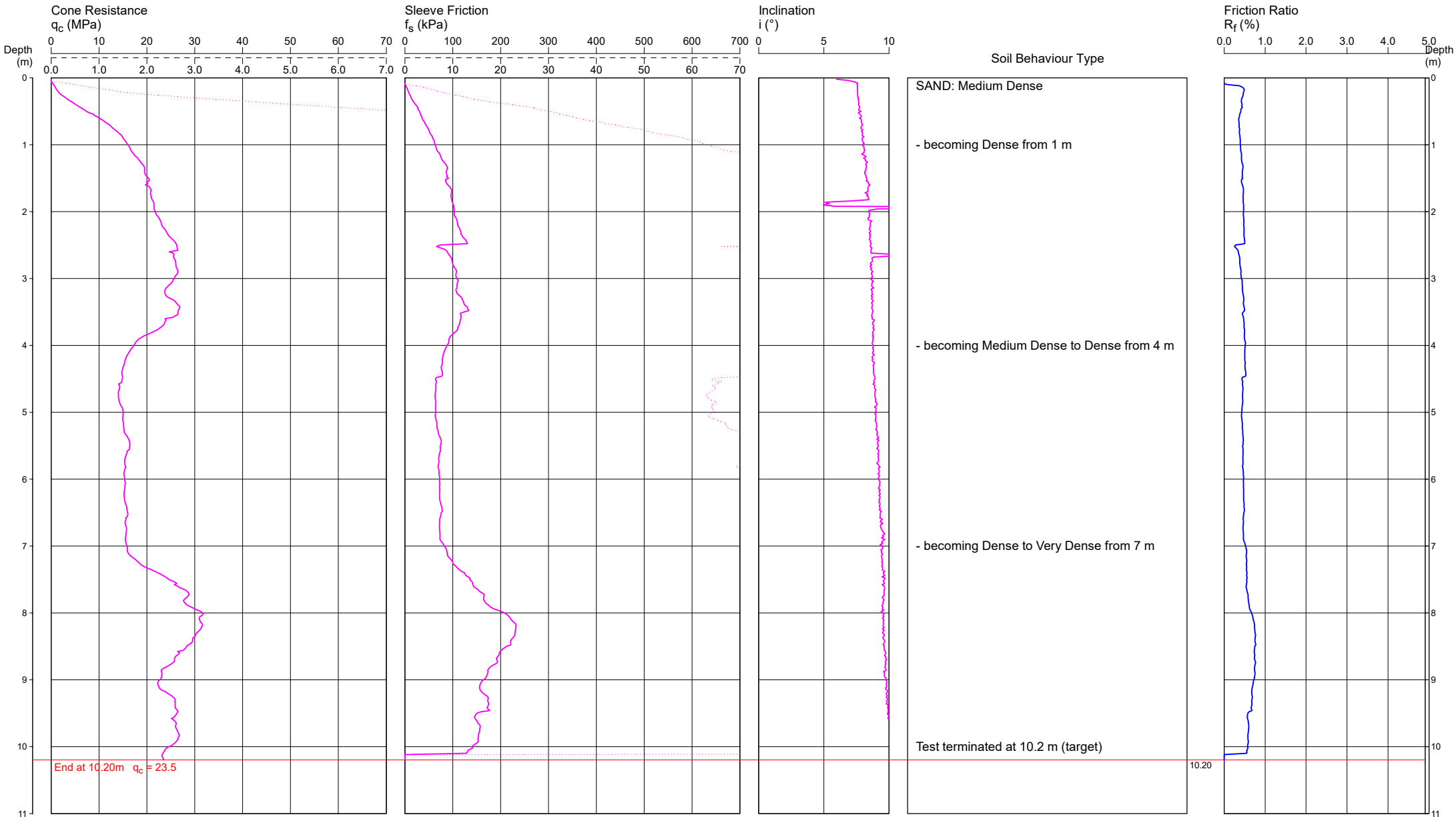
REDUCED LEVEL: 37.3

COORDINATES: 394294E 6444462N

CPT 21

DATE 2/09/2019

PROJECT No: 96594.00



REMARKS: Surface level interpolated from publicly available LiDAR data.

File: P:\96594.00 - BANJUP, Lot 821 Armadale Road\4.0 Field Work\CPT\DP\96594 - CPT 21.CP5
Cone ID: Probedrill **Type:** EC05

ConePlot Version 5.9.2

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CONE PENETRATION TEST

CLIENT: Anstey Road Developments Pty Ltd

PROJECT: Proposed Residential Development

LOCATION: Lot 821 Armadale Road

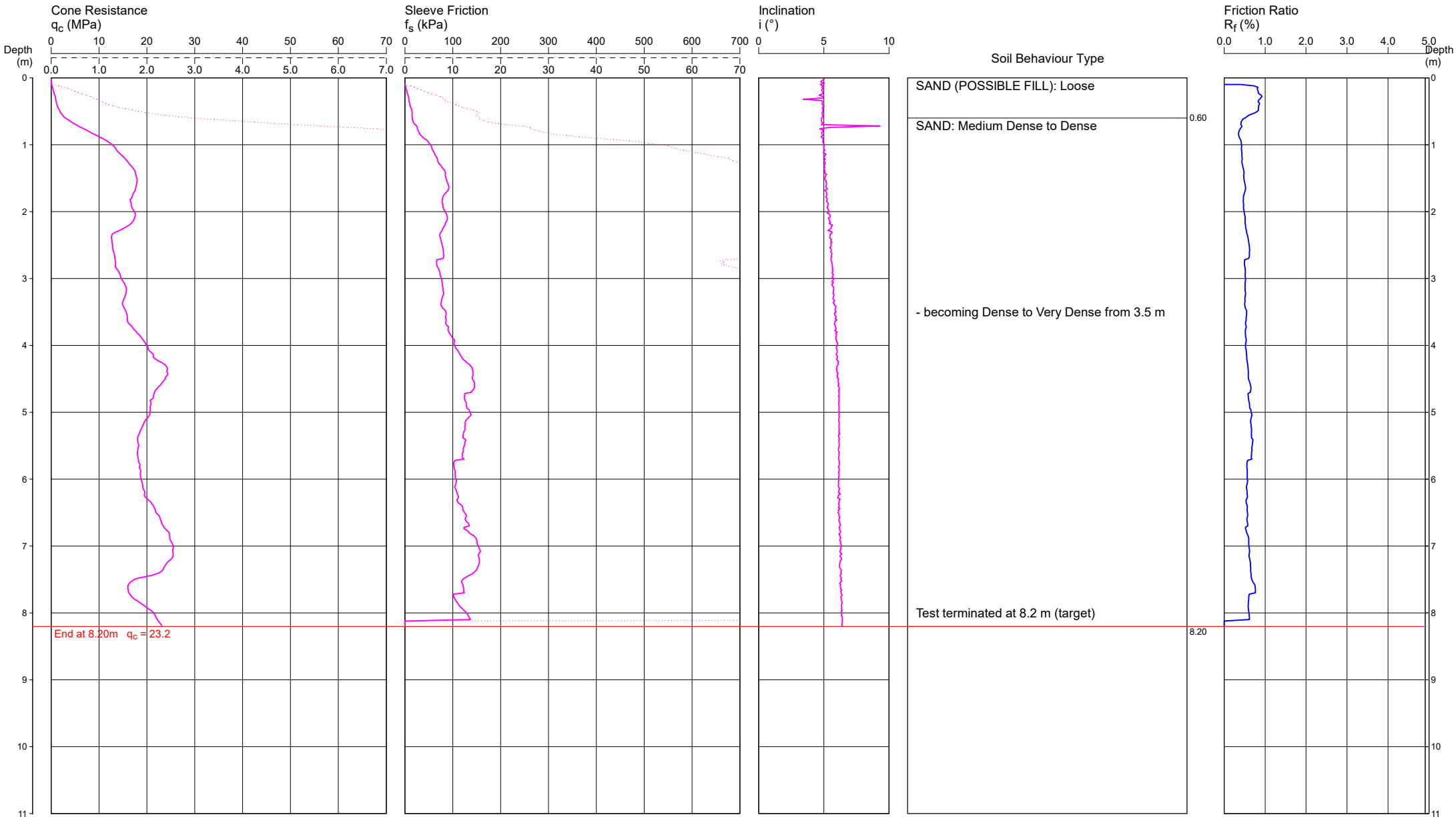
REDUCED LEVEL: 36.5

COORDINATES: 394093E 6444572N

CPT 22

DATE 2/09/2019

PROJECT No: 96594.00



REMARKS: Surface level interpolated from publicly available LiDAR data.

File: P:\96594.00 - BANJUP, Lot 821 Armadale Road\4.0 Field Work\CPT\DP\96594 - CPT 22.CP5
Cone ID: Probedrill **Type:** EC05

ConePlot Version 5.9.2

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CONE PENETRATION TEST

CLIENT: Anstey Road Developments Pty Ltd

PROJECT: Proposed Residential Development

LOCATION: Lot 821 Armadale Road

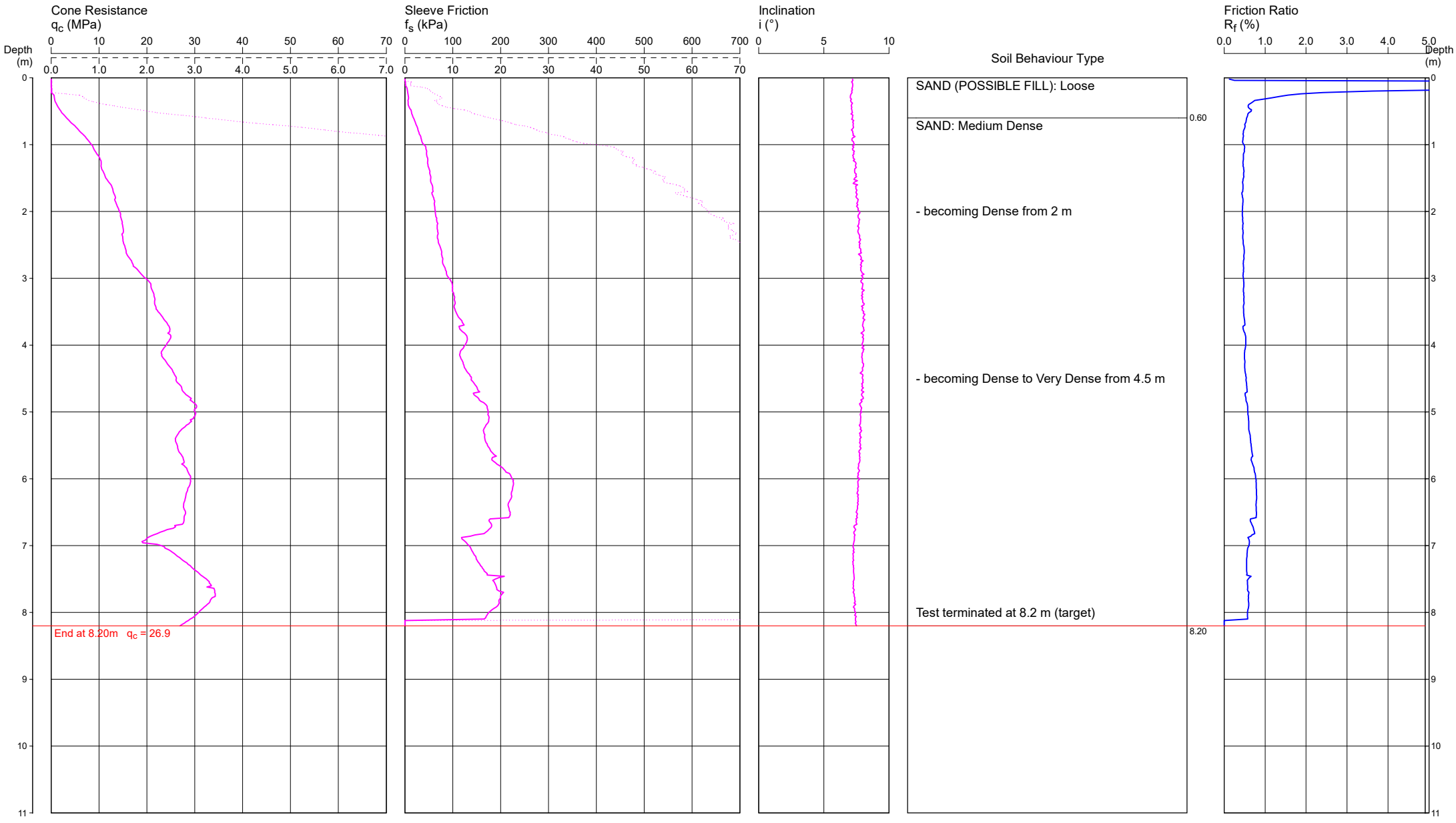
REDUCED LEVEL: 35.6

COORDINATES: 394028E 6444826N

CPT 23

DATE 2/09/2019

PROJECT No: 96594.00



REMARKS: Surface level interpolated from publicly available LiDAR data.

File: P:\96594.00 - BANJUP, Lot 821 Armadale Road\4.0 Field Work\CPT\DP\96594 - CPT 23.CP5
Cone ID: Probedrill **Type:** EC05

ConePlot Version 5.9.2

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CONE PENETRATION TEST

CLIENT: Anstey Road Developments Pty Ltd

PROJECT: Proposed Residential Development

LOCATION: Lot 821 Armadale Road

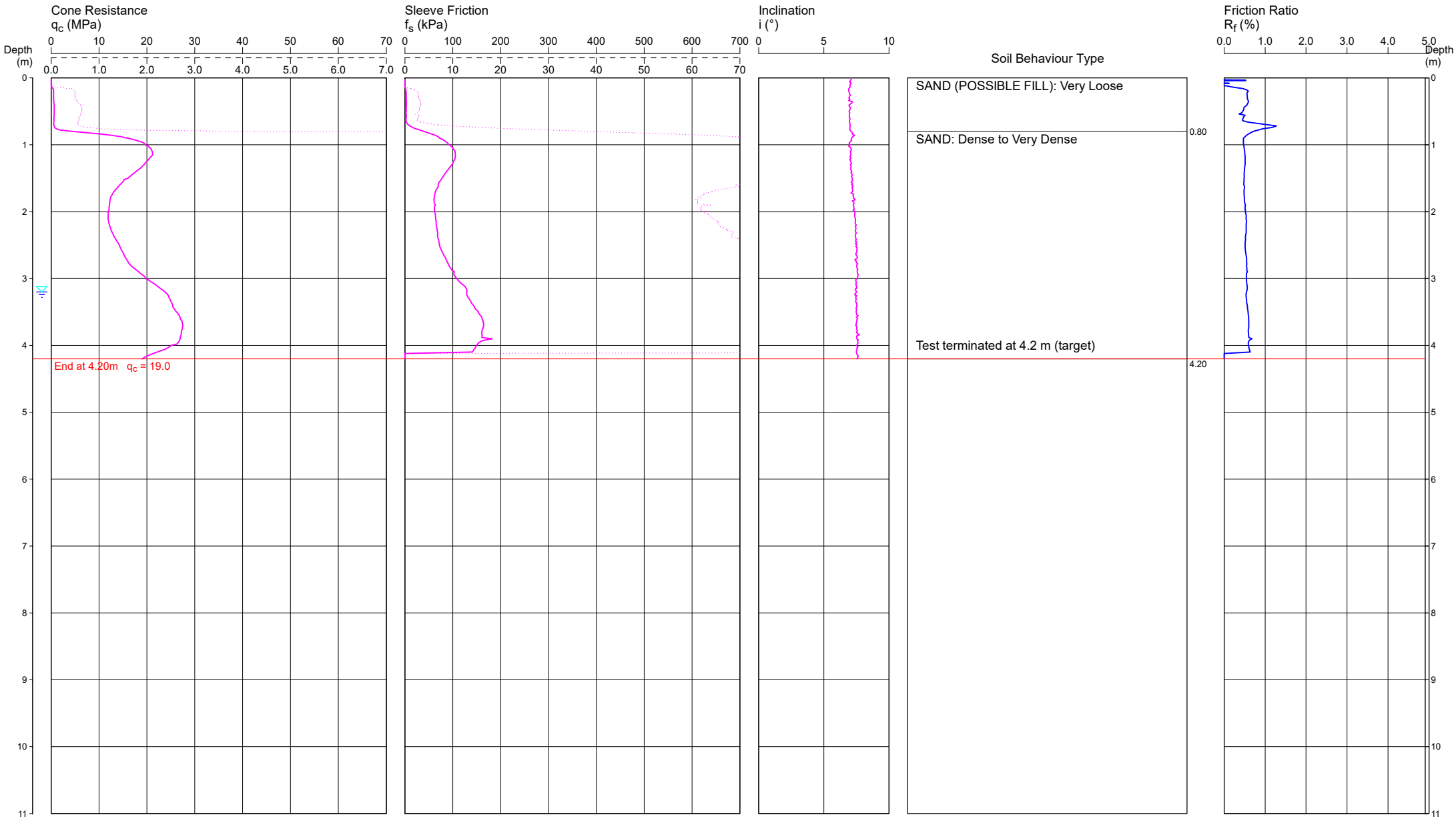
REDUCED LEVEL: 30

COORDINATES: 394158E 6444769N

CPT 24

DATE 2/09/2019

PROJECT No: 96594.00



REMARKS: Surface level interpolated from publicly available LiDAR data.

