NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

[01GG13A]

DPWS Sydney Region
(Bankstown Office)

North Sydney Boys High School – Proposed Carpark & Sports Courts

Geotechnical Investigation

Geotechnical and Environmental

Report No: 01-GG13A
Date: July 2001

ABSTRACT

DPWS Sydney Region (Bankstown Office) commissioned the Geotechnical and Environmental Section to undertake a geotechnical investigation for the proposed new carpark and sports courts within the complex of the existing North Sydney Boys High School, at North Sydney, NSW.

Fieldwork was carried out on 6.6.01, and comprised drilling of twelve (12) boreholes.

The purpose of the investigation was to determine the subsurface conditions, recommend pavement design parameters, and comment on excavation conditions and earthworks requirements.

The report presents the data obtained from field and laboratory investigations, and discusses the above geotechnical aspects for design and construction of the proposed development.

P. Carter
Principal Engineer
Dams and Civil Engineering

TABLE OF CONTENTS

1. INTRODUCTION

1.1. General

DPWS Sydney Region (Bankstown Office) commissioned the Geotechnical and Environmental Section to undertake a geotechnical investigation, for the proposed new carpark and sports courts within the complex of the existing North Sydney Boys High School, at North Sydney, NSW.

The site development plan is shown in **Figure 2**. It is understood that the existing parking spaces along the eastern and southern boundaries of the carpark (spaces 1 to 21 shown on the plan) will remain.

The civil engineering consultant (Miller Milston Ferris Consulting Engineers) designated 12 test locations on the contour plan provided by Region (Proj No: D11576-SK1, dated 27.2.01). It was later agreed in a joint site visit (5.6.01) that eleven (11) boreholes would be drilled within the proposed development area, and one (1) borehole drilled further to east in the area where a drainage pit is proposed. The site visit was carried out in the company of G Mass (DPWS Sydney Region) and a representative of the civil engineering consultant.

The current report presents the data obtained from this investigation, and discusses relevant geotechnical aspects for design and construction of the proposed development.

1.2. Location and Site Conditions

The school is located in North Sydney, about 3 km north of Sydney CBD. The site location is shown in **Figure 1**. The proposed development area (site) lies within the northern section of the school complex, and is adjacent to Falcon Street.

Generally the site slopes very gently towards north, and is intercepted by low height brick walls near the northern and eastern site boundaries. The proposed carpark area (area A, see **Photograph 1**) is generally bare with some trees. The proposed sports courts area (area B, see **Photograph 2**) is generally grass covered with some trees. A patch of bare surface and a shipping container occur along the eastern boundary of area B.

1.3. Aims of Investigation

The aims of this investigation were to report on:

- subsurface and groundwater conditions within the site;
- properties of subsurface materials;
- excavation characteristics of the encountered strata and earthwork requirements; and
- pavement design parameters.

1.4. Terminology

The methods used in this report to describe the subsurface profiles, and visual classification of material types encountered at discrete borehole locations are in accordance with AS1726 - SAA Geotechnical Site Investigation. The definitions of terminology used are presented in **Appendix A**.

2. GEOLOGY, MINE SUBSIDENCE AND FLOOD VULNERABILITY

2.1 Geology

The site lies within the major structural unit known as the Sydney Basin. The Sydney 1:100,000 Geological Series Sheet 9130 (Edition 1, 1983) shows that the site is underlain by Ashfield Shale (part of Wianamatta Group). This formation comprises black to dark-grey shale and laminite of Triassic age.

The current investigation revealed that the subsurface profile comprises a layer of topsoil/fill underlain by residual soils (silty clay/clayey silt), and then by weathered siltstone.

2.2 Mine Subsidence

The site does not lie within a proclaimed Mine Subsidence District (coal mining), and hence is not affected by associated subsidence.

2.3 Flood Vulnerability

The site is unlikely to be affected by the 1 in 100 year ARI flood event due to the topography of the site.

3. FIELDWORK

Fieldwork was carried out on 6.6.01 and comprised drilling of 12 boreholes (B1 to B12) to depths of 1.65m to 3.0m.

One of the boreholes (B12) was located about 50m towards east of the site, and next to an access road. Access for the drill rig to the area immediately on the eastern side of this access road was difficult, because of obstructions from existing seats and trees. The proposed drainage pit will be located within this area.

The boreholes were drilled by Saxon Drilling Co using a Explorer X2 drill rig mounted on a Land Rover. Each borehole was advanced using a solid spiral flight auger equipped with a vee bit. Standard Penetration Testing (SPT) was generally carried out in the boreholes. The fieldwork was supervised by a geologist from our Section, who also carried out field logging and soil sampling.

The borehole logs are presented in **Appendix B,** and the locations of the boreholes are shown in **Figure 3**.

4. LABORATORY GEOTECHNICAL TESTING

Four (4) soil samples were selected from boreholes B2 (bulk 0.6-0.9m, U 0.6-0.87m), B3 (0.8-1.3m) and B9 (0.7-1.1m) for testing in accordance with the relevant methods in AS 1289. The following tests were carried out on the selected soil samples at the DPWS Geotechnical Centre laboratory, at Ultimo :

- 4 Field moisture content
- 2 Field wet density
- 3 Atterberg limits
- 3 Linear shrinkage
- 1 Particle size distribution
- 2 Standard compaction
- 2 California Bearing Ratio (CBR)

The results of the above tests are presented in **Appendix C**.

5. CHEMICAL TESTING

5.1. Topsoil

Two (2) topsoil samples from boreholes B9 and B11, were taken from the proposed sports courts area and sent to Sydney Environmental and Soil Laboratory Pty Ltd to determine suitability for landscaping purposes.

The results indicate that the pH of the samples is acceptable. Generally, the soils should be treated with additions of chemicals/fertilisers prior to use as topsoil. Full results of the tests and recommendations from the laboratory are presented in **Appendix D**.

5.2. Soil Aggressiveness

Three (3) soil samples from boreholes B2 (0.6-0.9m), B3 (0.8-1.3m) and B12 (1.0-1.45m) were sent to the DPWS Analytical Services Laboratory at Lidcombe to determine soil aggressiveness.

The results of the chemical tests on the samples indicate the following :

B2 and B3 = Not Aggressive

B12 = Highly Aggressive

Full results of the chemical tests with an assessment by a chemical engineer from the DPWS Wastewater Services are presented in **Appendix D**.

6. SUBSURFACE CONDITIONS

6.1. General

The distribution of eleven (11) boreholes (B1 to B11) within the proposed development area is indicated below :

Development Area	Boreholes
Carpark (area A)	B1 to B4 and B6
Sports Courts (area B)	B5 and B7 to B11

The subsurface conditions encountered in the above two areas are summarised in subsequent sections.

6.2. Ground Conditions

Carpark (area A)

The subsurface profile generally comprises a layer of topsoil/fill to depths of 0.3m to 1.3m, underlain by residual soils to depths of 1.4m to 1.65m, and then underlain by weathered siltstone to depths of 1.65m to 2.3m, where vee bit refusal was registered. In boreholes B4 and B6, weathered rock was encountered only at the termination depths (auger refusal) of 1.65m and 1.9m, respectively.

The residual soils comprise soft to firm silty clay (yellow-brown/orange-brown, moist) to stiff clayey silt with some fine sand (light grey mottled yellow-brown, moist to just moist). Fill (dark grey-brown/brown to dark grey/grey, moist to just moist) generally comprises bitumen/roadbase (B1) or poorly compacted sandy silt to sandy clayey silt / silty sand with some roots, glass, tile, brick, steel bar and concrete. In borehole B2, one fibro fragment was encountered.

Sports Courts (area B)

The subsurface profile generally comprises a layer of topsoil/fill to depths of 0.05m to 1.6m, underlain by residual soils to depths of 2.15m to 3.0m. In boreholes B5, B7 and B8, vee bit refusal was registered at depths of 2.15m to 2.8m.

The residual soils comprise soft-firm to firm-stiff silty clay (yellow-brown/grey-brown, moist) to stiff clayey silt with some fine sand (light grey mottled yellow-brown/orange-brown/red, moist to dry). Fill (dark grey-brown/grey, moist) generally comprises bitumen/roadbase (B7) or poorly compacted sandy clayey silt with some roots, gravel, coke/ash and tile. Borehole B10, which was located near the northern site boundary, encountered a thick layer of fill (1.6m thick) comprising sandy silt with gravel, and some coke/ash/slag below 0.9m depth. Borehole B9, which was also located near the northern boundary, encountered a silty clay layer to a depth of 1.3m that is interpreted to be probably fill.

6.3. Soil Properties

The plasticity properties of the tested residual and fill soil samples were found to be as follows:

Liquid limit = 33 – 51%
Plastic limit = 15 – 18%
Plasticity index = 18 – 33%
Linear shrinkage = 10 – 14.5%

6.4. Groundwater Conditions

At the time of fieldwork the groundwater table was not registered within the depth of investigation. However, in boreholes B7 and B9, seepage was encountered at depths of 2.3m and 1.2m, respectively. The seepage may be associated with ground infiltration of surface water, or leaking pipes, or other unknown sources.

7. DISCUSSION AND RECOMMENDATIONS

7.1. Earthworks

The proposed finished levels of the new carpark and sports courts were not available to our Section. However, it is understood that only minor levelling will be required for the proposed development area.

The excavated residual local soils (silty clay/clayey silt) are of medium to high plasticity and are considered to have poor compaction characteristics for use as engineered fill. If used, the materials should be placed in maximum 150mm (loose) layers, and be compacted to the following minimum standard dry density ratios (AS 1289.5.4.1- 1993) at a moisture content within 2% of optimum:

- Pavement subgrade to a depth of 0.3m = 98%
- Fill to support pavement = 95%
- Fill under sports courts = 95%

In the proposed sports courts area, the topsoil/fill and the underlying soils should be stripped to a minimum depth of 0.5m. The exposed surface should then be examined and proof rolled to ensure subgrade strength and consistency, prior to placement of controlled fill. Recommendations for foundation preparation for the new carpark pavement are presented in **Section 7.2**.

If the excavated fill soils contain 'unsuitable materials', as described in Section 4 of Australian Standard AS3798-1996 '*Guideline on Earthworks for Commercial and Residential Development*', they should not be used as controlled fill. If imported fill materials are required, 'suitable materials' (preferably crushed rock) as described in the above Standard should be used with appropriate minimum relative compaction as given in Table 5.1 of the Standard.

Conventional earthmoving equipment such as backhoes and small to medium size bulldozers should be capable of excavating the local soils and extremely weathered rock. Excavation of highly weathered or better quality rock is likely to be difficult, and a larger excavator is likely to be required.

7.2. Carpark Pavement

Two bulk samples were taken from borehole B2 (0.6-0.9m, silty clay with sand) and B3 (0.8-1.3m, sandy silty clay) for CBR testing. These boreholes were located within the proposed carpark area. The sample taken from borehole B3 is fill. The samples were remoulded to a dry density ratio of 101% standard, and a soaked CBR value of 5% was obtained for both samples. Considering our experience with the similar materials, and the potential for ground variation, a CBR value of 4% is recommended for pavement design.

The above recommendation is made on the assumptions that:

- Stripping the topsoil, and the fill soils to a minimum depth of 1.0m, followed by careful examination of the excavated surface and proof rolling to ensure subgrade strength and consistency. Proof rolling may be carried out with a smooth static roller of a minimum of 7 tonnes operating weight by typically 6 to 8 passes. Any soft spots detected in the subgrade should be excavated by at least 0.3m, and be recompacted to a standard as described in **Section 7.1**.
- Adequate subsoil drainage should be provided to prevent ingress of water into the subgrade.

The thickness of pavement will depend on design traffic loading (equivalent standard axles, ESA). For example, if the type of pavement selected is unbound granular materials with thin bituminous surfacing, then based on Figure 8.4 of "Pavement Design : A Guide to the Structural Design of Road Pavement" by Austroads (1992), the recommended thickness of granular materials is as follows:

Design Traffic (ESAs)	Minimum thickness of Granular Materials (mm)
1×10^5	330
1×10^6	440

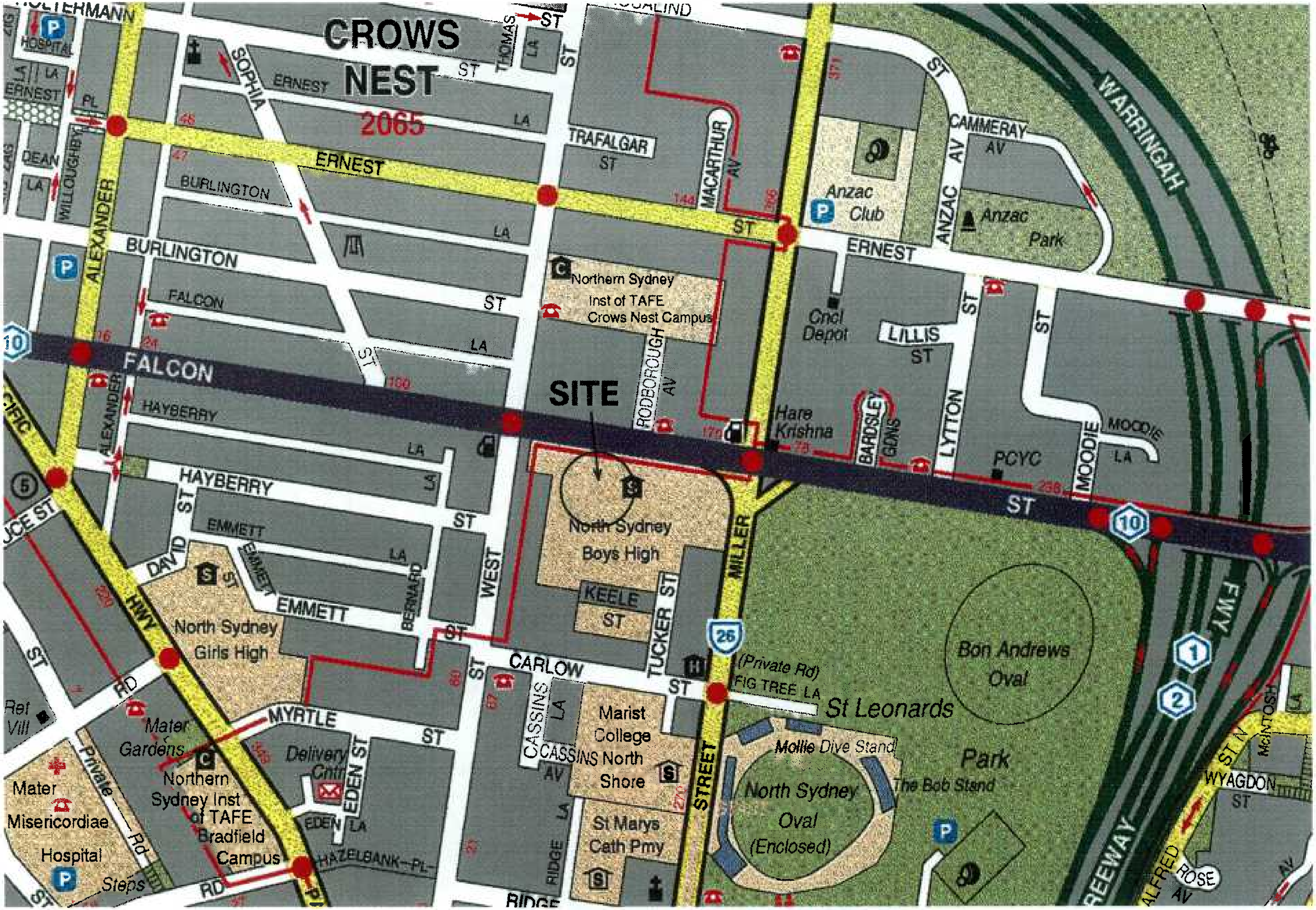
Alternatively, a suitably thick asphaltic concrete wearing course with appropriate thickness of granular materials may be adopted. The final design selected will depend on the economy and life expectancy of the pavement.

