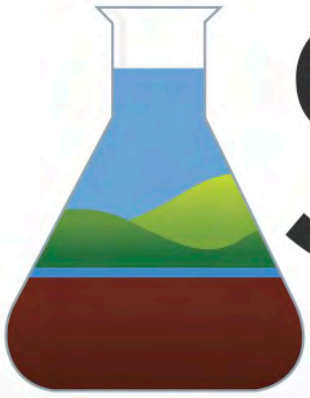


SESL AUSTRALIA
Environment & Soil Sciences

Acid Sulfate Preliminary Site Investigation and Management Plan

Manly Civic Club JV

2 West Promenade

Manly NSW 2095

Lot 1 DP 859455

Prepared for:

Trevor Jolly of Eastview Australia

On behalf of Manly Civic Club JV

June 2016

(Report: C8823.Q5585.B39013 ASSMP Manly CC FA)

Executive Summary

SESL was engaged by Trevor Jolly of Eastview Australia, on behalf of Manly Civic Club JV (the client), to review and update Environmental Investigation Services 2007 Acid Sulfate Soil Investigation and Management Plan for 2 West Promenade, Manly NSW 2095, legally defined as Lot 1 In DP 859455. The previous report, completed in 2007, was submitted as part of a recent DA to develop the currently vacant site. Council requested the 2007 investigation and management plan be updated.

The environmental assessment works undertaken during this ASS PSI comprised of the following:

- *Review of previous investigation and management plan (Environmental Investigation Services, Preliminary Acid Sulfate Soil Assessment and Acid Sulfate Soil Management Plan, E21496FK-Let, 14 September 2007);*
- *Visual inspection of the site on 31/05/2016;*
- *Preparation of this report detailing methodologies used during this investigation, update of result findings and conclusions regarding the acid sulfate soil risk associated with the proposed development at the site.*

SESL have also been engaged to conducted a Tier 1 Detailed Site Assessment on the site (See SESL Report: DRAFT C8823Q5710B39331 MCC DSI). Site inspections and sampling as part of that investigation have provided additional details about soil materials at the site.

Investigative work was conducted in accordance with the following applicable guidelines:

- *Acid Sulfate Soils Manual (NSW Acid Sulfate Soils Management Advisory Committee, 1998) and*
- *Assessing and Managing Acid Sulfate Soils - Guidelines for and Management in NSW Coastal Areas (EPA, 1995).*

From the results obtained during this ASS PSI and from previous laboratory assessment included in EIS 2007 report, the soil encountered in the region of proposed works consists of fill to approximately 1-2.5m overlying natural grey and brown sands to a depth of least 9m.

Based on the desktop assessment, laboratory analytical data and review of the EIS 2007 report, it was determined that there is a Potential Acid Sulfate Soil (PASS) risk at the site for all natural soils. The maximum depth of excavation for the proposed work is approximately 6m.

All natural site soils will be treated as Potential Acid Sulfate Soil (PASS). Fill material above natural sands will be handled in accordance with SESL report: DRAFT C8823Q5710B39331 MCC DSI. For the proposed works to go ahead, implementation of the above Management Plan included in Section 6, will prevent the formation of Actual Acid Sulfate Soils and the generation of sulfuric acid

SESL considers the site suitable for the proposed redevelopment following the implementation of the management plan.

Reference should be made to Section 9 of the report that sets out details of the limitations of the assessment.

SESL AUSTRALIA

Fiona Warden
Environmental Scientist

Ryan Jacka
Senior Environmental Scientist

TABLE OF CONTENTS

DOCUMENT FIGURES

DOCUMENT TABLES

APPENDICES

Appendix A – Site Map
Appendix B – Acid Sulfate Soil Risk Map LEP 2014
– Groundwater Bore Map
Appendix C – Previous Report (Includes Result Summary)

ABBREVIATIONS

AHD	– Australian Height Datum
AASS	– Actual Acid Sulfate Soil
ASS	– Acid Sulfate Soil
ASS DA	– Acid Sulfate Soil Desktop Assessment
ASSMAC	– Acid Sulfate Soil Management Advisory Committee
ASSMP	– Acid Sulfate Soil Management Plan
BTEX	– Benzene, Toluene, Ethyl Benzene, Xylenes
CBD	– Central Business District
CLM Act	– Contaminated Land Management Act
COC	– Chain of Custody
DEC	– Department of Environment and Conservation NSW
DECC	– Department of Environment and Climate Change NSW
DECCW	– Department of Environment, Climate Change and Water NSW
DNR	– Department of Natural Resources (Formerly part of the Department of Infrastructure, Planning and Natural Resources)
DoP	– Department of Planning (Formerly part of the Department of Infrastructure, Planning and Natural Resources)
DP	– Deposited Plan
EPA	– Environment Protection Authority
N/A	– Not Available
NATA	– The National Association of Testing Authorities
NRAtlas	– Natural Resources Atlas
NSW	– New South Wales
PASS	– Potential Acid Sulfate Soil
PQL	– Practical Quantitation Limits
PSI	– Preliminary Site Investigation
SESL	– SESL Australia
sPOCAS	– Suspended Peroxide Oxidation-Combined Acidity and Sulfate
UCL	– Upper confidence Limit

1 INTRODUCTION

1.1 Background

SESL was engaged by Trevor Jolly of Eastview Australia, on behalf of Manly Civic Club JV (the client), to review and update Environmental Investigation Services 2007 Acid Sulfate Soil Investigation and Management Plan for 2 West Promenade, Manly NSW 2095, legally defined as Lot 1 In DP 859455. The previous report, completed in 2007, was submitted as part of a recent DA to develop the currently vacant site. Council requested the 2007 investigation and management plan be updated. See Appendix C for previous report. SESL understands that previous report was prepared prior to the demolition of the former Manly Civic Club. The site has been vacant since the demolition works in 2007. The proposed works to the site in the new DA involve the construction of a new Manly Civic Club with upper levels of residential and two levels of basement parking.

1.2 Purpose and Scope

The environmental assessment works undertaken during this ASS PSI comprised of the following:

- Review of previous investigation and management plan (Environmental Investigation Services, Preliminary Acid Sulfate Soil Assessment and Acid Sulfate Soil Management Plan, E21496FK-Let, 14 September 2007);
- Visual inspection of the site on 31/05/2016;
- Preparation of this report detailing methodologies used during this investigation, update of result findings and conclusions regarding the acid sulfate soil risk associated with the proposed development at the site.

Investigative work was conducted in accordance with the following applicable guidelines:

- Acid Sulfate Soils Manual (NSW Acid Sulfate Soils Management Advisory Committee, 1998)

1.3 Definition of Acid Sulfate Soils

Acid sulfate soil is the common name given to naturally occurring sediments and soils containing iron sulfides (principally iron sulfide or iron disulfide or their precursors). The exposure of the sulfide in these soils to oxygen by drainage or excavation leads to the generation of sulfuric acid.

Acid sulfate soils (ASS) include actual acid sulfate soils or potential acid sulfate soils. Actual and potential acid sulfate soils are often found in the same profile, with actual acid sulfate soils generally overlying potential acid sulfate soil horizons.

Actual acid sulfate soils are soils containing highly acidic soil layers caused by the oxidation of soils that are rich in iron sulfides. This oxidation produces acidity in excess of the soil's capacity to neutralise it

and results in soils of pH of 4 or less. These soils can usually be identified by the presence of pale yellow mottles and coatings of jarosite.

Potential acid sulfate soils (PASS) are soils that contain iron sulfides that have not been exposed to air and oxidised. The field pH of these soils in the undisturbed state is 4 or more and is commonly neutral or slightly alkaline. However, they pose a considerable environmental risk when disturbed, as they will become more acidic when exposed to air and oxidised.

2 DESCRIPTION OF SITE AND WORKS

2.1 Site Location

The site is located on the end block of West Promenade, bordered by Gilbert Street and Eustace Street. Manly Cove is located approximately 150m to the south, and Manly Beach approximately 500m to the east of the site. Access to the site is currently from Gilbert Street. The investigation area where the (the vicinity of the proposed works) is approximately 1500m^2 and comprises Lot 1 in DP859455.

2.2 Site Identification

The following details describe the portion of land subjected to the ASS PSI:

Table 1 – Site Identification

Site Address	2 West Promenade, Manly NSW 2095
Lot and DP Number	Lot 1 DP 859455
Local Government Area	Northern Beaches Council (Formerly Manly Council)
Current Zoning	B2 Local Centre
Distance from Sydney CBD	Approximately 14k.4m north east of the Sydney CBD
Geographical Coordinates	33°47'52.72"S 151°17'01.32"E
Investigation Area	Approximately 1500m^2
Site Elevation	Approximately 4m AHD
Locality Map	Figure 1

Figure 1 – Site Locality- 2 West Promenade, Manly NSW 2095

(Courtesy of Land and Property Information 2016)

2.3 Site Layout and Infrastructure

The site layout can be viewed in Figure 1 and Appendix A. The site is predominately vacant with hardstand coverings. The south eastern corner of the site has a single building. The buildings interior is concrete hardstand with gyprock walls dividing internal rooms. The buildings exterior is in poor condition. The building layout has been included in Appendix A. The client has advised this building is heritage listed as a former service station and workshop and will be incorporated into the new development.

Mains supply of electricity is connected to the building and water is accessible from a single outdoor tap. Water and sewer are connected to the internal of the building, however the water was not actively connected at the time of assessment.

2.4 Description of Geology

The 2007 EIS Investigation (See Appendix C) has identified from the *1:100 000 geological map of Sydney (Department of Primary industries, 1983)* that the site is located in the vicinity of two geological formations. Quaternary aged deposits of coarse quartz sand with varying amounts of shell fragments generally occurs in the areas to the south of the site, whilst Quaternary age deposits of medium to fine-grained 'marine' sand generally occurs in the areas to the north of the site.

The *Soil Landscapes of the Sydney 1:100,000 Sheet* (Chapman et al. 1989) indicates the site to be within the Woy Woy soil landscape group with dark brown loose loamy sand topsoils overlying grey bleached loose sand and brown loose sand subsoils. Underlying geology is Holocene sediments of predominately coarse to fine quartz sand with shell fragments and silt. Limitations of this soil landscape include permanently high water tables, localised flooding, periodic water logging in depressions, very low to low soil fertility, localised areas of high soil erosion hazard. The soils in this landscape group are noted to be strongly to slightly acidic.

The above description is consistent with the findings of the site investigation. Brown loose loamy sand topsoils were not observed, but are expected to have been mixed with the overlying fill layer or removed from site.

2.5 Description of Hydrology

From review of previous reports and site conditions the aquifer appears to be a highly permeable sand aquifer. J&K 2016 noted that the permeability of sands was approximately 1 x 10^{-4} m/sec. Due to the nature of the site and proximity to coastal waterways, the aquifer is likely tidal in nature.

On site inspection as part of the DSI undertaken by SESL identified natural sands with groundwater at approximately 3m.

A groundwater bore search was undertaken using the groundwater database under Office of Water, Department of Primary Industries (www.allwaterdata.water.nsw.gov.au). Five (5) groundwater bores were located within a 500m radius of the site (see Appendix C). Five (5) groundwater bore were licensed for recreation purpose namely (GW110294), (GW109245), (GW109304), (GW106341) and (GW102856). Standing water levels at these bores are listed as 4m, 4.8m, 4.83m, 18.3m and 4.3m respectively.

2.6 Description of Works

The advised scope of works to be carried out includes the construction of a new Civic Club with the upper levels to be used for residential purposes and two levels of basement parking. The former service station is to remain on site and will be incorporated into the Civic Club.

The basement carpark is proposed to a finished level ~3m below groundwater level. This will require dewatering management during works.

2.7 Acid Sulfate Soil Occurrence

The Manly Local Environmental Plan (LEP) 2013 Acid Sulfate Soil Risk Map indicates the site to be a Class 4 Risk. In this area, works more than 2 metres below the natural ground surface and works by which the watertable is likely to be lowered more than 2 metres below the natural ground surface

require development consent. Based on previous report findings (Jeffery Katauskas 2007) and information provided by the client, acid sulfate soils are expected to be present with the proposed works expected to impact soils and lower groundwater below 2 metres. See LEP Acid Sulfate Risk Map in Appendix B.

The Acid Sulfate Soils Management Advisory Committee (ASSMAC) Guidelines 1998 considers the following geomorphic conditions when determining the ASS risk status of a given area:

- Sediments of recent geological age (Holocene) ~ 6000 to 10,000 years old;
- Soil horizons less than 5m AHD (Australian Height Datum);
- Marine or estuarine sediment and tidal lakes;
- In coastal wetlands or back swamp areas, waterlogged or scalded areas; interdune swales or coastal sand dunes;
- In areas where the dominant vegetation is mangroves, reeds, rushes and other swamp tolerant and marine vegetation such as swamp mahogany (*Eucalyptus robusta)*, paperbark (*Melaleuca quinquenervia*) and swamp oak (*Casuarina glauca*);
- In areas identified in geological descriptions or in maps bearing sulfide minerals, coal deposits or former marine shales/ sediments; and
- Deeper older estuarine sediments >10m below the ground surface, Holocene or Pleistocene age (only an issue if deep excavation or drainage is proposed).

2.8 Waste Classification for Offsite Disposal (If Required)

All soil and water identified for offsite disposal requires a waste classification according to the NSW Environmental Protection Authority *Waste Classification Guidelines Part 1: Classifying Waste* (NSW EPA 2014).

All acid sulfate soils must satisfy the disposal criteria as identified in the NSW EPA *Waste Classification Guidelines Part 4: Acid Sulfate Soils* (NSW EPA, 2014).

For waste to be considered non-liquid it must meet all of the following requirements:

- It has an angle of repose of greater then five degrees (5^0);
- It liberates no free liquids when transported;
- It does not become free flowing at or below 60^0C or when transported; and
- It is spadeable.

