REPORT TO
FULTON TROTTERS ARCHITECTS

ON
PRELIMINARY SALINITY ASSESSMENT

FOR
PROPOSED SCHOOL DEVELOPMENT

AT
WENTWORTHVILLE PUBLIC SCHOOL, 70-100 FULLAGAR ROAD, WENTWORTHVILLE, NSW

Date: 6 May 2019
Ref: E31057BTrpt2

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Executive Summary

Fulton Trotter Architects ('the client') commissioned Environmental Investigation Services (EIS)[1] to undertake a preliminary salinity assessment for the proposed school development at Wentworthville Public School, 70-100 Fullagar Road, Wentworthville, NSW. The site location is shown on Figure 1 and the assessment was confined to the site boundaries as shown on Figure 2.

EIS have previously undertaken a Preliminary Environmental Screening at the site. A summary of this information has been included in Section 2.

The scope of work included the following:

- Review site information including topography, soils maps, regional geology and hydro-geology in the vicinity of the site;
- A walkover site inspection to identify obvious visual indicators of salinity or potential problem areas;
- Design and implementation of a field sampling and laboratory analysis program;
- Interpretation of the analytical results based on established assessment criteria; and
- Preparation of a report presenting the results of the assessment.

In November 2017, EIS were engaged to undertake a Preliminary Environmental Screening at the site. The screening included a walkover inspection and soil sampling from eight boreholes. Fill at the site ranged in depth between 0.1m to 0.7m across the site. The fill typically comprised silty clay, clayey silt, and sandy gravel. The fill contained inclusions of roots, root fibres, brick fragments, crushed concrete ironstone and shale gravel. The fill was underlain by residual silty clay soils to depths of between 1.0m to 2.0m, underlain by shale bedrock.

The salinity investigation included soil sampling from five locations as directed by the client. The sampling locations are shown on Figure 2. The sampling was confined to the depth of approximately 1.95m below existing ground level.

Soil results indicate that the soils are non-saline. The shale bedrock sample obtained from BH101 at a depth of 1.5m was classed as slightly saline. A number of samples encountered pH values in the range of 5 to 5.5. These samples were classed as mildly aggressive to concrete piles and foundations. Structural advice should be obtained for the design of concrete structures in aggressive soils. In the event of any changes to the proposed development (including depth of cut/fill activities in other areas of the site), additional sampling and analysis may be required. Foundations or services installed below the investigation depth of 2m, will require further review to assess for aggressive conditions.

The conclusions and recommendations should be read in conjunction with the limitations presented in the body of this report.

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[1] Environmental consulting division of Jeffery & Katauskas Pty Ltd (J&K)

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ABBREVIATIONS

Australian Height Datum	**AHD**
Acid Sulfate Soil	**ASS**
Below Ground Level	**BGL**
Borehole	**BH**
Cation Exchange Capacity	**CEC**
Calcium	**Ca**
Cement, Concrete and Aggregates Australia	**CCAA**
Chain of Custody	**COC**
Damp Proof Course	**DPC**
Department of Land and Water Conservation	**DLWC**
Dissolved Oxygen	**DO**
Environmental Investigation Services	**EIS**
International Organisation of Standardisation	**ISO**
Local Government Authority	**LGA**
Map Grid of Australia	**MGA**
Magnesium	**Mg**
National Association of Testing Authorities	**NATA**
Potassium	**K**
Polyvinyl Chloride	**PVC**
Practical Quantitation Limit	**PQL**
Redox Potential	**Eh**
Site Assessment Criteria	**SAC**
Standard Penetration Test	**SPT**
Standard Sampling Procedure	**SSP**
Standing Water Level	**SWL**
Standard Sampling Procedure	**SSP**
Sodium	**Na**
Western Sydney Regional Organisation of Councils	**WSROC**

Units

deci Siemens per Metre	**dS/m**
Electrical Conductivity	**EC**
Exchangeable Sodium Percentage (Sodicity)	**ESP%**
Litres	**L**
Metres	**m**
Metres Below Ground Level	**mBGL**
Millivolts	**mV**
Millilitres	**ml**
Milliequivalents	**meq**
Milligrams per Litre	**mg/L**
Milligrams per Kilogram	**mg/kg**
ohm Centimetres	**ohm.cm**
Parts Per Million	**ppm**
micro Siemens per Centimetre	**µS/cm**

1 INTRODUCTION

Fulton Trotter Architects ('the client') commissioned Environmental Investigation Services (EIS)[2] to undertake a preliminary salinity assessment for the proposed school development at Wentworthville Public School, 70-100 Fullagar Road, Wentworthville, NSW. The site location is shown on Figure 1 and the assessment was confined to the site boundaries as shown on Figure 2.

EIS have previously undertaken a Preliminary Environmental Screening at the site. A summary of this information has been included in Section 2.

EIS are currently in a transitional phase of re-branding and will commence trading as JK Environments in 2019. JK Environments, like EIS, will function as the environmental division of Jeffery and Katauskas Pty Ltd and will continue to operate alongside JK Geotechnics.

Background information on salinity is included in the appendices.

1.1 Proposed Development Details

EIS have not been provided with any proposed development plans and it has been assumed that only relatively minor earthworks (e.g. cut/fill <1-2m) may be required.

1.2 Aim and Objectives

The primary aim of the assessment was to characterise the broad scale salinity conditions at the site in the context of the proposed development works. The assessment objectives were to:

- Assess the current site conditions via a site walkover inspection;
- Assess the soil salinity conditions via implementation of a preliminary sampling and analysis program; and
- Provide salinity management recommendations (if/where required).

1.3 Scope of Work

The assessment was undertaken generally in accordance with an EIS proposal (Ref: EP49365P) of 24 April 2019 and written acceptance from the client of 24 April 2019. The scope of work included the following:

- Review site information including topography, soils maps, regional geology and hydrogeology in the vicinity of the site;
- A walkover site inspection to identify obvious visual indicators of salinity or potential problem areas;
- Design and implementation of a field sampling and laboratory analysis program;
- Interpretation of the analytical results based on established assessment criteria; and
- Preparation of a report presenting the results of the assessment.

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[2] Environmental consulting division of Jeffery & Katauskas Pty Ltd (J&K)

The assessment was designed and the report was prepared with reference to regulations/guidelines outlined in the table below. Individual guidelines/documents are also referenced within the text of the report.

Table 1-1: Guidelines

Guidelines/Regulations/Documents
Site Investigations for Urban Salinity (2002[3])
Salinity Code of Practice (2004)[4]
Managing Urban Stormwater – Soil and Construction (4th ed.) (2004)[5]
Salinity Potential in Western Sydney Map (2002[6])
Piling – Design and Installation AS2159-2009 (2009)[7]
Industry Guide T56: Residential Slabs and Footings in Saline Environments (20018[8])

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[3] Department of Land and Water Conservation (DLWC), (2002). *Site Investigations for Urban Salinity,* (referred to as DLWC 2002)

[4] Western Sydney Regional Organisation of Councils (WSROC) and Department of Infrastructure, Planning and Natural Resources (DIPNR), (2003 amended 2004). *Western Sydney Salinity Code of Practice* (referred to as Salinity Code of Practice)

[5] NSW Government/Landcom, (2004). *Managing Urban Stormwater – Soil and Construction*, (4th ed.) (referred to as Blue Book)

[6] DIPNR, (2002). *1:100,000 Map – Salinity Potential in Western Sydney*, (referred to as Salinity Potential Map)

[7] Standards Australia, (2009). *Piling – Design and Installation, AS2159-2009* (referred to as AS2159-2009)

[8] Cement, Concrete and Aggregates Australia (CCAA), (2018). Industry Guide *T56: Residential Slabs and Footings in Saline Environments* (referred to as CCAA 2018)

2 SITE INFORMATION

2.1 Background

2.1.1 Preliminary Environmental Screening (EIS, 2017[9])

In November 2017, EIS were engaged to undertake a Preliminary Environmental Screening at the site. The screening included a walkover inspection and soil sampling from eight boreholes.

During the site walkover, exposed fill soils were observed at the surface in various areas of the site and several fibre cement fragments (FCF) were identified in these areas. Four representative fragments were collected for analysis (F1, F2, F3 and F4). All fragments were found to contain asbestos.

Fill at the site ranged in depth between 0.1m to 0.7m across the site. The fill typically comprised silty clay, clayey silt, and sandy gravel. The fill contained inclusions of roots, root fibres, brick fragments, crushed concrete ironstone and shale gravel. The fill was underlain by residual silty clay soils to depths of between 1.0m to 2.0m, underlain by shale bedrock.

2.2 Site Identification

Table 2-1: Site Identification

Site Address:	Wentworthville Public School, 70-100 Fullagar Road, Wentworthville, NSW
Lot & Deposited Plan:	Lot 1 in P1245593
Current Land Use:	Primary School (Kindergarten to Year 6)
Proposed Land Use:	Continued use as a primary School (Kindergarten to Year 6)
Local Government Authority (LGA):	Cumberland Council
Site Area (Ha):	2.2 Ha
RL (AHD in m) (approx.):	32-42
Geographical Location (decimal degrees) (approx.):	Latitude: -33.814020 Longitude: 150.968464

2.3 Site Location and Regional Setting

The site is located in a predominantly residential area of Wentworthville. The site is bounded by Fullagar Road to the north, Station Street to the east, Monash Street to the south and Garfield Street to the west. The site is located approximately 275m to the west of Finlaysons Creek.

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[9] EIS (2017). Letter to Fulton Trotter Architects, Preliminary Environmental Screening, Proposed School Development, Wentworthville Public School, NSW (report ref: E31057Klet, dated 22 December 2017).

2.4 Topography

The site is located in regionally undulating topography. The site is located at the crest of a hill that slopes down to the north. The site itself is rectangular in shape with the eastern, western and central (north to south) portions sloping down to the north-east, north-west and north at 3° to 4°, 1° to 2° and 2° to 3°, respectively.

2.5 Site Inspection

A walkover inspection of the site was undertaken by EIS on 29 April 2019. The inspection was limited to accessible areas of the site and was focussed on assessing the site conditions relevant to salinity-related factors only.

At the time of the inspection the site was occupied by Wentworthville Public School and comprised various buildings, including permanent and demountable buildings, grassed and paved recreational areas. Vegetation at the site appeared to be in good condition with no evidence of plant stress or die back.

2.6 Surrounding Land Use

The site is surrounded by residential properties in all direction; low density residential properties to the north, west and south and medium residential properties to the east.

3 GEOLOGY AND HYDROGEOLOGY

3.1 Regional Geology and Soils

A review of the regional geological map of Penrith (1991[10]), indicates that the site is underlain by Bringelly Shale of the Wianamatta Group, which typically consists of shale, carbonaceous claystone, claystone, laminite, fine to medium grained lithic sandstone, rare coal and tuff.

The Soil Landscape Map of Penrith (1990[11]) indicates that the site is located within the Blacktown soil landscape. Blacktown soils are characterised by moderate erodibility with some higher local occurrences, low dispersivity and localised areas of moderate salinity.

