GREEN GEOTECHNICS

GEOTECHNICAL INVESTIGATION

FOR

DESIGN N SKETCH

47 WARRIEWOOD ROAD, WARRIEWOOD

REPORT GG10247.001

7th JULY 2021

Geotechnical Investigation for a proposed new swimming pool at 47 Warriewood Road, Warriewood

Prepared for

Design N Sketch
47 Warriewood Road
Warriewood NSW 2102

Prepared by

Green Geotechnics Pty Limited
PO Box 3244
Rouse Hill, NSW, 2155
ABN: 786 438 493 89
www.greengeo.com.au
matt@greengeo.com.au

7th July 2021

Document Authorisation

Our Ref: GG10247.001

For and on behalf of Green Geotechnics

Matthew Green
Principal Engineering Geologist

Document Control

Revision	Description	Format	Date	Author	Distributed to
A	Final	PDF	7/7/2021	MG	Design N Sketch (Client)

Table of Contents

FIGURES

APPENDICIES

1. INTRODUCTION

This report presents the results of a geotechnical investigation for proposed alterations and additions to an existing residential dwelling at 47 Warriewood Road, Warriewood, NSW. The investigation was commissioned by Design N Sketch by return acceptance of Proposal PROP-2021-0203, dated 25th June 2021.

We understand from the supplied architectural drawings, that it is proposed to install a below ground swimming pool at the above address. The swimming pool will be constructed in the south west corner of the site immediately adjacent to the existing dwelling. The swimming pool has proposed dimensions of 5 metres by 2.7 metres and is rectangular in shape. The pool will be offset 0.5 metres from the existing dwelling.

The proposed top of pool level is RL19.195 metres AHD. The deepest part of the pool is approximately 1.7 metres deep, with an additional 150mm of excavation required for the pool shell, therefore a maximum bulk excavation level of RL17.346 metres AHD is anticipated.

The purpose of the investigation was to

- assess the subsurface conditions over the site,
- provide recommendations regarding the appropriate foundation system for the site including design parameters and recommendations for the construction of pool shell,
- comment on excavation conditions including vibration control during rock excavation,
- provide parameters for the temporary and permanent support of the excavations including recommendations for construction immediately adjacent to the existing dwelling, and
- comment on the potential impacts of the pool excavation on the adjoining sewer.

2. INVESTIGATION PROCEDURE

The fieldwork was carried out on the 1st July 2021 and comprised a detailed site walkover together with the drilling of two (2) boreholes numbered BH1 and BH2. Due to restricted site access the boreholes were drilled using hand auger equipment.

The site location is shown in the attached Figure A. The borehole locations, as shown on Figure B, were determined by taped measurements from existing surface features shown on the provided architectural drawings from Design N Sketch. Photos of the site are attached as Figure C.

The strength of the soils encountered in the boreholes was assessed by undertaking Dynamic Cone Penetrometer (DCP) tests adjacent to each borehole. The DCP testing also enabled the potential depth to bedrock to be "probed".

Groundwater observations were made in all boreholes during drilling, on completion of drilling and a short time after completion of drilling. No longer term groundwater monitoring was carried out.

The fieldwork was completed in the full-time presence of our senior field geologist who set out the boreholes, nominated the sampling and testing, and prepared the borehole logs. The logs are attached to this report, together with a glossary of the terms and symbols used in the logs.

For further details of the investigation techniques adopted, reference should be made to the attached explanation notes.

Environmental and contamination testing of the soils was beyond the agreed scope of the works

3. RESULTS OF INVESTIGATION

3.1 Site Description

The site is located on gently sloping terrain and comprises a roughly rectangular parcel of land with an area of approximately 403m^2. At the time of the fieldwork the site was occupied by a recently constructed double storey residential dwelling with tile roof and internal double garage. We understand that the dwelling is supported by a piled slab type foundation with the piles extending to a depth of around 3.0 metres.

The ground surface on the site falls approximately 1.8 metres to the west from RL20.4 metres AHD in the front garden to RL 18.6 metres AHD in the rear garden. Site vegetation comprised grass laws and growing trees and shrubs.

An existing sewer traverses the rear garden area. The sewer has a diameter of approximately 150mm and has an invert depth of around 2.15 metres. At its closest point the sewer is offset around 2.6 metres from the pool.

