JKEnvironments

14 April 2022
Ref: E33691PHlet2-ASS

Anthony Brooks
13 Monash Crescent
Clontarf NSW 2093

SUPPLEMENTARY ACID SULFATE SOIL ASSESSMENT
PROPOSED SEA WALL DEVELOPMENT
13 MONASH CRESCENT, CLONTARF

1 INTRODUCTION

Anthony Brooks ('the client') commissioned JK Environments (JKE) to undertake a supplementary acid sulfate soil (ASS) assessment for the proposed sea wall development at 13 Monash Crescent, Clontarf, NSW. The site is identified as Lot 53 in DP9745. The site location is shown on Figure 1 and the investigation was confined to the site boundaries/proposed development area as shown on Figure 2 attached in the appendices.

JKE have previously completed a Preliminary ASS Assessment[1] at the site that included soil sampling from two boreholes (BH2 and BH4) drilled on the high side of the sea wall at the site to a maximum depth of approximately 2.2m below ground level (BGL). JKE considered that there was a low potential for ASS materials (AASS or PASS) to be disturbed to a depth of approximately 2.2mBGL. Council have requested additional investigation beyond this depth due to the proposed works associated with the sea wall. The supplementary assessment aims to:

- Better assess the potential for acid sulfate soil (ASS) to be disturbed during development works; and
- Assess the need to prepare an ASS management plan (ASSMP)

The investigation was undertaken generally in accordance with a JKE proposal (Ref: EP56312PH) of 30 March 2022 and written acceptance from Anthony Brooks by email of 30 March 2022.

The aims of the assessment were to establish whether ASS may be disturbed during the proposed sea wall development works, and to assess whether an ASS management plan (ASSMP) is required.

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[1] Preliminary Acid Sulfate Soil Assessment, Proposed Residential Development, 13 Monash Crescent, Clontarf, NSW (ref: E33691Plet, dated 15 January 2021)

1.1 Assessment Guidelines and Background

The ASS assessment and preparation of this report were undertaken with reference to the National Acid Sulfate Soil Guidance (2018) documents and the Acid Sulfate Soil Management Advisory Committee (ASSMAC) Acid Sulfate Soil Manual (1998)[2].

ASS materials include potential acid sulfate soils (PASS or sulfidic soil materials) and actual acid sulfate soils (AASS or sulfuric soil materials). These are often found in the same profile, with AASS overlying PASS. AASS and PASS are defined further as follows:

- PASS are soil materials which contain Reduced Inorganic Sulfur (RIS) such as pyrite. The field pH of these soils in their undisturbed state is usually more than pH 4 and is commonly neutral to alkaline (pH 7–9). These soil materials are invariably saturated with water in their natural state. Their texture may be peat, clay, loam, silt or sand and is often dark grey in colour and soft in consistence, but these materials may also exhibit colours that are dark brown, or medium to pale grey to white; and
- AASS are soil materials which contained RIS such as pyrite that have undergone oxidation. This oxidation results in low pH (that is pH less than 4) and often a yellow (jarosite) and/or orange to red mottling (ferric iron oxides) in the soil profile. Actual ASS contains Actual Acidity, and commonly also contains RIS (the source of Potential Sulfuric Acidity) as well as Retained Acidity.

Further background information on ASS and the assessment process is provided in the appendices.

1.2 Proposed Development Details

Based on the details provided, it is understood that the proposed development includes redevelopment of the site for residential purposes, including replacement of the sea wall. Soil disturbance is expected to occur to a maximum depth of approximately -0.9mAHD for the construction of the sea wall.

2 SITE INFORMATION

2.1 Summary of Preliminary ASS Assessment

The preliminary assessment included soil sampling from two boreholes (BH2 and BH4) to a maximum depth of approximately 2.2mBGL (approximately 0.1mAHD). The subsurface conditions encountered generally consisted of fill material from the surface to a depth of approximately 0.8mBGL in BH2 and to the termination/refusal of BH4 at a depth of approximately 1.1mBGL. The fill was underlain by marine silty sand soil in BH2 to the termination depth of approximately 2.2mBGL. Groundwater seepage was encountered in BH2 at approximately 2.0mBGL, at which point shell fragments were encountered in the natural soil.

Four selected samples were analysed for ASS characteristics. The laboratory results were all less than the action criteria.

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[2] Acid Sulfate Soils Management Advisory Committee (ASSMAC), (1998). *Acid Sulfate Soils Manual* (ASS Manual 1998)

Based on the weight of evidence collected and evaluated for the preliminary assessment, there was considered to be a low potential for ASS materials (AASS or PASS) to be disturbed to a depth of approximately 2.2mBGL. If no excavation is required beyond this depth, an ASSMP was not considered necessary for the proposed development. If, however, excavation beyond this depth is required, then further assessment would be required to better assess potential ASS conditions beyond 2.2mBGL.

2.2 Site Information and Description

Table 2-1: Site Identification

Site Address:	13 Monash Crescent, Clontarf, NSW
Lot & Deposited Plan:	Lot 53 DP9745
Current Land Use:	Residential
Site Area (m^2):	485
Site Elevation (metres Australian Height Datum – mAHD approx.)	2.3-2.5
Geographical Location (approx.):	Latitude: -33.808831 Longitude: 151.253084

The site is located in a residential area of Clontarf, on the south-west side of Monash Crescent and north-east of Middle Harbour. The regional topography is characterised by gently undulating terrain and an alluvial plain which descends towards the south. The site is located at the bottom of the plain on Clontarf Beach and is relatively flat.

At the time of the fieldwork, the site was occupied by a two storey residential house in the southern section of the property, which was constructed from brick, tile, concrete and fibre cement (eaves). A one storey garage was located in the northern section of the property, which was constructed from concrete and tile. An assortment of native and exotic grass, shrubs and trees were located on site which all appeared in good condition with no signs of stress or dieback. An existing sea wall retained the site above Clontarf Beach and was approximately 2m high.

An access easement was located immediately north-west of the site, with residential properties beyond. Similar residential properties were located to the north-east and south-east of the site. Clontarf Beach and Middle Harbour were located to the south-west of the site.

2.3 Regional Geology

The geological map of Sydney (1983)[3] indicates the site to be underlain by Quaternary aged deposits of coarse quartz sand, varying amounts of shell fragment.

2.4 Acid Sulfate Soil Risk Map

A review of the ASS risk maps prepared by Department of Land and Water Conservation (1997)[4] indicates that the site is located in an area classed as having 'low risk' of occurrence of ASS between 1m and 3m below the ground surface.

2.5 Warringah Council Local Environmental Plan (LEP) 2000

A review of the Warringah council LEP indicates that the site is located on the boundary of ASS risk Classes 3 and 5 (refer to appendices for further details on each risk class).

3 INVESTIGATION REQUIREMENTS AND ASSESSMENT CRITERIA

3.1 Investigation Requirements

The National Acid Sulfate Soil Guidance (2018) requires sampling to a depth of 1m beyond the depth of disturbance (including the depth of any groundwater disturbance). A summary of the sampling densities and analysis requirements outlined in the *National Acid Sulfate Soil Guidance: National acid sulfate soils sampling and identification methods manual* (2018) is provided in the following tables:

Table 3-1: Minimum Soil Sampling Densities for ASS Investigations

Type of disturbance	Extent of site	Sample point frequency
Small volumes (≤ 1000 m^3) – prior to disturbance	Volume of disturbance (m^3)	Number of boreholes
	< 250	2
	251–500	3
	501–1000	4
Large volumes (> 1000 m^3) – prior to disturbance	Project area (ha)	Number of boreholes
	<1	4
	1-2	6
	2-3	8
	3-4	10
	>4	10 plus 2 per additional hectare
Linear	Width and volume	Intervals (m)
	Minor[1]	100
	Major[2]	50

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[3] Department of Mineral Resources, (1983). *1:100,000 Geological Map of Sydney (Series 9130)*

[4] Department of Land and Water Conservation, (1997). *1:25,000 Acid Sulfate Soil Risk Map (Series 9130N2, Ed 2)*

Type of disturbance	**Extent of site**	**Sample point frequency**
Existing stockpiles & verification testing	Volume (m^3)	Number of samples
	<250	2
	251-500	3
	1,000	4
	>1,000	4 plus 1 per additional 500m^3

[1] Minor Linear Disturbance – for example underground services, narrow shallow drains (less than 1 m below ground level).