8. GENERAL REMARKS

It should be noted that this report is based on interpolation of data from discrete boreholes and may not represent actual conditions between them. If different conditions are encountered during the course of construction, the contractor should seek advice from a geotechnical consultant.

P. Shun
Geotechnical Engineer

FIGURES



FROM: UBD SYDNEY 2001 STREET DIRECTORY

MK	DETAILS OF AMENDMENTS	APPROVED	DATE

DICK PERSSON
DIRECTOR GENERAL - DPWS

INFRASTRUCTURE & ENVIRONMENTAL SERVICES
WATER TECHNOLOGIES
LEVEL 13, McKELL BUILDING
2-24 RAWSON PLACE
SYDNEY 2000
PHONE (02) 9372 7868 FAX (02) 9372 7877

GEOTECHNICAL AND ENVIRONMENTAL

WATER TECHNOLOGIES

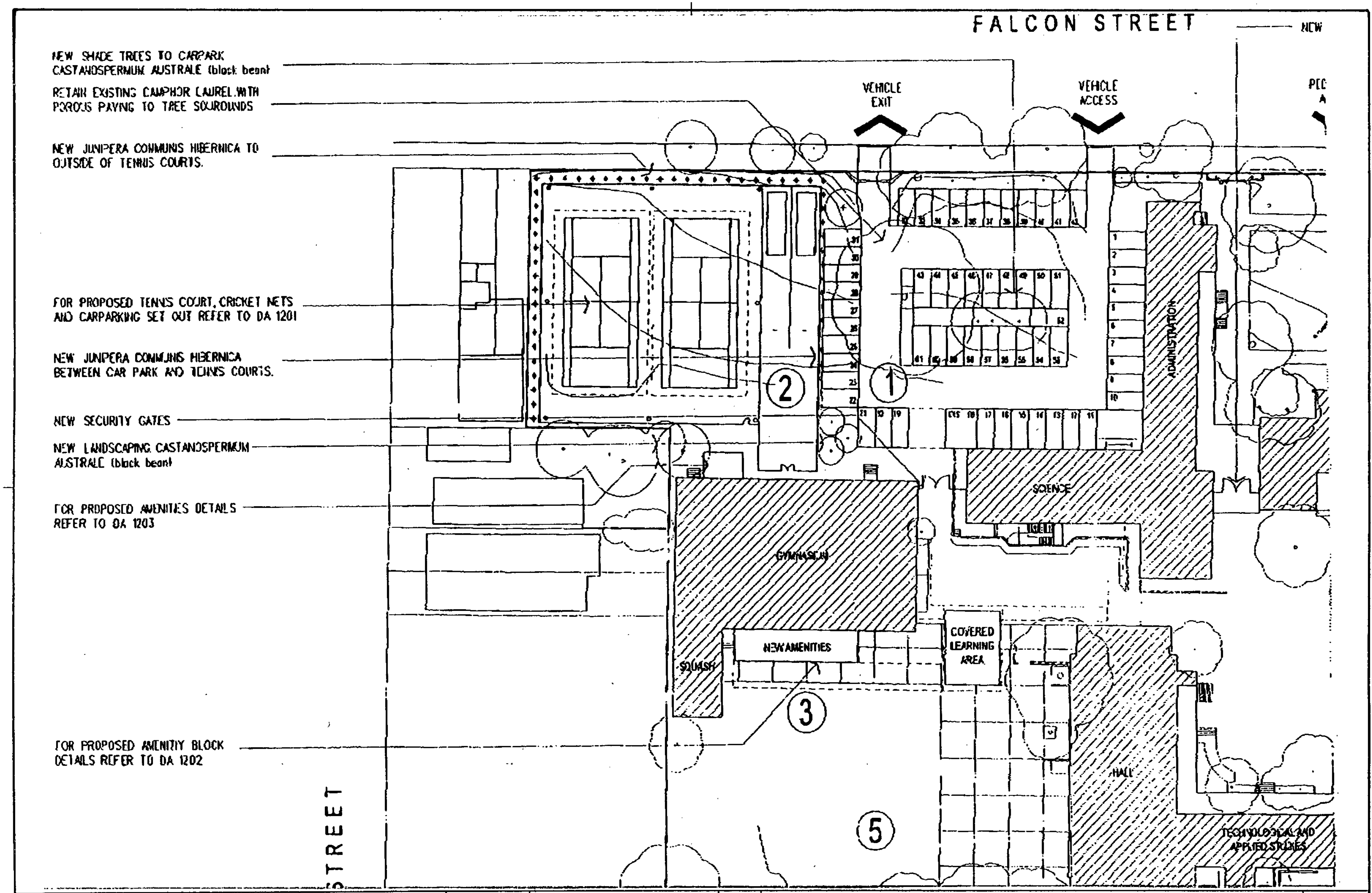
DESIGNED		
DRAFTED	J.D.EDWARDS	
CHECKED	P.SHUN	JUNE 2001

DPWS

NORTH SYDNEY BOYS HIGH SCHOOL
PROPOSED CARPARK & SPORTS COURTS
Site Location Plan

JOB NO.
GG13A.

FIGURE NO.
1



NEW SHADE TREES TO CARPARK CASTANOSPERMUM AUSTRALE (black bean)

RETAIN EXISTING CAMPHOR LAUREL WITH POROUS PAVING TO TREE SOUROUNDS

NEW JUNIPERA COMMUNIS HIBERNICA TO OUTSIDE OF TENNIS COURTS.

FOR PROPOSED TENNIS COURT, CRICKET NETS AND CARPARKING SET OUT REFER TO DA 1201

NEW JUNPERA COMMUNIS HIBERNICA BETWEEN CAR PARK AND TENNIS COURTS.

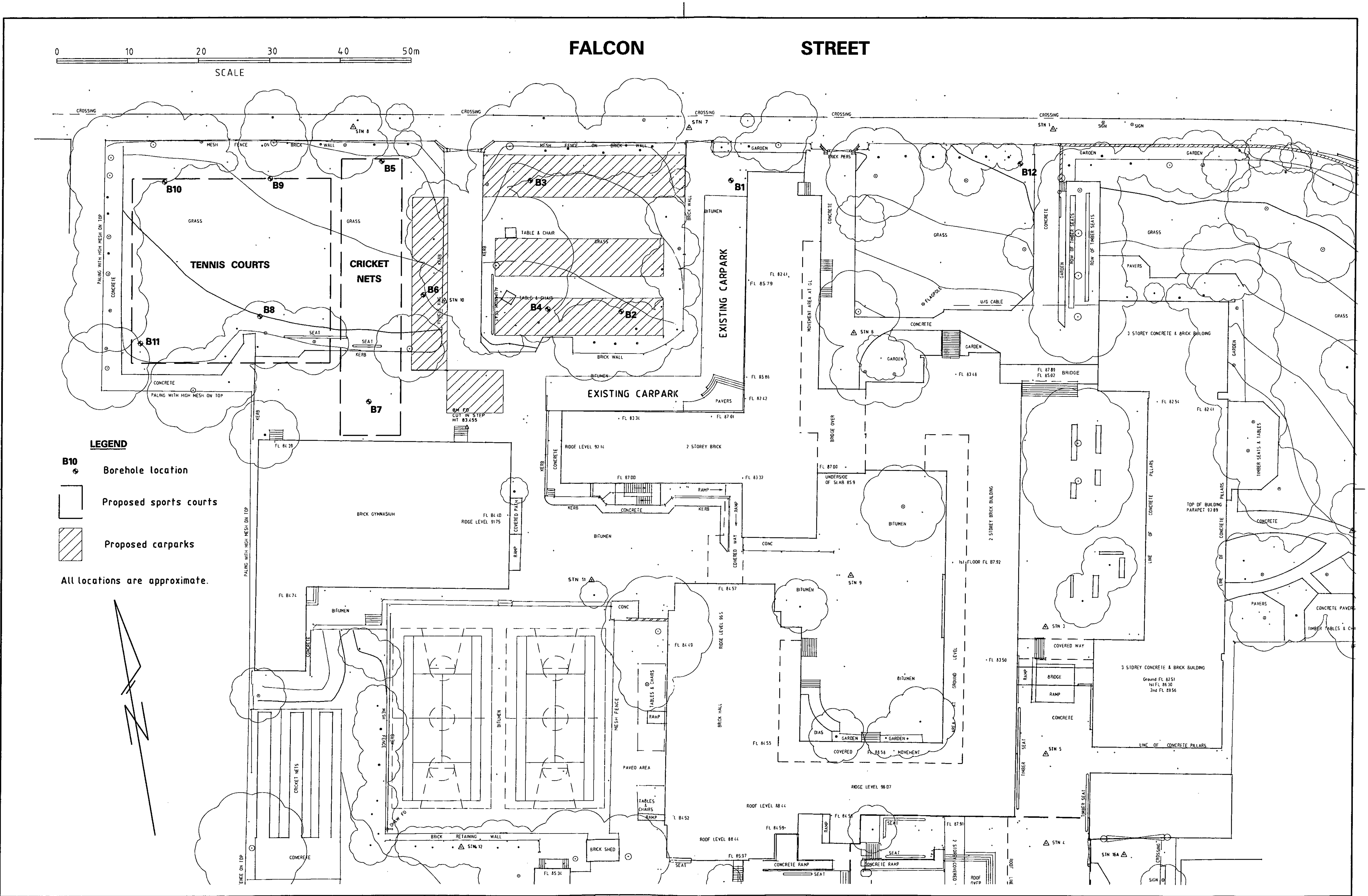
NEW SECURITY GATES

NEW LANDSCAPING CASTANOSPERMUM AUSTRALE (black bean)

FOR PROPOSED AMENITIES DETAILS REFER TO DA 1203

FOR PROPOSED AMENITIY BLOCK DETAILS REFER TO DA 1202

				DICK PERSSON DIRECTOR GENERAL - DPWS	GEOTECHNICAL AND ENVIRONMENTAL	WATER TECHNOLOGIES			NORTH SYDNEY BOYS HIGH SCHOOL PROPOSED CARPARK & SPORTS COURTS Site Plan	JOB NO. GG13A
				INFRASTRUCTURE & ENVIRONMENTAL SERVICES WATER TECHNOLOGIES LEVEL 13, McKELL BUILDING 2-24 RAWSON PLACE SYDNEY 2000 PHONE (02) 9372 7860 FAX (02) 9372 7877		DESIGNED				FIGURE NO. 2
						DRAFTED	J.O.EDWARDS			
MK	DETAILS OF AMENDMENTS	APPROVED	DATE			CHECKED	P.SHUN	JUNE 2001		



g:\is\watertec\geotech\pcad\nthsyd\g53568shl.dgn 11:34:42 23 JUL 2001

MK	DETAILS OF AMENDMENTS	APPROVED	DATE

DICK PERSSON
DIRECTOR GENERAL - DPWS

INFRASTRUCTURE & ENVIRONMENTAL SERVICES
GEOTECHNICAL & ENVIRONMENTAL
LEVEL 13, McKELL BUILDING
2-24 RAWSON PLACE
SYDNEY 2000
PHONE (02) 93727875 FAX (02) 93727877

PLAN RM NO

DESIGNED P.SHUN/P.ANDERSON	S.E. WATER TECHNOLOGIES
DRAFTED	P.E. WATER TECHNOLOGIES
CHECKED P.SHUN	DATE JULY 2001

DPWS
NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

NORTH SYDNEY BOYS HIGH SCHOOL
Proposed Carpark & Sports Courts
Borehole Location Plan

FILE GG13A
FIGURE 3

B1 0 960 100 200 300

PHOTOGRAPHS

Appendix A

Geotechnical Terminology and Technical Aids

CHARACTERISATION OF GEOTECHNICAL DATA

Geotechnical data generally fall into the categories of fact, interpretation and opinion, as defined by the Institution of Engineers, Australia, 1987 - Guidelines for the Provision of Geotechnical Information in Construction Contracts.

Facts are defined as the materials, statistics and properties which may be seen, measured or identified by means of accepted and preferably standardised criteria, classifications and tests. Examples of facts include: exploration locations, outcrop locations, samples and drill core, lithological names/descriptions of soils and rocks, measured water levels, laboratory test results and seismic time/distance plots.

Interpretative data is defined as information derived from competently made interpretation of facts using accepted and proven techniques, or reasonable judgement exercised in the knowledge of geological conditions or processes evident at the site. Examples of interpretative data are: borehole and test pit logs, inferred stratigraphy and correlations between boreholes or test pits, material and rock mass properties used in analysis (e.g. permeability), and seismic interpretation (yielding velocity and layer depths).

Opinion is derived from consideration of relevant available facts, interpretations and analysis and/or the exercise of judgement. Examples of opinions based on geotechnical/geological interpretations include bearing capacity and foundation suitability, need for foundation treatment, settlements, potential for grouting, excavation stability, ease of excavation, and suitability of construction materials.

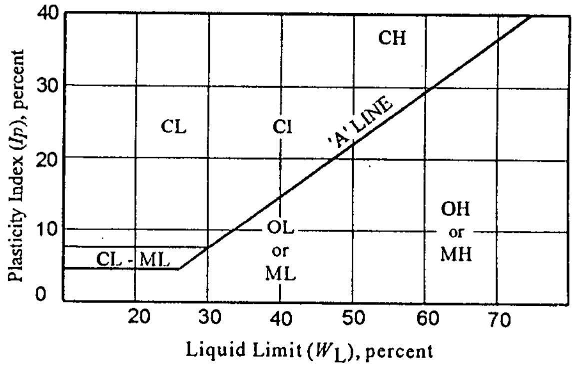
NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

GEOTECHNICAL ENGINEERING

GUIDE TO THE DESCRIPTION IDENTIFICATION AND CLASSIFICATION OF SOILS

Major Divisions		Particle Size (mm)	Group Symbol	Typical Names	Field Identification Sand and Gravels	Laboratory Classification					
							% < 0.06mm (see note 2)	Plasticity of Fine Fraction	$C_u = \frac{D_{50}}{D_{10}}$	$C_c = \frac{(D_{30})^2}{D_{10}D_{60}}$	Notes
COARSE GRAINED SOILS (more than half of material less than 63 mm is larger than 0.075 mm)	**BOULDERS**	200				Use the gradation curve of material passing 63mm for classification of fractions according to the criteria given in "Major Divisions"	—	—	—	—	
	COBBLES	63					—	—	—	—	
	GRAVELS (more than half of coarse fraction is larger than 2.36mm)	coarse 20	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength		0-5	—	> 4	between 1 and 3	1. Identify lines by the method given for fine grained soils.
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines, uniform gravels	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength		0-5	—	Fails to comply with above	—	
		medium 6	GM	Silty gravels, gravel-sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength		12-50	Below 'A' line or $I_p < 4$	—	—	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
		fine 2.36	GC	Clayey gravels, gravel-sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength		12-50	Above 'A' line or $I_p > 7$	—	—	
	SANDS (more than half of coarse fraction is smaller than 2.36mm)	coarse 0.6	SW	Well graded sands, gravelly sands, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength		0-5	—	> 6	between 1 and 3	3. I_p = Plasticity Index
			SP	Poorly graded sands and gravelly sands; little or no fines	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength		0-5	—	Fails to comply with above	Fails to comply with above	
		medium 0.2	SM	Silty sands, sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength		12-50	Below 'A' line or $I_p < 4$	—	—	
		fine 0.075	SC	Clayey sands, sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength		12-50	Above 'A' line or $I_p > 7$	—	—	

GUIDE TO THE DESCRIPTION, IDENTIFICATION AND CLASSIFICATION OF SOILS (CONT.)