3.2 Salinity Hazard Map

The site is located within the area of Western Sydney included in the Salinity Potential Map. Based upon interpretation from the geological formations and soil groups presented on the map, the site is located in a region of moderate salinity potential.

The moderate classification is attributed to scattered areas of scalding and indicator vegetation, in areas where concentrations have not been mapped. Saline areas may occur in this zone, which have not been identified or may occur if risk factors change adversely.

3.3 Acid Sulfate Soil Risk and Planning

The site is not located in an acid sulfate soil (ASS) risk area according to the risk maps prepared by the Department of Land and Water Conservation.

3.4 Hydrogeology

A review of groundwater bore records available on the NSW Office of Water online database was undertaken on 1 May 2019. The search was limited to registered bores located within a radius of approximately 500m of the site.

Table 3-1: Summary of Groundwater Bores

Reference	Distance From Site (m) (approx)	Direction From Site	Final Depth (m)	Standing Water Level (SWL)	Registered Purpose
GW113429	75m	South-east	7.70	NA	Monitoring
GW113430	75m	South-east	8.00	NA	Monitoring
GW113435	75m	South-east	4.00	NA	Monitoring
GW113433	75m	South-east	6.00	NA	Monitoring

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[10] Department of Mineral Resources, (1991). *1:100,000 Geological Map of Penrith (Series 9030).*

[11] Soil Conservation Service of NSW, (1990) *1:100,000 Map - Soil Landscapes of the Penrith Sheet 9030*

GW113434	75m	South-east	5.00	NA	Monitoring
GW113432	75m	South-east	7.00	NA	Monitoring
GW113431	75m	South-east	14.00	NA	Monitoring
GW113436	75m	South-east	4.00	NA	Monitoring

The stratigraphy of the site is expected to consist of residual clayey soils overlying relatively shallow bedrock. Based on these conditions and the results of the groundwater bore search, groundwater is not considered to be a significant resource for abstraction purposes in the immediate vicinity of the site. A perched aquifer located in the shallow subsurface is not considered to be a resource due to high salinity, poor water quality and low yield.

The Wianamatta Formation is characterised by very low permeability, low storage and high groundwater salinity as a consequence of the depositional environment during the middle Triassic period. This typically renders the shale groundwater unsuitable for any use due to low yield and poor quality. A perched groundwater table condition may occur in the residual soils overlying the Shale at some locations especially during prolonged wet conditions. This occurs due to the relatively higher permeability of soil at the soil-rock interface. Due to the shorter residence time, the perched water is typically less saline than flows within the bedrock.

3.5 Receiving Water Bodies and Surface Water Run-off

Surface water bodies were not identified in the immediate vicinity of the site. The closest surface water body is Finlaysons Creek located approximately 275m to the east of the site.

4 SAMPLING AND ANALYSIS PLAN

4.1 Soil Sampling Rationale

The investigation included soil sampling from five locations as directed by the client and shown on Figure 2. This density is equivalent to approximately 2.3 sampling points per hectare (the area of the site is approximately 2.2 hectares) and meets the requirements for an ‘initial site investigation’ recommended in the DLWC 2002 document for ‘moderately intensive construction’. The density was considered adequate to identify large areas of salinity impacted soils at the site.

Soil sampling for this assessment was confined to the depth of approximately 1.95m below existing ground level. This was considered adequate as the proposed development details are unknown, however it is assumed that only relatively minor earthworks (e.g. cut/fill <1-2m) may be required.

4.2 Soil Sampling Methods

Fieldwork for this investigation was undertaken on 29 April 2019. Sampling locations were set out using a tape measure. Locations were marked using spray paint and were cleared for underground services prior to drilling.

The sample locations were drilled using a truck mounted hydraulically operated drill rig equipped with spiral flight augers. Soil samples were obtained from a Standard Penetration Test (SPT) sampler or directly from the auger when conditions did not allow use of the SPT sampler.

Soil samples were collected from the fill and natural profiles encountered during the investigation based on distinct change in lithology or field observations. All samples were recorded on the borehole logs attached in the appendices.

Samples were placed in plastic bags and sealed using twist ties. Sampling personnel used disposable nitrile gloves during sampling activities. The samples were labelled with the job number, sampling location, sampling depth and date.

On completion of the fieldwork, the samples were delivered in the insulated sample container to a NATA registered laboratory for analysis under standard COC procedures. Field sampling protocols adopted for this assessment are summarised in the appendices.

4.3 Laboratory Analysis

Samples were analysed by Envirolab Services Pty Ltd (NATA accreditation number 2901). Reference should be made to the laboratory report (Ref: 216408) attached in the appendices for further details of the analytical methods.

4.4 Analytical Schedule

The analytical schedule is outlined in the following table:

Table 4-1: Analytical Schedule

Analyte	Fill Samples	Natural Soil Samples	Natural Bedrock Samples
CEC	1	1	NA
pH	4	7	4
Electrical Conductivity (EC)	4	7	4
Resistivity	4	7	4
Sulphate	4	7	4
Chloride	4	7	4
Texture (used to determine EC extract – ECe)	4	7	4

5 SITE ASSESSMENT CRITERIA (SAC)

5.1 Soil Salinity and Plant Growth

The electrical conductivity (EC) of a 1:5 soil:water extract is commonly used as an indicator of soil salinity conditions as the reading is directly related to the electrolyte (salt) concentration of the extract. In order to compare the laboratory data with published salinity classes, the results are converted to equivalent saturated paste (ECe) using texture adjustment values presented in DLWC 2002.

The following table provides a summary of plant response with reference to salinity:

Table 5-1: Plant Response to Soil Salinity

ECe (dS/m)	Salinity Class	Plant Response[1]
<2	Non-saline	**Salinity effects mostly negligible**
2-4	Slightly saline	**Yields of very sensitive crops may be affected**
4-8	Moderately saline	**Yield of many crops affected**
8-16	Very saline	**Only tolerant crops yield satisfactorily**
>16	**Highly saline**	**Only a few very tolerant crops yield satisfactorily**

Note:

1 - Plant Response to Salinity Class has been adopted from DLWC 2002

5.2 Soil pH and Plant Growth

Soil pH is a measure of the acidity or alkalinity of the soils and values have been assessed as an indicator of soil fertility with respect to plant growth. The optimal pH for plant growth is between 5.5 and 7. Beyond this range, effective revegetation of exposed soil following disturbance is increasingly difficult and the potential for erosion is considered to increase.

Highly alkaline soils are commonly associated with saline and sodic soil conditions and can limit the ability of plants to take up water and nutrients. Highly acidic soils exhibit aluminium toxicity toward plants and can limit the ability of plants to take up other essential nutrients including molybdenum.

Interpretation of soil pH with respect to plant growth is undertaken using the ratings published in Bruce and Rayment (1982[12]) presented below:

Table 5-2: Plant Response to Soil pH

pH	Rating
<4.5	**Extremely acidic**
4.5-5.0	**Very strongly acidic**

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[12] Bruce, R.C. and Rayment, G.E., (1982). *Analytical Methods and Interpretations used by the Agricultural Chemistry Branch for Soil and Land Use Surveys,* (referred to as Bruce and Rayment 1982)

5.1-5.5	**Strongly acidic**
5.6 – 7.3	**Optimal plant growth**
7.4-7.8	**Mildly alkaline**
7.9-8.4	**Moderately alkaline**
8.5-9.0	**Strongly alkaline**
>9.1	**Very strongly alkaline**

5.3 Cation Exchange Capacity (CEC) in Soil

The ability of soils to attract, retain and exchange cations (positively charged ions) is estimated by the calculated CEC value. CEC represents the major controlling factor in stability of clay soil structure, nutrient availability for plant growth, soil pH and the reaction of the soil to chemical applications (fertilisers, conditioners etc.).

High CEC soils have a greater capacity to retain nutrients, however, deficient soils require greater applications of nutrients to correct imbalances. Low CEC soils have a reduced capacity to retain nutrients and may result in leaching of nutrients from the soil in the event of excess nutrient applications.

Metson (1961[13]) developed a set of ratings for effective CEC and the most abundant cations. These are summarised below (values are in meq/100g):

Table 5-3: CEC Rating

Rating	eCEC	Exch Na	Exch K	Exch Ca	Exch Mg
Very low	<6	0-0.1	0-0.2	0-2	**0-0.3**
Low	6-12	0.1-0.3	0.2-0.3	2-5	**0.3-1**
Moderate	12-25	0.3-0.7	0.3-0.7	5-10	**1-3**
High	25-40	0.7-2	0.7-2	10-20	**3-8**
Very high	**>40**	**>2**	**>2**	**>20**	**>8**

Note: CEC – Cation Exchange Capacity, Na – Sodium, K – Potassium, Ca – Calcium, Mg – Magnesium

5.3.1 Ratio of Exchangeable Calcium to Magnesium

To maintain soil structure there should be a ratio of around 4:1 to 6:1 calcium to magnesium for a balanced soil (Eckert 1987[14]). At ratios of less than 4:1 calcium is considered to be deficient, whilst at ratios of greater than 6:1 are considered to be magnesium deficient.

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[13] Metson, A.J, (1961). *Methods of Chemical Analysis for Soil Survey Samples* (referred to as Metson 1961)

[14] Eckert, D.J, (1987) .*Soil Test Interpretation: Basic Cation Saturation Ratios and Sufficiency Levels* (referred to as Eckert 1987)

5.4 Exchangeable Sodium Percentage or Sodicity (ESP%)

Exchangeable sodium is an important soil stability and salinity parameter. Excessive exchangeable sodium leads to unstable soils, increased runoff, potential salinity, dispersivity and water logging problems.

Normally the sodium content is expressed as a percentage of the CEC as other cations counteract the negative effects of sodium (known as ESP% and termed sodicity). The effect of the exchangeable sodium (exchangeable sodium percentage, ESP) varies with other soil factors such as the type of clay, the relative quantity of magnesium and the quantity of organic matter. However, Charman & Murphy (2000[15]) indicate that a soil is generally considered sodic if the ESP exceeds 6% and extremely sodic if the ESP exceeds 15%.

5.5 Recommendations for Concrete Slabs and Footings in Saline Soils

In the absence of endorsed recommendations for buildings in saline environments, reference is made to the CCAA 2018. The guide provides recommendations on the minimum concrete grade/strength required for slabs and footings in saline soils. Reference should be made to the CCAA 2018 publication for further information:

Table 5-4: Minimum Concrete Grade for Slabs and Footings in Saline Soils

ECe (dS/m)	Salinity Class	Concrete Grade[1]
<2	Non-saline	N20
2-4	Slightly saline	N20
4-8	Moderately saline	N25
8-16	Very saline	N32
>16	Highly saline	≥N40

Note:

1 - Concrete Grade for Salinity Class has been adopted from CCAA 2018

5.6 Recommendations for Durability with Reference to AS2159-2009

In designing for durability, reference should be made to the requirements listed in the AS2159-2009. The exposure classification for concrete and steel piles and foundations is outlined in the tables on the following page.