[2] Major Linear Disturbance – for example roads, railways, canals, deep sewer, wide drains, deep drains and dredging projects[#].

[#] Further guidance is provided in the Guidelines for the dredging of acid sulfate soil sediments and associated dredge spoil management (Simpson et al. 2017).

Table 3-2: Minimum Number of Soil Samples to be Submitted for Laboratory Analysis (small-scale disturbance)

Volume of disturbed soils	**Maximum disturbance depth**			
	< 1 m	1–2 m	2-3 m	3-4 m
≤ 250m^3	3	4	5	6
251–500m^3	4	5	6	7
500–1,000m^3	5	6	7	8

Note: Small scale is considered less than or equal to 1,000 m^3 and does not involve dewatering or groundwater pumping (excluding linear disturbances). Number of samples to be analysed per total volume of soil to be disturbed, not per borehole. Depth of disturbance to be measured from ground surface. Borehole depth must be at least 1 m below maximum proposed depth of disturbance.

The supplementary assessment was specifically targeted at the sea wall works and does not meet the minimum sampling density and analysis frequency. The low sampling density is considered reasonable given the localised extent of soil disturbance.

3.2 Action Criteria

The action criteria presented in the *National Acid Sulfate Soil Guidance: National acid sulfate soils sampling and identification methods manual* (2018) are summarised in the following table:

Table 3-3: ASS Action Criteria Based on Soil Texture and Volume of Material Being Disturbed

Type of material		**Net Acidity**			
Texture range* (NCST 2009)	Approximate clay content (%)	1–1000 t materials disturbed		> 1000 t materials disturbed	
		% S-equiv. (oven-dried basis)	mol H^+/t (oven-dried basis)	% S-equiv. (oven-dried basis)	mol H^+/t (oven-dried basis)
Fine - light medium to heavy clays	>40	≥0.10	≥62	≥0.03	≥18
Medium - clayey sand to light clays	5–40	≥0.06	≥36	≥0.03	≥18
Coarse and Peats - sands to loamy sands	<5	≥0.03	≥18	≥0.03	≥18

* If bulk density values are not available for the conversion of cubic meters to tonnes of soil, then default bulk densities, based on the soil texture, may be used.

The action criteria for coarse soils were used for this assessment.

3.3 Field Tests

The soil field tests commonly used for investigations for ASS materials include field pH (pH_F) and field pH peroxide (pH_{FOX}) tests. The pH_F test can help identify Actual ASS. While a pH_F of less than or equal to pH 4 is indicative of the presence of Actual ASS, it is not conclusive of the presence of ASS on its own, as naturally occurring, non ASS soils such as many organic soils (for example peats) and heavily leached soils may also have pH_F less than or equal to pH 4. To identify an Actual ASS other evidence must be presented that indicates the low pH_F has been mainly caused by the oxidation of reduced inorganic sulfur. Such information includes the presence of jarosite in the soil layer/horizon, or the location of other Actual ASS or PASS materials within the sampling location or in the nearby vicinity.

The difference between the pH_F and the pH_{FOX} is helpful in the preliminary identification of PASS. Combined, the pH_F and pH_{FOX} results can be a useful aid with soil sample selection for laboratory analysis. Additional Information in relation to interpretation of the pH field tests is provided in the appendices.

4 INVESTIGATION PROCEDURE

4.1 Subsurface Investigation and Soil Sampling Methods

Field work was undertaken on 1 April 2022. Soil samples were collected from two locations (BH101 and BH102) at the base of the sea wall, to a maximum borehole depth of 0.9mBGL. The sampling locations are shown on the attached Figure 2.

The sample locations were drilled using hand equipment due to access restrictions. The depth of boreholes was limited by groundwater infiltration into the boreholes. Boreholes were drilled at low tide in an attempt to reach the maximum possible depth.

Soil samples were obtained at various depths, based on observations made during the field investigation. All samples were placed in plastic bags and sealed with plastic ties with minimal headspace. Each sample was labelled with a unique job number, the sampling location, sampling depth and date. All samples were recorded on the borehole logs attached in the appendices.

The samples were preserved by immediate storage in an insulated sample container with ice and delivered in the insulated sample container (on ice or with ice packs) to a NATA registered laboratory for analysis under standard chain of custody (COC) procedures.

4.2 Laboratory Analysis

Samples for this assessment were analysed for ASS field tests (including pH_F and pH_{FOX}) and using the chromium reducible sulfur (S_{CR}) acid base accounting analytical methods. All tests/analysis were performed at the laboratory and JKE did not carry out the testing in the field due to time constraints. Samples were analysed by Envirolab Services (NATA Accreditation Number – 2901). Reference should be made to the laboratory report (Ref: 292445 and 292445-A) attached in the appendices for further information regarding the laboratory methods used.

5 RESULTS OF THE INVESTIGATION

5.1 Subsurface Conditions

The boreholes (BH101 and BH102) were drilled approximately 0.5m from the base of the sea wall, at an elevation of approximately 0.4mAHD. The subsurface conditions encountered generally consisted of sand from the surface to the termination of the boreholes at a maximum depth of approximately 0.9mBGL. The sand was yellow-brown and contained traces of shell fragments.

Groundwater seepage was encountered at depths of approximately 0.4m to 0.5mBGL. Borehole collapsed due to groundwater inundation occurred at depths of approximately 0.8m to 0.9mBGL.

5.2 Laboratory Results

The soil laboratory results were assessed against the action criteria adopted for the assessment. The results are presented in the attached report tables and are summarised below.

Table 5-1: Summary of Results

Results	Comments
pH_F and pH_{FOX}	pH_F results ranged from 7.4 to 9.2. pH_{FOX} results ranged from 6.5 to 7.0.
pH_{FOX} reaction rates	All samples recorded a low reaction rate.
Net Acidity % S-equiv.	All net acidity results were <0.005%.
Net Acidity mol H^+/t	All net acidity results were <5molH^+/t.
S_{CR}%	The S_{CR}% results were all <0.005%. These results indicated that the soils did not contain significant oxidisable sulfur concentrations.
Liming Rate	The liming rate required for neutralisation was <0.75kg$CaCO_3$/tonne in all samples.

6 CONCLUSION

Based on the weight of evidence collected and evaluated for this assessment, there is considered to be a low potential for ASS materials (AASS or PASS) to be disturbed during the proposed development described in Section 1.2 of this report. We note that sampling was limited to a depth of approximately -0.5mAHD, however, given the consistency of the natural sand encountered during both stages of assessment and the very low analysis results, the natural soil in considered unlikely to be AASS or PASS. On this basis, an ASSMP is not considered necessary for the proposed development including the sea wall works.

In the event conditions encountered during excavation differ from those encountered in the boreholes (i.e. yellow-brown marine sand), all work should cease and an experienced consultant should be contacted to address any potential action.

7 LIMITATIONS

The report limitations are outlined below:

- JKE accepts no responsibility for any unidentified AASS or PASS issues at the site. Any unexpected problems/subsurface features that may be encountered during development works should be inspected by an environmental consultant as soon as possible;
- This report has been prepared based on site conditions which existed at the time of the investigation; scope of work and limitation outlined in the JKE proposal; and terms of contract between JKE and the client (as applicable);
- The conclusions presented in this report are based on investigation of conditions at specific locations, chosen to be as representative as possible under the given circumstances, visual observations of the site and immediate surrounds and documents reviewed as described in the report;
- Subsurface soil and rock conditions encountered between investigation locations may be found to be different from those expected. Groundwater conditions may also vary, especially after climatic changes;
- The investigation and preparation of this report have been undertaken in accordance with accepted practice for environmental consultants, with reference to applicable environmental regulatory authority and industry standards, guidelines and the assessment criteria outlined in the report;
- Where information has been provided by third parties, JKE has not undertaken any verification process, except where specifically stated in the report;
- JKE accept no responsibility for potentially asbestos containing materials that may exist at the site. These materials may be associated with demolition of pre-1990 constructed buildings or fill material at the site;
- JKE have not and will not make any determination regarding finances associated with the site;
- Additional investigation work may be required in the event of changes to the proposed development or landuse. JKE should be contacted immediately in such circumstances;
- This report has been prepared for the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose;
- Copyright in this report is the property of JKE. JKE has used a degree of care, skill and diligence normally exercised by consulting professionals in similar circumstances and locality. No other warranty expressed or implied is made or intended. Subject to payment of all fees due for the investigation, the client alone shall have a licence to use this report;
- If the client, or any person, provides a copy of this report to any third party, such third party must not rely on this report except with the express written consent of JKE; and
- Any third party who seeks to rely on this report without the express written consent of JKE does so entirely at their own risk and to the fullest extent permitted by law, JKE accepts no liability whatsoever, in respect of any loss or damage suffered by any such third party.