Major Divisions		Particle Size (mm)	Group Symbol	Typical Names	Field Identification			Laboratory Classification			
					Dry* Strength	Dilatancy†	Toughness ‡			Plasticity of Fine Fraction	Notes
FINE GRAINED SOILS (more than half of material less than 63 mm is smaller than 0.075 mm)	SILTS & CLAYS (liquid limit < 50%)	<0.075	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	None to low	Quick to slow	None	Use the gradation curve of material passing 63mm for classification of fractions according to the criteria given in "Major Divisions"	More than 50% passing 0.06 mm	Below 'A' line	PLASTICITY CHART FOR CLASSIFICATION OF FINE GRAINED SOILS 
			CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	Medium to high	None to very slow	Medium			Above 'A' line	
			OLΦ	Organic silts and organic silty clays of low plasticity	Low to medium	Slow	Low			Below 'A' line	
	SILTS & CLAYS (liquid limit > 50%)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, clastic silts	Low to medium	Slow to none	Low to medium			Below 'A' line	
			CH	Inorganic clays of high plasticity, fat clays	High to very high	None	High			Above 'A' line	
			OHΦ	Organic clays of medium to high plasticity, organic silts	Medium to high	None to very slow	Low to medium			Below 'A' line	
	HIGHLY ORGANIC SOILS		PtΦ	Peat and other highly organic soils	Identified by colour, odour, spongy feel and generally by fibrous texture					—	Φ Effervesces with H_2O_2

FIELD IDENTIFICATION PROCEDURE FOR FINE GRAINED SOILS OR FRACTIONS

THESE PROCEDURES ARE TO BE PERFORMED ON THE MINUS 0.2MM SIZE PARTICLES. FOR FIELD CLASSIFICATION PURPOSES, SCREENING IS NOT INTENDED, SIMPLY REMOVE BY HAND THE COARSE PARTICLES THAT INTERFERE WITH THE TESTS.

* Dry strength (Crushing characteristics)

After removing particles larger than 0.2mm 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 for clays of 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 the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

† Dilatancy (Reaction to shaking)

After removing particles larger than 0.2mm size, prepare a pat of moist soil with a volume of 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 assist in identifying the character of the fines in a 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, shows a moderately quick reaction.

‡ Toughness (Consistency near plastic limit)

After removing particles larger than 0.2mm size, a specimen of soil about 10cm^3 in size is moulded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. The specimen is then rolled out by hand on a smooth surface or between the palms into a thread about 3mm in 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 with 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.

SOIL DESCRIPTION

The methods of description and classification of soils are based on Australian Standard 1726, the SAA Site Investigation Code. The description of a soil is based on particle size distribution and plasticity as shown in the "GUIDE TO THE DESCRIPTION, IDENTIFICATION AND CLASSIFICATION OF SOILS".

SOIL CLASSIFICATION

The basic soil types and their subdivisions are defined by their particle sizes:

MAJOR SOIL CATEGORIES

Soil Classification	Particle Size
Boulders	Greater than 200mm
Cobbles	63 - 200mm
Gravel	2.36 - 63mm
Sand	0.075 - 2.36mm
Silt	0.002 - 0.075mm
Clay	Less than 0.002mm

MINOR SOIL CONSTITUENTS

As most natural soils are combinations of various constituents, the primary soil is further described and modified by its minor components:

Coarse grained soils		**Fine grained soils**	
% Fines	**Modifier**	**% Coarse**	**Modifier**
≤ 5	Omit, or use 'trace'	≤ 15	Omit, or use 'trace'
> 5 ≤ 12	Describe as 'with clay/silt', as applicable	> 15 ≤ 30	Describe as 'with sand/gravel', as applicable
> 12	Prefix soil as 'silty/clayey', as applicable	> 30	Prefix soil as 'sand/gravelly', as applicable

COHESIVE SOILS

Clay and silt may be described according to their plasticity:

Descriptive Term	**Range of liquid limit (percent)**
Of low plasticity	≤ 35
Of medium plasticity	> 35 ≤ 50
Of high plasticity	> 50

MOISTURE CONDITION

Term	Description
Dry (D)	Cohesive soils; hard and friable or powdery, well dry of plastic limit. Granular soils; cohesionless and free-running.
Moist (M)	Soil feels cool, darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.
Wet (W)	Soil feels cool, darkened in colour. Cohesive soils usually weakened and free water forms on hands when handling. Granular soils tend to cohere.

CONSISTENCY - NON-COHESIVE SOILS

Term	Density index %		SPT "N" value
Very loose		≤ 15	< 5
Loose	> 15	≤ 35	5 - 10
Medium dense	> 35	≤ 65	10 - 30
Dense	> 65	≤ 85	30 - 50
Very dense	> 85		> 50

CONSISTENCY - COHESIVE SOILS

Term	Undrained shear strength (kPa)		Field guide to consistency	SPT "N" value
Very soft		≤ 12	Exudes between the fingers when squeezed in hand.	< 2
Soft	> 12	≤ 25	Can be moulded by light finger pressure.	2 - 4
Firm	> 25	≤ 50	Can be moulded by strong finger pressure.	4 - 8
Stiff	> 50	≤ 100	Cannot be moulded by fingers; can be indented by thumb	8 - 16
Very stiff	> 100	≤ 200	Can be indented by thumb nail.	16 - 32
Hard	> 200		Can be indented with difficulty by thumb nail.	> 32

GRAPHICAL SYMBOLS USED FOR GEOTECHNICAL BOREHOLE AND TEST PIT LOGS

SOIL - COARSE GRAINED

⬚ GW
⬚ GP
▨ GM
▨ GC

▤ SW
⬚ SP
▨ SM
▨ SC

SOIL - FINE GRAINED

▥ MH
▤ MI
▤ ML

▥ CH
▤ CI
▤ CL

⬚ OH
⬚ OL
⬚ Pt

ROCK

▤ Sedimentary rock
⊞ Igneous rock
≈ Metamorphic rock

FILL MATERIAL

▩ Fill

GROUNDWATER

▼ Level
➤ Inflow

NGE No Groundwater Encountered

SOIL HORIZON BOUNDARIES

——— Boundary measured or determined from drilling conditions

·········· Diffuse or uncertain boundary

DEFINITIONS OF ENGINEERING GEOLOGICAL TERMS

This classification system provides a standard terminology for the engineering description of rock.

DEGREE OF WEATHERING [1]

TERM	SYMBOL	DEFINITION
Residual Soil	RS	Rock is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.
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 bleaching or deposition. The colour and strength of the original 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 (stained)	F_S	Rock substance unaffected by weathering. Weathering is limited to the surface of major discontinuities, for example an iron-stained joint.
Fresh	F	Rock substance unaffected by weathering.

ROCK STRENGTH ^{2}

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.

TERM	Is (50)	FIELD GUIDE	APPROX. qu MPa *
Extremely Weak (EW)		Easily remoulded by hand to a material with soil properties.	
	0.03		0.7
Very weak (VW)		May be crumbled in the hand. Sandstone is "sugary" and friable.	
	0.1		2.4
Weak (W)		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		7
Medium Strong (MS)		A piece of core 150mm long x 50mm dia. may be broken by hand with considerable difficulty. Readily scored with a knife.	
	1		24
Strong (S)		A piece of core 150mm long x 50mm dia. cannot be broken by unaided hands, may be slightly scratched or scored with knife.	
	3		70
Very Strong (VS)		A piece of core 150mm long x 50mm dia. may be broken readily with hand held hammer. Cannot be scratched with pen knife.	
	10		240
Extremely Strong (ES)		A piece of core 150mm long x 50mm dia. is difficult to break with hand held hammer. Rings when struck with 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 and should be calibrated on site.

STRATIFICATION SPACING [2]

TERM	SEPARATION OF STRATIFICATION PLANES
Thinly laminated	< 6mm
Laminated	6mm - 20mm
Very thinly bedded	20mm - 60mm
Thinly bedded	60mm - 200mm
Medium bedded	200mm - 600mm
Thickly bedded	600mm - 2m
Very thickly bedded	> 2m

DISCONTINUITY SPACING [3]

TERM	SPACING
Very widely spaced	> 2m
Widely spaced	600mm - 2m
Moderately widely spaced	200mm 600mm
Closely spaced	60mm - 200mm
Very closely spaced	20mm - 60mm
Extremely closely spaced	< 20mm

APERTURE OF DISCONTINUITY SURFACES [4]

The degree to which a discontinuity is open, or to which the faces of the discontinuity have been separated and the space subsequently infilled (such as in a vein, fault or joint).

TERM	APERTURE THICKNESS (Discontinuities, veins, faults, joints)
Wide	> 200mm
Moderately wide	60mm - 200mm
Moderately narrow	20mm - 60mm
Narrow	6mm - 20mm
Very narrow	2mm - 6mm
Extremely narrow	> 0 - 2 mm
Tight	Zero

BLOCK SHAPE AND SIZE [4]

The following descriptive terms define shape:

Blocky - approximately equidimensional.
Tabular - one dimension considerably shorter than the other two.
Columnar - one dimension considerably larger than the other two.

Block sizes are defined by the following descriptive terms:

TERM	BLOCK SIZE	EQUIVALENT DISCONTINUITY SPACINGS IN BLOCKY ROCK
Very large	$> 8m^3$	Extremely wide
Large	$> 0.2m^3 - 8m^3$	Very wide
Medium	$> 0.008m^3 - 0.2m^3$	Wide
Small	$> 0.0002m^3 - 0.008m^3$	Moderately wide
Very small	$\leq 0.0002m^3$	Less than moderately wide

REFERENCES

1. Modifications of:
   (a) McMahon, B.K., Douglas, D.J., & Burgess, P.J., 1975. Engineering classification of sedimentary rocks in the Sydney area. Australian Geomechanics Journal, G5 (1), 51-53.
   (b) Geological Society Engineering Group Working Party, 1977. The description of rock masses for engineering purposes. Quarterly Jour. Engg. Geology, 10 (4), 355-388.

2. McMahon, B.K., Douglas , D.J., & Burgess, P. J., 1975. Engineering classification of sedimentary rocks in the Sydney area. Australian Geomechanics Journal, G5 (1), 51 -53.

3. ISRM Commission on Standardisation of Laboratory and Field Tests, 1978. Suggested methods for the quantitative description of discontinuities in rock masses. Jl. Rock Mechanics Min. Sci. and Geomech. Abstra., 15, 319-368.

4. Geological Society Engineering Group Working Party, 1977. The description of rock masses for engineering purposes. Quarterly Journ. Engg Geology, 10 (4), 355-388.

NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

GEOTECHNICAL & ENVIRONMENTAL

EXPLANATION OF LOGGING TERMS FOR ENGINEERING GEOLOGY BOREHOLE LOGGING

ROCK SUBSTANCE WEATHERING CLASSIFICATION

RS	Residual soil
EW	Extremely weathered
HW	Highly weathered
MW	Moderately weathered
SW	Slightly weathered
F(s)	Fresh (stained defects)
F	Fresh

ESTIMATED STRENGTH CLASSIFICATION

EW	Extremely weak
VW	Very weak
W	Weak
MS	Medium strong
S	Strong
VS	Very strong
ES	Extremely strong

DEFECTS

Defects include all joints, bedding planes, fracture zones, seams, veins and cleavage partings.

RQD

Rock quality designation:

$$RQD = \frac{\text{length of core in pieces 100mm or longer}}{\text{length of run}} \times 100\%$$

WATER

▼ DATE	Water table, with date
►	Water inflow
◁	Partial drilling water loss
◄	Complete drilling water loss

Angles of joint inclination (and other geological features and drill holes) are angles between the feature and a horizontal plane. In core, angles of joints (and other geological structures) are angles between the structure and the plane normal to the axis of the core. In vertical holes these angles are then the true inclination (dip) of the structure.

CSIRO AUSTRALIA
DIVISION OF BUILDING, CONSTRUCTION AND ENGINEERING
information service
Sheet No. 10-91
Revised November 1988

Note: This is a revision of CSIRO Division of Building Research Information Sheet No. 10-91. (The Division of Building Research is now incorporated as part of the Division of Building, Construction and Engineering.)

GUIDE TO HOME OWNERS ON FOUNDATION MAINTENANCE AND FOOTING PERFORMANCE (updated for AS 2870-1988)

1. INTRODUCTION

This guide was prepared by Dr P.F. Walsh of CSIRO, with advice from the Standards Australia Committee on Residential Slabs and Footings, to provide guidance to home owners on their responsibilities for the care of a clay foundation, and to discuss the performance that can be expected from a footing system. (The ground that supports a house is called a foundation, and the concrete structure that transfers the load to this foundation is the footing system).

The best information about the design and construction of footing systems is contained in the Australian Standard 'AS 2870 – Residential Slabs and Footings'. That Standard gives a system of site classification, prescribed footing and slab designs and construction methods that provides an excellent footing system for Australian houses. However, a warning is given that the chance of a footing failure is higher if extreme site conditions, such as the following, are permitted to occur.

(a) planting of trees too close to a footing;
(b) excessive watering of gardens adjacent to the house;
(c) lack of maintenance of site drainage; and
(d) failure to repair plumbing leaks.

The Standard further states that compliance with this guide is a way to avoid extreme site conditions.

Clay foundations are the cause of major problems for houses. Clays are very fine-grained soils that are plastic and sticky when wet, and hard and strong when dry. All clays swell or shrink to some degree as they become wet or dry out. 'Reactive' clays swell or shrink to such an extent that foundation movements can damage houses.

All house sites are classified. Reactive-clay sites are classified as M, H, or E, in order of increasing reactivity. Proper maintenance of such clay sites requires that the moisture content of the clay should be kept reasonably constant.

