ENVIRONMENTAL INVESTIGATION SERVICES

REPORT

TO

MANLY COUNCIL

ON

PRELIMINARY ENVIRONMENTAL SITE ASSESSMENT

FOR

PROPOSED MANLY ANDREW 'BOY' CHARLTON SWIM CENTRE REDEVELOPMENT

AT

CORNER OF KENNETH AND BALGOWLAH ROADS, MANLY, NSW

30 AUGUST 2013

REF: E26655KHrpt

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EXECUTIVE SUMMARY

Introduction, Objectives and Scope of Work

Manly Council ('the client') commissioned Environmental Investigation Services (EIS)[1] to undertake a preliminary Environmental Site Assessment (ESA) for the proposed redevelopment of Manly Andrew 'Boy' Charlton Swim Centre, corner of Kenneth and Balgowlah Road, Manly, NSW. The proposed development area is referred to as 'the site' in this report. The site location is shown on Figure 1 and the ESA was confined to the site boundaries as shown on Figure 2.

Based on the information provided, we understand that the existing 'swim centre' will be extended towards the south and west. The works will comprise the construction of a two storey building that will incorporate a new leisure pool, 25m pool and program pool. The car park will also be extended.

The objectives of the ESA are to:

- Assess the potential risk for widespread soil and groundwater contamination at the site;
- Assess the potential risk to human health and the environment posed by soil contaminants;
- Provide a preliminary waste classification for the off-site disposal of soil excavated for the development;
- Make a preliminary assessment of potential acid sulfate soil (ASS) conditions at the site; and
- Comment on the suitability of the site for the proposed development from a contamination viewpoint.

In summary, the scope of work included: review of site information and aerial photographs; preparation of a Conceptual Site Model (CSM) to outline the Areas of Environmental Concern (AEC), Potential Contaminants of Concern (PCC) and potential receptors; design and implementation of a field sampling and laboratory analysis program; interpretation of the analytical results against the adopted Site Assessment Criteria (SAC); and preparation of a report presenting the results of the ESA.

Site Information

A walkover inspection of the site and immediate surrounds was undertaken on 19 August 2013. At the time of the inspection, the western section of the site was predominantly grassed and formed part of Grahams Reserve. A wire-mesh fence separated the reserve from the existing swim centre car park. Exposed sandy soils were evident at the ground surface along the fence-line. Traces of gravels and demolition rubble, including fibre cement fragments, were also noted at the ground surface at the base of the fence.

The existing swim centre car park occupied the majority of the eastern section of the site. The car park was paved with asphaltic concrete and was in relatively average condition. Landscaped areas extended along the majority of the eastern and southern site boundaries. The landscaped areas were either grassed or surfaced with leaf-litter and/or exposed soils. Small to medium sized trees were scattered throughout these areas.

The review historical aerial photographs indicated that the site was formerly occupied by a number of buildings that were demolished throughout the 1900s.

The site is located in an area that it close to the geological contact between sandstone bedrock and Quaternary aged alluvial soils. The alluvial soils are an acid sulfate soil (ASS) risk.

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

CSM
Based on the site inspection and review of aerial photographs, the potential contamination sources at the site (referred to as AEC) were considered to include: potentially contaminated imported fill material; hazardous building materials; and unknown commercial/industrial land uses. The PCC associated with these potential contamination sources included: heavy metals; petroleum hydrocarbons (TPH/BTEX); polycyclic aromatic hydrocarbons (PAHs); pesticides (OCP/OPPs); polychlorinated biphenyls (PCBs); and asbestos.

Site Investigation
The investigation included sampling from four boreholes (BH102, BH105, BH106 and BH107) which were drilled in conjunction with a geotechnical investigation by JK Geotechnics. Additional fragments of fibre cement were also obtained from the ground surface at four locations. A selection of samples were analysed for the PCC and ASS characteristics.

Discussion
Based on the results of the preliminary ESA, the potential risk for significant widespread soil and groundwater contamination at the site is considered to be relatively high.

An elevated concentration of benzo(a)pyrene TEQ was encountered in the fill soil sample obtained from BH102 (0.9-1.1m). Elevated concentrations of lead and benzo(a)pyrene were also encountered in the fill soil sample obtained from BH105 (1-1.2m). The horizontal and vertical extent of the contamination has not been established during the preliminary ESA.

Asbestos was also encountered in fragments of fibre cement collected from the ground surface at four locations (several additional fragments were also observed in the immediate vicinity of the samples that were collected). EIS consider that the asbestos issue is likely to be widespread across the site.

The contamination data is shown on Figure 3.

Hydrocarbon odours were noted in the soils during drilling of BH102 (and BH101 drilled for the geotechnical investigation). This may indicate the presence of an unknown hydrocarbon contamination source (such as a UST).

The preliminary ASS assessment identified results above the SAC. Based on these results, an ASS management plan (ASSMP) will be required prior to disturbance of the soils at the site.

The primary data gaps identified during the preliminary ESA include:

- The lack of detailed site history information including land title records, WorkCover records, EPA records and council records;
- Limited soil sampling and limited laboratory analysis for contaminants and ASS; and
- The lack of groundwater contamination data and groundwater flow/direction information.

Conclusions and Recommendations
EIS consider that the report objectives (see **Sections 1.2** and **Section 2**) have been addressed. Based on the scope of work undertaken, EIS provide the following conclusions and recommendations:

- The potential for widespread contamination at the site is considered to be relatively high;
- Soil contamination (lead and PAHs) was identified at two locations. Fragments of fibre cement (containing asbestos) was also identified at the ground surface at several locations;
- The contaminants encountered at the site are considered to pose a medium to high risk to the potential human receptors identified in the CSM;
- The contaminants encountered at the site are considered to pose a relatively low risk to the potential ecological receptors identified in the CSM;

- In order to address the data gaps and better assess potential risks associated with the site contamination conditions, EIS recommend the following:
  - A stage 2 ESA should be undertaken. The stage 2 work should incorporate a more thorough site history assessment, which as a minimum, should include an assessment of land title records, WorkCover records, EPA records and council records;
  - The stage 2 investigation should be designed to meet the minimum sampling density specified by the EPA (17 boreholes in total). Additional boreholes should be targeted in the vicinity of BH101 and BH102 in to assess the potential presence of hydrocarbon contamination in this section of the site;
  - Sampling and analysis of the fill and natural soils should be undertaken. Samples should be analysed for ASS conditions (sPOCAS) and the PCC identified in the CSM. TCLP analysis should also be undertaken as required;
  - A minimum of four groundwater monitoring should be installed at the site. The wells should be positioned to assess the conditions in the vicinity of BH101 and BH102, the central section of the site, and at the northern site boundary;
  - Groundwater samples from each location should be analysed for TPH, Volatile Organic Compounds (VOCs), PAHs, heavy metals, pH, EC and hardness; and
  - A Remedial Action Plan (RAP) and ASSMP should be prepared based on the results of the Stage 2 investigation and additional ASS analysis.

EIS consider that the site could be made suitable for the proposed recreational development, provided that the recommendations detailed above are implemented accordingly. The suitability of the site for the proposed development will rely on the success of the site remediation process.

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

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1 INTRODUCTION

Manly Council ('the client') commissioned Environmental Investigation Services (EIS)[2] to undertake a preliminary Environmental Site Assessment (ESA) for the proposed redevelopment of Manly Andrew 'Boy' Charlton Swim Centre, corner of Kenneth and Balgowlah Road, Manly, NSW.

The proposed development area is referred to as 'the site' in this report. The site location is shown on Figure 1 and the ESA was confined to the site boundaries as shown on Figure 2.

The ESA was undertaken generally in accordance with an EIS proposal (Ref: EP7321KH) of 16 July 2013 and written acceptance from the client dated 24 July 2013.

A geotechnical investigation was undertaken concurrently with the ESA by JK Geotechnics[3]. The results of the investigation are presented in a separate report (Ref: 26655ZH2rpt 16 August 2013[4]).

1.1 Proposed Development Details

Based on the information provided, we understand that the existing 'swim centre' will be extended towards the south and west. The works will comprise the construction of a two storey building that will incorporate a new leisure pool, 25m pool and program pool. The concourse level will be constructed at reduced levels (RLs) between RL4.2m and RL6.0m. With the exception of the north-eastern portion of the proposed building that will abut the existing 50m pool, the proposed ground floor level will be between approximately 0.5m and 2.6m above existing grade.

The maximum depths of the proposed pools will be approximately 1m (leisure pool), 1.5m (25m pool) and 1.25m (program pool). Based on a base slab thickness of 0.25m (as shown on the sketches provided), the base of each pool will extend down to approximately RL4.2m (leisure pool), RL2.4m (25m pool) and RL2.7m (program pool). To achieve these levels, excavation to a maximum depth of approximately 0.5m will be required in areas external to the existing 'swim centre'.

Localised excavation to a maximum depth of approximately 2m will be required for the proposed program pool and 25m pool immediately adjacent to the existing 50m pool where ground surfaced levels have been raised by past filling.

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

[3] Geotechnical consulting division of J&K

[4] Referred to as JK Report

The floor level for the proposed plant room that will be located below the proposed leisure pool will be at RL3.4m (as per the level shown on the architectural drawings) and therefore will be at or close to existing grade.

An on-grade car park and kiosk/amenities building are proposed on the north-western side of the existing swim centre.

A plan showing the proposed development layout is attached in the appendices.

1.2 Objectives

The objectives of the ESA are to:

- Assess the potential risk for widespread soil and groundwater contamination at the site;
- Assess the potential risk to human health and the environment posed by soil contaminants;
- Provide a preliminary waste classification for the off-site disposal of soil excavated for the development;
- Make a preliminary assessment of potential acid sulfate soil (ASS) conditions at the site; and
- Comment on the suitability of the site for the proposed development from a contamination viewpoint.

1.3 Scope of Work

The scope of work included:

- Preparation of site specific Data Quality Objectives (DQOs) and Data Quality Indicators (DQIs);
- A review of site information and site history documents;
- A site inspection to identify areas of environmental concern (AEC);
- Preparation of a Conceptual Site Model (CSM) to outline the AEC, Potential Contaminants of Concern (PCC) and potential receptors;
- Design and implementation of a field sampling and laboratory analysis program;
- Interpretation of the analytical results against the adopted Site Assessment Criteria (SAC); and
- Preparation of a report presenting the results of the ESA.

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

Table 1-1: Guidelines

Guidelines/Regulations/Documents
Contaminated Land Management Amendment Act (2008[5])
State Environmental Planning Policy No.55 – Remediation of Land (1998[6])
NSW EPA Guidelines for Consultants Reporting on Contaminated Sites (1997[7])
Guidelines on the Duty to Report Contamination[8]
Guidelines for the NSW Site Auditor Scheme, 2nd Edition (2006[9])
National Environmental Protection (Assessment of Site Contamination) Amendment Measure (2013[10])
NSW EPA Contaminated Sites Sampling Design Guidelines (1995[11])
NSW DECCW Waste Classification Guidelines - Part 1: Classifying Waste (2009[12])

[5] *Contaminated Land Management Amendment Act,* NSW Government Legislation, 2008 (CLM Amendment Act 2008)

[6] *State Environmental Planning Policy No. 55 – Remediation of Land,* NSW Government, 1998 (SEPP55)

[7] *Guidelines for Consultants Reporting on Contaminated Sites,* NSW EPA, 1997 (Reporting Guidelines 1997)

[8] *Guidelines on the Duty to Report Contamination*, NSW EPA, Draft 2011 (Duty to Report Contamination 2011)

[9] *Guidelines for the NSW Site Auditor Scheme, 2nd ed.,* NSW DEC, 2006 (Site Auditor Guidelines 2006)

[10] *National Environmental Protection (Assessment of Site Contamination) Amendment Measure 2013 (No.1),* National Environment Protection Council (NEPC), 2013 (NEPM 2013)

[11] *Contaminated Sites Sampling Design Guidelines,* NSW EPA, 1995 (EPA Sampling Design Guidelines 1995)

[12] *Waste Classification Guidelines, Part 1: Classifying Waste,* NSW DECCW, 2009 (Waste Classification Guidelines 2009)

2 DATA QUALITY ASSESSMENT

2.1 Data Quality Objectives (DQOs)

The DQOs provide a systematic approach for undertaking the assessment and outlines the criteria against which the data can be assessed.

A methodology for establishing the DQOs is presented in the document *Data Quality Objectives Process for Hazardous Waste Site Investigations* (2000[13]). This methodology has been adopted in the NEPM 2013, AS4482.1-2005[14] and the Site Auditor Guidelines 2006. The main steps involved in preparing the DQOs are summarised in the table below:

Table 2-1: DQOs

Step	Input
State the Problem	The presence of contamination may pose a risk to human health and the environment. An ESA is required to assess the potential risk and to comment on the suitability of the site for the proposed development. An assessment of ASS potential and a waste classification is required as soil disturbance and off-site disposal of surplus materials will occur during the development works.
Identify the Decisions	The assessment aims to address the objectives outlined in **Section 1.2.**
Identify Inputs into the Decision	The following inputs will be used to address the decisions: • Review of site information including regional geology, topography, setting, acid sulfate soil (ASS) potential, hydrogeology, surface water flow and review of major services (see **Section 3**); • Review of limited site history information (see **Section 4);** • Undertake a site inspection to identify the AEC (see **Section 3**); • Prepare a CSM (see **Section 5)**; • Design and implementation of a field sampling program (see **Section 7)**; • Design and implementation of a laboratory analysis program (see **Section 7**); • Assessment of analytical data. The DQIs that will be used to assess the analytical data are outlined in **Section 2.2**; and • Compare the analytical results against the SAC outlined in **Section 6.**

[13] *Data Quality Objectives Process for Hazardous Waste Site Investigations,* US EPA, *2000* (US EPA 2000)
[14] *Guide to the Investigation and Sampling of sites with Potentially Contaminated Soil,* Standards Australia, 2005 (AS 2005)

Step	Input
Study Boundary	The investigation was confined to the site boundaries as shown in Figure 2.
Develop a Decision Rule	The analytical results will be assessed against the SAC (see **Section 6**). The NEPM 2013 recommends using statistical analysis to assess the laboratory data for soil samples against the health based SAC. The data set should be assessed against the following criteria: • The 95% Upper Confidence Limit (UCL) value of the arithmetic mean concentration of each contaminant should be less than the SAC; • The standard deviation (SD) of the results must be less than 50% of the SAC; and • No single value exceeds 250% of the relevant SAC. Statistical calculations are not be required if all results are below the SAC and are not undertaken for the ecological assessment data.
Specific Limits on Decision Errors	Decision errors are false positive (i.e. stating the site is free of contamination when it is not) or false negative (i.e. stating that the site is contaminated when it is not). The more significant error is the false positive which may result in potential risks to human health and the environment. To account for this, the assessment has assumed that elevated concentrations of contaminants are present in the samples unless demonstrated otherwise.
Optimise the Design for Obtaining Data	The Site Auditor Guidelines 2006 recommend evaluating the data set as a whole to determine any limitations within the data set. The overall data set will be optimised by reviewing the data as the project proceeds. When necessary, adjustments will be made to the sampling or analytical program.

2.2 Data Quality Indicators (DQIs)

The DQIs required to address inputs into the decision include: precision, accuracy, representativeness, completeness and comparability. Reference should be made to the appendices for further information of the DQIs. The DQIs will be addressed as follows:

Table 2-2: DQIs

Indicator	Methods
Completeness	Data and documentation completeness will be achieved by: • Preparation of sampling and analysis plan; • Preparation of chain of custody (COC) records; • Review of the laboratory sample receipt information; • Use of National Association of Testing Authorities (NATA) registered laboratories for all analysis; • Visual, olfactory and PID screening of samples during the investigation;

Indicator	Methods
	and • Laboratory analysis to target PCC. Any changes to the analytical schedule to be documented.
Comparability	Data comparability will be achieved by: • Maintaining consistency in sampling techniques; • Use of appropriate preservation, storage and transport methods; and • Use of consistent analysis techniques and reporting standards by the laboratories.
Representativeness	Data representativeness will be achieved by: • Good coverage of sample locations across accessible areas of the site; and • Representative coverage of analysis for PCC. Any changes to the analytical schedule to be documented.
Precision	Precision will be achieved by: • Calculating the relative percentage difference (RPD) of duplicate samples; • The following acceptance criteria will be used to assess the RPD results: ➢ results > 10 times the practical quantitation limit (PQL), RPDs < 50% are acceptable; ➢ results between 5 and 10 times PQL, RPDs < 75% are acceptable; ➢ results > 5 times PQL, RPDs < 100% are acceptable; and • An explanation is provided if RPD results are outside the acceptance criteria.
Accuracy	Accuracy will be achieved by: • Use of trained and qualified field staff; • Appropriate industry standard sampling equipment and decontamination procedures; • Sampling and screening equipment will be factory calibrated on a regular basis. Calibration will be checked internally prior to use; • Sampling and equipment decontamination; • Collection and analysis of field Quality Assurance (QA) and Quality Control (QC) samples for PCC; • The field QA/QC analysis will include the analysis of one intra-laboratory duplicate for heavy metals; • Appropriate sample preservation, handling, holding time and COC procedure; • Review of the primary laboratory QA/QC data including: RPDs, surrogate recovery, repeat analysis, blanks, laboratory control samples (LCS) and matrix spikes; • The following acceptance criteria will be used to assess the primary

Indicator	Methods
	laboratory QA/QC results. Non-compliance to be documented: ➢ RPDs: o results that are < 5 times the PQL, any RPD is acceptable; and o results > 5 times the PQL, RPDs between 0-50% are acceptable; ➢ LCS recovery and matrix spikes: o 70-130% recovery acceptable for metals and inorganics; o 60-140% recovery acceptable for organics; and o 10-140% recovery acceptable for VOCs; ➢ Surrogate spike recovery: o 60-140% recovery acceptable for general organics; and o 10-140% recovery acceptable for VOCs; ➢ Blanks: All less than PQL; and • Reporting to industry standards.

3 SITE INFORMATION AND PHYSICAL SETTING

3.1 Site Identification

Table 3-1: Site Identification Information

Site Address:	Corner of Balgowlah and Kenneth Roads, Manly, NSW
Lot & Deposited Plan:	Part Lot 1 DP168527 Part Lot 1 DP168526 Part Lot 1 DP65674 Part Lot 4 DP1161541 Lots 82-86 (inclusive) DP939916 Lots 34-37 (inclusive) DP939916 Part Lot 8 and part Lots 29-33 (inclusive) DP939916 Part of an unidentified Lot of Balgowlah Road
Current Land Use:	Recreational (sports field, swim centre and car park)
Proposed Land Use:	Recreational (swim centre and car park)
Local Government Authority:	Manly Council
Current Zoning:	RE1 (Public Recreation) – Manly LEP 2013
Site Area (m^2):	7,000
RL (AHD in m) (approx.):	2.5-4.0
Geographical Location (MGA) (approx.):	N: 6259873 E: 340658
Site Location Plan:	Figure 1
Borehole Location Plan:	Figure 2
Site Contamination Data:	Figure 3

3.2 Site Location and Setting

The site is located to the south-west of the junction between Kenneth and Balgowlah Roads. The surrounds have been developed for recreational and residential land uses. Residential properties were generally located to the south and east of the site. Recreational areas (Manly Golf Club and Grahams Reserve) were located to the north and west of the site.

3.3 Topography

The site is located just north of the toe of a moderately sloping, north facing hillside. The site and the adjacent areas to the north, east and west are relatively flat and are characterised by low lying areas in the vicinity of Manly Lagoon (the lagoon itself is located approximately 500m to the north of the site).

The site levels have been altered to accommodate the existing swim centre development. This includes a retained area (generally in the central-eastern section of the site) which is to the south and west of the existing 50m swimming pool (see Figure 2). The areas to the south and west of the retaining walls are typically flat and level.

3.4 Site Inspection

A walkover inspection of the site and immediate surrounds was undertaken on 19 August 2013. At the time of the inspection, the western section of the site was predominantly grassed and formed part of Grahams Reserve. A wire-mesh fence separated the reserve from the existing swim centre car park. Exposed sandy soils were evident at the ground surface along the fence-line. Traces of gravels and demolition rubble, including fibre cement fragments, were also noted at the ground surface at the base of the fence (see Asb 2, 3 and 4 as shown on Figure 2). A concrete basketball court was located in the northern section of the reserve area.

The existing swim centre car park occupied the majority of the eastern section of the site. The car park was paved with asphaltic concrete and was in relatively average condition. Landscaped areas extended along the majority of the eastern and southern site boundaries. The landscaped areas were either grassed or surfaced with leaf-litter and/or exposed soils. Small to medium sized trees were scattered throughout these areas.

Part of the south-eastern section of the site was retained approximately 2m above the car park. The areas above the retaining wall were generally grassed. A fragment of fibre cement was identified at the ground surface adjacent to the retaining wall (see Asb 1, as shown on Figure 2).

There were no obvious signs of chemical or waste storage at the site. It is understood that chemicals associated with the existing pool maintenance were stored to the east of the site. These areas were not visually inspected by EIS during the site visit, however, it is understood that the storage area is paved with concrete.

3.5 Surrounding Land Use

The immediate surrounds included the following landuses:

- North – Recreational (Manly Golf Club);
- South – Residential;
- East – Remaining areas of Manly Swim Centre, with residential areas further to the east; and
- West – Recreational (Grahams Reserve).

3.6 Regional Geology

A review of the regional geological map of Sydney (1983[15]) indicates that the site is underlain by Hawkesbury Sandstone, which typically consists of medium to coarse grained quartz sandstone with minor shale and laminite lenses. The site lies close to the contact between the sandstone and Quaternary aged alluvial deposits of silty to peaty quartz sand, silt and clay with ferruginous cementation in places and common shell layers.

3.7 Acid Sulfate Soil (ASS) Risk Map

A review of the ASS risk maps prepared by Department of Land and Water Conservation (1997[16]) indicates that the site is located in an area classed as having a 'high probability' of ASS potential at depths between 1m and 3m below the ground surface.

3.8 Hydrogeology

A review of groundwater bores registered with the NSW Office of Water[17] (NOW) was undertaken by EIS. The search was limited to registered bores located within approximately 500m of the site.

The search identified approximately 18 registered groundwater bores in the search radius (with a number of additional bores located further to the east). The majority of the bores were registered for recreational or domestic use. A copy of the groundwater bore map indicating the location and identification numbers of the registered bores is attached in the appendices.

The stratigraphy of the site is expected to consist of relatively high permeability alluvial sandy soil overlying deep bedrock (we note that residual soils and relatively shallower

[15] *1:100,000 Geological Map of Sydney (Series 9130),* Department of Mineral Resources (1983)

[16] *1:25,000 Acid Sulfate Soil Risk Map (Series 9130N2, Ed 2),* Department of Land and Water Conservation (1997)

[17] http://www.waterinfo.nsw.gov.au/gw/, visited on 2 August 2013

bedrock could be expected towards the southern section of the site). Based on these conditions and the results of the groundwater bore search, groundwater is considered to be a resource in the vicinity of the site.

3.9 Surface Water Flows

Natural surface water bodies were not identified at the site. The closest surface water body is Manly Lagoon which is located approximately 500m to the north of the site. The lagoon is considered to be a potential receptor.

During rain events, surface water would be expected to infiltrate the grassed areas through the sandy soils. Some surface water runoff from the paved car park would be expected to enter the stormwater system which we anticipate discharges either into Manly Lagoon and/or to Manly Beach.

4 SITE HISTORY ASSESSMENT

4.1 Aerial Photographs

Historical aerial photographs of the site and immediate surrounds were reviewed for the assessment. The majority of the photographs were obtained from the NSW Department of Lands. A summary of the relevant information is presented in the following table:

Table 4-1: Summary of Historical Aerial Photos

Year	Details
1930	The photograph was of relatively poor quality and the site features were not easily discernible. The site appeared to be occupied by a number of buildings and sheds (of unknown use). What are currently (2013) referred to as Kenneth and Balgowlah Road were visible to the north and east/south of the site respectively. Manly Golf Course was located to the north of the site, beyond Kenneth Road. Larger properties including several buildings and possibly sheds (of unknown use) were located to the west of the site. Residential properties were located to the south and east of the site.
1943[18]	The site was occupied by what appeared to be an open, hard surfaced area, surrounded by a fence (possibly a tennis complex). A rectangular-shaped building was located towards the central-southern end of the site. A number of smaller buildings (likely to have been for residential use) were located in the southern and north-western sections of the site. A number of relatively large, semi-detached buildings and smaller buildings/sheds (of unknown use) were located immediately to the east of the site.
1951	The site generally appeared to be similar to the 1943 aerial photograph. Additional buildings were visible immediately to the east of the site. The remainder of the surrounds generally appeared to be similar to the 1943 photograph.
1961	A number of the residential-type buildings in the north-western and southern sections of the site had been demolished. The majority of the southern and western sections of the site appeared to be grassed. The buildings in the areas to the west of the site had also been demolished and this wider area was also grassed (overall, this area appeared consistent with the layout of Grahams Reserve). Alterations and additions had been made to development adjacent to the east site boundary.

[18] https://six.maps.nsw.gov.au/wps/portal/SIXViewer, visited on 2 August 2013

Year	Details
1970	The residential-type building in the north-western section of the site had been demolished and replaced with a relatively small building (possibly an amenities building associated with the reserve area). The remainder of the site generally appeared similar to the 1961 photograph. Minor alterations had been made to the reserve area to the west of the site.
1978	The tennis courts and rectangular building had been demolished. The site comprised a grassed area along the western section of the site and a car park over the majority of the eastern section of the site. The areas to the east and north-east of the site had been redeveloped as a swim centre and the 50m and 25m swimming pools were visible.
1986	The site appeared relatively similar to the existing (2013) site layout. The immediate surrounds appeared to be relatively similar to the existing (2013) surrounds.
1994	The site and immediate surrounds generally appeared to be similar to the 1986 photograph.
2004	The site and immediate surrounds generally appeared to be similar to the 1994 photograph, with the exception of a number of shade structures that were visible to the east of the site (within the main swim centre grounds).

5 PRELIMINARY CONCEPTUAL SITE MODEL (CSM)

5.1 Areas of Environmental Concern (AEC) & Potential Contaminants of Concern (PCC)

The AEC identified in the table below are based on a review of the historical aerial photographs, desktop information and site walkover.

Table 5-1: AEC and PCC

AEC	PCC
Fill Material: Fill material on site may have been historically imported from various sources and can contain elevated concentrations of contaminants.	HM, TPH, BTEX, PAHs, OCPs, OPPs, PCBs and asbestos
Hazardous Building Materials: The aerial photographs indicated that a number of structures have been demolished at the site. The use of hazardous building material (e.g. asbestos and lead-based paints) in the former buildings could have resulted in contamination. It was not uncommon practice for demolition waste to be buried or spread throughout the surficial soils following demolition works.	Asbestos and lead
Unknown Commercial/Industrial Land Use: The aerial photographs indicated that the site and immediate surrounds were developed prior to the early 1900s and it is likely that various parts of the site were utilised for different purposes. Details of specific on-site and nearby off-site activities were not obtained for this ESA. On this basis, there is a potential for contamination from former land uses. This may include additional AEC such as buried waste and/or former underground storage tanks (USTs) etc.	HM, TPH, BTEX, PAHs, OCPs, OPPs, PCBs and asbestos

Note:
HM – Heavy metals including arsenic, cadmium, chromium, copper, lead, mercury, nickel & zinc
TPH – Total petroleum hydrocarbons including light, mid and heavy fractions
BTEX – Monocyclic aromatic hydrocarbons
PAHs - Polycyclic aromatic hydrocarbons
OCPs - Organochlorine pesticides
OPPs - Organophosphorus pesticides
PCBs - Polychlorinated Biphenyls

The AEC identified at the site are generally associated with surface based contamination sources. Further consideration of potential AEC and PCC associated with groundwater will be assessed following review of the site investigation findings.

5.2 Contamination Fate and Transport

The fate and transport of PCC identified at the site is summarised in the following table:

Table 5-2: Fate and Transport of PCC

PCC	Fate and Transport
Non-volatile contaminants including: metals, heavy fraction PAHs, OCPs, OPPs, PCBs and asbestos	With the exception of asbestos, non-volatile contaminants are predominantly confined to the soil and groundwater medium. The mobility of these contaminants varies depending on: the nature and type of contaminant present (e.g. leachability, viscosity etc); soil type/porosity; surface water infiltration; groundwater levels; and the rate of groundwater movement. At this site, surface water has the potential to infiltrate into the subsurface via garden beds and grassed areas which could increase the migration potential of certain contaminants. Excess runoff can potentially discharge into Manly Lagoon or to Manly Beach via the regional stormwater system. Non-volatile contaminants associated with ash and slag waste (some heavy metals, heavy fraction PAHs, and sometimes heavy fraction TPHs) are bound within a relatively insoluble matrix. Slag and ash is usually formed as a by-product of combustion at high temperatures which 'locks in' the contaminants within the matrix. The potential transport of asbestos fibres is associated with the disturbance of asbestos contaminated soils and release of fibres into the atmosphere. This is more likely to occur during excavation works. A number of studies have found that soils effectively filter out asbestos fibres and retain them within the soil matrix. The studies concluded that there is no significant migration of asbestos fibres, either through soil or groundwater.
Volatile contaminants including: TPH, BTEX, VOCs and light fraction PAHs	Volatile contaminants are usually more mobile when compared to the non-volatile compounds. The potential for migration of volatile contaminants such as light fraction PAHs and TPH is relatively high in sandy soil with a high water table. These contaminants break down rapidly as a result of microbial activity and availability of nutrients including nitrogen, oxygen etc. The mobile contaminants would be expected to move down to the rock surface or groundwater table and migrate down gradient from the source. The mobility would depend on a range of factors such as: soil

PCC	Fate and Transport
	type/porosity; surface water infiltration; groundwater levels; porosity, confining layers within the aquifer, solubility in groundwater etc. At this site, the potential for migration of volatile contaminants is considered to be relatively high due to the presence of sandy soils and relatively shallow groundwater table.

5.3 Sensitive Receptors and Exposure Pathways

The potential receptors and exposure pathways identified at the site are presented in the following table:

Table 5-3: Potential Receptors and Exposure Pathways

Receptor	Pathway
Human Receptors: • Site occupants; • Site visitors; • Contractors and workers; • Future site occupants; and • Adjacent land users.	• Dermal contact, ingestion and inhalation; • Inhalation of airborne asbestos fibres; and • Abstraction and use of contaminated groundwater.
Environmental Receptors: • Manly Lagoon located approximately 500m to the north of the site; • Existing and proposed landscaped areas.	• Exposure by direct contact with plants and animals; and • Extraction and use of contaminated water for irrigation purposes.

6 SITE ASSESSMENT CRITERIA (SAC)

The SAC adopted for this ESA is outlined in the table below. The SAC has been derived from NEPM 2013 and other guidelines as outlined in **Section 1.3**. Explanatory notes are included in the attached appendices.

The guidelines values for individual contaminants outlined in Schedule B1 of the NEPM 2013 are reproduced in the appendices. The criterion for the individual contaminants analysed for this assessment are presented in the attached report tables.

Table 6-1: SAC Adopted for this Investigation

Guideline	Applicability
Health Investigation Levels (HILs)	The proposed land use is for a recreational swim centre therefore the HIL-C criteria have been adopted for this ESA. The preliminary ESA has not included an assessment of the soils for Volatile Organic Chlorinated Compound (VOCCs) contamination.
Health Screening Levels (HSLs)	The HSL-C criteria for soil have been adopted for this ESA. The HSL calculation summaries are attached in the appendices. An assessment of soil vapour is outside the scope of this ESA.
Ecological Assessment Criteria (EAC)	A detailed assessment of ecological risk has not been undertaken for this ESA. The EIL/ESL calculation summaries are attached in the appendices. In the absence of site specific Added Contaminant Limit (ACL) values for soil pH, Cation Exchange Capacity (CEC) and clay content in all samples, we have adopted the most conservative guideline values for these parameters. Ambient Background Concentrations (ABCs) for metals have utilised the results from the natural soils at the site. Where heavy metal concentrations in the natural sample were below the laboratory PQL, half of the PQL has been adopted.
Management Limits for TPH	These limits have not been utilised for the preliminary ESA.
Asbestos in Soil	The 'presence/absence' of asbestos in soil has been adopted as the assessment criterion for the Preliminary Site Investigation (PSI).
Waste Classification (WC) Criteria	The criteria outlined in Part 1 of the Waste Classification Guidelines 2009 have been adopted for this investigation.

Guideline	Applicability
ASS	The action criteria for coarse textured soils detailed in the Acid Sulfate Soil Manual (1998[19]) have been adopted for this ESA. This includes the following: • pH - less than 5; • TAA/TSA/TPA (pH5.5) – greater than 18mol H^+/tonne; and • S_{pos} – greater than 0.03% sulfur oxidisable.

