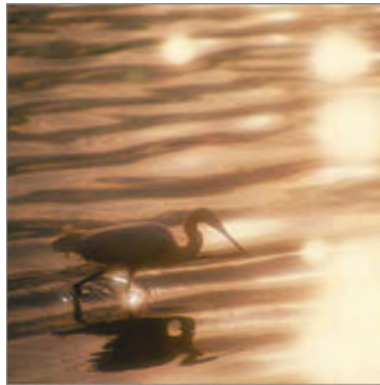


Prepared for

University of Sydney

Abercrombie Precinct Redevelopment

Phase II Environmental Assessment



Final Report

June 2011

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Executive Summary

CH2M HILL Australia Pty Ltd (CH2M HILL) has been commissioned by The University of Sydney (UoS) to conduct a Phase II Environmental Assessment (Phase II EA) as part of the Abercrombie Precinct Redevelopment in Darlington, New South Wales (the Site). The Phase II EA is in support of a Part 3a Major Project Application for the Abercrombie Precinct Redevelopment. This Phase II EA focused on characterising soil and groundwater in accessible areas of the Site. A second phase of investigation will be required to characterise areas of the Site that are currently covered by building footprints and their immediate surrounds.

The objective of the Phase II EA was to further investigate and characterise the potential areas of concern (PAOC) identified by Sinclair Knight Merz Pty Ltd (SKM) in their Phase I EA (2010). In addition to the PAOC identified by SKM, this Phase II EA also serves to provide baseline information on the soil and groundwater quality across other areas of the Site. The scope of work conducted onsite has also allowed for a preliminary waste classification of material present at the Site.

The Site is approximately 1.92 hectares (ha), which includes both accessible and inaccessible areas, and is zoned Special Use (University). Current land use is primarily tertiary education, comprising a number of existing buildings owned by UoS, along with several roads that are currently being purchased from the City of Sydney Council. Various buildings onsite have been used historically as storage facilities for fuels, oils and lubricants and two transformers were identified onsite by SKM during the Phase I EA (2010).

The scope of works comprised a review of background information including aerial photographs and the previous Phase 1 EA performed by SKM (2010). An intrusive site investigation was performed including the excavation of 13 boreholes and the installation of three groundwater monitoring wells (GWMWs). Soil and groundwater samples were collected and analysed for a range of typical contaminants associated with the former uses and possible import of fill onsite. Results from the analyses were assessed against the adopted site criteria, which forms the basis of this report.

The soils across the Site generally consisted of 0.5 – 0.7 m of fill, underlain by natural clays and shale. Contaminant levels in soil samples collected from the Site were generally found to be below the adopted site criteria for commercial / industrial land use (suitable for the existing and future 'Special Use (University)' land use), with the exception of a few specific locations where adopted site criteria were exceeded for total petroleum hydrocarbons (TPH) and polycyclic aromatic hydrocarbons (PAH), primarily within the ash material used in the fill across the Site.

In general, based on the samples analysed, the majority of fill material at the Site is classified as 'general solid waste'. However, at one location, where there were no visual or olfactory signs of contamination, a limited volume of soil is classified as 'restricted solid waste'.

Groundwater samples collected from the GWMWs generally reported levels of contamination below the adopted site criteria, with the exception of low level exceedences of several heavy metals. These heavy metals are considered likely to be migrating onto the Site from up-hydraulic gradient. Although TPH and PAH concentrations in the fill material exceeded the adopted site criteria, these contaminants were not detected above the laboratory limit of reporting (LOR) in the groundwater. Therefore, it is unlikely that the TPH and PAH detected in the fill material is mobilising into the groundwater.

Due to the contamination identified at the Site, management and remediation is recommended prior to or during redevelopment in order to reduce the risk to site workers and future users of the Site. The key recommendation is remediation / management of the soil hotspot contamination, which is predominantly associated with ash material. Suitable remediation / management techniques may include capping and implementation of an Environmental Management Plan (EMP) and/or hotspot excavation for offsite disposal. These options should be further evaluated through the development of a Remedial Action Plan (RAP) for the Site.

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Abbreviations	
ACM	Asbestos Containing Material
AHD	Australian Height Datum
ALS	Australian Laboratory Services
ANZECC	Australia and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
CH2M HILL	CH2M HILL Australia Pty Ltd
CLM Act	Contaminated Land Management Act 1997 (as amended)
CoC	Chain of Custody
CoPC	Contaminants of Potential Concern
CT	Contaminant Threshold
DO	Dissolved Oxygen
DQI	Data Quality Indicators
DQO	Data Quality Objectives
DSI	Detailed Site Investigation
DUAP	NSW Department of Urban Affairs and Planning
EA	Environmental Assessment
EC	Electrical Conductivity
EMP	Environmental Management Plan
ESA	Environmental Site Assessment
GWMW	Groundwater Monitoring Well
ha	Hectares
HIL	Health Investigation Level
HSEP	Health, Safety and Environment Plan
km	Kilometre
LCS	Laboratory Control Sample
LOR	Limit of Reporting
m	Metres
mbgl	Metres Below Ground Level

Abbreviations	
mbTOC	Metres Below Top of Casing
µg/L	Micrograms Per Litre
mg/L	Milligrams Per Litre
MS/MSD	Matrix spike and Matrix Spike Duplicate
NA	Not Applicable
NATA	National Association of Testing Authorities
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NHMRC	National Health and Medical Research Council
NSW	New South Wales
NSW DEC	New South Wales Department of Environment and Conservation
NSW DECC	New South Wales Department of Environment and Climate Change
NSW DECCW	New South Wales Department of Environment, Climate Change and Water
NSW EPA	New South Wales Environment Protection Authority
NW	North West
OCP / OPP	Organochlorine Pesticides / Organophosphate Pesticides
OEH	NSW Office of Environment and Heritage
PAH	Polycyclic Aromatic Hydrocarbons
PAOC	Potential areas of concern
PARCC	Precision, Accuracy, Representativeness, Comparability and Completeness
PCB	Polychlorinated Biphenyls
PID	Photo Ionisation Detector
ppm	Parts Per Million
QA/QC	Quality Assurance / Quality Control
RPDs	Relative Percent Differences
S	South
SAQP	Sampling Analysis and Quality Plan
SCC	Specific Contaminant Concentration
SKM	Sinclair Knight Merz Pty Ltd

Abbreviations	
SOP	Standard Operating Procedure
SW	South West
SWL	Static Water Level
TCLP	Toxicity Characterisation Leaching Procedure
TPH	Total Petroleum Hydrocarbons
UCL	Upper Confidence Limit
UoS	The University of Sydney
USEPA	United States Environment Protection Authority
UST	Underground Storage Tank
VOC	Volatile Organic Compounds

1 Introduction

CH2M HILL Australia Pty Ltd (CH2M HILL) was commissioned by the University of Sydney (UoS) to conduct a Phase II Environmental Assessment (Phase II EA) as part of the Abercrombie Precinct Redevelopment in Darlington, New South Wales (NSW) (the Site). The site location is presented on **Figure 1**.

The Site is approximately 1.92 hectares (ha) and is zoned Special Use (University). The Site comprises a number of buildings owned by the UoS, a number of access roadways owned by the City of Sydney Council (Council), the UoS landscaping compound and a small park located on the north-eastern corner of Abercrombie Street and Codrington Street. The Council roads and assets are currently being purchased by the UoS from Council. This Phase II EA focused on Stage 1 of the Abercrombie Precinct Redevelopment, which excludes buildings H69, H09, H08, H67 and H68 and their immediate surrounds (as shown on **Figure 2**). Building H69 has been redeveloped already, whereas the other buildings and their surrounds will be redeveloped as Stage 2 of the Redevelopment works.

This report has been prepared in accordance with the documents made or endorsed by the NSW Office of Environment and Heritage (OEH)¹ under the Contaminated Land Management Act (CLM Act) 1997 (as amended), and other relevant guidance. The following documents have been used as guidance to prepare this report:

- Australia and New Zealand Environment and Conservation Council (ANZECC) and National Health and Medical Research Council (NHMRC) (ANZECC, 1992) *Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites*.
- ANZECC and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (ANZECC, 2000) *Australia and New Zealand Guidelines for Fresh and Marine Water Quality*.
- NSW Department of Environment and Conservation (NSW DEC, 2007), *Contaminated Sites: Guidelines for the Assessment and Management of Groundwater Contamination*.
- Department of Urban Affairs and Planning (DUAP, 1998), *Managing Land Contamination: Planning Guidelines SEPP55 Remediation of Land*.
- enHealth (2005) *Management of Asbestos in the Non-Occupational Environment*.

¹ In September 2003, the NSW Environment Protection Authority (NSW EPA) became a part of the NSW Department of Environment and Conservation (NSW DEC), on 27th April 2007, the NSW DEC was renamed as the NSW Department of Environment and Climate Change (NSW DECC) with the department changing to the NSW Department of Environment, Climate Change and Water (DECCW) in August 2009. On 4 April 2011, the NSW DECCW was abolished with the majority of its functions transferred to the new NSW Office of Environment and Heritage (OEH), a division in the Department of Premier and Cabinet. However, certain statutory functions and powers continue to be exercised in the name of the NSW EPA. The use of the names OEH, NSW DECCW, NSW DECC, NSW DEC and NSW EPA in this report are considered interchangeable and are to be interpreted as one and the same.

