Geotechnical Report

Southern River Precinct 3D
Lots 9 and 1792 Holmes Street Southern River

January 2018

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Geotechnical Report

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Prepared for: Land owners of lots 9 and 1792 Holmes Street, Southern River

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Document Control

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1	01/07/2012	R. Bromfield	P. Keating	P. Keating
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1.0 Executive Summary

This report covers lots 9 and 1792 Holmes street, contained within precinct 3D of the Southern River structure plan. The objective of this report is to determine the suitability of the area for urban development from a geotechnical perspective. The site is gently undulating Bassendean sand ranging in height from 21 - 24m AHD, with the Forrestdale main drain forming the northwest boundary of the site. Groundwater occurs between 0.7 and 2.6 metres below ground level over the site at maximum levels.

Bioscience undertook field and laboratory investigations of the soils over the site to determine their physical and chemical properties to in relation to soil profiles, permeability, reactivity and acid sulphate potential. Field investigation consisted of 8 mechanically augered holes from which soils profiles were logged, and samples taken for laboratory analysis.

Acid sulphate soil testing showed low acid sulphate potential, with none of the tested samples displaying properties of potential acid sulphate soils, however, soils are generally acid in nature and further investigation would be required if there is to be large scale excavation of natural soils.

Soil profiles show the site to be Bassendean sand of varying depth over Guilford formation clays of low reactivity. Sands were found to be medium textured with thickness ranging from 2.25 to 4.2 metres, whilst clays are sandy clays. Coffee rock (indurated iron rich silty sands) was intersected in some of the holes at varying depths generally at the interface between the clays and sandy clays.

The majority of the site is Class A" as defined in the Residential Slab and Footings (Australian Standard 2870). An area with sandy clay at the surface, which full extent was inferred from the GSWA mapping, was defined as Class H.

2.0 Introduction

This report describes the geotechnical investigations undertaken by Bioscience Pty Ltd in the precinct 3D area of Southern River, with a specific focus on Lots 9 and 1792 Holmes street, Southern River (figure1). The investigation was commissioned by the owners of the properties who are seeking to develop the land into an urban subdivision. The lots collectively cover 15.94ha.

This report has been developed for the owners, based on the proposals presented and their contained terms of reference which have been accepted. The advice contained within this report is based on the information obtained and the assumptions which are expressed herein. Should the information received or the assumptions be incorrect, then Bioscience shall accept no liability in respect of the advice whether under law of contract, tort or otherwise.

Within Southern River region, the City of Gosnells has identified several precincts, of which the site is located within Precinct 3D. Precinct 3D is bounded by Passmore street, Holmes Street, Matison street, Phoebe street, the Forrestdale main drain and Furley road and is characterised by areas of flat, low lying land and a relatively high water table. Bioscience was asked to investigate the land, with the objective of determining the geotechnical condition present, and whether it is suitable for rezoning to urban, and any requirements to enable development.

3.0 Proposed Development

The site is proposed to be developed into a residential subdivision consisting of varying densities of housing, a retirement living area, a commercial area and areas of public open space (figure 2).

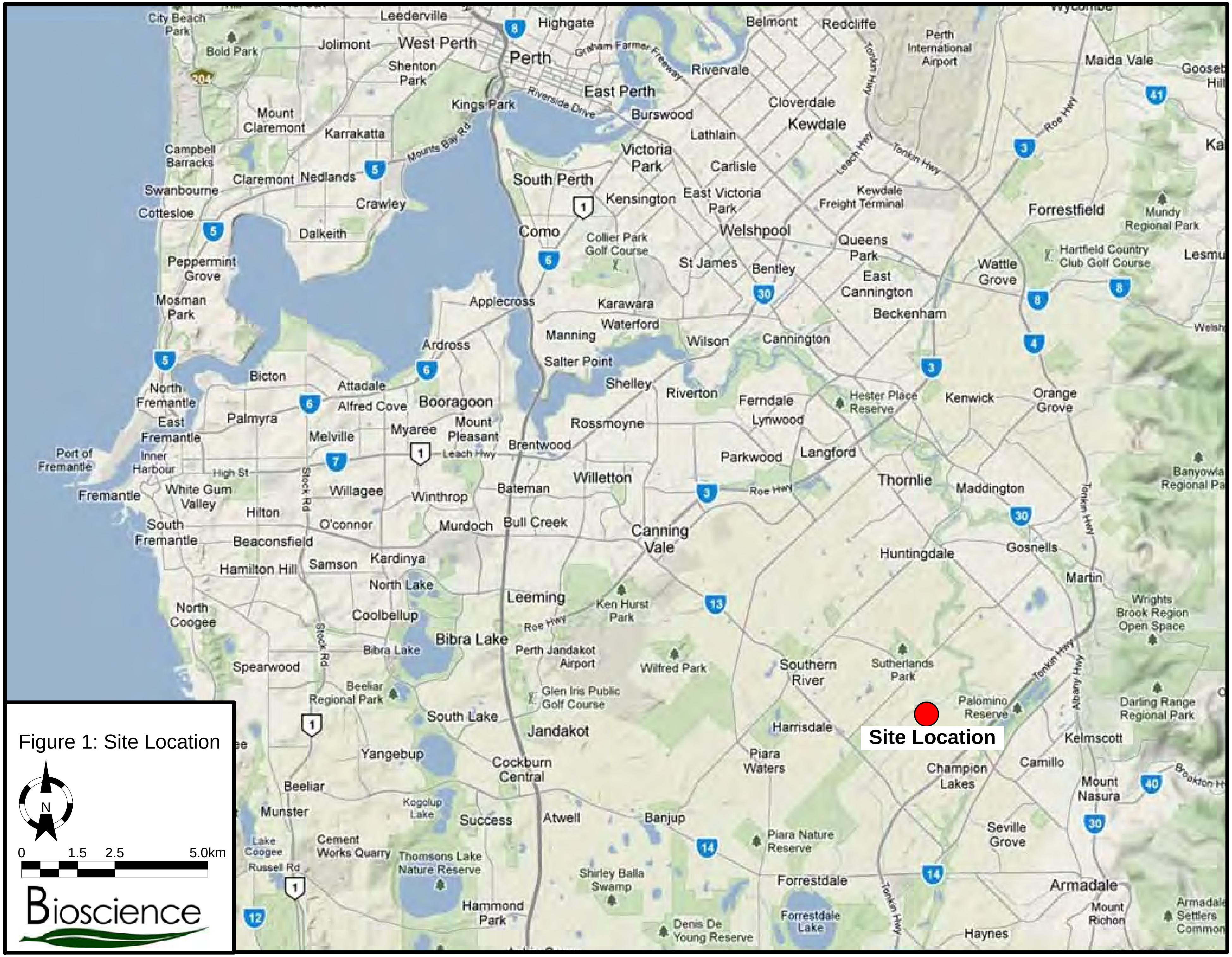
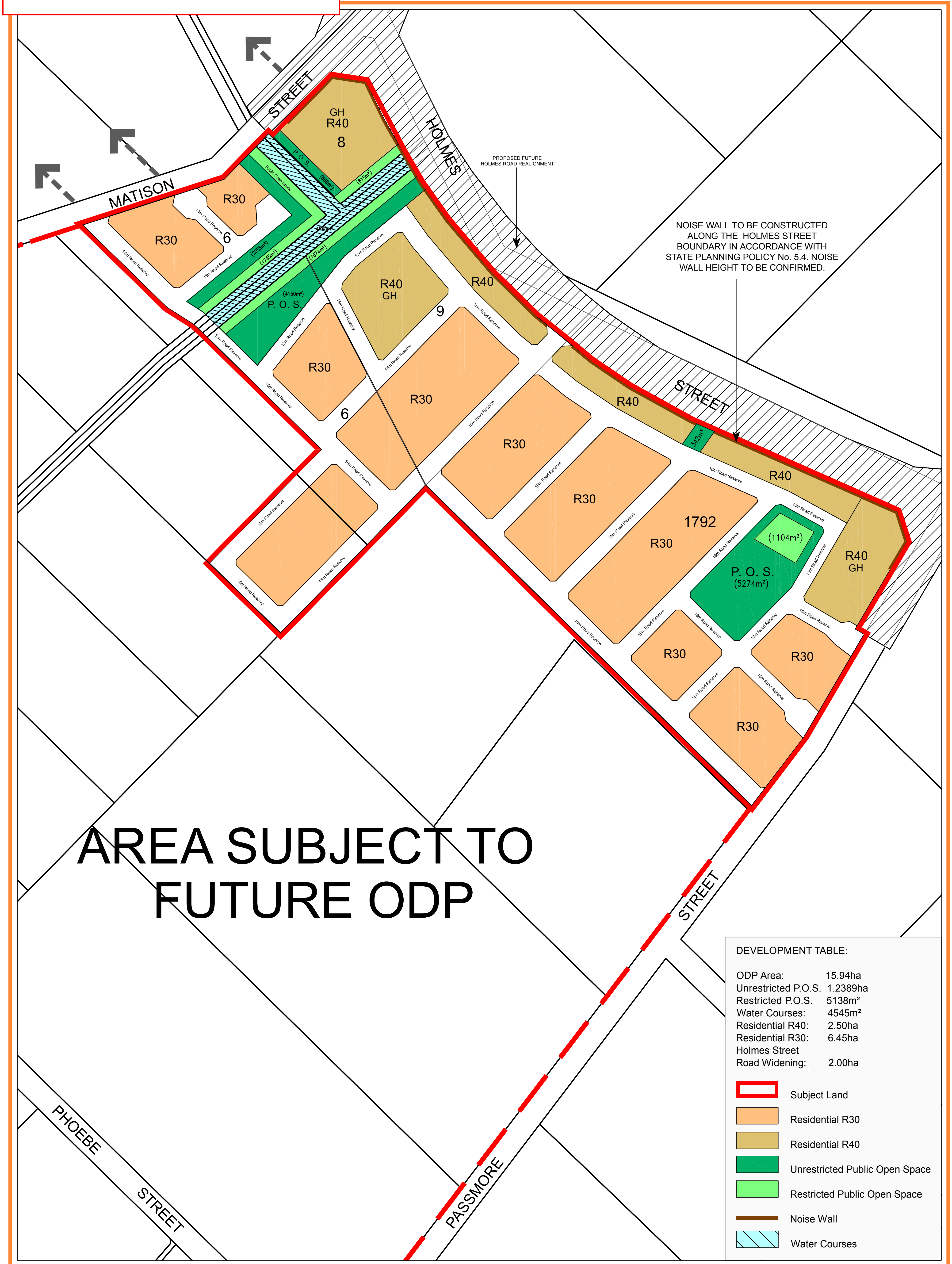


