REPORT

TO

SPEC (FOREST RD) PTY LTD

ON

GEOTECHNICAL INVESTIGATION

FOR

PROPOSED MEDICAL PRECINCT

AT

FOREST ROAD, ORANGE, NSW

8 October 2007

Ref: 21529SBrpt

Jeffery and Katauskas Pty Ltd

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REPORT EXPLANATION NOTES

1 INTRODUCTION

This report presents the results of a geotechnical investigation for the proposed medical precinct located on Forest Road, Orange, NSW. The investigations was commissioned by Mr Bill Lozevski of SPEC (Forest Rd) Pty Ltd by returned Acceptance of Proposal Form, Ref: P14521S. The investigation was commissioned in consultation with Mr Robert Facioni of Structural Design Solutions.

It is understood that it is proposed to redevelop the approximate 6 hectare site into a medical precinct, which will be occupied by the following:

- Private hospital in the eastern corner of the site comprising four buildings of two or three storeys.
- Retail/commercial area at the front of the site comprising three buildings of one or two storeys.
- Motel in the southern corner of the site comprising three buildings of two storeys.
- Hostel in the western corner of the site comprising three buildings of two storeys.
- Residential houses and townhouses in the northern corner of the site comprising 22 houses and 14 townhouses of two storeys.

The above buildings will be serviced by on grade roadways and parking areas, service yards and outdoor communal spaces. The exact levels of the proposed developments have not been determined at this stage, but given the gentle slope of the site we would expect only minor earthworks being required for site regrading to a maximum of about 1m to 2m.

The purpose of the investigation was to obtain geotechnical information on subsurface conditions as a basis for comments and recommendations on earthworks, retaining walls, footings and pavements.

A preliminary environmental site assessment was carried out by our specialist division, Environmental Investigation Services (EIS), in conjunction with this geotechnical investigation. Reference should be made to the separate report by EIS (Ref: E21529FK) for the results of the environmental site assessment.

2 INVESTIGATION PROCEDURE

Boreholes BH1 to BH14 were auger drilled using our truck mounted JK350 rig to depths ranging from 0.9m to 5.8m below the existing ground surface. The borehole locations, as shown on Figure 1, were set out by taped measurements from existing surface features and inferred site boundaries. The approximate surface levels of the boreholes, as shown on the borehole logs, were estimated by interpolation between spot levels and contours shown on the supplied survey plan by Carpenter Collins & Associates (Job No. 20470, Drawing No. 20470.DWG, dated 20/4/04), which forms the basis of Figure 1. The datum of the levels is Australian Height Datum (AHD).

The strength of the subsurface soils was assessed with reference to Standard Penetration Test (SPT) 'N' values, augmented by hand penetrometer readings on cohesive samples returned by the SPT split tube sampler. The strength of the underlying basalt was assessed by observation of the drilling resistance of a Tungsten Carbide (TC) bit attached to the augers, together with examination of the recovered rock chip samples.

Groundwater observations were made both during drilling and soon after completion of the boreholes. No long term monitoring of groundwater levels was carried out.

Our geotechnician, Mr Jeffrey Mail, set out the borehole locations, nominated the sampling and testing locations, and prepared logs of the strata encountered. A site visit was also made by our Senior Associate, Mr Daniel Bliss, at the start of the fieldwork. The borehole logs, which include field test results and groundwater observations, are attached to this report together with a set of explanatory notes, which describe the investigation techniques and their limitations and define the logging terms and symbols used.

Selected samples were tested by Soil Test Services Pty Ltd (STS), a NATA registered laboratory, to determine moisture contents, Atterberg limits, linear shrinkages, standard compaction, four day soaked CBR and Emerson class number. Tube (U_{50}) samples of the clays were taken within selected boreholes, but on extraction the samples were not suitable for shrink/swell (I_{ss}) testing and Atterberg limit and linear shrinkage tests were carried out on these samples. The results of the laboratory testing are summarised in Tables A, B and C. Samples were obtained from the boreholes for testing as part of the environmental assessment by EIS.

3 RESULTS OF INVESTIGATION

3.1 Site Description

The site is located within gently undulating to flat terrain and itself slopes down towards the north-west mostly at 1° to 2°, but with slightly steeper slopes at about 3° towards the rear of the site.

The site comprises a former drive-in theatre and was predominantly covered with a sprayed coat sealed pavement. However, the surface was in poor condition with many weeds growing through the seal. The remainder of the site was grass covered, together with very occasional trees. A filled mound was located along the south-western edge of the site with a height of up to about 1.2m. In the centre of the site was a single storey, concrete block, former amenities building. The building was in poor condition having been vacant for some time. About 30m to the rear of the building were two concrete tanks. The former drive-in screen was located about 30m from the front of the site and was also in poor condition. A single storey gatehouse building was located in the south-western corner of the site and was also in poor condition.

The site was bounded by Forest Road to the south-east and by vacant farm land on the remaining sides. Some single storey buildings were located to the south-western of the site but were located about 80m from the common boundary.

3.2 Subsurface Conditions

Reference to the Bathurst 1:250 000 Geological Series Sheet indicates that the site is located within an area mapped to be underlain by Tertiary Basalt. The boreholes confirmed this profile, encountering surface fill covering silty clay and clayey silt that graded into bedrock with the general appearance of basalt, though a petrographic analysis would be necessary to confirm the mineralogy. Further comments on the subsurface conditions encountered are provided below. Graphical summaries of the borehole information are presented as Figures 2 and 3. Reference should be made to the borehole logs for detailed descriptions of the subsurface conditions encountered.

Fill and Topsoil

Where the boreholes were drilled through the existing drive-in pavement, fill was encountered below the sprayed seal surface comprising a granite gravel of 0.15m thickness. Whilst clearly not affine crushed rock, the gravel had obviously been placed as a base course layer. Where the boreholes were drilled within the grassed areas, no fill was encountered, but a clayey silt topsoil layer was encountered in BH5 and BH14 of 0.3m thickness and roots were encountered within the remaining boreholes to depths of 0.2m.

Natural Soils

The natural soils predominantly comprised silty clay with some clayey silt and silty gravelly clay layers. The clays were assessed to be generally of medium plasticity, with some low plasticity and high plasticity clays encountered in some boreholes. The clays were generally of stiff to very stiff strength, with firm to stiff clays encountered in BH12. The clays contained varying proportions of igneous gravel.

Basalt

Basalt was encountered in BH1 to BH13 at depths ranging from 1.55m to 5.5m. The basalt was generally of high strength, with the TC bit only being able to penetrate the basalt for short depths before reaching practical refusal. In BH11 and BH12, extremely weathered basalt was encountered on first contact at depths of 1.55m and 3.1m, respectively, with high strength rock encountered at depths of 2.8m and 3.8m, respectively. In BH13, silty gravelly clay (basalt gravel) was encountered below a depth of 1.5m and this is assessed to comprise the extremely weathered profile of the basalt overlying high strength basalt at a depth of 5.2m.

Groundwater

Groundwater seepage was encountered during drilling of BH2, BH4, BH5, BH7, BH9, BH10 and BH12 at depths ranging from 2.9m to 3.5m. Groundwater was measured on completion of BH9 and BH13 at depths of 3m. Further groundwater readings were made 2 days after drilling of BH1 to BH6, BH9 and BH11 to BH13 and groundwater was measured at depths ranging from 1.3m to 2.8m.

3.3 Laboratory Test Results

Based on the Atterberg limit and linear shrinkage test results, the silty clays tested are mostly of low or medium plasticity and are assessed to have a low to moderate shrink/swell potential with changes in moisture content. However, one sample from

BH1 is of high plasticity and is assessed to have a moderate to high shrink/swell reactivity.

The four day soaked CBR tests on samples of the silty clay gave CBR values of 2% to 4%. The Emerson class numbers of the samples were 5 or 6, indicating that the clays are non-dispersive.

4 COMMENTS AND RECOMMENDATIONS

4.1 Earthworks

The exact details of the proposed earthworks have not been determined at this stage, but given the gently sloping nature of the site we would expected that only minor site regrading would be required with cut/fill of no more than about 1m to 2m.

At the start of the earthworks the topsoil and root affected soils should be fully stripped and stockpiled separately. This material would not be suitable for reuse as engineered fill, but may be used within landscaped areas where no structures or pavements are proposed. The existing granite gravel placed below the existing sprayed seal pavement surface may also be stripped and stockpiled separately for use as a granular fill for treatment of weak subgrade areas or as a working platform on the various building pads to be formed on site.

Excavations within the soils would be able to be achieved using conventional earthmoving equipment, such as the buckets of hydraulic excavators. Excavation of the basalt will represent 'hard rock' or 'heavy ripping' excavation conditions and would required rock breaking/ripping equipment for effective excavation, such as hydraulic rock hammers, ripping hooks, rotary grinders or rock saws. Given the high strength of the majority of the basalt encountered excavation is expected to be slow and we suggest that it would be more economically to limit excavation depths so that the basalt is not encountered. This should be achievable since basalt was only encountered at depths of less than 2m in BH3 and BH11. If possible, excavations should also be limited to above the encountered groundwater seepage levels to reduce difficulties that would be experienced where groundwater is encountered.