- National Environment Protection Council (NEPC, 1999) *National Environment Protection (Assessment of Site Contamination) Measure (NEPM) – Schedule B(1) Guideline on the Investigation Levels for Soil and Groundwater*.
- NSW Environment Protection Authority (NSW EPA, 1995) *Contaminated Sites: Sampling Design Guidelines*.
- NSW DEC (2006) *Contaminated Sites: Guidelines for the NSW Site Auditor Scheme* (2nd Ed.).
- NSW EPA (1994) *Contaminated Sites: Guidelines for Assessing Service Station Sites, 1994*.
- NSW EPA (1997) *Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites*.
- NSW Department of Environment and Climate Change (NSW DECC, 2009) *Contaminated Sites: Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997*.
- NSW Department of Environment, Climate Change and Water (NSW DECCW, 2009) *Waste Classification Guidelines*.

1.1 Background and Objectives

The UoS plan to redevelop the Site to create a new Economics and Business School that will form part of the UoS Darlington Campus (UoS, 2010). Prior to the redevelopment of the Site, the UoS has requested that a Phase II EA be conducted focusing on the characterisation of soil and groundwater in areas currently accessible to support their Part 3a Major Project Application for the Site. A second stage of investigation will be required to characterise areas of the Site that are currently covered by building footprints, and those that comprise Stage 2 of the redevelopment.

A Phase I EA was recently carried out for the Site by Sinclair Knight Merz Pty Ltd (SKM) in 2010. The SKM report (2010) identified a number of Potential Areas of Concern (PAOC) for the Site, based on the history of filling and particular land uses at the Site. This Phase II EA addresses recommendations from the SKM report (2010).

The main objective of the Phase II EA was to further investigate and characterise the PAOC identified by SKM in the Phase I EA. In addition to the PAOC, the Phase II EA also serves to provide baseline information on the soil and groundwater quality across other areas of the Site that were not investigated by SKM and to provide a preliminary waste classification of material present at the Site.

1.2 Scope of Work

To achieve the objective above, the following scope of work was completed by CH2M HILL:

- reviewed background information and data for the project

- prepared and submitted site safety and environmental documentation for the fieldworks, in the form of a Health, Safety and Environment Plan (HSEP)
- completed underground service searches
- prepared and submitted a Sampling, Analysis and Quality Plan (SAQP) for the works
- completed field investigations in accordance with the approved SAQP
- surveyed the position and elevation of the groundwater monitoring wells (GWMWs) installed as part of the investigation
- provided a Phase II EA report (this report).

2 Site Description

2.1 Site Location and Identification

The Site forms part of the UoS Darlington Campus, located in the suburb of Darlington, NSW, and is located on the north-eastern corner of Abercrombie Street and Codrington Street (**Figure 1**). The Site has an area of approximately 1.92 ha. **Table 2-1** below provides identification information for the Site. Site photos are presented in **Appendix A**.

Table 2-1
Site Identification Data

Street Address	Corner Abercrombie and Codrington Street, Darlington, NSW
Property Description	Forms part of the UoS Darlington Campus. The Site comprises operational and vacated UoS buildings, Council owned access roads, a grassed park and a landscaping compound.
Area	Approximately 1.92 ha (including areas excluded in this Phase II EA)
Current Zoning	Special use (university)
Current Land Use	Tertiary educational purposes
Proposed Land Use	Tertiary educational purposes - economics and business school
Local Government Area	City of Sydney
Parish	Petersham
County	Cumberland

2.2 Site Details and Condition

The majority of the Site is owned by the UoS, mostly comprising of existing UoS buildings, some still operational and some vacated. The UoS owned buildings are summarised below and identified on **Figure 2**:

- Economics and Business Building (H69)
- Clark Building (H12)
- Joiners Shop (H05)
- Geology Temporary Buildings (H11)
- University Computing Centre (H08)
- Mandelbaum House (H67)
- Shepherd Centre (H68)
- Boundary Lane Childcare Centre (H09).

As mentioned in Section 1, this Phase II EA focused on Stage 1 of the Abercrombie Precinct Redevelopment, which excludes buildings H69 (which has already been redeveloped), H09, H08, H67 and H68 and their immediate surrounds.

2.3 Surrounding Land Use

The Site is located in an area of mixed residential and further UoS owned (tertiary education) land. The land uses of the areas surrounding the Site are as follows:

- North* The Site is bound by Darlington Lane. UoS owned residential terrace buildings are located beyond Darlington Lane and additional educational UoS facilities are located to the north of the terrace buildings.
- East* The Site is bound by Codrington Street. The UoS services building and sports and aquatic centre are located to the east of this street.
- South* The Site is bound by Abercrombie Street and further to the south is the Eveleigh carriage works, the train line and residential terrace housing.
- West* Darlington Public School is located to the west of the Site, with residential properties located further west.

2.4 Topography

The general topography of the Site is flat with a slight incline from the small park located at the south-eastern corner of the Site to the landscaping compound located on Darlington Lane. The landscaping compound located on Darlington Lane is therefore generally elevated compared to the rest of the Site. There is also a slightly elevated mound located between buildings H05 and H12.

2.5 Soil and Geology

The soils landscape sheet 9130 (Soil Conservation Service, 1983) shows the area as Blacktown soil landscape. This type of landscape is characterised by gently undulating rises on Wianamatta Group shales and Hawkesbury shale. The soils landscape sheet (Soil Conservation Service, 1983) indicates local relief of up to 30 m and slopes of <5%. At the Site, gentle slopes were observed, however local filling has altered the natural topography of the land. The soils landscape sheet (Soil Conservation Service, 1983) indicates that natural vegetation would have comprised cleared woodland and tall open forest, however this area is now completely developed with no natural vegetation remaining.

The geological series sheet 9130 (Geological Survey of NSW, 1983) shows the geology of the Site consists of Ashfield Shale, which consists of black to dark grey shale and laminate. Within the site boundary, field observations indicate that the natural geological series and soils are overlain by imported fill and natural reworked material, of between at least approximately 0.5 m and 0.7 m.

2.6 Hydrogeology

There are no permanent water courses located at the Site. The nearest water course to the Site, Johnson's creek, is located 1.7 kilometres (km) west of the Site. Blackwattle Bay is located approximately 1.75 km north of the Site.

A search of registered groundwater bore records from the NSW Natural Resource Atlas was reviewed by CH2M HILL on the 17th March 2011 and the results are summarised in **Table 2-2** below.

Table 2-2

NSW Natural Resource Atlas Groundwater Bore Records within 1km of the Site

<i>Bore ID</i>	<i>Drilled Depth</i>	<i>Standing Water Level</i>	<i>Distance from Site</i>	<i>Screen Depth</i>	<i>Authorised/Intended Purpose</i>
GW110247	210 m	30 m	200 m NW	NA	Domestic
GW105938	NA	NA	400 m S	NA	Domestic
GW10729	2.4 m	2 m	500 m SW	3-6 m	Monitoring
GW109730	6.5 m	1 m	500 m SW	3-6.5 m	Monitoring

Table Notes:

m – metres

NA – not applicable

NW – north west

S – south

SW – south west

Section 8 details the field observations and groundwater flow direction.

3 Site History

Prior to use of the Site for the purpose of “Special Use (University)”, the Site has been used for a number of activities with the potential to cause contamination. The results of an aerial photo review and review of previous reports are discussed below.

3.1 Aerial Photographs

Aerial photographs were sourced and reviewed as part of the scope of works to assess the history of filling activities at the Site. SKM (2010) reviewed historical aerial photographs, however CH2M HILL reviewed a limited number of the same photographs and some different photographs to identify any potential for contamination. Photographs from a total of seven periods were reviewed comprising 1961, 1970, 1986, 1994, 1999, 2006 and 2011. Copies of the aerial photographs viewed during CH2M HILL’s appraisal are included in **Appendix B**. The findings are detailed below:

1961

The aerial photograph shows the Site to be residentially developed with low rise terrace houses covering the entire site. There also appears to be a large building in the location of the building currently identified as the Joiners Hop (H05). Further details of the Site are not clearly defined in the photograph. The gradient and elevation of the Site is unclear. There does not appear to be any vegetation present on site.

The area north of the Site consists of residential housing, similar to that of the Site, and UoS grounds. The area south of the Site consists of residential housing and train lines. The area east and west of the Site appears to be used for residential housing.

1970

The Site remains similar to the previous photo with residential housing covering the entire site, with the exception of the Joiners Shop (H05) building. There is no observable vegetation present on site.

Several buildings have been demolished on land east of the Site and remains as cleared land, possibly being used for car parking. Apart from the clearing of land to the east of the Site, surrounding areas have changed very little.

1986

The majority of the Site appears to have changed dramatically. The residential buildings have been demolished across the Site. The building now identified as the Clark Building (H12) and the Joiners Shop (H05) have been constructed and the majority of the Site appears to be used as a car park. The land now identified as the economics and business building (H69) appears to be cleared and unused. A large building now identified as Boundary Lane Child Care Centre (H09) appears to have been built. The park at the Abercrombie Road end of the Site is present and is grassed and vegetated.

