ACT Geotechnical Engineers Pty Ltd

QUEANBEYAN CITY COUNCIL

URBAN CAPABILITY
PLANNING PROPOSAL AREA WITHIN SOUTH JERRABOMBERRA NSW

PRELIMINARY GEOTECHNICAL INVESTIGATION REPORT

OCTOBER 2014

Geotechnical Engineers

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Queanbeyan City Council
PO Box 90
QUEANBEYAN NSW 2620

Attention: Ms Arthean McBride

Dear Madam

URBAN CAPABILITY
PLANNING PROPOSAL AREA WITHIN SOUTH JERRABOMBERRA NSW

PRELIMINARY GEOTECHNICAL INVESTIGATION REPORT

We are pleased to present our preliminary geotechnical investigation for the urban capability of the planning proposal area within South Jerrabomberra, NSW.

The report outlines the methods and results of exploration, describes site subsurface conditions, presents the results of laboratory testing, and provides advice on suitability for residential development and the presence of any geotechnical constraints, and provides preliminary recommendations for structure footing design, site earthworks, and site drainage.

Should you require any further information regarding this report, please do not hesitate to contact our office.

Yours faithfully
ACT Geotechnical Engineers Pty Ltd

Jeremy Murray
Director

QUEANBEYAN CITY COUNCIL

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EXECUTIVE SUMMARY

ACT Geotechnical Engineers conducted a preliminary geotechnical investigation for the urban capability of the planning proposal area within South Jerrabomberra, NSW. The fieldwork for the investigation was carried out on 20 June, 4 and 7 July, 2014, comprising 26 boreholes and one test pit, drilled and dug by a JCB 3CX Backhoe, terminating in alluvium and weathered bedrock at 1.2m/3.0m depth. Seven samples of the site soils were taken and tested in a NATA laboratory for modified compaction, soaked California Bearing Ratio (CBR), grading and Atterberg limits, pH, Emerson, acid sulphate (SPOCAS), and suite of salinity, which includes salinity, ESP, phosphorus, nitrogen and sulphur, in a NATA laboratory.

The investigation determined that there were three distinct areas with differing subsurface conditions ie. Area 1 that comprises deeper alluvial soils, Area 2 that comprises shallow bedrock and Area 3 that comprises deeper uncontrolled fill, which is fill that has not been placed and compacted in accordance with AS3798 "Guidelines on Earthworks for Commercial & Residential Developments" (Reference 1) and is therefore not suitable as a foundation for structures and stockpiles of uncontrolled fill. The subsurface profile in the study area generally comprises topsoil, over alluvial/residual soils, underlain by weathered bedrock. The bedrock is at shallow depth on the higher ground at the southern and a northern portion of the site, with alluvial soils extending to deeper than 2m in the central area of the site close to Dogtrap Creek and the western and northern boundaries of the site.

Based on the investigation, the study area is assessed to be suitable for residential development from a geotechnical engineering perspective, except for the small isolated areas of uncontrolled fill, which are not suitable as a foundation for roads and structures, and the very steep sections of the area. Some geotechnical constraints that can be managed during or after construction include potential erosion, slope instability, local springs, and strong rock at shallow depth. Mitigation measures for geotechnical constraints includes maintaining existing vegetation cover in the erosion gullies and revegetating after construction. No special provisions are envisaged to be necessary for residential development on slopes up to ~15°, beyond normal compliance with AS2870 "Residential Slabs & Footings", and the implementation of suitable engineering practice for sloping sites, such as minimisation of cut and/or fill, use of structural retaining walls, installation of appropriate drainage, and surface stabilisation of disturbed or filled ground. There are slopes at the steeper wooded hilltops at the southern end of the study area with slopes of >20° that could require more costly excavation and retention works, and a more detailed examination of slope stability is recommended for these areas, if development is to occur in these areas.

QUEANBEYAN CITY COUNCIL

URBAN CAPABILITY
PLANNING PROPOSAL AREA WITHIN SOUTH JERRABOMBERRA NSW

GEOTECHNICAL INVESTIGATION REPORT

1 INTRODUCTION

In response to a request by Queanbeyan City Council, ACT Geotechnical Engineers Pty Ltd conducted a preliminary geotechnical investigation for the urban capability of the planning proposal area within South Jerrabomberra, NSW.

The South Jerrabomberra urban development area has been identified as a key future urban area, to be developed over the next 10 to 20 years. The key structural elements of the South Jerrabomberra area include major roads, residential and commercial areas, urban open space, ponds, shopping centre and local neighbourhood centres.

To assist in planning and design of any future development, a preliminary geotechnical investigation is required to establish the broad subsurface conditions across the development area, and identify any possible geotechnical constraints. The aim of the investigation was to:

(i) Identify subsurface conditions, including the extent and nature of any fill materials, natural soil profile, bedrock type and depth, and groundwater presence.

(ii) Preliminary assessment of the site classification to AS2870 "Residential Slabs & Footings".

(iii) Soil foundation strength and suitability for standard residential development, and suitable structure footing types including founding strata and allowable bearing pressures.

(iv) Advise on preparation of subgrades for building slabs and vehicle pavements.

(v) Advise on excavation conditions and suitability of excavated materials for use in controlled fill platforms and construction of structure platforms.

(vi) Advise on stability of cut batters, and provide retaining wall design parameters.

(vii) Advise on pavement subgrade preparation and provide indicative design CBR values and pavement thickness design.

(viii) Identify areas of potential soil salinity.

(ix) Provide the Earthquake Site Factor.

(x) Identify areas of potential slope instability.

(xi) Advise on site drainage and other relevant geotechnical issues.

2 SITE DESCRIPTION & GEOLOGY

2.1 Site Description

The South Jerrabomberra site is bounded by the ACT border (a disused railway line) to the west, Tralee Hills to the south and east, and the proposed Tralee Hills Residential Development to the north. The area is currently divided into two parcels, parcel 1, which is ~54.1ha in size and parcel 2, which is ~57.2ha in size. Figure 1 shows the site locality.

The site is presently undeveloped greenfield, although an incomplete airfield runway is present on the site. There are large stockpiles of uncontrolled fill present on the site, these are roughly outlined in Figure 3 and photographs of some of these are attached to this report, more stockpiles may be present on site. Uncontrolled fill is fill that has not been placed and compacted in accordance with AS3798 "Guidelines on Earthworks for Commercial & Residential Developments" (Reference 1) and is therefore not suitable as a foundation for structures. Figure 3 is a recent aerial photograph that shows the present site layout and the location of the auger holes and test pit.

2.2 Topography

The topographic landform of the study area is dominated by a drainage line (Dogtrap Gully) that flows NW through the centre of the site, then through the suburb of Hume, and to Woden Creek. There are also several small tributaries that flow into the main drainage line.

The landform has resulted from regional geological faulting and folding, and subsequent erosion has produced a system of ridges of generally more durable rock, with intervening depressions or valleys, mostly parallelling the geological trend.

The land on either side of the Dogtrap Gully is gently undulating, with some moderately inclined rolling hills, and is incised by shallow gullies. Surface slopes are generally less than 15% (8.5°), with much of the area having surface slopes less than 10% (5.7°).

There is an area with surface slopes steeper than 15%. This area of steeper surface slopes is near the southern boundary and in the SE corner of the study area, where several small wooded hilltops (including Tralee Hill) rise to between RL870 and RL880. Surface slopes here are greater than 15% (8.5°), with a few up to 50% (26°).

Figure 2 shows the topography of the site, including surface contours and drainage lines, and Figure 3 is a recent aerial photograph of the area.

2.3 Vegetation

The study area has two distinct vegetation areas/land uses. The area covering the majority of the study area has been cleared for stock grazing purposes, and the groundsurface in this area has a thick cover of pasture and cereal grasses, which has generally afforded protection against erosion. Apart from scour of the banks of several small erosion gullies, erosion is limited to minor stripped ground and some vehicle tracks. Some scattered eucalyptus trees are present in this area, with scattered rocks and outcrops mostly at the top of hills.

The southern end and SE corner of the area comprises steep hilltops, which are covered by remnant open woodland, comprising mostly eucalyptus trees. It is assumed that when the surrounding areas were cleared for stock grazing and forestry uses, this area remained timbered due to the relatively steep slopes.

2.4 Geology

The 1:50,000 Canberra, Queanbeyan & Environs Geology Map (Reference 2) documents the area to be underlain by Silurian age Deakin Volcanics bedrock that green-grey, red-purple and purple

rhyodacite, green-grey, purple and cream rhyolite, agglomerate, purple tuff, tuffaceous sandstone, and rhyodacitic crystal tuff.

3 INVESTIGATION METHODS

The field investigation was carried out on 20 June, 4 and 7 July, 2014, comprising 26 boreholes, designated 1A and 3A to 27A, and one test pit, designated 2T drilled and dug by a JCB 3CX Backhoe, terminating in alluvium and weathered bedrock at 1.2m/3.0m depth. The locations of the boreholes and test pit are shown on Figure 2, and the borehole and test pit logs are included in Appendix A.

Seven samples, designated as samples 2T/1D, 2T/2D, 7A/1D, 8A/1D, 15A/1D, 21A/1D and 25A/1D, were taken and tested in a NATA laboratory for modified compaction, soaked California Bearing Ration (CBR) (a test that determines the relative strength of road subgrades), grading and Atterberg limits (a test that determines the soil type, plasticity, and critical water contents of a fine-grained soil), pH, Emerson (a test to determine the cohesion properties of a soil), acid sulphate (SPOCAS), and suite of salinity, which includes salinity, ESP, phosphorus, nitrogen and sulphur, in a NATA laboratory. The laboratory test certificates are included as Appendix B.

The auger and test pit profiles were visually logged in accordance with the Unified Soil Classification System (USCS). Definitions of geotechnical engineering terms used on the auger hole and test pit logs, including a copy of the USCS chart, are provided in Appendix C.

4 INVESTIGATION RESULTS

The site under investigation has been categorised into three areas: Area 1 that comprises deeper alluvial soils, Area 2 that comprises shallow bedrock and Area 3 that comprises deeper uncontrolled fill and stockpiles of uncontrolled fill. Figure 3 roughly outlines the three areas.

4.1 Subsurface Conditions – Area 1

Area 1 describes the area of the site that is covered by alluvial soils that are at least 2m in depth and is generally through the centre of the site close to Dogtrap Creek. The investigation boreholes and test pit in Area 1 include test pit 2T, and boreholes 3A, 8A, in 12A, 15A, 24A, 26A and 27A, and found the subsurface profile to comprise:

Geological Profile	Typical Depth Interval	Description
TOPSOIL	0m to 0.05m/0.2m	SILTY SAND; fine to coarse sand, low plasticity silt, dark brown, orange-brown, some grass roots, moist, loose. Not encountered in boreholes 8A, 12A, 15A and 27A.
ALLUVIAL SOIL	0m/0.2m to >3.0m	SANDY CLAY, SILTY SANDY CLAY, CLAYEY SAND & GRAVELLY CLAYEY SAND; low and low to medium plasticity fines, some medium plasticity clay, fine to coarse sand, sub-angular rhyodacite gravels up to 30mm size, brown, orange-brown, yellow-brown, purple-brown, pale grey, white, black, mostly dry and dry to moist, some moist to wet and wet, some slightly to strongly cemented, some vesicules, very stiff to hard, medium dense to dense.

4.2 Subsurface Conditions – Area 2

Area 2 describes the area of the site that is underlain by shallow bedrock, where the investigation boreholes encountered bedrock below 0.1m/1.6m depth. This area is generally on the higher slopes at the southern and northern ends of the site, (away from Dogtrap Creek). The investigation boreholes in Area 2 include boreholes 1A, 4A, 5A, 6A, 7A, 9A, 10A, 11A, 13A, 14A, 18A, 19A, 20A, 21A, 22A, 23A and 25A, and found the subsurface profile to comprise:

Geological Profile	Typical Depth Interval	Description
UNCONTROLLED FILL	0m to 0.5m	CLAYEY SAND & SAND; fine to coarse sand, low plasticity clay, dark brown, red-brown, pale grey, some tree and grass roots, dry to moist and moist, loose to medium dense. Only encountered in borehole 1A.
TOPSOIL	0m to 0.1m/0.2m	SANDY CLAY & SILTY SAND; low and low to medium plasticity fines, fine to coarse sand, brown, dark brown, yellow-brown, dark yellow-brown, some orange-brown, some sub-angular rhyodacite gravels up to 50mm size, some grass roots, moist, soft, loose. Not encountered in borehole 20A.
SLOPEWASH	0.1m to 0.4m	SILTY CLAYEY SAND; fine to coarse sand, low plasticity fines, pale brown, pale grey-brown, moist, medium dense. Only encountered in borehole 6A and 11A.
ALLUVIAL/ RESIDUAL SOIL	0m/0.5m to 0.1m/1.6m	SANDY CLAY, GRAVELLY SANDY CLAY, CLAYEY SAND, CLAYEY GRAVELLY SAND; low and low to medium plasticity fines, some medium plasticity clay, fine to coarse sand, sub-angular rhyodacite gravels up to 100mm size, pale brown, yellow-brown, orange-brown, red-brown, purple-brown, grey, pale grey, some sub-rounded volcanic gravels up to 20mm size, some ferruginous nodules up to 5mm size, dry, dry to moist and moist, some slightly to strongly cemented, very stiff to hard, medium dense to dense. Not encountered in borehole 7A and 9A.
WEATHERED BEDROCK	below 0.1m/1.6m	RHYODACITE; fine to coarse grained, brown, orange-brown, yellow-brown, red-brown, purple-brown, purple, grey, pale grey, white speckled, mostly dry, some dry to moist, some moist to wet. Extremely weathered (EW) and extremely weak rock, generally grading to extremely to highly weathered (EW/HW) and very weak, highly weathered (HW) and weak, highly to moderately weathered (HW/MW) and weak to medium strong, and moderately weathered (MW) and medium strong rock.

4.3 Subsurface Conditions – Area 3

Area 3 describes the area of the site that is covered in uncontrolled fill that is greater than 0.5m in depth. The investigation boreholes in Area 3 include boreholes 16A and 17A, and found the subsurface profile to comprise:

Geological Profile	Typical Depth Interval	Description
UNCONTROLLED FILL	0m to 0.8m/>2.0m	SAND & CLAYEY SAND; fine to coarse sand, low plasticity clay, brown, orange-brown, some sub-angular volcanic gravels up to 40mm size, some metal fragments, some grass roots, moist, loose and loose to medium dense.
ALLUVIAL SOIL	below 0.8m/>2.0m	CLAYEY SAND; fine to coarse sand, low plasticity clay, brown, moist, loose to medium dense. Not encountered in borehole 16A.

4.4 Groundwater

Permanent groundwater is expected to occur within fractured rock aquifers, probably below about 5m/10m of existing ground surface levels in the Jerrabomberra and Hume areas. Yields of bores are expected to be in the range of 0.1 to 5L/s, with possibly higher yields in closely jointed rock along fault zones. Bores may have to be greater than 50m deep to obtain a reliable supply of extractable groundwater. Groundwater salinity is expected to be typically less than 2,000mg/L total dissolved solids, but is dependent on geology and recharge conditions. A value of 2,000mg/L is relatively low, a safe drinking water limit is about 1,000mg/L, average seawater is about 35,000mg/L and brines are >50,000mg/L.

Transient perched seepages can occur at shallower depth following rainfall in pervious slopewash and alluvial soils and upper fractured sections of the bedrock. It is possible that where such perched seepage flows are interrupted by bands of low permeability clayey soils, the seepage may emerge at the surface as "springs". Such springs are common in areas of nearby Hume.

4.5 Laboratory Test Results

Modified compaction and soaked CBR laboratory tests were performed on the potential subgrade soils on samples 2T/1D, 7A/1D, 8A/1D, 15A/1D and 21A/1D, and are summarised in Table 1 below. The CBR test specimens were compacted to a nominal 95% ModMDD at about optimum moisture content, and soaked for four days prior to testing. The NATA test certificates are presented in Appendix B.