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

7 INVESTIGATION PROCEDURE

7.1 Soil Sampling Plan

The NSW EPA Sampling Design Guidelines 1995 recommend a sampling density for a contamination assessment based on a systematic sampling pattern. Based on the size of the investigation area, the guidelines provide a minimum number of sampling points required for the investigation. For a site of this size (approximately 7,000m^2) the guidelines recommend sampling from a minimum of 17 evenly spaced sampling points.

Samples for the preliminary ESA were obtained from four evenly spaced sampling points as shown on the attached Figure 2 (BH102, BH105, BH106 and BH107). This density is approximately 23% of the minimum sampling density recommended for a Stage 2 ESA.

The geotechnical investigation included the drilling of 10 boreholes (BH101 to BH1110 inclusive). All ten borehole logs have been attached in the appendices for reference purposes.

Additional samples of fibre cement (presumed to contain asbestos) were also collected from the ground surface at four locations (Asb 1 to Asb 4 as shown on Figure 2).

7.2 Soil Sampling Methodology

Fieldwork for this investigation was undertaken on 30 July 2013. The sampling locations were set out using a tape measure. Locations were marked using spray paint and were cleared for underground services prior to drilling.

The sample locations were drilled using a 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.

Soil samples were collected from the fill and natural profiles encountered during the investigation. Additional fill samples were obtained when relatively deep fill (>0.5m) was encountered. Samples were also obtained when there was a distinct change in lithology or based on the observations made during the investigation. All samples were recorded on the borehole logs attached in the appendices.

During sampling, soil at selected depths was split into primary and duplicate samples for field QA/QC analysis.

Samples were placed in glass jars with plastic caps and teflon seals with minimal headspace. Samples for asbestos analysis were placed in zip-lock plastic bags. Sampling personnel used disposable nitrile gloves during sampling activities. The samples were labelled with the job number, sampling location, sampling depth and date.

7.2.1 VOC Screening

A portable Photoionisation Detector (PID) was used to screen the samples for the presence of VOCs and to assist with selection of samples for BTEX analysis.

The sensitivity of the PID is dependent on the organic compound and varies for different mixtures of hydrocarbons. Some compounds give relatively high readings and some can be undetectable even though present in identical concentrations. The portable PID is best used semi-quantitatively to compare samples contaminated by the same hydrocarbon source.

The PID is calibrated before use by measurement of an isobutylene standard gas. All the PID measurements are quoted as parts per million (ppm) isobutylene equivalents.

PID screening for VOCs was undertaken on soil samples using the soil sample headspace method. VOC data was obtained from partly filled zip-lock plastic bags following equilibration of the headspace gases. The PID headspace data is presented on the COC documents attached in the appendices. PID calibration records are retained on file by EIS.

7.2.2 Decontamination and Sample Preservation

Details of the decontamination procedure adopted during sampling are presented in the appendices. Where applicable, the sampling equipment was decontaminated using a scrubbing brush and potable water and Decon 90 solution (phosphate free detergent) followed by rinsing with potable water.

Soil samples were preserved by immediate storage in an insulated sample container with ice in accordance with AS4482.1-2005 and AS4482.2-1999[20] as summarised in the following table:

[20] *Guide to the Sampling and Investigation of Potentially Contaminated Soil Part2: Volatile Substances,* Standards Australia, 1999 (AS 1999)

Table 7-1: Soil Sample Preservation and Storage

Analyte	Preservation	Storage
Heavy metals	Unpreserved glass jar with Teflon lined lid	Store at <4°, analysis within 28 days (mercury and Cr[VI]) and 180 days (other metals).
VOCs (TPH/BTEX)	As above	Store at <4°, analysis within 14 days
PAHs, OCP, OPP & PCBs	As above	Store at <4°, analysis within 14 days
ASS	Sealed plastic bag	Remove air and freeze
Asbestos	Sealed plastic bag	None

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

7.3 Laboratory Analysis

The samples were analysed by the following laboratory:

Table 7-2: Laboratory Details

Samples	Laboratory	Report Reference
All primary samples and intra-laboratory duplicates	Envirolab Services Pty Ltd, NATA Accreditation Number – 2901 (ISO/IEC 17025 compliance)	94822, 94822-A, 94822-B and 95848

Samples were analysed by the laboratory using the analytical methods detailed in Schedule B(3) of NEPM 2013. Reference should be made to the laboratory reports attached in the appendices for further details.

8 INVESTIGATION RESULTS

8.1 Subsurface Conditions

A summary of the subsurface conditions encountered in the (EIS) boreholes during the investigation is presented in the table below. Reference should be made to the borehole logs attached in the appendices for further details (Note: borehole logs BH101 to BH110 inclusive have also been attached for references purposes).

Table 8-1: Summary of Subsurface Conditions

Profile	Depth[1]	Description
Fill	1.3m to 1.7m	Fill material was encountered at the surface in all four boreholes and extended to depths ranging from approximately 1.3m to 1.7m. The fill material typically comprised brown and dark brown silty sand with inclusions of glass fragments, root fibres, igneous and sandstone gravels, and shell fragments. Hydrocarbon odours were encountered in the fill profile in BH102 at a depth of approximately 1.2-1.7m (note that hydrocarbon odours were also encountered in BH101 at a depth of approximately 3-4.7m).
Natural Soil	1.3m to 10.2m	Natural sand and silty sand soils were encountered beneath the fill material in all four boreholes. The sand was typically grey or grey brown. Shell fragments were noted in BH106. The natural soils extended to the termination depth of 3m in BH106 and BH107, and to depths of approximately 3.3m and 10.2m in BH102 and BH105 respectively.
Bedrock	3.3m to 10.2m	Sandstone bedrock was encountered beneath the natural soils in BH102 and BH105. The sandstone was light grey and/or red brown and extended to the termination depth of BH102 and BH105 at approximately 3.6m and 11.5m respectively.
Groundwater	1m to 1.8m	Groundwater seepage was encountered during drilling in all four boreholes. The standing water levels (SWL) recorded in BH102, BH105, BH106 and BH107 on completion of drilling were approximately 1.4m, 1.6m, 0.9m and 1.5m respectively.

Note:

1 – Depths described in metres below ground level

8.1.1 VOC Screening

PID soil sample headspace readings are presented in attached report tables and the COC documents attached in the appendices. All results were 0 ppm equivalent isobutylene which indicates a lack of PID detectable VOCs.

8.2 Soil Laboratory Results

The soil laboratory results are compared to the relevant SAC in the attached report tables. Statistical calculations undertaken on the results using ProUCL (version 4.1) are attached in the appendices. A summary of the results assessed against the SAC is presented below.

Table 8-2: Summary of Soil Laboratory Results

Analyte	Results Compared to SAC
Heavy Metals	**HILs:** An elevated concentration of lead (620mg/kg) was encountered in the fill soil sample obtained from BH105 (1-1.2m) which was above the HIL-C SAC of 600mg/kg. The remaining results were below the SAC. The 95% UCL was calculated using the lead data from the fill soil samples. The 95% UCL for lead was 471mg/kg which is below the HIL-C SAC of 600mg/kg. The lead concentration in BH105 (1-1.2m) was less than 250% of the SAC and the Standard Deviation (SD) met the acceptance criteria outlined in **Section 2**. **EILs:** The zinc concentrations in two samples obtained from BH105 (1-1.2m) and BH106 (1-1.2m) exceeded the EIL. The remaining results were below the EILs. **WC:** With the exception of the lead concentrations in two fill samples, all results were less than the relevant CT1 and SCC1 criteria. The elevated lead concentrations did not exceed the SCC1 criterion. TCLP leachates were prepared from the two relevant fill samples and the leachates were analysed for lead. The results were less than the TCLP1 criterion.
TPH	**HSLs:** All results were below the SAC. **ESLs:** The >C16-C34 TPH concentrations in two samples obtained from BH102 (0.9-1.1m) and BH105 (1-1.2m) exceeded the ESL. The remaining TPH results were below the ESLs. **WC:** All results were below the relevant SCC1 criteria.

Analyte	Results Compared to SAC
BTEX	**HSLs:** All results were below the HSL-C SAC. **ESLs:** All results were below the ESLs. **WC:** All results were less than the relevant CT1 and SCC1 criteria.
PAHs	**HILs:** Elevated concentrations of benzo(a)pyrene TEQ (13mg/kg and 11mg/kg) were encountered in the fill soil samples obtained from BH102 (0.9-1.1m) and BH105 (1-1.2m) respectively. These results exceeded the HIL-C SAC of 3mg/kg. The remaining benzo(a)pyrene results and all total PAH results were less than the SAC. The 95% UCL was calculated using the benzo(a)pyrene TEQ data from the fill soil samples. The 95% UCL for benzo(a)pyrene TEQ was 15.3mg/kg which is above the HIL-C SAC of 3mg/kg. Both elevated benzo(a)pyrene TEQ concentrations were greater than 250% of the SAC and the Standard Deviation (SD) was greater than 50% of the SAC. **EILs and ESLs:** The benzo(a)pyrene concentrations in four samples obtained from BH102 (0.9-1.1m), BH105 (1-1.2m), BH106 (1-1.2m) and BH107 (0-0.2m) exceeded the ESL. The remaining benzo(a)pyrene results and all of the naphthalene results were below the respective ESL and EIL values. **WC:** The benzo(a)pyrene concentrations in four fill samples exceeded the CT1 criterion. All benzo(a)pyrene results and all total PAH results were below the SCC1 criteria. TCLP leachates were prepared from the relevant fill samples and the leachates were analysed for PAHs. The benzo(a)pyrene results were less than the TCLP1 criterion.
OCPs & OPPs	**HILs:** All results were below the HIL-C SAC. **EILs:** The DDT results were below the EIL-C SAC. **WC:** All results were less than the relevant CT1 and SCC1 criteria.
PCBs	**HILs:** All results were below the HIL-C SAC.

Analyte	Results Compared to SAC
	WC: All results were less than the SCC1 criterion.
Asbestos	**PSI:** No asbestos was detected in the soil samples analysed for the investigation. Asbestos was detected in all four fragments of fibre cement obtained from the ground surface (Asb 1 to Asb 4).
ASS	The pH_{KCl} results ranged from 5.8 to 9.5. The results indicate that prior to oxidation the pH values of the soil suspended in potassium chloride solution ranged from slightly acidic to alkaline. Following oxidation, the pH_{ox} results for the samples ranged from 3.5 to 7.3. The pH in half of the samples dropped. The pH of the samples typically dropped by 2 or more pH units following oxidiation, and dropped below the SAC of pH5 in half of the samples analysed. The acid and sulfur trail results are summarised below: • TAA results indicated that the soils were generally non-acidic prior to oxidation, with all results below the laboratory PQL; • TPA results ranged from less than the PQL to 37mol H^+/tonne. One sample obtained from BH102 (1.8-2m) encountered a TPA result that exceeded the SAC of 18mol H^+/tonne; • TSA results ranged from less than the PQL to 37mol H^+/tonne. One sample obtained from BH102 (1.8-2m) encountered a TPA result that exceeded the SAC of 18mol H^+/tonne; and • The S_{pos}% results ranged from 0.005% to 0.35%. Two of the samples encountered results above the SAC of 0.03%.

9 QA/QC ASSESSMENT

The QA/QC assessment includes a review of the DQIs established for the investigation (see **Section 2.2**). A summary of the field QA/QC samples are outlined below:

Table 9-1: Field QA/QC Samples

Field QA/QC	Frequency	Sample Details
Intra-laboratory duplicates	One sample (approximately 12% of primary samples)	Soil Samples: Dup 1 is a soil duplicate of sample BH107 (0-0.2m).

An assessment of the DQIs is summarised in the following table:

Table 9-2: Assessment of DQIs

Completeness

Data and documentation completeness was achieved through the following measures:

- A sampling and analysis plan was prepared for the investigation;
- COC records were prepared for each batch of samples sent to the labs (refer to appendices);
- Laboratory sample receipt information was reviewed for each batch (refer to appendices);
- NATA registered laboratories were used for all analysis;
- Visual observations and PID screening of samples was undertaken during the investigation as noted on the boreholes logs and COC documents (refer to appendices); and
- All soil samples were analysed for the PCC identified in **Section 5.1**.

Comparability

Data comparability was achieved through the following measures:

- Similar sampling techniques were used during the investigation;
- Appropriate preservation, storage and transport methods were adopted for all samples; and
- Consistent analysis techniques and reporting standards were adopted by the laboratories.

Representativeness

Data representativeness was achieved through the following measures:

- The sampling plan was optimised to obtain a reasonable coverage of sample locations; and
- The assessment included a representative coverage of analysis for PCC.

Precision

Intra-laboratory RPD Results:

The intra-laboratory soil RPD results are presented in the attached report tables. The results indicated that field precision was acceptable.

Accuracy

Accuracy was achieved through the following measures:

- Trained and qualified field staff were used for the investigation;

- Appropriate industry standard sampling equipment and decontamination procedures were adopted for the investigation as outlined in the attached appendices;
- Sampling and screening equipment are routinely factory calibrated. An in-house calibration check was undertaken prior to using onsite;
- Appropriate sample preservation, handling, holding time and COC procedures were adopted for the investigation;
- The report was prepared generally in accordance with Reporting Guidelines 1997;
- Review of laboratory QA/QC data is summarised below:
  - Laboratory Duplicate RPD Results: Laboratory duplicate RPD results for the soil analysis were generally within the acceptance criteria adopted by the laboratory. Marginally elevated RPDs were encountered for lead and chromium, however, as the initial and duplicate results were below the health-based SAC, these results are not considered to have had an adverse impact on the dataset as a whole;
  - Matrix spike recovery concentrations were within the acceptable limits;
  - Surrogate Spike Recovery: Surrogate spike recovery concentrations were within the acceptable limits;
  - LCS recovery: LCS recovery concentrations were within the acceptable limits.

The DQIs adopted for this investigation (see **Section 2.2**) have been addressed.

10 DISCUSSION

Based on the results of the preliminary ESA, the potential risk for significant widespread soil and groundwater contamination at the site is considered to be relatively high.

10.1 Soil Contamination Details

An elevated concentration of benzo(a)pyrene TEQ was encountered in the fill soil sample obtained from BH102 (0.9-1.1m). Elevated concentrations of lead and benzo(a)pyrene were also encountered in the fill soil sample obtained from BH105 (1-1.2m). The horizontal and vertical extent of the contamination has not been established during the preliminary ESA.

Asbestos was also encountered in fragments of fibre cement collected from the ground surface at four locations (several additional fragments were also observed in the immediate vicinity of the samples that were collected). EIS consider that the asbestos issue is likely to be widespread across the site.

Hydrocarbon odours were noted in the soils during drilling of BH102 (and BH101 drilled for the geotechnical investigation). This may indicate the presence of an unknown hydrocarbon contamination source (such as a UST).

10.2 Source of Soil Contamination

The lead and benzo(a)pyrene are considered likely to be associated with ash and slag deposits in the fill soils. Although ash and slag were not noted on the borehole logs, these inclusions may have been present at trace quantities that can still produce relatively high analytical concentrations in soil.

Slag and ash were frequently used as fill material during the 1900s. The slag and ash may have originated from various metal processing industries and from coal burning respectively. EIS have undertaken a number of investigations in the area that have identified similar fill material types and associated contamination conditions.

The asbestos is most likely from demolition of former buildings at the site which occurred throughout the 1900s. The lead may also be associated with these activities.

10.3 Groundwater Contamination Details

An assessment of the groundwater contamination conditions was outside the scope of the preliminary ESA.

10.4 ASS

The preliminary ASS assessment identified sPOCAS results above the SAC. Based on these results, an ASS management plan (ASSMP) will be required prior to disturbance of the soils at the site.

10.5 Data Gaps

The primary data gaps identified during the preliminary ESA include:

- The lack of detailed site history information including land title records, WorkCover records, EPA records and council records;
- Limited soil sampling and limited laboratory analysis for contaminants and ASS; and
- The lack of groundwater contamination data and groundwater flow/direction information.

11 WASTE CLASSIFICATION (WC)

11.1 Preliminary Classification of Fill Soil for Off-Site Disposal

The waste classification for the fill material is summarised in the following table:

Table 11-1: Preliminary Waste Classification of Fill

Extent	Classification	Disposal Option
All fill soils	To be confirmed by additional testing: General Solid Waste (non-putrescible) containing asbestos (special waste) This classification must be confirmed following the additional ASS assessment. The presence of ASS or potential ASS (PASS) in the fill soils will need to be noted in the classification.	A licensed NSW EPA landfill capable of receiving the waste stream. The landfill should be contacted to obtain the required approvals prior to commencement of excavation.

Note:
1. Waste Classification Guidelines 2009

The fill material must be disposed of to a NSW EPA licensed facility. It is the responsibility of the receiving facility to ensure that the material meets their EPA license conditions. EIS accepts no liability whatsoever for illegal or inappropriate disposal of excavated material.

11.2 Classification of Natural Soil for Off-Site Disposal

Due to the potential presence of PASS/ASS at the site and the PAHs in the natural soil sample obtained from BH107 1.5-1.7m, the natural material cannot be assigned a VENM classification. This can be reassessed following completion of the additional investigation work.

12 TIER 1 RISK ASSESSMENT AND REVIEW OF CSM

12.1 Human-Health Risks

As the contamination levels in the soil samples analysed were above the health-based SAC, EIS consider that the AEC pose a medium to high risk (with regards to dermal contact and inhalation exposure) to the potential human receptors identified in **Section 5.3**.

The source and nature of the potential hydrocarbon impacts in the vicinity of BH101 and BH102 requires further consideration. The presence of hydrocarbons in the groundwater may impact off-site users who currently utilise groundwater as a resource.

12.2 Vapour Risks

The preliminary ESA did not identify the presence of hydrocarbons in the soils at concentrations that can result in potential vapour risks. The presence of hydrocarbon odours in BH101 and BH102 requires further assessment.

12.3 Ecological Risk

The presence of zinc, TPH and benzo(a)pyrene at concentrations above the EILs/ESLs is considered to pose a relatively low risk to the environmental receptors identified in **Section 5.3.**

Manly Lagoon is located approximately 500m to the north of the site and there is considered to be a relatively low potential for the site contamination to adversely impact the lagoon.

The proposed landscaped areas (on-site) may be more susceptible to potential ecological impacts. However, EIS are of the opinion that these impacts could be minimised via the provision of suitable, nutrient rich topsoil and the selection of appropriate plant species.

13 CONCLUSIONS AND RECOMMENDATIONS

EIS consider that the report objectives (see **Sections 1.2** and **Section 2**) have been addressed. Based on the scope of work undertaken, EIS provide the following conclusions and recommendations:

- The potential for widespread contamination at the site is considered to be relatively high;
- Soil contamination (lead and PAHs) was identified at two locations. Fragments of fibre cement (containing asbestos) was also identified at the ground surface at several locations;
- The contaminants encountered at the site are considered to pose a medium to high risk to the potential human receptors identified in the CSM;
- The contaminants encountered at the site are considered to pose a relatively low risk to the potential ecological receptors identified in the CSM;
- In order to address the data gaps and better assess potential risks associated with the site contamination conditions, EIS recommend the following:
    - A stage 2 ESA should be undertaken. The stage 2 work should incorporate a more thorough site history assessment, which as a minimum, should include an assessment of land title records, WorkCover records, EPA records and council records;
    - The stage 2 investigation should be designed to meet the minimum sampling density specified by the EPA (17 boreholes in total). Additional boreholes should be targeted in the vicinity of BH101 and BH102 in to assess the potential presence of hydrocarbon contamination in this section of the site;
    - Sampling and analysis of the fill and natural soils should be undertaken. Samples should be analysed for ASS conditions (sPOCAS) and the PCC identified in the CSM. TCLP analysis should also be undertaken as required;
    - A minimum of four groundwater monitoring should be installed at the site. The wells should be positioned to assess the conditions in the vicinity of BH101 and BH102, the central section of the site, and at the northern site boundary;
    - Groundwater samples from each location should be analysed for TPH, VOCs, PAHs, heavy metals, pH, EC and hardness; and
    - A Remedial Action Plan (RAP) and ASSMP should be prepared based on the results of the Stage 2 investigation and additional ASS analysis.

EIS consider that the site could be made suitable for the proposed recreational development, provided that the recommendations detailed above are implemented accordingly. The suitability of the site for the proposed development will rely on the success of the site remediation process.

13.1 Regulatory Requirement

The regulatory requirements applicable for the site are outlined in the following table:

Table 13-1: Regulatory Requirement

Guideline	Applicability
Duty to Report Contamination 2008[21]	The requirement to notify the NSW EPA regarding the site contamination should be assessed following completion of the Stage 2 ESA. Please note that in the event the recommendations for additional work and remediation/management are not undertaken, there may be justification to notify the EPA. EIS can be contacted for further advice regarding notification.
POEO Act 1997	Section 143 of the POEO Act 1997 states that if waste is transported to a place that cannot lawfully be used as a waste facility for that waste, then the transporter and owner of the waste are each guilty of an offence. The transporter and owner of the waste have a duty to ensure that the waste is disposed of in an appropriate manner.
UPSS Regulation 2008	Under the regulation and the AS4976-2008[22], all storage systems must be removed from the site in compliance with Section 5 of the standards. In-situ abandonment should only be considered in special circumstances, e.g. where removal will cause serious risks to adjoining tanks, underground structures and adjoining buildings. Approval from the applicable authorities (i.e. WorkCover, Council, NSW EPA) may be required under these circumstances.
Work Health and Safety Code of Practice 2011[23]	Sites contaminated with asbestos become a 'workplace' when work is carried out there and require a register and asbestos management plan.

[21] *Guidelines on the Duty to Report Contamination*, NSW Government Legislation, 2008 (Duty to Report Contamination 2008)

[22] The Removal and Disposal of Underground Petroleum Storage Tanks, Standards Australia, 2008 (AS4976-2008)

[23] Code of Practice – How to Manage and Control Asbestos in the Workplace, WHS Regulation 2011

14 LIMITATIONS

The report limitations are outlined below:

- EIS accepts no responsibility for any unidentified contamination issues at the site. Any unexpected problems/subsurface features that may be encountered during development works should be inspected by an environmental consultant as soon as possible;
- Previous use of this site may have involved excavation for the foundations of buildings, services, and similar facilities. In addition, unrecorded excavation and burial of material may have occurred on the site. Backfilling of excavations could have been undertaken with potentially contaminated material that may be discovered in discrete, isolated locations across the site during construction work;
- This report has been prepared based on site conditions which existed at the time of the investigation; scope of work and limitation outlined in the EIS proposal; and terms of contract between EIS and the client (as applicable);
- The conclusions presented in this report are based on investigation of conditions at specific locations, chosen to be as representative as possible under the given circumstances, visual observations of the site and immediate surrounds and documents reviewed as described in the report;
- Subsurface soil and rock conditions encountered between investigation locations may be found to be different from those expected. Groundwater conditions may also vary, especially after climatic changes;
- The investigation and preparation of this report have been undertaken in accordance with accepted practice for environmental consultants, with reference to applicable environmental regulatory authority and industry standards, guidelines and the assessment criteria outlined in the report;
- Where information has been provided by third parties, EIS has not undertaken any verification process, except where specifically stated in the report;
- EIS has not undertaken any assessment of off-site areas that may be potential contamination sources or may have been impacted by site contamination, except where specifically stated in the report;
- EIS accept no responsibility for potentially asbestos containing materials that may exist at the site. These materials may be associated with demolition of pre-1990 constructed buildings or fill material at the site;
- EIS have not and will not make any determination regarding finances associated with the site;
- Additional investigation work may be required in the event of changes to the proposed development or landuse. EIS should be contacted immediately in such circumstances;
- Material considered to be suitable from a geotechnical point of view may be unsatisfactory from a soil contamination viewpoint, and vice versa;

- This report has been prepared for the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose;
- Copyright in this report is the property of EIS. EIS has used a degree of care, skill and diligence normally exercised by consulting professionals in similar circumstances and locality. No other warranty expressed or implied is made or intended. Subject to payment of all fees due for the investigation, the client alone shall have a licence to use this report;
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- Any third party who seeks to rely on this report without the express written consent of EIS does so entirely at their own risk and to the fullest extent permitted by law, EIS accepts no liability whatsoever, in respect of any loss or damage suffered by any such third party.

LIST OF IN-TEXT TABLES

IMPORTANT INFORMATION ABOUT THIS REPORT

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

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

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

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

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

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

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

Assessment Limitations

Although information provided by a site assessment can reduce exposure to the risk of the presence of contamination, no environmental site assessment can eliminate the risk. Even a rigorous professional assessment may not detect all contamination on a site. Contaminants may be present in areas that were not surveyed or sampled, or may migrate to areas which showed no signs of contamination when sampled. Contaminant analysis cannot possibly cover every type of contaminant which may occur; only the most likely contaminants are screened.

Misinterpretation of Site Assessments by Design Professionals

Costly problems can occur when other design professionals develop plans based on misinterpretation of an assessment report. To minimise problems associated with misinterpretations, the environmental consultant should be retained to work with appropriate professionals to explain relevant findings and to review the adequacy of plans and specifications relevant to contamination issues.

Logs Should not be Separated from the Assessment Report

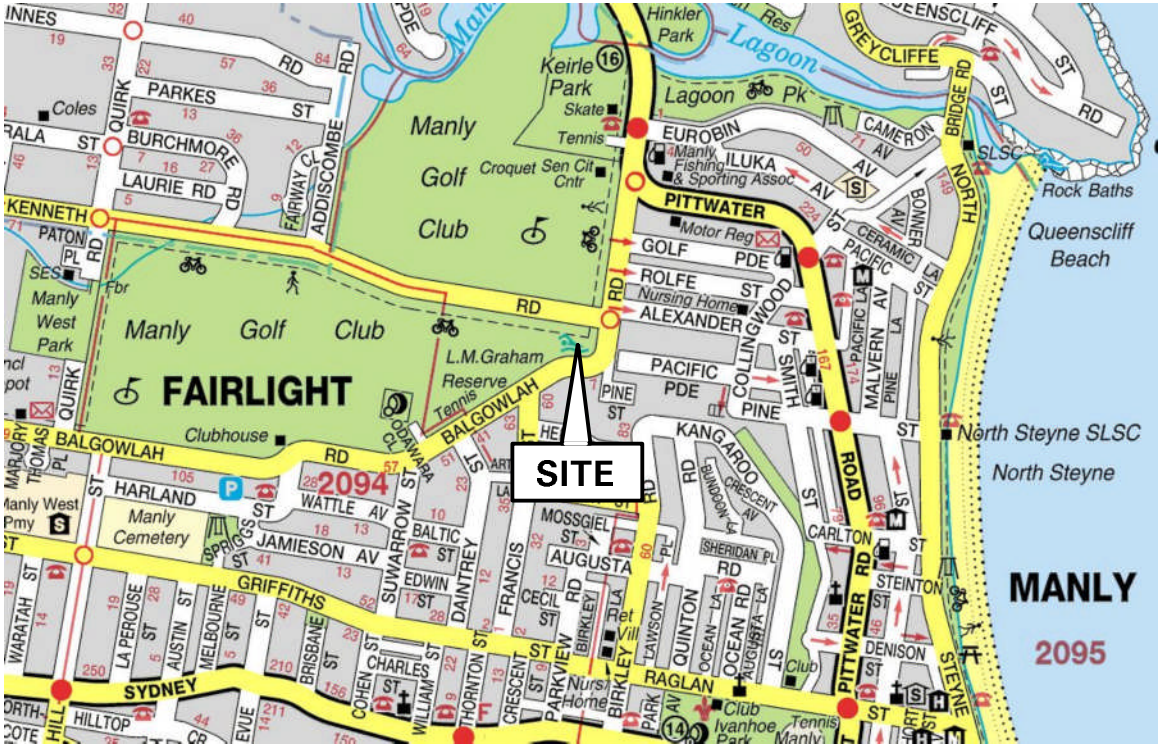
Borehole and test pit logs are prepared by environmental scientists, engineers or geologists based upon interpretation of field conditions and laboratory evaluation of field samples. Logs are normally provided in our reports and these should not be re-drawn for inclusion in site remediation or other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

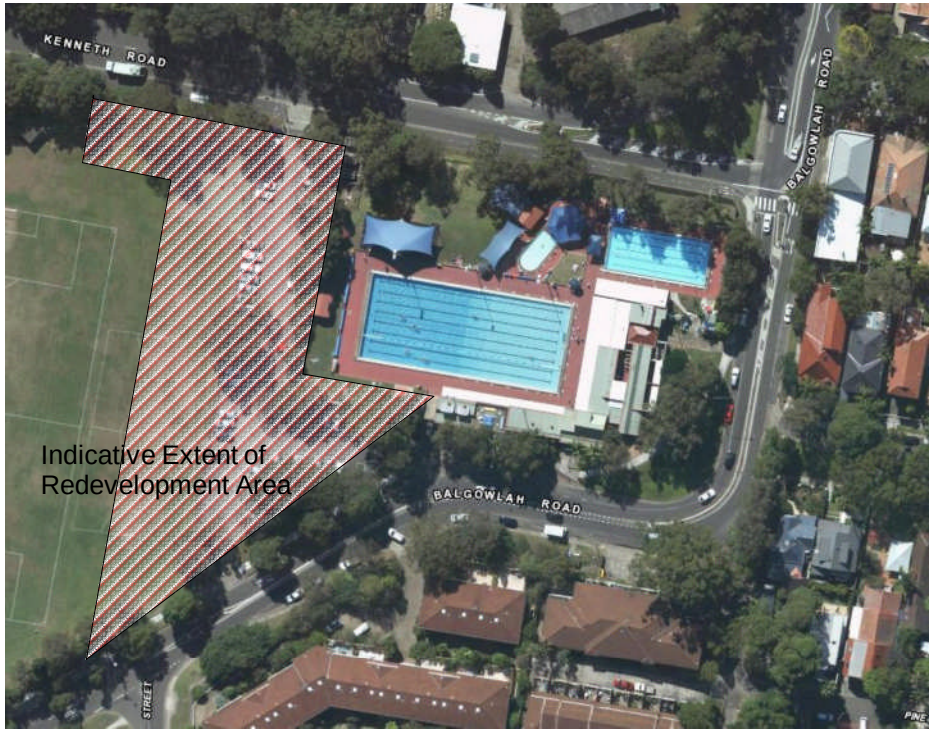
To reduce the likelihood of borehole and test pit log misinterpretation, the complete assessment should be available to persons or organisations involved in the project, such as contractors, for their use. Denial of such access and disclaiming responsibility for the accuracy of subsurface information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

Read Responsibility Clauses Closely

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

REPORT FIGURES



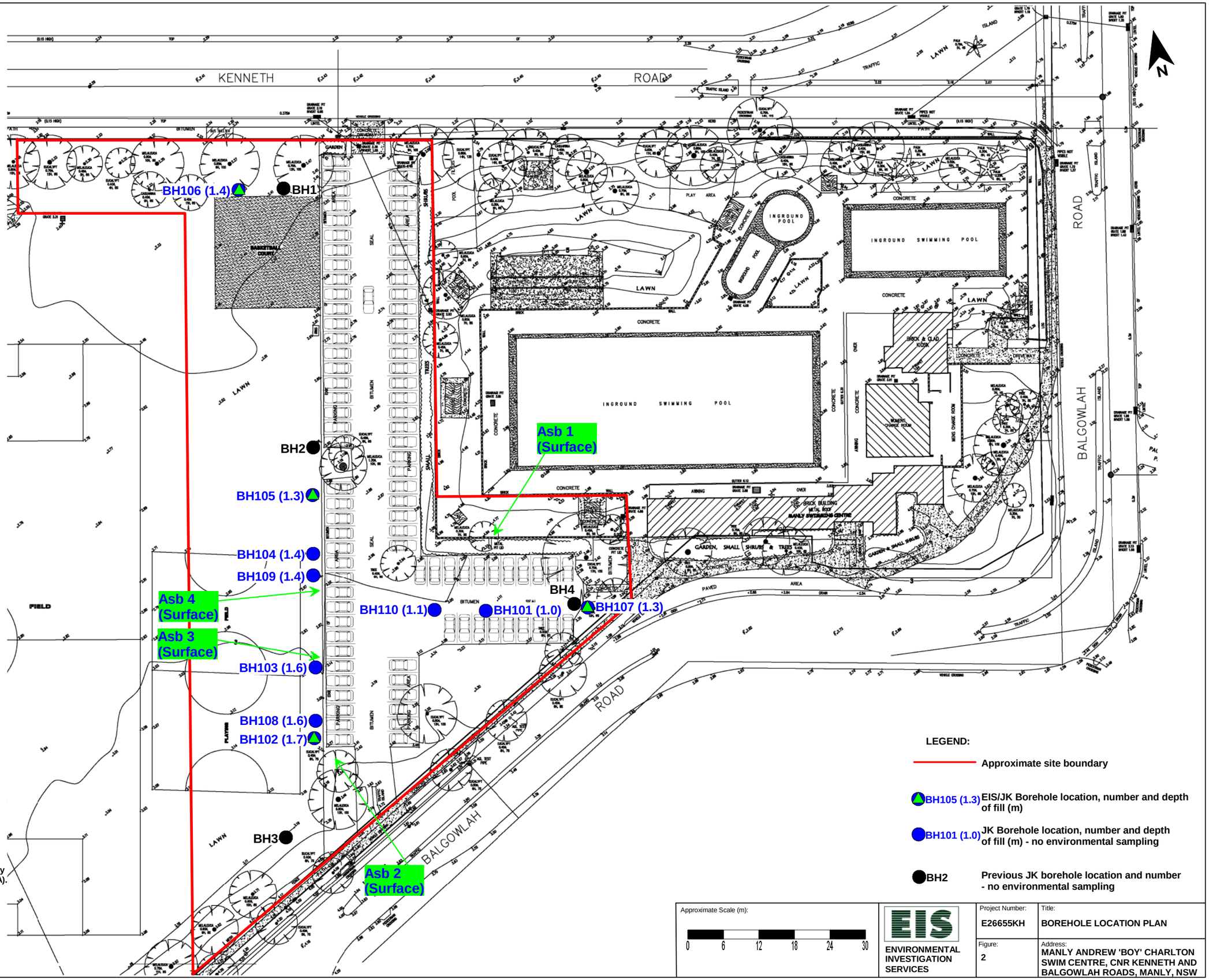


NOTES:
Figure 1 has been recreated from UBD on disc (version 5.0) and http://maps.six.nsw.gov.au/

Figure is not to scale. UBD Map ref: 197 Q6

Reference should be made to the report text for a full understanding of this plan.