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[15] Charman, P.E.V and Murphy, B.W (eds), (2000).*Soils: Their Management and Properties,* (referred to as Charman and Murphy 2000)

Table 5-5: Exposure Classification for Concrete Piles

Exposure Conditions				Exposure Classification	
Sulphate (expressed as SO_4)		**pH**	**Chlorides in Groundwater (ppm)**	**Soil Conditions A**[1]	**Soil Conditions B**[2]
In Soil (ppm)	**In Groundwater (ppm)**				
<5,000	<1,000	>5.5	<6,000	Mild	Non-aggressive
5,000-10,000	1,000-3,000	4.5-5.5	6,000-12,000	Moderate	Mild
10,000-20,000	3,000-10,000	4-4.5	12,000-30,000	Severe	Moderate
>20,000	>10,000	<4	>30,000	Very severe	Severe

Notes:

1 - High permeability soils (eg sands and gravels) which are in groundwater

2 – Low permeability soils (eg silts and clays) or all soils above groundwater

Table 5-6: Exposure Classification for Steel Piles

Exposure Conditions				Exposure Classifications	
pH	**Chlorides**		**Resistivity (ohm.cm)**	**Soil Conditions A**[1]	**Soil Conditions B**[2]
	In Soil (ppm)	**In Groundwater (ppm)**			
>5	<5,000	<1,000	>5,000	Non-aggressive	Non-aggressive
4-5	5,000-20,000	1,000-10,000	2,000-5,000	Mild	Non-aggressive
3-4	20,000-50,000	10,000-20,000	1,000-2,000	Moderate	Mild
<3	>50,000	>20,000	<1,000	Severe	Moderate

Notes:

1 - High permeability soils (eg sands and gravels) which are in groundwater

2 – Low permeability soils (eg silts and clays) or all soils above groundwater

6 INVESTIGATION RESULTS

6.1 Subsurface Conditions

A summary of the subsurface conditions encountered during the investigation is presented in the table below. Reference should be made to the borehole logs attached in the appendices for further details.

Table 6-1: Summary of Subsurface Conditions

Profile	Description (metres below ground level - mBGL)
Pavement	Asphaltic concrete pavement was encountered in BH102 and BH103 and ranged in thickness between 50mm and 100mm.
Fill	Fill material was encountered at the surface or beneath the pavement in all boreholes and extended to depths of approximately 0.05m to 0.3m. The fill typically comprised of: clayey silt, silty clay, and gravelly sand. The fill contained inclusions of: ironstone gravel, root fibres, igneous gravel, and ash. Neither odours nor staining was observed in the fill material during the fieldwork. No asbestos containing materials were observed in the fill material during the fieldwork.
Natural Soil	Silty clay natural soils were encountered beneath the fill material in all boreholes and extended to depths of approximately 0.9m to 2.2m. Neither odours nor staining was observed in the natural soils during the fieldwork.
Bedrock	Shale bedrock was encountered beneath the natural soils in all boreholes.
Groundwater	Groundwater seepage was not encountered in the boreholes during drilling. All boreholes remained dry on completion of drilling and a short time after.

6.2 Laboratory Results

A summary of the results is presented below.

Table 6-2: Summary of Laboratory Results

Analyte	Results
EC & ECe	The EC results ranged from 12µS/m to 300µS/m. The ECe results ranged from less than the practical quantification limit (PQL) to 2.5dS/m.
Resistivity	Resistivity values were calculated based on the raw EC values. The resistivity values for the soil samples ranged from 3,333ohm.cm to 83,333ohm.cm.
pH	The pH results ranged from 5 to 9.
CEC	The results of the analysis ranged from: • CEC – 11meq/100g to 16meq/100g; • Exchangeable Na – 0meq/100g to 0meq/100g;

Analyte	Results
	- Exchangeable K – 0.5meq/100g to 0.5meq/100g; - Exchangeable Ca – 7.1meq/100g to 13meq/100g; and - Exchangeable Mg – 2.6meq/100g to 3.7meq/100g.
Sulphate	The sulphate results ranged from 10mg/kg to 250mg/kg.
Chloride	The chloride results ranged from 10mg/kg to 420mg/kg.

Note:

Na – Sodium, K – Potassium, Ca – Calcium, Mg – Magnesium

7 RESULTS INTERPRETATION

The soil laboratory results are compared to the relevant SAC in the attached report tables. Interpretation of the results against the SAC is provided in the following table.

Table 7-1: Interpretation of Laboratory Results

Parameter	Notes
Soil Salinity and Plant Growth	The ECe results generally ranged from less than the PQL to 2.5. The majority of the samples were classed as non-saline. One soil sample (BH101 1.5-1.6) was classed as slightly saline.
Soil pH and Plant Growth	The soil pH results ranged from 5 to 9 and are classed as very strongly acidic to strongly alkaline. The majority of the surficial soils were generally within the optimum range for plant growth. The acidic conditions generally increased with depth. The proposed excavations will generally expose acidic soils and may require treatment with lime or gypsum in order to make the soils suitable for plant growth.
CEC in Soil	The CEC values ranged from 11meq/100g to 16meq/100g in the low to moderate range.
Ratio of Calcium to Magnesium	The results indicate that the soils have more calcium than magnesium. The CEC of the soil is generally very low to moderate. Lime and gypsum can be used to stabilise the soil which will improve soil structure for both engineering and fertility purposes.
ESP%	The ESP% values of the samples ranged from 0.6% to 0.9%. All the ESP results were below the 5% threshold and were classed as non-sodic.
Concrete Slabs and Footings in Saline Soils (CCAA 2018)	The proposed earthworks are anticipated to expose soils generally classed as non-saline at the site with the exception of the shale from 1.5m in the vicinity of BH101. Reference should also be made to AS2159-2009 for minimum concrete strengths and reinforcement cover for concrete piles/foundations.
Soil Conditions for Exposure Classification (AS2159-2009)	The boreholes drilled for the investigation have indicated that the subsurface conditions at the site generally comprise of low permeability soils (i.e. silts and clays). Based on this, the exposure classification outlined under 'Soil Conditions B' has been adopted for the assessment.

Exposure Classification for Concrete Piles/Foundations (AS2159-2009)	The soil pH and sulphate results indicate that the soils are non-aggressive to mildly aggressive towards buried concrete.
Exposure Classification for Steel Piles/Foundations (AS2159-2009)	The soil resistivity, pH and chloride results indicate that the soils are non-aggressive towards buried steel.

7.1 Recommendations

Soil results indicated that the soils at the site are classed as non-saline. The shale bedrock sample obtained from BH101 at a depth of 1.5m was classed as slightly saline. A number of samples encountered pH values in the range of 5 to 5.5. These samples were classed as mildly aggressive to concrete piles and foundations. Structural advice should be obtained for the design of concrete structures in aggressive soils. In the event of any changes to the proposed development (including depth of cut/fill activities in other areas of the site), additional sampling and analysis may be required. Foundations or services installed below the investigation depth of 2m, will require further review to assess for aggressive conditions.

8 LIMITATIONS

The report limitations are outlined below:

- Salinity is a natural phenomenon and can change over time based on site conditions and climatic variations. Changes to existing drainage patters can also impact the salinity at the site. The results outlined in this report are a snap shot of conditions present at the time of the investigation and is bound to change over time;
- EIS accepts no responsibility for any unidentified salinity 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;
- EIS accepts no responsibility for non-compliance of salinity management recommends outlined in this report;
- 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 EIS proposal; and terms of contract between EIS 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, EIS has not undertaken any verification process, except where specifically stated in the report;
- EIS has not undertaken any assessment of off-site areas that may be potential salinity sources or may have been impacted by adverse salinity conditions, except where specifically stated in the report;
- EIS 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;
- EIS 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 land use. EIS should be contacted immediately in such circumstances;
- Material considered to be suitable from a geotechnical point of view may be unsatisfactory from a salinity viewpoint, and vice versa;
- 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 EIS. EIS 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 EIS; and
- Any third party who seeks to rely on this report without the express written consent of EIS does so entirely at their own risk and to the fullest extent permitted by law, EIS accepts no liability whatsoever, in respect of any loss or damage suffered by any such third party.

Important Information About This Report

These notes have been prepared by EIS to assist with the assessment and interpretation of this report.

The Report is based on a Unique Set of Project Specific Factors
This report has been prepared in response to specific project requirements as stated in the EIS proposal document which may have been limited by instructions from the client. This report should be reviewed, and if necessary, revised if any of the following occur:

- The proposed land use is altered;
- The defined subject site is increased or sub-divided;
- The proposed development details including size, configuration, location, orientation of the structures or landscaped areas are modified;
- The proposed development levels are altered, eg addition of basement levels; or
- Ownership of the site changes.

EIS/J&K will not accept any responsibility whatsoever for situations where one or more of the above factors have changed since completion of the assessment. If the subject site is sold, ownership of the assessment report should be transferred by EIS to the new site owners who will be informed of the conditions and limitations under which the assessment was undertaken. No person should apply an assessment for any purpose other than that originally intended without first conferring with the consultant.

Changes in Subsurface Conditions
Subsurface conditions are influenced by natural geological and hydrogeological process and human activities. Groundwater conditions are likely to vary over time with changes in climatic conditions and human activities within the catchment (e.g. water extraction for irrigation or industrial uses, subsurface waste water disposal, construction related dewatering). Soil and groundwater salinity concentrations may also vary over time through migration and accumulation of salts, importation of materials, construction and landscaping. The conclusions of an assessment report may have been affected by the above factors if a significant period of time has elapsed prior to commencement of the proposed development.

This Report is based on Professional Interpretations of Factual Data
Site assessments identify actual subsurface conditions at the actual sampling locations at the time of the investigation. Data obtained from the sampling and subsequent laboratory analyses, available site history information and published regional information is interpreted by geologists, engineers or environmental scientists and opinions are drawn about the overall subsurface conditions, the nature and extent of salinity, the likely impact on the proposed development and appropriate management measures.

Actual conditions may differ from those inferred, because no professional, no matter how qualified, and no subsurface exploration program, no matter how comprehensive, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than an assessment indicates. Actual conditions in areas not sampled may differ from predictions. Nothing can be done to prevent the unanticipated, but steps can be taken to help minimise the impact. For this reason, site owners should retain the services of their consultants throughout the development stage of the project, to identify variances, conduct additional tests which may be needed, and to recommend solutions to problems encountered on site.

Assessment Limitations
The assessment is designed to identify major salinity risks at the site. Implementing the management recommends can minimise the risks. No assessment can identify all risks as salinity is a natural phenomenon which can change over time. Even a rigorous professional assessment may not detect all potential salinity impacts on a site. Salinity may be present in areas that were not surveyed or sampled, or may accumulate in areas which showed no signs of salinity when sampled.

Misinterpretation of Site Assessments by Design Professionals
Costly problems can occur when other design professionals develop plans based on misinterpretation of an assessment report. To minimise problems associated with misinterpretations, the environmental consultant

should be retained to work with appropriate professionals to explain relevant findings and to review the adequacy of plans and specifications relevant to contamination issues.

