Crozier Geotechnical Consultants
Unit 12/ 42-46 Wattle Road
Brookvale NSW 2100
Crozier Geotechnical Consultants, a division of PJC Geo-Engineering Pty Ltd
ABN: 96 113 453 624
Phone: (02) 9939 1882
Email: info@croziergeotech.com.au

GEOTECHNICAL REPORT INTO ACID SULFATE SOILS

for

PROPOSED DEVELOPMENT

at

9 – 11 BIRDWOOD AVENUE, COLLAROY

Prepared For

Birdwood Projects Pty Ltd

Project No.: 2019-139.1

February, 2020

Document Revision Record

Issue No	Date	Details of Revisions
0	13th February 2020	Original

TABLE OF CONTENTS

CROZIER GEOTECHNICAL CONSULTANTS

Crozier Geotechnical Consultants ABN: 96 113 453 624
Unit 12/ 42-46 Wattle Road Phone: (02) 9939 1882
Brookvale NSW 2100 Email: info@croziergeotech.com.au
Crozier Geotechnical Consultants a division of PJC Geo-Engineering Pty Ltd

GEOTECHNICAL REPORT INTO ACID SULFATE SOILS FOR PROPOSED NEW DEVELOPMENT 9-11 BIRDWOOD AVENUE, COLLAROY, NSW

1. INTRODUCTION:

This report details the results of a geotechnical assessment into Acid Sulfate Soil conditions carried out for proposed new development at No. 9-11 Birdwood Avenue, Collaroy, NSW. The assessment was undertaken by Crozier Geotechnical Consultants (CGC) at the request of the client Birdwood Projects Pty Ltd.

It is understood that the proposed works involve demolition of the existing residential house and construction of a new two to three storey residential apartment development across the centre of the site with above ground pools. The works require excavation of up to 5.60m depth, which reduces to nil towards the front north boundary, to achieve the basement level with a finished floor level at RL4.75. The excavation will extend to within 1.90m of the east side boundary, 1.00m of the west side boundary and 13.0m of the south boundary. It also appears to require fill up to 1.40m depth at the rear of the property.

The site is classified under Warringah Councilôs Local Environmental Plan (LEP) 2011 as being within ó Class 4ô Acid Sulfate soils hazard zone. Therefore, an assessment of acid sulfate soils and groundwater conditions is required.

This report includes a description of the field work, plan showing test locations and provides an assessment of the acid sulfate soil conditions.

The investigation comprised:

a) A detailed geotechnical inspection and mapping of the site and adjacent properties by a Geotechnical Engineer.
b) Drilling of four boreholes with regular SPT testing
c) Installation of one groundwater well to assess groundwater seepage rate
d) Soil sampling and chemical testing by NATA accredited laboratories for site classification and geotechnical conditions.

The following plans and drawings were supplied for the work:

- Architectural drawings by edaa, Drawing No.: PDA.01 to PDA.07, Dated: 29/09/2019
- Survey Plan by Byrne and Associates, Plan No.: A1 ï 11019D, Dated of Survey: 21/06/2019.

2. SITE FEATURES:

2.1. Description:

The site is a rectangular shaped block located on the high south side of Birdwood Avenue, within gentle to moderate north dipping topography. The site has front north and rear south boundaries of 36.58m and east and west side boundaries of 40.24m.

An aerial photograph of the site and its surrounds is provided below, as sourced from NSW Government Six Map spatial data, as Photograph 1.

Photograph: 1 – Aerial photo of site and surrounds.

The site is currently occupied by a two storey rendered house at the centre of the block with a moderate sloping front yard. A front view of the site is provided in Photograph 2 below.

Photograph: 2 – Front view of the site, facing south.

2.2. Geology:

Reference to the Sydney 1:100,000 Geological Series sheet (9130) indicates that the site is underlain by Newport Formation (Upper Narrabeen Group) rock (Rnn) which is of middle Triassic Age. The Newport Formation typically comprises interbedded laminite, shale and quartz to lithic quartz sandstones and pink clay pellet sandstones.

3. FIELD WORK:

3.1. Methods:

The field assessment comprised the drilling of four boreholes (BH1 to BH4) on the 13th and 16th September 2019 by the contractor BG Drilling Pty Ltd under the supervision of a geotechnical engineer from CGC. It also included the sampling and laboratory testing for actual and potential acid sulphate characteristics.

Explanatory notes are included in Appendix: 1. Mapping information and test locations are shown on Figure: 1, along with detailed log sheets in Appendix: 2.