ENVIRONMENTAL INVESTIGATION SERVICES	Project Number: E26655KH	Title: SITE LOCATION PLAN
	Figure: 1	Address: MANLY ANDREW 'BOY' CHARLTON SWIM CENTRE, CNR KENNETH AND BALGOWLAH ROADS, MANLY, NSW



NOTES:
Figure 2 has been recreated from site survey by Planning and Strategy (ref: EX01, Issue A).

The borehole locations presented on this plan have been established from site measurements only and should not be construed as survey points.

Reference should be made to the report text for a full understanding of this plan.

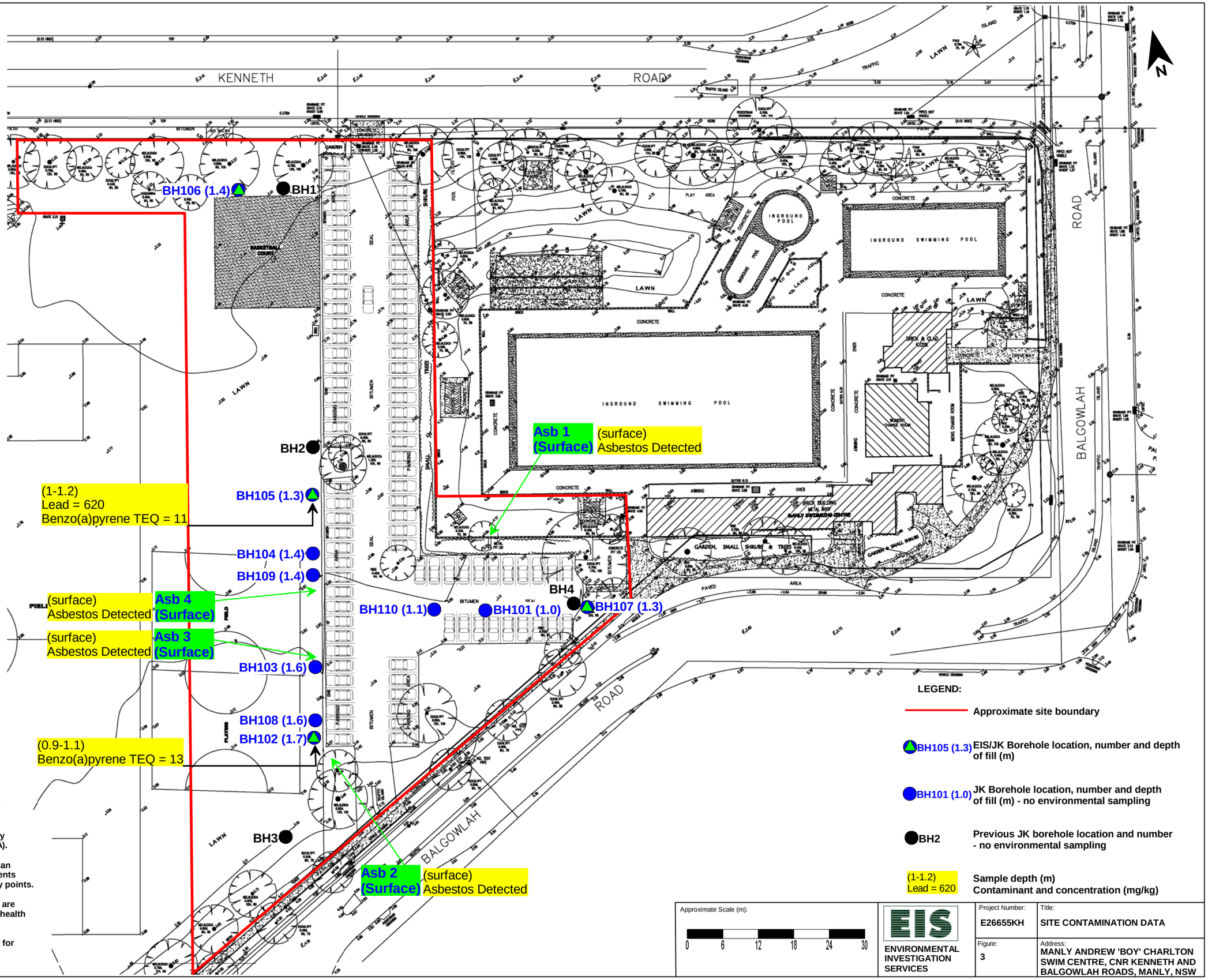
LEGEND:

- **Approximate site boundary**
- **BH105 (1.3)** EIS/JK Borehole location, number and depth of fill (m)
- **BH101 (1.0)** JK Borehole location, number and depth of fill (m) - no environmental sampling
- **BH2** Previous JK borehole location and number - no environmental sampling

Approximate Scale (m): 0 6 12 18 24 30

ENVIRONMENTAL INVESTIGATION SERVICES

Project Number:	Title:
E26655KH	BOREHOLE LOCATION PLAN
Figure: 2	Address: MANLY ANDREW 'BOY' CHARLTON SWIM CENTRE, CNR KENNETH AND BALGOWLAH ROADS, MANLY, NSW



NOTES:
Figure 3 has been recreated from site survey by Planning and Strategy (ref: EX01, Issue A).

The borehole locations presented on this plan have been established from site measurements only and should not be construed as survey points.

The contamination data shown on this plan are only those contaminants above the human-health based SAC.

Reference should be made to the reporttext for a full understanding of this plan.

LEGEND:

- **Approximate site boundary**
- **BH105 (1.3)** — **EIS/JK Borehole location, number and depth of fill (m)**
- **BH101 (1.0)** — **JK Borehole location, number and depth of fill (m) - no environmental sampling**
- **BH2** — **Previous JK borehole location and number - no environmental sampling**
- (1-1.2) Lead = 620 — **Sample depth (m) Contaminant and concentration (mg/kg)**

Approximate Scale (m): 0 6 12 18 24 30

ENVIRONMENTAL INVESTIGATION SERVICES

Project Number:	Title:
E26655KH	SITE CONTAMINATION DATA
Figure: 3	Address: MANLY ANDREW 'BOY' CHARLTON SWIM CENTRE, CNR KENNETH AND BALGOWLAH ROADS, MANLY, NSW

REPORT TABLES

TABLE A

CHEMICAL CONTAMINANT CRITERIA FOR WASTE CLASSIFICATION

Waste Classification Guidelines Part 1: Classifying Waste DECC NSW July 2009

All data in mg/kg unless stated otherwise

CONTAMINANT	GENERAL SOLID WASTE			RESTRICTED SOLID WASTE		
	CT1 (mg/kg)	TCLP1 (mg/L)	SCC1 (mg/kg)	CT2 (mg/kg)	TCLP2 (mg/L)	SCC2 (mg/kg)
Heavy Metals						
Arsenic	100	5	500	400	20	2,000
Beryllium	20	1	100	80	4	400
Cadmium	20	1	100	80	4	400
Chromium VI	100	5	1,900	400	20	7,600
Cyanide (total)	320	16	5,900	1280	64	23,600
Cyanide (Amenable)	70	3.5	300	280	14	1,200
Fluoride	3,000	150	10,000	12,000	600	40,000
Lead	100	5	1,500	400	20	6,000
Mercury	4	0.2	50	16	0.8	200
Molybdenum	100	5	1,000	400	20	4,000
Nickel	40	2	1,050	160	8	4,200
Selenium	20	1	50	80	4	200
Silver	100	5	180	400	20	720
Monocyclic Aromatic Hydrocarbons						
Benzene	10	0.5	18	40	2	72
Toluene	288	14.4	518	1,152	57.6	2,073
Ethyl benzene	600	30	1,080	2,400	120	4,320
Total xylenes	1,000	50	1,800	4,000	200	7,200
Petroleum Hydrocarbons (TPH)						
Light Fraction TPH (C6-C9)	nsl	nsl	650	nsl	nsl	2,600
Mid to Heavy Fraction TPH (C10-C36)	nsl	nsl	10,000	nsl	nsl	40,000
Polycyclic Aromatic Hydrocarbons (PAHs)						
Benzo(a)pyrene	0.8	0.04	10	3.2	0.16	23
Total PAHs	nsl	nsl	200	nsl	nsl	800
Others						
Polychlorinated biphenyls	nsl	nsl	<50	nsl	nsl	<50
Phenol (non-halogenated)	288	14.4	518	1,152	57.6	2,073
Scheduled chemicals	nsl	nsl	<50	nsl	nsl	<50

Explanation:

1). General Solid Waste (GSW):

- If SCC ≤ CT1 then TCLP not needed to classify the material as GSW
- If TCLP ≤ TCLP1 and SCC ≤ SCC1 then treat as GSW

2). Restricted Solid Waste (RSW):

- If SCC ≤ CT2 then TCLP not needed to classify the material as RSW
- If TCLP ≤ TCLP2 and SCC ≤ SCC2 then treat as RSW

3). Hazardous Waste (HW):

- If SCC > CT2 then TCLP not needed to classify the material as HW
- If TCLP > TCLP2 and/or SCC > SCC2 then treat as HW

Abbreviations:

SCC – Specific Contaminant Concentration

CT – Contaminant Threshold

TCLP – Toxicity Characteristics Leaching Procedure

nsl - No Set Limit

DECC - NSW Department of Environment and Climate Change (now OEH)

TABLE B
SOIL LABORATORY RESULTS COMPARED TO HIL
All data in mg/kg unless stated otherwise

			HEAVY METALS									PAHs		ORGANOCHLORINE PESTICIDES (OCPs)							OP PESTICIDES (OPPs)	TOTAL PCBs	ASBESTOS FIBRES
			Arsenic	Cadmium	Chromium	Chromium VI	Copper	Lead	Mercury	Nickel	Zinc	Total PAHs	B(a)P TEQ [2]	HCB	Endosulfan	Methoxychlor	Aldrin & Dieldrin	Chlordane	DDT, DDD & DDE	Heptachlor	Chlorpyrifos		
PQL - Envirolab Services			4	0.5	1	1	1	1	0.1	1	1	-	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0,1	0.1	100
Site Assessment Criteria (SAC) [1]			300	90	nsl	300	17000	600	80	1200	30000	300	3	10	340	400	10	70	400	10	250	1	Detected/Not Detected
Sample Reference	**Sample Depth**	**Sample Description**																					
BH102	0-0.2	Fill: silty sand	8	LPQL	8	na	7	19	LPQL	4	48	1.9	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	Not Detected
BH102	0.9-1.1	Fill: silty sand	LPQL	LPQL	5	na	14	220	LPQL	2	45	87	**13**	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	Not Detected
BH105	0-0.2	Fill: silty sand	4	LPQL	10	na	6	17	0.2	3	25	1.4	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	Not Detected
BH105	1-1.2	Fill: silty sand	6	0.9	10	na	32	**620**	0.5	6	630	82	**11**	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	Not Detected
BH106	0-0.2	Fill: silty sand	LPQL	LPQL	5	na	5	27	LPQL	2	45	3	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	Not Detected
BH106	1-1.2	Fill: silty sand	LPQL	LPQL	8	na	6	70	LPQL	2	88	15	2	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	Not Detected
BH107	0-0.2	Fill: silty sand	LPQL	LPQL	13	na	14	33	LPQL	11	43	17	2	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	Not Detected
BH107	1.5-1.7	Silty sand	LPQL	LPQL	6	na	LPQL	5	LPQL	LPQL	14	1.8	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	Not Detected
Asb 1	Surface	Fibre Cement	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	Asbestos Detected
Asb 2	Surface	Fibre Cement	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	Asbestos Detected
Asb 3	Surface	Fibre Cement	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	Asbestos Detected
Asb 4	Surface	Fibre Cement	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	Asbestos Detected
Total Number of Samples			8	8	8	0	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	12
Maximum Value			8	0.9	13	nc	32	620	0.5	11	630	87	13	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	nc
Mean Value [3]			nc	nc	nc	nc	nc	144	nc	nc	nc	nc	4.11	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
Standard Deviation [3]			nc	nc	nc	nc	nc	222	nc	nc	nc	nc	5.48	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
Coefficient of Variation [3]			nc	nc	nc	nc	nc	1.5	nc	nc	nc	nc	1.33	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
Distribution [3]			nc	nc	nc	nc	nc	Gamma	nc	nc	nc	nc	Gamma	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc
95% UCL [3]			nc	nc	nc	nc	nc	471	nc	nc	nc	nc	**15.3**	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc

Explanation:
1 - Site Assessment Criteria (SAC): NEPM 2013, HIL-C: 'Public open space; secondary schools; and footpaths'
2 - B(a)P TEQ - Benzo(a)pyrene Toxicity Equivalence Quotient has been calculated based on 8 carcinogenic PAHs and their Toxic Equivalence Factors (TEFs) outlined in NEPM 2013
3 - Statistical calculation undertaken using ProUCL version 4.1 (USEPA). Statistical calculation has only been undertaken using data from fill samples

Concentration above the SAC **VALUE**

Abbreviations:

PAHs: Polycyclic Aromatic Hydrocarbons	UCL: Upper Level Confidence Limit on Mean Value
B(a)P: Benzo(a)pyrene	HILs: Health Investigation Levels
PQL: Practical Quantitation Limit	na: Not Analysed
LPQL: Less than PQL	nc: Not Calculated
OPP: Organophosphorus Pesticides	nsl: No Set Limit
OCP: Organochlorine Pesticides	SAC: Site Assessment Criteria
PCBs: Polychlorinated Biphenyls	NEPM: National Environmental Protection Measure

TABLE C
SOIL LABORATORY RESULTS COMPARED TO HSL
All data in mg/kg unless stated otherwise

				C_6-C10 (F1)	$>C_{10}$-C_{16} (F2)	Benzene	Toluene	Ethylbenzene	Xylenes	Naphthalene	PID [2]
PQL - Envirolab Services				25	50	0.2	0.5	1	3	1	
HSL Land Use Category [1]				RECREATIONAL							
Sample Reference	**Sample Depth**	**Depth Category**	**Soil Category**								
BH102	0-0.2	0m to < 1m	Sand	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0
BH102	0.9-1.1	1m to <2m	Sand	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0
BH105	0-0.2	0m to < 1m	Sand	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0
BH105	1-1.2	1m to <2m	Sand	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0
BH106	0-0.2	0m to < 1m	Sand	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0
BH106	1-1.2	1m to <2m	Sand	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0
BH107	0-0.2	0m to < 1m	Sand	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0
BH107	1.5-1.7	1m to <2m	Sand	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0
Total Number of Samples [3]				8	8	8	8	8	8	8	8
Maximum Value				LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0

Explanation:
1 - Site Assessment Criteria (SAC): NEPM 2013
2 - Field PID values obtained during the investigation

Concentration above the SAC **VALUE**

Abbreviations:
UCL: Upper Level Confidence Limit on Mean Value
HSLs: Health Screening Levels
na: Not Analysed
nc: Not Calculated
NL: Not Limiting
PQL: Practical Quantitation Limit
LPQL: Less than PQL
SAC: Site Assessment Criteria
NEPM: National Environmental Protection Measure

TABLE D
SOIL LABORATORY RESULTS COMPARED TO WASTE CLASSIFICATION GUIDELINES (2009)
All data in mg/kg unless stated otherwise

			HEAVY METALS								PAHs		OCPs				TOTAL	Total	TPH				BTEX COMPOUNDS				ASBESTOS FIBRES
			Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc	Total PAHs	B(a)P	Aldrin & Dieldrin	Chlordane	DDT, DDD & DDE	Heptachlor	OPPs	PCBs	C_6-C_9	C_{10}-C_{14}	C_{15}-C_{28}	C_{29}-C_{36}	Total C_{10}-C_{36}	Benzene	Toluene	Ethyl benzene	Total Xylenes	
PQL - Envirolab Services			4	0.5	1	1	1	0.1	1	1	-	0.05	0.1	0.1	0.1	0.1	0.1	0.1	25	50	100	100	250	0.5	0.5	1	3	100
General Solid Waste CT1 [1]			100	20	100	nsl	100	4	40	nsl	nsl	0.8	nsl	nsl	nsl	nsl	detect[2]	nsl	nsl		nsl		nsl	10	288	600	1000	-
General Solid Waste SCC1 [1]			500	100	1900	nsl	1500	50	1050	nsl	200	10	Scheduled Chemicals <50					50	650		nsl		10000	18	518	1080	1800	-
Restricted Solid Waste CT2 [1]			400	80	400	nsl	400	16	160	nsl	nsl	3.2	nsl	nsl	nsl	nsl	detect[2]	nsl	nsl		nsl		nsl	40	1152	2400	4000	-
Restricted Solid Waste SCC2 [1]			2000	400	7600	nsl	6000	200	4200	nsl	800	23	Scheduled Chemicals <50					50	2600		nsl		40000	72	2073	4320	7200	-
Sample Reference	**Sample Depth**	**Sample Description**																										
BH102	0-0.2	Fill: silty sand	8	LPQL	8	7	19	LPQL	4	48	1.9	0.19	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	Not Detected
BH102	0.9-1.1	Fill: silty sand	LPQL	LPQL	5	14	**220**	LPQL	2	45	87	**8.9**	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	250	150	400	LPQL	LPQL	LPQL	LPQL	Not Detected
BH105	0-0.2	Fill: silty sand	4	LPQL	10	6	17	0.2	3	25	1.4	0.16	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	Not Detected
BH105	1-1.2	Fill: silty sand	6	0.9	10	32	**620**	0.5	6	630	82	**7.9**	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	320	280	600	LPQL	LPQL	LPQL	LPQL	Not Detected
BH106	0-0.2	Fill: silty sand	LPQL	LPQL	5	5	27	LPQL	2	45	3	0.38	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	Not Detected
BH106	1-1.2	Fill: silty sand	LPQL	LPQL	8	6	70	LPQL	2	88	15	**1.4**	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	Not Detected
BH107	0-0.2	Fill: silty sand	LPQL	LPQL	13	14	33	LPQL	11	43	17	**1.6**	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	130	150	280	LPQL	LPQL	LPQL	LPQL	Not Detected
BH107	1.5-1.7	Silty sand	LPQL	LPQL	6	LPQL	5	LPQL	LPQL	14	1.8	0.18	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	Not Detected
Total Number of samples			8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Maximum Value			8	0.9	13	32	620	0.5	11	630	87	8.9	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	320	280	600	LPQL	LPQL	LPQL	LPQL	nc

EXPLANATION:

1 - NSW DECCW Waste Classification Guidelines (2009)

2 - Some Individual OPPs have CT1 & CT2 values. Reference should be made to the Waste Classification Guidelines in the event of any detections

Concentration above the CT1 — VALUE
Concentration above SCC1 — VALUE
Concentration above the SCC2 — VALUE

Abbreviations:

PAHs: Polycyclic Aromatic Hydrocarbons
B(a)P: Benzo(a)pyrene
PQL: Practical Quantitation Limit
LPQL: Less than PQL
OPP: Organophosphorus Pesticides
PID: Photoionisation Detector
PCBs: Polychlorinated Biphenyls
UCL: Upper Level Confidence Limit on Mean Value
ALPQL: All values less than PQL
na: Not Analysed
nc: Not Calculated
nsl: No Set Limit
SAC: Site Assessment Criteria
TPH: Total Petroleum Hydrocarbons
BTEX: Monocyclic Aromatic Hydrocarbons
OCP: Organochlorine Pesticides
CT: Contaminant Threshold
SCC: Specific Contaminant Concentration
HILs: Health Investigation Levels
NEPM: National Environmental Protection Measure

TABLE E
SOIL LABORATORY TCLP RESULTS
All data in mg/L unless stated otherwise

			Arsenic	Cadmium	Chromium	Lead	Mercury	Nickel	B(a)P
PQL - Envirolab Services			0.05	0.01	0.01	0.03	0.0005	0.02	0.001
TCLP1 - General Solid Waste [1]			5	1	5	5	0.2	2	0.04
TCLP2 - Restricted Solid Waste [1]			20	4	20	20	0.8	8	0.16
TCLP3 - Hazardous Waste [1]			>20	>4	>20	>20	>0.8	>8	>0.16
Sample Reference	**Sample Depth**	**Sample Description**							
BH102	0.9-1.1	Fill: silty sand	na	na	na	0.3	na	na	LPQL
BH105	1-1.2	Fill: silty sand	na	na	na	0.5	na	na	LPQL
BH106	1-1.2	Fill: silty sand	na	na	na	na	na	na	LPQL
BH107	0-0.2	Fill: silty sand	na	na	na	na	na	na	LPQL
Total Number of samples			0	0	0	2	0	0	4
Maximum Value			-	-	-	0.5	-	-	LPQL

EXPLANATION:

1 - NSW DECCW Waste Classification Guidelines (2009)

General Solid Waste	**VALUE**
Restricted Solid Waste	**VALUE**
Hazardous Waste	**VALUE**

ABBREVIATIONS:

PQL: Practical Quantitation Limit
LPQL: Less than PQL
B(a)P: Benzo(a)pyrene
nc: Not Calculated
na: Not Analysed
TCLP: Toxicity Characteristics Leaching Procedure

TABLE F
SOIL LABORATORY RESULTS COMPARED AGAINST THE EILs and ESLs
All data in mg/kg unless stated otherwise

Land Use Category [1]			URBAN RESIDENTIAL AND PUBLIC OPEN SPACE																		
						AGED HEAVY METALS-EILs						EILs		ESLs							
			pH	CEC ($cmol_c/kg$)	Clay Content (% clay)	Arsenic	Chromium	Copper	Lead	Nickel	Zinc	Naphthalene	DDT	C_6-C_{10}	>C_{10}-C_{16}	>C_{16}-C_{34}	>C_{34}-C_{40}	Benzene	Toluene	Ethylbenzene	Total Xylenes	B(a)P
PQL - Envirolab Services			-	1	-	4	1	1	1	1	1	0.05	0.1	25	50	100	100	0.2	0.5	1	3	0.05
Ambient Background Concentration (ABC)			-	-	-	nsl	6	0.5	nsl	0.5	14	nsl	nsl	nsl	nsl	nsl	nsl	nsl	nsl	nsl	nsl	nsl
Sample Reference	**Sample Depth**	**Soil Texture**																			
BH102	0-0.2	Coarse	5.7	3.6	10	8	8	7	19	4	48	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0.19
BH102	0.9-1.1	Coarse	NA	NA	NA	LPQL	5	14	220	2	45	LPQL	LPQL	LPQL	LPQL	370	LPQL	LPQL	LPQL	LPQL	LPQL	8.9
BH105	0-0.2	Coarse	6.9	6.8	12	4	10	6	17	3	25	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0.16
BH105	1-1.2	Coarse	NA	NA	NA	6	10	32	620	6	630	0.3	LPQL	LPQL	LPQL	530	200	LPQL	LPQL	LPQL	LPQL	7.9
BH106	0-0.2	Coarse	NA	NA	NA	LPQL	5	5	27	2	45	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0.38
BH106	1-1.2	Coarse	NA	NA	NA	LPQL	8	6	70	2	88	0.1	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	1.4
BH107	0-0.2	Coarse	NA	NA	NA	LPQL	13	14	33	11	43	0.1	LPQL	LPQL	LPQL	240	LPQL	LPQL	LPQL	LPQL	LPQL	1.6
BH107	1.5-1.7	Coarse	NA	NA	NA	LPQL	6	LPQL	5	LPQL	14	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL	0.18
Total Number of Samples			2	2	2	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Maximum Value			6.9	6.8	12	8	13	32	620	11	630	0.3	LPQL	LPQL	LPQL	530	200	LPQL	LPQL	LPQL	LPQL	8.9

Explanation:
1 - Site Assessment Criteria (SAC): NEPM 2013
ABC values are based on the natural soil sample obtained from BH107 (1.5-1.7m). Half of the PQL has been substituted for those analytes that were LPQL.

Concentration above the SAC — VALUE

Abbreviations:

EILs: Ecological Investigation Levels
B(a)P: Benzo(a)pyrene
PQL: Practical Quantitation Limit
LPQL: Less than PQL
SAC: Site Assessment Criteria
NEPM: National Environmental Protection Measure
UCL: Upper Level Confidence Limit on Mean Value
ESLs: Ecological Investigation Levels
na: Not Analysed
nc: Not Calculated
nsl: No Set Limit

TABLE G
SUMMARY OF LABORATORY RESULTS - ACID SULFATE SOILS ANALYSIS (sPOCAS)

Sample Reference	Sample Depth (m)	Sample Description	pH_{KCL}	TAA pH 6.5	pH_{ox}	TPA pH 6.5	TSA pH 6.5	S_{POS} %w/w	Ca A %w/w	Mg A %w/w	Liming Rate kg $CaCO_3$/tonne
BH102	0.9-1.1	Fill: silty sand	9.3	LPQL	7.3	LPQL	LPQL	0.01	1.5	0.008	LPQL
BH102	1.8-2	Sand	8.1	LPQL	5	**37**	**37**	**0.06**	0.054	LPQL	2.8
BH105	2-2.3	Silty sand	8.3	LPQL	**4.8**	LPQL	LPQL	0.005	0.005	LPQL	LPQL
BH105	3-3.2	Silty sand	9.4	LPQL	7.3	LPQL	LPQL	LPQL	0.14	LPQL	LPQL
BH106	1-1.2	Fill: silty sand	9.5	LPQL	6.8	LPQL	LPQL	**0.35**	0.63	0.034	1.7
BH106	1.4-1.6	Sand	7.4	LPQL	**4.5**	LPQL	LPQL	0.008	0.005	LPQL	LPQL
BH107	1.5-1.7	Silty sand	6.8	LPQL	**4.5**	LPQL	LPQL	LPQL	LPQL	LPQL	LPQL
BH107	2.7-3	Silty sand	5.8	LPQL	**3.5**	LPQL	LPQL	0.02	LPQL	LPQL	1.3
Total Number of Samples			8	8	8	8	8	8	8	8	8
Minimum Value			5.8	LPQL	3.5	LPQL	LPQL	0.005	0.005	0.008	LPQL
Maximum Value			9.5	LPQL	7.3	37	37	0.35	1.5	0.034	2.8

EXPLANATION:

Action criteria are defined as follows:

- coarse textured soils (sands to loamy sands):
  - pH < 5
  - TAA/TSA/TPA (pH 5.5) > 18mol H^+/tonne
  - S_{pos} > 0.03% sulfure oxidisable

Values Exceeding Action Criteria **VALUE**

Abbreviations:

pH_{KCL} : pH of filtered 1:20, 1M KCL extract, shaken overnight
TAA pH 6.5 : Total Actual Acidity in 1M KCL extract titrated to pH6.5
pH_{ox} : pH filtered 1:20 1M KCl after peroxide digestion
TPA : Total Potential Acidity, 1M KCL peroxide digest titrated to pH6.5
TSA: Total Sulfide Acidity
S_{POS}: Peroxide oxidisable Sulfur (SP - SKCL)
Ca $_A$/Mg $_A$: Calcium/Magnesium reacted with acid generated by peroxide digest
Calcium and Magnesium values used to estimate additional Ca/Mg from acid-shell/carbonate/dolomite reaction
Reference: ASSMAC (Acid Sulfate Soils management Advisory Committee - Acid Sulfate Soil Manual, August 1998).

