assetgeoenviro

Bayside Council

Proposed Replacement Commercial Building
179 Russell Avenue, Dolls Point NSW

Geotechnical Investigation

Our ref: 5763-1-G1
25 November 2019

Geotechnics | Groundwater | Environmental

DOCUMENT AUTHORISATION

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Geotechnical Investigation

Prepared for Bayside Council

Our ref: 5763-1-G1
25 November 2019

For and on behalf of
AssetGeoEnviro

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Managing Director | Senior Principal Geotechnical Engineer

DOCUMENT CONTROL

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Contents

1. INTRODUCTION

1.1 General

This report presents the results of a geotechnical investigation and preliminary acid sulfate soil assessment for the above project. The investigation was commissioned on 15 October 2019 by Yasmin McHutchison of Bayside Council. The work was carried out in accordance with the proposal by AssetGeoEnviro (Asset) dated 8 October 2019, reference 5763-P1.

Drawings supplied to us for this investigation comprised:

- Investigation location plans (provided by: Bayside Council; prepared by: Yasmin McHutchison; dated: 25 September 2019)

Based on the supplied drawings, we understand that the project involves the replacement of the existing "Le Beach Hut" café/restaurant on Depena Reserve. The replacement building is likely to be similar in scale and unlikely to have any significant below ground structure considering its closeness to Botany Bay. No scheme or detailed drawings have bene provided at this stage.

1.2 Scope of Work

The main objectives of the investigation were to assess the surface and subsurface conditions and to provide comments and recommendations relating to:

- Key geotechnical constraints to the development.
- Commentary on risk of saline soils.
- Assessment of risk of ASS from screening test results with recommendation for further testing as required.
- Excavation conditions and methodology.
- Subgrade preparation and earthworks.
- Site Classification as per AS2870 'Residential Slabs and Footings' (2011).
- Suitable foundation options and founding stratum.
- Allowable bearing pressure, end bearing and shaft adhesion for piles.
- Commentary on settlement.
- Maximum allowable permanent and temporary batter slopes.
- Groundwater conditions.

The following scope of work was carried out to achieve the project objectives:

- A review of existing regional maps and reports relevant to the site held within our files.
- Clearance of underground services at proposed test locations.
- Visual observations of surface features.
- Subsurface investigation at four locations to sample and assess the nature and consistency of subsurface soils and bedrock at accessible areas of the site.
- Acid sulfate screening tests.
- Further chemical analysis for acid sulfate soils based on the screening results.
- Engineering assessment and reporting.

This report must be read in conjunction with the attached "Important Information about your Geotechnical Report" in Appendix A. Attention is drawn to the limitations inherent in site investigations and the importance of verifying the subsurface conditions inferred herein.

2. SITE DESCRIPTION

The site is located on the southern side of Russell Avenue, Dolls Point, as shown in Figure 1. Located within Depena Reserve, it is bounded to the west by Waradiel Creek, to the south by Dolls Point Beach and to the east by Dolls Point.

Topographically, the site is located on gently sloping terrain to the north. The overall ground surface slopes in the region are about 2º.

At the time of the investigation, the site was occupied by Le Beach Hut, a single storey commercial building within Depena Reserve, part of Cooks Park. Paving comprising concrete and segmental pavers is located around the exterior of the building. There were no obvious cracks or settlement observed on the building or the external paved areas. The building and the surrounds appeared to be in moderate to good visual condition with respect to ground movement.

Vegetation comprises a thin covering of grass with Sandy topsoil present over much of the area peripheral to the building, and scattered large trees including fig, pine, and native species.

3. FIELDWORK & LABORATORY TESTING

3.1 Borehole Investigation

The fieldwork was undertaken on 1 November 2019 under the full-time supervision of a Geotechnical Engineer from Asset and included invasive investigation at four locations.

The test locations are shown in the attached Figure 2 and were set out by our Geotechnical Engineer by measurements relative to existing site features. Surface levels at the test locations were estimated by interpolation from Google Earth.

Buried metallic services and utilities within the site boundaries near the test locations were cleared by an accredited service location subcontractor and by referring to DBYD utility maps.

The invasive investigation included drilling of machine-drilled boreholes at four locations. The boreholes were auger drilled to a target depths of 6m below ground level (bgl). Standard Penetrometer Testing (SPT) was carried out within the soils at nominally 1.5m depth intervals to aid with an assessment of in-situ conditions.

Selected soil samples were retained for laboratory testing. Soils samples for Acid Sulfate Soil screening were taken at nominal 0.5m depth intervals and transported to a NATA registered laboratory under chain-of-custody protocols.

The subsurface conditions encountered were logged during drilling and testing. On completion of logging and sampling, the boreholes were backfilled with the drilling spoil.

Engineering logs are provided in Appendix B together with their explanatory notes.

3.2 Laboratory Testing

Soil and rock samples recovered during the fieldwork were delivered to a NATA registered laboratory. The following tests were carried out on selected samples:

- Potential acid sulfate soil (PASS) indicator tests (pH_f and pH_{fox}).
- Chromium Suite tests (Chromium Reducible Sulfur).

Test results are attached. Testing was carried out as described in the laboratory test results.

4. SUBSURFACE CONDITIONS

4.1 Geology

The Sydney 1:100,000 Geological Map indicates that the site is underlain by windblown sands with some silt and minor shell content.

4.2 Subsurface Conditions

A generalised geotechnical model for the site has been developed is shown in Table 1. For a detailed description of the subsurface conditions, refer the attached engineering logs and explanatory notes. For specific design input, reference should be made to the logs and/or the specific test results, in place of the following summary.

Table 1 - Generalised Site Geotechnical Model

Unit	Origin	Description	Depth to Top of Unit [1] (m)	Unit Thickness [1] (m)
1	Fill	FILL, Silty SAND, dark brown, fine grained, subrounded; trace gravel, fine grained, subangular, very loose to loose	Ground surface	0.2-0.5
2	Dune sand	SAND, pale brown/ grey / pale brown mottled dark brown/ pale brown mottled brown/ pale brown becoming grey , fine to medium grained, subrounded. Loose to dense	0.2-0.5	1.8-3.2
3	Marine sand	SAND, grey, fine to medium grained, subrounded, medium dense. SAND with shell fragments, grey, fine to medium grained, subrounded, loose to medium dense. Silty Clayey SAND with shell fragments, grey/dark grey, fine to medium grained, subrounded, medium dense Silty SAND with shell fragments, grey becoming dark grey, fine to medium grained, subrounded; trace organic material, loose to medium dense	2.2-3.4	Not proven beyond a depth of 6.0m

Notes:

1. The depths and unit thicknesses are based on the information from the test locations only and do not necessarily represent the maximum and minimum values across the site.

4.3 Groundwater

Groundwater was observed at a depth of 1.7m to 2.3m below ground level in the boreholes during auger drilling to depths of 6m bgl.

It is noted that the groundwater observation may have been made before water levels had stabilised. No long-term groundwater monitoring was carried out.

4.4 Laboratory Test Results

Results from the laboratory testing undertaken on selected soil samples are included in Appendix C summarised in Table 2 .

5. DISCUSSIONS & RECOMMENDATIONS

5.1 Acid Sulfate Soil Assessment

5.1.1 Geomorphic Criteria

ASSMAC[1] recommends the following geomorphic or site criteria be used to determine if acid sulfate soils are likely to be present:

a) Sediments of recent geological age (Holocene).

b) Soil horizons less than 5m AHD.

c) Marine or estuarine sediments and tidal lakes.

d) In coastal wetlands or back swamp areas; waterlogged or scalded areas; interdunal swales or coastal sand dunes (if deep excavation or drainage is proposed).

e) In areas where the dominant vegetation is mangroves, reeds, rushes and other swamp-tolerant or marine vegetation.

f) In areas identified in geological descriptions or in maps as bearing acid sulfide minerals, coal deposits or former marine shales/sediments.

g) Deep older estuarine sediments >10 metres below the ground surface, Holocene, or Pleistocene age (only an issue if deep drainage is proposed).

We note that criteria b) and c) are met for the subject site.

5.1.2 Soil Indicators

In accordance with ASSMAC, pH values of less than or equal to 4 indicate that actual acid sulfate soils (AASS) are present. Potential acid sulfate soils (PASS) are indicated where there is one but preferably more of the following:

- change in colour of the soil from grey tones to brown tones;
- effervescence (reaction rating of 2 or more):
  - 1 = no reaction to slight
  - 2 = moderate reaction
  - 3 = strong reaction with persistent froth
  - 4 = extreme reaction
- the release of sulfur smelling gases such as sulfur dioxide or hydrogen sulfide;
- a lowering of the soil pH by at least one unit; and
- a final pH_{fox} of < 3.5 (preferably <3)

[1] Stone, Y, Ahern CR, and Blunden B (1998). Acid Sulfate Soils Manual 1998. Acid Sulfate Soil Management Advisory Committee, Wollongbar, NSW, Australia.

Table 2 – Laboratory Test Results: Acid Sulfate Soil

Assumed tonnes disturbed: 1000

Test location	Depth (m)	pH Screening Test Results					CRS Test Results								Action Criteria	
		Field pH (pHf)	Actual ASS?	pH fox	Drop in pH	Reaction Rating	Texture	pHKCL	TAAs (% pyrite S)	S_{NAS} if pH-KCL <4.5 (%S)	Scr (%S)	ANC if pH-KCL >= 6.5 (%S)	Net Acidity (%S)	Net Acidity (mol H+/tonne)	Sulphur Trail S-POS (%)	Acid Trail TPA or TSA (mol/T)
BH2	0.5	8.2	No	5.1	3.1	1	C	6.5	<0.003	n/a	<0.005	n/a	0.02	10	0.03	18
BH2	1	8.5	No	4.8	3.7	1	C	6.9	<0.003	n/a	<0.005	0.02	0.02	10	0.03	18
BH2	1.5	9.4	No	7.1	2.3	3										
BH2	2	9.6	No	7.5	2.1	1										
BH2	2.5	9.7	No	7.5	2.2	1										
BH2	3	9.8	No	7.6	2.2	1	C	8.7	<0.003	n/a	<0.005	0.3	0.02	10	0.03	18
BH2	3.5	9.3	No	7	2.3	4										
BH2	4	9.3	No	7.6	1.7	1										
BH2	4.5	9.3	No	7.6	1.7	4										
BH2	5	9.3	No	7.6	1.7	1										
BH2	5.5	9.7	No	7.6	2.1	2										
BH2	6	9.5	No	7.2	2.3	1										
BH4	0.5	8.4	No	5.3	3.1	4										
BH4	1	9.6	No	7.5	2.1	1										
BH4	1.5	9.3	No	7.2	2.1	2										
BH4	2	9.8	No	7.6	2.2	2										
BH4	2.5	9.5	No	7.5	2	1										
BH4	3	9.5	No	7.6	1.9	1										
BH4	3.5	9.2	No	7.5	1.7	1										
BH4	4	9.2	No	7.4	1.8	3										
BH4	4.5	9.4	No	7.5	1.9	1										
BH4	5	9.4	No	7.2	2.2	3										
BH4	5.5	9.3	No	8	1.3	1										
BH4	6	9.3	No	7.5	1.8	1										

Samples tested in Table 2 indicated that PASS could be present, and therefore target samples were selected for further testing by Chromium Suite (Chromium Reducible Sulfur – CRS) testing.