There is no evidence of stockpiling of fill materials, which indicates possible filling has occurred prior to this photo being taken. Changes to the gradient and elevation of the Site are unclear.

The land that appeared to be cleared east of the Site in the previous photo is now developed into UoS buildings. The residential houses to the west of the Site, in the current location of the Darlington Public School, have also been demolished and the area redeveloped. Other land surrounding the Site has no significant changes.

1994

The building now identified as the Shepherd Centre (H08) appears to have been built. The majority of the rest of the Site appears to remain the same as the previous photo. Some grass and vegetation has grown on the cleared areas. The land now identified as the Geology Temporary Buildings (H11) appears to be used as a car park.

The land surrounding the Site has no significant changes.

1999

There appears to have been some changes to the Site. Land where the current landscaping area is located appears to have been cleared of grass, indicating it may be being used as the landscaping area at this point in time. Mandelbaum House (H67) appears to have been built. The rest of the Site appears to remain the same.

Further development to building east of the Site has occurred. No other significant changes to the land surrounding the Site have occurred.

2006

All of the university buildings that are now present on site have been built, including the Economics and Business Building (H69) and the Geology Temporary Buildings (H11). There is also a shed present in western corner of the landscaping compound, which exists currently.

No significant changes have been made to the land surrounding the Site.

2011

The Site is in similar condition to the 2006 photo, with no apparent changes observed.

No significant changes have been made to the land surrounding the Site.

3.2 Previous Investigations

Three previous reports have been provided by the UoS and reviewed as part of this Phase II EA, as discussed below.

Report on Geotechnical Investigation and Preliminary Contamination Assessment, Douglas Partners (1998)

A Preliminary Contamination Assessment for the Economics and Business Building (H69) area was carried out in 1998 by Douglas Partners. This report was carried out to provide information on the subsurface conditions of the Site and to make a preliminary assessment of the degree of heavy metal, polycyclic aromatic hydrocarbon (PAH) and total petroleum hydrocarbon (TPH) contamination, if any, of the soils beneath the Site. The results of the assessment found a hot spot of PAH contamination located below the future building. Douglas Partners advised that the development of the Site was suitable on the proviso that all of the fill material from under the proposed building was excavated, classified and removed to a NSW EPA approved landfill.

Phase 1 Environmental Assessment, SKM (2010)

A Phase 1 EA was undertaken at the Site by SKM in 2010. The Phase I EA included all of the Site, as well as several adjacent areas also owned by UoS. SKM undertook a review of sources of historical information including aerial photos, Department of Health files held by council, council property files and historical titles search. SKM also reviewed publicly available council records, performed a site inspection and a review of the site condition and surrounding environment. After a review of this information, SKM (2010) concluded the following, of relevance to the current area of investigation:

- Potential fill at the Site is likely present as fill embankments. The source of the fill material is believed to be unknown, though it may be construction material that was displaced during the demolition or construction of buildings on the Site.
- The chemicals of significance identified on the Site include fertilisers stored in the area now identified as the landscaping compound.
- Chemicals associated within the Joiner's Shop (H05) are likely to have been removed post 2008.
- PAOC identified for the Precinct include:
 - Fill areas around the borders of existing buildings, including larger areas identified to the west of Building H69 and between Buildings H12 and H05
 - Building H05 (Joiners Shop)
 - Chemical storage in the shed in the landscaping compound
 - A generator located to the east of Building H08
 - Transformers located between Buildings H67 and H08, and to the west of Building H69 near Darlington Lane.

- Potential fill areas, possibly containing construction waste materials from previous development within the Precinct, is considered to present a medium relative level of risk with respect to contamination. The Joiners Shop (H05), shed in the landscaping compound, generator, and transformers are considered to represent lower risks with respect to contamination.

Based on the available information and site observations, it was concluded that the levels of contamination, if present, are unlikely to prevent the proposed development.

SKM provided the following recommendations based on their findings:

- that an intrusive Phase II EA be conducted at the Site in order to further define the potential risks associated with possible contamination at the Site; and
- that a combination of systematic and judgemental sampling be undertaken as part of the above recommended Phase II EA to allow a general characterisation of the Site and to target the PAOC identified during the Phase I EA.

Stage II Environmental Site Assessment, 2-10 Golden Grove Street, Darlington NSW, AECOM (2010)

A Stage II Environmental Site Assessment (ESA) of the area identified as the Boundary Lane Childcare Centre (H09) was undertaken by AECOM in 2010. The ESA was undertaken prior to the development of the childcare centre to assess the suitability for development. It is understood that two petroleum Underground Storage Tanks (USTs) were previously installed at this location and had been removed in 1998, prior to the ESA being conducted, and backfilled with a sand and cement mixture. An asphalt hardstand area located east of building H09 was noted to have 'several oil / fuel containers, with some staining evident on the ground surface'. TPH contamination was identified in soil, likely to have been sourced from the previous UST at the Site. PAH contamination was also identified in soil, likely to be associated with fill material located across the assessment area.

The following recommendations were included in the report:

- soil vapour assessments should be conducted across the assessment area – these need to show that an unacceptable risk is not present
- a concrete slab should be put in place prior to the development of the area into a childcare centre, with an Environmental Management Plan (EMP) implemented and adhered to.

CH2M HILL notes that the childcare centre has now been built, and a concrete slab over the fill material is visible across the area.

4 Data Quality Objectives

The Data Quality Objectives (DQO) process is a seven-step planning approach used to prepare plans for environmental data collection activities. It provides a systematic approach for defining the criteria that a data collection design should satisfy, including when, where and how to collect samples or measurements; determination of tolerable decision error rates; and the number of samples or measurements that should be collected (United States Environment Protection Agency - USEPA, 2000).

The seven step DQO process is outlined in the SAQP (CH2M HILL, 2011) and summarised in the followings sections.

Step 1 – State the Problem

Existing UoS land that forms the Site is to be redeveloped for the purpose of a new Economics and Business school on the UoS Darlington campus. A number of PAOC have previously been identified at the Site (SKM, 2010). In support of a Part 3a Major Project Application, information is required on potential contamination in soil and groundwater, as well as management actions that may be necessary to permit the proposed works.

Step 2 – Identify the Decision

The principal study questions that arise from Step 1:

- Is there contamination in soil or groundwater at the Site?
- Is any contamination migrating onto or off the Site?
- What implications does the contamination have on the suitability of the Site for the proposed development (considered to be commercial/industrial landuse)?
- Could identified contamination require UoS to provide notification to the NSW EPA?
- Is remediation and/or management of the Site required to enable the Site to be suitable for the proposed land use?

These questions will in-turn provide a basis to complete the study objectives.

Step 3 – Identify Inputs to the Decision

The primary inputs required include:

- Any relevant background data provided by UoS, previous reports, and data obtained from regulatory searches
- Visual and olfactory observations made during field investigations and field screening of volatile compounds using a photo ionisation detector (PID)
- Laboratory results of surface and sub-surface soil samples for contaminants of potential concern (CoPC)
- Laboratory results of groundwater samples for CoPC; and

- Appropriate assessment criteria. The following assessment criteria have been adopted:
 - Soils – NEPM (1999) Health Investigation Level F (HIL F) – Commercial / industrial (based on the current and proposed use of the Site as ‘Special Use (University)’), NSW EPA (1994) threshold concentrations for TPH and benzene, toluene, ethylbenzene and xylenes (BTEX);
 - Groundwater – ANZECC (2000) Aquatic Ecosystem 95% Protection Trigger Values for Marine Water (based on anticipated groundwater conditions and the receiving environment);
 - Waste – NSW DECC (2009) Waste Classification Guidelines.

Step 4 – Define the Study Boundaries

The purpose of this step is to specify the spatial and temporal aspects of the environmental media that the data must represent to support the decision.

Spatial Boundaries

The spatial boundary of the Phase II EA is limited to the area of the Site shown on **Figure 1**, which comprises a total area of 1.92 ha. CH2M HILL understands that the proposed redevelopment of the Site will not include the existing Economics and Business building (H69). This building occupies approximately 0.27 ha of the Site, therefore reducing the overall site area to 1.65 ha. Further, CH2M HILL believes that the redevelopment of the Site will occur in two stages, therefore a further four buildings and their surrounds have been excluded from this Phase II EA, further reducing the site area currently under investigation. A number of the suggested soil boring locations (marked in yellow on **Figure 2**) are located beneath existing building footprints. These locations will be sampled in a second stage of investigation following building demolition. The scope of work is therefore restricted to the 16 boring locations that are currently accessible (marked in blue and red on **Figure 2**). These comprised soil boreholes BH01 – BH13 and GWMW MW01 – MW03.

The depth of sample points varied depending on the location. Sample points generally penetrated 0.5 m into natural material and extended to a maximum depth of 1.5 m below ground level (mbgl). At two locations (BH11 and BH12), refusal occurred before natural material was encountered. These locations were on a steep fill embankment and therefore the intrusive works were restricted to the use of a hand auger.

