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Radiation Consultancy & Training Services

Health Physics Report on

Waste Classification of Fill Materials at legacy radium extraction plant, Nelson Parade, Hunters Hill

For State Property Authority NSW

14th March 2012

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REPORT DETAILS

Title: **Waste Classification of Fill Materials at No. 7 to 11 Nelson Parade, Hunters Hill**

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Executive Summary

The Australian Nuclear Science and Technology Organisation (ANSTO) was approached by the NSW State Property Authority (SPA) to undertake an in situ waste classification of fill materials present at certain parts of the properties located at Nos. 7 to 11 (excluding under the building footprint of No. 11), and foreshore land fronting Nos. 5, 7, 9, 11 and 13 Nelson Parade, Hunters Hill, NSW, for the purpose of classifying the materials for disposal to a landfill licensed to receive the appropriate class of waste.

Review of historical land use and related recent studies undertaken in the area indicate that some or all of the areas listed above may be impacted by radioactive residues from the processing of uranium bearing ore for extraction of radium by the Radium Hill Company up until 1915. In addition there is also the potential for chemical impact of the soil from other industries that occupied the site.

The in situ classification of the fill material is required to be undertaken prior to the commencement of remediation activities including the removal of fill to a licensed waste management facility.

Analysis of the site for both chemical and radiological contaminants concludes that the entire site may be classified as *Restricted Solid Waste* in accordance with the NSW waste classification system.

The majority of the site could be classified as *General Solid Waste* with respect to chemical contaminants; however the entire site is classified as *Restricted Solid Waste* with regard to radiological contaminants.

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Abbreviations	
ACM	Asbestos Containing Material
ANSTO	Australian Nuclear Science and Technology Organisation
BaP	Benzo(a)Pyrene
BGL	Below Ground Level
Bq	Becquerel
BTEX	Benzene, Toluene, Ethylbenzene and Toluene
CoC	Chain of Custody
CoPC	Contaminants of Potential Concern
CT	Contaminant Threshold
DECC	Department of Environmental and Climate Change
mbgl	Metres below ground level
PID	Photoionisation Detector
GHD	GHD Pty Ltd
LG	Location Grouping
LOR	Laboratory Limit of Reporting
mg/kg	Milligrams per kilogram
mSv	Millisievert
NORM	Naturally Occurring Radioactive Material
OCP	Organochlorine Pesticides
PAH	Polycyclic Aromatic Hydrocarbons
PBIL	Provisional phytotoxicity investigation level
PCB	Polychlorinated Biphenyls
PPE	Personal Protective Equipment
QA	Quality Assurance
QC	Quality Control
SCC	Specific Contaminant Concentration
SOP	Standard Operating Procedure

TCLP	Toxicity Characteristic Leaching Procedure
TPH	Total Petroleum Hydrocarbon
UCL	Upper Confidence Limit
µg/L	Micrograms per litre
µGy/hr	Micro Gray per hour
µSv/hr	Microsievert per hour
WCR	Waste Classification Report

1. Introduction

1.1 General

The Australian Nuclear Science and Technology Organisation (ANSTO) was approached by the NSW State Property Authority (SPA) to undertake an in situ waste classification of fill materials present at certain parts of the properties located at Nos. 7 to 11 (inclusive), and foreshore land fronting Nos. 5, 7, 9, 11 and 13 Nelson Parade, Hunters Hill, NSW, for the purpose of classifying the materials for disposal to a landfill licensed to receive the appropriate class of waste. The material under the building footprint of No. 11 Nelson Parade was excluded from this assessment as it will be managed separately during any remediation work.

Review of historical land use and related recent studies undertaken in the area indicate that some or all of the areas listed above may be impacted by radioactive residues from the processing of uranium bearing ore for extraction of radium by the Radium Hill Company up until 1915. Subsequent to the sites being vacated by the Radium Hill Company, the sites have been landscaped and filled with materials of unidentified origin. As a result, there is potential for non-uniform distribution of radiological materials and also the potential for chemical impact of the soil.

The in situ classification of the fill material was required to be undertaken prior to the commencement of excavation and immediate removal of fill to a licensed waste management facility as part of remediation works proposed for the site. This method was preferred because there is minimal potential for dust generation and potential soil migration in storm water that may be associated with excavating, stockpiling and later loading the fill into vehicles for transport to a licensed waste management facility. It was considered that in situ classification of the waste materials would provide environmental and human health benefits as a result of the ability to load the pre-classified materials directly for transport to a licensed waste management facility.

Previous studies have been undertaken on parts of the properties described above. An in situ waste classification of radiological (only) contaminants has been completed on the properties located at No 7 and 9 and approved by the Site Auditor. However the material on these particular properties still required classification with respect to chemicals of concern. Both radiological and chemical classification was required on the remaining properties.

This waste classification assessment has been undertaken by ANSTO, which sub-contracted CH2M Hill to undertake the chemical analysis of the site.

1.2 Objectives

The waste classification program was being undertaken to provide suitable data to enable the in situ classification of the fill materials, both radiological and chemical, prior to the commencement of remediation works.

The objective of the program was to classify the fill material located on the site against the relevant NSW waste classification guidelines for both radiological and chemical contaminants that may be present in the soil, prior to remediation and disposal via an appropriate route. The waste classification program is designed to complement previous assessments undertaken on adjacent properties.

The radiological and chemical contaminants of concern of the fill material during the analysis are based upon a historical assessment of the site.

As all of the areas included in the work are potentially impacted by both radiological and chemical contaminants, all of the fill material has been assessed as it can all be potentially managed under a single remediation project.

1.3 Scope of Work

The scope of work is to suitably assess the properties of land at Nelson Parade for both radiological and chemical contaminants, in order to classify the material (in situ) that may undergo remediation, in accordance with the NSW waste classification.

1.4 Limitations

This Waste Classification Report (WCR) is given strictly in accordance with, and subject to, the following limitations:

- The WCR was prepared for the SPA ("the Client") in accordance with the scope of work agreed between ANSTO and the Client.
- ANSTO assumes no responsibility for conditions it was not authorised and directed by the Client to investigate.
- This report is based, in part, on unverified information supplied to ANSTO from several sources during the project research. Therefore, ANSTO does not guarantee its completeness or accuracy, and assumes no responsibility for errors or omissions related to this externally supplied information.
- 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.
- This report should not be altered, amended or abbreviated, issued in part or issued incomplete in any way without the prior written consent of ANSTO. ANSTO accepts no responsibility for any circumstances that arise from the issue of a modified report without the permission of ANSTO.
- The Radium Hill Company operated at Hunters Hill from 1911 until 1915, extracting radium from ore for a number of uses including in medical equipment. The Australian Nuclear Science and Technology Organisation (ANSTO) had no historic involvement with the site other than recent radiological surveys of the area.

2. Site Information

2.1 Site Identification and Description

'The site' consists of the following parcels of land in the residential suburb of Hunters Hill, Sydney, NSW, as shown in Figure 1;

- Foreshore land fronting No. 5 Nelson Parade, Hunters Hill;
- Foreshore land fronting No. 13 Nelson Parade, Hunters Hill;
- No. 11 Nelson Parade, Hunters Hill, excluding under the residential building footprint;
- Foreshore area Lots 7 & 9 Nelson Parade, Hunters Hill;
- Foreshore land fronting No. 11 Nelson Parade, Hunters Hill; and
- No. 7 & No. 9 Nelson Parade, Hunters Hill.

The area in its pre-remediated state generally is a series of sloping terraces from the northern perimeter and high point at Nelson Parade, sloping southward towards the Parramatta River which makes up the southern boundary.

The ground surface appears generally shallow in terms of loose sediment deposits to a depth of 1m below ground level (BGL) in much of the area, with regions of rocky outcropping and retaining walls that have been backfilled that contribute to the terracing. Mature trees are scattered around the site. Two large sandstone cliffs are found on the site; one dividing the area adjacent to Nelson Parade at the top of No's 7 and 9, and another dividing the foreshore areas in front of No's 5, 7, 9, 11, and 13 and the rest of the site.