Testing for non-liquid waste is to include (but not limited to) a heavy metal screen (M8), Total Petroleum Hydrocarbons (TPH), BTEX, Organochlorine Pesticides (OCP), Polychlorinated Biphenyls (PCB), Polycyclic Aromatic Hydrocarbons (PAH) and asbestos. Testing ratios to be decided by supervising Environmental Scientist.

Types of non-liquid waste classifications are:

- Hazardous;
- Special;
- Restricted Solid;
- General Solid (putrescible);
- General Solid (non-putrescible); and
- Virgin Excavated Natural Material (VENM).

As on site fill material overlying natural soils has been identified as contaminated and must be managed in accordance with an RAP to be developed for the site. Reference should be made the the groundwater quality results presented in the DSI to determine appropriate offsite disposal options.

2.9 Proximity to Local Sensitive Environments

The site is located in an environmentally sensitive zone due to its proximity to Manly Cove, part of North Harbour, which feeds into the Pacific Ocean. No other sensitive cultural or other environmental receptors are identified in close proximity to the site.

3 RELEVANT GUIDELINES FOR ACID SULFATE SOIL ASSESSMENT & MANAGEMENT

3.1 Relevant Guidelines

Assessment criteria will be based on the *Acid Sulfate Soils Manual* (Acid Sulfate Soils Management Advisory Committee [ASSMAC] 1998 which incorporate the following guidelines:

- The Acid Sulfate Soils Assessment Guidelines 1998;
- The Acid Sulfate Soils Planning Guidelines 1998;
- The Acid Sulfate Soils Management Guidelines 1998; and
- The Acid Sulfate Soils Laboratory Method Guidelines 1998.

The ASS Manual developed by ASSMAC provides advice on best practice in planning, assessment and management of activities in areas containing acid sulfate soils. These guidelines update and expand on the *Environmental Guidelines: Assessing and Managing Acid Sulfate Soils* issued by the EPA in 1995.

3.2 The Acid Sulfate Soils Assessment Guidelines (ASSMAC 1998)

The Acid Sulfate Soils Assessment Guidelines have been developed primarily for proponents of activities that are likely to disturb acid sulfate soils, and for councils and government authorities responsible for assessing these proposals. The guidelines recommend the adoption of best management practice in the planning, design and undertaking of activities that disturb acid sulfate soils.

The guidelines outlines the following:

- How to undertake a preliminary assessment to confirm if acid sulfate soils are present on site, and if present, the likelihood of the works to disturb the soils and potential impacts of works;
- How to develop mitigation and management strategies for a particular proposal and the preparation of an acid sulfate soil management plan;
- Steps in the assessment and approval process and matters that should be included in an application for approval of works disturbing acid sulfate soils; and
- Matters that approval authorities should consider in making a decision in relation to works disturbing acid sulfate soils.

The guidelines apply to all the following activities undertaken in areas likely to affect or use coastal sediments, warrant an assessment of the risk of exposing acid sulfate soil:

- Excavation or disturbance of acid sulfate soil (i.e. roads and foundation constructions, drainage works, land forming works, flood mitigation works, dams and aquaculture ponds, sand or gravel extraction, dredging). When acid sulfate materials are being excavated, attention must be given to the excavation site as well as the location where the excavated material is placed or used;
- Lowering the water table (i.e. new drainage works, deepening existing drains, groundwater use, dams de-watering, wetlands or quarries, dredging works lowering river bed);

- Use of acid sulfate soil (i.e. aquaculture pond walls, dams, flood mitigation works, imported fill material, reclamation or foreshore works);
- Physical habitat modification for mosquito control (i.e. runnelling, drainage and selective ditching to remove water or allow predatory fish access to dial pools).

The guidelines provide the action criteria to interpret analytical results that trigger the need for a management plan based on the percentage of oxidisable sulfur for broad categories of soil types.

3.3 The Acid Sulfate Soils Planning Guidelines (ASSMAC 1998)

The Acid Sulfate Soils Planning Guidelines supplements Local Environmental Plans (LEP) as a key regulatory mechanism to ensure sustainable management of acid sulfate soils in the coastal zone. The zoning and development control provisions in LEPs provide councils with the opportunity to ensure that land uses are carried out in an appropriate manner and that any intensification of land use does not pose unacceptable risks to the environment.

The LEP establishes a two-stage assessment.

1. Prior to undertaking works in an area mapped as having a likely risk that acid sulfate soils are present, a person may:
    - Accept that acid sulfate soils are present and proceed to preparing a development application and an acid sulfate soils management plan or;
    - Undertake a Preliminary Assessment to confirm whether an acid sulfate soils management plan is required. The *ASS Assessment Guidelines* set out the steps in a preliminary assessment. After the person has completed the preliminary assessment and ascertained that an acid sulfate soils management plan is not required, they must present their preliminary assessment to their local council seeking agreement with their decision. If council agrees in writing that an acid sulfate soils management plan is not required, then a development application is not required. If not, then the person must submit an acid sulfate soils management plan and obtain development consent prior to undertaking the works.

2. Where required, an acid sulfate soils management plan must be prepared in accordance with the *ASS Assessment Guidelines* and is to be reviewed by both the council and the Department of Land and Water Conservation.

The Department of Land and Water Conservation has prepared Acid Sulfate Soil Risk Maps for the coastal areas in NSW that predicts the distribution of acid sulfate soils based on an understanding of the factors that led to their formation reinforced by extensive soil surveying. The Acid Sulfate Soil Risk Maps have also been converted into Acid Sulfate Soil Planning Maps for use with Local Environmental Plans.

The Acid Sulfate Soil Planning Maps establish five classes (Table 2) of land based on the probability of acid sulfate soils occurrence and the type of works that might disturb them. The five classes in the Acid Sulfate Soils Planning Maps were developed by:

- Amalgamating risk classes in the Acid Sulfate Soils Risk Maps and relating them to the expected depth of occurrence of acid sulfate soils materials based on geomorphology; in amalgamating these classes the precautionary principle was applied with a conservative estimation of expected depths;
- Matching the expected depth of occurrence of acid sulfate soil materials with the depths that works would be expected to disturb soils by excavation or reduction in water table depths; and
- Including areas marked on the Acid Sulfate Soils Risk Maps as disturbed terrain. Where disturbed terrain occurred, the likely level of the natural ground surface was determined by stereoscopic examination of air photo pairs of adjacent lands. Disturbed terrain is land where soil, or other material, has been either removed or imported to significantly change the ground surface.

Table 2 – Acid Sulfate Soil Planning Map Risk Class

Class of land as shown on Acid Sulfate Soils Planning Maps	Works
1	▪ Any works
2	▪ Works below natural ground surface Works by which the water table is likely to be lowered
3	▪ Works beyond 1 meter below natural ground surface ▪ Works by which the water table is likely to be lowered beyond 1 meter below natural ground surface
4	▪ Works beyond 2 meters below natural ground surface ▪ Works by which the water table is likely to be lowered beyond 2 meters below natural ground surface
5	▪ Works within 500 meters of adjacent Class 1, 2, 3 or 4 land which are likely to lower the water table below 1 meter AHD on adjacent Class 1, 2, 3 or 4 land

3.4 The Acid Sulfate Soils Management Guidelines (ASSMAC 1998)

The Acid Sulfate Soils Management Guidelines outline the best practice in managing the impacts of proposed works in areas likely to contain acid sulfate soils. It provides mitigation and management strategies focusing on minimising the disturbance of acid sulfate soils and to mitigate and impacts if disturbance is necessary.

This guideline forms the assessment criteria and foundation for an ASSMP if acid sulfate soils is found on site. The guidelines also outlines techniques to manage extracted acid sulfate materials, remediate

degraded areas affected by acid sulfate soils and advices on selecting standardised material to be applied for treatment.

3.5 The Acid Sulfate Soils Laboratory Method Guidelines (ASSMAC 1998)

The Acid Sulfate Soils Laboratory Method Guidelines provides the standard methods for routine laboratory analysis of soil samples to provide information for the assessment and management of acid sulfate soils. This guideline also recommends best practice methods in the sampling, handling and transport of soil samples.

The guidelines focus on a standardised approach to routine laboratory determination of actual and potential acid production from oxidation of iron sulfides, mainly pyrite (FeS_2) in estuarine and coastal sediments. It outlines methods for acid sulfate soil related analytical work including the amount of neutralizing material required for acid sulfate soil management/treatment.

A sampling and analysis program should be designed to understand the risks of disturbing acid sulfate soils and to provide information to develop a management strategy. The level of investigation and analysis will depend on the characteristics of the site (particular site variability), the type of disturbance proposed and the sensitivity of the surrounding environment. The guidelines outlines recommendation on the number of sampling sites required based on the size of the site, field analysis, sample handling, transportation and storage for all laboratory analytical works.

4 LABORATORY ASSESSMENT

Assessment of acid sulfate soil conditions and the impacts of the proposed development are based on information provided in the Acid Sulfate Soil Assessment Guidelines presented in the ASSMAC *Acid Sulfate Soil Manual* (1998). The guidelines include information on assessment of the likelihood that the site lies within an acid sulfate soil area, the need for an acid sulfate soil management plan, and the development of mitigation methods for the proposed development.

From EIS 2007 report, two (2) soil samples were analysed from one borehole at two depths (3-3.45m and 7-7.5m) in relation to soil horizon change, the presence of odour or acid sulfate colouration. Suspended Peroxide Oxidation-Combined Acidity and Sulfate (sPOCAS) analysis was undertaken to confirm the actual acidity and sulfur trail of the material.

As the Manly Council requested a 'technical update' of the previous report, no additional sampling was undertaken by SESL Australia. The samples analysed in the previous Acid Sulfate Investigation by EIS in 2007 are a variation on the ASSMAC 1998 sampling density guidelines. Laboratory analysis is considered to have been completed in accordance with the guidelines. It is noted that the previous assessment was based on a very limited investigation and analytical campaign. Further analysis during excavation works is required to ensure the liming rates are appropriate.

The laboratory results from the previous report will be compared to the "action criteria" presented in the Acid Sulfate Soil Manual (ASSMAC, 1998). These "action criteria" define the need to prepare a management plan and are based on the percentage of oxidisable sulfur (or equivalent Total Potential Acidity) for broad categories of soil types.

Table 3 **–** Action criteria based on ASS soil analysis for three broad texture categories

Type of Material		**Action Criteria 1–1000 tonnes ASS disturbed**		**Action Criteria if more than 1000 tonnes disturbed**	
Texture range. McDonald et al. (1990)	**Approx. clay content *(%<0.02mm)***	**Sulfur trail *% S oxidisable (oven-dry basis) e.g. S_{TOS} or S_{POS}***	**Acid trail *mol H^+/tonne (oven-dry basis) e.g. TPA of TSA***	**Sulfur trail *% S oxidisable (oven-dry basis) e.g. S_{TOS} or S_{POS}***	**Acid trail *mol H+/tonne (oven-dry basis) e.g. TPA of TSA***
Coarse Texture Sands to loamy sands	≤5	0.03	18	**0.03**	**18**
Medium Texture Sandy loams to light clays	5 - 40	0.06	36	0.03	18
Fine Texture	≥40	0.1	62	0.03	18

Medium to heavy clays and silty clays					

(ASSMAC 1998)

The “action criteria” for coarse textured soils (sands to loamy sands) has been adopted for this assessment.

Levels of oxidisable sulfur within a soil or sediment indicate the risk to the environment on disturbance of the soils. For soils with results greater than the “action criteria” a soil management plan must be developed to manage the potential harm to the environment.

5 RESULTS

The material on site, according to the investigations undertaken in 2007 by EIS and during SESL's concurrent Tier DSI site investigation, consists of fill material to a depth of approximately 1-2.5m overlying natural grey and brown moist sands to a depth of at least 9m. The water table was encountered at approximately 3m. Laboratory analysis conducted as part of the 2007 investigation was analysed two (2) natural soil samples from one borehole at two depths, 3-3.45m and 7-7.5m. Table 4 outlines the results of the sPOCAS analysis conducted on the samples collected during the 2007 investigation. See Appendix C for previous report and laboratory results.

Table 4 – Summary of 2007 sPOCAS Test Results

Location (Sample depth, m)	Soil Description	pH_{KCl}	pH_{FOX}	TAA H^+/tonne	TPA H^+/tonne	TSA H^+/tonne	S_{pos} %	Lime Requirement
BH3 (3-3.4m)	Fine to medium grained, grey brown sand	6.0	**3.4**	<5	**22**	**22**	0.013	0.63kg/t
BH3 (7-7.5m)	Fine to medium grained, grey brown silty sand	6.2	**2.8**	<5	**30**	**30**	**0.038**	1.8kg/t
Values exceeding action criteria are identified in **Bold Underlined** Action criteria are defined as: pH = <5 %Spos = >0.03 TAA/TSA/TPA = > 18mol H^+/tonne								

The results indicate that natural soil materials are Potential Acid Sulfate Soils (PASS) with a hazardous pH drop in one depth sample. A relatively low liming treatment rate is recommended, likely due to the soils natural buffering capacity. Due to the identified PASS exceeding the action criteria, an Acid Sulfate Management Plan will be required to manage the generation of acidic leachate during excavation for the redevelopment works.

6 ACID SULFATE SOIL MANAGEMENT

6.1 Introduction

This ASSMP has been prepared generally in accordance with the Acid Sulfate Soil Manual -1998, which was developed by the *Acid Sulfate Soils Management Advisory Committee (ASSMAC)* and using information included in the *Queensland Acid Sulfate Soils Technical Manual (Dear et al. 2002).*

The following issues are addressed in this management plan:

- Strategies for the management of potential acid sulfate soils during excavation;
- Management of soil materials and water on site;
- Classification and disposal of soil materials; and
- Contingency procedures to be implemented in the event of the failure of management strategies.

6.2 Objectives

The objectives of this ASSMP are to reduce the potential onsite and offsite environmental impacts associated with the disturbance of potential acid sulfate soils within the area of excavation associated with the proposed works. The techniques outlined in the ASSMP will reduce the impact of the proposed works.