If you have any questions concerning the contents of this letter please do not hesitate to contact us.

Kind Regards

tHore

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VB

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Appendices:

Appendix A: Report Figures
Appendix B: Laboratory Results Summary Table
Appendix C: Information on Acid Sulfate Soils
Appendix D: Borehole Logs
Appendix E: Laboratory Reports & COC Documents

Appendix A: Report Figures

SOURCE: http://www.whereis.com/

AERIAL IMAGE SOURCE: MAPS.AU.NEARMAP.COM

This plan should be read in conjunction with the Environmental report.

Title:
SITE LOCATION PLAN

Location: 13 MONASH CRESCENT, CLONTARF, NSW

Project No: E33691PH

Figure No: 1

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PLOT DATE: 11/04/2022 9:34:34 AM DWG FILE: S:\5 EIS\5C EIS JOBS\33000'S\E33691P CLONTARF\CAD\E33691PH.DWG

LEGEND

▬ ▬ ▬	APPROXIMATE SITE BOUNDARY
● BH(Fill Depth)	BOREHOLE LOCATION, NUMBER AND DEPTH OF FILL (m)

0 2 4 6 8 10
SCALE 1:200 @A3 METRES

This plan should be read in conjunction with the Environmental report.

Title:
SAMPLE LOCATION PLAN

Location: 13 MONASH CRESCENT, CLONTARF, NSW

Project No: E33691PH

Figure No: 2

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PLOT DATE: 11/04/2022 9:34:44 AM DWG FILE: S:\5 EIS\5C EIS JOBS\33000'S\E33691P CLONTARF\CAD\E33691PH.DWG

Appendix B: Laboratory Results Summary Table

ABBREVIATIONS AND EXPLANATIONS FOR ACID SULFATE SOIL TABLE

Abbreviations used in the Tables:

ANC_{BT}	Acid Neutralising Capacity - Back Titration
ANCE	Excess Acid Neutralising Capacity
$CaCO_3$	Calcium Carbonate
kg	kilogram
mol H^+/t	moles hydrogen per tonne
pHF	Field pH
pHFOX	Field peroxide pH
pH_{KCl}	Pottasium chloride pH
S	Sulfur
SCr	The symbol given to the result from the Chromium Reducible Sulfur method
S_{NAS}	Net Acid Soluble Sulfur
% w/w	Percentage by mass

Results have been assessed against the criteria specified in Table 1.1 of National Acid sulfate Soil Guidance - National acid sulfate soil identification and laboratory method manual. Water Quality Australia. June 2018

TABLE A
SUMMARY OF LABORATORY RESULTS - ACID SULFATE SOIL ANALYSIS

Soil Texture:	**Coarse**	**Analysis**	**pH_F and pH_{FOX}**					**Actual Acidity (Titratable Actual Acidity - TAA)**	**Potential Sulfidic Acidity**		**Retained Acidity**	**Acid Neutralising Capacity (ANC_{BT})**	**a-Net Acidity without ANCE**	**s-Net Acidity without ANCE**	**Liming Rate - without ANCE**
			pH_F	**pH_{FOX}**	**Reaction**	**$pH_F - pH_{FOX}$**	**pH_{KCL}**	**(mol H^+/t)**	**(% SCr)**	**(mol H^+/t)**	**($\%S_{NAS}$)**	**(% $CaCO_3$)**	**(mol H^+/t)**	**(%w/w S)**	**(kg $CaCO_3$/tonne)**
National Acid Sulfate Soils Guidance (2018)			-	-	-	-	-	-	-	-	-	-	18	0.03	-
Sample Reference	**Sample Depth (m)**	**Sample Description**													
BH101	0-0.3	Sand	7.4	6.5	Low reaction	0.9	10	<5	<0.005	<3	[NT]	2.6	<5	<0.005	<0.75
BH101	0-0.3	Lab Replicate	NA	NA	NA	NA	10	<5	<0.005	<3	[NT]	2.8	<5	<0.005	<0.75
BH101	0.3-0.6	Sand	9.2	7	Low reaction	2.2	10.1	<5	<0.005	<3	[NT]	4.2	<5	<0.005	<0.75
BH101	0.6-0.8	Sand	9.2	6.6	Low reaction	2.6	10.1	<5	<0.005	<3	[NT]	4	<5	<0.005	<0.75
BH102	0-0.3	Sand	8.8	6.6	Low reaction	2.2	10	<5	<0.005	<3	[NT]	3	<5	<0.005	<0.75
BH102	0.3-0.6	Sand	9	6.7	Low reaction	2.3	10	<5	<0.005	<3	[NT]	4	<5	<0.005	<0.75
BH102	0.6-0.9	Sand	9.1	6.8	Low reaction	2.3	10.1	<5	<0.005	<3	[NT]	4.1	<5	<0.005	<0.75
Total Number of Samples			6	6	-	6	7	7	7	7	7	7	7	7	7
Minimum Value			7.4	6.5	-	0.9	10	<PQL	<PQL	<PQL	<PQL	2.60	<PQL	<PQL	<PQL
Maximum Value			9.2	7.0	-	2.6	10.1	<PQL	<PQL	<PQL	<PQL	4.20	<PQL	<PQL	<PQL

Values Exceeding Action Criteria 🟨

Appendix C: Information on Acid Sulfate Soils

A. Background

Acid Sulfate Soil (ASS) is formed from iron rich alluvial sediments and sulfate (found in seawater) in the presence of sulfate reducing bacteria and plentiful organic matter. These conditions are generally found in mangroves, salt marsh vegetation or tidal areas and at the bottom of coastal rivers and lakes. ASS materials are distinguished from other soil or sediment materials (referred to as 'soil materials' throughout the National Acid Sulfate Soils Guidance) by having properties and behaviour that have either:

1) Been affected considerably by the oxidation of Reduced Inorganic Sulfur (RIS), or
2) The capacity to be affected considerably by the oxidation of their RIS constituents.

Acid sulfate soil materials include potential acid sulfate soils (PASS or sulfidic soil materials) and actual acid sulfate soils (AASS or sulfuric soil materials). These are often found in the same profile, with AASS overlying PASS. PASS and AASS are defined further below:

- PASS are soil materials which contain RIS such as pyrite. The field pH of these soils in their undisturbed state is usually more than pH 4 and is commonly neutral to alkaline (pH 7–9). These soil materials are invariably saturated with water in their natural state. Their texture may be peat, clay, loam, silt or sand and is often dark grey in colour and soft in consistence, but these materials may also exhibit colours that are dark brown, or medium to pale grey to white; and
- AASS are soil materials which contained RIS such as pyrite that have undergone oxidation. This oxidation results in low pH (that is pH less than 4) and often a yellow (jarosite) and/or orange to red mottling (ferric iron oxides) in the soil profile. Actual ASS contains Actual Acidity, and commonly also contains RIS (the source of Potential Sulfuric Acidity) as well as Retained Acidity.

B. The ASS Planning Maps

The ASS planning maps provide an indication of the relative potential for disturbance of ASS to occur at locations within the council area. These maps do not provide an indication of the actual occurrence of ASS at a site or the likely severity of the conditions.

The maps are divided into five classes dependent upon the type of activities/works that if undertaken, may represent an environmental risk through the development of acidic conditions associated with ASS:

Table 1: Risk Classes

Risk Class	Description
Class 1	All works.
Class 2	All works below existing ground level and works by which the water table is likely to be lowered.
Class 3	Works at depths beyond 1m below existing ground level or works by which the water table is likely to be lowered beyond 1m below existing ground level.
Class 4	Works at depths beyond 2m below existing ground level or works by which the water table is likely to be lowered beyond 2m below existing ground level.
Class 5	Works within 500m of adjacent Class 1, 2, 3, 4 land which are likely to lower the water table below 1m AHD on the adjacent land.