Some minor cracking of masonry walls is almost inevitable despite proper design, construction and maintenance. Very slight cracks up to 1 mm wide could be expected in most houses. Larger cracks, up to 5 mm, may occur in some houses with properly designed and constructed footings, if reactive clay sites have been subject to large changes of moisture. Cracks larger than 5 mm are regarded as significant damage.

Further information on these topics is given in the following sections. The guide has been updated to be consistent with the revised edition of AS 2870 which was published in 1989.

2. SITE CLASSIFICATION

AS 2870 requires all sites to be classified by an engineer or the builder. The emphasis has been placed on reactive clays that swell and shrink with changes of moisture content because these are the most common cause of problems. The classification system is fairly complicated but, as a general guide, the following may be helpful in understanding the system for clay sites.

S	Clays that have not given trouble in the past.
M	Moderately reactive clays that may cause minor damage to brick houses on old-style light strip footings. Moderately reactive clays are common and occur, for example, in eastern Melbourne and western Sydney.
H	Highly reactive clays that often damage houses, paths and fences. Examples occur in northern and western Melbourne and in parts of Adelaide.
E	Extremely reactive clays that frequently damage houses even with strong footings. No examples occur in major cities except Adelaide. Other occurrences include outback NSW, Darling Downs and Horsham.

Since the precautions necessary depend on the reactivity of the site, the owner should check the classification that is shown on the house plans.

The maintenance of the building and the site is the responsibility of the owner, and so the owner should be familiar with the requirements of this guide.

3. CARE OF CLAY FOUNDATIONS

All clays move with changes of moisture content, so the aim is to minimise such changes in the clay by

- draining the site;
- keeping gardens and trees away from the house;
- adequate but moderate garden watering; and
- repairing plumbing leaks.

On a reactive-clay site there are some restrictions on the way the owner can develop the garden around the house. These restrictions apply mainly to brick houses. In most cases, only minimal precautions are justified for framed houses clad with timber or sheeting.

The site must be well drained. Under no circumstances should water be allowed to lie against the house or even near the house. The ground immediately next to the

CSIRO Division of Building, Construction and Engineering, P.O. Box 56, Highett, Victoria 3190, Australia.

Telephone: (03) 556 2211

ISSN 0314-5956.

house should be graded away with a slope of about 50 mm over the first metre. Suitable surface drains should be provided to take the surface water away from the house. Where topsoil is brought in, it should not interfere with the site drainage, nor should it raise the ground level enough to block the weepholes in the brick walls or any subfloor vents.

Large garden beds are best not located near the house. This will avoid the possibility of introducing too much moisture to the foundation clay by over watering. The zone near the house should be planned for paths or covered with gravel and plastic sheeting. Small shrubs may be planted at reasonable spacings.

Gardens and lawns should be watered adequately but not excessively. Uniform, consistent watering can be important to prevent damage to the foundation during dry spells such as droughts or dry summers.

Trees and large shrubs require substantial amounts of water, and if the soil near the tree dries out, the roots will extend in search of soil moisture. Tree watering is important in late summer and in drought. The use of slow drip watering systems may be appropriate. It has also been found useful to drill holes near trees and fill them with gravel to allow water better access to the tree roots. Otherwise, clays will shrink as they dry, and a house may settle as shown below.

Removal of large trees creates the opposite problem. As soil moisture is gradually restored, clays swell and may lift shallow footings.

Many factors determine the extent of clay drying by trees, and the more important include the soil type, the size and number of trees, and their species. Trees obtain moisture from roots that spread sideways and the drying zone is influenced by the extent of these roots. For single trees, the drying zone is usually one-half to twice the tree height, but the zone may be larger for groups or rows of trees. Although it is known that the species can influence the extent and severity of the drying zone, little definite information is available. Some Australian trees are particularly efficient in extracting water from very dry soils and can be more dangerous than non-Australian species that use large amounts of water in normal conditions. The effect of tree drying on the amount of movement is also related to the reactivity of the clay. To minimise the risk of damage, trees (especially groups of trees) should not be planted near the house on a reactive clay site, and the following limits are recommended.

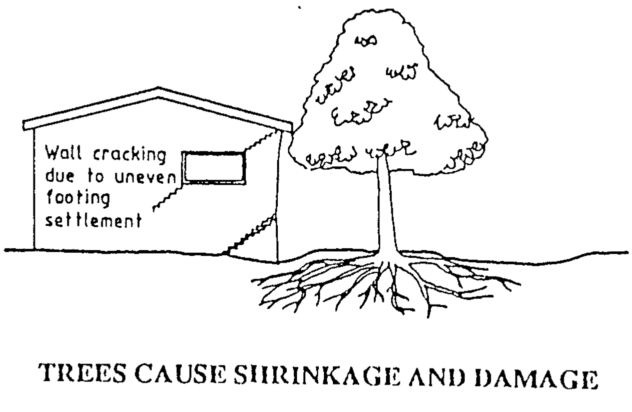
d = 1 1/2 h for Class E sites
d = 1 h for Class H sites
d = 3/4 h for Class M sites

where d is the distance of the tree from the house, and h is the eventual mature height of the tree. These values should be increased by 50% if the trees are in a dense group. These rules mean that on the average suburban block, trees that grow higher than 8 to 9 m are often impractical unless the owner accepts the risk of some damage to the house. If large trees are desired, it may be practical to adopt a specially designed footing system, e.g., a piled footing system.

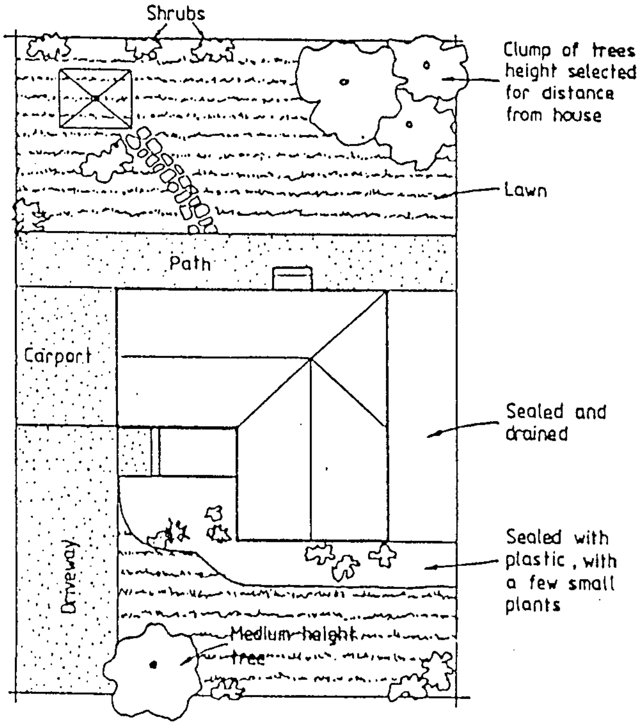
A leak in the plumbing can cause the footings of a house on a reactive clay to move. The water seeps into the clay causing it to swell and push the footing system upwards. Any obvious leaks in stormwater, drainage, or sewerage pipes should be investigated. Leaking water pipes can be detected by turning off all the taps and checking if the water meter records any flow.

The above restrictions may seem onerous for new home owners, but lack of site maintenance on a reactive clay can cause damage to the house. Still, the whole issue should be kept in some perspective. The damage to houses caused by reactive clays is mostly unsightly cracks in the brickwork. In the typical Australian brick-veneer house, the brickwork does not support the structure. It is the timber frame that carries the walls and roof loads, so brick cracks do not affect the structural safety of the house.

If owners choose to disregard some of the above restrictions and, say, plant large trees all around the house, they should not blame the builder, the engineer, or the Council if the house suffers some cracking.



TREES CAUSE SHRINKAGE AND DAMAGE



GARDENS FOR REACTIVE SITES

4. PERFORMANCE OF FOOTING SYSTEMS

All building materials move. Concrete and timber shrink, bricks grow, and so on. Many building practices have been evolved to reduce the damage that such movements cause, and the minor difficulties that arise are usually repaired without significant problems.

The footing of a house is more likely to move on reactive clays. Some house walls may be more sensitive than usual, and may crack even though the footing system has performed its design task. Such cracking must be expected occasionally and this is expressed in the performance requirements of AS 2870 (see Appendix A).

The performance requirement of AS 2870 suggests that Category 0 to 1 damage may be expected for houses on a reactive-clay site, but that the damage is of little consequence. Category 2 is clearly not satisfactory (isolated cracks up to 5 mm wide), but it still does not constitute significant failure and could be expected to occur under adverse conditions for the occasional house.

For these categories of damage, it is the intention of AS 2870 that consequent repairs are part of the normal house maintenance and are therefore the responsibility of the owner.

Nonetheless, to ensure that the damage does not proceed to a more serious state, the owner should take some action.

(a) Check that the recommendations on site treatment, drainage, garden arrangement, trees etc., have been observed.

(b) Keep a record of the crack width against the time of the year. If the damage is as high as Category 2 and seems to be increasing, the owner should consult the builder who may be able to offer more specific advice. If this does not prove satisfactory, the owner should engage a consulting engineer who specialises in house footings.

(c) Engage a plumber to check for leaks if this is suspected to be the cause.

(d) Replace soil mositure in dry spells by watering. Such watering can be more effective if holes or trenches are dug into the clay. The holes or trenches should be filled with compacted crushed rock or gravel and moderately watered. Some trees may need to be removed or kept pruned.

Complete stability is difficult to achieve, so repairs to damaged walls should include methods that will disguise further movements. Extra joints should be included in external masonry walls and further cracking in internal walls can be concealed by flexible paints, wall paper, or panelling. Repairing of cracks with brittle fillers should be avoided unless the cracks have stabilised.

For the more serious categories of damage, the steps to be taken are similar, except that there should be little delay in seeking advice. Remedial action for significant failure may still only include attention to stabilising moisture conditions as described above, but could also involve constructing a concrete wall in the ground to stop drying of the foundation clay. Underpinning is usually not satisfactory in reactive clays.

Experience indicates that lack of maintenance is responsible for many failures. Even with proper design and site maintenance the occasional failure may still occur because footing behaviour is so complex.

5. SHRINKAGE OF CONCRETE FLOORS

Concrete needs water. Firstly to allow the fresh concrete to flow and, secondly, to develop strength during its first few weeks. As a slab starts to dry, it shrinks and tries to contract. Some of this movement is restrained or resisted by friction on the bottom of the slab and by the beams in the ground. This restraint causes tension or stretching forces in the slab and these forces are often large enough to crack the slab.

Shrinkage cracking is almost inevitable and does not represent failure. Most owners never notice the cracks because they often do not occur until after the carpets are laid. Cracks under brittle or sensitive floor coverings are of concern but the risk of damage can be reduced by using flexible mortars and glues for fixing slate and tiles, etc. Also it helps to delay installing the floor covering until after the shrinkage has occurred. The length of delay should be at least three months after the slab has started to dry (i.e. from the time the slab is last wet from rain or during construction.

6. ADHESIVE-FIXED FLOOR COVERINGS

A concrete slab takes a long time to dry. For example, under temperate conditions a slab will take about three months to dry. Moisture in the concrete can interfere with the bond or break down the adhesive used to attach floor coverings. However, a range of adhesives is available for various floor coverings and these should perform quite well on slabs that have been allowed to dry sufficiently.

7. CONCLUSION

This guide has been prepared to advise owners on how to care for the foundation of their houses and what to expect from a well-designed footing system. The main concern with foundation maintenance is to prevent the foundation soil becoming too wet or too dry, and a variety of recommendations are given to achieve this.

Additional information may be found in the following reports which are available from their publishers.

CSIRO (1985). 'House Cracking in Drought Periods', CSIRO Australia Information Sheet No. 10-88. Division of Building Research.

Cameron, D.A. and Earl, I. (1982). Trees and Houses: A Question of Function. Cement and Concrete Association, Melbourne.

Martin, K.G., Lewis, R.K., Palmer, R.E. and Walsh, P.F. (1983). Floor Coverings on Concrete Slab-on-ground. CSIRO Australia Division of Building Research Report.

Cameron, D.A. and Walsh, P.F. (1984). Damage to Buildings on Clay Soils. National Trust Technical Bulletin 5.1.

Appendix B

Borehole Logs

NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

GEOTECHNICAL & ENVIRONMENTAL

BOREHOLE B1

PROJECT: NORTH SYDNEY BOYS HIGH SCHOOL
DATE: 6/6/01
LOCATION: NORTH SYDNEY
SURFACE RL: 80.9m AHD approx.
CONTRACTOR: SAXON
DRILLER: P. CLOSE
RIG TYPE: EXPLORER X2

DEPTH (m)	WATER	BIT	SAMPLE or TEST	SOIL GROUP	GRAPHIC LOG	SOIL DESCRIPTION Soil type, colour, consistency, grainsize, moisture, remarks	
0	No Groundwater Encountered	Vee		FILL	▨	**BITUMEN**	0.05
				FILL	▨	**ROADBASE;** gravelly sand; black; dry.	0.30
				CI/CH (v)	☰	**SILTY CLAY;** yellow-brown with orange-brown mottle; soft to firm; moist.	0.80
1			SPT 2,7,11 N : 18	ML (v)	⁙	**CLAYEY SILT** with some fine sand; light grey with yellow-brown and orange-brown mottle; stiff; moist. - sand content decreasing below 1.65m depth.	1.80
				ROCK	⁄	**SILTSTONE;** extremely weathered; extremely weak; behaves as clayey silt/silty clay; light grey with red mottle (Fe-stained).	END at 1.90
2						Vee Bit refusal at 1.9m depth.	
3							
4							

SAMPLE OR TEST
U........Undisturbed
D........Disturbed
SPT....Standard Penetration Test
CPT....Cone Penetration Test

v : visual
l : laboratory

WATER
▼ Water Table
➤ Water Inflow

DRILLING SUPERVISOR: P. ANDERSON
PROJECT COORDINATOR: P. SHUN
SHEET 1 OF 1 SHEETS
SCALE 1 :20

NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

GEOTECHNICAL & ENVIRONMENTAL

BOREHOLE B2

PROJECT: **NORTH SYDNEY BOYS HIGH SCHOOL**
DATE: **6/6/01**
LOCATION: **NORTH SYDNEY**
SURFACE RL: **82.1m AHD approx.**
CONTRACTOR: **SAXON**
DRILLER: **P. CLOSE**
RIG TYPE: **EXPLORER X2**

DEPTH (m)	WATER	BIT	SAMPLE or TEST	SOIL GROUP	GRAPHIC LOG	SOIL DESCRIPTION Soil type, colour, consistency, grainsize, moisture, remarks
0 – 0.40	No Groundwater Encountered	Vee		FILL		**SANDY SILT/ SILTY SAND with pieces of brick, fibro, glass and plastic; dark grey-brown; poorly compacted; just moist.** 0.40
0.40 – 0.80			U D	CI/CH (v)		**SILTY CLAY; yellow-brown; firm; moist.** 0.80
0.80 – 1.40			SPT 9,15,20 N = 35	ML (v)		**CLAYEY SILT with some fine sand; light grey with yellow-brown mottle; stiff; moist.** **- grading to extremely weathered siltstone.** 1.40
1.40 – 1.80				ROCK		**SILTSTONE; extremely weathered; extremely weak; light grey with yellow-brown and red mottle (Fe-stained).** END at 1.80
1.80 – 4						**Vee bit refusal at 1.8m depth.**