To the east of the site is Warriewood Road and to the north and south are vacant parcels of land. To the west of the site is a two storey dwelling under construction. The dwelling to the west includes a swimming pool which has been excavated and formed with concrete. The adjoining site to the west is around 1 metre lower than the subject site, with the subject site retained by a core filled concrete block wall.

3.2 Regional Geology & Subsurface Conditions

The 1:100,000 series geological map of Sydney (Geological Survey of NSW, Geological Series Sheet 9130) indicates that the site is located along a geological boundary between Quaternary Age alluvial soils and Triassic Age bedrock belonging to the Newport Formation of Narrabeen Group. The Quaternary Age soils comprise clays, silts, sands and gravels. Bedrock within the Newport formation comprises interbedded laminite, shale and quartz sandstone.

The encountered subsurface conditions consist of fill, present from the surface to the depth of hand auger refusal, 1.1 to 1.2 metres.

The fill materials comprise a gravelly sandy clay and gravelly silty clay. The fill contains sandstone gravels and cobbles that could not be penetrated with a hand auger. The fill appears moderately to well compacted and was likely placed during construction of the recent subdivision. Based on the results of the DCP testing the fill and/or natural soils extend to depths of at least 2.0 metres.

Groundwater seepage was not observed during auger drilling of the boreholes, and the DCP rods were dry on extraction.

4. GEOTECHNICAL RECOMMENDATIONS

4.1 Primary Geotechnical Considerations

Based on the results of the assessment, we consider the following to be the primary geotechnical considerations for the development:

- The construction of cut slopes in the immediate vicinity of existing structures, and
- Foundation design for structural loads.

4.2 Excavation Conditions and Vibration Control

Based on the subsurface conditions observed in the boreholes and results of the DCP testing, bulk excavation works for the swimming pool are expected to encounter a silty clay fill and potentially natural clayey soils. We do not anticipate the excavations for the pool encountering bedrock.

Excavation of the swimming pool should be achievable using conventional earthmoving equipment, such as a small sized tracked excavator fitted with a toothed bucket attachment. Some ripping may be required if large cobbles or obstructions are encountered within the fill. We do not anticipate use the use of hydraulic rock hammers during the bulk excavation works.

4.3 Excavation Stability

All excavation recommendations should be complemented with reference to the NSW Government Code of Practice for Excavation work, dated January 2020.

Construction of the swimming pool will require excavating up to 1.8 metres below the existing ground surface. The pool excavations are offset around 0.5 metres from the existing dwelling and 1 metre from the southern site boundary, which is demarked by a timber fence. We understand that the pool excavation will be permanently supported by the shell, and therefore only temporary excavation conditions need to be considered.

Based on the results of the borehole drilling we expect the sidewalls of the pool excavations to remain stable provided the exposed soils are adequately protected from wet weather, and no surcharge loads are placed within 1.5 metres of the pool excavation. The pool excavation will be undertaken close to the existing dwelling; however we understand that the dwelling is supported on piled foundations that extend well below the zone of influence of the pool excavation. The presence of the piled foundations should be confirmed prior to commencing construction of the pool.

Based on the position and depth of the proposed pool we are of the opinion that construction of the pool will not impact on the adjoining buried sewer.

4.4 Foundation Design

On completion of bulk excavation of the swimming pool, the exposed materials will likely comprise a clayey fill, and possibly natural clays over the deeper areas of excavation. The fill appears moderately to well compacted however we have not been provided with certification reports for the fill.

Footings founded in certified controlled engineered fill may be designed for an allowable bearing pressure of 100 kPa. A value of 150 kPa may be adopted for footings founded in stiff natural clays. We would not recommend relying on the fill for foundation support if there is no certification available.

In order to ensure the bearing values given can be achieved, care should be taken to ensure that the base of excavations are free of all loose material prior to concreting. It is recommended that all footing excavations be protected with a layer of blinding concrete as soon as possible, preferably immediately after excavating, cleaning, inspection and approval.

5. GENERAL RECOMMENDATIONS

The recommendations presented in this report include specific issues to be addressed during the construction phase of the project. In the event that any of the construction phase recommendations presented in this report are not implemented, the general recommendations may become inapplicable and Green Geotechnics accept no responsibility whatsoever for the performance of the structure where recommendations are not implemented in full and properly tested, inspected and documented.