TABLE 1

CBR Test Results Summary

Sample No.	**2T/1D**	**7A/1D**	**8A/1D**	**15A/1D**	**21A/1D**
Depth Interval	0.4m – 0.5m	0.3m – 1.0m	0m – 0.4m	0.5m – 1.0m	0.4m – 1.0m
Material Description	**ALLUVIAL SOIL** Clayey Sand/Sandy Clay; fine to coarse sand, low plasticity clay, brown, orange-brown, white.	**HW & HW/MW RHYODACITE BEDROCK** fine to coarse grained, yellow-brown, purple-brown, grey.	**ALLUVIAL SOIL** Clayey Sand; fine to coarse sand, low plasticity clay, pale grey, orange-brown, some sub-angular volcanic gravels up to 10mm size, strongly cemented.	**ALLUVIAL SOIL** Clayey Sand; fine to coarse sand, low plasticity clay, brown, pale grey, orange-brown.	**ALLUVIAL SOIL** Clayey Sand; fine to coarse sand, low plasticity clay, pale grey, yellow-brown.
USCS	SC/CL	SW	SC	SC	SC
Modified Compaction					
Mod. Max. Dry Density (t/m^3)	2.07	2.08	2.13	2.08	2.09
Optimum Moisture Content (%)	9.0	8.0	7.5	9.5	7.5
Soaked CBR					
Placement Moisture Content (%)	9.1	8.0	7.4	9.5	7.5
Placement Density Ratio (%)	95.0	95.0	95.0	95.0	95.0
Post-Soak Density Ratio (%)	93.5	95.0	95.0	94.5	95.0
Swell After Soak (%)	1.5	0	0	0	0
CBR Value (4-day soak) (%)	11	45	25	18	25

Samples 2T/1D, 7A/1D, 8A/1D, 15A/1D and 21A/1D were also taken for particle size distribution and Atterberg limits testing, the results of which are summarised in Table 2 below. Full details are provided on the NATA test certificates in Appendix B.

TABLE 2

Soil Classification Test Results Summary

Sample No.	**2T/1D**	**7A/1D**	**8A/1D**	**15A/1D**	**21A/1D**
Depth Interval	0.4m – 0.5m	0.3m – 1.0m	0m – 0.4m	0.5m – 1.0m	0.4m – 1.0m
Material Type	Alluvial Clayey Sand/Sandy Clay	HW & HW/MW Rhyodacite Bedrock	Alluvial Clayey Sand	Alluvial Clayey Sand	Alluvial Clayey Sand
USCS	SC/CL	SW	SC	SC	SC
Particle Size Distribution - % Passing by Dry Mass					
75mm	-	-	-	-	-
53mm	-	100	-	-	-
37.5mm	-	98	-	-	100
26.5mm	-	96	-	-	99
19.0mm	-	93	100	100	99
13.2mm	100	91	100	99	98
9.5mm	99	88	99	98	98
6.7mm	98	82	98	98	97
4.75mm	95	76	95	96	96
2.36mm	88	58	84	87	90
1.18mm	78	40	65	69	78
600µm	69	28	51	54	65
425µm	65	23	45	47	58
300µm	61	20	40	43	52
150µm	53	15	33	36	41
75µm	47	12	28	31	35
Atterberg Limits (%)					
Liquid Limit	27	23	19	18	15
Plastic Limit	16	19	14	14	13
Plasticity Index	11	4	5	4	1
Linear Shrinkage	6.5	2.0	2.0	1.5	1.0

Note: USCS - Unified Soil Classification System

The results of the pH testing on samples 2T/1D, 7A/1D, 8A/1D, 15A/1D and 21A/1D are summarised in Table 3 below. Full details are provided on the NATA test certificates in Appendix B.

TABLE 3

pH Test Results Summary

Sample No.	**2T/1D**	**7A/1D**	**8A/1D**	**15A/1D**	**21A/1D**
Depth Interval	0.4m – 0.5m	0.3m – 1.0m	0m – 0.4m	0.5m – 1.0m	0.4m – 1.0m
pH	6.7	6.6	6.3	6.5	6.3

The results of the Emerson testing on samples 2T/1D, 7A/1D, 8A/1D, 15A/1D and 21A/1D are summarised in Table 4 below. Full details are provided on the NATA test certificates in Appendix B.

TABLE 4

Emerson Test Results Summary

Sample No.	**2T/1D**	**7A/1D**	**8A/1D**	**15A/1D**	**21A/1D**
Depth Interval	0.4m – 0.5m	0.3m – 1.0m	0m – 0.4m	0.5m – 1.0m	0.4m – 1.0m
Emerson Class Number	2	2	2	2	2

Results of the acid sulphate (SPOCAS) are summarised in Table 5 below. Full details are provided on the NATA test certificates in Appendix B.

TABLE 5

SPOCAS Test Results Summary

Sample No. & Depth	**2T/1D** 0.4m – 0.5m	**25A/1D** 0.4m – 0.9m
Material Type	**ALLUVIAL SOIL** Clayey Sand/Sandy Clay; fine to coarse sand, low plasticity clay, brown, orange-brown, white.	**ALLUVIAL SOIL** Clayey Sand; fine to coarse sand, low plasticity clay, pale grey.
pH_{KCl} (before oxidation)	5.3	5.1
pH_{OX} (after oxidation)	4.2	5.8
Total Actual Acidity (mol H^+/tonne)	<5	6
Total Potential Acidity (mol H^+/tonne)	<5	<5
Total Sulphuric Acidity (mol H^+/tonne)	<5	<5
a-Net Acidity (mol H^+/tonne)	20	<10
Limiting Rate (kg $CaCO_3$/tonne)	1.5	<0.75

Suite of salinity test results are summarised in Table 6 below. Full details are provided on the NATA test certificates in Appendix B.

TABLE 6

Suite of Salinity Test Results Summary

Sample No. & Depth	**2T/2D** 0.4m – 0.5m	**8A/1D** 0m – 0.4m
Material Type	**ALLUVIAL SOIL** Clayey Sand/Sandy Clay; fine to coarse sand, low plasticity clay, brown, orange-brown, white.	**ALLUVIAL SOIL** Clayey Sand; fine to coarse sand, low plasticity clay, pale grey, orange-brown.
Total Soluble Salts (mg/kg)	484	27
Moisture Content (dried @ 103°C) (%)	7.6	4.5
Exchangable Sodium Percent (%)	26.0	4.2
Sulfur – Total as S (LECO) (%)	0.08	0.02
Nitrite + Nitrate as N (Sol.) (mg/kg)	4.4	0.7
Total Kjeldahl Nitrogen as N (mg/kg)	90	40
Total Nitrogen as N ** (mg/kg)	90	40
Total Phosphorus (mg/kg)	31	23

5 DISCUSSION & RECOMMENDATIONS

Area 1 describes the area of the site that is covered by alluvial soils that are at least 2m in depth and is generally through the centre of the site close to Dogtrap Creek. Area 2 describes the area of the site that is underlain by shallow bedrock, where the investigation boreholes encountered bedrock below 0.1m/1.6m depth. This area is generally on the higher slopes at the southern and northern ends of the site, (away from Dogtrap Creek). Area 3 describes the area of the site that is covered in uncontrolled fill that is greater than 0.5m in depth. The approximate locations of Areas 1 to 3 are shown in Figure 3.

5.1 Discussion

The subsurface profile in the study area generally comprises topsoil, over alluvial/residual soils, underlain by weathered bedrock. The bedrock is at shallow depth on the higher ground at the southern and northern sides of Dogtrap Creek, with alluvial soils extending to deeper than 2m in the central area of the site close to Dogtrap Creek, and generally the western and northern boundaries of the study area. These soils would provide a competent foundation for houses, units, commercial buildings, and road pavements.

There is no geotechnical reason why the site cannot be developed for residential purposes.

There are numerous stockpiles of soil present on the site, the approximate locations of which are shown in Figure 3, denoted as Area 3. Structures and roads cannot be founded on these stockpiles, however, assuming contaminants are not present, these soils could be used in required earthworks in subdivision/road construction.

5.2 Site Classification

It is expected that the site would generally consist of Class "S" (slightly reactive) lots in accordance with AS2870 "Residential Slabs and Footings – Construction" (Reference 3) Guidelines. There is uncontrolled fill of more than 0.4m in depth in some areas, the lots in these areas would be a Class "P" (problem) unless the uncontrolled fill is removed. The actual site classifications of individual lots would be provided in a more detailed geotechnical investigation.

Deemed-to-comply footing designs provided by AS2870 are applicable specifically to residential-style one and two-storey structures, or buildings with similar loads and superstructure stiffness.

5.3 Structure Footings & Ground Slabs

Suitable footings for on-grade structures such as houses include pads/strips founding in the natural alluvial and residual soil, newly placed controlled fill (Section 5.6) in Area 1, alternatively bored piers founding in weathered bedrock can be used. The same footings for on-grade structures can be used in Area 2, although pads/strips can also be used where there is shallow bedrock. Area 3 comprises uncontrolled fill, which is not a suitable foundation for footings. All footings should be taken below the silty topsoil, slopewash, uncontrolled fill or disturbed ground.

Indicative allowable end-bearing pressures and allowable shaft adhesion values for various footing systems are provided in Table 7.

TABLE 7

Indicative Allowable End-Bearing Pressures & Shaft Adhesion Values for Footings

Foundation Material Type	Depth From Existing Surface Levels	Allowable End-Bearing Pressure			Allowable Shaft Adhesion	
		Strips	Pads	Piers	Downward Loading	Uplift
Newly Placed Controlled Fill	-	100kPa	125kPa	N.A.	N.A.	N.A.
Very Stiff or Hard or Medium Dense to Dense Alluvial/Residual Soil	0m/>2.0m	125kPa	150kPa	N.A.	N.A.	N.A.
HW & Less Weathered Rhyodacite Bedrock	>0.4m/3.0m (Area 1) 0.1m/1.6m (Area 2) >2.0m (Area 3)	500kPa	750kPa	1000kPa	100kPa	50kPa

All footing excavations should be inspected and approved by an experienced geotechnical engineer to confirm the foundation material and design values, and to ensure the excavations are clean and stable.

Groundslabs can be constructed on the natural soils or newly placed controlled, following the removal of any silty topsoil, uncontrolled fill and disturbed ground. Following excavation to required level, slab areas on soil should be proof-rolled by a pad-foot roller to check for any weak, wet or deforming soils that may require replacement. Suitable replacement fill should be compacted in not thicker than 150mm layers to not less than 98%StdMDD.

If required for design of ground slabs, a modulus of subgrade reaction of between 30kPa/mm to 60kPa/mm can be assumed for a natural soil foundation and 100kPa/mm for a weathered bedrock foundation.

5.4 Excavation Conditions & Use of Excavated Material

Excavations to 3m depth in Area 1 would be through topsoil, slopewash, alluvial and residual soil, which can generally be dug by backhoe and medium-sized excavator. Although some of the more cemented sandy alluvial soils below 0.4m/2.6m depth in the vicinities of boreholes 8A and 15A respectively may require ripping or rock hammering. MW and less weathered bedrock is expected below 1.0m/3.0m depth in Area 2, near boreholes 4A, 5A, 6A, 7A, 9A, 10A, 11A, 18A, 19A, 20A, 22A, 23A and 25A, which would require ripping or rock hammering using a large excavator or bulldozer. The uncontrolled fill and alluvial soils in Area 3 can easily be dug by backhoe and medium-sized excavator. A small piering rig such as an auger attachment on a backhoe or excavator, would be required to drill and socket into weak bedrock.

Permanent groundwater is not expected within the 3m depth. However, temporary perched seepages can be present at shallower depth following rain, but should be readily controllable during construction.

The low and low to medium plasticity clayey and sandy alluvial/residual soils are suitable for use in controlled fill construction. Any excavated weathered bedrock can also be used for controlled fill, as it is expected to break down during excavation and compaction to a gravelly clayey sand or clayey sandy gravel. All particles should be broken down to less than 75mm size. The stockpile fill material generally comprises a low and low to medium plasticity clayey/sandy/gravelly and can be used as controlled fill provided there are no contaminants present and all particles greater than 75mm are either broken down or removed.

The silty topsoil is not generally suitable for controlled fill, but could be used in non-structural applications such as landscaping. These soils will also make trafficking the site difficult after rainfall.

If imported fill is required, a suitable select fill material would include a low or medium plasticity soil such as clayey sand or gravelly clayey sand, containing between 25% and 50% fines less than 0.075mm size (silt and clay), and no particles greater than 75mm size. It is recommended that any imported fill is Virgin Excavated Natural Material (VENM).

5.5 Stable Batter Slopes

Temporary site excavations to 1.5m depth can be formed near-vertical in the natural alluvial/residual/slopewash soils or weathered bedrock, although the loose topsoil, should be cut at 1(H):1(V). If required, deeper temporary cuts can be benched or formed at 1(H):1(V). Temporary site excavations to 1.5m depth in the uncontrolled fill in Area 3 should be cut at 1(H):1(V). Exposed temporary batters in soil should be protected from the weather by black plastic pinned to the face with line-wire mesh or similar, and should be inspected during construction by a geotechnical engineer.

Permanent cut and fill soil batters should be formed at no steeper than 2(H):1(V). All soil cut and fill surfaces should be protected against erosion by topsoiling and grassing, or other suitable means. It is advisable that permanent batters are inspected during excavation by an experienced geotechnical engineer to confirm stability.

5.6 Controlled Fill Construction

The following procedure is recommended for construction of controlled fill foundation platforms for buildings and pavements:

1) Areas be fully stripped of all topsoil, uncontrolled fill, and any underlying moisture-softened alluvial/residual/slopewash soils (a stripping depth of 0m/0.5m is expected, although would be deeper where stockpiles and the fill around boreholes 16A and 17A is present).
2) Stripped foundations be proof-rolled by a vibratory pad-foot roller of not less than 9 tonne static mass to check for any weak or wet areas that require replacement.
3) Replacement fill and platform fill of suitable materials (Section 5.3) be compacted to required level in not thicker than 150mm layers to not less than 98%StdMDD at about optimum moisture content.
4) Fill placement and control testing be overviewed and certified by a geotechnical engineer at Level 1 or 2 as defined in AS3798 - 1996 "Guidelines on Earthworks for Commercial & Residential Developments" (Reference 3).

5.7 Pavement Subgrades & Design

Pavement subgrades should be prepared as outlined in Section 5.3. On-grade road subgrades are expected to comprise in-situ sandy/clayey alluvial/residual soils, weathered bedrock or newly placed controlled fill of similar material. As a preliminary guide, pavements with clayey soil subgrades be designed using a subgrade CBR value of 3%, pavements with sandy soil subgrades be designed using a CBR value of 6%, and pavements with weathered rock subgrades using a CBR value of 10%. Exposed subgrades should be inspected by a geotechnical engineer to check the recommended design CBR value.

Pavements should be constructed following the removal of any topsoil, uncontrolled fill and disturbed ground. Following excavation to required level, slab areas on soil should be proof-rolled by a pad-foot roller to check for any weak, wet or deforming soils that may require replacement.

5.8 Low Retaining Walls

Retaining walls can be constructed in open excavation, with the gap between the excavation face and the wall backfilled later, and can be designed using a triangular earth/rock pressure distribution given by:

$$\sigma_h = (K\gamma' h) + Kq$$

where,

σ_h is the horizontal earth pressure acting on the back of the wall, in kPa
K is the dimensionless coefficient of earth pressure; this can be assumed to be 0.4 when the top of the wall is unrestrained horizontally, and 0.6 when the top of the wall is restrained (i.e. by building slabs etc.)
γ' is the effective unit weight of the backfill, and can be assumed to be 20kN/m^3 for a lightly compacted soil backfill
h is the height of the backfill, in metres
q is any uniform distributed vertical surcharge acting on the top of the backfill, in kPa

Apart from structural restraints such as floor slabs, resistance to overturning and sliding of retaining walls is provided by frictional and adhesive resistance on the base, and by passive resistance at the toe of the wall. For a natural soil or controlled fill foundation, an ultimate base friction factor (tanδ) of 0.4, base adhesion (c) of 30kPa, and allowable passive earth pressure coefficient Kp=2.5 can be used for calculation of sliding resistance. For a weak bedrock foundation, an ultimate base friction factor (tanδ) of 0.55, base adhesion (c) of 10kPa, and allowable passive earth pressure coefficient Kp=3 can be used for calculation of sliding resistance.