SAMPLE OR TEST
U........Undisturbed
D........Disturbed
SPT....Standard Penetration Test
CPT....Cone Penetration Test

v : visual
l : laboratory

WATER
▼ Water Table
➤ Water Inflow

DRILLING SUPERVISOR: **P. ANDERSON**
PROJECT COORDINATOR: **P. SHUN**
SHEET **1** OF **1** SHEETS
SCALE **1 :20**

NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

GEOTECHNICAL & ENVIRONMENTAL

BOREHOLE B3

PROJECT: **NORTH SYDNEY BOYS HIGH SCHOOL**
DATE: **6/6/01**
LOCATION: **NORTH SYDNEY**
SURFACE RL: **81.6m AHD approx.**
CONTRACTOR: **SAXON**
DRILLER: **P. CLOSE**
RIG TYPE: **EXPLORER X2**

DEPTH (m)	WATER	BIT	SAMPLE or TEST		SOIL GROUP	GRAPHIC LOG	SOIL DESCRIPTION Soil type, colour, consistency, grainsize, moisture, remarks	
0	No Groundwater Encountered	Vee			FILL		**TOPSOIL - SANDY CLAYEY SILT with some gravel, grass roots and tree roots; dark brown; soft; moist.**	**0.40**
			D		FILL		**SANDY SILTY CLAY with piece of concrete (0.4x0.2m), rio, terracotta tile; grey to dark grey with white mottle; poorly compacted; moist.**	**1.30**
1			U		CI/CH (v)		**SILTY CLAY; yellow-brown and orange-brown; firm; moist.**	**1.55**
			SPT	8,15,- N = R	ML (v)		**CLAYEY SILT; light grey with red and orange-brown mottle; stiff; moist.**	**2.00**
2					ROCK		**SILTSTONE; extremely weathered; extremely weak; light grey with red and orange-brown mottle (Fe-stained).**	**END at 2.30**
							Vee Bit refusal at 2.3m depth.	
3								
4								

SAMPLE OR TEST
U........Undisturbed
D........Disturbed
SPT....Standard Penetration Test
CPT....Cone Penetration Test

v : visual
l : laboratory

WATER
Water Table
Water Inflow

DRILLING SUPERVISOR: **P. ANDERSON**
PROJECT COORDINATOR: **P. SHUN**
SHEET 1 OF 1 SHEETS
SCALE 1 :20

NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES **GEOTECHNICAL & ENVIRONMENTAL**

BOREHOLE B4

PROJECT: **NORTH SYDNEY BOYS HIGH SCHOOL**
DATE: **6/6/01**
LOCATION: **NORTH SYDNEY**
SURFACE RL: **82.3m AHD approx.**
CONTRACTOR: **SAXON**
DRILLER: **P. CLOSE**
RIG TYPE: **EXPLORER X2**

DEPTH (m)	WATER	BIT	SAMPLE or TEST	SOIL GROUP	GRAPHIC LOG	SOIL DESCRIPTION Soil type, colour, consistency, grainsize, moisture, remarks
0	No Groundwater Encountered	Vee		FILL	▩	**SANDY SILT** with piece of terracotta tile and glass; dark brown and grey-brown; poorly compacted; moist. 0.60
				CI/CH (v)	☰	**SILTY CLAY;** yellow-brown; firm; moist. 1.00
1			SPT 5,4,13 N : 17	ML (v)	⋯	**CLAYEY SILT** with fine sand; light grey with yellow-brown mottle; stiff; moist. END at 1.65
						Vee Bit refusal at 1.65m depth.
2						
3						
4						

SAMPLE OR TEST
U........Undisturbed
D........Disturbed
SPT....Standard Penetration Test
CPT....Cone Penetration Test

v : visual
l : laboratory

WATER
▼ Water Table
➤ Water Inflow

DRILLING SUPERVISOR: **P. ANDERSON**
PROJECT COORDINATOR: **P. SHUN**
SHEET 1 OF 1 SHEETS
SCALE 1 :20

g:\ls\watertec\geotech\pcad\borelogs\gg13a.dgn - 23-Jul-01 09:49

NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

GEOTECHNICAL & ENVIRONMENTAL

BOREHOLE B5

PROJECT: **NORTH SYDNEY BOYS HIGH SCHOOL**
DATE: **6/6/01**
LOCATION: **NORTH SYDNEY**
SURFACE RL: **81.6m AHD approx.**
CONTRACTOR: **SAXON**
DRILLER: **P. CLOSE**
RIG TYPE: **EXPLORER X2**

DEPTH (m)	WATER	BIT	SAMPLE or TEST	SOIL GROUP	GRAPHIC LOG	SOIL DESCRIPTION Soil type, colour, consistency, grainsize, moisture, remarks
0	No Groundwater Encountered	Vee		FILL	▩	**TOPSOIL - CLAYEY SILT with some sand, gravel, grass roots and tree roots;** **dark grey/grey-brown; soft to firm; moist** **-sand content increasing at 0.5m.** 0.90
1			SPT 2,2,2 N : 4	CH (v)	▥	**SILTY CLAY;** **yellow-brown; soft to firm; moist.** 1.80
2				ML (v)	░	**CLAYEY SILT with some fine sand;** **light grey with red mottle;** **stiff; just moist to dry.** END at 2.80
3 4						**Vee Bit refusal at 2.8m depth.**

SAMPLE OR TEST
U........Undisturbed
D........Disturbed
SPT....Standard Penetration Test
CPT....Cone Penetration Test

v : visual
l : laboratory

WATER
Water Table
Water Inflow

DRILLING SUPERVISOR: **P. ANDERSON**
PROJECT COORDINATOR: **P. SHUN**
SHEET **1** OF **1** SHEETS
SCALE **1 :20**

NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

GEOTECHNICAL & ENVIRONMENTAL

BOREHOLE B6

PROJECT: **NORTH SYDNEY BOYS HIGH SCHOOL**
DATE: **6/6/01**
LOCATION: **NORTH SYDNEY**
SURFACE RL: **82.2m AHD approx.**
CONTRACTOR: **SAXON**
DRILLER: **P. CLOSE**
RIG TYPE: **EXPLORER X2**

DEPTH (m)	WATER	BIT	SAMPLE or TEST	SOIL GROUP	GRAPHIC LOG	SOIL DESCRIPTION Soil type, colour, consistency, grainsize, moisture, remarks
0	No Groundwater Encountered	Vee		FILL	▨	**TOPSOIL - CLAYEY SILT;** **dark grey and black; soft to firm; moist.** **0.35**
				CH (v)		**SILTY CLAY with trace sand;** **yellow-brown with red mottle; firm; moist.** **0.80**
1			SPT 2,13,- N : R	ML (v)		**CLAYEY SILT with some fine sand;** **yellow-brown with light grey and red mottle;** **stiff; moist.** **- becoming light grey with yellow-brown mottle;** **just moist.** **1.60**
				ML (v)		**CLAYEY SILT;** **light grey with red mottle (Fe-stained); stiff; just moist.** **END at 1.90**
2						**Vee Bit refusal at 1.9m depth.**
3						
4						

SAMPLE OR TEST
U........Undisturbed
D........Disturbed
SPT....Standard Penetration Test
CPT....Cone Penetration Test

v : visual
l : laboratory

WATER
Water Table
Water Inflow

DRILLING SUPERVISOR: **P. ANDERSON**
PROJECT COORDINATOR: **P. SHUN**
SHEET **1** OF **1** SHEETS
SCALE **1 :20**

g:\is\watertec\geotech\pcad\borelogs\gg13a.dgn - 23-Jul-01 09:49

NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

GEOTECHNICAL & ENVIRONMENTAL

BOREHOLE B7

PROJECT: NORTH SYDNEY BOYS HIGH SCHOOL
DATE: 6/6/01
LOCATION: NORTH SYDNEY
SURFACE RL: 83.3m AHD approx.
CONTRACTOR: SAXON
DRILLER: P. CLOSE
RIG TYPE: EXPLORER X2

DEPTH (m)	WATER	BIT	SAMPLE or TEST	SOIL GROUP	GRAPHIC LOG	SOIL DESCRIPTION Soil type, colour, consistency, grainsize, moisture, remarks	
0				FILL		BITUMEN	0.01
						ROADBASE	0.05
				CI/CH (v)		SILTY CLAY with trace fine sand; dark yellow-brown; firm to stiff; moist.	
1		Vee	SPT 3,4,5 N : 9			- becoming mottled orange-brown and red.	
							1.90
2	➤			ML (v)		CLAYEY SILT with some fine sand; light grey with orange-brown mottle; firm; moist.	2.29
						Vee Bit refusal at 2.3m depth. Seepage at approximately 2.0m depth.	
3							
4							

SAMPLE OR TEST
U........Undisturbed
D........Disturbed
SPT....Standard Penetration Test
CPT....Cone Penetration Test

v : visual
l : laboratory

WATER
▼ Water Table
➤ Water Inflow

DRILLING SUPERVISOR: P. ANDERSON
PROJECT COORDINATOR: P. SHUN
SHEET 1 OF 1 SHEETS
SCALE 1 :20

g:\ls\watertec\geotech\pcad\borelogs\gg13a.dgn - 23-Jul-01 09:49

NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES **GEOTECHNICAL & ENVIRONMENTAL**

BOREHOLE B8

PROJECT: **NORTH SYDNEY BOYS HIGH SCHOOL**
DATE: **6/6/01**
LOCATION: **NORTH SYDNEY**
SURFACE RL: **82.5m AHD approx.**
CONTRACTOR: **SAXON**
DRILLER: **P. CLOSE**
RIG TYPE: **EXPLORER X2**

DEPTH (m)	WATER	BIT	SAMPLE or TEST	SOIL GROUP	GRAPHIC LOG	SOIL DESCRIPTION Soil type, colour, consistency, grainsize, moisture, remarks
0	No Groundwater Encountered	Vee		FILL	▦	**TOPSOIL - SANDY CLAYEY SILT;** **dark grey-brown; soft to firm; moist.** **0.30**
			SPT 2,2,4 N = 6	CH (v)	▥	**SILTY CLAY with trace gravel;** **yellow-brown with some red mottle; firm; moist.** **1.20**
1				ML (v)	⁙	**CLAYEY SILT with some tree roots;** **light grey with yellow-brown and red mottle; firm to stiff; moist.** **1.80**
2				ML (v)	⁙	**CLAYEY SILT;** **light grey with red mottle (Fe-stained);** **stiff; just moist to dry.** **END at 2.15**
3						**Vee Bit refusal at 2.15m depth.**
4						

SAMPLE OR TEST
U........Undisturbed
D........Disturbed
SPT....Standard Penetration Test
CPT....Cone Penetration Test

v : visual
l : laboratory

WATER
Water Table
Water Inflow

DRILLING SUPERVISOR: **P. ANDERSON**
PROJECT COORDINATOR: **P. SHUN**
SHEET **1** OF **1** SHEETS
SCALE **1 :20**

NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

GEOTECHNICAL & ENVIRONMENTAL

BOREHOLE B9

PROJECT: **NORTH SYDNEY BOYS HIGH SCHOOL** DATE: **6/6/01**
LOCATION: **NORTH SYDNEY** SURFACE RL: **81.8m AHD approx.**
CONTRACTOR: **SAXON** DRILLER: **P. CLOSE** RIG TYPE: **EXPLORER X2**

DEPTH (m)	WATER	BIT	SAMPLE or TEST	SOIL GROUP	GRAPHIC LOG	SOIL DESCRIPTION Soil type, colour, consistency, grainsize, moisture, remarks
0			D	FILL		**TOPSOIL - SANDY CLAYEY SILT with gravel and coke/ash; dark grey-brown; soft to firm; moist.** **0.45**
			U D	CH (v)		**SILTY CLAY (FILL?); grey-brown and yellow-brown; soft to firm; moist.** **1.30**
1	➤					
		Vee	SPT 5,3,3 N = 6	ML (v)		**CLAYEY SILT with some fine sand; light grey with red and yellow-brown mottle; firm to stiff; moist.** **2.65**
2						
				ML (v)		**CLAYEY SILT with some fine sand; light grey with red mottle; stiff; just moist.** **END at 3.00**
3						**Seepage at approximately 1.2m depth.**
4						

SAMPLE OR TEST
U........Undisturbed
D........Disturbed
SPT....Standard Penetration Test
CPT....Cone Penetration Test

v : visual
l : laboratory

WATER
▼ Water Table
➤ Water Inflow

DRILLING SUPERVISOR: **P. ANDERSON**
PROJECT COORDINATOR: **P. SHUN**
SHEET **1** OF **1** SHEETS
SCALE **1 :20**

g:\ls\watertec\geotech\pcad\borelogs\gg13a.dgn - 23-Jul-01 11:38

NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES **GEOTECHNICAL & ENVIRONMENTAL**

BOREHOLE B10

PROJECT: **NORTH SYDNEY BOYS HIGH SCHOOL**
DATE: **6/6/01**
LOCATION: **NORTH SYDNEY**
SURFACE RL: **82.2m AHD approx.**
CONTRACTOR: **SAXON**
DRILLER: **P. CLOSE**
RIG TYPE: **EXPLORER X2**

DEPTH (m)	WATER	BIT	SAMPLE or TEST	SOIL GROUP	GRAPHIC LOG	SOIL DESCRIPTION Soil type, colour, consistency, grainsize, moisture, remarks
0	No Groundwater Encountered	Vee		FILL	▨	**TOPSOIL -SANDY CLAYEY SILT with some gravel and grass roots;** **grey-brown; firm; moist.** 0.20
				FILL	▨	**CLAYEY SILT with pieces of broken tile;** **light grey-brown; poorly compacted; moist.** 0.70
				FILL	▨	**SILTY CLAY;** **yellow-brown with light grey; firm; moist.** 0.90
1			SPT 4,3,3 N = 6	FILL	▨	**SANDY SILT with gravel, coke/ash and slag;** **black with light grey slag; firm; moist.** 1.60
2				ML (v)	⋯	**CLAYEY SILT with some fine sand and gravel;** **light grey with red and yellow-brown mottle;** **firm to stiff; moist.** 2.40
				ML (v)	⋯	**CLAYEY SILT;** **light grey with red mottle; stiff; dry to just moist.** END at 3.00
3						
4						

SAMPLE OR TEST
U........Undisturbed
D........Disturbed
SPT....Standard Penetration Test
CPT....Cone Penetration Test

v : visual
l : laboratory

WATER
▼ Water Table
➤ Water Inflow

DRILLING SUPERVISOR: **P. ANDERSON**
PROJECT COORDINATOR: **P. SHUN**
SHEET **1** OF **1** SHEETS
SCALE **1 :20**

g:\ls\watertec\geotech\pcad\borelogs\gg13a.dgn - 23-Jul-01 09:50

NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES

GEOTECHNICAL & ENVIRONMENTAL

BOREHOLE B11

PROJECT: **NORTH SYDNEY BOYS HIGH SCHOOL**
DATE: **6/6/01**
LOCATION: **NORTH SYDNEY**
SURFACE RL: **82.9m AHD approx.**
CONTRACTOR: **SAXON**
DRILLER: **P. CLOSE**
RIG TYPE: **EXPLORER X2**