Logs Should not be Separated from the Assessment Report
Borehole and test pit logs are prepared by environmental scientists, engineers or geologists based upon interpretation of field conditions and laboratory evaluation of field samples. Logs are normally provided in our reports and these should not be re-drawn for inclusion in site management or other design drawings, as subtle but significant drafting errors or omissions may occur in the transfer process. Photographic reproduction can eliminate this problem, however contractors can still misinterpret the logs during bid preparation if separated from the text of the assessment. If this occurs, delays, disputes and unanticipated costs may result. In all cases it is necessary to refer to the rest of the report to obtain a proper understanding of the assessment. Please note that logs with the 'Environmental Log' header are not suitable for geotechnical purposes as they have not been peer reviewed by a Senior Geotechnical Engineer.

To reduce the likelihood of borehole and test pit log misinterpretation, the complete assessment should be available to persons or organisations involved in the project, such as contractors, for their use. Denial of such access and disclaiming responsibility for the accuracy of subsurface information does not insulate an owner from the attendant liability. It is critical that the site owner provides all available site information to persons and organisations such as contractors.

Read Responsibility Clauses Closely
Because an environmental site assessment is based extensively on judgement and opinion, it is necessarily less exact than other disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, model clauses have been developed for use in written transmittals. These are definitive clauses designed to indicate consultant responsibility. Their use helps all parties involved recognise individual responsibilities and formulate appropriate action. Some of these definitive clauses are likely to appear in the environmental site assessment, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to any questions.

Appendix A: Report Figures

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

AERIAL IMAGE SOURCE: MAPS.AU.NEARMAP.COM, 07 APR 2019.

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

Title:

SITE LOCATION PLAN

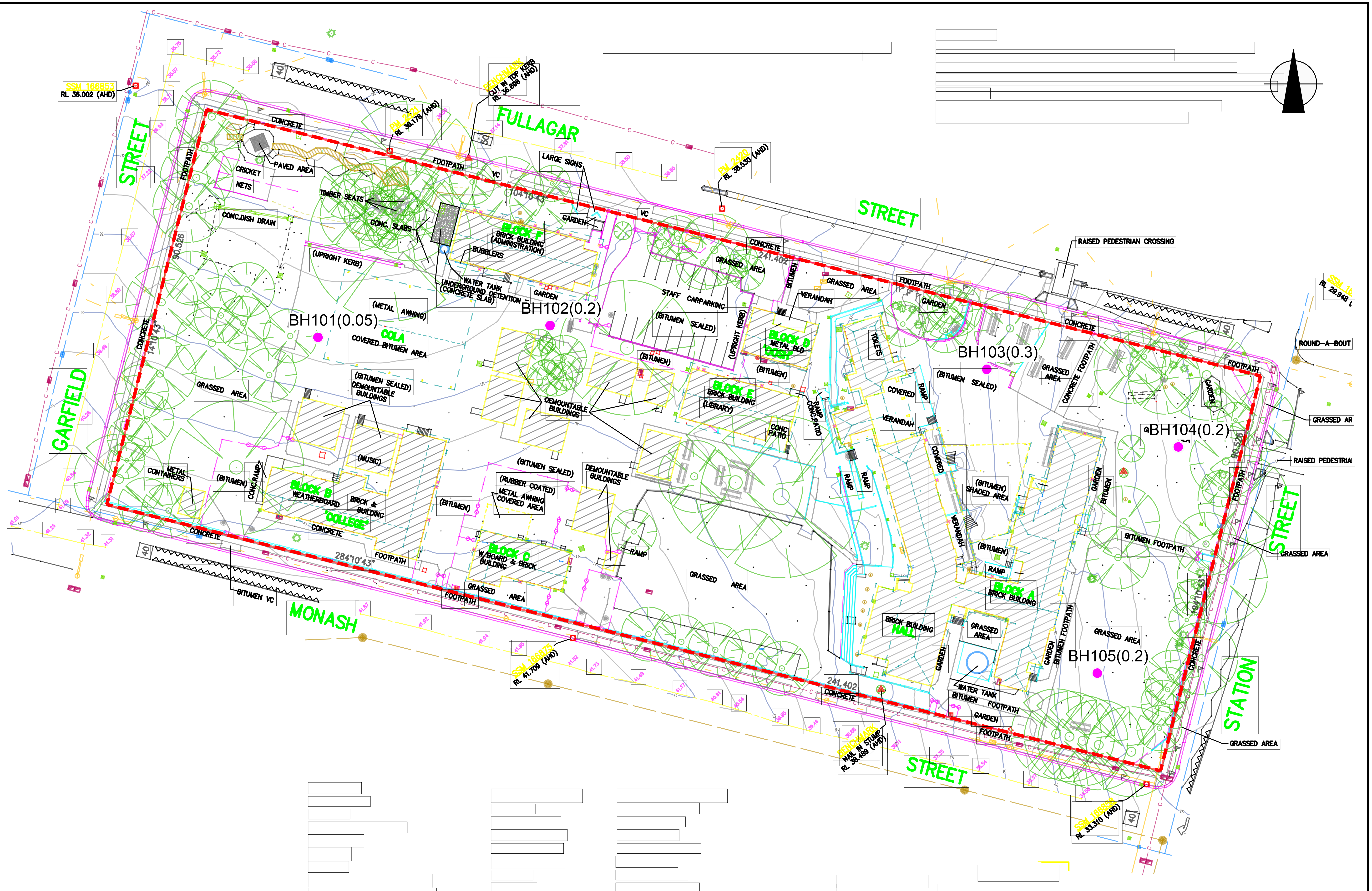
Location: WENTWORTHVILLE PUBLIC SCHOOL
70-100 FULLAGAR ROAD, WENTWORTHVILLE, NSW

Report No: E31057K

Figure No: 1

JKEnvironments

PLOT DATE: 3/05/2019 1:28:15 PM DWG FILE: S:\5 EIS\5C EIS JOBS\31000'S\E31057K WENTWORTHVILLE\CAD\E31057BTRPT2.DWG



LEGEND

▬ ▬ ▬ APPROXIMATE SITE BOUNDARY

● BH (Fill Depth) BOREHOLE LOCATION, NUMBER AND DEPTH OF FILL (m)

0 8 16 24 32 40

SCALE 1:800 @A3 METRES

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

Title:

SAMPLE LOCATION PLAN

Location: WENTWORTHVILLE PUBLIC SCHOOL
70-100 FULLAGAR ROAD, WENTWORTHVILLE, NSW

Report No: E31057BT

Figure No: 2

JKEnvironments

PLOT DATE: 6/05/2019 4:32:05 PM DWG FILE: S:\5 EIS\5C EIS JOBS\31000's\E31057K WENTWORTHVILLE\CAD\E31057BTRPT2.DWG

Appendix B: Laboratory Summary Tables

TABLE A
SUMMARY OF SOIL LABORATORY RESULTS - EC and ECe

Borehole Number	Sample Depth (m)	Sample Description	EC (µS/cm)	ECe (dS/m)	Salinity Class[1]
Sample Depth Range - 0m to 1.95m					
BH101	0.05-0.2	Silty clay	110	<2	**Non-saline**
BH101	0.5-0.95	Silty clay	180	<2	**Non-saline**
BH101	1.5-1.65	Shale	300	2.5	**Slightly Saline**
BH102	0.1-0.2	Fill: silty clay	46	<2	**Non-saline**
BH102	0.5-0.9	Silty clay	160	<2	**Non-saline**
BH102	0.9-0.95	Shale	120	<2	**Non-saline**
BH103	0.05-0.2	Fill: gravelly sand	65	<2	**Non-saline**
BH103	0.5-0.9	Silty clay	64	<2	**Non-saline**
BH103	1.5-1.6	Shale	39	<2	**Non-saline**
BH104	0-0.1	Fill: silty clay	33	<2	**Non-saline**
BH104	0.5-0.8	Silty clay	12	<2	**Non-saline**
BH104	1.5-1.95	Silty clay	110	<2	**Non-saline**
BH105	0-0.2	Fill: silty clay	36	<2	**Non-saline**
BH105	0.5-0.95	Silty clay	47	<2	**Non-saline**
BH105	1.5-1.6	Shale	41	<2	**Non-saline**
Total Number of Samples			15	1	-
Minimum Value			12	2.5	-
Maximum Value			300	2.5	-

Explanation

1 - Salinity Class has been adopted from '*Site Investigations for Urban Salinity*' DLWC 2002.

(dS/m)	Salinity Class
<2	**Non-Saline**
2 to 4	**Slightly Saline**
4 to 8	**Moderately Saline**
8 to 16	**Very Saline**
>16	**Highly Saline**

Abbreviations

EC - Electrical Conductivity

ECe - Extract Electrical Conductivity

TABLE B
SUMMARY OF RESISTIVITY CALCULATION ON SOIL EC RESULTS

Borehole Number	Sample Depth (m)	Sample Description	EC (μS/cm)	Resistivity[1] (ohm.cm)	Classification[2] Condition B
Sample Depth Range - 0m to 1.95m					
BH101	0.05-0.2	Silty clay	110	9,091	Non-Aggressive
BH101	0.5-0.95	Silty clay	180	5,556	Non-Aggressive
BH101	0.5-0.95	Laboratory duplicate	180	5,556	Non-Aggressive
BH101	1.5-1.65	Shale	300	3,333	Non-Aggressive
BH102	0.1-0.2	Fill: silty clay	46	21,739	Non-Aggressive
BH102	0.5-0.9	Silty clay	160	6,250	Non-Aggressive
BH102	0.9-0.95	Shale	120	8,333	Non-Aggressive
BH103	0.05-0.2	Fill: gravelly sand	65	15,385	Non-Aggressive
BH103	0.5-0.9	Silty clay	64	15,625	Non-Aggressive
BH103	1.5-1.6	Shale	39	25,641	Non-Aggressive
BH103	1.5-1.6	Laboratory duplicate	36	27,778	Non-Aggressive
BH104	0-0.1	Fill: silty clay	33	30,303	Non-Aggressive
BH104	0.5-0.8	Silty clay	12	83,333	Non-Aggressive
BH104	1.5-1.95	Silty clay	110	9,091	Non-Aggressive
BH105	0-0.2	Fill: silty clay	36	27,778	Non-Aggressive
BH105	0.5-0.95	Silty clay	47	21,277	Non-Aggressive
BH105	1.5-1.6	Shale	41	24,390	Non-Aggressive
Total Number of Samples			17	17	-
Minimum Value			12	3,333	-
Maximum Value			300	83,333	-

Explanation

1 - Resistivity values have been calculated on the laboratory EC values presented in Table B

2 - Classification derived from the Australian Standard 2159-2009 Piling Design and Installation (Table 6.5.2 [A] & [C])

Resistivity Values (ohm.cm)	Classification for Steel Piles
>5,000	**Non-Aggressive**
2,000 - 5,000	**Non-Aggressive**
1,000 - 2,000	**Mildly Aggressive**
<1,000	**Moderately Aggressive**

