Douglas Partners
Geotechnics | Environment | Groundwater

Report on
Preliminary Acid Sulfate Soil Assessment

Proposed Residential Unit Development
53 - 55 Donnison Street West, Gosford

Prepared for
VLZ Construction Pty Ltd

Project 203360.02
July 2022

Integrated Practical Solutions

Douglas Partners
Geotechnics | Environment | Groundwater

Document History

Document details

Project No.	203360.02	Document No.	R.001.Rev0
Document title	Report on Preliminary Acid Sulfate Soil Assessment Proposed Residential Unit Development		
Site address	53 - 55 Donnison Street West, Gosford		
Report prepared for	VLZ Construction Pty Ltd		
File name	203360.02.R.001.Rev0.West Gosford PASSA		

Document status and review

Status	Prepared by	Reviewed by	Date issued
Revision 0	Troy McClelland	Brent Kerry	23 July 2022

Distribution of copies

Status	Electronic	Paper	Issued to
Revision 0	1	0	Shane Zerafa, VLZ Construction Pty Ltd

The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author	T. McClelland	22 July 2022
Reviewer	B Kerry	22 July 2022

bsi ISO 9001 Quality Management Systems CERTIFIED
FS 604853

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
Unit 5, 3 Teamster Close
Tuggerah NSW 2259
Phone (02) 4351 1422

Table of Contents

Page

Report on Preliminary Acid Sulfate Soil Assessment
Proposed Residential Unit Development
53 - 55 Donnison Street West, Gosford

1. Introduction

This report presents the results of a preliminary acid sulfate soil assessment (PASSA) undertaken for a proposed residential unit development at 53 - 55 Donnison Street West, Gosford. The investigation was commissioned in a service order dated 2 June 2022 by Shane Zerafa of VLZ Construction Pty Ltd and was undertaken in accordance with Douglas Partners' proposal 215834.00 dated 2 June 2022.

The purpose of this PASSA was to confirm the presence / absence of acid sulfate soils (ASS) which may be disturbed during construction of the proposed development. The assessment was carried out with reference to Stone et al (1998), Ahern et al (2004), Dear et al (2014) and Sullivan et al (2018) and involved the drilling of two boreholes, ASS screening and laboratory analysis of select soil samples.

The PASSA comprised a desktop review, the drilling of two boreholes and laboratory testing (screening) of selected samples for acid sulfate soils. The details of the field work are presented in this report, together with comments and recommendations on the items listed above.

2. Proposed Development

It is understood that the proposed development of the site includes a multi-storey residential unit development including two basement levels. Excavation is expected to be required to depths of up to 7.5 m.

3. Site Description

3.1 Site Identification

The key site details are presented in Table 1 below:

Table 1: Site Identification

Site Detail	Description
Site Address	53 - 55 Donnison Street West, Gosford
Legal Description	Lots A and B Deposited Plan 312912
Local Council Area	Central Coast Council
Current Use	Residential (western portion, Lot B) and Vacant (eastern portion, Lot A)
Surrounding Land Uses	Residential in all directions. The neighbouring sites to the south and west are currently occupied by multi-storey residential unit developments. Site is bounded by Donnison Street West to the north and Batley Street to the west.
Topography	Reference to NSW 2 m Elevation Contours, the site slopes down to the south from approximately 39 m AHD to approximately 33 m AHD. The surrounding area also slopes down to the south.
Geology	Reference to the interim 1:25 000 scale Geological Series Sheet for Gosford indicates that the site is mapped as being underlain by the Terrigal Formation. The Terrigal Formation typically comprises interbedded laminite, siltstone and quartz to lithic-quartz sandstone, and weathers to form medium and high plasticity clay soils.
Soil Landscapes	Soil Landscape mapping (1:100,000 Sydney-Newcastle-Wollongong Soils Landscape Series Sheet) indicates that the site is underlain by Erina Erosional soil landscape group.
Acid Sulfate Soils	Reference to the Department of Land and Water Conservation 1:25 000 scale acid sulfate soil risk map for Gosford indicates that the site is located in an area where there is no known occurrence of acid sulfate soils. Furthermore, the mapping indicates that the site is located approximately 250 m from areas mapped as having a probability of acid sulfate soils.