DEPTH (m)	WATER	BIT	SAMPLE or TEST	SOIL GROUP	GRAPHIC LOG	SOIL DESCRIPTION Soil type, colour, consistency, grainsize, moisture, remarks	
0	No Groundwater Encountered	Vee	D	FILL		**TOPSOIL - SANDY CLAYEY SILT with grass roots; dark grey-brown; soft to firm; moist.**	0.30
1			SPT 2,2,3 N : 5	CH (v)		**SILTY CLAY; yellow-brown; firm; moist.**	1.40
				ML (v)		**SILTY CLAY/ CLAYEY SILT with trace fine sand; light grey with yellow-brown and red mottle; firm; moist.**	2.05
2				ML (v)		**CLAYEY SILT with trace fine sand; light grey with red mottle; firm to stiff; dry.**	2.54
3						**Vee Bit refusal at 2.55m depth.**	
4							

SAMPLE OR TEST
U........Undisturbed
D........Disturbed
SPT....Standard Penetration Test
CPT....Cone Penetration Test

v : visual
l : laboratory

WATER
Water Table
Water Inflow

DRILLING SUPERVISOR: **P. ANDERSON**
PROJECT COORDINATOR: **P. SHUN**
SHEET **1** OF **1** SHEETS
SCALE **1 :20**

NSW DEPARTMENT OF PUBLIC WORKS AND SERVICES **GEOTECHNICAL & ENVIRONMENTAL**

BOREHOLE B12

PROJECT: **NORTH SYDNEY BOYS HIGH SCHOOL**
DATE: **6/6/01**
LOCATION: **NORTH SYDNEY**
SURFACE RL: **79.9m AHD approx.**
CONTRACTOR: **SAXON**
DRILLER: **P. CLOSE**
RIG TYPE: **EXPLORER X2**

DEPTH (m)	WATER	BIT	SAMPLE or TEST		SOIL GROUP	GRAPHIC LOG	SOIL DESCRIPTION Soil type, colour, consistency, grainsize, moisture, remarks	
0	No Groundwater Encountered	Vee			FILL	▩	**TOPSOIL - SANDY CLAYEY SILT;** dark grey-brown; soft to firm; moist.	0.20
					CI/MI (v)	▤	**SANDY CLAYEY SILT;** grey-brown and yellow-brown; firm; moist.	0.55
1			SPT	3,4,5 N = 9	ML (v)	▒	**CLAYEY SILT with some fine sand;** light grey with yellow-brown mottle; firm to stiff; moist. - some tree roots in SPT sample.	1.60
					ML (v)	▒	**CLAYEY SILT;** light grey with red mottle (Fe- stained); stiff; just moist to dry.	2.04
2							Vee Bit refusal at 2.05m.	
3								
4								

SAMPLE OR TEST
U........Undisturbed
D........Disturbed
SPT....Standard Penetration Test
CPT....Cone Penetration Test

v : visual
l : laboratory

WATER
▼ Water Table
➤ Water Inflow

DRILLING SUPERVISOR: **P. ANDERSON**
PROJECT COORDINATOR: **P. SHUN**
SHEET **1** OF **1** SHEETS
SCALE **1 :20**

g:\is\watertec\geotech\pcad\borelogs\gg13a.dgn - 23-Jul-01 09:50

Appendix C

Results of Geotechnical Testing

Geotechnical Centre
Unit W4K, 42 Wattle St, ULTIMO, NSW 2007
Telephone 02- 9552 4864 Facsimile 02-9552 3615

NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

CLIENT:	DPWS GEOTECHNICAL ENVIRONMENTAL	BATCH No:	01031

SOIL SUMMARY SHEET

PROJECT:	North Sydney Boy's High School	COMPILED BY:	ZG
LOCATION:	Carpark and Sports Courts	DATE:	02/07/2001

General Information

Note: All test methods are as indicated on accompanying test reports.

Sample No.	**4779**	**4780**	**4781**	**4789**		
Bore/Reference	B2	B2	B3	B9		
Depth (m)	0.6 - 0.9	0.6 - 0.87	0.8 - 1.3	0.7 - 1.1		
Sample Type	Bulk	U	Bulk	U		
Soil Colour & Description	Yellow Brown Silty Clay with Sand	Yellow Brown Silty Clay with Sand	Grey Brown Sandy Silty Clay	Yellow Brown Silty Clay with Sand		
Unified Classification	CI (l)	CI (v)	CL (l)	CH (v)		

Moisture Content & Density

Field Moisture Content (%)	21.6	23.0	20.4	25.2		
Field Wet Density (t/m³)		2.02		1.99		
Field Dry Density (t/m³)		1.63		1.59		
Soil Particle Density (t/m³)						

Particle Size Distribution

Cobble Size (%)	0		0			
Gravel Size (%)	3		2			
Sand Size (%)	28		42			
Silt Size (%)	18		19			
Clay Size (%)	51		37			
Effective Size (mm)						
Uniformity Coefficient						
Curvature Coefficient						

Plasticity

Liquid Limit (%)	47		33	51		
Plastic Limit (%)	17		15	18		
Plasticity Index (%)	30		18	33		
Linear Shrinkage (%)	13.5		10.0	14.5		

Dispersion

Dispersal Index						
Percent Dispersion (%)						
Emerson Class No.						

Compaction

Compaction Type	STD		STD			
Optimum Moisture Content (%)	18.5		15.5			
Maximum Dry Density (t/m³)	1.70		1.79			

California Bearing Ratio

Placement Moisture Content (%)	18.8		15.7			
Placement Dry Density (t/m³)	1.72		1.80			
Swell under 4.5kg Surcharge (%)	0.1		0.2			
C.B.R. at 2.5% Penetration (%)	5.0		5.0			
C.B.R. at 5.0% Penetration (%)	4.5		5.0			

Geotechnical Centre
Unit W4K, 42 Wattle Street, ULTIMO NSW 2007
Telephone 02 9552 4864 Facsimile 02 9552 3615

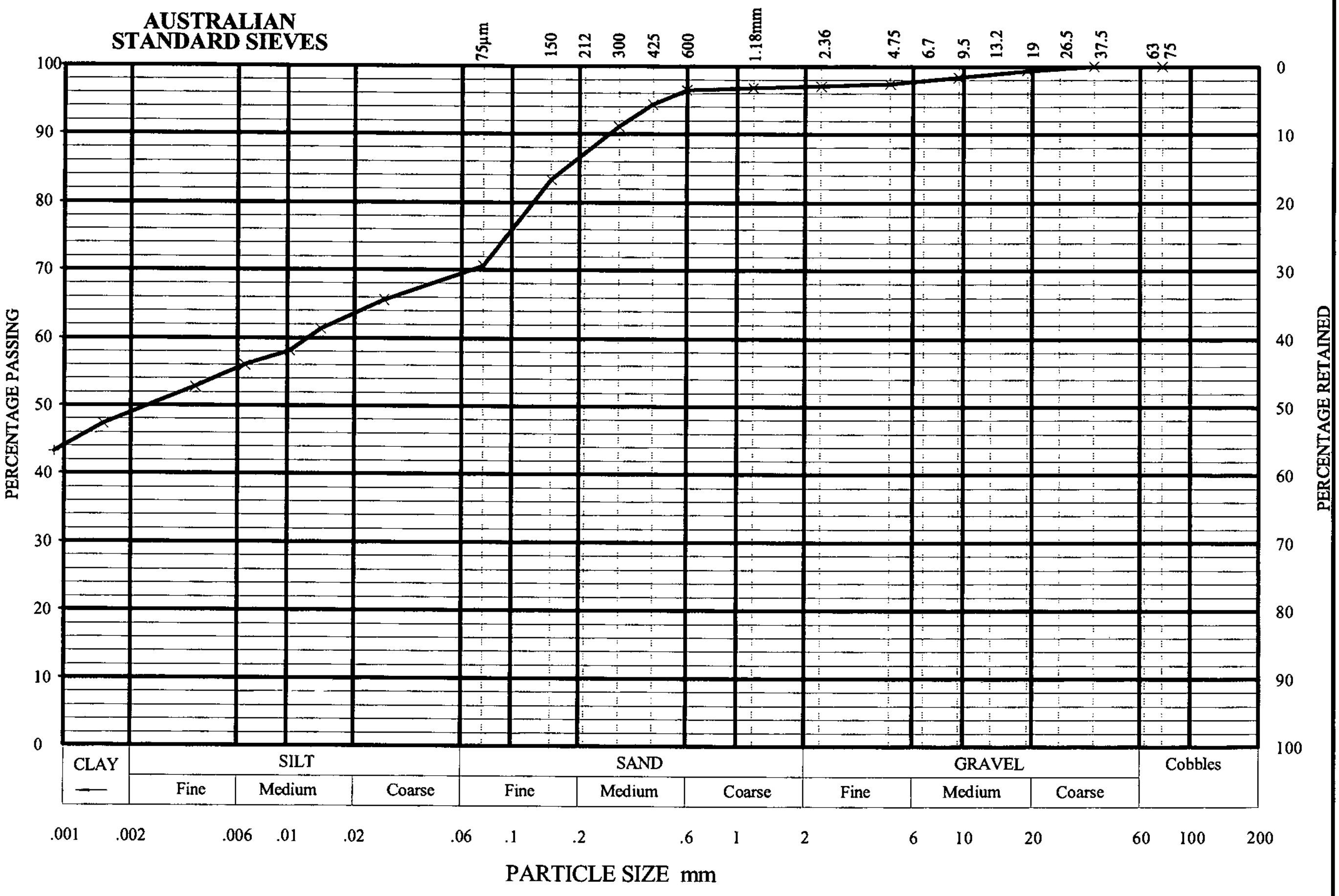
NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

CLIENT: DPWS GEOTECHNICAL ENVIRONMENTAL | REPORT No: 01031/4779/R1119

PARTICLE SIZE DISTRIBUTION

PROJECT: North Sydney Boy's High School | SAMPLE No: 4779

LOCATION: Carpark and Sports Courts | HOLE No: B2 | DEPTH (m): 0.6



SIZE DISTRIBUTION

COBBLES	0 %
GRAVEL	3 %
SAND	28 %
SILT	18 %
CLAY	51 %
EFFECTIVE SIZE D10:	-
UNIFORMITY COEFFICIENT D60/D10(Cu):	-
CURVATURE COEFFICIENT $D30^2$ /(D60 x D10) (Cc):	-

Soil Particle Density: 2.65 t/m^3 (estimated for analysis)

Loss in pre-treatment: 0 %

Method of dispersion: End-over-end shaking

Hydrometer: ASTM 152H

Dispersion chemical: Sodium hexametaphosphate
+ Anhydrous sodium carbonate

Notes on Test: Sample tested as received from client

Test Methods:
DPWS GM 9: Determination of the Particle Size Distribution of a Soil

NATA Accredited Laboratory
Number: 13380
NATA endorsed test report.
This document shall not be
reproduced, except in full.

APPROVED SIGNATORY

DATE 2-7-2001

Geotechnical Centre

Unit W4K, 42 Wattle Street, ULTIMO NSW 2007

Telephone 02 9552 4864 Facsimile 02 9552 3615

NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

CLIENT: DPWS GEOTECHNICAL ENVIRONMENTAL

REPORT No: 01031/4779/R1115

SOIL INDEX PROPERTIES

PROJECT: North Sydney Boy's High School

SAMPLE No: 4779

LOCATION: Carpark and Sports Courts

HOLE No: B2

DEPTH (m): 0.6

SOIL INDEX PROPERTIES	RESULT	TEST METHOD
Moisture Content (as received)	: 21.6 %	AS 1289.2.1.1
Liquid Limit	: 47 %	AS 1289.3.1.1
Plastic Limit	: 17 %	AS 1289.3.2.1
Plasticity Index	: 30 %	AS 1289.3.3.1
Linear Shrinkage	: 13.5 %	AS 1289.3.4.1
Soil Particle Density	: -	AS 1289.3.5.1
Classification	: CI (1)	AS 1726

Sample History: ☐ Natural State ☒ Air Dried ☐ Oven Dried

Method of Preparation: ☐ Wet Sieved ☒ Dry Sieved

Linear Shrinkage Sample: ☒ Curling ☐ Crumbling

Notes on test: Sample tested as received from client.

NATA Accredited Laboratory
Number: 13380
NATA endorsed test report.
This document shall not be
reproduced, except in full.

APPROVED SIGNATORY

DATE 2-7-2001

ATTERBERG LIMITS R1115 (ISSUE 2, 1998)

Geotechnical Centre

Unit W4K, 42 Wattle Street, ULTIMO NSW 2007

Telephone 02 9552 4864 Facsimile 02 9552 3615

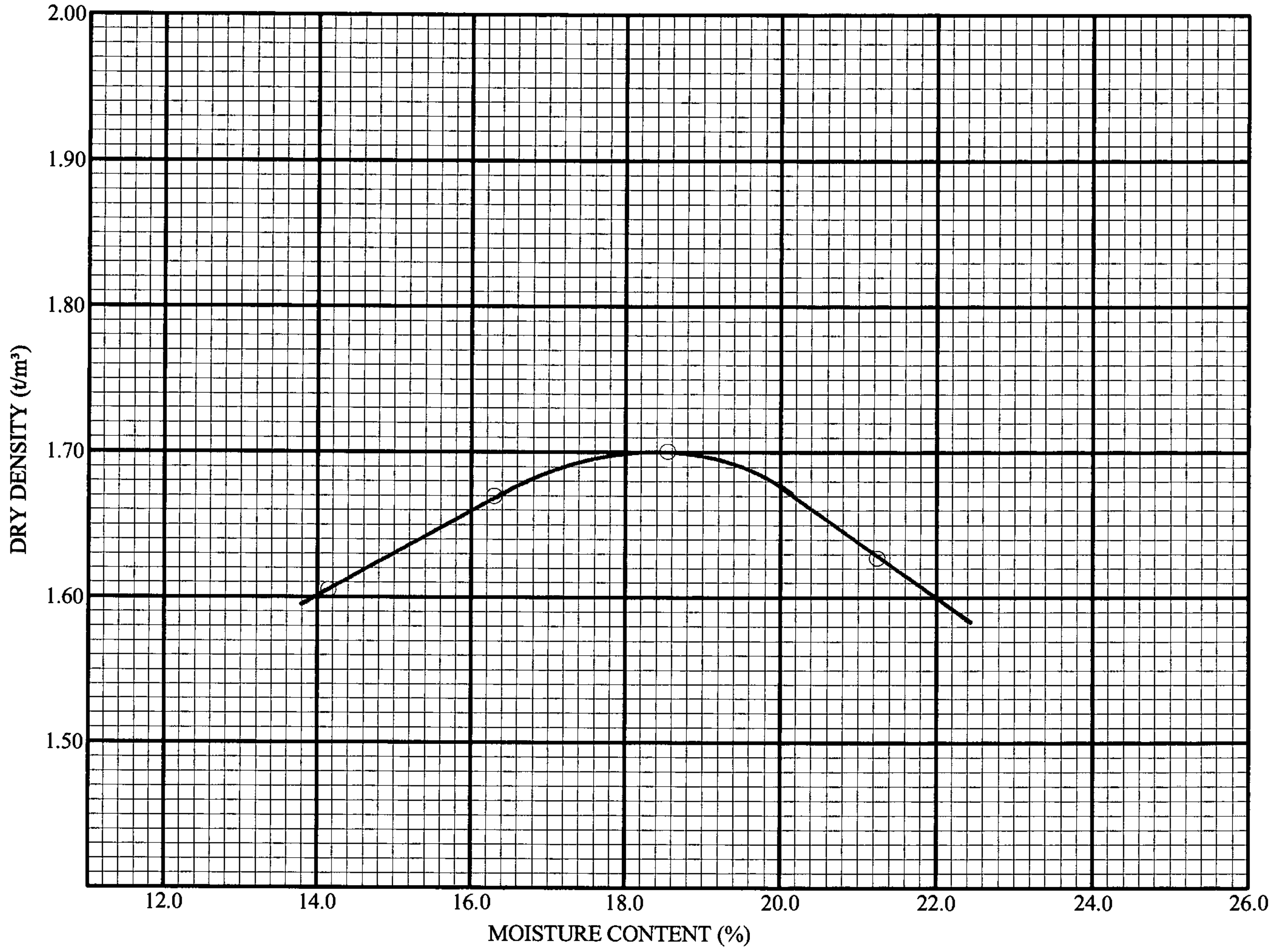
NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