Where fill is to be placed and for building and pavement areas, subgrade preparation measures should include the following after stripping of root affected soils:

- Proof-roll the exposed subgrade with a minimum 7 tonne dead weight smooth drum vibratory roller. The final pass of the proof-rolling should be carried out without vibration and with the observation of a geotechnical engineer or experienced geotechnician. The purpose of the proof-rolling should be to improve the compaction of the near surface soils and to detect any weak or unstable areas.
- During proof-rolling care should be taken to avoid damage to nearby structures and buried services due to vibrations generated by the roller. If necessary, the vibrations should be reduced or ceased.
- Treat any unstable areas detected during proof rolling by excavation to a sound base and replacement with engineered fill or further advice should be sought.
- Place engineered fill to the required level in horizontal layers not greater than 200mm loose thickness (but of lesser thickness if light rollers are used).
- Any fill used to raise site levels or replace unstable areas must comprise engineered fill. Compaction of each fill layer should be done to the specifications provided below.

From the borehole results we expect that some unstable areas may occur where firm to stiff clays are present such as near BH12. The extent of the unstable areas may be kept low provided good site drainage is maintained and the earthworks are carried out during good weather. Should any soft areas be found then further advice and inspections will be required to assess the most suitable method of subgrade improvement. Allowance should be made for either, tyning, aerating and drying the subgrade, or removal and replacement with a select imported fill. If the clay is exposed to prolonged periods of rainfall, softening will result and site trafficability will be poor. If soil softening occurs, the subgrade should be over-excavated to below the depth of moisture softening and the excavated material replaced with engineered fill.

4.2 Engineered Fill and Compaction Control

Engineered fill should preferably comprise well graded granular materials free of deleterious substances and having a maximum particle size not exceeding 75mm. Such fill should be compacted in horizontal layers of not greater than 200mm loose thickness, to a density of at least 98% of Standard Maximum Dry Density (SMDD). For backfilling confined excavations such as service trenches, a similar compaction to engineered fill should be adhered to, but if light compaction equipment is used then the layer thickness should be limited to 100mm loose thickness.

The natural silty clays may be reused as engineered fill provided they are free of deleterious materials and particles greater than 75mm in size. Any excavated clayey silts should preferably not be reused as silts are highly moisture sensitive and can be difficult to compact if the moisture content is not closely controlled and maintained. Any clay fill should be compacted in maximum 200mm loose thickness layers to a density strictly between 98% and 102% of SMDD and at moisture contents within 2% of Standard Optimum Moisture Content (SOMC).

Density tests should be regularly carried out on the fill to confirm the above specifications are achieved. The frequency of density testing should be at least one test per layer per 500m^2 or three tests per visit, whichever requires the most tests. Where the fill is to support building loads it should be placed under Level 1 control in accordance with AS3798-2007. We can complete the abovementioned testing and supervision if required. Preferably the geotechnical testing authority should be engaged directly on behalf of the client and not by the earthworks subcontractor.

4.3 Batters and Retaining Walls

Temporary excavation batters within the silty clays which are less than 3m in height should be no steeper than 1 Vertical in 1 Horizontal (1V:1H). Such batters should remain stable in the short term provided all surcharge loads, including construction loads, are kept well clear of the crest of the batters. If batters of more than 3m are proposed site specific geotechnical advice should be obtained on suitable batter slopes.

Permanent excavation or fill batters should be no steeper than 1V:2H, but flatter batters of the order of 1V:3H may be preferred to allow access for maintenance of vegetation. Permanent batters should be covered with topsoil and planted with a deep rooted runner grass following construction to reduce erosion. All stormwater run-off should be directed away from all temporary and permanent slopes.

Cantilevered retaining walls, of less than 3m height, should be designed based on a conventional triangular earth pressure distribution using an active earth pressure coefficient, K_a, of 0.35 and a bulk unit weight of 20kN/m^3. Where walls are restrained from some lateral movements, such as by other structural elements in front of the walls, a higher earth pressure coefficient, K, of 0.5 should be used.

The above coefficients assume horizontal backfill surfaces and where inclined backfill is proposed the coefficients should be increased or the inclined backfill taken as a surcharge load. All surcharge loads should be allowed for in the design. Full hydrostatic pressures should be considered unless measures are undertaken to provide complete and permanent drainage of the ground behind the wall. Caution will be required not to overcompact and cause excessive lateral pressures on the retaining walls. Only small rollers should be used for fill compaction adjacent to any retaining wall.

4.4 Footings

For this site two options may be considered for the design of footings to support the proposed buildings and different footing systems may be adopted between separate buildings. The footing system for each building will depend on the building loads and the earthworks undertaken for each building pad.

The proposed buildings may be supported on shallow footings, such as stiffened raft slabs, founded within the natural silty clays and/or engineered fill, or piles founded within the underlying basalt. Where excavations are undertaken into or close to the basalt, the use of pad or strip footings may be more practical. Each building must be supported on similar foundation materials throughout, either all within engineered fill/natural clays or all within rock, to provide uniform support and reduce the risk of differential movements.

The borehole and laboratory test results indicate somewhat variable subsurface conditions, with the clays ranging from low plasticity to high plasticity and rock depths varying. As stated in Section 3.3, I_{ss} tests were unable to be completed on the U_{50} tube samples and classification must be based on Atterberg limits and linear shrinkage test results, which are less reliable for shrink/swell assessments than I_{ss} results. Therefore, we recommend that the design of shallow footings should be based on a conservative site classification of Class H in accordance with AS2870. This classification may be revised for individual building areas following site specific I_{ss} testing and taking into account the local subsurface profile for each building area.

Where fill is placed, the classification would depend on the reactivity of the fill used and its depth and should be assessed for each building area. However, we would expect a Class H classification for filled sites.

It must be recognised that the standard footing designs in AS2870 are applicable only to detached residential buildings of 'normal' size and proportions. All other footings should be based on engineered design.

Footings founded within the natural silty clays of at least stiff strength or engineered fill may be designed based on an allowable bearing pressure of 100kPa. The design of such footings should be carried out taking into account the reactivity of the site in accordance with AS2870. The performance expectations, site maintenance, vegetation precautions and additional architectural and construction requirements given in AS2870 for reactive sites should also be followed.

Alternatively, the proposed buildings may be supported on footings founded within the basalt. Where rock is exposed or is at shallow depths of less than 1m, pad or strip footings may be used. Where rock is at greater depths piers would be more appropriate. Bored piers may be used, but some difficulties may be experienced due to groundwater seepage and the use of pumps and/or tremie concreting techniques may be required. However, any seepage is expected to be low and if the piers are poured shortly following drilling groundwater is not expected to be a significant issue.

Footings founded within the basalt of at least low strength may be designed for an allowable end bearing pressure of 1000kPa. Even though a shaft adhesion of 100kPa would be appropriate within the rock, given the high strength of the rock large capacity drilling rigs would be required to socket into the rock and it may be more cost effective to adopt end bearing piles only, possibly at closer centres, to eliminate the need for time consuming rock drilling. Note that the rock surface is likely to be very irregular as the development of weathering often penetrates deeply along joints in the basalt, with 'corestones' of rock at much higher levels between.

Higher bearing pressures would be appropriate within the high strength basalt, but additional cored boreholes would be required in order penetrate further into the rock to allow assess of the rock strength and defects present. Due to the weathering pattern of the basalt it may be very difficult the define levels at which higher bearing pressures are appropriate.

The initial stages of footing excavation should be inspected by a geotechnical engineer to ascertain that the recommended foundation has been reached and to check initial assumptions about foundation conditions and possible variations that may occur between borehole locations. Variable weathering of the basalt should be expected with subsequent variations in pile founding depths. The need for further inspections can be assessed following the initial visit. We can assist with future geotechnical inspections if you wish to commission us at the appropriate time.
In accordance with Table 2.4(a) of AS1170.4-1993 a site factor (S) of 1.0 would be appropriate for this site together with an acceleration coefficient (a) of 0.08 from Figure 2.3(b), based on the subsurface conditions encountered and the site location.

4.5 Pavements

Based on the CBR testing carried out, we recommend that the proposed pavements be designed based on a design CBR of 2%, or an estimated modulus of subgrade reaction of 18kPa/mm (750mm plate). Some variation in CBR values was measured of between 2% and 4% and some adjustment of the design CBR values may be able to be made in specific areas of the site following additional CBR testing of the subgrade soils. However, the four CBR tests gave similar CBR values and only minor improvement to CBRs of 3% or 4% at best may be possible. Such additional testing could be targeted once the exact location and subgrade level of specific pavements are known. However, the existing low result of 2% may well represent the lowest ten percentile value which is normally taken as the basis for design.

Where fill is used to raise site levels, or replace unsuitable subgrade by the appropriate depth, pavements may be designed on the basis of the four day soaked CBR value of the imported material.

Due to the low CBR values measured, consideration could be given to some form of subgrade improvement as part of the overall pavement design. A select fill layer of good quality granular fill with a CBR of at least 10% could be used as part of the overall pavement thickness to reduce the required thickness of the pavement materials. Alternatively, the additional of lime could be used to strengthen the subgrade and increase the design CBR. The amount of lime required must be determined by laboratory testing, but we would expect that say 3% or 4% lime would result in a CBR in excess of 6%.