TABLE H
SOIL INTRA-LABORATORY DUPLICATE RESULTS & RPD CALCULATIONS
All results in mg/kg unless stated otherwise

SAMPLE	ANALYSIS	Envirolab PQL	INITIAL	REPEAT	MEAN	RPD %
BH107 (0-0.2m)	Arsenic	4	LPQL	LPQL	nc	nc
= Dup 1	Cadmium	0.5	LPQL	LPQL	nc	nc
	Chromium	1	13	20	16.5	42.4
Envirolab Report: 94822	Copper	1	14	15	14.5	6.9
	Lead	1	33	38	35.5	14.1
	Mercury	0.1	LPQL	LPQL	nc	nc
	Nickel	1	11	16	13.5	37.0
	Zinc	1	43	57	50	28.0

EXPLANATION:
The RPD value is calculated as the absolute value of the difference between the initial and repeat results divided by the average value expressed as a percentage. The following acceptance criteria will be used to assess the RPD results:
Results > 10 times PQL = RPD value < = 50% are acceptable
Results between 5 & 10 times PQL = RPD value < = 75% are acceptable
Results < 5 times PQL = RPD value < = 100% are acceptable

RPD Results Above the Acceptance Criteria **VALUE**

ABBREVIATIONS:
PQL: Practical Quantitation Limit
LPQL: Less than PQL
na: Not Analysed
nc: Not Calculated

Appendix A: Borehole Logs and Explanatory Notes

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BOREHOLE LOG

Borehole No. 101 1/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 3.1m

Date: 30-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

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			ASPHALTIC CONCRETE: 30mm.t FILL: Sandy gravel, fine to medium grained igneous, dark grey, fine to medium grained sand. FILL: Silty sand, fine to medium grained, dark brown, with clay.	M			
ON COMPLET-ION ▼						1		SM	SILTY SAND: fine to medium grained, grey and light grey.	M	-		ALLUVIAL PURPOSE OF BOREHOLE WAS TO PROVE BEDROCK ONLY. THE SOIL DESCRIPTION WAS ASSESSED FROM THE DRILL SPOIL
▶						2				W			
						3							STRONG HYDROCARBON ODOUR BETWEEN APPROXIMATELY 3.0m AND 4.7m DEPTH
						4							
						5		-	SANDSTONE: fine to medium grained, light grey, brown and red brown, with L strength bands.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
						6			SANDSTONE: fine to medium grained, light grey and red brown.	DW	L		LOW RESISTANCE
						7							

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BOREHOLE LOG

Borehole No. **101** 2/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 3.1m

Date: 30-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

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
									SANDSTONE: fine to medium grained, light grey and red brown.	DW	L-M		
									END OF BOREHOLE AT 7.5m				
						8							
						9							
						10							
						11							
						12							
						13							
						14							

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BOREHOLE LOG

Borehole No. 102
1/1

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 30-7-13
Method: SPIRAL AUGER JK305
Logged/Checked by: O.F./A.J.H.
R.L. Surface: ≈ 3.2m
Datum: ASSUMED

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			FILL: Silty sand, fine to medium grained, dark brown, trace of fine to medium grained sandstone gravel, roots and root fibres.	M			GRASS COVER
▼ ON COMPLET-ION						1				W			HYDROCARBON ODOUR BETWEEN APPROXIMATELY 1.2m AND 1.7m DEPTH
						2		SP	SAND: fine to medium grained, grey.	W	-		ALLUVIAL PURPOSE OF BOREHOLE WAS TO PROVE BEDROCK ONLY. THE SOIL DESCRIPTION WAS ASSESSED FROM THE DRILL SPOIL
						3		-	SANDSTONE: fine to medium grained, light grey and red brown.	DW	L-M		LOW TO MODERATE 'TC' BIT RESISTANCE
											H		HIGH RESISTANCE 'TC' BIT REFUSAL
									END OF BOREHOLE AT 3.6m				
						4							
						5							
						6							
						7							

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BOREHOLE LOG

Borehole No. **103** 1/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 3.1m

Date: 30-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

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			FILL: Silty sand, fine to medium grained, dark brown, with fine to medium grained sandstone and igneous gravel, roots and root fibres.	M			
▼ ON COMPLET-ION						1		SP	SAND: fine to medium grained, grey and light grey, trace of quartz gravel.	W	-		ALLUVIAL PURPOSE OF BOREHOLE WAS TO PROVE BEDROCK ONLY. THE SOIL DESCRIPTION WAS ASSESSED FROM THE DRILL SPOIL
						2							
						3							
						4							
						5							
						6							
						7		-	SANDSTONE: fine to coarse grained, light grey.	SW	L		LOW 'TC' BIT RESISTANCE

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BOREHOLE LOG

Borehole No. **103** 2/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 3.1m

Date: 30-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

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
									SANDSTONE: fine to coarse grained, light grey.	SW	L		
				■		8					L-M		LOW TO MODERATE RESISTANCE
						9			END OF BOREHOLE AT 9.0m				
						10							
						11							
						12							
						13							
						14							

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BOREHOLE LOG

Borehole No. **104** 1/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 2.9m

Date: 30&31-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

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			FILL: Silty sand, fine to medium grained, brown, trace of clay fines, roots and root fibres.	M			GRASS COVER
									FILL: Silty sand, fine to medium grained, brown, trace of clay fines.				
ON COMPLET-ION ▼						1		SM	SILTY SAND: fine to medium grained, grey brown.	M	-		ALLUVIAL
▶						2				W			PURPOSE OF BOREHOLE WAS TO PROVE BEDROCK ONLY. THE SOIL DESCRIPTION WAS ASSESSED FROM THE DRILL SPOIL
						3							
						4							
						5							
						6							
						7							

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BOREHOLE LOG

Borehole No. **104** 2/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 2.9m

Date: 30&31-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

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
						8		SM	SILTY SAND: fine to medium grained, grey.	W	-		
						9							
						10		-	SANDSTONE: fine to coarse grained, light grey and orange brown.	DW	VL-L		LOW 'TC' BIT RESISTANCE
				■							L-M		
						11					M-H		MODERATE TO HIGH RESISTANCE
									END OF BOREHOLE AT 11.0m				
						12							
						13							
						14							

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BOREHOLE LOG

Borehole No. **105** 1/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 2.7m

Date: 30&31-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./

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			FILL: Silty sand, fine to medium grained, brown and dark brown, trace of clay fines and glass fragments.	M			
ON COMPLET-ION						1		SM	SILTY SAND: fine to medium grained, grey brown.	M	-		ALLUVIAL PURPOSE OF BOREHOLE WAS TO PROVE BEDROCK ONLY. THE SOIL DESCRIPTION WAS ASSESSED FROM THE DRILL SPOIL
						2				W			
						3			as above, but light grey.				
						4							
						5							
						6							
						7							

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BOREHOLE LOG

Borehole No. **105** 2/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 2.7m

Date: 30&31-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./

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
	■					8		SM	SILTY SAND: fine to medium grained, light grey.	W	-		
						9							
						10		-	SANDSTONE: fine to medium grained, light grey.	DW	VL-L		LOW 'TC' BIT RESISTANCE
						11				SW	M-H		MODERATE RESISTANCE
						12			END OF BOREHOLE AT 11.5m				
						13							
						14							

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BOREHOLE LOG

Borehole No. **106** 1/1

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 2.4m

Date: 30&31-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

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
ON COMPLETION ▼	■					0			FILL: Silty sand, fine to medium grained, brown, trace of shell fragments and root fibres.	M			
									FILL: Silty sand, fine to medium grained, brown, trace of shell fragments.				
▶	■					1				W			
	■							SP	SAND: fine to medium grained, light grey, trace of shell fragments.	W	-		ALLUVIAL
	■					2							
	■					3			END OF BOREHOLE AT 3.0m				
						4							
						5							
						6							
						7							

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BOREHOLE LOG

Borehole No. **107** 1/1

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 3.4m

Date: 30&31-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

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			FILL: Silty sand, fine to medium grained, dark brown, trace of fine to medium grained igneous gravel and root fibres.	M			GRASS COVER
						1			as above, but with fine to medium grained igneous gravel.				
ON COMPLET-ION ▼								SM	SILTY SAND: fine to medium grained, light grey and brown.	M	-		ALLUVIAL
▶						2				W			
						3			END OF BOREHOLE AT 3.0m				
						4							
						5							
						6							
						7							

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BOREHOLE LOG

Borehole No. **108** 1/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK350 **R.L. Surface:** ≈ 3.2m

Date: 31-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

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
ON COMPLET-ION ▼						0			FILL: Silty sand, fine to medium grained, dark brown, trace of fine to medium grained sandstone gravel, roots and root fibres.	M			
						1				W			
						2		SP	SAND: fine to medium grained, grey.	W	-		ALLUVIAL PURPOSE OF BOREHOLE WAS TO PROVE BEDROCK ONLY. THE SOIL DESCRIPTION WAS ASSESSED FROM THE DRILL SPOIL
						3							
						4		-	SANDSTONE: fine to coarse grained, light grey.	SW-FR	M-H		MODERATE 'TC' BIT RESISTANCE
						5			REFER TO CORED BOREHOLE LOG				
						6							
						7							

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CORED BOREHOLE LOG

Borehole No. **108** **2/2**

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Core Size:** NMLC **R.L. Surface:** ≈ 3.2m

Date: 31-7-13 **Inclination:** VERTICAL **Datum:** ASSUMED

Drill Type: JK350 **Bearing:** - **Logged/Checked by:** O.F./A.J.H.

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_S(50)$ EL VL L M H VH EH	DEFECT SPACING (mm) 500 300 100 50 30 10	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific / General
		4		START CORING AT 4.39m					
				CORE LOSS 0.09m					
NO RET-URN		5		SANDSTONE: fine to coarse grained, light grey, bedded at 0-5°.	SW - FR	M-H M			- Be, 0-10°, Un, S - XWS, 0°, 15mm.t
		6		as above, but with dark grey laminae bedded at 0-5°, spacing 0-20mm.		M			
		7		END OF BOREHOLE AT 7.05m					- Be, 0°, P, S
		8							
		9							
		10							

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BOREHOLE LOG

Borehole No. **109** 1/3

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK350 **R.L. Surface:** ≈ 2.9m

Date: 31-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

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
ON COMPLET-ION ▼						0			FILL: Silty sand, fine to medium grained, brown and dark brown, with clay and fine to medium grained sandstone gravel, trace of roots and root fibres.	M			GRASS COVER
						1				W			
								SM	SILTY SAND: fine to medium grained, grey brown.	W	-		ALLUVIAL PURPOSE OF BOREHOLE WAS TO PROVE BEDROCK ONLY. THE SOIL DESCRIPTION WAS ASSESSED FROM THE DRILL SPOIL
						2							
						3							
						4							
						5							
						6							
								SP	SAND: fine to medium grained, grey and light grey.				
						7							

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **109** 2/3

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK350 **R.L. Surface:** ≈ 2.9m

Date: 31-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

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
								SP	SAND: fine to medium grained, grey and light grey.	W	-		
						8		-	SANDSONE: fine to coarse grained, light grey.	DW	VL-L		LOW 'TC' BIT RESISTANCE
						9			REFER TO CORED BOREHOLE LOG				
						10							
						11							
						12							
						13							
						14							

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CORED BOREHOLE LOG

Borehole No. 109 3/3

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Core Size:** NMLC **R.L. Surface:** ≈ 2.9m

Date: 31-7-13 **Inclination:** VERTICAL **Datum:** ASSUMED

Drill Type: JK350 **Bearing:** - **Logged/Checked by:** O.F./A.J.H.

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION (Rock Type, grain characteristics, colour, structure, minor components.)	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_S(50)$ EL VL L M H VH EH	DEFECT SPACING (mm) 500 300 100 50 30 10	DEFECT DETAILS DESCRIPTION (Type, inclination, thickness, planarity, roughness, coating.) Specific / General
		8		START CORING AT 8.97m					
FULL RET-URN		9		SANDSTONE: fine to coarse grained, light grey, bedded at 0-5°.	DW	VL-L			- CS, 0°, 70mm.t - CS, 0°, 40mm.t - J, 45°, P, R - XWS, 10°, 5mm.t - XWS, 0-5°, 50mm.t
					XW	EL			
		10		as above, but dark brown and light grey, bedded at 5-15°.	DW	M-H			
		11							- XWS, 10°, 3mm.t - HEALED J, 80-90°, Un, IS
		12							- XWS, 5°, 3mm.t
				END OF BOREHOLE AT 12.14m					
		13							
		14							

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BOREHOLE LOG

Borehole No. 110
1/3

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 30-7-13
Method: SPIRAL AUGER JK350
Logged/Checked by: O.F./A.J.H.
R.L. Surface: ≈ 3.0m
Datum: ASSUMED

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		-	ASPHALTIC CONCRETE: 50mm.t FILL: Sandy gravel, fine to medium grained igneous, dark grey.	M			
ON COMPLET-ION ▼						1			FILL: Silty sand, fine to medium grained, dark brown, with clay fines.				
▶								SM	SILTY SAND: fine to medium grained, grey and dark grey.	M	-		ALLUVIAL PURPOSE OF BOREHOLE WAS TO PROVE BEDROCK ONLY. THE SOIL DESCRIPTION WAS ASSESSED FROM THE DRILL SPOIL
						2				W			
						3							
						4							
						5							
						6		-	SANDSTONE: fine to medium grained, light grey brown and red brown.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
						7							

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. 110
2/3

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 30-7-13

Method: SPIRAL AUGER
JK350

Logged/Checked by: O.F./A.J.H.

R.L. Surface: ≈ 3.0m
Datum: ASSUMED

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
									SANDSTONE: fine to medium grained, light grey and red brown.	DW	L-M		LOW TO MODERATE RESISTANCE
						8			REFER TO CORED BOREHOLE LOG				
						9							
						10							
						11							
						12							
						13							
						14							

JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

CORED BOREHOLE LOG

Borehole No. **110** **3/3**

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Core Size:** NMLC **R.L. Surface:** ≈ 3.0m

Date: 31-7-13 **Inclination:** VERTICAL **Datum:** ASSUMED

Drill Type: JK350 **Bearing:** - **Logged/Checked by:** O.F./A.J.H.

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_S(50)$ EL VL L M H VH EH	DEFECT SPACING (mm) 500 300 100 50 30 10	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific / General
		7		START CORING AT 7.56m					
		8		SANDSTONE: fine to medium grained, light grey and brown, with dark grey laminae at 0°-5°.	DW	M			- Be, 5°, P, S - CS, 0°, 220mm.t
				CORE LOSS 0.15m					
				SANDSTONE: fine to medium grained, light grey, trace of quartz gravel, bedded at 0-5°.	SW	M			
				CORE LOSS 0.43m					
FULL RET-URN		9		SANDSTONE: fine to medium grained, light grey, massive.	XW SW-FR	EL M			- XWS, 5°, 5mm.t
		10							
				END OF BOREHOLE AT 10.82m					
		11							
		12							
		13							

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 (e.g. sandy clay) as set out below:

Soil Classification	Particle Size
Clay	less than 0.002mm
Silt	0.002 to 0.075mm
Sand	0.075 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.

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

Wash Boring: The borehole is usually advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be 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.

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

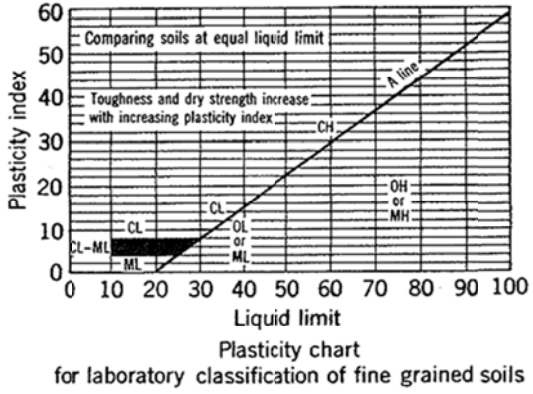
OTHER MATERIALS


CONCRETE


BITUMINOUS CONCRETE, COAL


COLLUVIUM

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 (The 75 μm sieve size is about the smallest particle visible to naked eye)	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 (eg. 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.

LOG SYMBOLS

LOG COLUMN	SYMBOL	DEFINITION
Groundwater Record	▼	Standing water level. Time delay following completion of drilling may be shown.
	C	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.
	ASB	Soil sample taken over depth indicated, for asbestos screening.
	ASS	Soil sample taken over depth indicated, for acid sulfate soil analysis.
	SAL	Soil sample taken over depth indicated, for salinity analysis.
Field Tests	N = 17 4, 7, 10	Standard Penetration Test (SPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration. '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 (I_D) 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.

LOG SYMBOLS continued

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 and Geomechanics. Abstract Volume 22, No 2, 1985.

TERM	SYMBOL	Is (50) MPa	FIELD GUIDE
Extremely Low:	EL		Easily remoulded by hand to a material with soil properties.
----------	----------	0.03	
Very Low:	VL		May be crumbled in the hand. Sandstone is "sugary" and friable.
----------	----------	0.1	
Low:	L		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.
----------	----------	0.3	
Medium Strength:	M		A piece of core 150mm long x 50mm dia. can be broken by hand with difficulty. Readily scored with knife.
----------	----------	1	
High:	H		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.
----------	----------	3	
Very High:	VH		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.
----------	----------	10	
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	

Appendix B: Laboratory Reports and Chain of Custody Documents

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

CERTIFICATE OF ANALYSIS 94822

Client:

Environmental Investigation Services
PO Box 976
North Ryde BC
NSW 1670

Attention: Todd Hore

Sample log in details:

Your Reference:	**E26655KH, Manly**		
No. of samples:	23 soils		
Date samples received / completed instructions received	01/08/13	/	01/08/13

Analysis Details:

Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by: / Issue Date:	9/08/13	/	8/08/13
Date of Preliminary Report:	Not issued		

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

Results Approved By:

Jacinta Hurst
Laboratory Manager

vTRH(C6-C10)/BTEXN in Soil						
Our Reference:	UNITS	94822-1	94822-3	94822-6	94822-8	94822-13
Your Reference	----------	BH102	BH102	BH105	BH105	BH106
Depth	----------	0-0.2	0.9-1.1	0-0.2	1-1.2	0-0.2
Date Sampled		30/07/2013	30/07/2013	30/07/2013	30/07/2013	31/07/2013
Type of sample		soil	soil	soil	soil	soil
Date extracted	-	05/08/2013	05/08/2013	05/08/2013	05/08/2013	05/08/2013
Date analysed	-	05/08/2013	05/08/2013	05/08/2013	05/08/2013	05/08/2013
TRHC6 - C9	mg/kg	<25	<25	<25	<25	<25
TRHC6 - C10	mg/kg	<25	<25	<25	<25	<25
vTPHC6 - C10 less BTEX (F1)	mg/kg	<25	<25	<25	<25	<25
Benzene	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	mg/kg	<1	<1	<1	<1	<1
m+p-xylene	mg/kg	<2	<2	<2	<2	<2
o-Xylene	mg/kg	<1	<1	<1	<1	<1
naphthalene	mg/kg	<1	<1	<1	<1	<1
Surrogate aaa-Trifluorotoluene	%	120	130	119	116	126

vTRH(C6-C10)/BTEXN in Soil				
Our Reference:	UNITS	94822-15	94822-18	94822-21
Your Reference	----------	BH106	BH107	BH107
Depth	----------	1-1.2	0-0.2	1.5-1.7
Date Sampled		31/07/2013	31/07/2013	31/07/2013
Type of sample		soil	soil	soil
Date extracted	-	05/08/2013	05/08/2013	05/08/2013
Date analysed	-	05/08/2013	05/08/2013	05/08/2013
TRHC6 - C9	mg/kg	<25	<25	<25
TRHC6 - C10	mg/kg	<25	<25	<25
vTPHC6 - C10 less BTEX (F1)	mg/kg	<25	<25	<25
Benzene	mg/kg	<0.2	<0.2	<0.2
Toluene	mg/kg	<0.5	<0.5	<0.5
Ethylbenzene	mg/kg	<1	<1	<1
m+p-xylene	mg/kg	<2	<2	<2
o-Xylene	mg/kg	<1	<1	<1
naphthalene	mg/kg	<1	<1	<1
Surrogate aaa-Trifluorotoluene	%	118	127	119

svTRH (C10-C40) in Soil						
Our Reference:	UNITS	94822-1	94822-3	94822-6	94822-8	94822-13
Your Reference	----------	BH102	BH102	BH105	BH105	BH106
Depth	----------	0-0.2	0.9-1.1	0-0.2	1-1.2	0-0.2
Date Sampled		30/07/2013	30/07/2013	30/07/2013	30/07/2013	31/07/2013
Type of sample		soil	soil	soil	soil	soil
Date extracted	-	05/08/2013	05/08/2013	05/08/2013	05/08/2013	05/08/2013
Date analysed	-	06/08/2013	06/08/2013	06/08/2013	06/08/2013	06/08/2013
TRHC$_{10}$ - C$_{14}$	mg/kg	<50	<50	<50	<50	<50
TRHC$_{15}$ - C$_{28}$	mg/kg	<100	250	<100	320	<100
TRHC$_{29}$ - C$_{36}$	mg/kg	<100	150	<100	280	<100
TRH>C$_{10}$-C$_{16}$	mg/kg	<50	<50	<50	<50	<50
TRH>C$_{10}$ - C$_{16}$ less Naphthalene (F2)	mg/kg	<50	<50	<50	<50	<50
TRH>C$_{16}$-C$_{34}$	mg/kg	<100	370	<100	530	<100
TRH>C$_{34}$-C$_{40}$	mg/kg	<100	<100	<100	200	<100
Surrogate o-Terphenyl	%	96	108	94	113	97

svTRH (C10-C40) in Soil				
Our Reference:	UNITS	94822-15	94822-18	94822-21
Your Reference	----------	BH106	BH107	BH107
Depth	----------	1-1.2	0-0.2	1.5-1.7
Date Sampled		31/07/2013	31/07/2013	31/07/2013
Type of sample		soil	soil	soil
Date extracted	-	05/08/2013	05/08/2013	05/08/2013
Date analysed	-	06/08/2013	06/08/2013	06/08/2013
TRHC$_{10}$ - C$_{14}$	mg/kg	<50	<50	<50
TRHC$_{15}$ - C$_{28}$	mg/kg	<100	130	<100
TRHC$_{29}$ - C$_{36}$	mg/kg	<100	150	<100
TRH>C$_{10}$-C$_{16}$	mg/kg	<50	<50	<50
TRH>C$_{10}$ - C$_{16}$ less Naphthalene (F2)	mg/kg	<50	<50	<50
TRH>C$_{16}$-C$_{34}$	mg/kg	<100	240	<100
TRH>C$_{34}$-C$_{40}$	mg/kg	<100	<100	<100
Surrogate o-Terphenyl	%	98	104	95

PAHs in Soil Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ---------- ----------	94822-1 BH102 0-0.2 30/07/2013 soil	94822-3 BH102 0.9-1.1 30/07/2013 soil	94822-6 BH105 0-0.2 30/07/2013 soil	94822-8 BH105 1-1.2 30/07/2013 soil	94822-13 BH106 0-0.2 31/07/2013 soil
Date extracted	-	05/08/2013	05/08/2013	05/08/2013	05/08/2013	05/08/2013
Date analysed	-	05/08/2013	05/08/2013	05/08/2013	05/08/2013	05/08/2013
Naphthalene	mg/kg	<0.1	<0.1	<0.1	0.3	<0.1
Acenaphthylene	mg/kg	<0.1	1	<0.1	1.2	<0.1
Acenaphthene	mg/kg	<0.1	<0.1	<0.1	0.2	<0.1
Fluorene	mg/kg	<0.1	0.3	<0.1	0.5	<0.1
Phenanthrene	mg/kg	0.2	3.0	<0.1	7.9	0.2
Anthracene	mg/kg	<0.1	1.3	<0.1	1.9	<0.1
Fluoranthene	mg/kg	0.3	18	0.3	14	0.5
Pyrene	mg/kg	0.3	16	0.3	14	0.5
Benzo(a)anthracene	mg/kg	0.2	9.4	0.1	6.4	0.3
Chrysene	mg/kg	0.2	7.5	0.1	6.1	0.3
Benzo(b+k)fluoranthene	mg/kg	0.3	14	0.3	12	0.5
Benzo(a)pyrene	mg/kg	0.19	8.9	0.16	7.9	0.38
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	4.1	0.1	4.9	0.2
Dibenzo(a,h)anthracene	mg/kg	<0.1	1	<0.1	0.9	<0.1
Benzo(g,h,i)perylene	mg/kg	0.1	3.4	0.1	4.7	0.3
Benzo(a)pyrene TEQ NEPM B1	mg/kg	<0.5	13	<0.5	11	<0.5
Total +ve PAH's	mg/kg	1.9	87	1.4	82	3.0
Surrogate p-Terphenyl-d14	%	97	101	98	97	100

PAHs in Soil Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ---------- ----------	94822-15 BH106 1-1.2 31/07/2013 soil	94822-18 BH107 0-0.2 31/07/2013 soil	94822-21 BH107 1.5-1.7 31/07/2013 soil
Date extracted	-	05/08/2013	05/08/2013	05/08/2013
Date analysed	-	05/08/2013	05/08/2013	05/08/2013
Naphthalene	mg/kg	0.1	0.1	<0.1
Acenaphthylene	mg/kg	0.2	0.1	<0.1
Acenaphthene	mg/kg	<0.1	0.1	<0.1
Fluorene	mg/kg	0.2	0.2	<0.1
Phenanthrene	mg/kg	1.5	1.7	0.2
Anthracene	mg/kg	0.4	0.5	<0.1
Fluoranthene	mg/kg	2.4	2.8	0.3
Pyrene	mg/kg	2.4	2.8	0.3
Benzo(a)anthracene	mg/kg	1.2	1.4	0.1
Chrysene	mg/kg	1.1	1.3	0.1
Benzo(b+k)fluoranthene	mg/kg	2.0	2.4	0.3
Benzo(a)pyrene	mg/kg	1.4	1.6	0.18
Indeno(1,2,3-c,d)pyrene	mg/kg	0.8	0.9	0.1
Dibenzo(a,h)anthracene	mg/kg	0.2	0.2	<0.1
Benzo(g,h,i)perylene	mg/kg	0.8	1	0.1
Benzo(a)pyrene TEQ NEPM B1	mg/kg	2	2	<0.5
Total +ve PAH's	mg/kg	15	17	1.8
Surrogate p-Terphenyl-d14	%	99	100	98

Organochlorine Pesticides in soil						
Our Reference:	UNITS	94822-1	94822-3	94822-6	94822-8	94822-13
Your Reference	----------	BH102	BH102	BH105	BH105	BH106
Depth	----------	0-0.2	0.9-1.1	0-0.2	1-1.2	0-0.2
Date Sampled		30/07/2013	30/07/2013	30/07/2013	30/07/2013	31/07/2013
Type of sample		soil	soil	soil	soil	soil
Date extracted	-	05/08/2013	05/08/2013	05/08/2013	05/08/2013	05/08/2013
Date analysed	-	06/08/2013	06/08/2013	06/08/2013	06/08/2013	06/08/2013
HCB	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
gamma-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
beta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
delta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aldrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor Epoxide	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
gamma-Chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan I	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
pp-DDE	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Dieldrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
pp-DDD	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan II	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
pp-DDT	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin Aldehyde	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan Sulphate	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Methoxychlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate TCMX	%	91	96	92	91	100

Organochlorine Pesticides in soil				
Our Reference:	UNITS	94822-15	94822-18	94822-21
Your Reference	----------	BH106	BH107	BH107
Depth	----------	1-1.2	0-0.2	1.5-1.7
Date Sampled		31/07/2013	31/07/2013	31/07/2013
Type of sample		soil	soil	soil
Date extracted	-	05/08/2013	05/08/2013	05/08/2013
Date analysed	-	06/08/2013	06/08/2013	06/08/2013
HCB	mg/kg	<0.1	<0.1	<0.1
alpha-BHC	mg/kg	<0.1	<0.1	<0.1
gamma-BHC	mg/kg	<0.1	<0.1	<0.1
beta-BHC	mg/kg	<0.1	<0.1	<0.1
Heptachlor	mg/kg	<0.1	<0.1	<0.1
delta-BHC	mg/kg	<0.1	<0.1	<0.1
Aldrin	mg/kg	<0.1	<0.1	<0.1
Heptachlor Epoxide	mg/kg	<0.1	<0.1	<0.1
gamma-Chlordane	mg/kg	<0.1	<0.1	<0.1
alpha-chlordane	mg/kg	<0.1	<0.1	<0.1
Endosulfan I	mg/kg	<0.1	<0.1	<0.1
pp-DDE	mg/kg	<0.1	<0.1	<0.1
Dieldrin	mg/kg	<0.1	<0.1	<0.1
Endrin	mg/kg	<0.1	<0.1	<0.1
pp-DDD	mg/kg	<0.1	<0.1	<0.1
Endosulfan II	mg/kg	<0.1	<0.1	<0.1
pp-DDT	mg/kg	<0.1	<0.1	<0.1
Endrin Aldehyde	mg/kg	<0.1	<0.1	<0.1
Endosulfan Sulphate	mg/kg	<0.1	<0.1	<0.1
Methoxychlor	mg/kg	<0.1	<0.1	<0.1
Surrogate TCMX	%	98	103	99

Organophosphorus Pesticides						
Our Reference:	UNITS	94822-1	94822-3	94822-6	94822-8	94822-13
Your Reference	----------	BH102	BH102	BH105	BH105	BH106
Depth	----------	0-0.2	0.9-1.1	0-0.2	1-1.2	0-0.2
Date Sampled		30/07/2013	30/07/2013	30/07/2013	30/07/2013	31/07/2013
Type of sample		soil	soil	soil	soil	soil
Date extracted	-	05/08/2013	05/08/2013	05/08/2013	05/08/2013	05/08/2013
Date analysed	-	06/08/2013	06/08/2013	06/08/2013	06/08/2013	06/08/2013
Diazinon	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Dimethoate	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chlorpyriphos-methyl	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Ronnel	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chlorpyriphos	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fenitrothion	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Bromophos-ethyl	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Ethion	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate TCMX	%	91	96	92	91	100

Organophosphorus Pesticides				
Our Reference:	UNITS	94822-15	94822-18	94822-21
Your Reference	----------	BH106	BH107	BH107
Depth	----------	1-1.2	0-0.2	1.5-1.7
Date Sampled		31/07/2013	31/07/2013	31/07/2013
Type of sample		soil	soil	soil
Date extracted	-	05/08/2013	05/08/2013	05/08/2013
Date analysed	-	06/08/2013	06/08/2013	06/08/2013
Diazinon	mg/kg	<0.1	<0.1	<0.1
Dimethoate	mg/kg	<0.1	<0.1	<0.1
Chlorpyriphos-methyl	mg/kg	<0.1	<0.1	<0.1
Ronnel	mg/kg	<0.1	<0.1	<0.1
Chlorpyriphos	mg/kg	<0.1	<0.1	<0.1
Fenitrothion	mg/kg	<0.1	<0.1	<0.1
Bromophos-ethyl	mg/kg	<0.1	<0.1	<0.1
Ethion	mg/kg	<0.1	<0.1	<0.1
Surrogate TCMX	%	98	103	99

PCBs in Soil						
Our Reference:	UNITS	94822-1	94822-3	94822-6	94822-8	94822-13
Your Reference	----------	BH102	BH102	BH105	BH105	BH106
Depth	----------	0-0.2	0.9-1.1	0-0.2	1-1.2	0-0.2
Date Sampled		30/07/2013	30/07/2013	30/07/2013	30/07/2013	31/07/2013
Type of sample		soil	soil	soil	soil	soil
Date extracted	-	05/08/2013	05/08/2013	05/08/2013	05/08/2013	05/08/2013
Date analysed	-	06/08/2013	06/08/2013	06/08/2013	06/08/2013	06/08/2013
Arochlor 1016	mg/kg	<0.1	<0.1	<0.1	<0.5	<0.1
Arochlor 1221	mg/kg	<0.1	<0.1	<0.1	<0.5	<0.1
Arochlor 1232	mg/kg	<0.1	<0.1	<0.1	<0.5	<0.1
Arochlor 1242	mg/kg	<0.1	<0.1	<0.1	<0.5	<0.1
Arochlor 1248	mg/kg	<0.1	<0.1	<0.1	<0.5	<0.1
Arochlor 1254	mg/kg	<0.1	<0.1	<0.1	<0.5	<0.1
Arochlor 1260	mg/kg	<0.1	<0.1	<0.1	<0.5	<0.1
Surrogate TCLMX	%	91	96	92	91	100

PCBs in Soil				
Our Reference:	UNITS	94822-15	94822-18	94822-21
Your Reference	----------	BH106	BH107	BH107
Depth	----------	1-1.2	0-0.2	1.5-1.7
Date Sampled		31/07/2013	31/07/2013	31/07/2013
Type of sample		soil	soil	soil
Date extracted	-	05/08/2013	05/08/2013	05/08/2013
Date analysed	-	06/08/2013	06/08/2013	06/08/2013
Arochlor 1016	mg/kg	<0.1	<0.1	<0.1
Arochlor 1221	mg/kg	<0.1	<0.1	<0.1
Arochlor 1232	mg/kg	<0.1	<0.1	<0.1
Arochlor 1242	mg/kg	<0.1	<0.1	<0.1
Arochlor 1248	mg/kg	<0.1	<0.1	<0.1
Arochlor 1254	mg/kg	<0.1	<0.1	<0.1
Arochlor 1260	mg/kg	<0.1	<0.1	<0.1
Surrogate TCLMX	%	98	103	99

Acid Extractable metals in soil						
Our Reference:	UNITS	94822-1	94822-3	94822-6	94822-8	94822-13
Your Reference	----------	BH102	BH102	BH105	BH105	BH106
Depth	----------	0-0.2	0.9-1.1	0-0.2	1-1.2	0-0.2
Date Sampled		30/07/2013	30/07/2013	30/07/2013	30/07/2013	31/07/2013
Type of sample		soil	soil	soil	soil	soil
Date digested	-	05/08/2013	05/08/2013	05/08/2013	05/08/2013	05/08/2013
Date analysed	-	05/08/2013	05/08/2013	05/08/2013	05/08/2013	05/08/2013
Arsenic	mg/kg	8	<4	4	6	<4
Cadmium	mg/kg	<0.4	<0.4	<0.4	0.9	<0.4
Chromium	mg/kg	8	5	10	10	5
Copper	mg/kg	7	14	6	32	5
Lead	mg/kg	19	220	17	620	27
Mercury	mg/kg	<0.1	<0.1	0.2	0.5	<0.1
Nickel	mg/kg	4	2	3	6	2
Zinc	mg/kg	48	45	25	630	45

Acid Extractable metals in soil						
Our Reference:	UNITS	94822-15	94822-18	94822-21	94822-23	94822-24
Your Reference	----------	BH106	BH107	BH107	Dup1	BH107 triplicate
Depth	----------	1-1.2	0-0.2	1.5-1.7	-	1.5-1.7
Date Sampled		31/07/2013	31/07/2013	31/07/2013	31/07/2013	31/07/2013
Type of sample		soil	soil	soil	soil	soil
Date digested	-	05/08/2013	05/08/2013	05/08/2013	05/08/2013	05/08/2013
Date analysed	-	05/08/2013	05/08/2013	05/08/2013	05/08/2013	05/08/2013
Arsenic	mg/kg	<4	<4	<4	<4	<4
Cadmium	mg/kg	<0.4	<0.4	<0.4	<0.4	<0.4
Chromium	mg/kg	8	13	6	20	2
Copper	mg/kg	6	14	<1	15	<1
Lead	mg/kg	70	33	5	38	2
Mercury	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Nickel	mg/kg	2	11	<1	16	<1
Zinc	mg/kg	88	43	14	57	12

Moisture						
Our Reference:	UNITS	94822-1	94822-3	94822-6	94822-8	94822-13
Your Reference	----------	BH102	BH102	BH105	BH105	BH106
Depth	----------	0-0.2	0.9-1.1	0-0.2	1-1.2	0-0.2
Date Sampled		30/07/2013	30/07/2013	30/07/2013	30/07/2013	31/07/2013
Type of sample		soil	soil	soil	soil	soil
Date prepared	-	5/08/2013	5/08/2013	5/08/2013	5/08/2013	5/08/2013
Date analysed	-	6/08/2013	6/08/2013	6/08/2013	6/08/2013	6/08/2013
Moisture	%	11	11	13	21	11

Moisture					
Our Reference:	UNITS	94822-15	94822-18	94822-21	94822-23
Your Reference	----------	BH106	BH107	BH107	Dup1
Depth	----------	1-1.2	0-0.2	1.5-1.7	-
Date Sampled		31/07/2013	31/07/2013	31/07/2013	31/07/2013
Type of sample		soil	soil	soil	soil
Date prepared	-	5/08/2013	5/08/2013	5/08/2013	5/08/2013
Date analysed	-	6/08/2013	6/08/2013	6/08/2013	6/08/2013
Moisture	%	10	4.9	17	14