Figure 1: Site Location

FIGURE 2. ODP



PROPOSED OUTLINE DEVELOPMENT PLAN - R30/40
LOT 9 (No. 419) HOLMES STREET
SOUTHERN RIVER

UDIA Urban Development Institute of Australia WESTERN AUSTRALIA

PIA Planning Institute Australia

CPP CERTIFIED PRACTISING PLANNER

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DATE: 9th JANUARY 2018
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N W E S

4.0 Site Description

4.1 Land Use

The land is used for horse paddocks and stables, with horses grazing lots 9 and 1972 Holmes street, and a stable on lot 1792. There are fences around the lots and numerous rubbish and rubble piles. The remnants of a small piggery are present on lot 1792 Holmes street.

4.2 Topography

The area has a low relief with minor variations in topography. The area generally lies between 20m AHD and 22m AHD with some areas above 22m AHD (figure 3).

4.3 Vegetation

The site is mostly devoid of native vegetation as it has been cleared for grazing. The majority of vegetation on the site is introduced trees, pasture and low scrub.

4.4 Geology and Geomorphology

The subject site is located on the Swan Coastal Plain within the Bassendean dune system, an area characterised by low dunes of siliceous sand interspersed with poorly drained areas or wetlands. Soils tend to be a deep bleached grey colour sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than 2 m.

Underlying the Bassendean formation is the Guildford formation. The soils of the Guildford formation are complex, and comprise a successive layering of soils formed from erosion of material from the scarp to the east. Rivers and streams have mostly carried the eroded material, which is deposited from the water as fans of alluvium. The Guildford formation is characterised by poor drainage due to the low permeability of sub-soil clays which prevent the downward infiltration of rainfall, consequently during the winter month's water logging and surface inundation can occur. In addition, the clay fraction of the Guildford formation is known to have highly variable Plasticity Indices (Hillman et al., 2003).

The geology at the site as per the Geological Survey of Western Australia 1:50000 Environmental Geological Series Armadale Map part of sheet 2033 I and part of sheet 2133 IV is:

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

- S10 – SAND – As for S8 over sandy clay to clayey sand of the Guilford formation, of eolian origin
- Sp1 – PEATY SAND – grey to black, fine to medium grained, moderately sorted quartz sand, slightly peaty, of lacustrine origin

A soil geology map can be seen in figure 4.

4.5 Groundwater

The hydrology of the Southern River area on a broad scale is characterised by flat land of Bassendean sand dunes with quite low relief hosting a superficial aquifer which is about 30 m thick. The Southern River itself acts as a local discharge point for this superficial aquifer and is thus the lowest local groundwater level. The Perth Groundwater Atlas (2004) shows the groundwater contours slope downwards in a north easterly direction towards the Southern River, but also strongly influenced by the Forresdale main drain. The groundwater atlas suggests that groundwater is approximately 1 to 2.5 m below the surface across the site, based on May 2003 data when local groundwater would be approaching annual minimum levels (Figure 3). Groundwater monitoring and modelling of the southern river district was conducted initially by JDA (2002) and then by Rockwater (2005). Both the JDA and Rockwater reports indicate that groundwater flow on the site is in a north easterly direction towards the Southern River with an Average Annual Maximum Groundwater Levels (AAMGL) of 20 mAHD.