Free-draining granular backfill or synthetic fabric drains should be installed behind all walls. These should connect to weep holes and/or a collector drain, and ultimately to the stormwater system. Granular backfill should be wrapped in a suitable filter fabric to minimise infiltration of silt/clay fines.

5.9 Earthquake Site Factor

The Geoscience website (Reference 4) lists the earthquake acceleration coefficients for major centres to be considered in structural design. The South Jerrabomberra area has an acceleration coefficient of 0.06.

Section 4 of AS1170.4 "Minimum Design Loads on Structures - Part 4: Earthquake Loads" (Reference 5) summarises the Site Subsoil Class which depends on the subsurface conditions at the site in question. A Site Subsoil Class C_e is applicable for this development.

5.10 Site Drainage

Suitable surface drainage should be provided to ensure rainfall run-off or other surface water cannot pond against structures or pavements. Perched groundwater seepages could occur following rainfall, so site infrastructure drainage, including provision for floodways, stormwater detention ponds, and installation of road subsoil drains will be required as appropriate.

5.11 Expected Slope Stability

As the surface slopes over the majority of the study area are at less than 10°, and as there are no scarps, humps, or boulder trains to indicate past instability, the hills are considered geotechnically stable at present. No special provisions are envisaged to be necessary for residential development on these slopes, beyond normal compliance with AS2870 "Residential Slabs & Footings", and the implementation of suitable engineering practice for sloping sites, such as minimisation of cut and/or fill, use of structural retaining walls, installation of appropriate drainage, and surface stabilisation of disturbed or filled ground. Nearby Canberra suburbs with similar geology and topography, such as Gordon, Conder and Fadden have been successfully developed on steeper hillsides with slopes up to about 15°.

The steeper wooded hilltops at the southern end of the site, having slopes >20° could require more costly excavation and retention works, and a more detailed examination of slope stability is recommended for these areas, if development is to occur in these areas. These steeper areas are delineated on Figure 2.

It is suggested that the existing drainage gullies be retained in their present state, and incorporated into the development as drainage reserves. The majority of the gullies besides Dogtrap Creek and its tributaries are steep v-shaped with shallow depth to bedrock, and few signs of ongoing erosion. Erosion has occurred in Dogtrap creek and its tributaries, and has exposed vertical batters in the alluvial soils of up to ~2m in height. The alluvial soils are expected to extend below the base of the creek. Where possible, the existing vegetation cover should be maintained in these gullies. If vegetation has to be removed for construction purposes, these areas should be revegetated as soon as possible to prevent erosion.

5.12 Geotechnical Constraints

The study area appears to be generally suitable for residential development from a geotechnical engineering perspective. The constraints include potential erosion, slope instability, local springs, and strong rock at shallow depth.

There are potential erosion issues over the whole site once the topsoil is exposed, although these risks are minor and can be mitigated through good practice during and after construction.

There are some areas of the site with surface slopes greater than 10°, and some greater than about 25°, including the wooded hilltops at the western side of the site. Although there are few apparent signs of slope instability in these areas, it is recommended that residential development does not take place in the very steep sections.

The depth to bedrock in the southern and northern sections of the study area is expected to be generally less than 1m/2m below natural surface levels. The presence of rock outcrops in these areas suggests that strong rock can be close to the surface. Therefore excavations for roads, house foundation platforms, and underground services may be difficult on the higher ground.

Following installation of appropriate drainage systems, and creation of open space along creek/gully corridors, the site is expected to be geotechnically suitable for development of housing and associated infrastructure.

6 FURTHER INVESTIGATION

The information in this report is of a preliminary nature, based on limited available site information, on our knowledge of the various geological formations, and a limited subsurface investigation. To fully assess the site conditions or specific locations, more detailed subsurface geotechnical investigations will need to be conducted.

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REFERENCES

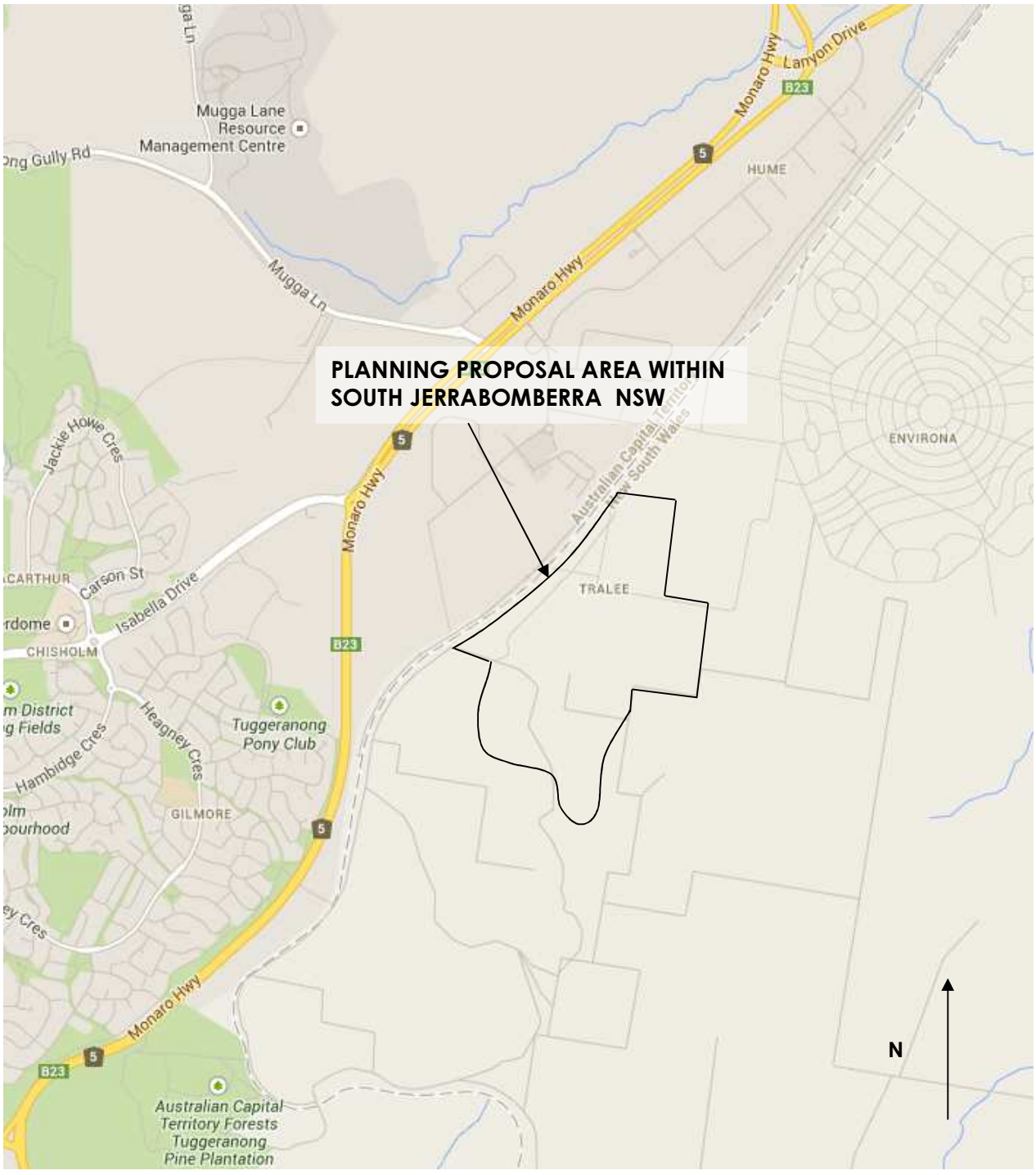
Reference 1 Standards Australia, "AS3798 - Guidelines on Earthworks for Commercial & Residential Developments", 1996.

Reference 2 Bureau of Mineral Resources, Commonwealth of Australia, "Canberra, Queanbeyan & Environs - 1:50,000 Engineering Geology Series", 1980.

Reference 3 Standards Australia, "AS2870 - 2011 - Residential Slabs & Footings - Construction".

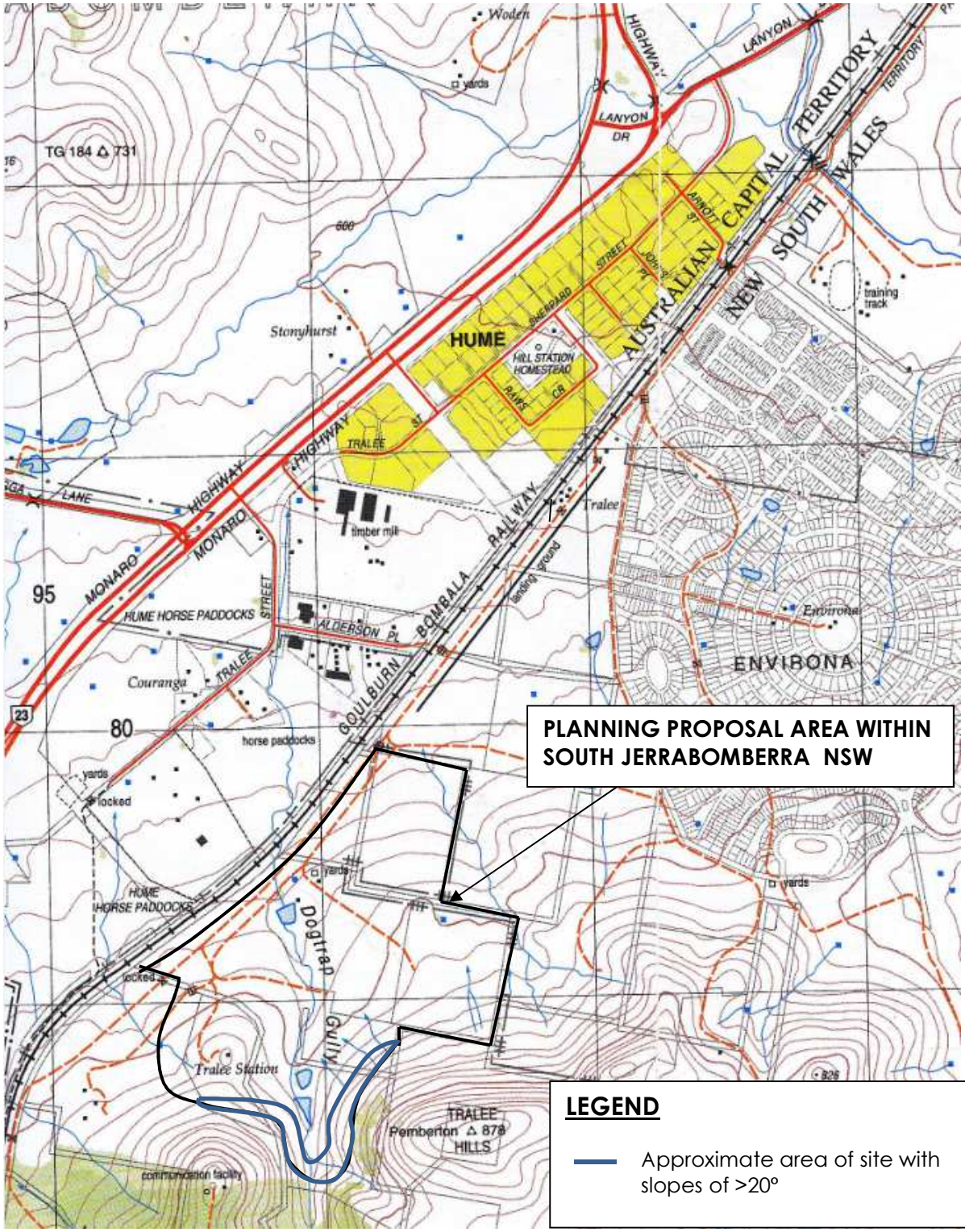
Reference 4 Geoscience Australia - http://www.ga.gov.au/darwin-view/hazards.xhtml# 23 July 2014.

Reference 5 Standards Australia, "AS1170.4 - 1993 - Minimum Design Loads on Structures Part 4: Earthquake Loads".



QUEANBEYAN CITY COUNCIL
URBAN CAPABILITY
PANNING PROPOSAL AREA WITHIN SOUTH JERRABOMBERRA NSW
SITE LOCALITY

ACT Geotechnical Engineers Pty Ltd	**C7070**	**FIGURE 1**



QUEANBEYAN CITY COUNCIL
URBAN CAPABILITY
PANNING PROPOSAL AREA WITHIN SOUTH JERRABOMBERRA NSW
TOPOGRAPHICAL MAP

ACT Geotechnical Engineers Pty Ltd	**C7070**	**FIGURE 2**

LEGEND

- Location of Borehole
- Location of Test Pit

(Depth of Fill)
(Depth to Bedrock)

Area 1 ----------
Area 2 ----------
Area 3 ----------

N

QUEANBEYAN CITY COUNCIL
URBAN CAPABILITY
PANNING PROPOSAL AREA WITHIN SOUTH JERRABOMBERRA NSW
RECENT AERIAL PHOTOGRAPH & LOCATION OF BOREHOLES AND TEST PIT

ACT Geotechnical Engineers Pty Ltd	**C7070**	**FIGURE 3**

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URBAN CAPABILITY
PLANNING PROPOSAL AREA WITHIN SOUTH JERRABOMBERRA NSW

PRELIMINARY GEOTECHNICAL INVESTIGATION

SITE PHOTOGRAPHS

Photos 1 to 4 (above) – 18/7/14 – View of road fill and fill stockpiles on north-western side of the site.

QUEANBEYAN CITY COUNCIL

URBAN CAPABILITY
PLANNING PROPOSAL AREA WITHIN SOUTH JERRABOMBERRA NSW

PRELIMINARY GEOTECHNICAL INVESTIGATION

SITE PHOTOGRAPHS

Photos 5 to 6 (above) – 18/7/14 – View of road fill and fill stockpiles on north-western side of the site.

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URBAN CAPABILITY
PLANNING PROPOSAL AREA WITHIN SOUTH JERRABOMBERRA NSW

PRELIMINARY GEOTECHNICAL INVESTIGATION

SITE PHOTOGRAPHS

Photos 7 to 9 (above) – 18/7/14 – View of cut-to-fill berms near the residence in the south-western corner of the site.

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URBAN CAPABILITY
PLANNING PROPOSAL AREA WITHIN SOUTH JERRABOMBERRA NSW

PRELIMINARY GEOTECHNICAL INVESTIGATION

SITE PHOTOGRAPHS

Photos 10 to 12 (above) – 18/7/14 – View of fill stockpiles near the residence in the south-western corner of the site.

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PLANNING PROPOSAL AREA WITHIN SOUTH JERRABOMBERRA NSW

PRELIMINARY GEOTECHNICAL INVESTIGATION

SITE PHOTOGRAPHS

Photo 13 (above) – 18/7/14 – View of fill stockpiles near the residence in the south-western corner of the site.

Photo 14 (above) – 18/7/14 – View of possible fill stockpiles east of borehole 6A.

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PLANNING PROPOSAL AREA WITHIN SOUTH JERRABOMBERRA NSW

PRELIMINARY GEOTECHNICAL INVESTIGATION

SITE PHOTOGRAPHS

Photos 15 to 17 (above) – 18/7/14 – View of fill stockpiles and waste near the residence at the mid-western side of the site.

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URBAN CAPABILITY
PLANNING PROPOSAL AREA WITHIN SOUTH JERRABOMBERRA NSW

PRELIMINARY GEOTECHNICAL INVESTIGATION

SITE PHOTOGRAPHS

Photo 18 (above) – 18/7/14 – View of cut-to-fill platform north-east of the residence at the mid-western side of the site.