Water depth after test: 3.20m depth (assumed)

File: P:\96594.00 - BANJUP, Lot 821 Armadale Road\4.0 Field Work\CPT\DP\96594 - CPT 24.CP5
Cone ID: Probedrill **Type:** EC05

ConePlot Version 5.9.2
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CONE PENETRATION TEST

CLIENT: Anstey Road Developments Pty Ltd

PROJECT: Proposed Residential Development

LOCATION: Lot 821 Armadale Road

REDUCED LEVEL: 30

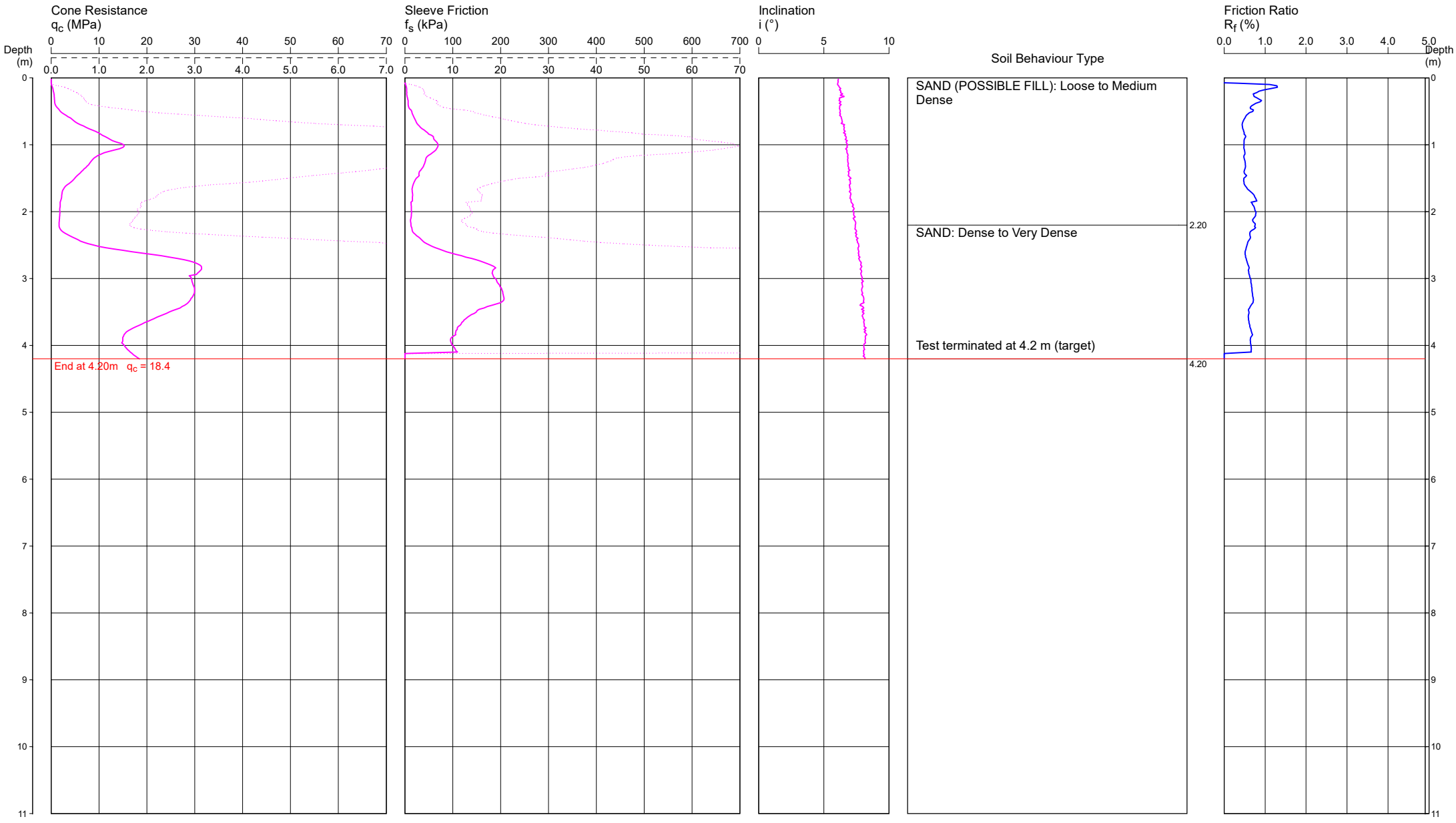
COORDINATES: 394252E 6444636N

CPT 25

Page 1 of 1

DATE 2/09/2019

PROJECT No: 96594.00



REMARKS: Surface level interpolated from publicly available LiDAR data.

File: P:\96594.00 - BANJUP, Lot 821 Armadale Road\4.0 Field Work\CPT\DP\96594 - CPT 25.CP5
Cone ID: Probedrill **Type:** EC05

ConePlot Version 5.9.2
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CONE PENETRATION TEST

CLIENT: Anstey Road Developments Pty Ltd

PROJECT: Proposed Residential Development

LOCATION: Lot 821 Armadale Road

REDUCED LEVEL: 30

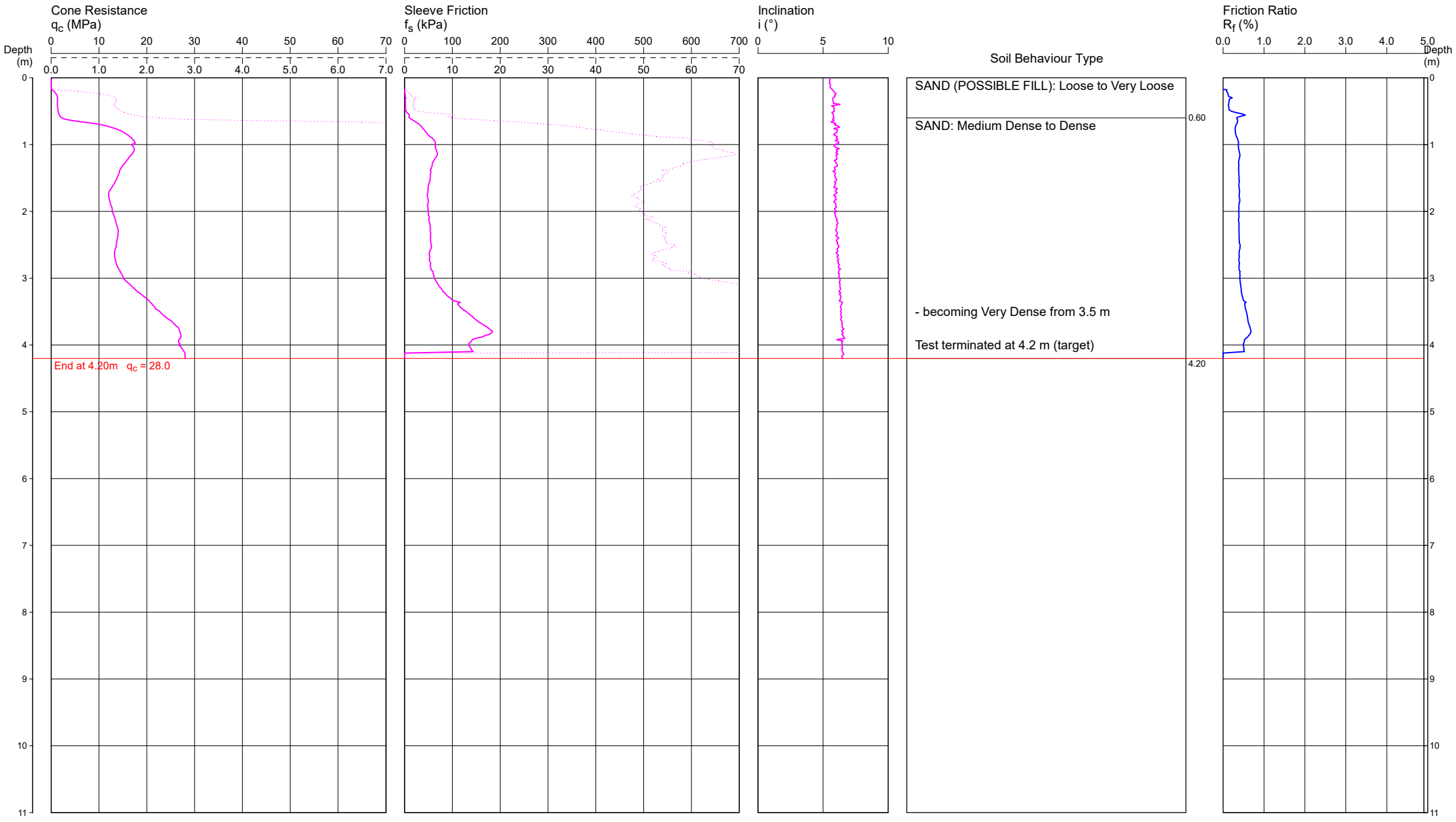
COORDINATES: 394418E 6444628N

CPT 26

Page 1 of 1

DATE 2/09/2019

PROJECT No: 96594.00



REMARKS: Surface level interpolated from publicly available LiDAR data.

File: P:\96594.00 - BANJUP, Lot 821 Armadale Road\4.0 Field Work\CPT\DP\96594 - CPT 26.CP5
Cone ID: Probedrill **Type:** EC05

ConePlot Version 5.9.2
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CONE PENETRATION TEST

CLIENT: Anstey Road Developments Pty Ltd

PROJECT: Proposed Residential Development

LOCATION: Lot 821 Armadale Road

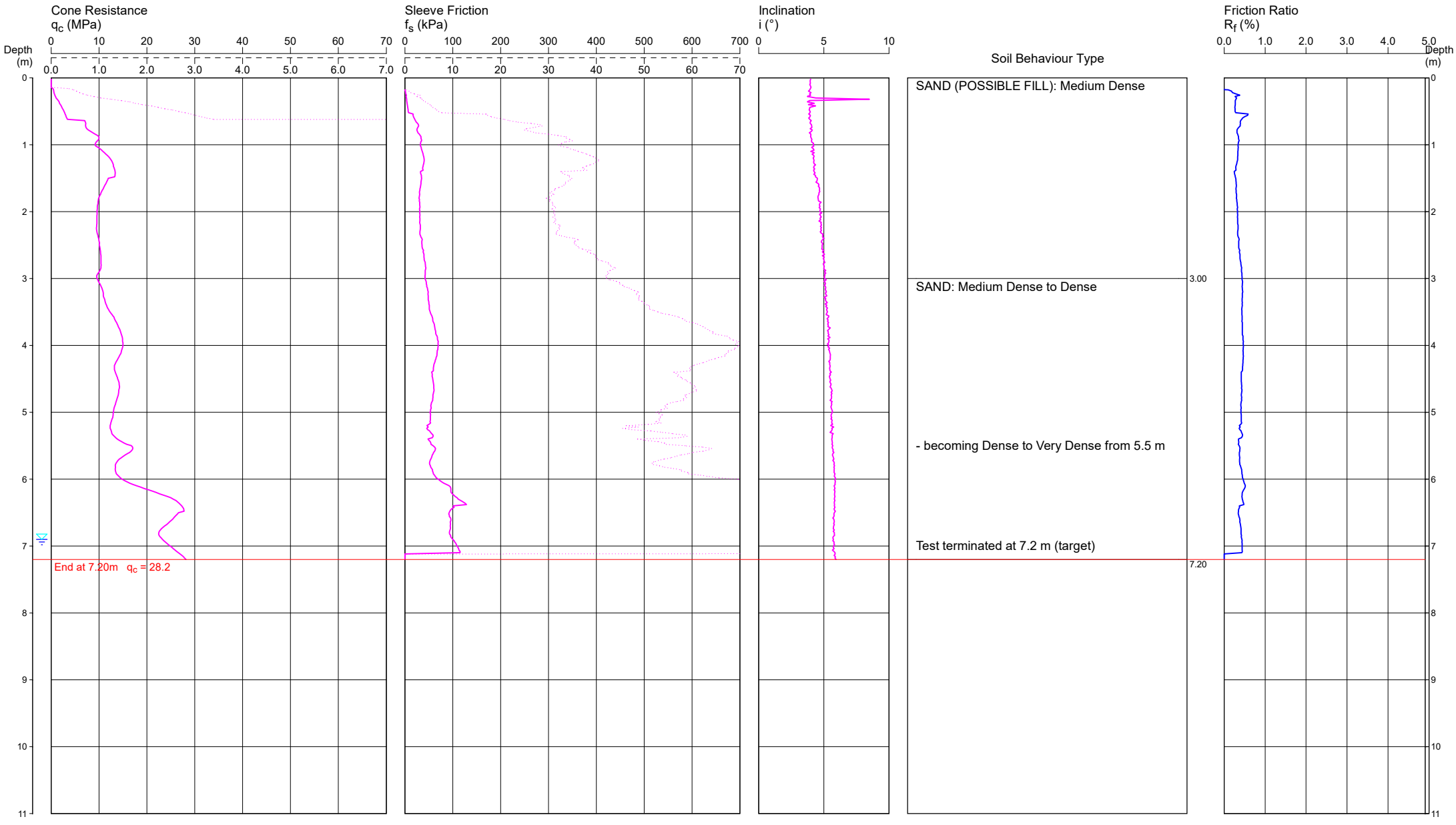
REDUCED LEVEL: 33.8

COORDINATES: 394330E 6444843N

CPT 27

DATE 2/09/2019

PROJECT No: 96594.00



REMARKS: Surface level interpolated from publicly available LiDAR data.