3.2. Field Testing:

The boreholes (BH1 to BH4) were drilled approximately at the corners of the proposed basement. BH1 was discontinued at 9.23m depth in extremely weathered siltstone. BH2 and BH3 were drilled to 7.80m and 10.50m depth, respectively, in low strength siltstone. BH4 encountered auger refusal at 5.70m depth on interpreted low strength siltstone. SPT testing was undertaken at regular intervals during augering.

Based on the borehole logs and SPT test results, the sub-surface conditions at the project site can be classified as follows:

- **TOPSOIL/FILL –** this layer was encountered at all test locations to 0.50m depth. It is classified as black, fine grained, moist silty sand.
- **Silty CLAY –** this layer was encountered in BH1 and BH3 to depths of 3.00m (BH1) and 4.00m (BH3). It is classified as stiff to very stiff, orange/red brown to grey, medium to high plasticity, moist silty clay.
- **Silty SAND –** this layer was encountered in BH2 and BH4 to 2.00m depth. It is classified as loose to medium dense, dark grey to brown, moist silty sand.
- **SILTSTONE –** this layer was encountered at all test locations below the silty clay and silty sand layers. Siltstone of extremely low strength with very low strength bands extends to varying depths from 5.70m (BH4) to below 9.23m (BH1). It then graded to low strength, which was identified by coring in BH2 and BH3.

Water inflow was encountered during the investigation at varying depth from 4.50m (BH4) to 7.00m (BH1). Following pump-out of BH3 a standpipe was installed within the open bore and was allowed to develop for over 24 hours prior to measurement on the 20th and 23rd September 2019. A groundwater table was not encountered within the depth of the borehole however seepage was encountered (<0.5L/min).

3.3. Laboratory Testing

Soil samples collected from the boreholes were sent to NATA accredited laboratories for chemical testing (Envirolab) and geotechnical testing (Macquarie Geotechnical).

Five samples were tested at Envirolab to via the pH, pHFOX methods, based on the recommendations of the Acid Sulfate Soils Laboratory Methods Guidelines, Version: 2.1, June 2004. The results are summarised in Table 1.

Table 1: Summary of Envirolab Laboratory Test Results

Borehole:	Depth (m)	pH	pH_{FOX}	Reaction Rate
BH3	0.5-1.0	6.4	6.2	Moderate
BH3	5.0-5.5	5.0	3.6	Moderate
BH4	0.5-1.0	5.8	5.7	Slight
BH4	1.5-2.0	6.4	5.6	Slight
BH4	3.0-3.45	5.4	4.3	Slight

The full set of laboratory results analysis sheets is included in Appendix: 3.

4. COMMENTS:

4.1. Geotechnical Assessment:

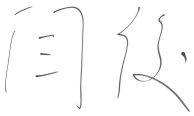
The site investigation identified the presence of a layer of topsoil/fill to 0.50m depth overlying stiff to very stiff silty clay and loose to medium dense silty sand to the surface of extremely low strength to very low strength siltstone at approximately RL3.95 (BH2) to RL5.95 (BH3). The siltstone graded to low strength below RL-0.74 in BH2 and RL0.96 in BH3. Minor groundwater seepage (<0.5L/min) was encountered at varying level from RL-1.30 (BH2) to RL4.35 (BH3). No freestanding groundwater table was encountered during the investigation.

The works require excavation of up to 5.60m depth, which reduces to nil towards the front north boundary, to achieve the basement level with a finished floor level at RL4.75. The excavation will extend to within 1.90m of the east side boundary, 1.00m of west side boundary and 13.0m of the south boundary. It also requires fill up to 1.40m depth at the rear of the property.

The site is classified as being within an Acid Sulphate Soils Class 4 Zone. The laboratory test results indicate that the soils have a óslight to Moderateô Reaction Rate, whilst both natural pH and oxidised pH are above 4. As the ground conditions encountered and the proposed works there is a low likelihood of intersecting Actual or Potential Acid Sulfate Soils. A water table was not encountered in the boreholes to below the base of excavation level, therefore the works will not lowering or impact the local water table. As such, according to the Acid Sulphate Soils Management Advisory Committee (ASSMAC), a management plan will not be required.