Subsoil drains should be provided along the perimeter of the pavements, with inverts not less than 0.2m below clay subgrade level. The drainage trench should be excavated with a longitudinal fall to appropriate discharge points so as to reduce the risk of water ponding. The pavement subgrade should be graded to promote water flow or infiltration towards the subsoil drains.

Concrete pavements should have a subbase layer of at least 100mm thickness of crushed rock to RTA QA specification 3051 (1994) unbound base material (or equivalent good quality and durable fine crushed rock), which is compacted to at least 100% of SMDD. Concrete pavements should be designed with an effective shear transmission at all joints by way of either doweled or keyed joints.

5 GENERAL COMMENTS

The recommendations presented in this report include specific issues to be addressed during the construction phase of the project. As an example, special treatment of soft spots may be required as a result of their discovery during proof-rolling, etc. In the event that any of the construction phase recommendations presented in this report are not implemented, the general recommendations may become inapplicable and Jeffery and Katauskas Pty Ltd accept no responsibility whatsoever for the performance of the structure where recommendations are not implemented in full and properly tested, inspected and documented.

The long-term successful performance of floor slabs and pavements is dependent on the satisfactory completion of the earthworks. In order to achieve this, the quality assurance program should not be limited to routine compaction density testing only. Other critical factors associated with the earthworks may include subgrade preparation, selection of fill materials, control of moisture content and drainage, etc. The satisfactory control and assessment of these items may require judgement from an experienced engineer. Such judgement often cannot be made by a technician who may not have formal engineering qualifications and experience. In order to identify potential problems, we recommend that a pre-construction meeting be held so that all parties involved understand the earthworks requirements and potential difficulties. This meeting should clearly define the lines of communication and responsibility.

Occasionally, the subsurface conditions between the completed boreholes may be found to be different (or may be interpreted to be different) from those expected. Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact this office.

This report provides advice on geotechnical aspects for the proposed civil and structural design. As part of the documentation stage of this project, Contract Documents and Specifications may be prepared based on our report. However, there may be design features we are not aware of or have not commented on for a variety of reasons. The designers should satisfy themselves that all the necessary advice has been obtained. If required, we could be commissioned to review the geotechnical aspects of contract documents to confirm the intent of our recommendations has been correctly implemented.

The offsite disposal of soil will most likely require classification in accordance with the Department of Environment & Conservation (NSW) guidelines as inert, solid, industrial or hazardous waste. We can complete the necessary classification and testing if you wish to commission us. As testing requires about seven days to complete, allowance should be made for such testing in the construction program unless testing is completed prior to construction. If contamination is found to be present then substantial further testing and delays should be expected. We strongly recommend this issue be addressed prior to commencement of excavation on site.

If there is any change in the proposed development described in this report then all recommendations should be reviewed.

This report has been prepared for the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. Copyright in this report is the property of Jeffery and Katauskas Pty Ltd. We have used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended. Subject to payment of all fees due for the investigation, the client alone shall have a licence to use this report. The report shall not be reproduced except in full.

Should you have any queries regarding this report, please do not hesitate to contact the undersigned.

For and on behalf of
JEFFERY AND KATAUSKAS PTY LTD.

Daniel Bliss
Senior Associate

Reviewed by:

for Paul Stubbs
Principal

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SOIL TEST SERVICES
ABN 43 002 145 173

Ref No:21529SB

TABLE A
SUMMARY OF LABORATORY TEST RESULTS

AS 1289	TEST METHOD	2.1.1	3.1.2	3.2.1	3.3.1	3.4.1
BOREHOLE NUMBER	DEPTH m	MOISTURE CONTENT %	LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %	LINEAR SHRINKAGE %
1	1.50-1.95	53.0	61	25	36	14.5
3	1.60-2.00	14.1				
4	1.95-2.35	23.0	40	18	22	10.0
5	4.80-5.20	12.5				
6	0.50-0.95	23.6	43	17	26	13.0
7	1.00-1.40	20.8	40	16	24	11.0
8	0.50-0.95	20.8	30	13	17	8.0
10	3.00-3.50	14.7				
12	1.50-1.90	22.2	32	15	17	6.5
13	5.40-5.80	12.6				

Notes:

- The test sample for liquid and plastic limit was oven-dried(50^{o}C) & dry-sieved
- The linear shrinkage mould was 125mm
- Refer to appropriate notes for soil descriptions

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SOIL TEST SERVICES
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TABLE B
SUMMARY OF FOUR DAY SOAKED C.B.R.TEST RESULTS

BOREHOLE NUMBER	3	6	9	14
DEPTH (m)	0.20 - 1.00	0.20 - 1.00	0.10 - 1.00	0.20 - 0.80
Surcharge (kg)	9.0	9.0	9.0	9.0
Maximum Dry Density (t/m^3)	1.68 STD	1.65 STD	1.70 STD	1.70 STD
Optimum Moisture Content (%)	20.6	21.0	18.8	18.6
Moulded Dry Density (t/m^3)	1.65	1.62	1.67	1.67
Sample Density Ratio (%)	98	98	98	98
Sample Moisture Ratio (%)	100	100	100	100
Moisture Contents				
Insitu (%)	22.6	25.0	22.1	23.0
Moulded (%)	20.6	21.0	18.8	18.6
After soaking and After Test, Top 30mm(%)	23.8	26.9	23.3	24.2
Remaining Depth (%)	22.3	24.5	22.7	23.3
Material Retained on 19mm Sieve (%)	0	0	0	0
Swell (%)	0.0	2.0	0.0	0.0
C.B.R. value: @5.0mm penetration	3.5	2.0	4	4

NOTES:

- Refer to appropriate Borehole logs for soil descriptions
- Test Methods :
  - (a) Soaked C.B.R. : AS 1289 6.1.1
  - (b) Standard Compaction : AS 1289 5.1.1
  - (c) Moisture Content : AS 1289 2.1.1

NATA
NATA Accredited Laboratory Number:1327

Approved Signatory/
Authorised Signature
(A.Tatikonda)

Date: 25/9/07

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SOIL TEST SERVICES
ABN 43 002 145 173

TABLE C
SUMMARY OF EMERSON CLASS NUMBER TEST RESULTS

BOREHOLE NUMBER	DEPTH (m)	Air dried soil crumbs in water	Remoulded soil samples in water	Contact with hydrochloric acid	1: 5 Soil/Water Suspension	Emerson Class Number
3	0.20-1.00	Slaking (No Dispersion)	No Dispersion	No Reaction	Flocculation	6
5	0.20-1.00	Slaking (No Dispersion)	No Dispersion	No Reaction	Flocculation	6
6	0.20-1.00	Slaking (No Dispersion)	No Dispersion	No Reaction	Dispersion	5
9	0.10-1.00	Slaking (No Dispersion)	No Dispersion	No Reaction	Flocculation	6
11	0.20-1.00	Slaking (No Dispersion)	No Dispersion	No Reaction	Dispersion	5
14	0.20-0.80	Slaking (No Dispersion)	No Dispersion	No Reaction	Flocculation	6

NOTES:
- The lowest Emerson Class Number refers to the highest dispersion potential(Range: Class 1 to Class 8)
- Test Method: AS 1289 3.8.1
- All contact water was distilled water: water temperature was between 22 & 23^{o}C
- Refer to appropriate Borehole logs for soil descriptions

Approved Signatory/
Authorised Signature
(A.Tatikonda)

Date: 25/9/07

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **1**

1/1

Client: SPEC (FOREST ROAD) PTY LTD

Project: PROPOSED MEDICAL PRECINCT

Location: FOREST ROAD, ORANGE, NSW

Job No. 21529SB

Date: 10-9-07

Method: SPIRAL AUGER JK350

R.L. Surface: ≈ 909.8m

Datum: AHD

Logged/Checked by: J.M./

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION			0			FILL: Gravel, medium to coarse grained, brown and grey, granite.	D			SPRAYED SEAL SURFACE
					CH	SILTY CLAY: high plasticity, brown and red brown.	MC>PL	St -VSt	-	
		N = 13 4,6,7							200	
			1			SILTY CLAY: high plasticity, brown, red brown and light brown, with igneous gravel.				
AFTER 48 HRS		N = 12 3,5,7								
			2							
		SPT 11/100mm REFUSAL	3		-	BASALT: light grey and grey.	DW	H	-	HIGH 'TC' BIT RESISTANCE
			4			END OF BOREHOLE AT 3.96m				PRACTICAL 'TC' BIT REFUSAL
			5							
			6							
			7							

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Borehole No. **2**

1/1

BOREHOLE LOG

Client: SPEC (FOREST ROAD) PTY LTD

Project: PROPOSED MEDICAL PRECINCT

Location: FOREST ROAD, ORANGE, NSW

Job No. 21529SB

Date: 11-9-07

Method: SPIRAL AUGER JK350

Logged/Checked by: J.M./[signature]