6.3 Management Strategies

The preferential sequence of management strategies (least risk to highest risk) to prevent environmental impacts is outlined as follows:

I. Avoidance – where possible, disturbance of potential acid sulfate soil (PASS) should be avoided.
II. Minimisation – should disturbance of PASS be required, the amount of disturbance and potential exposure time should be restricted.
III. Neutralisation – where disturbance and/or exposure is required, neutralisation of the potential acidity should be undertaken through the addition of lime.

As the proposed development requires removal of soils to a depth of approximately 6m, avoidance is not considered an option. The disturbance will be minimised to ensure sediments remaining in the excavation are not disturbed. All disturbed soils will undergo neutralisation.

6.4 Management of Site Works

The desktop review indicated that onsite soils are considered a Class 4 Acid Sulfate risk. From a review of previous reports and during the site inspection on 31/05/2016, site soils consisted of approximately 1-2.5m of fill with natural grey and brown sandy soils below to a depth of at least 9m. The watertable

was encountered at approximately 3m. The laboratory results from the 2007 EIS investigation indicated that natural underlying soils were Potential Acid Sulfate Soils (PASS). All natural materials beneath fill should be considered to be PASS.

The final depth of excavation is believed to be around 6m below the current surface level. Excavation works will be undertaken as follows:

1) All material excavated during the proposed works will be handled as follows in the section titled "Management of Excavated Material".
2) In the event that excavations are to occur below 6m, all excavated soils is to be treated as PASS and handled as outlined in "Management of Excavated Natural Material."
3) At the conclusion of excavations, all walls and base of the void are to be treated with lime.
4) As geotechnical reports have identified dewatering is required, extracted water will require storage and validation before discharge or disposal. Should a significant pH drop be observed, treatment will be required.
5) On site assessment of materials during excavation beneath the water table and lime blending shall be supervised by a suitably qualified Environmental Scientist.
6) As SESL's contamination investigation has identified contamination within fill materials, all fill on site is to be handled in accordance with the RAP generated for the site (to be completed at a later date) (See SESL report: DRAFT C8823Q5710B39331 MCC DSI).

6.5 Management of Excavated Material

6.5.1 Non-Acid Sulfate Soil Material

The 2007 preliminary site investigation assumed that fill material to approximately 1.0m was to be non-acid sulfate. Materials identified as fill will need be handled in accordance with an RAP (See SESL report: DRAFT C8823Q5710B39331 MCC DSI). The boundary between the fill and natural PASS materials will be confirmed during excavation through field observations and measurements.

6.5.2 Acid Sulfate Soils

Potential acid generation is typically managed by the addition of lime to neutralise acid that may be generated during and after the excavation works. For this project, a low solubility product such as agricultural lime shall be used. This form of lime is chemically stable and any excess lime takes significant period of time (years) to influence soil pH beyond the depth of mixing. The lime particles eventually become coated with an insoluble layer of ferrihydrite ($Fe_5HO_8 \cdot 4H_2O$) that further inhibits additional reaction. Long-term alteration of groundwater conditions is not expected to occur as a result of the use of lime during the proposed works.

The plan detailed below outlines the procedures that shall be implemented to excavate and treat the PASS:

- The laboratory analysis results included in the EIS 2007 report indicate that approximately **2kg of lime per tonne** of soil is recommended to adequately stabilise any PASS soil encountered.
- The acid sulfate soils will be excavated with an excavator or similar earth moving equipment and immediately transferred to the treatment area. The treatment area must be located onsite and must be bound by an earthen bund of at least 300mm in height (or a plastic lined area of similar height), and the base should be lined with 1kg/m^2 of agricultural lime, as to neutralise any acidic leachate from the excavated soil material.
- The material will be treated immediately on-site.
- To successfully manage the large volume of soil to be excavated and treated, SESL recommends a staged approach where a selected volume of soil is excavated, treated, validation and stockpiled for disposal.
- Following excavation, natural soils will be spread across the treatment area to a depth of approximately 0.2m to maximise surface area for lime addition.
- Lime will be applied at the designated rate established. A backhoe (or similar) will be used to thoroughly mix the lime into the soil. Monitoring will be undertaken by qualified personnel to ensure the mixing is undertaken to a suitable extent. The success of the neutralisation method relies on the effectiveness of the mixing process.
- Following treatment, field screening will be conducted by a qualified environmental scientist to ensure treatment has been successful. If required, additional lime will need to be added.
- Once treated and validated, material can be stockpiled outside the treatment area prior to offsite disposal. This stockpile should be bunded and covered with an impermeable layer.
- At the conclusion of excavations, all walls and base of the void are to be treated with lime at a rate of 1kg/m^2.
- An alternate treatment approach would see the required lime rate applied to the surface of the proposed excavation area, and incorporated into the surface layers prior to temporary stockpiling for validation and subsequent disposal.
- Should circumstances prevent the spreading and treatment of the material, the surface area will be minimised by avoided “spreading out” of the stockpile and forming a relatively high-coned shape. This will limit the surface area exposed to oxidation. Water infiltration will be minimised by covering the stockpile during wet weather. This will limit the formation and transport of acid leachate due to rainfall. The stockpile will be bunded to prevent erosion of the PASS and any movement of potential acid leachate.
- All neutralised material will need to be classified in accordance with NSW Waste Classification Guidelines and be disposed of off-site to a NSW EPA licensed landfill able to accept treated acid sulfate soils.

6.6 Groundwater Management During Construction Activities

In coastal areas underlain by PASS, it is important to maintain the groundwater level above the PASS layer so that it does not dry out. If the watertable drops below the top of this layer, air can enter the

PASS, oxidise them and produce sulfuric acid. After rain, the watertable rises and washes the sulfuric acid out of the oxidised acid sulfate soil layer.
The excavation created during site works and dewatering will increase the risk of acid leachate being generated, management and monitoring of groundwater is required.

As the watertable was encountered at a depth of 3m and excavations are to extend to approximately 6m, it is expected dewatering will be required during excavations. To prevent acid generation in the exposed areas of the excavation, lime is to be added to the walls and base at a rate 1kg/m^2.

As excavation works will disturb PASS soils within the excavation, there is a risk that acidic leachate will be generated and influence groundwater. To determine if the works have impacted the pH of groundwater:

- Groundwater monitoring wells must be installed downgradient of the excavation area. The
- pH established during SESL's contamination works of 5.15 to 6.2 units is to be used as a baseline. Initial confirmation of this pH range is required from the new wells prior to the commencement of dewatering.
- The quality of the water must be monitored continually over the entire period of the works. The pH will be measured and recorded. This is ideally done using pH dataloggers.
- Immediate advice is to be sought from an Environmental Scientist if the pH within the channel is not within 10% of the baseline pH. Where required, corrective action is to be taken as soon as possible. Laboratory analysis will be required on water samples as part of the corrective action to assess the quantity of neutralising agents required if treatment is necessary.

6.7 Contingency Plan for Groundwater

Should monitoring of the groundwater well indicate a significant change in acidic conditions, the contingency plan for the neutralisation of the PASS disturbed by excavation works may need to be implemented.

Should water monitoring indicate that the pH varies by more than 10% from the baseline value, all work should be placed on hold until further action is taken to limit the oxidation of PASS soils in the area of the current earthworks. Remedial works will be undertaken as follows:

- The depth to groundwater (i.e. the extent of de-watering) in the area of current excavation will be measured;
- The pH of soils exposed to oxygen will be measured to establish the source of the acidic condition;
- Material found to be acidic will be excavated and neutralised in accordance with the methods presented in the previous section titled "Management of Excavated Material"; and

- The material will be tested and replaced following the addition of lime to the base of the excavation. Where suitable, in-place treatment involving lime addition by mixing may be adopted.
- Following sampling or when any delays in addressing site conditions is expected, it is advised that the groundwater table be allowed to rise to re-saturate the site soils further halting additional oxidation.

In the case that unacceptable pH levels are recorded during the groundwater monitoring:

- Installation of a neutralisation trench (or similar) may be required to intercept and treat acidic groundwater prior to discharge. This could consist of an excavation filled with sand/lime mixture to filter, intercept and treat groundwater flowing across the trench.
- It may be required that neutralising materials are used down-well. Further technical will be required in this eventuality.
- Discharged water must have a pH between 6.5 and 8.5 and be licensed by the NSW EPA.

7 CONCLUSIONS AND RECOMMENDATIONS

From the results obtained, the soil encountered in the region of the proposed works consists of fill material to a depth of 1-2.5m overlying natural grey and brown sands to a depth of at least 9m. The region of the proposed works falls under a Class 4 Acid Sulfate Soil Risk works more than 2 metres below the natural ground surface and works by which the watertable is likely to be lowered more than 2 metres below the natural ground surface require development consent, as identified in the Manly Local Environment Plan 2013.

The results of the sPOCAS analysis conducted by EIS in 2007 indicated that natural soils are Potential Acid Sulfate Soils (PASS). Due to the identified PASS exceeding the action criteria, site soils must be managed through the Acid Sulfate Management Plan included in Section 6, to manage the generation of acidic leachate during excavation for the redevelopment works.

Based on the samples collect by EIS described in the 2007 report, all natural site soils will be treated as Potential Acid Sulfate Soil (PASS). Fill material above natural sands will be handled in accordance with SESL report: *DRAFT C8823Q5710B39331 MCC DSI*. For the proposed works to go ahead, implementation of the above Management Plan will prevent the formation of Actual Acid Sulfate Soils and the generation of sulfuric acid.

This report is based on the field data obtained from samples collected in 2007 by EIS from one (1) bore hole in the investigation area. If any materials are identified during excavation that is different to what has been described in this report, management via lime application described in the management plan will be required. It is noted that due to the limiated scope of the original investigation, that a higher level of ongoing field assessment is required during the implementation of this plan to ensure the adequate treatment is achieved.

Any material identified for offsite disposal must have a waste classification as outlined in Section 2.8 of this report. This can be undertaken by discrete sampling of the material by a SESL Environmental Scientist, with laboratory analysis and reporting on the findings.

8 LIMITATIONS

This report only covers the site conditions at the time of SESL's site inspection on 31/05/2016. Should there be any variation in the site conditions beyond this date, such as imported fill, chemical spillage, illegal dumping, further assessment will be required.

This report is for the use of the client and any relevant authorities that rely on the information for development applications and approval processes. Any reliance on this report by third parties shall be at such parties' sole risk. This report shall only be presented in full and may not be used to support any other objective other than those set out in the report.

SESL's assessment is necessarily based on the result of limited site investigations and upon the restricted program of visual assessment of the surface and consultation of available records. Neither SESL, nor any other reputable consultant, can provide unqualified warranties nor does SESL assume any liabilities for site conditions not observed, or accessible during the time of investigations.

No site investigations can be thorough enough to provide absolute confirmation of the presence or absence of substances, which may be considered contaminating, hazardous or polluting. Similarly, the level of testing undertaken cannot be considered to unequivocally characterise the degree or extent of contamination on site. In addition, regulatory or guideline criteria for the evaluation of environmental soil and groundwater quality are frequently being reviewed and concentrations of contaminants which are considered acceptable at present may in the future be considered to exceed acceptance criteria. Similar conditions may prevail in regard to site remediation standards as different regulatory mechanisms are developed and implemented.

9 REFERENCES

Acid Sulfate Soil Planning Guidelines, NSW Acid Sulfate Soils Management Advisory Committee (1998).

Chapman, G.A and Murphy, C.L. (1989), *Soil Landscapes of Sydney 1:100 000 Sheet.* Soil Conservation Service of NSW, Sydney

Environmental Protection Authority, Assessing and Managing Acid Sulfate Soils – Guidelines for Management in NSW Coastal Area, 1995).

Hazelton, P.A, Bannerman, S. M. and Tille, P. J. (1989), *Soil Series Sheet 9030.* Soil Conservation Service of NSW, Sydney

Manly Council Local Environment Plan (2012)

Waste Classification Guidelines Part 1: Classifying Waste, NSW Environmental Protection Authority (NSW EPA, 2014).

Waste Classification Guidelines Part 4: Acid Sulfate Soils, Department of Environment and Climate Change (NSW 2014).