Boreholes for the installation of GWMWs were drilled to at least 1 m below the level of encountered groundwater, but to a maximum depth of 9 mbgl, to ensure that a suitable thickness of groundwater is penetrated for sample collection.

Temporal Boundaries

The drilling and soil sampling of the boreholes and GWMWs was undertaken on 22 and 23 March 2011. Drilling was scheduled to commence on 21 March 2011, but was postponed due to inclement weather. The groundwater sampling was undertaken on 1 April 2011.

Step 5 – Develop a Decision Rule

The purpose of this step is to develop a logical “if...then...” statement, or a series of such statements, that defines the conditions that would cause the decision maker to choose among alternative actions.

The decision rules for the Phase II EA are:

- If a soil sample concentration for a CoPC exceeds the adopted site criteria by 250% ($>2.5 \times$ criteria), then this area shall be treated as a contamination ‘hotspot’ requiring further assessment or management.
- If the 95% upper confidence limit of the arithmetic average (95% UCL) concentration for a CoPC in the analysed soil samples collected exceeds the adopted site criteria, then make conclusions as to potential risks to human health and the environment and the Site’s suitability for proposed Special Use (University) development based on statistical analysis and current regulatory guidance.
- If the standard deviation of the arithmetic average concentration for a CoPC in the analysed soil samples collected exceeds 50% of the adopted site criteria ($>0.5 \times$ criteria), then make conclusions as to potential risks to human health and the environment and the Site’s suitability for proposed Special Use (University) development based on statistical analysis and current regulatory guidance.
- If concentrations of groundwater contaminants exceed adopted site criteria, then make conclusions as to potential risks to human health and the environment.
- If quality control sample results are outside of the data quality assessment criteria forming the data quality indicators (DQI), then implement non-conformance action.
- If aesthetics impacts (such as odours, staining or deleterious materials), or multiple contaminants that may form a chemical mixture, are identified these will be assessed in the context of the proposed site use and conclusions will be made as to whether management of these impacts is required.

An additional decision rule noted in the SAQP was that if unexpected conditions on site require adjustment to the SAQP, then CH2M HILL would contact UoS to discuss appropriate changes while already on site to avoid, where possible, re-mobilisation. During the underground services clearance, it was identified that multiple soil sampling locations had to be moved in order to avoid buried services. The locations of all final soil sampling locations were discussed with UoS personnel prior to installation.

Step 6 – Specify the Limits on Decision Errors

The purpose of this step is to specify the decision maker's tolerable limits on decision errors, which are used to establish performance goals for limiting uncertainty in the data.

Specific limits, or DQI, for this project are in accordance with the appropriate guidance from the NSW EPA, NEPC (1999), ANZECC (2000), appropriate indicators of data quality, and standard CH2M HILL procedures for field sampling and handling. The DQI are presented in **Appendix H**.

Decision errors are sampling errors (i.e., samples do not represent site conditions) and measurement errors (fieldwork and laboratory quality assurance). Significant decision errors will be minimised in this investigation by:

- A robust quality assurance / quality control (QA/QC) program; and
- Undertaking data collection activities using guidance provided in the documents listed in **Section 1** and CH2M HILL SOPs.

This step also examines the certainty of conclusive statements based on the available site data collected. This should include the following points to quantify tolerable limits:

- A decision can be made based on a 95% probability that the 'true' arithmetic average contaminant concentration will be below the calculated 95% UCL value. This follows the guidance given in NSW EPA (1995) guidelines for comparing 95% UCLs to the relevant adopted site criteria. 95% UCL values have been calculated on particular soil types where there are more than six samples with concentrations reported above the level of reporting (LOR). Therefore, a limit on the decision error will be 5% that a conclusive statement may be incorrect.
- a decision can be made based on the probability that a contamination hotspot of a certain circular diameter will be detected with 95% confidence using systematic sampling data points. The decision error will be limited to a probability of 5% that a contamination hotspot may not be detected.

Step 7 – Optimise the Design

The purpose of this step is to identify a resource-effective field investigation sampling design that generates data that is expected to satisfy the decision performance criteria, as specified in the preceding steps of the DQO process. The output of this step is the sampling design that guided development of the SAQP, based on a conceptual site model. This step provides a general description of the activities necessary to generate and select data collection designs that satisfy decision performance criteria. **Section 7** provides methodology and rationale for the sampling design.

5 Contaminants of Potential Concern

Based on CH2M HILL's review of the SKM (2010) Phase I EA, the following CoPC have been considered:

- Heavy Metals
- TPH and BTEX
- PAH
- Organochlorine Pesticides (OCP) and Organophosphate Pesticides (OPP)
- Asbestos
- Polychlorinated Biphenyl (PCB).

It was noted that OCP and OPP may be present in the soils in the vicinity of the shed in the UoS landscaping compound, as these pesticides may have been stored and used in these areas. Therefore, OCP and OPP are considered a CoPC in this area.

An existing transformer was identified in SKM (2010) to be located to the west of building H69, therefore PCBs are considered a CoPC in this area.

The remaining CoPC may have been introduced to the Site either through the import of fill material or from spillages of fuels, lubricants and oils across the Site.

6 Site Investigation Criteria

6.1 Soil

The adopted soil assessment criteria for the Site are based on those provided in the guideline documents referred to in **Section 1**. As the future land use of the Site is to continue as Special Use (University) and the objective of the Phase II EA is to assess the potential human health and environmental risks during and after site redevelopment works, CH2M HILL considers it appropriate that concentrations of contaminants in the soil be compared against the commercial / industrial Health-based Investigation Levels (HIL F) sourced from NSW DEC (2006).

The NSW DEC (2006) guideline provides a range of HILs for contaminants in soils considered to be appropriate for a range of generic land uses in Australia. These HILs are sourced from NEPC (1999) and have been endorsed by the EPA.

NSW DEC (2006) does not provide criteria for TPH or BTEX, as such criteria comprising threshold TPH and BTEX concentrations for sensitive landuse have been sourced from the EPA (1994) guidelines.

There are currently no adopted national or state criteria for the assessment of asbestos contamination. EnHealth, a sub-committee of the National Public Health Strategy, provides suggestions in the qualitative assessment of asbestos contamination, namely that each site be assessed individually by a suitably experienced professional. For this investigation, a trigger value of 'no detection of fibres or fragments in surface soils' as suggested by EnHealth (2005) will be used to assess the need for further action including further investigation, remediation and / or management options.

The adopted soil assessment criteria for the investigation are listed in **Table 6-1** below.

Table 6-1

Adopted Soil Assessment Criteria

Analyte	HIL F (mg/kg)	EPA 1994 (mg/kg)
<i>Heavy Metals</i>		
Arsenic	500	
Cadmium	100	
Chromium(VI)	500	
Copper	5,000	
Lead	1,500	
Nickel	3,000	
Zinc	35,000	
Mercury	75	

Table 6-1

Adopted Soil Assessment Criteria

Analyte	HIL F (mg/kg)	EPA 1994 (mg/kg)
<i>Total Petroleum Hydrocarbons</i>		
TPH (C ₆ -C ₉)		65
TPH (C ₁₀ -C ₃₆)		1,000
<i>Monocyclic Aromatic Hydrocarbons</i>		
Benzene		1
Toluene		130
Ethylbenzene		50
Xylenes (total)		25
<i>Polycyclic Aromatic Hydrocarbons</i>		
Benzo(a)pyrene	5	
Total PAH	100	
<i>Organochlorine and Organophosphate Pesticides</i>		
Aldrin + Dieldrin	50	
Chlordane	250	
DDT + DDD + DDE	1,000	
Heptachlor	50	
<i>Polychlorinated Biphenyls</i>		
PCBs (total)	50	
Asbestos	No detection of fibres in surface soils	

6.2 Groundwater

Groundwater results are assessed against marine trigger values from the ANZECC (2000) guidelines due to the marine receiving water body of Blackwattle Bay. Results will be assessed against the 95% ecosystem level of protection.

The adopted groundwater assessment criteria for the investigation, along with their reliability, are listed in **Table 6-2** below. Although the low reliability trigger values are reported below, CH2M HILL has used only high and moderate reliability values as a trigger point for further consideration of management of the identified contaminant. ANZECC (2000) indicates that low reliability figures should not be used as default guidelines, but they have been provided below as an indication of which analytes could require further site specific risk assessment should they be

detected above either the low reliability trigger value, or in most cases, the laboratory level of reporting.