CLIENT: DPWS GEOTECHNICAL ENVIRONMENTAL | REPORT No: 01031/4779/R1111

STANDARD COMPACTION TEST

PROJECT: North Sydney Boy's High School | SAMPLE No: 4779

LOCATION: Carpark and Sports Courts | HOLE No: B2 | DEPTH (m): 0.6



Standard Maximum Dry Density:	1.70	t/m³
Standard Optimum Moisture Content:	18.5	%
Percentage of Material Retained on the 19 mm sieve	0.6	%
Notes on Test: Specimen tested as received from client		
Test Method: AS 1289.5.1.1 Mould: A (1 Litre) ☒ B (2 Litre) ☐		

COMPACTION R1111 (ISSUE 2, 1998)

NATA Accredited Laboratory
Number: 13380
NATA endorsed test report.
This document shall not be reproduced, except in full.

APPROVED SIGNATORY

DATE 2-7-2001

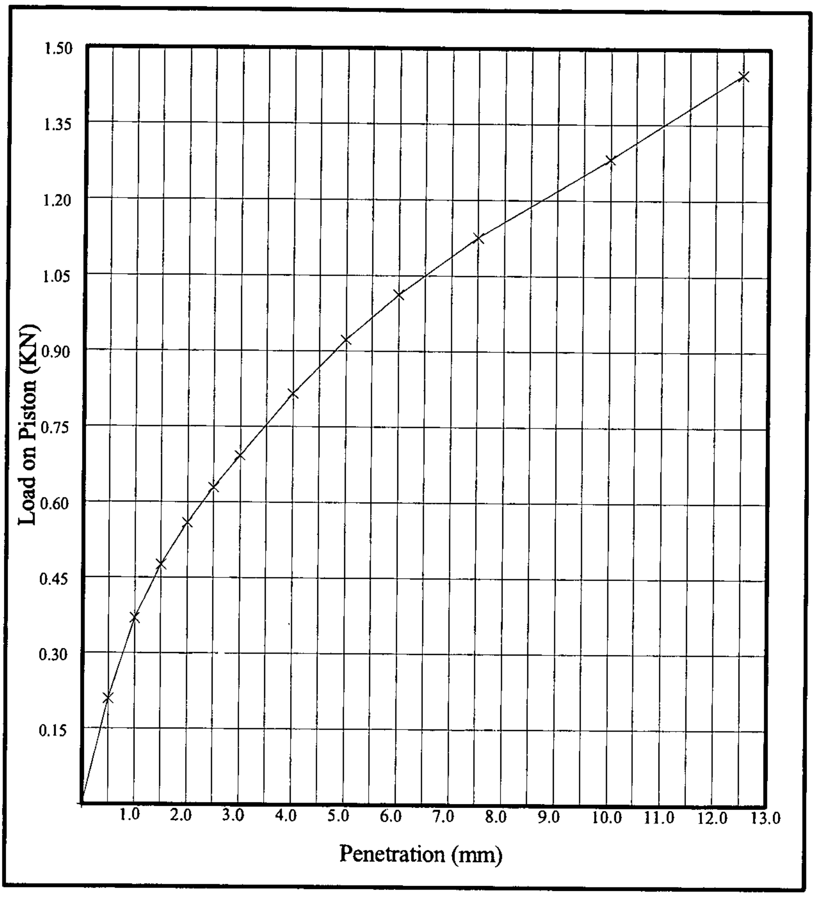
Geotechnical Centre
Unit W4K, 42 Wattle Street, ULTIMO NSW 2007
Telephone 02 9552 4864 Facsimile 02 9552 3615

NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

CLIENT: DPWS GEOTECHNICAL ENVIRONMENTAL
REPORT No: 01031/4779/R1113

CALIFORNIA BEARING RATIO - REMOULDED SPECIMEN

PROJECT: North Sydney Boy's High School
SAMPLE No: 4779
LOCATION: Carpark and Sports Courts
HOLE No: B2
DEPTH (m): 0.6



CBR at 2.5 mm	%	5.0
CBR at 5.0 mm	%	4.5
Surcharge Mass	kg	4.5

Compaction Type

☒ Standard (AS1289.5.1.1) ☐ Modified (AS1289.5.2.1)

Soil Description:
Yellow Brown Silty Clay with Sand

Sample Condition:

☒ Soaked (4 days) ☐ Unsoaked

Material retained 19 mm : 0.6%
Included Y ☐ N ☒

Notes on Test:
Specimen tested as received from client

Test Method: AS1289.6.1.1

Density Parameters			Moisture Parameters		
Maximum Dry Density:	t/m³	1.70	Optimum Moisture Content:	%	18.5
Dry Density Before Soak:	t/m³	1.72	M.C. Before Soak:	%	18.8
Percentage of M.D.D:	%	101	Percentage of O.M.C:	%	102
Dry Density After Soak:	t/m³	1.71	M.C. After Test-top 30 mm:	%	19.6
Percentage Swell	%	0.1	M.C. After Test-whole:	%	18.6

NATA Accredited Laboratory
Number: 13380
NATA endorsed test report.
This document shall not be reproduced, except in full.

APPROVED SIGNATORY
DATE 2-7-2001

CBR R1113 (ISSUE 2, 1998)

Geotechnical Centre

Unit W4K, 42 Wattle Street, ULTIMO NSW 2007

Telephone 02 9552 4864 Facsimile 02 9552 3615

NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

CLIENT: DPWS GEOTECHNICAL ENVIRONMENTAL

REPORT No: 01031/4781/R1119

PARTICLE SIZE DISTRIBUTION

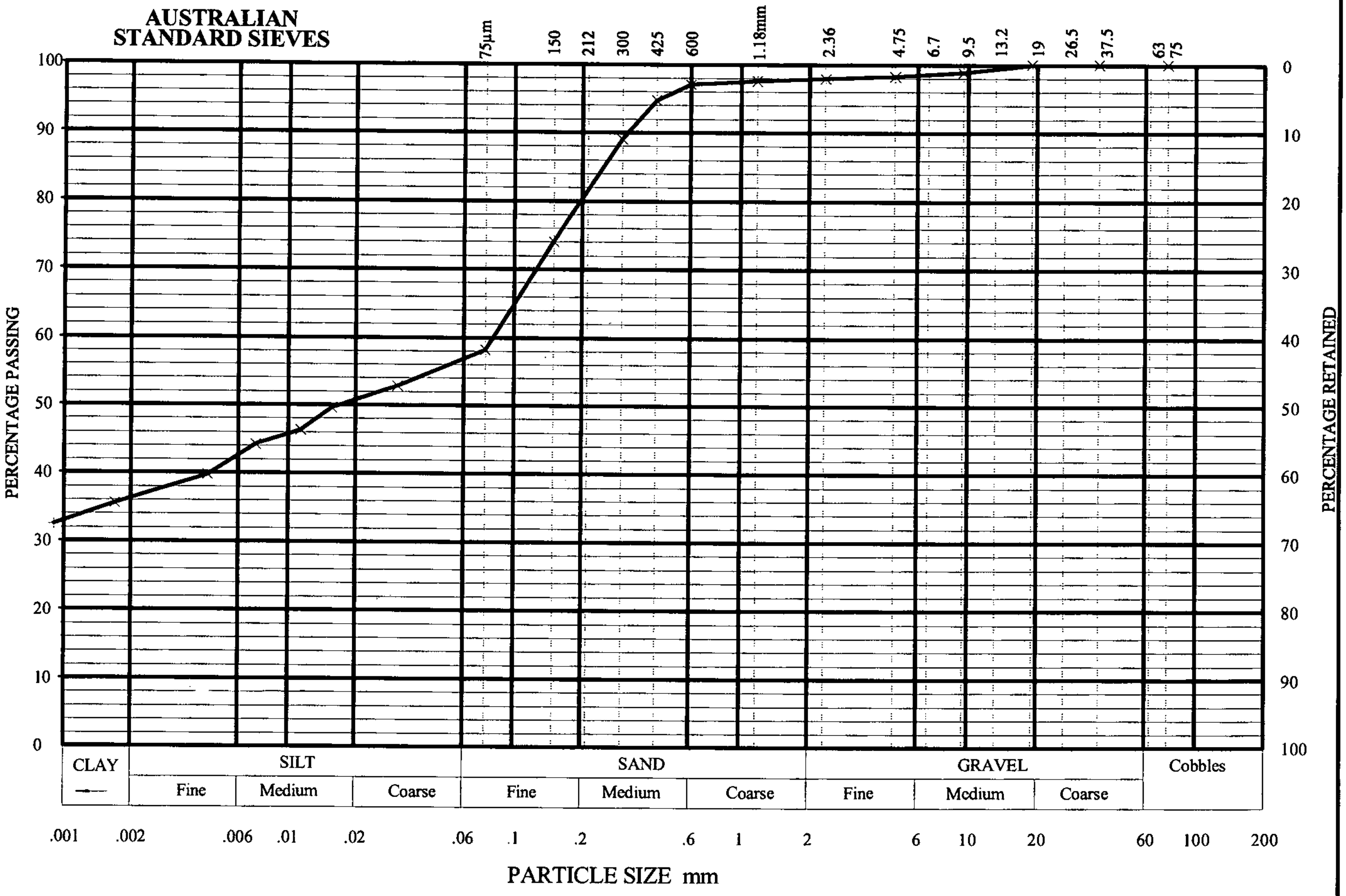
PROJECT: North Sydney Boy's High School

SAMPLE No: 4781

LOCATION: Carpark and Sports Courts

HOLE No: B3

DEPTH (m): 0.8



SIZE DISTRIBUTION

COBBLES	0 %
GRAVEL	2 %
SAND	42 %
SILT	19 %
CLAY	37 %
EFFECTIVE SIZE D10:	-
UNIFORMITY COEFFICIENT D60/D10(Cu):	-
CURVATURE COEFFICIENT $D30^2/(D60 \times D10)$ (Cc):	-

Soil Particle Density: 2.65 t/m³ (estimated for analysis)

Loss in pre-treatment: 0 %

Method of dispersion: End-over-end shaking

Hydrometer: ASTM 152H

Dispersion chemical: Sodium hexametaphosphate
+ Anhydrous sodium carbonate

Notes on Test: Sample tested as received from client

Test Methods:
DPWS GM 9: Determination of the Particle Size Distribution of a Soil

**NATA Accredited Laboratory
Number: 13380
NATA endorsed test report.
This document shall not be
reproduced, except in full.**

APPROVED SIGNATORY

DATE 2-7-2001

Geotechnical Centre

Unit W4K, 42 Wattle Street, ULTIMO NSW 2007
Telephone 02 9552 4864 Facsimile 02 9552 3615

NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

CLIENT: DPWS GEOTECHNICAL ENVIRONMENTAL
REPORT No: 01031/4781/R1115

SOIL INDEX PROPERTIES

PROJECT: North Sydney Boy's High School
SAMPLE No: 4781
LOCATION: Carpark and Sports Courts
HOLE No: B3
DEPTH (m): 0.8

SOIL INDEX PROPERTIES		RESULT	TEST METHOD
Moisture Content (as received)	:	20.4 %	AS 1289.2.1.1
Liquid Limit	:	33 %	AS 1289.3.1.1
Plastic Limit	:	15 %	AS 1289.3.2.1
Plasticity Index	:	18 %	AS 1289.3.3.1
Linear Shrinkage	:	10.0 %	AS 1289.3.4.1
Soil Particle Density	:	-	AS 1289.3.5.1
Classification	:	CL (I)	AS 1726

Sample History: ☐ Natural State ☒ Air Dried ☐ Oven Dried
Method of Preparation: ☐ Wet Sieved ☒ Dry Sieved
Linear Shrinkage Sample: ☐ Curling ☐ Crumbling

Notes on test: Sample tested as received from client.

ATTERBERG LIMITS R1115 (ISSUE 2, 1998)

NATA

NATA Accredited Laboratory
Number: 13380
NATA endorsed test report.
This document shall not be reproduced, except in full.

APPROVED SIGNATORY
DATE 2-7-2001

Geotechnical Centre
Unit W4K, 42 Wattle Street, ULTIMO NSW 2007
Telephone 02 9552 4864 Facsimile 02 9552 3615

NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

CLIENT: DPWS GEOTECHNICAL ENVIRONMENTAL | REPORT No: 01031/4781/R1111

STANDARD COMPACTION TEST

PROJECT: North Sydney Boy's High School | SAMPLE No: 4781

LOCATION: Carpark and Sports Courts | HOLE No: B3 | DEPTH (m): 0.8

Standard Maximum Dry Density:	1.79	t/m³
Standard Optimum Moisture Content:	15.5	%
Percentage of Material Retained on the 19 mm sieve	0	%

Notes on Test: Specimen tested as received from client

Test Method: AS 1289.5.1.1 Mould: A (1 Litre) ☒ B (2 Litre) ☐

COMPACTION R1111 (ISSUE 2, 1998)

NATA Accredited Laboratory
Number: 13380
NATA endorsed test report.
This document shall not be reproduced, except in full.