Occasionally, the subsurface conditions 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.

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. If there is any change in the proposed development described in this report then all recommendations should be reviewed. Copyright in this report is the property of Green Geotechnics. 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.

REPORT INFORMATION

Introduction

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

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

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation.

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

Groundwater

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

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

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

Reports

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

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

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

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

Site Anomalies

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

Copyright

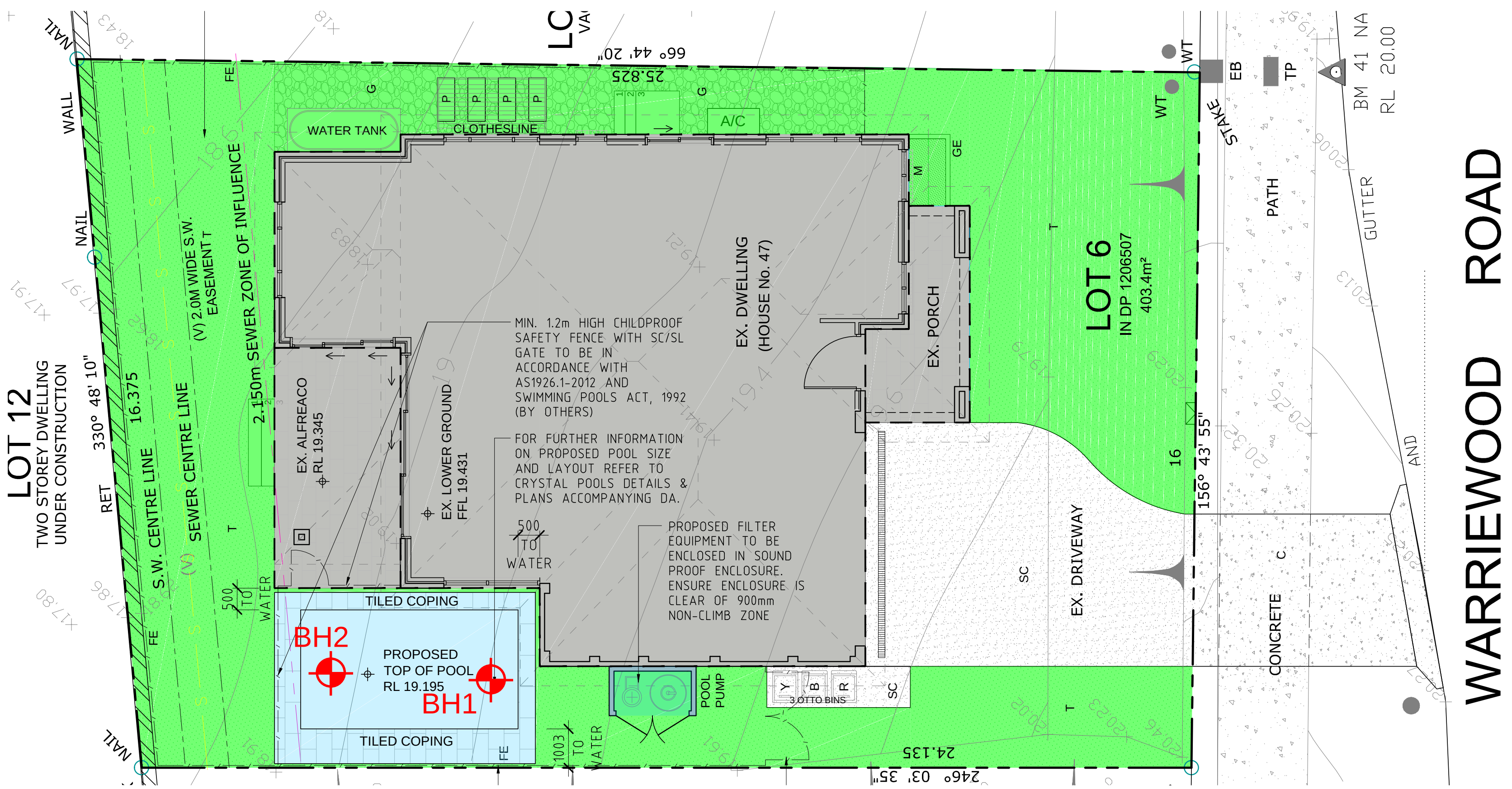
This report is the property of Green Geotechnics Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