5.1.3 Chemical Analysis

CRS test results were used to calculate "net acidity" by acid-based accounting methods as described below:

Net Acidity = Actual Acidity (as TAA) + Retained Acidity (as S_{NAS}) + Potential Acidity (as S_{CR}) – Acid Neutralising Capacity (ANC)

The test results indicated the following:

- All samples analysed returned existing acidity (TAA) below the laboratory detection limit (0.003%S).
- All samples had a pH-KCL of more than 4.5 so S_{NAS} not reported.
- All samples analysed returned an S_{CR} result below the laboratory detection limit (0.005%S).
- All samples had a pH-KCL of not greater than or equal to 6.5 so ANC not reported.
- Net Acidity (sulfur units) was below the ASSMAC Action Criteria (see Table 3, 1–1,000T disturbed, fine texture soils) of 0.03%S for all samples tested.
- Net Acidity (acidity units) was below the ASSMAC Action Criteria (see Table 3, 1–1,000T disturbed, fine texture soils) for Acid trail of 62 mol/T for all samples tested.

Table 3 – Action Criteria for Acid Sulfate Soil Management Plan

Soil Type/Texture Range	Action Criteria 1 - 1000 tonnes disturbed		Action Criteria > 1000 tonnes disturbed	
	Sulfur Trail S-POS (%)	Acid Trail TPA or TSA (mol/T)	Sulfur Trail S-POS (%)	Acid Trail TPA or TSA (mol/T)
Coarse Texture (sands to loamy sands)	0.03	18	0.03	18
Medium Texture (sandy loams to light clays)	0.06	36	0.03	18
Fine Texture (medium to heavy clays and silty clays)	0.1	62	0.03	18

5.1.4 Construction Implications / Management Strategies

The field observations and laboratory results on soil samples do not indicate the presence of PASS or AASS to a depth of 6.0m bgl. Excavation below this depth is not proposed. No further investigation or testing is required for Acid Sulfate Soils.

Based on the investigation findings, no specific ASS management is required for the proposed ground disturbances associated with the development.

5.2 Key Geotechnical Site Constraints

Based on client advice, no significant excavation is anticipated. Ground water was observed at relatively shallow depth. If excavation depth will exceed a depth of 1.7m, bulk excavation level could encounter groundwater.

Key geotechnical constraints to the development include excavation conditions, groundwater control (during construction and long-term), temporary shoring, permanent retaining, and foundation conditions. Recommendations for design and construction of the development are provided in the following sections.

5.3 Earthworks

5.3.1 Excavation

The excavation for the proposed development is anticipated to be fully within soils. Excavation within the soils would be achievable using conventional earthmoving equipment (i.e. hydraulic excavator bucket).

5.3.2 Subgrade Preparation

The following general recommendations are provided for subgrade preparation for earthworks, pavements, slab-on-ground construction, and minor structures:

- Strip any fill and topsoil. Remove unsuitable materials from the site (e.g. material containing deleterious matter). Stockpile remainder for re-use as landscaping material or remove from site.
- Excavate natural soils to design subgrade level, stockpiling for re-use as engineered fill or remove to spoil.
- Compact the upper 150mm depth to a density index (AS1289.5.6.1–1998) not less than 80%. Areas which show visible heave under compaction equipment should be over-excavated a further 0.3m and replaced with approved fill compacted to a density index not less than 80%.

Any waste soils being removed from the site must be classified in accordance with current regulatory authority requirements to enable appropriate disposal to an appropriately licensed landfill facility. Asset can provide further advice on this matter if required.

5.3.3 Filling

Where filing is required, place in horizontal layers over prepared subgrade and compact as per Table 4.

Table 4 – Compaction Specifications

Parameter	Cohesive Fill	Non Cohesive Fill
Fill layer thickness (loose measurement):		
• Within 1.5m of the rear of retaining walls	0.2m	0.2m
• Elsewhere	0.3m	0.3m
Density:		
• Beneath Pavements	≥ 95% Std	≥ 70% ID
• Beneath Structures	≥ 98% Std	≥ 80% ID
• Upper 150mm of subgrade	≥ 100% Std	≥ 80% ID
Moisture content during compaction	± 2% of optimum	Moist but not wet

Filling within 1.5m of the rear of any retaining walls should be compacted using lightweight equipment (e.g. hand-operated plate compactor or ride-on compactor not more than 3 tonnes static weight) to limit compaction-induced lateral pressures.

Any soils to be imported onto the site for back-filling and reinstatement of excavated areas should be free of contamination and deleterious material and should include appropriate validation documentation in accordance with current regulatory authority requirements which confirms its suitability for the proposed land use. Asset can provide further advice on this matter if required.

5.3.4 Batter Slopes

Recommended maximum slopes for permanent and temporary batters are presented in Table 5.

Table 5 – Recommended Maximum Dry Batter Slopes

Unit	Maximum Batter Slope (H : V)	
	Permanent	Temporary
Medium Dense Sand (or denser)	3 : 1	2 : 1

5.4 Site Classification

Where footings are founded on the underlying natural soils (Dune SAND or Marine SAND), then footings may be designed and constructed in accordance with the requirements in AS2870-2011 for a Class A site.

Footings should also be designed as per the recommendations in Section 5.5.

The classification and footing recommendations given above and in Section 5.5 are provided on the basis that the performance expectations set out in Appendix B of AS2870–2011 are acceptable and that future site maintenance is in accordance with CSIRO BTF 18, a copy of which is attached.

5.5 Footings

Suitable footings might comprise a slab on ground and pad and strip footings supporting the upper building loads. Any heavily concentrated loads could be founded on short piles (founded at nominally 2 m to 4 m below ground level) supported in friction within the medium dense sands.

Edge beams for slabs, pad footings, and friction piles may be designed for the parameters in Table 6.

Table 6 – Preliminary Foundation Design Parameters

Founding Stratum	Maximum Allowable (Serviceability) Values (kPa)			Ultimate Strength Limit State Values (kPa)			
	End Bearing	Shaft Friction – Compression #	Shaft Friction – Tension	End Bearing	Shaft Friction – Compression #	Shaft Friction – Tension*	Typical E_{field} MPa
Medium dense sand - shallow	150	– –	– –	450	– –	– –	7
Medium dense sand – piles nominal 2m to 4m bgl	500	15	10	1,500	45	30	7

Note:

* Uplift capacity of piles in tension loading should also be checked for inverted cone pull out mechanism.

clean socket of roughness category R2 or better is assumed

In accordance with AS2159-2009 "Piling–Design and Installation", for limit state design, the ultimate geotechnical pile capacity shall be multiplied by a geotechnical reduction factor (Φg). This factor is derived from an Average Risk Rating (ARR) which considers geotechnical uncertainties, redundancy of the foundation system, construction supervision, and the quantity and type of pile testing (if any). Where testing is undertaken, or more comprehensive ground investigation is carried out, it may be possible to adopt a larger

Φg value that results in a more economical pile design. Further geotechnical advice will be required in consultation with the pile designer and piling contractor, to develop an appropriate Φg value.

Settlements for pad footings on medium dense sand are anticipated to be up to about 25mm where loading does not exceed the maximum allowable values. Settlement for shallow piles designed in accordance with the above parameters is anticipated to be not more than about 10 mm. Settlement is predominantly immediate, occurring as construction proceeds.

Options for piles include:

Bored Piles. Uncased bored piles are not recommended within sand layer, due to hole collapsing once groundwater is encountered. Bored piles must be fully cased if this option is selected.

Continuous Flight Auger (CFA) Piles. CFA piles are constructed by drilling a hollow-stemmed continuous flight auger to the required founding depth. Concrete is then injected under pressure through the auger stem as the auger is extracted from the soil. The reinforcing cage is then inserted upon completion of the concreting process. Pile diameters vary from 300mm to 1200mm. Drilled spoil is produced during CFA piling, and must subsequently be removed from the site. CFA piles are considered non-displacement piles as defined in AS2159.

Steel Screw Piles. Hollow-stemmed steel piles fitted with a single or double helix at the tip are installed using specially modified hydraulic excavators. Shaft diameters typically vary from 90mm to 220mm and helix diameters vary from 350mm to 600mm. Single pile capacities range from 2 to 65 tonnes. However, given the anticipated relatively shallow founding depths, steel screw piles may be a practical and economical solution for this site.

Driven piles are not likely to be suitable as environmental factors including noise and vibration are likely to be unacceptable for the adjacent development.

An experienced Geotechnical Engineer should review footing designs to check that the recommendations of the geotechnical report have been included, and should assess footing excavations to confirm the design assumptions.

5.6 Groundwater Control

Limited groundwater observations made for this investigation are described in Section 4.3. The observations indicate that groundwater is unlikely to be a constraint to the proposed development. However, good practice should be followed to cater for potential groundwater, such as designing retaining walls with adequate subsoil drainage. Further geotechnical advice must be sought if significant groundwater is encountered during construction.

6. LIMITATIONS

In addition to the limitations inherent in site investigations (refer to the attached Information Sheets), it must be pointed out that the recommendations in this report are based on assessed subsurface conditions from limited investigations. To confirm the assessed soil and rock properties in this report, further investigation would be required such as coring and strength testing of rock and should be carried out if the scale of the development warrants, or if any of the properties are critical to the design, construction or performance of the development.