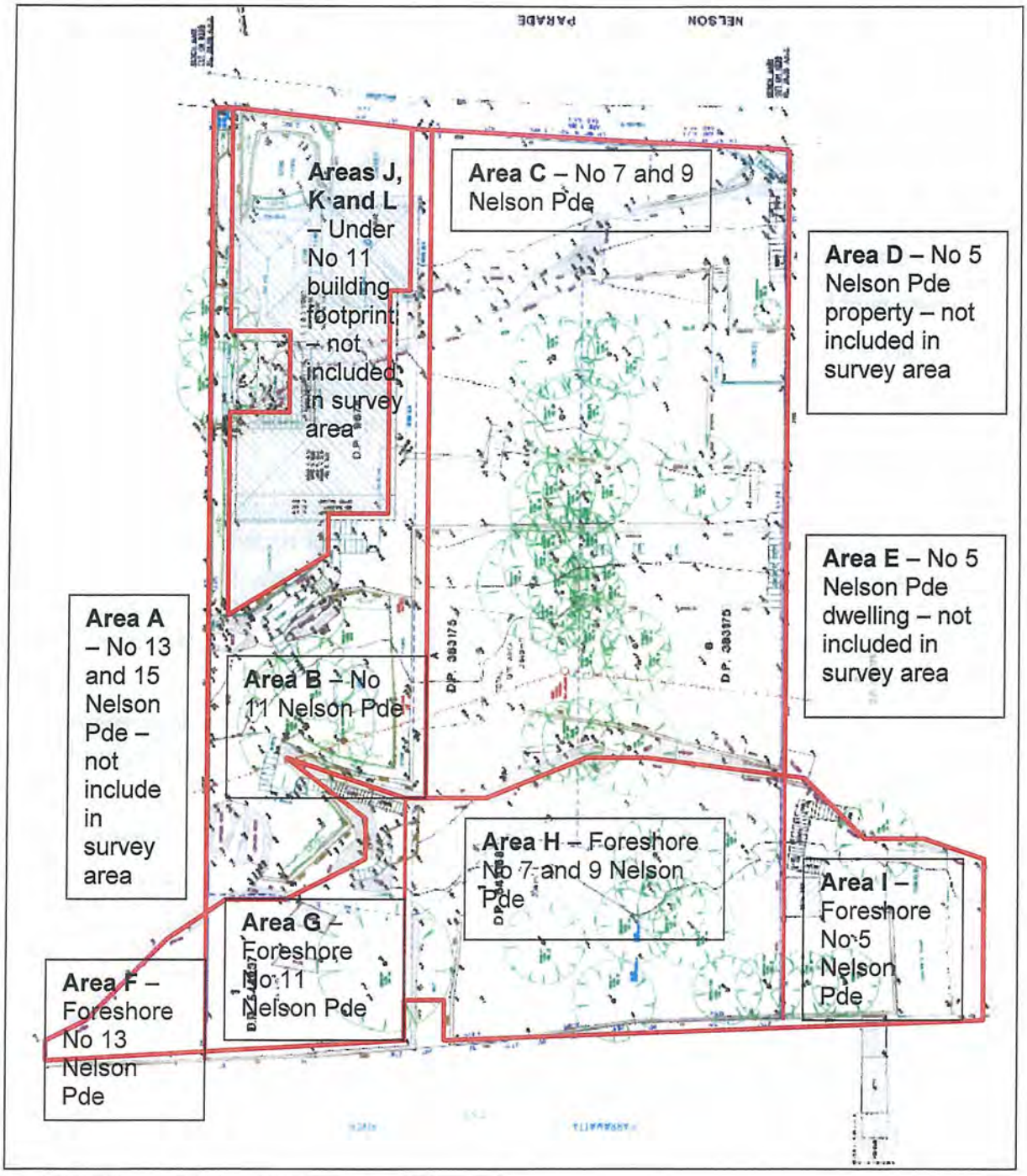
The southern perimeter of the site at the Parramatta River is bound by a sandstone seawall, with slipway penetrations at the No's 5 and 9. There is a small shed remaining on the foreshore area of No 5.

No 11 contains a functional dwelling, which provides access to the site from Nelson Parade

The foundations of historical buildings are present on the first terrace of No 7 and No 9.

Figure 1 - The location of the site from the Parramatta River, looking north

Figure 2 - The locations of the soil materials classified and type of analysis undertaken



Classification type and area;

Radiological and Chemical
- B (No.11 Excl. under Building Footprint)
- F (Foreshore No.13)
- I (Foreshore No. 5)
- G (Foreshore No.11)
- H (Foreshore No.7 & 9)

Chemical only
- C (No.7 & 9)

2.2 Site History

In the early part of the last century, the Radium Hill Company established a processing works in the area of Nelson Parade at Hunters Hill in NSW for the purposes of extracting radium from uranium-bearing ore for medical and other uses. The uranium came from Radium Hill in South Australia and was shipped to the site in Hunters Hill. A report by Sinclair Knight and Partners in 1987 described the ores processed at the plant as being a mixture of ilmenite, magnetite and rutile in association with black mica and carnotite. Historically the process has incorrectly been described as being a smelting process; however, as described by Ratcliff (1914), the extraction process was a chemical process. During the processing of the concentrates a number of solid and liquid waste streams were generated and disposed of on the site. The Radium Hill Company went bankrupt and the plant was closed in June 1915, leaving some residual materials containing isotopes of the uranium decay chain.

In addition to the radium extraction plant, from 1895 until 1966 a tin smelter operated on what is now Kelly's Bush Reserve, which borders Nelson Parade at Hunters Hill. The smelter processed tin ore that contained thorium-bearing and uranium-bearing monazite minerals. Low levels of these radiological contaminants remained in the resultant tin slag produced by the smelter at the site.

A carbolic acid plant also operated on reclaimed land on the lower portion of Lot 7 Nelson Parade from the late 1880's until 1900. The disposal of chemical contaminants from this plant is not known, however chemical contaminants including hydrocarbons and metals are suspected to be present on the site as a result.

When the potential hazards from the residual materials from the radium extraction plant were recognised in the 1950's, the soil and associated material was relocated to one area, predominately the current Lots 7 and 9 on Nelson Parade. Site redevelopment to date has included the construction of houses on each block of land. Extensive soil relocation has occurred within the study area during the construction of walls, terraces and swimming pools.

Following a Parliamentary Inquiry in 2008, the NSW Department of Health engaged the Australian Nuclear Science and Technology Organisation (ANSTO) to carry out an extensive radiological survey and characterisation of the area on and surrounding Nelson Parade, Hunters Hill, including in the Parramatta River immediately adjacent to the site.

2.3 Site Setting

This section provides an overview of the site area, topographical, hydrogeological and geological setting.

2.3.1 Site Area and Condition

The land being assessed comprises of three blocks of land and an area of reclaimed land on the foreshore of the Parramatta River, as shown in Figures 1 and 2.

Two of the blocks, referred to as No.7 Nelson Parade and No.9 Nelson Parade are vacant terraced blocks of vacant land, on which residential dwellings previously resided but have since been demolished and removed.

The other block of land, referred to as No.11 Nelson Parade has a four storey residential dwelling on the upper terraced section of the block.

These blocks of land are not currently privately owned and there is nobody currently residing on this land.

The foreshore area is reclaimed land below the cliff line of the above mentioned properties. The area consists of soil retained behind sandstone walls and comprises two slipways into the Parramatta River and a pontoon. There are no permanent buildings on this land, and although accessible from the water, it has no current public or private land use.

The entire site is currently surrounded by a secure fence to prevent access to the area.

Figure 3 - The Site Location

2.3.2 Geology, Topography and Hydrogeology

The 1:100,000 Soil Landscape Series (1993) map of Sydney identifies the localised landscape as '*undulating to rolling low hills on Hawkesbury sandstone and discontinuous earthy sands*'. Similarly, the 1:100,000 Geological Series Sheet (1983) of Sydney shows the underlying bedrock to be Triassic Hawkesbury sandstone which is described as '*medium to coarse-grained quartz sandstone with very minor shale and laminate lenses*'.

The Site is situated on a Hawkesbury sandstone outcrop on the banks of the Parramatta River. The topography of foreshore land between Nelson Parade and the water's edge drops off sharply due to the outcropping sandstone and cutting activities used during development of the Site.

Due to the proximity of the Site to the Parramatta River, groundwater is expected to infiltrate into the sandstone bedrock and flow in a southerly direction towards the river. However, due to the steep topographical change from Nelson Parade to the river, it is expected that only the immediate foreshore area of the Site would be affected by groundwater infiltration.

Observations during the field investigation identified a silty sand fill layer over natural sandstone bedrock. The depth of the fill layer varied from 0.00 m to 1.70 m. Refer to **Section 5.1** and **Appendix C** for detailed descriptions of the lithology.

2.4 Previous Investigations

The following previous relevant investigations have been undertaken at the Site:

- Radiation Branch of the Department of Health, 1966.
- Scott, B. W., *Investigation of Radioactive contamination at Nelson Parade Woolwich*, September 1977.
- Sinclair Knight and Partners, *Radium waste clean up Nelson Parade, Hunters Hill, Review of Environmental Factors*, August 1987.
- GHD Pty Ltd (GHD), *Contamination Investigation of Foreshore Land Fronting 5 and 13 Nelson Parade, Hunters Hill*, June 2009.
- ANSTO, *Radiological survey of Nelson Parade, Hunters Hill – Stages 1 and 2*, June 2009.

A review of these reports has been undertaken by ANSTO and CH2MHILL, with summaries provided in the following section.

2.4.1 Radiation Branch of the Department of Health (1966)

Between September 1965 and May 1966 a radiological investigation was conducted by officers of the Radiation Branch of the Department of Health. The investigation included analysis of soil surveys for radium, dose rates inside private residential buildings (including the then existing buildings on Nos 7 and 9 Nelson Parade) and analysis of plants for radium content. The report concluded that although localised areas of higher dose rates were observed, the average dose rates at the site did not constitute a significant health hazard.

2.4.2 Scott, W. B, Radiological Investigation (1977)

At the request of the then Health Commission of NSW, Mr B W Scott undertook a comprehensive radiological assessment of the site, including monitoring for radon and radon decay products inside the private residences of No.5, No.7, No.9 and No.11 Nelson Parade. Elevated readings of radon were detected inside No.7 Nelson Parade, only. The residential building on No.7 was subsequently vacated and demolished in 1983.

2.4.3 Sinclair Knight and Partners (1987)

Sinclair Knight and Partners undertook an extensive radiological investigation of the site in 1987. The findings of the report are summarised as:

- 70% of the samples collected at the site contain more than 2 Bqg^{-1} of radium-226, with an average of 4 Bqg^{-1} of radium-226 for the site. Some more elevated

levels were measured on No.9 and to a lesser extent on No.7 and No.11. The spread of material was consistent with its use as fill behind retaining walls and over rock shelves.

- The levels of activity were not higher than those typically encountered in uranium mining and milling.

A detailed map of the distribution of radium-226 radioactivity across the site was included in the report.