FIGURES

GREEN GEOTECHNICS	Project No: GG10247.001	Geotechnical Investigation 47 WARRIEWOOD ROAD, WARRIEWOOD **SITE LOCATION PLAN**	Figure No: GG10247.001A
	Client: Design N Sketch		Drawn By: MG
	Date: 7th July 2021		Scale: Unknown

Legend:

- = Borehole
- = DCP
- = Test Pit



GREEN GEOTECHNICS	Project No: GG10247.001	Geotechnical Investigation 47 WARRIEWOOD ROAD, WARRIEWOOD **TEST LOCATION PLAN**	Figure No: GG10247.001B
	Client: Design N Sketch		Drawn By: MG
	Date: 7th July 2021		Scale: Unknown

Proposed Pool Location

View of pool location from adjoining site

Cut face on adjoining site with retaining wall, prior to backfill

GREEN GEOTECHNICS	Project No: GG10247.001	Geotechnical Investigation 47 WARRIEWOOD ROAD, WARRIEWOOD **SITE PHOTOS**	Figure No: GG10247.001C
	Client: Design N Sketch		Drawn By: MG
	Date: 7th July 2021		Scale: Unknown

APPENDIX A – BOREHOLE LOGS

GEOTECHNICAL LOG - NON CORED BOREHOLE

GREEN GEOTECHNICS

Project No: GG10247 | Surface RL: 19.2m AHD | Date Logged : 1/7/2021

Address: 47 Warriewood Road, Warriewood | Logged By: JK

Client: Design N Sketch | Checked By: MG

BOREHOLE NO.: BH 1

Sheet 1 of 1

WATER TABLE	SAMPLES	DEPTH (M)	DESCRIPTION (Soil type, colour, grain size, plasticity, minor components, observations)	USC SYMBOL	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	MOISTURE
			FILL: Gravelly Sandy CLAY: Dark brown with dark grey, low plasticty with fine to medium grained sand and some gravel	CL	APPEARS MODERATELY COMPACTED	M-W
		0.5 1.0	FILL: Gravelly Silty CLAY: Orange brown with light grey and dark brown, medium to high plasticity with some gravel and cobbles	CI / CL	APPEARS MODERATELY COMPACTED APPEARS WELL COMPACTED	M-D
		1.5 2.0 2.5	HAND AUGER REFUSAL AT 1.1m IN FILL			

D - Disturbed sample | U - Undisturbed tube sample | B - Bulk sample

S - Chemical Sample | SPT - Standard Penetration Test

WT - Standing Water Table | SP - Water Seepage Level

NOTES: See explanation sheets for meaning of all descriptive terms and symbols

Contractor: Green Geotechnics

Equipment: Hand Auger

Hole Diameter (mm): 62

Angle from Vertical (^{o}): 0

Drill Bit: Mild Steel

GEOTECHNICAL LOG - NON CORED BOREHOLE

GREEN GEOTECHNICS

Project No: GG10247 | Surface RL: 19.0m AHD | Date Logged : 1/7/2021
Address: 47 Warriewood Road, Warriewood | Logged By: JK
Client: Design N Sketch | Checked By: MG

BOREHOLE NO.: BH 2
Sheet 1 of 1

WATER TABLE	SAMPLES	DEPTH (M)	DESCRIPTION (Soil type, colour, grain size, plasticity, minor components, observations)	USCS SYMBOL	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	MOISTURE
			FILL: Gravelly Sandy CLAY: Dark brown with dark grey, low plasticty with fine to medium grained sand and some gravel	CL	APPEARS MODERATELY COMPACTED	M-W
		0.5 1.0	FILL: Gravelly Silty CLAY: Orange brown with light grey and dark brown, medium to high plasticity with some gravel and cobbles	CI / CL	APPEARS MODERATELY COMPACTED	M-D
		1.5 2.0 2.5	HAND AUGER REFUSAL AT 1.2m IN FILL		APPEARS MODERATELY COMPACTED	

D - Disturbed sample | U - Undisturbed tube sample | B - Bulk sample
S - Chemical Sample | SPT - Standard Penetration Test
WT - Standing Water Table | SP - Water Seepage Level