APPENDIX A

Borehole Logs 1A & 3A to 27A & Test Pit 2T

Excavation Log

Excavation No.	1A
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth (Metres)	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.2		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, pale grey, red-brown, some grass roots, dry to moist.	LOOSE		FILL?
			0.4		SP	SAND; fine to coarse sand, dark brown, some tree roots, moist.	LOOSE/ MEDIUM DENSE		
			0.5		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, pale grey, red-brown, some grass roots, dry to moist.	LOOSE/ MEDIUM DENSE		ALLUVIUM
			0.9		CL/SC	SANDY CLAY/CLAYEY SAND; low to medium plasticity clay, fine to coarse sand, grey, yellow-brown, dry to moist, slightly cemented.	VERY STIFF/ HARD or MEDIUM DENSE/ DENSE		
			1.0		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, pale grey, yellow-brown, dry to moist, slightly cemented.	DENSE		
			1.2			HW RHYODACITE; fine to coarse grained, purple, white speckled, some orange-brown and yellow-brown, dry.	WEAK ROCK		HW BEDROCK
			2.0			EW/HW RHYODACITE; fine to coarse grained, brown, yellow-brown, dry.	VERY WEAK ROCK		EW/HW BEDROCK
			2.3			EW/HW & HW RHYODACITE; fine to coarse grained, brown, yellow-brown, dry.	VERY WEAK & WEAK ROCK		EW/HW & HW BEDROCK
			2.8			EXCAVATION TERMINATED AT 2.8m			
			3.0						
			4.0						
			5.0						

Logged By : HR Date : 20/6/14 | Checked By : Date :

BOREHOLE/EXCAVATION LOG C7070.GPJ ACT GEO.GDT 18/7/14

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Excavation Log

Excavation No.	2T
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.2		SM	SILTY SAND; fine to coarse sand, low plasticity silt, dark brown, some grass roots, moist.	LOOSE		TOPSOIL
2T/1D 2T/2D			0.6		SC/CL	CLAYEY SAND/SANDY CLAY; fine to coarse sand, low to medium plasticity clay, brown, orange-brown, white, dry to moist.	MEDIUM DENSE/ DENSE or VERY STIFF/ HARD	DISTURBED SAMPLE DISTURBED SAMPLE	ALLUVIUM
			1.0		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, white, orange-brown, dry, some vesicules, slightly to moderately cemented.	DENSE		
			2.0						
			2.7			EXCAVATION TERMINATED AT 2.7m			
			3.0						
			4.0						
			5.0						

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Excavation Log

Excavation No.	3A
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth (Metres)	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.05		SM	SILTY SAND; fine to coarse sand, low plasticity silt, orange-brown, some grass roots, moist.	LOOSE		TOPSOIL
			0.1		CL		SOFT/ FIRM		ALLUVIUM
					SC	SANDY CLAY; low to medium plasticity clay, fine to coarse sand, orange-brown, moist.	MEDIUM DENSE		
						CLAYEY SAND; fine to coarse sand, low plasticity clay, pale grey, purple-brown, wet.			
			1.0		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, orange-brown, wet.	MEDIUM DENSE		
			1.3		CL/SC	SANDY CLAY/CLAYEY SAND; low to medium plasticity clay, fine to coarse sand, orange-brown, grey, wet.	VERY STIFF/ HARD or MEDIUM DENSE/ DENSE		
			1.9		CL	SANDY CLAY; low to medium plasticity clay, fine to coarse sand, grey, some sub-rounded rhyodacite gravels up to 80mm size, moist to wet.	VERY STIFF/ HARD		
			2.0						
			3.0			EXCAVATION TERMINATED AT 3m			
			4.0						
			5.0						

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Excavation Log

Excavation No.	4A
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.2		CL	SANDY CLAY; low to medium plasticity clay, fine to coarse sand, brown, some orange-brown, some grass roots, moist.	SOFT		TOPSOIL
			0.5		SC	CLAYEY GRAVELLY SAND; fine to coarse sand, sub-angular rhyodacite gravels up to 20mm size, yellow-brown, dry.	DENSE		RESIDUAL? ALLUVIUM?
			0.7			EW RHYODACITE excavates as CLAYEY GRAVELLY SAND; fine to coarse sand, sub-angular rhyodacite gravels up to 20mm size, yellow-brown, dry.	EXTREMELY WEAK ROCK		EW BEDROCK
			1.0			EW/HW RHYODACITE; fine to coarse grained, yellow-brown, dry.	VERY WEAK ROCK		EW/HW BEDROCK
			1.4			HW & HW/MW RHYODACITE; fine to coarse grained, orange-brown, purple-brown, dry.	WEAK & WEAK TO MEDIUM STRONG ROCK		HW & HW/MW BEDROCK
			2.0			EXCAVATION TERMINATED AT 1.4m DUE TO NEAR AUGER REFUSAL IN HW/MW BEDROCK			
			3.0						
			4.0						
			5.0						

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Excavation Log

Excavation No.	**5A**
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.1		SM	SILTY SAND; fine to coarse sand, low plasticity silt, dark brown, some grass roots, moist.	LOOSE		TOPSOIL
					SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, pale grey, moist.	DENSE		RESIDUAL
			0.4			EW RHYODACITE; fine to coarse grained, yellow-brown, purple-brown, dry to moist.	EXTREMELY WEAK ROCK		EW BEDROCK
			0.5			HW & HW/MW RHYODACITE; fine to coarse grained, yellow-brown, purple-brown, dry.	WEAK & WEAK TO MEDIUM STRONG ROCK		HW & HW/MW BEDROCK
			1.0						
			1.3			EXCAVATION TERMINATED AT 1.3m DUE TO NEAR AUGER REFUSAL IN MW BEDROCK			
			2.0						
			3.0						
			4.0						
			5.0						

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Excavation Log

Excavation No.	**6A**
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability
Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.1		SM	SILTY SAND; fine to coarse sand, low plasticity silt, brown, some grass roots, moist.	LOOSE		TOPSOIL
					SC	SILTY CLAYEY SAND; fine to coarse sand, low plasticity fines, pale brown, moist.	MEDIUM DENSE		SLOPEWASH
			0.4		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, orange-brown, pale brown, yellow-brown, dry to moist.	DENSE		RESIDUAL?
			1.0						
			1.4			EW RHYODACITE; fine to coarse grained, yellow-brown, dry.	EXTREMELY WEAK ROCK		EW BEDROCK
			1.6			HW RHYODACITE; fine to coarse grained, yellow-brown, orange-brown, purple-brown, dry.	WEAK ROCK		HW BEDROCK
			2.0						
			2.3			EW/HW RHYODACITE; fine to coarse grained, yellow-brown, orange-brown, dry.	VERY WEAK ROCK		EW/HW BEDROCK
			3.0			EXCAVATION TERMINATED AT 3m DUE TO NEAR AUGER REFUSAL IN HW/MW BEDROCK			
			4.0						
			5.0						

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BOREHOLE/EXCAVATION LOG C7070.GPJ ACT GEO.GDT 18/7/14

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Excavation Log

Excavation No.	7A
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.2		SM	SILTY SAND; fine to coarse sand, low plasticity silt, brown, some sub-angular rhyodacite gravels up to 50mm size, some grass roots, moist.	LOOSE		TOPSOIL
7A/1D			0.9			HW RHYODACITE; fine to coarse grained, yellow-brown, purple-brown, dry.	WEAK ROCK	DISTURBED SAMPLE	HW BEDROCK
			1.0			HW & HW/MW RHYDACITE; fine to coarse grained, purple-brown, grey, dry.	WEAK & WEAK TO MEDIUM STRONG ROCK		HW & HW/MW BEDROCK
			1.5			EXCAVATION TERMINATED AT 1.5m DUE TO NEAR AUGER REFUSAL IN MW BEDROCK			
			2.0						
			3.0						
			4.0						
			5.0						

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Excavation Log

Excavation No.	8A
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability
Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
8A/1D	None Encountered		0.4		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, pale grey, orange-brown, some sub-angular volcanic gravels up to 10mm size, dry, strongly cemented.	DENSE	DISTURBED SAMPLE	ALLUVIUM
						EXCAVATION TERMINATED AT 0.4m DUE TO AUGER REFUSAL IN DENSE ALLUVIAL CEMENTED GRAVEL			
			1.0						
			2.0						
			3.0						
			4.0						
			5.0						

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BOREHOLE/EXCAVATION LOG C7070.GPJ ACT GEO.GDT 18/7/14

ACT Geotechnical Engineers

ACT Geotechnical Engineers Pty Ltd

Excavation Log

Excavation No.	9A
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability
Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.1		SM	SILTY SAND; fine to coarse sand, low plasticity silt, dark yellow-brown, some grass roots, moist.	LOOSE		TOPSOIL
						HW/MW RHYODACITE; fine to coarse grained, purple-brown, yellow-brown, orange-brown, dry.	WEAK TO MEDIUM STRONG ROCK		HW/MW BEDROCK
			1.0						
			1.1			EXCAVATION TERMINATED AT 1.1m DUE TO AUGER REFUSAL IN MW BEDROCK			
			2.0						
			3.0						
			4.0						
			5.0						

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Excavation Log

Excavation No.	**10A**
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.2		SM	SILTY SAND; fine to coarse sand, low plasticity silt, dark brown, some grass roots, moist.	LOOSE		TOPSOIL
			1.0		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, pale brown, red-brown, moist.	DENSE		RESIDUAL?
			1.6			EW RHYODACITE excavates as CLAYEY SAND; fine to coarse sand, low plasticity clay, purple-brown, moist to wet.	EXTREMELY WEAK ROCK		EW BEDROCK
			1.8			HW RHYODACITE; fine to coarse grained, yellow-brown, dry.	WEAK ROCK		HW BEDROCK
			2.0			EXCAVATION TERMINATED AT 2m DUE TO AUGER REFUSAL IN MW BEDROCK			
			3.0						
			4.0						
			5.0						

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BOREHOLE/EXCAVATION LOG C7070.GPJ ACT GEO.GDT 18/7/14

ACT Geotechnical Engineers

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Excavation Log

Excavation No.	**11A**
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability
Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.1		SM	SILTY SAND; fine to coarse sand, low plasticity silt, brown, some grass roots, moist.	LOOSE		TOPSOIL
					SC	SILTY CLAYEY SAND; fine to coarse sand, low plasticity fines, pale grey-brown, moist.	MEDIUM DENSE		SLOPEWASH
			0.4		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, yellow-brown, dry.	DENSE		RESIDUAL
			0.9						
			1.0			HW & HW/MW RHYODACITE; fine to coarse grained, yellow-brown, orange-brown, dry.	WEAK & WEAK TO MEDIUM STRONG ROCK		HW & HW/MW BEDROCK
			1.2			EXCAVATION TERMINATED AT 1.2m DUE TO AUGER REFUSAL IN MW BEDROCK			
			2.0						
			3.0						
			4.0						
			5.0						

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Excavation Log

Excavation No.	12A
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.0		SC	GRAVELLY CLAYEY SAND; fine to coarse sand, low plasticity clay, sub-angular rhyodacite gravels up to 30mm size, pale grey, orange-brown, yellow-brown, some black, dry, strongly cemented.	DENSE		ALLUVIUM
			0.6		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, pale grey, orange-brown, yellow-brown, some black, some sub-angular rhyodacite gravels up to 10mm size, dry, strongly cemented.	DENSE		
			1.0						
			1.5		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, pale grey, orange-brown, yellow-brown, some black, some sub-angular rhyodacite gravels up to 10mm size, dry, strongly cemented.	LOOSE/ MEDIUM DENSE		
			1.7		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, pale grey, orange-brown, yellow-brown, some black, some sub-angular rhyodacite gravels up to 10mm size, dry, strongly cemented.	DENSE		
			2.0						
			2.2			EXCAVATION TERMINATED AT 2.2m			
			3.0						
			4.0						
			5.0						

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BOREHOLE/EXCAVATION LOG C7070.GPJ ACT GEO.GDT 18/7/14

ACT Geotechnical Engineers

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Excavation Log

Excavation No.	13A
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.1		SM	SILTY SAND; fine to coarse sand, low plasticity silt, brown, some grass roots, moist.	LOOSE		TOPSOIL
			1.0		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, purple-brown, pale grey, some orange-brown, some sub-rounded volcanic gravels up to 20mm size, moist.	DENSE		ALLUVIUM?
			1.2		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, yellow-brown, purple-brown, dry to moist.	DENSE		RESIDUAL
			1.5			EW RHYODACITE; fine to coarse grained, yellow-brown, purple-brown, dry.	EXTREMELY WEAK ROCK		EW BEDROCK
			2.0			EW & EW/HW RHYODACITE; fine to coarse grained, yellow-brown, purple-brown, dry.	EXTREMELY WEAK & VERY WEAK ROCK		EW & EW/HW BEDROCK
			2.3			EXCAVATION TERMINATED AT 2.3m			
			3.0						
			4.0						
			5.0						

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BOREHOLE/EXCAVATION LOG C7070.GPJ ACT GEO.GDT 18/7/14

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Excavation Log

Excavation No.	**14A**
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.2		SM	SILTY SAND; fine to coarse sand, low platicity silt, brown, moist.	LOOSE		TOPSOIL
			1.0		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, pale grey, orange-brown, moist.	DENSE		ALLUVIUM?
			1.3			EW RHYODACITE excavates as CLAYEY SAND; fine to coarse sand, low plasticity clay, purple-brown, yellow-brown, dry to moist.	EXTREMELY WEAK ROCK		EW BEDROCK
			1.6			HW RHYODACITE; fine to coarse grained, purple-brown, yellow-brown, dry.	WEAK ROCK		HW BEDROCK
			2.0						
			2.4			HW & HW/MW RHYODACITE; fine to coarse grained, purple-brown, yellow-brown, dry.	WEAK & WEAK TO MEDIUM STRONG ROCK		HW & HW/MW BEDROCK
			3.0			EXCAVATION TERMINATED AT 3m			
			4.0						
			5.0						

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Excavation Log

Excavation No.	**15A**
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability
Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
15A/1D	None Encountered		1.0		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, orange-brown, pale grey, brown, dry to moist, moist.	LOOSE/ MEDIUM DENSE	DISTURBED SAMPLE	ALLUVIUM
			2.0						
			2.4		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, pale grey, some orange-brown, dry, slightly cemented.	DENSE		
			2.6			EXCAVATION TERMINATED AT 2.6m DUE TO NEAR AUGER REFUSAL IN DENSE ALLUVIAL CEMENTED SAND			
			3.0						
			4.0						
			5.0						

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Excavation Log

Excavation No.	**16A**
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability
Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.1		SP	SAND; fine to coarse sand, orange-brown, brown, some sub-angular volcanic gravels up to 40mm size, some grass roots, some metal fragments, moist.	LOOSE		FILL
					SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, brown, some metal fragments, moist.	LOOSE		
			1.0						
			2.0			EXCAVATION TERMINATED AT 2m			
			3.0						
			4.0						
			5.0						

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Excavation Log

Excavation No.	17A
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability
Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.8		SP	SAND; fine to coarse sand, orange-brown, brown, some grass roots, moist.	LOOSE/ MEDIUM DENSE		FILL?
			1.0		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, brown, moist.	LOOSE/ MEDIUM DENSE		ALLUVIUM?
			3.0			EXCAVATION TERMINATED AT 3m			
			4.0						
			5.0						

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Excavation Log

Excavation No.	18A
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.2		SM	SILTY SAND; fine to coarse sand, low plasticity silt, brown, some grass roots, moist.	LOOSE		TOPSOIL
			0.4		CL	GRAVELLY SANDY CLAY; low to medium plasticity clay, fine to coarse sand, sub-angular rhyodacite gravels up to 100mm size, orange-brown, moist.	VERY STIFF/ HARD		ALLUVIUM
			1.0			HW/MW RHYODACITE; fine to coarse grained, yellow-brown, purple-brown, dry.	WEAK TO MEDIUM STRONG ROCK		HW/MW BEDROCK
			1.2			EXCAVATION TERMINATED AT 1.2m DUE TO NEAR AUGER REFUSAL IN HW/MW BEDROCK			
			2.0						
			3.0						
			4.0						
			5.0						

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Excavation Log

Excavation No.	**19A**
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.1		SM	SILTY SAND; fine to coarse sand, low plasticity silt, brown, orange-brown, some grass roots, moist.	LOOSE		TOPSOIL
					SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, pale grey, orange-brown, some ferruginous nodules up to 5mm size, moist.	MEDIUM DENSE/ DENSE		ALLUVIUM
			1.0						
			1.2		CL	SANDY CLAY; medium plasticity clay, fine to coarse sand, pale grey, dry to moist.	VERY STIFF/ HARD		
			1.4		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, pale grey, dry, slightly to moderately cemented.	DENSE		
			1.5			HW/MW RHYODACITE; fine to coarse grained, purple-brown, white speckled, dry.	WEAK TO MEDIUM STRONG ROCK		HW/MW BEDROCK
			1.6			EXCAVATION TERMINATED AT 1.6m DUE TO NEAR AUGER REFUSAL IN HW/MW BEDROCK			
			2.0						
			3.0						
			4.0						
			5.0						