Asbestos ID - soils						
Our Reference:	UNITS	94822-1	94822-3	94822-6	94822-8	94822-13
Your Reference	----------	BH102	BH102	BH105	BH105	BH106
Depth	----------	0-0.2	0.9-1.1	0-0.2	1-1.2	0-0.2
Date Sampled		30/07/2013	30/07/2013	30/07/2013	30/07/2013	31/07/2013
Type of sample		soil	soil	soil	soil	soil
Date analysed	-	7/08/2013	7/08/2013	7/08/2013	7/08/2013	7/08/2013
Sample mass tested	g	Approx 40g	Approx 40g	Approx 40g	Approx 40g	Approx 40g
Sample Description	-	Dark brown fine-grained soil	Brown sandy soil	Dark brown fine-grained soil	Dark brown fine-grained soil	Dark brown fine-grained soil
Asbestos ID in soil	-	No asbestos detected at reporting limit of 0.1g/kg	No asbestos detected at reporting limit of 0.1g/kg	No asbestos detected at reporting limit of 0.1g/kg	No asbestos detected at reporting limit of 0.1g/kg	No asbestos detected at reporting limit of 0.1g/kg
Trace Analysis	-	No respirable fibres detected	No respirable fibres detected	No respirable fibres detected	No respirable fibres detected	No respirable fibres detected

Asbestos ID - soils				
Our Reference:	UNITS	94822-15	94822-18	94822-21
Your Reference	----------	BH106	BH107	BH107
Depth	----------	1-1.2	0-0.2	1.5-1.7
Date Sampled		31/07/2013	31/07/2013	31/07/2013
Type of sample		soil	soil	soil
Date analysed	-	7/08/2013	7/08/2013	7/08/2013
Sample mass tested	g	Approx 40g	Approx 40g	Approx 40g
Sample Description	-	Dark brown fine-grained soil	Dark brown fine-grained soil	Dark brown fine-grained soil
Asbestos ID in soil	-	No asbestos detected at reporting limit of 0.1g/kg	No asbestos detected at reporting limit of 0.1g/kg	No asbestos detected at reporting limit of 0.1g/kg
Trace Analysis	-	No respirable fibres detected	No respirable fibres detected	No respirable fibres detected

Miscellaneous Inorg - soil			
Our Reference:	UNITS	94822-1	94822-6
Your Reference	----------	BH102	BH105
Depth	----------	0-0.2	0-0.2
Date Sampled		30/07/2013	30/07/2013
Type of sample		soil	soil
Date prepared	-	03/08/2013	03/08/2013
Date analysed	-	03/08/2013	03/08/2013
pH 1:5 soil:water	pH Units	5.7	6.9
Electrical Conductivity 1:5 soil:water	µS/cm	48	82
Clay in soils <2um	% (w/w)	10	12

sPOCAS Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ---------- ----------	94822-3 BH102 0.9-1.1 30/07/2013 soil	94822-4 BH102 1.8-2 30/07/2013 soil	94822-9 BH105 2-2.3 30/07/2013 soil	94822-10 BH105 3-3.2 30/07/2013 soil	94822-15 BH106 1-1.2 31/07/2013 soil
Date prepared	-	05/08/2013	05/08/2013	05/08/2013	05/08/2013	05/08/2013
Date analysed	-	05/08/2013	05/08/2013	05/08/2013	05/08/2013	05/08/2013
pH $_{kcl}$	pH units	9.3	8.1	8.3	9.4	9.5
TAA pH 6.5	moles H^+/t	<5	<5	<5	<5	<5
s-TAA pH 6.5	%w/w S	<0.01	<0.01	<0.01	<0.01	<0.01
pH $_{Ox}$	pH units	7.3	5.0	4.8	7.3	6.8
TPA pH 6.5	moles H^+/t	<5	37	<5	<5	<5
s-TPA pH 6.5	%w/w S	<0.01	0.06	<0.01	<0.01	<0.01
TSA pH 6.5	moles H^+/t	<5	37	<5	<5	<5
s-TSA pH 6.5	%w/w S	<0.01	0.06	<0.01	<0.01	<0.01
ANC_E	%$CaCO_3$	4.5	<0.05	<0.05	0.77	0.38
a-ANC_E	moles H^+/t	900	[NT]	[NT]	150	76
s-ANC_E	%w/w S	1.4	<0.05	<0.05	0.25	0.12
S_{KCl}	%w/w S	<0.005	0.02	<0.005	0.06	<0.005
S_P	%w/w	0.02	0.07	0.007	0.02	0.36
S_{POS}	%w/w	0.01	0.06	0.005	<0.005	0.35
a-S_{POS}	moles H^+/t	9	36	<5	<5	220
Ca_{KCl}	%w/w	0.23	0.26	0.05	0.16	0.13
Ca_P	%w/w	1.8	0.32	0.05	0.31	0.76
Ca_A	%w/w	1.5	0.054	0.005	0.14	0.63
Mg_{KCl}	%w/w	<0.005	0.005	<0.005	0.008	<0.005
Mg_P	%w/w	0.011	0.008	<0.005	0.011	0.038
Mg_A	%w/w	0.008	<0.005	<0.005	<0.005	0.034
Fineness Factor	-	1.5	1.5	1.5	1.5	1.5
a-Net Acidity	moles H^+/t	<10	37	<10	<10	23
Liming rate	kg $CaCO_3$/t	<0.75	2.8	<0.75	<0.75	1.7
a-Net Acidity without ANCE	moles H^+/t	<10	NA	NA	<10	220
Liming rate without ANCE	kg $CaCO_3$/t	<0.75	NA	NA	<0.75	17

sPOCAS Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ---------- ----------	94822-16 BH106 1.4-1.6 31/07/2013 soil	94822-21 BH107 1.5-1.7 31/07/2013 soil	94822-22 BH107 2.7-3 31/07/2013 soil
Date prepared	-	05/08/2013	05/08/2013	05/08/2013
Date analysed	-	05/08/2013	05/08/2013	05/08/2013
pH $_{kcl}$	pH units	7.4	6.8	5.8
TAA pH 6.5	moles H^+/t	<5	<5	<5
s-TAA pH 6.5	%w/w S	<0.01	<0.01	<0.01
pH $_{Ox}$	pH units	4.5	4.5	3.5
TPA pH 6.5	moles H^+/t	<5	<5	<5
s-TPA pH 6.5	%w/w S	<0.01	<0.01	<0.01
TSA pH 6.5	moles H^+/t	<5	<5	<5
s-TSA pH 6.5	%w/w S	<0.01	<0.01	<0.01
ANC_E	% $CaCO_3$	<0.05	<0.05	<0.05
s-ANC_E	%w/w S	<0.05	<0.05	<0.05
S_{KCl}	%w/w S	<0.005	0.005	<0.005
S_P	%w/w	0.007	0.007	0.03
S_{POS}	%w/w	0.008	<0.005	0.02
a-S_{POS}	moles H^+/t	<5	<5	16
Ca_{KCl}	%w/w	0.04	0.03	0.03
Ca_P	%w/w	0.05	0.03	0.02
Ca_A	%w/w	0.005	<0.005	<0.005
Mg_{KCl}	%w/w	<0.005	<0.005	<0.005
Mg_P	%w/w	<0.005	<0.005	<0.005
Mg_A	%w/w	<0.005	<0.005	<0.005
Fineness Factor	-	1.5	1.5	1.5
a-Net Acidity	moles H^+/t	<10	<10	17
Liming rate	kg $CaCO_3$/t	<0.75	<0.75	1.3
a-Net Acidity without ANCE	moles H^+/t	NA	NA	NA
Liming rate without ANCE	kg $CaCO_3$/t	NA	NA	NA

Method ID	Methodology Summary
Org-016	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS. Water samples are analysed directly by purge and trap GC-MS. F1 = (C6-C10)-BTEX as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater.
Org-014	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS.
Org-003	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-FID. F2 = (>C10-C16)-Naphthalene as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater.
Org-012 subset	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013.
Org-005	Soil samples are extracted with dichloromethane/acetone and waters with dichloromethane and analysed by GC with dual ECD's.
Org-008	Soil samples are extracted with dichloromethane/acetone and waters with dichloromethane and analysed by GC with dual ECD's.
Org-006	Soil samples are extracted with dichloromethane/acetone and waters with dichloromethane and analysed by GC-ECD.
Metals-020 ICP-AES	Determination of various metals by ICP-AES.
Metals-021 CV-AAS	Determination of Mercury by Cold Vapour AAS.
Inorg-008	Moisture content determined by heating at 105+/-5 deg C for a minimum of 12 hours.
ASB-001	Asbestos ID - Qualitative identification of asbestos in bulk samples using Polarised Light Microscopy and Dispersion Staining Techniques including Synthetic Mineral Fibre and Organic Fibre as per Australian Standard 4964-2004.
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA 22nd ED, 4500-H+.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell and dedicated meter, in accordance with APHA 22nd ED 2510 and Rayment & Lyons.
AS1289.3.6.3	Determination Particle Size Analysis using AS1289.3.6.3 and AS1289.3.6.1 and in house method INORG-107. Clay fraction at <2um reported.
Inorg-064	sPOCAS determined using titrimetric and ICP-AES techniques. Based on Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004.

QUALITY CONTROL vTRH(C6-C10)/BTEXN in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			05/08/2013	94822-21	05/08/2013 || 05/08/2013	LCS-1	05/08/2013
Date analysed	-			05/08/2013	94822-21	05/08/2013 || 05/08/2013	LCS-1	05/08/2013
TRHC$_6$ - C$_9$	mg/kg	25	Org-016	<25	94822-21	<25 || <25	LCS-1	86%
TRHC$_6$ - C$_{10}$	mg/kg	25	Org-016	<25	94822-21	<25 || <25	LCS-1	86%
Benzene	mg/kg	0.2	Org-016	<0.2	94822-21	<0.2 || <0.2	LCS-1	94%
Toluene	mg/kg	0.5	Org-016	<0.5	94822-21	<0.5 || <0.5	LCS-1	84%
Ethylbenzene	mg/kg	1	Org-016	<1	94822-21	<1 || <1	LCS-1	86%
m+p-xylene	mg/kg	2	Org-016	<2	94822-21	<2 || <2	LCS-1	84%
o-Xylene	mg/kg	1	Org-016	<1	94822-21	<1 || <1	LCS-1	78%
naphthalene	mg/kg	1	Org-014	<1	94822-21	<1 || <1	[NR]	[NR]
Surrogate aaa-Trifluorotoluene	%		Org-016	119	94822-21	119 || 118 || RPD: 1	LCS-1	110%

QUALITY CONTROL svTRH (C10-C40) in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			05/08/2013	94822-21	05/08/2013 || 05/08/2013	LCS-1	05/08/2013
Date analysed	-			06/08/2013	94822-21	06/08/2013 || 06/08/2013	LCS-1	06/08/2013
TRHC$_{10}$ - C$_{14}$	mg/kg	50	Org-003	<50	94822-21	<50 || <50	LCS-1	91%
TRHC$_{15}$ - C$_{28}$	mg/kg	100	Org-003	<100	94822-21	<100 || <100	LCS-1	108%
TRHC$_{29}$ - C$_{36}$	mg/kg	100	Org-003	<100	94822-21	<100 || <100	LCS-1	88%
TRH>C$_{10}$-C$_{16}$	mg/kg	50	Org-003	<50	94822-21	<50 || <50	LCS-1	91%
TRH>C$_{16}$-C$_{34}$	mg/kg	100	Org-003	<100	94822-21	<100 || <100	LCS-1	108%
TRH>C$_{34}$-C$_{40}$	mg/kg	100	Org-003	<100	94822-21	<100 || <100	LCS-1	88%
Surrogate o-Terphenyl	%		Org-003	96	94822-21	95 || 96 || RPD: 1	LCS-1	109%

QUALITY CONTROL PAHs in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			05/08/2013	94822-21	05/08/2013 || 05/08/2013	LCS-1	05/08/2013
Date analysed	-			05/08/2013	94822-21	05/08/2013 || 05/08/2013	LCS-1	05/08/2013
Naphthalene	mg/kg	0.1	Org-012 subset	<0.1	94822-21	<0.1 || <0.1	LCS-1	94%
Acenaphthylene	mg/kg	0.1	Org-012 subset	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
Acenaphthene	mg/kg	0.1	Org-012 subset	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
Fluorene	mg/kg	0.1	Org-012 subset	<0.1	94822-21	<0.1 || <0.1	LCS-1	95%
Phenanthrene	mg/kg	0.1	Org-012 subset	<0.1	94822-21	0.2 || 0.1 || RPD: 67	LCS-1	92%
Anthracene	mg/kg	0.1	Org-012 subset	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
Fluoranthene	mg/kg	0.1	Org-012 subset	<0.1	94822-21	0.3 || 0.2 || RPD: 40	LCS-1	87%

QUALITY CONTROL PAHs in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Pyrene	mg/kg	0.1	Org-012 subset	<0.1	94822-21	0.3 || 0.2 || RPD: 40	LCS-1	90%
Benzo(a)anthracene	mg/kg	0.1	Org-012 subset	<0.1	94822-21	0.1 || 0.1 || RPD: 0	[NR]	[NR]
Chrysene	mg/kg	0.1	Org-012 subset	<0.1	94822-21	0.1 || 0.1 || RPD: 0	LCS-1	91%
Benzo(b+k)fluoranthene	mg/kg	0.2	Org-012 subset	<0.2	94822-21	0.3 || 0.2 || RPD: 40	[NR]	[NR]
Benzo(a)pyrene	mg/kg	0.05	Org-012 subset	<0.05	94822-21	0.18 || 0.15 || RPD: 18	LCS-1	100%
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	Org-012 subset	<0.1	94822-21	0.1 || <0.1	[NR]	[NR]
Dibenzo(a,h)anthracene	mg/kg	0.1	Org-012 subset	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
Benzo(g,h,i)perylene	mg/kg	0.1	Org-012 subset	<0.1	94822-21	0.1 || 0.1 || RPD: 0	[NR]	[NR]
Surrogate p-Terphenyl-d14	%		Org-012 subset	99	94822-21	98 || 99 || RPD: 1	LCS-1	95%

QUALITY CONTROL Organochlorine Pesticides in soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			05/08/2013	94822-21	05/08/2013 || 05/08/2013	LCS-1	05/08/2013
Date analysed	-			06/08/2013	94822-21	06/08/2013 || 06/08/2013	LCS-1	06/08/2013
HCB	mg/kg	0.1	Org-005	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
alpha-BHC	mg/kg	0.1	Org-005	<0.1	94822-21	<0.1 || <0.1	LCS-1	89%
gamma-BHC	mg/kg	0.1	Org-005	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
beta-BHC	mg/kg	0.1	Org-005	<0.1	94822-21	<0.1 || <0.1	LCS-1	80%
Heptachlor	mg/kg	0.1	Org-005	<0.1	94822-21	<0.1 || <0.1	LCS-1	82%
delta-BHC	mg/kg	0.1	Org-005	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
Aldrin	mg/kg	0.1	Org-005	<0.1	94822-21	<0.1 || <0.1	LCS-1	84%
Heptachlor Epoxide	mg/kg	0.1	Org-005	<0.1	94822-21	<0.1 || <0.1	LCS-1	86%
gamma-Chlordane	mg/kg	0.1	Org-005	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
alpha-chlordane	mg/kg	0.1	Org-005	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
Endosulfan I	mg/kg	0.1	Org-005	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
pp-DDE	mg/kg	0.1	Org-005	<0.1	94822-21	<0.1 || <0.1	LCS-1	84%
Dieldrin	mg/kg	0.1	Org-005	<0.1	94822-21	<0.1 || <0.1	LCS-1	92%
Endrin	mg/kg	0.1	Org-005	<0.1	94822-21	<0.1 || <0.1	LCS-1	73%
pp-DDD	mg/kg	0.1	Org-005	<0.1	94822-21	<0.1 || <0.1	LCS-1	92%
Endosulfan II	mg/kg	0.1	Org-005	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
pp-DDT	mg/kg	0.1	Org-005	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
Endrin Aldehyde	mg/kg	0.1	Org-005	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
Endosulfan Sulphate	mg/kg	0.1	Org-005	<0.1	94822-21	<0.1 || <0.1	LCS-1	83%
Methoxychlor	mg/kg	0.1	Org-005	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
Surrogate TCMX	%		Org-005	91	94822-21	99 || 102 || RPD: 3	LCS-1	87%

QUALITY CONTROL Organophosphorus Pesticides	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			05/08/2013	94822-21	05/08/2013 || 05/08/2013	LCS-1	05/08/2013
Date analysed	-			06/08/2013	94822-21	06/08/2013 || 06/08/2013	LCS-1	06/08/2013
Diazinon	mg/kg	0.1	Org-008	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
Dimethoate	mg/kg	0.1	Org-008	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
Chlorpyriphos-methyl	mg/kg	0.1	Org-008	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
Ronnel	mg/kg	0.1	Org-008	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
Chlorpyriphos	mg/kg	0.1	Org-008	<0.1	94822-21	<0.1 || <0.1	LCS-1	70%
Fenitrothion	mg/kg	0.1	Org-008	<0.1	94822-21	<0.1 || <0.1	LCS-1	103%
Bromophos-ethyl	mg/kg	0.1	Org-008	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
Ethion	mg/kg	0.1	Org-008	<0.1	94822-21	<0.1 || <0.1	LCS-1	86%
Surrogate TCMX	%		Org-008	91	94822-21	99 || 102 || RPD: 3	LCS-1	92%
QUALITY CONTROL PCBs in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			05/08/2013	94822-21	05/08/2013 || 05/08/2013	LCS-1	05/08/2013
Date analysed	-			06/08/2013	94822-21	06/08/2013 || 06/08/2013	LCS-1	06/08/2013
Arochlor 1016	mg/kg	0.1	Org-006	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
Arochlor 1221	mg/kg	0.1	Org-006	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
Arochlor 1232	mg/kg	0.1	Org-006	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
Arochlor 1242	mg/kg	0.1	Org-006	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
Arochlor 1248	mg/kg	0.1	Org-006	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
Arochlor 1254	mg/kg	0.1	Org-006	<0.1	94822-21	<0.1 || <0.1	LCS-1	104%
Arochlor 1260	mg/kg	0.1	Org-006	<0.1	94822-21	<0.1 || <0.1	[NR]	[NR]
Surrogate TCLMX	%		Org-006	91	94822-21	99 || 102 || RPD: 3	LCS-1	94%
QUALITY CONTROL Acid Extractable metals in soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date digested	-			05/08/2013	94822-21	05/08/2013 || 05/08/2013	LCS-1	05/08/2013
Date analysed	-			05/08/2013	94822-21	05/08/2013 || 05/08/2013	LCS-1	05/08/2013
Arsenic	mg/kg	4	Metals-020 ICP-AES	<4	94822-21	<4 || <4	LCS-1	106%
Cadmium	mg/kg	0.4	Metals-020 ICP-AES	<0.4	94822-21	<0.4 || <0.4	LCS-1	105%
Chromium	mg/kg	1	Metals-020 ICP-AES	<1	94822-21	6 || 2 || RPD: 100	LCS-1	107%
Copper	mg/kg	1	Metals-020 ICP-AES	<1	94822-21	<1 || <1	LCS-1	104%
Lead	mg/kg	1	Metals-020 ICP-AES	<1	94822-21	5 || 3 || RPD: 50	LCS-1	105%
Mercury	mg/kg	0.1	Metals-021 CV-AAS	<0.1	94822-21	<0.1 || <0.1	LCS-1	85%

QUALITY CONTROL Acid Extractable metals in soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Nickel	mg/kg	1	Metals-020 ICP-AES	<1	94822-21	<1 || <1	LCS-1	107%
Zinc	mg/kg	1	Metals-020 ICP-AES	<1	94822-21	14 || 13 || RPD: 7	LCS-1	108%

QUALITY CONTROL Moisture	UNITS	PQL	METHOD	Blank
Date prepared	-			[NT]
Date analysed	-			[NT]
Moisture	%	0.1	Inorg-008	[NT]

QUALITY CONTROL Asbestos ID - soils	UNITS	PQL	METHOD	Blank
Date analysed	-			[NT]

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			03/08/2013	[NT]	[NT]	LCS-1	03/08/2013
Date analysed	-			03/08/2013	[NT]	[NT]	LCS-1	03/08/2013
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	LCS-1	101%
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	[NT]	[NT]	LCS-1	104%
Clay in soils <2um	% (w/w)		AS1289.3.6.3	[NT]	[NT]	[NT]	[NR]	[NR]

QUALITY CONTROL sPOCAS	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			05/08/2013	94822-3	05/08/2013 || 05/08/2013	LCS-1	05/08/2013
Date analysed	-			05/08/2013	94822-3	05/08/2013 || 05/08/2013	LCS-1	05/08/2013
pH_{kcl}	pH units		Inorg-064	[NT]	94822-3	9.3 || 9.5 || RPD: 2	LCS-1	99%
TAA pH 6.5	moles H^+/t	5	Inorg-064	<5	94822-3	<5 || <5	LCS-1	97%
s-TAA pH 6.5	%w/w S	0.01	Inorg-064	<0.01	94822-3	<0.01 || <0.01	[NR]	[NR]
pH_{Ox}	pH units		Inorg-064	[NT]	94822-3	7.3 || 7.3 || RPD: 0	LCS-1	97%
TPA pH 6.5	moles H^+/t	5	Inorg-064	<5	94822-3	<5 || <5	LCS-1	108%
s-TPA pH 6.5	%w/w S	0.01	Inorg-064	<0.01	94822-3	<0.01 || <0.01	[NR]	[NR]
TSA pH 6.5	moles H^+/t	5	Inorg-064	<5	94822-3	<5 || <5	LCS-1	109%
s-TSA pH 6.5	%w/w S	0.01	Inorg-064	<0.01	94822-3	<0.01 || <0.01	[NR]	[NR]
ANC_E	% $CaCO_3$	0.05	Inorg-064	<0.05	94822-3	4.5 || 4.5 || RPD: 0	[NR]	[NR]
a-ANC_E	moles H^+/t	5	Inorg-064	<5	94822-3	900 || 890 || RPD: 1	[NR]	[NR]

Client Reference: E26655KH, Manly

QUALITY CONTROL sPOCAS	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
s-ANCE	%w/w S	0.05	Inorg-064	<0.05	94822-3	1.4 || 1.4 || RPD: 0	[NR]	[NR]
SKCl	%w/w S	0.005	Inorg-064	<0.005	94822-3	<0.005 || <0.005	LCS-1	96%
SP	%w/w	0.005	Inorg-064	<0.005	94822-3	0.02 || 0.02 || RPD: 0	LCS-1	86%
SPOS	%w/w	0.005	Inorg-064	<0.005	94822-3	0.01 || 0.01 || RPD: 0	LCS-1	83%
a-SPOS	moles H^+/t	5	Inorg-064	<5	94822-3	9 || 9 || RPD: 0	[NR]	[NR]
CaKCl	%w/w	0.005	Inorg-064	<0.005	94822-3	0.23 || 0.22 || RPD: 4	LCS-1	83%
CaP	%w/w	0.005	Inorg-064	<0.005	94822-3	1.8 || 1.8 || RPD: 0	LCS-1	94%
CaA	%w/w	0.005	Inorg-064	<0.005	94822-3	1.5 || 1.6 || RPD: 6	[NR]	[NR]
MgKCl	%w/w	0.005	Inorg-064	<0.005	94822-3	<0.005 || <0.005	[NR]	[NR]
MgP	%w/w	0.005	Inorg-064	<0.005	94822-3	0.011 || 0.010 || RPD: 10	LCS-1	93%
MgA	%w/w	0.005	Inorg-064	<0.005	94822-3	0.008 || 0.008 || RPD: 0	[NR]	[NR]
SHCl	%w/w S	0.005	Inorg-064	<0.005	[NT]	[NT]	[NR]	[NR]
SNAS	%w/w S	0.005	Inorg-064	<0.005	[NT]	[NT]	[NR]	[NR]
a-SNAS	moles H^+/t	5	Inorg-064	<5	[NT]	[NT]	[NR]	[NR]
s-SNAS	%w/w S	0.01	Inorg-064	<0.01	[NT]	[NT]	[NR]	[NR]
Fineness Factor	-	1.5	Inorg-064	<1.5	94822-3	1.5 || 1.5 || RPD: 0	[NR]	[NR]
a-Net Acidity	moles H^+/t	10	Inorg-064	<10	94822-3	<10 || <10	LCS-1	84%
Liming rate	kg $CaCO_3$/t	0.75	Inorg-064	<0.75	94822-3	<0.75 || <0.75	LCS-1	83%
a-Net Acidity without ANCE	moles H^+/t	10	Inorg-064	<10	94822-3	<10 || <10	[NR]	[NR]
Liming rate without ANCE	kg $CaCO_3$/t	0.75	Inorg-064	<0.75	94822-3	<0.75 || <0.75	[NR]	[NR]

QUALITY CONTROL Acid Extractable metals in soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date digested	-	[NT]	[NT]	LCS-2	05/08/2013
Date analysed	-	[NT]	[NT]	LCS-2	05/08/2013
Arsenic	mg/kg	[NT]	[NT]	LCS-2	108%
Cadmium	mg/kg	[NT]	[NT]	LCS-2	107%
Chromium	mg/kg	[NT]	[NT]	LCS-2	109%
Copper	mg/kg	[NT]	[NT]	LCS-2	107%
Lead	mg/kg	[NT]	[NT]	LCS-2	107%
Mercury	mg/kg	[NT]	[NT]	LCS-2	92%
Nickel	mg/kg	[NT]	[NT]	LCS-2	109%
Zinc	mg/kg	[NT]	[NT]	LCS-2	111%

Report Comments:

Acid Extractable Metals in Soil: The laboratory RPD acceptance criteriae has been exceeded for 94822-21 for Cr and Pb. Therefore a triplicate result has been issued as laboratory sample number 94822-24.

Asbestos:
A portion of the supplied sample 94822-1&2, was sub-sampled for asbestos analysis according to Envirolab procedures. We cannot guarantee that this sub-sample is indicative of the entire sample. Envirolab recommends supplying 40-50g of sample in its own container.

PCB's in soil:94822-8 PQL has been raised due to interference from analytes(other than those being tested) in the sample/s.

Asbestos ID was analysed by Approved Identifier:	Alex Tam
Asbestos ID was authorised by Approved Signatory:	Lulu Guo

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

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.

Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.

Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

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

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
enquiries@envirolabservices.com.au
www.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: Todd Hore

Sample log in details:

Your reference:	**E26655KH, Manly**
Envirolab Reference:	**94822**
Date received:	01/08/13
Date results expected to be reported:	**9/08/13**

Samples received in appropriate condition for analysis:	YES
No. of samples provided	23 soils
Turnaround time requested:	Standard
Temperature on receipt	9.3
Cooling Method:	Ice
Sampling Date Provided:	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 9910 6200 fax: 02 9910 6201
email: ahie@envirolabservices.com.au or jhurst@envirolabservices.com.au

SAMPLE AND CHAIN OF CUSTODY FORM

TO:
Envirolab Services Pty Ltd
12 Ashley Street
Chatswood NSW 2067
Phone: (02) 99106200
Fax: (02) 99106201

Attention: Aileen

EIS Job Number: E26655KH

Date Results Required: standard

Sheet 1 /

FROM:
Environmental Investigation Services
Rear 115 Wicks Road
Macquarie Park NSW 2113
Phone: (02) 9888 5000
Fax: (02) 9888 5004

Contact: Todd Hore

Project: Proposed Aquatic Centre Redevelopment
Location: Manly
Sampler: OF

Sample Preservation: In esky on ice

Tests Required

Date Sampled	Lab Ref:	Borehole/ Sample Number	Depth (m)	Sample Container	PID	Sample Description	Combo 6	Combo 6a	Combo 13	8 Metals	TPH	BTEX	PAHs	OCP/OPP/ PCBs	Asbestos	pH, CEC + clay content	sPOCAS
30/07/2013	1	BH102	0-0.2	Glass jar + Asb Bag	0	Fill		X								X	
30/07/2013	2	BH102	0.5-0.6	Glass jar + Plastic Bag	0	Fill											
30/07/2013	3	BH102	0.9-1.1	Glass jar + Plastic Bag	0	Fill		X									X
30/07/2013	4	BH102	1.8-2	Glass jar + Plastic Bag	0	Natural											X
30/07/2013	5	BH102	2.8-3	Glass jar + Plastic Bag	0	Natural											
30/07/2013	6	BH105	0-0.2	Glass jar + Plastic Bag	0	Fill		X								X	
30/07/2013	7	BH105	0.5-0.6	Glass jar + Plastic Bag	0	Fill											
30/07/2013	8	BH105	1-1.2	Glass jar + Plastic Bag	0	Fill		X									
30/07/2013	9	BH105	2-2.3	Glass jar + Plastic Bag	0	Natural											X
30/07/2013	10	BH105	3-3.2	Glass jar + Plastic Bag	0	Natural											X
30/07/2013	11	BH105	5-5.3	Glass jar + Plastic Bag	0	Natural											
30/07/2013	12	BH105	7.2-7.5	Glass jar + Plastic Bag	0	Natural											
31/07/2013	13	BH106	0-0.2	Glass jar + Plastic Bag	0	Fill		X									
31/07/2013	14	BH106	0.5-0.7	Glass jar + Plastic Bag	0	Fill											
31/07/2013	15	BH106	1-1.2	Glass jar + Plastic Bag	0	Fill		X									X
31/07/2013	16	BH106	1.4-1.6	Glass jar + Plastic Bag	0	Natural											X
31/07/2013	17	BH106	2.7-3	Plastic Bag	–	Natural											
31/07/2013	18	BH107	0-0.2	Glass jar + Plastic Bag	0	Fill		X									
31/07/2013	19	BH107	0.4-0.6	Glass jar + Plastic Bag	0	Fill											
31/07/2013	20	BH107	0.9-1.1	Glass jar + Plastic Bag	0	Fill											
31/07/2013	21	BH107	1.5-1.7	Glass jar + Plastic Bag	0	Natural		X									X
31/07/2013	22	BH107	2.7-3	Plastic Bag	–	Natural											X
31/07/2013	23	Dup 1		Glass jar	0	Soil				X							
				Glass jar + Asb Bag													
				Glass jar + Asb Bag													

ENVIROLAB
Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 94822
Date Received: 1/8/13
Time Received: 4:30
Received by: AW
Temp: Cool/Ambient
Cooling: Icepack 9.3 - 0°C
Security: Intact/Broken/None

Remarks (comments/detection limits required):

Relinquished By:	Date:	Time:	Received By:	
	1/8/13	1pm	A Weir	14:30 1/8/13

jars - 9.3°C
bags - less than 0°C (frozen)

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

CERTIFICATE OF ANALYSIS 94822-A

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

Attention: Todd Hore

Sample log in details:

Your Reference:	**E26655KH, Manly**
No. of samples:	Additional testing on 4 soils
Date samples received / completed instructions received	01/08/13 / 09/08/13

Analysis Details:
Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by: / Issue Date:	16/08/13 / 16/08/13
Date of Preliminary Report:	Not issued

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

Results Approved By:

Jacinta Hurst
Laboratory Manager

Metals in TCLP USEPA1311					
Our Reference:	UNITS	94822-A-3	94822-A-8	94822-A-15	94822-A-18
Your Reference	----------	BH102	BH105	BH106	BH107
Depth	----------	0.9-1.1	1-1.2	1-1.2	0-0.2
Date Sampled		30/07/2013	30/07/2013	31/07/2013	31/07/2013
Type of sample		soil	soil	soil	soil
Date extracted	-	12/08/2013	12/08/2013	12/08/2013	12/08/2013
Date analysed	-	12/08/2013	12/08/2013	12/08/2013	12/08/2013
pH of soil for fluid# determ.	pH units	9.5	9.4	9.2	8.6
pH of soil for fluid # determ. (acid)	pH units	1.9	1.7	1.6	1.7
Extraction fluid used	-	1	1	1	1
pH of final Leachate	pH units	6.3	5.1	5.2	5.0
Lead in TCLP	mg/L	0.3	0.5	[NA]	[NA]

PAHs in TCLP (USEPA 1311)					
Our Reference:	UNITS	94822-A-3	94822-A-8	94822-A-15	94822-A-18
Your Reference	----------	BH102	BH105	BH106	BH107
Depth	----------	0.9-1.1	1-1.2	1-1.2	0-0.2
Date Sampled		30/07/2013	30/07/2013	31/07/2013	31/07/2013
Type of sample		soil	soil	soil	soil
Date extracted	-	12/08/2013	12/08/2013	12/08/2013	12/08/2013
Date analysed	-	13/08/2013	13/08/2013	13/08/2013	13/08/2013
Naphthalene in TCLP	mg/L	<0.001	<0.001	<0.001	<0.001
Acenaphthylene in TCLP	mg/L	<0.001	<0.001	<0.001	<0.001
Acenaphthene in TCLP	mg/L	<0.001	<0.001	<0.001	<0.001
Fluorene in TCLP	mg/L	<0.001	<0.001	<0.001	<0.001
Phenanthrene in TCLP	mg/L	<0.001	<0.001	<0.001	<0.001
Anthracene in TCLP	mg/L	<0.001	<0.001	<0.001	<0.001
Fluoranthene in TCLP	mg/L	<0.001	<0.001	<0.001	<0.001
Pyrene in TCLP	mg/L	<0.001	<0.001	<0.001	<0.001
Benzo(a)anthracene in TCLP	mg/L	<0.001	<0.001	<0.001	<0.001
Chrysene in TCLP	mg/L	<0.001	<0.001	<0.001	<0.001
Benzo(b+k)fluoranthene in TCLP	mg/L	<0.002	<0.002	<0.002	<0.002
Benzo(a)pyrene in TCLP	mg/L	<0.001	<0.001	<0.001	<0.001
Indeno(1,2,3-c,d)pyrene - TCLP	mg/L	<0.001	<0.001	<0.001	<0.001
Dibenzo(a,h)anthracene in TCLP	mg/L	<0.001	<0.001	<0.001	<0.001
Benzo(g,h,i)perylene in TCLP	mg/L	<0.001	<0.001	<0.001	<0.001
Total +ve PAH's	mg/L	NIL (+)VE	NIL (+)VE	NIL (+)VE	NIL (+)VE
Surrogate p-Terphenyl-d14	%	120	119	115	104

Method ID	Methodology Summary
Inorg-004	Toxicity Characteristic Leaching Procedure (TCLP) using AS 4439 and USEPA 1311.
EXTRACT.7	Toxicity Characteristic Leaching Procedure (TCLP).
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA 22nd ED, 4500-H+.
Metals-020 ICP-AES	Determination of various metals by ICP-AES.
Org-012 subset	Leachates are extracted with Dichloromethane and analysed by GC-MS.
Org-012 subset	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013.
Org-012	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS.

