CONSULTING EARTH SCIENTISTS

EROSION AND SALINITY ASSESSMENT
COOKS COVE DEVELOPMENT ZONE
PREPARED FOR COOK COVE INLET PTY LTD
CES Document Reference: CES130608-BP-AU

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1 INTRODUCTION

This report has been prepared by Consulting Earth Scientists Pty Ltd (CES), on behalf of Cook Cove Inlet Pty Ltd (the Client), to support the public exhibition and assessment of the Cooks Cove Planning Proposal (PP-2022-1748), which was issued a Gateway Determination by the Department of Planning and Environment on 5 August 2022. The proposal seeks to amend Bayside Local Environmental Plan 2021 (BLEP 2021) to rezone and insert planning controls for certain land known as Cooks Cove within the BLEP 2021.

The Cooks Cove Planning Proposal aims to facilitate the long-planned transformation of 36.2ha of underutilised and strategically important land at Arncliffe, located to the north of the M5 Motorway and adjacent the western foreshore of the Cooks River. The project seeks a renewed focus on delivering a contemporary logistics and warehousing precinct within a well-connected location, surrounded by enhanced open space provisions. The site forms part of the broader Bayside West 2036 Precincts and generally comprises the footprint of the former Kogarah Golf Club, now in part occupied by a temporary M6 Stage 1 construction compound.

The Cooks Cove Master Plan , as prepared by Hassell, represents an optimised and refined reference scheme, to guide best practice design and the preparation of detailed planning controls to achieve an attractive precinct with high amenity. Key features of the Cooks Cove Master Plan are:

- A net development zone of approximately 15ha with up to 343,250m^2 Gross Floor Area (GFA) comprising
    - 290,000m^2 of multi-level logistics and warehousing;
    - 20,000m^2 for hotel and visitor accommodation uses;
    - 22,350m^2 for commercial office uses;
    - 10,900m^2 of retail uses;
- Multi-level logistics with building heights generally up to 5 storeys (approx. 48m)
- A retail podium with commercial office and hotel above, up to a total of 12 storeys (approx. 51m)
- Built form of a scale and composition which caters for the generation of approximately 3,300 new jobs
- A surrounding open space precinct including:

- A highly activated waterfront including the Fig Tree Grove outdoor dining and urban park precinct
- A significant extension to the regional Bay to Bay cycle link, 'Foreshore Walk', including active and passive recreational uses, together with environmental enhancements
- Master planned and Council-owned 'Pemulwuy Park' – with an agreed embellishment outcome of passive open space and environmental enhancements to be delivered in stages post construction of the M6 Stage 1 Motorway
- Complementary on and off-site infrastructure to be delivered by way of State and Local Voluntary Planning Agreements.

Cooks Cove is located in the suburb of Arncliffe within the Bayside Council Local Government Area (LGA). The site is located to the west of the Cooks River, approximately 10 km south of the Sydney Central Business District (CBD). The site enjoys adjacency to key trade-related infrastructure being immediately west of Sydney Kingsford Smith International Airport and approximately 6 km west of Port Botany.

Cooks Cove is strategically located within close proximity to a number of railway stations including Banksia, Arncliffe, Wolli Creek and the International Airport Terminal, which vary in distance from the site between 700m and 1.1km. The M5 Motorway, providing regional connectivity to the Sydney Metropolitan area, runs in an east-west direction immediately to the south of the site. The M8 and M6 Motorways are, and will be, constructed in tunnels approximately 60 metres beneath the adjoining Bayside Council 'Trust' lands. The Sydney Gateway project, presently under construction to the immediate north of Cooks Cove and Sydney Airport, will substantially improve future accessibility to the St Peters interchange and the wider M4/M5 WestConnex network, via toll free connections, as well as the Domestic Airport and Port Botany.

The Cooks Cove Development Zone (the site) is located to the north of the Southern and Western Suburbs Ocean Outfall Sewer (SWSOOS) and is generally bound by the Cooks River to the east and Marsh Street to the north and west. The site is approximately 36.2ha and is owned and managed by a number of landowners, both public and private. Surrounding development includes the Sydney Airport International Terminal precinct, Mercure Sydney Airport, an area of low density dwellings presently transitioning to medium-high density residential flat buildings, recreation and open space facilities and road and airport related infrastructure.

This report applies to the Cooks Cove Development Zone only and addresses an Erosion and Salinity Assessment for the site which is located to the south of Sydney International Airport as shown in **Figure 1**.

2 OBJECTIVE AND SCOPE

The scope of work as outlined in CES proposal referenced CES130608-BP-AQ dated 13 January 2017 includes the following:

- Initial desktop study
- Intrusive ground investigation comprising borehole drilling and sampling
- Groundwater sampling from existing monitoring wells
- Nominate samples for laboratory testing analysis
- Erosion and salinity assessment

The objective of this report is to assess the suitability of the site for the proposed development in terms of potential erosion and salinity risks.

This salinity assessment was undertaken in accordance with Department of Land and Water Conservation (DLWC, now part of Development of Environment, Climate Change and Water, DECCW) publication Site Investigations for Urban Salinity, 2002.

3 DESKTOP STUDY

3.1 SITE IDENTIFICATION

The site is referred to as the Cooks Cove Development Zone, Cooks Cove, NSW. The site was previously referred to as the Northern Precinct and Areas A and B, but have been consolidated as one portion of land in this report.

The site covers an area of approximately 36 Ha of which 15 Ha is proposed to be developed.

The legal description of the developable land is Part of Lot 1 Deposited Plan (DP) 329283, Part of Lot 1 DP 108492, Part of Lot 14 DP 213314, and Part of Lot 100 DP 1231954. It is located within the Local Government Area (LGA) of Bayside, Parish of St George, County of Cumberland.

3.2 SITE DESCRIPTION

Cooks Cove

Cooks Cove is located in the suburb of Arncliffe within the Bayside Council Local Government Area (LGA). The site is located to the west of the Cooks River, approximately 10km south of the Sydney Central Business District (CBD). The site enjoys adjacency to key trade-related infrastructure being immediately west of Sydney Kingsford Smith International Airport and approx 6km west of Port Botany.

Cooks Cove is strategically located within close proximity to a number of railway stations including Banksia, Arncliffe, Wolli Creek and the International Airport Terminal, which vary in

distance from the site between 700m and 1.1km. The M5 Motorway, providing regional connectivity to the Sydney Metropolitan area, runs in an east-west direction immediately to the south of the site. The M8 and M6 Motorways are, and will be, constructed in tunnels approximately 60 metres beneath the adjoining Bayside Council 'Trust' lands. The Sydney Gateway project, presently under construction to the immediate north of Cooks Cove and Sydney Airport, will substantially improve future accessibility to the St Peters interchange and the wider M4/M5 WestConnex network, via toll free connections, as well as the Domestic Airport and Port Botany.

The Cooks Cove Development Zone is located to the north of the Southern and Western Suburbs Ocean Outfall Sewer (SWSOOS), and is generally bound by the Cooks River to the east and Marsh Street to the north and west. The site is approximately 36.2ha and is owned and managed by a number of landowners, both public and private. Surrounding development includes the Sydney Airport International Terminal precinct, Mercure Sydney Airport, an area of low density dwellings presently transitioning to medium-high density residential flat buildings, recreation and open space facilities and road and airport related infrastructure.

Kogarah Golf Club

Kogarah Golf Club was established in 1928, with the Club occupying the land subject to the Planning Proposal boundary since 1955. At this time, the Cooks River was reconfigured to its current alignment to accommodate the expansion of Sydney Airport. The land presents a highly modified environment, with relatively flat topography, gently moulded fairways and greens, separated by strips of vegetation and man-made water bodies. The golf course clubhouse, car park and maintenance facilities are located in the northern corner of the site, adjacent the Cooks River. Access is provided via Levey Street. The members of Kogarah Golf Club will relocate from the site in May 2024 to new playing facilities.

Arncliffe Motorway Operation Complex

The temporary construction compound for the WestConnex M8 and M6 Stage 1 Motorway tunnelling works was originally established in June 2016. The temporary construction facility occupies approximately 7.5ha and is expected to remain until 2025. At this time the facility will reduce to 1.5ha to accommodate the permanent Arncliffe Motorway Operations Complex, located in the western corner of the site, adjacent Marsh Street. The complex will house ventilation and water treatment plant and maintenance equipment for both the M6 and M8 sub-grade motorways.

RTA Frog Ponds

The site contains the existing RTA Frog Ponds, located in the south-west corner of the site, adjacent Marsh Street and SWSOOS. The two fenced areas contain ponds, constructed by the RTA as part of the M5 Motorway construction in 2002, as compensatory habitat for the Green and Golden Bell Frog.

Easements and Affectations

The Sydney Desalination Plant pipeline runs through the development zone, north-south adjacent the Cooks River. The pipe has a diameter of 1.8m and sits within an easement of 6-9m in width. From south to north the pipeline is constructed in a combination of trench and above ground with mounded cover and then transitions to micro-tunnel and typical depth of circa 11m. The Moomba to Sydney Pipeline, containing ethane gas, follows a similar general alignment north-south adjacent the Cooks River. The pipe has a nominal 225mm diameter, within an easement generally 5m wide and with the pipe located at a depth of 1.2m-2.3m.

3.3 SITE ZONING AND LAND USE

The site is currently zoned a combination of Open Space, Trade and Technology and Special Use land use under the State Environmental Planning Policy (Precincts—Eastern Harbour City) 2021. It is proposed to rezone the site for SP2 Infrastructure, RE1 Public Recreation and SP4 Enterprise uses.

3.4 TOPOGRAPHY

A review of the Botany Bay 1:25,000 Topographic map (9130-3-S) indicated that the site elevation ranges from 0 to 6 m above Australian Height Datum (AHD). The site topography has been significantly modified through the placement of fill material over the original swamp and delta. An undulating surface has been created to form the golf course including several small lakes.

The site generally drains in an easterly direction towards the Cooks River, although localised flow paths occur across the golf course, including an un-named intermittent stream draining the golf course shown on the 1:25,000 Topographic Map. In addition, the central portion of the golf course drains internally towards a series of lakes.

3.5 GEOLOGY

A review of the Sydney 1:100,000 Geological Series map indicated that the site is underlain by silty to peaty quartz sand, silt and clay. Ferruginous and humic cementation occurs in places with common shell layers also reported. This material is most likely of alluvial origin, deposited as sub-aerial and sub-aqueous components of the Cooks River delta. This deposit was reworked significantly last century as part of river diversion and training works. These works would have involved significant dredging operations.

An outcrop of Hawkesbury Sandstone is also shown in the location of the existing Kogarah Golf Club House. A review of the Sydney 1: 100,000 Soil Landscape Sheet 9130 indicated that the site is underlain by anthropogenic fill material. The southern portion of the site is underlain by sandy soils which are believed to have been dredged from the Cooks River and deposited on the site to from the KGC golf course.

3.6 HYDROGEOLOGY

3.6.1 Regional Hydrogeology

The groundwater at this site is expected to lie within a shallow unconfined aquifer, although localised layers of low permeability (*eg.* clay, peat and layers of localised iron-cemented sand) may act as local confining layers. Groundwater at the site is expected to flow in an easterly direction towards the Cooks River.

The Cooks River, Muddy Creek and the Spring Street Canal are tidal in the study area. It is expected that saline or brackish intrusion occurs around the periphery of the site. Diurnal fluctuations in groundwater levels in the peripheral areas are also expected to occur in response to tidal cycles.

3.6.2 Local Hydrogeology

The only well registered in the site is GW027664 which was registered to Kogarah Golf Club for irrigation purposes. It is located in the north western corner of the golf course and was drilled to a depth of 6 m, which was equal to the depth of bedrock.

Inspection of DLWC work summaries reveals reported well yields of up to 3.0 L s^{-1}, with most yields of the order of 0.5 L s^{-1}. The salinity of wells installed was reported as "good". These data indicate that the study area is surrounded and underlain by relatively permeable strata. Low ("good") salinity of water extracted from the wells indicates that saline or brackish intrusion is likely to be limited to peripheral areas adjacent to the Cooks River and tidal reaches of tributaries thereof.

CES (2008) prepared a "Groundwater Contour Plan and SAC Exceedances in Area B" of the site, appended as **Figure 3** to this report. The groundwater at the site is shown to flow in easterly direction towards the Cooks River.

Existing monitoring wells BMW403 and AMW205 previously installed in 2008 within the site are covered in this report.

Typical hydraulic conductivity, K values referenced from Freeze & Cherry (1997) are expected to range from 10^{-4} to 10^{-6} m/s at the site.

3.7 PREVIOUS PRELIMINARY SALINITY ASSESSMENT (CES050706-BCC-18-F REVISION 2)

3.7.1 Soil Salinity

CES (2008) undertook a preliminary salinity assessment as part of the Environmental Site Assessment for the Site B (lower portion of the site). Seven fill type soil samples (six surface and one at 0.5 m depth) were subjected to specific chemical tests and the results reported as below:

- pH: 9.1 to 6.9 pH units;
- Electrical Conductivity: 43 µS/cm to 3100;
- Salinity as NaCl: 3.2 mg kg-1 to 200 mg kg-1;
- Resistivity: 33 ohm/m to 2000 ohm/m;
- Sulfate: <25 mg kg-1 to 6700 mg kg-1; and
- Chloride: <100 mg kg-1 to 200 mg kg-1.

The results of the ECe conversions were reported as below:

- BBH402 (sample 280408-05-KW) collected at 0.1-0.3 m was classified as sandy loam. The ECe was 0.6 dS m-1. Based on ECe, soil at BBH402 was classified as non-saline;

- BBH405 (sample 290408-48-KW) collected at 0-0.2 m was classified as loam. The ECe was 0.75 dS m-1. Based on ECe, soil at BBH405 was classified as non-saline;

- BBH411 (sample 290408-36-KW) collected at 0.2-0.4 m was classified as light clay. The ECe was 0.78 dS m-1. Based on ECe, soil at BBH411 was classified as non-saline;

- BBH437 (sample 290408-74-KW) collected at 0.1-0.2 m was classified as loamy sand. The ECe was 0.84 dS m-1. Based on ECe, soil at BBH437 was classified as non-saline;

- BBH442 (sample 300408-101-KW) collected at 0.1-0.4 m was classified as sandy loam. The ECe was 0.94 dS m-1. Based on ECe, soil at BBH442 was classified as non-saline;

- BBH445 (sample 010508-137-KW) collected at 0.1-0.4 m was classified as sand. The ECe was 0.94 dS m-1. Based on ECe, soil at BBH445 was classified as non-saline; and

- BBH448 (sample 300408-99-KW) collected at 0.4-0.5 m was classified as sandy loam. The ECe was 43.4 dS m-1. Based on ECe, soil at BBH448 was classified as highly-saline.