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Excavation Log

Excavation No.	**20A**
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		1.0		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, yellow-brown, orange-brown, pale grey, some sub-angular volcanic gravels up to 10mm size, dry to moist, some slightly cemented.	DENSE		ALLUVIUM?
			1.4			HW RHYODACITE; fine to coarse grained, purple-brown, yellow-brown, dry.	WEAK ROCK		HW BEDROCK
			1.7			HW/MW RHYODACITE; fine to coarse grained, purple-brown, yellow-brown, dry.	WEAK TO MEDIUM STRONG ROCK		HW/MW BEDROCK
			2.0			EXCAVATION TERMINATED AT 2m DUE TO NEAR AUGER REFUSAL IN HW/MW BEDROCK			
			3.0						
			4.0						
			5.0						

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BOREHOLE/EXCAVATION LOG C7070.GPJ ACT GEO.GDT 18/7/14

ACT Geotechnical Engineers

ACT Geotechnical Engineers Pty Ltd

Excavation Log

Excavation No.	**21A**
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.1		SM	SILTY SAND; fine to coarse sand, low plasticity silt, brown, some grass roots, dry to moist.	LOOSE		TOPSOIL
					SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, pale grey, yellow-brown, dry to moist.	MEDIUM DENSE/ DENSE		ALLUVIUM
21A/1D			**1.0**					DISTURBED SAMPLE	
			1.1		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, pale grey, yellow-brown, dry to moist, slightly cemented.	DENSE		
			1.3			EW RHYODACITE excavates as CLAYEY SAND; fine to coarse sand, yellow-brown, red-brown, dry.	EXTREMELY WEAK ROCK		EW BEDROCK
			1.7			EW & EW/HW RHYODACITE; fine to coarse grained, yellow-brown, red-brown, dry.	EXTREMELY WEAK & VERY WEAK ROCK		EW & EW/HW BEDROCK
			2.0						
			3.0			EXCAVATION TERMINATED AT 3m			
			4.0						
			5.0						

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Excavation Log

Excavation No.	22A
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability
Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.1		SM	SILTY SAND; fine to coarse sand, low plasticity silt, dark brown, some grass roots, moist.	LOOSE		TOPSOIL
					SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, pale grey, orange-brown, dry to moist.	DENSE		ALLUVIUM
			1.0						
			1.1			EW/HW RHYODACITE; fine to coarse grained, pale grey, orange-brown, dry.	VERY WEAK ROCK		EW/HW BEDROCK
			1.2			HW RHYODACITE; fine to coarse grained, pale grey, orange-brown, dry.			HW BEDROCK
			1.3			EXCAVATION TERMINATED AT 1.3m DUE TO NEAR AUGER REFUSAL IN HW/MW BEDROCK	WEAK ROCK		
			2.0						
			3.0						
			4.0						
			5.0						

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BOREHOLE/EXCAVATION LOG C7070.GPJ ACT GEO.GDT 18/7/14

ACT Geotechnical Engineers

ACT Geotechnical Engineers Pty Ltd

Excavation Log

Excavation No.	**23A**
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.1		SM	SILTY SAND; fine to coarse sand, low plasticity silt, dark brown, some grass roots, moist.	LOOSE		TOPSOIL
					SC	CLAYEY SAND; fine to coarse sand, low plasticity silt, pale grey, orange-brown, some sub-angular volcanic gravels up to 50mm size, dry to moist, slightly cemented.	DENSE		ALLUVIUM
			0.5			HW/MW RHYODACITE; fine to coarse grained, pale grey, orange-brown, dry.	WEAK TO MEDIUM STRONG ROCK		HW/MW BEDROCK
			1.0			EXCAVATION TERMINATED AT 1m DUE TO AUGER REFUSAL IN MW BEDROCK			
			2.0						
			3.0						
			4.0						
			5.0						

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BOREHOLE/EXCAVATION LOG C7070.GPJ ACT GEO.GDT 18/7/14

ACT Geotechnical Engineers

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Excavation Log

Excavation No.	**24A**
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability
Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth (Metres)	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.1		SM	SILTY SAND; fine to coarse sand, low plasticity silt, dark brown, some grass roots, moist.	LOOSE		TOPSOIL
					SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, pale grey, orange-brown, moist.	LOOSE/ MEDIUM DENSE		ALLUVIUM
			1.0						
			1.2		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, pale grey, orange-brown, dry to moist, slightly cemented.	DENSE		
			2.0						
			3.0			EXCAVATION TERMINATED AT 3m			
			4.0						
			5.0						

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Excavation Log

Excavation No.	25A
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability
Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.1		SM	SILTY SAND; fine to coarse sand, low plasticity silt, yellow-brown, dry to moist.	LOOSE		TOPSOIL
					SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, pale grey, moist.	DENSE		ALLUVIUM
25A/1D								DISTURBED SAMPLE	
			1.0		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, pale grey, some sub-angular volcanic gravels up to 10mm size, dry, slightly to strongly cemented.	DENSE		
			1.3			HW & HW/MW RHYODACITE; fine to coarse grained, pale grey, purple-brown, dry.	WEAK & WEAK TO MEDIUM STRONG ROCK		HW & HW/MW BEDROCK
			1.5			EXCAVATION TERMINATED AT 1.5m DUE TO NEAR AUGER REFUSAL IN HW/MW BEDROCK			
			2.0						
			3.0						
			4.0						
			5.0						

Logged By : HR Date : 7/7/14 | Checked By : Date :

BOREHOLE/EXCAVATION LOG C7070.GPJ ACT GEO.GDT 18/7/14

ACT Geotechnical Engineers

ACT Geotechnical Engineers Pty Ltd

Excavation Log

Excavation No.	**26A**
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability
Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.1		SM	SILTY SAND; fine to coarse sand, low plasticity silt, dark brown, some grass roots, moist.	LOOSE		TOPSOIL
					SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, pale grey, orange-brown, dry to moist.	LOOSE/ MEDIUM DENSE		ALLUVIUM
			1.0						
			1.2		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, pale grey, orange-brown, dry to moist.	MEDIUM DENSE/ DENSE		
			1.8		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, orange-brown, dry to moist, slightly cemented.	DENSE		
			2.0						
			3.0[3]			EXCAVATION TERMINATED AT 3m			
			4.0						
			5.0						

Logged By : HR Date : 7/7/14 | Checked By : Date :

BOREHOLE/EXCAVATION LOG C7070.GPJ ACT GEO.GDT 18/7/14

ACT Geotechnical Engineers

ACT Geotechnical Engineers Pty Ltd

Excavation Log

Excavation No.	**27A**
Sheet	1 of 1
Job No.	C7070

CLIENT: Southeast Engineering & Environmental

PROJECT: Urban Capability
Planning Proposal Area Within South Jerrabomberra

Location : See Figure 2

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm Diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.9		CL	SILTY SANDY CLAY; low to medium plasticity fines, fine to coarse sand, pale grey, moist.	VERY STIFF		ALLUVIUM
			1.0 1.1		CL	SANDY CLAY; low to medium plasticity clay, fine to coarse sand, orange-brown, pale grey, moist.	VERY STIFF/ HARD		
			1.4		CL	SANDY CLAY; medium plasticity clay, fine to coarse sand, orange-brown, pale grey, moist.	VERY STIFF/ HARD		
			2.0 2.2		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, grey, dry to moist, moist, slightly cemented.	DENSE		
			3.0 **4.0** **5.0**			EXCAVATION TERMINATED AT 2.2m DUE TO NEAR AUGER REFUSAL IN DENSE ALLUVIAL CEMENTED SAND			

Logged By : HR Date : 4/7/14 | Checked By : Date :

BOREHOLE/EXCAVATION LOG C7070.GPJ ACT GEO.GDT 18/7/14

ACT Geotechnical Engineers

ACT Geotechnical Engineers Pty Ltd

APPENDIX B

Laboratory Test Records

J & A GEOTECH TESTING PTY LTD

Unit 2/25 Dacre Street Mitchell ACT 2911

Certificate No 191476-191479

Test Certificate - California Bearing Ratio - CBR

Client	**ACT GEOTECHNICAL ENGINEERS PTY LTD**	Job No	**0010**
Principal		Date Tested	07.04.14
Project	South Jerrabomberra	Tested By	D.J
Location	Jerrabomberra NSW	Date Checked	11.04.14
Test Procedures		Checked By	J.S

[•] AS 1289 6.1.1 [•] AS 1289 2.1.1 [•] AS 1289 2.1.4 [ ] AS 1289 5.1.1 [•] AS 1289 5.2.1

[ ] RMS T102 [ ] RMS T111 [ ] RMS T112 [RMS 117 [ ] RMS 117A [ ] RMS T120 [ ] RMS T132 [ ] RMS T180

Sample Location		2T/1D	8A/1D	15A/1D	7A/1D
Level at Test Taken	BFL	0.4m-0.5m	0.0m-0.4m	0.5m-1.0m	0.3m-1.0m
Remoulding Parameters		95%MMDD@OMC	95%MMDD@OMC	95%MMDD@OMC	95%MMDD@OMC
Compactive Effort		Modified	Modified	Modified	Modified
Maximum Particle Size	mm	19.0	19.0	19.0	19.0
Percentage Oversize of Material	%	0.0	0.0	0.0	6.5
Oversize Material included in Sample		[ ] Yes [•] No	[ ] Yes [•] No	[ ] Yes [•] No	[ ] Yes [•] No
Maximum Dry Density	t/m^3	2.07	2.13	2.08	2.08
Optimum Moisture Content	%	9.0	7.5	9.5	8.0
Dry Density Before Soak	t/m^3	1.97	2.02	1.97	1.97
Dry Density After Soak	t/m^3	1.94	2.02	1.97	1.97
Dry Density Ratio Before Soak	%	95.0	95.0	95.0	95.0
Dry Density Ratio After Soak	%	93.5	95.0	94.5	95.0
Moisture Ratio Before Soak	%	100.0	100.0	100.0	100.0
Moisture Content Before Soak	%	9.1	7.4	9.5	8.0
Soaking					
Period of Soak days		4	4	4	4
Surcharge kg		4.5	4.5	4.5	4.5
Swell%		1.5	0.0	0.0	0.0
Penetration Test					
Sample Moisture Content	%	10.0	4.5	10.5	11.3
Top 30 mm	%	14.0	12.8	12.5	12.8
Whole Sample	%	13.2	10.1	11.9	11.2
CBR Value		**11**	**25**	**18**	**45**
Penetration at Which CBR Determined mm		2.5	5.0	5.0	5.0
Material Classification: Sampled by client Received on the 09.07.14		Sandy clay brown colour	Sandy clay brown colour	Sandy clay brown colour	Sandy clay brown colour

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15.07.14
Laboratory Manager/Date
Scott Miller

NATA Accredited Laboratory Number: 15049

J & A GEOTECH TESTING PTY LTD

Unit 2/25 Dacre Street Mitchell ACT 2911

Certificate No 191480

Test Certificate – California Bearing Ratio – CBR

Client	**ACT GEOTECHNICAL ENGINEERS PTY LTD**	Job No	**0010**
Principal		Date Tested	07.04.14
Project	South Jerrabomberra	Tested By	D.J
Location	Jerrabomberra NSW	Date Checked	11.04.14
Test Procedures		Checked By	J.S

[•] AS 1289 6.1.1 [•] AS 1289 2.1.1 [•] AS 1289 2.1.4 [ ] AS 1289 5.1.1 [•] AS 1289 5.2.1

[ ] RMS T102 [ ] RMS T111 [ ] RMS T112 [RMS 117 [ ] RMS 117A [ ] RMS T120 [ ] RMS T132 [ ] RMS T180

Sample Location		**21A/1D**	-	-	-
Level at Test Taken	BFL	**0.4m-1.0m**	-	-	-
Remoulding Parameters		**95%MMDD@OMC**	-	-	-
Compactive Effort		Modified	-	-	-
Maximum Particle Size	mm	19.0	-	-	-
Percentage Oversize of Material	%	1.0	-	-	-
Oversize Material included in Sample		[ ] Yes [•] No	[ ] Yes [ ] No	[ ] Yes [ ] No	[ ] Yes [ ] No
Maximum Dry Density	t/m^3	2.09	-	-	-
Optimum Moisture Content	%	7.5	-	-	-
Dry Density Before Soak	t/m^3	1.99	-	-	-
Dry Density After Soak	t/m^3	1.99	-	-	-
Dry Density Ratio Before Soak	%	95.0	-	-	-
Dry Density Ratio After Soak	%	95.0	-	-	-
Moisture Ratio Before Soak	%	100.2	-	-	-
Moisture Content Before Soak	%	7.5	-	-	-
Soaking					
Period of Soak days		4	-	-	-
Surcharge kg		4.5	-	-	-
Swell%		0.0	-	-	-
Penetration Test					
Sample Moisture Content	%	11.0	-	-	-
Top 30 mm	%	13.2	-	-	-
Whole Sample	%	11.8	-	-	-
CBR Value		**25**	-	-	-
Penetration at Which CBR Determined mm		2.5	-	-	-
Material Classification: Sampled by client Received on the 09.07.14		Sandy clay brown colour	-	-	-

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15.07.14
Laboratory Manager/Date
Scott Miller

NATA Accredited Laboratory Number: 15049

J & A GEOTECH TESTING PTY LTD

Unit 2/25 Dacre Street Mitchell ACT 2911

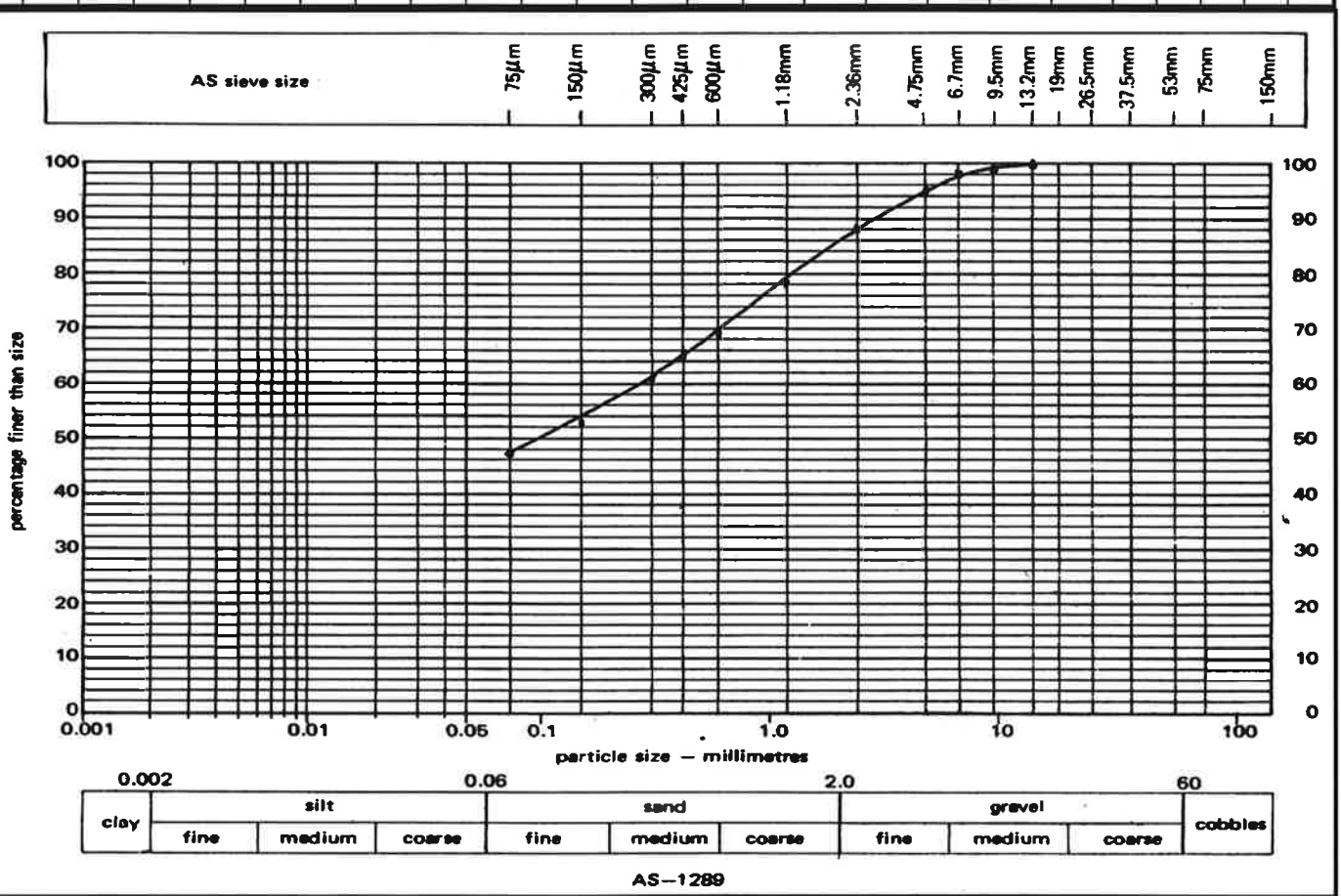
Particle Size Distribution / Atterberg Limits