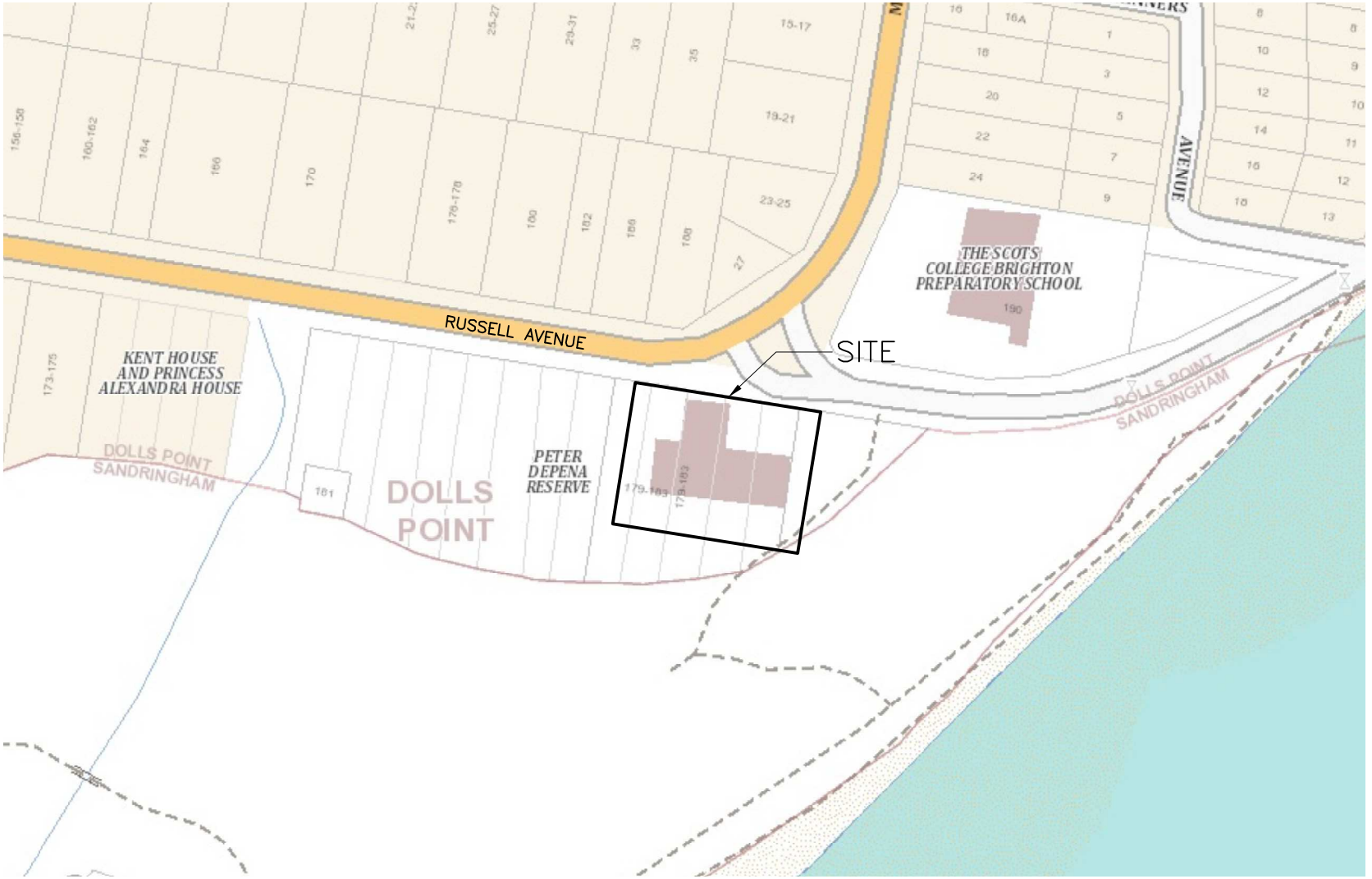
It is recommended that a qualified and experienced Geotechnical Engineer be engaged to provide further input and review during the design development; including site visits during construction to verify the site conditions and provide advice where conditions vary from those assumed in this report. Development of an appropriate inspection and testing plan should be carried out in consultation with the Geotechnical Engineer.

This report may have included geotechnical recommendations for design and construction of temporary works (e.g. temporary batter slopes or temporary shoring of excavations). Such temporary works are expected to perform adequately for a relatively short period only, which could range from a few days (for temporary batter slopes) up to six months (for temporary shoring). This period depends on a range of factors including but not limited to: site geology; groundwater conditions; weather conditions; design criteria; and level of care taken during construction. If there are factors which prevent temporary works from being completed and/or which require temporary works to function for periods longer than originally designed, further advice must be sought from the Geotechnical Engineer and Structural Engineer.

This report and details for the proposed development should be submitted to relevant regulatory authorities that have an interest in the property or are responsible for services that may be within or adjacent to the site (e.g. Sydney Water), for their review.

Asset accepts no liability where our recommendations are not followed or are only partially followed. The document "Important Information about your Geotechnical Report" in Appendix A provides additional information about the uses and limitations of this report.

FIGURES



APPROXIMATE ONLY – SUBJECT TO DETAIL SURVEY.

SOURCE: SIX MAPS

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issue	date	description
A	4.11.19	INITIAL ISSUE

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PROPOSED REPLACEMENT COMMERCIAL BUILDING
179 RUSSELL AVENUE, DOLLS POINT NSW
for
BAYSIDE COUNCIL

SITE LOCALITY

drawn: YG
date: 4.11.19
checked: MAG
scale: 1:2000 A4

job no.: 5763–1
fig: 1
issue: A

KEY

Borehole

APPROXIMATE ONLY – SUBJECT TO DETAIL SURVEY.

SOURCE: SIX MAPS

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issue	date	description
A	4.11.19	INITIAL ISSUE

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for
BAYSIDE COUNCIL

TEST LOCATIONS

drawn: YG
date: 4.11.19
checked: MAG
scale: 1:500 A4

job no.: 5763–1
fig: 2
issue: A

APPENDIX A

Important Information about your Geotechnical Report
CSIRO BTF 18

Important Information about your Geotechnical Report

SCOPE OF SERVICES

The geotechnical report ("the report") has been prepared in accordance with the scope of services as set out in the contract, or as otherwise agreed, between the Client and Asset Geotechnical Engineering Pty Ltd ("Asset"), for the specific site investigated. The scope of work may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

The report should not be used if there have been changes to the project, without first consulting with Asset to assess if the report's recommendations are still valid. Asset does not accept responsibility for problems that occur due to project changes if they are not consulted.

RELIANCE ON DATA

Asset has relied on data provided by the Client and other individuals and organizations, to prepare the report. Such data may include surveys, analyses, designs, maps and plans. Asset has not verified the accuracy or completeness of the data except as stated in the report. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations ("conclusions") are based in whole or part on the data, Asset will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to Asset.

GEOTECHNICAL ENGINEERING

Geotechnical engineering is based extensively on judgment and opinion. It is far less exact than other engineering disciplines. Geotechnical engineering reports are prepared for a specific client, for a specific project and to meet specific needs, and may not be adequate for other clients or other purposes (e.g. a report prepared for a consulting civil engineer may not be adequate for a construction contractor). The report should not be used for other than its intended purpose without seeking additional geotechnical advice. Also, unless further geotechnical advice is obtained, the report cannot be used where the nature and/or details of the proposed development are changed.

LIMITATIONS OF SITE INVESTIGATION

The investigation program undertaken is a professional estimate of the scope of investigation required to provide a general profile of subsurface conditions. The data derived from the site investigation program and subsequent laboratory testing are extrapolated across the site to form an inferred geological model, and an engineering opinion is rendered about overall subsurface conditions and their likely behavior with regard to the proposed development. Despite investigation, the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies.

The engineering logs are the subjective interpretation of subsurface conditions at a particular location and time, made by trained personnel. The actual interface between materials may be more gradual or abrupt than a report indicates.

Therefore, the recommendations in the report can only be regarded as preliminary. Asset should be retained during the project implementation to assess if the report's recommendations are valid and whether or not changes should be considered as the project proceeds.

SUBSURFACE CONDITIONS ARE TIME DEPENDENT

Subsurface conditions can be modified by changing natural forces or man-made influences. The report is based on conditions that existed at the time of subsurface exploration. Construction operations adjacent to the site, and natural events such as floods, or ground water fluctuations, may also affect subsurface conditions, and thus the continuing adequacy of a geotechnical report. Asset should be kept appraised of any such events, and should be consulted to determine if any additional tests are necessary.

VERIFICATION OF SITE CONDITIONS

Where ground conditions encountered at the site differ significantly from those anticipated in the report, either due to natural variability of subsurface conditions or construction activities, it is a condition of the report that Asset be notified of any variations and be provided with an opportunity to review the recommendations of this report. Recognition of change of soil and rock conditions requires experience and it is recommended that a suitably experienced geotechnical engineer be engaged to visit the site with sufficient frequency to detect if conditions have changed significantly.

REPRODUCTION OF REPORTS

This report is the subject of copyright and shall not be reproduced either totally or in part without the express permission of this Company. Where information from the accompanying report is to be included in contract documents or engineering specification for the project, the entire report should be included in order to minimize the likelihood of misinterpretation from logs.

REPORT FOR BENEFIT OF CLIENT

The report has been prepared for the benefit of the Client and no other party. Asset assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of Asset or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own inquiries and obtain independent advice in relation to such matters.

DATA MUST NOT BE SEPARATED FROM THE REPORT

The report as a whole presents the site assessment, and must not be copied in part or altered in any way.

Logs, figures, drawings, test results etc. included in our reports are developed by professionals based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These data should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

PARTIAL USE OF REPORT

Where the recommendations of the report are only partially followed, there may be significant implications for the project and could lead to problems. Consult Asset if you are not intending to follow all of the report recommendations, to assess what the implications could be. Asset does not accept responsibility for problems that develop where the report recommendations have only been partially followed if they have not been consulted.

OTHER LIMITATIONS

Asset will not be liable to update or revise the report to take into account any events or emergent circumstances or fact occurring or becoming apparent after the date of the report.

Foundation Maintenance and Footing Performance:
A Homeowner's Guide

CSIRO

BTF 18 replaces Information Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction
There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion
All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation
This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil
All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure
This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth

Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation

Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

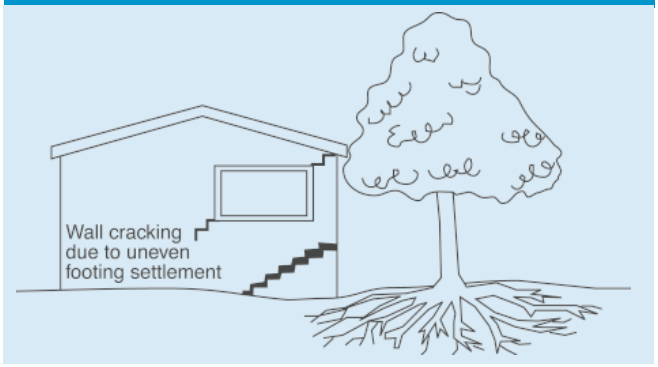
Seasonal swelling/shrinkage in clay

Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots

In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself

Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures

Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures
Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures
Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.
Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing
Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage
In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

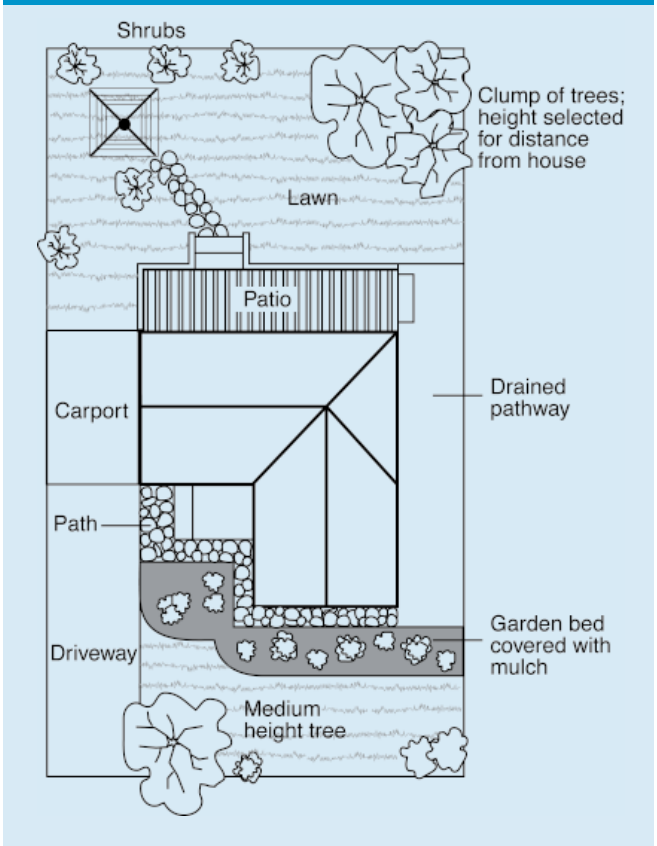
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4