NOTES: See explanation sheets for meaning of all descriptive terms and symbols

Contractor: Green Geotechnics
Equipment: Hand Auger
Hole Diameter (mm): 62
Angle from Vertical (^{o}): 0
Drill Bit: Mild Steel

Dynamic Cone Penetrometer Test Report

Project Number: GG10247
Site Address: 47 Warriewood Road, Warriewood
Test Date: 1/7/2021

Test Method: **AS1289.6.3.2**

Technician: JK

Test No	BH1	BH2				
Starting Level	Surface	Surface				
Depth (m)	Penetration Resistance (blows / 150mm)					
0.00 - 0.15	1	1				
0.15 - 0.30	3	3				
0.30 - 0.45	10	6				
0.45 - 0.60	15	7				
0.60 - 0.75	10	12				
0.75 - 0.90	7	6				
0.90 - 1.05	6	6				
1.05 - 1.20	12	5				
1.20 - 1.35	15	10				
1.35 - 1.50	12	18				
1.50 - 1.65	20	11				
1.65 - 1.80	15	18				
1.80 - 1.95	18	22				
1.95 - 2.10	20	Refusal				
2.10 - 2.25	Refusal					
2.25 - 2.40						
2.40 - 2.55						
2.55 - 2.70						
2.70 - 2.85						
2.85 - 3.00						

Remarks: * Pre drilled prior to testing

SAMPLING & IN-SITU TESTING

GREEN GEOTECHNICS

Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock. Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure. Undisturbed samples are taken by pushing a thin walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength and are necessary for laboratory determination of shear strength and compressibility.

Test Pits

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

Large Diameter Augers

Boreholes can be drilled using a large diameter auger, typically up to 300 mm or larger in diameter mounted on a standard drilling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration.

Diamond Core Rock Drilling

A continuous core sample of can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter (NMLC). The borehole is advanced using a water or mud flush to lubricate the bit and removed cuttings.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1. The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable, and the test is discontinued.

The test results are reported in the following form.

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

  4,6,7
  N=13

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

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

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.

- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

SOIL DESCRIPTIONS

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

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

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

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

Type	Particle Size (mm)
Coarse Gravel	20 – 63
Medium Gravel	6 – 20
Fine Sand	2.36 – 6
Coarse Sand	0.6 – 2.36
Medium Sand	0.2 – 0.6
Fine Sand	0.075 – 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion
And	Specify
Adjective	20 - 35%
Slightly	12 - 20%
With some	5 - 12%
With a trace of	0 - 5%

Definitions of grading terms used are:

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

Cohesive Soils

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

Description	Abbreviation	Undrained Shear Strength (kPa)
Very soft	VS	<12
Soft	S	12 - 25
Firm	F	25 - 50
Stiff	ST	50 - 100
Very stiff	VST	100 - 200
Hard	H	200

Cohesionless Soils

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

Relative Density	Abbreviation	SPT N Value	CPT qc value (MPa)
Very loose	VL	<4	<2
Loose	L	4 - 10	2 -5
Medium Dense	MD	10-30	5-15
Dense	D	30-50	15-25
Very Dense	VD	>50	>25

Soil Origin

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

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.

ROCK DESCRIPTIONS

Rock Strength

The Rock strength is defined by the Point Load Strength Index ($Is_{(50)}$) and refers to the strength of the rock substance and not the strength of the overall rock mass, which may be considerably weaker due to defects. The test procedure is described by Australian Standard 4133.4.1 - 1993. The terms used to describe rock strength are as follows:

Term	Abbreviation	Point Load Index $IS_{(50)}$ MPa	Approximate Unconfined Compressive Strength MPa*
Extremely low	EL	<0.03	<0.6
Very low	VL	0.03 - 0.1	0.6 - 2
Low	L	0.1 - 0.3	2 - 6
Medium	M	0.3 - 1.0	6 - 20
High	H	1 - 3	20 - 60
Very high	VH	3 - 10	60 - 200

* Assumes a ration of 20:1 for UCS to $IS_{(50)}$

Degree of Weathering

The degree of weathering of rock is classified as follows:

Term	Abbreviation	Description
Extremely weathered	EW	Rock substance has soil properties, i.e. it can be remoulded and classified as a soil but the texture of the original rock is still evident.
Highly weathered	HW	Limonite staining or bleaching affects whole of rock substance and other signs of decomposition are evident. Porosity and strength may be altered as a result of iron leaching or deposition. Colour and strength of original fresh rock is not recognisable.
Moderately weathered	MW	Staining and discolouration of rock substance has taken Place.
Slightly weathered	SW	Rock substance is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh stained	FS	Rock substance unaffected by weathering but staining visible along defects.
Fresh	FR	No signs of decomposition or staining.