QUALITY CONTROL Metals in TCLP USEPA1311	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			12/08/2013	94822-A-3	12/08/2013 || 12/08/2013	LCS-W1	12/08/2013
Date analysed	-			12/08/2013	94822-A-3	12/08/2013 || 12/08/2013	LCS-W1	12/08/2013
Lead in TCLP	mg/L	0.03	Metals-020 ICP-AES	<0.03	94822-A-3	0.3 || 0.3 || RPD: 0	LCS-W1	93%
QUALITY CONTROL PAHs in TCLP (USEPA 1311)	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			12/08/2013	[NT]	[NT]	LCS-W3	12/08/2013
Date analysed	-			13/08/2013	[NT]	[NT]	LCS-W3	13/08/2013
Naphthalene in TCLP	mg/L	0.001	Org-012 subset	<0.001	[NT]	[NT]	LCS-W3	96%
Acenaphthylene in TCLP	mg/L	0.001	Org-012 subset	<0.001	[NT]	[NT]	[NR]	[NR]
Acenaphthene in TCLP	mg/L	0.001	Org-012 subset	<0.001	[NT]	[NT]	[NR]	[NR]
Fluorene in TCLP	mg/L	0.001	Org-012 subset	<0.001	[NT]	[NT]	LCS-W3	97%
Phenanthrene in TCLP	mg/L	0.001	Org-012 subset	<0.001	[NT]	[NT]	LCS-W3	95%
Anthracene in TCLP	mg/L	0.001	Org-012 subset	<0.001	[NT]	[NT]	[NR]	[NR]
Fluoranthene in TCLP	mg/L	0.001	Org-012 subset	<0.001	[NT]	[NT]	LCS-W3	97%
Pyrene in TCLP	mg/L	0.001	Org-012 subset	<0.001	[NT]	[NT]	LCS-W3	95%
Benzo(a)anthracene in TCLP	mg/L	0.001	Org-012 subset	<0.001	[NT]	[NT]	[NR]	[NR]
Chrysene in TCLP	mg/L	0.001	Org-012 subset	<0.001	[NT]	[NT]	LCS-W3	93%
Benzo(b+k)fluoranthene in TCLP	mg/L	0.002	Org-012 subset	<0.002	[NT]	[NT]	[NR]	[NR]
Benzo(a)pyrene in TCLP	mg/L	0.001	Org-012 subset	<0.001	[NT]	[NT]	LCS-W3	103%
Indeno(1,2,3-c,d)pyrene - TCLP	mg/L	0.001	Org-012 subset	<0.001	[NT]	[NT]	[NR]	[NR]
Dibenzo(a,h)anthracene in TCLP	mg/L	0.001	Org-012 subset	<0.001	[NT]	[NT]	[NR]	[NR]
Benzo(g,h,i)perylene in TCLP	mg/L	0.001	Org-012 subset	<0.001	[NT]	[NT]	[NR]	[NR]
Surrogate p-Terphenyl-d14	%		Org-012	94	[NT]	[NT]	LCS-W3	99%

QUALITY CONTROL Metals in TCLP USEPA1311	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date extracted	-	[NT]	[NT]	94822-A-8	12/08/2013
Date analysed	-	[NT]	[NT]	94822-A-8	12/08/2013
Lead in TCLP	mg/L	[NT]	[NT]	94822-A-8	105%

Report Comments:

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

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

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.

Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.

Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

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

Aileen Hie

From: Todd Hore [thore@jkgroup.net.au]
Sent: Friday, 9 August 2013 3:14 PM
To: Aileen Hie
Subject: 94822

Aileen,
Could you please schedule the following additional TCLP analyses for the EIS project E26655KH, Manly:

- 94822-3 – lead and PAHs
- 94822-8 – lead and PAHs
- 94822-15 – PAHs
- 94822-18 – PAHs

94822 A
std T/A
due 16/8.

Please undertake the above on a standard turnaround.

Regards,

Todd Hore
Associate

EIS Environmental Investigation Services
CONSULTING ENVIRONMENTAL ENGINEERS AND SCIENTISTS

Tel: 02 9888 5000 PO Box 976 115 Wicks Road
Fax: 02 9888 5001 North Ryde BC NSW 1670 Macquarie Park NSW 2113
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Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
enquiries@envirolabservices.com.au
www.envirolabservices.com.au

CERTIFICATE OF ANALYSIS 94822-B

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

Attention: Todd Hore / Brendan Page

Sample log in details:

Your Reference:	**E26655KH, Manly**
No. of samples:	Testing on 2 soils
Date samples received / completed instructions received	01/08/13 / 09/08/13

Analysis Details:
Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by: / Issue Date:	30/08/13 / 2/09/13
Date of Preliminary Report:	Not issued

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

Results Approved By:

Jacinta Hurst
Laboratory Manager

ESP/CEC Our Reference: Your Reference Depth Date Sampled Type of sample	UNITS ---------- ----------	94822-B-1 BH102 0-0.2 30/07/2013 soil	94822-B-6 BH105 0-0.2 30/07/2013 soil
Exchangeable Ca	meq/100g	3.0	6.2
Exchangeable K	meq/100g	0.1	0.1
Exchangeable Mg	meq/100g	0.46	0.47
Exchangeable Na	meq/100g	<0.1	<0.1
Cation Exchange Capacity	meq/100g	3.6	6.8

Method ID	Methodology Summary
Metals-009	Determination of exchangeable cations and cation exchange capacity in soil based on Rayment and Lyons 2011.

QUALITY CONTROL ESP/CEC	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Exchangeable Ca	meq/100 g	0.1	Metals-009	<0.1	[NT]	[NT]	LCS-1	97%
Exchangeable K	meq/100 g	0.1	Metals-009	<0.1	[NT]	[NT]	LCS-1	100%
Exchangeable Mg	meq/100 g	0.1	Metals-009	<0.1	[NT]	[NT]	LCS-1	94%
Exchangeable Na	meq/100 g	0.1	Metals-009	<0.1	[NT]	[NT]	LCS-1	88%
Cation Exchange Capacity	meq/100 g	1	Metals-009	[NT]	[NT]	[NT]	[NR]	[NR]

Report Comments:

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

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

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.

Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.

Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

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

Jacinta Hurst

From: Brendan Page <bpage@jkgroup.net.au>
Sent: Thursday, 29 August 2013 14:58
To: Jacinta Hurst
Subject: 94822

Hi Jacinta,

I think there may have been an error with the analysis that was completed for report 94822.

We scheduled pH, CEC and clay content. I think they ran EC instead of the CEC.

Is it possible for you to have a quick check and let me know.

☺

Regards,

Brendan Page
Senior Environmental Scientist

Environmental Investigation Services
CONSULTING ENVIRONMENTAL ENGINEERS AND SCIENTISTS

Tel: 02 9888 5000 PO Box 976 115 Wicks Road
Fax: 02 9888 5001 North Ryde BC NSW 1670 Macquarie Park NSW 2113
bpage@jkgroup.net.au
www.jkgeotechnics.com.au

Appendix C: Site Information and Site History Documents

Appendix C1: Groundwater Bore Records

GROUNDWATER BORE SEARCH

Sourced from http://www.nratlas.nsw.gov.au/
date: 2/9/13

Appendix D: Report Explanatory Notes

Appendix D1: Abbreviations

Abbreviations

ABC	Ambient Background Concentrations
ACL	Added Contaminant Limits
AC	Asbestos Cement
ACM	Asbestos-Containing Material
ADWG	Australian Drinking Water Guidelines
AEC	Area of Environmental Concern
AF	Asbestos Fines
AHD	Australian Height Datum
As	Arsenic
ASL	Asbestos Health Screening Levels
ASS	Acid Sulfate Soil
AST	Above Ground Storage Tank
BA	Building Application
Bgl	Below Ground Level
BH	Borehole
BOM	Bureau of Meteorology
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
CLM	Contaminated Land Management
CMP	Construction Management Plan
COC	Chain of Custody Documentation
Cr	Chromium
CSM	Conceptual Site Model
CT	Contamination Threshold
Cu	Copper
DA	Development Application
DBYD	Dial Before You Dig
DQI	Data Quality Indicators
DQOs	Data Quality Objective
DSI	Detailed Site Investigation
EAC	Ecological Assessment Criteria
EC	Electrical Conductivity
EILs	Ecological Investigation Levels
EMP	Environmental Management Plan
ENM	Excavated Natural Material
EPA	Environmental Protection Agency
ESA	Environmental Site Assessment
ESL	Ecological Screening Level
FA	Fibrous Asbestos
FR	Field Rinsate
GAI	General Approvals of Immobilisation
GSW	General Solid Waste
HILs	Health Based Investigation Level
HM	Heavy Metals
HMTV	Hardness Modified Trigger Values
HSLs	Health Screening Level
HW	Hazardous Waste
ISO	International Organisation of Standardisation
JK	Jeffery and Katauskas
LCS	Lab Control Spike
LNAPL	Light Non-Aqueous Phase Liquid
MGA	Map Grid of Australia
MW	Monitoring Well

Abbreviations

NATA	National Association of Testing Authorities
NEPM	National Environmental Protection Measure
NSW	New South Wales
OCP	Organochlorine Pesticides
OPP	Organophosphate Pesticides
PAH	Polycyclic Aromatic Hydrocarbons
Pb	Lead
PCB	Polychlorinated Biphenyls
PCC	Potential Contaminants of Concern
PID	Photo-ionisation Detector
PQL	Practical Quantitation Limit
PSI	Preliminary Site Investigation
PVC	Polyvinyl chloride
QA	Quality Assurance
QC	Quality Control
RAP	Remediation Action Plan
RL	Reduced Level
RPD	Relative Percentage Difference
RSW	Restricted Solid Waste
SAC	Site Assessment Criteria
SAQP	Sampling, Analysis and Quality Plan
SAS	Site Audit Statement
SAR	Site Audit Report
SCC	Specific Contamination Concentration
SD	Standard Deviation
SIX	Six Maps
SPT	Hardness Modified Trigger Values
sVOC	Semi-Volatile Organic Compounds
SWL	Standard Water Level
TB	Trip Blank
TCLP	Toxicity Characteristic Leaching Procedure
TPH	Total Petroleum Hydrocarbons
TS	Trip Spike
UCL	Upper Confidence Limit
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VENM	Virgin Excavated Natural Material
VOC	Volatile Organic Compounds
VOCC	Volatile Organic Chlorinated Compound
WA	Western Australia
WHS	Workplace, Health and Safety
Zn	Zinc

Appendix D2: SAC Explanatory Notes

SAC EXPLANATORY NOTES

A brief summary of the SAC applicable to this investigation is presented below. Reference should be made to the NEPM 2013 for further information.

1. Health Investigation Levels (HILs) - Soil

The NEPM 2013 includes Health Based Investigation Levels (HILs) for a range of contaminants based on the risk of exposure, duration of exposure, toxicity and land use (availability). The HILs are scientifically based, generic assessment criteria designed to be used in the first stage of an assessment of potential risks to human health from exposure to contaminants (Tier 1 or 'screening stage').

The HILs are generally applicable to the top 3m of the soil profile for low-density residential land use. However, site specific conditions should determine the applicability of the HILs to soils below this depth for other land uses.

The HILs are divided into four categories outlined in the following table:

Table 1.1: HILs Categories – Soil

Category/Column	Land Use
HIL A	Residential with garden/accessible soil (home-grown produce contributing less than 10% of vegetable and fruit intake, no poultry); also includes children's day-care centres, preschools and primary schools.
HIL B	Residential with minimal opportunities for soil access, includes dwellings with fully and permanently paved yard space such as high-rise buildings and flats.
HIL C	Public open spaces like parks, playgrounds, playing fields (e.g. ovals), secondary schools and footpaths. Does not include undeveloped public open spaces such as urban bushland and reserves.
HIL D	Commercial/Industrial includes premises such as shops, offices, factories and industrial sites.

Where the proposed land use includes more than one land use category (for example a mixed-use development including residential/retail/commercial land uses) the exposure setting of the most 'sensitive' ground floor site use is considered to be the most appropriate.

2. Interim Soil Vapour HILs for Volatile Organic Chlorinated Compounds (VOCCs)

The NEPM 2013 includes interim soil vapour HILs for selected VOCCs [see Table 1A(2) of Schedule B (1), NEPM 2013] to assess the vapour inhalation/intrusion pathway. The interim guidelines provide Tier 1 guidance for health risks for soil contamination sources and

groundwater plumes associated with VOCCs. These values may be applied for general site assessments and sub-slab environments for evaluation of potential health risks for the 0-1m sub-slab profile. The VOCCs HILs for residential A and B (see landuse in Table 1.1 above) land uses are combined.

3. Health Screening Levels (HSLs) for Petroleum Compounds

The NEPM 2013 has adopted the HSLs for total petroleum hydrocarbon (TPH) compounds developed by the Cooperative Research Centre for Contamination Assessment and Remediation of the Environment (CRC CARE). The HSLs have been derived based on the recommended total recoverable hydrocarbons (TRH) analytical method which includes BTEX compounds and naphthalene.

HSLs have been derived for soil, groundwater and soil vapour and apply to exposure to petroleum hydrocarbons through the dominant vapour inhalation exposure pathway only. HSLs are applicable to the ground floor land use only.

HSLs are derived by taking into account multiple factors (referred to as the 'multiple lines of evidence approach') which are summarised in the table below.

Table 1.2: Multiple Factors Governing Site Specific HSLs

Factor	Description
Land use	HIL A to HIL D outlined in Table 1.1. The HSLs for Residential A and B land uses are combined. HSLs are applicable to the ground floor land use only.
Soil Type	The below classification is based on the soil texture classification in Table A1 of the standard AS1726: • Sand – Coarse grained soil; • Silt – Fine grained soil – silts and clays (liquid limit <50%); and • Clay – Fine grained soil – silts and clays (liquid limit >50%). Where there is reasonable doubt, a more conservative approach should be adopted or laboratory testing for particle size should be undertaken.
Soil Depth (mBGL)[1]	The soil depth range is outlined below: • 0m to <1m; • 1m to <2m; • 2m to <4m; and • >4m (4m+).
Groundwater (mBGL)[1]	Presence of moisture/groundwater is an important factor. The depth of occurrence, land use (outlined above) and soil type (outlined above) should be taken into account. The depth of occurrence is outlined below: • 2m to <4m;

Factor	Description
	• 4m to <8m; and • >8m (8m+).
Soil Vapour (mBGL)[1]	Presence of soil vapour, depth of occurrence, land use (outlined above) and soil type (outlined above) should be taken into account. The depth of occurrence is outlined below: • 0m to <1m; • 1m to <2m; • 2m to <4m; • 4m to <8m; and • >8m (8m+). Soil vapour measurements can provide a more accurate representation of vapour risk. This is preferred where contaminated groundwater is present at less than 2m below ground or basement levels.
Contaminants	BTEX, Naphthalene and TPH fractions F1-F4: • F1: C_6 – C_{10}. The BTEX concentration must be subtracted to obtain F1 value; • F2: >C_{10} – C_{16}. The naphthalene concentration must be subtracted to obtain the F2 value; • F3: >C_{16} – C_{34}; and • F4: >C_{34}. The F3 and F4 fractions are non-volatile and therefore not of concern for vapour intrusion. Exposure to these compounds can occur via direct contact. Reference should be made to the NEPM 2013 in the event direct contact can occur.

Bio-degradation	Account for bio-degradation due to the presence of oxygen:
	• Concentration of oxygen greater than >5% in soil vapour at a depth of 1m below the surface immediately adjacent to the concrete slab;
	• Maximum slab width of less than 15m, with oxygen access on both sides. A distance of 7-8m from the exposed soil at the slab boundary is considered the maximum lateral under-slab penetration of oxygen;
	• Provided the above conditions are met, the following bio-degradation factors can be applied:
	  ➢ Factor of x10 for depths to source of 2 to <4m; and
	  ➢ Factor of x100 for depths to source of 4m+ where the vapour source strength is 100mg/L (100,000mg/m^3) or less.
	• Bio-degradation is not applicable for depths less than 2m; and

Factor	Description
	• Not applicable to ecological receptors; and • Reference should also be made to management limits.
Other Factors	Consideration should also be given to the following: • Check the status and condition of the slab for the presence of cracks and deterioration. This can act as a preferential pathway; • Potential for direct contact to workers; and • The soil saturation concentration of a contaminant occurs when the pore water is at its solubility limit and soil vapour is at the maximum. When the HSLs exceed this limit, the vapour in soil or above the groundwater cannot result in an unacceptable vapour risk and is denoted as NL (not limited) in the HSLs tables.

Note:
mBGL – meters below ground level

a) Limitations of HSLs

A site specific approach of direct intervention should be development in the following cases:

- Identified contamination has an atypical petroleum composition;
- Groundwater contaminated with petroleum hydrocarbons is present at less than 2m below ground or basement surface;
- Contaminated groundwater or LNAPL is entering or in contact with a basement or building foundations;
- The impacted soil source thickness is >2m;
- A preferential migration pathway is present that could connect a vapour source to a building; and
- Hydrocarbon odour is present in buildings or utilities which indicate a preferential migratory pathway and an immediate human health risk.

b) Silica Gel Clean-Up

Soil samples are initially analysed for TRH without a preliminary silica gel clean-up of the sample. Consequently the TRH result may include other compounds such as phthalates, humic acids, fatty acids and sterols (if present).

Silica gel clean-up should remove these other compounds and result in a more accurate result for petroleum hydrocarbons. If undertaken these results have been referred to as TPH_{sgel} within this report.

4. Ecological Assessment Criteria (EAC)

The NEPM 2013 includes a methodology for developing site specific EAC for the protection of terrestrial ecosystems from site contamination. The EAC provide the basis for a Tier 1 site assessment of ecological risk. The factors to take into account for deriving site specific EAC are outlined in the following table:

Table 1.3: Factors for Deriving Site Specific EAC

Factor	Description
Land Use Setting	The EAC are applicable for the following generic land use settings based on protection of ecological significance: • Areas of ecological significance (99% protection); • Urban residential areas and public open space (80% protection); and • Commercial/Industrial land use (60% protection).
Application Depth	The EAC are applicable to the top 2m of soil at the finished surface/ground level which corresponds to the root zone and habitation zone of many species.
Ecological Investigation Levels (EILs)	EILs are derived for the following contaminants: • Aged contaminants (>2 years): Chromium III (CrIII), Copper (Cu), Lead (Pb), Nickel (Ni) and Zinc (Zn). The methodology for deriving site specific EILs for aged contaminants are outlined in below; and • Other contaminants with published EILs: Arsenic (As), DDT (pesticide) and Naphthalene (a PAH compound). EILs for fresh contaminants (i.e. present for less than 2 years) should be specifically derived for the site as outlined in NEPM 2013.
Ecological Screening Levels (ESLs)	ESLs apply to TRH fractions F1-F4 (see Table 1.2); BTEX and Benzo(a)pyrene (a PAH compound).

a) Ecological Investigation Levels (EILs)

The NEPM 2013 provides generic EILs for Arsenic, DDT and Naphthalene that are applicable to all soils as a total soil contaminant concentration. The EILs for the remaining aged contaminants (Cr III, Cu, Ni, Pb and Zn) are derived using the following methodology:

Table 1.4: Steps for Deriving Site Specific EILs

Step	Description
Step 1 – Soil Property	Analyse the soil samples for the following: • CEC ($cmol_c/kg$) to determine EILs for Cu, Ni and Zn; • pH (to determine EILs for Cu); and • Clay content (% clay) (to determine the EIL for CrIII).
Step 2 – Establish Added Contaminant Limits (ACLs)	The ACL is the added concentration of a contaminant above which further appropriate investigation and evaluation of the impact on ecological values is required. The ACL take into account the biological availability of the elements in various soils. For establishing the site specific ACLs, consideration should be given

Step	Description
	to the soil parameters outlined in Step 1. The ACL for Cu may be determined by pH or CEC. The lower of the determined value should be selected for the EIL calculation. The ACL for Pb is taken directly from the published data.
Step 3 – Calculate the Ambient Background Concentration (ABC)	The ABC takes into account the naturally occurring background levels and contaminant levels introduced by anthropogenic activity like emissions from vehicles etc. The NEPM 2013 provides the following methods for calculating the ABC: • Method 1: The preferred method is to measure the ABC at an appropriate reference site where there is a high naturally occurring background; • Method 2: Obtain ABC from the urban metal level studies undertaken by Olszowy et al. (1995) or Hamon et al. (2004). The ABC in this method varies based on the contaminant and the soil iron and/or manganese concentrations; and • Method 3: ABCs for individual suburbs which high and low traffic areas for NSW are available for CrIII, Cu, Pb, Ni and Zn from Olszowy et al. (1995) (see NEPM 2013 Schedule B5b).
Step 4 – Calculate the EIL	EIL is calculated by summing the ACL and ABC: **EIL = ACL + ABC**

b) Ecological Screening Levels (ESLs) for Petroleum Compounds

Similar to the HSLs outlined above, the NEPM 2013 has adopted the ESLs for TPH compounds developed by the Canadian Council of the Ministers of the Environment (CCME) in the publication *Canada-wide Standard for Petroleum Hydrocarbons (PHC) in soil* (CCME 2008[24]). Site specific ESLs are derived based on fresh contamination and should not be applied directly to the assessment of sediments. The following factors apply:

Table 1.5: Multiple Factors for Site Specific ESLs

Factor	Description
Land Use Setting and Application Depth	Refer to Table 1.1.
Soil Type	• Fine Grained – includes clays and silts; and • Coarse Grained – sands and gravels.
Contaminants	BTEX, Benzo(a)pyrene and TPH fractions F1-F4: • F1: C_6 – C_{10}. The BTEX concentration must be subtracted to obtain F1 value;

[24] *Canada-wide Standard for Petroleum Hydrocarbons (PHC) in soil* (CCME 2008[24]) (CWS PHC)

Factor	Description
	• F2: $>C_{10} - C_{16}$. The naphthalene concentration must be subtracted to obtain the F2 value; • F3: $>C_{16} - C_{34}$; and • F4: $>C_{34}$. The ESLs for F1 and F2 is of moderate reliability.

5. Management Limits for Petroleum Hydrocarbons

The NEPM 2013 has adopted the physical and aesthetic management limits outlined in the CWS PHC publication. These limits are applied after considering the relevant HSLs and ESLs for adverse effects of TPH contamination including: presence of free phase (LNAPL); fire hazards; explosive hazards; effects on buried infrastructure; and aesthetic considerations.

These limits are relevant for operating sites where significant sub-slab leakage of petroleum compounds has occurred and when decommissioning industrial and commercial sites.

6. Asbestos in Soil

The NEPM 2013 includes guidelines for the assessment of asbestos in soil. Asbestos is identified to occur as:

- ACM (asbestos containing material);
- Bonded ACM – e.g. fibro frags >7mm (identified during site inspection/sampling);
- Fibrous Asbestos (FA) – friable materials e.g. insulation products, weathered fibro that can be crushed by hand pressure, crumbled, woven materials etc (identified during site inspection/sampling); and
- Asbestos Fines (AF) –free fibres, fibre bundles, fibro frags <7mm (considered friable), generally only identified by laboratory.

The guidelines recommend undertaking a preliminary site investigation (PSI) if the site history or site inspection indicates the possibility or occurrence of potential asbestos contamination. In the event a detailed site investigation (DSI) is required, the NEPM 2013 recommends using the Western Australian (WA) Asbestos Guidelines 2009[25].

a) Criteria for PSI

EIS has adopted the 'presence/absence' method for the PSI in accordance with AS4964-2004[26]. If asbestos is present, the status of the asbestos material (friable or bonded/non-friable) is further considered due to the implications associated with site remediation and/or management. The presence of asbestos may require a DSI as outlined below.

b) Criteria for DSI

[25] *Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia*, WA Department of health, Perth, Australia, May 2009 (Western Australian Asbestos Guidelines 2009)

[26] Australian Standard 4964, *Method for the Qualitative Identification of Asbestos in Bulk Samples*, Australian Standards, 2004

The Western Australian Asbestos Guidelines 2009 prescribe a site investigative model for a DSI. The WA guidelines are based on various studies but generally use the Dutch guidelines with a conservation factor of 10. The asbestos health screening levels (ASLs) adopted by NEPM 2013 is outlined in the table below:

Table 1.6: ASLs for DSI

Form of Asbestos	ASLs (w/w)			
	Residential A[1]	Residential B[2]	Recreational C[3]	Commercial / Industrial D[4]
Bonded ACM	0.01%	0.04%	0.02%	0.05%
FA and AF[5] (Friable)	0.001%			
All forms	No Visible Asbestos at the Surface			

Notes:

1 to 4 – Refer to the landuse categories for HILs outlined in Table 1.1

5 – The guideline value only applies for analysis quantified by gravimetric procedures (see Section 4.10 of NEPM 2013). This is not applicable to free fibres.

The following considerations should be made for determining asbestos concentrations in soil:

- The occurrence of asbestos at the surface should be recorded on a grid system of 10m x 10m;
- Non-impacted soils should be excluded from the calculations to avoid dilution effects;
- Separate determination should be made for each stratum/unit of fill or soil;
- Averaging or using statistical procedures is not appropriate;
- Sub-surface samples obtained from boreholes and/or trenches, the calculation should be carried out per sample; and
- A weight-of-evidence approach is recommended for determining whether the exceedances are of concern.

The amount of asbestos in ACM for a measured/estimated amount of soil is expressed as a % weight for weight (%w/w). This can be estimated using the following expression:

$$\%\frac{w}{w}\ asbestos\ in\ soil = \frac{\%\ asbestos\ content \times bonded\ ACM\ (kg)}{soil\ volume\ (L) \times soil\ density\ (\frac{kg}{L})}$$

The % asbestos content within bonded ACM is estimated to be 15% by enHealth (2005). Soil density for sandy soils is approximately 1.65kg/L.

c) Limitation of adopting the Western Australian Asbestos Guidelines 2009

The following limitations have been identified for using the WA asbestos guidelines:

- The guidelines assume that the asbestos contamination is confined to the top 10cm of the soil profile;
- The guidelines are applicable to sandy soils which are the predominant soil type encountered in WA;
- The sampling methodology recommended in the guideline (wet soil, raking, tilling) may not be adequate in clayey and silty conditions;

- The presence of asbestos below the ASLs may still pose a risk to site receptors which will require remediation or management; and
- The sampling density recommend in the guideline (2 x NSW EPA density) may not be achievable for sites which are less than 500m^3 in area.

7. Waste Classification Criteria for Off-Site Disposal of Soil

Any material excavated for the proposed development will require a waste classification for off-site disposal in accordance with the Waste Classification Guidelines 2009.

Soils are classed into the following categories based on the chemical contaminant criteria outlined in the guidelines:

Table 1.7: Waste Categories

Category	Description
General Solid Waste (non-putrescible) (GSW)	• If SCC ≤ CT1 then TCLP not needed to classify the soil as GSW • If TCLP ≤ TCLP1 and SCC ≤ SCC1 then treat as GSW
Restricted Solid Waste (non-putrescible) (RSW)	• If SCC ≤ CT2 then TCLP not needed to classify the soil as RSW • If TCLP ≤ TCLP2 and SCC ≤ SCC2 then treat as RSW
Hazardous Waste (HW)	• If SCC > CT2 then TCLP not needed to classify the soil as HW • If TCLP > TCLP2 and/or SCC > SCC2 then treat as HW
Excavated Natural Material (ENM)	The criteria to classify material as ENM are outlined in The Excavated Natural Material Exemption (2012[27]).
Virgin Excavated Natural Material (VENM)	Natural material (such as clay, gravel, sand, soil or rock fines) that meet the following: • that has been excavated or quarried from areas that are not contaminated with manufactured chemicals, or with process residues, as a result of industrial, commercial mining or agricultural activities; • that does not contain sulfidic ores or other waste; and • includes excavated natural material that meets such criteria for virgin excavated natural material as may be approved from time to time by a notice published in the NSW Government Gazette.

Note:
SCC – Specific Contaminant Concentration
CT – Contaminant Threshold

[27] Protection of the Environment Operations (Waste) Regulation 2005 – General Exemption Under Part 6, Clase 51 and 51A, The excavated natural material exemption, 2012 (ENM exemption 2012)

TCLP – Toxicity Characteristics Leaching Procedure

a) General Approvals of Immobilisation (GAI)

Significant amounts of waste ash and gravely slag were available in the late nineteenth and early twentieth century as a result of the use of coal for industrial and domestic heating purposes. Widespread use of ash/slag waste (either as ash or mixed with other soil and waste materials) as fill material was common in the suburbs of Sydney at this time.

To account for the presence of ash and slag, the NSW EPA has published the following:

Table 1.8: GAIs

Approval Number	Waste Stream	Contaminants	Waste Assessment Requirements
1999/05[28]	Ash, ash-contaminated natural excavated materials or coal-contaminated natural excavated material	B(a)P and PAHs	The SCC limits for PAHs and B(a)P outlined in the Waste Classification Guidelines 2009 do not apply for the assessment of this waste stream. The material can be classified according to the leachable concentration (TCLP) value of B(a)P alone. Disposal restrictions apply for material classified under this GAI.
2009/07[29]	Metallurgical furnace slag or metallurgical furnace slag contaminated natural excavated materials	Beryllium, Chromium (VI), lead, nickel, PAHs and B(a)P	The SCC limits for these contaminants outlined in the Waste Classification Guidelines 2009 do not apply for the assessment of this waste stream. The material can be classified according to their leachable concentrations (TCLP) values alone.

Note:
SCC – Specific Contaminant Concentration
TCLP – Toxicity Characteristics Leaching Procedure
B(a)P - Benzo(a)pyrene
PAHs – Polycyclic Aromatic Hydrocarbons

8. Groundwater Investigation Levels (GILs)

The appropriate settings for current and potential uses of groundwater should be identified for establishing the GILs. Contaminated groundwater may pose a risk to receptors at the point of extraction or as a result of discharge into the receiving environment and groundwater resources. The assessment should be designed to consider the risk of groundwater contamination to all potential on site and off site receptors.

[28] http://www.environment.nsw.gov.au/resources/waste/GenImmobApp_1999-05_Ash_ACNEM_or_CCNEM.pdf (GAI 1999/05)
[29] http://www.environment.nsw.gov.au/resources/waste/2009-07_Metallurgical_furnace_slag.pdf (GAI 2009/07)

In assessing groundwater contamination, NEPM 2013 has adopted the framework outlined in the National Water Quality Management Strategy which includes the following guidelines:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (AWQG) (2000). This includes a framework for developing guidelines for aquifer assessment. The guidelines provide water quality parameters for aquatic ecosystems (fresh and marine waters), industrial, agricultural, recreational and irrigation uses;
- Australian Drinking Water Guidelines (ADWG) (2011). Includes the Australian Drinking Water Guidelines used to assess drinking water quality; and
- Guidelines for Managing Risk in Recreational Water (GMRRW) (NHMRC 2008).

The NEPM 2013 has adopted HSLs for the assessment of petroleum hydrocarbons in groundwater.

The presence of elevated contaminants above the GILs triggers further investigation to assess the source(s) and the extent of the contamination. Guidance on the remediation and management of contaminated groundwater is outlined in *NSW DECCW Guidelines for the Assessment and Management of Groundwater Contamination (2007[30])*.

a) Hardness Modified Trigger Values (HMTVs)

Water hardness can affect the bioavailability of metals/metalloids in fresh water. Consequently, Section 3.4.3.2 of the ANZECC 2000 guidelines includes algorithms to derive hardness modified trigger values (HMTVs) for metals/metalloid concentrations in fresh water.