5. CONCLUSION:

The test results indicate that Actual and Potential Acid Sulphate Soils are not present below the surface of the site, within the location of the proposed works, whilst a water table will not be intersected or lowered. The test results do not trigger the requirement for an acid sulphate management plan as the excavation is unlikely to intersect these soils or impact the water table. As per the guidelines of the NSW Acid Sulphate Soil Manual an Acid Sulphate Management Plan is not required.



Prepared By:
Jun Yan
Geotechnical Engineer

Reviewed By:
Troy Crozier
Principal
MAIG, RPGeo ï Geotechnical and Engineering
Registration No.: 10197

6. REFERENCES:

1. NSW Acid Sulfate Soil Management Advisory Committee 1998, ñNSW Acid Sulphate Soil Manualò.

CROZIER
GEOTECHNICAL CONSULTANTS

Appendix 1

Crozier Geotechnical Consultants
Unit 12/ 42-46 Wattle Road
Brookvale NSW 2100
ABN: 96 113 453 624
Phone: (02) 9939 1882
Email: info@croziergeotech.com.au
Crozier Geotechnical Consultants, a division of PJC Geo-Engineering Pty Ltd

NOTES RELATING TO THIS REPORT

Introduction

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

Geotechnical reports are based on information gained from limited subsurface test boring 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.

Description and classification Methods

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

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (eg. Sandy clay) on the following bases:

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

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

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

Non-cohesive soils are classified on the basis of relative density, generally from the results of standard penetration tests (SPT) or Dutch cone penetrometer tests (CPT) as below:

Relative Density	SPT "N" Value (blows/300mm)	CPT Cone Value (Qc – MPa)
Very loose	less than 5	less than 2
Loose	5 – 10	2 – 5
Medium dense	10 – 30	5 -15
Dense	30 – 50	15 – 25
Very dense	greater than 50	greater than 25

Rock types are classified by their geological names. Where relevant, further information regarding rock classification is given on the following sheet.

Sampling

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

Disturbed samples taken during drilling to allow 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 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.

Drilling Methods

The following is a brief summary of drilling methods currently adopted by the company and some comments on their use and application.

Test Pits – these are excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils if it is safe to descent into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (eg. Pengo) – the hole is advanced by a rotating plate or short spiral auger, generally 300mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5m) 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 sampling.

Continuous Sample Drilling – the hole is advanced by pushing a 100mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling soils, since moisture content is unchanged and soil structure, strength, etc. is only marginally affected.

Continuous Spiral Flight Augers – the hole is advanced using 90 – 115mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPT's or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling - the hole is advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from 'feel' and rate of penetration.

Rotary Mud Drilling – similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (eg. From SPT).

Continuous Core Drilling – a continuous core sample is obtained using a diamond-tipped core barrel, usually 50mm internal diameter. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

Standard Penetration Tests

Standard penetration tests (abbreviated as SPT) are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample. The test procedures 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 50mm diameter split sample tube under the impact of a 63kg hammer with a free fall of 760mm. It is normal for the tube to be driven in three successive 150mm increments and the 'N' value is taken

as the number of blows for the last 300mm. In dense sands, very hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150mm of say 4, 6 and 7 as 4, 6, 7 then N = 13
- In the case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm then as 15, 30/40mm.

The results of the test can be related empirically to the engineering properties of the soil. Occasionally, the test method is used to obtain samples in 50mm diameter thin wall sample tubes in clay. In such circumstances, the test results are shown on the borelogs in brackets.

Cone Penetrometer Testing and Interpretation

Cone penetrometer testing (sometimes referred to as Dutch Cone – abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in Australia Standard 1289, Test 6.4.1.

In tests, a 35mm diameter rod with a cone-tipped end is pushed continually into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the friction resistance on a separte 130mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected buy electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) their information is plotted on a computer screen and at the end of the test is stored on the computer for later plotting of the results.

The information provided on the plotted results comprises: -

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

There are two scales available for measurement of cone resistance. The lower scale (0 – 5 MPa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main scale (0 – 50 MPa) is less sensitive and is shown as a full line. The ratios of the sleeve friction to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios 1% - 2% are commonly encountered in sands and very soft clays rising to 4% - 10% in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range: -

Qc (MPa) = (0.4 to 0.6) N blows (blows per 300mm)

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range: -

Qc = (12 to 18) Cu

Interpretation of CPT values can also be made to allow estimation of modulus or compressibility values to allow calculations of foundation settlements.

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes, etc. This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on soil classification is required, direct drilling and sampling may be preferable.