SESL AUSTRALIA
Environment & Soil Sciences

Appendix A

ABN 70 106 810 708
T 1300 30 40 80
F 1300 64 46 89
E info@sesl.com.au
W sesl.com.au

POST
PO Box 357
Pennant Hills
NSW 1715

LAB
16 Chilvers Rd
Thornleigh
NSW 2120

ACT
Level 5
7 London Cct
Canberra
ACT 2601

VIC
Level 1
88 Mt Alexander Rd
Flemington
VIC 3031

QLD
Level 10
15 Green Square Cl
Fortitude Valley
QLD 4006

Courtesy of NSW Land and Property Information 2016

SESL AUSTRALIA
Environment & Soil Sciences

Title: Site Layout Map
Location: 2 West Promenade,Manly NSW
Project: C8823.Q5585.B39013 Manly Civic Club
Date: 14/06/2016

Legend
: 2007 Bore Hole Location

N

SESL AUSTRALIA
Environment & Soil Sciences

Appendix B

ABN 70 106 810 708
T 1300 30 40 80
F 1300 64 46 89
E info@sesl.com.au
W sesl.com.au

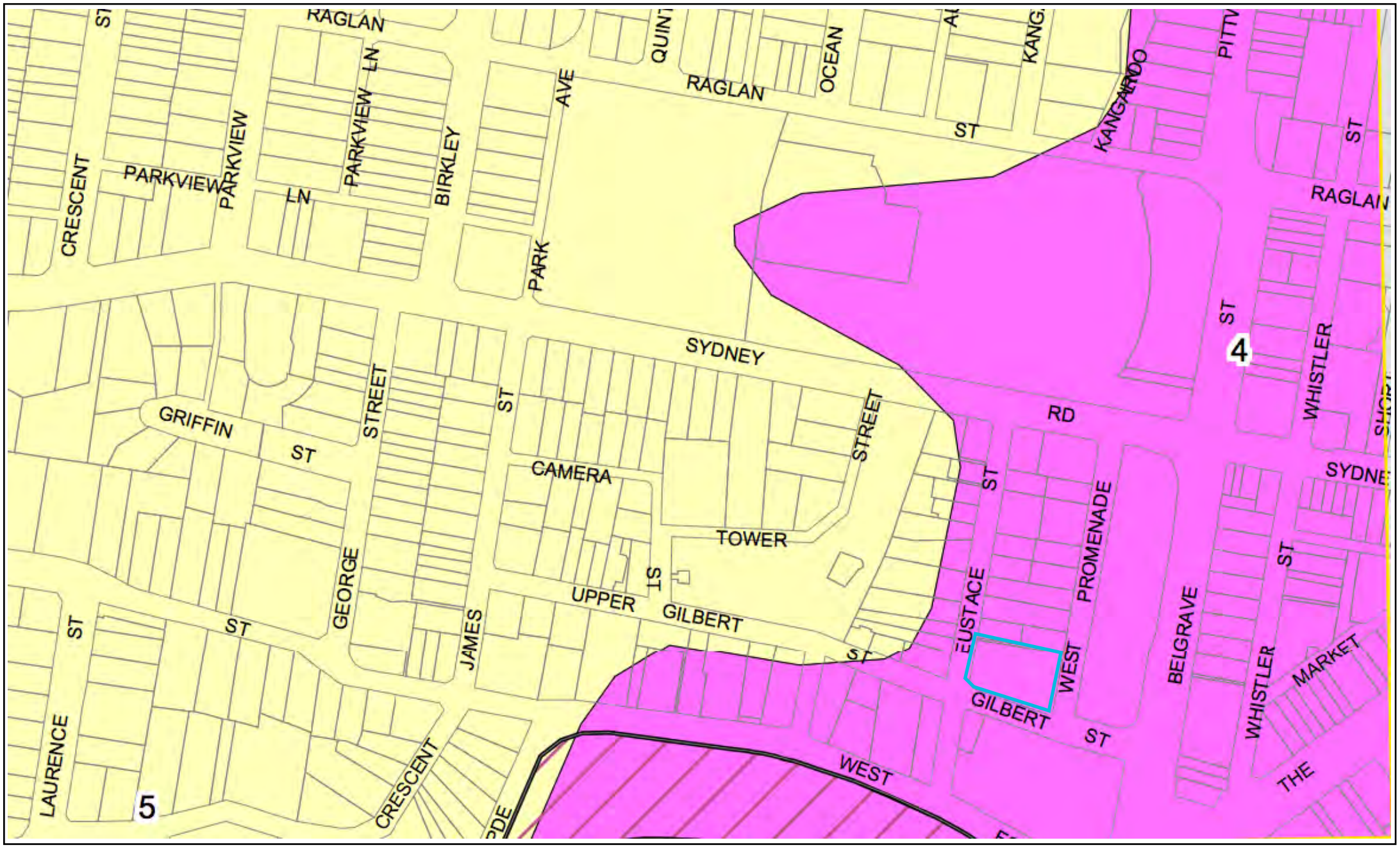
POST
PO Box 357
Pennant Hills
NSW 1715

LAB
16 Chilvers Rd
Thornleigh
NSW 2120

ACT
Level 5
7 London Cct
Canberra
ACT 2601

VIC
Level 1
88 Mt Alexander Rd
Flemington
VIC 3031

QLD
Level 10
15 Green Square Cl
Fortitude Valley
QLD 4006



Title: Acid Sulfate Risk Map

Location: 2 West Promenade Road, Manly NSW 2095

Project: C8823.Q5585. B39013 ASSMP Manly CC FA

Date: 15/06/2016

Courtesy of Northern Beaches Council Local Environment Plan

Legend

Site Location

Class 4

Class 5

N

SESL AUSTRALIA
Environment & Soil Sciences


GW106341
Satellite
Terrain
Map
Hybrid
Groundwater Works
Monitoring Bores
Telemetered Bores
Coal Basin Bores
Discontinued Bores
GW110294
GW109304
GW109245
GW102856

NSW Office of Water
Work Summary

GW102856

Licence: 10BL156555 **Licence Status:** LAPSED

Authorised Purpose(s): INDUSTRIAL
Intended Purpose(s): INDUSTRIAL

Work Type: Bore
Work Status:
Construct.Method: Auger
Owner Type:

Commenced Date: **Final Depth:** 28.70 m
Completion Date: 01/01/1994 **Drilled Depth:** 28.70 m

Contractor Name:
Driller:
Assistant Driller:

Property: N/A **Standing Water Level:** 4.300
GWMA: - **Salinity:**
GW Zone: - **Yield:** 0.180

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CUMBE	CUMBE.29	8//77172
Licensed:	CUMBERLAND	MANLY COVE	Whole Lot 8//77172

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

Elevation: 0.00 m (A.H.D.) **Northing:** 6258798.0 **Latitude:** 33°47'56.9"S
Elevation Source: Unknown **Easting:** 341557.0 **Longitude:** 151°17'18.2"E

GS Map: - **MGA Zone:** 0 **Coordinate Source:** Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	28.70	0			Unknown
1	1	Casing		0.00	27.00	100			
1	1	Opening	Screen	8.50	25.00			1	

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	4.20	4.20	SAND	Sand	
4.20	4.30	0.10	ROCK COFFEE	Rock	
4.30	8.40	4.10	SAND	Sand	
8.40	8.60	0.20	ROCK	Rock	
8.60	12.80	4.20	SAND	Sand	
12.80	12.90	0.10	SILT	Silt	
12.90	13.90	1.00	ROCK	Rock	
13.90	28.60	14.70	SAND	Sand	
28.60	28.70	0.10	ROCK	Rock	

Remarks

30/05/2000: PREVIOUS LIC No: 10BL154772

***** End of GW102856 *****

NSW Office of Water
Work Summary

GW106341

Licence: 10BL162907 **Licence Status:** CONVERTED

Authorised Purpose(s): RECREATION (GROUNDWATER)
Intended Purpose(s): RECREATION (GROUNDWATER)

Work Type: Bore
Work Status:
Construct.Method: Rotary
Owner Type:

Commenced Date: **Final Depth:** 42.50 m
Completion Date: 14/04/2004 **Drilled Depth:** 42.50 m

Contractor Name: INTERTEC DRILLING SERVICES
Driller: William Crump
Assistant Driller:

Property: IVANHOE PARK CNR SYDNEY RD& BELGRAVE ST MANLY 2095 NSW **Standing Water Level:** 18.300
GWMA: - **Salinity:**
GW Zone: - **Yield:** 3.100

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CUMBE	CUMBE.29	2502 752038
Licensed:	CUMBERLAND	MANLY COVE	Whole Lot 2502//752038

Region: 10 - Sydney South Coast **CMA Map:** 9130-2N
River Basin: 213 - SYDNEY COAST - GEORGES RIVER **Grid Zone:** **Scale:**
Area/District:

Elevation: 0.00 m (A.H.D.) **Northing:** 6259217.0 **Latitude:** 33°47'43.0"S
Elevation Source: (Unknown) **Easting:** 340934.0 **Longitude:** 151°16'54.3"E

GS Map: - **MGA Zone:** 0 **Coordinate Source:** Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	5.50	208			Down Hole Hammer
1		Hole	Hole	5.50	42.50	158			Down Hole Hammer
1	1	Casing	Pvc Class 9	-0.50	35.50	140			Suspended in Clamps, Screwed and Glued
1	1	Casing	Steel	-0.50	5.50	168	158		Driven into Hole

Water Bearing Zones

From	To	Thickness	WBZ Type	S.W.L.	D.D.L.	Yield	Hole	Duration	Salinity

(m)	(m)	(m)		(m)	(m)	(L/s)	Depth (m)	(hr)	(mg/L)
25.00	28.50	3.50	Unknown			0.50	30.50		355.00
36.60	36.70	0.10	Unknown	18.30		3.10	42.50		374.00

Geologists Log

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.50	2.50	FILL AND ROCKS	Fill	
2.50	25.00	22.50	SANDSTONE L/BROWN,SOFT BANDS	Sandstone	
25.00	26.50	1.50	SANDSTONE FINE QUARTZ	Sandstone	
26.50	28.50	2.00	SANDSTONE QUARTZ	Sandstone	
28.50	29.00	0.50	SANDSTONE GREY	Sandstone	
29.00	29.50	0.50	QUARTZ	Invalid Code	
29.50	36.00	6.50	SANDSTONE GREY	Sandstone	
36.00	36.20	0.20	SANDSTONE QUARTZ	Sandstone	
36.20	36.60	0.40	SANDSTONE GREY	Sandstone	
36.60	36.70	0.10	SANDSTONE FRACTURED	Sandstone	
36.70	40.00	3.30	SANDSTONE GREY	Sandstone	
40.00	42.50	2.50	SANDSTONE DARK GREY	Sandstone	

Remarks

***** End of GW106341 *****

NSW Office of Water
Work Summary

GW109245

Licence: 10BL602449 **Licence Status:** CANCELLED

Authorised Purpose(s): TEST BORE
Intended Purpose(s): RECREATION (GROUNDWATER)

Work Type: Bore
Work Status: Test Hole
Construct.Method: Auger
Owner Type: Other Govt

Commenced Date:
Completion Date: 20/08/2008
Final Depth: 11.00 m
Drilled Depth: 11.00 m

Contractor Name:
Driller: Michael Peter Sprouster
Assistant Driller:

Property: MANLY COUNCIL TOWN HALL BELGRAVE ST MANLY 2095 NSW
GWMA:
GW Zone:
Standing Water Level: 4.800
Salinity:
Yield: 1.000

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CUMBE	CUMBE.29	2317 1121139
Licensed:			

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

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6258847.0
Easting: 341223.0
Latitude: 33°47'55.1"S
Longitude: 151°17'05.3"E

GS Map: -
MGA Zone: 0
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	11.00	110			Auger
1	1	Casing	Pvc Class 9	0.00	9.00	110			Driven into Hole, Glued
1	1	Casing	Pvc Class 9	0.00	10.00	110			Driven into small hole, Glued
1	1	Opening	Screen	8.10	9.00	50		1	Stainless Steel, Screwed, SL: 60.0mm
1	1	Opening	Screen	10.00	11.00	50		1	Screwed, SL: 60.0mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

4.80	9.00	4.20	Unknown	4.80		1.00		02:00:00	140.00
5.00	11.00	6.00	Unknown	5.00		1.00		01:00:00	300.00

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.20	0.20	TOPSOIL	Unknown	
0.20	1.50	1.30	SANDSTONE,RUBBLE	Unknown	
1.50	3.00	1.50	SAND GREY	Unknown	
3.00	9.00	6.00	SAND YELLOW	Unknown	
9.00	11.00	2.00	SAND GREY	Unknown	

Remarks

10/03/2009: Previous Lic No:10BL602449
21/09/2009: Previous Lic No:10BL602761
23/09/2011: Slot Length and Width adjusted due to data entry errors with advice from Madhwan Keshwan. GDS Data Cleanup project 2011.Slot Length and Width adjusted due to data entry errors with advice from Madhwan Keshwan. GDS Data Cleanup project 2011.

***** End of GW109245 *****

NSW Office of Water
Work Summary

GW109304

Licence: 10BL602565 **Licence Status:** CONVERTED

Authorised Purpose(s): RECREATION (GROUNDWATER)
Intended Purpose(s): RECREATION (GROUNDWATER)

Work Type: Spear
Work Status:
Construct.Method: Jetted - Water
Owner Type: Other Govt

Commenced Date: **Final Depth:** 8.54 m
Completion Date: 08/09/2008 **Drilled Depth:** 8.54 m

Contractor Name:
Driller: Arthur Korkidas
Assistant Driller:

Property: CORSO GARDENS THE CORSO - WEST END MANLY 2095 NSW **Standing Water Level:** 4.830
GWMA: **Salinity:** Good
GW Zone: **Yield:** 1.000

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CUMBE	CUMBE.29	//1//91759
Licensed:			

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

Elevation: 0.00 m (A.H.D.) **Northing:** 6258857.0 **Latitude:** 33°47'54.8"S
Elevation Source: Unknown **Easting:** 341291.0 **Longitude:** 151°17'07.9"E

GS Map: - **MGA Zone:** 0 **Coordinate Source:** Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	8.54	100			Jetted - Water
1	1	Opening	Screen	0.00	0.00	50		1	Stainless Steel 304, Screwed
1	1	Casing	Pvc Class 9	0.00	7.63	100			Glued

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
4.88	8.54	3.66	Unknown	4.83		1.00			

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	8.54	8.54	UNCONSOLIDATED ALL SANDS	Ultramafic Rock	

Remarks

***** End of GW109304 *****

NSW Office of Water
Work Summary

GW110294

Licence: 10BL603048 **Licence Status:** CANCELLED

Authorised Purpose(s): TEST BORE
Intended Purpose(s): RECREATION (GROUNDWATER)

Work Type: Spear
Work Status:
Construct.Method: Auger
Owner Type: Private

Commenced Date: **Final Depth:** 8.00 m
Completion Date: 22/05/2009 **Drilled Depth:** 8.00 m

Contractor Name:
Driller: Michael Peter Sprouster
Assistant Driller:

Property: GILBERT PARK 1 BELGRAVE STREET MANLY 2095 NSW **Standing Water Level:** 4.000
GWMA: **Salinity:**
GW Zone: **Yield:** 1.000

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CUMBE	CUMBE.29	7143 1023242
Licensed:			

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

Elevation: 0.00 m (A.H.D.) **Northing:** 6258919.0 **Latitude:** 33°47'52.8"S
Elevation Source: Unknown **Easting:** 341175.0 **Longitude:** 151°17'03.5"E

GS Map: - **MGA Zone:** 0 **Coordinate Source:** Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	8.00	110			Auger
1		Annulus	Waterworn/Rounded	0.00	0.00				Graded
1	1	Casing	Pvc Class 9	0.00	6.88	110			Driven into Hole, Glued
1	1	Opening	Screen - Gauze/Mesh	7.00	8.00	50		1	Stainless Steel, Screwed, SL: 60.0mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
4.00	8.00	4.00	Unknown	4.00		1.00		01:00:00	

Geologists Log
Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.30	0.30	TOPSOIL	Topsoil	
0.30	0.60	0.30	RUBBLE	Regolith	
0.60	0.70	0.10	DARK SOIL	Soil	
0.70	0.80	0.10	SANDSTONE/RUBBLE	Sandstone	
0.80	1.80	1.00	SAND GREY	Sand Grains (Lithic)	
1.80	2.90	1.10	SAND WHITE	Sand Grains (Lithic)	
2.90	3.60	0.70	SOIL DARK	Soil	
3.60	3.80	0.20	SAND BROWN	Sand Grains (Lithic)	
3.80	4.00	0.20	SAND YELLOW	Sand Grains (Lithic)	
4.00	8.00	4.00	SAND WHITE	Sand Grains (Lithic)	

Remarks

21/09/2009: Previous Lic No:10BL603048
23/09/2011: Slot Length and Width adjusted due to data entry errors with advice from Madhwan Keshwan. GDS Data Cleanup project 2011.