The lowest salinity as NaCl recorded was 3.2 mg kg-1 at BBH448. The highest salinity as NaCl recorded was 200 mg kg-1 at BBH445.

CES (2008) concluded that the surface fill is typically non-aggressive towards concrete and non-corrosive towards unprotected steel. The fill material sampled from 0.5 m depth was assessed as being mildly aggressive towards concrete and non-corrosive towards unprotected steel.

3.7.2 Groundwater Salinity

CES (2008) reported electrical conductivity, total dissolved solids and salinity results for groundwater sampled at the site. The results suggested that the salinity of groundwater generally increases from the western portion of the site to the eastern portion of the site toward the Cooks River.

4 EROSION & SALINITY GROUND INVESTIGATION 2017

4.1 FIELDWORK

In March 2017, CES undertook a ground investigation programme comprising drilling and sampling of fourteen (14) boreholes (designated BH1 to BH14) across the site. The borehole locations are shown in **Figure 2**.

The fieldwork was carried out between 15 March and 17 March 2017. Prior to drilling, an electronic subsurface utility location survey was undertaken by Down Under Detection Services Pty Ltd (DUDS) to confirm the absence of existing underground services at the proposed borehole locations. The boreholes were drilled by subcontractor Site Drilling & Investigation Pty Ltd (SDI) using a utility vehicle mounted drilling rig. The boreholes were drilled using continuous flight augers fitted with a tungsten carbide (TC) drill bit. Strata identification was undertaken through observation of cutting returns and recovered samples. On completion, the boreholes were observed for groundwater and then backfilled with arisings.

The fieldwork was undertaken in the full-time presence of a CES Environmental Scientist who directed the fieldwork, logged the boreholes and collected soil samples at depths of 0.2m, 0.5m, 1m and every 0.5m thereafter in each borehole.

Field screening of recovered soil samples was also carried out to assess soil potential for salinity. The salinity screening was carried out using a portable electrical conductivity meter on 1:5 soil:water extract subsamples and corrected to consider soil texture

Field testing on two groundwater samples collected from the borehole BH13 was also conducted using a water quality meter. Selected representative soil samples from the drilled boreholes as well as two groundwater samples extracted from existing monitoring wells BMW403 and AMW205 within the site were dispatched to suitably accredited laboratories for environmental laboratory testing analysis. The borehole coordinates and groundwater table depths are presented in **Table 2**. The borehole positions were determined using a handheld GPS to a ± 5m accuracy.

4.2 SUBSURFACE CONDITIONS

Details of subsurface conditions encountered are shown on the borehole logs enclosed in **Appendix A**, together with the explanatory sheets describing the terms and symbols used. A generalised subsurface profile encountered at the site is presented in **Table 1**.

The subsurface conditions underlying the site generally consist of Fill: Silty Sand/Sand to depths typically between 0.5m to 2.8m with underlying alluvial sands and clays. Sandstone bedrock was encountered only in BH1 at 1.7m bgl.

4.3 CLASSIFICATION

4.3.1 Salinity

Salinity is a measure of the concentration of the soluble salts contained in the soil. Typical salinity indicators are pH, electrical conductivity, salinity, resistivity, texture, soluble sulfate and chloride. In order to establish the soil salinity class as per DLWC (2002) publication Site Investigations for Urban Salinity, the electrical conductivity results were converted into extract electrical conductivity (ECe) reported in dS m-1. The ECe was calculated using a multiplication factor (M*) based on the soil texture group. The relevant multiplication factors are 14 for sandy loam, 17 for sand, 10 for loam and 8.5 for light clay. Soil is classified as non-saline if the ECe is less than 2 dS m-1 and highly saline if the ECe is greater than 16 dS m-1. The relevant guidelines are presented in ws and **Table 5**.

4.3.2 Sodicity

Sodic soils are susceptible to erosion. The erosion potential of soils was assessed using Emerson Class. The Emerson Class test grades soils into eight classes with Class 1 being highly dispersive to Class 8 being non-dispersive. The standard test method for Emerson classification should be referenced from NSW Department of Sustainable Natural Resources (2002) publication Soil Survey Test Method – Emerson Test Aggregate flowchart in page 4.

Sodicity is expressed as the amount of sodium relative to exchangeable calcium and magnesium in the soil. A soil is sodic when there is sufficient sodium to interfere with its structural stability often affecting plant growth. The level of sodicity was measured by exchangeable sodium percentage (ESP) which is a percentage of cation exchange capacity (CEC). The general rating of sodicity in DLWC (2002) publication Site Investigations for Urban Salinity is presented in **Table 6**.

4.3.3 Aggressivity

To determine the aggressiveness of the soil and water environment on concrete or steel piles, the chemical test results are compared to Tables 6.4.2C and 6.5.2C from Section 6 of the Australian

Standard AS 2159 (2009) Piling Design and Installation. Guidelines are presented in **Table 7** and **Table 8**. This section provides assessment criteria to assess the 'exposure classification' for a concrete or steel pile. The Standard has two classes of soil conditions:

1) High permeability soils below groundwater; and
2) Low permeability soils and all soils above groundwater.

4.4 LABORATORY TESTING

Selected samples from the boreholes were tested at NATA-accredited laboratories (i.e. Macquarie Geotechnical Pty Ltd and Envirolab Services Pty Ltd). The scope of laboratory testing undertaken comprised:

- Six soil samples analysed for pH, Sodicity - Exchangeable Sodium Percentage (ESP), exchangeable cations (Ca^{2+}, $ApMg^{2+}$, Na^{+},K^{+}), anions Sulfates ($SO4^{2-}$) and Chlorides (Cl^{-}), Emerson Class, Organic Matter and Resistivity.
- Two groundwater samples analysed for Electrical Conductivity (EC), pH, Total Dissolved Solids, Salinity, Resistivity, Sulfates ($SO4^{2-}$) and Chlorides (Cl^{-})

The laboratory test certificates of analysis are presented in **Appendix B**.

4.4.1 TEST DATA SUMMARY

Field and laboratory test data along with CES assessment have been tabulated in **Table 2** for ease of reference. Groundwater samples were collected from existing monitoring wells BMW403 and AMW205, and the laboratory test results summarised in **Table 3**.

5 EROSION AND SALINITY ASSESSMENT

5.1 RESULTS DISCUSSION

The field and laboratory test results indicate the following:

5.1.1 Soil Samples

- Emerson classes are generally Class 4 for samples collected between 1.5m and 3.5m for BH2, BH5, BH8, BH10 and BH12 except for BH13 which resulted in Class 6.

- Organic matter content ranged from 0.9% to 3.1% for sample depths between 1.5m and 3.5m for BH2, BH5, BH8, BH10, BH12 and BH13.

- Laboratory pH values ranged from 7.3 to 7.8 for samples collected between 1.5m and 3.5m for BH2, BH5, BH8, BH10 and BH12 except for BH13 which resulted in pH value of 4.2.

- Field pH readings generally exceed pH value of 6.0 for samples collected in all boreholes with the exception of BH10 which had an average pH value of 2.6 from 1.5m to 2m.

- Field electrical conductivity ranged from 10 µS/cm for sample collected in BH2 to 1450 µS/cm for sample collected in BH5.

- Salinity classes ranged from non-saline to moderately saline for samples collected in the boreholes except for BH4, BH5 and BH8 which have highly saline to very saline soils.

- Sulfate content ranged from 98.9 ppm for sample collected at 2.5m in BH12 to 432.8 ppm for sample collected at 2.0m in BH13.

- Chloride content ranged from 117.4 ppm for sample collected at 2.0m in BH13 to 376.7 ppm for sample collected at 2.5m in BH12.

5.1.2 Groundwater Samples

- Salinity concentrations ranged from 1100 mg/L for sample collected in BMW403 to 2500 mg/L for sample collected in AMW205.

- Total dissolved solids ranged from 920mg/L for sample collected in BMW403 to 2500mg/L for sample collected in AMW205.

- Electrical conductivity ranged from 799 µs/cm for sample collected in BH14 to 3900 µs/cm for sample collected in AMW205.

- pH values ranged from 6.1 for sample collected in BH14 to 7.1 for sample collected in AMW205

5.2 RESULTS ASSESSMENT

- In general the site is assessed to be non-saline to moderately saline for both surface soils and subsoils. However, attention should be given to areas in close proximity to boreholes BH4, BH5 and BH8 which have highly saline to very saline soils, both surface and subsurface. For the areas in the vicinity of these boreholes, the saline soil management options and strategies described in **Section 7** should be implemented.

- Soils at the site are assessed to have moderate erosion potential with presence of calcium carbonate.

- Presence of calcium cations, being physically smaller than sodium cations, will reduce the distance between clay particles, which in turn increase the clay particle attraction and reduce dispersion. When calcium carbonate is brought to the surface, it is likely to be leached out, causing the soil to become unstable in its structure.

- Erosion potential can increase if poor drainage occurs during the construction, therefore Erosion and Sediment Control Plan should be developed, refer to **Section 7.1**.

- Soils at the site are generally non-aggressive to both concrete and steel. However the low pH value tested at BH13 should be analysed and assessed further should excavation occur in the area of this borehole.

- Soils at the site are generally non-sodic, particularly in areas close proximity to BH2, BH5, BH8 and BH12.

- According to the general water quality yardsticks in Table 2 of DPI publication (2009) "Interpreting Water Quality Results" on the basis of electrical conductivity results, in BH14 groundwater is within the range for "desirable limit for humans", in BH5 and BMW403 groundwater is within the range for "maximum for human consumption" and in AMW205 groundwater is within the range for "maximum for mixing herbicides".

6 SIGNIFICANCE & EFFECTS OF EROSION & SALINE SOILS

6.1 EROSION POTENTIAL

Soil erosion is the transportation and deposition of soil by water or wind. When soil is eroded in transport, soil sedimentation occurs. The rate of soil erosion usually depends on the climate, soil, topography, plant cover and land use.

Soil erosion potential at the site is generally controlled by the following water erosion processes:

- Splash erosion: defined by the splattering of small soil particles by the impact of raindrops. The soil particles are loosened and may not be removed by surface run-off.
- Sheet erosion: defined by even removal of surface soil. This process is caused by flowing water as the main transporting agent which is derived from rainstorms.
- Rill erosion: defined by the formation of gutters or miniature gullies by the action of run-off water concentrating into small rivulets.
- Gully erosion: defined by formation of steep sided channels by concentrated run-off.
- Tunnel erosion: defined by formation of underground channels or pipes through the removal of highly dispersive soil by seepage water.

6.2 EFFECTS OF SALINE SOILS

Saline soils are characterised by slow rates of water infiltration (from rain or irrigation), poor water and nutrient transport within the soil, restricted vegetation growth and severe surface crusting. When wet these soils are boggy and soft. Under undisturbed conditions natural systems are generally in balance with native landscape and flora and fauna evolve in balance with available rainfall and existing salinity over long periods of time. Site development can disrupt this balance and cause salts normally stored in soil and rocks to be dissolved in water and brought closer to the surface. When the water evaporates, the salts concentrate at or near the ground surface resulting in salinisation of the near surface soils. Common development activities that disrupt the natural water balance which can result in salinisation include:

Rising water table as a result of increased infiltration due to:

- Vegetation clearance.
- Application of excess water such as inappropriate watering of parks, lawns, gardens and other open spaces.
- Leaking water, sewerage and drainage pipelines.
- Inadequate stormwater management.
- Inefficient septic systems.
- Poor drainage.
- Blockage or impedance of natural drainage pathways.

Exposure of underlying more saline soil horizons or interception of saline groundwater during excavations associated with construction and development.

In areas where water gains access to buildings and infrastructure, salt can be carried with it. When the water evaporates, salt can crystallise that may cause physical stress on the building materials as the salt crystals expand. Salts dissolved in water can also react with compounds of calcium, aluminium, iron and magnesium to form crystals of different chemical compounds that have larger volumes. This volume change can result in damage and deterioration of the affected material. Increased salt levels also increase the rate of corrosion and/or oxidation of steel.

If saline material is exposed or brought close to the surface by development, it may prevent or retard the establishment of vegetation and where excess water enters the site, this material may also prevent or retard water from moving vertically through the soil profile. This may result in soil erosion issues and/or problematic drainage conditions.

Salinisation of soils therefore is not only harmful to plant growth, but also has the potential to affect structures such as buildings, paving, walls, roads and underground pipes and services. These

can be adversely impacted if appropriate protection and management is not implemented. Mitigation and management options are provided in **Section 7**.

7 SALINE SOIL MANAGEMENT OPTIONS AND STRATEGIES

The development should be planned, designed and constructed to consider the following management strategies for the saline soil areas in **Section 5.1**.

7.1 EARTHWORKS

Cut and fill operations should be minimised wherever practicable to reduce the risk of exposure of deeper more saline soils. Where cut and fill is necessary, the fill should be placed in a manner that avoids reversal of the soil profile, that is to say, soils excavated from the bottom of the profile should be placed at the bottom of the profile in the fill area.

Where import of fill material is necessary, the imported material should comprise a clean well graded durable, non-expansive granular material. The salt content of the imported fill material should be assessed to determine whether the material is likely to promote salinisation. Fill assessed to promote salinisation should not be used.

Stockpiles should be carefully planned and managed prior to and during construction to consider the following.

- Where space allows, stockpiles should be kept below 2m in height and placed as elongated mounds with side slopes no steeper than 2(horizontal):1(vertical).
- Stockpiles should be constructed on the contour at least 2m (preferably 5m) from drainage, roads, existing vegetation and slopes steeper than 10 percent.
- Where practicable, stockpiles should be located at least 40 metres from existing water bodies.
- Stockpile surfaces should be stabilised if the stockpile is to be left in place for more than 10 days, for example by vegetation/hydroseeding or by the addition of gypsum.
- Stockpiles should be protected from run-on water by installing water diversion measures. Such water diversion measures include construction of an adequate earthen bank on the upslope side of the stockpile to divert water around the stockpile and sediment filters/fencing placed 1m to 2m down slope to protect other lands and waterways from sediment egress.
- Dust emissions should be controlled from stockpiles, earthworks, unsealed roads and other exposed surfaces. Surface sealants and/or water spray carts or other appropriate equipment should be used. If water is to be applied as a dust suppressant, the minimum amount of water necessary should be applied to exposed surfaces to keep the surface moist and not wet.