C. The ASS Risk Maps

The ASS risk maps provide an indication of the probability of occurrence of ASS materials at a particular location based on interpretation from geological and soil landscape maps. The maps provide classes based on high probability, low probability, no known occurrence and areas of disturbed terrain (site specific assessment necessary) and the likely depth at which ASS materials are likely to be encountered.

D. Interpretation of ASS Field Tests

Tables A1 and A2 below provide some guidance on the interpretation of pH_F and pH_{FOX} test results, as detailed in the *National Acid Sulfate Soil Guidance: National acid sulfate soils sampling and identification methods manual* (2018):

Table A1: Interpretation of some pH_F test ranges

pH value	Result	Comments
$pH_F \leq 4$, jarosite not observed in the soil layer/horizon	May indicate an AASS indicating previous oxidation of RIS or may indicate naturally occurring, non ASS soils.	Generally not conclusive as naturally occurring, non ASS soils, such as many organic soils (for example peats) and heavily leached soils, often also return $pH_F \leq 4$.
$pH_F \leq 4$, jarosite observed in the soil layer/horizon	The soil material is an AASS.	Jarosite and other iron precipitate minerals in ASS such as schwertmannite require a pH < 4 to form and indicate prior oxidation of RIS.
$pH_F > 7$	Expected in waterlogged, unoxidised, or poorly drained soils.	Marine muds commonly have a pH > 7 which reflects a seawater (pH 8.2) influence. Oxidation of samples with H_2O_2 can help indicate if the soil materials contain RIS.

Source: Adapted from DER (2015a).

Table A2: Interpretation of pH_{FOX} test results

pH value and reaction	Result	Comments
Strong reaction of soil with H_2O_2 (that is X or V)	Useful indicator of the presence of RIS but cannot be used alone	Organic rich substrates such as peat and coffee rock, and soil constituents like manganese oxides, can also cause a reaction. Care must be exercised in interpreting these results. Laboratory analyses are required to confirm if appreciable RIS is present.
pH_{FOX} value at least one unit below field pH_F and strong reaction with H_2O_2 (that is X or V)	May indicate PASS	The difference between pH_F and pH_{FOX} is termed the ΔpH. Generally the larger the ΔpH the more indicative of PASS. The lower the final pH_{FOX} the better the likelihood of an appreciable RIS content. For example, a change from pH_F of 8 to pH_{FOX} of 7 (that is a ΔpH of 1) would not indicate PASS, however, a unit change from pH_F of 3.5 to pH_{FOX} of 2.5 would be indicative of PASS. Laboratory analyses are required to confirm if appreciable RIS is present.
$pH_{FOX} < 3$, large pH and a strong reaction with H_2O_2 (that is X or V)	Strongly indicates PASS	The lower the pH_{FOX} below 3, the greater the likelihood that appreciable RIS is present. A combination of all three parameters – pH_{FOX}, ΔpH and reaction strength – gives the

pH value and reaction	Result	Comments
		best indication of PASS. Laboratory analyses are required to confirm that appreciable RIS is present.
A pH_{FOX} 3–4 and Low, Medium or Strong reaction with H_2O_2	Inconclusive	RIS may be present; however, organic matter may also be responsible for the decrease in pH. Laboratory analyses are required to confirm the presence of RIS.
pH_{FOX} 4–5	Inconclusive	RIS may be present in small quantities, or poorly reactive under rapid oxidation, or the sample may contain shell/ carbonate which neutralises some or all acid produced on oxidation. Equally, the pH_{FOX} value may be due to the production of organic acids with no RIS present. Laboratory analyses are required to confirm if appreciable RIS is present.
pH_{FOX} > 5, small or no pH, but Low, Medium or Strong reaction with H_2O_2	Inconclusive	For neutral to alkaline pHF with shell or white concretions, the fizz test with 1 M HCl can be used to identify the presence of carbonates. Laboratory analyses are required to confirm if appreciable RIS is present and further testing is required to confirm that effective self-neutralising materials are present.

Source: Adapted from DER (2015a).

Appendix D: Borehole Logs

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ENVIRONMENTAL LOG

Log No.
101
1/1

Environmental logs are not to be used for geotechnical purposes

Client: ANTHONY BROOKS
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: 13 MONASH CRESCENT, CLONTARF, NSW

Job No.: E33691PH **Method:** HAND AUGER **R.L. Surface:** ≈0.4m
Date: 1/4/22 **Datum:** AHD
Plant Type: - **Logged/Checked by:** N.M./T.H.

Groundwater Record	SAMPLES ES ASS ASB SAL DB	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0		SP	SAND: fine to medium grained, yellow brown, trace of shell fragments.	M			
			0.25							
▶							W			WET FROM 0.4m
			0.5							
▼ ON COMPLETION										REPEATED HOLE COLLAPSE DUE TO WATER
			0.75							
						END OF BOREHOLE AT 0.8m				
			1							
			1.25							
			1.5							
			1.75							

JKEnvironments

ENVIRONMENTAL LOG

Log No.
102
1/1

Environmental logs are not to be used for geotechnical purposes

Client: ANTHONY BROOKS
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: 13 MONASH CRESCENT, CLONTARF, NSW

Job No.: E33691PH **Method:** HAND AUGER **R.L. Surface:** ≈0.4m
Date: 1/4/22 **Datum:** AHD
Plant Type: - **Logged/Checked by:** N.M./T.H.

Groundwater Record	SAMPLES ES	SAMPLES ASS	SAMPLES ASB	SAMPLES SAL	SAMPLES DB	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
		■					0	⁘	SP	SAND: fine to medium grained, yellow brown, trace of shell fragments.	M			
		■					0.25	⁘						
		■						⁘			W			WET FROM 0.4m
▶		■					0.5	⁘						
▼ ON COMPLETION		■					0.75	⁘						
										END OF BOREHOLE AT 0.9m				REPEATED HOLE COLASE DUE TO WATER
							1							
							1.25							
							1.5							
							1.75							

ENVIRONMENTAL LOGS EXPLANATION NOTES

INTRODUCTION

These notes have been provided to amplify the environmental report in regard to classification methods, field procedures and certain matters relating to the logging of soil and rock. Not all notes are necessarily relevant to all reports.

Where geotechnical borehole logs are utilised for environmental purpose, reference should also be made to the explanatory notes included in the geotechnical report. Environmental logs are not suitable for geotechnical purposes.

The ground is a product of continuing natural and man-made processes and therefore exhibits a variety of characteristics and properties which vary from place to place and can change with time. Environmental studies include gathering and assimilating limited facts about these characteristics and properties in order to understand or predict the behaviour of the ground on a particular site under certain conditions. This report may contain such facts obtained by inspection, excavation, probing, sampling, testing or other means of investigation. If so, they are directly relevant only to the ground at the place where and time when the investigation was carried out.

DESCRIPTION AND CLASSIFICATION METHODS

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726:2017 *'Geotechnical Site Investigations'*. In general, descriptions cover the following properties – soil or rock type, colour, structure, strength or density, and inclusions. Identification and classification of soil and rock involves judgement and the Company infers accuracy only to the extent that is common in current geoenvironmental practice.

Soil types are described according to the predominating particle size and behaviour as set out in the attached soil classification table qualified by the grading of other particles present (eg. sandy clay) as set out below:

Soil Classification	Particle Size
Clay	< 0.002mm
Silt	0.002 to 0.075mm
Sand	0.075 to 2.36mm
Gravel	2.36 to 63mm
Cobbles	63 to 200mm
Boulders	> 200mm

Non-cohesive soils are classified on the basis of relative density, generally from the results of Standard Penetration Test (SPT) as below:

Relative Density	SPT 'N' Value (blows/300mm)
Very loose (VL)	< 4
Loose (L)	4 to 10
Medium dense (MD)	10 to 30
Dense (D)	30 to 50
Very Dense (VD)	> 50

Cohesive soils are classified on the basis of strength (consistency) either by use of a hand penetrometer, vane shear, laboratory testing and/or tactile engineering examination. The strength terms are defined as follows.