4.6 Site Surface Drainage

The major surface water drainage feature of the site is the Forrestdale main drain which forms the north west boundary of the site, whilst in the eastern portion of the site, a seasonal lake forms as an expression of the groundwater, but is also a significant drainage feature. The topography of the site, with the high central area splits the surface drainage between west and east.

4.7 Wetlands

The Geomorphic Wetlands Dataset displays the location, boundary, geomorphic classification and management category of wetlands on the Swan Coastal Plain. The information contained within the dataset was originally digitised from the *Wetlands of the Swan Coastal Plain Volume 2B Wetland Mapping, Classification and Evaluation: Wetland Atlas*, which was captured at a scale of 1:25,000 (Hill et al. 1996b). According to the dataset the site has areas of Multiple Use Wetlands (MUW) (15633 Dampland, 15772 Dampland, and 15781 Dampland). On the north site of Holmes street there is a Conservation Category Wetland (CCW), Dampland 7720. Both

Dampland 15781 and 15633 which are on the site abut the CCW. Forrestdale main drain also flows into the CCW as a natural floodplain area before discharging into the Southern River. There are also numerous Resource Enhancement Wetlands (REW) near the site. The location of the wetlands can be seen in figure 5.

Around one third of lot 1792 has been classified by the City of Gosnells as an *Environmental Protection Policy (Swan Coastal Plains)* 1992 (EPP) lake in their 2004 structure plan (Figure 7). EPP lakes are generally recognised as having significant conservation value; however this seems to contradict the current MUW classification in regards to both management category and boundaries. The lake also appears to be experiencing increasing dry periods as observed by aerial photography. Bioscience is preparing a request to have the wetland removed from the EPP lakes register by following the guidance for modifying wetlands.

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FIGURE 3. Topography and Regional Groundwater Levels

Southern River Precinct 3D

Source: Cadastre (Landgate 13/12/2016); Aerial (Nearmap, 13/12/2016); Historical Max. Groundwater Levels (DoW, 13/12/2016);

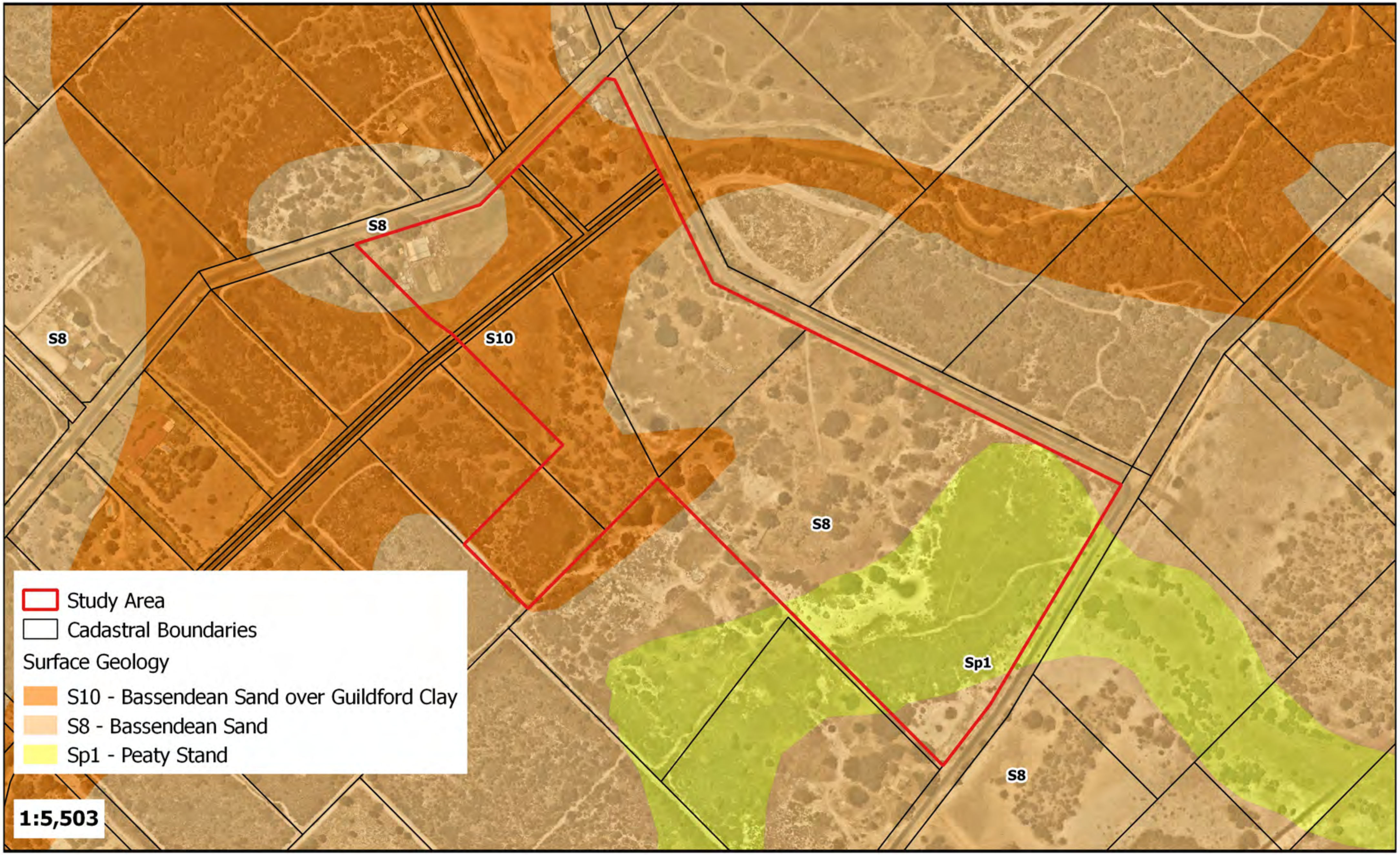

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FIGURE 4. Soil Geology

Southern River Precinct 3D

Source: Cadastre (Landgate 13/12/2016); Aerial (Nearmap, 13/12/2016);