- Further recommendations regarding location and treatment of stockpiles should be referenced from the Landcom publication (2004) "Managing Urban Stormwater: Soils and Construction". An Erosion and Sediment Control plan should be developed by the appointed Contractor in accordance with this publication.

7.2 BUILDING DESIGN AND CONSTRUCTION

Building design and construction should consider minimising moisture contact to building materials and be carried out in accordance with mandatory requirements for building on saline soils set out in the Building Code of Australia. Guidance for construction in saline environments is also provided in the following Australian Standards:

- AS 2159 – 2009 Piling – Design and Installation;
- AS 2870 – 2011 Residential Slabs and Footings – Construction;
- AS 3600- 2009 Concrete Structures; and
- AS 3700 – 2011 Masonry Structures.

Construction sites affected by saline soils typically have the following considerations. It should be noted that the below listed items are typical considerations when building on sites with saline soils and shall not be construed as overriding or superseding any mandatory requirements of applicable standards, building codes or government/council requirements. Typical general requirements include:

1) Appropriate sub-soil drainage should be installed for all slabs, footings, retaining walls and pavements.
2) Landscaping and garden designs should prevent soil being directly placed against walls. Water usage should be minimised at the site during construction and following completion of the development.
3) Low water requiring plants and water-wise garden designs should be considered.
4) Water use on the site should be minimised and leaky pipes or drains should be repaired immediately to avoid water logging.
5) The use of grey water for the watering of lawns and gardens should be monitored to avoid water logging. The quality of the grey water should also be monitored as grey water can be high in salts.
6) Installed moisture prevention membranes should not be breached by any later works or additions such as; steps, verandas, walls, rendering, bagging, pointing, paving or landscaping.

7.2.1 Typical construction requirements for Slab-On-Ground and Shallow Footings

1) A layer of sand at least 50 mm deep should be provided under slabs.
2) A high density damp proof membrane (rather than a vapour proof membrane) should be laid under slabs.

3) The damp proof membrane should be extended to the outside face of the external edge beam up to the finished ground level.
4) Class 32 MPa (N32) concrete should be used or sulphate resisting Type SR cement with a water cement ratio of 0.5 should be used.
5) Slabs should be vibrated and cured for a minimum of three days.
6) The minimum cover to reinforcement should be 50 mm from unprotected ground.
7) The minimum cover to reinforcement should be 30 mm from a membrane in contact with the ground.
8) The minimum cover to reinforcement should be 50 mm for strip footings and beams irrespective of whether a damp proof membrane is used.
7) Suitable admixtures for waterproofing and/or corrosion prevention can be used.
8) The external finished surface should be graded away from the building to prevent moisture accumulating around buildings and minimise the potential for it to seep and accumulate beneath the slabs.

7.2.2 Typical Piled Footing Requirements

Guidance on design and construction of piles in saline environments is provided in AS2159-2009 "Piling- Design and Installation". In consideration of this standard, CES assessed that pile footings should be designed and constructed based on a site exposure classification of "Non-aggressive". The recommendations provided in AS2159 with regards to concrete strength, reinforcement cover and corrosion should be followed should concrete or steel piles be constructed at the site.

7.2.3 Typical Brickwork Requirements

1) The damp proof course should consist of polyethylene or polyethylene coated metal and be correctly placed.
2) Exposure class masonry units should be used below the damp proof course including for strip footings.
3) Appropriate mortar and mixing ratio should be used with exposure class masonry units.
4) Admixtures for waterproofing and/or corrosion prevention may be used.

Note: The above shall not be construed as overriding or superseding any mandatory requirements of applicable standards, building codes or government/council requirements.

7.3 UNDERGROUND SERVICES

Service trenches should be well drained to avoid ponding of water. Metal pipes are potentially susceptible to increased corrosion on sites affected by saline soils. Alternative materials should therefore be considered such as polybutylene or polyethylene for water supply. Unplasticised polyvinyl chloride (uPVC) may also be considered for plumbing pipes. Plastic pipes as opposed to concrete pipes should also be considered for stormwater, since the concrete may be susceptible

to attack from saline soils. Consideration should also be given to cathodic protection of services to reduce the risk of corrosion.

The presence of potential saline conditions should be considered in the choice of materials for power supply, power poles, and underground cables.

7.4 STORMWATER AND DRAINAGE

Effective and efficient site drainage should be provided. All areas immediately surrounding buildings and slabs should be graded to slope away from the structure to reduce the risk of ponding and the potential for increased infiltration.

Taps, water pipes or downpipes adjacent to buildings can make these areas susceptible to salinity problems, particularly if there are leaks in the system. Leaking sewer pipes can cause similar problems. Good quality design, workmanship and materials should be used and a programme of inspection and maintenance implemented. Any leaking pipes, taps, downspouts or sewers should be repaired or replaced immediately.

On site detention basins should be lined to reduce infiltration into the underlying soil. Suitable liners could include compacted clay liners, geosynthetic liners (such as High Density Polyethylene (HDPE)) or geocomposite liners. Should clay liners or geocomposite clay liners be the preferred option, the salt content of the liner material should be assessed to determine whether it will promote salinisation. Liner material assessed to promote salinisation should not be used.

7.5 LANDSCAPED AREAS

Landscaped areas should be constructed in accordance with recommendations made in the DIPNR (2004) “Waterwise Parks and Gardens” and a suitably qualified and experienced Landscape designer and horticulturalist should be engaged. General recommendations for the preparation of landscaped areas in saline soil affected areas typically include:

- Landscape areas should be constructed where practicable with soils sourced on-site. Should it be necessary to import material, soils should comply with specifications provided in AS4419 “Soils for Landscaping and Garden Use”.
- Soils used in landscaped areas should be keyed into compacted soil to ensure roots and nutrients can move from the new soil into the underlying ground.
- Raised beds and the installing of drainage lines to ensure areas are not permanently waterlogged.
- Mulching to reduce soil moisture loss and the need for irrigation.

- Should it be necessary to provide irrigation, the irrigation system should be such that it responds to changes in soil moisture and climate conditions to ensure that over watering is avoided.
- If grey water is to be considered for irrigation purposes, its quality should be carefully monitored as grey water can have a high salt content.
- Grassed areas should be kept to a minimum or preferably replaced with groundcover, shrubs or trees using native plants, which do not require fertilisation and require little or no watering.
- Topsoil or other suitable growth medium should be provided to an adequate depth to ensure healthy plant growth.
- Water features should be designed and constructed so that they do not leak or loose water that could result in water logging or increased infiltration.

Note: The above are typical measures implemented in areas affected by saline soils. These shall not be construed as overriding or superseding any mandatory requirements or applicable standards, codes or government/council requirements.

7.6 PAVEMENTS

The most appropriate course of action with regards to the construction of pavements in areas with saline soils is to prevent salt or the salt bearing water from entering the pavement. Pavements should be constructed with good drainage including any verge areas to minimise infiltration and migration of moisture through the road or pavement. Salt tolerant and durable materials should also be used to reduce the risk of damage and corrosion from saline conditions.

Other management strategies typically include, raising the road or pavement above saline soils by constructing an embankment of suitable material and/or installation of a drainage blanket under the pavement. In areas of poor subgrade, it may be prudent to carry out the necessary soil improvement.

7.7 RETAINING WALLS

Retaining walls should be designed and constructed in accordance with AS4678 (2002) Earth Retaining Structures, with particular attention being given to the provision of good drainage to prevent water accumulating behind retaining structures.

8 LIMITATIONS OF THIS REPORT

This report has been prepared for use by the client who commissioned the works in accordance with the project brief and based on information provided by the client. The advice contained in this report relates only to the current project and all results, conclusions and recommendations should be reviewed by a competent person with experience in environmental and geotechnical investigations before being used for any other purpose. Consulting Earth Scientists (CES) accepts no liability for use or interpretation by any person or body other than the client. This report must not be reproduced except in full and must not be amended in any way without prior approval by the client and CES.

Soil, rock and aquifer conditions are variable, resulting in the heterogeneous distribution of salinity and sodicity across the site. Sodicity and salinity concentrations have been identified at discrete locations, however conditions between sample locations have been inferred based on estimated geological and hydrogeological conditions, the nature and extent of identified highly saline and sodic soils. Boundaries between zones of variable salinity and sodicity are generally unclear and have been interpreted based on available data and professional judgement. The accuracy with which subsurface conditions have been characterised depends on the frequency of sampling, field and laboratory methods, the uniformity of the substrate and is therefore limited by the scope of works undertaken. Should information become available regarding conditions at the site, CES reserves the right to review the report in the context of the additional information.

9 REFERENCES

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Figures

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Figure 1. Site Location Plan

CES Project ID:	Date:
CES130608-BP	17/02/2023
Prepared By: T.Goodbody	Checked By: D. Lowe

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Title

Figure 2. Site Layout Plan and Sampling Locations

CES Project ID:	Date:
CES130608-BP	17/02/2023
Prepared By: T. Goodbody	Checked By: D.Lowe

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Figure 3. Site Groundwater Contour Plan

CES Project ID:	Date:
CES130608-BP	20/02/2023
Prepared By: T. Goodbody	Checked By: D.Lowe

Tables

Table 1: Generalised Subsurface Profile

Unit	Description	Depth to Base of Unit (mbgl)	Thickness (m)	Boreholes encountered
1	Fill: Sand / Silty Sand	0.5 - 2.8	0.5 – 2.8	BH1 to BH13
2a	Sandy Clay / Silty Clay	1.5 – 3.5	0.2 - 1.8	BH2, BH3, BH4, BH5, BH6, BH7, BH9, BH11, BH12, BH13
2b	Silty Sand / Clayey Sand	0.0 - 3.0	0.5 - 1.5	BH8, BH10, BH11, BH12, BH14
3	Sandstone	1.7 - 3.5	1.8	BH1

Table 2: Summary of Field and Laboratory Test Data Assessment

Borehole ID	Borehole Coordinates (MGA 94)		Groundwater depth	Sample Depth Range	Field Data Assessment									Laboratory Data Assessment									
					Soil							Groundwater		Soil									
	Easting	Northing			Material Description	Soil Texture Group	pH range	Electrical Conductivity (1:5) range	ECe range	Salinity Class range	Salinity Class	pH	Electrical Conductivity	Sample Depth	pH	Sulfate content	Chloride ion content	Aggressivity		Emerson Class	Organic Matter	ESP	Sodicity Class
																		To Concrete	To Steel				
			mbgl	mbgl			pH units	µS/cm	dS m-1	Class No.		pH units	µS/cm		pH units	ppm	ppm	per AS2159		Class No.	%	%	
BH1	329917	6243435	1.6	0.0-1.7	Fill: Silty Sand to Sand	Sand	5.72 - 6.03	22 – 172	0.37 - 2.92	S0-S1	Non-saline to moderately saline	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
				1.7-3.5	Sandstone	Sand	6.14 - 6.32	94 – 345	1.60 - 5.87	S0-S2													
BH2	330007	6243305	NE	0.0-2.8	Fill: Silty Sand to Sand	Sand	6.74 - 9.60	10 – 160	0.30 - 3.23	S0-S1	Non-saline to slightly saline	NT	NT	3.5	7.8	185.8	148.5	Non-aggressive	Non-aggressive	4	2.8	3	Non-sodic
				2.8-3.5	Sandy Clay	Clay Loam	8.54 - 9.11	376 – 450	3.23 – 3.87	S1													
BH3	329931	6243090	1.2	0.0-0.8	Fill: Sand	Sand	8.33 - 8.67	113 – 145	1.92 – 2.47	S0-S1	Non-saline to slightly saline	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
				0.8-1.5	Clay	Light Clay	7.78 - 8.20	190 – 193	1.63 - 1.66	S0													
BH4	329932	6242922	1.5	0.0-0.6	Fill: Sand	Sand to Sandy Loam	7.76 - 7.78	1100 – 1200	16.8 - 18.7	S4	Slightly saline to highly saline	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
				0.6-1.5	Sandy Clay	Light Clay	8.51 - 8.31	415 – 899	3.57 - 7.73	S1-S2													
BH5	329907	6242824	0.9	0.0-0.5	Fill: Sand	Sand	5.30 - 6.05	867 - 1450	7.45 - 24.65	S2-S4	Moderately to highly saline	6.63	1024	1.5	7.5	248.4	178.4	Non-aggressive	Non-aggressive	4	0.9	2	Non-sodic
				0.5-1.5	Sandy Clay	Clay Loam	6.50 - 6.61	1151 – 1162	9.90 - 9.99	S3													
BH6	6242930	329751	2.2	0.0-2.0	Fill: Sand	Sand	7.82 - 8.05	128 - 466	2.18 - 7.92	S1-S2	Non-saline to moderately saline	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
				2.0-3.5	Sandy Clay	Clay Loam to Light Clay	7.38 - 7.71	196 - 860	1.69 - 7.40	S0-S2													
BH7	6243050	329819	1	0.0-0.7	Fill: Sand	Sand	7.59 - 7.68	100 - 380	1.7-6.46	S1-S2	Non-saline to moderately saline	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
				0.7-2.5	Sandy Clay	Clay Loam to Light Clay	7.45 - 8.05	244 – 411	2.39 - 3.53	S0-S1													
BH8	6243200	329845	0.9	0.0-1.7	Fill: Sand	Sand	7.45 - 7.73	114 – 550	1.94 - 9.35	S0-S3	Non-saline to very saline	NT	NT	3	7.8	149.3	164	Non-aggressive	Non-aggressive	4	2.4	3	Non-sodic
				1.7-3.0	Clayey Sand	Sandy Loam	7.55 - 7.60	330 – 592	4.62 - 8.29	S2-S3													
BH9	6243330	329836	1.1	0.0-1.0	Fill: Sand	Sand	7.81 - 8.08	132 – 180	2.24 - 3.06	S1	Slightly saline	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
				1.0-2.5	Sandy Clay	Clay Loam	7.01 - 7.12	180 – 442	2.28 - 3.80	S1													
BH10	6243490	329790	NE	0.0-1.5	Fill: Sand	Sand	2.63 - 6.00	103 – 350	1.38 - 5.95	S1-S2	Slightly saline to very saline	NT	NT	2	7.4	154.2	323.5	Non-aggressive	Non-aggressive	4	2.9	NT	NT
				1.5-2.0	Silty Sand	Sand to Sandy Loam	2.53 - 2.65	773 – 875	10.8 - 14.88	S3													
BH11	6243360	329690	NE	0.0-0.5	Fill: Sand	Sand	7.05 - 7.53	40 – 70	0.68 - 1.19	S0	Non-saline to slightly saline	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
				0.5-1.5	Silty Clay	Clay Loam	6.22	132	1.14	S0													
				1.5-2.0	Silty Sand	Sand	6.41 - 6.45	112 – 156	1.90 - 2.65	S0-S1													
BH12	6243230	329639	1.3	0.0-0.8	Fill: Sand	Sand	8.02 - 8.15	54 – 75	0.92 - 1.28	S0	Non-saline	NT	NT	2.5	7.3	98.9	376.7	Non-aggressive	Non-aggressive	4	3.1	3	Non-sodic
				0.8-1.0	Silty Clay	Clay Loam	7.83	120	1.03	S0													
				1.0-2.5	Silty Sand	Clay Loam to Sandy Loam	7.05 - 7.45	40 – 132	0.34 - 1.85	S0													
BH13	6243070	329611	1.1	0.0-0.5	Fill: Sand	Sand	7.45 - 7.76	63 – 76	1.07 - 1.29	S0	Non-saline	NT	NT	2	4.2	432.8	117.4	Non-aggressive+	Non-aggressive+	6	3.1	*	NT
				0.5-1.5	Silty Clay	Sandy Loam	7.52	15	0.2	S0													
				1.5-2.0	Sandy Clay	Clay Loam	7.11 - 7.26	75 – 101	0.65 - 0.87	S0													
BH14	6243200	329449	0.4	0.0-1.5	Clayey Sand	Sand to Sandy Loam	6.16 - 6.41	38 – 85	0.53 - 1.44	S0	Non-saline	6.11	799	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT

*CEC < 10meq/100g, ESP cannot be calculated

+ Soils assessed to be non-aggressive to concrete and steel but pH is 4.2.

NE = Not encountered

NT = Not tested

ESP = Exchangeable sodium percentage

ECE = Electrical Conductivity x Multiplication Factor (M*)

Table 3: Laboratory Test Results for Groundwater Samples

Existing Monitoring Well ID	Salinity	Total Dissolved Solids	Resistivity	Electrical Conductivity	pH	Sulfate content	Chloride ion content
	mg/L	mg/L	Ohm m	µS/cm	pH units	ppm	ppm
BMW403	1100	920	6	1700	7.1	17	320
AMW205	2500	2500	2.6	3900	7	410	880

Table 4: Factors for Converting EC (1:5) to ECe (Table 6.1 of DLWC's Site Investigations for Urban Salinity, 2002)

Soil Texture Group	Multiplication Factors (M*)
Sands	17
Sandy loams	14
Loams	10
Clay loam	9
Light clays	8.5
Light medium clay	8
Medium clay	7
Heavy clays	6

Table 5: Soil Salinity Classification (Table 6.2 of DLWC's Site Investigations for Urban Salinity, 2002)

Class	Symbol	ECe	Comments
Non-saline	S0	<2	Salinity effects mostly negligible
Slightly saline	S1	2-4	Yield of very sensitive crops may be affected
Moderately saline	S2	4-8	Yields of many crops affected
Very saline	S3	8-16	Only tolerant crops yield satisfactorily
Highly saline	S4	>16	Only a few very tolerant crops yield satisfactorily

Table 6: Sodicity Rating (DLWC's Site Investigations for Urban Salinity, 2002)

ESP (%)	Rating
<5	Non-sodic
5-15	Sodic
>15	Highly Sodic

Table 7: Exposure Classification for Concrete Piles (Table 6.4.2C of AS2159- 2009 Piling Design and Installation)

Exposure Conditions		Exposure Classification	
Sulfates (SO_4) in Soil ppm	**pH**	**Soil Conditions A**	**Soil Conditions B**
<5,000	>5.5	Mild	Non-aggressive
5,000-10,000	4.5-5.5	Moderate	Mild
10,000-20,000	4-4.5	Severe	Moderate
>20,000	<4	Very Severe	Severe

Soil Conditions A: High permeability soils which are in groundwater

Soil Conditions B: Low permeability soils or all soils above groundwater

Table 8: Exposure Classification for Steel Piles (Table 6.5.2C of AS2159- 2009 Piling Design and Installation)

Exposure Conditions		Exposure Classification	
Chlorides Cl in Soil ppm	**pH**	**Soil Conditions A**	**Soil Conditions B**
<5,000	>5	Non-aggressive	Non-aggressive
5,000-20,000	4-5	Mild	Non-aggressive
20,000-50,000	3-4	Moderate	Mild
>50,000	<3	Severe	Moderate

Appendix A
Borehole Logs

Borelog Symbols and Notes

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DRILLING INFORMATION:

Support		Method		Water	
None	No support provided	HA	HAND AUGER		Inflow of water
Mud	Drilling mud used	RA	ROTARY AIR		Water Loss
NQ	NQ size drilling pipe (69.9 mm ODia)	ADV	Auger 'V'-STEEL BIT		Water Level during drilling / excavation
HQ	HQ size drilling pipe (88.9 mm ODia)	ADTC	Auger 'TUNGSTEN-CARBIDE' BIT		Stabilised Water Level
PQ	PQ size drilling pipe (139.9mm ODia)	NMLC	DIAMOND CORING		Inflow of water/Stabilised water level
		HFAD	HOLLOW FLIGHT AUGUER DRILLING		

SAMPLING:

Sample ID

ddmmyy-01-SM Date-Sample Number-Initials of Sampler

Note : Sample Depth is indicated by horizontal lines which define the start and end depths

Type		
	D	Small Disturbed Sample
	U50	Undisturbed 50mm dia. tube sample
	B	Bulk Disturbed Sample
	PT	Geoprobe Push Tube Sample in
	J	Environmental Sample collected in a laboratory supplied glass jar
	SPT	SPT Split Tube Sampler

FIELD TESTS:

Standard Penetration Test (SPT)

2 / 3 / 4	Number of blows per 150mm over a depth of 450mm
N = 7	SPT "N" number = sum of last two blow counts
R	Refusal. SPT not able to penetrate
HB	Hammer Bouncing

Vane Shear

VS=30 Vane Shear Reading of 30 kPa

Pocket Penetrometer

PP=100 Pocket Penetrometer Reading of 100 kPa

SYMBOLS:

Soils			Rocks		Other	
FILL	SAND		GNEISS		NO CORE	
TOPSOIL	CLAYEY SAND		CONGLOMERATE		ASPHALT	
CLAY	SILTY SAND		GRANITE		BENTONITE PLUG	
SANDY CLAY	GRAVELLY SAND		LIMESTONE		WELL SCREEN	
SILTY CLAY	GRAVEL		SANDSTONE		WELL BACKFILLED SAND	
GRAVELLY CLAY	CLAYEY GRAVEL		SILTSTONE, MUDSTONE		CONCRETE	
SILT	SILTY GRAVEL		SHALE			
CLAYEY SILT	SANDY GRAVEL		SHALEY CLAY (Extremely Weathered Shale)			
SANDY SILT	PEAT		VOLCANIC BRECCIA			
GRAVELLY SILT			BASALT			

NATURAL ROCK DEFECTS:

Description Order:

Fracture Type, Orientation, Infilling, Shape, Roaghness, Other

Fracture Type		Orientation		Infilling	
JT	Joint	VT	Vertical	CN	Clean
PT	Bedding Plane Parting	HZ (or 0o)	Horizontal	X	Carbonaceous
SM	Seam	X o	X' degrees from Horizontal	CLAY	Clay
FZ	Fragmented Zone			CA	Calcite
SZ	Shear Zone			FE	Iron Oxide
VN	Vein			MI	Micaceous
				QZ	Quartz

Shape		Roughness		Others	
PLN	Planar	POL	Polished	DIS	Discontinuous
CU	Curved	SLK	Slickensided	TI	Tight
UN	Undulose	SO	Smooth		
ST	Stepped	RF	Rough		
IR	Irregular	VR	Very		

Notes:

* relative density for gravels and sands have been assumed based on qualitative observatins

Project ID:	CES130608-BP	**Easting:**	329917
Project:	Cooks Cove Northern Precinct	**Northing:**	6243435
Client:	Boyd Properties Pty Ltd	**Elevation:**	-
Location:	Kogarah Golf Club		

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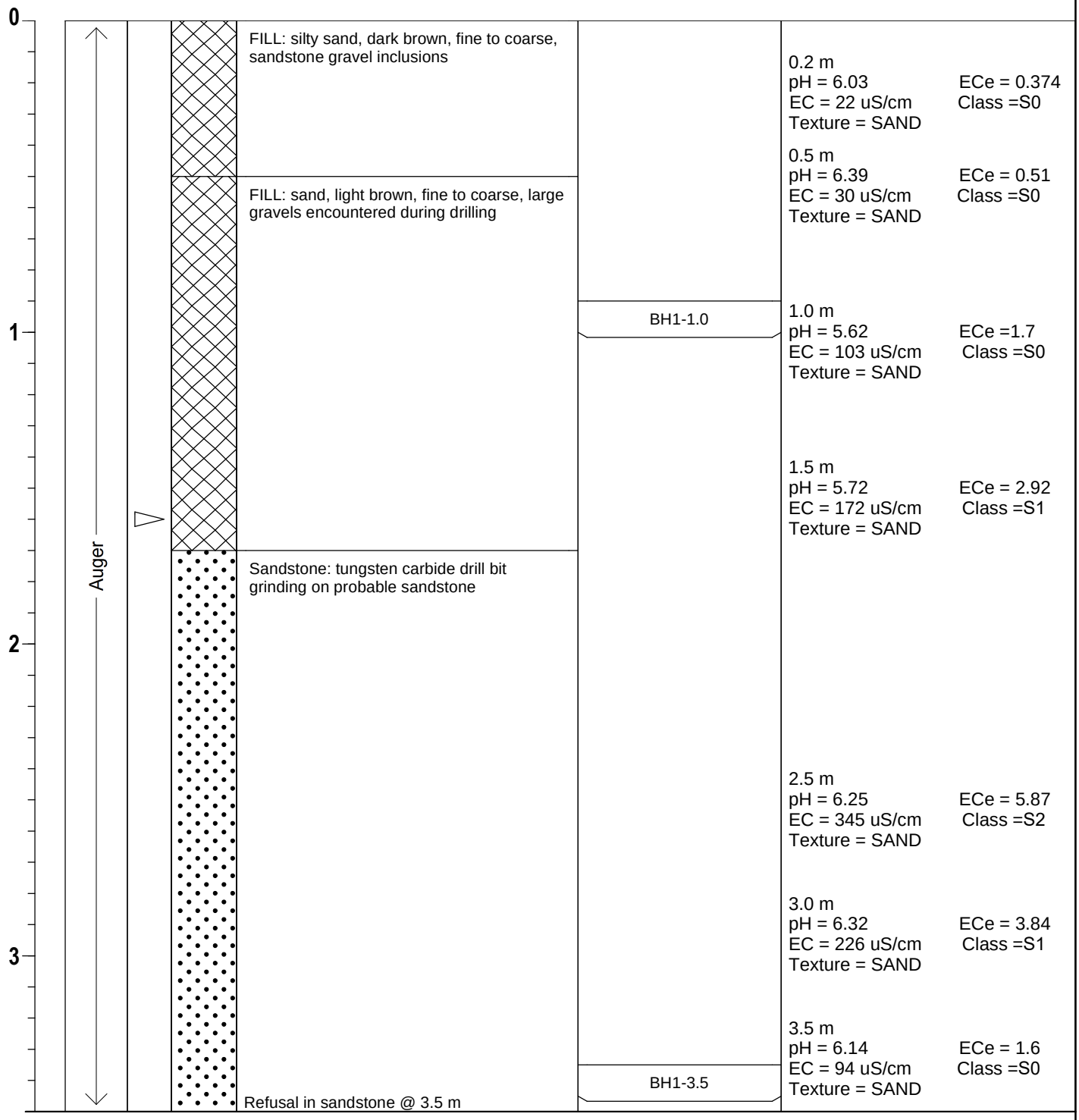
Environmental Log: BH1



Drill Company:	SDI	**Date Commenced:**	24/02/17
Drill Model:	Landcruiser Rig	**Date Completed:**	24/02/17
Hole Diameter (mm):	100	**Logged/checked by:**	MR/MC

Project ID:	CES130608-BP	**Easting:**	330007
Project:	Cooks Cove Northern Precinct	**Northing:**	6243305
Client:	Boyd Properties Pty Ltd	**Elevation:**	-
Location:	Kogarah Golf Club		

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Environmental Log: BH2

DRILLING INFO.			LITHOLOGY		SAMPLING & SCREENING INFORMATION	
Depth	Method	Water	Symbol	Description	Sample ID	Salinity Assessment
0	Auger			FILL: silty sand, dark brown, fine to coarse, coarse gravel inclusions		0.2 m pH = 6.74 ECe = 0.3 EC = 18 uS/cm Class =S0 Texture = SAND 0.5 m pH = 6.78 ECe = 0.17 EC = 10 uS/cm Class =S0 Texture = SAND
1					BH2-1.0	1.0 m pH = 7.39 ECe =0.34 EC = 20 uS/cm Class = S0 Texture = SAND
				FILL: sand, dark brown, fine to coarse, brick fragments, steel, fly ash inclusions		1.5 m pH = 7.40 ECe =0.85 EC = 50 uS/cm Class =S0 Texture = SAND
2						2.0 m pH = 9.74 ECe = 3.23 EC = 190 uS/cm Class =S1 Texture = SAND
						2.5 m pH = 9.60 ECe = 2.72 EC = 160 uS/cm Class =S1 Texture = SAND
3				Sandy CLAY: grey/ dark brown, fine to coarse sand, medium plasticity, damp, swampy odour		3.0 m pH = 9.11 ECe = 3.87 EC = 450 uS/cm Class =S1 Texture = CLAY LOAM
				BH terminated in natural ground @ 3.5	BH2-3.5	3.5 m pH = 8.54 ECe =3.23 EC = 376 uS/cm Class =S1 Texture = CLAY LOAM