Abbreviations

EC - Electrical Conductivity

TABLE C
SUMMARY OF SOIL LABORATORY RESULTS - pH

Borehole Number	Sample Depth (m)	Sample Description	pH	Classification for Concrete Piles[1] Soil Condition B[2]	Classification for Steel Piles[1] Soil Condition B[2]
Sample Depth Range - 0m to 1.95m					
BH101	0.05-0.2	Silty clay	7	**Non-Aggressive**	**Non-Aggressive**
BH101	0.5-0.95	Silty clay	5.1	**Mildly Aggressive**	**Non-Aggressive**
BH101	0.5-0.95	Laboratory duplicate	5.1	**Mildly Aggressive**	**Non-Aggressive**
BH101	1.5-1.65	Shale	5	**Mildly Aggressive**	**Non-Aggressive**
BH102	0.1-0.2	Fill: silty clay	7.6	**Non-Aggressive**	**Non-Aggressive**
BH102	0.5-0.9	Silty clay	5	**Mildly Aggressive**	**Non-Aggressive**
BH102	0.9-0.95	Shale	5.1	**Mildly Aggressive**	**Non-Aggressive**
BH103	0.05-0.2	Fill: gravelly sand	9	**Non-Aggressive**	**Non-Aggressive**
BH103	0.5-0.9	Silty clay	7.4	**Non-Aggressive**	**Non-Aggressive**
BH103	1.5-1.6	Shale	5.9	**Non-Aggressive**	**Non-Aggressive**
BH103	1.5-1.6	Laboratory duplicate	5.7	**Non-Aggressive**	**Non-Aggressive**
BH104	0-0.1	Fill: silty clay	6.2	**Non-Aggressive**	**Non-Aggressive**
BH104	0.5-0.8	Silty clay	7.1	**Non-Aggressive**	**Non-Aggressive**
BH104	1.5-1.95	Silty clay	5.5	**Mildly Aggressive**	**Non-Aggressive**
BH105	0-0.2	Fill: silty clay	6.1	**Non-Aggressive**	**Non-Aggressive**
BH105	0.5-0.95	Silty clay	5.5	**Mildly Aggressive**	**Non-Aggressive**
BH105	1.5-1.6	Shale	5.8	**Non-Aggressive**	**Non-Aggressive**
Total Number of Samples			17	-	-
Minimum Value			5	-	-
Maximum Value			9	-	-

Explanation

1 - pH Classification derived from the Australian Standard 2159-2009 Piling Design and Installation (Tables 6.4.2 [C] & 6.5.2 [C])

2 - Classification is based on Soil condition 'B' - low permeability soils (e.g. silts & clays) or all soils above groundwater.

pH Value	**Classification for Concrete Piles**	**pH Value**	**Classification for Steel Piles**
>5.5	**Non-Aggressive**	>5	**Non-Aggressive**
4.5 - 5.5	**Mildly Aggressive**	4.0 - 5.0	**Non-Aggressive**
4 - 4.5	**Moderately Aggressive**	3.0 - 4.0	**Mildly Aggressive**
<4	**Severely Aggressive**	<3	**Moderately Aggressive**

TABLE D
SUMMARY OF SOIL LABORATORY RESULTS - SULPHATE & CHLORIDES

Borehole Number	**Sample Depth (m)**	**Sample Description**	**Sulphate (mg/kg)**	**Chloride (mg/kg)**	**Classification for Concrete Piles[1] SO4 - Soil Condition B[2]**	**Classification for Steel Piles[1] Cl - Soil Condition B[2]**
Sample Depth Range - 0m to 1.95m						
BH101	0.05-0.2	Silty clay	25	10	Non-Aggressive	Non-Aggressive
BH101	0.5-0.95	Silty clay	190	130	Non-Aggressive	Non-Aggressive
BH101	0.5-0.95	Laboratory duplicate	180	130	Non-Aggressive	Non-Aggressive
BH101	1.5-1.65	Shale	160	420	Non-Aggressive	Non-Aggressive
BH102	0.1-0.2	Fill: silty clay	20	<10	Non-Aggressive	Non-Aggressive
BH102	0.5-0.9	Silty clay	250	39	Non-Aggressive	Non-Aggressive
BH102	0.9-0.95	Shale	190	52	Non-Aggressive	Non-Aggressive
BH103	0.05-0.2	Fill: gravelly sand	20	<10	Non-Aggressive	Non-Aggressive
BH103	0.5-0.9	Silty clay	29	<10	Non-Aggressive	Non-Aggressive
BH103	1.5-1.6	Shale	35	<10	Non-Aggressive	Non-Aggressive
BH103	1.5-1.6	Laboratory duplicate	42	<10	Non-Aggressive	Non-Aggressive
BH104	0-0.1	Fill: silty clay	<10	<10	Non-Aggressive	Non-Aggressive
BH104	0.5-0.8	Silty clay	<10	<10	Non-Aggressive	Non-Aggressive
BH104	1.5-1.95	Silty clay	44	54	Non-Aggressive	Non-Aggressive
BH105	0-0.2	Fill: silty clay	10	<10	Non-Aggressive	Non-Aggressive
BH105	0.5-0.95	Silty clay	74	10	Non-Aggressive	Non-Aggressive
BH105	1.5-1.6	Shale	47	<10	Non-Aggressive	Non-Aggressive
Total Number of Samples			15	8	-	-
Minimum Value			10	10	-	-
Maximum Value			250	420	-	-

Explanation

1 - Classification derived from the Australian Standard 2159-2009 Piling Design and Installation (Tables 6.4.2 [C] & 6.5.2 [C])

2 - Classification is based on Soil condition 'B' - low permeability soils (e.g. silts & clays) or all soils above groundwater.

Sulphate (SO4) Values	**Classification for Concrete Piles**	**Chloride (Cl) Values**	**Classification for Steel Piles**
<5,000	**Non-Aggressive**	<5,000	**Non-Aggressive**
5,000 - 10,000	**Mildly Aggressive**	5,000 - 20,000	**Non-Aggressive**
10,000 - 20,000	**Moderately Aggressive**	20,000 - 50,000	**Mildly Aggressive**
>20,000	**Severely Aggressive**	>50,000	**Moderately Aggressive**

TABLE E
SUMMARY OF SOIL LABORATORY RESULTS - CEC & ESP

Borehole Number	Sample Depth (m)	Sample Description	Total CEC	Ca	K	Mg	Na	ESP^{1*}
			(meq/100g)					%
BH101	0.05-0.2	Silty clay	16	13	0.5	2.6	<0.1	0.6
BH105	0-0.2	Fill: silty clay	12	8	0.5	3.7	<0.1	0.8
BH105	0-0.2	Laboratory duplicate	11	7.1	0.5	3.3	<0.1	0.9
Total Number of Samples			3	3	3	3	0	3
Minimum Value			11.0	7.1	0.5	2.6	0.0	0.6
Maximum Value			16.0	13.0	0.5	3.7	0.0	0.9

Explanation

1 - Sodicity rating has been adopted from the publication *'Site Investigations for Urban Salinity' DLWC* 2002.

* - 0.1 used as value to calculate ESP value as all results for sodium were <0.1

ESP Value	Sodicity Rating
< 5%	**Non-Sodic**
5% to 15%	**Sodic**
> 15%	**Highly Sodic**

Abbreviation

CEC: Cation Exchange Capacity

ESP: Exchangeable Sodium Percentage (Each Na/CEC)

Mg: Exchangeable Magnesium

Na: Exchangeable Sodium

K: Exchangeable Potassium

Ca: Exchangeable Calcium

Appendix C: Background on Salinity

Background on Salinity

A. General Information on Salinity

Salinity is the accumulation and concentration of salt at or near the ground surface or within surface water bodies. Salt is naturally present in the landscape through deposition of salt from the ocean in coastal areas and through weathering of bedrock that contains salt, accumulated during deposition of original sediments in a prehistoric marine environment. The salts are commonly soluble chlorides, sulphates or carbonates of sodium and magnesium.

In Sydney, salinity issues are typically associated with the Wianamatta Group shales and their derived soil landscapes. The natural vegetation of western Sydney is dominated by large isolated trees with deep root systems that remove subsurface moisture. Slow rates of percolation through the relatively impermeable clay soil and uptake of a large proportion of rainfall by the trees results in limited recharge of the groundwater system by rainfall. The depth to groundwater has developed a natural equilibrium and there is little tendency for salt contained in the groundwater or subsoils to rise to the surface.

B. Salinity and Urban Development

Salinity becomes a problem in urban areas when changes in the land use result in changes to the way water moves through the environment. This can result in vegetation die-back, decrease in water quality and damage to urban infrastructure.

Removal of deep rooted tree species during development and replacement with urban infrastructure, houses and industrial developments reduces the mechanism for the removal of subsurface moisture.

The development of urban salinity is commonly associated with changes in the hydrological cycle through the environment (rainfall, surface run-off, water infiltration and groundwater system). An increase in the quantity of water reaching the groundwater table as a result of vegetation clearance, irrigation of parklands, leaking water infrastructure and changes in drainage patterns, can cause a relatively rapid rise in the groundwater table. Earthworks that include excavation of natural soil profiles and exposure of more saline subsurface soils or shale bedrock may also result in an increase in salt concentrations at the ground surface.

Construction of roads, pipelines and buildings commonly results in removal of topsoil leading to exposure of the subsoils and interception of surficial and shallow subsurface drainage. In addition, over-irrigation of urban gardens, leaking water infrastructure and concentrated drainage patterns can result in increased water movement through the subsoil to the groundwater system leading to a relatively rapid rise in the groundwater table.

A rise in groundwater levels and impediments to subsurface drainage patterns can transport salt formerly stored in the bedrock to the surficial soil profile. This may result in salt encrustation of exposed soils, building foundations, roads, drainage infrastructure and corrosion of metal, concrete and other building materials. Increasing salt concentrations in surficial soils (and consequently in surface waters) may also result in die-off of the existing vegetation, further reducing the hydrological load on the groundwater system and resulting in further groundwater table rises.

C. Potential Salinity Impacts on Urban Development

Some of the adverse impacts that can arise from saline conditions include:

- Salt scalds caused by a rise in the subsoil moisture content that mobilises salt to the ground surface;
- Salt scalds caused by modification of former drainage patterns which leads to the day lighting of subsurface seepage (either perched water or groundwater) in areas lower in the catchment, either at breaks in the slope or within drainage lines;
- A rise in groundwater table or accumulation of salt rich seepage leading to corrosion of subsurface facilities including concrete structures, metal pipework, cables, foundations, underground services, etc;
- Rising damp, where salt rich moisture is drawn into building and pavement materials by capillary action leading to deterioration of brick, mortar and concrete;
- Structural cracking, damage or building collapse which may occur as a result of shifting and or sinking foundations;
- Plant die-back associated with a rise in groundwater table level that mobilises excess salt to the plant root zone; and
- Subsurface water discharge and subsequent pollution of streams and drainage channels.