***** End of GW110294 *****

SESL AUSTRALIA
Environment & Soil Sciences

Appendix C

ABN 70 106 810 708
T 1300 30 40 80
F 1300 64 46 89
E info@sesl.com.au
W sesl.com.au

POST
PO Box 357
Pennant Hills
NSW 1715

LAB
16 Chilvers Rd
Thornleigh
NSW 2120

ACT
Level 5
7 London Cct
Canberra
ACT 2601

VIC
Level 1
88 Mt Alexander Rd
Flemington
VIC 3031

QLD
Level 10
15 Green Square Cl
Fortitude Valley
QLD 4006

ENVIRONMENTAL INVESTIGATION SERVICES

14 September 2007
Ref: E21496FK-Let

Manly Civic Club Ltd
C/- Axil Architects Pty Ltd
PO Box 884
ROZELLE NSW 2039

ATTENTION: Mr David Herron

PRELIMINARY ACID SULFATE SOIL ASSESSMENT AND ACID SULFATE SOIL MANAGEMENT PLAN PROPOSED REDEVELOPMENT OF MANLY CIVIC CLUB 2 WEST PROMENADE, MANLY

Introduction

Axil Architects Pty Ltd, acting on behalf of Manly Civic Club Ltd, commissioned Environmental Investigation Services (EIS), a division of Jeffery & Katauskas Pty Ltd (J&K), to undertake a preliminary acid sulfate soil assessment for the proposed redevelopment at 2 West Promenade, Manly. The proposed development includes demolition of the existing club and construction of a 5 storey building with a two level basement car park. Details of the finished floor levels for the basement car park were not available at the time of the investigation, however the basement was expected to extend to a depth of approximately 6.0m below the existing site levels. Disturbance/excavation of soils below the basement may be required for the building foundations.

The assessment was undertaken generally in accordance with an EIS proposal (EP3332F) of 14 August 2007 and a written commission by Axil Architects Pty Ltd on behalf of Manly Civic Club Ltd of 24 August 2007. A geotechnical investigation was undertaken in conjunction with the preliminary acid sulfate soil assessment by J&K. The results are presented in a separate report (ref: 21496SB, dated 14 September 2007).

The scope of work included sampling from one borehole (BH3) and laboratory analysis of two subsurface soil samples.

Background

Acid sulfate soils (ASS) is the common term for naturally occurring soil and sediment that contains iron sulfides which, when exposed to oxygen generate sulfuric acid. These soils are formed from iron rich alluvial sediments and sulfate (found in seawater) in the presence of

sulfate reducing bacteria and plentiful organic matter. These conditions are generally found in mangroves, salt marsh vegetation or tidal areas and at the bottom of coastal rivers and lakes.

Disturbance and exposure to air of these sulfides, commonly through drainage or excavation, causes oxidation and the eventual production of sulfuric acid. This sulfuric acid can then drain into waterways through groundwater and surface flows. The impacts of acid drainage can include fish kills, oyster damage and mortality, adverse impacts on soil structure and stability and damage to steel and concrete structures including bridge and building footings and corrosion of underground pipes.

The NSW government formed the Acid Sulfate Soils Management Advisory Committee (ASSMAC) in 1994 to coordinate a response to acid sulfate soil issues. In 1998 this group released the Acid Sulfate Soil Manual providing best practice advice for planning, assessment, management, laboratory methods, drainage, groundwater and the preparation of acid sulfate soil management plans.

Site Description

The acid sulfate soil risk maps indicate areas of high risk, low risk and no known occurrence of acid sulfate soils. The acid sulfate soil risk map for Sydney Heads (Acid Sulfate Soil Risk Map-9130N2 edition 2, December 1997, 1:25000, Department of Land and Soil Conservation now part of Department of Environment and Climate Change - DECC) indicates that the site is located within an area of "low probability" of acid sulfate soils at depths greater than 3m below ground levels.

The 1:100,000 geological map of Sydney (Map 9130, 1:100,000 Department of Mineral Resources [now NSW Department of Primary Industries] – 1983) indicates the site to be located in the vicinity of two geological formations. Quaternary aged deposits of coarse quartz sand with varying amounts of shell fragments generally occurs in the areas to the south of the site, whilst Quaternary aged deposits of medium to fine-grained 'marine' sand generally occurs in the areas to the north of the site.

The site is located on the west side of West Promenade, Manly and lies approximately 50m beyond the toe of an east facing regional hill slope. The site is relatively flat and is bounded by Gilbert Street, West Promenade and Eustace Street to the south, east and west respectively and by a three storey apartment block to the north. The site is located approximately 150m north of Manly Cove and approximately 500m west of Manly Beach.

At the time of the investigation, the south section of the site was occupied by a single storey building (understood to be an old service station building) and a paved car park. The north section of the site was occupied by a 2 and 4 storey building, referred to as the Manly Civic Club.

Generally the surrounding areas were occupied by multi storey residential complexes with the exception of a grassed area and car park located beyond West Promenade and Eustace Street respectively.

Subsurface Investigation and Soil Sampling Methods

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

The SPT sampler was washed with phosphate free detergent and rinsed following each sampling event. The spiral flight augers were decontaminated using a scrubbing brush and potable water and Decon 90 solution (phosphate free detergent) followed by rinsing with potable water. Sampling personnel used disposable Nylex gloves during sampling activities.

Soil samples were obtained at various depths, based on observations made during the field investigation. All samples were placed in plastic bags and sealed with plastic ties with minimal headspace. During the investigation, samples were preserved by immediate storage in an insulated sample container with ice. Each sample was labelled with a unique job number, the sampling location, sampling depth and date. All samples were recorded on the borehole logs and on the chain of custody (COC) record presented as attachments to this letter.

On completion of the fieldwork, the samples were delivered in the insulated sample container to a NATA registered laboratory for analysis under standard chain of custody procedures. Additional samples were frozen and stored pending further analysis requirements.

Subsurface Conditions

The field investigation included soil sampling from one borehole, located as indicated on the attached Figure 2. For details of the subsurface soil profile, reference should be made to the borehole log (BH3) attached to this letter. The borehole encountered concrete pavement from the surface to a depth of approximately 0.11m, underlain by gravelly sand and clayey sand fill to a depth of approximately 1.0m. The fill was typically dark grey or orange grey-brown with inclusions of sandstone and igneous gravel.

Natural sandy soil underlay the fill and extended to a depth of approximately 9.0m, where the borehole was terminated. The sand was typically grey and/or brown. Organic odours were noted within the natural soils from beyond a depth of approximately 3.5m.

Immediate groundwater seepage was encountered during drilling at a depth of approximately 3.5m. The standing water level was measured at 3.0m, approximately 15 minutes following completion of drilling. No long-term groundwater monitoring was undertaken during the investigation.

Laboratory Assessment

Assessment of acid sulfate soil conditions and the impacts of the proposed development are based on information provided in the Acid Sulfate Soil Assessment Guidelines presented in the ASSMAC *Acid Sulfate Soil Manual* (1998). The guidelines include information on assessment of the likelihood that the site lies within an acid sulfate soil area, the need for an acid sulfate soil management plan, and the development of mitigation methods for the proposed development.

The assessment guidelines include recommendations for the density of sampling locations within the site. A minimum of four sampling locations should be undertaken for a site with an area up to 1 Ha in size to assess development constraints with a reduced density for sites greater than 4Ha of two locations per hectare. The sampling locations should include all areas where significant disturbance of soils will occur and/or areas with a high environmental sensitivity. In some instances a varied sampling plan may be more suitable, particularly for sites less than 1000m^2 in area.

The depth of investigation should be at least one metre beyond the depth of proposed excavation/disturbance or estimated drop in watertable height, or to a minimum of two metres below existing ground level, whichever is greatest.

Standard methods for the laboratory analysis of samples are presented in the Laboratory Methods Guidelines presented in the ASSMAC *Acid Sulfate Soil Manual* (1998). The principle analytical methods are:

- TOS – Total Oxidisable Sulfur;
- sPOCAS – suspention Peroxide Oxidation Combined Acidity and Sulfate.

sPOCAS testing provides a greater understanding of oxidisable sulfur content of the soil, particularly where the soil pH is less than 5.6 and is generally the preferred method.

In order to assess the presence of actual or potential acid sulfate soil, suspension Peroxide Oxidation-Combined Acidity and Sulfate (sPOCAS) analyses was undertaken on two natural soil samples. The samples analysed were obtained from BH3 at depth intervals of 3.0m to 3.45m and 7.0m to 7.5m. The laboratory results were compared to the "action criteria" presented in the Acid Sulfate Soil Manual (ASSMAC, 1998). These "action criteria" define the need to prepare a management plan and are based on the percentage of oxidisable sulfur (or equivalent Total Potential Acidity) for broad categories of soil types. Where greater than 1,000 tonnes of ASS is to be disturbed the most sensitive criteria apply:

- pH - less than 5.
- TAA/TSA/TPA (pH5.5) – greater than 18mol H^+/tonne.
- S_{pos} – greater than 0.03% sulfur oxidisable.

Levels of oxidisable sulfur within a soil or sediment indicate the risk to the environment on disturbance of the soils. For soils with results greater than the "action criteria" a soil management plan must be developed to manage the potential harm to the environment. As a general rule the highest result from either the "acid trail" or "sulfur trail" should be used as the action criteria.

Results

The results of the laboratory analysis are summarised below:

- The pH_{KCl} results for the soil samples obtained from BH3 at depth intervals of 3.0m to 3.45m and 7.0m to 7.5m prior to oxidation were 6.0 and 6.2 respectively. The total actual acidity (TAA) results were less than the method detection limits for both samples. These results indicated that acidic soil conditions are not present prior to disturbance of the soils.

- Following oxidation the pH_{ox} results for the soil samples obtained from BH3 at depth intervals of 3.0m to 3.45m and 7.0m to 7.5m following oxidation were 2.3 and 2.7 respectively.

- The total potential acidity (TPA) results for the samples obtained from BH3 at depth intervals of 3.0m to 3.45m and 7.0m to 7.5m were 22 mol H^+/tonne and 30 mol H^+/tonne respectively. The TSA results for the samples were 22 mol H^+/tonne and 30 mol H^+/tonne respectively, indicating that the acidity may be due to the sulfide compounds within the soil.

- The S_{pos}% result for the soil samples obtained from BH3 at depth intervals of 3.0m to 3.45m and 7.0m to 7.5m were 0.013% and 0.038% respectively. This indicates that the acidic conditions are likely associated with significant levels of available sulfides in the soils.

- The sulfur trail, S_{pos}% results for one of the two soil samples was greater than the 'action criteria' of 0.03%. Based on the sPOCAS laboratory analysis results, the soils are considered to be potentially acidic following disturbance and consistent with potential acid sulfate soils occurring beneath the standing groundwater table at the site.

- Lime requirement calculations for these two samples indicate that approximately 2kg of lime/tonne of soil will be necessary to neutralise the potential acidity.

Discussion and Conclusions

The proposed development includes demolition of the existing club and construction of a 5 storey building with a two level basement car park. Details of the finished floor levels for the basement car park were not available at the time of the investigation, however the basement was expected to extend to a depth of approximately 6.0m below the existing site levels. Disturbance/excavation of soils below the basement may be required for the building foundations.

The preliminary acid sulfate soil assessment included the analysis of two natural soil samples, obtained from the one borehole located within the proposed basement footprint, using laboratory sPOCAS analysis methods.

sPOCAS results for the samples identified conditions greater than the site 'action criteria'. As such, potential acid sulfate soil (PASS) conditions are considered to be present at the site and may be disturbed during the proposed development works.

Concrete that may come into contact with these soils (i.e. piled footings, floor slabs and pool basins) should be designed to resist acid and sulfate attack. Reference should be made to the Cement and Concrete Association of Australia Technical Note TN57 for appropriate precautionary measures.

Based on the site inspection and limited laboratory analysis results, potential acid sulfate soil conditions are considered to exist at the site. There is considered to be a significant risk to the development of actual acid sulfate conditions developing following disturbance of the natural soils at the site. Preparation of an acid sulfate soil management plan is considered necessary for the proposed development to minimise the risk.

Following is a management plan which should be implemented during the proposed works.

ACID SULFATE SOILS MANAGEMENT PLAN

Introduction

The ASSMP has been prepared generally in accordance with the Acid Sulfate Soil Manual – 1998, which was developed by the *Acid Sulfate Soils Management Advisory Committee (ASSMAC)* and using information included in the *Queensland Acid Sulfate Soils Technical Manual (Dear et al. 2002).*

The following issues are addressed in this management plan:

- Strategies for the management of potential acid sulfate soils during construction of the new development.
- Soil and groundwater monitoring program.
- Contingency procedures to be implemented in the event of the failure of management strategies.