Acid sulfate soils are normally present in low lying alluvial or marine sediments where surface elevations are less than RL 5 m AHD. Surface elevations at the site are well above RL 5 m AHD (see Table 1) and the area is not mapped as having alluvial soils. These conditions are consistent with the acid sulfate soil risk mapping.

3.2 Site Description

A site walkover was completed on 6 June 2021. The eastern portion of the site was unoccupied and was covered by grass. The western portion of the site was occupied by a three-storey residential building.

The site sloped down to the south. The surrounding area sloped down to the south, east and west.

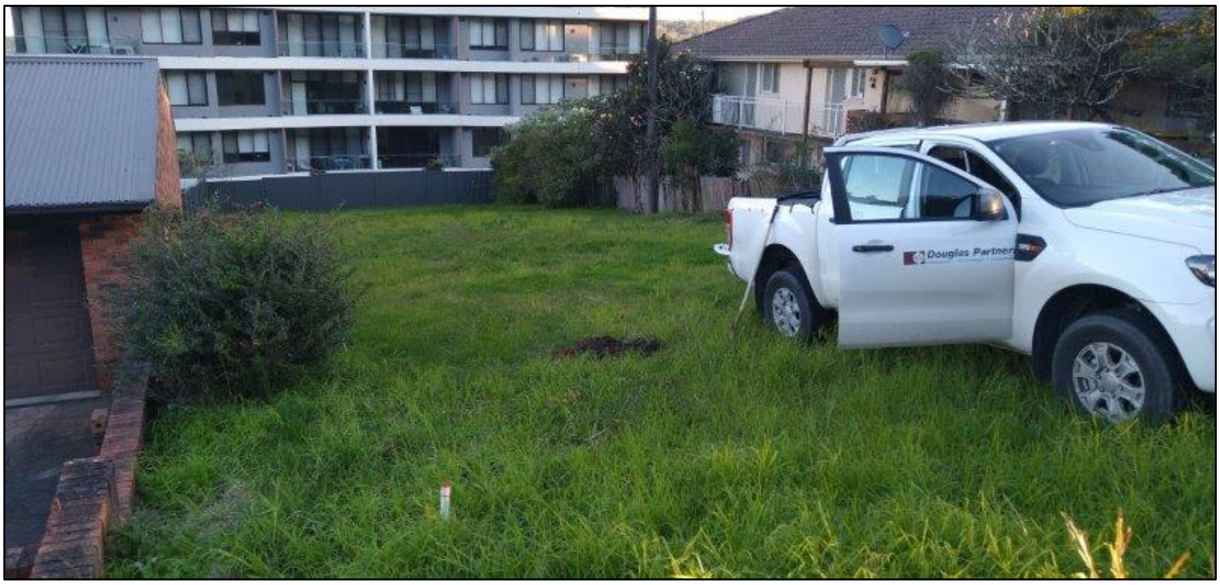

Figure 1: General site photograph. Photo facing south-west.

Figure 2: General site photograph. Photo facing north.

4. Field Work

4.1 Field Work Methods

The field work was undertaken on 6 June 2022 by a DP Environmental Engineer and comprised the drilling of two boreholes to a depth of approximately 1.0 m below ground level (m bgl) using a shovel and 75 mm diameter hand auger. The approximate location of the boreholes is shown on Drawing 1, Appendix A.

Soil samples were collected from the boreholes at approximately 0.25 m depth intervals or observed changes in the soil strata. A log was completed for each borehole indicating the geological profile observed (refer to Appendix C). The log included, where relevant, sample identification, coordinates, date of collection, a description of the substrate conditions encountered, the depth of samples, the sampler and equipment used.