Dynamic Penetrometers

Dynamic penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150mm increments of penetration. Normally, there is a depth limitation of 1.2m but this may be extended in certain conditions by the use of extension rods.

Two relatively similar tests are used.

- Perth sand penetrometer – a 16mm diameter flattened rod is driven with a 9kg hammer, dropping 600mm (AS1289, Test 6.3.3). The test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
- Cone penetrometer (sometimes known as Scala Penetrometer) – a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS 1289, Test 6.3.2). The test was developed initially for pavement sub-grade investigations, and published correlations of the test results with California bearing ratio have been published by various Road Authorities.

Laboratory Testing

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

Borehole Logs

The bore logs presented herein 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. 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 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, the frequency of sampling and the possibility of other than 'straight line' variations between the boreholes.

Details of the type and method of sampling are given in the report and the following sample codes are on the borehole logs where applicable:

D	Disturbed Sample	E	Environmental sample	DT	Diatube
B	Bulk Sample	PP	Pocket Penetrometer Test		
U50	50mm Undisturbed Tube Sample	SPT	Standard Penetration Test		
U63	63mm " " " " "	C	Core		

Ground Water

Where ground water levels are measured in boreholes there are several potential problems:

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

Engineering Reports

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

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

- unexpected variations in ground conditions – the potential for this will depend partly on bore spacing and sampling frequency,
- changes in policy or interpretation of policy by statutory authorities,
- the actions of contractors responding to commercial pressures,

If these occur, the Company will be pleased to assist with investigation 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, the Company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed than at some later stage, well after the event.

Reproduction of Information for Contractual Purposes

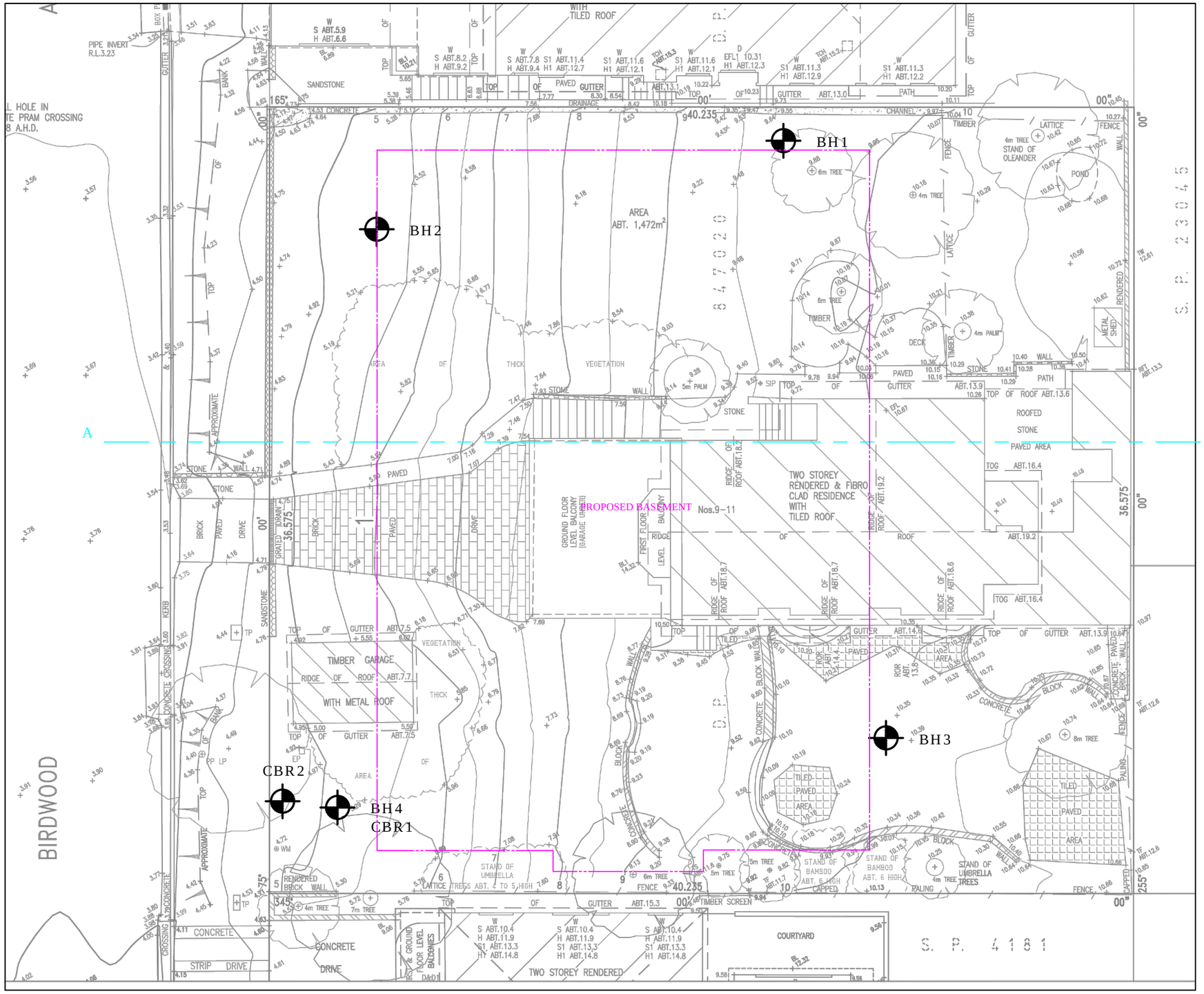
Attention is drawn to the document “Guidelines for the Provision of Geotechnical Information in Tender Documents”, published by the Institution of Engineers Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including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