Table 6-2

Adopted Groundwater Assessment Criteria

Analyte	Highly Disturbed System Trigger Values (µg/L)	Reliability of Trigger Value
<i>Heavy Metals</i>		
Arsenic	2.3	Low
Cadmium	5.5	High
Chromium	4.4 ^a	High
Copper	1.3	High
Lead	4.4	High
Nickel	70	High
Zinc	15	High
Mercury	0.4	High
<i>Total Petroleum Hydrocarbons</i>		
TPH	---	---
<i>Monocyclic Aromatic Hydrocarbons</i>		
Benzene	700	Moderate
Toluene	180	Low
Ethylbenzene	5	Low
Xylene	75 ^b	Low
<i>Polycyclic Aromatic Hydrocarbons</i>		
Anthracene	0.4	Low
Benzo(a)pyrene	0.2	Low
Fluoranthene	1.4	Low
Naphthalene	70	Moderate
Phenanthrene	2	Low
<i>Organochlorine Pesticides</i>		
Chlordane	0.001	Low
Aldrin	0.003	Low
Dieldrin	0.01	Low

Table 6-2

Adopted Groundwater Assessment Criteria

DDE	0.0005	Low
DDT	0.0004	Low
Endosulfan	0.01	Moderate
Methoxychlor	0.004	Low
Endrin	0.008	Moderate
Heptachlor	0.0004	Low
<i>Organophosphorus Pesticides</i>		
Azinphos-methyl	0.01	Low
Chlorpyrifos	0.009	High
Demeton-S-methyl	4	Low
Diazinon	0.01	Low
Dimethoate	0.15	Low
Malathion	0.05	Low
Parathion	0.004	Low

Notes:

^a High reliability trigger value for chromium (VI) provided. High reliability trigger value for chromium (III) is 27.4 µg/L.

^b Low reliability trigger value for m-xylene provided. Low reliability trigger value for o-xylene is 350 µg/L and for p-xylene is 200 µg/L.

With regard to detection limits, or LOR, for groundwater analytes, it should be noted that even low level detection limits do not meet the requirements of the trigger values for OCP and OPP. In accordance with guidance in NSW DEC (2007), where the trigger values are below the achievable detection limit, the detection limit shall be used instead of the trigger value.

6.3 Comparison of Analytical Data

The statistical methodology used for comparison of the investigation data to adopted site criteria is based on the methods referred to in NSW EPA (1995):

- Comparison of the 95% upper confidence limit of the arithmetic mean soil concentration (95% UCL) of each contaminant to the adopted site criteria
- Comparison of individual soil analytical results to 250% of the adopted site criteria to identify contamination 'hotspots'
- Comparison of calculated soil type standard deviations to a value of 50% of the adopted site criteria
- Comparison of groundwater data will be against individual adopted groundwater assessment criteria.

6.4 Waste Classification

Waste classification will be undertaken according to NSW DECC (2009). Contaminant threshold values for waste classification of non-liquid wastes without leachate concentrations (based on contaminant threshold values – CT) are adopted from Table 1 of the Waste Classification Guidelines. Maximum values for toxicity characterisation leaching procedure (TCLP) and specific contaminant concentration (SCC) for waste classification are adapted from Table 2 of the Waste Guidelines. Threshold values for with and without TCLP are presented in **Table 6-3** below.

Table 6-3

Waste Classification Contaminant Threshold Values with and without TCLP

Analyte	Without TCLP		With TCLP			
	General solid waste	Restricted soil waste	General solid waste		Restricted soil waste	
	CT1 (mg/kg)	CT2 (mg/kg)	TCLP1 (mg/L)	SCC1 (mg/kg)	TCLP2 (mg/L)	SCC2 (mg/kg)
Arsenic	100	400	5.0	500	20	2,000
Benzene	10	40	0.5	18	2	72
Benzo(a)pyrene	0.8	3.2	0.04	10	0.16	23
Cadmium	20	80	1.0	100	4	400
Chlorpyrifos	4	16	0.2	7.5	0.8	30
Chromium VI	100	400	5	1,900	20	7,600
Endosulfan	60	240	3	108	12	432
Ethylbenzene	600	2,400	30	1,080	120	4,320
Lead	100	400	5	1,500	20	6,000
Mercury	4	16	0.2	50	0.8	200
Nickel	40	160	2	1,050	8	4,200
PCBs	N/A	N/A	N/A	<50	N/A	<50
PAH (total)	N/A	N/A	N/A	200	N/A	800
Toluene	288	1,152	14.4	518	57.6	2,073
Xylenes (total)	1,000	4,000	50	1,800	200	7,200

Notes: CT – Contaminant Threshold
TCLP – Toxicity Characteristic Leaching Potential
SCC – Specific Contaminant Concentration
n/a – not applicable

7 Investigation Methodology

7.1 Scope of Fieldwork

The fieldwork program was completed over six days. A site inspection with the drilling subcontractor was undertaken on 21 March 2011, however, intrusive investigations were postponed on that day due to inclement weather. Soil sampling was undertaken on 22 – 23 March 2011 and groundwater sampling was undertaken on 1 April 2011. In addition, underground service clearance was undertaken prior to field work on 18 March 2011 (with a second clearance undertaken on 23 March 2011) and survey of the GWMWs was undertaken on 7 April 2011. Field tasks completed for this investigation included:

- underground service clearance
- site inspection
- CH2M HILL project specific safety induction and daily toolbox talks
- excavation of 13 boreholes across the Site
- collection of soil samples from each of the boreholes
- installation of 3 GWMWs, including collection of soil and groundwater samples from each of the GWMWs
- submission of soil and groundwater samples for laboratory analysis
- survey of GWMWs.

7.2 Health and Safety

A Health, Safety and Environment Plan (HSEP) was prepared by CH2M HILL to identify the relevant health and safety risks, along with environmental risks, associated with the proposed activities and to provide plans and strategies to mitigate those risks. Prior to commencement of the fieldwork, both CH2M HILL field staff and sub-contractors commissioned by CH2M HILL were required to participate in a UoS Campus Infrastructure and Services (CIS) Contractor Campus Induction. This induction included familiarisation with the information presented in the CIS Contractor Campus Induction Handbook, along with a formal acknowledgment that each person had read and understood the contents of the Handbook and an assessment. Each sub-contractor also completed a CH2M HILL site induction and provided evidence of an appropriate Safe Work Method Statement (SWMS).

7.3 Fieldwork Methodology

Fieldwork including the collection of soil and groundwater samples and was completed in accordance with CH2M HILL Fieldwork Standard Operating Procedures (SOPs), Australian Standards (AS) and guidance documents outlined in **Section 1**.

7.3.1 Soil Sampling Program

A Dial-Before-You-Dig search request was submitted by CH2M HILL as a prerequisite for the identification of utilities running above or beneath the Site. An underground service clearance was completed prior to the commencement of intrusive works by On Line Pipe & Cable Locating. One of the proposed borehole locations was cleared for underground services, but was later discovered to be located within 3 m of an above ground service, therefore On Line Pipe and Cable Locating were called back to the Site to reposition that borehole.

CH2M HILL mobilised a two-person field team to undertake the soil sampling investigation. Two separate areas (Areas 1 and 2, as shown on **Figure 2**) were identified for soil investigations with a total number of 32 primary soil samples collected.

Two samples were collected from each borehole and the soil boreholes were drilled to a maximum of 1.5 mbgl, apart from the GWMWs, which were installed to a maximum depth of 9 mbgl.

All borehole locations were logged by a qualified environmental scientist, noting the lithology encountered, soil texture, discolouration and presence of odours. Photographs were taken of each sample location. Borehole logs were prepared for each borehole, describing the excavated material and recording sampling depths. Borehole logs are presented in **Appendix C**.

Soil samples collected during the excavation program were screened in the field for presence of volatile organic compounds (VOC) with a PID. The PID readings for each sample are noted on the corresponding borehole logs presented in **Appendix C**. In between each reading the PID was allowed to stabilise to normal background air quality conditions.

A total of 16 boreholes were advanced using a GeoProbe, by Epoca Environmental. Thirteen remained as boreholes, while three were converted into GWMWs. Excavated soil material was placed on the ground surface in the vicinity of each borehole during excavation works. All boreholes were then backfilled with the excavated material and nominally compacted.

Soil samples were collected by hand directly from the PVC Geoprobe liner, whilst wearing disposable nitrile gloves and placed into acid washed glass jars with Teflon® lids, provided by the laboratory. Two boreholes, BH11 and BH12, were hand augered, and samples from these boreholes were collected directly from the auger. The hand auger was decontaminated using Decon 90 between each borehole to reduce the potential for cross-contamination.

7.3.2 Groundwater Sampling Program

The GWMWs were installed across the Site to provide information on the potential for contaminated groundwater to be present onsite and also the potential for contaminated groundwater to be flowing both off the Site and/or onto the Site. The

GWMWs locations are shown on **Figure 2**. The GWMWs were constructed as documented in the soil and groundwater borelogs presented in **Appendix D**.

7.3.3 Monitoring Well Development

Each GWMW was developed to remove sediment and fine materials from the GWMW screen and filter pack and to maximise the efficiency of the GWMW to produce groundwater. A submersible pump, decontaminated between each location, was used to develop all three GWMWs.

7.3.4 Groundwater Purging

Each GWMW was purged using a mircopurge low flow pump. The GWMWs were purged until the field parameters were considered stable, at which point they are considered suitable for the collection of groundwater samples.

Groundwater Sampling Purge Field Data Sheets are presented in **Appendix E**.

7.3.5 Groundwater Sample Collection

One sample from each GWMW, was collected, in the order of the potentially most volatile to the least volatile analyte, and placed into laboratory prepared and supplied sample bottles. Samples analysed for heavy metals were field filtered with disposable 45 micron filters during sample collection.