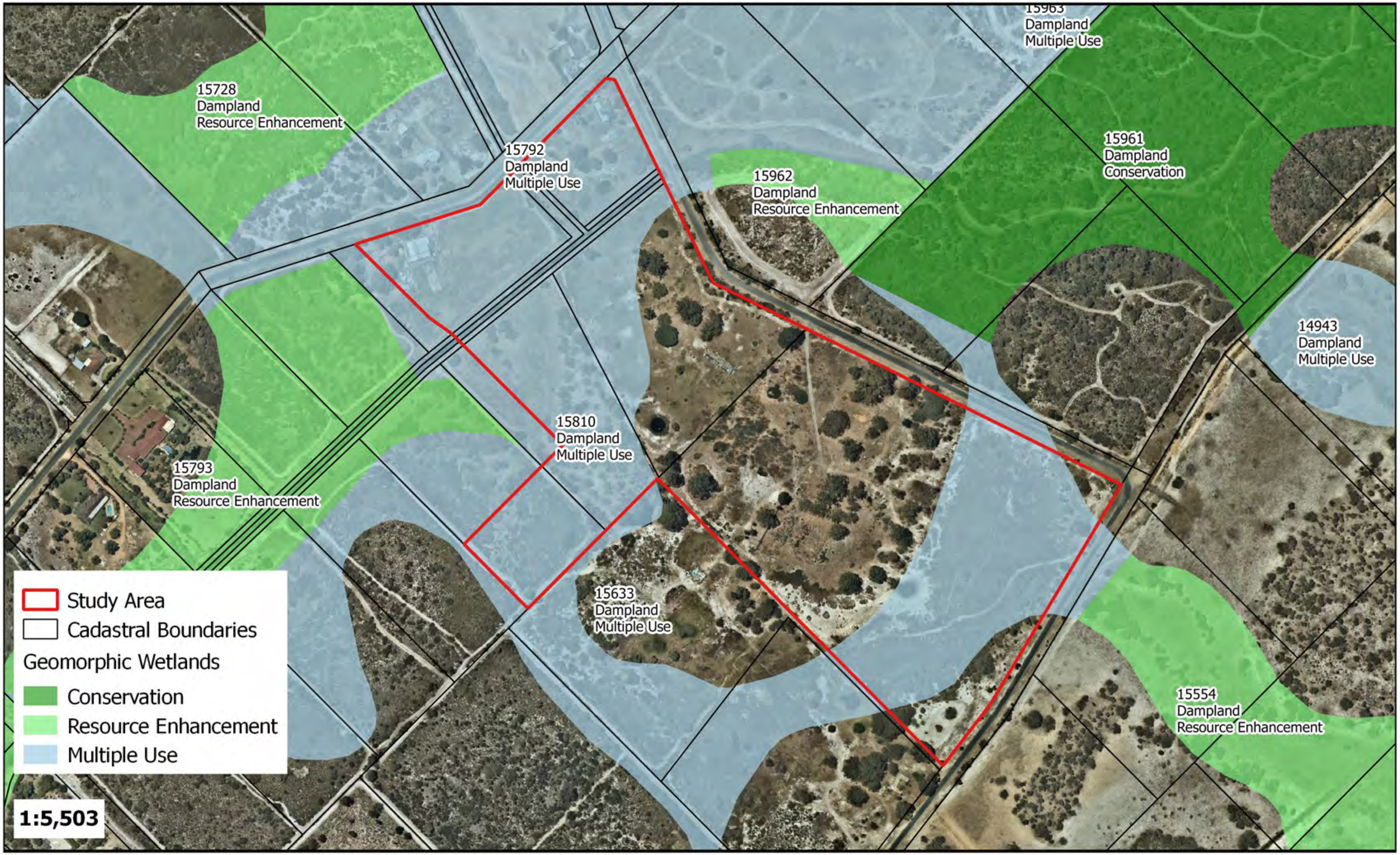

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FIGURE 5. Geomorphic Wetlands

Southern River Precinct 3D

Source: Cadastre (Landgate 13/12/2016); Aerial (Nearmap, 13/12/2016);

5.0 Geotechnical Investigation

5.1 Objectives

- Determine soil and groundwater (if encountered) conditions to a depth of 2.5 metres below current ground level.
- Provide advice on any need for groundwater control or subsoil drainage
- Determine soil permeability and suitability for stormwater infiltration.
- Determine the site classification according to AS 2870 (1996), and recommend measures to upgrade classification if required.
- Provide advice in relation to excavation control requirements, site preparation earthworks, characteristics of fill requirements and compaction control.

5.2 Field Investigations

Field investigations took place in April 2011 with 8 boreholes dug using a mechanical hollow tipped auger drill rig that provides core samples of the soil profile as the hole is drilled. From the soils cores, soil profiles were logged and samples taken for laboratory analysis (Figure 6). Piezometers were installed into the drilled boreholes for groundwater investigations.

5.3 Soil Profiles

The site has a typical soil profile of sand over sandy clays, with a layer of weakly cemented iron rich silty sand (coffee rock) commonly found between the sand and clays.

The common soil profile was found at all boring locations except for D3, which was loamy and clayey sands all the way through the profile. The depth of sand at each location varied between 4200mm at D4 and 2250mm at D5, the sand was generally grey and white medium textured Bassendean sand. Coffee rock was intersected at all except two of the locations, D3 and D 6, and occurred at variable locations within the soil profile, most commonly at the interface between sands and clayey sands. Clayey sands are of the Guilford formation and varied from grey to brown in colour. Soil profile logs and photos can be seen in Appendix 1.

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FIGURE 6. Geotechnical Investigation Locations

Southern River Precinct 3D

Source: Cadastre (Landgate 13/12/2016); Aerial (Nearmap, 13/12/2016);

5.4 Groundwater

Groundwater conditions at the site have been assessed through the use of piezometers installed during drilling and collection of soil cores. Groundwater has since been monitored on a regular basis to determine seasonal fluctuations in groundwater levels and how they may impact upon development of the site. Groundwater at the site has occurs between 0.7 and 2.6 metres below ground level and has a seasonal fluctuation of up to 2m. Groundwater levels can be seen in Appendix 2. Given that the Forrestdale Main Drain runs through the site it will have a lowering effect on the groundwater of the site when the groundwater rises and intersects the level of the drain.

5.5 Laboratory Investigations

At the completion of the fieldwork, a program of laboratory tests was performed on selected soil samples. Test results have been used to assist with the classification and determination of engineering properties of the soil for this geotechnical investigation.

- Particle size distribution – AS1289.3.6.1
- Atterberg limit
  - Liquid limit – AS1289.3.1.2
  - Plastic limit - AS1289.3.2.1
  - Plasticity index – AS1289.3.3.1
  - Linear shrinkage – AS1289.3.4.1
- Acid Sulfate Soil DEC field test plus total Carbon and Sulphur

The laboratory tests were carried out in accordance with the requirements specified in AS 1289 by Bioscience's soil laboratory in Forrestdale.

5.5.1 Particle Size Distribution

Particle size distribution (PSD) was determined on soils collected during the field investigation that gave a representative example of the soils present in the soil profiles of the site. The results of the PSD analysis show that the sands on the site are generally a medium textured, poorly to uniformly sorted sand with less than 5 per cent fines (<0.075mm). The clays on the site are actually clayey sands with a fines content between 15 and 30 per cent. Graphs of PSD can be seen in figure 7.

Fours samples contained more than 12 per cent fines and were therefore classified as clayey sands, four of the samples contained less than 5 per cent fines and are classed as clean sands generally poorly or uniformly sorted. The remaining three samples that underwent PSD are borderline classifications between sands and clayey sands, with two of them being closer to sands with between 5 and 8 per cent fines, and the other closer to clayey sands at 11.57 per cent fines.