D. Soils and Groundwater Planning Strategy in Western Sydney

The aim of the DLWC 2002 document is to provide a framework for the sustainable development and management of new developments in the western region of Sydney. In relation to salinity management, the development should be designed and constructed such that there is no significant increase in the water table level and no adverse salinity impacts.

The proposed development controls that relate to soils and groundwater issues are summarised below:

1. A water management strategy should be prepared to address the following:
    - Reduction of potable water usage onsite;
    - Development of best practice measures for stormwater reuse for open space irrigation;
    - Reduction of potable water demand;
    - Reduction of adverse impacts on local groundwater regimes;
    - Reduction of change in local flow regimes; and
    - Preparation of water maintenance and a monitoring management system.
2. A salinity management plan should be prepared that includes a groundwater management strategy related to:
    - Adoption of small landscaped areas to reduce irrigation requirements;
    - Use of native and other low water requirement plants;
    - Use of mulch cover (not in drainage lines);
    - Use of low flow watering facilities for landscaped areas;
    - Implementation of a tree planting program, especially in high recharge areas, of native, deep rooted, large growing species to assist retention of the groundwater at existing levels;

- Retention of existing native tree cover where possible; and
- Not permitting infiltration pits or tanks to disperse surface water.

3. An assessment of soil and rock conditions at the site, including erosion, expansive and dispersive soil conditions, and plant growth potential should be undertaken.
4. Use of the Blue Book (2004) as a guide to prepare soil and water management plans. The approved plan and subsequent works are to be supervised by appropriately qualified experienced personnel.

Appendix D: Groundwater Bore Summary Sheets

WaterNSW
Work Summary

GW113429

Licence:
Licence Status:

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore
Work Status: Equipped
Construct.Method:
Owner Type: Private

Commenced Date:
Completion Date: 27/03/2006
Final Depth: 7.70 m
Drilled Depth: 7.70 m

Contractor Name: Terratest
Driller: Craig Williams
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CUMBERLAND	PROSPECT	38/3/963
Licensed:			

Region: 10 - Sydney South Coast
CMA Map:
River Basin: - Unknown
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6256490.000
Easting: 312098.000
Latitude: 33°48'54.4"S
Longitude: 150°58'11.4"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Remarks

30/07/2014: Nat Carling, 30-July-2014; Added status, drill method & depth, updated work type.

***** End of GW113429 *****

WaterNSW
Work Summary

GW113430

Licence:
Licence Status:

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore
Work Status: Equipped
Construct.Method:
Owner Type: Private

Commenced Date:
Completion Date: 28/03/2006
Final Depth: 8.00 m
Drilled Depth: 8.00 m

Contractor Name: Terratest
Driller: Craig Williams
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CUMBERLAND	PROSPECT	10/3/963
Licensed:			

Region: 10 - Sydney South Coast
CMA Map:
River Basin: - Unknown
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6256479.000
Easting: 312097.000
Latitude: 33°48'54.8"S
Longitude: 150°58'11.3"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Remarks

30/07/2014: Nat Carling, 30-July-2014; Added status, drill method & depth, updated work type.

***** End of GW113430 *****

WaterNSW
Work Summary

GW113435

Licence:
Licence Status:

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore
Work Status: Equipped
Construct.Method:
Owner Type: Private

Commenced Date:
Completion Date: 27/03/2006
Final Depth: 4.00 m
Drilled Depth: 4.00 m

Contractor Name: Terratest
Driller: Craig Williams
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CUMBERLAND	PROSPECT	38/3/963
Licensed:			

Region: 10 - Sydney South Coast
CMA Map:
River Basin: - Unknown
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6256476.000
Easting: 312142.000
Latitude: 33°48'54.9"S
Longitude: 150°58'13.1"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Remarks

30/07/2014: Nat Carling, 30-July-2014; Added status, drill method & depth, updated work type.

***** End of GW113435 *****

WaterNSW
Work Summary

GW113433

Licence:
Licence Status:

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore
Work Status: Equipped
Construct.Method:
Owner Type: Private

Commenced Date:
Completion Date: 28/03/2006
Final Depth: 6.00 m
Drilled Depth: 6.00 m

Contractor Name: Terratest
Driller: Craig Williams
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CUMBERLAND	PROSPECT	10/3/963
Licensed:			

Region: 10 - Sydney South Coast
CMA Map:
River Basin: - Unknown
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6256461.000
Easting: 312096.000
Latitude: 33°48'55.4"S
Longitude: 150°58'11.3"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Remarks

30/07/2014: Nat Carling, 30-July-2014; Added status, drill method & depth, updated work type.

***** End of GW113433 *****

WaterNSW
Work Summary

GW113434

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore
Work Status: Equipped
Construct.Method:
Owner Type: Private

Commenced Date:
Completion Date: 27/03/2006

Final Depth: 5.00 m
Drilled Depth: 5.00 m

Contractor Name: Terratest
Driller: Craig Williams
Assistant Driller:

Property:
GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CUMBERLAND	PROSPECT	6/3/963
Licensed:			

Region: 10 - Sydney South Coast
River Basin: - Unknown
Area/District:

CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown

Northing: 6256468.000
Easting: 312139.000

Latitude: 33°48'55.2"S
Longitude: 150°58'13.0"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Remarks

30/07/2014: Nat Carling, 30-July-2014; Added status, drill method & depth, updated work type.

***** End of GW113434 *****

WaterNSW
Work Summary

GW113432

Licence:
Licence Status:

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore
Work Status: Equipped
Construct.Method:
Owner Type: Private

Commenced Date:
Completion Date: 27/03/2006
Final Depth: 7.00 m
Drilled Depth: 7.00 m

Contractor Name: Terratest
Driller: Craig Williams
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CUMBERLAND	PROSPECT	6/3/963
Licensed:			

Region: 10 - Sydney South Coast
CMA Map:
River Basin: - Unknown
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6256462.000
Easting: 312131.000
Latitude: 33°48'55.4"S
Longitude: 150°58'12.7"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Remarks

30/07/2014: Nat Carling, 30-July-2014; Added status, drill method & depth, updated work type.

*** End of GW113432 ***

WaterNSW
Work Summary

GW113431

Licence:
Licence Status:

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore
Work Status: Equipped
Construct.Method:
Owner Type: Private

Commenced Date:
Completion Date: 20/03/2006
Final Depth: 14.00 m
Drilled Depth: 14.00 m

Contractor Name: Terratest
Driller: Craig Williams
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CUMBERLAND	PROSPECT	8/3/963
Licensed:			

Region: 10 - Sydney South Coast
CMA Map:
River Basin: - Unknown
Grid Zone:
Scale:
Area/District:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6256454.000
Easting: 312114.000
Latitude: 33°48'55.6"S
Longitude: 150°58'12.0"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Remarks

30/07/2014: Nat Carling, 30-July-2014; Added status, drill method & depth, updated work type.

***** End of GW113431 *****

WaterNSW
Work Summary

GW113436

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore
Work Status: Equipped
Construct.Method:
Owner Type: Private

Commenced Date:
Completion Date: 20/03/2006

Final Depth: 4.00 m
Drilled Depth: 4.00 m

Contractor Name: Terratest
Driller: Craig Williams
Assistant Driller:

Property:
GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CUMBERLAND	PROSPECT	6/3/963
Licensed:			

Region: 10 - Sydney South Coast
River Basin: - Unknown
Area/District:

CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown

Northing: 6256449.000
Easting: 312131.000

Latitude: 33°48'55.8"S
Longitude: 150°58'12.6"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Remarks

30/07/2014: Nat Carling, 30-July-2014; Added status, drill method & depth, updated work type.

***** End of GW113436 *****

Appendix E: Borehole Logs

JKEnvironments

ENVIRONMENTAL LOG

Log No.
BH101
1/1

Environmental logs are not to be used for geotechnical purposes

Client: FULTON TROTTER ARCHITECTS
Project: PROPOSED ALTERATIONS AND ADDITIONS
Location: WENTWORTHVILLE PUBLIC SCHOOL - 70-100 FULLAGAR RD, WENTWORTHVILLE, NSW

Job No.: E31057BT
Method: SPIRAL AUGER
R.L. Surface: N/A
Date: 29/4/19
Datum:
Plant Type: JK350
Logged/Checked by: H.W./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
DRY ON COMPLETION				■			0	× × × ×	-	FILL: Clayey silt, low plasticity, brown, trace of igneous gravel and root fibres.	w<PL			
				■		N = 17 6,7,10	1	▨	CI-CH	Silty CLAY: medium to high plasticity, grey mottled orange brown, trace of ironstone gravel, root fibres and ash.	w<PL			RESIDUAL
				■		N = SPT 14/ 150mm REFUSAL	2		-	Extremely Weathered shale: silty CLAY, high plasticity, orange brown.	XW			
				■			3			as above, but grey.				
				■					-	SHALE: grey.	DW			
							4 5 6 7			END OF BOREHOLE AT 4.0m				'TC' BIT REFUSAL ON SHALE BEDROCK

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JKEnvironments

ENVIRONMENTAL LOG

Log No. BH102
1/1

Environmental logs are not to be used for geotechnical purposes

Client: FULTON TROTTER ARCHITECTS

Project: PROPOSED ALTERATIONS AND ADDITIONS

Location: WENTWORTHVILLE PUBLIC SCHOOL - 70-100 FULLAGAR RD, WENTWORTHVILLE, NSW

Job No.: E31057BT **Method:** SPIRAL AUGER **R.L. Surface:** N/A

Date: 29/4/19 **Datum:**

Plant Type: JK350 **Logged/Checked by:** H.W./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
DRY ON COMPLETION							0		-	ASPHALTIC CONCRETE: 100mm.t.	w<PL			
									-	FILL: Silty clay, low to medium plasticity, brown, trace of igneous gravel and ash.				
						N = 14 5,7,7			CH	Silty CLAY: high plasticity, orange brown, trace of ironstone gravel, root fibres and ash.	w<PL			RESIDUAL
							1		-	Extremely Weathered shale: silty CLAY, medium to high plasticity, light brown.	XW			
							2							
							3		-	SHALE: brown.	DW			
							4							
										END OF BOREHOLE AT 4.5m				
							5							
							6							
							7							

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ENVIRONMENTAL LOG

Log No.
BH103
1/1

Environmental logs are not to be used for geotechnical purposes

Client: FULTON TROTTER ARCHITECTS

Project: PROPOSED ALTERATIONS AND ADDITIONS

Location: WENTWORTHVILLE PUBLIC SCHOOL - 70-100 FULLAGAR RD, WENTWORTHVILLE, NSW

Job No.: E31057BT **Method:** SPIRAL AUGER **R.L. Surface:** N/A

Date: 29/4/19 **Datum:**

Plant Type: JK350 **Logged/Checked by:** H.W./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
DRY ON COMPLETION							0		-	ASPHALTIC CONCRETE: 50mm.t.				
									-	FILL: Gravelly sand, fine to medium grained, grey, trace of igneous gravel.	M			
						N > 19 5,7, 12/ 100mm REFUSAL			CI-CH	Silty CLAY: medium to high plasticity, grey mottled orange brown, trace of root fibres and ash.	w<PL			RESIDUAL
							1		-	Extremely Weathered shale: silty CLAY, high plasticity, grey and brown.	XW			
						N = SPT 12/ 100mm REFUSAL	2 3		-	SHALE: light brown.	DW			
							4			as above, but brown.				MODERATE 'TC'BIT RESISTANCE
							5 6 7			END OF BORHOLE AT 4.5m				