Classification	Unconfined Compressive Strength (kPa)	Indicative Undrained Shear Strength (kPa)
Very Soft (VS)	≤ 25	≤ 12
Soft (S)	> 25 and ≤ 50	> 12 and ≤ 25
Firm (F)	> 50 and ≤ 100	> 25 and ≤ 50
Stiff (St)	> 100 and ≤ 200	> 50 and ≤ 100
Very Stiff (VSt)	> 200 and ≤ 400	> 100 and ≤ 200
Hard (Hd)	> 400	> 200
Friable (Fr)	Strength not attainable – soil crumbles	

Rock types are classified by their geological names, together with descriptive terms regarding weathering, strength, defects, etc. Where relevant, further information regarding rock classification is given in the text of the report. In the Sydney Basin, 'shale' is used to describe fissile mudstone, with a weakness parallel to bedding. Rocks with alternating inter-laminations of different grain size (eg. siltstone/claystone and siltstone/fine grained sandstone) are referred to as 'laminite'.

INVESTIGATION METHODS

The following is a brief summary of investigation methods currently adopted by the Company and some comments on their use and application. All methods except test pits, hand auger drilling and portable Dynamic Cone Penetrometers require the use of a mechanical rig which is commonly mounted on a truck chassis or track base.

Test Pits: These are normally excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils and 'weaker' bedrock if it is safe to descend into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for a large excavator. Limitations of test pits are the problems associated with disturbance and difficulty of reinstatement and the consequent effects on close-by structures. Care must be taken if construction is to be carried out near test pit locations to either properly recompact the backfill during construction or to design and construct the structure so as not to be adversely affected by poorly compacted backfill at the test pit location.

Hand Auger Drilling: A borehole of 50mm to 100mm diameter is advanced by manually operated equipment. Refusal of the hand auger can occur on a variety of materials such as obstructions within any fill, tree roots, hard clay, gravel or ironstone, cobbles and boulders, and does not necessarily indicate rock level.

Continuous Spiral Flight Augers: The borehole is advanced using 75mm to 115mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling and insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface by the flights or may be collected after withdrawal of the auger flights, but they can be very disturbed and layers may become mixed. Information from the auger sampling (as distinct from specific sampling by SPTs or undisturbed samples) is of limited reliability due to mixing or softening of samples by groundwater, or uncertainties as to the original depth of the samples. Augering below the groundwater table is of even lesser reliability than augering above the water table.

Rock Augering: Use can be made of a Tungsten Carbide (TC) bit for auger drilling into rock to indicate rock quality and continuity by variation in drilling resistance and from examination of recovered rock cuttings. This method of investigation is quick and relatively inexpensive but provides only an indication of the likely rock strength and predicted values may be in error by a strength order. Where rock strengths may have a significant impact on construction feasibility or costs, then further investigation by means of cored boreholes may be warranted.

Wash Boring: The borehole is usually advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be assessed from the cuttings, together with some information from "feel" and rate of penetration.

Mud Stabilised Drilling: Either Wash Boring or Continuous Core Drilling can use drilling mud as a circulating fluid to stabilise the borehole. The term 'mud' encompasses a range of products ranging from bentonite to polymers. The mud tends to mask the cuttings and reliable identification is only possible from intermittent intact sampling (eg. from SPT and U50 samples) or from rock coring, etc.

Continuous Core Drilling: A continuous core sample is obtained using a diamond tipped core barrel. Provided full core recovery is achieved (which is not always possible in very low strength rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation. In rocks, NMLC or HQ triple tube core barrels, which give a core of about 50mm and 61mm diameter, respectively, is usually used with water flush. The length of core recovered is compared to the length drilled and any length not recovered is shown as NO CORE. The location of NO CORE recovery is determined on site by the supervising engineer; where the location is uncertain, the loss is placed at the bottom of the drill run.

Standard Penetration Tests: Standard Penetration Tests (SPT) are used mainly in non-cohesive soils, but can also be used in cohesive soils, as a means of indicating density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289.6.3.1–2004 (R2016) *'Methods of Testing Soils for Engineering Purposes, Soil Strength and Consolidation Tests – Determination of the Penetration Resistance of a Soil – Standard Penetration Test (SPT)'*.

The test is carried out in a borehole by driving a 50mm diameter split sample tube with a tapered shoe, under the impact of a 63.5kg hammer with a free fall of 760mm. It is normal for the tube to be driven in three successive 150mm increments and the 'N' value is taken as the number of blows for the last 300mm. In dense sands, very hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form:

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

  N = 13
  4, 6, 7

- In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm, as

  N > 30
  15, 30/40mm

The results of the test can be related empirically to the engineering properties of the soil.

A modification to the SPT is where the same driving system is used with a solid 60° tipped steel cone of the same diameter as the SPT hollow sampler. The solid cone can be continuously driven for some distance in soft clays or loose sands, or may be used where damage would otherwise occur to the SPT. The results of this Solid Cone Penetration Test (SCPT) are shown as 'N_c' on the borehole logs, together with the number of blows per 150mm penetration.

LOGS

The borehole or test pit logs presented herein are an interpretation of the subsurface conditions, and their reliability will depend to some extent on the frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will enable the most reliable assessment, but is not always practicable or possible to justify on economic grounds. In any case, the boreholes or test pits represent only a very small sample of the total subsurface conditions.

The terms and symbols used in preparation of the logs are defined in the following pages.

Interpretation of the information shown on the logs, and its application to design and construction, should therefore take into account the spacing of boreholes or test pits, the method of drilling or excavation, the frequency of sampling and testing and the possibility of other than 'straight line' variations between the boreholes or test pits. Subsurface conditions between boreholes or test pits may vary significantly from conditions encountered at the borehole or test pit locations.

GROUNDWATER

Where groundwater levels are measured in boreholes, there are several potential problems:

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

More reliable measurements can be made by installing standpipes which are read after the groundwater level has stabilised at intervals ranging from several days to perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from perched water tables or surface water.

FILL

The presence of fill materials can often be determined only by the inclusion of foreign objects (eg. bricks, steel, etc) or by distinctly unusual colour, texture or fabric. Identification of the extent of fill materials will also depend on investigation methods and frequency. Where natural soils similar to those at the site are used for fill, it may be difficult with limited testing and sampling to reliably assess the extent of the fill.

The presence of fill materials is usually regarded with caution as the possible variation in density and material type is much greater than with natural soil deposits. Consequently, there is an increased risk of adverse environmental characteristics or behaviour. If the volume and nature of fill is of importance to a project, then frequent test pit excavations are preferable to boreholes.

LABORATORY TESTING

Laboratory testing has not been undertaken to confirm the soil classification and rock strengths indicated on the environmental logs unless noted in the report.

SYMBOL LEGENDS

SOIL

- ▩ FILL
- ≋ TOPSOIL
- ▨ CLAY (CL, CI, CH)
- ▥ SILT (ML, MH)
- ░ SAND (SP, SW)
- ⁘ GRAVEL (GP, GW)
- ▨ SANDY CLAY (CL, CI, CH)
- ▨ SILTY CLAY (CL, CI, CH)
- ▨ CLAYEY SAND (SC)
- ░ SILTY SAND (SM)
- ▨ GRAVELLY CLAY (CL, CI, CH)
- ▨ CLAYEY GRAVEL (GC)
- ▥ SANDY SILT (ML, MH)
- ⁂ PEAT AND HIGHLY ORGANIC SOILS (Pt)

ROCK

- ⁘ CONGLOMERATE
- ░ SANDSTONE
- ▤ SHALE/MUDSTONE
- ▥ SILTSTONE
- ▤ CLAYSTONE
- ■ COAL
- ▥ LAMINITE
- ▦ LIMESTONE
- ≋ PHYLLITE, SCHIST
- ▤ TUFF
- ⁘ GRANITE, GABBRO
- ⁘ DOLERITE, DIORITE
- ⁘ BASALT, ANDESITE
- ≋ QUARTZITE