Drill Company:	SDI	**Date Commenced:**	24/02/17
Drill Model:	Landcruiser Rig	**Date Completed:**	24/02/17
Hole Diameter (mm):	100	**Logged/checked by:**	MR/MC

Project ID: CES130608-BP **Easting:** 329931

Project: Cooks Cove Northern Precinct **Northing:** 6243090

Client: Boyd Properties Pty Ltd **Elevation:** -

Location: Kogarah Golf Club

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Suite 3, Level 1
55-65 Grandview Street, Pymble NSW 2073
PH: (02) 8569 2200 FAX: (02) 9983 0582

Environmental Log: BH3

DRILLING INFO.			LITHOLOGY		SAMPLING & SCREENING INFORMATION	
Depth	Method	Water	Symbol	Description	Sample ID	Salinity Assessment
0	Auger			FILL: sand, light brown, medium to coarse, moist, coarse gravel inclusions		0.2 m pH = 8.67 ECe = 1.92 EC = 113 uS/cm Class =S0 Texture = SAND
					BH3-0.5	0.5 m pH = 8.33 ECe = 2.465 EC = 145 uS/cm Class =S1 Texture = SAND
1				CLAY: with sand, dark brown/ black, high plasticity, fine to coarse sand, swampy odour		1.0 m pH = 7.78 ECe =1.634 EC = 190 uS/cm Class =S0 Texture = LIGHT CLAY
					BH3-1.5	1.5 m pH = 8.20 ECe =1.66 EC = 193 uS/cm Class =S0 Texture = LIGHT CLAY
2				BH terminated in natural ground @ 1.5 m		
3						

Drill Company: SDI **Date Commenced:** 24/02/17

Drill Model: Landcruiser Rig **Date Completed:** 24/02/17

Hole Diameter (mm): 100 **Logged/checked by:** MR/MC

Project ID:	CES130608-BP	**Easting:**	329932
Project:	Cooks Cove Northern Precinct	**Northing:**	6242922
Client:	Boyd Properties Pty Ltd	**Elevation:**	-
Location:	Kogarah Golf Club		

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Environmental Log: BH4

DRILLING INFO.			LITHOLOGY		SAMPLING & SCREENING INFORMATION	
Depth	Method	Water	Symbol	Description	Sample ID	Salinity Assessment
0	Auger			FILL: sand, light brown/grey, medium to coarse, moist, coarse gravel and organic (rootlets) inclusions		0.2 m pH = 7.76 ECe = 18.7 EC = 1100 uS/cm Class =S4 Texture = SAND
					BH4-0.5	0.5 m pH = 7.78 ECe = 16.8 EC = 1200 uS/cm Class =S4 Texture = SANDY LOAM
1				Sandy CLAY: dark brown/ black, fine to coarse sand, moist, swampy odour grading into silty clay		1.0 m pH = 8.51 ECe =3.57 EC = 415 uS/cm Class =S1 Texture = LIGHT CLAY
					BH4-1.5	1.5 m pH = 8.31 ECe =7.73 EC = 899 uS/cm Class =S2 Texture = LIGHT CLAY
2				BH terminated in natural ground @ 1.5 m		
3						

Drill Company:	SDI	**Date Commenced:**	24/02/17
Drill Model:	Landcruiser Rig	**Date Completed:**	24/02/17
Hole Diameter (mm):	100	**Logged/checked by:**	MR/MC

Project ID:	CES130608-BP	**Easting:**	329907
Project:	Cooks Cove Northern Precinct	**Northing:**	6242824
Client:	Boyd Properties Pty Ltd	**Elevation:**	-
Location:	Kogarah Golf Club		

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Environmental Log: BH5

DRILLING INFO.			LITHOLOGY		SAMPLING & SCREENING INFORMATION	
Depth	Method	Water	Symbol	Description	Sample ID	Salinity Assessment
0	Auger			FILL: sand with gravel, mottled brown, dark brown, grey and orange, fine to coarse, coarse gravels		0.2 m pH = 5.30 ECe = 24.65 EC = 1450 uS/cm Class =S4 Texture = SAND
					BH5-0.5	0.5 m pH = 6.05 ECe = 7.45 EC = 867 uS/cm Class =S2 Texture = CLAY LOAM
1				Sandy CLAY: dark brown/ grey, fine to coarse sand, wet, high plasticity, swampy odour		1.0 m pH = 6.61 ECe =9.9 EC = 1151 uS/cm Class =S3 Texture = CLAY LOAM
					BH5-1.5	1.5 m pH = 6.50 ECe =9.99 EC = 1162 uS/cm Class =S3 Texture = CLAY LOAM
				BH terminated in natural ground @ 1.5 m		
2						Groundwater sample: DO = 0.10 mg/L EC = 10240 uS/cm pH = 6.63 Redox = -27 mV Temperature = 23.7 deg C
3						

Drill Company:	SDI	**Date Commenced:**	24/02/17
Drill Model:	Landcruiser Rig	**Date Completed:**	24/02/17
Hole Diameter (mm):	100	**Logged/checked by:**	MR/MC

Project ID:	CES130608-BP	**Easting:**	329751
Project:	Cooks Cove Northern Precinct	**Northing:**	6242930
Client:	Boyd Properties Pty Ltd	**Elevation:**	-
Location:	Kogarah Golf Club		

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Environmental Log: BH6

DRILLING INFO.			LITHOLOGY		SAMPLING & SCREENING INFORMATION	
Depth	Method	Water	Symbol	Description	Sample ID	Salinity Assessment
0	Auger			FILL: sand, light brown, medium to coarse		0.2 m pH = 8.05 ECe = 2.21 EC = 130 uS/cm Class =S1 Texture = SAND 0.5 m pH = 8.06 ECe = 2.176 EC = 128 uS/cm Class =S1 Texture = SAND
1				becoming silty	BH6-1.0	1.0 m pH = 8.19 ECe =2.278 EC = 134 uS/cm Class =S1 Texture = SAND 1.5 m pH = 7.82 ECe =7.92 EC = 466 uS/cm Class =S2 Texture = SAND
2				Sandy CLAY: dark brown/ black, fine to coarse sand, wet, high plasticity, peaty/organic odour		2.0 m pH = 7.38 ECe =2.39 EC = 278 uS/cm Class =S1 Texture = CLAY LOAM 2.5 m pH =7.68 ECe =1.69 EC = 196 uS/cm Class =S0 Texture = CLAY LOAM
3				BH terminated in natural ground @ 3.5 m	BH6-3.5	3.0 m pH = 7.61 ECe =7.03 EC = 817 uS/cm Class =S2 Texture = LIGHT CLAY 3.5 m pH = 7.71 ECe =7.4 EC = 860 uS/cm Class =S2 Texture = LIGHT CLAY

Drill Company:	SDI	**Date Commenced:**	23/02/17
Drill Model:	Landcruiser Rig	**Date Completed:**	23/02/17
Hole Diameter (mm):	100	**Logged/checked by:**	MR/MC

Project ID:	CES130608-BP	**Easting:**	329819
Project:	Cooks Cove Northern Precinct	**Northing:**	6243050
Client:	Boyd Properties Pty Ltd	**Elevation:**	-
Location:	Kogarah Golf Club		

CONSULTING EARTH SCIENTISTS
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Environmental Log: BH7

DRILLING INFO.			LITHOLOGY		SAMPLING & SCREENING INFORMATION	
Depth	Method	Water	Symbol	Description	Sample ID	Salinity Assessment
0	Auger			FILL: sand, dark brown, medium to coarse, shell inclusions		0.2 m pH = 7.59 ECe = 1.7 EC = 100 uS/cm Class =S0 Texture = SAND
				becoming grey		0.5 m pH = 7.68 ECe = 6.46 EC = 380 uS/cm Class =S2 Texture = SAND
1				Sandy CLAY: dark brown, high plasticity, medium to coarse sand, grey sand lense @ 1.0 m (0.2 m thick)	BH7-1.0	1.0 m pH = 7.45 ECe =2.39 EC = 278 uS/cm Class =S1 Texture = CLAY LOAM
						1.5 m pH = 8.05 ECe =2.10 EC = 244 uS/cm Class =S1 Texture = CLAY LOAM
2						2.0 m pH = 7.84 ECe = 2.82 EC = 328 uS/cm Class =S1 Texture = LIGHT CLAY
					BH7-2.5	2.5 m pH =7.76 ECe = 3.53 EC = 411 uS/cm Class =S1 Texture = LIGHT CLAY
3				BH terminated in natural ground @ 2.5 m		

Drill Company:	SDI	**Date Commenced:**	23/02/17
Drill Model:	Landcruiser Rig	**Date Completed:**	23/02/17
Hole Diameter (mm):	100	**Logged/checked by:**	MR/MC

Project ID: CES130608-BP **Easting:** 329845

Project: Cooks Cove Northern Precinct **Northing:** 6243200

Client: Boyd Properties Pty Ltd **Elevation:** -

Location: Kogarah Golf Club

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Environmental Log: BH8

DRILLING INFO.			LITHOLOGY		SAMPLING & SCREENING INFORMATION	
Depth	Method	Water	Symbol	Description	Sample ID	Salinity Assessment
0	Auger			FILL: sand, light brown, shell inclusions, fine to coarse		0.2 m pH = 7.45 ECe = 1.94 EC = 114 uS/cm Class =S0 Texture = SAND 0.5 m pH = 7.66 ECe = 2.10 EC = 123 uS/cm Class =S1 Texture = SAND
1					BH8-1.0	1.0 m pH = 7.73 ECe =2.99 EC = 176 uS/cm Class =S1 Texture = SAND
						1.5 m pH = 7.67 ECe =9.35 EC = 550 uS/cm Class =S3 Texture = SAND
2				Clayey SAND: dark brown/ black, high plasticity, medium to coarse sand, peaty/ organic odour		2.0 m pH = 7.60 ECe = 4.62 EC = 330 uS/cm Class =S2 Texture = SANDY LOAM
						2.5 m pH =7.63 ECe = 8.29 EC = 592 uS/cm Class =S3 Texture = SANDY LOAM
3				BH terminated in natural ground @ 3 m	BH8-3.0	3.0 m pH =7.55 ECe = 7.91 EC = 565 uS/cm Class =S3 Texture = SANDY LOAM

Drill Company: SDI **Date Commenced:** 23/02/17

Drill Model: Landcruiser Rig **Date Completed:** 23/02/17

Hole Diameter (mm): 100 **Logged/checked by:** MR/MC

Project ID:	CES130608-BP	**Easting:**	329836
Project:	Cooks Cove Northern Precinct	**Northing:**	6243330
Client:	Boyd Properties Pty Ltd	**Elevation:**	-
Location:	Kogarah Golf Club		

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Environmental Log: BH9

DRILLING INFO.			LITHOLOGY		SAMPLING & SCREENING INFORMATION	
Depth	Method	Water	Symbol	Description	Sample ID	Salinity Assessment
0	Auger			FILL: sand, light brown/ grey, fine to coarse, orange/brown stains		0.2 m pH = 8.08 ECe = 2.24 EC = 132 uS/cm Class =S1 Texture = SAND 0.5 m pH = 7.92 ECe = 2.567 EC = 151 uS/cm Class =S1 Texture = SAND
1				Sandy CLAY: dark brown, high plasticity, medium to coarse sand, shell inclusions	BH9-1.0	1.0 m pH = 7.81 ECe = 3.06 EC = 180 uS/cm Class =S1 Texture = SAND 1.5 m pH = 7.02 ECe =3.76 EC = 437 uS/cm Class =S1 Texture = CLAY LOAM
2						2.0 m pH = 7.12 ECe = 2.28 EC = 265 uS/cm Class =S1 Texture = CLAY LOAM
3				BH terminated in natural ground @ 2.5 m	BH9-2.5	2.5 m pH =7.01 ECe = 3.8 EC = 442 uS/cm Class =S1 Texture = CLAY LOAM

Drill Company:	SDI	**Date Commenced:**	23/02/17
Drill Model:	Landcruiser Rig	**Date Completed:**	23/02/17
Hole Diameter (mm):	100	**Logged/checked by:**	MR/MC

Project ID: CES130608-BP **Easting:** 329790

Project: Cooks Cove Northern Precinct **Northing:** 329790

Client: Boyd Properties Pty Ltd **Elevation:** -

Location: Kogarah Golf Club

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Environmental Log: BH10

DRILLING INFO.			LITHOLOGY		SAMPLING & SCREENING INFORMATION	
Depth	Method	Water	Symbol	Description	Sample ID	Salinity Assessment
0				FILL: sand, light to dark brown, fine grain, traces of silt		0.2 m pH = 6.00 ECe = 5.95 EC = 350 uS/cm Class =S2 Texture = SAND
					BH10-0.5	0.5 m pH = 4.81 ECe = 1.75 EC = 103 uS/cm Class =S0 Texture = SAND
1	Auger					1.0 m pH = 2.63 ECe = 5.236 EC = 308 uS/cm Class =S2 Texture = SAND
				Silty SAND: dark grey, medium to coarse, saturated		1.5 m pH = 2.53 ECe =14.875 EC = 875 uS/cm Class =S3 Texture = SAND
2				BH terminated in natural ground @ 2 m	BH10-2.0	2.0 m pH = 2.65 ECe = 10.8 EC =773 uS/cm Class =S3 Texture = SANDY LOAM
3						