Site Inspection

The Company will always be pleased to provide engineering inspection services for geotechnical 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.

CROZIER
GEOTECHNICAL CONSULTANTS

Appendix 2



0 1 2 3 4 5 6 7 8 9 10

SCALE: 1:200

SITE PLAN & TEST LOCATIONS FIGURE 1.

LEGEND

A — A' CROSS-SECTION REFERENCE LINE

BH BOREHOLE LOCATIONS

CROZIER GEOTECHNICAL CONSULTANTS

Crozier Geotechnical ABN: 96 113 453 624
Unit 12, 42-46 Wattle Road Phone: (02) 9939 1882
Brookvale NSW 2100 Fax: (02) 9939 1883
Crozier Geotechnical is a division of PJC Geo-Engineering Pty Ltd

SCALE:	1:200 @ A3
DRAWING:	FIGURE 1
DATE:	04/10/2019
APPROVED BY:	TMC
DRAWN BY:	JY
PROJECT:	2019-139

PREPARED FOR:

Birdwood Projects Pty Ltd

ADDRESS:

9-11 Birdwood Ave, Collaroy

Client: Birdwood Projects Pty Ltd **Date:** 13/09/2019 **Borehole:** 1

Project: New apartment development **Project No.:** 2019-139

Location: 9-11 Birdwood Avenue, Collaroy **Surface Level:** RL9.70 **Sheet:** 1 of 1

Depth (m)	Description of Strata Soil/rock name, grainsize, texture/fabric, colour	Discontinuities	Weathering Extremely / Highly / Moderately / Slightly / Fresh	Rock Strength Ex. Low / Very Low / Low / Medium / High / Very High	Defect Spacing < 0.05m / 0.05 to 0.20m / 0.20 to 0.50m / 0.50 to 1.00m / > 1.00m	Installation Details	Sampling and In Situ Testing Type / Depth (m) / Core Rec. % / RQD % / Test Results
	TOPSOIL: Black, fine grained, moist silty sand						
0.50	Silty CLAY: Stiff to very stiff, orange brown, medium to high plasticity, moist silty clay						0.50 Water Content=23.4% LL=57% PL=21% PI=36% Linear Shrinkage=12.0%
1.00	é becoming orange mottled grey, low plasticity below 1.00m depth						D 1.00 SPT SPT 2, 3, 5 N=8
1.30	é becoming grey						1.45 D 1.50
2.00							D 2.00
							SPT 4, 9, 12 N=21
3.00							2.45 3.00
4.00	SILTSTONE: Grey, fine grained, extremely weathered, extremely low strength with very low strength bands						SPT 15, 16, 23 N=39 3.45
4.50	é becoming red brown below 4.50m depth						4.50 SPT SPT 9, 25 for 110mm
5.00							4.95 D
6.00							6.00
							SPT 13, 25 for 70mm
6.45							6.45 Water Content=18.8%
7.00	é becoming wet below 7.00m depth						D
7.50	é becoming dark grey below 7.50m depth						7.50 SPT SPT 14, 28, 25 for 40mm
8.00							7.95
9.00							9.00 SPT SPT 25, 25 for 75mm
9.23	Auger discontinued at 9.23m depth in weathered siltstone						9.25
10.00							

Rig: Multi-Purpose CE180 **Driller:** BG drilling

Type of Boring: Solid stem spiral flight auger, tungsten carbide bit **Logged By:** JY