2.4.4 GHD Contamination Investigation (2009)

GHD was commissioned by the NSW Department of Commerce (DoC) to undertake a contamination assessment of foreshore land fronting Nos 5 and 13 Nelson Parade, Hunters Hill. A review of historical land use records undertaken by GHD indicated that both properties could be contaminated through the presence of residual radioactive materials from the extraction of uranium ore by the Radium Hill Company between 1911 and 1915-6. Numerous filling and reclamation activities were reported to have been undertaken on the lower foreshore lands.

In order to characterise the foreshore fill material, a total of six soil borings were completed using a hand auger. Two samples were collected from each boring location and submitted for both chemical and radiological analysis. In addition, a gamma radiation field survey was undertaken at each property using a SE Inspector EXP handheld radiation detector unit.

Fill materials observed at the foreshore of each property were described as follows:

- **No. 5 Nelson Parade foreshore:** brown to tan fine-grained fill sands with crushed sandstone, brick fragments, ash, charcoal and glassy black gravels.
- **No. 13 Nelson Parade foreshore:** dark brown sandy topsoil underlain by orange / tan and white sands.

Asbestos containing material (ACM) was not observed on either property and a PID screen at each sample interval indicated low (< 1.7 parts per million) readings. Contaminants of potential concern (CoPC) that were identified at No. 5 and No. 13 Nelson Parade at concentrations exceeding the adopted human health investigation (HIL – Residential [A]) or phytotoxicity assessment criteria included:

- **No. 5 Nelson Parade foreshore:** Lead, arsenic, mercury, zinc and PAH
- **No. 13 Nelson Parade foreshore:** Lead and arsenic

Lead concentrations above the HIL A criteria (300 mg/kg) were reported in one sample collected at No. 5 Nelson Parade foreshore and two samples collected from No. 13 Nelson Parade foreshore. The maximum lead concentration was 570 mg/kg. A total of four samples exceeded the HIL A criteria for arsenic (100 mg/kg). Two of the arsenic exceedances were from No. 5 Nelson Parade foreshore and two were from No. 13 Nelson Parade foreshore. The maximum arsenic concentration was 470 mg/kg.

The following Provisional Phytotoxicity Investigation Level (PBIL) exceedances were reported for arsenic, mercury and zinc:

- Arsenic: Two exceedances of the associated PBIL (20 mg/kg) in samples collected at No. 5 Nelson Parade foreshore and two exceedances for samples collected at No. 13 Nelson Parade
- Mercury: Four exceedances of the PBIL (1 mg/kg) in samples collected at No.5 Nelson Parade foreshore
- Zinc: Two exceedances of the PBIL (200 mg/kg) in samples collected at No.5 Nelson Parade foreshore

Total petroleum hydrocarbon (TPH) concentrations were reported above the laboratory limit of reporting (LOR) in all samples collected from No. 5 Nelson Parade foreshore and a single sample collected from No.13 Nelson Parade foreshore. The maximum TPH (C_{10}-C_{36}) concentration was 940 mg/kg (sample 5HA1), less than the adopted criteria of 1000 mg/kg.

Total polycyclic aromatic hydrocarbon (PAH) concentrations were detected above the adopted HIL A criteria (20 mg/kg) in all samples collected at No. 5 Nelson Parade foreshore. The maximum PAH concentration was reported to be 216.9 mg/kg in the near surface (0.1 metres below ground level [mbgl]) sample. Similarly, concentrations of Benzo(a)pyrene (BaP) in all samples from No.5 Nelson Parade foreshore exceeded the adopted HIL A criteria (1 mg/kg), with a maximum concentration of 16 mg/kg. All samples analysed from No.13 Nelson Parade foreshore reported concentrations of total PAH and BaP below the HIL A criteria.

Concentrations of benzene, toluene, ethylbenzene and xylene (BTEX), organochlorine pesticides (OCP) and polychlorinated biphenyls (PCB) in all samples analysed were less than the laboratory LOR.

GHD attributed the elevated concentrations of PAH, lead, arsenic, mercury, zinc and PAH at No.5 Nelson Parade foreshore to the presence of ash and charcoal observed within the fill materials.

Radiological analytical results were reported below the adopted site criterion for all samples. The gamma ray field survey indicated a greater level of activity at the foreshore of No. 13 Nelson Parade than No.5 Nelson Parade, with 12 out of 26 surveyed locations exceeding the assessment criterion of 0.7 microgray per hour (µGy/hr).

All measured Toxicity Characteristic Leaching Potential (TCLP) results were below the laboratory LOR.

GHD concluded that fill materials at No. 5 Nelson Parade foreshore could be disposed of off-site under the general immobilisation approval (1999/05). The immobilisation approval allows for waste classification of materials impacted by PAH using TCLP values only.

Due to the elevated levels of gamma radiation in fill material at No.13 Nelson Parade foreshore, GHD concluded that the material would require disposal as *Restricted Solid Waste* at a suitable registered facility and subject to NSW DECCW approval.

2.4.5 ANSTO Radiological Survey of Nelson Parade (2009)

ANSTO was commissioned by the NSW Department of Health and the NSW DECC to undertake a radiological survey of the areas surrounding the properties covered by this in-situ waste classification report. Surveys were not undertaken on the Lots No's 5, 7, 9 and 11 Nelson Parade.

Surveys were completed in the yards and houses of residents in Nelson Parade adjacent to the properties of No's 5, 7, 9 and 11. The survey results within the survey area varied significantly, depending upon their location. Most areas indicated nil or negligible presence of radioactivity above natural background levels. The areas of the highest radiological activity measured were from roadways in Hunters Hill; however this was assessed to be a result of the inclusion of thorium-bearing slag from the tin smelter formerly located in nearby Kelly's Bush. The other areas of highest radiological readings were from properties immediately adjacent to the former radium extraction plant site in Nelson Parade.

The report details the areas surveyed, the methodology used and the potential exposure levels arising from external gamma radiation and the internal exposure from potential inhalation of radioactive dusts and radon, and the ingestion of particles and foodstuffs. It also provides guidance on the spatial and vertical distribution of contamination and the level of uranium and thorium in the soil.

The exposures from ingestion, dust inhalation and external exposure pathways were analysed, with the total exposure assessed to be less than 1 mSv per year.

Indicative radon concentrations were measured inside targeted dwellings, with all results being below the recommended action level for possible remediation action. However, in one dwelling elevated radon levels which were just below this action level were measured. Core samples were taken in the areas of elevated radioactivity and the cores analysed. From the activity screening and analysis, the maximum activities were calculated, the radionuclide ratios identified and the vertical extent of the contamination estimated at each site.

2.5 Potential Nearby Sensitive Receptors

As part of the site setting, the following potential sensitive receptors are identified in each direction from the site:

Direction	Potential Nearby Sensitive Receptor
North	Nelson Parade roadway then private residences
East	Private Residences No.5 and No.3 Nelson Parade
South	Marine ecosystems as part of the Parramatta River
West	Private Residences No.13 and No.15 Nelson Parade

3. Contaminants of Concern and Investigation Criteria

3.1 Contamination Sources

Review of historical land use and related recent studies undertaken in the area indicate that some or all of the areas listed above may be impacted by radioactive residues from the processing of uranium bearing ore for extraction of radium by the Radium Hill Company up until 1915. Any potential impact on the site from the legacy slag from the former tin smelter in Kelly's Bush is anticipated to be low due to the distance of the site from the tin smelter site. In addition the area may also be impacted by chemical residues from the carbolic acid plant. Subsequent to the sites being vacated by the carbolic acid plant and Radium Hill Company, the sites have been landscaped and filled with materials of unidentified origin. As a result, there is potential for non-uniform distribution of radiological materials and also the potential for chemical impact of the soil.

The waste classification program proposed in the areas identified above is designed to complement previous assessments undertaken on adjacent properties and to provide a suitable level of information to determine the waste classification of the soil for remediation works planned for the sites.

3.1.1 Radiological

Radioactive material exists naturally within soils. These are due to the presence of isotopes from the uranium, thorium and actinium decay chains, and from potassium-40. Due to the transportation of uranium-bearing ores from the Radium Hill mines in South Australia to the site at Hunters Hill and the subsequent processing for extraction of radium-226, there is potential for elevated levels of radioactive material predominately from the uranium decay chain. No other evidence exists to indicate the presence of significant amounts of other isotopes. Therefore the radiological contaminants of concern are the isotopes of the uranium-238, thorium-232 and uranium-235 decay chains. These are summarised in Table 1 below, including the limits of reporting for the preferred laboratory assessment methodology.

Table 1: ANSTO laboratory methods for proposed isotopic analysis and Limits of Reporting

Radionuclide	Lab Method	Lab Limit of Reporting (mg/kg)
Th-234	VP-2747	2.9
Pa-234m	VP-2747	22
Th-230	VP-2747	14
Pb-214	VP-2747	0.3
Bi-214	VP-2747	0.3
Pb-210	VP-2747	5.4
Ac-228	VP-2747	0.7
Th-228	VP-2747	30
Ra-224	VP-2747	2.4

Pb-212	VP-2747	0.2
Bi-212	VP-2747	1.9
Tl-208	VP-2747	0.2
U-235	VP-2747	0.6
Th-227	VP-2747	0.8
K-40	VP-2747	6.0

3.1.2 Chemical

A carbolic acid plant was located on the foreshore area of No7 Nelson Parade. Due to the subsequent relocation of soil around the site, and the potential contaminants from the radium extraction plant and carbolic acid plant, the following broad range of analyte groups are the main chemical contaminants of concern, as summarised in Table 2 below.