Drill Company: SDI **Date Commenced:** 23/02/17

Drill Model: Landcruiser Rig **Date Completed:** 23/02/17

Hole Diameter (mm): 100 **Logged/checked by:** MR/MC

Project ID: CES130608-BP **Easting:** 329690

Project: Cooks Cove Northern Precinct **Northing:** 6243360

Client: Boyd Properties Pty Ltd **Elevation:** -

Location: Kogarah Golf Club

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Environmental Log: BH11

DRILLING INFO.			LITHOLOGY		SAMPLING & SCREENING INFORMATION	
Depth	Method	Water	Symbol	Description	Sample ID	Salinity Assessment
0				FILL: sand, fine to coarse, light brown, shell inclusions		0.2 m pH = 7.05 ECe = 0.68 EC = 40 uS/cm Class =S0 Texture = SAND
						0.5 m pH = 7.53 ECe = 1.19 EC = 70 uS/cm Class =S0 Texture = SAND
1	Auger			Silty CLAY: dark brown, medium to coarse, high plasticity	BH11-1.0	1.0 m pH = 6.22 ECe = 1.135 EC = 132 uS/cm Class = S0 Texture = CLAY LOAM
						1.5 m pH = 6.41 ECe =2.65 EC = 156 uS/cm Class =S1 Texture = SAND
				Silty SAND: grey, medium to coarse, saturated		
2				BH terminated in natural ground @ 2 m	BH11-2.0	2.0 m pH = 6.45 ECe = 1.90 EC =112 uS/cm Class =S0 Texture = SAND
3						

Drill Company: SDI **Date Commenced:** 23/02/17

Drill Model: Landcruiser Rig **Date Completed:** 23/02/17

Hole Diameter (mm): 100 **Logged/checked by:** MR/MC

Project ID:	CES130608-BP	**Easting:**	329639
Project:	Cooks Cove Northern Precinct	**Northing:**	6243230
Client:	Boyd Properties Pty Ltd	**Elevation:**	-
Location:	Kogarah Golf Club		

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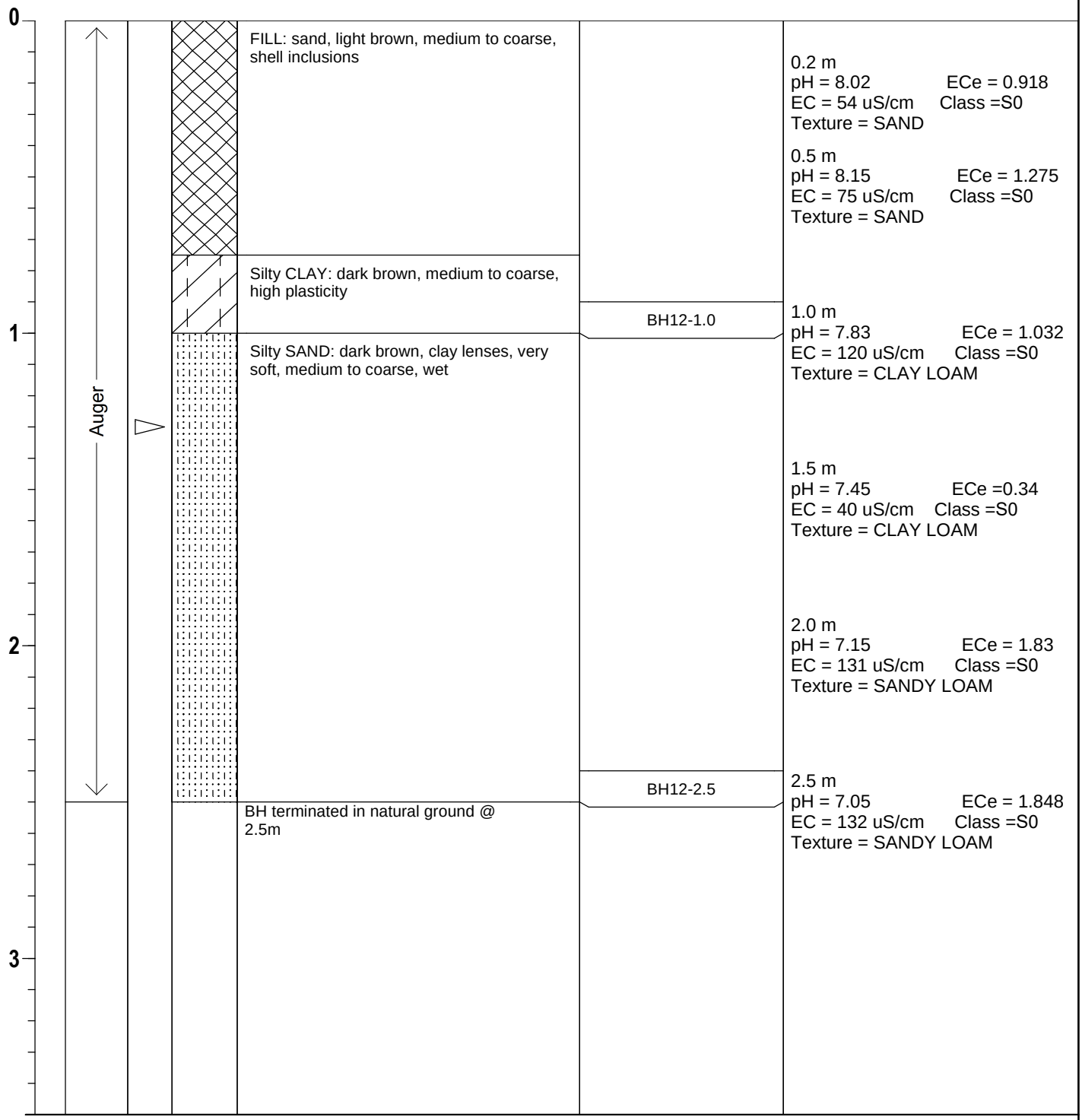
Environmental Log: BH12



DRILLING INFO.			LITHOLOGY		SAMPLING & SCREENING INFORMATION	
Depth	Method	Water	Symbol	Description	Sample ID	Salinity Assessment

Drill Company:	SDI	**Date Commenced:**	23/02/17
Drill Model:	Landcruiser Rig	**Date Completed:**	23/02/17
Hole Diameter (mm):	100	**Logged/checked by:**	MR/MC

Project ID: CES130608-BP
Project: Cooks Cove Northern Precinct
Client: Boyd Properties Pty Ltd
Location: Kogarah Golf Club

Easting: 329611
Northing: -6243070
Elevation: -

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Environmental Log: BH13

DRILLING INFO.			LITHOLOGY		SAMPLING & SCREENING INFORMATION	
Depth	Method	Water	Symbol	Description	Sample ID	Salinity Assessment
0				FILL: sand, light brown, fine to coarse		0.2 m pH = 7.76 ECe = 1.29 EC = 76 uS/cm Class =S0 Texture = SAND 0.5 m pH = 7.45 ECe = 1.07 EC = 63 uS/cm Class =S0 Texture = SAND
1	Auger			Silty CLAY: dark brown, high plasticity becoming wet	BH13-1.0	1.0 m pH = 7.52 ECe = 0.2 EC = 14.6 uS/cm Class =S0 Texture = SANDY LOAM
				Sandy CLAY: dark brown/ black, fine to coarse sand, medium to high plasticity, wet, peaty/ organic odour		1.5 m pH = 7.26 ECe =0.87 EC = 101 uS/cm Class =S0 Texture = CLAY LOAM
2				BH terminated in natural ground @ 2.0m	BH13-2.0	2.0 m pH = 7.11 ECe = 0.65 EC = 75 uS/cm Class =S0 Texture = CLAY LOAM
3						Groundwater sample: DO = 0.52 mg/L pH = 6.65 pH units EC = 1079 uS/cm Redox = 95 mV Temperature = 24.1 deg C

Drill Company: SDI
Drill Model: Landcruiser Rig
Hole Diameter (mm): 100

Date Commenced: 23/02/17
Date Completed: 23/02/17
Logged/checked by: MR/MC

Project ID:	CES130608-BP	**Easting:**	329449
Project:	Cooks Cove Northern Precinct	**Northing:**	6243200
Client:	Boyd Properties Pty Ltd	**Elevation:**	-
Location:	Kogarah Golf Club		

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Environmental Log: BH14

DRILLING INFO.			LITHOLOGY		SAMPLING & SCREENING INFORMATION	
Depth	Method	Water	Symbol	Description	Sample ID	Salinity Assessment
0	Auger			Clayey SAND: dark brown, fine to coarse, medium plasticity, peaty/organic odour		0.2 m pH = 6.39 ECe = 1.438 EC = 84.6 uS/cm Class =S0 Texture = SAND 0.5 m pH = 6.16 ECe = 0.85 EC = 50 uS/cm Class =S0 Texture = SAND
1				clay seam 0.1 m thick clay seam 0.1 m thick		1.0 m pH = 6.46 ECe = 0.532 EC = 38 uS/cm Class =S0 Texture = SANDY LOAM
				BH terminated in natural ground @ 1.5m	BH14-1.5	1.5 m pH = 6.41 ECe =0.532 EC = 38 uS/cm Class =S0 Texture = SANDY LOAM
2						Groundwater sample: DO = 0.38 mg/L EC = 799 uS/cm pH = 6.11 pH units Redox = 50 mV Temperature = 24.8 deg C
3						

Drill Company:	SDI	**Date Commenced:**	23/02/17
Drill Model:	Landcruiser Rig	**Date Completed:**	23/02/17
Hole Diameter (mm):	100	**Logged/checked by:**	MR/MC

Appendix B
Laboratory Certificates of Analysis

EMERSON CLASS REPORT

Client:	Consulting Earth Scientists	**Source:**	BH2-3.5
Address:	Suite 3, Level 1, 55, Grandview Street, Pymble, NSW, 2073	**Sample Description:**	silty clayey SAND
Project:	Cooks Cove	**Report No:**	S22121-ECT
Job No:	S17071	**Lab No:**	S22121

Test Procedure: ☑ AS1289 3.8.1 Soil classification tests - Dispersion - Determination of Emerson class number of a soil

Sampling: Sampled by Client **Date Sampled:** 23-24.02.17

Preparation: Prepared in accordance with the test method

"IMMERSION"

- ☐ does not slake
- ☑ slakes
  - 7 ☐ swells
  - 8 ☐ does not swell

1 ☐ complete dispersion
2 ☐ partial dispersion
☑ no dispersion
- 2.1 ☐ moderate
- 2.2 ☐ slight

"REMOULD ETC."

3 ☐ disperses
☑ does not disperse
- 3.1 ☐ complete
- 3.2 ☐ moderate
- 3.3 ☐ slight

"CARBONATE & GYPSUM"

4 ☑ present
☐ absent

"VIGOROUS SHAKING"

- ☐ disperses 5
- ☐ does not disperse 6

Water Type	**Distilled**
Water Source	**Lab**
Water Temperature (°c)	**21**

RESULT:

Emerson Class No. **4**

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NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

20/03/2017

Date:

MACQUARIE GEOTECH
Macquarie Geotechnical
Unit 8/10
Bradford Street
Alexandria NSW 2015

ORGANIC MATTER REPORT

Client:	Consulting Earth Scientists	**Source:**	BH2 3.5
Address:	Cooks Cove	**Sample Description:**	Silty SAND
Project:	Cooks Cove	**Report No:**	B36868-OC
Job No:	S17071	**Lab No:**	B36868 (S22121)

Test Procedure: ☑ AS1289 4.1.1 Soil Chemical Tests - Determination of the organic matter content of a soil - Normal method

Sampling:	Sampled by Client	**Date Sampled:**	23-24/02/17
Preparation:	Prepared in accordance with the test method		

Organic Matter (%)	2.8

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NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Brad Morris

14/03/2017

Date:

Macquarie Geotechnical
3 Watt Drive
Bathurst NSW 2795

SOIL CHEMICAL PROPERTIES REPORT

Client:	Consulting Earth Scientists	**Source:**	BH2 3.5
Address:	Cooks Cove	**Sample Description:**	Silty SAND
Project:	Cooks Cove	**Report No:**	B36868-SCP
Job No:	S17071	**Lab No:**	B36868 (S22121)

Test Procedure:

☐	AS1289 4.2.1	Soil Chemical Tests - Determination of a sulfate content of a natural soil and the sulfate content of the groundwater - Normal Method
☐	AS1289 4.3.1	Soil Chemical Tests - Determination of the pH value of a soil - Electrometric method
☑	AS 1289 4.4.1	Soil Chemical Tests - Determination of the electrical resistivity of a soil - Method for sands and granular material
☐	AS 1012.20	Chloride and sulphate
☐	RMS T123	pH value of a soil (electrometric method)
☐	RMS T185	Resistivity of sands and granular road construction materials
☐	RMS T200	Chloride content of roadbase
☐	RMS T1010	Quantitative determination of chlorides in soil
☐	RMS T1011	Quantitative determination of sulphates in soil
☐	BS1377(1990 pt.3)	Water soluble sulphate content
☑	APHA 4500 H+B	pH
☑	APHA 4500 SO4 2-B	Sulphate
☑	APHA 4500 Cl-B	Chloride
☐	APHA 2510 & 2520-B	Electrical Conductivity
☐	TAI B117	Sulphides Present (This service Not Covered by NATA Accreditation)

Sampling:	Sampled by Client	**Date Sampled:**	23-24/02/17
Preparation:	Prepared in accordance with the test method		

Sulphides Present	-
Sulphur Peroxide (%)	-
Sulphate content (ppm)	185.8
Sulphate content (%)	-
Chloride ion content (ppm)	148.5
Chloride ion content (%)	0.01
pH	7.8
Electrical Conductivity (uS/cm)	-
Mean Resistivity Ω.m	44
(Resisitivity) Density ratio (R_D)	90
(Resisitivity) Density index (I_D)	-

NATA

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NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Brad Morris

14/03/2017

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
Unit 8/10
Bradford Street
Alexandria NSW 2015