R.L. Surface: ≈ 910.6m

Datum: AHD

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
		0		FILL: Gravel, medium to coarse grained, brown and grey, granite.	D			SPRAYED SEAL SURFACE
	N = 7 5,2,5		CL-CH	SILTY CLAY: medium to high plasticity, brown and red brown.	MC>PL	St	- 100 130 150	
	N = 9 1,2,7	1	CL	SILTY CLAY: medium plasticity, grey brown and red brown, with igneous gravel.		VSt	200	
AFTER 48 HRS		2						
	N = 12 2,5,7	3						
	N = 17 10,7,10	4	ML	CLAYEY SILT: medium plasticity, brown and grey, with igneous gravel.	MC>PL	St	100	
		5	-	BASALT: grey, dark grey and red brown.	DW	H	-	HIGH 'TC' BIT RESISTANCE
				END OF BOREHOLE AT 5.6m				PRACTICAL 'TC' BIT REFUSAL
		6						
		7						

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BOREHOLE LOG

Borehole No. **3**
1/1

Client: SPEC (FOREST ROAD) PTY LTD
Project: PROPOSED MEDICAL PRECINCT
Location: FOREST ROAD, ORANGE, NSW

Job No. 21529SB
Date: 10-9-07
Method: SPIRAL AUGER JK350
R.L. Surface: ≈ 910.1m
Datum: AHD
Logged/Checked by: J.M./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION			0			FILL: Gravel, medium to coarse grained, brown, granite.	D			SPRAYED SEAL SURFACE
		N = 8 4,4,4			CL	SILTY CLAY: medium plasticity, dark brown, with igneous gravel.	MC>PL	St	- 150 170	
			1		ML	CLAYEY SILT: low plasticity, grey brown, with gravel.				
AFTER 48 HRS		SPT 8/100mm REFUSAL			-	BASALT: grey and dark grey.	DW	H	-	HIGH 'TC' BIT RESISTANCE
			2			END OF BOREHOLE AT 2.0m				PRACTICAL 'TC' BIT REFUSAL
			3							
			4							
			5							
			6							
			7							

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BOREHOLE LOG

Borehole No. **4**
1/1

Client: SPEC (FOREST ROAD) PTY LTD
Project: PROPOSED MEDICAL PRECINCT
Location: FOREST ROAD, ORANGE, NSW

Job No. 21529SB
Date: 11-9-07
Method: SPIRAL AUGER JK350
Logged/Checked by: J.M./
R.L. Surface: ≈ 910.9m
Datum: AHD

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0		FILL: Gravel, medium to coarse grained, brown, granite gravel.	D			SPRAYED SEAL SURFACE
	ES			CL	SILTY CLAY: medium plasticity, dark brown and red brown.	MC>PL	St	-	
	ES, DS	N = 21 3,5,16						150 170 190	
			1						
	DS	N = 11 2,5,6			SILTY CLAY: medium plasticity, grey, dark brown and red brown, with igneous gravel.	MC>PL	VSt		
AFTER 48 HRS	U50		2						
▶ (on completion)	DS	N = 11 2,5,6	3					200	
			4						
	DS	N = 19 4,7,12	5						
				-	BASALT: grey and dark grey.	DW	H	-	HIGH 'TC' BIT RESISTANCE
					END OF BOREHOLE AT 5.8m				PRACTICAL 'TC' BIT REFUSAL
			6						
			7						

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. **5**
1/1

BOREHOLE LOG

Client: SPEC (FOREST ROAD) PTY LTD
Project: PROPOSED MEDICAL PRECINCT
Location: FOREST ROAD, ORANGE, NSW

Job No. 21529SB
Date: 11-9-07
Method: SPIRAL AUGER JK350
R.L. Surface: ≈ 911.0m
Datum: AHD
Logged/Checked by: J.M./[signature]

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0		CL	CLAYEY SILT/SILTY CLAY: medium plasticity, red brown, with roots and gravel.	MC>PL			GRASS COVER
		N = 10 5,5,5			CL	SILTY CLAY: medium plasticity, red brown.	MC>PL	VSt	- 200 230 250	
			1							
		N = 11 3,5,6								
			2							
AFTER 48 HRS										
		N = 12 4,6,6	3							
			4							
					-	BASALT: grey and dark grey.	DW	H	-	MODERATE TO HIGH 'TC' BIT RESISTANCE
			5							
						END OF BOREHOLE AT 5.2m				PRACTICAL 'TC' BIT REFUSAL
			6							
			7							

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **6**
1/1

Client: SPEC (FOREST ROAD) PTY LTD
Project: PROPOSED MEDICAL PRECINCT
Location: FOREST ROAD, ORANGE, NSW

Job No. 21529SB
Date: 11-9-07
Method: SPIRAL AUGER JK350
R.L. Surface: ≈ 910.0m
Datum: AHD
Logged/Checked by: J.M./[signature]

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0			FILL: Gravel, medium to coarse grained, brown, granite.	D			SPRAYED SEAL SURFACE
		N = 9 4,5,4			CL	SILTY CLAY: medium plasticity, red brown.	MC>PL	VSt	- 200 150	
		N = 12 4,6,6	1		CL/ML	SILTY CLAY/CLAYEY SILT: medium plasticity, dark brown.		St	150 130	
▼ AFTER 48 HRS			2		-	BASALT: brown and grey.	DW	H	-	HIGH 'TC' BIT RESISTANCE
						END OF BOREHOLE AT 2.40m				PRACTICAL 'TC' BIT REFUSAL
			3							
			4							
			5							
			6							
			7							

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Borehole No. **7**

1/1

BOREHOLE LOG

Client: SPEC (FOREST ROAD) PTY LTD

Project: PROPOSED MEDICAL PRECINCT

Location: FOREST ROAD, ORANGE, NSW

Job No. 21529SB

Date: 11-9-07

Method: SPIRAL AUGER JK350

Logged/Checked by: J.M./[signature]

R.L. Surface: ≈ 912.3m

Datum: AHD

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0			FILL: Gravel, medium to coarse grained, brown, granite.	D			SPRAYED SEAL SURFACE
		N = 11 4,6,5			CL	SILTY CLAY: medium plasticity, brown and red brown, with igneous gravel.	MC<PL	St	- 130 150 170	
		N = 13 5,4,9	1–2					VSt	200	
▶ (approx. 3.0m)		N = 15 3,4,11	3							
					-	BASALT: light grey, grey and brown.	DW	VL-L M-H	-	
						END OF BOREHOLE AT 3.6m				PRACTICAL 'TC' BIT REFUSAL
			4							
			5							
			6							
			7							

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. **8**
1/1

BOREHOLE LOG

Client: SPEC (FOREST ROAD) PTY LTD
Project: PROPOSED MEDICAL PRECINCT
Location: FOREST ROAD, ORANGE, NSW

Job No. 21529SB
Date: 11-9-07
Method: SPIRAL AUGER JK350
R.L. Surface: ≈ 912.2m
Datum: AHD
Logged/Checked by: J.M./

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLET -ION			0		CH	SILTY CLAY: high plasticity, dark brown, with roots.	MC>PL	St		GRASS COVER
	ES				CL	SILTY CLAY: low plasticity, brown and red brown.				
	ES, DS	N = 8 4,4,4							170 180 100	
			1							
	DS	N = 14 3,5,9								
			2							
			3							
	DS	N = 22 2,8,14				SILTY CLAY: medium plasticity, light grey, grey and brown, with basalt bands.	MC<PL	H	350 400	
			4							
AFTER 48 HRS	DS				-	BASALT: grey and dark grey.	DW	H	-	HIGH 'TC' BIT RESISTANCE
						END OF BOREHOLE AT 4.5m				PRACTICAL 'TC' BIT REFUSAL
			5							
			6							
			7							

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Borehole No. **9**
1/1

BOREHOLE LOG

Client: SPEC (FOREST ROAD) PTY LTD
Project: PROPOSED MEDICAL PRECINCT
Location: FOREST ROAD, ORANGE, NSW

Job No. 21529SB
Date: 11-9-07
Method: SPIRAL AUGER JK350
R.L. Surface: ≈ 911.7m
Datum: AHD
Logged/Checked by: J.M./[illegible]

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
		0		FILL: Gravel, medium to coarse grained, brown, granite.	D			SPRAYED SEAL SURFACE
			CL	SILTY CLAY: medium plasticity, red brown and grey brown, with igneous gravel.	MC>PL	St	-	
	N = 9 5,4,5						100 150	
		1						
	N = 20 6,9,11					VSt	280 250	
		2						
AFTER 48 HRS								
ON COMPLETION	N = 9 2,3,6	3					200 220	
		4						
	N = 20 2,3,17							
			-	BASALT: dark grey and brown.	DW	H	-	HIGH 'TC' BIT RESISTANCE
		5		END OF BOREHOLE AT 5.1m				PRACTICAL 'TC' BIT REFUSAL
		6						
		7						

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BOREHOLE LOG

Borehole No. **10**
1/1

Client: SPEC (FOREST ROAD) PTY LTD
Project: PROPOSED MEDICAL PRECINCT
Location: FOREST ROAD, ORANGE, NSW

Job No. 21529SB
Date: 11-9-07
Method: SPIRAL AUGER JK350
Logged/Checked by: J.M./
R.L. Surface: ≈ 911.4m
Datum: AHD