4.2 General Sampling Procedure

Sampling data was recorded to comply with routine chain-of-custody requirements and DP's standard operating procedures outlined in the DP Field Procedures Manual. The general sampling, handling, transport and tracking procedures are detailed below:

- Soils were sampled directly from the auger. Disposable nitrile gloves were used to collect all samples. Gloves were replaced prior to the collection of each sample in order to minimise the risk of cross-contamination;
- Samples were transferred into air tight zip-lock plastic bags which were hand-pressed to remove excess air;
- Samples were labelled with individual and unique identification including project number, sample ID, depth and date of sampling;
- Placement of sample bags into a cooled, insulated and sealed container for transport to the laboratory; and
- Use of chain of custody documentation so that sample tracking and custody could be cross-checked at any point in the transfer of samples from the field to the laboratory.

4.3 Field Work Results

Details of the subsurface conditions encountered are given in the borehole log in Appendix C, together with notes defining classification methods and descriptive terms. A summary of the subsurface profile encountered is given below for both Bore 1 and Bore 2:

Bore 1

- TOPSOIL / Silty SAND: brown silty sand with ironstone gravel and rootlets to a depth of 0.25 m underlain by
- Silty CLAY (Residual Soil): red brown and grey silty clay a depth of 0.9 m

Bore 2

- FILL / Silty SAND: brown silty sand with sandstone gravel and trace rootlets to a depth of 0.2 m underlain by
- Silty SAND (Original Topsoil Layer): brown grey silty sand with ironstone gravel and rootlets to a depth of 0.5 m, underlain by
- Silty CLAY (Residual Soil): red brown and grey silty clay to a depth of 0.95 m.

The fill material encountered in Bore 2 may be related to historical development at the site (i.e. suspected reworked site soils). Free groundwater was not observed in Bores 1 or 2. It should be noted that groundwater levels are variable and can be affected by factors such as soil permeability and recent weather conditions.

5. Assessment Criteria

Indicators of ASS from field screening comprise one, or preferably more of the following:

- Field pH / pH in distilled H_2O (pH_F) is less than or equal to 4 pH units. The pH_F (non-oxidised) is a measure of existing acidity;
- pH following addition of H_2O_2 (pH_{Fox}) is less than 3.5 pH units. The pH_{Fox} (oxidised pH) is a measure of potential acidity;
- A decrease of more than 1 pH unit from the pH_F to the pH_{Fox};
- Effervescence including bubbling, production of heat or release of sulfur odours during pH_{Fox} testing; and
- Change in colour from grey to brown tones during oxidation.

It should be noted the field screening is indicative only and can give false positive (and false negative) indications of the presence of ASS. False positives can be caused by organic matter, which often "froths" during oxidation.

The action criteria which define the requirement for management of acid sulfate soils vary depending on the amount of soil disturbed (i.e. < 1000 tonnes) and the textural classification of the soil. The relevant criteria are shown on Table B1, Appendix B.

6. Assessment Results and Comments

Select soil samples from the boreholes were screened for ASS using a calibrated pH meter to measure pH in water (H_2O) and hydrogen peroxide (H_2O_2). The results of the ASS screening are shown on Table B1, Appendix B.

The screening results indicated that only the topsoil or fill samples with rootlets reported a difference of pH_F and pH_{Fox} exceeding the screening guideline, with all other samples reporting results that did not exceed the respective screening guideline. The positive screening result in Samples 1/0.1 and 2/0.1 was considered to be associated with the presence of organics in the sample.

In summary, based on the following evidence, site soils are assessed as not containing sulfidic ores or minerals (i.e. no acid sulfate soils present) and no further investigation or testing is warranted:

- Site elevation of approximately 33 m to 39 m AHD;
- The site and nearby areas are mapped as having no known occurrence of acid sulfate soils;

- Subsurface conditions encountered in the boreholes were consistent with mapped conditions and comprised shallow topsoil/fill material underlain by residual clay soils that were assessed as being weathered from the underlying parent rock (i.e. Terrigal Formation); and
- Acid sulfate soil screening tests reported no substantial indicators of acid sulfate soils.

It is considered that the works can be undertaken without the need for an acid sulfate soil management plan. However, if different subsurface conditions are encountered, further advice should be sought from DP.