Water Observations: Sample became wet below 7.0m depth **Casing:** NA

Comments:

CROZIER GEOTECHNICAL CONSULTANTS

Client: Birdwood Projects Pty Ltd **Date:** 13/09/2019 **Borehole:** 2

Project: New apartment development **Project No.:** 2019-139

Location: 9-11 Birdwood Avenue, Collaroy **Surface Level:** RL5.21 **Sheet:** 1 of 1

Depth (m)	Description of Strata Soil/rock name, grainsize, texture/fabric, colour	Discontinuities	Weathering Extremely / Highly / Moderately / Slightly / Fresh	Rock Strength Ex. Low / Very Low / Low / Medium / High / Very High	Defect Spacing < 0.05m / 0.05 to 0.20m / 0.20 to 0.50m / 0.50 to 1.00m / > 1.00m	Installation Details	Sampling and In Situ Testing Type / Depth (m) / Core Rec. % / RQD % / Test Results
	TOPSOIL: Black, fine grained, moist silty sand						
0.50	Silty SAND: Medium dense, dark grey, fine grained, moist						D 0.50 – Water Content=18.0% LL=29% PL=16% PI=13% Linear Shrinkage=6.0%
							D 1.00 SPT 1.00 – SPT 3, 7, 8 N=15
1.40	é becoming red brown below 1.40m depth						SPT 1.45
2.00							D 2.00
	SILTSTONE: Grey, fine grained, extremely weathered, extremely low strength with very low strength bands						SPT 2.45 – SPT 15, 27, 25 for 90mm Water Content=13.6%
3.00							SPT 3.00 – SPT 9, 25, 25 for 95mm Water Content=17.0%
4.00							SPT 3.45
4.50	é becoming brown below 4.50m depth						
5.00	é becoming dark grey below 5.00m depth						
5.50	é zone of very stiff silty clay between 5.50m and 6.70m depth						Water Content=15.2%
6.00							6.00
							SPT 6.45 – SPT 3, 7, 11 N=18
6.70	Core loss between 6.70m and 7.24m depth						
7.00							
7.24	SILTSTONE: Grey, thinly laminated, low to medium strength, slightly weathered	series of bedding defects, 0°-10°, PL, SO, Clean					7.24 - 7.34m: $I_{s(50)}$ = 0.14MPa (Diametral), $I_{s(50)}$ = 0.40MPa (Axial), Moisture Content = 8.2%
7.80	End of borehole at 7.80m depth on low to medium strength siltstone						7.67 - 7.77m: $I_{s(50)}$ = 0.04MPa (Diametral), $I_{s(50)}$ = 0.10MPa (Axial), Moisture Content = 8.5%
8.00							
9.00							
9.23							
10.00							

Rig: Multi-Purpose CE180 **Driller:** BG drilling

Type of Boring: Auger to 6.70m, then NMLC coring **Logged By:** JY

Water Observations: Sample became wet below 6.5m depth, water at 2.0m depth after auger **Casing:** 4.50m

Comments:

Client: Birdwood Projects Pty Ltd **Date:** 16/09/2019 **Borehole:** 3

Project: New apartment development **Project No.:** 2019-139

Location: 9-11 Birdwood Avenue, Collaroy **Surface Level:** RL10.35 **Sheet:** 1 of 2