Objectives

The objective of the ASSMP is to reduce the potential on-site and off-site environmental impacts associated with the disturbance of potential acid sulfate soils within the area of excavation associated with the proposed development. Following the techniques outlined in this Management Plan will reduce the impact of the proposed works.

Management Strategies

The preferential sequence of management strategies (least risk to highest risk) to prevent environmental impacts is outlined as follows:

1. Avoidance – where possible disturbance of potential acid sulfate soils (PASS) should be avoided.
2. Minimisation – should disturbance of PASS be required, the amount of disturbance and potential exposure time should be restricted.
3. Neutralisation – where disturbance and/or exposure is required, neutralisation of the potential acidity should be undertaken through addition of lime.

The proposed development is anticipated to include requirements for all three strategies to be integrated.

Management of Site Works

Excavation works (including piling and/or foundation works) for the construction of the development will be undertaken as follows:

4. All material excavated for the basement carpark and installation of foundations associated with the development will be handled as follows in the section titled "Management of Excavated Material".
5. During excavation works a neutralising agent such as lime will be added to the exposed PASS soils at the base of the basement and pile excavations as soon as possible after exposure to air to neutralise any possible acid generation.
6. In the event that de-watering of the basement excavation is required during construction works, de-watering should be undertaken using sump and pump or alterative techniques. The water extracted during de-watering should be stored in a detention tank or constructed pond prior to assessment of pH and sediment loads. Treatment should be undertaken as required prior to re-injection or disposal of the water.
7. Should any fill material be used to raise the site to the proposed development level the material should be validated to ensure that the imported fill is suitable for the proposed residential site use.

Management of Excavated Material

Fill Soils

The fill soils excavated for the proposed development will be stockpiled separately to the natural soils. The fill soils are not expected to be potential acid sulfate soils, however, if suspected acid sulfate fill soils are encountered during the excavation works, the materials will be stockpiled separately in suitably bunded areas prior to additional assessment and treatment. Any excess excavated fill soil will be assessed and classified prior to off-site disposal in accordance with the NSW DECC Waste Classification Guidelines (1999).

Natural Soils

Potential acid generation is typically managed by the addition of lime to neutralise acid that may be generated during and after the excavation works. For this project, a slightly alkaline, low solubility product such as agricultural lime should be used. This form of lime is chemically stable and any excess lime takes a significant period of time (years) to influence soil pH beyond the depth of mixing. The lime particles eventually become coated with an insoluble layer of ferrihydrite ($Fe[OH]_3$) that further inhibits additional reaction. Long term alteration of groundwater conditions is not expected to occur as a result of the use of lime during the proposed development works.

Field trials should be undertaken prior to the commencement of the bulk excavation works to establish the amount of lime required for adequate neutralisation of the soils at the site. The laboratory analysis results undertaken to date indicate that up to approximately 1.8kg of lime per tonne of soil is required to adequately stabilise the PASS soil below a depth of 2.5m below existing site levels. Further assessment of the soils is recommended prior to the commencement of works to better assess the acid sulfate soils at the site and the quantity of lime necessary to neutralise all potential acidity.

The natural soil excavated to a depth of 2.5m (below existing site levels) for the construction of the basement car park will be stockpiled separately. The natural soils to a depth of 2.5m below existing site levels are not expected to be potential acid sulfate soils, however, if suspected acid sulfate fill soils are encountered during the excavation works (particularly if groundwater seepage is encountered), the materials will be stockpiled separately in suitably bunded areas prior to additional assessment and treatment. Any excess excavated natural soil will be assessed and classified prior to off-site disposal in accordance with the NSW DECC Waste Classification Guidelines (1999).

Construction of the basement and building foundations will include excavation of natural PASS soil at the site and the following procedures should be implemented to excavate and treat the PASS:

- The natural (PASS) soils below a depth of 2.5m below existing site levels will be excavated with a backhoe, excavator or similar earth moving equipment and immediately transferred to the treatment area and spread to a depth of approximately 0.2m to 0.5m (this includes any spoil generated from a piling rig). The material should be spread on an impervious pad, or alternatively a bed of lime should be established to isolate the stockpiled material from the underlying soil.
- The material will be treated immediately on-site. Several bunded areas may be necessary for stockpiling and treatment.
- Lime will be applied at the designated rate established from the results of the field trials. A backhoe will be used to thoroughly mix the lime into the soil. Monitoring will be undertaken by qualified personnel (see contact details at the end of this letter) to ensure

the mixing is undertaken to a suitable extent. The success of the neutralisation method relies on the effectiveness of the mixing process.

- Field pH measurements will be undertaken to confirm that the soils have been neutralised by lime addition. If required, additional lime will be added to the soil and additional mixing undertaken.
- Should circumstances prevent the spreading and treatment of the material, the surface area will be minimised by avoiding 'spreading-out' the stockpile and forming a relatively high coned shape. This will limit the surface area exposed to oxidation. Water infiltration will be minimised by covering the stockpile during wet weather. This will limit the formation and transport of acid leachate due to rainfall. The stockpile will be bunded to prevent erosion of the PASS and any movement of potential acid leachate. Upstream surface runoff water will also be diverted around the stockpile.
- The material will subsequently be classified according to the Chemical Contaminant Criteria for Waste Classification as outlined in the Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-Liquid Wastes – NSW DECC (formerly the EPA) 1999. All neutralised material will be disposed of off-site to a NSW DECC (EPA) licensed landfill able to accept treated acid sulfate soils. If necessary the material will be removed from the treatment area into a bunded area and covered prior to disposal. Additional pH monitoring will be required to ensure that the material is suitable for disposal if the material is stockpiled following treatment.

Groundwater Management During Construction Activities

Excavation for the construction of the two level basement is likely to require dewatering activities to lower the standing water table during construction. Several groundwater monitoring locations should be established beyond the extent of excavation, particularly down gradient of the excavation zone at the south site boundary, prior to the commencement of excavation works at the site. Monitoring of groundwater levels and water chemistry should be undertaken to establish baseline site conditions before commencement of site works.

The quality of the groundwater should be monitored on a regular basis over the entire construction period. The pH will be measured and recorded. Immediate advice is to be sought from an experienced consultant if the pH at any location is not within 10% of the baseline pH. Where required, corrective action is to be taken as soon as possible, consistent with protection of the safety of the works. Laboratory analysis will be required on water samples as part of the corrective action to assess the quantity of neutralising agents required if treatment is necessary.

Contingency Plan

Should monitoring of the groundwater monitoring well indicate a significant change in acidic conditions, the contingency plan for neutralisation of the PASS disturbed by excavation works may need to be implemented.

Should water monitoring indicate that the pH varies by more than 10% from the baseline value, all work should be placed on hold until further action is taken to limit the oxidation of PASS soils in the area of the current earthworks. Remedial works will be undertaken as follows:

- The depth to groundwater (ie the extent of de-watering) in the area of current excavation will be measured;
- The pH of soils exposed to oxygen will be measured to establish the source of the acidic conditions;
- Material found to be acidic will be excavated and neutralised in accordance with the methods presented in the previous section titled "Management of Excavated Material"; and
- The material will be tested and replaced following addition of lime to the base of the excavation. Where suitable, in-place treatment involving lime addition and mixing may by adopted.

In the case that unacceptable acid levels are recorded during the groundwater monitoring, installation of a neutralisation trench (or similar) may be required to intercept and treat acidic groundwater prior to discharge. This could consist of an excavation filled with a sand/lime mixture designed to filter, intercept and treat groundwater flowing across the trench.

Limitations

The findings presented in this letter are based on data that existed at the time of the assessment. They are based on investigation of conditions at specific locations, chosen to be as representative as possible under the given circumstances, and visual observations of the site and vicinity. Subsurface soil and rock conditions encountered between investigation locations may be found to be different from those expected. Groundwater conditions may also vary, especially after climatic changes.

This letter has been prepared for the particular project described and no responsibility is accepted for the use of any part of this letter in any other context or for any other purpose. Copyright in this letter is the property of EIS. EIS has used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended. Subject to payment of all fees due for the assessment, the client alone shall have a licence to use this letter.

Should you require any further information regarding the above please do not hesitate to contact the undersigned.

Note: Field trials and future site work associated with the excavation/treatment of the acid sulfate soils at the site can be carried out by SESL (Sydney Environmental Soil Laboratories). Phone: 9980 6554, Fax: 9484 2427.

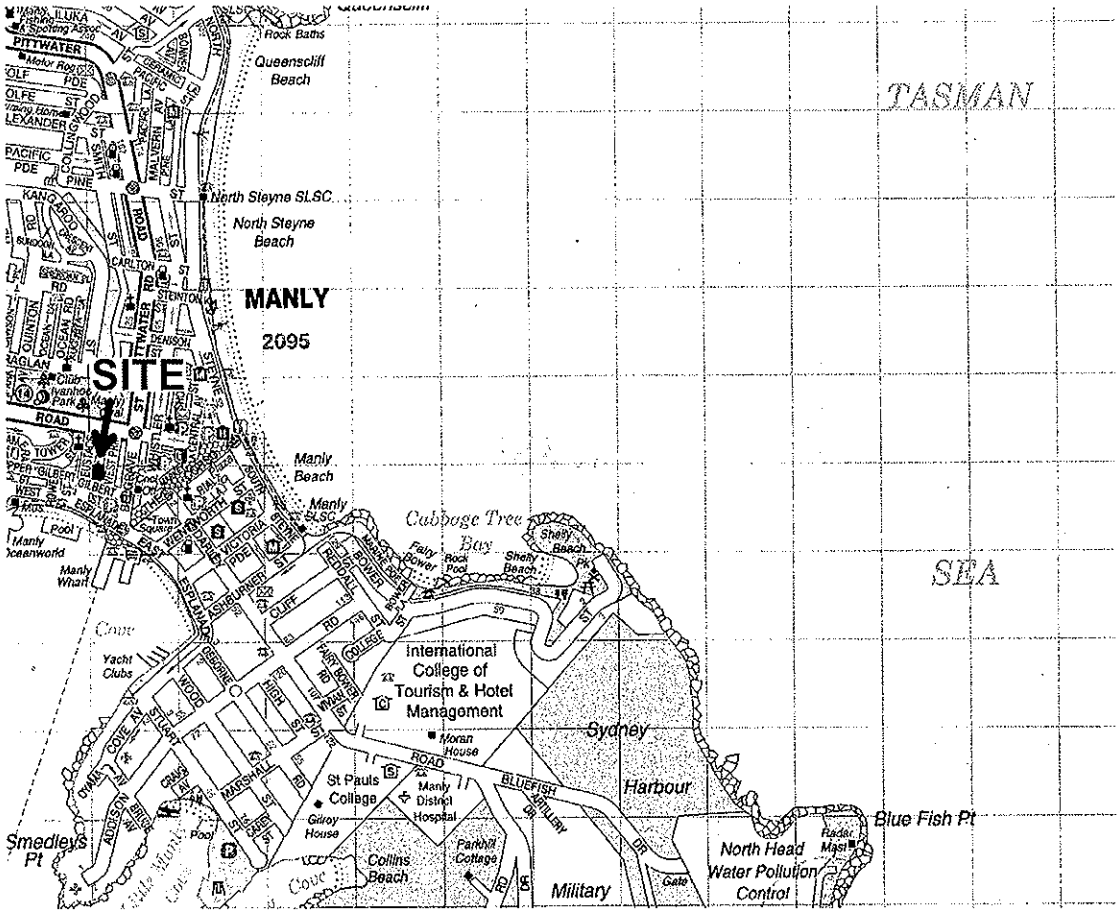
Yours faithfully
For and on behalf of
ENVIRONMENTAL INVESTIGATION SERVICES

Brendan Page
Environmental Scientist

E H Fletcher
Principal Engineer

Attachments:

Site Location Plan.
Borehole Location Plan.
Environmental Borehole log BH3.
Envirolab Services Environmental Laboratory Report No: 13474.



Recreated from UBD
Ref: 198 B10

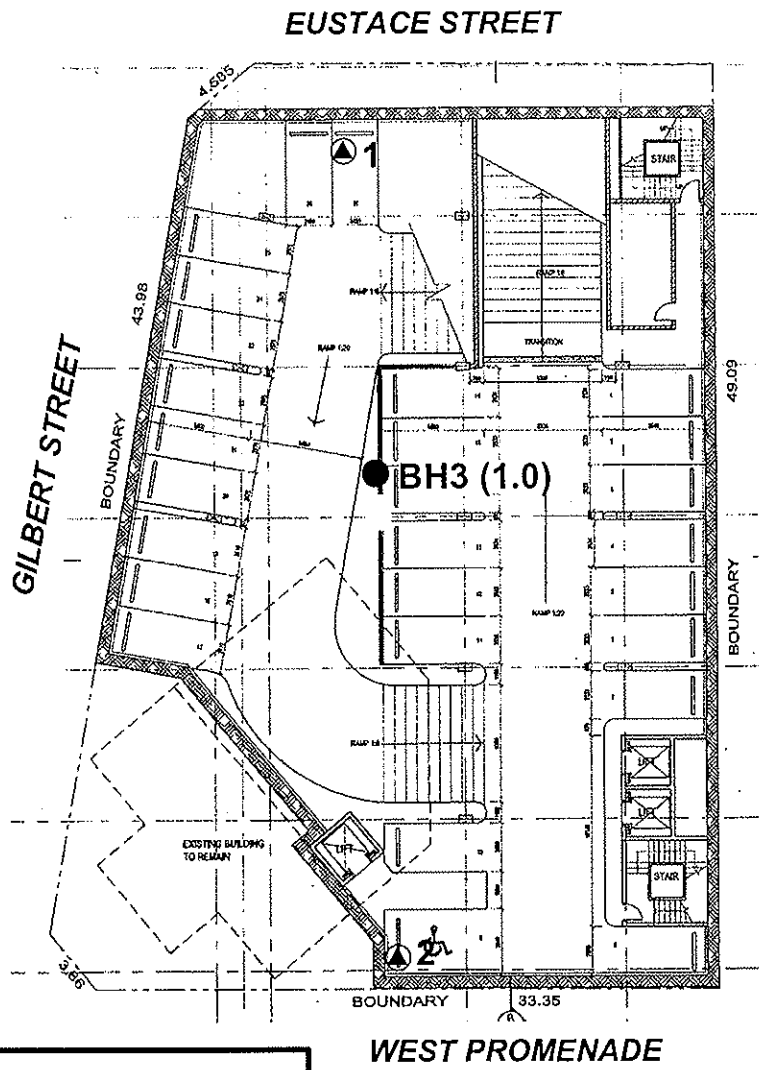
SITE LOCATION PLAN

2 West Promenade, Manly

ENVIRONMENTAL INVESTIGATION SERVICES

Job No: E21496FK
Figure: 1

Note: Reference should be made to the text for a full understanding of this plan



Legend:

▲1	J&K EFCP TEST LOCATION
●BH3 (1.0)	BOREHOLE LOCATION, NUMBER AND DEPTH OF FILL (m)

BOREHOLE LOCATION PLAN

2 West Promenade, Manly

Approximate Scale (m)

0 4 8 12 16 20

Note: Reference should be made to the text for a full understanding of this plan

ENVIRONMENTAL INVESTIGATION SERVICES

Job No: E21496FK
Figure: 2

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. 3 1/2

BOREHOLE LOG

Client: MANLY CIVIC CLUB LIMITED

Project: PROPOSED REDEVELOPMENT OF MANLY CIVIC CLUB

Location: 2 WEST PROMENADE, MANLY, NSW

Job No. 21496SB **Method:** SPIRAL AUGER JK300 **R.L. Surface:** N/A

Date: 31-8-07 **Datum:**

Logged/Checked by: N.E.S./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			CONCRETE: 110mm.t				8mm DIAMETER REINFORCEMENT, 45mm TOP COVER
					N = 7 3,3,4			-	FILL: Gravelly sand, fine to coarse grained, dark grey, fine to medium grained igneous gravel.	M	-	-	
						1		SP	FILL: Clayey sand, fine to medium grained, orange grey brown, with fine to medium grained sandstone gravel.				APPEARS MODERATELY COMPACTED
					N = 5 2,3,2				SAND: fine to medium grained, grey.	M	L	-	
						2			as above, but light grey.				
AFTER 15 MINS					N = 7 3,2,5	3			SAND: fine to medium grained, grey brown, with a trace of silt fines.				
										W			SLIGHT ORGANIC ODOUR
					N > 34 13,19 15/100mm	4					D		
					END	5							
									SAND: fine to coarse grained, grey, with a trace of fine grained quartz gravel.				
					N = 39 7,17,22	6							
						7							

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. 3 2/2

BOREHOLE LOG

Client: MANLY CIVIC CLUB LIMITED

Project: PROPOSED REDEVELOPMENT OF MANLY CIVIC CLUB

Location: 2 WEST PROMENADE, MANLY, NSW

Job No. 21496SB **Method:** SPIRAL AUGER JK300 **R.L. Surface:** N/A

Date: 31-8-07 **Datum:**

Logged/Checked by: N.E.S./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	■				N = 10 2,4,6	8		SM	SILTY SAND: fine to medium grained, dark grey brown.	W	L-MD		ORGANIC ODOUR NO SAMPLE RETURN IN SPT SPLIT SPOON SAMPLER
						9			END OF BOREHOLE AT 9.0m				PVC STANDPIPE PIEZOMETER INSTALLED TO 9m, 6m SCREEN, 3m CASING, CAST IRON GATIC COVER AT SURFACE
						10							
						11							
						12							
						13							
						14							

Envirolab Services Pty Ltd
ABN 37 112 535 645
54 Frenchs Rd Willoughby NSW 2068
ph 02 9958 5801 fax 02 9958 5803
email: tnotaras@envirolabservices.com.au

CERTIFICATE OF ANALYSIS 13474

Client:
Environmental Investigation Services
PO Box 976
North Ryde BC
NSW 1670

Attention: Brendan Page

Sample log in details:

Your Reference:	**E21496FK, Manly**
No. of samples:	2 Soils
Date samples received:	03/09/07
Date completed instructions received:	03/09/07

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:	12/09/07
Date of Preliminary Report:	Not Issued
Issue Date:	6/09/07

NATA accreditation number 2901. This document shall not be reproduced except in full.
This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025.
Tests not covered by NATA are denoted with *.

Results Approved By:

David Springer
Business Development & Quality Manager

sPOCAS Our Reference: Your Reference Depth Date Sampled	UNITS ---------- ---------- 	13474-1 BH3 3.0/3.45 31/08/07	13474-2 BH3 7.0/7.5 31/08/07
pH KCl	pH units	6.0	6.2
TAA pH 6.5	moles H^+/ tonne	<5	<5
s-TAA pH 6.5	%w/w S	<0.01	<0.01
pH Ox	pH units	3.4	2.8
TPA pH 6.5	moles H^+/ tonne	22	30
s-TPA pH 6.5	%w/w S	0.036	0.048
TSA pH 6.5	moles H^+/ tonne	22	30
s-TSA pH 6.5	%w/w S	0.036	0.048
ANCE	% $CaCO_3$	<0.05	<0.05
a-ANCE	moles H^+/ tonne	<5	<5
s-ANCE	%w/w S	<0.05	<0.05
SKCl	%w/w	<0.005	<0.005
SP	%w/w	0.015	0.039
SPOS	%w/w	0.013	0.038
a-SPOS	moles H^+/ tonne	8.4	23
CaKCl	%w/w	0.015	0.017
CaP	%w/w	0.019	0.022
CaA	%w/w	<0.005	0.006
MgKCl	%w/w	<0.005	<0.005
MgP	%w/w	<0.005	<0.005
MgA	%w/w	<0.005	<0.005
SRAS	%w/w	<0.005	<0.005
SHCl	%w/w	<0.005	<0.005
SNAS	%w/w	<0.005	<0.005
a-SNAS	moles H^+/ tonne	<5	<5
a-SNAS	%w/w S	<0.01	<0.01
a-Net Acidity	moles H^+/ tonne	<10	23
Liming rate	kg $CaCO_3$/tonne	0.63	1.8

Method ID	Methodology Summary
LAB.64	sPOCAS determined using titrimetric and ICP-AES techniques. Based on Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004.

QUALITY CONTROL sPOCAS	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
pH kcl	pH units		LAB.64	[NT]	[NT]	[NT]	LCS	97%
TAA pH 6.5	moles H^+/ tonne	5	LAB.64	<5	[NT]	[NT]	LCS	110%
s-TAA pH 6.5	%w/w S	0.01	LAB.64	<0.01	[NT]	[NT]	[NR]	[NR]
pH ox	pH units		LAB.64	[NT]	[NT]	[NT]	LCS	95%
TPA pH 6.5	moles H^+/ tonne	5	LAB.64	<5.0	[NT]	[NT]	LCS	96%
s-TPA pH 6.5	%w/w S	0.01	LAB.64	<0.01	[NT]	[NT]	[NR]	[NR]
TSA pH 6.5	moles H^+/ tonne	5	LAB.64	<5.0	[NT]	[NT]	[NR]	[NR]
s-TSA pH 6.5	%w/w S	0.01	LAB.64	<0.01	[NT]	[NT]	[NR]	[NR]
ANCE	% $CaCO_3$	0.05	LAB.64	<0.05	[NT]	[NT]	[NR]	[NR]
a-ANCE	moles H^+/ tonne	5	LAB.64	<5	[NT]	[NT]	[NR]	[NR]
s-ANCE	%w/w S	0.05	LAB.64	<0.05	[NT]	[NT]	[NR]	[NR]
SKCl	%w/w	0.005	LAB.64	<0.005	[NT]	[NT]	LCS	135%
SP	%w/w	0.005	LAB.64	<0.005	[NT]	[NT]	LCS	104%
SPOS	%w/w	0.005	LAB.64	<0.005	[NT]	[NT]	[NR]	[NR]
a-SPOS	moles H^+/ tonne	5	LAB.64	<5.0	[NT]	[NT]	[NR]	[NR]
CaKCl	%w/w	0.005	LAB.64	<0.005	[NT]	[NT]	LCS	84%
CaP	%w/w	0.005	LAB.64	<0.005	[NT]	[NT]	LCS	92%
CaA	%w/w	0.005	LAB.64	<0.005	[NT]	[NT]	[NR]	[NR]
MgKCl	%w/w	0.005	LAB.64	<0.005	[NT]	[NT]	LCS	91%
MgP	%w/w	0.005	LAB.64	<0.005	[NT]	[NT]	LCS	88%
MgA	%w/w	0.005	LAB.64	<0.005	[NT]	[NT]	[NR]	[NR]
SRAS	%w/w	0.005	LAB.64	<0.005	[NT]	[NT]	[NR]	[NR]
SHCl	%w/w	0.005	LAB.64	<0.005	[NT]	[NT]	LCS	119%
SNAS	%w/w	0.005	LAB.64	<0.005	[NT]	[NT]	[NR]	[NR]
a-SNAS	moles H^+/ tonne	5	LAB.64	<5	[NT]	[NT]	[NR]	[NR]
a-SNAS	%w/w S	0.01	LAB.64	<0.01	[NT]	[NT]	[NR]	[NR]
a-Net Acidity	moles H^+/ tonne	10	LAB.64	<10	[NT]	[NT]	[NR]	[NR]

QUALITY CONTROL sPOCAS	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Liming rate	kg $CaCO_3$ /tonne	0.1	LAB.64	<0.1	[NT]	[NT]	[NR]	[NR]

Report Comments:

Asbestos analysed by: Not applicable for this job

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

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:

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes and LCS: Generally 70-130% for inorganics/metals; 60-140% for organics and 10-140% for SVOC and speciated phenols is acceptable. Surrogates: Generally 60-140% is acceptable.

Envirolab Services Pty Ltd
ABN 37 112 535 645
54 Frenchs Rd Willoughby NSW 2068
ph 02 9958 5801 fax 02 9958 5803
email: tnotaras@envirolabservices.com.au

SAMPLE RECEIPT ADVICE

Client:

Environmental Investigation Services
PO Box 976
North Ryde BC NSW 1670

ph: 02 9888 5000
Fax: 02 9888 5001

Attention: Brendan Page

Sample log in details:

Your reference:	**E21496FK, Manly**
Envirolab Reference:	**13474**
Date received:	03/09/07
Date results expected to be reported:	**12/09/07**

Samples received in appropriate condition for analysis:	YES
Turnaround time requested:	Standard
Temperature on receipt	Cool
Cooling Method:	Ice
Completed documentation received:	YES

Comments:

Samples will be held for 1 month for water samples and 2 months for soil samples from date of receipt of samples.

Contact details:

Please direct any queries to Aileen Hie or Jacinta Hurst
ph: 02 9958 5801 fax: 02 9958 5803
email: ahie@envirolabservices.com.au or jhurst@envirolabservices.com.au

TO:
Envirolab Services Pty Ltd
54 Frenchs Road Willoughby 2068

Phone: (02) 9958 5801
Fax: (02) 9958 5803

Attention: Aileen

Date Results Required: Standard TAT

SAMPLE AND CHAIN OF CUSTODY FORM

EIS Job Number: E21496FK

Sheet 1 / 1

FROM:
Environmental Investigation Services

Rear 115 Wicks Road
Macquarie Park NSW 2113

Phone: (02) 9888 5000
Fax: (02) 9888 5004

Contact: Brendan Page

Project: Proposed Redevelopment
Location: Manly
Sampler: NES

Tests Required

Sample Preservation:
In esky on ice

Date Sampled	Time Sampled	Location	Sample/ Borehole Number	Depth (m)	Sample Container	PID (ppm/ Odour)	Sample Description	sPOCAS								Comments/Detection Limits Required
31-8-07			BH3	3.0 / 3.45	Plastic Bag		Sand	X								
31-8-07			BH3	7.0 / 7.5	Plastic Bag		Sand	X								
					Plastic Bag											
					Plastic Bag											
					Plastic Bag											
					Plastic Bag											

Envirolab Services
54 Frenchs Rd
Willoughby NSW 2068
Ph: 9958 5801

Job No: 13474
Date received: 3/9/07
Received by: AM
Time: 10:30am
Temp: Cool/Ambient
Security: Intact/Broken/None

Relinquished By:	Date: 3/9/07 Time: 10:00am	Received By: AM
Relinquished By:	Date: Time:	Received By:

Remarks:

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
ABN 17 003 550 801

REPORT EXPLANATION NOTES

INTRODUCTION

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

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

DESCRIPTION AND CLASSIFICATION METHODS

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

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

Soil Classification	Particle Size
Clay	less than 0.002mm
Silt	0.002 to 0.06mm
Sand	0.06 to 2mm
Gravel	2 to 60mm

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

Relative Density	SPT 'N' Value (blows/300mm)
Very loose	less than 4
Loose	4 – 10
Medium dense	10 – 30
Dense	30 – 50
Very Dense	greater than 50

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

Classification	Unconfined Compressive Strength kPa
Very Soft	less than 25
Soft	25 – 50
Firm	50 – 100
Stiff	100 – 200
Very Stiff	200 – 400
Hard	Greater than 400
Friable	Strength not attainable – soil crumbles

Rock types are classified by their geological names, together with descriptive terms regarding weathering, strength, defects, etc. Where relevant, further information regarding rock classification is given in the text of the report. In the Sydney Basin, "Shale" is used to describe thinly bedded to laminated siltstone.

SAMPLING

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

Disturbed samples taken during drilling provide information on plasticity, grain size, colour, moisture content, minor constituents and, depending upon the degree of disturbance, some information on strength and structure. Bulk samples are similar but of greater volume required for some test procedures.

Undisturbed samples are taken by pushing a thin-walled sample tube, usually 50mm diameter (known as a U50), into the soil and withdrawing it with a sample of the soil contained in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling used are given on the attached logs.