7.4 Sample Handling and Transport

Each soil and groundwater sample was labelled with a unique identifier consisting of the Site name, borehole / GWMW location identification and depth and then placed directly into an ice-filled esky. The samples were then transported to the laboratory under CH2M HILL chain-of-custody (CoC) protocols. Copies of CoC documentation are included in **Appendix F**. ALS Laboratory Group (ALS) was used as the primary laboratory for the project with Envirolab Services (Envirolab) as the secondary laboratory (for the analysis of inter-laboratory duplicate samples). Each laboratory is National Association of Testing Authorities (NATA) accredited for the performed analyses.

Depending on the required analysis, samples were placed in the appropriate sample jars provided by the laboratories. Soil samples collected for analysis of potential heavy metals, PAH, TPH, BTEX, OCP, OPP, PCB and asbestos contamination and were placed in 250 mL acid washed glass jars with Teflon lids provided by ALS. Collection of groundwater samples involves numerous preserved and unpreserved sample bottles depending on the required analysis, with all groundwater sample containers provided by ALS. Both soil and groundwater samples were preserved in accordance with laboratory analytical requirements through utilisation of the correct sample jars and bottles depending on analysis requested.

7.5 Field Equipment Calibration

The water quality meter used to measure the water quality parameters in the GWMWs was a TPS 90FLMV, capable of measuring the pH, dissolved oxygen (DO), redox potential, temperature and conductivity of the groundwater. Calibration certificates, provided by the supplier, are presented in **Appendix G**.

7.6 Decontamination

The decontamination of personnel, PPE and sampling equipment was performed in accordance with the procedures outlined in CH2M HILL SOPs, to minimise risks to health and safety, and to reduce the potential for cross-contamination of site environmental samples.

At each sample location, a new set of disposable nitrile gloves was used to collect each soil and groundwater sample. The samples were then placed into the laboratory prepared clean glass sample jars/bottles.

Between each groundwater sample, the non-dedicated soil sampling equipment was decontaminated. This process included a scrubbing brush and a solution of Decon 90 and tap water to remove soil material, followed by a rinse in deionised water.

A rinsate sample was collected from the micro-purge groundwater pump to assess the effectiveness of the decontamination procedures.

7.7 Field QA/QC

Field QA/QC samples included the collection of two intra-laboratory duplicates and two inter-laboratory duplicates for soil and one intra-laboratory duplicate for groundwater. The soil intra and inter laboratory duplicate samples were collected by taking a larger quantity of soil from a single sampling point and dividing small sections of the samples into two sample jars. The groundwater duplicates were collected by splitting a groundwater sample and filling duplicate sample bottles in the same order as the primary sample. Both the intra and inter laboratory duplicate samples were labelled with a unique identifier, which did not identify the corresponding primary sample to the laboratory. Duplicate samples were collected at the rate of 1 sample every 10 primary samples (10%).

Trip spikes, trip blanks and sample equipment rinsate blanks were also part of the QA/QC. Two trip spikes and two trip blanks were kept with the samples during the soil sampling event (one per esky) and one trip spike and one trip blank were kept with the groundwater samples during the groundwater sampling event (only one esky). One rinsate sample was collected during the groundwater sampling event from the low-flow micropurge pump.

7.8 Analytical Program

Table 7-1 below summarises the schedule of analysis for the project based on the sample locations (PAOC) and CoPC.

Table 7-1

Sampling and Analysis Schedule

Sample Location / Analyte	Asbestos	Heavy Metals	PCB	OCP / OPP	PAH	BTEX	TPH
Soil Samples							
BH01/0.1-0.3		√	√	√	√	√	√
DUP01 (Intralab)		√	√	√	√	√	√
BH01/0.8-1.0		√	√		√	√	√
BH02/0.1-0.3	√	√			√	√	√
BH02/0.8-1.0		√			√	√	√

**Table 7-1
Sampling and Analysis Schedule**

Sample Location/ Analyte	Asbestos	Heavy Metals	PCB	OCP/ OPP	PAH	BTEX	TPH
BH03/0.2-0.4	√	√			√	√	√
BH03/0.6-0.8		√			√	√	√
BH04/0.1-0.3		√			√	√	√
BH04/0.6-1.0		√			√	√	√
BH05/0.3-0.4		√			√	√	√
BH05/0.5-0.7		√			√	√	√
BH06/0.1-0.3	√	√		√	√	√	√
BH06/0.5-0.7		√		√	√	√	√
BH07/0.2-0.4		√		√	√	√	√
BH07/0.6-0.7		√		√	√	√	√
BH08/0.1-0.2	√	√			√	√	√
BH08/1.0-1.2		√			√	√	√
BH09/0.1-0.2		√		√	√	√	√
BH09/0.4-0.5		√			√	√	√
DUP03 (Interlab)		√			√	√	√
BH10/0.3-0.5	√	√			√	√	√
DUP02 (Intralab)		√			√	√	√
BH10/0.5-0.6		√			√	√	√
BH11/0.2-0.3		√			√	√	√
DUP04 (Interlab)		√			√	√	√
BH11/0.5-0.6		√			√	√	√
BH12/0.2-0.3		√			√	√	√
BH12/0.4-0.5		√			√	√	√
BH13/0.3-0.4	√	√			√	√	√
BH13/0.4-0.6		√			√	√	√
MW01/0.1-0.3		√			√	√	√
MW01/0.4-0.5		√			√	√	√
MW02/0.1-0.2		√			√	√	√
MW02/0.4-0.5		√			√	√	√
MW03/0.1-0.2		√			√	√	√
MW03/0.4-0.6		√			√	√	√
Trip Spike / Trip Blank						√	
TCLP Analysis							
BH01/0.1-0.3		√					
BH05/0.3-0.4		√					
BH06/0.1-0.3		√			√		
MW03/0.1-0.2					√		
MW02/0.4-0.5					√		
Groundwater Samples							
MW01		√	√	√	√	√	√
DUP01 (Intralab)		√	√	√	√	√	√
MW02		√	√	√	√	√	√
MW03		√	√	√	√	√	√
Rinsate		√				√	
Trip Spike / Trip Blank						√	

The analytical methods adopted for the contaminants listed above are provided with the laboratory reports in **Appendix F** and are in accordance with standard analytical methods approved by NATA.

8 Field Observations

8.1 Soil

Two distinct areas in terms of general soil profile were identified during the field investigation. These areas are presented in **Figure 2**.

Area 1 comprised the majority of the locations investigated and can generally be described as the land that appeared to be the same topography as the surrounding areas. This consisted of the landscaping compound, the park on the north-eastern corner of Abercrombie and Codrington Streets and the car park between the childcare centre and the landscaping compound. Area 1 generally comprised 0.5 – 0.7 m of fill material, underlain by natural sandy clay / clay, then shale. The fill material was generally described as silty sand, sand, gravel, sandy clay, with occasional sandstone nodules, building rubble, ash and crushed brick. This is likely a combination of imported material and reworked natural material.

Area 2 comprised the fill embankment located between buildings H05 and H12, consisting of BH11 and BH12. This fill material was observed to consist of predominantly building rubble, crushed porcelain / brick and crushed sandstone. Due to the steepness of the embankment, hand augers were used and penetrated to a maximum depth of 0.5 mbgl. It is anticipated that the fill in this area would be deeper than that observed in Area 1.

One exception to the general descriptions described above is MW03, where a layer of ash, slag and crushed brick was observed between 0.3 and 0.6 mbgl. The extent of placement of this type of fill is expected to be fairly localised, as ash and slag were not observed in BH08 and BH09, which were located approximately 9 m and 15 m away respectively.

Table 8-1 below summarises the general soil conditions encountered at the Site. Refer to **Appendices C** and **D** for detailed borelogs.

Table 8-1

Summary of Soil Conditions

Area	Soil Description	Thickness (m)
1	FILL: mixed sand, gravel, sandy clay, with occasional sandstone nodules, building rubble and ash.	0.0-0.6
	CLAY: clay / weathered shale underlain by shale	0.6-end of borehole
2	FILL: building rubble and crushed sandstone	0.0-end of borehole

Potential Contamination

During the field sampling event, limited observations of potential contamination were noted. As mentioned above, a thick layer of ash and slag was noted in MW03 and ash was also noted in BH05 and BH06.

8.2 Groundwater

Groundwater Levels and Flow Direction

Site groundwater elevation was calculated for each GWMW, based on field measurements of static water level (SWL) in metres below top of casing (mbTOC) and survey data (in metres Australian Height Datum - mAHD) for the top of GWMW casing. The data is presented below in **Table 8-2**. Using this data, the general groundwater flow direction is presented on **Figure 3**. The data indicates that groundwater flow is likely to be to the north / north-west towards Blackwattle Bay. It should be noted that the SWL in the GWMWs are likely to fluctuate due to the amount of rainfall over the area, seasonal and diurnal effects.

Table 8-2

Groundwater Monitoring Well Survey Data

GWMW I.D.	Easting (AGS)	Northing (AGS)	SWL (mAHD)
MW01	332762.532	6248315.208	21.01
MW02	332612.692	6248285.733	28.80
MW03	332614.616	6248341.591	31.39

Field Parameter Results

Each GWMW was purged using the low-flow micropurge sampling equipment until field parameters of the recharge water were considered stable. Groundwater within the GWMWs was generally very turbid and did not reduce in turbidity during purging. A slight sheen was observed in the groundwater at MW02.