Job No 0010

Sample No 191476

Client	**ACT GEOTECHNICAL ENGINEERS PTY LTD**	Date Prepared	**10.7.14**
Principal		Prepared By	**D.J**
Project	**South Jerrabomberra**	Date Tested	**14.7.14**
Location	**Jerrabomberra NSW**	Tested By	**D.J**
Sample Identification	**2T/1D 0.4m-0.5m**	Date Checked	**15.7.14**
Test Procedures	[•] AS 1289 3.1.2 [•] AS 1289 3.2.1 [•] AS 1289 3.3.1 [•] AS 1289 3.4.1 [•] AS 1289 3.6.1 [•] Wet Prep [ ] Dry Prep [ ] RMS T108 [ ] RMS T109 [ ] RMS T113 [•] AS1289 4.3.1	Checked By	**J.S**

AS sieve size	200mm	150 mm	75 mm	53 mm	37.5 mm	26.5 mm	19.0 mm	13.2 mm	9.5 mm	6.7 mm	4.75 mm	2.36 mm	1.18 mm	600 µm	425 µm	300 µm	150 µm	75 µm	0.02 µm
Percent Passing								100	99	98	95	88	78	69	65	61	53	47	N/A



Atterberg Limits	Liquid Limit	**27%**	Plastic Limit	**16%**
	Linear Shrinkage	**6.5%**	Plasticity Index	**11%**

Comments: Sampled by Client received on 9.7.14 **pH: 6.7**

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15.7.14
Manager/Date
Justin Smith

Form: R-PSD ATT June 13

J & A GEOTECH TESTING PTY LTD

Unit 2/25 Dacre Street Mitchell ACT 2911

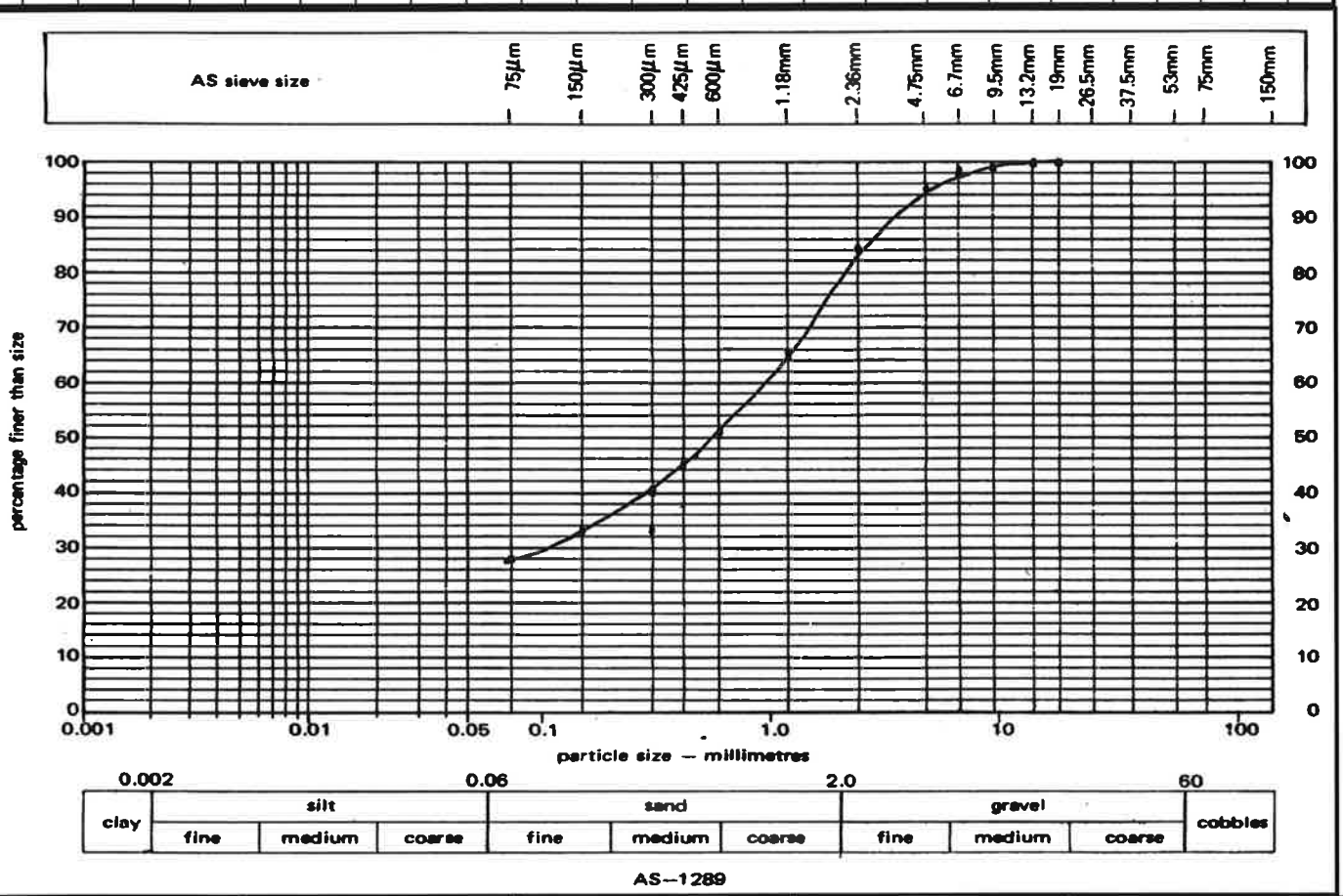
Particle Size Distribution / Atterberg Limits

Job No 0010

Sample No 191477

Client	**ACT GEOTECHNICAL ENGINEERS PTY LTD**	Date Prepared	**10.7.14**
Principal		Prepared By	**D.J**
Project	**South Jerrabomberra**	Date Tested	**14.7.14**
Location	**Jerrabomberra NSW**	Tested By	**D.J**
Sample Identification	**8A/1D 0.0m-0.4m**	Date Checked	**15.7.14**
Test Procedures	[•] AS 1289 3.1.2 [•] AS 1289 3.2.1 [•] AS 1289 3.3.1 [•] AS 1289 3.4.1 [•] AS 1289 3.6.1 [•] Wet Prep [ ] Dry Prep [ ] RMS T108 [ ] RMS T109 [ ] RMS T113 [•] AS1289 4.3.1	Checked By	**J.S**

AS sieve size	200mm	150 mm	75 mm	53 mm	37.5 mm	26.5 mm	19.0 mm	13.2 mm	9.5 mm	6.7 mm	4.75 mm	2.36 mm	1.18 mm	600 µm	425 µm	300 µm	150 µm	75 µm	0.02 µm
Percent Passing							100	100	99	98	95	84	65	51	45	40	33	28	N/A



Atterberg Limits	Liquid Limit	**19%**	Plastic Limit	**14%**
	Linear Shrinkage	**2.0%**	Plasticity Index	**5%**

Comments: Sampled by Client received on 9.7.14 **pH: 6.3**

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15.7.14
Manager/Date
Justin Smith

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Unit 2/25 Dacre Street Mitchell ACT 2911

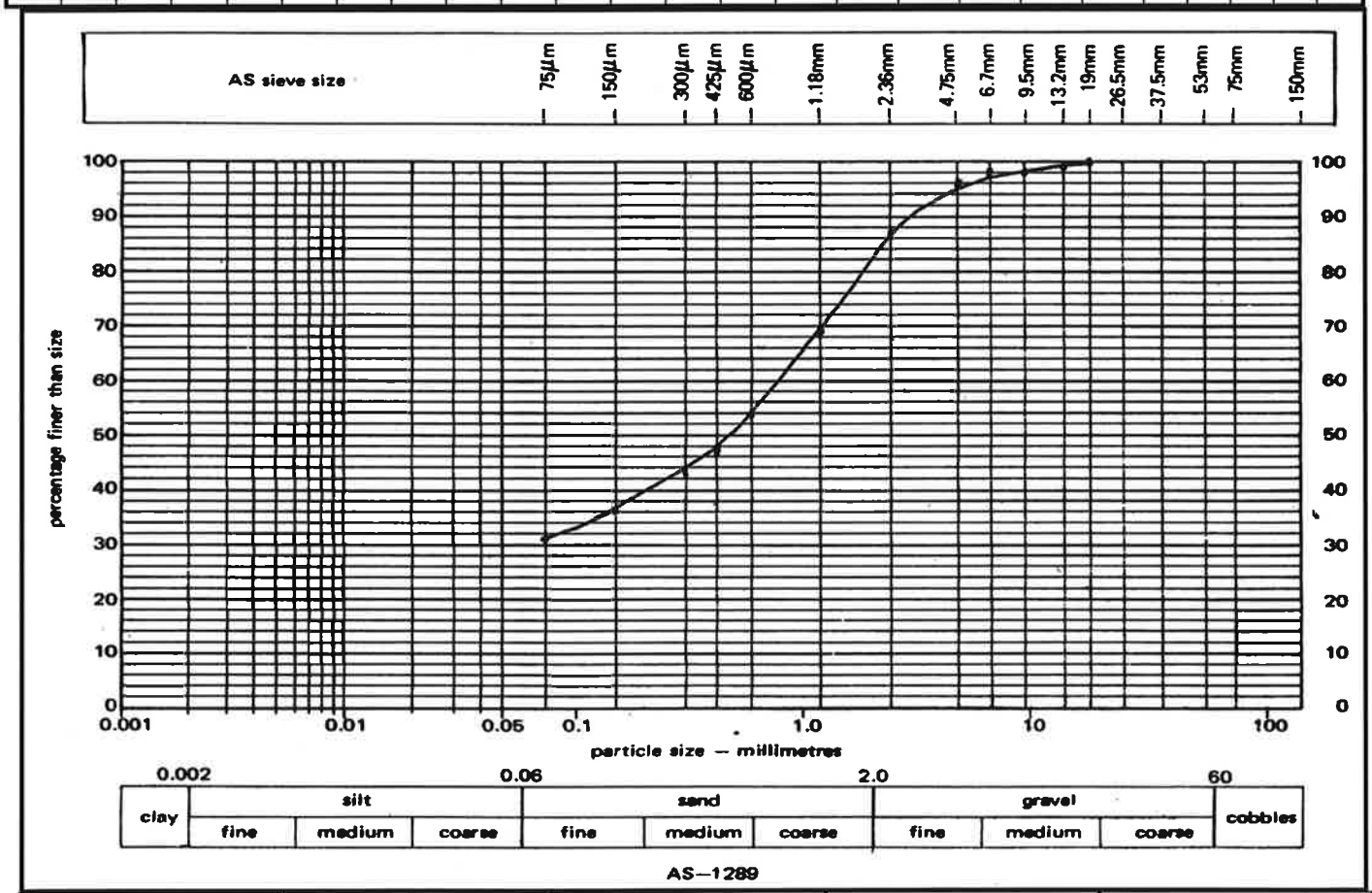
Particle Size Distribution / Atterberg Limits

Job No 0010

Sample No 191478

Client	**ACT GEOTECHNICAL ENGINEERS PTY LTD**	Date Prepared	**10.7.14**
Principal		Prepared By	**D.J**
Project	**South Jerrabomberra**	Date Tested	**14.7.14**
Location	**Jerrabomberra NSW**	Tested By	**D.J**
Sample Identification	**15A/1D 0.5m-1.0m**	Date Checked	**15.7.14**
Test Procedures	[•] AS 1289 3.1.2 [•] AS 1289 3.2.1 [•] AS 1289 3.3.1 [•] AS 1289 3.4.1 [•] AS 1289 3.6.1 [•] Wet Prep [ ] Dry Prep [ ] RMS T108 [ ] RMS T109 [ ] RMS T113 [•] AS1289 4.3.1	Checked By	**J.S**

AS sieve size	200mm	150 mm	75 mm	53 mm	37.5 mm	26.5 mm	19.0 mm	13.2 mm	9.5 mm	6.7 mm	4.75 mm	2.36 mm	1.18 mm	600 µm	425 µm	300 µm	150 µm	75 µm	0.02 µm
Percent Passing							100	99	98	98	96	87	69	54	47	43	36	31	N/A



Atterberg Limits				
	Liquid Limit	18%	Plastic Limit	14%
	Linear Shrinkage	1.5%	Plasticity Index	4%

Comments: Sampled by Client received on 9.7.14 **pH: 6.5**

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Manager/Date
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Unit 2/25 Dacre Street Mitchell ACT 2911

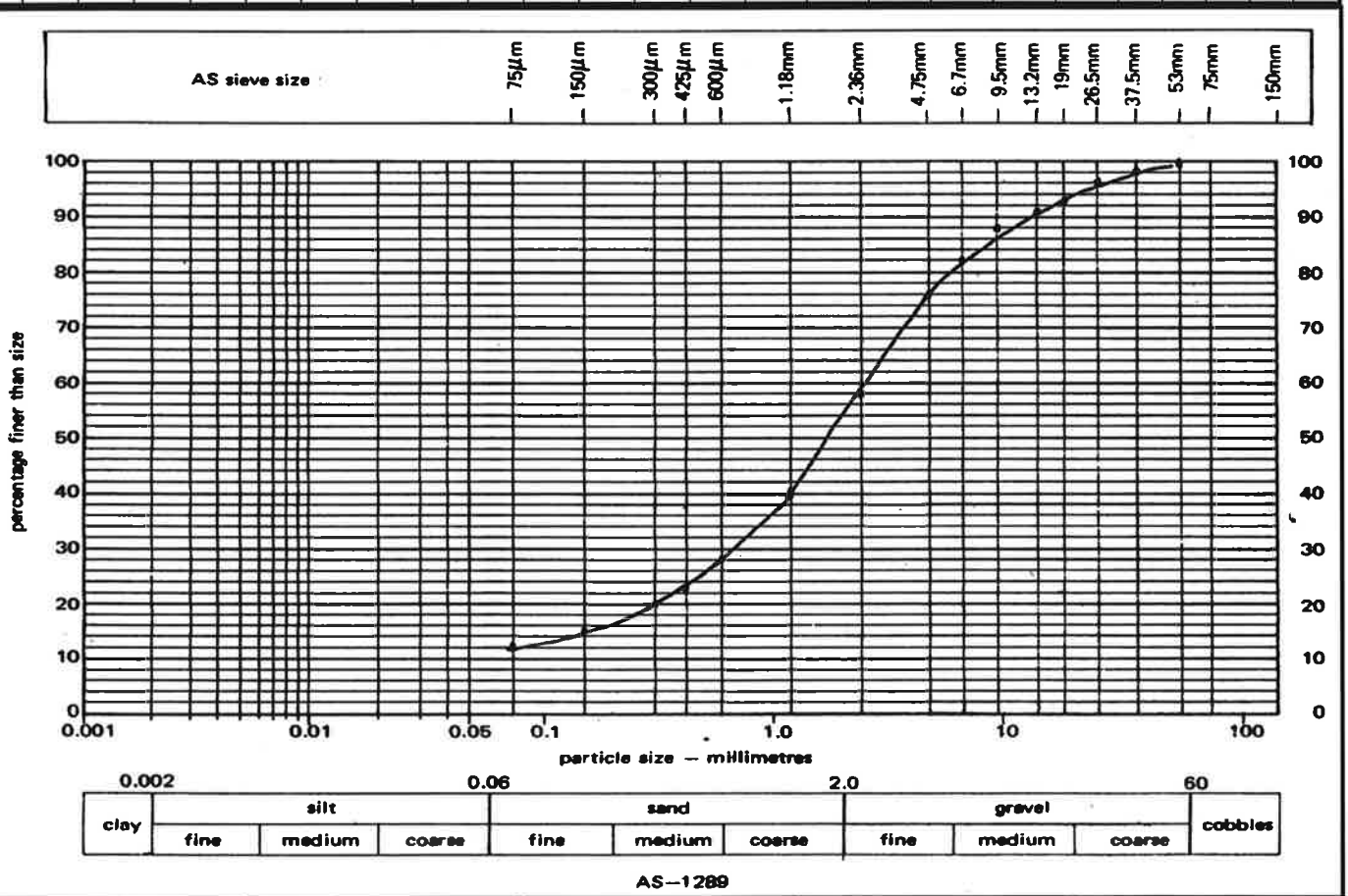
Particle Size Distribution / Atterberg Limits