Depth (m)	Description of Strata Soil/rock name, grainsize, texture/fabric, colour	Discontinuities	Weathering Extremely / Highly / Moderately / Slightly / Fresh	Rock Strength Ex. Low / Very Low / Low / Medium / High / Very High	Defect Spacing < 0.05m / 0.05 to 0.20m / 0.20 to 0.50m / 0.50 to 1.00m / > 1.00m	Installation Details	Sampling and In Situ Testing Type / Depth (m) / Core Rec. % / RQD % / Test Results
	TOPSOIL: Black, fine grained, moist silty sand						
0.50	Silty CLAY: Stiff to very stiff, orange brown, medium plasticity, moist silty clay						0.5
							D 1
1.00							SPT 2, 5, 7 N=12
							1.45
1.50	é becoming pale brown/grey below 1.50m depth						1.5 Water Content=22.1% LL=58% PL=21% PI=37%
							D
2.00	é becoming red brown, low plasticity below 2.00m depth						2 Linear Shrinkage=11.5%
							SPT 3, 6, 13 N=19
							2.45
							2.5
							D Water Content=19.9%
3.00							3
	é becoming grey below 3.00m depth						SPT 9, 15, 14 N=29
							3.45
4.00							4.00
	SILTSTONE: Grey, fine grained, extremely low strength with very low strength bands						D Water Content=18.2% LL=49% PL=20% PI=29%
4.50	é becoming red brown below 4.50m depth						4.5 Linear Shrinkage=11.0%
							SPT 6, 19 (B) refusal at 4.80m depth
							4.95
5.00							5
							D
							5.5 Water Content=28.5% LL=50% PL=18% PI=32%
							D
6.00	é wet SPT rod on retrieval						6 Linear Shrinkage=10.5%
							SPT 30 for 120mm
							6.45
7.00							
8.00							8
							D Water Content=21.3%
9.05							9 SPT 12 for 10mm
	SILTSTONE: Grey, thinly laminated, low to medium strength, slightly weathered	series of bedding defects, 0°-10°, PL, SO, Clean					9.55 - 9.74m: $I_{s(50)}$ = 0.12MPa (Diametral), $I_{s(50)}$ = 0.48MPa (Axial), Moisture Content = 6.4%
10.00							

Rig: Multi-Purpose CE180 **Driller:** BG drilling

Type of Boring: Auger to 9.00m, then NMCL coring **Logged By:** JY

Water Observations: Sign of water on retrieval of SPT rod at 6.00m depth, water level at 5.90m depth after bailing **Casing:** 7.50m

Comments:

CROZIER GEOTECHNICAL CONSULTANTS

Client: Birdwood Projects Pty Ltd **Date:** 16/09/2019 **Borehole:** 3

Project: New apartment development **Project No.:** 2019-139

Location: 9-11 Birdwood Avenue, Collaroy **Surface Level:** RL10.35 **Sheet:** 2 of 2

Depth (m)	Description of Strata Soil/rock name, grainsize, texture/fabric, colour	Discontinuities	Weathering Extremely / Highly / Moderately / Slightly / Fresh	Rock Strength Ex. Low / Very Low / Low / Medium / High / Very High	Defect Spacing < 0.05m / 0.05 to 0.20m / 0.20 to 0.50m / 0.50 to 1.00m / > 1.00m	Installation Details	Sampling and In Situ Testing Type / Depth (m) / Core Rec. % / RQD % / Test Results
							10.00 - 10.12m: $I_{s(50)}$ = 0.15MPa (Diametral), $I_{s(50)}$ = 0.44MPa (Axial), Moisture Content = 6.9%
10.50	End of borehole at 10.50m depth on low to medium strength siltstone						

Rig: Multi-Purpose CE180 **Driller:** BG drilling

Type of Boring: Auger to 9.00m, then NMCL coring **Logged By:** JY

Water Observations: Sign of water on retrieval of SPT rod at 6.00m depth, water level at 5.90m depth after bailing **Casing:** NA

Comments:

CROZIER GEOTECHNICAL CONSULTANTS

Client: Birdwood Projects Pty Ltd **Date:** 13/09/2019 **Borehole:** 4

Project: New apartment development **Project No.:** 2019-139

Location: 9-11 Birdwood Avenue, Collaroy **Surface Level:** RL5.21 **Sheet:** 1 of 1

Depth (m)	Description of Strata Soil/rock name, grainsize, texture/fabric, colour	Discontinuities	Weathering Extremely / Highly / Moderately / Slightly / Fresh	Rock Strength Ex. Low / Very Low / Low / Medium / High / Very High	Defect Spacing < 0.05m / 0.05 to 0.20m / 0.20 to 0.50m / 0.50 to 1.00m / > 1.00m	Installation Details	Sampling and In Situ Testing Type / Depth (m) / Core Rec. % / RQD % / Test Results
0.50	TOPSOIL: Black, fine grained, moist silty sand						0.5
	Silty SAND: Loose, dark grey, fine grained, moist						D
1.00	é becoming brown below 1.00m depth						1 SPT — SPT 3, 3, 4 N=7
							1.45 1.5
2.00							D 2
	SILTSTONE: Grey, fine grained, extremely low strength with very low strength bands						SPT — SPT 10, 10, 9 for 50mm
							2.45 2.5
3.00							D 3
							SPT — SPT 20, 3 for 20mm
							3.45
4.00							4
							D
4.50	é wet on retrieval of SPT						4.5 SPT — SPT 40 for 150mm
							4.95
5.00							5
							D
5.70	Auger refusal at 5.70m depth on low to medium strength bedrock						5.7
6.00							
7.00							
8.00							
9.00							
10.00							