Groundwater Record	Samples (ES / U50 / DB / DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0		CL	SILTY CLAY: medium plasticity, red brown and brown.	MC>PL	(St-VSt)		GRASS COVER
		N = 8 4,4,4								
			1							
		N = 27 8,15,17								
			2							
AFTER 48 HRS										
			3		-	BASALT: dark grey, grey and brown.	DW	H	-	HIGH 'TC' BIT RESISTANCE
						END OF BOREHOLE AT 3.5m				PRACTICAL 'TC' BIT REFUSAL
			4							
			5							
			6							
			7							

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BOREHOLE LOG

Borehole No. **11**
1/1

Client: SPEC (FOREST ROAD) PTY LTD
Project: PROPOSED MEDICAL PRECINCT
Location: FOREST ROAD, ORANGE, NSW

Job No. 21529SB
Date: 11-9-07
Method: SPIRAL AUGER JK350
Logged/Checked by: J.M./[illegible]
R.L. Surface: ≈ 911.3m
Datum: AHD

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION	N = 9 4,4,5	0	CL	SILTY CLAY: medium plasticity, red brown and brown, with igneous gravel and root fibres.	MC>PL	VSt	200 250	GRASS COVER ROOTS TO 0.2m
AFTER 48 HRS	N > 21 6,21/ 100mm	1.5	-	BASALT: brown, dark brown and dark grey.	XW	EL	-	
		2.8		BASALT: dark grey.	DW	H		HIGH 'TC' BIT RESISTANCE
		3.1		END OF BOREHOLE AT 3.1m				PRACTICAL 'TC' BIT REFUSAL

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BOREHOLE LOG

Borehole No. **12**
1/1

Client: SPEC (FOREST ROAD) PTY LTD
Project: PROPOSED MEDICAL PRECINCT
Location: FOREST ROAD, ORANGE, NSW

Job No. 21529SB
Date: 11-9-07
Method: SPIRAL AUGER JK350
Logged/Checked by: J.M./JW
R.L. Surface: ≈ 910.3m
Datum: AHD

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
		0	CL	SILTY CLAY: low plasticity, red brown and brown, with igneous gravel.	MC>PL	F-St		GRASS COVER ROOTS TO 0.2m
	N = 5 1,2,3						70 80 100	
AFTER 48 HRS		1 – 2						
	N = 5 2,2,3	3	-	BASALT: red brown, grey, brown and dark grey.	XW	EL	-	
		4		BASALT: dark grey.	DW	H		HIGH 'TC' BIT RESISTANCE
				END OF BOREHOLE AT 4.1m				PRACTICAL 'TC' BIT REFUSAL
		5						
		6						
		7						

SAMPLES: ES, U50, DB, DS

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BOREHOLE LOG

Borehole No. **13** 1/1

Client: SPEC (FOREST ROAD) PTY LTD
Project: PROPOSED MEDICAL PRECINCT
Location: FOREST ROAD, ORANGE, NSW

Job No. 21529SB
Date: 11-9-07
Method: SPIRAL AUGER JK350
R.L. Surface: ≈ 909.5m
Datum: AHD
Logged/Checked by: J.M./[signature]

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0		CL	SILTY CLAY: medium plasticity, dark brown and red brown, with a trace of igneous gravel.	MC>PL	(St)		GRASS COVER
		N = 3 1,1,2	1							
AFTER 48 HRS		N = 19 3,6,13			CL	SILTY GRAVELLY CLAY: low plasticity, dark grey, brown, grey and red brown, basalt gravel.	MC<PL	(VSt - H)		
ON COMPLETION		N = 10 3,4,6	2 3 4 5							
					-	BASALT: dark grey and grey.	DW	H	-	HIGH 'TC' BIT RESISTANCE
			6 7			END OF BOREHOLE AT 5.8m				PRACTICAL 'TC' BIT REFUSAL

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BOREHOLE LOG

Borehole No. **14**

1/1

Client: SPEC (FOREST ROAD) PTY LTD

Project: PROPOSED MEDICAL PRECINCT

Location: FOREST ROAD, ORANGE, NSW

Job No. 21529SB

Date: 13-9-07

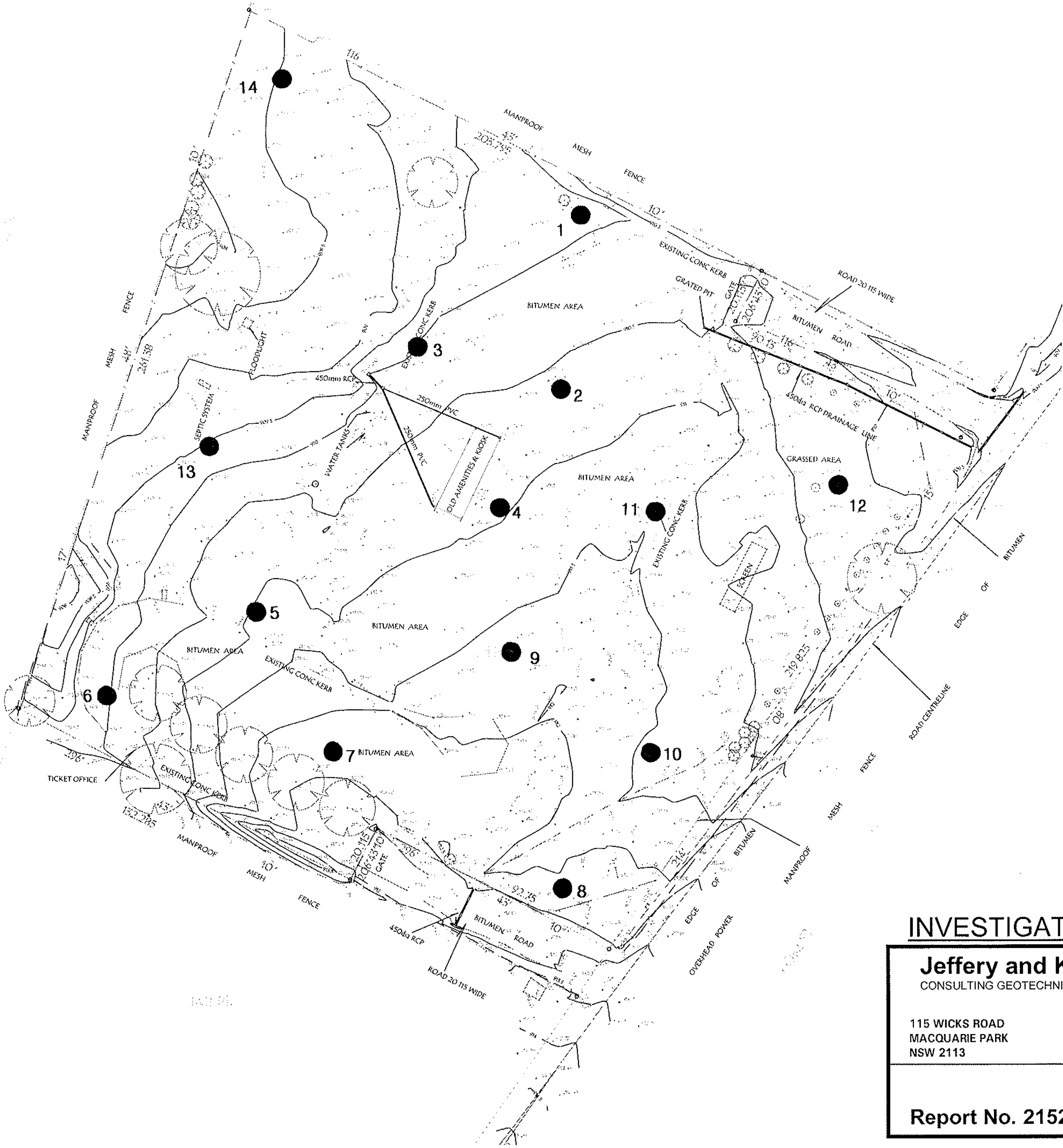
Method: SPIRAL AUGER JK350

R.L. Surface: ≈ 908.5m

Datum: AHD

Logged/Checked by: J.M./[illegible]

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION			■			0		ML	CLAYEY SILT: medium plasticity, red brown, brown, with igneous gravel.	MC≈PL			GRASS COVER
								CL	SILTY CLAY: medium plasticity, red brown.	MC<PL	(St-VSt		
						1			END OF BOREHOLE AT 0.90m				
						2							
						3							
						4							
						5							
						6							
						7							



SCALE (m)