Gardens for a reactive site



should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

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APPENDIX B

Soil & Rock Explanation Sheets
Borehole Logs

Soil and Rock Explanation Sheets (1 of 2)

LOG ABBREVIATIONS AND NOTES

METHOD

borehole logs		**excavation logs**	
AS	auger screw *	NE	natural excavation
AD	auger drill *	HE	hand excavation
RR	roller / tricone	BH	backhoe bucket
W	washbore	EX	excavator bucket
CT	cable tool	DZ	dozer blade
HA	hand auger	R	ripper tooth
D	diatube		
B	blade / blank bit		
V	V-bit		
T	TC-bit		

* bit shown by suffix e.g. ADV

coring
NMLC, NQ, PQ, HQ

SUPPORT

borehole logs		***excavation logs***	
N	nil	N	nil
M	mud	S	shoring
C	casing	B	benched
NQ	NQ rods		

CORE—LIFT

casing installed

barrel withdrawn

NOTES, SAMPLES, TESTS

D	disturbed
B	bulk disturbed
U50	thin-walled sample, 50mm diameter
HP	hand penetrometer (kPa)
SV	shear vane test (kPa)
DCP	dynamic cone penetrometer (blows per 100mm penetration)
SPT	standard penetration test
N*	SPT value (blows per 300mm) * denotes sample taken
Nc	SPT with solid cone
R	refusal of DCP or SPT

USCS SYMBOLS

GW	Gravel and gravel-sand mixtures, little or no fines.
GP	Gravel and gravel-sand mixtures, little or no fines, uniform gravels
GM	Gravel-silt mixtures and gravel-sand-silt mixtures.
GC	Gravel-clay mixtures and gravel-sand-clay mixtures.
SW	Sand and gravel-sand mixtures, little or no fines.
SP	Sand and gravel sand mixtures, little or no fines.
SM	Sand-silt mixtures.
SC	Sand-clay mixtures.
ML	Inorganic silt and very fine sand, rock flour, silty or clayey fine sand or silt with low plasticity.
CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays.
OL	Organic silts
MH	Inorganic silts
CH	Inorganic clays of high plasticity.
OH	Organic clays of medium to high plasticity, organic silt
PT	Peat, highly organic soils.

MOISTURE CONDITION

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

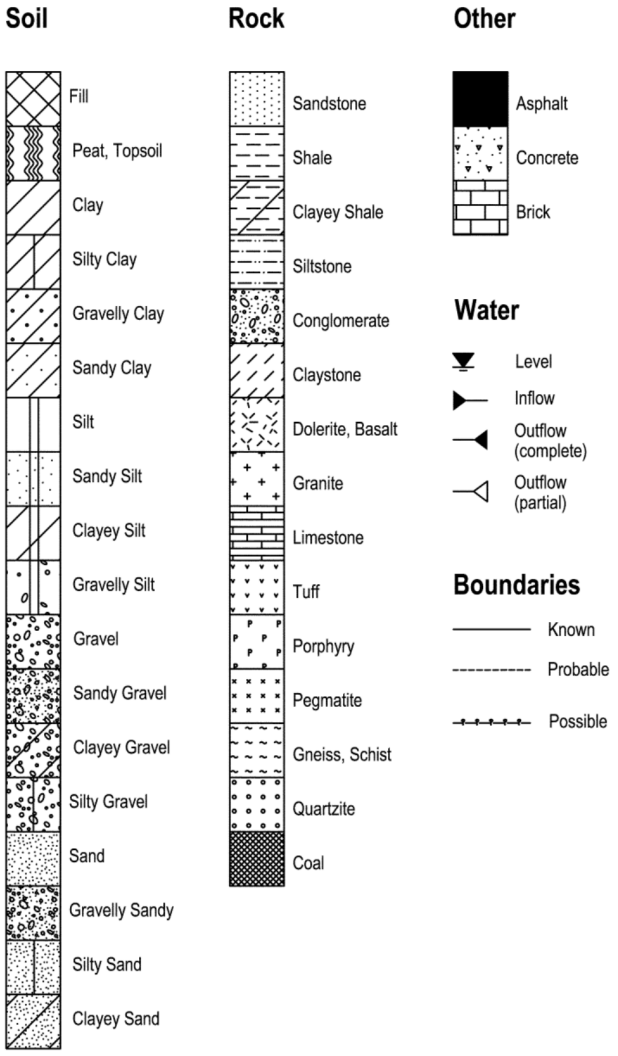
CONSISTENCY

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable

DENSITY INDEX

VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

GRAPHIC LOG



WEATHERING

XW	extremely weathered
HW	highly weathered
MW	moderately weathered
SW	slightly weathered
FR	fresh

STRENGTH

VL	very low
L	low
M	medium
H	high
VH	very high
EH	extremely high

RQD (%)

= sum of intact core pieces > 2 x diameter / total length of core run drilled x 100

DEFECTS:

type		***coating***	
JT	joint	cl	clean
PT	parting	st	stained
SZ	shear zone	ve	veneer
SM	seam	co	coating

shape		***roughness***	
pl	planar	po	polished
cu	curved	sl	slickensided
un	undulating	sm	smooth
st	stepped	ro	rough
ir	irregular	vr	very rough

inclination
measured above axis and perpendicular to core

Soil and Rock Explanation Sheets (2 of 2)

AS1726-2017

Soils and rock are described in the following terms, which are broadly in accordance with AS1726-2017.

SOIL

MOISTURE CONDITION

Term	Description
Dry	Looks and feels dry. Fine grained and cemented soils are hard, friable or powdery. Uncemented coarse grained soils run freely through hand.
Moist	Soil feels cool and darkened in colour. Fine grained soils can be moulded. Coarse soils tend to cohere.
Wet	As for moist, but with free water forming on hand.

Moisture content of cohesive soils may also be described in relation to plastic limit (W_P) or liquid limit (W_L) [>> much greater than, > greater than, < less than, << much less than].

CONSISTENCY OF FINE GRAINED SOILS

Term	Su (kPa)	Term	Su (kPa)
Very soft	< 12	Very Stiff	>100 – ≤200
Soft	>12 – ≤25	Hard	> 200
Firm	>25 – ≤50	Friable	–
Stiff	>50 – ≤100		

RELATIVE DENSITY OF COURSE GRAINED SOILS

Term	Density Index (%)	Term	Density Index (%)
Very Loose	< 15	Dense	65 – 85
Loose	15 – 35	Very Dense	>85
Medium Dense	35 – 65		

PARTICLE SIZE

Name	Subdivision	Size (mm)
Boulders		> 200
Cobbles		63 – 200
Gravel	coarse	19 – 63
	medium	6.7 – 19
	fine	2.36 – 6.7
Sand	coarse	0.6 – 2.36
	medium	0.21 – 0.6
	fine	0.075 – 0.21
Silt & Clay		< 0.075

MINOR COMPONENTS

Term	Proportion by Mass:	
	coarse grained	*fine grained*
Trace	≤ 15%	≤ 5%
With	>15% – ≤30%	>5% – ≤12%

SOIL ZONING

Layers	Continuous across exposures or sample.
Lenses	Discontinuous, lenticular shaped zones.
Pockets	Irregular shape zones of different material.

SOIL CEMENTING

Weakly	Easily broken up by hand pressure in water or air.
Moderately	Effort is required to break up by hand in water or in air.

USCS SYMBOLS

Symbol	Description
GW	Gravel and gravel-sand mixtures, little or no fines.
GP	Gravel and gravel-sand mixtures, little or no fines, uniform gravels.
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OL	Organic silts
MH	Inorganic silts
CH	Inorganic clays of high plasticity.
OH	Organic clays of medium to high plasticity, organic silt
PT	Peat, highly organic soils.

ROCK

SEDIMENTARY ROCK TYPE DEFINITIONS

Rock Type	Definition (more than 50% of rock consists of .....)
Conglomerate	... gravel sized (>2mm) fragments.
Sandstone	... sand sized (0.06 to 2mm) grains.
Siltstone	... silt sized (<0.06mm) particles, rock is not laminated.
Claystone	... clay, rock is not laminated.
Shale	... silt or clay sized particles, rock is laminated.

LAYERING

Term	Description
Massive	No layering apparent.
Poorly Developed	Layering just visible. Little effect on properties.
Well Developed	Layering distinct. Rock breaks more easily parallel to layering.

STRUCTURE

Term	Spacing (mm)	Term	Spacing
Thinly laminated	<6	Medium bedded	200 – 600
Laminated	6 – 20	Thickly bedded	600 – 2,000
Very thinly bedded	20 – 60	Very thickly bedded	> 2,000
Thinly bedded	60 – 200		

STRENGTH (NOTE: Is50 = Point Load Strength Index)

Term	Is50 (MPa)	Term	Is50 (MPa)
Extremely Low	<0.03	High	1.0 – 3.0
Very low	0.03 – 0.1	Very High	3.0 – 10.0
Low	0.1 – 0.3	Extremely High	>10.0
Medium	0.3 – 1.0		

WEATHERING

Term	Description
Residual Soil	Material is weathered to an extent that it has soil properties. Rock structures are no longer visible, but the soil has not been significantly transported.
Extremely	Material is weathered to the extent that it has soil properties. Mass structures, material texture & fabric of original rock is still visible.
Highly	Rock strength is significantly changed by weathering; rock is discolored, usually by iron staining or bleaching. Some primary minerals have weathered to clay minerals.
Moderately	Rock strength shows little or no change of strength from fresh rock; rock may be discolored.
Slightly	Rock is partially discolored but shows little or no change of strength from fresh rock.
Fresh	Rock shows no signs of decomposition or staining.

DEFECT DESCRIPTION

Type

Joint	A surface or crack across which the rock has little or no tensile strength. May be open or closed.
Parting	A surface or crack across which the rock has little or no tensile strength. Parallel or sub-parallel to layering/bedding. May be open or closed.
Sheared Zone	Zone of rock substance with roughly parallel, near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects.
Seam	Seam with deposited soil (infill), extremely weathered insitu rock (XW), or disoriented usually angular fragments of the host rock (crushed).

Shape

Planar	Consistent orientation.
Curved	Gradual change in orientation.
Undulating	Wavy surface.
Stepped	One or more well defined steps.
Irregular	Many sharp changes in orientation.

Roughness

Polished	Shiny smooth surface.
Slickensided	Grooved or striated surface, usually polished.
Smooth	Smooth to touch. Few or no surface irregularities.
Rough	Many small surface irregularities (amplitude generally <1mm). Feels like fine to coarse sandpaper.
Very Rough	Many large surface irregularities, amplitude generally >1mm. Feels like very coarse sandpaper.