OTHER MATERIALS

- ▦ BRICKS OR PAVERS
- ⁘ CONCRETE
- ■ ASPHALTIC CONCRETE

CLASSIFICATION OF COARSE AND FINE GRAINED SOILS

Major Divisions		Group Symbol	Typical Names	Field Classification of Sand and Gravel	Laboratory Classification	
Coarse grained soil (more than 65% of soil excluding oversize fraction is greater than 0.075mm)	GRAVEL (more than half of coarse fraction is larger than 2.36mm	GW	Gravel and gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	$C_u > 4$ $1 < C_c < 3$
		GP	Gravel and gravel-sand mixtures, little or no fines, uniform gravels	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	Fails to comply with above
		GM	Gravel-silt mixtures and gravel-sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength	≥ 12% fines, fines are silty	Fines behave as silt
		GC	Gravel-clay mixtures and gravel-sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength	≥ 12% fines, fines are clayey	Fines behave as clay
	SAND (more than half of coarse fraction is smaller than 2.36mm)	SW	Sand and gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	$C_u > 6$ $1 < C_c < 3$
		SP	Sand and gravel-sand mixtures, little or no fines	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	Fails to comply with above
		SM	Sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength	≥ 12% fines, fines are silty	N/A
		SC	Sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength	≥ 12% fines, fines are clayey	

Major Divisions		Group Symbol	Typical Names	Field Classification of Silt and Clay			Laboratory Classification
				Dry Strength	Dilatancy	Toughness	% < 0.075mm
ine grained soils (more than 35% of soil excluding oversize fraction is less than 0.075mm)	SILT and CLAY (low to medium plasticity)	ML	Inorganic silt and very fine sand, rock flour, silty or clayey fine sand or silt with low plasticity	None to low	Slow to rapid	Low	Below A line
		CL, CI	Inorganic clay of low to medium plasticity, gravelly clay, sandy clay	Medium to high	None to slow	Medium	Above A line
		OL	Organic silt	Low to medium	Slow	Low	Below A line
	SILT and CLAY (high plasticity)	MH	Inorganic silt	Low to medium	None to slow	Low to medium	Below A line
		CH	Inorganic clay of high plasticity	High to very high	None	High	Above A line
		OH	Organic clay of medium to high plasticity, organic silt	Medium to high	None to very slow	Low to medium	Below A line
	Highly organic soil	Pt	Peat, highly organic soil	–	–	–	–

Laboratory Classification Criteria

A well graded coarse grained soil is one for which the coefficient of uniformity $Cu > 4$ and the coefficient of curvature $1 < C_c < 3$. Otherwise, the soil is poorly graded. These coefficients are given by:

$$C_U = \frac{D_{60}}{D_{10}} \quad and \quad C_C = \frac{(D_{30})^2}{D_{10}\,D_{60}}$$

Where D_{10}, D_{30} and D_{60} are those grain sizes for which 10%, 30% and 60% of the soil grains, respectively, are smaller.

NOTES:

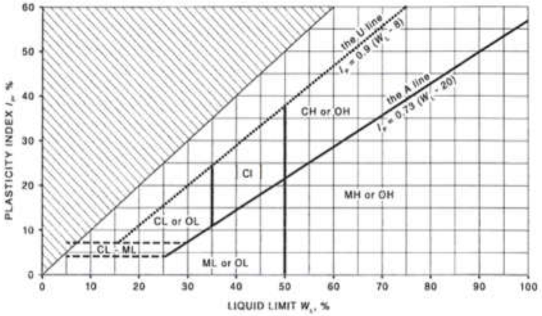
1 For a coarse grained soil with a fines content between 5% and 12%, the soil is given a dual classification comprising the two group symbols separated by a dash; for example, for a poorly graded gravel with between 5% and 12% silt fines, the classification is GP-GM.

2 Where the grading is determined from laboratory tests, it is defined by coefficients of curvature (C_c) and uniformity (C_u) derived from the particle size distribution curve.

3 Clay soils with liquid limits > 35% and ≤ 50% may be classified as being of medium plasticity.

4 The U line on the Modified Casagrande Chart is an approximate upper bound for most natural soils.

Modified Casagrande Chart for Classifying Silts and Clays according to their Behaviour



LOG SYMBOLS

Log Column	Symbol	Definition
Groundwater Record	—▼—	Standing water level. Time delay following completion of drilling/excavation may be shown.
	—C—	Extent of borehole/test pit collapse shortly after drilling/excavation.
	▶—	Groundwater seepage into borehole or test pit noted during drilling or excavation.
Samples	ES	Sample taken over depth indicated, for environmental analysis.
	U50	Undisturbed 50mm diameter tube sample taken over depth indicated.
	DB	Bulk disturbed sample taken over depth indicated.
	DS	Small disturbed bag sample taken over depth indicated.
	ASB	Soil sample taken over depth indicated, for asbestos analysis.
	ASS	Soil sample taken over depth indicated, for acid sulfate soil analysis.
	SAL	Soil sample taken over depth indicated, for salinity analysis.
	PFAS	Soil sample taken over depth indicated, for analysis of Per- and Polyfluoroalkyl Substances.
Field Tests	N = 17 4, 7, 10	Standard Penetration Test (SPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration. 'Refusal' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	N_c = 5 7 3R	Solid Cone Penetration Test (SCPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration for 60° solid cone driven by SPT hammer. 'R' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	VNS = 25	Vane shear reading in kPa of undrained shear strength.
	PID = 100	Photoionisation detector reading in ppm (soil sample headspace test).
Moisture Condition (Fine Grained Soils)	*w* > PL	Moisture content estimated to be greater than plastic limit.
	w ≈ PL	Moisture content estimated to be approximately equal to plastic limit.
	w < PL	Moisture content estimated to be less than plastic limit.
	w ≈ LL	Moisture content estimated to be near liquid limit.
	w > LL	Moisture content estimated to be wet of liquid limit.
(Coarse Grained Soils)	D	DRY – runs freely through fingers.
	M	MOIST – does not run freely but no free water visible on soil surface.
	W	WET – free water visible on soil surface.
Strength (Consistency) Cohesive Soils	VS	VERY SOFT – unconfined compressive strength ≤ 25kPa.
	S	SOFT – unconfined compressive strength > 25kPa and ≤ 50kPa.
	F	FIRM – unconfined compressive strength > 50kPa and ≤ 100kPa.
	St	STIFF – unconfined compressive strength > 100kPa and ≤ 200kPa.
	VSt	VERY STIFF – unconfined compressive strength > 200kPa and ≤ 400kPa.
	Hd	HARD – unconfined compressive strength > 400kPa.
	Fr	FRIABLE – strength not attainable, soil crumbles.
	( )	Bracketed symbol indicates estimated consistency based on tactile examination or other assessment.

Log Column	Symbol	Definition	Density Index (I_D) Range (%)	SPT 'N' Value Range (Blows/300mm)
Density Index/ Relative Density (Cohesionless Soils)	VL	VERY LOOSE	≤ 15	0 – 4
	L	LOOSE	> 15 and ≤ 35	4 – 10
	MD	MEDIUM DENSE	> 35 and ≤ 65	10 – 30
	D	DENSE	> 65 and ≤ 85	30 – 50
	VD	VERY DENSE	> 85	> 50
	( )	Bracketed symbol indicates estimated density based on ease of drilling or other assessment.		

Log Column	Symbol	Definition
Hand Penetrometer Readings	300 250	Measures reading in kPa of unconfined compressive strength. Numbers indicate individual test results on representative undisturbed material unless noted otherwise.
Remarks	'V' bit	Hardened steel 'V' shaped bit.
	'TC' bit	Twin pronged tungsten carbide bit.
	T_{60}	Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.
	Soil Origin	The geological origin of the soil can generally be described as: RESIDUAL – soil formed directly from insitu weathering of the underlying rock. No visible structure or fabric of the parent rock. EXTREMELY WEATHERED – soil formed directly from insitu weathering of the underlying rock. Material is of soil strength but retains the structure and/or fabric of the parent rock. ALLUVIAL – soil deposited by creeks and rivers. ESTUARINE – soil deposited in coastal estuaries, including sediments caused by inflowing creeks and rivers, and tidal currents. MARINE – soil deposited in a marine environment. AEOLIAN – soil carried and deposited by wind. COLLUVIAL – soil and rock debris transported downslope by gravity, with or without the assistance of flowing water. Colluvium is usually a thick deposit formed from a landslide. The description 'slopewash' is used for thinner surficial deposits. LITTORAL – beach deposited soil.