0 75

INVESTIGATION LOCATION PLAN

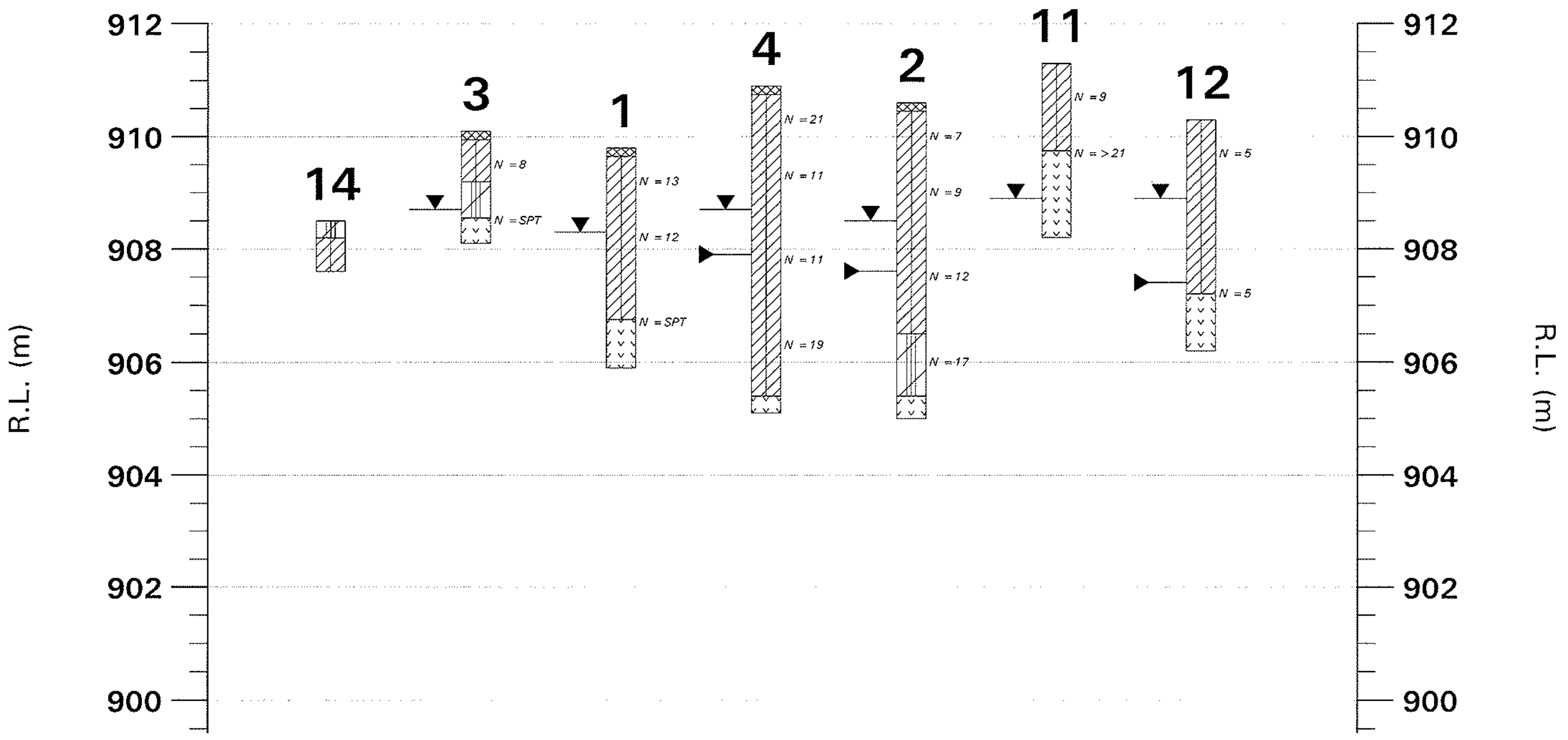
Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL & ENVIRONMENTAL ENGINEERS

115 WICKS ROAD
MACQUARIE PARK
NSW 2113

Tel: 02-9888 5000
Fax: 02-9888 5001

Report No. 21529SB **Figure No. 1**

GRAPHICAL BOREHOLE SUMMARY



Clayey Silt	Basalt, Andesite	N	SPT "N" VALUE		
Silty Clay	Observed water level	Nc	SOLID CONE BLOW COUNTS PER 150mm		
Fill	Groundwater seepage level				

NOTE: REFER TO BOREHOLE LOGS

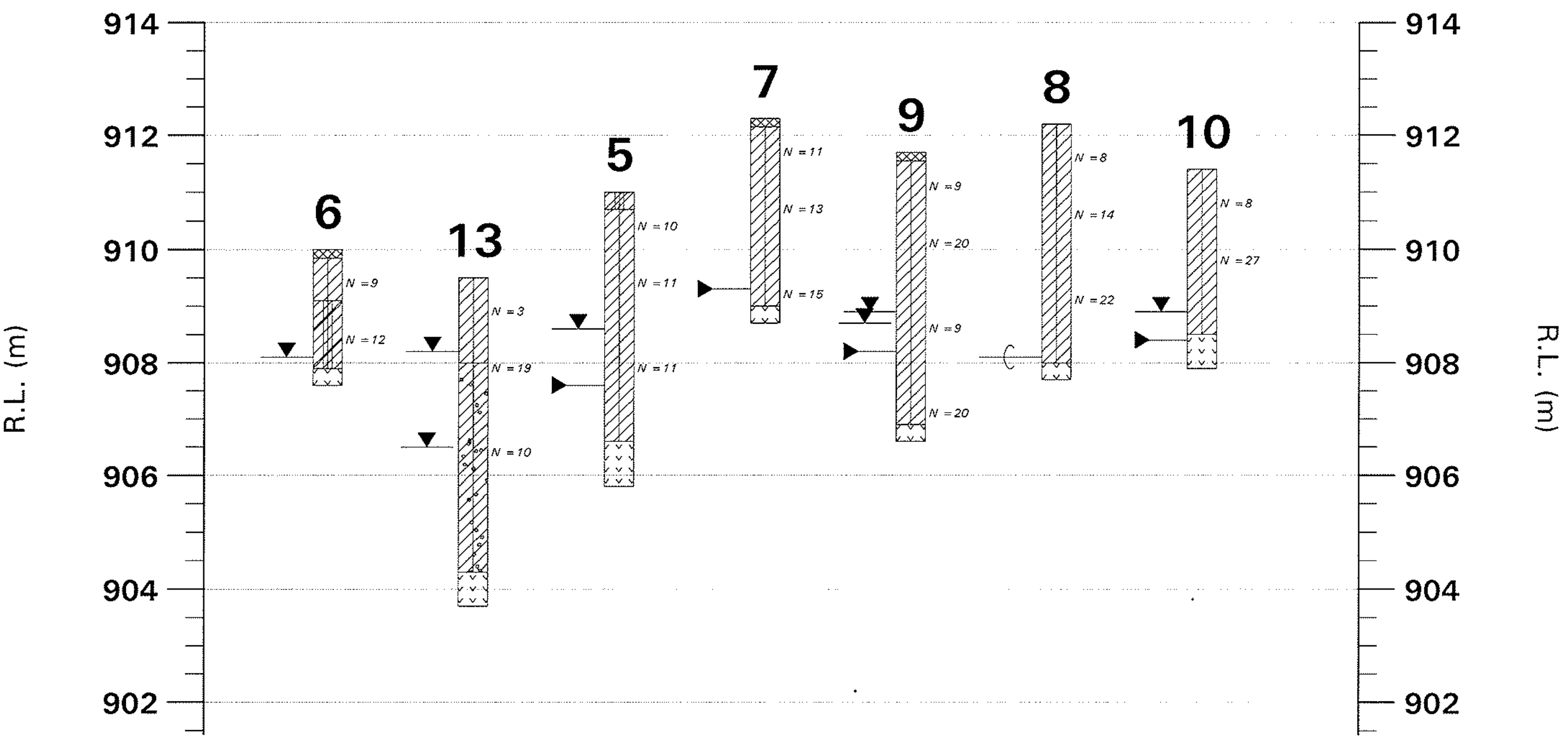
Scale: 1 : 100 (vert) ; NTS (horiz)

Jeffery and Katauskas Pty Ltd

Job No.: 21529SB

Figure No.: 2

GRAPHICAL BOREHOLE SUMMARY



Fill

Basalt, Andesite

Groundwater seepage level

Nc SOLID CONE BLOW COUNTS PER 150mm

Silty Clay

Silty Gravelly Clay

Borehole Collapse Depth

Clayey Silt/ Silty Clay

Observed water level

N SPT "N" VALUE

NOTE: REFER TO BOREHOLE LOGS

Scale: 1 : 100 (vert) ; NTS (horiz)

Jeffery and Katauskas Pty Ltd

Job No.: 21529SB

Figure No.: 3

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ABN 17 003 550 801

REPORT EXPLANATION NOTES

INTRODUCTION

These notes have been provided to amplify the geotechnical report in regard to classification methods, field procedures and certain matters relating to the Comments and Recommendations section. Not all notes are necessarily relevant to all reports.

The ground is a product of continuing natural and man-made processes and therefore exhibits a variety of characteristics and properties which vary from place to place and can change with time. Geotechnical engineering involves gathering and assimilating limited facts about these characteristics and properties in order to understand or predict the behaviour of the ground on a particular site under certain conditions. This report may contain such facts obtained by inspection, excavation, probing, sampling, testing or other means of investigation. If so, they are directly relevant only to the ground at the place where and time when the investigation was carried out.

DESCRIPTION AND CLASSIFICATION METHODS

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726, the SAA Site Investigation Code. In general, descriptions cover the following properties – soil or rock type, colour, structure, strength or density, and inclusions. Identification and classification of soil and rock involves judgement and the Company infers accuracy only to the extent that is common in current geotechnical practice.