Coating

Clean	No visible coating or discolouring.
Stained	No visible coating but surfaces are discolored.
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Coating	Visible coating =1mm thick. Thicker soil material described as seam.

Borehole Log

BH no:	**BH1**
sheet:	1 of 2
job no.:	5763-1

client:	Bayside Council	**started:**	1.11.2019
principal:		**finished:**	1.11.2019
project:	Proposed Replacement Commercial Building	**logged:**	YG
location:	179 Russell Avenue, Dolls Point NSW	**checked:**	MAG
equipment:	GEO205	**RL surface:**	3 m approx.
diameter:	100mm **inclination:** -90° **bearing:** --- **E:** **N:**	**datum:**	AHD

drilling information | **material information**

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
ADT	N		D-BH1, ACM D-BH1 D-ASS	2.5	0.5		SM	FILL, Silty SAND, dark brown, fine grained; trace gravel, fine grained, subrounded to subangular.	D	L		Fill PID - 0.4 ppm (base reading: 0.3 ppm)
					.5		SP	SAND, pale brown, fine to medium grained, subrounded.	D	L		Dune Sand
			D-ASS SPT 4,3,4 N*=7 D-ASS	2.0 1.5	1.0 1.5							
					1.6		SP	SAND, pale brown mottled dark brown, fine to medium grained, subrounded.	M-W	L-MD		Dune Sand
		▼	D-ASS D-ASS SPT 5,4,5 N*=9	1.0 0.5	2.0 2.5							
					2.8		SP	SAND, pale brown becoming grey, fine to medium grained, subrounded.	W	MD		Dune Sand
			D-ASS	0.0	3.0							
					3.2		SP	SAND, grey, fine to medium grained, subrounded.	W	MD		Marine Sand
			D-ASS	-0.5	3.5							
			D-ASS	-1.0	4.0							
					3.9		SP	SAND with shell fragments, grey, fine to medium grained, subrounded.	W	L-MD		Marine Sand

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Borehole Log

BH no:	**BH1**
sheet:	2 of 2
job no.:	5763-1

client:	Bayside Council	**started:**	1.11.2019
principal:		**finished:**	1.11.2019
project:	Proposed Replacement Commercial Building	**logged:**	YG
location:	179 Russell Avenue, Dolls Point NSW	**checked:**	MAG
equipment:	GEO205	**RL surface:**	3 m approx.
diameter:	100mm **inclination:** -90° **bearing:** --- **E:** **N:**	**datum:**	AHD

drilling information | **material information**

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetro-meter kPa (100 200 300 400)	structure and additional observations
ADT			SPT 1.5,1.5,2 N*=3.5				SP	SAND with shell fragments, grey, fine to medium grained, subrounded. *(continued)*	W	L-MD		
			D-ASS	-1.5	4.5							
			D-ASS	-2.0	5.0							
			D-ASS	-2.5	5.5							
			SPT 2,3,3 N*=6									
			D-ASS	-3.0	6.0							
					6			ADT terminated at 6m, reaching target depth. Borehole No: BH1 terminated at 6m				
				-3.5	6.5							
				-4.0	7.0							
				-4.5	7.5							
				-5.0	8.0							

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Borehole Log

BH no:	**BH2**
sheet:	1 of 2
job no.:	5763-1

client:	Bayside Council	**started:**	1.11.2019
principal:		**finished:**	1.11.2019
project:	Proposed Replacement Commercial Building	**logged:**	YG
location:	179 Russell Avenue, Dolls Point NSW	**checked:**	MAG
equipment:	GEO205	**RL surface:**	3 m approx.
diameter:	100mm **inclination:** -90° **bearing:** --- **E:** **N:**	**datum:**	AHD

drilling information | **material information**

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
ADT	N		D-BH2, ACM				SM	FILL, Silty SAND, dark brown, fine grained, subrounded; trace gravel, fine grained, subangular.	D	L		Fill PID - 0.3 ppm (base reading: 0.3 ppm)
					.2		SP	SAND, pale brown mottled dark brown, fine to medium grained, subrounded.	D-M	L		Dune Sand
			D-BH2, DUP1									
			D-ASS	2.5	0.5							
			D-ASS	2.0	1.0							
			SPT 3,3,4 N*=7									
			D-ASS	1.5	1.5							
		▼	D-ASS	1.0	2.0							
					2.3		SP	SAND, pale brown becoming grey, fine to medium grained, subrounded.	W	MD-D		Dune Sand
			D-ASS	0.5	2.5							
			SPT 5,8,9 N*=17									
			D-ASS	0.0	3.0							
			D-ASS	-0.5	3.5							
					3.4		SP	Silty Clayey SAND with shell fragments, grey/dark grey, fine to medium grained, subrounded.	W	MD		Marine Sand
					3.7		SP	SAND with shell fragments, grey, fine to medium grained, subrounded.	W	L-MD		Marine Sand
			D-ASS	-1.0	4.0							

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Borehole Log

BH no:	**BH2**
sheet:	2 of 2
job no.:	5763-1

client:	Bayside Council	**started:**	1.11.2019
principal:		**finished:**	1.11.2019
project:	Proposed Replacement Commercial Building	**logged:**	YG
location:	179 Russell Avenue, Dolls Point NSW	**checked:**	MAG
equipment:	GEO205	**RL surface:**	3 m approx.
diameter:	100mm **inclination:** -90° **bearing:** --- **E:** **N:**	**datum:**	AHD

drilling information | **material information**

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetro-meter kPa (100 200 300 400)	structure and additional observations
ADT			SPT 1.5,1.5,2.5 N*=4				SP	SAND with shell fragments, grey, fine to medium grained, subrounded. *(continued)*	W	L-MD		
			D-ASS	-1.5	4.5							
			D-ASS	-2.0	5.0							
			D-ASS	-2.5	5.5							
			SPT 1.5,2.5,4 N*=6.5									
			D-ASS	-3.0	6.0							
					6			ADT terminated at 6m, reaching target depth. Borehole No: BH2 terminated at 6m				
				-3.5	6.5							
				-4.0	7.0							
				-4.5	7.5							
				-5.0	8.0							

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Borehole Log

BH no:	**BH3**
sheet:	1 of 2
job no.:	5763-1

client:	Bayside Council	**started:**	1.11.2019
principal:		**finished:**	1.11.2019
project:	Proposed Replacement Commercial Building	**logged:**	YG
location:	179 Russell Avenue, Dolls Point NSW	**checked:**	MAG
equipment:	GEO205	**RL surface:**	3 m approx.
diameter:	100mm **inclination:** -90° **bearing:** --- **E:** **N:**	**datum:**	AHD

drilling information | **material information**

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
ADT	N		D-BH3, ACM				SM	FILL, Silty SAND, dark brown, fine grained, subrounded; trace gravel, fine grained, subangular.	D	VL		Fill PID - 0.4 ppm (base reading: 0.3 ppm)
					.2		SP	SAND, pale brown mottled dark brown, fine to medium grained, subrounded.	D	L		Dune Sand
			D-BH3									
			D-ASS	2.5	0.5							
			D-ASS	2.0	.9 1.0		SP	SAND, pale brown, fine grained, subrounded.	D	L		Dune Sand
			SPT 3,3,4 N*=7									
			D-ASS	1.5	1.5							
					1.6		SP	SAND, pale brown becoming grey, fine to medium grained, subrounded.	M	L		Dune Sand
			D-ASS	1.0	2.0							
		▼			2.1		SP	SAND, grey, fine to medium grained, subrounded.	W	L		Dune Sand
			D-ASS	0.5	2.5							
			SPT 1,1,1 N*=2									
			D-ASS	0.0	3.0							
			D-ASS	-0.5	3.5							
					3.8		SP	SAND with shell fragments, grey, fine to medium grained, subrounded; trace oyster shell.	W	L		Marine Sand
							SM	Silty SAND with shell fragments, grey becoming dark grey, fine to medium grained, subrounded; trace organic material.	W	L-MD		Marine Sand
			D-ASS	-1.0	4.0							

REFER TO EXPLANATION SHEETS FOR DESCRIPTION OF TERMS AND SYMBOLS USED

Borehole Log - Revision 10

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Borehole Log

BH no:	**BH3**
sheet:	2 of 2
job no.:	5763-1

client:	Bayside Council	**started:**	1.11.2019
principal:		**finished:**	1.11.2019
project:	Proposed Replacement Commercial Building	**logged:**	YG
location:	179 Russell Avenue, Dolls Point NSW	**checked:**	MAG
equipment:	GEO205	**RL surface:**	3 m approx.
diameter:	100mm **inclination:** -90° **bearing:** --- **E:** **N:**	**datum:**	AHD

drilling information | **material information**

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetro-meter kPa (100 200 300 400)	structure and additional observations
ADT			SPT 1,1.5,2.5 N*=4				SM	Silty SAND with shell fragments, grey becoming dark grey, fine to medium grained, subrounded; trace organic material. *(continued)*	W	L-MD		
			D-ASS	-1.5	4.5							
			D-ASS	-2.0	5.0							
			D-ASS	-2.5	5.5							
			SPT 2.5,1.5,2 N*=3.5									
			D-ASS	-3.0	6.0							
					6			ADT terminated at 6m, reaching target depth. Borehole No: BH3 terminated at 6m				
				-3.5	6.5							
				-4.0	7.0							
				-4.5	7.5							
				-5.0	8.0							

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Borehole Log

BH no:	**BH4**
sheet:	1 of 2
job no.:	5763-1

client:	Bayside Council	**started:**	1.11.2019
principal:		**finished:**	1.11.2019
project:	Proposed Replacement Commercial Building	**logged:**	YG
location:	179 Russell Avenue, Dolls Point NSW	**checked:**	MAG
equipment:	GEO205	**RL surface:**	3 m approx.
diameter:	100mm **inclination:** -90° **bearing:** --- **E:** **N:**	**datum:**	AHD

drilling information | **material information**

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
ADT	N		D-BH4, ACM		0.5		SM	FILL, Silty SAND, dark brown, fine grained, subrounded; trace gravel, fine grained, subangular.	D	VL		Fill PID - 0.4 ppm (base reading 0.3 ppm)
			D-ASS	2.5			SP	SAND, pale brown mottled brown, fine to medium grained, subrounded.	D-M	VL-L		Dune Sand
			D-BH4									
			D-ASS	2.0	1.0							
			SPT 2,3,3 N*=6				SP	SAND, pale brown becoming grey, fine to medium grained, subrounded.	M-W	L		Dune Sand
		▼	D-ASS	1.5	1.5							
			D-ASS	1.0	2.0							
			D-ASS	0.5	2.5		SP	SAND with shell fragments, grey, fine to medium grained, subrounded.	W	L-MD		Marine Sand
			SPT 1,1,1 N*=2									
			D-ASS	0.0	3.0							
			D-ASS	-0.5	3.5							
			D-ASS	-1.0	4.0							