Classification of Material Weathering

Term		Abbreviation		Definition
Residual Soil		RS		Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are no longer visible, but the soil has not been significantly transported.
Extremely Weathered		XW		Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are still visible.
Highly Weathered	Distinctly Weathered (Note 1)	HW	DW	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Rock strength is significantly changed by weathering. Some primary minerals have weathered to clay minerals. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Moderately Weathered		MW		The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable, but shows little or no change of strength from fresh rock.
Slightly Weathered		SW		Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.
Fresh		FR		Rock shows no sign of decomposition of individual minerals or colour changes.

NOTE 1: The term 'Distinctly Weathered' is used where it is not practicable to distinguish between 'Highly Weathered' and 'Moderately Weathered' rock. 'Distinctly Weathered' is defined as follows: *'Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores'*. There is some change in rock strength.

Rock Material Strength Classification

			Guide to Strength	
Term	Abbreviation	Uniaxial Compressive Strength (MPa)	Point Load Strength Index $Is_{(50)}$ (MPa)	Field Assessment
Very Low Strength	VL	0.6 to 2	0.03 to 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 30mm thick can be broken by finger pressure.
Low Strength	L	2 to 6	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show in the specimen with firm blows of the pick point; has dull sound under hammer. A piece of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium Strength	M	6 to 20	0.3 to 1	Scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High Strength	H	20 to 60	1 to 3	A piece of core 150mm long by 50mm diameter cannot be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High Strength	VH	60 to 200	3 to 10	Hand specimen breaks with pick after more than one blow; rock rings under hammer.
Extremely High Strength	EH	> 200	> 10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.

Appendix E: Laboratory Reports & COC Documents

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CERTIFICATE OF ANALYSIS 292445

Client Details

Client	JK Environments
Attention	Todd Hore
Address	PO Box 976, North Ryde BC, NSW, 1670

Sample Details

Your Reference	**E33691PH, Clontarf**
Number of Samples	6 SOIL
Date samples received	01/04/2022
Date completed instructions received	01/04/2022

Analysis Details

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

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

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

Report Details

Date results requested by	06/04/2022
Date of Issue	06/04/2022

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Results Approved By
Jenny He, Chemist

Authorised By

Nancy Zhang, Laboratory Manager

Chromium Suite						
Our Reference	UNITS	292445-1	292445-2	292445-3	292445-4	292445-5
Your Reference		BH101	BH101	BH101	BH102	BH102
Depth		0-0.3	0.3-0.6	0.6-0.8	0-0.3	0.3-0.6
Date Sampled		01/04/2022	01/04/2022	01/04/2022	01/04/2022	01/04/2022
Type of sample		SOIL	SOIL	SOIL	SOIL	SOIL
Date prepared	-	06/04/2022	06/04/2022	06/04/2022	06/04/2022	06/04/2022
Date analysed	-	06/04/2022	06/04/2022	06/04/2022	06/04/2022	06/04/2022
pH $_{kcl}$	pH units	10.0	10.1	10.1	10.0	10.0
s-TAA pH 6.5	%w/w S	<0.01	<0.01	<0.01	<0.01	<0.01
TAA pH 6.5	moles H^+ /t	<5	<5	<5	<5	<5
Chromium Reducible Sulfur	%w/w	<0.005	<0.005	<0.005	<0.005	<0.005
a-Chromium Reducible Sulfur	moles H^+ /t	<3	<3	<3	<3	<3
S_{HCl}	%w/w S	[NT]	[NT]	[NT]	[NT]	[NT]
S_{KCl}	%w/w S	[NT]	[NT]	[NT]	[NT]	[NT]
S_{NAS}	%w/w S	[NT]	[NT]	[NT]	[NT]	[NT]
ANC_{BT}	% $CaCO_3$	2.6	4.2	4.0	3.0	4.0
s-ANC_{BT}	%w/w S	0.83	1.3	1.3	0.98	1.3
s-Net Acidity	%w/w S	<0.005	<0.005	<0.005	<0.005	<0.005
a-Net Acidity	moles H^+ /t	<5	<5	<5	<5	<5
Liming rate	kg $CaCO_3$ /t	<0.75	<0.75	<0.75	<0.75	<0.75
a-Net Acidity without ANCE	moles H^+ /t	<5	<5	<5	<5	<5
Liming rate without ANCE	kg $CaCO_3$ /t	<0.75	<0.75	<0.75	<0.75	<0.75
s-Net Acidity without ANCE	%w/w S	<0.005	<0.005	<0.005	<0.005	<0.005

Chromium Suite		
Our Reference		292445-6
Your Reference	UNITS	BH102
Depth		0.6-0.9
Date Sampled		01/04/2022
Type of sample		SOIL
Date prepared	-	06/04/2022
Date analysed	-	06/04/2022
pH $_{kcl}$	pH units	10.1
s-TAA pH 6.5	%w/w S	<0.01
TAA pH 6.5	moles H^+ /t	<5
Chromium Reducible Sulfur	%w/w	<0.005
a-Chromium Reducible Sulfur	moles H^+ /t	<3
S_{HCl}	%w/w S	[NT]
S_{KCl}	%w/w S	[NT]
S_{NAS}	%w/w S	[NT]
ANC_{BT}	% $CaCO_3$	4.1
s-ANC_{BT}	%w/w S	1.3
s-Net Acidity	%w/w S	<0.005
a-Net Acidity	moles H^+ /t	<5
Liming rate	kg $CaCO_3$ /t	<0.75
a-Net Acidity without ANCE	moles H^+ /t	<5
Liming rate without ANCE	kg $CaCO_3$ /t	<0.75
s-Net Acidity without ANCE	%w/w S	<0.005

Method ID	Methodology Summary
Inorg-068	Chromium Reducible Sulfur - Hydrogen Sulfide is quantified by iodometric titration after distillation to determine potential acidity. Net acidity including ANC has a safety factor of 1.5 applied. Neutralising value (NV) of 100% is assumed for liming rate. Based on National acid sulfate soils identification and laboratory methods manual June 2018. The recommendation that the SHCL concentration be multiplied by a factor of 2 to ensure retained acidity is not underestimated, has not been applied in the SHCL results reported.

QUALITY CONTROL: Chromium Suite					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			06/04/2022	1	06/04/2022	06/04/2022		06/04/2022	[NT]
Date analysed	-			06/04/2022	1	06/04/2022	06/04/2022		06/04/2022	[NT]
pH_{kcl}	pH units		Inorg-068	[NT]	1	10.0	10.0	0	96	[NT]
s-TAA pH 6.5	%w/w S	0.01	Inorg-068	<0.01	1	<0.01	<0.01	0	[NT]	[NT]
TAA pH 6.5	moles H^+/t	5	Inorg-068	<5	1	<5	<5	0	85	[NT]
Chromium Reducible Sulfur	%w/w	0.005	Inorg-068	<0.005	1	<0.005	<0.005	0	121	[NT]
a-Chromium Reducible Sulfur	moles H^+/t	3	Inorg-068	<3	1	<3	<3	0	[NT]	[NT]
S_{HCl}	%w/w S	0.005	Inorg-068	<0.005	1	[NT]	[NT]		[NT]	[NT]
S_{KCl}	%w/w S	0.005	Inorg-068	<0.005	1	[NT]	[NT]		[NT]	[NT]
S_{NAS}	%w/w S	0.005	Inorg-068	<0.005	1	[NT]	[NT]		[NT]	[NT]
ANC_{BT}	% $CaCO_3$	0.05	Inorg-068	<0.05	1	2.6	2.8	7	[NT]	[NT]
s-ANC_{BT}	%w/w S	0.05	Inorg-068	<0.05	1	0.83	0.91	9	[NT]	[NT]
s-Net Acidity	%w/w S	0.005	Inorg-068	<0.005	1	<0.005	<0.005	0	[NT]	[NT]
a-Net Acidity	moles H^+/t	5	Inorg-068	<5	1	<5	<5	0	[NT]	[NT]
Liming rate	kg $CaCO_3$/t	0.75	Inorg-068	<0.75	1	<0.75	<0.75	0	[NT]	[NT]
a-Net Acidity without ANCE	moles H^+/t	5	Inorg-068	<5	1	<5	<5	0	[NT]	[NT]
Liming rate without ANCE	kg $CaCO_3$/t	0.75	Inorg-068	<0.75	1	<0.75	<0.75	0	[NT]	[NT]
s-Net Acidity without ANCE	%w/w S	0.005	Inorg-068	<0.005	1	<0.005	<0.005	0	[NT]	[NT]

Result Definitions

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

Quality Control Definitions

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

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

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

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

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

Spikes for Physical and Aggregate Tests are not applicable.