7. References

Ahern, C. R., McElnea, A. E., & Sullivan, L. A. (2004). *Acid Sulfate Soils Laboratory Methods Guidelines. In Queensland Acid Sulfate Soils Manual 2004.* (QASSIT) Indooroopilly, Queensland, Australia: Department of Natural Resources, Mines and Energy.

Dear, S., Ahern, C., O'Brien, L., Dobos, S., McElnea, A., Moore, N., & Watling, K. (2014). *Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines.* (QASSIT). Brisbane: Department of Science: Department of Science, Information, Technology, Innovation and the Arts, Queensland Government.

Stone, Y., Ahern, C. R., & Blunden, B. (1998). *Acid Sulfate Soil Manual.* Acid Sulfate Soil Management Committee (ASSMAC).

Sullivan, L., Ward, N., Toppler, N., & Lancaster, G. (2018). *National Acid Sulfate Soils Guidance: National Acid Sulfate Soils Sampling and Identification Methods Manual.* Canberra ACT CC BY 4.0: Department of Agriculture and Water Resources.

8. Limitations

Douglas Partners (DP) has prepared this report (or services) for this project at 53 - 55 Donnison Street West, Gosford in accordance with DP’s proposal dated 2 June 2022 and acceptance received from Shane Zerafa dated 2 June 2022 The work was carried out under DP’s Conditions of Engagement. This report is provided for the exclusive use of VLZ Construction Pty Ltd for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

The assessment of atypical safety hazards arising from this advice is restricted to the environmental components set out in this report and based on known project conditions and stated design advice and assumptions. While some recommendations for safe controls may be provided, detailed 'safety in design' assessment is outside the current scope of this report and requires additional project data and assessment.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

Douglas Partners Pty Ltd

Appendix A

About This Report
Drawing 1

About this Report

Douglas Partners

Introduction

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

DP's 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.

Copyright

This report is the property of Douglas Partners 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.

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. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

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 potential problems, 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. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if 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, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

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.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Drawing adapted from Metromap Image, dated 15 August 2021

Drawing adapted from Metromap Image, dated 15 August 2021, with Acid Sulfate Soil Risk Mapping Overlay

20 0 20 40 60 80 m

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: ABC Client Pty Ltd		TITLE:	**Test Location Plan**
OFFICE: Central Coast	DRAWN BY: JBR		**Proposed Residential Unit Development**
SCALE: 1:788.39 @A3	DATE: 21.07.22		**53 - 55 Donnison Street West, Gosford**

N

PROJECT No: 203360.02	
DRAWING No:	1
REVISION:	0

Appendix B

Table B1: Laboratory Summary Table

Table B1 - Laboratory Summary Table (Acid Sulfate Soil Assessment)

	Screening Test (as reported by the laboratory)				
Sample ID	Strata / Soil Texture	pH_F	pH_{FOX}	pH_F - pH_{FOX}	Strength of Reaction
1/0.1	Topsoil / Silty Sand (coarse)	5.8	4.7	1.1	1F (organics)
1/0.3	Silty Clay (fine)	6.0	5.9	0.1	1
1/0.5	Silty Clay (fine)	6.0	6.2	-0.2	1
1/0.9	Silty Clay (fine)	5.6	5.6	0.0	1
2/0.1	Fill / Silty Sand (coarse)	6.1	4.2	1.9	1F (organics)
2/0.3	Silty Sand (coarse)	6.1	5.2	0.9	1F (organics)
2/0.6	Silty Clay (fine)	5.3	5.6	-0.3	1
2/0.9	Silty Clay (fine)	5.8	5.8	0.0	1
Action Criteria (Sullivan et al 2018)					
Screening Levels		≤4	<3.5	>1	-
Action Criteria (<1000 t) (Coarse texture - sands to loamy sands)		-	-	-	-
Action Criteria (<1000 t) (Medium texture - sandy loams to light clays)		-	-	-	-
Action Criteria (<1000 t) (Fine texture - medium to heavy clays and silty clays)		-	-	-	-

Notes:

NT	Not Tested
pH_F	non-oxidised pH (soil in distilled water) measures existing acidity
pH_{FOX}	oxidised pH (soil oxidised in hydrogen peroxide) measures potential acidity
pH_F - pH_{FOX}	change in pH - the greater the difference from pH_F to pHfox, the more likely of the soil being PASS
Strength of Reaction	chemical reaction may include colour change, effervescence (bubbling), gas evolution, heat and pungent/irritating odour (sulfur dioxide/hydroge
1	no or slight reaction
2	moderate reaction
3	vigorous reaction
4	high reaction
F	bubbling/frothy reaction indicative of organics
(light orange shading)	exceeds screening criteria
(dark red shading)	exceeds action criteria

Appendix C

Logs
Sampling, Testing and Excavation Methodology
Soil Descriptions
Terminology, Symbols and Abbreviations

BOREHOLE LOG

CLIENT: VLZ Construction Pty Ltd
PROJECT: Proposed Residential Unit Development
LOCATION: 53 Donnison Street West, Gosford

SURFACE LEVEL: 33.5 AHD
COORDINATE E:345207 **N:** 6300203
DATUM/GRID: MGA94 Zone 56 H
DIP/AZIMUTH: 90°/---

LOCATION ID: 1
PROJECT No: 203360.02
DATE: 06/06/22
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
06/06/22, No free groundwater observed		0.0	TOPSOIL/ Silty SAND, with gravel; brown; sand fraction fine; gravel fraction trace ironstone and rootlets; 30%-40% non plastic fines		TOP		M		D		0.1		
		0.25	(CL) Silty CLAY, trace sand; red brown grey; clay fraction medium plasticity; sand fraction fine to coarse grained 0.5-0.9m: some iron indurated sandy bands		RES	F TO VST	>PL		D D		0.3 0.5		
	33												
		0.9	Borehole discontinued at 0.90m depth - limit of investigation						D		0.9		

NOTES: (#)Soil origin is "probable" unless otherwise stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: Hand Tools
METHOD: Shovel and 75mm diameter Hand Auger
REMARKS: Coordinates and elevation inferred on-line mapping

OPERATOR: BJK
CASING:

LOGGED: BJK

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: VLZ Construction Pty Ltd
PROJECT: Proposed Residential Unit Development
LOCATION: 53 Donnison Street West, Gosford

SURFACE LEVEL: 37.5 AHD
COORDINATE E:345221 **N:** 6300237
DATUM/GRID: MGA94 Zone 56 H
DIP/AZIMUTH: 90°/---

LOCATION ID: 2
PROJECT No: 203360.02
DATE: 06/06/22
SHEET: 1 of 1

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
06/06/22, No free groundwater observed		0.0	FILL/ Silty SAND, with gravel; brown; gravel fraction sandstone; trace rootlets		FILL		M		D		0.1		
		0.2	Silty SAND, with gravel; brown/grey; sand fraction fine; gravel fraction trace ironstone and rootlets; 30%-40% non plastic fines (original topsoil layer)				M		D		0.3		
	37	0.5	(CL) Silty CLAY, trace sand; red brown grey; clay fraction medium plasticity; sand fraction fine to coarse grained		RES	F TO VST	>PL		D		0.6		
									D		0.9		
		0.95	Borehole discontinued at 0.95m depth - limit of investigation										

NOTES: (#)Soil origin is "probable" unless otherwise stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: Hand Tools
METHOD: Shovel and 75mm diameter Hand Auger
REMARKS: Coordinates and elevation inferred on-line mapping

OPERATOR: BJK
CASING:

LOGGED: BJK

EXPORTED 21/07/22 16:48. TEMPLATE ID: DP_101.02.00_SOILLOG

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

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. Undisturbed sampling is generally effective only in cohesive soils.

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. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling 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. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

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. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

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. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 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. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. 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.