Water depth after test: 6.90m depth (assumed)

File: P:\96594.00 - BANJUP, Lot 821 Armadale Road\4.0 Field Work\CPT\DP\96594 - CPT 27.CP5
Cone ID: Probedrill **Type:** EC05

ConePlot Version 5.9.2
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CONE PENETRATION TEST

CLIENT: Anstey Road Developments Pty Ltd

PROJECT: Proposed Residential Development

LOCATION: Lot 821 Armadale Road

REDUCED LEVEL: 30

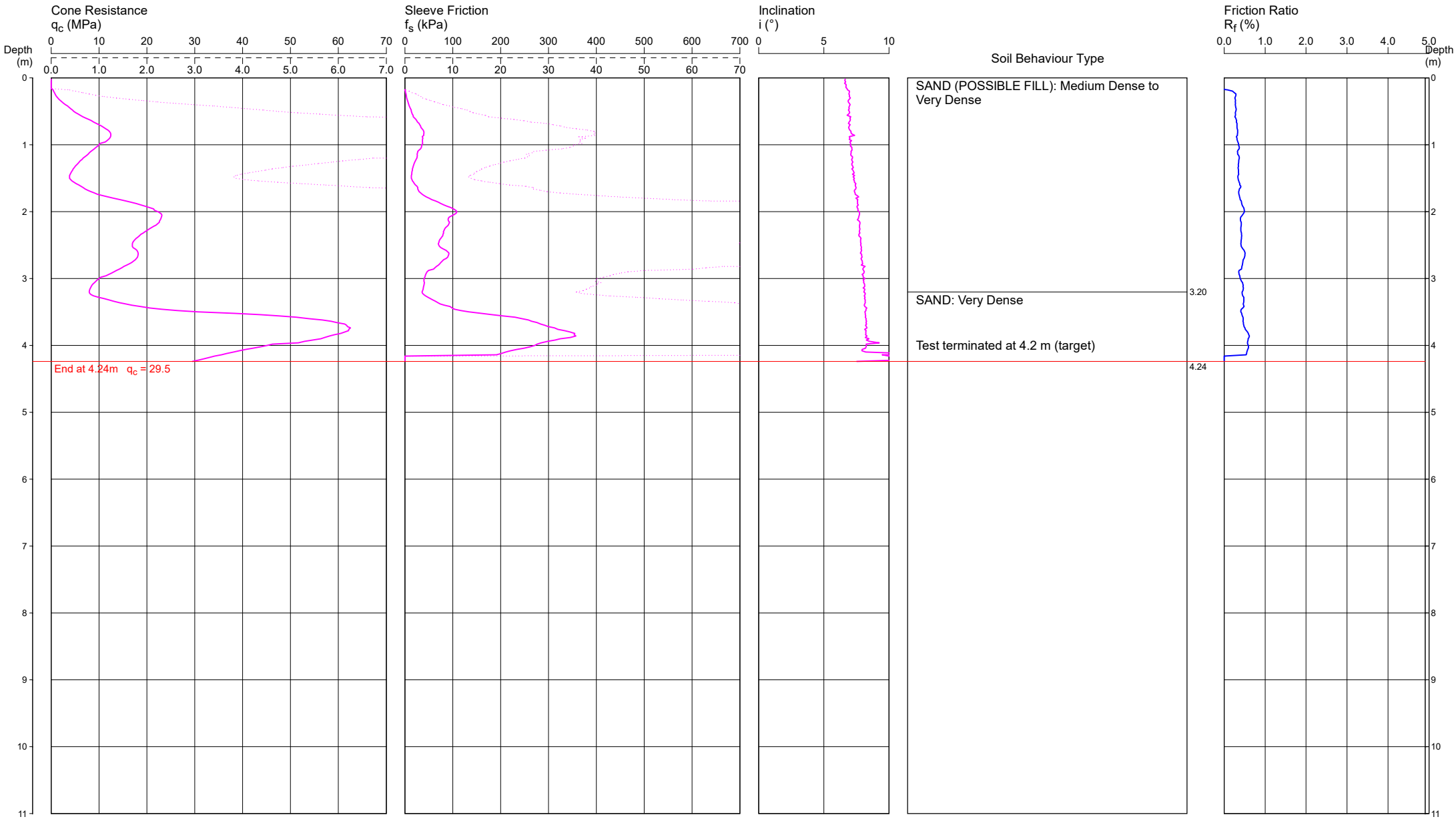
COORDINATES: 394540E 6444802N

CPT 28

Page 1 of 1

DATE 2/09/2019

PROJECT No: 96594.00



REMARKS: Surface level interpolated from publicly available LiDAR data.

File: P:\96594.00 - BANJUP, Lot 821 Armadale Road\4.0 Field Work\CPT\DP\96594 - CPT 28.CP5
Cone ID: Probedrill **Type:** EC05

ConePlot Version 5.9.2
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Appendix C

Results of Laboratory Testing

WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

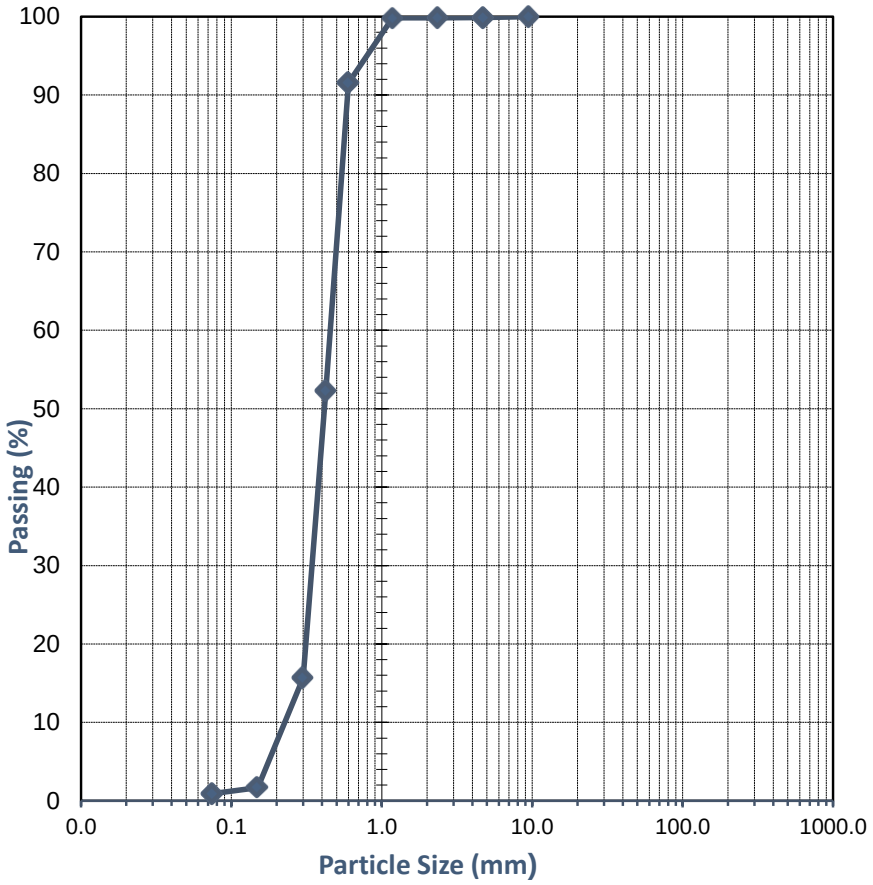
TEST REPORT - AS 1289.3.6.1

Client:	Anstey Road Developments Pty Ltd	*Ticket No.*	S341
Client Address:	-	*Report No.*	WG19/2669_1_PSD
Project:	Proposed Residential Development	*Sample No.*	WG19/2669
Location:	Lot 821 Armadale Road, Banjup	*Date Sampled:*	1-09-2019
Sample Identification:	TP2 1.9-2.0m	*Date Tested:*	4-09-2019

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve
75.0	
53.0	
37.5	
19.0	
9.5	100
4.75	100
2.36	100
1.18	100
0.600	92
0.425	52
0.300	16
0.150	2
0.075	1



Comments:

Approved Signatory:

Name: Matt van Herk
Function: General Manager
Date: 05-September-2019

Accreditation No. 20599
Accredited for compliance with ISO/IEC 17025 - Testing

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

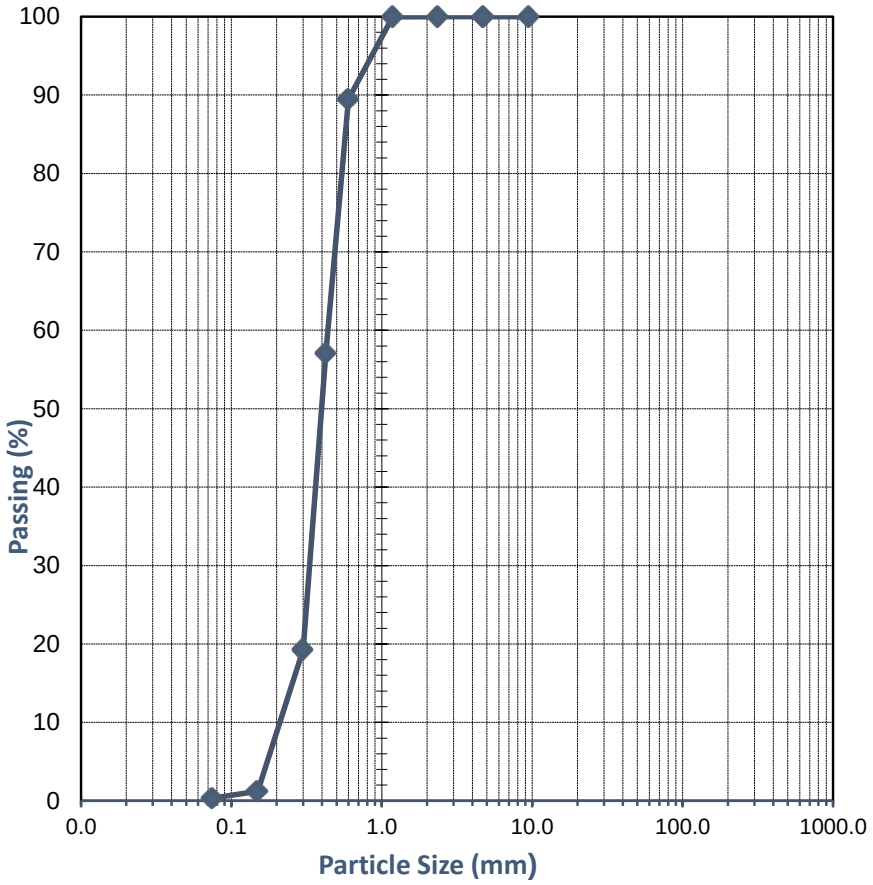
TEST REPORT - AS 1289.3.6.1

Client:	Anstey Road Developments Pty Ltd	*Ticket No.*	S341
Client Address:	-	*Report No.*	WG19/2671_1_PSD
Project:	Proposed Residential Development	*Sample No.*	WG19/2671
Location:	Lot 821 Armadale Road, Banjup	*Date Sampled:*	1-09-2019
Sample Identification:	TP12 0.6-0.7m	*Date Tested:*	4-09-2019

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve
75.0	
53.0	
37.5	
19.0	
9.5	100
4.75	100
2.36	100
1.18	100
0.600	89
0.425	57
0.300	19
0.150	1
0.075	0



Comments:

Approved Signatory:

Name: Matt van Herk
Function: General Manager
Date: 05-September-2019

Accreditation No. 20599
Accredited for compliance with ISO/IEC 17025 - Testing

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

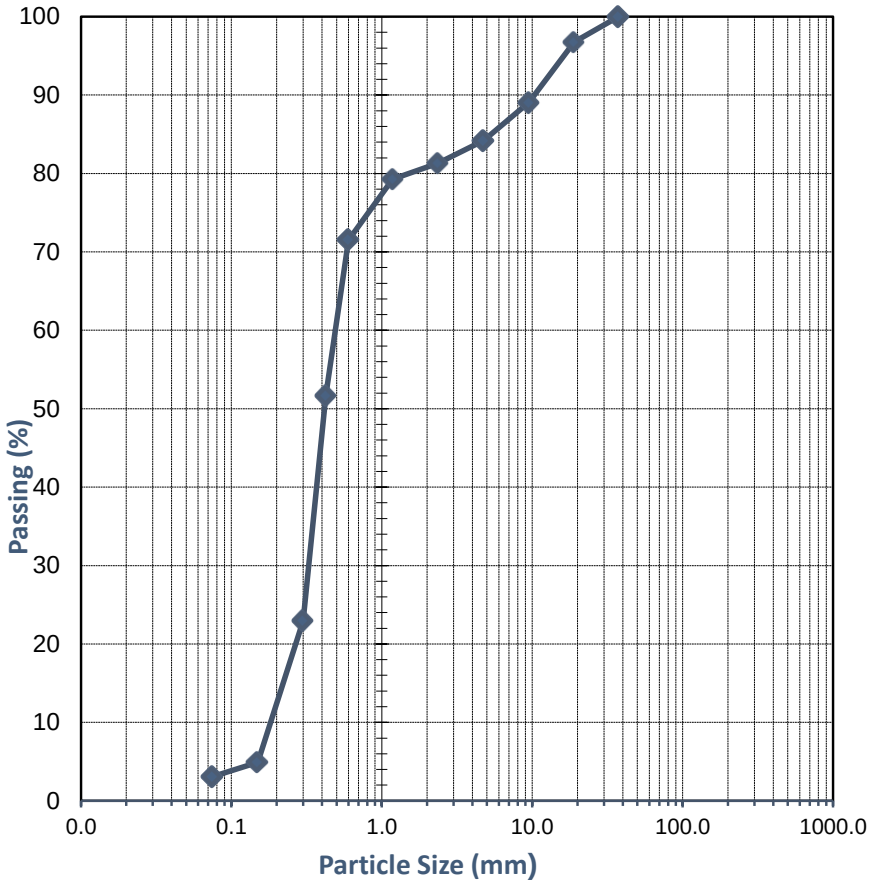
TEST REPORT - AS 1289.3.6.1

Client:	Anstey Road Developments Pty Ltd	*Ticket No.*	S341
Client Address:	-	*Report No.*	WG19/2673_1_PSD
Project:	Proposed Residential Development	*Sample No.*	WG19/2673
Location:	Lot 821 Armadale Road, Banjup	*Date Sampled:*	1-09-2019
Sample Identification:	TP14 0.2-0.3m	*Date Tested:*	4-09-2019

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve
75.0	
53.0	
37.5	100
19.0	97
9.5	89
4.75	84
2.36	81
1.18	79
0.600	72
0.425	52
0.300	23
0.150	5
0.075	3



Comments:

Approved Signatory:

Name: Matt van Herk
Function: General Manager
Date: 05-September-2019

Accreditation No. 20599
Accredited for compliance with ISO/IEC 17025 - Testing

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

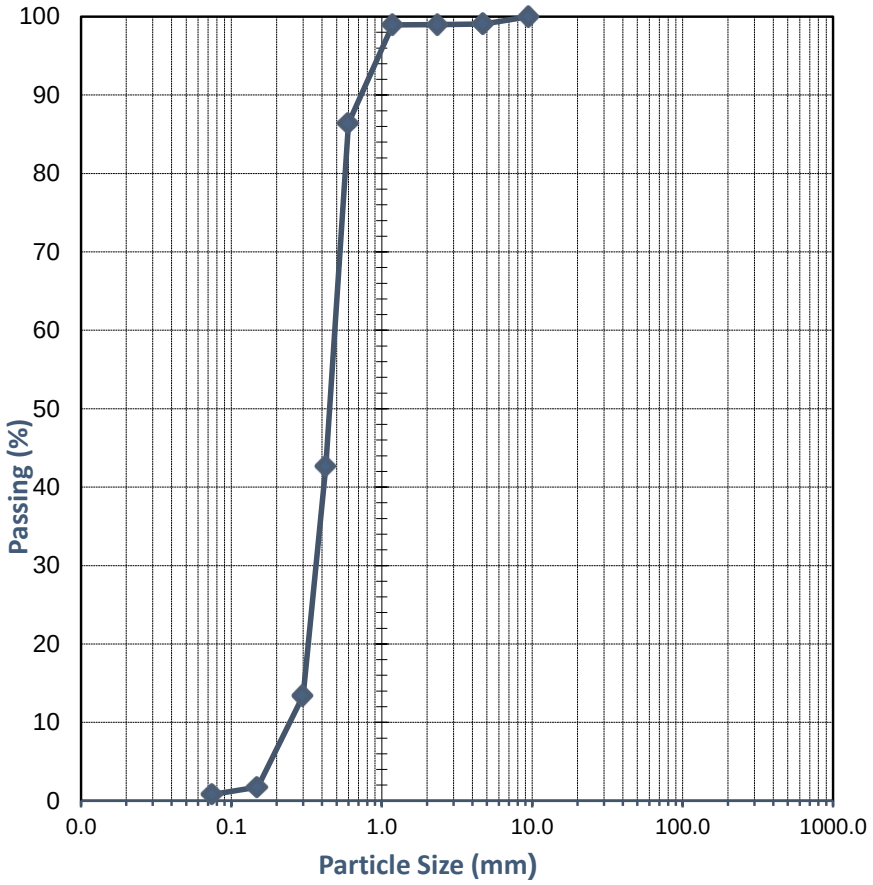
TEST REPORT - AS 1289.3.6.1

Client:	Anstey Road Developments Pty Ltd	*Ticket No.*	S341
Client Address:	-	*Report No.*	WG19/2672_1_PSD
Project:	Proposed Residential Development	*Sample No.*	WG19/2672
Location:	Lot 821 Armadale Road, Banjup	*Date Sampled:*	1-09-2019
Sample Identification:	Perm31 0.65-0.75m	*Date Tested:*	4-09-2019

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve
75.0	
53.0	
37.5	
19.0	
9.5	100
4.75	99
2.36	99
1.18	99
0.600	86
0.425	43
0.300	13
0.150	2
0.075	1



Comments:

Approved Signatory:

Name: Matt van Herk
Function: General Manager
Date: 05-September-2019

NATA WORLD RECOGNISED ACCREDITATION

Accreditation No. 20599
Accredited for compliance with ISO/IEC 17025 - Testing

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

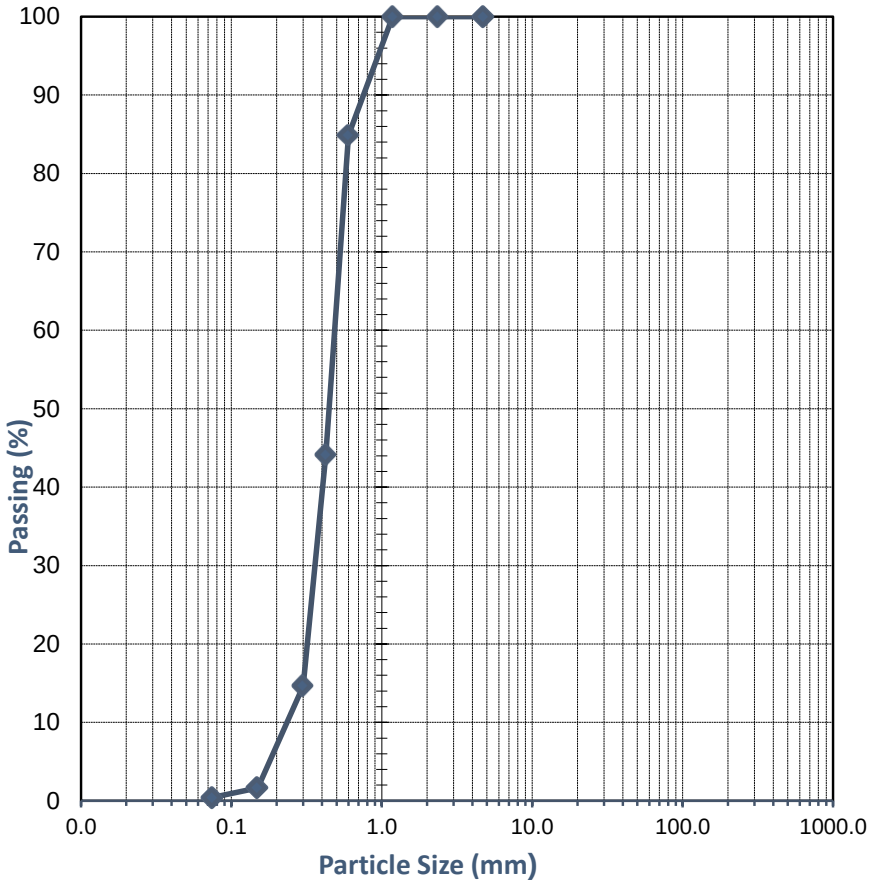
TEST REPORT - AS 1289.3.6.1

Client:	Anstey Road Developments Pty Ltd	*Ticket No.*	S341
Client Address:	-	*Report No.*	WG19/2670_1_PSD
Project:	Proposed Residential Development	*Sample No.*	WG19/2670
Location:	Lot 821 Armadale Road, Banjup	*Date Sampled:*	1-09-2019
Sample Identification:	Perm34 0.55-0.7m	*Date Tested:*	4-09-2019

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve
75.0	
53.0	
37.5	
19.0	
9.5	
4.75	100
2.36	100
1.18	100
0.600	85
0.425	44
0.300	15
0.150	2
0.075	0



Comments:

Approved Signatory:

Name: Matt van Herk
Function: General Manager
Date: 05-September-2019

Accreditation No. 20599
Accredited for compliance with ISO/IEC 17025 - Testing

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

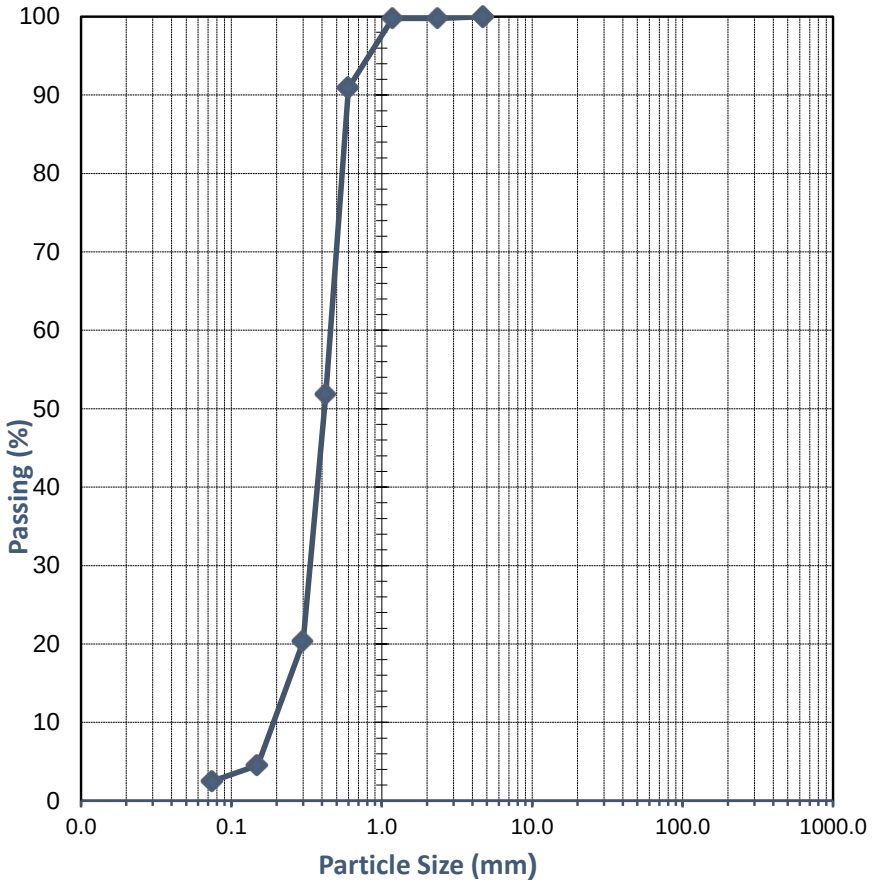
TEST REPORT - AS 1289.3.6.1

Client:	Anstey Road Developments Pty Ltd	*Ticket No.*	S341
Client Address:	-	*Report No.*	WG19/2674_1_PSD
Project:	Proposed Residential Development	*Sample No.*	WG19/2674
Location:	Lot 821 Armadale Road, Banjup	*Date Sampled:*	1-09-2019
Sample Identification:	Stockpile 4	*Date Tested:*	4-09-2019

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve
75.0	
53.0	
37.5	
19.0	
9.5	
4.75	100
2.36	100
1.18	100
0.600	91
0.425	52
0.300	20
0.150	5
0.075	3



Comments:

Approved Signatory:

Name: Matt van Herk
Function: General Manager
Date: 05-September-2019

Accreditation No. 20599
Accredited for compliance with ISO/IEC 17025 - Testing

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - ASTM D2974-14 (Test Method C)

Client:	Anstey Road Developments Pty Ltd	*Ticket No.*	S341
Client Address:	-	*Report No.*	WG19/2669-2675_1_ORG
Project:	Proposed Residential Development	*Sample No.*	WG19/2669-2675
Location:	Lot 821 Armadale Road, Banjup	*Date Sampled:*	1-09-2019
Sample Identification:	Various, see below	*Date Tested:*	4-09-2019

TEST RESULTS - Organic Content

Sampling Method: Sampled by Client, Tested as Received

Testing Completed By: Kirk McConachy

Furnace Temperature (°): 442

Sample Number	Sample Identification	Ash Content (%)	Organic Content (%)
WG19/2669	TP2 1.9-2.0m	99.7	0.3
WG19/2671	TP12 0.6-0.7m	99.9	0.1
WG19/2674	Stockpile 4	98.5	1.5
WG19/2675	Stockpile 3	96.9	3.1

Comments:

Approved Signatory:

Name: Matt van Herk
Function: General Manager
Date: 05-September-2019

NATA WORLD RECOGNISED ACCREDITATION

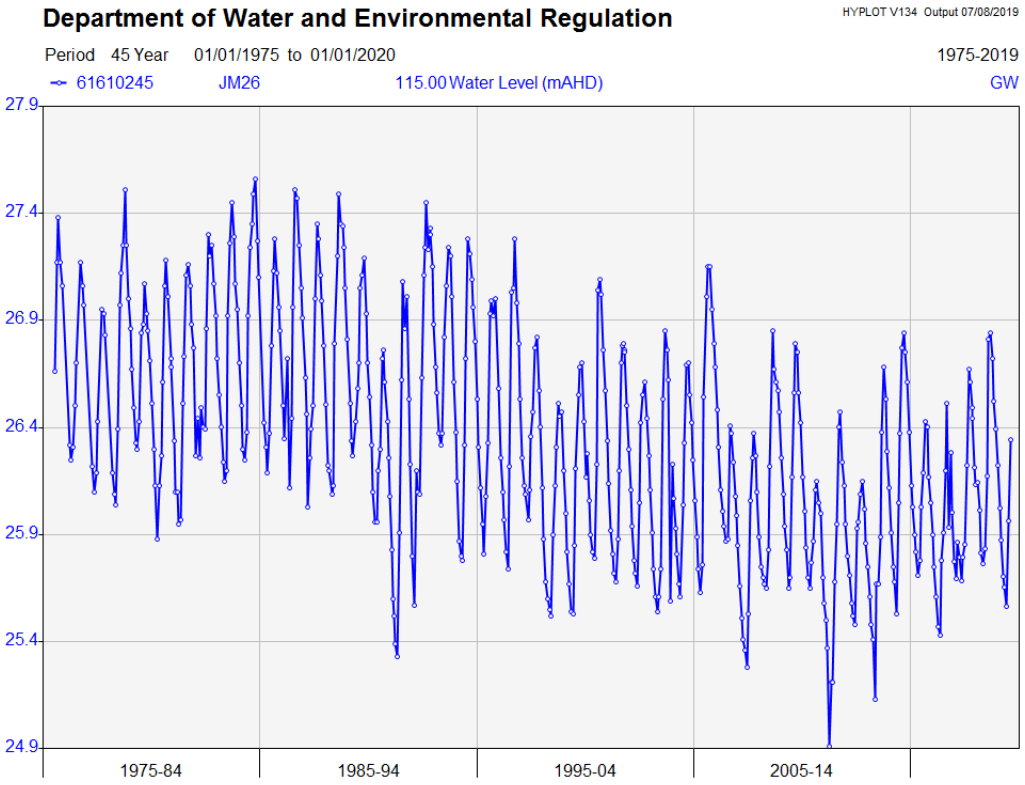
Accreditation No. 20599
Accredited for compliance with ISO/IEC 17025 - Testing