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JKEnvironments

ENVIRONMENTAL LOG

Log No.
BH104
1/1

Environmental logs are not to be used for geotechnical purposes

Client: FULTON TROTTER ARCHITECTS

Project: PROPOSED ALTERATIONS AND ADDITIONS

Location: WENTWORTHVILLE PUBLIC SCHOOL - 70-100 FULLAGAR RD, WENTWORTHVILLE, NSW

Job No.: E31057BT **Method:** SPIRAL AUGER **R.L. Surface:** N/A

Date: 29/4/19 **Datum:**

Plant Type: JK350 **Logged/Checked by:** H.W./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		-	FILL: Silty clay, low plasticity, brown, trace of root fibres.	w<PL			GRASS COVER
									CI-CH	Silty CLAY: medium to high plasticity, brown, trace of root fibres and ash.	w>PL			RESIDUAL
						N = 7 2,3,4								
							1		CH	Silty CLAY: high plasticity, brown mottled orange brown, trace of ironstone gravel, root fibres and ash.	w≈PL			
						N = 13 5,6,7								
							2			as above, but grey mottled orange brown.				
									-	SHALE: light brown.	DW			MODERATE 'TC' BIT RESISTANCE
							3							
							4							
										END OF BOREHOLE AT 4.5m				
							5							
							6							
							7							

ENVIRONMENTAL LOG

Environmental logs are not to be used for geotechnical purposes

Log No.
BH105
1/1

Client: FULTON TROTTER ARCHITECTS
Project: PROPOSED ALTERATIONS AND ADDITIONS
Location: WENTWORTHVILLE PUBLIC SCHOOL - 70-100 FULLAGAR RD, WENTWORTHVILLE, NSW

Job No.: E31057BT
Method: SPIRAL AUGER
R.L. Surface: N/A
Date: 29/4/19
Datum:
Plant Type: JK350
Logged/Checked by: H.W./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
DRY ON COMPLETION							0		-	FILL: Silty clay, low plasticity, brown, trace of root fibres.	w<PL			GRASS COVER
						N = 11 3,4,7	1		CH	Silty CLAY: high plasticity, grey mottled orange brown.	w≈PL			RESIDUAL
							2		-	Extremely Weathered shale: silty CLAY, medium to high plasticity, light brown.	XW			
							3							
							4		-	SHALE: grey.	DW			MODERATE 'TC' BIT RESISTANCE
							5			END OF BOREHOLE AT 4.5m				
							6							
							7							

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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:

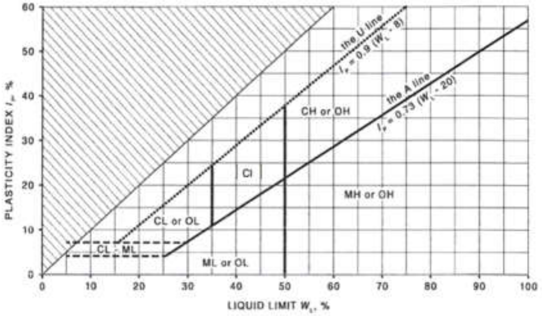
1 For a coarse grained soil with a fines content between 5% and 12%, the soil is given a dual classification comprising the two group symbols separated by a dash; for example, for a poorly graded gravel with between 5% and 12% silt fines, the classification is GP-GM.

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.		
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.		
Density Index/ Relative Density (Cohesionless Soils)			**Density Index (I_D) Range (%)**	**SPT 'N' Value Range (Blows/300mm)**
	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.		
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.		

Log Column	Symbol	Definition
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 F: Laboratory Report & COC Documents

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CERTIFICATE OF ANALYSIS 216408

Client Details

Client	Environmental Investigation Services
Attention	Katrina Taylor
Address	PO Box 976, North Ryde BC, NSW, 1670

Sample Details

Your Reference	**E31057BT, Wentworthville**
Number of Samples	34 Soil
Date samples received	29/04/2019
Date completed instructions received	29/04/2019

Analysis Details

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

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

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

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	01/05/2019
Date of Issue	01/05/2019

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Results Approved By
Giovanni Agosti, Group Technical Manager
Nick Sarlamis, Inorganics Supervisor

Authorised By

Nancy Zhang, Laboratory Manager

CEC			
Our Reference		216408-1	216408-28
Your Reference	UNITS	BH101	BH105
Depth		0.05-0.2	0-0.2
Date Sampled		29/04/2019	29/04/2019
Type of sample		Soil	Soil
Date prepared	-	01/05/2019	01/05/2019
Date analysed	-	01/05/2019	01/05/2019
Exchangeable Ca	meq/100g	13	8.0
Exchangeable K	meq/100g	0.5	0.5
Exchangeable Mg	meq/100g	2.6	3.7
Exchangeable Na	meq/100g	<0.1	<0.1
Cation Exchange Capacity	meq/100g	16	12

Soil Aggressivity						
Our Reference		216408-1	216408-2	216408-3	216408-6	216408-7
Your Reference	UNITS	BH101	BH101	BH101	BH102	BH102
Depth		0.05-0.2	0.5-0.95	1.5-1.65	0.1-0.2	0.5-0.9
Date Sampled		29/04/2019	29/04/2019	29/04/2019	29/04/2019	29/04/2019
Type of sample		Soil	Soil	Soil	Soil	Soil
pH 1:5 soil:water	pH Units	7.0	5.1	5.0	7.6	5.0
Electrical Conductivity 1:5 soil:water	µS/cm	110	180	300	46	160
Resistivity by calculation	ohm m	88	55	34	220	63
Chloride, Cl 1:5 soil:water	mg/kg	10	130	420	<10	39
Sulphate, SO4 1:5 soil:water	mg/kg	25	190	160	20	250

Soil Aggressivity						
Our Reference		216408-8	216408-14	216408-15	216408-16	216408-21
Your Reference	UNITS	BH102	BH103	BH103	BH103	BH104
Depth		0.9-0.95	0.05-0.2	0.5-0.9	1.5-1.6	0-0.1
Date Sampled		29/04/2019	29/04/2019	29/04/2019	29/04/2019	29/04/2019
Type of sample		Soil	Soil	Soil	Soil	Soil
pH 1:5 soil:water	pH Units	5.1	9.0	7.4	5.9	6.2
Electrical Conductivity 1:5 soil:water	µS/cm	120	65	64	39	33
Resistivity by calculation	ohm m	82	150	160	260	300
Chloride, Cl 1:5 soil:water	mg/kg	52	<10	<10	<10	<10
Sulphate, SO4 1:5 soil:water	mg/kg	190	20	29	35	<10

Soil Aggressivity						
Our Reference		216408-22	216408-24	216408-28	216408-29	216408-30
Your Reference	UNITS	BH104	BH104	BH105	BH105	BH105
Depth		0.5-0.8	1.5-1.95	0-0.2	0.5-0.95	1.5-1.6
Date Sampled		29/04/2019	29/04/2019	29/04/2019	29/04/2019	29/04/2019
Type of sample		Soil	Soil	Soil	Soil	Soil
pH 1:5 soil:water	pH Units	7.1	5.5	6.1	5.5	5.8
Electrical Conductivity 1:5 soil:water	µS/cm	12	110	36	47	41
Resistivity by calculation	ohm m	830	94	280	210	240
Chloride, Cl 1:5 soil:water	mg/kg	<10	54	<10	10	<10
Sulphate, SO4 1:5 soil:water	mg/kg	<10	44	10	74	47

Texture and Salinity*						
Our Reference		216408-1	216408-2	216408-3	216408-6	216408-7
Your Reference	UNITS	BH101	BH101	BH101	BH102	BH102
Depth		0.05-0.2	0.5-0.95	1.5-1.65	0.1-0.2	0.5-0.9
Date Sampled		29/04/2019	29/04/2019	29/04/2019	29/04/2019	29/04/2019
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	30/04/2019	30/04/2019	30/04/2019	30/04/2019	30/04/2019
Date analysed	-	30/04/2019	30/04/2019	30/04/2019	30/04/2019	30/04/2019
Electrical Conductivity 1:5 soil:water	µS/cm	110	180	300	46	160
Texture Value	-	9.0	6.0	8.5	10	6.0
Texture		CLAY LOAM	HEAVY CLAY	LIGHT CLAY	LOAM	HEAVY CLAY
ECe	dS/m	<2	<2	2.5	<2	<2
Class		NON SALINE	NON SALINE	SLIGHTLY SALINE	NON SALINE	NON SALINE

Texture and Salinity*						
Our Reference		216408-8	216408-14	216408-15	216408-16	216408-21
Your Reference	UNITS	BH102	BH103	BH103	BH103	BH104
Depth		0.9-0.95	0.05-0.2	0.5-0.9	1.5-1.6	0-0.1
Date Sampled		29/04/2019	29/04/2019	29/04/2019	29/04/2019	29/04/2019
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	30/04/2019	30/04/2019	30/04/2019	30/04/2019	30/04/2019
Date analysed	-	30/04/2019	30/04/2019	30/04/2019	30/04/2019	30/04/2019
Electrical Conductivity 1:5 soil:water	µS/cm	120	65	64	39	33
Texture Value	-	6.0	17	6.0	14	9.0
Texture		HEAVY CLAY	SAND	HEAVY CLAY	SANDY LOAM	CLAY LOAM
ECe	dS/m	<2	<2	<2	<2	<2
Class		NON SALINE	NON SALINE	NON SALINE	NON SALINE	NON SALINE

Texture and Salinity*						
Our Reference		216408-22	216408-24	216408-28	216408-29	216408-30
Your Reference	UNITS	BH104	BH104	BH105	BH105	BH105
Depth		0.5-0.8	1.5-1.95	0-0.2	0.5-0.95	1.5-1.6
Date Sampled		29/04/2019	29/04/2019	29/04/2019	29/04/2019	29/04/2019
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	30/04/2019	30/04/2019	30/04/2019	30/04/2019	30/04/2019
Date analysed	-	30/04/2019	30/04/2019	30/04/2019	30/04/2019	30/04/2019
Electrical Conductivity 1:5 soil:water	µS/cm	12	110	36	47	41
Texture Value	-	6.0	6.0	9.0	6.0	14
Texture		HEAVY CLAY	HEAVY CLAY	CLAY LOAM	HEAVY CLAY	SANDY LOAM
ECe	dS/m	<2	<2	<2	<2	<2
Class		NON SALINE	NON SALINE	NON SALINE	NON SALINE	NON SALINE

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25°C in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA 22nd ED 2510 and Rayment & Lyons. Resistivity is calculated from Conductivity.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Alternatively determined by colourimetry/turbidity using Discrete Analyer.
INORG-123	Determined using a "Texture by Feel" method.
Metals-009	Determination of exchangeable cations and cation exchange capacity in soils using 1M Ammonium Chloride exchange and ICP-AES analytical finish.