Rig: Multi-Purpose CE180 **Driller:** BG drilling

Type of Boring: Solid stem spiral flight auger, tungsten carbide bit **Logged By:** JY

Water Observations: Sign of water on retrieval of SPT rod at 4.50m depth, water level at 1.40m depth after auger **Casing:** NA

Comments:

CROZIER
GEOTECHNICAL CONSULTANTS

Appendix 3

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 226375

Client Details

Client	Crozier Geotechnical Consultants
Attention	Troy Crozier
Address	Unit 12/42-46 Wattle Rd, Brookvale, NSW, 2100

Sample Details

Your Reference	**9-11 Birdwood Ave, Collaroy 2019-139**
Number of Samples	5 SOIL
Date samples received	18/09/2019
Date completed instructions received	18/09/2019

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

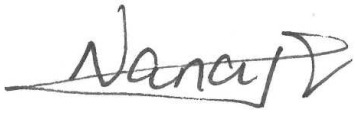
Date results requested by	25/09/2019
Date of Issue	24/09/2019

NATA Accreditation Number 2901. This document shall not be reproduced except in full.

Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Results Approved By
Priya Samarawickrama, Senior Chemist

Authorised By



Nancy Zhang, Laboratory Manager

Soil Aggressivity						
Our Reference		226375-1	226375-2	226375-3	226375-4	226375-5
Your Reference	UNITS	BH3 0.5-1.0	BH3 5.0-5.5	BH4 0.5-1.0	BH4 1.5-2.0	BH4 3.0-3.45
Depth		0.5-1.0	5.0-5.5	0.5-1.0	1.5-2.0	3.0-3.45
Date Sampled		16/09/2019	16/09/2019	16/09/2019	16/09/2019	16/09/2019
Type of sample		SOIL	SOIL	SOIL	SOIL	SOIL
pH 1:5 soil:water	pH Units	7.4	5.0	7.1	7.5	5.6
Electrical Conductivity 1:5 soil:water	µS/cm	120	87	45	50	40
Resistivity by calculation	ohm m	83	120	220	200	250
Chloride, Cl 1:5 soil:water	mg/kg	34	20	35	23	20
Sulphate, SO4 1:5 soil:water	mg/kg	64	120	20	10	40

sPOCAS field test						
Our Reference		226375-1	226375-2	226375-3	226375-4	226375-5
Your Reference	UNITS	BH3 0.5-1.0	BH3 5.0-5.5	BH4 0.5-1.0	BH4 1.5-2.0	BH4 3.0-3.45
Depth		0.5-1.0	5.0-5.5	0.5-1.0	1.5-2.0	3.0-3.45
Date Sampled		16/09/2019	16/09/2019	16/09/2019	16/09/2019	16/09/2019
Type of sample		SOIL	SOIL	SOIL	SOIL	SOIL
Date prepared	-	19/09/2019	19/09/2019	19/09/2019	19/09/2019	19/09/2019
Date analysed	-	19/09/2019	19/09/2019	19/09/2019	19/09/2019	19/09/2019
pH_F (field pH test)*	pH Units	6.4	5.0	5.8	6.4	5.4
pH_{FOX} (field peroxide test)*	pH Units	6.2	3.6	5.7	5.6	4.3
Reaction Rate*	-	Moderate	Moderate	Slight	Slight	Slight

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25°C in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA 22nd ED 2510 and Rayment & Lyons. Resistivity is calculated from Conductivity (non NATA). Resistivity (calculated) may not correlate with results otherwise obtained using Resistivity-Current method, depending on the nature of the soil being analysed.
Inorg-063	pH- measured using pH meter and electrode. Soil is oxidised with Hydrogen Peroxide or extracted with water. Based on section H, Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004. To ensure accurate results these tests are recommended to be done in the field as pH may change with time thus these results may not be representative of true field conditions.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Waters samples are filtered on receipt prior to analysis. Alternatively determined by colourimetry/turbidity using Discrete Analyser.

QUALITY CONTROL: Soil Aggressivity					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	226375-3
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	2	5.0	5.0	0	102	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	2	87	92	6	104	[NT]
Resistivity by calculation	ohm m	0.1	Inorg-002	<0.1	2	120	110	9	[NT]	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	2	20	25	22	110	82
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	2	120	120	0	115	91

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.