Degree of Fracturing

The following classification applies to the spacing of natural fractures in core samples (bedding plane partings, joints and other defects, excluding drilling breaks

Term	Description
Fragmented	Fragments of <20 mm
Highly Fractured	Core lengths of 20-40 mm with some fragments
Fractured Core	Core lengths of 40-200 mm with some shorter and longer sections
Slightly Fractured	Core lengths of 200-1000 mm with some shorter and loner sections
Unbroken	Unbroken Core lengths mostly > 1000 mm

Stratification Spacing

For sedimentary rocks the following terms may be used to describe the spacing of bedding partings:

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

Rock Quality Designation

The quality of the cored rock can be measured using the Rock Quality Designation (RQD) index, defined as:

$$\text{RQD \%} = \frac{\text{cumulative length of 'sound' core sections} \geq 100\text{ mm long}}{\text{total drilled length of section being assessed}}$$

'sound' rock is assessed to be rock of low strength or better. The RQD applies only to natural fractures. If the core is broken by drilling/handling, then the broken pieces are fitted back together and are not included in the calculation of RQD.

ABBREVIATIONS

GREEN GEOTECHNICS

Introduction

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

Drilling or Excavation Methods

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

Water

Z	Water seep
V	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
S	Chemical sample
U50	Undisturbed tube sample (50mm)
W	Water sample
PP	Pocket Penetrometer (kPa)
PL	Point load strength Is(50) MPa
S	Standard Penetration Test
V	Shear vane (kPa)

Description of Defects in Rock

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

Defect Type

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

Orientation

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

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

Coating or Infilling Term

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

Coating Descriptor

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

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

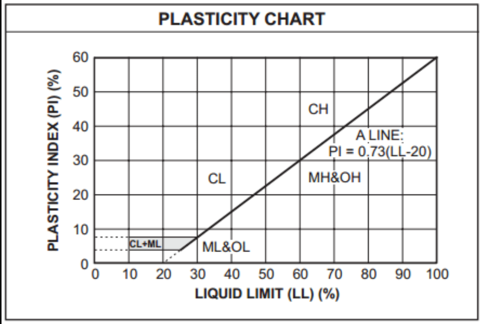
Other

fg	fragmented
bnd	band
qtz	quartz

UNIFIED SOIL CLASSIFICATION TABLE

Field Identification Procedures (Excluding particles larger than 75um and basing fractions on estimated weights)				Group Symbols	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria
Coarse-grained soils More than half of the material is large that 75um sieve size[b] The 75um sieve size is about the particle visible to the naked eye	Gravels More than half of the coarse fraction is larger than a 4mm sieve	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: indicative approximate percentages of sand and gravel; maximum size; angularity; surface condition, and hardness of the coarse grains; local of 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 12mm maximum size; rounded and subangular sand grains, coarse to fine, about 15% non-plastic fines 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 75um 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 symbol $C_u = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or range of sizes with some intermediate sizes missing	*GP*	Poorly graded gravels, grave-sand mixtures, little or no fines		Not meeting all graduation 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 of 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 the coarse fraction is smaller than a 4mm sieve	Clean sands (little or no fines)	Wide range in grain size 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 range of sizes with some intermediate sizes missing	*SP*	Poorly graded sands, gravelly sands, little or no fines		Not meeting all graduation 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 of requiring use of dual symbols
			Plastic fines (for identification procedures see *CL* below)	*SC*	Clayey sands, poorly graded sand-clay mixtures		Atterberg limits above "A" line with *PI* greater than 7

Major division	Identification Procedures of Fractions Smaller than 380 um Sieve Size: Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)	Group Symbols	Typical Names	Information Required for Describing Soils
Find-grained soils, More than half of the material is smaller than 75um 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 slit plasticity	Give typical name: indicative 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, clastic 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 (eg. 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