Soil types are described according to the predominating particle size and behaviour as set out in the attached Unified Soil Classification Table qualified by the grading of other particles present (eg sandy clay) as set out below:

Soil Classification	Particle Size
Clay	less than 0.002mm
Silt	0.002 to 0.06mm
Sand	0.06 to 2mm
Gravel	2 to 60mm

Non-cohesive soils are classified on the basis of relative density, generally from the results of Standard Penetration Test (SPT) as below:

Relative Density	SPT 'N' Value (blows/300mm)
Very loose	less than 4
Loose	4 – 10
Medium dense	10 – 30
Dense	30 – 50
Very Dense	greater than 50

Cohesive soils are classified on the basis of strength (consistency) either by use of hand penetrometer, laboratory testing or engineering examination. The strength terms are defined as follows.

Classification	Unconfined Compressive Strength kPa
Very Soft	less than 25
Soft	25 – 50
Firm	50 – 100
Stiff	100 – 200
Very Stiff	200 – 400
Hard	Greater than 400
Friable	Strength not attainable – soil crumbles

Rock types are classified by their geological names, together with descriptive terms regarding weathering, strength, defects, etc. Where relevant, further information regarding rock classification is given in the text of the report. In the Sydney Basin, "Shale" is used to describe thinly bedded to laminated siltstone.

SAMPLING

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

Disturbed samples taken during drilling provide information on plasticity, grain size, colour, moisture content, minor constituents and, depending upon the degree of disturbance, some information on strength and structure. Bulk samples are similar but of greater volume required for some test procedures.

Undisturbed samples are taken by pushing a thin-walled sample tube, usually 50mm diameter (known as a U50), into the soil and withdrawing it with a sample of the soil contained in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling used are given on the attached logs.

INVESTIGATION METHODS

The following is a brief summary of investigation methods currently adopted by the Company and some comments on their use and application. All except test pits, hand auger drilling and portable dynamic cone penetrometers require the use of a mechanical drilling rig which is commonly mounted on a truck chassis.

Test Pits: These are normally excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils if it is safe to descend into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for an excavator. Limitations of test pits are the problems associated with disturbance and difficulty of reinstatement and the consequent effects on close-by structures. Care must be taken if construction is to be carried out near test pit locations to either properly recompact the backfill during construction or to design and construct the structure so as not to be adversely affected by poorly compacted backfill at the test pit location.

Hand Auger Drilling: A borehole of 50mm to 100mm diameter is advanced by manually operated equipment. Premature refusal of the hand augers can occur on a variety of materials such as hard clay, gravel or ironstone, and does not necessarily indicate rock level.

Continuous Spiral Flight Augers: The borehole is advanced using 75mm to 115mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling and insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface by the flights or may be collected after withdrawal of the auger flights, but they can be very disturbed and layers may become mixed. Information from the auger sampling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability due to mixing or softening of samples by groundwater, or uncertainties as to the original depth of the samples. Augering below the groundwater table is of even lesser reliability than augering above the water table. Use can be made of a Tungsten Carbide (TC) bit for auger drilling into rock to indicate rock quality and continuity by variation in drilling resistance and from examination of recovered rock fragments.

Wash Boring: The borehole is usually advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from "feel" and rate of penetration.

Mud Stabilised Drilling: Either Wash Boring or Continuous Core Drilling can use drilling mud as a circulating fluid to stabilise the borehole. The term "mud" encompasses a range of products ranging from bentonite to polymers such as Revert or Biogel. The mud tends to mask the cuttings and reliable identification is only possible from intermittent intact sampling (eg from SPT and U50 samples) or from rock coring, etc.

Continuous Core Drilling: A continuous core sample is obtained using a diamond tipped core barrel. Provided full core recovery is achieved (which is not always possible in very low strength rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation. In rocks, an NMLC triple tube core barrel, which gives a core of about 50mm diameter, is usually used with water flush. The length of core recovered is compared to the length drilled and any length not recovered is shown as CORE LOSS. The location of losses are determined on site by the supervising engineer; where the location is uncertain, the loss is placed at the top end of the drill run.

Standard Penetration Tests: Standard Penetration Tests (SPT) are used mainly in non-cohesive soils, but can also be used in cohesive soils as a means of indicating density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" – Test F3.1.

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

The test results are reported in the following form:

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

  N = 13

  4, 6, 7

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

  N>30

  15, 30/40mm

The results of the test can be related empirically to the engineering properties of the soil.

Occasionally, the drop hammer is used to drive 50mm diameter thin walled sample tubes (U50) in clays. In such circumstances, the test results are shown on the borehole logs in brackets.

A modification to the SPT test is where the same driving system is used with a solid 60° tipped steel cone of the same diameter as the SPT hollow sampler. The solid cone can be continuously driven for some distance in soft clays or loose sands, or may be used where damage would otherwise occur to the SPT. The results of this Solid Cone Penetration Test (SCPT) are shown as "N_c" on the borehole logs, together with the number of blows per 150mm penetration.

Static Cone Penetrometer Testing and Interpretation: Cone penetrometer testing (sometimes referred to as a Dutch Cone) described in this report has been carried out using an Electronic Friction Cone Penetrometer (EFCP). The test is described in Australian Standard 1289, Test F5.1.

In the tests, a 35mm diameter rod with a conical tip is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the frictional resistance on a separate 134mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are electrically connected by wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) the information is output as incremental digital records every 10mm. The results given in this report have been plotted from the digital data.

The information provided on the charts comprise:

- Cone resistance – the actual end bearing force divided by the cross sectional area of the cone – expressed in MPa.
- Sleeve friction – the frictional force on the sleeve divided by the surface area – expressed in kPa.
- Friction ratio – the ratio of sleeve friction to cone resistance, expressed as a percentage.

The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1% to 2% are commonly encountered in sands and occasionally very soft clays, rising to 4% to 10% in stiff clays and peats. Soil descriptions based on cone resistance and friction ratios are only inferred and must not be considered as exact.

Correlations between EFCP and SPT values can be developed for both sands and clays but may be site specific.

Interpretation of EFCP values can be made to empirically derive modulus or compressibility values to allow calculation of foundation settlements.

Stratification can be inferred from the cone and friction traces and from experience and information from nearby boreholes etc. Where shown, this information is presented for general guidance, but must be regarded as interpretive. The test method provides a continuous profile of engineering properties but, where precise information on soil classification is required, direct drilling and sampling may be preferable.

Portable Dynamic Cone Penetrometers: Portable Dynamic Cone Penetrometer (DCP) tests are carried out by driving a rod into the ground with a sliding hammer and counting the blows for successive 100mm increments of penetration.

Two relatively similar tests are used:

- Cone penetrometer (commonly known as the Scala Penetrometer) – a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS1289, Test F3.2). The test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various Road Authorities.
- Perth sand penetrometer – a 16mm diameter flat ended rod is driven with a 9kg hammer, dropping 600mm (AS1289, Test F3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.

LOGS

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

The attached explanatory notes define the terms and symbols used in preparation of the logs.

Interpretation of the information shown on the logs, and its application to design and construction, should therefore take into account the spacing of boreholes or test pits, the method of drilling or excavation, the frequency of sampling and testing and the possibility of other than "straight line" variations between the boreholes or test pits. Subsurface conditions between boreholes or test pits may vary significantly from conditions encountered at the borehole or test pit locations.

GROUNDWATER

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

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

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

FILL

The presence of fill materials can often be determined only by the inclusion of foreign objects (eg bricks, steel etc) or by distinctly unusual colour, texture or fabric. Identification of the extent of fill materials will also depend on investigation methods and frequency. Where natural soils similar to those at the site are used for fill, it may be difficult with limited testing and sampling to reliably determine the extent of the fill.

The presence of fill materials is usually regarded with caution as the possible variation in density, strength and material type is much greater than with natural soil deposits. Consequently, there is an increased risk of adverse engineering characteristics or behaviour. If the volume and quality of fill is of importance to a project, then frequent test pit excavations are preferable to boreholes.

LABORATORY TESTING

Laboratory testing is normally carried out in accordance with Australian Standard 1289 "Methods of Testing Soil for Engineering Purposes". Details of the test procedure used are given on the individual report forms.

ENGINEERING REPORTS

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg a three storey building) the information and interpretation may not be relevant if the design proposal is changed (eg to a twenty storey building). If this happens, the company will be pleased to review the report and the sufficiency of the investigation work.

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

- Unexpected variations in ground conditions – the potential for this will be partially dependent on borehole spacing and sampling frequency as well as investigation technique.
- Changes in policy or interpretation of policy by statutory authorities.
- The actions of persons or contractors responding to commercial pressures.

If these occur, the company will be pleased to assist with investigation or advice to resolve any problems occurring.

SITE ANOMALIES

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

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Tender Documents", published by the Institution of Engineers, Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Copyright in all documents (such as drawings, borehole or test pit logs, reports and specifications) provided by the Company shall remain the property of Jeffery and Katauskas Pty Ltd. Subject to the payment of all fees due, the Client alone shall have a licence to use the documents provided for the sole purpose of completing the project to which they relate. License to use the documents may be revoked without notice if the Client is in breach of any objection to make a payment to us.

REVIEW OF DESIGN

Where major civil or structural developments are proposed <u>or</u> where only a limited investigation has been completed <u>or</u> where the geotechnical conditions/ constraints are quite complex, it is prudent to have a joint design review which involves a senior geotechnical engineer.

SITE INSPECTION

The company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related.