QUALITY CONTROL: CEC						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			01/05/2019	28	01/05/2019	01/05/2019		01/05/2019	[NT]
Date analysed	-			01/05/2019	28	01/05/2019	01/05/2019		01/05/2019	[NT]
Exchangeable Ca	meq/100g	0.1	Metals-009	<0.1	28	8.0	7.1	12	103	[NT]
Exchangeable K	meq/100g	0.1	Metals-009	<0.1	28	0.5	0.5	0	98	[NT]
Exchangeable Mg	meq/100g	0.1	Metals-009	<0.1	28	3.7	3.3	11	100	[NT]
Exchangeable Na	meq/100g	0.1	Metals-009	<0.1	28	<0.1	<0.1	0	93	[NT]

QUALITY CONTROL: Soil Aggressivity						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	216408-7
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	2	5.1	5.1	0	102	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	2	180	180	0	99	[NT]
Resistivity by calculation	ohm m	0.1	Inorg-002	<0.1	2	55	55	0	[NT]	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	2	130	130	0	105	124
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	2	190	180	5	119	#

QUALITY CONTROL: Soil Aggressivity						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	16	5.9	5.7	3	[NT]	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	[NT]	16	39	36	8	[NT]	[NT]
Resistivity by calculation	ohm m	0.1	Inorg-002	[NT]	16	260	280	7	[NT]	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	[NT]	16	<10	<10	0	[NT]	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	[NT]	16	35	42	18	[NT]	[NT]

QUALITY CONTROL: Texture and Salinity*					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			30/04/2019	[NT]	[NT]	[NT]	[NT]	30/04/2019	[NT]
Date analysed	-			30/04/2019	[NT]	[NT]	[NT]	[NT]	30/04/2019	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	[NT]	[NT]	[NT]	[NT]	99	[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.

Laboratory Acceptance Criteria

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

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

Spikes for Physical and Aggregate Tests are not applicable.

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

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

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

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

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

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

Measurement Uncertainty estimates are available for most tests upon request.

Report Comments

AGGRESSIVITY

Percent recovery is not possible to report due to the high concentration of the element/s in the sample/s. However an acceptable recovery was obtained for the LCS.

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	Environmental Investigation Services
Attention	Katrina Taylor

Sample Login Details	
Your reference	E31057BT, Wentworthville
Envirolab Reference	216408
Date Sample Received	29/04/2019
Date Instructions Received	29/04/2019
Date Results Expected to be Reported	01/05/2019

Sample Condition	
Samples received in appropriate condition for analysis	
No. of Samples Provided	34 Soil
Turnaround Time Requested	2 days
Temperature on Receipt (°C)	22.1
Cooling Method	None
Sampling Date Provided	YES

Comments

Nil

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	CEC	Soil Aggressivity	Texture and Salinity*	On Hold
BH101-0.05-0.2	✓	✓	✓	
BH101-0.5-0.95		✓	✓	
BH101-1.5-1.65		✓	✓	
BH101-2.8-3.0				✓
BH101-3.8-4.0				✓
BH102-0.1-0.2		✓	✓	
BH102-0.5-0.9		✓	✓	
BH102-0.9-0.95		✓	✓	
BH102-1.5-1.6				✓
BH102-1.8-2.0				✓
BH102-2.8-3.0				✓
BH102-3.8-4.0				✓
BH102-4.4-4.5				✓
BH103-0.05-0.2		✓	✓	
BH103-0.5-0.9		✓	✓	
BH103-1.5-1.6		✓	✓	
BH103-1.8-2.0				✓
BH103-2.8-3.0				✓
BH103-3.8-4.0				✓
BH103-4.4-4.5				✓
BH104-0-0.1		✓	✓	
BH104-0.5-0.8		✓	✓	
BH104-0.8-0.95				✓
BH104-1.5-1.95		✓	✓	
BH104-2.8-3.0				✓
BH104-3.8-4.0				✓
BH104-4.4-4.5				✓
BH105-0-0.2	✓	✓	✓	
BH105-0.5-0.95		✓	✓	
BH105-1.5-1.6		✓	✓	
BH105-1.8-2.0				✓
BH105-2.8-3.0				✓

Sample ID	CEC	Soil Aggressivity	Texture and Salinity*	On Hold
BH105-3.8-4.0				✓
BH105-4.4-4.5				✓

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.

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

EIS Job Number: E31057BT

Date Results Required: 48hr

Page: 1 of 2

FROM:
JKEnvironments
REAR OF 115 WICKS ROAD
MACQUARIE PARK, NSW 2113
P: 02-9888 5000 **F: 02-9888 5001**
Attention: Katrina Taylor

Location: Wentworthville

Sampler: HW

Tests Required

Date Sampled	Lab Ref:	Sample Number	Depth (m)	Sample Container	Sample Description	CEC	Agressivity	ECe (texture)									
29.4.2019	1	BH101	0.05-0.2	P	SiltyCLAY	X	X	X									
	2		0.5-0.95		↓		X	X									
	3		1.5-1.65		Extremely W Shale		X	X									
	4		2.8-3.0		↓												
	5	↓	3.8-4.0		Shale												
	6	BH102	0.1-0.2		F: Silty clay		X	X									
	7		0.5-0.9		SiltyCLAY		X	X									
	8		0.9-0.95		Extremely W Shale		X	X									
	9		1.5-1.6														
	10		1.8-2.0														
	11		2.8-3.0		↓												
	12		3.8-4.0		Shale												
	13	↓	4.4-4.5		↓												
	14	BH103	0.05-0.2		F: gravelly sand		X	X									
	15		0.5-0.9		SiltyCLAY		X	X									
	16		1.5-1.6		Extremely W Shale		X	X									
	17		1.8-2.0		Shale												
	18		2.8-3.0														
	19		3.8-4.0														
	20	↓	4.4-4.5		↓												
	21	BH104	0-0.1		F: Silty Clay		X	X									
	22		0.5-0.8		Silty CLAY		X	X									
	23		0.8-0.95														
	24		1.5-1.95		↓		X	X									
↓	25	↓	2.8-3.0	↓	Shale												

ENVIROLAB
Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 216403
Date Received: 29/4/19.
~~Time Received~~ 16:40.
Received by: TN
Temp: Cool/[✓ Ambient]
Cooling: Ice/Icepack
Security: [✓ Intact]/Broken/None

Remarks (comments/detection limits required):

Sample Containers:

P - Plastic Bag

Relinquished By:	**Date:**	**Time:**	**Received By:**	**Date:**
			T.Nguyen	29/4/19

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

EIS Job Number: E31057BT

Date Results Required: ~~24hr~~ 48hr

Page: 2 of 2

FROM:
JKEnvironments
REAR OF 115 WICKS ROAD
MACQUARIE PARK, NSW 2113
P: 02-9888 5000 **F: 02-9888 5001**
Attention: Katrina Taylor

Location: Wentworthville
Sampler: HW

Date Sampled	Lab Ref:	Sample Number	Depth (m)	Sample Container	Sample Description	CEC	Agressivity	ECe (texture)									
						Tests Required											
29.4.2019	26	BH 104	3.8-4.0	P	Shale												
│	27	↓	4.4-4.5	│	↓												
│	28	BH105	0-0.2	│	F: Silty Clay	X	X	X									
│	29	│	0.5-0.95	│	Silty CLAY		X	X									
│	30	│	1.5-1.6	│	Extremely W shale		X	X									
│	31	│	1.8-2.0	│	│												
│	32	│	2.8-3.0	│	↓												
│	33	│	3.8-4.0	│	Shale												
↓	34	↓	4.4-4.5	↓	↓												

Remarks (comments/detection limits required):

Sample Containers:

P - Plastic Bag

Relinquished By:	Date:	Time:	Received By:	Date:
			T.Nguyen	29/4/19

216403

Appendix G: Report Explanatory Notes

Standard Sampling Procedure (SSP)

These protocols specify the basic procedures to be used when sampling soils or groundwater for environmental site assessments undertaken by EIS.

The purpose of these protocols is to provide standard methods for: sampling, decontamination procedures for sampling equipment, sample preservation, sample storage and sample handling. Deviations from these procedures must be recorded.

A. Soil Sampling:

- Prepare a borehole/test pit log or made a note of the sample description for stockpiles.
- Layout sampling equipment on clean plastic sheeting to prevent direct contact with ground surface. The work area should be at a distance from the drill rig/excavator such that the machine can operate in a safe manner.
- Ensure all sampling equipment has been decontaminated prior to use.
- Remove any surface debris from the immediate area of the sampling location.
- Collect samples and place in glass jar with a Teflon seal. This should be undertaken as quickly as possible to prevent the loss of any volatiles. If possible, fill the glass jars completely.
- Collect samples for asbestos analysis and place in a zip-lock plastic bag.
- Label the sampling containers with the EIS job number, sample location (eg. BH1), sampling depth interval and date. If more than one sample container is used, this should also be indicated (eg. 2 = Sample jar 1 of 2 jars).
- Photoionisation detector (PID) screening of volatile organic compounds (VOCs) should be undertaken on samples using the soil sample headspace method. Headspace measurements are taken following equilibration of the headspace gasses in partly filled zip-lock plastic bags. PID headspace data is recorded on the borehole/test pit log and the chain of custody forms.
- Record the lithology of the sample and sample depth on the borehole/test pit log generally in accordance with AS1726-1993[16].
- Store the sample in a sample container cooled with ice or chill packs. On completion of the sampling the sample container should be delivered to the lab immediately or stored in the refrigerator prior to delivery to the lab. All samples are preserved in accordance with the standards outlined in the report.
- Check for the presence of groundwater after completion of each borehole using an electronic dip metre or water whistle. Boreholes should be left open until the end of fieldwork. All groundwater levels in the boreholes should be rechecked on the completion of the fieldwork.
- Backfill the boreholes/test pits with the excavation cuttings or clean sand prior to leaving the site.

B. Decontamination Procedures for Soil Sampling Equipment

- All sampling equipment should be decontaminated between every sampling location. This excludes single use PVC tubing used for push tubes etc. Equipment and materials required for the decontamination include:
  - Phosphate free detergent (Decon 90);
  - Potable water;
  - Stiff brushes; and
  - Plastic sheets.
- Ensure the decontamination materials are clean prior to proceeding with the decontamination.
- Fill both buckets with clean potable water and add phosphate free detergent to one bucket.

---

[16] Standards Australia, (1993), *Geotechnical Site Investigations.* (AS1726-1993)

- In the bucket containing the detergent, scrub the sampling equipment until all the material attached to the equipment has been removed.
- Rinse sampling equipment in the bucket containing potable water.
- Place cleaned equipment on clean plastic sheets.

If all materials are not removed by this procedure, high-pressure water cleaning is recommended. If any equipment is not completely decontaminated by both these processes, then the equipment should not be used until it has been thoroughly cleaned.