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Borehole Log

BH no:	**BH4**
sheet:	2 of 2
job no.:	5763-1

client:	Bayside Council	**started:**	1.11.2019
principal:		**finished:**	1.11.2019
project:	Proposed Replacement Commercial Building	**logged:**	YG
location:	179 Russell Avenue, Dolls Point NSW	**checked:**	MAG
equipment:	GEO205	**RL surface:**	3 m approx.
diameter:	100mm **inclination:** -90° **bearing:** --- **E:** **N:**	**datum:**	AHD

drilling information | **material information**

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetro-meter kPa (100 200 300 400)	structure and additional observations
ADT			SPT 1,1.5,1.5 N*=3				SP	SAND with shell fragments, grey, fine to medium grained, subrounded. *(continued)*	W	L-MD		
			D-ASS	-1.5	4.5							
			D-ASS	-2.0	5.0							
			D-ASS	-2.5	5.5							
			SPT 2,2,2 N*=4									
			D-ASS	-3.0	6.0							
					6			ADT terminated at 6m, reaching target depth. Borehole No: BH4 terminated at 6m				
				-3.5	6.5							
				-4.0	7.0							
				-4.5	7.5							
				-5.0	8.0							

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APPENDIX C

Laboratory Test Results

eurofins | mgt

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Unit F3 - 6 Building F, 16 Mars Road, Lane Cove
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☐ Brisbane
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☐ Melbourne
2 Kingston Town Close, Oakleigh, VIC 3166
Phone: +613 8564 5000 Fax: +613 8564 5090
Email: enquiries.melb@mgtlabmark.com.au

CHAIN OF CUSTODY RECORD

CLIENT DETAILS

Company Name : Asset Geotechnical	**Contact Name:** Yeongbin Gim	**Purchase Order :** 2912	**COC Number :**
Office Address : Suite 2.05 56 Delhi Road, North Ryde	**Project Manager :**	**PROJECT Number :** 5763-1	**Eurofins | mgt quote ID :**
	Email for results : ygim@assetgeoenviro.com.au	**PROJECT Name :** 179 Russell Avenue, Dolls Point NSW	**Data output format:**

Special Directions & Comments :

Eurofins | mgt DI water batch number:

	Sample ID	Date	Matrix	Salinity (Salinity (EC), % moisture, Sulfate(SO4), pH)	Aggressivity soil set (chloride, resistivity)	Acid sulphate soils screen (pH-F, pH-FOX)	Acid sulphate soils (sPOCAS)	See Attached
1	BH2: 0.5m	1.11.19	Soils			✓		
2	BH2: 1.0m	"	"			✓		
3	BH2: 1.5m	"	"			✓		
4	BH2: 2.0m	"	"			✓		
5	BH2: 2.5m	"	"			✓		
6	BH2: 3.0m	"	"			✓		
7	BH2: 3.5m	"	"			✓		
8	BH2: 4.0m	"	"			✓		
9	BH2: 4.5m	"	"			✓		
10	BH2: 5.0m	"	"			✓		
11	BH2: 5.5m	"	"			✓		
12	BH2: 6.0m	"	"			✓		
13	BH4: 0.5m	"	"			✓		
14	BH4: 1.0m	"	"			✓		
15	BH4: 1.5m	"	"			✓		
16	BH4: 2.0m	"	"			✓		

Analytes

Some common holding times (with correct preservation).
For further information contact the lab

Waters		Soils	
BTEX, MAH, VOC	14 days	BTEX, MAH, VOC	14 days
TRH, PAH, Phenols, Pesticides	7 days	TRH, PAH, Phenols, Pesticides	14 days
Heavy Metals	6 months	Heavy Metals	6 months
Mercury, CrVI	28 days	Mercury, CrVI	28 days
Microbiological testing	24 hours	Microbiological testing	72 hours
BOD, Nitrate, Nitrite, Total N	2 days	Anions	28 days
Solids - TSS, TDS etc	7 days	SPOCAS, pH Field and FOX, CrS	24 hours
Ferrous iron	7 days	ASLP, TCLP	7 days

Containers:

1LP	250P	125P	1LA	40mL vial	125mL A	Jar	Zip-lock bag
							✓

Sample comments:

Laboratory Staff

Relinquished By:

Date & Time::

Signature:

Received By:

Turn around time

☐ 1 DAY ☐ 2 DAY ☐ 3 DAY ☐
☐ 5 DAY ☑ 10 DAY ☐ Other:

Method Of Shipment

☐ Courier
☐ Hand Delivered
☐ Postal
Courier Consignment #:

Temperature on arrival:

Report number: 686108

eurofins | mgt

☑ Sydney
Unit F3 - 6 Building F, 16 Mars Road, Lane Cove
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Email: enquiries.melb@mgtlabmark.com.au

CHAIN OF CUSTODY RECORD

CLIENT DETAILS

Company Name: Asset Geotechnical	Contact Name: Yeongbin Gim	Purchase Order: 2912	COC Number:
Office Address: Suite 2.05 56 Delhi Road, North Ryde	Project Manager:	PROJECT Number: 5763-1	Eurofins | mgt quote ID:
	Email for results: ygim@assetgeoenviro.com.au	PROJECT Name: 179 Russell Avenue, Dolls Point NSW	Data output format:

Special Directions & Comments:

Eurofins | mgt DI water batch number:

Some common holding times (with correct preservation). For further information contact the lab

Waters		Soils	
BTEX, MAH, VOC	14 days	BTEX, MAH, VOC	14 days
TRH, PAH, Phenols, Pesticides	7 days	TRH, PAH, Phenols, Pesticides	14 days
Heavy Metals	6 months	Heavy Metals	6 months
Mercury, CrVI	28 days	Mercury, CrVI	28 days
Microbiological testing	24 hours	Microbiological testing	72 hours
BOD, Nitrate, Nitrite, Total N	2 days	Anions	28 days
Solids - TSS, TDS etc	7 days	SPOCAS, pH Field and FOX, CrS	24 hours
Ferrous iron	7 days	ASLP, TCLP	7 days

Analytes

	Sample ID	Date	Matrix	Salinity (Salinity (EC), % moisture, Sulfate(SO4), pH)	Aggressivity soil set (chloride, resistivity)	Acid sulphate soils screen (pH-F, pH-FOX)	Acid sulphate soils (sPOCAS)	See Attached	Containers: 1LP	250P	125P	1LA	40mL vial	125mL A	Jar	Zip-lock bag	Sample comments:
17	BH4: 2.5m	1.11.19	Soils			✓										✓	
18	BH4: 3.0m	"	"			✓										✓	
19	BH4: 3.5m	"	"			✓										✓	
20	BH4: 4.0m	"	"			✓										✓	
21	BH4: 4.5m	"	"			✓										✓	
22	BH4: 5.0m	"	"			✓										✓	
23	BH4: 5.5m	"	"			✓										✓	
24	BH4: 6.0m	"	"			✓										✓	

Relinquished By:

Date & Time::

Signature:

Laboratory Staff

Turn around time

1 DAY ☐ 2 DAY ☐ 3 DAY ☐

5 DAY ☑ 10 DAY ☐ Other:

Method Of Shipment

☐ Courier
☐ Hand Delivered
☐ Postal
Courier Consignment #:

Temperature on arrival:

Report number: 686108

Asset Geotechnical Engineering Pty Ltd
Suite 2.05 / 56 Delhi Road
North Ryde
NSW 2113

Attention: **Yeongbin Gim**

Report **686108-S**
Project name 179 RUSSELL AVENUE DOLLS POINT NSW
Project ID 5763-1
Received Date Nov 04, 2019

Client Sample ID			BH2:0.5M	BH2:1.0M	BH2:1.5M	BH2:2.0M
Sample Matrix			Soil	Soil	Soil	Soil
Eurofins Sample No.			S19-No03878	S19-No03879	S19-No03880	S19-No03881
Date Sampled			Nov 01, 2019	Nov 01, 2019	Nov 01, 2019	Nov 01, 2019
Test/Reference	LOR	Unit				
Acid Sulfate Soils Field pH Test						
pH-F (Field pH test)*	0.1	pH Units	8.2	8.5	9.4	9.6
pH-FOX (Field pH Peroxide test)*	0.1	pH Units	5.1	4.8	7.1	7.5
Reaction Ratings*[S05]		comment	1.0	1.0	3.0	1.0

Client Sample ID			BH2:2.5M	BH2:3.0M	BH2:3.5M	BH2:4.0M
Sample Matrix			Soil	Soil	Soil	Soil
Eurofins Sample No.			S19-No03882	S19-No03883	S19-No03884	S19-No03885
Date Sampled			Nov 01, 2019	Nov 01, 2019	Nov 01, 2019	Nov 01, 2019
Test/Reference	LOR	Unit				
Acid Sulfate Soils Field pH Test						
pH-F (Field pH test)*	0.1	pH Units	9.7	9.8	9.3	9.3
pH-FOX (Field pH Peroxide test)*	0.1	pH Units	7.5	7.6	7.0	7.6
Reaction Ratings*[S05]		comment	1.0	1.0	4.0	1.0

Client Sample ID			BH2:4.5M	BH2:5.0M	BH2:5.5M	BH2:6.0M
Sample Matrix			Soil	Soil	Soil	Soil
Eurofins Sample No.			S19-No03886	S19-No03887	S19-No03888	S19-No03889
Date Sampled			Nov 01, 2019	Nov 01, 2019	Nov 01, 2019	Nov 01, 2019
Test/Reference	LOR	Unit				
Acid Sulfate Soils Field pH Test						
pH-F (Field pH test)*	0.1	pH Units	9.3	9.3	9.7	9.5
pH-FOX (Field pH Peroxide test)*	0.1	pH Units	7.6	7.6	7.6	7.2
Reaction Ratings*[S05]		comment	4.0	1.0	2.0	1.0

Client Sample ID			BH4:0.5M	BH4:1.0M	BH4:1.5M	BH4:2.0M
Sample Matrix			Soil	Soil	Soil	Soil
Eurofins Sample No.			S19-No03890	S19-No03891	S19-No03892	S19-No03893
Date Sampled			Nov 01, 2019	Nov 01, 2019	Nov 01, 2019	Nov 01, 2019
Test/Reference	LOR	Unit				
Acid Sulfate Soils Field pH Test						
pH-F (Field pH test)*	0.1	pH Units	8.4	9.6	9.3	9.8
pH-FOX (Field pH Peroxide test)*	0.1	pH Units	5.3	7.5	7.2	7.6
Reaction Ratings*[S05]		comment	4.0	1.0	2.0	2.0

Client Sample ID			BH4:2.5M	BH4:3.0M	BH4:3.5M	BH4:4.0M
Sample Matrix			Soil	Soil	Soil	Soil
Eurofins Sample No.			S19-No03894	S19-No03895	S19-No03896	S19-No03897
Date Sampled			Nov 01, 2019	Nov 01, 2019	Nov 01, 2019	Nov 01, 2019
Test/Reference	LOR	Unit				
Acid Sulfate Soils Field pH Test						
pH-F (Field pH test)*	0.1	pH Units	9.5	9.5	9.2	9.2
pH-FOX (Field pH Peroxide test)*	0.1	pH Units	7.5	7.6	7.5	7.4
Reaction Ratings*[S05]		comment	1.0	1.0	1.0	3.0