Field measurements for groundwater quality parameters, including EC, pH, redox-Eh, dissolved oxygen (DO) and temperature (°C) were recorded during GWMW purging. A summary of the results of these measurements is provided in **Table 8-3** below.

Table 8-3

Water Quality Data (Post Completion of Purging)

GWMW I.D.	Date	Time	Temp (°C)	pH	Redox (mV)	EC (µS/cm)	DO (ppm)
MW01	1/4/11	14:51	20.5	4.35	160	1406	1.02
MW02	1/4/11	16:59	21.2	5.67	108	2011	0.69
MW03	1/4/11	16:06	20.0	4.16	167	2210	0.26

The measured water quality parameters were similar across the Site. Dissolved oxygen is low at each location which indicates possible anaerobic conditions. The low pH measurements at each GWMW suggest slightly acidic conditions. Measured redox results were not found to have varied considerably from each GWMW and support the low dissolved oxygen readings by indicating slightly reducing, anaerobic conditions. Electric conductivity (EC) results from all three GWMWs indicate

marginal water quality, although results from MW03, which is slightly up-hydraulic gradient from the other two GWMs, were bordering on being classified as brackish.

9 Analytical Results

9.1 Soil

Soil analytical results for the investigation are summarised in **Table A**. Final laboratory certificates and CoC documentation are provided in **Appendix F**.

Results for all analytes were either reported below the LOR or below the adopted site criteria except for those exceedances discussed in **Sections 9.1.1** and **9.1.2** below. The locations of soil sample exceedances are shown on **Figure 4**.

9.1.1 HIL F and NSW EPA 1994 Exceedances

There were no metal concentrations reported above the adopted site criteria in any of the soil samples. All BTEX, PCB, OCP and OPP concentrations were reported below the LOR. TPH C₆ – C₉ concentrations were also all reported below the LOR.

TPH C₁₀ – C₃₆ concentrations were generally below the adopted site criteria of 1,000 mg/kg, with the exception of:

- BH05 (0.3-0.4), which reported a concentration of 1,880 mg/kg
- BH06 (0.1-0.3), which reported a concentration of 4,770 mg/kg
- MW03 (0.1-0.2), which reported a concentration of 5,230 mg/kg.

The concentration of TPH C₁₀ – C₃₆ in BH06 and MW03 was in excess of 2.5 x the adopted site criteria, and these locations are therefore considered a 'hotspot'.

Total PAH concentrations were generally below the adopted site criteria of 100 mg/kg, with the exception of:

- BH05 (0.3-0.4), which reported a concentration of 157.4 mg/kg
- BH06 (0.1-0.3), which reported a concentration of 1,193.7 mg/kg
- MW02 (0.4-0.5), which reported a concentration of 194.7 mg/kg
- MW03 (0.1-0.2), which reported a concentration of 938.4 mg/kg

The concentration of total PAH in BH06 and MW03 was in excess of 2.5 x the adopted site criteria, and these locations are therefore considered a 'hotspot'.

Benzo(a)pyrene concentrations were generally below the adopted site criteria of 5 mg/kg, with the exception of:

- BH05 (0.3-0.4), which reported a concentration of 15.8 mg/kg
- BH06 (0.1-0.3), which reported a concentration of 42.5 mg/kg
- MW02 (0.4-0.5), which reported a concentration of 15.9 mg/kg
- MW03 (0.1-0.2), which reported a concentration of 73.8 mg/kg
- MW03 (0.4-0.6), which reported a concentration of 5.3 mg/kg

The concentration of benzo (a)pyrene in BH05, BH06, MW02 and MW03 was in excess of 2.5 x the adopted site criteria, and these locations are therefore considered 'hotspots'.

9.1.2 Statistical Analysis

Statistical assessment procedures were completed on the soil data as outlined in **Section 4**. Since only four samples were collected from the fill material in Area 2, all fill material was analysed together. Statistical analysis was not undertaken on the natural material since only four samples were collected from natural material and no sample results exceeded the adopted site criteria.

It is noted that up to four hotspot samples ($> 2.5 \times$ adopted site criteria) were identified during the initial analytical review within the fill material, relating to TPH $C_{10}-C_{36}$ (two hotspots), benzo(a)pyrene (four hotspots) and total PAH (two hotspots). These hotspots have been excluded from statistical calculations. The statistical calculations are presented in **Table B**.

The statistical analysis indicated that there were no exceedences of the 95% UCL or the standard deviation criteria.

9.1.3 Asbestos

Six soil samples collected from across the Site were analysed for the presence of asbestos. Laboratory results indicated that asbestos fibres were not detected in any of these soil samples.

9.2 Groundwater

Groundwater collected from the three GWMWs was analysed for CoPC and assessed against the 95% ecosystem protection trigger values for marine water as discussed in **Section 6**. The analytical results are presented in **Table C**.

The vast majority of analytes were not detected above the LOR. This included all organic compounds (BTEX, TPH, PCB, OCP and OPP) and selected heavy metals (arsenic, cadmium, chromium and mercury). Nickel was detected at each of the GWMWs, however the concentrations were all below the adopted site criteria.

Copper concentrations were above the adopted site criteria of $1.3 \mu\text{g/L}$ in two of the GWMWs:

- MW01, which reported a concentration of $2 \mu\text{g/L}$
- MW03, which reported a concentration of $5 \mu\text{g/L}$

The only GWMW to report a lead concentration above the adopted site criteria of $4.4 \mu\text{g/L}$ was MW03, which reported a concentration of $8 \mu\text{g/L}$.

Zinc concentrations were above the adopted site criteria of $15 \mu\text{g/L}$ in all three GWMWs, with their concentrations reported as follows:

- MW01, which reported a concentration of $58 \mu\text{g/L}$
- MW02, which reported a concentration of $42 \mu\text{g/L}$

- MW03, which reported a concentration of 92 µg/L.

9.3 Waste Classification

Results from analysis of soil samples reported for the Site were compared to the threshold values provided in the NSW DECC 2009 guidelines for the classification of wastes. The vast majority of soils across the Site, both fill and natural, are classified as 'general solid waste' based on the total concentrations of contaminants. However, the total concentrations of lead, benzo(a)pyrene and total PAH in some of the soil samples exceeded the maximum permissible total concentrations (CT) without TCLP for 'general solid waste'. Therefore, TCLP analysis was undertaken on selected samples for heavy metals and PAH to allow comparison of the analytical results to the maximum permissible concentrations with TCLP for 'general solid waste'.

The leachable concentrations in all samples submitted for TCLP analysis showed TCLP concentrations below the maximum permissible TCLP concentrations for 'general solid waste'. Since the total lead concentration (SCC) in all samples is below the maximum permissible total lead concentration for general solid waste (SCC1), this indicates that the soils with only elevated lead concentrations can also be disposed of as 'general solid waste'.

However, the total benzo(a)pyrene and total PAH concentrations (SCC) are above the maximum permissible total concentration for 'general solid waste' in four of the primary samples collected. In BH05/0.3-0.4 and MW02/0.4-0.5, the SCC concentrations result in these samples being classified as 'restricted solid waste'. In BH06/0.1-0.3 and MW03/0.1-0.2, the SCC concentrations result in these samples being classified as 'hazardous' waste. TCLP analyses were undertaken on three of these samples.

It should be noted that NSW DECC has issued a number of general immobilisation approvals for wastes classified as 'hazardous' wastes. One of these general immobilisation approvals relates specifically to ash, ash-contaminated natural excavated materials or coal-contaminated natural excavated materials. There are only two locations where the total benzo(a)pyrene and total PAH concentrations would result in the classification of the soils as 'hazardous' – BH06 and MW03. Ash was observed in both of these locations. Therefore, these soils can be classified according to their leachable concentration (TCLP) alone, which results in a 'general solid waste' classification. Ash was also observed in BH05, but not in MW02, therefore the soil from MW02 within the impacted horizon is still classified as 'restricted solid waste'.

Therefore, if only the soil hotspots are excavated and disposed of offsite, then the material associated with hotspot MW02/0.4-0.5 (this is expected to extend vertically between 0.4 and 0.7 mbgl, and the lateral extent would need to be further investigated), would need to be classified as 'restricted solid waste' and the other soil could be disposed of as 'general solid waste'. If all of the fill material is excavated and disposed of offsite, then the 95% UCL of the total concentrations also results in the material being classified as 'restricted solid waste', therefore it would be prudent to separate the excavated material from MW02/0.4-0.5 from the remainder of the

material, to allow the vast majority of the soil to be disposed of as 'general solid waste' and only that material from MW02/0.4-0.5 to be disposed of as 'restricted solid waste'.

Soil samples tested for asbestos material showed no detections of asbestos fibres present in the soil, therefore the soil does not need to be disposed of as 'asbestos special waste'.

The TCLP analytical results and comparison to waste classification guideline concentrations are reported in **Table D**.