Table 2. Accredited laboratory methods for proposed chemical analytical suites and Limits of Reporting

Analyte Group	Lab Method	Lab Limit of Reporting (mg/kg)
Heavy Metals (As, Cd, Cr, Cu, Pb, Ni, Zn)	EG005T	1-5
Mercury	EG035T	0.1
Polycyclic Aromatic Hydrocarbons (PAH)	EP075 (SIM) B	0.5
Total Petroleum Hydrocarbons (TPH)	EP080/071	10-100
Organochlorine Pesticides (OCP)	EP068A	0.05 – 0.2
Asbestos	AS 4964	--
Total Polychlorinated Biphenyls (PCB)	EP066	0.1
Total Characteristic Leaching Procedures (TCLP) – Heavy Metals	EG005C	0.1 mg/L
Total Characteristic Leaching Procedures (TCLP) – PAH	EP075 (SIM) B	0.5 – 1 µg/L

3.1.3 3.1.3 Asbestos

Although none was identified during previous investigations and from the historical review, there does exist the possibility that asbestos from either former buildings or from unknown fill materials used on the site may be present. However, no direct evidence exists to indicate that asbestos is present. Asbestos is included in the decision-making process only if visible asbestos-containing material is identified during the site assessment.

3.2 Contaminants of Potential Concern

The predominant radiological contaminants of concern are from the uranium-238 decay chain, and to a lesser extent uranium-235 and the thorium-232 decay chains, all of which are present at some level both naturally and as a result of the activities undertaken on the site. As the ores

containing these isotopes have been processed, it is unknown if these decay chains are currently in a status of secular equilibrium. Therefore isotopes from different parts of each of the decay chains were analysed to determine the ratios between each isotope. This eliminated the potential underestimation or overestimation of the total radioactivity present on the site if the decay chains are not in secular equilibrium and only a single isotope is analysed.

The exact chemical contaminants that may be present on the site are not known. However, from analysis of the historical uses of the site, particularly from the carbolic acid plant, and from previous chemical assessments of the site, a broad range of chemical contaminants were chosen for analysis, as listed in Table 2. There is no evidence which would suggest a need to analyse for any other specific chemical contaminants.

3.3 Waste Classification Criteria

3.3.1 Soil – Radiological

The DECC Guideline *'Waste Classification Guidelines, Part 3: Waste Containing Radioactive Material'* (October 2008) defines how to classify wastes containing radioactive material. Samples were analysed for the ^{238}U decay chain, ^{232}Th decay chain and ^{235}U decay chain and assessed against the protocol outlined in NSW DECC (2008) *'Waste Classification Guidelines, Part 3: Waste Containing Radioactive Material'*.

The Guideline states that 'liquid or non-liquid wastes with:

- A Specific Activity of 100 Bq/g^{-1} AND;
- Consist of, or containing more than, the prescribed activity of a radioactive element in Schedule 1 of the Radiation Control Regulation 2003 whether natural or artificial;

must be classified as *hazardous waste'*.

For material containing radionuclides in the U-238, Th-232 and U-235 decay chain, the total specific activity should be used, which is the sum of radioactivity concentrations for each radionuclide present.

For material containing a total specific activity of less than 1 Bq/g^{-1}, the material can be classified as *General Solid Waste*, in accordance with the guidelines.

Material containing a total specific activity of between 1 Bq/g^{-1} and 100 Bq/g^{-1} can be classified as *Restricted Solid Waste*, in accordance with the guidelines.

3.3.2 Soil – Chemical

Chemical analytical results were used to determine the waste classification of the material in accordance with the NSW DECC, *Waste Classification Guidelines*, 2008. Contaminant threshold (CT) values for waste classification without completion of leaching tests have been adopted from Table 1 of NSW DECC (2008). Maximum values for leachable concentrations (TCLP) and total specific contaminant concentrations (SCC) when used together have been adopted from Table 2 of the NSW DECC (2008).

Table 3 summarises the adopted criteria for the CoPC associated with the Site.

Table 3

Waste Classification Criteria

Waste Classification Report

Analyte	General Solid Waste			Restricted Solid Waste		
	CT1 (mg/kg)	TCLP1 (mg/L)	SCC1 (mg/kg)	CT2 (mg/kg)	TCLP2 (mg/L)	SCC2 (mg/kg)
Monocyclic Aromatic Hydrocarbons						
Benzene	10	0.5	18	40	2	72
Toluene	288	14.4	518	1152	57.6	2,073
Ethylbenzene	600	30	1080	2400	120	4,320
Xylene	1000	50	1800	4000	200	7,200
Total Petroleum Hydrocarbons						
TPH (C_6-C_9)	—	—	650	—	—	2,600
TPH (C_{10}-C_{36})	—	—	10,000	—	—	40,000
Polycyclic Aromatic Hydrocarbons						
Benzo(a)pyrene	0.8	0.04	10	3.2	0.16	23
PAH Total	—	—	200	—	—	800
Polychlorinated Biphenyls						
Total PCB	—	—	< 50	—	—	< 50
Organochlorine Pesticides						
Aldrin + Dieldrin	—	—	250	—	—	1,000
DDT	—	—	< 50	—	—	< 50
DDD	—	—	< 50	—	—	< 50
DDE	—	—	< 50	—	—	< 50
Heavy Metals						
Arsenic	100	5	500	400	20	2,000
Cadmium	20	1	100	80	4	400
Chromium (VI)	100	5	1,900	400	20	7,600
Lead	100	5	1,500	400	20	6,000
Mercury (inorganic)	4	0.2	50	16	0.8	200
Nickel	40	2	1,050	160	8	4,200

3.3.3 Soil – Asbestos

As noted above, asbestos was to be included in the waste classification assessment only if visible asbestos containing materials (ACM) was identified during the field investigation. NSW DECC (2008) states that if asbestos is detected in the waste classification sample collected, the waste should be designated as *Special Waste – Asbestos* and disposed of at a suitable waste receiving facility.

3.4 Comparison of Analytical Data

The statistical methodology used for the comparison of the analytical concentrations to the adopted waste classification criteria is based on the methods referred to in the NSW EPA, *Contaminated Sites: Sampling Design Guidelines*, 1995 and National Environment Protection Council (NEPC), *National Environment (Assessment of Site Contamination) Protection Measure (NEPM)*, 1999, namely:

- comparison of the 95% upper confidence limit of the arithmetic mean concentration (95% UCL) values of each contaminant (with the exception of asbestos) to the nominated site criterion;
- comparison of the calculated standard deviations to a value of 50% of the nominated site criteria; and
- determination of the required number of samples (Procedure B) to allow calculation of an average concentration.

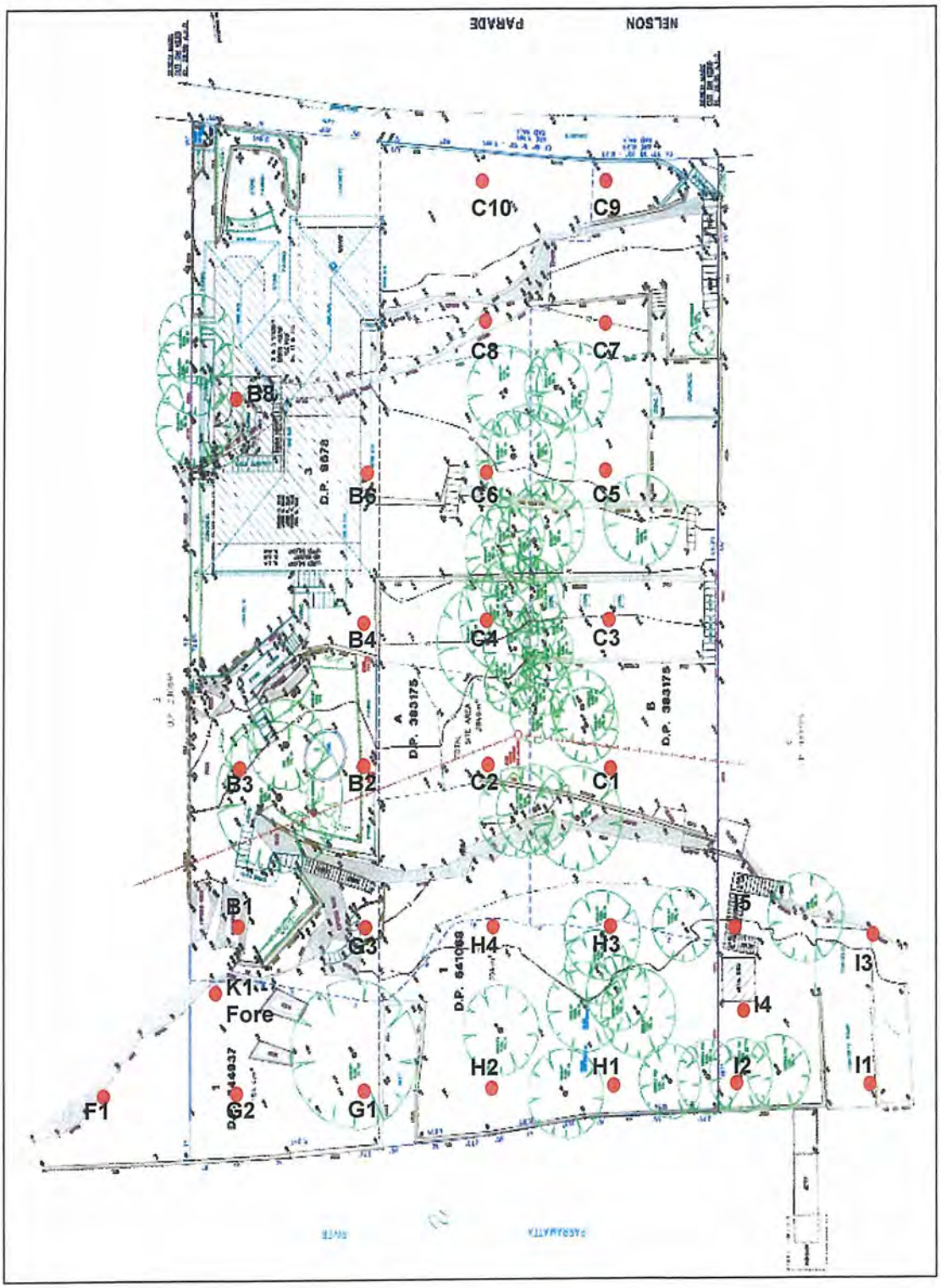
4. Assessment Methodology

4.1 Scope of Fieldwork

All field work was conducted in accordance with ANSTO's Quality Management system, CH2M Hill's standard operating procedures, and relevant State regulations. Each separate area of the survey was slightly different. However the following general methodology was used:

1. Radiological mapping of the areas using 2 inch NaI detectors and Geiger-Muller detectors mounted on a tripod at a distance of 1 metre above the ground for a count time of 300 seconds each count, in a systematic sampling pattern;
2. A continuous 'walk-over' survey technique at a height of 5 centimetres above the ground along spatial lines at a nominal separation of 1 m, but with allowance for inaccessible areas. The radiological mapping assisted in determining the spatial distribution of radiological materials and reduction when determining the critical size of radiological hotspots;
3. Soil sampling at regular intervals in a systematic sampling pattern using a hand auger;
4. Laboratory analysis of soil samples for radiological and chemical impacts; and
5. Data interpretation and reporting.

Figure 4 – Borehole locations



4.2 Data Quality Objectives (DQOs) Process

The Data Quality Objectives (DQOs) process is a seven step planning approach used to prepare plans for environmental data collection activities. The purpose of establishing Data Quality Objectives (DQO) is to ensure that the field investigations and subsequent analyses are undertaken in a way that ensures the reporting of data is reliable.

As identified in Appendix IV of the *Guidelines for the NSW Site Auditor Scheme (2nd Edition)*[1] a series of steps are involved in the DQO process. They are:

1. State the problem
2. Identify the decision
3. Identify inputs to the decision
4. Define the study boundaries
5. Develop a decision rule
6. Specify limits on decision errors
7. Optimise the design for obtaining data

4.2.1 Step 1 – State the Problem

The waste classification program was undertaken to provide suitable data to enable the in situ classification of the fill materials prior to the commencement of remediation works, if required. Waste materials consequently did not have to be excavated and stockpiled prior to collection of samples and waiting for results of chemical and radiological analyses for waste classification purposes.

It was considered that in situ classification of the waste materials would provide environmental and human health benefits resulting from the ability to load the pre-classified materials directly for transport to the licensed waste management facility.

4.2.2 Step 2 – Identify the Decision

The key decision to be made as a result of the classification program was:

- What are the radiological and chemical classifications of the soil with respect to the relevant NSW waste classification guidelines?

4.2.3 Step 3 – Identify Inputs to the Decision

A number of inputs were required in the decision making process. These included:

- Historical information gained from previous related reports and historical records of the area;
- Identification of elevated levels of radiological materials via direct probe monitoring;
- Intrusive sampling of soil to a depth of 2 m or bedrock;

[1] NSW DEC 2006, Contaminated Sites: Guidelines for NSW Site Auditors Scheme

- Quantitative data obtained from intrusive soil sampling and analytical investigation; and
- Comparison of data with appropriate screening level criteria.

4.2.4 Step 4 – Define the Study Boundaries

The lateral boundaries of the survey area are described in the Introduction and viewed in **Figure 2**.

The vertical boundaries of the survey were to a depth of 2 metres of soil or to bedrock. Previous studies of adjacent areas indicated no clearly defined stratification of radiological materials within the vertical profile.

4.2.5 Step 5 – Develop a Decision Rule

Project data collected were compared to the appropriate NSW DECC guidance material for classification of chemical and radiological waste materials.

The classification of the soil in terms of potential waste was determined against the DECC *Waste classification guidelines, Part 1: Classifying Waste* (2009) and *Part 3: Waste Containing Radioactive Material* (2008)

Asbestos was reported only if it is visible on the site, and as either presence or absence of friable and bonded asbestos. If friable or bonded asbestos were present, then this would have been quantified and reported in terms of volume and location and its presence assessed to allow for appropriate classification of the waste.

4.2.6 Step 6 – Specify the Limits on Decision Errors

Two primary decision errors may have occurred due to uncertainties or limitations in data:

- Type A error: An investigation area may have been assessed to pose no unacceptable risk when in reality it did (a false negative). This may be due to limitations in the sampling plan or unreliable data sets.
- Type B error: An investigation area may have been assessed to pose an unacceptable risk when in reality it didn't (a false positive). This may be due to inappropriate sampling, sample handling or analytical procedures.

The reliability of both the field and laboratory programs were assessed in terms of the Data Quality Indicators (DQIs - precision, accuracy, representativeness, completeness and comparability), as set out in Appendix V of NSW DEC (2006).*Guidelines for the NSW Site Auditor Scheme (2nd edition)*. The laboratory program for analysis of radiological and chemical impacts is separate; as such DQI's for precision and accuracy are addressed separately.

Precision

Precision is a measure of agreement among replicate measurements of the same property, under prescribed similar conditions[2].

[2] Multi Agency Radiation Survey and Site Investigation Manual (MARSSIM) 2000, Rev.1

Precision of Radiological data is achieved by collection and analysis of duplicate samples. Blind duplicate samples are collected at a rate of not less than one per 20 (i.e. 5%) soil samples and are assessed by comparing the relative percentage difference in activity between the anonymous samples. Samples were mixed and homogenised on site before being split into duplicates

Precision of Chemical data is achieved by collection of Blind (one per 20 samples) and Split (one per 20) duplicate samples. Analysis of samples for chemical impacts was undertaken at NATA accredited laboratories for both Primary and Secondary samples

Accuracy

Accuracy is a measure the trueness of a measuring system, which is determined by the closeness of measurements of standards compared to their known true value.

Accuracy of Radiological data was achieved by using ANSTO Building 21 Gamma Ray Spectrometer in compliance with ANSTO procedure VP-2747 for sample preparation, system operation and quality maintenance. This includes calibration of the instrument against reference standards. The Gamma Ray Spectrometer system also scored 'A' under annual International Atomic Energy Agency (IAEA), Worldwide Proficiency Testing for 'trueness' and 'precision'.

Accuracy of Chemical data was achieved by using laboratory methodologies in accordance with those stipulated by NATA accreditation scheme.

Representativeness

Representativeness is a measure of the degree to which data accurately and precisely represent a characteristic of a population parameter at a sampling point.

Representativeness of data was achieved by collecting samples and data in an appropriate pattern across the site and by collecting a suitable number of samples to characterise the site. This soil sampling program complied with the NSW EPA *Sampling Design Guidelines*[3].

A systematic sampling pattern was used, as specified in Section 2.6 of the guidance material *MARSSIM (2000)*. Samples were collected every 10 metres, at a greater population than the above mentioned NSW EPA, *Sampling Design Guidelines* recommends.

Completeness

Completeness is a measure of valid data obtained, expressed as a percentage of the total measurements made.

Sufficient valid data was generated during the study.

Comparability

Comparability is a qualitative term expressing the confidence with which subsequent data sets within a study may be compared, specifically with respect to field, laboratory and interpretation

Comparability was achieved through maintaining a level of consistency in sampling techniques, sample handling techniques, analytical laboratory techniques and reporting methodology.

[3] NSW EPA (1995), Contaminated Sites: Sampling Design Guidelines

4.2.7 Step 7 – Optimise the Design

To determine the most resource-effective sampling and analysis program, a sampling and analysis plan was prepared. ANSTO and CH2M Hill conducted fieldwork in accordance with their quality management system which specifies field techniques, sample collection, analytical sample counting and assessment, and sample management (chain of custody). The program was also prepared with guidance from MARSSIM (2002). The general methodology is outlined in the 'Methodology' above.

4.3 Fieldwork Methodology

A continuous radiological survey was undertaken across the entire site at a distance of approximately 5 centimetres above the ground, in lines 1 metre apart across the site. Areas where access was not possible, such as cliff lines, were omitted from the continuous survey. Results were recorded manually at intervals of 1 metre on a map of the site. Additional results were recorded if an area of significantly elevated radioactivity was detected, to identify the boundaries of the elevated activity. All detectors were checked in accordance with ANSTO Instruction S-ROH-I-006 Operational Checks – Health Physics Contamination Monitors prior to use. All detectors performed satisfactorily during the radiological survey.

Soil borings were advanced across the Site using a hand auger to a maximum depth of two mbgl or until refusal. Each soil boring was backfilled with the material removed.

Sample locations were based on a systematic grid pattern. A site plan indicating the boring locations is provided on **Figure 4**.

Soil samples were collected from every boring at a frequency of one sample per 0.5 mbgl or if visual or olfactory signs of contamination were observed. Samples scheduled for analysis for volatile compounds were collected directly from the auger head to minimise disturbance of the sample and the potential loss of volatile contaminants. The remaining soil was then transferred to a stainless steel container to allow homogenisation of the sample prior to collection. In addition, material for radiological analysis was collected in a laboratory-supplied plastic jar. Samples for confirming the presence and / or absence of asbestos were placed in laboratory-supplied re-sealable sample bags.