Job No 0010

Sample No 191479

Client	**ACT GEOTECHNICAL ENGINEERS PTY LTD**	Date Prepared	**10.7.14**
Principal		Prepared By	**D.J**
Project	**South Jerrabomberra**	Date Tested	**14.7.14**
Location	**Jerrabomberra NSW**	Tested By	**D.J**
Sample Identification	**7A/1D 0.3m-1.0m**	Date Checked	**15.7.14**
Test Procedures	[•] AS 1289 3.1.2 [•] AS 1289 3.2.1 [•] AS 1289 3.3.1 [•] AS 1289 3.4.1 [•] AS 1289 3.6.1 [•] Wet Prep [ ] Dry Prep [ ] RMS T108 [ ] RMS T109 [ ] RMS T113 [•] AS1289 4.3.1	Checked By	**J.S**

AS sieve size	200mm	150 mm	75 mm	53 mm	37.5 mm	26.5 mm	19.0 mm	13.2 mm	9.5 mm	6.7 mm	4.75 mm	2.36 mm	1.18 mm	600 µm	425 µm	300 µm	150 µm	75 µm	0.02 µm				
Percent Passing				100	98	96	93	91	88	82	76	58	40	28	23	20	15	12	N/A				



Atterberg Limits				
	Liquid Limit	**23%**	Plastic Limit	**19%**
	Linear Shrinkage	**2.0%**	Plasticity Index	**4%**

Comments: Sampled by Client received on 9.7.14 **pH: 6.6**

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15.7.14
Manager/Date
Justin Smith

J & A GEOTECH TESTING PTY LTD

Unit 2/25 Dacre Street Mitchell ACT 2911

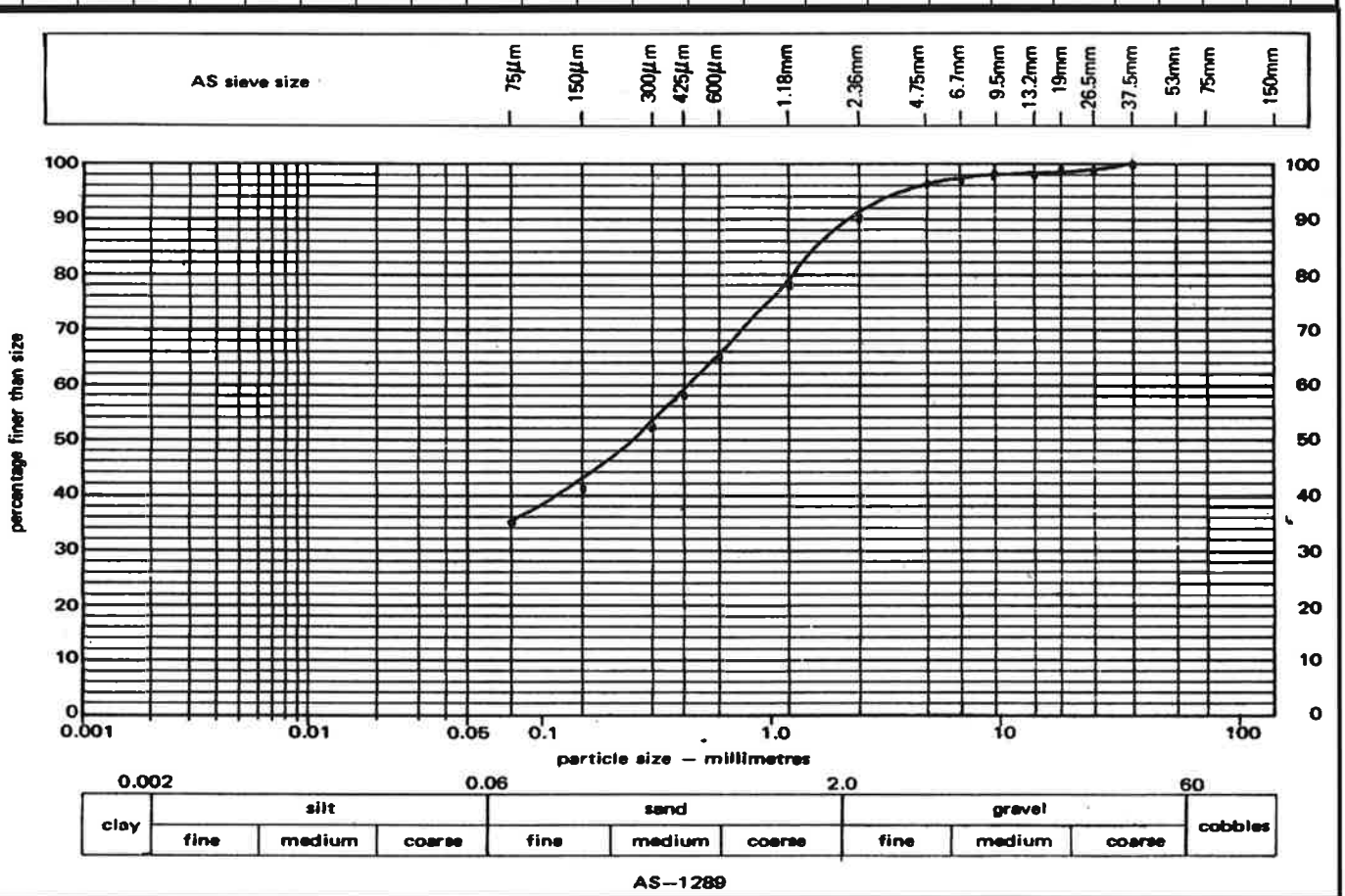
Particle Size Distribution / Atterberg Limits

Job No 0010

Sample No 191480

Client	**ACT GEOTECHNICAL ENGINEERS PTY LTD**	Date Prepared	**10.7.14**
Principal		Prepared By	**D.J**
Project	**South Jerrabomberra**	Date Tested	**14.7.14**
Location	**Jerrabomberra NSW**	Tested By	**D.J**
Sample Identification	**21A/1D 0.4m-1.0m**	Date Checked	**15.7.14**
Test Procedures	[•] AS 1289 3.1.2 [•] AS 1289 3.2.1 [•] AS 1289 3.3.1 [•] AS 1289 3.4.1 [•] AS 1289 3.6.1 [•] Wet Prep [ ] Dry Prep [ ] RMS T108 [ ] RMS T109 [ ] RMS T113 [•] AS1289 4.3.1	Checked By	**J.S**

AS sieve size	200mm	150 mm	75 mm	53 mm	37.5 mm	26.5 mm	19.0 mm	13.2 mm	9.5 mm	6.7 mm	4.75 mm	2.36 mm	1.18 mm	600 µm	425 µm	300 µm	150 µm	75 µm	0.02 µm
Percent Passing					100	99	99	98	98	97	96	90	78	65	58	52	41	35	N/A



Atterberg Limits				
	Liquid Limit	15%	Plastic Limit	13%
	Linear Shrinkage	1.0%	Plasticity Index	1%

Comments: Sampled by Client received on 9.7.14 **pH: 6.3**

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15.7.14
Manager/Date
Justin Smith

Form: R-PSD ATT June 13

J & A GEOTECH TESTING PTY LTD

Unit 2/25 Dacre Street Mitchell ACT 2911
ABN 28110760079

Telephone: 02 6255 5363
Fax: 02 6255 4647
Mobile: 0438 010 988

Client: **ACT Geotechnical Engineers PTY LTD**
Project: **South Jerrabomberra**
Location: **Jerrabomberra NSW**

Determination of Emerson class number of a soil

Sample Identification: **2T/1D 0.4m-0.5m**
Emerson Class Number: 2

Sample Identification: **8A/1D 0.0m-0.4m**
Emerson Class Number: 2

Sample Identification: 15A/1D 0.5m-1.0m
Emerson Class Number: 2

Sample Identification: 7A/1D 0.3m-1.0m
Emerson Class Number: 2

Sample Identification: 7A/1D 0.3m-1.0m
Emerson Class Number: 2

Date of Test: 15.7.14 sampled by client received on 2.6.14
Type & temperature of water used: Distilled water 19degrees C

Test was performed in accordance with AS1289.3.8.1-1997
Method 3.8.1 Determination of Emerson class number of a soil.

Manager
(Justin Smith) 15.7.14

Report No: NAA14-1323 **Page 1 of 3**

Date Received: 9/07/2014

Date Reported: 23/07/2014

Order No: COC dated 8/07/2014

Attention: Hermann Retief

ACT Geotechnical Engineers Pty Ltd.
5/9 Beaconsfield Street
Fyshwick ACT 2609

LabPoint
LabPoint Pty Ltd
ABN 82 096 903 749
Phone: (02) 9624 5588
Fax: (02) 9624 2266
E-Mail: labpoint@bigpond.net.au
Unit 31, 35 Foundry Road,
Seven Hills NSW 2147
P.O. Box 177
Kings Langley NSW 2147

Type of Samples: sPOCAS analysis of two soil samples identified as 'South Jerrabomberra' as listed on pages 1 and 2. Samples in glass jars were dispatched by customer in an esky cooled by icepacks on 8/07/2014. The analysis was performed by Envirolab laboratory at Sydney, NATA Accreditation No. 2901, Report No 112977. Analysed 'as received'.

Tests	Units	2T/2D 0.4-0.5 m	25A/1D 0.4-0.9 m	Method: Analysed by Envirolab
pH KCl	pH Units	5.3	5.1	Envirolab: Inorg 064
TAA pH 6.5	moles H^+/t	<5	6	Envirolab: Inorg 064
s-TAA pH 6.5	% w/w S	<0.01	0.01	Envirolab: Inorg 064
pH Ox	pH Units	4.2	5.8	Envirolab: Inorg 064
TPA pH 6.5	moles H^+/t	<5	<5	Envirolab: Inorg 064
s-TPA pH 6.5	% w/w S	<0.01	<0.01	Envirolab: Inorg 064
TSA pH 6.5	moles H^+/t	<5	<5	Envirolab: Inorg 064
s-TSA pH 6.5	% w/w S	<0.01	<0.01	Envirolab: Inorg 064
ANCE	% $CaCO_3$	<0.05	<0.05	Envirolab: Inorg 064
a-ANCE	moles H^+/t	<5	<5	Envirolab: Inorg 064
s-ANCE	% w/w S	<0.05	<0.05	Envirolab: Inorg 064
SKCl	% w/w S	<0.005	<0.005	Envirolab: Inorg 064
SP	% w/w	0.03	0.005	Envirolab: Inorg 064
SPOS	% w/w	0.03	<0.005	Envirolab: Inorg 064
a-SPOS	moles H^+/t	16	<5	Envirolab: Inorg 064
CaKCl	% w/w	0.04	0.05	Envirolab: Inorg 064
CaP	% w/w	0.04	0.05	Envirolab: Inorg 064

Note: Units: Measurements as listed on the table. Analysed "as received".
Samples will be disposed of 30 days after issue of this report unless otherwise notified.
< Denotes 'less than'. NA Denotes 'Test not required'
Envirolab: Method Inorg 064 summary: sPOCAS determined using titrimetric and ICP-AES techniques, based on Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1-June 2004.
Envirolab: Report 112977

Dr Rama Bhat
Approved Signatory

Sarita Chand
Approved Signatory

NATA ACCREDITED FOR TECHNICAL COMPETENCE
Accredited for compliance with ISO/IEC 17025
Laboratory No.11111

LabPoint

Type of Samples: sPOCAS analysis of two soil samples identified as 'South Jerrabomberra' as listed on pages 1 and 2. Samples in glass jars were dispatched by customer in an esky cooled by icepacks on 8/07/2014. The analysis was performed by Envirolab laboratory at Sydney, NATA Accreditation No. 2901, Report No 112977. Analysed 'as received'.

Tests	Units	2T/2D 0.4-0.5 m	25A/1D 0.4-0.9 m	Method: Analysed by Envirolab
CaA	% w/w	<0.005	<0.005	Envirolab: Inorg 064
MgKCl	% w/w	0.032	0.009	Envirolab: Inorg 064
MgP	% w/w	0.035	0.012	Envirolab: Inorg 064
MgA	% w/w	<0.005	<0.005	Envirolab: Inorg 064
Fineness Factor	-	1.5	1.5	Envirolab: Inorg 064
a-Net Acidity	moles H^+/t	20	<10	Envirolab: Inorg 064
Liming Rate	kg $CaCO_3$/t	1.5	<0.75	Envirolab: Inorg 064
a-Net Acidity without ANCE	moles H^+/t	NA	NA	Envirolab: Inorg 064
Liming Rate without ANCE	kg $CaCO_3$/t	NA	NA	Envirolab: Inorg 064

Note: Units: as listed on the table. Analysed "as received".
Samples will be disposed of 30 days after issue of this report unless otherwise notified.
< Denotes 'less than'. NA Denotes 'Test not required'
Envirolab: Method Inorg 064 summary: sPOCAS determined using titrimetric and ICP-AES techniques, based on Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1-June 2004.
Envirolab: Report 112977

NATA ACCREDITED FOR TECHNICAL COMPETENCE
Accredited for compliance with ISO/IEC 17025
Laboratory No.11111

Type of Samples: Analysis of two soil samples identified as 'South Jerrabomberra' as listed below. Samples in glass jars were dispatched by customer in an esky cooled by icepacks on 8/07/2014. Analysed 'as received'.

Tests	Units	2T/2D 0.4-0.5 m	8A/1D 0.0-0.4 m	Methods
Total Soluble Salts	mg/kg	484	27	ALS: EA014
Moisture Content (dried @ 103°C)	%	7.6	4.5	ALS: EA055
Exchangeable Sodium Percent	%	26.0	4.2	ALS: ED007 *
Sulfur- Total as S (LECO)	%	0.08	0.02	ALS: ED042T
Nitrite + Nitrate as N (Sol.)	mg/kg	4.4	0.7	ALS: EK059G
Total Kjeldahl Nitrogen as N	mg/kg	90	40	ALS: EK061G
Total Nitrogen as N **	mg/kg	90	40	ALS: EK062
Total Phosphorus	mg/kg	31	23	APHA 4500 P B/D

Note: Units: Measurements as listed on the table. Analysed "as received".
Samples will be disposed of 30 days after issue of this report unless otherwise notified.
* ED007: When exchangeable AI is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests exchange acidity by 1M KCL (Method 15G1) is a more suitable method for the determination of exchange acidity)$H^+ + Al_3^+$).
** This result is computed from individual analyte detections at or above the level of reporting.
All above analysis except total phosphorus were performed by ALS Environmental Division Sydney, NATA Accreditation No. 825, Work Order ES1415252.