[30] *Guidelines for the Assessment and Management of Groundwater Contamination,* NSW DECCW, 2007 (Groundwater Contamination Guidelines 2007)

Appendix D3: NEPM 2013 Guideline Values

6 Tabulated investigation and screening levels

ROUNDING APPLIED TO INVESTIGATION AND SCREENING LEVELS

Tables 1A (HILs and interim HILs)

Rounded to 1 or 2 significant figures (see Schedule B7 Appendix C for details)

Tables 1A (HSLs) and 1B (EILs and ESLs) rounding rules

< 1	**to nearest 0.1**
1–<10	**to nearest whole number**
1–< 100	**to nearest 5**
100–<1,000	**to nearest 10**
1,000–<10,000	**to nearest 100**
≥10,000	**to nearest 1,000**

Numbers ending in '5' are rounded up, for example:

0.05 rounded to 0.1

1.5 rounded to 2

115 rounded to 120

Table 1A(1) Health investigation levels for soil contaminants

Chemical	Health-based investigation levels (mg/kg)			
	Residential[1] A	Residential[1] B	Recreational[1] C	Commercial/ industrial[1] D
Metals and Inorganics				
Arsenic[2]	100	500	300	3 000
Beryllium	60	90	90	500
Boron	4500	40 000	20 000	300 000
Cadmium	20	150	90	900
Chromium (VI)	100	500	300	3600
Cobalt	100	600	300	4000
Copper	6000	30 000	17 000	240 000
Lead[3]	300	1200	600	1 500
Manganese	3800	14 000	19 000	60 000
Mercury (inorganic)[5]	40	120	80	730
Methyl mercury[4]	10	30	13	180
Nickel	400	1200	1200	6 000
Selenium	200	1400	700	10 000
Zinc	7400	60 000	30 000	400 000
Cyanide (free)	250	300	240	1 500
Polycyclic Aromatic Hydrocarbons (PAHs)				
Carcinogenic PAHs (as BaP TEQ)[6]	3	4	3	40
Total PAHs[7]	300	400	300	4000
Phenols				
Phenol	3000	45 000	40 000	240 000
Pentachlorophenol	100	130	120	660
Cresols	400	4 700	4 000	25 000
Organochlorine Pesticides				
DDT+DDE+DDD	240	600	400	3600
Aldrin and dieldrin	6	10	10	45
Chlordane	50	90	70	530
Endosulfan	270	400	340	2000
Endrin	10	20	20	100
Heptachlor	6	10	10	50
HCB	10	15	10	80
Methoxychlor	300	500	400	2500
Mirex	10	20	20	100
Toxaphene	20	30	30	160
Herbicides				
2,4,5-T	600	900	800	5000
2,4-D	900	1600	1300	9000
MCPA	600	900	800	5000

Chemical	Health-based investigation levels (mg/kg)			
	Residential[1] A	Residential[1] B	Recreational[1] C	Commercial/ industrial[1] D
MCPB	600	900	800	5000
Mecoprop	600	900	800	5000
Picloram	4500	6600	5700	35000
Other Pesticides				
Atrazine	320	470	400	2500
Chlorpyrifos	160	340	250	2000
Bifenthrin	600	840	730	4500
Other Organics				
PCBs[8]	1	1	1	7
PBDE Flame Retardants (Br1–Br9)	1	2	2	10

Notes:

(1) Generic land uses are described in detail in Schedule B7 Section 3

HIL A – Residential with garden/accessible soil (home grown produce <10% fruit and vegetable intake (no poultry), also includes childcare centres, preschools and primary schools.

HIL B – Residential with minimal opportunities for soil access; includes dwellings with fully and permanently paved yard space such as high-rise buildings and apartments.

HIL C – Public open space such as parks, playgrounds, playing fields (e.g. ovals), secondary schools and footpaths. This does not include undeveloped public open space where the potential for exposure is lower and where a site-specific assessment may be more appropriate.

HIL D – Commercial/industrial, includes premises such as shops, offices, factories and industrial sites.

(2) Arsenic: HIL assumes 70% oral bioavailability. Site-specific bioavailability may be important and should be considered where appropriate (refer Schedule B7).

(3) Lead: HIL is based on blood lead models (IEUBK for HILs A, B and C and adult lead model for HIL D where 50% oral bioavailability has been considered. Site-specific bioavailability may be important and should be considered where appropriate.

(4) Methyl mercury: assessment of methyl mercury should only occur where there is evidence of its potential source. It may be associated with inorganic mercury and anaerobic microorganism activity in aquatic environments. In addition the reliability and quality of sampling/analysis should be considered.

(5) Elemental mercury: HIL does not address elemental mercury. A site-specific assessment should be considered if elemental mercury is present, or suspected to be present,

(6) Carcinogenic PAHs: HIL is based on the 8 carcinogenic PAHs and their TEFs (potency relative to B(a)P) adopted by CCME 2008 (refer Schedule B7). The B(a)P TEQ is calculated by multiplying the concentration of each carcinogenic PAH in the sample by its B(a)P TEF, given below, and summing these products.

PAH species	TEF	PAH species	TEF
Benzo(a)anthracene	0.1	Benzo(g,h,i)perylene	0.01
Benzo(a)pyrene	1	Chrysene	0.01
Benzo(b+j)fluoranthene	0.1	Dibenz(a,h)anthracene	1
Benzo(k)fluoranthene	0.1	Indeno(1,2,3-c,d)pyrene	0.1

Where the B(a)P occurs in bitumen fragments it is relatively immobile and does not represent a significant health risk.

(7) Total PAHs: HIL is based on the sum of the 16 PAHs most commonly reported for contaminated sites (WHO 1998). The application of the total PAH HIL should consider the presence of carcinogenic PAHs and naphthalene (the most volatile PAH). Carcinogenic PAHs reported in the total PAHs should meet the B(a)P TEQ HIL. Naphthalene reported in the total PAHs should meet the relevant HSL.

(8) PCBs: HIL relates to non-dioxin-like PCBs only. Where a PCB source is known, or suspected, to be present at a site, a site-specific assessment of exposure to all PCBs (including dioxin-like PCBs) should be undertaken.

Table 1A(2) Interim soil vapour health investigation levels for volatile organic chlorinated compounds

Chemical	Interim soil vapour HIL (mg/m^3)			
	Residential[1] A	Residential[1] B	Recreational[1] C	Commercial / Industrial[1] D
TCE	0.02	0.02	0.4	0.08
1,1,1-TCA	60	60	1200	230
PCE	2	2	40	8
cis-1,2-dichloroethene	0.08	0.08	2	0.3
Vinyl chloride	0.03	0.03	0.5	0.1

Notes:

1. Land use settings are equivalent to those described in Table 1A(1) Footnote 1 and Schedule B7, though secondary school buildings should be assessed using residential 'A/B' for vapour intrusion purposes.
2. Interim HILs for VOCCs are conservative soil vapour concentrations that can be adopted for the purpose of screening sites where further investigation is required on a site-specific basis. They are based on the potential for vapour intrusion using an indoor air-to-soil vapour attenuation factor of 0.1 and an outdoor air-to-soil vapour attenuation factor of 0.05.
3. Application of the interim HILs is based on a measurement of shallow (to 1 m depth) soil vapour (or deeper where the values are to be applied to a future building with a basement) or sub-slab soil vapour.
4. The applicability of the interim HILs needs to be further considered when used for other building types such as homes with a crawl-space and no slab, which may require site-specific assessment.
5. Use of the interim HILs requires comparison with data that has been collected using appropriate methods and meets appropriate data quality requirements.
6. Oral and dermal exposure should be considered on a site-specific basis where direct contact exposure is likely to occur.

Table 1A(3) Soil HSLs for vapour intrusion (mg/kg)

	HSL A & HSL B Low – high density residential				HSL C recreational / open space				HSL D Commercial / Industrial				
CHEMICAL	**0 m to <1 m**	**1 m to <2 m**	**2 m to <4m**	**4 m+**	**0 m to <1 m**	**1 m to <2 m**	**2 m to <4 m**	**4 m+**	**0 m to <1 m**	**1 m to <2 m**	**2 m to <4 m**	**4 m+**	**Soil saturation concentration (Csat)**
SAND													
Toluene	160	220	310	540	NL	NL	NL	NL	NL	NL	NL	NL	560
Ethylbenzene	55	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	64
Xylenes	40	60	95	170	NL	NL	NL	NL	230	NL	NL	NL	300
Naphthalene	3	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	9
Benzene	0.5	0.5	0.5	0.5	NL	NL	NL	NL	3	3	3	3	360
F1[9]	45	70	110	200	NL	NL	NL	NL	260	370	630	NL	950
F2[10]	110	240	440	NL	NL	NL	NL	NL	NL	NL	NL	NL	560
SILT													
Toluene	390	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	640
Ethylbenzene	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	69
Xylenes	95	210	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	330

	HSL A & HSL B Low – high density residential				HSL C recreational / open space				HSL D Commercial / Industrial				
Naphthalene	4	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	10
Benzene	0.6	0.7	1	2	NL	NL	NL	NL	4	4	6	10	440
F1[9]	40	65	100	190	NL	NL	NL	NL	250	360	590	NL	910
F2[10]	230	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	570
CLAY													
Toluene	480	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	630
Ethylbenzene	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	68
Xylenes	110	310	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	330
Naphthalene	5	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	10
Benzene	0.7	1	2	3	NL	NL	NL	NL	4	6	9	20	430
F1[9]	50	90	150	290	NL	NL	NL	NL	310	480	NL	NL	850
F2[10]	280	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	560

Notes:

(1) Land use settings are equivalent to those described in Table 1A(1) Footnote 1 and Schedule B7. HSLs for vapour intrusion for high density residential assume residential occupation of the ground floor. If communal car parks or commercial properties occupy the ground floor, HSL D should be used,

(2) The key limitations of the HSLs should be referred to prior to application and are presented in Friebel and Nadebaum (2011b and 2011d).

(3) Detailed assumptions in the derivation of the HSLs and information on how to apply the HSLs are presented in Friebel and Nadebaum (2011a and 2011b).

(4) Soil HSLs for vapour inhalation incorporate an adjustment factor of 10 applied to the vapour phase partitioning to reflect the differences observed between theoretical estimates of soil vapour partitioning and field measurements. Refer Friebel & Nadebaum (2011a) for further information.

(5) The soil saturation concentration (Csat) is defined as the soil concentration at which the porewater phase cannot dissolve any more of an individual chemical. The soil vapour that is in equilibrium with the porewater will be at its maximum. If the derived soil HSL exceeds Csat, a soil vapour source concentration for a petroleum mixture could not exceed a level that would result in the maximum allowable vapour risk for the given scenario. For these scenarios, no HSL is presented for these chemicals and the HSL is shown as 'not limiting' or 'NL'.

(6) The HSLs for TPH C_6-C_{10} in sandy soil are based on a finite source that depletes in less than seven years, and therefore consideration has been given to use of sub-chronic toxicity values. The >C_8-C_{10} aliphatic toxicity has been adjusted to represent sub-chronic exposure, resulting in higher HSLs than if based on chronic toxicity. For further information refer to Section 8.2 and Appendix J in Friebel and Nadebaum (2011a).

(7) The figures in the above table may be multiplied by a factor to account for biodegradation of vapour. A factor of 10 may apply for source depths from 2 m to <4 m or a factor of 100 for source depths of 4 m and deeper. To apply the attenuation factor for vapour degradation, a number of conditions must be satisfied. Firstly the maximum length of the shorter side of the concrete slab and surrounding pavement cannot exceed 15 m, as this would prevent oxygen penetrating to the centre of the slab. Secondly, measurement of oxygen in the subsurface is required to determine the potential for biodegradation. Oxygen must be confirmed to be present at >5% to use these factors.

(8) For soil texture classification undertaken in accord with AS 1726, the classifications of sand, silt and clay may be applied as coarse, fine with liquid limit <50% and fine with liquid limit>50% respectively, as the underlying properties to develop the HSLs may reasonably be selected to be similar. Where there is uncertainty, either a conservative approach may be adopted or laboratory analysis should be carried out.

(9) To obtain F1 subtract the sum of BTEX concentrations from the C_6-C_{10} fraction.

(10) To obtain F2 subtract naphthalene from the >C_{10}-C_{16} fraction.

Table 1A(4) Groundwater HSLs for vapour intrusion (mg/L)

	HSL A & HSL B Low – high density residential			HSL C recreational / open space			HSL D Commercial / industrial			
CHEMICAL	**2 m to <4 m**	**4 m to <8 m**	**8 m+**	**2 m to <4 m**	**4 m to <8 m**	**8 m+**	**2 m to <4 m**	**4 m to <8 m**	**8 m+**	**Solubility limit**
SAND										
Toluene	NL	NL	NL	NL	NL	NL	NL	NL	NL	61
Ethylbenzene	NL	NL	NL	NL	NL	NL	NL	NL	NL	3.9
Xylenes	NL	NL	NL	NL	NL	NL	NL	NL	NL	21
Naphthalene	NL	NL	NL	NL	NL	NL	NL	NL	NL	0.17
Benzene	0.8	0.8	0.9	NL	NL	NL	5	5	5	59
F1[7]	1	1	1	NL	NL	NL	6	6	7	9.0
F2[8]	1	1	1	NL	NL	NL	NL	NL	NL	3.0
SILT										
Toluene	NL	NL	NL	NL	NL	NL	NL	NL	NL	61
Ethylbenzene	NL	NL	NL	NL	NL	NL	NL	NL	NL	3.9
Xylenes	NL	NL	NL	NL	NL	NL	NL	NL	NL	21
Naphthalene	NL	NL	NL	NL	NL	NL	NL	NL	NL	0.17

	HSL A & HSL B Low – high density residential			HSL C recreational / open space			HSL D Commercial / industrial			
Benzene	4	5	5	NL	NL	NL	30	30	30	59
F1[7]	6	6	6	NL	NL	NL	NL	NL	NL	9.0
F2[8]	NL	NL	NL	NL	NL	NL	NL	NL	NL	3.0
CLAY										
Toluene	NL	NL	NL	NL	NL	NL	NL	NL	NL	61
Ethylbenzene	NL	NL	NL	NL	NL	NL	NL	NL	NL	3.9
Xylenes	NL	NL	NL	NL	NL	NL	NL	NL	NL	21
Naphthalene	NL	NL	NL	NL	NL	NL	NL	NL	NL	0.17
Benzene	5	5	5	NL	NL	NL	30	30	35	59
F1[7]	NL	NL	NL	NL	NL	NL	NL	NL	NL	9.0
F2[8]	NL	NL	NL	NL	NL	NL	NL	NL	NL	3.0

Notes:

(1) Land use settings are equivalent to those described in Table 1A(1) Footnote 1 and Schedule B7. HSLs for vapour intrusion for high density residential assume residential occupation of the ground floor. If communal car parks or commercial properties occupy the ground floor, HSL D should be used,

(2) The key limitations of the HSLs are presented in Friebel and Nadebaum (2011d) and should be referred to prior to application.

(3) Detailed assumptions in the derivation of the HSLs and information on the application of the HSLs are presented in Friebel and Nadebaum (2011a and 2011b).

(4) The solubility limit is defined as the groundwater concentration at which the water cannot dissolve any more of an individual chemical based on a petroleum mixture. The soil vapour that is in equilibrium with the groundwater will be at its maximum. If the derived groundwater HSL exceeds the water solubility limit, a soil vapour source concentration for a petroleum mixture could not exceed a level that would result in the maximum allowable vapour risk for the given scenario. For these scenarios, no HSL is presented for these chemicals and the HSL is shown as 'not limiting' or 'NL'.

(5) The figures in the above table may be multiplied by a factor to account for biodegradation of vapour. A factor of 10 may apply for source depths from 2 m to <4 m or a factor of 100 for source depths of 4 m and deeper. To apply the attenuation factor for vapour degradation, a number of conditions must be satisfied. Firstly, the maximum length of the shorter side of the concrete slab and surrounding pavement cannot exceed 15 m, as this would prevent oxygen penetrating to the centre of the slab. Secondly, measurement of oxygen in the subsurface is required to determine the potential for biodegradation. Oxygen must be confirmed to be present at >5% to use these factors.

(6) For soil texture classification undertaken in accord with AS 1726, the classifications of sand, silt and clay may be applied as coarse, fine with liquid limit <50% and fine with liquid limit >50% respectively, as the underlying properties to develop the HSLs may reasonably be selected to be similar. Where there is uncertainty, either a conservative approach may be adopted or laboratory analysis should be carried out.

(7) To obtain F1 subtract the sum of BTEX concentrations from the C_6-C_{10} fraction.

(8) To obtain F2 subtract naphthalene from the >C_{10}-C_{16} fraction.

Table 1A(5) Soil vapour HSLs for vapour intrusion (mg/m³)

	HSL A & HSL B Low – high density residential					HSL C recreational / open space					HSL D Commercial / Industrial				
CHEMICAL	**0 m to <1 m**	**1 m to <2 m**	**2 m to <4 m**	**4 m to <8 m**	**8 m+**	**0 m to <1 m**	**1 m to <2 m**	**2 m to <4 m**	**4 m to <8 m**	**8 m+**	**0 m to <1 m**	**1 m to <2 m**	**2 m to <4 m**	**4 m to <8 m**	**8 m+**
SAND															
Toluene	1300	3800	7300	15 000	29 000	NL	NL	NL	NL	NL	4800	16 000	39 000	84 000	NL
Ethylbenzene	330	1100	2200	4300	8700	NL	NL	NL	NL	NL	1300	4600	11 000	25 000	53 000
Xylenes	220	750	1500	3000	6100	NL	NL	NL	NL	NL	840	3,200	8000	18 000	37 000
Naphthalene	0.8	3	6	10	25	410	NL	NL	NL	NL	3	15	35	75	150
Benzene	1	3	6	10	20	360	2400	4700	9500	19 000	4	10	30	65	130
F1[8]	180	640	1,300	2600	5300	86 000	NL	NL	NL	NL	680	2800	7000	15 000	32 000
F2[9]	130	560	1200	2400	4800	NL	NL	NL	NL	NL	500	2400	NL	NL	NL
SILT															
Toluene	1400	14 000	32 000	69 000	140 000	NL	NL	NL	NL	NL	5700	63 000	NL	NL	NL
Ethylbenzene	380	4200	9700	21 000	43 000	NL	NL	NL	NL	NL	1500	19 000	54 000	NL	NL
Xylenes	260	2900	6800	15 000	30 000	NL	NL	NL	NL	NL	1000	13 000	38 000	NL	NL
Naphthalene	0.9	10	25	60	120	NL	NL	NL	NL	NL	4	50	150	350	750
Benzene	1	10	25	55	110	1800	12 000	24 000	48 000	97 000	4	50	140	320	670
F1[8]	210	2600	6000	13 000	26 000	NL	NL	NL	NL	NL	850	11 000	33 000	77 000	160 000

	HSL A & HSL B Low – high density residential					HSL C recreational / open space					HSL D Commercial / Industrial				
F2[9]	160	2300	5400	NL	NL	NL	NL	NL	NL	NL	670	NL	NL	NL	NL
CLAY															
Toluene	1600	23 000	53 000	110 000	NL	NL	NL	NL	NL	NL	6500	100 000	NL	NL	NL
Ethylbenzene	420	6800	16 000	35 000	NL	NL	NL	NL	NL	NL	1800	31 000	NL	NL	NL
Xylenes	280	4800	11 000	24 000	50 000	NL	NL	NL	NL	NL	1200	21 000	NL	NL	NL
Naphthalene	1	20	45	95	200	NL	NL	NL	NL	NL	4	85	240	560	1200
Benzene	1	15	40	90	180	3000	20 000	40 000	81 000	160 000	5	80	230	530	1100
F1[8]	230	4200	9900	21 000	44 000	NL	NL	NL	NL	NL	1000	19 000	55 000	130 000	270 000
F2[9]	180	3,800	NL	NL	NL	NL	NL	NL	NL	NL	800	NL	NL	NL	NL

1. Land use settings are equivalent to those described in Table 1A(1) Footnote 1 and Schedule B7. HSLs for vapour intrusion for high density residential assume residential occupation of the ground floor. If communal car parks or commercial properties occupy the ground floor, HSL D should be used,
2. The key limitations of the HSLs should be referred to prior to application and are presented in Friebel and Nadebaum (2011b and 2011d).
3. Detailed assumptions in the derivation of the HSLs and information on how to apply the HSLs are presented in Friebel and Nadebaum (2011a and 2011b).
4. The maximum possible soil vapour concentrations have been calculated based on vapour pressures of the pure chemicals. Where soil vapour HSLs exceed these values a soil-specific source concentration for a petroleum mixture could not exceed a level that would result in the maximum allowable vapour risk for the given scenario. For these scenarios, no HSL is presented for these chemicals and the HSL is shown as 'not limiting' or 'NL'.
5. Soil vapour HSLs should be compared with measurements taken as laterally close as possible to the soil or groundwater sources of vapour (i.e. within or above vapour sources). Consideration is required of where the sample is taken, the current condition of the site and the likely future condition of the site. Shallow gas measurements in open space (1ess than 1 m below ground surface) may be subject to influences of weather conditions and moisture.
6. The figures in the above table may be multiplied by a factor to account for biodegradation of vapour. A factor of 10 may apply for source depths from 2 m to <4 m or a factor of 100 for source depths of 4 m and deeper. To apply the attenuation factor for vapour degradation, a number of conditions must be satisfied. Firstly, the maximum length of the shorter side of the concrete slab and surrounding pavement cannot exceed 15 m, as this would prevent oxygen penetrating to the centre of the slab. Secondly, measurement of oxygen in the subsurface is required to determine the potential for biodegradation. Oxygen must be confirmed to be present at >5% to use these factors.
7. For soil texture classification undertaken in accord with AS 1726, the classifications of sand, silt and clay may be applied as coarse, fine with liquid limit <50% and fine with liquid limit >50% respectively as the underlying properties to develop the HSLs may reasonably be selected to be similar. Where there is uncertainty, either a conservative approach may be adopted or laboratory analysis should be carried out.
8. To obtain F1 subtract the sum of BTEX concentrations from the C_6-C_{10} fraction.

9. To obtain F2 subtract naphthalene from the $>C_{10}$-C_{16} fraction.

Table 1B(1) Soil-specific added contaminant limits for aged zinc in soil

Zn added contaminant limits (ACL, mg added contaminant/kg)						
Areas of ecological significance						
pH[a]	***CEC[b] ($cmol_c$/kg)***					
	5	***10***	***20***	***30***	***40***	***60***
4.0	15	20	20	20	20	20
4.5	20	25	25	25	25	25
5.0	30	40	40	40	40	40
5.5	40	60	60	60	60	60
6.0	50	90	90	90	90	90
6.5	50	90	130	130	130	130
7.0	50	90	150	190	190	190
7.5	50	90	150	210	260	280
Urban residential/public open space[1]						
pH[a]	***CEC[b] ($cmol_c$/kg)***					
	5	***10***	***20***	***30***	***40***	***60***
4.0	70	85	85	85	85	85
4.5	100	120	120	120	120	120
5.0	130	180	180	180	180	180
5.5	180	270	270	270	270	270
6.0	230	400	400	400	400	400
6.5	230	400	590	590	590	590
7.0	230	400	700	880	880	880
7.5	230	400	700	960	1200	1300
Commercial/industrial						
pH[a]	***CEC[b] ($cmol_c$/kg)***					
	5	***10***	***20***	***30***	***40***	***60***
4.0	110	130	130	130	130	130
4.5	150	190	190	190	190	190
5.0	210	290	290	290	290	290
5.5	280	420	420	420	420	420
6.0	360	620	620	620	620	620
6.5	360	620	920	920	920	920
7.0	360	620	1100	1400	1400	1400
7.5	360	620	1100	1500	1900	2000

1. Urban residential/public open space is broadly equivalent to the HIL A, HIL B and HIL C land use scenarios in Table 1A(1) Footnote 1 and as described in Schedule B7.
2. Aged values apply to contamination present in soil for at least two years. For fresh contamination refer to Schedule B5c.
3. The EIL is calculated from summing the ACL and the ABC.

a = pH measured using the $CaCl_2$ method (Rayment & Higginson 1992).

b = CEC measured using the silver thiourea method (Chabra et al. 1972).

Table 1B(2) Soil-specific added contaminant limits for aged copper in soils

Cu added contaminant limits (ACL, mg added contaminant/kg)					
Areas of ecological significance					
CEC ($cmol_c/kg$)[a] based					
5	***10***	***20***	***30***	***40***	***60***
30	65	70	70	75	80
pH[b] based					
4.5	***5.5***	***6***	***6.5***	***7.5***	***8.0***
20	45	65	90	190	270
Urban residential/public open space[1]					
CEC ($cmol_c/kg$)[a] based					
5	***10***	***20***	***30***	***40***	***60***
95	190	210	220	220	230
pH[b] based					
4.5	***5.5***	***6***	***6.5***	***7.5***	***8.0***
60	130	190	280	560	800
Commercial/industrial					
CEC ($cmol_c/kg$)[a] based					
5	***10***	***20***	***30***	***40***	***60***
140	280	300	320	330	340
pH[b] based					
4.5	***5.5***	***6***	***6.5***	***7.5***	***8.0***
85	190	280	400	830	1200

Notes:

1. Urban residential/public open space is broadly equivalent to the HIL A, HIL B and HIL C land use scenarios in Table 1A(1) Footnote 1 and as described in Schedule B7.
2. The lower of the CEC or the pH-based ACLs for the land use and soil conditions is the ACL to be used.
3. Aged values apply to contamination present in soil for at least two years. For fresh contamination refer to Schedule B5c.
4. The EIL is calculated from summing the ACL and the ABC.

a = CEC measured using the silver thiourea method (Chabra et al. 1972).

b = pH measured using the $CaCl_2$ method (Rayment & Higginson 1992).

Table 1B(3) Soil-specific added contaminant limits for aged chromium III and nickel in soil

CHEMICAL	Clay content (% clay)	Added contaminant limits (mg added contaminant/kg) for various land uses		
		Areas of ecological significance	Urban residential and public open space	Commercial and industrial
Chromium III	*1*	60	190	310
	2.5	80	250	420
	5	100	320	530
	≥10	130	400	660
Nickel	CEC[a] ($cmol_c/kg$)	Areas of ecological significance	Urban residential and public open space[1]	Commercial and industrial
	5	5	30	55
	10	30	170	290
	20	45	270	460
	30	60	350	600
	40	70	420	730
	60	95	560	960

Notes:

1. Urban residential/public open space is broadly equivalent to the HIL A, HIL B and HIL C land use scenarios in Table 1A(1) Footnote 1 and as described in Schedule B7.
2. Aged values apply to contamination present in soil for at least two years. For fresh contamination refer to Schedule B5c.
3. The EIL is calculated from summing the ACL and the ABC.

a = CEC measured using the silver thiourea method (Chabra et al. 1972).

Table 1B(4) Generic added contaminant limits for lead in soils irrespective of their physicochemical properties

	Pb added contaminant limit (ACL, mg added contaminant/kg) for various land uses		
CHEMICAL	Areas of ecological significance	Urban residential and public open space[1]	Commercial and industrial
Lead	470	1100	1800

Notes:

1. Urban residential/public open space is broadly equivalent to the HIL A, HIL B and HIL C land use scenarios in Table 1A(1) Footnote 1 and as described in Schedule B7.
2. Aged values are applicable to lead contamination present in soil for at least two years. For fresh contamination refer to Schedule B5c.
3. The EIL is calculated from summing the ACL and the ABC.

Table 1B(5) Generic EILs for aged As, fresh DDT and fresh naphthalene in soils irrespective of their physicochemical properties

	Ecological Investigation Levels (mg total contaminant/kg)		
CHEMICAL	**Areas of ecological significance**	**Urban residential and public open space[1]**	**Commercial and industrial**
Arsenic[2]	40	100	160
DDT[3]	3	180	640
Naphthalene[3]	10	170	370

Notes:

1. Urban residential/public open space is broadly equivalent to the HIL-A, HIL-B and HIL-C land use scenarios in Table 1A(1) Footnote 1 and as described in Schedule B7.
2. Aged values are applicable to arsenic contamination present in soil for at least two years. For fresh contamination refer to Schedule B5c.
3. Insufficient data was available to calculate aged values for DDT and naphthalene, consequently the values for fresh contamination should be used.
4. Insufficient data was available to calculate ACLs for As, DDT and naphthalene. The EIL should be taken directly from Table 1B(5).

Table 1B(6) ESLs for TPH fractions F1 – F4, BTEX and benzo(a)pyrene in soil

CHEMICAL	Soil texture	ESLs (mg/kg dry soil)		
		Areas of ecological significance	Urban residential and public open space	Commercial and industrial
F1 C_6-C_{10}	*Coarse/ Fine*	125*	180*	215*
F2 >C_{10}-C_{16}		25*	120*	170*
F3 >C_{16}-C_{34}	*Coarse*	-	300	1700
	Fine	-	1300	2500
F4 >C_{34}-C_{40}	*Coarse*	-	2800	3300
	Fine	-	5600	6600
Benzene	*Coarse*	10	50	75
	Fine	10	65	95
Toluene	*Coarse*	10	85	135
	Fine	65	105	135
Ethylbenzene	*Coarse*	1.5	70	165
	Fine	40	125	185
Xylenes	*Coarse*	10	105	180
	Fine	1.6	45	95
Benzo(a)pyrene	*Coarse*	0.7	0.7	0.7
	Fine	0.7	0.7	0.7

Notes:

(1) ESLs are of low reliability except where indicated by * which indicates that the ESL is of moderate reliability.

(2) '-' indicates that insufficient data was available to derive a value.

(3) To obtain F1, subtract the sum of BTEX concentrations from C_6-C_{10} fraction and subtract naphthalene from >C_{10}-C_{16} to obtain F2.

Table 1 B(7) Management Limits for TPH fractions F1–F4 in soil

TPH fraction	Soil texture	Management Limits[1] (mg/kg dry soil)	
		Residential, parkland and public open space	Commercial and industrial
F1[2] C_6- C_{10}	*Coarse*	700	700
	Fine	800	800
F2[2] >C_{10}-C_{16}	*Coarse*	1000	1000
	Fine	1000	1000
F3 >C_{16}-C_{34}	*Coarse*	2500	3500
	Fine	3500	5000
F4 >C_{34}-C_{40}	*Coarse*	10 000	10 000
	Fine	10 000	10 000

[1] Management limits are applied after consideration of relevant ESLs and HSLs

[2] Separate management limits for BTEX and naphthalene are not available hence these should not be subtracted from the relevant fractions to obtain F1 and F2.