This document shall not be reproduced expect in full

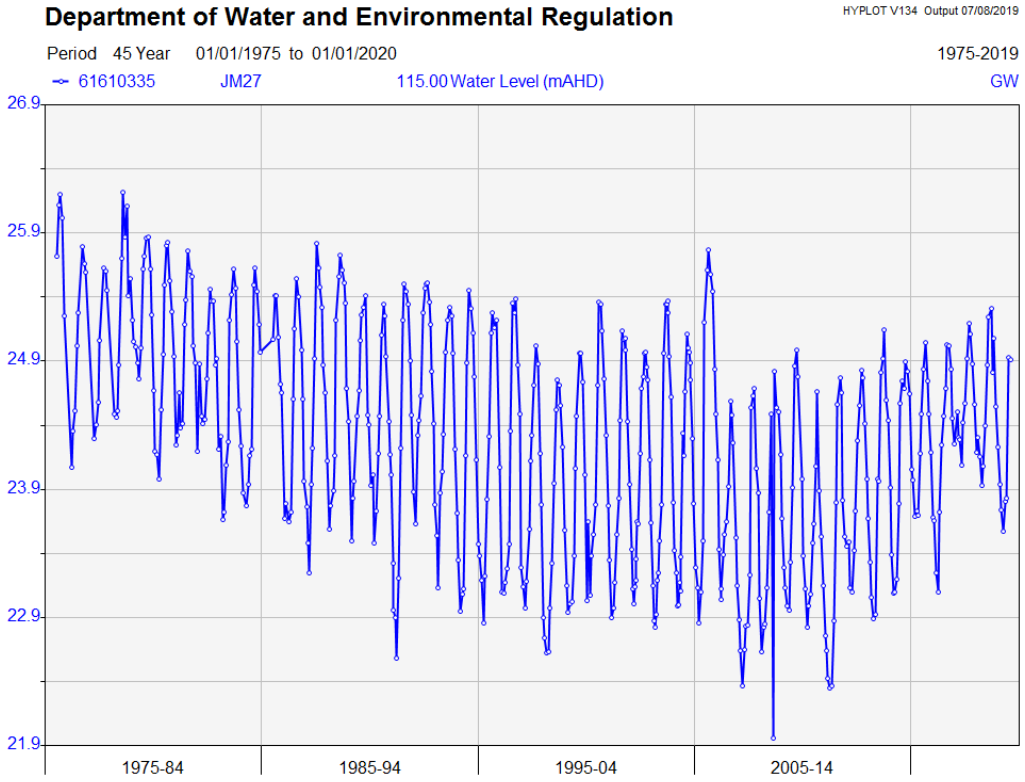
Appendix C

DWER groundwater monitoring bore hydrographs

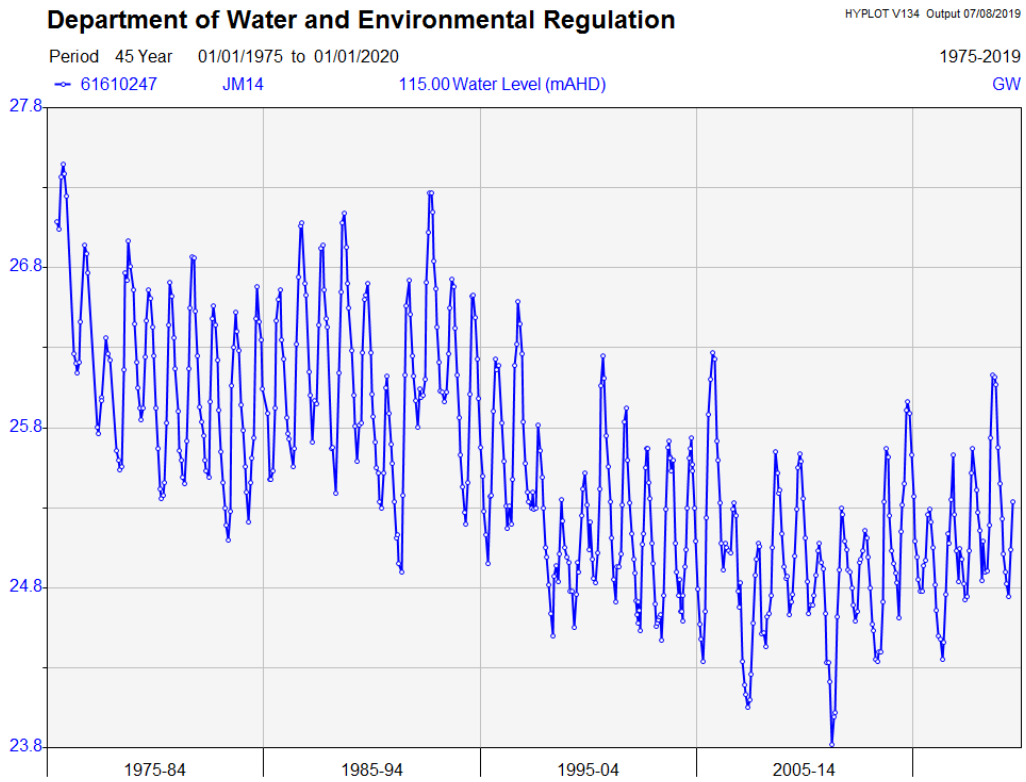
APPENDIX C: DWER GROUNDWATER MONITORING BORE HYDROGRAPHS



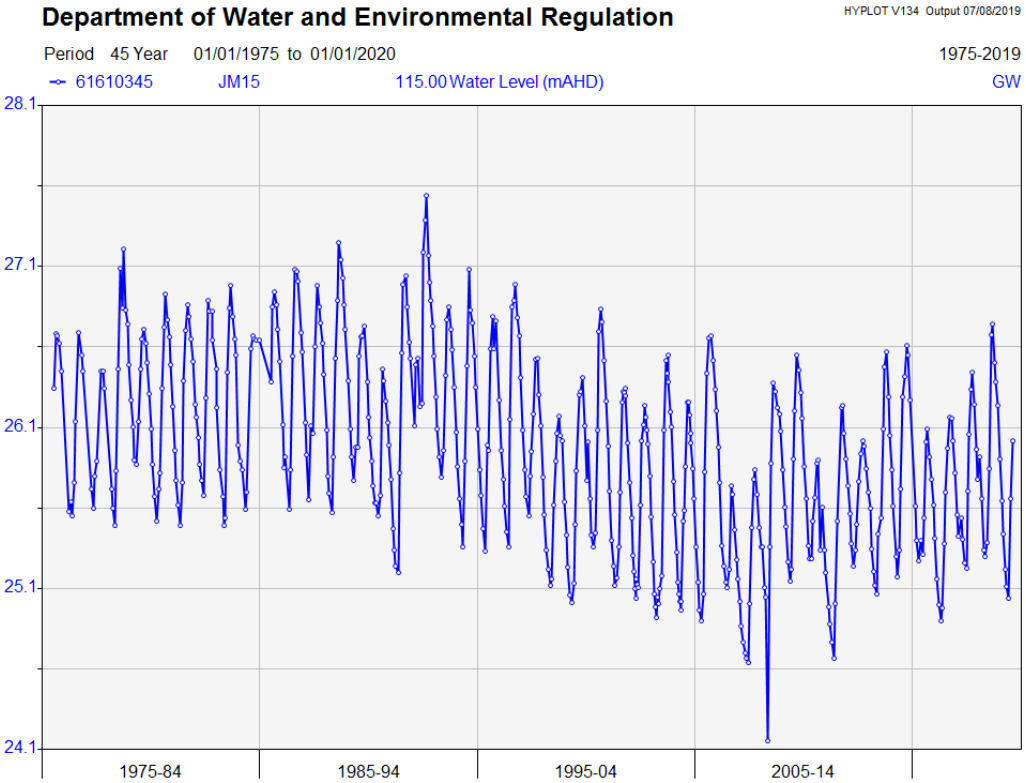
Graph C.1: DWER groundwater monitoring bore AWRC no. 61610245 hydrograph



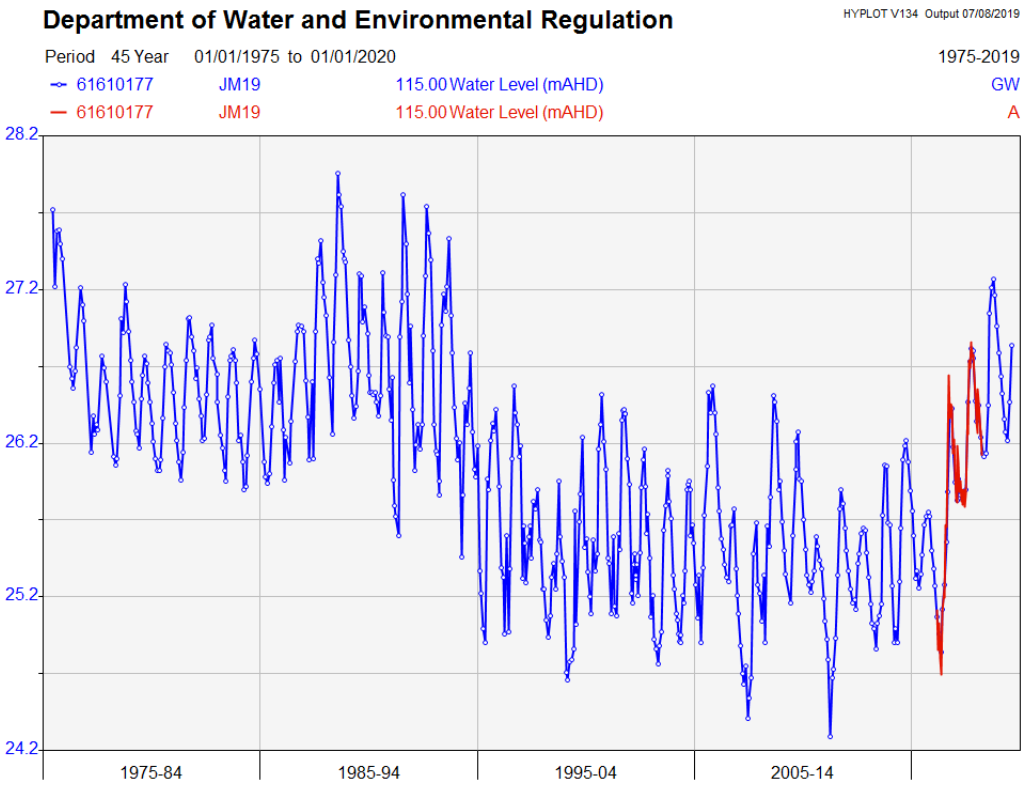
Graph C.2: DWER groundwater monitoring bore AWRC no. 61610335 hydrograph



Graph C.3: DWER groundwater monitoring bore AWRC no. 61610247 hydrograph



Graph C.4: DWER groundwater monitoring bore AWRC no. 61610345 hydrograph



Graph C.5: DWER groundwater monitoring bore AWRC no. 61610177 hydrograph

Appendix D

RPS groundwater monitoring results

Envirolab Services (WA) Pty Ltd trading as MPL Laboratories
ABN 53 140 099 207
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CERTIFICATE OF ANALYSIS 228939

Client Details

Client	RPS Australia West Pty Ltd
Attention	Shae Miller-White
Address	Level 2, 27-31 Troode St, WEST PERTH, WA, 6005

Sample Details

Your Reference	**EEC17096.001 Treeby**
Number of Samples	6 Waters
Date samples received	28/06/2019
Date completed instructions received	28/06/2019

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	09/07/2019
Date of Issue	09/07/2019

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Results Approved By
Michael Kubiak, Laboratory Manager
Michael Mowle, Metals/Inorganics Supervisor

Authorised By



Michael Kubiak, Laboratory Manager

Miscellaneous Inorganics						
Our Reference	UNITS	PQL	228939-1	228939-2	228939-3	228939-4
Your Reference			BM2	BM4	BM5	WZ01
Date Sampled			28/06/2019	28/06/2019	28/06/2019	28/06/2019
Type of sample			Water	Water	Water	Water
Date prepared	-		09/07/2019	09/07/2019	09/07/2019	09/07/2019
Date analysed	-		09/07/2019	09/07/2019	09/07/2019	09/07/2019
pH	pH Units		6.6	5.0	4.8	5.0
Electrical Conductivity (EC)	µS/cm	1	160	240	150	240
Total Dissolved Solids (grav)	mg/L	5	98	150	120	150
Acidity as $CaCO_3$	mg/L	5	8	44	24	38
Ammonia as N	mg/L	0.005	0.006	0.051	0.016	0.050
Total Nitrogen	mg/L	0.1	1.7	0.4	6.5	0.4
Total Phosphorus	mg/L	0.05	<0.05	<0.05	<0.05	<0.05

Dissolved Metals in Water							
Our Reference			228939-1	228939-2	228939-3	228939-4	228939-5
Your Reference	UNITS	PQL	BM2	BM4	BM5	WZ01	WR01
Date Sampled			28/06/2019	28/06/2019	28/06/2019	28/06/2019	28/06/2019
Type of sample			Water	Water	Water	Water	Water
Date prepared	-		03/07/2019	03/07/2019	03/07/2019	03/07/2019	02/07/2019
Date analysed	-		03/07/2019	03/07/2019	03/07/2019	03/07/2019	02/07/2019
Aluminium-Dissolved	mg/L	0.01	0.04	0.69	0.40	0.63	<0.01
Arsenic-Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium-Dissolved	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium-Dissolved	mg/L	0.001	<0.001	0.002	<0.001	0.002	<0.001
Copper-Dissolved	mg/L	0.001	<0.001	0.001	<0.001	0.002	<0.001
Iron-Dissolved	mg/L	0.01	0.01	0.03	0.06	0.03	<0.01
Mercury-Dissolved	mg/L	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Manganese-Dissolved	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Nickel-Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead-Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium-Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc-Dissolved	mg/L	0.001	0.001	0.002	0.002	0.005	<0.001

Dissolved Metals in Water			
Our Reference			228939-6
Your Reference	UNITS	PQL	WB01
Date Sampled			28/06/2019
Type of sample			Water
Date prepared	-		02/07/2019
Date analysed	-		02/07/2019
Aluminium-Dissolved	mg/L	0.01	<0.01
Arsenic-Dissolved	mg/L	0.001	<0.001
Cadmium-Dissolved	mg/L	0.0001	<0.0001
Chromium-Dissolved	mg/L	0.001	<0.001
Copper-Dissolved	mg/L	0.001	0.001
Iron-Dissolved	mg/L	0.01	<0.01
Mercury-Dissolved	mg/L	0.00005	<0.00005
Manganese-Dissolved	mg/L	0.005	<0.005
Nickel-Dissolved	mg/L	0.001	<0.001
Lead-Dissolved	mg/L	0.001	<0.001
Selenium-Dissolved	mg/L	0.001	<0.001
Zinc-Dissolved	mg/L	0.001	0.001

Total Metals in water						
Our Reference	UNITS	PQL	228939-1	228939-2	228939-3	228939-4
Your Reference			BM2	BM4	BM5	WZ01
Date Sampled			28/06/2019	28/06/2019	28/06/2019	28/06/2019
Type of sample			Water	Water	Water	Water
Date digested	-		03/07/2019	03/07/2019	03/07/2019	03/07/2019
Date analysed	-		03/07/2019	03/07/2019	03/07/2019	03/07/2019
Aluminium-Total	mg/L	0.01	0.12	0.98	3.9	1.0
Iron-Total	mg/L	0.01	0.11	0.05	1.3	0.06

vTRH(C6-C10)/MBTEXN in water							
Our Reference			228939-1	228939-2	228939-3	228939-4	228939-5
Your Reference	UNITS	PQL	BM2	BM4	BM5	WZ01	WR01
Date Sampled			28/06/2019	28/06/2019	28/06/2019	28/06/2019	28/06/2019
Type of sample			Water	Water	Water	Water	Water
Date analysed	-		01/07/2019	01/07/2019	01/07/2019	01/07/2019	01/07/2019
TRH C_6 - C_9	µg/L	10	<10	<10	<10	<10	<10
TRH C_6 - C_{10}	µg/L	10	<10	<10	<10	<10	<10
TRH C_6-C_{10} less BTEX (F1)	µg/L	10	<10	<10	<10	<10	<10
MTBE	µg/L	1	<1	<1	<1	<1	<1
Benzene	µg/L	1	<1	<1	<1	<1	<1
Toluene	µg/L	1	<1	<1	<1	<1	<1
Ethylbenzene	µg/L	1	<1	<1	<1	<1	<1
m+p-xylene	µg/L	2	<2	<2	<2	<2	<2
o-xylene	µg/L	1	<1	<1	<1	<1	<1
Naphthalene	µg/L	1	<1	<1	<1	<1	<1
Surrogate Dibromofluoromethane	%		108	102	108	105	103
Surrogate toluene-d8	%		108	103	107	104	107
Surrogate 4-BFB	%		103	102	100	101	101

vTRH(C6-C10)/MBTEXN in water			
Our Reference			228939-6
Your Reference	UNITS	PQL	WB01
Date Sampled			28/06/2019
Type of sample			Water
Date analysed	-		01/07/2019
TRH C_6 - C_9	µg/L	10	<10
TRH C_6 - C_{10}	µg/L	10	<10
TRH C_6-C_{10} less BTEX (F1)	µg/L	10	<10
MTBE	µg/L	1	<1
Benzene	µg/L	1	<1
Toluene	µg/L	1	<1
Ethylbenzene	µg/L	1	<1
m+p-xylene	µg/L	2	<2
o-xylene	µg/L	1	<1
Naphthalene	µg/L	1	<1
Surrogate Dibromofluoromethane	%		104
Surrogate toluene-d8	%		104
Surrogate 4-BFB	%		101

svTRH(C10-C40) in water						
Our Reference	UNITS	PQL	228939-1	228939-2	228939-3	228939-4
Your Reference			BM2	BM4	BM5	WZ01
Date Sampled			28/06/2019	28/06/2019	28/06/2019	28/06/2019
Type of sample			Water	Water	Water	Water
Date extracted	-		02/07/2019	02/07/2019	02/07/2019	02/07/2019
Date analysed	-		04/07/2019	04/07/2019	04/07/2019	04/07/2019
TRH C_{10} - C_{14}	µg/L	50	<50	<50	<50	<50
TRH C_{15} - C_{28}	µg/L	100	<100	<100	<100	<100
TRH C_{29} - C_{36}	µg/L	100	<100	<100	<100	<100
TRH >C_{10} - C_{16}	µg/L	50	<50	<50	<50	<50
TRH >C_{10} -C_{16} less N (F2)	µg/L	50	<50	<50	<50	<50
TRH >C_{16} - C_{34}	µg/L	100	<100	<100	<100	<100
TRH >C_{34} - C_{40}	µg/L	100	<100	<100	<100	<100
Surrogate o-Terphenyl	%		86	79	89	76