A soil boring log was completed at each location. It includes a description of the lithology observed, details of the samples collected and any observations of visual or olfactory signs of contamination (**Appendix C**).

All soil samples collected were screened in the field during sample collection for volatile organic compounds with a photoionisation detector (PID). The reported PID readings for each sample were noted on the corresponding boring log (**Appendix C**). Between each reading the PID was allowed to stabilise to normal background air quality conditions.

Table 4 summarises the number of soil borings per area of the Site.

Table 4

Summary of Soil Borings

Waste Classification Report

Area Identification	Total No. of Soil Borings	Maximum Depth Achieved (mbgl)
B	6 (B1, B2, B3, B4, B6, B8)	1.00
C	10 (C1, C2, C3, C4, C5, C6, C7, C8, C9, C10)	1.70
F	1 (F1)	1.40
G	3 (G1, G2, G3)	1.00
H	4 (H1, H2, H3, H4)	0.50
I	5 (I1, I2, I3, I4, I5)	0.60

4.3.1 Service Clearance

All sample locations were cleared for services using Dial-before-you-dig information and an electromagnetic sweep by an accredited service locator. If services were identified at a proposed sample location, the sample location was relocated to the nearest safe location.

In addition a radiological survey was undertaken of the site prior to the collection of samples, as specified in the risk assessment for the sampling program.

4.3.2 Sampling and Analytical Program

Radiological

Soil samples collected for radiological analysis were analysed at ANSTO's environmental analysis gamma spectroscopy laboratories in Sydney for the analysis listed in **Table 1**.

Chemical

Soil samples collected for chemical analysis were submitted to ALS Laboratory Group (ALS) in Sydney for the analysis listed in **Table 2**

ALS Laboratory Group was used as the primary laboratory and Envirolab Services (Envirolab) was used as the secondary laboratory.

4.3.3 Sample Handling and Transport Methods

All samples were labelled with a unique identified consisting of the sample location (i.e. B1_1), date collected and sampler. A field worksheet was completed for each sample including depth of sample, required analysis, time of sample collection and signature of the sampler.

Samples for analysis of volatile compounds (i.e. BTEX and TPH (C_6-C_9)) were placed in 150 mL laboratory prepared and supplied glass jars. Samples for the analysis of heavy metals, TPH (C_{10}-C_{36}), PAH, OCP and PCB were placed in 250 mL glass jars.

Soil samples collected for chemical analysis were kept cool in eskies containing ice and sent on the day they were collected via courier to ALS. Each sample shipment had accompanying chain of custody (CoC) documentation.

Samples of no less than 200g for analysis of radiological activity were placed in air-tight sealable 1L plastic containers. As the radiological activity of the samples does not degrade with temperature there is no requirement to transport the samples for radiological analysis packed in ice. Upon receipt of the samples for radiological analysis, the samples were prepared by being crushed to a powder, large pieces of organic material removed and then dried in an oven to reduce the moisture content of the sample. 100g of each sample was then weighed and re-sealed in their screw capped container using a silicone sealant for a period of at least 3 weeks to allow the in-growth of the radon decay products present in each of the decay chains. Samples were then counted on the calibrated gamma spectroscopy system for a period of 24 hours each sample.

4.3.4 Field Equipment Calibration

The PID used by CH2M HILL to screen for the presence of volatile contaminants was calibrated on a daily basis using an isobutylene calibration gas and according to the manufacturer's instructions. Certificates recording the daily calibration results are included in **Appendix F**.

Each of the radiological monitoring devices and electronic personal dosimeters was calibrated and recorded on an annual basis in accordance with ANSTO Instrument Calibration quality procedure S-RIC-P-001 against known standards.

Instruments underwent a daily instrument response check against natural background radiation in accordance with ANSTO Instruction S-ROH-I-006 Operational Checks – Health Physics Contamination Monitors prior to use.

4.3.5 Decontamination Methods

The decontamination of personnel, personal protective equipment (PPE) and sampling equipment was performed in accordance with the procedures outlined in CH2M HILL's standard operating procedures (SOP), to minimise risks to health and safety and prevent cross-contamination of contaminants.

At each sample location a new set of disposable nitrile gloves was used to collect the soil sample. Between each sample location, all soil sampling equipment was decontaminated using a scrubbing brush and a solution of Decon90 and tap water to remove soil material, followed by a rinse in deionised water. A rinsate sample was collected by pouring deionised water over the decontaminated hand auger. This rinsate sample was submitted for analysis to assess potential cross contamination which may have occurred between sampling locations.

At the conclusion of each day of fieldworks, disposable sampling equipment and PPE, including coveralls, gloves, PID bags and dust masks, were collected and scanned with a radiation contamination monitor to determine whether any residual radiological

contamination was present. After the scan, the equipment was secured in a rubbish bag and stored at the Site awaiting later disposal. In addition, to prevent potential exposure to the courier driver, the samples that were to be dispatched to the laboratory were scanned to ensure that residual radiological contamination was not present outside the sample jars or on the outside of the esky.

4.3.6 Field Quality Control / Quality Assurance

In addition to the sampling program specified in **Section 4.3.2,** QA/QC samples were also collected. **Table 5** summarises the QA/QC samples collected and the analysis scheduled.

Table 5

QA/QC Sample Frequency

Waste Classification Report

QA/QC Sample Type	Frequency of Collection	Analysis Scheduled
Inter-lab duplicate samples	5% of primary samples	Analysis for CoPC
Intra-lab duplicate samples	5% of primary samples	Analysis for CoPC and total radioactivity
Trip spike and trip blank samples	One trip spike and trip blank per sample shipment for analysis of volatile compound loss and potential cross contamination	BTEX, volatile contaminants
Rinsate samples	Four rinsate samples collected over one week sampling period	Analysis for CoPC

4.3.7 Chain of Custody Documentation

Refer to **Appendix G** for copies of the CoC documentation.

5. Investigation Results

The fieldwork undertaken as part of this investigation was completed between 23 and 27 August 2010. The location of each of the soil borings are shown in **Figure 4**. The following sections describe the findings of the waste classification investigation at the Site.

5.1 Field Observations

The lithology encountered during the advancement of the soil borings was consistent across the areas investigated. Fill materials consisted of orange / brown silt and sand topsoil with frequent inclusions of angular sandstone fragments. Fill material was underlain by Hawkesbury sandstone that outcrops along the banks of the Parramatta River.

PID readings reported during the investigation were low (< 2.3 ppm) and there were no olfactory signs of chemical contamination observed. Minor quantities of charcoal/ash material were observed at three locations, and potential coking waste from the former radium extraction plant was observed in one sample in the foreshore area. In addition, infrequent glass, brick fragments and gravel were identified in fill materials. Potential ACM was not identified at the locations investigated or observed on the surface of the Site.

Table 6

Visual Observation Summary

Waste Classification Report

Location ID	Depth Interval (mbgl)	Material Observed
C1	0.0 - 0.3	Charcoal / ash deposits
C1	0.4 - 1.4	Charcoal / ash fragments
G2	0.60 - 1.0	Glass / ash and gravel fill
I4	0.0 - 0.3	Ash and suspected coking waste

5.2 Analytical Results

Chemical results are summarised in **Appendix I** attached to this report. Laboratory Certificates of Analysis and CoC documentation are provided in **Appendix G.**

The following sub-sections provide an assessment of both the chemical and radiological results against the adopted assessment criteria. Chemical results were initially compared to Contaminant Threshold (CT) values for general and restricted solid waste, prior to an assessment based on representative TCLP concentrations. It is noted that some contaminants, such as total PAH, do not have an associated CT value with the Specific Contaminant Concentrations (SCC) adopted as the most appropriate assessment value.

For the purpose of the **chemical** results discussion, the areas of the site investigated have been combined into the following location groupings (LG) based upon their property boundaries and usage:

- LG1 – Parramatta River foreshore (Areas F, G, H and I).
- LG2 – Outdoor area of No. 11 Nelson Parade (Area B), excluding foreshore.
- LG4 - No. 7 and No. 9 Nelson Parade, excluding foreshore (Area C);

The radiological in situ waste classification did not include Area C (LG4) which has previously been assessed for radiological contamination. Based upon the walk over radiation survey results of the areas and previous survey results, slightly elevated levels of activity were detected across the site (a walk over survey was also conducted in Area C for comparison against previously reported spatial distribution of radiological material – see results in section 5.2.1 below). Therefore for the purpose of the **radiological** results discussion, the majority of the areas were combined into a single grouping covering the majority of the site (excluding LG4). This impacts on the potential remediation actions of the site, as the remaining areas (LG1 and LG2) will radiologically be treated as a single area.

The assessment of the building footprint on No. 11 Nelson Parade was excluded from this report as it will be treated separately from the remainder of the site as the remediation actions for the material under the footprint will be managed differently.

Radiological results of different isotopes within the same decay chain were analysed to determine the ratios of isotopes and assess if the decay chains were in a state of secular equilibrium.

From this analysis the total radioactivity of the samples were calculated and compared against the Contaminant Threshold values for general and restricted solid waste.