Client Sample ID			BH4:4.5M	BH4:5.0M	BH4:5.5M	BH4:6.0M
Sample Matrix			Soil	Soil	Soil	Soil
Eurofins Sample No.			S19-No03898	S19-No03899	S19-No03900	S19-No03901
Date Sampled			Nov 01, 2019	Nov 01, 2019	Nov 01, 2019	Nov 01, 2019
Test/Reference	LOR	Unit				
Acid Sulfate Soils Field pH Test						
pH-F (Field pH test)*	0.1	pH Units	9.4	9.4	9.3	9.3
pH-FOX (Field pH Peroxide test)*	0.1	pH Units	7.5	7.2	8.0	7.5
Reaction Ratings*[S05]		comment	1.0	3.0	1.0	1.0

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Acid Sulfate Soils Field pH Test	Brisbane	Nov 06, 2019	7 Days

- Method: LTM-GEN-7060 Determination of field pH (pHF) and field pH peroxide (pHFOX) tests

eurofins | Environment Testing

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Brisbane
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NATA # 1261 Site # 20794

Perth
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Kewdale WA 6105
Phone : +61 8 9251 9600
NATA # 1261
Site # 23736

Company Name:	Asset Geotechnical Engineering Pty Ltd	**Order No.:**	2912	**Received:**	Nov 4, 2019 9:19 AM
Address:	Suite 2.05 / 56 Delhi Road North Ryde NSW 2113	**Report #:**	686108	**Due:**	Nov 11, 2019
		Phone:	02 9878 6005	**Priority:**	5 Day
		Fax:		**Contact Name:**	Yeongbin Gim
Project Name:	179 RUSSELL AVENUE DOLLS POINT NSW				
Project ID:	5763-1				

Eurofins Analytical Services Manager : Asim Khan

Sample Detail						HOLD	Acid Sulfate Soils Field pH Test
Melbourne Laboratory - NATA Site # 1254 & 14271							
Sydney Laboratory - NATA Site # 18217							
Brisbane Laboratory - NATA Site # 20794						X	X
Perth Laboratory - NATA Site # 23736							
External Laboratory							
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**		
1	BH2:0.5M	Nov 01, 2019		Soil	S19-No03878		X
2	BH2:1.0M	Nov 01, 2019		Soil	S19-No03879		X
3	BH2:1.5M	Nov 01, 2019		Soil	S19-No03880		X
4	BH2:2.0M	Nov 01, 2019		Soil	S19-No03881		X
5	BH2:2.5M	Nov 01, 2019		Soil	S19-No03882		X
6	BH2:3.0M	Nov 01, 2019		Soil	S19-No03883		X
7	BH2:3.5M	Nov 01, 2019		Soil	S19-No03884		X
8	BH2:4.0M	Nov 01, 2019		Soil	S19-No03885		X
9	BH2:4.5M	Nov 01, 2019		Soil	S19-No03886		X

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Company Name: Asset Geotechnical Engineering Pty Ltd
Address: Suite 2.05 / 56 Delhi Road
North Ryde
NSW 2113

Project Name: 179 RUSSELL AVENUE DOLLS POINT NSW
Project ID: 5763-1

Order No.: 2912
Report #: 686108
Phone: 02 9878 6005
Fax:

Received: Nov 4, 2019 9:19 AM
Due: Nov 11, 2019
Priority: 5 Day
Contact Name: Yeongbin Gim

Eurofins Analytical Services Manager : Asim Khan

Sample Detail						HOLD	Acid Sulfate Soils Field pH Test
Melbourne Laboratory - NATA Site # 1254 & 14271							
Sydney Laboratory - NATA Site # 18217							
Brisbane Laboratory - NATA Site # 20794						X	X
Perth Laboratory - NATA Site # 23736							
10	BH2:5.0M	Nov 01, 2019		Soil	S19-No03887		X
11	BH2:5.5M	Nov 01, 2019		Soil	S19-No03888		X
12	BH2:6.0M	Nov 01, 2019		Soil	S19-No03889		X
13	BH4:0.5M	Nov 01, 2019		Soil	S19-No03890		X
14	BH4:1.0M	Nov 01, 2019		Soil	S19-No03891		X
15	BH4:1.5M	Nov 01, 2019		Soil	S19-No03892		X
16	BH4:2.0M	Nov 01, 2019		Soil	S19-No03893		X
17	BH4:2.5M	Nov 01, 2019		Soil	S19-No03894		X
18	BH4:3.0M	Nov 01, 2019		Soil	S19-No03895		X
19	BH4:3.5M	Nov 01, 2019		Soil	S19-No03896		X
20	BH4:4.0M	Nov 01, 2019		Soil	S19-No03897		X
21	BH4:4.5M	Nov 01, 2019		Soil	S19-No03898		X

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Contact Name: Yeongbin Gim

Eurofins Analytical Services Manager : Asim Khan

Sample Detail						HOLD	Acid Sulfate Soils Field pH Test
Melbourne Laboratory - NATA Site # 1254 & 14271							
Sydney Laboratory - NATA Site # 18217							
Brisbane Laboratory - NATA Site # 20794						X	X
Perth Laboratory - NATA Site # 23736							
22	BH4:5.0M	Nov 01, 2019		Soil	S19-No03899		X
23	BH4:5.5M	Nov 01, 2019		Soil	S19-No03900		X
24	BH4:6.0M	Nov 01, 2019		Soil	S19-No03901		X
25	BH1:0.5M	Nov 01, 2019		Soil	S19-No03955	X	
26	BH1:1.0M	Nov 01, 2019		Soil	S19-No03956	X	
27	BH1:1.5M	Nov 01, 2019		Soil	S19-No03957	X	
28	BH1:2.0M	Nov 01, 2019		Soil	S19-No03958	X	
29	BH1:2.5M	Nov 01, 2019		Soil	S19-No03959	X	
30	BH1:3.0M	Nov 01, 2019		Soil	S19-No03960	X	
31	BH1:3.5M	Nov 01, 2019		Soil	S19-No03961	X	
32	BH1:4.0M	Nov 01, 2019		Soil	S19-No03962	X	
33	BH1:4.5M	Nov 01, 2019		Soil	S19-No03963	X	

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Sample Detail						HOLD	Acid Sulfate Soils Field pH Test
Melbourne Laboratory - NATA Site # 1254 & 14271							
Sydney Laboratory - NATA Site # 18217							
Brisbane Laboratory - NATA Site # 20794						X	X
Perth Laboratory - NATA Site # 23736							
34	BH1:5.0M	Nov 01, 2019		Soil	S19-No03964	X	
35	BH1:5.5M	Nov 01, 2019		Soil	S19-No03965	X	
36	BH1:6.0M	Nov 01, 2019		Soil	S19-No03966	X	
37	BH3:0.5M	Nov 01, 2019		Soil	S19-No03967	X	
38	BH3:1.0M	Nov 01, 2019		Soil	S19-No03968	X	
39	BH3:1.5M	Nov 01, 2019		Soil	S19-No03969	X	
40	BH3:2.0M	Nov 01, 2019		Soil	S19-No03970	X	
41	BH3:2.5M	Nov 01, 2019		Soil	S19-No03971	X	
42	BH3:3.0M	Nov 01, 2019		Soil	S19-No03972	X	
43	BH3:3.5M	Nov 01, 2019		Soil	S19-No03973	X	
44	BH3:4.0M	Nov 01, 2019		Soil	S19-No03974	X	
45	BH3:4.5M	Nov 01, 2019		Soil	S19-No03975	X	

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Company Name:	Asset Geotechnical Engineering Pty Ltd	**Order No.:**	2912	**Received:**	Nov 4, 2019 9:19 AM
Address:	Suite 2.05 / 56 Delhi Road North Ryde NSW 2113	**Report #:**	686108	**Due:**	Nov 11, 2019
		Phone:	02 9878 6005	**Priority:**	5 Day
		Fax:		**Contact Name:**	Yeongbin Gim
Project Name:	179 RUSSELL AVENUE DOLLS POINT NSW				
Project ID:	5763-1				

Eurofins Analytical Services Manager : Asim Khan

Sample Detail						HOLD	Acid Sulfate Soils Field pH Test
Melbourne Laboratory - NATA Site # 1254 & 14271							
Sydney Laboratory - NATA Site # 18217							
Brisbane Laboratory - NATA Site # 20794						X	X
Perth Laboratory - NATA Site # 23736							
46	BH3:5.0M	Nov 01, 2019		Soil	S19-No03976	X	
47	BH3:5.5M	Nov 01, 2019		Soil	S19-No03977	X	
48	BH3:6.0M	Nov 01, 2019		Soil	S19-No03978	X	
Test Counts						24	24

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Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE:** pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram

mg/L: milligrams per litre

ug/L: micrograms per litre

ppm: Parts per million

ppb: Parts per billion

%: Percentage

org/100mL: Organisms per 100 millilitres

NTU: Nephelometric Turbidity Units

MPN/100mL: Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Duplicate									
Acid Sulfate Soils Field pH Test				Result 1	Result 2	RPD			
pH-F (Field pH test)*	S19-No03878	CP	pH Units	8.2	8.1	pass	30%	Pass	
Reaction Ratings*	S19-No03878	CP	comment	1.0	1.0	pass	30%	Pass	
Duplicate									
Acid Sulfate Soils Field pH Test				Result 1	Result 2	RPD			
pH-F (Field pH test)*	S19-No03888	CP	pH Units	9.7	9.6	pass	30%	Pass	
Reaction Ratings*	S19-No03888	CP	comment	2.0	2.0	pass	30%	Pass	
Duplicate									
Acid Sulfate Soils Field pH Test				Result 1	Result 2	RPD			
pH-F (Field pH test)*	S19-No03890	CP	pH Units	8.4	8.6	pass	30%	Pass	
Reaction Ratings*	S19-No03890	CP	comment	4.0	4.0	pass	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
S05	Field Screen uses the following fizz rating to classify the rate the samples reacted to the peroxide: 1.0; No reaction to slight. 2.0; Moderate reaction. 3.0; Strong reaction with persistent froth. 4.0; Extreme reaction.

Authorised By

Asim Khan	Analytical Services Manager
Mylee Clark	Senior Analyst-SPOCAS (QLD)

Glenn Jackson
General Manager

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

#AU03_EnviroSampleBris

From: Asim Khan
Sent: Tuesday, 12 November 2019 2:45 PM
To: #AU03_EnviroSampleBris
Subject: 5 DAY TAT ADDITIONAL ANALYSIS FW: 5763-1: request for CRS testing
Attachments: 5763-1 Eurofins Test Request crs.pdf

Follow Up Flag: Follow up
Flag Status: Flagged

Categories: REBATCH WAITING

Additional analysis please on standard TAT.

Please let me know once logged.

Thanks,

Kind regards,

Asim Khan
Analytical Services Manager

Eurofins | Environment Testing

From: Woochul Yang
Sent: Tuesday, 12 November 2019 3:36 PM
To: Asim Khan
Subject: 5763-1: request for CRS testing

EXTERNAL EMAIL*

Hi Asim,

Could you please arrange 3 CRS tests as per COC?
Please issue PO# seperately. Po# for CRS tests is included on COC.

Thank you.