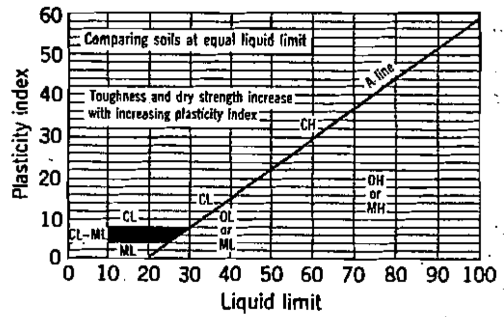
Requirements could range from:

i) a site visit to confirm that conditions exposed are no worse than those interpreted, to
ii) a visit to assist the contractor or other site personnel in identifying various soil/rock types such as appropriate footing or pier founding depths, or
iii) full time engineering presence on site.

UNIFIED SOIL CLASSIFICATION TABLE

Major Divisions			Field Identification Procedures (Excluding particles larger than 75 μm and basing fractions on estimated weights)	Group Symbols[a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria	
Coarse-grained soils More than half of material is *larger* than 75 μm sieve size[b] (The 75 μm sieve size is about the smallest particle visible to naked eye)	Gravels More than half of coarse fraction is larger than 4 mm sieve size	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	*GW*	Well graded gravels, 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 geologic name and other pertinent descriptive information; and symbols in parentheses 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 12 mm maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (*SM*)	Use grain size curve in identifying the fractions as given under field identification Determine percentages of gravel and sand from grain size curve Depending on percentage of fines (fraction smaller than 75 μm sieve size) coarse grained soils are classified as follows: Less than 5% *GW, GP, SW, SP* More than 12% *GM, GC, SM, SC* 5% to 12% *Borderline* cases requiring use of dual symbols	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing	*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines			Not meeting all gradation requirements for *GW*
		Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)	*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures			Atterberg limits below "A" line, or *PI* less than 4 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures			Atterberg limits above "A" line, with *PI* greater than 7
	Sands More than half of coarse fraction is smaller than 4 mm sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	*SW*	Well graded sands, gravelly sands, little or no fines			$C_U = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing	*SP*	Poorly graded sands, gravelly sands, little or no fines			Not meeting all gradation requirements for *SW*
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)	*SM*	Silty sands, poorly graded sand-silt mixtures			Atterberg limits below "A" line or *PI* less than 5 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*SC*	Clayey sands, poorly graded sand-clay mixtures			Atterberg limits below "A" line with *PI* greater than 7

Major Divisions		Identification Procedures on Fraction Smaller than 380 μm Sieve Size: Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)	Group Symbols	Typical Names	Information Required for Describing Soils
Fine-grained soils More than half of material is *smaller* than 75 μm sieve size	Silts and clays liquid limit less than 50	None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	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 geologic name, and other pertinent descriptive information, and symbol in parentheses For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)
		Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
		Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity	
	Silts and clays liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	
		High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays	
		Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity	
Highly Organic Soils		Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils	



Plasticity chart
for laboratory classification of fine grained soils

NOTE: 1) Soils possessing characteristics of two groups are designated by combinations of group symbols (e.g. GW-GC, well graded gravel-sand mixture with clay fines).

2) Soils with liquid limits of the order of 35 to 50 may be visually classified as being of medium plasticity.

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GRAPHIC LOG SYMBOLS FOR SOILS AND ROCKS

SOIL

- FILL
- TOPSOIL
- CLAY (CL, CH)
- SILT (ML, MH)
- SAND (SP, SW)
- GRAVEL (GP, GW)
- SANDY CLAY (CL, CH)
- SILTY CLAY (CL, CH)
- CLAYEY SAND (SC)
- SILTY SAND (SM)
- GRAVELLY CLAY (CL, CH)
- CLAYEY GRAVEL (GC)
- SANDY SILT (ML)
- PEAT AND ORGANIC SOILS

ROCK

- CONGLOMERATE
- SANDSTONE
- SHALE
- SILTSTONE, MUDSTONE, CLAYSTONE
- LIMESTONE
- PHYLLITE, SCHIST
- TUFF
- GRANITE, GABBRO
- DOLERITE, DIORITE
- BASALT, ANDESITE
- QUARTZITE

DEFECTS AND INCLUSIONS

- CLAY SEAM
- SHEARED OR CRUSHED SEAM
- BRECCIATED OR SHATTERED SEAM/ZONE
- IRONSTONE GRAVEL
- ORGANIC MATERIAL

OTHER MATERIALS

- CONCRETE
- BITUMINOUS CONCRETE, COAL
- COLLUVIUM

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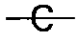
LOG SYMBOLS

LOG COLUMN	SYMBOL	DEFINITION
Groundwater Record		Standing water level. Time delay following completion of drilling may be shown.
		Extent of borehole collapse shortly after drilling.
		Groundwater seepage into borehole or excavation noted during drilling or excavation.
Samples	ES	Soil sample taken over depth indicated, for environmental analysis.
	U50	Undisturbed 50mm diameter tube sample taken over depth indicated.
	DB	Bulk disturbed sample taken over depth indicated.
	DS	Small disturbed bag sample taken over depth indicated.
Field Tests	N = 17 4, 7, 10	Standard Penetration Test (SPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration. 'R' as noted below.
	N_c = 5 7 3R	Solid Cone Penetration Test (SCPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration for 60 degree solid cone driven by SPT hammer. 'R' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	VNS = 25	Vane shear reading in kPa of Undrained Shear Strength.
	PID = 100	Photoionisation detector reading in ppm (Soil sample headspace test).
Moisture Condition (Cohesive Soils)	MC>PL	Moisture content estimated to be greater than plastic limit.
	MC≈PL	Moisture content estimated to be approximately equal to plastic limit.
	MC<PL	Moisture content estimated to be less than plastic limit.
(Cohesionless Soils)	D	DRY - runs freely through fingers.
	M	MOIST - does not run freely but no free water visible on soil surface.
	W	WET - free water visible on soil surface.
Strength (Consistency) Cohesive Soils	VS	VERY SOFT - Unconfined compressive strength less than 25kPa
	S	SOFT - Unconfined compressive strength 25-50kPa
	F	FIRM - Unconfined compressive strength 50-100kPa
	St	STIFF - Unconfined compressive strength 100-200kPa
	VSt	VERY STIFF - Unconfined compressive strength 200-400kPa
	H	HARD - Unconfined compressive strength greater than 400kPa
	( )	Bracketed symbol indicates estimated consistency based on tactile examination or other tests.
Density Index/ Relative Density (Cohesionless Soils)		**Density Index (I_D) Range (%)** — **SPT 'N' Value Range (Blows/300mm)**
	VL	Very Loose — <15 — 0-4
	L	Loose — 15-35 — 4-10
	MD	Medium Dense — 35-65 — 10-30
	D	Dense — 65-85 — 30-50
	VD	Very Dense — >85 — >50
	( )	Bracketed symbol indicates estimated density based on ease of drilling or other tests.
Hand Penetrometer Readings	300 250	Numbers indicate individual test results in kPa on representative undisturbed material unless noted otherwise.
Remarks	'V' bit	Hardened steel 'V' shaped bit.
	'TC' bit	Tungsten carbide wing bit.
	T 60	Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.

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LOG SYMBOLS

ROCK MATERIAL WEATHERING CLASSIFICATION

TERM	SYMBOL	DEFINITION
Residual Soil	RS	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely weathered rock	XW	Rock is weathered to such an extent that it has "soil" properties, ie it either disintegrates or can be remoulded, in water.
Distinctly weathered rock	DW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by ironstaining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Slightly weathered rock	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh rock	FR	Rock shows no sign of decomposition or staining.

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 Journal of Rock Mechanics, Mining, Science end Geomechanics. Abstract Volume 22, No 2, 1985.

TERM	SYMBOL	Is (50) MPa	FIELD GUIDE
Extremely Low:	EL		Easily remoulded by hand to a material with soil properties.
		0.03	
Very Low:	VL		May be crumbled in the hand. Sandstone is "sugary" and friable.
		0.1	
Low:	L		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.
		0.3	
Medium Strength:	M		A piece of core 150mm long x 50mm dia. can be broken by hand with difficulty. Readily scored with knife.
		1	
High:	H		A piece of core 150mm long x 50mm dia. core cannot be broken by hand, can be slightly scratched or scored with knife; rock rings under hammer.
		3	
Very High:	VH		A piece of core 150mm long x 50mm dia. may be broken with hand-held pick after more than one blow. Cannot be scratched with pen knife; rock rings under hammer.
		10	
Extremely High:	EH		A piece of core 150mm long x 50mm dia. is very difficult to break with hand-held hammer. Rings when struck with a hammer.

ABBREVIATIONS USED IN DEFECT DESCRIPTION

ABBREVIATION	DESCRIPTION	NOTES
Be	Bedding Plane Parting	Defect orientations measured relative to the normal to the long core axis (ie relative to horizontal for vertical holes)
CS	Clay Seam	
J	Joint	
P	Planar	
Un	Undulating	
S	Smooth	
R	Rough	
IS	Ironstained	
XWS	Extremely Weathered Seam	
Cr	Crushed Seam	
60t	Thickness of defect in millimetres	