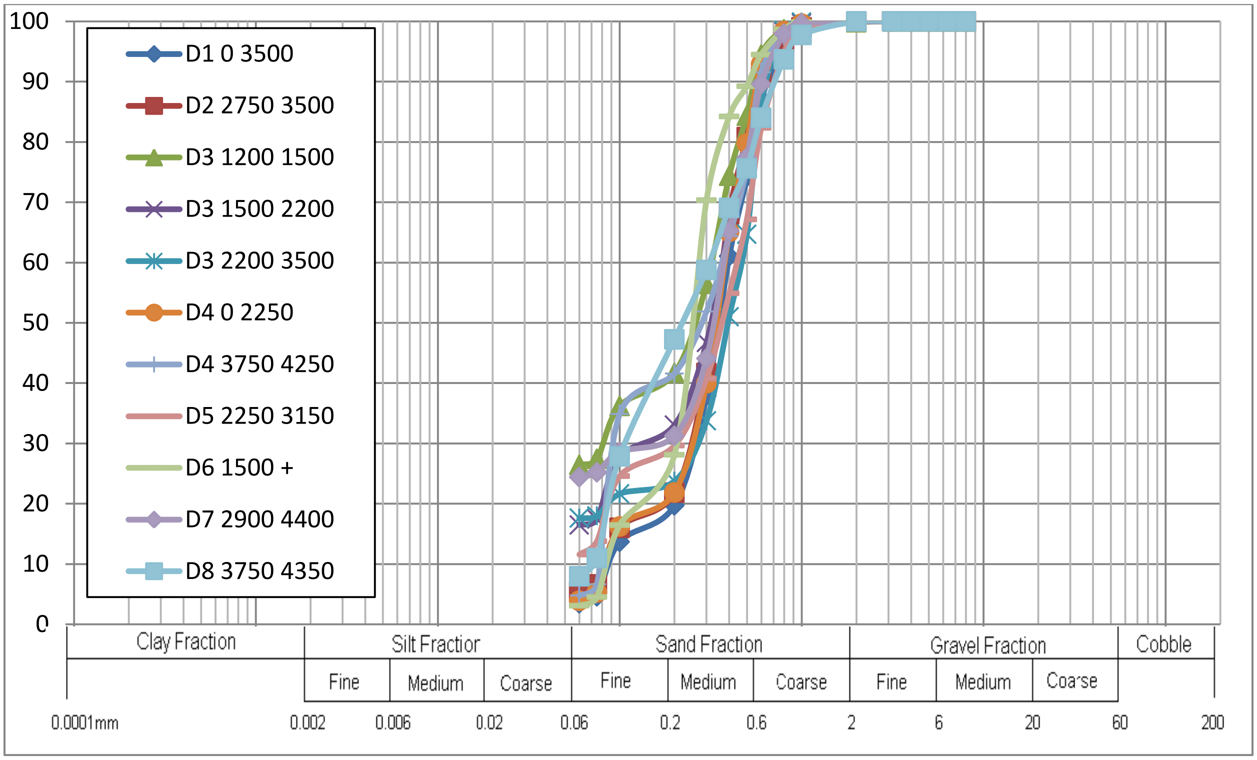

Figure 7: Particle Size Distribution Graph

5.5.2 Attergberg Limit

The Atterberg limits tests are simple standardized tests that were developed to determine the water contents that will induce particular behaviour, and provides a useful measure of potential soil reactivity and ground movements, which are fundamental in foundation design. Samples that contained more than 20% of fines in PSD analysis underwent Atterberg testing.

Both samples plotted above the "A" Line , with sample D7 2900-4400 classified as a clay of low plasticity. Sample D3 1200-1500 classified as a clay of high plasticity, making it a highly reactive clay. The raw results for these tests are summarised in table 1.

Table 1: Atterberg Testing Results

Borehole	Sample Depth (m)		Soil Weight		Liquid Limits			Plastic Limits (PL)	Plastic Index (PI)	Linear Shrinkage (LS)	Atterberg Classification
			Total soil Weight (g)	% fines (<425um)	No Blows (15 to 35)	Water content (%)	Liquid Limits (LL)	Water content (%) OR Plastic Limits (PL)	PI = LL - PL	Linear Shrinkage (LS) (%)	
D3	1200	1500	208.6	89.07	28	92.02	92.91	27.56	65.35	6.67	CH
D7	2900	4400	246.5	147.8	26	31.52	31.57	17.68	13.89	8.00	CL

NOTE: M = Silt, C = Clay, L = Low plasticity, I = Intermediate plasticity, H = High plasticity

These can be seen in Figure 8 where the A - Line separates soils that behave in the way of organics and silts, plotting below the A - Line, to those that are clays and plot above the A - Line. Given the fact that both soils have a high percentage of sand fraction and are classified as clayey sands, the reactivity of the clay will not cause as much ground movement as if they were more pure clays. Also the depth of the sand cover at D7 limits any impact the clay would have on the surface.