PAHs in Water						
Our Reference	UNITS	PQL	228939-1	228939-2	228939-3	228939-4
Your Reference			BM2	BM4	BM5	WZ01
Date Sampled			28/06/2019	28/06/2019	28/06/2019	28/06/2019
Type of sample			Water	Water	Water	Water
Date extracted	-		02/07/2019	02/07/2019	02/07/2019	02/07/2019
Date analysed	-		06/07/2019	06/07/2019	06/07/2019	06/07/2019
Naphthalene	µg/L	0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	µg/L	0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthene	µg/L	0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	µg/L	0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene	µg/L	0.1	<0.1	<0.1	<0.1	<0.1
Anthracene	µg/L	0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	µg/L	0.1	<0.1	<0.1	<0.1	<0.1
Pyrene	µg/L	0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)anthracene	µg/L	0.1	<0.1	<0.1	<0.1	<0.1
Chrysene	µg/L	0.1	<0.1	<0.1	<0.1	<0.1
Benzo(b,j+k)fluoranthene	µg/L	0.2	<0.2	<0.2	<0.2	<0.2
Benzo(a)pyrene	µg/L	0.1	<0.1	<0.1	<0.1	<0.1
Indeno(1,2,3-c,d)pyrene	µg/L	0.1	<0.1	<0.1	<0.1	<0.1
Dibenzo(a,h)anthracene	µg/L	0.1	<0.1	<0.1	<0.1	<0.1
Benzo(g,h,i)perylene	µg/L	0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)pyrene TEQ	µg/L	0.5	<0.5	<0.5	<0.5	<0.5
Total +ve PAH's	µg/L	0.1	<0.1	<0.1	<0.1	<0.1
Surrogate p-Terphenyl-D_{14}	%		74	83	80	65

Low Level OCP in water						
Our Reference	UNITS	PQL	228939-1	228939-2	228939-3	228939-4
Your Reference			BM2	BM4	BM5	WZ01
Date Sampled			28/06/2019	28/06/2019	28/06/2019	28/06/2019
Type of sample			Water	Water	Water	Water
Date extracted	-		02/07/2019	02/07/2019	02/07/2019	02/07/2019
Date analysed	-		05/07/2019	05/07/2019	05/07/2019	05/07/2019
Hexachlorobenzene (HCB)	µg/L	0.01	<0.01	<0.01	<0.01	<0.01
a-BHC	µg/L	0.05	<0.05	<0.05	<0.05	<0.05
Lindane (g-BHC)	µg/L	0.05	<0.05	<0.05	<0.05	<0.05
b-BHC	µg/L	0.05	<0.05	<0.05	<0.05	<0.05
Heptachlor	µg/L	0.01	<0.01	<0.01	<0.01	<0.01
d-BHC	µg/L	0.05	<0.05	<0.05	<0.05	<0.05
Aldrin	µg/L	0.01	<0.01	<0.01	<0.01	<0.01
Heptachlor Epoxide	µg/L	0.01	<0.01	<0.01	<0.01	<0.01
g-Chlordane	µg/L	0.01	<0.01	<0.01	<0.01	<0.01
a-Chlordane	µg/L	0.01	<0.01	<0.01	<0.01	<0.01
a-Endosulfan	µg/L	0.02	<0.02	<0.02	<0.02	<0.02
pp-DDE	µg/L	0.01	<0.01	<0.01	<0.01	<0.01
Dieldrin	µg/L	0.01	<0.01	<0.01	<0.01	<0.01
Endrin	µg/L	0.01	<0.01	<0.01	<0.01	<0.01
pp-DDD	µg/L	0.01	<0.01	<0.01	<0.01	<0.01
b-Endosulfan	µg/L	0.02	<0.02	<0.02	<0.02	<0.02
pp-DDT	µg/L	0.006	<0.006	<0.006	<0.006	<0.006
Endosulfan Sulphate	µg/L	0.02	<0.02	<0.02	<0.02	<0.02
Methoxychlor	µg/L	0.02	<0.02	<0.02	<0.02	<0.02
Surrogate p-Terphenyl-D_{14}	%		71	74	121	120

Trace Level OPP in water						
Our Reference	UNITS	PQL	228939-1	228939-2	228939-3	228939-4
Your Reference			BM2	BM4	BM5	WZ01
Date Sampled			28/06/2019	28/06/2019	28/06/2019	28/06/2019
Type of sample			Water	Water	Water	Water
Date extracted	-		02/07/2019	02/07/2019	02/07/2019	02/07/2019
Date analysed	-		05/07/2019	05/07/2019	05/07/2019	05/07/2019
Azinphos methyl	µg/L	0.02	<0.02	<0.02	<0.02	<0.02
Bromophos-ethyl	µg/L	0.2	<0.2	<0.2	<0.2	<0.2
Chlorpyrifos	µg/L	0.009	<0.009	<0.009	<0.009	<0.009
Chlorpyriphos-methyl	µg/L	0.2	<0.2	<0.2	<0.2	<0.2
Diazinon	µg/L	0.01	<0.01	<0.01	<0.01	<0.01
Dichlorvos	µg/L	0.2	<0.2	<0.2	<0.2	<0.2
Dimethoate	µg/L	0.15	<0.15	<0.15	<0.15	<0.15
Ethion	µg/L	0.2	<0.2	<0.2	<0.2	<0.2
Fenitrothion	µg/L	0.2	<0.2	<0.2	<0.2	<0.2
Malathion	µg/L	0.05	<0.05	<0.05	<0.05	<0.05
Parathion	µg/L	0.004	<0.004	<0.004	<0.004	<0.004
Methyl Parathion	µg/L	0.2	<0.2	<0.2	<0.2	<0.2
Ronnel	µg/L	0.2	<0.2	<0.2	<0.2	<0.2
Surrogate p-Terphenyl-D_{14}	%		71	74	121	128

Method ID	Methodology Summary
INORG-001	pH - Measured using pH meter and electrode base on APHA latest edition, Method 4500-H+. Please note that the results for water analyses may be indicative only, as analysis can be completed outside of the APHA recommended holding times. Soils are reported from a 1:5 water extract unless otherwise specified.
INORG-002	Conductivity and Salinity - measured using a conductivity cell at 25°C based on APHA latest edition Method 2510. Soils reported from a 1:5 water extract unless otherwise specified.
INORG-005	Acidity - determined by titration based on APHA latest edition, Method 2310 B. Soils reported from a 1:5 water extract unless otherwise specified.
INORG-018	Total Dissolved Solids - determined gravimetrically. The solids are dried at 180±5°C
INORG-057	Ammonia by colourimetric analysis based on APHA latest edition 4500-NH3 F.
INORG-110	Total Nitrogen by high temperature catalytic combustion with chemiluminescence detection. Dissolved/Total Carbon and Dissolved/Total Organic and Inorganic Carbon by high temperature catalytic combustion with NDIR
METALS-020	Metals in soil and water by ICP-OES.
METALS-021	Determination of Mercury by Cold Vapour AAS. For urine samples total Mercury is determined, however, mercury in urine is almost entirely in the inorganic form (CDC).
METALS-022	Determination of various metals by ICP-MS.
ORG-003	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-FID. F2 = (>C10-C16)-Naphthalene as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater (HSLs Tables 1A (3, 4)). Note Naphthalene is determined from the VOC analysis.
ORG-004	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS.
ORG-008/015	Organophosphorus Pesticides in soil by DCM:Acetone extraction and water by DCM extraction with determination by GC-ECD/GC-MS.
ORG-012	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS.
ORG-012	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS. Benzo(a)pyrene TEQ as per NEPM draft B1 Guideline on Investigation Levels for Soil and Groundwater.
ORG-015	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS or GC-MS/MS.
ORG-016	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS. Water samples are analysed directly by purge and trap GC-MS. F1 = (C6-C10)-BTEX as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater.

QUALITY CONTROL: Miscellaneous Inorganics						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	228939-2
Date prepared	-			09/07/2019	1	09/07/2019	09/07/2019		09/07/2019	28/06/2019
Date analysed	-			09/07/2019	1	09/07/2019	09/07/2019		09/07/2019	28/06/2019
pH	pH Units		INORG-001	[NT]	1	6.6	6.7	2	101	[NT]
Electrical Conductivity (EC)	µS/cm	1	INORG-002	<1	1	160	160	0	101	[NT]
Total Dissolved Solids (grav)	mg/L	5	INORG-018	<5	1	98	100	2	102	[NT]
Acidity as $CaCO_3$	mg/L	5	INORG-005	<5	1	8	8	0	100	[NT]
Ammonia as N	mg/L	0.005	INORG-057	<0.005	1	0.006	0.006	0	92	[NT]
Total Nitrogen	mg/L	0.1	INORG-110	<0.1	1	1.7	1.8	6	99	97
Total Phosphorus	mg/L	0.05	METALS-020	<0.05	1	<0.05	<0.05	0	114	[NT]

QUALITY CONTROL: Miscellaneous Inorganics						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	228939-3
Date prepared	-			[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	28/06/2019
Date analysed	-			[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	28/06/2019
Total Phosphorus	mg/L	0.05	METALS-020	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]	110

QUALITY CONTROL: Dissolved Metals in Water						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			03/07/2019	4	03/07/2019	03/07/2019		03/07/2019	[NT]
Date analysed	-			03/07/2019	4	03/07/2019	03/07/2019		03/07/2019	[NT]
Aluminium-Dissolved	mg/L	0.01	METALS-022	<0.01	4	0.63	[NT]		87	[NT]
Arsenic-Dissolved	mg/L	0.001	METALS-022	<0.001	4	<0.001	[NT]		96	[NT]
Cadmium-Dissolved	mg/L	0.0001	METALS-022	<0.0001	4	<0.0001	[NT]		98	[NT]
Chromium-Dissolved	mg/L	0.001	METALS-022	<0.001	4	0.002	[NT]		92	[NT]
Copper-Dissolved	mg/L	0.001	METALS-022	<0.001	4	0.002	[NT]		91	[NT]
Iron-Dissolved	mg/L	0.01	METALS-022	<0.01	4	0.03	[NT]		107	[NT]
Mercury-Dissolved	mg/L	0.00005	METALS-021	<0.00005	4	<0.00005	<0.00005	0	119	[NT]
Manganese-Dissolved	mg/L	0.005	METALS-022	<0.005	4	<0.005	[NT]		90	[NT]
Nickel-Dissolved	mg/L	0.001	METALS-022	<0.001	4	<0.001	[NT]		92	[NT]
Lead-Dissolved	mg/L	0.001	METALS-022	<0.001	4	<0.001	[NT]		104	[NT]
Selenium-Dissolved	mg/L	0.001	METALS-022	<0.001	4	<0.001	[NT]		101	[NT]
Zinc-Dissolved	mg/L	0.001	METALS-022	<0.001	4	0.005	[NT]		91	[NT]

QUALITY CONTROL: Total Metals in water						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	228939-2
Date digested	-			03/07/2019	1	03/07/2019	03/07/2019		03/07/2019	03/07/2019
Date analysed	-			03/07/2019	1	03/07/2019	03/07/2019		03/07/2019	03/07/2019
Aluminium-Total	mg/L	0.01	METALS-022	<0.01	1	0.12	0.11	9	99	#
Iron-Total	mg/L	0.01	METALS-022	<0.01	1	0.11	0.10	10	110	127

QUALITY CONTROL: vTRH(C6-C10)/MBTEXN in water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date analysed	-			01/07/2019	[NT]	[NT]	[NT]	[NT]	01/07/2019	[NT]
TRH C_6 - C_9	µg/L	10	ORG-016	<10	[NT]	[NT]	[NT]	[NT]	100	[NT]
TRH C_6 - C_{10}	µg/L	10	ORG-016	<10	[NT]	[NT]	[NT]	[NT]	100	[NT]
MTBE	µg/L	1	ORG-016	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Benzene	µg/L	1	ORG-016	<1	[NT]	[NT]	[NT]	[NT]	106	[NT]
Toluene	µg/L	1	ORG-016	<1	[NT]	[NT]	[NT]	[NT]	106	[NT]
Ethylbenzene	µg/L	1	ORG-016	<1	[NT]	[NT]	[NT]	[NT]	95	[NT]
m+p-xylene	µg/L	2	ORG-016	<2	[NT]	[NT]	[NT]	[NT]	96	[NT]
o-xylene	µg/L	1	ORG-016	<1	[NT]	[NT]	[NT]	[NT]	94	[NT]
Naphthalene	µg/L	1	ORG-016	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Surrogate Dibromofluoromethane	%		ORG-016	103	[NT]	[NT]	[NT]	[NT]	99	[NT]
Surrogate toluene-d8	%		ORG-016	105	[NT]	[NT]	[NT]	[NT]	105	[NT]
Surrogate 4-BFB	%		ORG-016	101	[NT]	[NT]	[NT]	[NT]	101	[NT]

QUALITY CONTROL: svTRH(C10-C40) in water						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date extracted	-			02/07/2019	[NT]	[NT]	[NT]	[NT]	02/07/2019	[NT]
Date analysed	-			04/07/2019	[NT]	[NT]	[NT]	[NT]	04/07/2019	[NT]
TRH C_{10} - C_{14}	µg/L	50	ORG-003	<50	[NT]	[NT]	[NT]	[NT]	94	[NT]
TRH C_{15} - C_{28}	µg/L	100	ORG-003	<100	[NT]	[NT]	[NT]	[NT]	107	[NT]
TRH C_{29} - C_{36}	µg/L	100	ORG-003	<100	[NT]	[NT]	[NT]	[NT]	95	[NT]
TRH >C_{10} - C_{16}	µg/L	50	ORG-003	<50	[NT]	[NT]	[NT]	[NT]	101	[NT]
TRH >C_{16} - C_{34}	µg/L	100	ORG-003	<100	[NT]	[NT]	[NT]	[NT]	100	[NT]
TRH >C_{34} - C_{40}	µg/L	100	ORG-003	<100	[NT]	[NT]	[NT]	[NT]	114	[NT]
Surrogate o-Terphenyl	%		ORG-003	97	[NT]	[NT]	[NT]	[NT]	92	[NT]