APPROVED SIGNATORY

DATE 2-7-2001

Geotechnical Centre

Unit W4K, 42 Wattle Street, ULTIMO NSW 2007

Telephone 02 9552 4864 Facsimile 02 9552 3615

NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

CLIENT: DPWS GEOTECHNICAL ENVIRONMENTAL

REPORT No: 01031/4781/R1113

CALIFORNIA BEARING RATIO - REMOULDED SPECIMEN

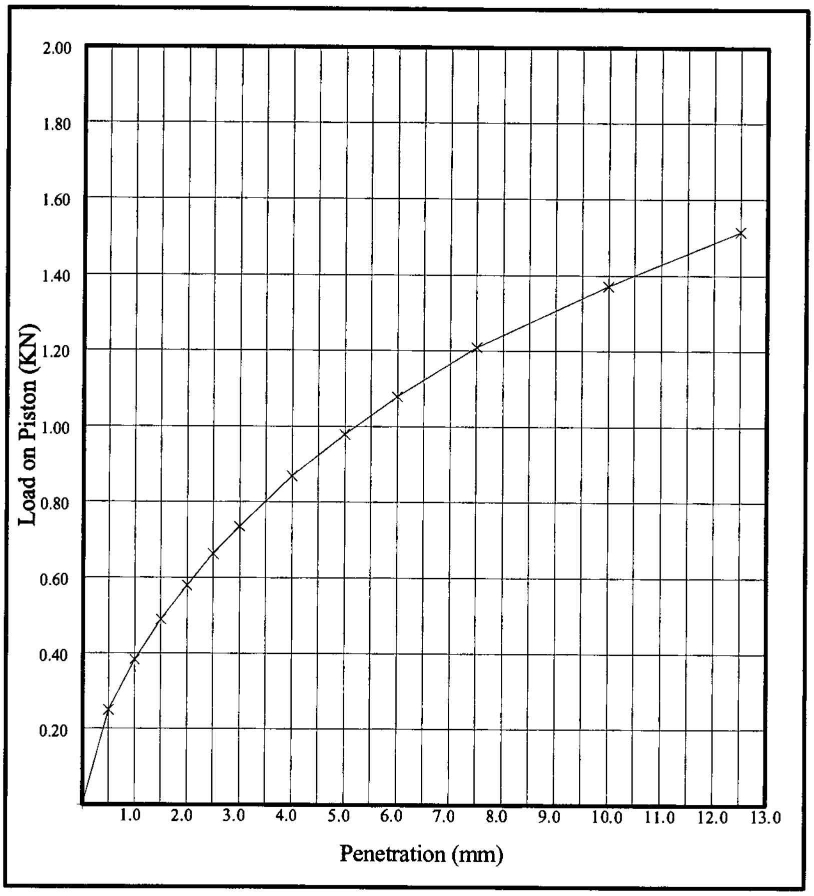
PROJECT: North Sydney Boy's High School

SAMPLE No: 4781

LOCATION: Carpark and Sports Courts

HOLE No: B3

DEPTH (m): 0.8



CBR at 2.5 mm	%	5.0
CBR at 5.0 mm	%	5.0
Surcharge Mass	kg	4.5

Compaction Type

☒ Standard (AS1289.5.1.1) ☐ Modified (AS1289.5.2.1)

Soil Description:
Grey Brown Sandy Silty Clay

Sample Condition:

☒ Soaked (4 days) ☐ Unsoaked

Material retained 19 mm : 0.0%

Included Y ☐ N ☐

Notes on Test:
Specimen tested as received from client

Test Method: AS1289.6.1.1

Density Parameters			Moisture Parameters		
Maximum Dry Density:	t/m³	1.79	Optimum Moisture Content:	%	15.5
Dry Density Before Soak:	t/m³	1.80	M.C. Before Soak:	%	15.7
Percentage of M.D.D:	%	101	Percentage of O.M.C:	%	101
Dry Density After Soak:	t/m³	1.80	M.C. After Test-top 30 mm:	%	16.8
Percentage Swell	%	0.2	M.C. After Test-whole:	%	15.8

**NATA Accredited Laboratory
Number: 13380
NATA endorsed test report.
This document shall not be
reproduced, except in full.**

APPROVED SIGNATORY

DATE 2-7-2001

CBR R1113 (ISSUE 2, 1998)

Geotechnical Centre
Unit W4K, 42 Wattle Street, ULTIMO NSW 2007
Telephone 02 9552 4864 Facsimile 02 9552 3615

NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

CLIENT: DPWS GEOTECHNICAL ENVIRONMENTAL
REPORT No: 01031/4789/R1115

SOIL INDEX PROPERTIES

PROJECT: North Sydney Boy's High School
SAMPLE No: 4789
LOCATION: Carpark and Sports Courts
HOLE No: B9
DEPTH (m): 0.7

SOIL INDEX PROPERTIES	RESULT	TEST METHOD
Moisture Content (as received)	: 25.2 %	AS 1289.2.1.1
Liquid Limit	: 51 %	AS 1289.3.1.1
Plastic Limit	: 18 %	AS 1289.3.2.1
Plasticity Index	: 33 %	AS 1289.3.3.1
Linear Shrinkage	: 14.5 %	AS 1289.3.4.1
Soil Particle Density	: -	AS 1289.3.5.1
Classification	: CH (v)	AS 1726

Sample History: ☐ Natural State ☒ Air Dried ☐ Oven Dried

Method of Preparation: ☐ Wet Sieved ☒ Dry Sieved

Linear Shrinkage Sample: ☒ Curling ☐ Crumbling

Notes on test: Sample tested as received from client.

NATA Accredited Laboratory
Number: 13380
NATA endorsed test report.
This document shall not be reproduced, except in full.

APPROVED SIGNATORY

DATE 2-7-2001

ATTERBERG LIMITS R1115 (ISSUE 2, 1998)

Appendix D

Results of Chemical Testing

Soil Chemistry Profile

Test Type: MS
Order No: Job No: GG13A
Reference North Sydney Boys High School
Sample Name: B9 0.0-0.1m
Sample No: 61536
Date Received 08/06/2001 Total No Pages: 2
CLIENT: DPWS - State Projects, Geotechnic
Peter Shun
Level 13, McKell Building
2-24 Rawson Place 2000
Sydney

Laboratory
Certified Laboratory Practice
ISO 9002/G25 LIC031
Standards Australia

Sydney Environmental and Soil Laboratory
Specialists in Soil Chemistry and Agronomy

Sydney Environmental
and Soil Laboratory Pty Ltd
(Inc in NSW)
ACN 002 825 569
ABN 23 002 825 569
16 Chilvers Road
Thornleigh NSW 2120
Australia
Address Mail to
PO Box 357
Pennant Hills NSW 2120
Telephone (02) 9980 6554
Facsimile (02) 9484 2427
Email: sesl@sesl.com.au

Tests are performed under a quality system certified as complying with ISO 9002.
Results & Conclusions assume that sampling is representative. This document shall not be reproduced except in full

TEST	RESULT	COMMENTS
pH in water 1:2	6.0	
pH in $CaCl_2$ 1:2	5.1	acidic
EC mS/cm 1:2	.13	low salinity level
Chlorides mg/kg		

CATION ANALYSIS

TEST	SOLUBLE		EXCHANGEABLE		
Unit	meq%	Comment	meq%	% of ECEC	Comment
Sodium			.18	1.40	low - not sodic
Potassium			.65	4.90	low
Calcium			9.85	74.70	good
Magnesium			2.51	19.00	good
Aluminium					
		ECEC	13.19		
		Ca/Mg	3.90		balanced ratio

	mg/kg	
Phosphate as P	39.1	suitable for general plantings - too high for phosphorus sensitive sp.
Ammonium as N	18.8	OK
Nitrate as N	9.7	low
Sulphate as S	10.2	low
Iron		
Zinc		
Copper		
Manganese		
Boron		

Recommendations

The pH of this material is acceptable but slightly below the preferred range for general plantings. To fine tune, apply dolomite at 200-300g/sqm (2-3kg/m^3) and incorporate into the surface 100-150mm. Dolomite is recommended rather than lime as it will maintain the balanced Ca:Mg ratio. Salinity and sodium levels are suitably low and pose no limitations. Phosphorus is within a good range for general plantings but too high for phosphorus sensitive species (ie plants from the Proteaceae family), so avoid the selection of these. Ammonium levels are good but nitrate and potassium are low and should be boosted with potassium nitrate at 30-40g/sqm (300-400g/m^3), watered in well.

Explanation of the Methods:
pH, EC, Soluble Cations, Nitrate: Bradley et al (1983). **Exchangeable Cations, ECEC:** Method 15A1 Rayment & Higginson (1992)
Chloride: Vogel (1961). **Aluminium:** Method 3500 APHA (1992). **Phosphate:** Method 9E1 Rayment & Higginson (1992). **Ammonium, Sulphate, Iron, Copper, Manganese + Zinc:** Method 83-1 to 83-5 Black (1983). **Boron:** Method 12C2 Rayment & Higginson (1992).

Checked by Principal..................................
Simon Leake Date of Report 18/06/2001

Consultant...Burrows...........
N.Burrows

Soil Chemistry Profile

Test Type: MS
Order No: Job No: GG13A
Reference North Sydney Boys High School
Sample Name: B11 0.0-0.1m
Sample No: 61537
Date Received 08/06/2001 Total No Pages: 2
CLIENT: DPWS - State Projects, Geotechnic
Peter Shun
Level 13, McKell Building
2-24 Rawson Place 2000
Sydney

Laboratory
Certified Laboratory Practice
ISO 9002/G25 LIC031
Standards Australia

Sydney Environmental and Soil Laboratory
Specialists in Soil Chemistry and Agronomy

Sydney Environmental
and Soil Laboratory Pty Ltd
(Inc in NSW)
ACN 002 825 569
ABN 23 002 825 569
16 Chilvers Road
Thornleigh NSW 2120
Australia
Address Mail to
PO Box 357
Pennant Hills NSW 2120
Telephone (02) 9980 6554
Facsimile (02) 9484 2427
Email: sesl@sesl.com.au

Tests are performed under a quality system certified as complying with ISO 9002.
Results & Conclusions assume that sampling is representative. This document shall not be reproduced except in full

TEST	RESULT	COMMENTS
pH in water 1:2	6.9	
pH in $CaCl_2$ 1:2	6.2	acidic - appropriate
EC mS/cm 1:2	.27	low salinity level
Chlorides mg/kg		

CATION ANALYSIS

TEST	SOLUBLE		EXCHANGEABLE		
Unit	meq%	Comment	meq%	% of ECEC	Comment
Sodium	.12		.16	1.00	low - not sodic
Potassium	.08		.53	3.20	low
Calcium	.39		13.71	81.80	good
Magnesium	.08		2.36	14.10	good
Aluminium					
		ECEC	16.76		
		Ca/Mg	5.80		balanced ratio

	mg/kg	
Phosphate as P	11.9	OK - acceptable for most phosphorus sensitive species
Ammonium as N	67.2	good
Nitrate as N	13.3	low
Sulphate as S	9	low
Iron		
Zinc		
Copper		
Manganese		
Boron		

Recommendations

The pH of this material is within a good range for plant growth and requires no adjustment. Salinity and sodium levels are suitably low and pose no limitations. Calcium and magnesium levels are acceptable and the ratio between these is well balanced. Phosphorus is currently acceptable for all but the most sensitive phosphorus sensitive species. For these ensure no further phosphorus is applied to the soil. For general plantings superphosphate at 20g/sqm will raise phosphorus to a suitable level for these plants. Potassium should be boosted for all plantings with sulphate of potash at 5-10g/sqm.

Explanation of the Methods:
pH, EC, Soluble Cations, Nitrate: Bradley et al (1983). **Exchangeable Cations, ECEC:** Method 15A1 Rayment & Higginson (1992)
Chloride: Vogel (1961). **Aluminium:** Method 3500 APHA (1992). **Phosphate:** Method 9E1 Rayment & Higginson (1992). **Ammonium, Sulphate, Iron, Copper, Manganese + Zinc:** Method 83-1 to 83-5 Black (1983). **Boron:** Method 12C2 Rayment & Higginson (1992).

Checked by Principal.......................................
Simon Leake Date of Report 18/06/2001

Consultant. Burrows. ....
N.Burrows

Analytical Services
Cnr Joseph Street and Weeroona Road
(PO Box 42) LIDCOMBE NSW 2141
Telephone 02-97492222 Facsimile 02-97492755

NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

Client DPWS - WATER TECHNOLOGIES (GEOTECHNICAL)	**Reference** GG13A-P.Shun	**Report Number**
Project Name NORTH SYDNEY BOYS HIGH SCHOOL	**Date Received** 13.06.01	**010558**

REPORT ON ANALYSIS OF SOILS / SANDS

Results expressed in mg/kg on dry basis unless otherwise stated

All samples are analysed "as received"

Lab. No.	Sample Markings	pH units	Acidity as $CaCO_3$ pH in NaCl	methyl orange	phenolphthalein	Chloride as NaCl	Sulphate as SO_3	Sulphide, S colour test
1	4779 B2 0.6-0.9m	6.1	5.4	NIL	5600	210	<10	250
2	4781 B3 0.8-1.3m	6.7	6.1	NIL	4500	91	<10	250
3	4794 B12 1.0-1.45m	4.7	3.8	1000	6400	120	<10	250
4								
5								
6								
7								
8								
9								
10								
Test Methods used with preparation by method # A		# B	# C			# G	# F	# E

Public Works Department, Pipe Protection Against Corrosion - Soil Criteria Guidelines, Appendix 2

NATA Accreditation No. 121

National Association of Testing Authorities, Australia
NATA Endorsed Test Report
This document may not be reproduced except in full.

Approved Signatory

Margaret Rhodes,BSc
Laboratory Manager

Date 27.06.01

FORM R2, Issue 4

MEMORANDUM

McKell Building
2-24 Rawson Place
Sydney NSW 2000

NSW DEPARTMENT
OF PUBLIC WORKS
AND SERVICES

Telephone: 02 9372 8062
Facsimile: 02 9372 8077

TO **Peter Shun**
CC
DATE **9 July 2001**
FROM Jose Pante
SUBJECT **North Sydney Boys High School**

RECEIVED 10.9.01

Ref:

NORTH SYDNEY BOYS HIGH SCHOOL
SOIL ANALYSIS AND MATERIALS RECOMMENDATIONS

Based on analysis in Report No. 010558 dated 27/06/01, the soil is not aggressive at site B2 and B3 and highly aggressive to concrete at site B12 (due to very low pH). The following recommendations are made:

Sites B2 and B3

Concrete, ductile iron, copper, uPVC, VC and FRP pipes and fittings can be used underground without special protection.

Site B12

PIPES AND FITTINGS

(a) Concrete pipes and fittings require polyethylene sleeving* if groundwater is not present at the site. If groundwater is present, concrete is not recommended.

(b) Ductile iron pipes and fittings require polyethylene sleeving* if groundwater is present at the site.

(c) Copper, uPVC, VC and FRP pipes and fittings can be used underground without special protection.

**Adequate repairs should be carried out if the polyethylene sleeves are cut or damaged.*

STRUCTURES

The soil's high aggressiveness to concrete should be taken into account when designing unprotected concrete structures.

Information on the conditions of existing pipes and structures in the area is the best indicator of potential failure due to corrosion and should be utilised when available to determine material suitability.

9/7/01
Jose Pante
Project Engineer
Wastewater Services

PHOTO 1: General view of the proposed carpark area.

PHOTO 2: General view of the proposed sports courts area.