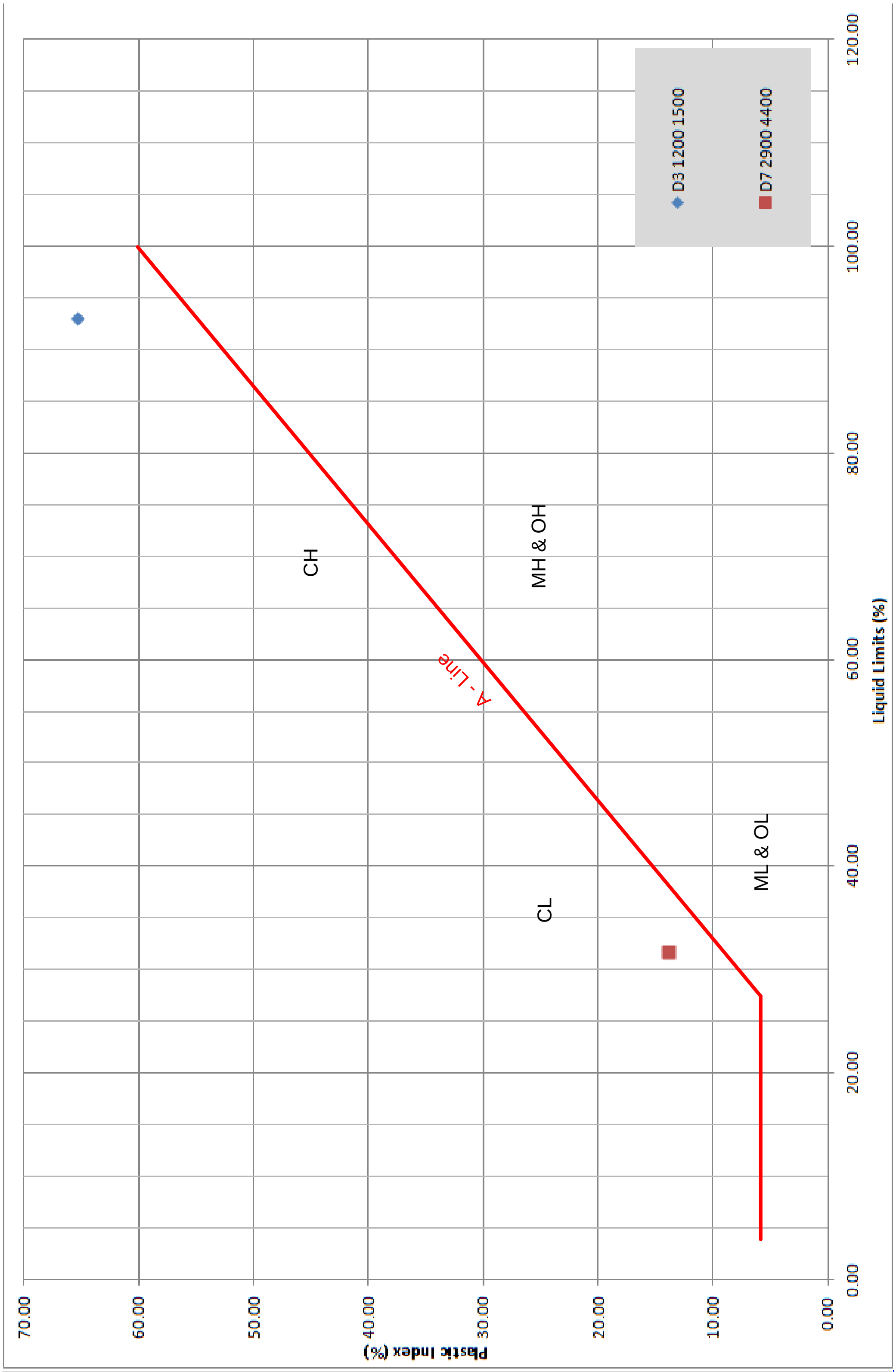

Figure 8: Atterberg Graph

5.5.3 Acid Sulphate Soil Exclusion Tests

The acid sulphate risk maps for the site shows a large area of lot 1792 Holmes street to have a high to moderate risk of acid sulphate soils occurring within 3m of the natural soil surface. The rest of the site has a moderate to low risk of acid sulphate soils occurring within 3m of the natural soil surface, but high to moderate risk below 3m. As a result of this, exclusion testing was done on the soils collected during field investigation to determine the acid sulphate potential.

Acid sulphate soils (ASS) exclusion testing involves the use of field testing and determination of total sulphur content. If the Field test procedure indicated potential or actual acid sulphate soils, determining the total sulphur can confirm or eliminate the result. For a sample to be classified as potential acid sulphate soil the minimum "oxidisable" (S_{POS}) sulphur present must be greater than 0.03% for a sand, or greater than 0.06% for sandy loams and light clay or greater than 0.1% for silts and clays. Therefore if total sulphur is less than the specified levels, then the sample cannot be potential or actual ASS.

The field test procedure involves measuring the field pH of the soil (pH_F) and then using hydrogen peroxide to oxidize the soil and then measure its oxidized pH (pH_{FOX}). A field pH of less than 3 can indicate an actual acid sulphate soil whereas if the field pH was not low and the oxidized pH drops to less than 3, then the soil may be a potential acid sulphate soil. Drops in pH of greater than 2 ph units indicate that a soil has potential to be oxidised and could be a risk of becoming acid sulphate soils. Table 2 summarises the results of the acid sulphate testing.

Selected soil samples collected during geotechnical investigation were analysed using the DEC field test procedure as well as LECO carbon sulphur analyser and redox potential. Overall these give an indication of whether or not soils are actual, potential or non acid sulphate soils. Twenty samples underwent these tests and 3 samples came back as being potential acid sulphate soils. These soils are generally soils deeper than 2.5 metres with higher clay contents, or the presence of coffee rock. 13 samples returned results that indicate they are not acid sulphate soils but have a sulphur content above the 0.03% threshold for treatment of acid sulphate soils.

Any excavations of natural soils on the site will require more detailed investigation of the soils in order to develop an acid sulphate soils management plan specific to the excavations that would take place. If dewatering is to be required as part of any excavations, a dewatering management plan would be required and a groundwater abstraction licence needed before any dewatering can take place.

Table 2: Acid Sulphate Testing Results

Sample ID	Depth	pH_F	pH_{FOX}	ΔpH	Reaction	Sulphur %	Redox
D1	3950-4200	4.44	3.72	0.72	L	0.08451	329.9
D2	2750-3500	4.72	3.52	1.2	L	0.03371	300.2
D2	3500+	4.54	2.1	2.44	L	0.041	401.8
D3	750-1200	7.37	6.27	1.1	L	0.01417	286.9
D3	1200-1500	7.2	6.05	1.15	L	0.02193	315.7
D3	1500-2200	7.88	6.47	1.41	L	0.00993	306.5
D3	2200-3500	7.6	5.62	1.98	L	0.02398	265.3
D4	2250-2500	5.4	3.91	1.49	L	0.2006	392.3
D4	3000-3750	4.42	3.33	1.09	L	0.03832	371.8
D4	4250+	4.95	3.19	1.76	L	0.2666	347.1
D5	2250-2550	5.51	4.49	1.02	L	0.02606	355.9
D5	2550-3150	5.37	3.73	1.64	L	0.07597	305.2
D5	3150+	5.54	3.23	2.31	L	0.07045	339.9
D7	2750-2900	4.53	3.45	1.08	L	0.05975	386.1
D7	4400+	5.24	2.8	2.44	L	0.1041	321.7
D8	3450-3700	4.62	3.22	1.4	L	0.08865	359.3
D8	3700-4350	4.84	3.59	1.25	L	0.03415	319.7
D8	4350+	5.08	3.34	1.74	L	0.1025	340.2

6.0 Site Evaluation and Recommendations

6.1 Site Classification

The “Residential Slab and Footings Australian Standard 2870” provides a site classification system and associated generic foundation design recommendations, for residential development. The site classification system is based on the potential soil reactivity, and associated ground movements, attributable to seasonal soil moisture variations or potential problems sites due to adverse geotechnical conditions.

Where the sand is only a thin layer overlying clay substrate, the depth of sand will have a major impact on the classification and hence the type and consequent cost of the slab and footing construction. This classification is related to the amount of movement that the foundation can accommodate without causing damage to the structure. This movement can be either settlement or seasonal movement due to the swelling and shrinkage of the clayey soils due to the wetting and drying caused by the varying water levels.

The site classification was determined using a combination of field and laboratory investigations. Spatial variation in soils and topography mean caution must be observed when assuming that site classification is continuous between any two investigation sites.

All of the site except the area around D3 (inferred from the GSWA mapping) is "Class A", as defined in the Residential Slab and Footings (Australian Standard 2870), as these areas have 1.5m or greater sand over loamy/clayey soils. Site D3 is a "Class H" classification as defined in the Residential Slab and Footings (Australian Standard 2870), as there is less than 1.5m of sand cover over the loamy/clayey soils and surface movement may result from the reactive soils due to moisture changes (Figure 9). This can be improved to a class A by the application of engineered fill to the site after the removal of the reactive clays and creation of a separation of 1.5m to the loamy/clayey soils.

6.2 Soil Reactivity

Of the two samples tested for Atterberg limits D7 2900-4400 displayed low reactivity and D3 1200-1500 displayed high reactivity. As a result of this there is likely to be minimal surface movement at D7 as a result of changes in moisture of the subsoil clays. Surface movement at D3 are likely due to the proximity of the reactive clays to the surface and the shallow depth to groundwater. Post development surface levels should be carefully considered to ensure any ground movements from clays do not detrimentally impact upon buildings.