5.2.1 Radiological Results

Spatial Distribution

As described in the methodology above, radiological mapping was undertaken of all of the areas using 2 inch NaI detectors and Geiger-Muller detectors, and a continuous 'walk-over' survey technique along lines at a nominal separation of 1 m, but with allowance for inaccessible areas. These results provided an increased representation of the spatial distribution of radioactive material across the site. This allowed for significantly increased identification of contaminant 'hotspots' and aided in ensuring that samples were representative of the entire site. These results have been plotted and presented in **Appendix A** in units of relative levels of radioactivity (counts per second, cps). It should be noted that, with the exception of the first plot, the colour grading of the plots is different for each area. The grading was chosen to most clearly identify areas of elevated radioactivity within each area and not for inter-area comparison.

As can be seen by the plots, the radioactivity is not distributed homogeneously across the site. However it did provide additional confidence that the location of the soil sample sites provided a suitable representation of the radiological contaminants present on the site. It also allowed the identification of the location and extent of any radiological 'hotspots' which did not fall in a soil sample site. Subsequent soil samples were then able to be taken of hotspots, if statistically required. The spatial distribution of radioactive material across No 7 and 9 Nelson Parade (Area C) was similar to the reported spatial distribution map in the Sinclair Knight and Partners report, *Radium waste clean up Nelson Parade, Hunters Hill, Review of Environmental Factors*, August 1987.

Secular Equilibrium

Due to the history of the site, the predominant radiological contaminants of concern were isotopes from the uranium-238 decay chain, and to a lesser extent isotopes from the thorium-232 and uranium-235 decay chains.

If undisturbed for a suitable period of time, these decay chains will be in a state of secular equilibrium, where the ratios between each isotope in the decay chain are the same. However if the material has been processed it is probable that the equilibrium of the decay chain has been disturbed. This can have a significant influence over the total activity of the sample being analysed and the total activity of the sample at a later time period.

Soil samples collected were analysed for a number of isotopes from different parts of each of the decay chains. This allowed a comparison of the ratios of the isotopes in a chain to determine if they are in secular equilibrium and if not, where the decay chain has been disrupted. This comprehensive analysis methodology was implemented to investigate the assumptions made in previous historical radiological surveys and to reduce any potential errors associated with these assumptions.

In this analysis of secular equilibrium the following assumptions have been made:

- Th-234, Pa-234m and Th-230 were measured and assumed to be representative of U-238 and U-234, due to the long half-lives of these isotopes.
- The measured concentration of Pb-210 was assumed to be representative of Rn-222, Po-218, Po-214, Bi-214, Pb-214, Bi-210 and Po-210. To test this assumption Po-210, Pb-214 and Bi-214 were all measured and then compared. The test confirmed this assumption.
- Isotopes from the Th-232 decay chain were assumed to be in a state of secular equilibrium due to the relative half- lives of the isotopes. To test this assumption six isotopes from different parts of the decay chain were analysed and compared. The test confirmed this assumption.
- The activity of U-235 was measured and assumed to be representative of the U-235 decay chain based upon the relatively short half-lives of the decay products.
- The levels of K-40 were assumed to be at background levels and independent of the operations that historically occurred at the site. To test this assumption K-40 was measured and compared to background levels, which confirmed this assumption.

Comparison of the Th-234 activity (upper part of the U-238 decay chain) against the Pb-210 activity (lower part of the U-238 decay chain), and the Ra-224 activity (upper part of the Th-232 decay chain) against the Bi-212 activity (lower part of the Th-232 decay chain) provided some indication of the level of secular equilibrium of the U-238 and Th-232 decay chains. A number of the results were reported as 'less than' figures due to the lower limit of detection of the detectors. Where possible, if a 'less than' figure was reported, another suitable isotope was used for comparison, based on the above assumptions.

Analysis of the samples suggests that the radioactive material from each of the decay chains is close to being in secular equilibrium. There is a slight increase in the measured activities of isotopes in the lower part of the decay chain in some samples; however this would only lead to a slight over-estimation of total radioactivity of each sample. The total radioactivity of the sample from the different decay chains can be calculated by the multiplication of an isotope's activity by the number of isotopes present in the decay chain. In the case of the U-238 decay

chain the total activity is a multiplication of the Pb-210 activity, and in the case of the Th-232 decay chain the total activity is a multiplication of the Bi-212 activity.

As the results indicate that the samples are in or close to a state of secular equilibrium, the total activity of the samples, and as a consequence the results of the assessment, will not vary significantly due to in-growth of decay products over time.

As the isotopic activity of the lower sections of the decay chains was generally slightly higher than the upper half of the decay chains, this resulted in a potential slight over-estimation of the total activity present.

Vertical Distribution

Across the site there existed no clear consistent stratification of radiological material deposition. In some sample locations stratification of material did exist; however this was generally localised and not consistent across the site. Where a variation in activity was detected in a single borehole, multiple samples were taken at differing depths and analysed separately. To represent the material from a single bore hole being homogenised prior to assessment, the individual results from samples taken at different depths in a single borehole were averaged. As the samples containing the highest activity and second highest activities in each borehole were normally analysed, this methodology would result in a slightly higher activity being reported than if all of the samples from a single borehole were homogenised prior to analysis. However it did provide additional information on the highest activities present on the site.

Background Radioactivity

As these isotopes of interest occur naturally in soils, background readings were measured at different non-impacted locations which had similar geology to the site. Five background readings and samples were taken from an area adjacent to the site at Nelson Parade and suburbs near Hunters Hill (Five Dock, Huntley's Cove, Padstow and Ryde). As these isotopes occur naturally in soils, the natural background readings have been subtracted for the radioactivity results.

Radioactivity Results

The total activity of the soil samples was calculated by summing the total activity of isotopes from the uranium-238, thorium-232 and uranium-235 decay chains. As these isotopes occur naturally in soils, background readings were measured. This background could have been subtracted from these results however in this assessment the background results were not subtracted to add another layer of conservatism in the assessment. The results were compared against the total activity limits for classification as General Solid Waste and Restricted Solid Waste.

Additional samples (K1 Fore, K2 Fore and K3 Fore) were taken at a hotspot identified by the continuous walk-over survey under the cliff line on the foreshore of No.11/13 Nelson Parade which fell outside of the sample grid pattern. Inclusion of these samples will result in a positive bias to the results but accounts for a hotspot identified from the continuous walk over survey. These results have been included in **Table 7** below.

The total number of samples collected, as reported in **Table 7** below, represents the total number of boreholes sampled. The total number of samples analysed, including where multiple samples were analysed for a single borehole are indicated in parenthesises in *italics*.

Table 7

Summary of Total Radioactivity Exceedances

Waste Classification Report

Total Activity Limit (gross)	Location	No. of Samples Collected	No. of Criteria Exceedances	Maximum Concentration (Bq/g)
>1 Bq/g	LG1	14, *(20)*	13, *(19)*	269 (K1 Fore)
	LG2	6, *(8)*	5, *(7)*	122 (B6-1)
	LG4	0	0	n/a
	Total	**20 *(28)***	**18 *(26)***	
>100 Bq/g	LG1	14, *(20)*	3, *(4)*	269 (K1 Fore)
	LG2	6, *(8)*	1, *(1)*	122 (B6-1)
	LG4	0	0	n/a
	Total	**20 *(28)***	**4 *(5)***	

Note: The location(s) of the maximum concentration is indicated in the last column in parenthesises

5.2.2 Chemical Results

Heavy Metals

Heavy metals that exceeded the CT1 and CT2 adopted assessment criteria included arsenic, lead and mercury. All other heavy metals were below the respective criterion. A summary of the number of exceedances and the maximum concentration detected in each of the four LGs is provided in **Table 8**.

Table 8

Summary of Heavy Metal Exceedances

Waste Classification Report

Analyte [CT1 Value]	Location Grouping	No. of Samples Collected	No. of Criteria Exceedances	Maximum Concentration (mg/kg)*
Arsenic [100 mg/kg]	LG1	16	7	258 (I2-1)
	LG2	8	1	106 (B6-1)
	LG4	12	3	452 (C1-1)
Lead [100 mg/kg]	LG1	16	11	1,610 (I4-1)
	LG2	8	2	361 (B6-1)
	LG4	12	9	2,320 (C1-1)
Mercury [4 mg/kg]	LG1	16	2	41.4 (I4-1)
	LG2	8	0	0.2 (B6-1 & B8-1)
	LG4	12	0	0.5 (C1-1)

*Table Notes: * - Sample location/s at which maximum concentration was detected is shown in parenthesises.*

Organics

Organic contaminants in exceedance of the adopted waste classification criteria were limited to BaP and total PAH. A summary of the number of exceedances and the maximum concentration detected in each of the four LGs is provided in **Table 9**.

Table 9

Summary of total PAH and Benzo(a)pyrene Exceedances

Waste Classification Report

Analyte [CT1 Value	Location Grouping	No. of Samples Collected	No. of Criteria Exceedances	Maximum Concentration (mg/kg)
Benzo(a)pyrene [0.8 mg/kg]	LG1	16	8	10.8 (I4-1)
	LG2	8	2	1.6 (B8-1)
	LG4	12	8	183 (C1-1)
Total PAH [200 mg/kg]*	LG1	16	1	301.1 (I4-1)
	LG2	8	0	20.6 (B8-1)
	LG4	12	1	1,739 (C1-1)

Table Notes: *Samples in which the maximum concentration was detected are shown in parenthesises.*
** No CT1 exists for Total PAH. Value shown is the associated SCC1 value.*

Asbestos

Potential ACM was not observed at any of the sample locations or on the surface of the Site.