QUALITY CONTROL: PAHs in Water						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date extracted	-			02/07/2019	[NT]	[NT]	[NT]	[NT]	02/07/2019	[NT]
Date analysed	-			06/07/2019	[NT]	[NT]	[NT]	[NT]	06/07/2019	[NT]
Naphthalene	µg/L	0.1	ORG-012	<0.1	[NT]	[NT]	[NT]	[NT]	91	[NT]
Acenaphthylene	µg/L	0.1	ORG-012	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Acenaphthene	µg/L	0.1	ORG-012	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Fluorene	µg/L	0.1	ORG-012	<0.1	[NT]	[NT]	[NT]	[NT]	94	[NT]
Phenanthrene	µg/L	0.1	ORG-012	<0.1	[NT]	[NT]	[NT]	[NT]	103	[NT]
Anthracene	µg/L	0.1	ORG-012	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Fluoranthene	µg/L	0.1	ORG-012	<0.1	[NT]	[NT]	[NT]	[NT]	105	[NT]
Pyrene	µg/L	0.1	ORG-012	<0.1	[NT]	[NT]	[NT]	[NT]	99	[NT]
Benzo(a)anthracene	µg/L	0.1	ORG-012	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Chrysene	µg/L	0.1	ORG-012	<0.1	[NT]	[NT]	[NT]	[NT]	100	[NT]
Benzo(b,j+k)fluoranthene	µg/L	0.2	ORG-012	<0.2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Benzo(a)pyrene	µg/L	0.1	ORG-012	<0.1	[NT]	[NT]	[NT]	[NT]	91	[NT]
Indeno(1,2,3-c,d)pyrene	µg/L	0.1	ORG-012	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Dibenzo(a,h)anthracene	µg/L	0.1	ORG-012	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Benzo(g,h,i)perylene	µg/L	0.1	ORG-012	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Surrogate p-Terphenyl-D_{14}	%		ORG-012	69	[NT]	[NT]	[NT]	[NT]	72	[NT]

QUALITY CONTROL: Low Level OCP in water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date extracted	-			02/07/2019	[NT]	[NT]	[NT]	[NT]	02/07/2019	[NT]
Date analysed	-			05/07/2019	[NT]	[NT]	[NT]	[NT]	05/07/2019	[NT]
Hexachlorobenzene (HCB)	µg/L	0.01	ORG-015	<0.01	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
a-BHC	µg/L	0.05	ORG-015	<0.05	[NT]	[NT]	[NT]	[NT]	110	[NT]
Lindane (g-BHC)	µg/L	0.05	ORG-015	<0.05	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
b-BHC	µg/L	0.05	ORG-015	<0.05	[NT]	[NT]	[NT]	[NT]	99	[NT]
Heptachlor	µg/L	0.01	ORG-015	<0.01	[NT]	[NT]	[NT]	[NT]	102	[NT]
d-BHC	µg/L	0.05	ORG-015	<0.05	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Aldrin	µg/L	0.01	ORG-015	<0.01	[NT]	[NT]	[NT]	[NT]	96	[NT]
Heptachlor Epoxide	µg/L	0.01	ORG-015	<0.01	[NT]	[NT]	[NT]	[NT]	105	[NT]
g-Chlordane	µg/L	0.01	ORG-015	<0.01	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
a-Chlordane	µg/L	0.01	ORG-015	<0.01	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
a-Endosulfan	µg/L	0.02	ORG-015	<0.02	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
pp-DDE	µg/L	0.01	ORG-015	<0.01	[NT]	[NT]	[NT]	[NT]	87	[NT]
Dieldrin	µg/L	0.01	ORG-015	<0.01	[NT]	[NT]	[NT]	[NT]	98	[NT]
Endrin	µg/L	0.01	ORG-015	<0.01	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
pp-DDD	µg/L	0.01	ORG-015	<0.01	[NT]	[NT]	[NT]	[NT]	86	[NT]
b-Endosulfan	µg/L	0.02	ORG-015	<0.02	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
pp-DDT	µg/L	0.006	ORG-015	<0.006	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Endosulfan Sulphate	µg/L	0.02	ORG-015	<0.02	[NT]	[NT]	[NT]	[NT]	109	[NT]
Methoxychlor	µg/L	0.02	ORG-015	<0.02	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Surrogate p-Terphenyl-D_{14}	%		ORG-008/015	105	[NT]	[NT]	[NT]	[NT]	87	[NT]

QUALITY CONTROL: Trace Level OPP in water						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date extracted	-			02/07/2019	[NT]	[NT]	[NT]	[NT]	02/07/2019	[NT]
Date analysed	-			05/07/2019	[NT]	[NT]	[NT]	[NT]	05/07/2019	[NT]
Azinphos methyl	µg/L	0.02	ORG-015	<0.02	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Bromophos-ethyl	µg/L	0.2	ORG-015	<0.2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Chlorpyrifos	µg/L	0.009	ORG-015	<0.009	[NT]	[NT]	[NT]	[NT]	106	[NT]
Chlorpyriphos-methyl	µg/L	0.2	ORG-015	<0.2	[NT]	[NT]	[NT]	[NT]	105	[NT]
Diazinon	µg/L	0.01	ORG-015	<0.01	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Dichlorvos	µg/L	0.2	ORG-015	<0.2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Dimethoate	µg/L	0.15	ORG-015	<0.15	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Ethion	µg/L	0.2	ORG-015	<0.2	[NT]	[NT]	[NT]	[NT]	111	[NT]
Fenitrothion	µg/L	0.2	ORG-015	<0.2	[NT]	[NT]	[NT]	[NT]	119	[NT]
Malathion	µg/L	0.05	ORG-015	<0.05	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Parathion	µg/L	0.004	ORG-015	<0.004	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Methyl Parathion	µg/L	0.2	ORG-015	<0.2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Ronnel	µg/L	0.2	ORG-015	<0.2	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Surrogate p-Terphenyl-D_{14}	%		ORG-008/015	105	[NT]	[NT]	[NT]	[NT]	87	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available).

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) a

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Report Comments

Percent recovery not available due to the analyte signal being much greater than the spike amount. An acceptable recovery was achieved for the LCS.

Appendix E

Groundwater licence

LICENCE TO TAKE WATER

Granted by the Minister under section 5C of the Rights in Water and Irrigation Act 1914

Licensee(s)	LWP Property Group Pty Ltd		
Description of Water Resource	Jandakot Perth - Superficial Swan	**Annual Water Entitlement**	46,975kL
Location of Water Source	LOT 703 ON PLAN 413031 - Volume/Folio 2941/911 - Lot 703 TREEBY		

Authorised Activities	**Taking of water for**	**Location of Activity**
	Dust suppression for earthworks and construction purposes	LOT 703 ON PLAN 413031 - Volume/Folio 2941/911 - Lot 703 TREEBY
	Irrigation of up to 5.46 ha of public open space	LOT 703 ON PLAN 413031 - Volume/Folio 2941/911 - Lot 703 TREEBY
Duration of Licence	From 9 October 2019 to 9 October 2029	

This Licence is subject to the following terms, conditions and restrictions:

1. The annual water year for water taken under this licence is defined as 1 June to 31 May.

2. The licensee shall not use water for sprinkler irrigation between 9 am and 6 pm except for the establishment of newly planted areas. For newly planted areas water may be used within these hours for a period of up to 28 consecutive days, commencing from the date of planting.

3. Between 1 June and 31 August in any year, the licence-holder must not water a lawn, garden, or grass-covered area ("turf") by reticulation, provided always that this restriction shall not apply to watering with a hand held hose; or watering, by way of reticulation: newly planted areas for a period of up to 28 days from the date of planting; for renovating turf; or for maintenance of reticulation systems.

4. The licensee must not, in any water year, take more water than the annual water entitlement specified in this licence.

5. The licensee must install an approved meter on each water draw-point through which water is taken under this licence.

6. The licensee must submit a completed ‘Form 8 – Information to be provided on installation of a water meter' to the Department within 30 days of the date that a water meter is installed.

7. The ‘Form 8 – Information to be provided on installation of a water meter’ must include the date on which the water meter was installed, the location of the installed water meter, the meter reading at the time of installation, and the make, size, type and serial number of the installed meter.

8. The licensee must submit, within 30 days of the date that a water meter is installed, drawings or annotated photographs of the meter after the installation that show the length of pipe connecting the draw point to the upstream flange of the meter, the length of pipe between the downstream flange of the meter and the first bend or take off, and the direction of the water flow through the meter.

9. The licensee must submit, within 30 days of the date that a water meter is installed, a copy of the manufacturer’s specification for installation of the meter or written advice from the person who installed the meter that it complies with the manufacturer’s specifications for installation.

10. The licensee must record the meter reading at the end of each month.

11. The licensee must provide a copy of the meter readings to the Department, using the Water Online Metering Portal, within 30 days after the end of the relevant water year.

12. The licensee must maintain the meter in good condition and ensure that it is operating within a range of plus or minus 5% of the quantity of water that passes through it when tested in field conditions.

13. The licensee must notify the Department within 7 days of detecting a malfunction of the meter.

This Licence is granted subject to the Rights in Water and Irrigation Regulations 2000.

LICENCE TO TAKE WATER

Granted by the Minister under section 5C of the Rights in Water and Irrigation Act 1914

This Licence is subject to the following terms, conditions and restrictions:

14. The licensee must obtain authorisation from the Department of Water and Environmental Regulation before removing, replacing or interfering with any meter required under this licence.

End of terms, conditions and restrictions

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Government of **Western Australia**
Department of **Water and Environmental Regulation**

Instrument No. CAW203460(1)

LICENCE TO CONSTRUCT OR ALTER WELL

Granted by the Minister under section 26D of the Rights in Water and Irrigation Act 1914

Licensee(s)	LWP Property Group Pty Ltd
Description of Water Resource	Jandakot Perth - Superficial Swan
Location of Well(s)	LOT 703 ON PLAN 413031 - Volume/Folio 2941/911 - Lot 703 TREEBY

Authorised Activities	**Activity**	**Location of Activity**
	Construct 1 non-artesian well(s).	LOT 703 ON PLAN 413031 - Volume/Folio 2941/911 - Lot 703 TREEBY
Duration of Licence	From 9 October 2019 to 9 October 2020	

This Licence is subject to the following terms, conditions and restrictions:

1. The well must be constructed by a driller having a current class 1 water well drillers certificate issued by the Western Australian branch of the Australian Drilling Industry Association or equivalent certification recognised nationally by the Australian Drilling Industry Association.

2. The casing(s) shall be equipped with centralisers not less than one per six metres of casing length to ensure that the casing remains central to the borehole.

3. The clearance (annulus) between the casing and the side of the borehole shall be cement grouted above the production zone using methods described in "Minimum construction requirements for water bores in Australia, 3rd edition, National Uniform Drillers Licensing Committee (2012)".

4. The licensee shall construct the well using materials and methods for single aquifer described in "Minimum construction requirements for water bores in Australia, 3rd edition, National Uniform Drillers Licensing Committee (2012)".

5. The depth of the well(s) shall be limited to the superficial aquifer.

End of terms, conditions and restrictions

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Appendix F

Engineering plans

GHOSTGUM AVENUE

ARMADALE ROAD

LEGEND

- EXISTING CONTOUR (1.0m) — 25.0
- DESIGN CONTOUR (0.5m) — 28.0
- PROPOSED DESIGN LOT PAD LEVEL — 25.00
- EARTHWORKS BOUNDARY

REV	DATE	DRN	CKD	APP	AMENDMENT
A	11.10.19	AMP	-		ISSUED FOR APPROVAL

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DIAL BEFORE YOU DIG www.1100.com.au

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1:1000

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DESIGNED AMP

SCALE 1:1000

PROJECT LOT 821 ARMADALE RD, BANJUP

TITLE PRELIMINARY EARTHWORKS

WAPC No.

DRAWING No. 6234-LWP-SK06

REVISION A

ORIGINAL SIZE A1

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GHOSTGUM AVENUE

ARMADALE ROAD

OUTLET INTO EXISTING DRAIN

LEGEND

- 25.0 — EXISTING CONTOUR (1.0m)
- 28.0 — DESIGN CONTOUR (0.5m)
- 25.00 — PROPOSED DESIGN LOT PAD LEVEL
- PROPOSED SUBSOIL DRAINAGE

0m 20 40 60m

1:1000

REV	DATE	DRN	CKD	APP	AMENDMENT
A	11.10.19	AMP	-	mjwalk	ISSUED FOR APPROVAL

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PROJECT LOT 821 ARMADALE RD, BANJUP

TITLE PROPOSED SUBSOIL DRAINAGE PLAN

WAPC No.

DRAWING No. 6234-LWP-SK07

REVISION A

ORIGINAL SIZE A1

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A SK09

B SK09

C SK09

1 IN 6 BATTERS (TYP.)

BASE LEVEL
RL 29.15

TWL(100YR) RL 29.35

TWL(5YR) RL 29.15

BASE LEVEL
RL 28.20

TWL(1YR) RL 28.70

LEGEND

- 25.0 — EXISTING CONTOUR (1.0m)
- 28.0 — DESIGN CONTOUR (0.5m)
- (35.00) PROPOSED DESIGN LOT PAD LEVEL

REV	DATE	DRN	CKD	APP	AMENDMENT
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0m 10 20 30
1:500

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SCALE 1:500

PROJECT LOT 821 ARMADALE RD, BANJUP

TITLE DRAINAGE BASIN PLAN

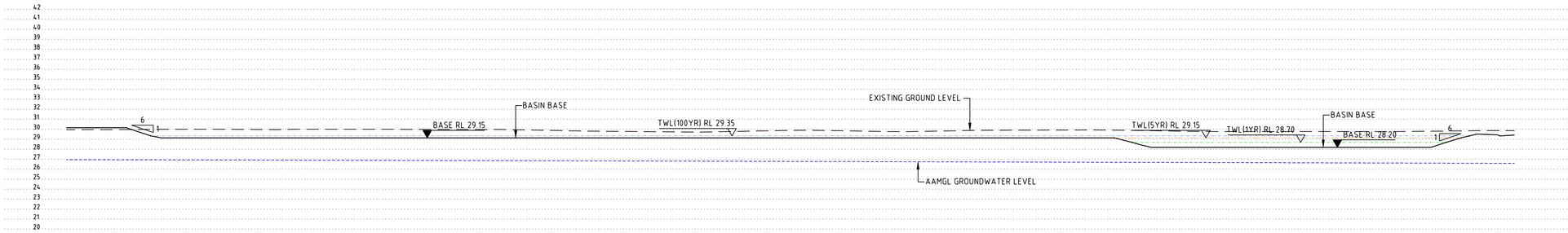
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DRAWING No. 6234-LWP-SK08

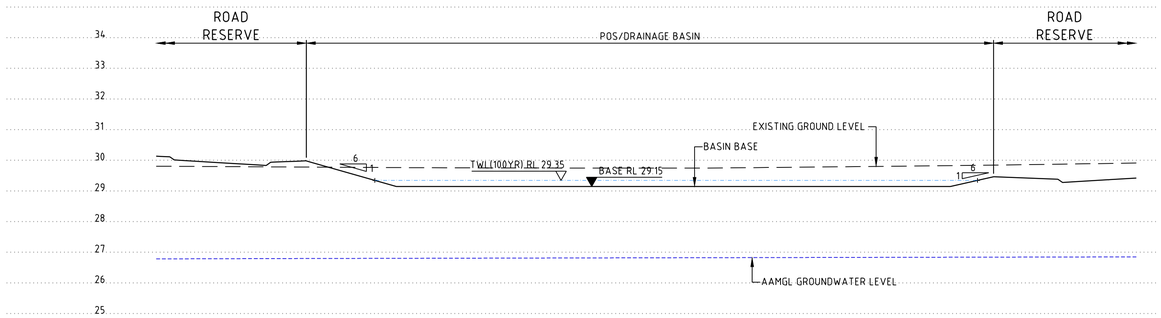
REVISION A

ORIGINAL SIZE A1

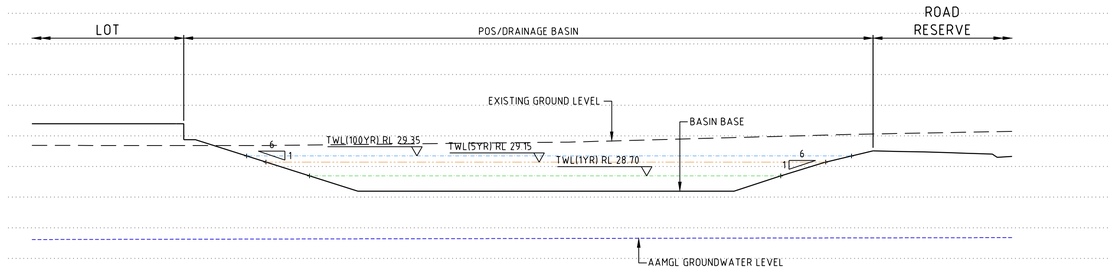
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SECTION A
1:500 HORIZ.
1:250 VERT.