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FIGURE 9. Geotechnical Classification

Southern River Precinct 3D

Source: Cadastre (Landgate 13/12/2016); Aerial (Nearmap, 13/12/2016);

Further investigation of the class H area around D3 is recommended so as to determine the true extent of the reactive clays to allow determination of appropriate treatment of that area. The extent of the S10 soil type was assumed to be Class H. This should be confirmed through the excavation of more test pits in the vicinity.

6.3 Soil Permeability and Drainage

The Bassendean sand surface soils have a permeability in the order of $10^{-3}$and 10^{-5} m/s based on particle size distribution. This is generally suitable for onsite disposal of stormwater, however the underlying low permeability coffee rock and clays, with permeabilities between 10^{-7} and 10^{-9}m/s, mean drainage will have to be carefully considered. Fill material can be used to increase the separation to clays to ensure effective performance of soak wells and infiltration areas.

6.4 Site Preparation

The following site preparation procedure is recommended

- Identification and diversion or protection of any buried services within the work area.
- Removal of topsoil, organics, root, old services and other deleterious material from the site.
- Contouring/shaping of the ground surface to ensure surface runoff drains appropriately form the site.
- Proof compact the exposed surface using a suitable compaction plant. A minimum of 12 tonne static mass vibratory smooth drum roller is preferred to achieve densification of sandy soil at depth. A minimum of eight overlapping passes should be provided.
- Where the surface deforms excessively during compaction or wet and/or weak material is exposed, over-excavation and replacement with compacted free draining sand fill may be required.
- Site works and preparation should be undertaken in summer or autumn, where groundwater levels are near their seasonal lows, as soil will become very difficult to work with in wet conditions.
- Dewatering or drainage may be required to control groundwater levels. Experience indicates that difficulties with compaction may occur when groundwater is present within about 1.0 to 1.5m of the level at which compaction is applied.
- Confirm that adequate compaction is achieved as outlined below.
- Should compaction to satisfactory depth not be achieved by surface compaction it may be necessary to over excavate, compact the base of the excavation and replace the soil in compaction layers.

- Place and compact approved clean free draining fill material in layers of no greater than 0.3m thickness, up to the level required.

6.5 Excavation and Dewatering

Based on the observed soil properties intersected during the fieldwork it is anticipated that excavations across the site should be achieved using standard earthmoving equipment. Excavations in sand areas are prone to instability; consequently care must be exercised in such excavation and appropriate safety measures adapted where necessary.

Where excavations are required to extend into the clayey Guildford formation soils, before building up with sand fill it's will be necessary to re-establish a smooth clay surface to prevent "tanking" of groundwater. Tanking of groundwater has the potential to significantly decrease foundation stability.

Where excavations extend close to groundwater levels, dewatering may be required to draw down the groundwater levels to 1m below the base of the excavation to achieve adequate compaction. If possible, site preparation should occur during dry periods to reduce or cease the dewatering requirements. Should dewatering be required, care must be taken to ensure nearby groundwater dependent ecosystems are not adversely affected.

There remains a small potential of ASS occurring during dewatering and/or excavation, consequently Bioscience recommends that site works attempt to maintain a low project risk and defined by table 3 below. A dewatering licence would need to be obtained from the Department of Water before any such work is undertaken. Any dewatering would require a dewatering management plan and effluent discharge carefully monitored due to the proximity to the Southern River.

Table 3: Acid Sulphate Soils Project Risk Assessment

Project Factors	Project Risk Level		
	Low	Medium	High
Duration of Project	Less than 1 month	1-3 months	Greater than 3 months
Volume of Excavation	< $100m^3$	100 - $1000m^3$	> $1000m^3$
Depth of Excavation	Less than 3m BGL	3-10m BGL	Greater than 10m BGL
Depth of Groundwater	Depth to groundwater > depth of excavation	Depth of excavation <3m below groundwater	Depth of excavation >3m below groundwater
Distance to Sensitive Receptors	> 500m	200 - 500m	< 200m
Sensitivity of Environmental Receptors	Unclassified water body	Multiple use	Conservation
Beneficial Use of Groundwater Resources	Irrigation or lower quality	Priority 3 resource	Priority 1/2 resource

6.6 Compaction

Fill materials, placement and compaction methods and quality control should apply with relevant structure fill requirements according to standard industry practice and AS 3798 "Guidelines on Earthworks for Commercial and Residential Developments". The fill should generally be placed in loose layers not exceeding 300mm thickness and each layer should be compacted with suitable equipment to a minimum of 95% modified maximum density (MMDD) or 70% density index as appropriate.

A Perth Sand Penetrometer in accordance with AS1289.6.3.3 may be used for compaction control in sand provided it is calibrated for each material type on-site. All areas within the building envelopes should be compacted to achieve a minimum blow count of 8 blows per 300 mm penetration to a depth of 1 m below the existing ground level, when tested in accordance with the above test method. If difficulties arise in achieving this blow count, then *in situ* density testing in accordance with AS 1289 should be performed to confirm the correlation between blow counts and density to ensure that a density index of 70% is achieved.

6.7 Fill Material

Fill material will be required on site to ensure that an adequate separation of groundwater is maintained (i.e. greater than 1.5m above AAMGL) on the provision that it contains less than 5% fines (i.e. <0.075mm) and has a maximum particle size of 40mm and is free of any organic or deleterious material.

7.0 References

AS 1289-2000. Methods of Testing Soils for Engineering Purposes. Standards Australia.

AS 1729-1993. Geotechnical Site Investigations. Standards Australia.

Davidson, W.A., 1995, Hydrogeology and Groundwater Resources of the Perth Region, Western Australia. Geological Survey of West. Australia, Bull. 142.

Hillman M, Cocks, G and Ameratunga J. (2003) Guildford Formation, Australian Geomechanics 38: 31-39

JDA., (2002) Main Report: Impact of Existing Drains and Proposed Living Streams on Groundwater Table and Nutrient Export. In Southern River/Forrestdale/Brookdale/Wungong, Structure Plan, Urban Water Management Strategy.

Jordan J.E. (1986), Armadale, part sheets 2033 I and 2133 IV, Perth Metropolitan Region, Environmental Geology Series, Geological Survey of Western Australia.

Perth Groundwater Atlas (2004) - Department of Water.

8.0 Limitations

Bioscience Pty Ltd has prepared this report for Lots 9 & 1792 Holmes Street, Southern River, WA. The work was carried out under Bioscience's Conditions of Engagement. This report is provided for the exclusive use of the landholders for this project only and for the purposes 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. In preparing this report Bioscience 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 only at the specific sampling 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 anthropogenic influences. Such changes may occur after Bioscience's field testing has been completed.

Bioscience's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by Bioscience in this report may be limited by undetected variations in ground conditions between sampling 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 notes and should be kept in its entirety without separation of individual pages or sections. Bioscience cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion given 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 Bioscience. This is because this report has been written as advice and opinion rather than instructions for construction.