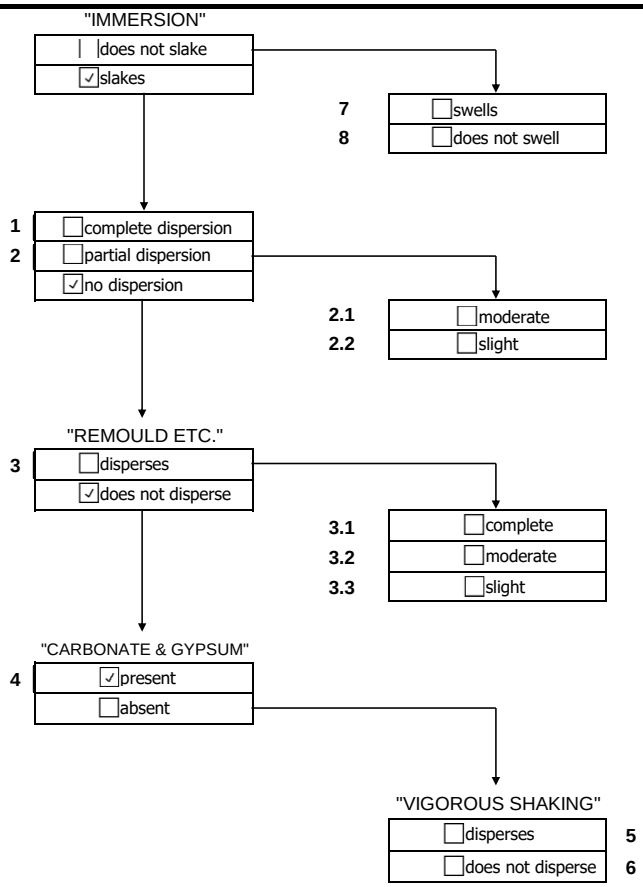
EMERSON CLASS REPORT

Client:	Consulting Earth Scientists	**Source:**	BH5-1.5
Address:	Suite 3, Level 1, 55, Grandview Street, Pymble, NSW, 2073	**Sample Description:**	silty clayey SAND
Project:	Cooks Cove	**Report No:**	S22122-ECT
Job No:	S17071	**Lab No:**	S22122

Test Procedure: ☑ AS1289 3.8.1 Soil classification tests - Dispersion - Determination of Emerson class number of a soil

Sampling: Sampled by Client **Date Sampled:** 23-24.02.17

Preparation: Prepared in accordance with the test method



Water Type	**Distilled**
Water Source	**Lab**
Water Temperature (°c)	**21**

RESULT:

Emerson Class No. **4**

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NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

Date: 20/03/2017

MACQUARIE GEOTECH

Macquarie Geotechnical
Unit 8/10
Bradford Street
Alexandria NSW 2015

ORGANIC MATTER REPORT

Client:	Consulting Earth Scientists	**Source:**	BH5 1.5
Address:	Cooks Cove	**Sample Description:**	Silty SAND
Project:	Cooks Cove	**Report No:**	B36869-OC
Job No:	S17071	**Lab No:**	B36869 (S22122)

Test Procedure: ☑ AS1289 4.1.1 Soil Chemical Tests - Determination of the organic matter content of a soil - Normal method

Sampling:	Sampled by Client	**Date Sampled:**	23-24/02/17
Preparation:	Prepared in accordance with the test method		

Organic Matter (%)	0.9

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Brad Morris

14/03/2017

Date:

Macquarie Geotechnical
Unit 8/10
Bradford Street
Alexandria NSW 2015

SOIL CHEMICAL PROPERTIES REPORT

Client:	Consulting Earth Scientists	**Source:**	BH5 1.5
Address:	Cooks Cove	**Sample Description:**	Silty SAND
Project:	Cooks Cove	**Report No:**	B36869-SCP
Job No:	S17071	**Lab No:**	B36869 (S22122)

Test Procedure:

☐	AS1289 4.2.1	Soil Chemical Tests - Determination of a sulfate content of a natural soil and the sulfate content of the groundwater - Normal Method
☐	AS1289 4.3.1	Soil Chemical Tests - Determination of the pH value of a soil - Electrometric method
☑	AS 1289 4.4.1	Soil Chemical Tests - Determination of the electrical resistivity of a soil - Method for sands and granular material
☐	AS 1012.20	Chloride and sulphate
☐	RMS T123	pH value of a soil (electrometric method)
☐	RMS T185	Resistivity of sands and granular road construction materials
☐	RMS T200	Chloride content of roadbase
☐	RMS T1010	Quantitative determination of chlorides in soil
☐	RMS T1011	Quantitative determination of sulphates in soil
☐	BS1377(1990 pt.3)	Water soluble sulphate content
☑	APHA 4500 H+B	pH
☑	APHA 4500 SO4 2-B	Sulphate
☑	APHA 4500 Cl-B	Chloride
☐	APHA 2510 & 2520-B	Electrical Conductivity
☐	TAI B117	Sulphides Present (This service Not Covered by NATA Accreditation)

Sampling:	Sampled by Client	**Date Sampled:**	23-24/02/17
Preparation:	Prepared in accordance with the test method		

Sulphides Present	-
Sulphur Peroxide (%)	-
Sulphate content (ppm)	248.4
Sulphate content (%)	-
Chloride ion content (ppm)	178.4
Chloride ion content (%)	0.02
pH	7.5
Electrical Conductivity (uS/cm)	-
Mean Resistivity Ω.m	34
(Resisitivity) Density ratio (R_D)	90
(Resisitivity) Density index (I_D)	-

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Brad Morris

14/03/2017

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
Unit 8/10
Bradford Street
Alexandria NSW 2015

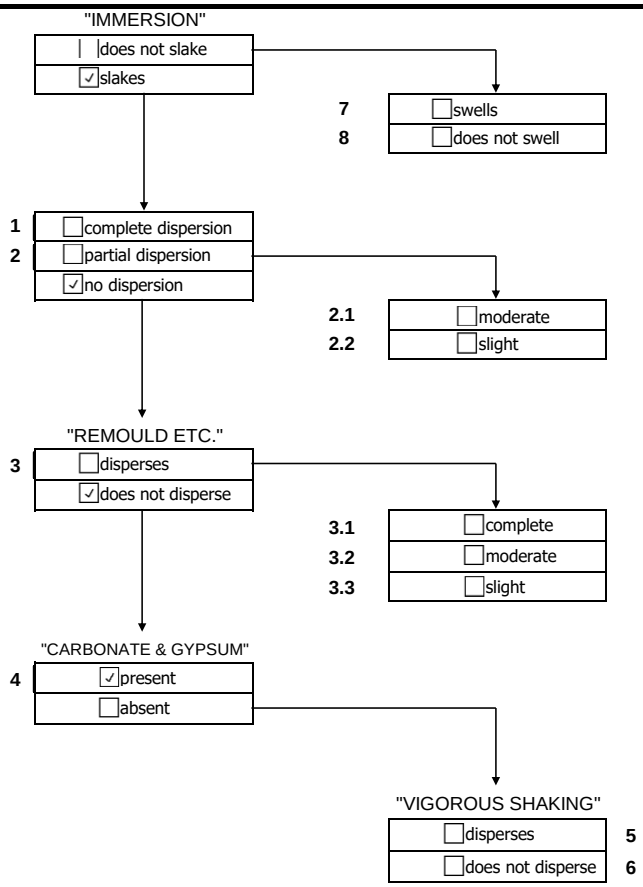
EMERSON CLASS REPORT

Client:	Consulting Earth Scientists	**Source:**	BH8-3.0
Address:	Suite 3, Level 1, 55, Grandview Street, Pymble, NSW, 2073	**Sample Description:**	silty clayey SAND
Project:	Cooks Cove	**Report No:**	S22123-ECT
Job No:	S17071	**Lab No:**	S22123

Test Procedure: ☑ AS1289 3.8.1 Soil classification tests - Dispersion - Determination of Emerson class number of a soil

Sampling: Sampled by Client **Date Sampled:** 23-24.02.17

Preparation: Prepared in accordance with the test method



Water Type	**Distilled**
Water Source	**Lab**
Water Temperature (°c)	**21**

RESULT:

Emerson Class No. **4**

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Authorised Signatory:

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20/03/2017

Date:

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Unit 8/10
Bradford Street
Alexandria NSW 2015

ORGANIC MATTER REPORT

Client:	Consulting Earth Scientists	**Source:**	BH8 3.0
Address:	Cooks Cove	**Sample Description:**	Silty SAND
Project:	Cooks Cove	**Report No:**	B36870-OC
Job No:	S17071	**Lab No:**	B36870 (S22123)

Test Procedure: ☑ AS1289 4.1.1 Soil Chemical Tests - Determination of the organic matter content of a soil - Normal method

Sampling:	Sampled by Client	**Date Sampled:**	23-24/02/17
Preparation:	Prepared in accordance with the test method		

Organic Matter (%)	2.4

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Authorised Signatory:

Brad Morris

14/03/2017

Date:

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Unit 8/10
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Alexandria NSW 2015

SOIL CHEMICAL PROPERTIES REPORT

Client:	Consulting Earth Scientists	**Source:**	BH8 3.0
Address:	Cooks Cove	**Sample Description:**	Silty SAND
Project:	Cooks Cove	**Report No:**	B36870-SCP
Job No:	S17071	**Lab No:**	B36870 (S22123)

Test Procedure:

☐	AS1289 4.2.1	Soil Chemical Tests - Determination of a sulfate content of a natural soil and the sulfate content of the groundwater - Normal Method
☐	AS1289 4.3.1	Soil Chemical Tests - Determination of the pH value of a soil - Electrometric method
☑	AS 1289 4.4.1	Soil Chemical Tests - Determination of the electrical resistivity of a soil - Method for sands and granular material
☐	AS 1012.20	Chloride and sulphate
☐	RMS T123	pH value of a soil (electrometric method)
☐	RMS T185	Resistivity of sands and granular road construction materials
☐	RMS T200	Chloride content of roadbase
☐	RMS T1010	Quantitative determination of chlorides in soil
☐	RMS T1011	Quantitative determination of sulphates in soil
☐	BS1377(1990 pt.3)	Water soluble sulphate content
☑	APHA 4500 H+B	pH
☑	APHA 4500 SO4 2-B	Sulphate
☑	APHA 4500 Cl-B	Chloride
☐	APHA 2510 & 2520-B	Electrical Conductivity
☐	TAI B117	Sulphides Present (This service Not Covered by NATA Accreditation)

Sampling:	Sampled by Client	**Date Sampled:**	23-24/02/17
Preparation:	Prepared in accordance with the test method		

Sulphides Present	-
Sulphur Peroxide (%)	-
Sulphate content (ppm)	149.3
Sulphate content (%)	-
Chloride ion content (ppm)	164.0
Chloride ion content (%)	0.02
pH	7.8
Electrical Conductivity (uS/cm)	-
Mean Resistivity Ω.m	50
(Resisitivity) Density ratio (R_D)	90
(Resisitivity) Density index (I_D)	-

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Brad Morris

14/03/2017

Date:

MACQUARIE GEOTECH

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Bradford Street
Alexandria NSW 2015

EMERSON CLASS REPORT

Client:	Consulting Earth Scientists	**Source:**	BH10-2.0
Address:	Suite 3, Level 1, 55, Grandview Street, Pymble, NSW, 2073	**Sample Description:**	silty SAND
Project:	Cooks Cove	**Report No:**	S22124-ECT
Job No:	S17071	**Lab No:**	S22124

Test Procedure: ☑ AS1289 3.8.1 Soil classification tests - Dispersion - Determination of Emerson class number of a soil

Sampling: Sampled by Client **Date Sampled:** 23-24.02.17

Preparation: Prepared in accordance with the test method

"IMMERSION"

- ☐ does not slake
- ☑ slakes
  - 7 ☐ swells
  - 8 ☐ does not swell

1 ☐ complete dispersion
2 ☐ partial dispersion
☑ no dispersion
- 2.1 ☐ moderate
- 2.2 ☐ slight

"REMOULD ETC."

3 ☐ disperses
☑ does not disperse
- 3.1 ☐ complete
- 3.2 ☐ moderate
- 3.3 ☐ slight

"CARBONATE & GYPSUM"

4 ☑ present
☐ absent

"VIGOROUS SHAKING"

- ☐ disperses 5
- ☐ does not disperse 6

Water Type	**Distilled**
Water Source	**Lab**
Water Temperature (°c)	**22**

RESULT:

Emerson Class No. **4**

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Authorised Signatory:

Chris Lloyd

Date: 20/03/2017

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Unit 8/10
Bradford Street
Alexandria NSW 2015

ORGANIC MATTER REPORT

Client:	Consulting Earth Scientists	**Source:**	BH10 2.0
Address:	Cooks Cove	**Sample Description:**	Silty SAND
Project:	Cooks Cove	**Report No:**	B36871-OC
Job No:	S17071	**Lab No:**	B36871 (S22124)

Test Procedure: ☑ AS1289 4.1.1 Soil Chemical Tests - Determination of the organic matter content of a soil - Normal method

Sampling:	Sampled by Client	**Date Sampled:**	23-24/02/17
Preparation:	Prepared in accordance with the test method		

Organic Matter (%)	2.9

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Brad Morris

14/03/2017

Date:

Macquarie Geotechnical
3 Watt Drive
Bathurst NSW 2795

SOIL CHEMICAL PROPERTIES REPORT

Client:	Consulting Earth Scientists	**Source:**	BH10 2.0
Address:	Cooks Cove	**Sample Description:**	Silty SAND
Project:	Cooks Cove	**Report No:**	B36871-SCP
Job No:	S17071	**Lab No:**	B36871 (S22124)

Test Procedure:

☐	AS1289 4.2.1	Soil Chemical Tests - Determination of a sulfate content of a natural soil and the sulfate content of the groundwater - Normal Method
☐	AS1289 4.3.1	Soil Chemical Tests - Determination of the pH value of a soil - Electrometric method
☑	AS 1289 4.4.1	Soil Chemical Tests - Determination of the electrical resistivity of a soil - Method for sands and granular material
☐	AS 1012.20	Chloride and sulphate
☐	RMS T123	pH value of a soil (electrometric method)
☐	RMS T185	Resistivity of sands and granular road construction materials
☐	RMS T200	Chloride content of roadbase
☐	RMS T1010	Quantitative determination of chlorides in soil
☐	RMS T1011	Quantitative determination of sulphates in soil
☐	BS1377(1990 pt.3)	Water soluble sulphate content
☑	APHA 4500 H+B	pH
☑	APHA 4500 SO4 2-B	Sulphate
☑	APHA 4500 Cl-B	Chloride
☐	APHA 2510 & 2520-B	Electrical Conductivity
☐	TAI B117	Sulphides Present (This service Not Covered by NATA Accreditation)

Sampling:	Sampled by Client	**Date Sampled:**	23-24/02/17
Preparation:	Prepared in accordance with the test method		

Sulphides Present	-
Sulphur Peroxide (%)	-
Sulphate content (ppm)	154.2
Sulphate content (%)	-
Chloride ion content (ppm)	323.5
Chloride ion content (%)	0.03
pH	7.4
Electrical Conductivity (uS/cm)	-
Mean Resistivity Ω.m	14
(Resisitivity) Density ratio (R_D)	90
(Resisitivity) Density index (I_D)	-

NATA

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Authorised Signatory:

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14/03/2017

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
Unit 8/10
Bradford Street
Alexandria NSW 2015

EMERSON CLASS REPORT

Client:	Consulting Earth Scientists	**Source:**	BH12-2.5
Address:	Suite 3, Level 1, 55, Grandview Street, Pymble, NSW, 2073	**Sample Description:**	silty SAND
Project:	Cooks Cove	**Report No:**	S22125-ECT
Job No:	S17071	**Lab No:**	S22125

Test Procedure: ☑ AS1289 3.8.1 Soil classification tests - Dispersion - Determination of Emerson class number of a soil

Sampling: Sampled by Client **Date Sampled:** 23-24.02.17

Preparation: Prepared in accordance with the test method

"IMMERSION"

- ☐ does not slake
- ☑ slakes
  - 7 ☐ swells
  - 8 ☐ does not swell

1 ☐ complete dispersion
2 ☐ partial dispersion
☑ no dispersion
- 2.1 ☐ moderate
- 2.2 ☐ slight

"REMOULD ETC."