INVESTIGATION METHODS

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

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

Hand Auger Drilling: A borehole of 50mm to 100mm diameter is advanced by manually operated equipment. Premature refusal of the hand augers can occur on a variety of materials such as hard clay, gravel or ironstone, and does not necessarily indicate rock level.

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

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

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

Continuous Core Drilling: A continuous core sample is obtained using a diamond tipped core barrel. Provided full core recovery is achieved (which is not always possible in very low strength rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation. In rocks, an NMLC triple tube core barrel, which gives a core of about 50mm diameter, is usually used with water flush. The length of core recovered is compared to the length drilled and any length not recovered is shown as CORE LOSS. The location of losses are determined on site by the supervising engineer; where the location is uncertain, the loss is placed at the top end of the drill run.

Standard Penetration Tests: Standard Penetration Tests (SPT) are used mainly in non-cohesive soils, but can also be used in cohesive soils as a means of indicating density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" – Test F3.1.

The test is carried out in a borehole by driving a 50mm diameter split sample tube with a tapered shoe, under the impact of a 63kg hammer with a free fall of 760mm. It is normal for the tube to be driven in three successive 150mm increments and the 'N' value is taken as the number of blows for the last 300mm. In dense sands, very hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form:

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

  N = 13

  4, 6, 7

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

  N>30

  15, 30/40mm

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

Occasionally, the drop hammer is used to drive 50mm diameter thin walled sample tubes (U50) in clays. In such circumstances, the test results are shown on the borehole logs in brackets.

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

together with the number of blows per 150mm penetration.

Static Cone Penetrometer Testing and Interpretation: Cone penetrometer testing (sometimes referred to as a Dutch Cone) described in this report has been carried out using an Electronic Friction Cone Penetrometer (EFCP). The test is described in Australian Standard 1289, Test F5.1.

In the tests, a 35mm diameter rod with a conical tip is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the frictional resistance on a separate 134mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are electrically connected by wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) the information is output as incremental digital records every 10mm. The results given in this report have been plotted from the digital data.

The information provided on the charts comprise:

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

The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1% to 2% are commonly encountered in sands and occasionally very soft clays, rising to 4% to 10% in stiff clays and peats. Soil descriptions based on cone resistance and friction ratios are only inferred and must not be considered as exact.

Correlations between EFCP and SPT values can be developed for both sands and clays but may be site specific.

Interpretation of EFCP values can be made to empirically derive modulus or compressibility values to allow calculation of foundation settlements.

Stratification can be inferred from the cone and friction traces and from experience and information from nearby boreholes etc. Where shown, this information is presented for general guidance, but must be regarded as interpretive. The test method provides a continuous profile of engineering properties but, where precise information on soil classification is required, direct drilling and sampling may be preferable.

Portable Dynamic Cone Penetrometers: Portable Dynamic Cone Penetrometer (DCP) tests are carried out by driving a rod into the ground with a sliding hammer and counting the blows for successive 100mm increments of penetration.

Two relatively similar tests are used:

- Cone penetrometer (commonly known as the Scala Penetrometer) – a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS1289, Test F3.2). The test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various Road Authorities.
- Perth sand penetrometer – a 16mm diameter flat ended rod is driven with a 9kg hammer, dropping 600mm (AS1289, Test F3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.

LOGS

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

The attached explanatory notes define the terms and symbols used in preparation of the logs.

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

GROUNDWATER

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

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

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

FILL

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

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

LABORATORY TESTING

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

ENGINEERING REPORTS

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

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

- Unexpected variations in ground conditions – the potential for this will be partially dependent on borehole spacing and sampling frequency as well as investigation technique.
- Changes in policy or interpretation of policy by statutory authorities.
- The actions of persons or contractors responding to commercial pressures.

If these occur, the company will be pleased to assist with investigation or advice to resolve any problems occurring.

SITE ANOMALIES

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed that at some later stage, well after the event.

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

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

Copyright in all documents (such as drawings, borehole or test pit logs, reports and specifications) provided by the Company shall remain the property of Jeffery and Katauskas Pty Ltd. Subject to the payment of all fees due, the Client alone shall have a licence to use the documents provided for the sole purpose of completing the project to which they relate. License to use the documents may be revoked without notice if the Client is in breach of any objection to make a payment to us.

REVIEW OF DESIGN

Where major civil or structural developments are proposed or where only a limited investigation has been completed or where the geotechnical conditions/ constraints are quite complex, it is prudent to have a joint design review which involves a senior geotechnical engineer.

SITE INSPECTION

The company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related.

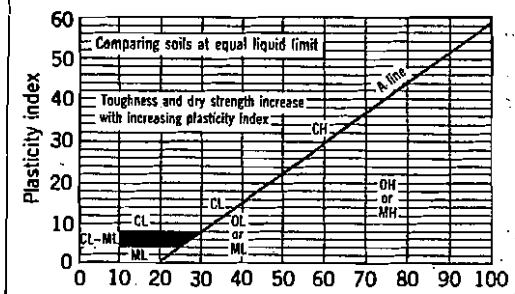
Requirements could range from:

i) a site visit to confirm that conditions exposed are no worse than those interpreted, to
ii) a visit to assist the contractor or other site personnel in identifying various soil/rock types such as appropriate footing or pier founding depths, or
iii) full time engineering presence on site.

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL & ENVIRONMENTAL ENGINEERS

UNIFIED SOIL CLASSIFICATION TABLE

Field Identification Procedures (Excluding particles larger than 75 μm and basing fractions on estimated weights)						Group Symbols[a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria
Coarse-grained soils: More than half of material is *larger* than 75 μm sieve size[b] (The 75 μm sieve size is about the smallest particle visible to naked eye)	Gravels: More than half of coarse fraction is larger than 4 mm sieve size	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes			*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name: indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics Example: *Silty sand*, gravelly; about 20% hard, angular gravel particles 12 mm maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (*SM*)	Use grain size curve in identifying the fractions as given under field identification Determine percentages of gravel and sand from grain size curve Depending on percentage of fines (fraction smaller than 75 μm sieve size) coarse grained soils are classified as follows: Less than 5% *GW, GP, SW, SP* More than 12% *GM, GC, SM, SC* 5% to 12% *Borderline* cases requiring use of dual symbols $C_U = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 Not meeting all gradation requirements for *GW* Atterberg limits below "A" line, or *PI* less than 4 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols Atterberg limits above "A" line, with *PI* greater than 7 $C_U = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 Not meeting all gradation requirements for *SW* Atterberg limits below "A" line or *PI* less than 5 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols Atterberg limits below "A" line with *PI* greater than 7
		Gravels with fines (appreciable amount of fines)	Predominantly one size or a range of sizes with some intermediate sizes missing			*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines		
			Nonplastic fines (for identification procedures see *ML* below)			*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures		
			Plastic fines (for identification procedures, see *CL* below)			*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures		
	Sands: More than half of coarse fraction is smaller than 4 mm sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes			*SW*	Well graded sands, gravelly sands, little or no fines		
			Predominantly one size or a range of sizes with some intermediate sizes missing			*SP*	Poorly graded sands, gravelly sands, little or no fines		
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)			*SM*	Silty sands, poorly graded sand-silt mixtures		
			Plastic fines (for identification procedures, see *CL* below)			*SC*	Clayey sands, poorly graded sand-clay mixtures		
Fine-grained soils: More than half of material is *smaller* than 75 μm sieve size	Identification Procedures on Fraction Smaller than 380 μm Sieve Size		Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)				
	Silts and clays: liquid limit less than 50		None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)	
			Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays		
			Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity		
	Silts and clays: liquid limit greater than 50		Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts		
			High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays		
			Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity		
Highly Organic Soils			Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils		



Plasticity chart
for laboratory classification of fine grained soils

NOTE: 1) Soils possessing characteristics of two groups are designated by combinations of group symbols (e.g. GW-GC, well graded gravel-sand mixture with clay fines).

2) Soils with liquid limits of the order of 35 to 50 may be visually classified as being of medium plasticity.

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL & ENVIRONMENTAL ENGINEERS

GRAPHIC LOG SYMBOLS FOR SOILS AND ROCKS

SOIL


FILL


TOPSOIL


CLAY (CL, CH)


SILT (ML, MH)


SAND (SP, SW)


GRAVEL (GP, GW)


SANDY CLAY (CL, CH)


SILTY CLAY (CL, CH)


CLAYEY SAND (SC)


SILTY SAND (SM)


GRAVELLY CLAY (CL, CH)


CLAYEY GRAVEL (GC)


SANDY SILT (ML)


PEAT AND ORGANIC SOILS

ROCK


CONGLOMERATE


SANDSTONE


SHALE


SILTSTONE, MUDSTONE, CLAYSTONE


LIMESTONE


PHYLLITE, SCHIST


TUFF


GRANITE, GABBRO


DOLERITE, DIORITE


BASALT, ANDESITE


QUARTZITE

DEFECTS AND INCLUSIONS


CLAY SEAM


SHEARED OR CRUSHED SEAM


BRECCIATED OR SHATTERED SEAM/ZONE


IRONSTONE GRAVEL


ORGANIC MATERIAL

OTHER MATERIALS


CONCRETE


BITUMINOUS CONCRETE, COAL


COLLUVIUM

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

A.B.N. 17 003 550 801 A.C.N. 003 550 801

LOG SYMBOLS

LOG COLUMN	SYMBOL	DEFINITION
Groundwater Record		Standing water level. Time delay following completion of drilling may be shown.
		Extent of borehole collapse shortly after drilling.
		Groundwater seepage into borehole or excavation noted during drilling or excavation.
Samples	ES	Soil sample taken over depth indicated, for environmental analysis.
	U50	Undisturbed 50mm diameter tube sample taken over depth indicated.
	DB	Bulk disturbed sample taken over depth indicated.
	DS	Small disturbed bag sample taken over depth indicated.
Field Tests	N = 17 4, 7, 10	Standard Penetration Test (SPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration. 'R' as noted below.
	N_c = 5 7 3R	Solid Cone Penetration Test (SCPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration for 60 degree solid cone driven by SPT hammer. 'R' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	VNS = 25	Vane shear reading in kPa of Undrained Shear Strength.
	PID = 100	Photoionisation detector reading in ppm (Soil sample headspace test).
Moisture Condition (Cohesive Soils)	MC > PL	Moisture content estimated to be greater than plastic limit.
	MC ≈ PL	Moisture content estimated to be approximately equal to plastic limit.
	MC < PL	Moisture content estimated to be less than plastic limit.
(Cohesionless Soils)	D	DRY - runs freely through fingers.
	M	MOIST - does not run freely but no free water visible on soil surface.
	W	WET - free water visible on soil surface.
Strength (Consistency) Cohesive Soils	VS	VERY SOFT - Unconfined compressive strength less than 25kPa
	S	SOFT - Unconfined compressive strength 25-50kPa
	F	FIRM - Unconfined compressive strength 50-100kPa
	St	STIFF - Unconfined compressive strength 100-200kPa
	VSt	VERY STIFF - Unconfined compressive strength 200-400kPa
	H	HARD - Unconfined compressive strength greater than 400kPa
	( )	Bracketed symbol indicates estimated consistency based on tactile examination or other tests.
Density Index/ Relative Density (Cohesionless Soils)		**Density Index (Ib) Range (%)** — **SPT 'N' Value Range (Blows/300mm)**
	VL	Very Loose — <15 — 0-4
	L	Loose — 15-35 — 4-10
	MD	Medium Dense — 35-65 — 10-30
	D	Dense — 65-85 — 30-50
	VD	Very Dense — >85 — >50
	( )	Bracketed symbol indicates estimated density based on ease of drilling or other tests.
Hand Penetrometer Readings	300 250	Numbers indicate individual test results in kPa on representative undisturbed material unless noted otherwise.
Remarks	'V' bit	Hardened steel 'V' shaped bit.
	'TC' bit	Tungsten carbide wing bit.
	T 60	Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

A.B.N. 17 003 550 801 A.C.N. 003 550 801

LOG SYMBOLS

ROCK MATERIAL WEATHERING CLASSIFICATION

TERM	SYMBOL	DEFINITION
Residual Soil	RS	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely weathered rock	XW	Rock is weathered to such an extent that it has "soil" properties, ie it either disintegrates or can be remoulded, in water.
Distinctly weathered rock	DW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by ironstaining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Slightly weathered rock	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh rock	FR	Rock shows no sign of decomposition or staining.

ROCK STRENGTH

Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance in the direction normal to the bedding. The test procedure is described by the International Journal of Rock Mechanics, Mining, Science end Geomechanics. Abstract Volume 22, No 2, 1985.

TERM	SYMBOL	Is (50) MPa	FIELD GUIDE
Extremely Low:	EL	0.03	Easily remoulded by hand to a material with soil properties.
Very Low:	VL	0.1	May be crumbled in the hand. Sandstone is "sugary" and friable.
Low:	L	0.3	A piece of core 150mm long x 50mm dia. may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.
Medium Strength:	M	1	A piece of core 150mm long x 50mm dia. can be broken by hand with difficulty. Readily scored with knife.
High:	H	3	A piece of core 150mm long x 50mm dia. core cannot be broken by hand, can be slightly scratched or scored with knife; rock rings under hammer.
Very High:	VH	10	A piece of core 150mm long x 50mm dia. may be broken with hand-held pick after more than one blow. Cannot be scratched with pen knife; rock rings under hammer.
Extremely High:	EH		A piece of core 150mm long x 50mm dia. is very difficult to break with hand-held hammer. Rings when struck with a hammer.

ABBREVIATIONS USED IN DEFECT DESCRIPTION

ABBREVIATION	DESCRIPTION	NOTES
Be	Bedding Plane Parting	Defect orientations measured relative to the normal to the long core axis (ie relative to horizontal for vertical holes)
CS	Clay Seam	
J	Joint	
P	Planar	
Un	Undulating	
S	Smooth	
R	Rough	
IS	Ironstained	
XWS	Extremely Weathered Seam	
Cr	Crushed Seam	
60t	Thickness of defect in millimetres	