Appendix 1: Soil Profile Logs

D1

Depth		Type	Colour	Grade	Shape	Condition	Consistency	Structure
From	To							
0	3500	Sand	white grey	uniform	sub rounded	dry	soft/loose	layer
3500	3950	Sand	grey brown	uniform	sub rounded	wet	soft/loose	layer
3950	4200	Sand	brown	uniform	sub rounded	wet	hard	layer

D2

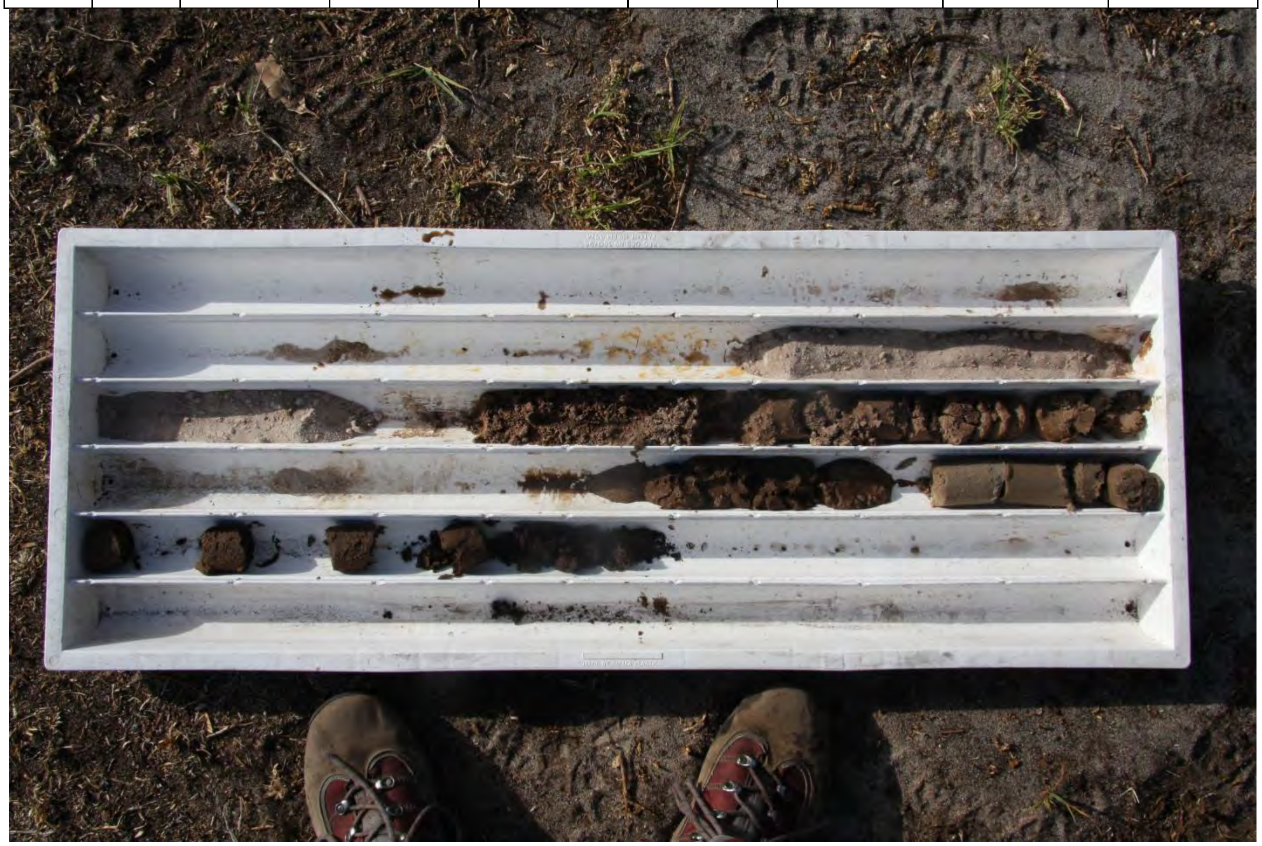
Depth		Type	Colour	Grade	Shape	Condition	Consistency	Structure
From	To							
0	1250	Sand	grey	uniform	sub rounded	dry	soft	layer
1250	2250	Sand	white	uniform		dry	soft	layer
2250	2750	Sand	brown	uniform		moist	soft	layer
2750	3500	Sand	brown	fine uniform		wet	hard	layer
3500	+	Clayey Sand	grey brown	well		wet	firm	layer

D3

Depth		Type	Colour	Grade	Shape	Condition	Consistency	Structure
From	To							
0	500	loamy sand	light brown	well		dry	firm	layer
500	750	loamy sand	yellow	well		moist	firm	layer
750	1200	clayey sand	grey mottled orange	well		moist	firm	layer
1200	1500	sandy clay	orange mottled grey	well		moist	firm	layer
1500	2200	clayey sand	grey mottled orange	coarse well sorted		moist	firm	layer
2200	3500	sandy clay	grey	well		wet	firm	layer
3500	+	sandy clay	grey	fine well sorted		wet	firm	layer

D4

Depth		Type	Colour	Grade	Shape	Condition	Consistency	Structure
From	To							
0	2250	Sand	grey	unifrom		dry	soft/ loose	layer
2250	2500	Sand	brown	fine uniform		moist	soft	layer
2500	3000	Sand	grey brown	unifrom		moist	soft	layer
3000	3750	Sand	brown			wet	soft	layer
3750	4250	Sand	grey brown			wet	soft	layer
4250	+	Sand	brown			wet	firm	layer



D5

Depth		Type	Colour	Grade	Shape	Condition	Consistency	Structure
From	To							
0	750	Sand	white	uniform meduim texture		dry	soft	layer
750	1500	Sand	grey white	uniform meduim texture		dry	soft	layer
1500	2250	Sand	brown white	uniform meduim texture		dry	soft	layer
2250	2550	silty sand	brown	uniform		wet	soft	layer
2550	3150	silty sand	light brown	fine uniform		wet	soft	layer
3150	+	silty sand	white	poorly sorted		wet	hard	layer

D6

Depth		Type	Colour	Grade	Shape	Condition	Consistency	Structure
From	To							
0	1500	Sand	grey white	unifrom	sub rounded	dry	soft/loose	layer
1500	+	Sand	white	unifrom	sub rounded	moist to wet	soft	layer

D7

Depth		Type	Colour	Grade	Shape	Condition	Consistency	Structure
From	To							
0	1500	Sand	dark grey	uniform		dry	soft/loose	layer
1500	2750	Sand	off white	uniform		moist	soft/loose	layer
2750	2900	silty sand	brown	poor		moist	firm	layer
2900	4400	sandy clay	brown	well		moist	firm	layer
4400	+	silty sand	brown	poor		wet	firm	layer

D8

Depth		Type	Colour	Grade	Shape	Condition	Consistency	Structure
From	To							
0	1500	Sand	grey	uniform		dry	soft/loose	layer
1500	3450	Sand	light yellow brown	uniform		damp	soft/loose	layer
3450	3700	Sand	dark brown	poor		wet	fard	layer
3700	4350	Sandy clay	brown	well		wet	firm	layer
4350	+	silty sand	brown	well		wet	firm	layer

Appendix 2: Groundwater Monitoring Data