Dr Rama Bhat
Approved Signatory

Sarita Chand
Approved Signatory

NATA Accredited for compliance with ISO/IEC 17025 Laboratory No.11111

APPENDIX C

Definitions of Geotechnical Engineering Terms

UNIFIED SOIL CLASSIFICATION SYSTEM (METRICATED)
DATA FOR DESCRIPTION IDENTIFICATION AND CLASSIFICATION OF SOILS

MAJOR DIVISIONS			GROUP SYMBOL	GRAPHIC SYMBOL	TYPICAL NAME	DESCRIPTIVE DATA
COARSE GRAINED SOILS	More than 50% by dry mass less than 60mm is greater than 0.06mm	GRAVELS	GW		Well graded gravels and gravel-sand mixtures, little or no fines.	Give typical name, indicate approximate percentages of sand and gravel, maximum size, angularity, surface condition and hardness of the coarse grains, local or geological name and other pertinent descriptive information; symbols in parenthesis. For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics. EXAMPLE: Silty Sand, gravelly, about 20% hard, angular gravel particles, 10mm maximum size, rounded and sub angular sand grains coarse to fine; about 15% non-plastic fines with low dry strength; well compacted and moist in place, light brown alluvial sand, (SM)
			GP		Poorly graded gravels and gravel-sand mixtures, little or no fines.	
		GRAVELLY SOILS	GM		Silty gravels, gravel-sand-silt mixtures.	
			GC		Clayey gravels gravel-sand-clay mixtures.	
		SANDS	SW		Well graded sands and gravelly sands, little or no fines.	
			SP		Poorly graded sands and gravelly sands, little or no fines.	
		SANDY SOILS	SM		Silty sand, sand-silt mixtures.	
		More than 50% of coarse grains are less than 2.0mm	SC		Clayey sands, sand-clay mixtures.	
FINE GRAINED SOILS	More than 50% by dry mass, less than 60mm is less than 0.06mm	Liquid Limit less than 50%	ML		Inorganic silts, very fine sands, rock flour, silty or clayey fine sands.	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains, colour in wet condition, odour if any, local or geological name and other pertinent descriptive information; symbols in parenthesis. For undisturbed soil add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions. EXAMPLE: Clayey Silt, brown; low plasticity, small percentage of fine sand, numerous vertical root-holes, firm and dry in place, fill, (ML)
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	
			OL		Organic silts and organic silty clays of low plasticity.	
		Liquid Limit more than 50%	MH		Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts.	
			CH		Inorganic clays of high plasticity, fat clays.	
			OH		Organic clays of medium to high plasticity.	
			Pt		Peat muck and other highly organic soils.	

FIELD IDENTIFICATION

Determine approximate percentages of material over 60mm in size, maximum size, shape, surface texture, hardness of material, geological description. Identify an estimated percentage mass of the various fractions.

COARSE GRAINED SOILS — More than half of the material less than 60 mm is larger than 0.06mm is about the smallest particle visible to the naked eye

GRAVELS AND SANDS

GRADATIONS		NATURE OF FINES	DRY STRENGTH	GROUP SYMBOL	% (2) < 0.06mm	PLASTICITY OF FINE FRACTION	$C_U = \frac{D_{60}}{D_{10}}$	$C_c = \frac{(D_{30})^2}{D_{60} D_{10}}$
GOOD	Wide range in grain size	"Clean" materials (not enough fines to bind coarse grains)	None	GW	0-5	-	>4	between 1 and 3
POOR	Predominantly one size or range of sizes			GP	0-5	-	Fails to comply with above	
GOOD to FAIR	"Dirty" materials (excess of fines)	Fines are non-plastic (1)	None to medium	GM	12-50	Below 'A' line or $I_p < 4$	-	-
		Fines are plastic (1)	Medium to high	GC	12-50	Above 'A' line and $I_p > 7$	-	-
GOOD	Wide range in grain size	"Clean" materials (not enough fines to bind coarse grains)	None	SW	0-5	-	>6	between 1 and 3
POOR	Predominately one size or range of sizes.			SP	0-5	-	Fails to comply with above	
GOOD to FAIR	"Dirty" materials (excess of fines)	Fines are non-plastic (1)	None to medium	SM	12-50	Below 'A' line or $I_p < 4$	-	-
		Fines are plastic (1)	Medium to high	SC	12-50	Above 'A' line and $I_p > 7$	-	-

Use the gradation curve of material passing 60 mm for classification of fractions according to the criteria given under 'Major Divisions'

SILT AND CLAY FRACTION
Fraction smaller than 0.20mm AS sieve size

DRY STRENGTH	DILATANCY	TOUGHNESS	GROUP SYMBOL	More than 50% passing 0.06mm
None to low	Quick to slow	None	ML	Below 'A' line
Medium to high	None to very slow	Medium	CL	Above 'A' line
Low to medium	Slow	Low	OL*	Below 'A' line
Low to medium	Slow to none	Low to medium	MH	Below 'A' line
High to very high	None	High	CH	Above 'A' line
Medium to high	None to very slow	Low to medium	OH*	Below 'A' line

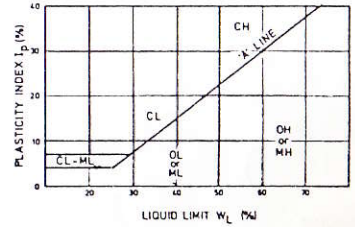
Readily identified by colour, odour, spongy feel and generally by fibrous texture — Pt*

* Effervesces with H_2O_2

LABORATORY CLASSIFICATION

NOTES

1. Identify fines by the method given for fine grained soils.
2. Borderline classifications occur when the percentage of fines (fraction smaller than 0.06mm size) is greater than 5% and less than 12%. Borderline classifications require the use of dual symbols e.g. SP-SM, GW-GC



PLASTICITY CHART
FOR CLASSIFICATION OF FINE GRAINED SOILS

FIELD IDENTIFICATION PROCEDURES FOR FINE GRAIN SOILS OR FRACTIONS

These proceedures are to be performed on the minus 0.6mm size particles. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests

Dilatancy (Reaction to Shaking)

After removing particles larger than 0.6mm size, prepare a pat of moist soil with a volume of about 10 cm^3. Add enough water if necessary to make the soil soft but not sticky.

Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens, and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assists in identifying the character of the fines in the soil.

Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Dry Strength (Crushing Characteristics)

After removing particles larger than 0.6mm size, mould a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun, or air drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic of clays in the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength but can be distinguished by feel when powdering the dry specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

Toughness (Consistency Near Plastic Limit)

After removing particles larger than 0.6 mm size, a specimen of soil, about 10 cm^3 in size, is moulded to the consistency of putty. If too dry, water must be add and, if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about 3mm diameter. The thread is then folded and re-rolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.

Highly organic clays have a very weak and spongy feel at the plastic limit.

Notes

1. *The above follows the original Unified Classification System (US BR Earth Manual) and ASTM Designation D2487-69 except that it adopts the particle size limits given in AS 1289 and other standards, viz*

Gravel	2 - 60mm
Sand	0.06 - 2mm
Silt and Clay	less than 0.06mm

The system excludes the boulder and cobble fractions of the soil and classifies only the material less than 60mm in size.

2. *As 60mm, 2mm and 0.06mm sieve sizes are not normally used, the percentages passing these sizes can be obtained from a particle size distribution curve determined from a laboratory test. Alternatively, the percentages passing maybe estimated in the field.*
3. *Australian Standard Code of Practice for Site Investigation, Appendix D, and ASTM Designation D2488-69, Tables I to V, contain standard terms and manual tests for describing and identifying soils.*

DESCRIPTION AND CLASSIFICATION OF SOILS

The methods of description and classification of soils used in this report are based on Australian Standard 1726 - 1981, the SAA Site Investigation Code. In general, descriptions cover the following properties - soil type, colour, secondary grain size, structure, inclusions, strength or density and geological description.

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (e.g. sandy clay) on the following basis:

Classification	Particle Size
Clay	less than 0.002mm
Silt	0.002 to 0.06mm
Sand	0.06 to 2.00mm
Gravel	2.00 to 60.00mm

Soils are also classified according to the Unified Soil Classifications System which is included in this Appendix.

Rock types are classified by their geological names.

Cohesive soils are classified on the basis of strength either by laboratory testing or engineering examination. The terms are defined as follows:

Classification	Shear Strength kPa
Very soft	less than 12
Soft	12 - 25
Firm	25 - 50
Stiff	50 - 100
Very stiff	100 - 200
Hard	Greater than 200

Non-cohesive soils are classified on the basis of relative density, generally from the results of insitu standard penetration tests as below:

Relative Density	"N" Value blows/300mm
Very loose	less than 5
Loose	5 - 10
Medium dense	10 - 30
Dense	30 - 50
Very dense	greater than 50

SAMPLING

Sampling is carried out during drilling 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 generally taken by one of two methods:

(i) driving or pushing a thinwalled sample tube into the soil and withdrawing with a sample of the soil in a relatively undisturbed state.

(ii) Core drilling using a retractable inner tube (R.I.T.) core barrel.

Such samples yield information on structure and strength in addition to that obtained from disturbed samples and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling are given in the report.

PENETRATION TESTING

The relative density of non-cohesive soils is generally assessed by insitu penetration tests, the most common of which is the standard penetration test. The test procedure is described in Australian Standard 1289 "Testing Soils for Engineering Purposes" - Test No. F3.1.

The standard penetration test is carried out by driving a 50mm diameter split tube penetrometer of standard dimensions under the impact of a 63 kg hammer having a free fall of 750mm.

The "N" value is determined as the number of blows to achieve 300mm of penetration (generally after disregarding the first 150mm penetration through possibly disturbed material). The results of these tests can be related empirically to the engineering properties of the soil.

The test is also used to provide useful information in cohesive soils under certain conditions, a good quality disturbed sample being recovered with each test.

Other forms of insitu testing are used under certain conditions and where this occurs, details are given in the report.

DEFINITIONS OF ROCK, SOIL, AND DEGREES OF CHEMICAL WEATHERING

(A) GENERAL DEFINITIONS — ROCK AND SOIL

ROCK In engineering usage, rock is a natural aggregate of minerals connected by strong and permanent cohesive forces.

Note: Since "strong" and "permanent" are subject to different interpretations, the boundary between rock and soil is necessarily an arbitrary one.

SOIL In engineering usage, soil is a natural aggregate of mineral grains which can be separated by such gentle mechanical means as agitation in water, can be remoulded and can be classified according to the Unified Soil Classification System. Three principal classes of soil recognised are:

(a) Residual soils: soils which have been formed insitu by the chemical weathering of parent rock. Residual soil may retain evidence of the original rock texture or fabric or, when mature, the original rock texture may be destroyed.

(b) Transported soils: soils which have been moved from their places of origin and deposited elsewhere. The principal agents of erosion, transport and deposition are water, wind and gravity. Two important types of transported soil in engineering geology and materials investigations are:

(i) Colluvium - a soil, often including angular rock fragments and boulders, which has been transported downslope predominantly under the action of gravity assisted by water. The principal forming process is that of soil creep in which the soil moves after it has been weakened by saturation. It may be water borne for short distances

(ii) Alluvium - a soil which has been transported and deposited by running water. The larger particles (sand and gravel size) are water worn.

(c) Lateritic soils: soils which have formed insitu under the effects of tropical weathering and include all reddish residual and non residual soils which genetically form a chain of material ranging from decomposed rock through clays to sesquioxide rich crusts. The term does not necessarily imply any compositional, textural or morphological definition; all distinctions useful for engineering purposes are based on the differences in geotechnical characteristics.

(B) ROCK WEATHERING DEFINITIONS

Extremely Weathered (EW)
Rock substance affected by weathering to the extent that the rock exhibits soil properties, i.e. it can be remoulded and can be classified according to the Unified Classification System, but the texture of the original rock is still evident.

Highly Weathered (HW)
Rock substance affected by weathering to the extent that limonite staining or bleaching affects the whole of the rock substance and other signs of chemical or physical decomposition are evident. Porosity and strength may be increased or decreased compared to the fresh rock usually as a result of iron leaching or deposition. The colour and strength of the original fresh rock substance is no longer recognisable.

Moderately Weathered (MW)
Rock substance affected by weathering to the extent that staining extends throughout the whole of the rock substance and the original colour of the fresh rock is no longer recognisable.

Slightly Weathered (SW)
Rock substance affected by weathering to the extent that partial staining or discolouration of the rock substance, usually by limonite, has taken place. The colour and texture of the fresh rock is recognisable.

Fresh (Fr)
Rock substance unaffected by weathering.

The degrees of rock weathering may be gradational. Intermediate stages are described by dual symbols with the prominent degree of weathering first (e.g. EW-HW).

The various degrees of weathering do not necessarily define strength parameters as some rocks are weak, even when fresh, to the extent that they can be broken by hand across the fabric, and some rocks may increase in strength during the weathering process.

Fresh drill cores of some rock types, such as basalt and shale may disintegrate after exposure to the atmosphere due to slaking, desiccation, expansion or contraction, stress relief or a combination of any of these factors.

AN ENGINEERING CLASSIFICATION OF SEDIMENTARY ROCKS

This classification system provides a standardized terminology for the engineering description of the sandstone and shales in the Sydney area, but the terms and definitions may be used elsewhere when applicable. Where other rock types are encountered, such as in dykes, standard geological descriptions are used for rock types and the same descriptions as below are used for strength, fracturing and weathering.

Under this system rocks are classified by Rock Type, Strength, Stratification Spacing, Degree of Fracturing and Degree of Weathering. These terms do not cover the full range of engineering properties. Descriptions of rock may also need to refer to other properties (e.g. durability, abrasiveness, etc) where these are relevant.

ROCK TYPE DEFINITIONS

ROCK TYPE	DEFINITION
Conglomerate:	More than 50% of the rock consists of gravel sized (greater than 2mm) fragments.
Sandstone:	More than 50% of the rock consists of sand sized (.06 to 2mm) grains.
Siltstone:	More than 50% of the rock consists of silt-sized (less than .06mm) granular particles and the rock is not laminated.
Claystone:	More than 50% of the rock consists of clay or sericitic material and the rock is not laminated.
Shale:	More than 50% of the rock consists of silt or clay sized particles and the rock is laminated.

Rocks possessing characteristics of two groups are described by their predominant particle size with reference also to the minor constituents, e.g. clayey sandstone, sandy shale.

STRATIFICATION SPACING

Term	Separation of Stratification Planes
Thinly laminated	< 6mm
Laminated	6mm to 20mm
Very thinly bedded	20mm to 60mm
Thinly bedded	60mm to 0.2m
Medium bedded	0.2m to 0.6m
Thickly bedded	0.6m to 2m
Very thickly bedded	> 2m

DEGREE OF FRACTURING

This classification applies to diamond drill cores and refers to the spacing of all types of natural fractures along which the core is discontinuous. These include bedding plane partings, joints and other rock defects, but exclude known artificial fractures such as drilling breaks.

Term	Description
Fragmented:	The core is comprised primarily of fragments of length less than 20mm, and mostly of width less than the core diameter.
Highly Fractured:	Core lengths are generally less than 20mm - 40mm with occasional fragments.
Fractured:	Core lengths are mainly 30mm - 100mm with occasional shorter and longer section.
Slightly Fractured:	Core lengths are generally 300mm - 1000mm with occasional longer sections and occasional sections of 100mm - 300mm.
Unbroken:	The core does not contain any fracture.

ROCK STRENGTH

Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance in the direction normal to the bedding. The test procedure is described by the International Society of Rock Mechanics.

Term	Is(50) MPa	Field Guide	Approx. qu MPa*
Extremely Weak:	0.03	Easily remoulded by hand to a material with soil properties.	0.7
Very Weak:	0.1	May be crumbled in the hand. Sandstone is "sugary" and friable.	2.4
Weak:	0.3	A piece of core 150mm long x 50mm dia. may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.	7
Medium Strong:	1	A piece of core 150mm long x 50mm dia. can be broken by hand with considerable difficulty. Readily scored with knife.	24
Strong:	3	A piece of core 150mm long x 50mm dia. core cannot be broken by unaided hands, can be slightly scratched or scored with knife.	70
Very Strong	10	A piece of core 150mm long x 50mm dia. may be broken readily with hand held hammer. Cannot be scratched with pen knife.	240
Extremely Strong:		A piece of core 150mm long x 50mm dia. is difficult to break with hand held hammer. Rings when struck with a hammer.	

The approximate unconfined compressive strength (qu) shown in the table is based on an assumed ratio to the point load index of 24:1. This ratio may vary widely.

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