3 ☐ disperses
☑ does not disperse
- 3.1 ☐ complete
- 3.2 ☐ moderate
- 3.3 ☐ slight

"CARBONATE & GYPSUM"

4 ☑ present
☐ absent

"VIGOROUS SHAKING"

- ☐ disperses 5
- ☐ does not disperse 6

Water Type	**Distilled**
Water Source	**Lab**
Water Temperature (°c)	**21**

RESULT:

Emerson Class No. **4**

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Authorised Signatory:

Chris Lloyd

20/03/2017

Date:

NATA Accredited Laboratory Number: 14874

MACQUARIE GEOTECH
Macquarie Geotechnical
Unit 8/10
Bradford Street
Alexandria NSW 2015

ORGANIC MATTER REPORT

Client:	Consulting Earth Scientists	**Source:**	BH12 2.5
Address:	Cooks Cove	**Sample Description:**	Silty SAND
Project:	Cooks Cove	**Report No:**	B36872-OC
Job No:	S17071	**Lab No:**	B36872 (S22125)

Test Procedure: ☑ AS1289 4.1.1 Soil Chemical Tests - Determination of the organic matter content of a soil - Normal method

Sampling:	Sampled by Client	**Date Sampled:**	23-24/02/17
Preparation:	Prepared in accordance with the test method		

Organic Matter (%)	3.1

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NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Brad Morris

14/03/2017

Date:

Macquarie Geotechnical
Unit 8/10
Bradford Street
Alexandria NSW 2015

SOIL CHEMICAL PROPERTIES REPORT

Client:	Consulting Earth Scientists	**Source:**	BH12 2.5
Address:	Cooks Cove	**Sample Description:**	Silty SAND
Project:	Cooks Cove	**Report No:**	B36872-SCP
Job No:	S17071	**Lab No:**	B36872 (S22125)

Test Procedure:

☐	AS1289 4.2.1	Soil Chemical Tests - Determination of a sulfate content of a natural soil and the sulfate content of the groundwater - Normal Method
☐	AS1289 4.3.1	Soil Chemical Tests - Determination of the pH value of a soil - Electrometric method
☑	AS 1289 4.4.1	Soil Chemical Tests - Determination of the electrical resistivity of a soil - Method for sands and granular material
☐	AS 1012.20	Chloride and sulphate
☐	RMS T123	pH value of a soil (electrometric method)
☐	RMS T185	Resistivity of sands and granular road construction materials
☐	RMS T200	Chloride content of roadbase
☐	RMS T1010	Quantitative determination of chlorides in soil
☐	RMS T1011	Quantitative determination of sulphates in soil
☐	BS1377(1990 pt.3)	Water soluble sulphate content
☑	APHA 4500 H+B	pH
☑	APHA 4500 SO4 2-B	Sulphate
☑	APHA 4500 Cl-B	Chloride
☐	APHA 2510 & 2520-B	Electrical Conductivity
☐	TAI B117	Sulphides Present (This service Not Covered by NATA Accreditation)

Sampling:	Sampled by Client	**Date Sampled:**	23-24/02/17
Preparation:	Prepared in accordance with the test method		

Sulphides Present	-
Sulphur Peroxide (%)	-
Sulphate content (ppm)	98.9
Sulphate content (%)	-
Chloride ion content (ppm)	376.7
Chloride ion content (%)	0.04
pH	7.3
Electrical Conductivity (uS/cm)	-
Mean Resistivity Ω.m	14
(Resisitivity) Density ratio (R_D)	90
(Resisitivity) Density index (I_D)	-

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Brad Morris

14/03/2017

Date:

MACQUARIE GEOTECH

Macquarie Geotechnical
Unit 8/10
Bradford Street
Alexandria NSW 2015

EMERSON CLASS REPORT

Client:	Consulting Earth Scientists	**Source:**	BH13-2.0
Address:	Suite 3, Level 1, 55, Grandview Street, Pymble, NSW, 2073	**Sample Description:**	silty clayey SAND
Project:	Cooks Cove	**Report No:**	S22126-ECT
Job No:	S17071	**Lab No:**	S22126

Test Procedure: ☑ AS1289 3.8.1 Soil classification tests - Dispersion - Determination of Emerson class number of a soil

Sampling: Sampled by Client **Date Sampled:** 23-24.02.17

Preparation: Prepared in accordance with the test method

"IMMERSION"

- ☐ does not slake
- ☑ slakes
  - 7 ☐ swells
  - 8 ☐ does not swell

1 ☐ complete dispersion
2 ☐ partial dispersion
☑ no dispersion
- 2.1 ☐ moderate
- 2.2 ☐ slight

"REMOULD ETC."

3 ☐ disperses
☑ does not disperse
- 3.1 ☐ complete
- 3.2 ☐ moderate
- 3.3 ☐ slight

"CARBONATE & GYPSUM"

4 ☐ present
☑ absent

"VIGOROUS SHAKING"

- ☐ disperses 5
- ☑ does not disperse 6

Water Type	**Distilled**
Water Source	**Lab**
Water Temperature (°c)	**21**

RESULT:

Emerson Class No. **6**

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NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Chris Lloyd

20/03/2017

Date:

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Macquarie Geotechnical
Unit 8/10
Bradford Street
Alexandria NSW 2015

ORGANIC MATTER REPORT

Client:	Consulting Earth Scientists	**Source:**	BH13 2.0
Address:	Cooks Cove	**Sample Description:**	Silty SAND
Project:	Cooks Cove	**Report No:**	B36873-OC
Job No:	S17071	**Lab No:**	B36873 (S22126)

Test Procedure: ☑ AS1289 4.1.1 Soil Chemical Tests - Determination of the organic matter content of a soil - Normal method

Sampling:	Sampled by Client	**Date Sampled:**	23-24/02/17
Preparation:	Prepared in accordance with the test method		

Organic Matter (%)	3.1

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Brad Morris

14/03/2017

Date:

Macquarie Geotechnical
Unit 8/10
Bradford Street
Alexandria NSW 2015

SOIL CHEMICAL PROPERTIES REPORT

Client:	Consulting Earth Scientists	**Source:**	BH13 2.0
Address:	Cooks Cove	**Sample Description:**	Silty SAND
Project:	Cooks Cove	**Report No:**	B36873-SCP
Job No:	S17071	**Lab No:**	B36873 (S22126)

Test Procedure:

☐	AS1289 4.2.1	Soil Chemical Tests - Determination of a sulfate content of a natural soil and the sulfate content of the groundwater - Normal Method
☐	AS1289 4.3.1	Soil Chemical Tests - Determination of the pH value of a soil - Electrometric method
☑	AS 1289 4.4.1	Soil Chemical Tests - Determination of the electrical resistivity of a soil - Method for sands and granular material
☐	AS 1012.20	Chloride and sulphate
☐	RMS T123	pH value of a soil (electrometric method)
☐	RMS T185	Resistivity of sands and granular road construction materials
☐	RMS T200	Chloride content of roadbase
☐	RMS T1010	Quantitative determination of chlorides in soil
☐	RMS T1011	Quantitative determination of sulphates in soil
☐	BS1377(1990 pt.3)	Water soluble sulphate content
☑	APHA 4500 H+B	pH
☑	APHA 4500 SO4 2-B	Sulphate
☑	APHA 4500 Cl-B	Chloride
☐	APHA 2510 & 2520-B	Electrical Conductivity
☐	TAI B117	Sulphides Present (This service Not Covered by NATA Accreditation)

Sampling:	Sampled by Client	**Date Sampled:**	23-24/02/17
Preparation:	Prepared in accordance with the test method		

Sulphides Present	-
Sulphur Peroxide (%)	-
Sulphate content (ppm)	432.8
Sulphate content (%)	-
Chloride ion content (ppm)	117.4
Chloride ion content (%)	0.01
pH	4.2
Electrical Conductivity (uS/cm)	-
Mean Resistivity Ω.m	55
(Resisitivity) Density ratio (R_D)	90
(Resisitivity) Density index (I_D)	-

NATA Accredited Laboratory Number: 14874

Authorised Signatory:

Brad Morris

14/03/2017

Date:

Macquarie Geotechnical
Unit 8/10
Bradford Street
Alexandria NSW 2015

12 Ashley Street, Chatswood, NSW 2067
tel: +61 2 9910 6200

email: sydney@envirolab.com.au
envirolab.com.au

Envirolab Services Pty Ltd - Sydney | ABN 37 112 535 645

CERTIFICATE OF ANALYSIS 162927

Client:
Macquarie Geotech
3 Watt Dr
Bathurst
NSW 2795

Attention: Chris Lloyd

Sample log in details:

Your Reference:	**S17071**		
No. of samples:	6 Soils		
Date samples received / completed instructions received	03/03/17	/	03/03/17

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: / Issue Date:	10/03/17	/	13/03/17
Date of Preliminary Report:	Not Issued		

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Results Approved By:

David Springer
General Manager

ESP/CEC Our Reference: Your Reference Sample ID Type of sample	UNITS ---------- - ---------- 	162927-1 S22121 BH2-3.5m Soil	162927-2 S22122 BH5-1.5m Soil	162927-3 S22123 BH8-3.0m Soil	162927-4 S22124 BH10-2.0m Soil	162927-5 S22125 BH12-2.5m Soil
Date prepared	-	08/03/2017	08/03/2017	08/03/2017	08/03/2017	08/03/2017
Date analysed	-	08/03/2017	08/03/2017	08/03/2017	08/03/2017	08/03/2017
Exchangeable Ca	meq/100g	15	23	21	<0.1	3.3
Exchangeable K	meq/100g	0.4	0.5	0.4	<0.1	0.3
Exchangeable Mg	meq/100g	3.1	4.0	3.4	<0.1	1.5
Exchangeable Na	meq/100g	0.49	0.64	0.73	<0.1	0.17
Cation Exchange Capacity	meq/100g	19	28	25	<1.0	5.2
ESP	%	3	2	3	[NT]	3

ESP/CEC Our Reference: Your Reference Sample ID Type of sample	UNITS ---------- - ---------- 	162927-6 S22126 BH13-2.0m Soil
Date prepared	-	08/03/2017
Date analysed	-	08/03/2017
Exchangeable Ca	meq/100g	8.4
Exchangeable K	meq/100g	0.1
Exchangeable Mg	meq/100g	0.34
Exchangeable Na	meq/100g	<0.1
Cation Exchange Capacity	meq/100g	8.9

Phosphorus Sorption						
Our Reference:	UNITS	162927-1	162927-2	162927-3	162927-4	162927-5
Your Reference	---------- -	S22121	S22122	S22123	S22124	S22125
Sample ID	----------	BH2-3.5m	BH5-1.5m	BH8-3.0m	BH10-2.0m	BH12-2.5m
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	07/03/2017	07/03/2017	07/03/2017	07/03/2017	07/03/2017
Date analysed	-	08/03/2017	08/03/2017	08/03/2017	08/03/2017	08/03/2017

Phosphorus Sorption		
Our Reference:	UNITS	162927-6
Your Reference	---------- -	S22126
Sample ID	----------	BH13-2.0m
Type of sample		Soil
Date prepared	-	07/03/2017
Date analysed	-	08/03/2017

Method ID	Methodology Summary
Metals-009	Determination of exchangeable cations and cation exchange capacity in soils using 1M Ammonium Chloride exchange and ICP-AES analytical finish.

QUALITY CONTROL ESP/CEC	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			08/03/2017	162927-1	08/03/2017 || 08/03/2017	LCS-1	08/03/2017
Date analysed	-			08/03/2017	162927-1	08/03/2017 || 08/03/2017	LCS-1	08/03/2017
Exchangeable Ca	meq/100g	0.1	Metals-009	<0.1	162927-1	15 || 15 || RPD: 0	LCS-1	111%
Exchangeable K	meq/100g	0.1	Metals-009	<0.1	162927-1	0.4 || 0.4 || RPD: 0	LCS-1	107%
Exchangeable Mg	meq/100g	0.1	Metals-009	<0.1	162927-1	3.1 || 2.7 || RPD: 14	LCS-1	110%
Exchangeable Na	meq/100g	0.1	Metals-009	<0.1	162927-1	0.49 || 0.54 || RPD: 10	LCS-1	125%
ESP	%	1	Metals-009	[NT]	162927-1	3 || 3 || RPD: 0	[NR]	[NR]

QUALITY CONTROL Phosphorus Sorption	UNITS	PQL	METHOD	Blank
Date prepared	-			[NT]
Date analysed	-			[NT]

Report Comments:

ESP: Where the exchangeable Sodium is less than the PQL and CEC is less than 10meq/100g, the ESP cannot be calculated.

P_sorp analysed by East West, report no EW170302 and report attached.

Asbestos ID was analysed by Approved Identifier:	Not applicable for this job
Asbestos ID was authorised by Approved Signatory:	Not applicable for this job

INS: Insufficient sample for this test	PQL: Practical Quantitation Limit	NT: Not tested
NR: Test not required	RPD: Relative Percent Difference	NA: Test not required
<: Less than	>: Greater than	LCS: Laboratory Control Sample

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.

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: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
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.