9.4 Data Quality Assessment

The QA/QC assessment is included in **Appendix H**. A brief summary is provided below:

- all trip blank samples reported BTEX concentrations below the LOR, which conforms with the data quality assessment criteria
- all trip spike samples reported BTEX recovery percentages within acceptable limits
- the rinsate sample collected from the micropurge low-flow sampling kit reported concentrations of all CoPC analysed below the LOR, which conforms with the data quality assessment criteria
- all calculated Relative Percent Differences (RPDs) in the intra-laboratory groundwater duplicate sample were within acceptable limits
- several heavy metal RPDs exceeded the acceptable limits in both the inter-laboratory and intra-laboratory duplicate soil samples
- TPH C15 - C28 RPDs exceeded the acceptable limits in one of the intra-laboratory duplicate soil samples
- two PAH RPDs exceeded the acceptable limits in one of the inter-laboratory duplicate soil samples
- all other RPDs calculated for the inter-laboratory and intra-laboratory duplicate soil samples were within acceptable limits
- the primary laboratory noted LCS recovery for some analytes in soil fall outside the laboratory dynamic control limits, however they fall within the acceptance criteria based on ALS DQO and no further action is required
- the primary laboratory noted poor precision was obtained for some elements in their quality control analysis for soils due to sample heterogeneity, however the results have been confirmed by re-extraction and re-analysis
- the primary laboratory noted poor matrix spike recoveries due to sample matrix effects in the groundwater samples

The majority of the precision, accuracy, representativeness, comparability and completeness (PARCC) indicators, were within the specified data quality indicators (DQIs) and therefore, overall, the data is considered to be of sufficient quality to meet the objectives of the Phase II EA.

10 Site Characterisation Discussion

10.1 Soil

Soils were assessed for the purpose of characterising the soil and identifying contamination. Samples were collected from various depths within the fill material. Two types of fill material were observed at different areas of the Site, which CH2M HILL has nominally called Area 1 and Area 2. The fill material in Area 1, which comprises the majority of the Site, was observed to be a heterogeneous mix of silty sand, sand, gravel, sandy clay, with occasional sandstone nodules, building rubble, ash and crushed brick. This fill material was generally observed to be 0.5 – 0.7 m deep and underlain by natural clays and shale. The fill material in Area 2 was observed to consist of predominantly building rubble, crushed porcelain / brick and crushed sandstone. This material was observed to be at least 0.5m deep and comprised a fill embankment between buildings H05 and H12.

The majority of the soil samples collected indicated that the Site is suitable for commercial / industrial use, and hence Special Use (University). TPH and PAH hotspots were identified in discrete horizons in the fill material at four locations - BH05, BH06, MW02 and MW03. The contamination was not observed to be widespread, as adjacent boreholes, and indeed samples collected within the same borehole in BH05, BH06 and MW02, did not report CoPC concentrations above the adopted site criteria. In the case of MW03, BH05 and BH06, the hotspot contamination is likely associated with the ash observed in the fill material. Slag material was also noted in MW03. Contamination in BH05 and BH06 may be associated with possible historical storage of heavy fuels in these areas. There were no visual / olfactory observations of contamination noted in MW02, but it is possible that ash is also present at this location, as the PAH contamination appeared similar to that observed elsewhere.

Selected soil samples that exhibited elevated concentrations of lead and PAH were submitted for TCLP analysis for waste classification purposes. Results from TCLP analysis reported that materials can generally be classified as 'general solid waste' based on an assessment of samples exceeding the adopted site criteria at the Site. Soils at MW02 between 0.4 and 0.7 mbgl are classified as 'restricted solid waste'.

10.2 Groundwater

Groundwater samples collected from the GWMWs generally reported levels of contamination below the adopted site criteria with the exception of zinc in all three GWMWs, copper in MW01 and MW03, and lead in MW03. Of particular importance is that the concentration of all three contaminants is higher in MW03, which is representative of groundwater migrating onto the Site. Since the concentrations of contaminants in the groundwater migrating off the Site at MW01 are lower than those reported in MW03, at the time of sampling, there was no evidence to suggest that any of the fill material, including the identified soil contamination, at the Site was contributing to groundwater contamination. The exceedences noted are only considered to represent low level heavy metal contamination of the groundwater.

11 Conclusions and Recommendations

11.1 Conclusions

The Phase II EA works comprised soil and groundwater investigations to assess risks to users and the environment posed by potential contamination.

Based on the results of the Phase II EA, the soil at the Site is generally considered suitable for commercial/industrial land use, though remediation or management is required to address soil contamination identified in specific locations, as discussed below. Once these have been addressed, soils at the Site are considered suitable for ongoing commercial/industrial land use.

The Site was divided into two nominal 'areas' based on site observations of the fill material. Area 1 reported a limited number of soil exceedances, with some classified as 'hotspots'. The material at these locations is considered to be localised contamination that requires remediation or management prior to or during the redevelopment of the Site as they currently pose a greater than acceptable risk to human health.

Soil samples collected and analysed at Area 2 (comprising the fill embankment between buildings H05 and H12) did not report exceedances of the adopted site criteria for the CoPC and therefore the surface soils in Area 2 are considered suitable for ongoing commercial/industrial land use. Material located deeper than 0.5 mbgl was not analysed due to access restrictions and therefore the suitability of this material was not assessed.

Should any material be required to be disposed of offsite, the waste classification of the vast majority of the material has been identified as 'general solid waste'. The only exception to this general classification is soils from MW02, between approximately 0.4 and 0.7 mbgl, which is classified as 'restricted solid waste'.

Based upon the data reviewed and collected as part of this Phase II EA, CH2M HILL concludes that:

- the human health risk associated with soil contamination at the Site is generally considered low in the context of the adopted site criteria;
- the associated risk with soils in Area 1 to workers and future users of the Site is considered low with respect to contamination, subject to the implementation of the following recommendations. Generally material in Areas 1 and 2 is suitable for reuse, with the exception of where ash has been observed;
- soil material at the Site is generally preliminarily classified as 'general solid waste', with the exception of soils from 0.4 to 0.7 mbgl in MW02; and
- low level groundwater contamination is considered to be migrating onto the Site and the risk to offsite receptors associated with the groundwater contamination is considered low.

11.2 Recommendations

Due to the contamination identified at the Site, although only limited, management and remediation is required prior to or during redevelopment in order to reduce the risk to site workers and future users of the Site.

Locations of soil hotspot contamination identified in Area 1 require remediation or management that can be undertaken prior to or as part of future redevelopment works. Given the limited and local nature of the contamination, suitable remediation techniques may include hotspot excavation for offsite disposal or capping along with the implementation of an EMP. These options should be further evaluated by way of development of a remedial action plan (RAP) that can be designed to assess various remedial options, select a preferred remedial approach and detail the appropriate management measures required during development works, and subsequent remediation such as inspection and validation for contaminated materials. It is noted that the hotspots within Area 1 may require further delineation to assess the extent of the hotspot location, however observations indicate that the contamination is primarily associated with ash, which can be visually identified.

12 Limitations

This Phase II EA report is given strictly in accordance with, and subject to, the following limitations:

- a) The Phase II EA was prepared for the UoS ("Client") in accordance with the Scope of Work agreed between CH2M HILL and the Client.
- b) CH2M HILL assumes no responsibility for conditions it was not authorised and directed by the Client to investigate or conditions not generally recognised as environmentally unacceptable when the services were performed.
- c) This report is based, in part, on unverified information supplied to CH2M HILL from several sources during the project research. Therefore, CH2M HILL does not guarantee its completeness or accuracy, and assumes no responsibility for errors or omissions related to this externally supplied information.
- d) The advice tendered in this report is based on information obtained from the field investigation locations, test points, sample points and field and laboratory data, and is not warranted in respect to the conditions that may be encountered across the Site at other than these locations. It is emphasised that the actual characteristics of the sub-surface and surface materials may vary between adjacent test points and sample intervals and at locations other than where observations, explorations and investigations have been made. Sub-surface conditions and contaminant concentrations can change in a short space and time.
- e) Changed or unanticipated sub-surface conditions may occur that could affect the outcomes of an investigation, because of the inherent uncertainties in sub-surface evaluations. Any opinions or recommendations presented herein apply to site conditions existing at the time when services were performed by CH2M HILL. CH2M HILL is unable to report on or accurately predict events that may change the Site conditions after the described services were performed, whether occurring naturally or otherwise.
- f) CH2M HILL notes that if the Site land use changes in the future, the soil and groundwater criteria, as detailed in this Report, and the recommendations and conclusions made in this Report may no longer apply to this Site.
- g) This report has not been prepared for the purposes of assessing the suitability of soil and fill on the Site for building or pavement foundations or the establishment of gardens.
- h) This report may not be altered, amended or abbreviated, issued in part and issued incomplete in any way without the prior written consent of CH2M HILL. CH2M HILL accepts no responsibility for any circumstances

that arise from the issue of a modified report without the permission of CH2M HILL.

- i) This report has been prepared for the exclusive use of the Client relating to the property as described in the report. No warranty, expressed or implied, is made. There are no beneficiaries to this report other than the Client, and no other person or entity is entitled to rely upon this report without the written consent of CH2M HILL, and a written agreement limiting CH2M HILL's liability.

13 References

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