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are generally based on Australian Standard AS1726:2017, Geotechnical Site Investigations. 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
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

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

Type	Particle size (mm)
Coarse gravel	19 - 63
Medium gravel	6.7 - 19
Fine gravel	2.36 – 6.7
Coarse sand	0.6 - 2.36
Medium sand	0.21 - 0.6
Fine sand	0.075 - 0.21

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

The proportions of secondary constituents of soils are described as follows:

In fine grained soils (>35% fines)

Term	Proportion of sand or gravel	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	>30%	Sandy Clay
With	15 – 30%	Clay with sand
Trace	0 - 15%	Clay with trace sand

In coarse grained soils (>65% coarse)
- with clays or silts

Term	Proportion of fines	Example
And	Specify	Sand (70%) and Clay (30%)
Adjective	>12%	Clayey Sand
With	5 - 12%	Sand with clay
Trace	0 - 5%	Sand with trace clay

In coarse grained soils (>65% coarse)
- with coarser fraction

Term	Proportion of coarser fraction	Example
And	Specify	Sand (60%) and Gravel (40%)
Adjective	>30%	Gravelly Sand
With	15 - 30%	Sand with gravel
Trace	0 - 15%	Sand with trace gravel

The presence of cobbles and boulders shall be specifically noted by beginning the description with 'Mix of Soil and Cobbles/Boulders' with the word order indicating the dominant first and the proportion of cobbles and boulders described together.

Soil Descriptions

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
Friable	Fr	-

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 (PSP). The relative density terms are given below:

Relative Density	Abbreviation	Density Index (%)
Very loose	VL	<15
Loose	L	15-35
Medium dense	MD	35-65
Dense	D	65-85
Very dense	VD	>85

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;
- Extremely weathered material – formed from in-situ weathering of geological formations. Has soil strength but retains the structure or fabric of the parent rock;
- Alluvial soil – deposited by streams and rivers;
- Estuarine soil – deposited in coastal estuaries;
- Marine soil – deposited in a marine environment;
- Lacustrine soil – deposited in freshwater lakes;
- Aeolian soil – carried and deposited by wind;
- Colluvial soil – soil and rock debris transported down slopes by gravity;
- Topsoil – mantle of surface soil, often with high levels of organic material.
- Fill – any material which has been moved by man.

Moisture Condition – Coarse Grained Soils

For coarse grained soils the moisture condition should be described by appearance and feel using the following terms:

- Dry (D) — Non-cohesive and free-running.
- Moist (M) — Soil feels cool, darkened in colour.
  Soil tends to stick together.
  Sand forms weak ball but breaks easily.
- Wet (W) — Soil feels cool, darkened in colour.
  Soil tends to stick together, free water forms when handling.

Moisture Condition – Fine Grained Soils

For fine grained soils the assessment of moisture content is relative to their plastic limit or liquid limit, as follows:

- 'Moist, dry of plastic limit' or 'w <PL' (i.e. hard and friable or powdery).
- 'Moist, near plastic limit' or 'w ≈ PL (i.e. soil can be moulded at moisture content approximately equal to the plastic limit).
- 'Moist, wet of plastic limit' or 'w >PL' (i.e. soils usually weakened and free water forms on the hands when handling).
- 'Wet' or 'w ≈LL' (i.e. near the liquid limit).
- 'Wet' or 'w >LL' (i.e. wet of the liquid limit).

Symbols & Abbreviations

Douglas Partners

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

▷	Water seep
▽	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
E	Environmental sample
U_{50}	Undisturbed tube sample (50mm)
W	Water sample
pp	Pocket penetrometer (kPa)
PID	Photo ionisation detector
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

Symbols & Abbreviations

Graphic Symbols for Soil and Rock

General

- Asphalt
- Road base
- Concrete
- Filling

Soils

- Topsoil
- Peat
- Clay
- Silty clay
- Sandy clay
- Gravelly clay
- Shaly clay
- Silt
- Clayey silt
- Sandy silt
- Sand
- Clayey sand
- Silty sand
- Gravel
- Sandy gravel
- Cobbles, boulders
- Talus

Sedimentary Rocks

- Boulder conglomerate
- Conglomerate
- Conglomeratic sandstone
- Sandstone
- Siltstone
- Laminite
- Mudstone, claystone, shale
- Coal
- Limestone

Metamorphic Rocks

- Slate, phyllite, schist
- Gneiss
- Quartzite

Igneous Rocks

- Granite
- Dolerite, basalt, andesite
- Dacite, epidote
- Tuff, breccia
- Porphyry