Table 1C Groundwater Investigation Levels (GILs)

Substance		Groundwater Investigation Levels		
		Fresh Waters[A]	Marine Waters[A]	Drinking Water[B]
		(µg/L)	(µg/L)	(mg/L)
Metals and Metalloids				
Aluminium, Al pH>6.5		55	-	-
Antimony		-	-	0.003
Arsenic		24 as As(III) 13 as As(V)	-	0.01
Barium		-	-	2
Beryllium		-	-	0.06
Boron		370[C]	-	4
Cadmium	H	0.2	0.7[D]	0.002
Chromium, Cr (III)	H	-	27	-
Chromium, Cr (VI)		1[C]	4.4	0.05
Cobalt		-	1	-
Copper	H	1.4	1.3	2
Iron, (Total)		-	-	-
Lead	H	3.4	4.4	0.01
Manganese		1900[C]	-	0.5
Mercury (Total)		0.06[D]	0.1[D]	0.001
Molybdenum		-	-	0.05
Nickel	H	11	7	0.02
Selenium (Total)		5[D]	-	0.01
Silver		0.05	1.4	0.1
Tributyl tin (as Sn)		-	0.006[C]	-
Tributyl tin oxide		-	-	0.001
Uranium		-	-	0.017
Vanadium		-	100	-
Zinc	H	8[C]	15[C]	-
Non-metallic Inorganics				
Ammonia[E] (as NH_3-N at pH 8)		900[C]	910	-
Bromate		-	-	0.02
Chloride		-	-	-
Cyanide (as un-ionised Cn)		7	4	0.08
Fluoride		-	-	1.5
Hydrogen sulphide (un-ionised H_2S measured as S)		1	-	-
Iodide		-	-	0.5

Substance	Groundwater Investigation Levels		
	Fresh Waters[A]	Marine Waters[A]	Drinking Water[B]
	(µg/L)	(µg/L)	(mg/L)
Nitrate (as NO_3)	refer to guideline	refer to guideline	50
Nitrite (as NO_2)	refer to guideline	refer to guideline	3
Nitrogen	refer to guideline	refer to guideline	-
Phosphorus	refer to guideline	refer to guideline	-
Sulphate (as SO_4)	-	-	500
Organic alchohols/other organics			
Ethanol	1400	-	-
Ethylenediamine tetra-acetic acid (EDTA)	-	-	0.25
Formaldehyde	-	-	0.5
Nitrilotriacetic acid	-	-	0.2
Anilines			
Aniline	8	-	-
2,4-Dichloroaniline	7	-	-
3,4-Dichloroaniline	3	150	-
Chlorinated Alkanes			
Dichloromethane	-	-	0.004
Trichloromethane (chloroform)	-	-	0.003
Trihalomethanes (total)	-	-	0.25
Tetrachloromethane (carbon tetrachloride)	-	-	0.003
1,2-Dichloroethane	-	-	0.003
1,1,2-Trichloroethane	6500	1900	-
Hexachloroethane	290[D]	-	-
Chlorinated Alkenes			
Chloroethene (vinyl chloride)	-	-	0.0003
1,1-Dichloroethene	-	-	0.03
1,2-Dichoroethene	-	-	0.06
Tetrachloroethene (PCE) (Perchloroethene)	-	-	0.05
Chlorinated Benzenes			
Chlorobenzene	-	-	0.3
1,2- Dichlorobenzene	160	-	1.5
1,3- Dichlorobenzene	260	-	-

Substance	Groundwater Investigation Levels		
	Fresh Waters[A]	Marine Waters[A]	Drinking Water[B]
	(µg/L)	(µg/L)	(mg/L)
1,4- Dichlorobenzene	60	-	0.04
1,2,3- Trichlorobenzene	3[D]	-	0.03 for individual or total trichlorobenzenes
1,2,4- Trichlorobenzene	85[D]	20[D]	
1,3,5-Trichlorobenzene	-	-	
Polychlorinated Biphenyls (PCBs)			
Aroclor 1242	0.3[D]	-	-
Aroclor 1254	0.01[D]	-	-
Other Chlorinated Compounds			
Epichlorohydrin	-	-	0.1
Hexachlorobutadiene	-	-	0.0007
Monochloramine	-	-	3
Monocyclic Aromatic Hydrocarbons			
Benzene	950	500[C]	0.001
Toluene	-	-	0.8
Ethylbenzene	-	-	0.3
Xylenes	350 (as o-xylene) 200 (as p-xylene)	-	0.6
Styrene (Vinyl benzene)	-	-	0.03
Polycyclic Aromatic Hydrocarbons (PAHs)			
Naphthalene	16	50[C]	-
Benzo[a]pyrene	-	-	0.00001
Phenols			
Phenol	320	400	-
2-Chlorophenol	340[C]	-	0.3
4-Chlorophenol	220	-	-
2,4-Dichlorophenol	120	-	0.2
2,4,6-Trichlorophenol	3[D]	-	0.02
2,3,4,6-Tetrachlorophenol	10[D]	-	-
Pentachlorophenol	3.6[D]	11[D]	0.01
2,4-Dinitrophenol	45	-	-
Phthalates			
Dimethylphthalate	3700	-	-
Diethylphthalate	1000	-	-
Dibutylphthalate	10[D]	-	-
Di(2-ethylhexyl) phthalate	-	-	0.01

Substance	Groundwater Investigation Levels		
	Fresh Waters[A]	Marine Waters[A]	Drinking Water[B]
	(µg/L)	(µg/L)	(mg/L)
Pesticides			
Acephate	-	-	0.008
Aldicarb	-	-	0.004
Aldrin plus Dieldrin	-	-	0.0003
Ametryn	-	-	0.07
Amitraz	-	-	0.009
Amitrole	-	-	0.0009
Asulam	-	-	0.07
Atrazine	13	-	0.02
Azinphos-methyl	-	-	0.03
Benomyl	-	-	0.09
Bentazone	-	-	0.4
Bioresmethrin	-	-	0.1
Bromacil	-	-	0.4
Bromoxynil	-	-	0.01
Captan	-	-	0.4
Carbaryl	-	-	0.03
Carbendazim (Thiophanate-methyl)	-	-	0.09
Carbofuran	0.06	-	0.01
Carboxin	-	-	0.3
Carfentrazone-ethyl	-	-	0.1
Chlorantraniliprole	-	-	6
Chlordane	0.03[D]	-	0.002
Chlorfenvinphos	-	-	0.002
Chlorothalonil	-	-	0.05
Chlorpyrifos	0.01[D]	0.009[D]	0.01
Chlorsulfuron	-	-	0.2
Clopyralid	-	-	2
Cyfluthrin, Beta-cyfluthrin	-	-	0.05
Cypermethrin isomers	-	-	0.2
Cyprodinil	-	-	0.09
1,3-Dichloropropene	-	-	0.1
2,2-DPA	-	-	0.5
2,4-D [2,4-dichlorophenoxy acetic acid]	280	-	0.03
DDT	0.006[D]	-	0.009
Deltramethrin	-	-	0.04

Substance	Groundwater Investigation Levels		
	Fresh Waters[A]	Marine Waters[A]	Drinking Water[B]
	(µg/L)	(µg/L)	(mg/L)
Diazinon	0.01	-	0.004
Dicamba	-	-	0.1
Dichloroprop	-	-	0.1
Dichlorvos	-	-	0.005
Dicofol	-	-	0.004
Diclofop-methyl	-	-	0.005
Dieldrin plus Aldrin	-	-	0.0003
Diflubenzuron	-	-	0.07
Dimethoate	0.15	-	0.007
Diquat	1.4	-	0.007
Disulfoton	-	-	0.004
Diuron	-	-	0.02
Endosulfan	0.03[D]	0.005[D]	0.02
Endothal	-	-	0.1
Endrin	0.01[D]	0.004[D]	-
EPTC	-	-	0.3
Esfenvalerate	-	-	0.03
Ethion	-	-	0.004
Ethoprophos	-	-	0.001
Etridiazole	-	-	0.1
Fenamiphos	-	-	0.0005
Fenarimol	-	-	0.04
Fenitrothion	0.2	-	0.007
Fenthion	-	-	0.007
Fenvalerate	-	-	0.06
Fipronil	-	-	0.0007
Flamprop-methyl	-	-	0.004
Fluometuron	-	-	0.07
Fluproponate	-	-	0.009
Glyphosate	370	-	1
Haloxyfop	-	-	0.001
Heptachlor	0.01[D]	-	-
Heptachlor epoxide	-	-	0.0003
Hexazinone	-	-	0.4
Imazapyr	-	-	9
Iprodione	-	-	0.1
Lindane (γ-HCH)	0.2	-	0.01

Substance	Groundwater Investigation Levels		
	Fresh Waters[A]	Marine Waters[A]	Drinking Water[B]
	(µg/L)	(µg/L)	(mg/L)
Malathion	0.05	-	0.07
Mancozeb (as ETU, ethylene thiourea)	-	-	0.009
MCPA	-	-	0.04
Metaldehyde	-	-	0.02
Metham (as methylisothiocyanate, MITC)	-	-	0.001
Methidathion	-	-	0.006
Methiocarb	-	-	0.007
Methomyl	3.5		0.02
Methyl bromide	-	-	0.001
Metiram (as ETU, ethylene thiourea)	-	-	0.009
Metolachlor/s–Metolachlor	-	-	0.30
Metribuzin	-	-	0.07
Metsulfuron-methyl	-	-	0.04
Mevinphos	-	-	0.006
Molinate	3.4	-	0.004
Napropamide	-	-	0.4
Nicarbazin	-	-	1
Norflurazon	-	-	0.05
Omethoate	-	-	0.001
Oryzalin	-	-	0.4
Oxamyl	-	-	0.007
Paraquat	-	-	0.02
Parathion	0.004[C]	-	0.02
Parathion methyl	-	-	0.0007
Pebulate	-	-	0.03
Pendimethalin	-	-	0.4
Pentachlorophenol	-	-	0.01
Permethrin	-	-	0.2
Picloram	-	-	0.30
Piperonyl butoxide	-	-	0.6
Pirimicarb	-	-	0.007
Pirimiphos methyl	-	-	0.09
Polihexanide	-	-	0.7
Profenofos	-	-	0.0003

Substance	Groundwater Investigation Levels		
	Fresh Waters[A]	Marine Waters[A]	Drinking Water[B]
	(µg/L)	(µg/L)	(mg/L)
Propachlor	-	-	0.07
Propanil	-	-	0.7
Propargite	-	-	0.007
Proparzine	-	-	0.05
Propiconazole	-	-	0.1
Propyzamide	-	-	0.07
Pyrasulfatole	-	-	0.04
Pyrazophos	-	-	0.02
Pyroxsulam	-	-	4
Quintozene	-	-	0.03
Simazine	3.2	-	0.02
Spirotetramat	-	-	0.2
Sulprofos	-	-	0.01
2,4,5-T	36	-	0.1
Tebuthiuron	2.2	-	-
Temephos	-	0.05[D]	0.4
Terbacil	-	-	0.2
Terbufos	-	-	0.0009
Terbuthylazine	-	-	0.01
Terbutryn	-	-	0.4
Thiobencarb	2.8	-	0.04
Thiometon	-	-	0.004
Thiram	0.01	-	0.007
Toltrazuril	-	-	0.004
Toxafene	0.1 [D]	-	-
Triadimefon	-	-	0.09
Trichlorfon	-	-	0.007
Triclopyr	-	-	0.02
Trifluralin	2.6[D]	-	0.09
Vernolate	-	-	0.04
Surfactants			
Linear alkylbenzene sulfonates (LAS)	280	-	-
Alcohol ethoxylated sulfate (AES)	650	-	-
Alcohol ethoxylated surfactants (AE)	140	-	-

Substance	Groundwater Investigation Levels		
	Fresh Waters[A]	Marine Waters[A]	Drinking Water[B]
	(µg/L)	(µg/L)	(mg/L)

A Investigation levels apply to typical slightly-moderately disturbed systems. See ANZECC & ARMCANZ (2000) for guidance on applying these levels to different ecosystem conditions.

B Investigation levels are taken from the health values of the Australian Drinking Water Guidelines (NHMRC 2011).

C Figure may not protect key species from chronic toxicity, refer to ANZECC & ARMCANZ (2000) for further guidance.

D Chemical for which possible bioaccumulation and secondary poisoning effects should be considered, refer to ANZECC & ARMCANZ (2000) for further guidance.

E For changes in GIL with pH refer to ANZECC & ARMCANZ (2000) for further guidance.

H Values have been calculated using a hardness of 30 mg/L $CaCO_3$ refer to ANZECC & ARMCANZ (2000) for further guidance on recalculating for site-specific hardness.

Appendix D4: Sampling Protocols and QA/QC Definitions

SOIL AND GROUNDWATER SAMPLING PROTOCOLS

These protocols specify the basic procedures to be used when sampling soils or groundwater for environmental site assessments undertaken by EIS. The purpose of these protocols is to provide standard methods for: sampling, decontamination procedures for sampling equipment, sample preservation, sample storage and sample handling. Deviations from these procedures must be recorded.

Soil Sampling

a) Prepare a test pit/borehole log.
b) Layout sampling equipment on clean plastic sheeting to prevent direct contact with ground surface. The work area should be at a distance from the drill/rig excavator such that the drill rig/excavator can operate in a safe manner.
c) Ensure all sampling equipment has been decontaminated prior to use.
d) Remove any surface debris from the immediate area of the sampling location.
e) Collect samples and place in glass jar with a Teflon seal. This should be undertaken as quickly as possibly to prevent the loss of volatiles. If possible, fill the glass jars completely.
f) Collect samples for asbestos analysis and place in a zip-lock plastic bag.
g) Label the jar and/or bag with the EIS job number, sample location (eg. BH1), sampling depth interval and date. If more than one sample container is used, this should also be indicated (eg. 2 = Sample jar 1 of 2 jars).
h) Photoionisation detector (PID) screening of volatile organic compounds (VOCs) should be undertaken on samples using the soil sample headspace method. Headspace measurements are taken following equilibration of the headspace gasses in partly filled zip-lock plastic bags. PID headspace data is recorded on the borehole/test pit log and the chain of custody forms.
i) Record the lithology of the sample and sample depth on the borehole/test pit log in accordance with AS1726-1993[31].
j) Store the sample in a sample container cooled with ice or chill packs. On completion of the sampling the sample container should be delivered to the lab immediately or stored in the refrigerator prior to delivery to the lab. All samples are preserved in accordance with AS 4482.1:2005, AS 4482.2:1999 and AS/NZS 5667.1:1998.
k) Check for the presence of groundwater after completion of each borehole using an electronic dip metre or water whistle. Boreholes should be left open until the end of fieldwork. All groundwater levels in the boreholes should be rechecked on the completion of the fieldwork.
l) Backfill the boreholes/test pits with the excavation cuttings or clean sand prior to leaving the site.

Decontamination Procedures for Soil Sampling Equipment

a) All of the equipment associated with the soil sampling procedure should be decontaminated between every sampling location.
b) The following equipment and materials are required for the decontamination procedure:
   - Phosphate free detergent (Decon 90)
   - Potable water
   - Stiff brushes
   - Plastic sheets
c) Ensure the decontamination materials are clean prior to proceeding with the decontamination.
d) Fill both buckets with clean potable water and add phosphate free detergent to one bucket.

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

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

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

Groundwater Sampling

Groundwater samples are more sensitive to contamination than soil samples and therefore adhesion to this protocol is particularly important to obtain reliable, reproducible results. The recommendations detailed in AS/NZS 5667.1:1998 are considered to form a minimum standard.

The basis of this protocol is to maintain the security of the borehole and obtain accurate and representative groundwater samples. The following procedure should be used for collection of groundwater samples from previously installed groundwater monitoring wells.

a) After monitoring well installation, at least three bore volumes should be pumped from the monitoring wells (well development) to remove any water introduced during the drilling process and/or the water that is disturbed during installation of the monitoring well. This should be completed prior to purging and sampling.
b) Groundwater monitoring wells should then be left to recharge for at least three days before purging and sampling. Prior to purging or sampling the condition of each well should observed and any anomalies recorded on the field data sheets. The following information should be noted: the condition of the well, noting any signs of damage, tampering or complete destruction; the condition and operation of the well lock; the condition of the protective casing and the cement footing (raised or cracked); and, the presence of water between protective casing and well.
c) Take the groundwater level from the collar of the piezometer/monitoring well using an electronic dip meter. The collar level should be taken (if required) during the site visit using a dumpy level and staff.
d) Purging and sampling of piezometers/monitoring wells is done on the same site visit when using micro-purge (or low flow) techniques. Layout and organize all equipment associated with groundwater sampling in a location where they will not interfere with the sampling procedure and will not pose a risk of contaminating samples. Equipment generally required includes:
    - Micropore filtration system or Stericup single-use filters (for heavy metals samples).
    - Filter paper for Micropore filtration system.
    - Bucket with volume increments.
    - Sample containers: teflon bottles with 1 ml nitric acid, 75mL glass vials with 1 mL hydrochloric acid, 1 L amber glass bottles.
    - Bucket with volume increments.
    - Flow cell.
    - pH/EC/Eh/T meters.
    - Plastic drums used for transportation of purged water.
    - Esky and ice.
    - Nitrile gloves.
    - Distilled water (for cleaning).
    - Electronic dip meter.
    - Micro-purge pump pack and pump head.
    - Air and water tubing for Micro-purge.
    - Groundwater sampling forms.
e) If single-use stericup filtration is not being used, clean the Micropore filtration system thoroughly with distilled water prior to use and between each sample. Filter paper should be changed between samples. 0.45um filter paper should be placed below the glass fibre filter paper in the filtration system.

f) Ensure all non-disposable sampling equipment is decontaminated or that new disposable equipment is available prior to any work commencing at a new location. The procedure for decontamination of groundwater equipment is outlined at the end of this section.

g) Disposable gloves should be used whenever samples are taken to protect the sampler and to assist in avoidance of contamination.

h) Groundwater samples are obtained from the monitoring wells using low flow/micro-purge sampling equipment to reduce the disturbance of the water column and loss of volatiles.

i) During pumping to purge the well, the pH, temperature, conductivity, dissolved oxygen, redox potential and groundwater levels are monitored (where possible) using calibrated field instruments to assess the development of steady state conditions. Steady state conditions are generally considered to have been achieved when the difference in the pH measurements was less than 0.2 units and the difference in conductivity was less than 10%.

j) All measurements are recorded on specific data sheets.

k) Once steady state conditions are considered to have been achieved, groundwater samples are obtained directly from the pump tubing and placed in appropriate glass bottles, BTEX vials or plastic bottles.

l) All samples are preserved in accordance with water sampling requirements detailed in the NEPM 1999 and placed in an insulated container with ice. Groundwater samples are preserved by immediate storage in an insulated sample container with ice in accordance with AS/NZS 5667.1:1998.

m) Record the sample on the appropriate log in accordance with AS1726:1993. At the end of each water sampling complete a chain of custody form.

Decontamination Procedures for Groundwater Sampling Equipment

a) All of the equipment associated with the groundwater sampling procedure (other than single-use items) should be decontaminated between every sampling location.

b) The following equipment and materials are required for the decontamination procedure:
   - Phosphate free detergent.
   - Potable water.
   - Distilled water
   - Plastic Sheets or bulk bags (plastic bags)

c) Fill one bucket with clean potable water and phosphate free detergent, and one bucket with distilled water.

d) Flush potable water and detergent through pump head. Wash sampling equipment and pump head using brushes in the bucket containing detergent until all materials attached to the equipment are removed.

e) Flush pump head with distilled water.

f) Change water and detergent solution after each sampling location.

g) Rinse sampling equipment in the bucket containing distilled water.

h) Place cleaned equipment on clean plastic sheets.

i) If all materials are not removed by this procedure that equipment should not be used until it has been thoroughly cleaned

QA/QC DEFINITIONS

The QA/QC terms used in this report are defined below. The definitions are in accordance with US EPA publication SW-846, entitled *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (1994[32]) methods and those described in *Environmental Sampling and Analysis, A Practical Guide,* (H. Keith 1991[33]).

Practical Quantitation Limit (PQL), Limit of Reporting (LOR) and Estimated Quantitation Limit (EQL)

These terms all refer to the concentration above which results can be expressed with a minimum 95% confidence level. The laboratory reporting limits are generally set at ten times the standard deviation for the Method Detection limit (MDL) for each specific analyte. For the purposes of this report the LOR, PQL, and EQL are considered to be equivalent.

When assessing laboratory data it should be borne in mind that values at or near the PQL have two important limitations. *"The uncertainty of the measurement value can approach, and even equal, the reported value. Secondly, confirmation of the analytes reported is virtually impossible unless identification uses highly selective methods. These issues diminish when reliably measurable amounts of analytes are present. Accordingly, legal and regulatory actions should be limited to data at or above the reliable detection limit"* Keith 1991.

Precision

The degree to which data generated from repeated measurements differ from one another due to random errors. Precision is measured using the standard deviation or Relative Percent Difference (RPD). Acceptable targets for precision in this report will be less than 50% RPD for concentrations greater than ten times the PQL, less than 75% RPD for concentrations between five and ten times the PQL and less than 100% RPD for concentrations that are less than five times the PQL.

Accuracy

Accuracy is a measure of the agreement between an experimental result and the true value of the parameter being measured. The assessment of accuracy for an analysis can be achieved through the analysis of known reference materials or assessed by the analysis of surrogates, field blanks, trip spikes and matrix spikes.

The proximity of an averaged result to the true value, where all random errors have been statistically removed. Accuracy is measured by percent recovery. Acceptable limits for accuracy generally lie between 70% to 130% recoveries. Certain laboratory methods may allow for values that lie outside these limits.

Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Representativeness is primarily dependent upon the design and implementation of the sampling program. Representativeness of the data is partially ensured by the avoidance of contamination, adherence to sample handing and analysis protocols and use of proper chain-of-custody and documentation procedures.

Completeness

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[32] *SW-846: Test Methods for Evaluating Solid Waste, Physical/Chemical Methods,* US EPA, 1994 (US EPA SW-846)

[33] *Environmental Sampling and Analysis, A Practical Guide*, Keith, H, 1991 (Keith 1991)

Completeness is a measure of the number of valid measurements in a data set compared to the total number of measurements made and overall performance against DQIs. The following information is assessed for completeness:

- Chain-of-custody forms;
- Sample receipt form;
- All sample results reported;
- All blank data reported;
- All laboratory duplicate and RPDs calculated;
- All surrogate spike data reported;
- All matrix spike and lab control spike (LCS) data reported and RPDs calculated;
- Spike recovery acceptable limits reported; and
- NATA stamp on reports.

Comparability

Comparability is the evaluation of the similarity of conditions (eg. sample depth, sample homogeneity) under which separate sets of data are produced. Data comparability checks include a bias assessment that may arise from the following sources:

- Collection and analysis of samples by different personnel;
- Use of different techniques;
- Collection and analysis by the same personnel using the same methods but at different times; and
- Spatial and temporal changes (due to environmental dynamics).

Blanks

The purpose of laboratory and field blanks is to check for artifacts and interferences that may arise during sampling and analysis.

Matrix Spikes

Samples are spiked with laboratory grade standards to detect interactive effects between the sample matrix and the analytes being measured. Matrix Spikes are reported as a percent recovery and are prepared for 1 in every 20 samples. Sample batches that contain less than 20 samples may be reported with a Matrix Spike from another batch. The percent recovery is calculated using the formula below. Acceptable recovery limits are 70% to 130%.

$$\frac{(\text{Spike Sample Result} - \text{Sample Result})}{\text{Concentration of Spike Added}} \times 100$$

Surrogate Spikes

Samples are spiked with a known concentration of compounds that are chemically related to the analyte being investigated but unlikely to be detected in the environment. The purpose of the Surrogate Spikes is to check the accuracy of the analytical technique. Surrogate Spikes are reported as percent recovery.

Duplicates

Laboratory duplicates measure precision, expressed as Relative Percent Difference. Duplicates are prepared from a single field sample and analysed as two separate extraction procedures in the laboratory. The RPD is calculated using the formula where D1 is the sample concentration and D2 is the duplicate sample concentration:

$$\frac{(D1 - D2)}{\{(D1 + D2)/2\}} \times 100$$

Appendix E: Calculation Sheets

Appendix E1: Statistical Calculations (UCLs)

General UCL Statistics for Full Data Sets

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Lead

General Statistics			
Number of Valid Observations	7	Number of Distinct Observations	7
Raw Statistics		**Log-transformed Statistics**	
Minimum	17	Minimum of Log Data	2.833
Maximum	620	Maximum of Log Data	6.43
Median	33	SD of log Data	1.359
Mean	143.7	Mean of log Data	4.092
SD	222		
Coefficient of Variation	1.544		
Std. Error of Mean	83.89		
Skewness	2.159		

Warning: A sample size of 'n' = 7 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!
If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Warning: There are only 7 Values in this data
Note: It should be noted that even though bootstrap methods may be performed on this data set,
the resulting calculations may not be reliable enough to draw conclusions

The literature suggests to use bootstrap methods on data sets having more than 10-15 observations.

Relevant UCL Statistics			
Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.663	Shapiro Wilk Test Statistic	0.878
Shapiro Wilk Critical Value	0.803	Shapiro Wilk Critical Value	0.803
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		**Assuming Lognormal Distribution**	
95% Student's-t UCL	306.7	95% H-UCL	2100
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	396.9
95% Adjusted-CLT UCL (Chen-1995)	354.8	97.5% Chebyshev (MVUE) UCL	515.1
95% Modified-t UCL (Johnson-1978)	318.1	99% Chebyshev (MVUE) UCL	747.4
Gamma Distribution Test		**Data Distribution**	
k star (bias corrected)	0.49	Data appear Gamma Distributed at 5% Significance Level	
Theta Star	293.2		
MLE of Mean	143.7		
MLE of Standard Deviation	205.3		
nu star	6.862		
Approximate Chi Square Value (.05)	2.095	**Nonparametric Statistics**	
Adjusted Level of Significance	0.0158	95% CLT UCL	281.7
Adjusted Chi Square Value	1.393	95% Jackknife UCL	306.7
		95% Standard Bootstrap UCL	272.4
Anderson-Darling Test Statistic	0.659	95% Bootstrap-t UCL	1459
Anderson-Darling 5% Critical Value	0.74	95% Hall's Bootstrap UCL	1300
Kolmogorov-Smirnov Test Statistic	0.282	95% Percentile Bootstrap UCL	284.7
Kolmogorov-Smirnov 5% Critical Value	0.324	95% BCA Bootstrap UCL	315.7
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	509.4
		97.5% Chebyshev(Mean, Sd) UCL	667.6
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	978.4
95% Approximate Gamma UCL	470.7		
95% Adjusted Gamma UCL	708		

Potential UCL to Use	Use 95% Approximate Gamma UCL	470.7

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)
and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

BaP TEQ

General Statistics			
Number of Valid Observations	7	Number of Distinct Observations	4
Raw Statistics		Log-transformed Statistics	
Minimum	0.25	Minimum of Log Data	-1.386
Maximum	13	Maximum of Log Data	2.565
Mean	4.107	Mean of log Data	0.313
SD	5.479		
Coefficient of Variation	1.334		
Std. Error of Mean	2.071		
Median	2	SD of log Data	1.75
Skewness	1.192		

Warning: There are only 4 Distinct Values in this data
There are insufficient Distinct Values to perform some GOF tests and bootstrap methods.
Those methods will return a 'N/A' value on your output display!

It is necessary to have 4 or more Distinct Values to compute bootstrap methods.
However, results obtained using 4 to 9 distinct values may not be reliable.
It is recommended to have 10-15 or more observations for accurate and meaningful bootstrap results.

Warning: A sample size of 'n' = 7 may not adequate enough to compute meaningful and reliable test statistics and estimates!

It is suggested to collect at least 8 to 10 observations using these statistical methods!
If possible compute and collect Data Quality Objectives (DQO) based sample size and analytical results.

Relevant UCL Statistics			
Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.728	Shapiro Wilk Test Statistic	0.828
Shapiro Wilk Critical Value	0.803	Shapiro Wilk Critical Value	0.803
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	8.131	95% H-UCL	446.1
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	16.16
95% Adjusted-CLT UCL (Chen-1995)	8.51	97.5% Chebyshev (MVUE) UCL	21.29
95% Modified-t UCL (Johnson-1978)	8.287	99% Chebyshev (MVUE) UCL	31.36
Gamma Distribution Test		Data Distribution	
k star (bias corrected)	0.419	Data appear Gamma Distributed at 5% Significance Level	
Theta Star	9.802		
MLE of Mean	4.107		
MLE of Standard Deviation	6.345		
nu star	5.866		
Approximate Chi Square Value (.05)	1.572	Nonparametric Statistics	
Adjusted Level of Significance	0.0158	95% CLT UCL	7.513
Adjusted Chi Square Value	0.996	95% Jackknife UCL	8.131
		95% Standard Bootstrap UCL	7.303
Anderson-Darling Test Statistic	0.625	95% Bootstrap-t UCL	22.31
Anderson-Darling 5% Critical Value	0.747	95% Hall's Bootstrap UCL	33.93
Kolmogorov-Smirnov Test Statistic	0.264	95% Percentile Bootstrap UCL	7.214
Kolmogorov-Smirnov 5% Critical Value	0.326	95% BCA Bootstrap UCL	7.714
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	13.13
		97.5% Chebyshev(Mean, Sd) UCL	17.04
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	24.71
95% Approximate Gamma UCL	15.33		
95% Adjusted Gamma UCL	24.2		

Potential UCL to Use	Use 95% Approximate Gamma UCL	15.33

Recommended UCL exceeds the maximum observation

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)
and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.

Appendix E1: Site Specific ESLs/EILs/HSLs

SITE ASSESSMENT CRITERIA

				C_6-C10 (F1)	$>C_{10}$-C_{16} (F2)	Benzene	Toluene	Ethylbenzene	Xylenes	Naphthalene
PQL - Envirolab Services				25	50	0.2	0.5	1	3	1
HSL Land Use Category [1]				**RECREATIONAL**						
Sample Reference	**Sample Depth**	**Depth Category**	**Soil Category**							
BH102	0-0.2	0m to < 1m	Sand	NL	NL	NL	NL	NL	NL	NL
BH102	0.9-1.1	1m to <2m	Sand	NL	NL	NL	NL	NL	NL	NL
BH105	0-0.2	0m to < 1m	Sand	NL	NL	NL	NL	NL	NL	NL
BH105	1-1.2	1m to <2m	Sand	NL	NL	NL	NL	NL	NL	NL
BH106	0-0.2	0m to < 1m	Sand	NL	NL	NL	NL	NL	NL	NL
BH106	1-1.2	1m to <2m	Sand	NL	NL	NL	NL	NL	NL	NL
BH107	0-0.2	0m to < 1m	Sand	NL	NL	NL	NL	NL	NL	NL
BH107	1.5-1.7	1m to <2m	Sand	NL	NL	NL	NL	NL	NL	NL

EIL AND ESL ASSESSMENT CRITERIA

Land Use Category [1]			URBAN RESIDENTIAL AND PUBLIC OPEN SPACE																		
			pH	CEC ($cmol_c/kg$)	Clay Content (% clay)	AGED HEAVY METALS-EILs						EILs		ESLs							
						Arsenic	Chromium	Copper	Lead	Nickel	Zinc	Naphthalene	DDT	C_6-C_{10}	$>C_{10}$-C_{16}	$>C_{16}$-C_{34}	$>C_{34}$-C_{40}	Benzene	Toluene	Ethylbenzene	Total Xylenes	B(a)P
PQL - Envirolab Services			-	1	-	4	1	1	1	1	1	0.05	0.1	25	50	100	100	0.2	0.5	1	3	0.05
Ambient Background Concentration (ABC)			-	-	-	nsl	6	0.5	nsl	0.5	14	nsl	nsl	nsl	nsl	nsl	nsl	nsl	nsl	nsl	nsl	nsl
Sample Reference	**Sample Depth**	**Soil Texture**																			
BH102	0-0.2	Coarse	5.7	3.6	10	100	406	190.5	1100	30.5	244	710	180	180	120	300	2800	50	85	70	105	0.7
BH102	0.9-1.1	Coarse	NA	NA	NA	100	196	95.5	1100	30.5	84	710	180	180	120	300	2800	50	85	70	105	0.7
BH105	0-0.2	Coarse	6.9	6.8	12	100	406	190.5	1100	170.5	414	710	180	180	120	300	2800	50	85	70	105	0.7
BH105	1-1.2	Coarse	NA	NA	NA	100	196	95.5	1100	30.5	84	710	180	180	120	300	2800	50	85	70	105	0.7
BH106	0-0.2	Coarse	NA	NA	NA	100	196	95.5	1100	30.5	84	710	180	180	120	300	2800	50	85	70	105	0.7
BH106	1-1.2	Coarse	NA	NA	NA	100	196	95.5	1100	30.5	84	710	180	180	120	300	2800	50	85	70	105	0.7
BH107	0-0.2	Coarse	NA	NA	NA	100	196	95.5	1100	30.5	84	710	180	180	120	300	2800	50	85	70	105	0.7
BH107	1.5-1.7	Coarse	NA	NA	NA	100	196	60	1100	30	84	710	180	180	120	300	2800	50	85	70	105	0.7

Appendix F: Proposed Development Plans

KENNETH ROAD

CHANGE & KIOSK AMENITIES

NEW BUS SHELTER

RL 2.7

EXISTING CAR PARK TO BE EXENDED
46 SPACES

RL 2.7

LANDSCAPED AREA

TODDLER'S POOL
TO BE RETAINED

TODDLER'S POOL
TO BE RETAINED

EXISTING 25m POOL TO BE RETAINED

RL 4.2

EXISTING HEATED 50m POOL TO BE RETAINED

RL 4.0

NEW SWITCH ROOM

EXISTING SUBSTATION

BALGOWLAH ROAD

PLAY ROOM

CRECHE
130sqm

COT ROOM

ENTRY

RL 5.4

BOY ROOM

LOBBY

RECEPTION

OFFICES

SHOP

CENTRE MANAGER

CONTROL ROOM

STAFF CHANGE

STAFF MEETING

FEMALE CHANGE

MALE CHANGE

USAC

FAMILY CHANGE

USAC

CONCOURSE LOCKERS

CONCOURSE SHOWERS

STORE

POOL PLANT

RL 4.2

RL 4.2

SUN DECK

25m POOL
485sqm

1.5m DEEP

1.25m DEEP

PROGRAM POOL
155sqm

1.25m DEEP

0.875m DEEP

SERVERY

FIRST AID

KITCHEN

PLANT ROOM TO BE RETAINED

SWIM CLUB TO BE RETAINED

SCHOOL ENTRY

BUS PARKING (3)

BALGOWLAH ROAD

RL 4.2

SPECTATOR SEATING

RL 4.2

RL 5.4

RL 5.4

BEACH ENTRY

LEISURE POOL
340sqm

SLIDE

RL 5.4

RL 6.0

SAUNA

SHR

STEAM

SPA

ACCESS WAY

RL 3.4

SPA PLANT

BALGOWLAH ROAD

Verify all dimensions shown at the site. Work only to figured dimensions. Do not scale the drawings. Report any discrepancies to the Architect for decision and clarification.

This drawing should be read in conjunction with the relevant Contracts, Specifications, and Drawings.

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Client

MANLY COUNCIL

Project

MANLY ANDREW "BOY" CHARLTON SWIM CENTRE REDEVELOPMENT

DRAWING TITLE

GROUND FLOOR PLAN

PROJECT/DRAWING NUMBER	1310	104
SCALE	1 : 250	@ B1
PLOT DATE	2013/08/01 1:22:03 PM	

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