Best regards,

Woochul Yang
Project Geotechnical Engineer

eurofins | mgt

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Phone: +613 8564 5000 Fax: +613 8564 5090
Email: enquiries.melb@mgtlabmark.com.au

CHAIN OF CUSTODY RECORD

CLIENT DETAILS

Company Name: Asset Geotechnical	Contact Name: Yeongbin Gim	Purchase Order: screening: 2912, CRS: 2949	COC Number:
Office Address: Suite 2.05 56 Delhi Road, North Ryde	Project Manager:	PROJECT Number: 5763-1	Eurofins | mgt quote ID:
	Email for results: labresults@assetgeoenviro.com.au	PROJECT Name: 179 Russell Avenue, Dolls Point NSW	Data output format:

Special Directions & Comments:

Eurofins | mgt DI water batch number:

	Sample ID	Date	Matrix	Salinity (Salinity (EC), % moisture, Sulfate(SO4), pH)	Aggressivity soil set (chloride, resistivity)	Acid sulphate soils screen (pH-F, pH-FOX)	Acid sulphate soils (sPOCAS)	See Attached	Chromium Reducible Surphur (CRS)	Containers: 1LP	250P	125P	1LA	40mL vial	125mL A	Jar	Zip-lock bag	Sample comments:
1	BH2: 0.5m	1.11.19	Soils			✓			✓								✓	requested on 12/11/19
2	BH2: 1.0m	"	"			✓			✓								✓	requested on 12/11/19
3	BH2: 1.5m	"	"			✓											✓	
4	BH2: 2.0m	"	"			✓											✓	
5	BH2: 2.5m	"	"			✓											✓	
6	BH2: 3.0m	"	"			✓											✓	
7	BH2: 3.5m	"	"			✓											✓	
8	BH2: 4.0m	"	"			✓											✓	
9	BH2: 4.5m	"	"			✓											✓	
10	BH2: 5.0m	"	"			✓											✓	
11	BH2: 5.5m	"	"			✓											✓	
12	BH2: 6.0m	"	"			✓											✓	
13	BH4: 0.5m	"	"			✓			✓								✓	requested on 12/11/19
14	BH4: 1.0m	"	"			✓											✓	
15	BH4: 1.5m	"	"			✓											✓	
16	BH4: 2.0m	"	"			✓											✓	

Some common holding times (with correct preservation). For further information contact the lab

Waters		Soils	
BTEX, MAH, VOC	14 days	BTEX, MAH, VOC	14 days
TRH, PAH, Phenols, Pesticides	7 days	TRH, PAH, Phenols, Pesticides	14 days
Heavy Metals	6 months	Heavy Metals	6 months
Mercury, CrVI	28 days	Mercury, CrVI	28 days
Microbiological testing	24 hours	Microbiological testing	72 hours
BOD, Nitrate, Nitrite, Total N	2 days	Anions	28 days
Solids - TSS, TDS etc	7 days	SPOCAS, pH Field and FOX, CrS	24 hours
Ferrous iron	7 days	ASLP, TCLP	7 days

Laboratory Staff		Turn around time	Method Of Shipment	Temperature on arrival:
Relinquished By:	Received By:	1 DAY ☐ 2 DAY ☐ 3 DAY ☐	☐ Courier	
Date & Time::	Date & Time:	5 DAY ☑ 10 DAY ☐ Other:	☐ Hand Delivered	Report number: 687623
Signature:	Signature:		☐ Postal	
			Courier Consignment #:	

Asset Geotechnical Engineering Pty Ltd
Suite 2.05 / 56 Delhi Road
North Ryde
NSW 2113

NATA Accredited
Accreditation Number 1261
Site Number 20794

Accredited for compliance with ISO/IEC 17025 – Testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Attention: **Yeongbin Gim**

Report **687623-S**
Project name 179 RUSSELL AVENUE DOLLS POINT NSW
Project ID 5763-1
Received Date Nov 12, 2019

Client Sample ID			**BH2:0.5M**	**BH2:1.0M**	**BH4:0.5M**
Sample Matrix			**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**B19-No16293**	**B19-No16294**	**B19-No16295**
Date Sampled			**Nov 01, 2019**	**Nov 01, 2019**	**Nov 01, 2019**
Test/Reference	LOR	Unit			
Chromium Suite					
pH-KCL	0.1	pH Units	6.5	6.9	8.7
Acid trail - Titratable Actual Acidity	2	mol H+/t	< 2	< 2	< 2
sulfidic - TAA equiv. S% pyrite	0.003	% pyrite S	< 0.003	< 0.003	< 0.003
Chromium Reducible Sulfur[S04]	0.005	% S	< 0.005	< 0.005	< 0.005
Chromium Reducible Sulfur -acidity units	3	mol H+/t	< 3	< 3	< 3
Sulfur - KCl Extractable	0.02	% S	n/a	n/a	n/a
HCl Extractable Sulfur Correction Factor	1	factor	2.0	2.0	2.0
HCl Extractable Sulfur	0.02	% S	n/a	n/a	n/a
Net Acid soluble sulfur	0.02	% S	n/a	n/a	n/a
Net Acid soluble sulfur - acidity units	10	mol H+/t	n/a	n/a	n/a
Net Acid soluble sulfur - equivalent S% pyrite[S02]	0.02	% S	n/a	n/a	n/a
Acid Neutralising Capacity (ANCbt)	0.01	% CaCO3	n/a	0.07	0.95
Acid Neutralising Capacity - acidity (a-ANCbt)	2	mol H+/t	n/a	14	190
Acid Neutralising Capacity - equivalent S% pyrite (s-ANCbt)[S03]	0.02	% S	n/a	0.02	0.30
ANC Fineness Factor		factor	1.5	1.5	1.5
CRS Suite - Net Acidity (Sulfur Units)	0.02	% S	< 0.02	< 0.02	< 0.02
CRS Suite - Net Acidity (Acidity Units)	10	mol H+/t	< 10	< 10	< 10
CRS Suite - Liming Rate[S01]	1	kg CaCO3/t	< 1	< 1	< 1
Extraneous Material					
<2mm Fraction	0.005	g	75	85	59
>2mm Fraction	0.005	g	< 0.005	< 0.005	< 0.005
Analysed Material	0.1	%	100	100	100
Extraneous Material	0.1	%	< 0.1	< 0.1	< 0.1
% Moisture	1	%	1.9	3.3	9.7

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Chromium Reducible Sulfur Suite			
Chromium Suite	Brisbane	Nov 12, 2019	6 Week
- Method: LTM-GEN-7070			
Extraneous Material	Brisbane	Nov 12, 2019	6 Week
- Method: LTM-GEN-7050/7070			
% Moisture	Brisbane	Nov 12, 2019	14 Days
- Method: LTM-GEN-7080 Moisture			

Melbourne
6 Monterey Road
Dandenong South VIC 3175
Phone : +61 3 8564 5000
NATA # 1261
Site # 1254 & 14271

Sydney
Unit F3, Building F
16 Mars Road
Lane Cove West NSW 2066
Phone : +61 2 9900 8400
NATA # 1261 Site # 18217

Brisbane
1/21 Smallwood Place
Murarrie QLD 4172
Phone : +61 7 3902 4600
NATA # 1261 Site # 20794

Perth
2/91 Leach Highway
Kewdale WA 6105
Phone : +61 8 9251 9600
NATA # 1261
Site # 23736

Company Name:	Asset Geotechnical Engineering Pty Ltd	**Order No.:**	2949	**Received:**	Nov 12, 2019 2:45 PM
Address:	Suite 2.05 / 56 Delhi Road North Ryde NSW 2113	**Report #:**	687623	**Due:**	Nov 19, 2019
		Phone:	02 9878 6005	**Priority:**	5 Day
		Fax:		**Contact Name:**	Yeongbin Gim
Project Name:	179 RUSSELL AVENUE DOLLS POINT NSW				
Project ID:	5763-1				

Eurofins Analytical Services Manager : Asim Khan

Sample Detail						Chromium Reducible Sulfur Suite	Moisture Set
Melbourne Laboratory - NATA Site # 1254 & 14271							
Sydney Laboratory - NATA Site # 18217							
Brisbane Laboratory - NATA Site # 20794						X	X
Perth Laboratory - NATA Site # 23736							
External Laboratory							
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**		
1	BH2:0.5M	Nov 01, 2019		Soil	B19-No16293	X	X
2	BH2:1.0M	Nov 01, 2019		Soil	B19-No16294	X	X
3	BH4:0.5M	Nov 01, 2019		Soil	B19-No16295	X	X
Test Counts						3	3

eurofins | Environment Testing

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE:** pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram | **mg/L:** milligrams per litre | **ug/L:** micrograms per litre

ppm: Parts per million | **ppb:** Parts per billion | **%:** Percentage

org/100mL: Organisms per 100 millilitres | **NTU:** Nephelometric Turbidity Units | **MPN/100mL:** Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test			Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
LCS - % Recovery									
Chromium Suite									
Chromium Reducible Sulfur			%	94			70-130	Pass	
Acid Neutralising Capacity (ANCbt)			%	104			70-130	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Duplicate									
Chromium Suite				Result 1	Result 2	RPD			
pH-KCL	S19-No10770	NCP	pH Units	8.8	8.8	<1	30%	Pass	
Acid trail - Titratable Actual Acidity	S19-No10770	NCP	mol H+/t	< 2	< 2	<1	30%	Pass	
sulfidic - TAA equiv. S% pyrite	S19-No10770	NCP	% pyrite S	< 0.003	< 0.003	<1	30%	Pass	
Chromium Reducible Sulfur	S19-No10770	NCP	% S	0.38	0.39	4.0	30%	Pass	
Chromium Reducible Sulfur -acidity units	S19-No10770	NCP	mol H+/t	230	240	4.0	30%	Pass	
Sulfur - KCl Extractable	S19-No10770	NCP	% S	n/a	n/a	n/a	30%	Pass	
Net Acid soluble sulfur	S19-No10770	NCP	% S	n/a	n/a	n/a	30%	Pass	
Net Acid soluble sulfur - acidity units	S19-No10770	NCP	mol H+/t	n/a	n/a	n/a	30%	Pass	
Net Acid soluble sulfur - equivalent S% pyrite	S19-No10770	NCP	% S	n/a	n/a	n/a	30%	Pass	
Acid Neutralising Capacity (ANCbt)	S19-No10770	NCP	% CaCO3	0.54	0.55	1.0	30%	Pass	
Acid Neutralising Capacity - equivalent S% pyrite (s-ANCbt)	S19-No10770	NCP	% S	0.17	0.18	1.0	30%	Pass	
ANC Fineness Factor	S19-No10770	NCP	factor	1.5	1.5	<1	30%	Pass	
CRS Suite - Net Acidity (Sulfur Units)	S19-No10770	NCP	% S	0.26	0.27	5.0	30%	Pass	
CRS Suite - Net Acidity (Acidity Units)	S19-No10770	NCP	mol H+/t	160	170	5.0	30%	Pass	
CRS Suite - Liming Rate	S19-No10770	NCP	kg CaCO3/t	12	13	5.0	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
% Moisture	B19-No15017	NCP	%	18	17	7.0	30%	Pass	