SECTION B
1:200 HORIZ.
1:100 VERT.



SECTION C
1:200 HORIZ.
1:100 VERT.

REV	DATE	DRN	CKD	APP	AMENDMENT
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1:200 0m 4 8 12
1:500 0m 10 20 30

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SCALE 1:200 1:500

PROJECT LOT 821 ARMADALE RD, BANJUP

TITLE DRAINAGE BASIN LONGSECTIONS

WAPC No.

DRAWING No. 6234-LWP-SK09

REVISION A

ORIGINAL SIZE A1

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Catchment b
Catchment c
Catchment d
Catchment a
0m 20 40 60m
1:1000

Appendix G

UNDO results

Government of **Western Australia**
Department of **Water and Environmental Regulation**

Project: Treeby

Date: 14/10/2019

Version: Version 1.1.2.19156

Subregion name: Catchment a

Landuse	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
Residential	54	8.37	249.61	70.04
Industrial, commercial & schools	0	0.00	0.00	0.00
Rural living	0	0.00	0.00	0.00
Public open space	18	2.79	139.45	4.28
Road reserve	28	4.34	36.47	1.17

Total area (ha)	Total percent (%)
15.51	78

Nitrogen input (kg/ha/yr)	Phosphorus input (kg/ha/yr)
32.67	5.02

Nitrogen export (kg/ha/yr)	Phosphorus (kg/ha/yr)
1.89	0.24

Residential

Size (m²)	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
<400	85	7.12	167.21	48.99
400-500 m²	15	1.26	82.40	21.05
501-600 m²	0	0.00	0.00	0.00
601-730 m²	0	0.00	0.00	0.00
>730 m²	0	0.00	0.00	0.00
Multiple dwellings	0	0.00	0.00	0.00

Total area (ha)	Total percent (%)
8.373456	54

Nitrogen input (kg)	Phosphorus input (kg)
249.61	70.04

Public Open Space (POS)

Landuse	Percent (%)	Area (ha)
Native gardens	37	1.03
Non-native gardens	0	0.00
Not fertilised	0	0.00
Nature	0	0.00
Sport	0	0.00
Recreation	60	1.67
Golf course	0	0.00
Bowling green	0	0.00
Impervious	3	0.08
Water body	0	0.00

Total area (ha)	Total percent (%)
2.79	18

Nitrogen input (kg)	Phosphorus input (kg)
139.45	4.28

Road reserve

Landuse	Percent (%)	Area (ha)
Roads	60	2.61
Road reserve - impervious	0	0.00
Road reserve - native garden	30	1.30
Road reserve - non-native garden	0	0.00
Road reserve - turf	0	0.00
Road reserve - not fertilised	10	0.43

Total area (ha)	Total percent (%)
4.341792	28

Nitrogen input (kg)	Phosphorus input (kg)
36.47	36.47

Soil and drainage information

Type of drainage	**Piped drainage**	**Does it contain imported fill?**	**Yes**
Soil type	**Bassendean**	Type of fill imported	**Yellow sand (Spearwood)**
Depth to groundwater (m)	**2**	Fill depth (m)	**0.5**
Groundwater slope (%)	**0.09**	Approximate PRI of imported fill	**11**
Soil PRI	**6.5**	**Does subregion contain onsite sewage diposal system?**	**No**

Note: Please attach the results of soil tests to this report when submitting.

Subregion name: **Catchment b**

Landuse	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
Residential	57	0.79	28.66	7.81
Industrial, commercial & schools	0	0.00	0.00	0.00
Rural living	0	0.00	0.00	0.00
Public open space	0	0.00	0.00	0.00
Road reserve	43	0.60	1.68	0.05

Total area (ha)	Total percent (%)
1.39	7
Nitrogen input (kg/ha/yr)	**Phosphorus input (kg/ha/yr)**
27.03	5.80
Nitrogen export (kg/ha/yr)	**Phosphorus (kg/ha/yr)**
1.70	0.28

Residential

Size (m²)	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
<400	70	0.56	13.04	3.82
400-500 m²	30	0.24	15.61	3.99
501-600 m²	0	0.00	0.00	0.00
601-730 m²	0	0.00	0.00	0.00
>730 m²	0	0.00	0.00	0.00
Multiple dwellings	0	0.00	0.00	0.00

Total area (ha)	Total percent (%)
0.793212	57
Nitrogen input (kg)	**Phosphorus input (kg)**
28.66	7.81

Road reserve

Landuse	Percent (%)	Area (ha)
Roads	60	0.36
Road reserve - impervious	0	0.00
Road reserve - native garden	10	0.06
Road reserve - non-native garden	0	0.00
Road reserve - turf	0	0.00
Road reserve - not fertilised	30	0.18

Total area (ha)	Total percent (%)
0.598388	43

Nitrogen input (kg)	Phosphorus input (kg)
1.68	1.68

Soil and drainage information

Type of drainage	**Piped drainage**	**Does it contain imported fill?**	**Yes**
Soil type	**Bassendean**	Type of fill imported	**Yellow sand (Spearwood)**
Depth to groundwater (m)	**2**	Fill depth (m)	**0.5**
Groundwater slope (%)	**0.1**	Approximate PRI of imported fill	**11**
Soil PRI	**6.5**	**Does subregion contain onsite sewage diposal system?**	**No**

Note: Please attach the results of soil tests to this report when submitting.

Subregion name: Catchment c

Landuse	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
Residential	53	0.74	17.33	5.08
Industrial, commercial & schools	0	0.00	0.00	0.00
Rural living	0	0.00	0.00	0.00
Public open space	8	0.11	3.12	0.10
Road reserve	39	0.54	1.52	0.05

Total area (ha)	Total percent (%)
1.39	7

Nitrogen input (kg/ha/yr)	Phosphorus input (kg/ha/yr)
21.01	3.90

Nitrogen export (kg/ha/yr)	Phosphorus (kg/ha/yr)
1.31	0.19

Residential

Size (m²)	Percent (%)	Input load Area (ha)	Nitrogen (kg)	Phosphorus (kg)
<400	100	0.74	17.33	5.08
400-500 m²	0	0.00	0.00	0.00
501-600 m²	0	0.00	0.00	0.00
601-730 m²	0	0.00	0.00	0.00
>730 m²	0	0.00	0.00	0.00
Multiple dwellings	0	0.00	0.00	0.00

Total area (ha)	Total percent (%)
0.737548	53

Nitrogen input (kg)	Phosphorus input (kg)
17.33	5.08

Public Open Space (POS)

Landuse	Percent (%)	Area (ha)
Native gardens	100	0.11
Non-native gardens	0	0.00
Not fertilised	0	0.00
Nature	0	0.00
Sport	0	0.00
Recreation	0	0.00
Golf course	0	0.00
Bowling green	0	0.00
Impervious	0	0.00
Water body	0	0.00

Total area (ha)	Total percent (%)
0.11	8

Nitrogen input (kg)	Phosphorus input (kg)
3.12	0.10

Road reserve

Landuse	Percent (%)	Area (ha)
Roads	60	0.33
Road reserve - impervious	0	0.00
Road reserve - native garden	10	0.05
Road reserve - non-native garden	0	0.00
Road reserve - turf	0	0.00
Road reserve - not fertilised	30	0.16

Total area (ha)	Total percent (%)
0.542724	39

Nitrogen input (kg)	Phosphorus input (kg)
1.52	1.52

Soil and drainage information

Type of drainage	**Piped drainage**	**Does it contain imported fill?**	**Yes**
Soil type	**Bassendean**	Type of fill imported	**Yellow sand (Spearwood)**
Depth to groundwater (m)	**2**	Fill depth (m)	**0.5**
Groundwater slope (%)	**0.09**	Approximate PRI of imported fill	**11**
Soil PRI	**6.5**	**Does subregion contain onsite sewage diposal system?**	**No**

Note: Please attach the results of soil tests to this report when submitting.

Subregion name: Catchment d

Landuse	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
Residential	53	0.84	19.80	5.80
Industrial, commercial & schools	0	0.00	0.00	0.00
Rural living	0	0.00	0.00	0.00
Public open space	3	0.05	1.34	0.04
Road reserve	44	0.70	1.96	0.06

Total area (ha)	Total percent (%)
1.59	8

Nitrogen input (kg/ha/yr)	Phosphorus input (kg/ha/yr)
19.75	3.86

Nitrogen export (kg/ha/yr)	Phosphorus (kg/ha/yr)
1.24	0.19

Residential

Size (m²)	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
<400	100	0.84	19.80	5.80
400-500 m²	0	0.00	0.00	0.00
501-600 m²	0	0.00	0.00	0.00
601-730 m²	0	0.00	0.00	0.00
>730 m²	0	0.00	0.00	0.00
Multiple dwellings	0	0.00	0.00	0.00

Total area (ha)	Total percent (%)
0.842912	53

Nitrogen input (kg)	Phosphorus input (kg)
19.80	5.80

Public Open Space (POS)

Landuse	Percent (%)	Area (ha)
Native gardens	100	0.05
Non-native gardens	0	0.00
Not fertilised	0	0.00
Nature	0	0.00
Sport	0	0.00
Recreation	0	0.00
Golf course	0	0.00
Bowling green	0	0.00
Impervious	0	0.00
Water body	0	0.00

Total area (ha)	Total percent (%)
0.05	3

Nitrogen input (kg)	Phosphorus input (kg)
1.34	0.04

Road reserve

Landuse	Percent (%)	Area (ha)
Roads	60	0.42
Road reserve - impervious	0	0.00
Road reserve - native garden	10	0.07
Road reserve - non-native garden	0	0.00
Road reserve - turf	0	0.00
Road reserve - not fertilised	30	0.21

Total area (ha)	Total percent (%)
0.699776	44

Nitrogen input (kg)	Phosphorus input (kg)
1.96	1.96

Soil and drainage information

Type of drainage	**Piped drainage**	**Does it contain imported fill?**	**Yes**
Soil type	**Bassendean**	Type of fill imported	**Yellow sand (Spearwood)**
Depth to groundwater (m)	**2**	Fill depth (m)	**0.5**
Groundwater slope (%)	**0.1**	Approximate PRI of imported fill	**11**
Soil PRI	**6.5**	**Does subregion contain onsite sewage diposal system?**	**No**

Note: Please attach the results of soil tests to this report when submitting.

Summary: Nutrient stripping devices

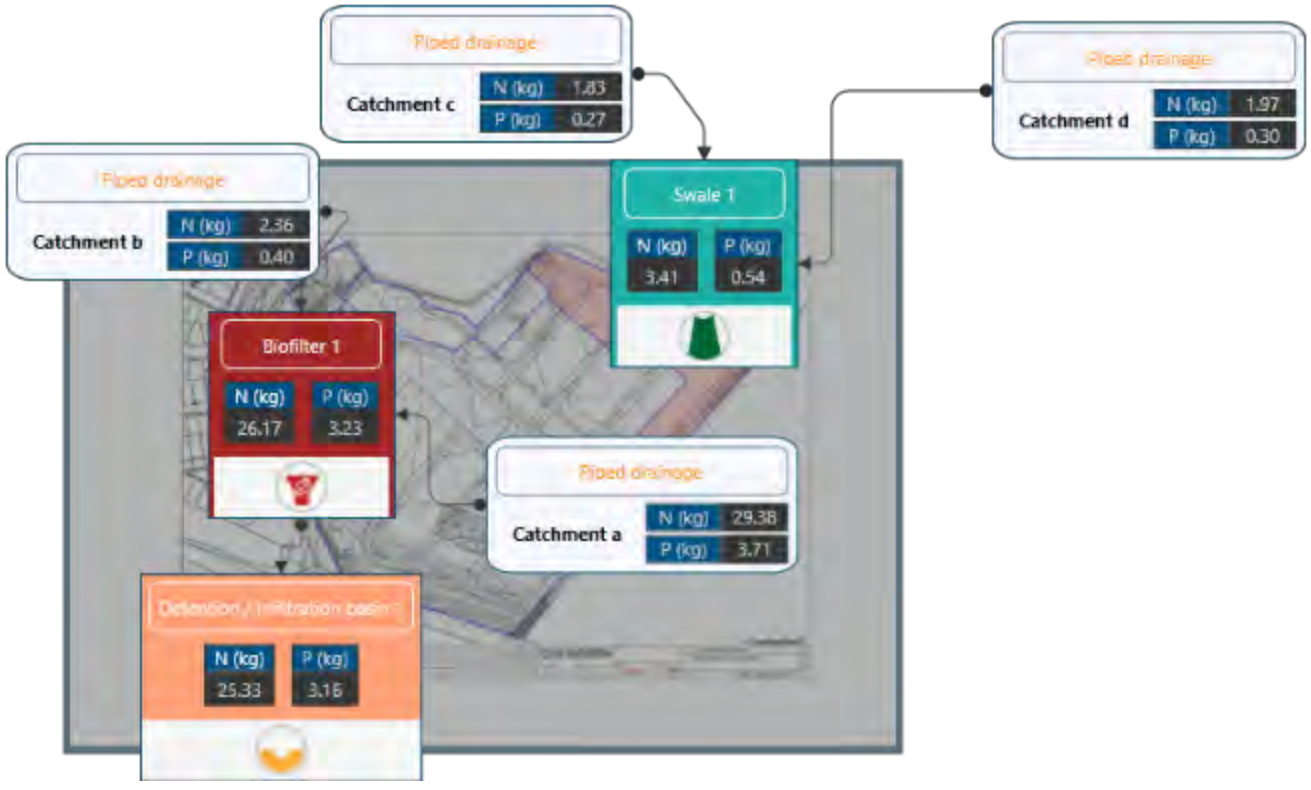
Treatment	Name	Size (m²)	Treated area (ha)	Treating	N removed (kg/ha/yr)	P removed (kg/ha/yr)
Swale	Swale 1	705.00	2.98	Sandy soils – Runoff only (infiltration on lots)	0.26	0.02
Biofilter	Biofilter 1	1400.00	16.90	Sandy soils – Runoff only (infiltration on lots)	0.63	0.11
Detention / infiltration basin	Detention / infiltration basin 1	5200.00	16.90	Sandy soils – Runoff only (infiltration on lots)	0.10	0.01
Load removed					**0.34**	**0.05**
Net export					**1.45**	**0.19**

Summary: Nutrient load exports

Region	Area (ha)	P export (kg/ha/yr)	N export (kg/ha/yr)
Catchment a	15.51	0.24	1.89
Catchment b	1.39	0.28	1.70
Catchment c	1.39	0.19	1.31
Catchment d	1.59	0.19	1.24

PRE-TREATMENT LOAD (kg/ha/yr)		LOAD REMOVED (kg/ha/yr)		NET LOAD EXPORT (kg/ha/yr)	
NITROGEN	PHOSPHORUS	NITROGEN	PHOSPHORUS	NITROGEN	PHOSPHORUS
1.79	0.24	0.34	0.05	1.45	0.19

Treatment diagram



Appendix H

Landscape master plan

Appendix I

LWMS checklist