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

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

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

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

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

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

Measurement Uncertainty estimates are available for most tests upon request.

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

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

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

SAMPLE RECEIPT ADVICE

Client Details

Client	JK Environments
Attention	Todd Hore

Sample Login Details

Your reference	E33691PH, Clontarf
Envirolab Reference	292445
Date Sample Received	01/04/2022
Date Instructions Received	01/04/2022
Date Results Expected to be Reported	06/04/2022

Sample Condition

Samples received in appropriate condition for analysis	Yes
No. of Samples Provided	6 SOIL
Turnaround Time Requested	3 days
Temperature on Receipt (°C)	3
Cooling Method	Ice
Sampling Date Provided	YES

Comments

Cr suite - 3 day is fast possible

Please direct any queries to:

Aileen Hie	Jacinta Hurst
Phone: 02 9910 6200	**Phone: 02 9910 6200**
Fax: 02 9910 6201	**Fax: 02 9910 6201**
Email: ahie@envirolab.com.au	**Email: jhurst@envirolab.com.au**

Analysis Underway, details on the following page:

Sample ID	Chromium Suite
BH101-0-0.3	✓
BH101-0.3-0.6	✓
BH101-0.6-0.8	✓
BH102-0-0.3	✓
BH102-0.3-0.6	✓
BH102-0.6-0.9	✓

The '✓' indicates the testing you have requested. **THIS IS NOT A REPORT OF THE RESULTS.**

Additional Info

Sample storage - Waters are routinely disposed of approximately 1 month and soils approximately 2 months from receipt.

Requests for longer term sample storage must be received in writing.

Please contact the laboratory immediately if observed settled sediment present in water samples is to be included in the extraction and/or analysis (exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, Total Recoverable metals and PFAS analysis where solids are included by default.

TAT for Micro is dependent on incubation. This varies from 3 to 6 days.

SAMPLE AND CHAIN OF CUSTODY FORM

TO:
ENVIROLAB SERVICES PTY LTD
12 ASHLEY STREET
CHATSWOOD NSW 2067
P: (02) 99106200
F: (02) 99106201

Attention: Aileen

JKE Job Number: E33691PH

Date Results Required: 48hr

Page: 1 of 1

FROM:
JKEnvironments
REAR OF 115 WICKS ROAD
MACQUARIE PARK, NSW 2113
P: 02-9888 5000 F: 02-9888 5001
Attention: Todd Hore
thore@jkenvironments.com.au

Location:	Clontarf					Sample Preserved in Esky on Ice											
Sampler:	NM					Tests Required											
Date Sampled	Lab Ref:	Sample Number	Depth (m)	Sample Container	Sample Description	SCr extended	pH field test (pHF apHFOX)										
1/04/2022	1	BH101	0-0.3	P	Sand	X											
1/04/2022	2	BH101	0.3-0.6	P	Sand	X											
1/04/2022	3	BH101	0.6-0.8	P	Sand	X											
1/04/2022	4	BH102	0-0.3	P	Sand	X											
1/04/2022	5	BH102	0.3-0.6	P	Sand	X											
1/04/2022	6	BH102	0.6-0.9	P	Sand	X											
1/04/2022																	
1/04/2022																	
1/04/2022																	
1/04/2022																	
1/04/2022																	
1/04/2022																	
1/04/2022																	
1/04/2022																	

Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 292445
Date Received: 01/04/22
Time Received: 1530
Received by: CR
Temp: [✓ Cool]/Ambient
Cooling: Ice/[✓ Icepack]
Security: [✓ Intact]/Broken/None
03°C

Remarks (comments/detection limits required):

Sample Containers:
G - 250mg Glass Jar
A - Ziplock Asbestos Bag
P - Plastic Bag

Relinquished By:	Date:	Time:	Received By:	Date:
Nic Mancic	1/4/22	3:20	CRoseman	1/4/22 1530

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200   fax 02 9910 6201
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CERTIFICATE OF ANALYSIS 292445-A

Client Details

Client	JK Environments
Attention	Todd Hore
Address	PO Box 976, North Ryde BC, NSW, 1670

Sample Details

Your Reference	**E33691PH, Clontarf**
Number of Samples	additional analysis
Date samples received	01/04/2022
Date completed instructions received	07/04/2022

Analysis Details

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

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

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

Report Details

Date results requested by	08/04/2022
Date of Issue	08/04/2022

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

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

Results Approved By
Jenny He, Chemist

Authorised By

Nancy Zhang, Laboratory Manager

Client Reference: E33691PH, Clontarf

sPOCAS field test						
Our Reference		292445-A-1	292445-A-2	292445-A-3	292445-A-4	292445-A-5
Your Reference	UNITS	BH101	BH101	BH101	BH102	BH102
Depth		0-0.3	0.3-0.6	0.6-0.8	0-0.3	0.3-0.6
Date Sampled		01/04/2022	01/04/2022	01/04/2022	01/04/2022	01/04/2022
Type of sample		SOIL	SOIL	SOIL	SOIL	SOIL
Date prepared	-	08/04/2022	08/04/2022	08/04/2022	08/04/2022	08/04/2022
Date analysed	-	08/04/2022	08/04/2022	08/04/2022	08/04/2022	08/04/2022
pH_F (field pH test)*	pH Units	7.4	9.2	9.2	8.8	9.0
pH_{FOX} (field peroxide test)*	pH Units	6.5	7.0	6.6	6.6	6.7
Reaction Rate*	-	Low reaction	Low reaction	Low reaction	Low reaction	Low reaction

sPOCAS field test		
Our Reference		292445-A-6
Your Reference	UNITS	BH102
Depth		0.6-0.9
Date Sampled		01/04/2022
Type of sample		SOIL
Date prepared	-	08/04/2022
Date analysed	-	08/04/2022
pH_F (field pH test)*	pH Units	9.1
pH_{FOX} (field peroxide test)*	pH Units	6.8
Reaction Rate*	-	Low reaction

Method ID	Methodology Summary
Inorg-063	pH- measured using pH meter and electrode. Soil is oxidised with Hydrogen Peroxide or extracted with water. Based on section H, Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004. To ensure accurate results these tests are recommended to be done in the field as pH may change with time thus these results may not be representative of true field conditions.

QUALITY CONTROL: sPOCAS field test					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			08/04/2022	[NT]	[NT]	[NT]	[NT]	08/04/2022	[NT]
Date analysed	-			08/04/2022	[NT]	[NT]	[NT]	[NT]	08/04/2022	[NT]
pH_F (field pH test)*	pH Units		Inorg-063	[NT]	[NT]	[NT]	[NT]	[NT]	101	[NT]
pH_{FOX} (field peroxide test)*	pH Units		Inorg-063	[NT]	[NT]	[NT]	[NT]	[NT]	101	[NT]

Result Definitions

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NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
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Ming To

Subject: FW: 292445

Ref: 292445-A
TAT: Standard
Due: 8/04/2022
MT.

292445-A

From: Todd Hore <THore@jkenvironments.com.au>
Sent: Thursday, 7 April 2022 7:04 AM
To: Aileen Hie <AHie@envirolab.com.au>
Subject: 292445

Hey Aileen,
Can you please schedule ASS field tests (pH$_F$ and pH$_{FOX}$) for all six samples ① - ⑥ from E33691PH (your ref: 292445).

Please undertake the above on a standard turnaround.

Regards
Todd Hore
Senior Associate | Environmental Engineer

T: +612 9888 5000
D: 0414 863 307
E: THore@jkenvironments.com.au
www.jkenvironments.com.au

PO Box 976
NORTH RYDE BC NSW 1670
115 Wicks Road
MACQUARIE PARK NSW 2113

JKEnvironments