5.2.3 Toxicity Characteristic Leaching Procedure Results

Field observations and analytical results for each LG were reviewed with reference to the NSW DECC (2008) guidelines. Analytical results reporting detections of contaminants in excess of the laboratory LOR were compared against the respective CT criteria. Contaminants with concentrations exceeding the CT criteria for *General Solid Waste* were considered to be the CoPC likely to drive the waste classification process. TCLP analysis was scheduled for samples with elevated contaminant concentrations in each LG to determine the leaching potential of the contaminants. TCLP analysis was scheduled for each LG where there were exceedances.

Samples identified for TCLP analysis included those with elevated concentrations of arsenic, lead, mercury and BaP. TCLP results are presented in **Appendix I** attached to this report. A summary of the TCLP analysis scheduled for each LG is provided in **Table 10.**

Table 10

Summary of Scheduled TCLP Analysis

Waste Classification Report

Location Grouping	Sample Location	Sample ID	TCLP Analysis
LG1	F1	F1-3	Arsenic, Lead
	G1	G1-1	Mercury, BaP
	G2	G2-2	Lead
	G4	G3-2	Arsenic, Lead
	H3	H3-1	Arsenic, Lead
	H4	H4-1	Arsenic, BaP
	I2	I2-1	Arsenic, Mercury
	I4	I4-1	Lead, BaP, Mercury
LG2	B6	B6-1	Arsenic, Lead
	B8	B8-1	Lead, BaP
LG4	C1	C1-1	BaP
	C4	C4-1	BaP

TCLP results were reported less than the TCLP1 criteria for *General Solid Waste* as specified in Table 2 of the NSW DECC (2008) guidelines. Further discussion in relation to the TCLP results and influence upon the overall waste classification of material in each LG is provided in **Section 5.6**.

5.3 Comparison of Statistical Data to Site Assessment Criteria

Chemical

For each LG with samples exceeding the relevant *General Solid Waste* criteria, statistical assessment was performed where six or more primary samples were analysed. A statistical assessment of chemical data was undertaken for LG1 to LG4 using the United States Environmental Protection Agency (USEPA) software package ProUCL Version 4.0. The LOR was used for sample results that were detected at less than this value.

In accordance with NSW EPA (1995), the dataset was initially assessed to determine if it represented a normal, log normal or non-parametric distribution, with the appropriate method for determining the 95 % UCL value applied. Normal distribution provides a representative description of data that is centred on the mean. It is the preferred distribution due to the high probability that the statistical result represents the actual data. Log-normal distribution is a probability distribution where the logarithm of the distribution is normal. Log-normal distribution routinely includes variable results as multiples of the mean. Non-parametric data does not fit any parameterised distribution, such as normal or log-normal, as is common when heterogeneous fill material is assessed. Non-parametric data does not invalidate any statistical analysis, but rather requires that a degree of caution to be attached to the results.

Summary tables presenting the statistical assessment for each LG reporting criteria exceedances are including in **Appendix I.**

5.3.1 LG1 – Statistical Data Assessment - Chemical

A statistical data assessment for CoPCs that exceeded the adopted assessment criteria for samples collected within LG1 is summarised below:

Arsenic – The dataset has a normal distribution with a 95% UCL of 120.1 mg/kg, below the SCC1 assessment criterion for *General Solid Waste* (500 mg/kg). The standard deviation is less than 50% of the criterion.

Lead – The dataset has a normal distribution with a 95% UCL of 504.4 mg/kg, below the SCC1 assessment criteria for *General Solid Waste* (1,500 mg/kg). The standard deviation is less than 50% of the criterion.

Mercury – The dataset is non-parametric due to a single result of 41.4 mg/kg, detected in sample I4-1. This result is an order of magnitude greater than other results obtained for mercury within LG1. TCLP analysis was conducted on sample I4-1, with the result (<0.001 mg/L) indicating a low leaching potential. Furthermore, the maximum result of 41.4 mg/kg is below the SCC1 assessment criterion for *General Solid Waste* (50 mg/kg). Due to non-parametric distribution of the data, resulting from inclusion of the result from sample I4-1, the Chebyshev method was used to calculate the 95% UCL value of 14.37 mg/kg, less than the SCC1 criteria for *General Solid Waste* (50 mg/kg).

BaP – The dataset has a normal distribution with a 95% UCL of 3.9 mg/kg, below the SCC1 assessment criteria for *General Solid Waste* (10 mg/kg). The standard deviation is less than 50% of the criterion.

PAH Total – The dataset is non-parametric, largely due to a single results of 301.1 mg/kg detected in sample I4-1. This result is an order of magnitude greater than other representative samples taken within LG1. Due to non-parametric distribution of the data, resulting from inclusion of the result from sample I4-1, the Chebyshev method was used to calculate the 95% UCL value of 129.7 mg/kg, less than the SCC1 criterion for *General Solid Waste* (200 mg/kg).

5.3.2 LG2 – Statistical Data Assessment - Chemical

The statistical data assessment for CoPCs that exceeded the adopted criteria for samples collected within LG2 is summarised below:

Arsenic – The dataset has a normal distribution with a 95% UCL of 56.96 mg/kg, less than the SCC1 criterion for *General Solid Waste* (500 mg/kg). The standard deviation is less than 50% of the criterion.

Lead – The dataset has a log normal distribution due to a coefficient of variation (1.3) greater than 1.2. This marginal exceedance is not considered to affect the validity of the dataset and the Chebyshev method was used to calculate the 95% UCL value of 283.2 mg/kg. This value is less than the SCC1 criterion for *General Solid Waste* (1,500 mg/kg). The standard deviation is less than 50% of the criterion.

BaP – The dataset has a normal distribution with a 95% UCL of 1.0 mg/kg, less than the SCC1 criterion for *General Solid Waste* (10 mg/kg). The standard deviation is less than 50% of the criterion.

5.3.3 LG4 – Statistical Assessment - Chemical

The statistical data assessment for CoPCs that exceeded the adopted criteria for samples collected within LG4 is summarised below:

Arsenic – The dataset has a lognormal distribution. The maximum concentration of 452 mg/kg is below the SCC1 criterion for *General Solid Waste* (500 mg/kg). Due to the skewed data, the Adjusted Gamma method was used to calculate the 95% UCL of 258.3 mg/kg, which is below the SCC1 criterion for *General Solid Waste* (500 mg/kg). The standard deviation is less than 50% of the criterion.

Lead – The maximum concentration of 2,320 mg/kg in sample C1-1 is the only result that exceeds the SCC1 criterion of 1,500 mg/kg. This value is an order of magnitude higher than the other results from within LG4. The data has a log-normal distribution with a standard deviation less than 50% of the criterion. Due to the elevated lead concentration at C1-1 and the log-normal distribution of the data, the Approximate Gamma method was used to calculate the 95% UCL of 848.4 mg/kg, which is below the SCC1 criterion for *General Solid Waste* (1,500 mg/kg).

BaP – The dataset has a lognormal distribution with a standard deviation greater than 50% of the criterion. The Procedure B calculation from NSW EPA (1995) indicates that 241 samples are required to allow representative characterisation of the material. As the total number of samples analysed in LG4 is less than 241 and the standard deviation is greater than 50% of the criterion, statistical analysis cannot be used to determine the waste classification of the material.

The maximum BaP concentration of 183 mg/kg in sample C1-1 exceeds the SCC1 and SCC2 criteria of 10 mg/kg and 23 mg/kg respectively. The associated soil bore log for this sample describes the material as '*brown, dry, sand and silt topsoil with occasional angular, hard charcoal fragments*'. Under the DECC *1999/05 General Approval of the Immobilisation of Contaminants in Waste,* 1999, total concentrations of PAH (total) and BaP do not apply for waste classification of ash, ash-contaminated natural excavated material or coal-contaminated natural excavated materials. The combustion of carbonaceous materials, such as coal, can take place at 700 to 1,500 degrees Celsius. Residual PAHs and BaPs present in ash generated at these temperatures are considered to be strongly bound within the coal's carbonaceous matrix (DECC, 1999). A copy of the DECC approval number 1999/05 is included as **Appendix I**.

With respect to BaP, natural excavated materials that are considered to contain ash or coal (such as those described at C1-1) can be classified according to their leachable concentration (TCLP) alone. The TCLP result reported for BaP at C1-1 was below the LOR (<0.0005 mg/L). This indicates a low leaching potential and is below the TCLP1 criterion value for *General Solid Waste* (0.04 mg/L).

The BaP concentration reported for C4-1 was 11 mg/kg, which exceeds the SCC1 criterion for *General Solid Waste* (10 mg/kg). There were no field observations suggesting that this material contained ash or charcoal related materials. Therefore, the DECC *1999/05 General Approval of the Immobilisation of Contaminants in Waste,* 1999, is not considered applicable for this sample location.

Total PAH – The dataset has a lognormal distribution with a standard deviation greater than 50% of the criterion. Similarly to BaP, the Procedure B calculation from NSW EPA (1995) indicates that 2,927 samples are required to allow representative

characterisation of the material. As the total number of samples analysed for total PAH in LG4 is less than 2,927 and the standard deviation is greater than 50% of the criterion, statistical analysis cannot be used to determine the waste classification of the material.

The maximum total PAH concentration of 1,739 mg/kg in sample C1-1, exceeds the SCC1 and SCC2 criterion of 200 mg/kg and 800 mg/kg. Total PAH concentrations reported for other samples collected from within LG4 are below the SCC1 criteria. The Total PAH value reported for C1-1 is considered to be attributed to the charcoal fragments contained within the soil material. Under the DECC *1999/05 General Approval of the Immobilisation of Contaminants in Waste,* 1999, the PAH content is considered immobile. The NSW DECC (2008) waste classification criterion for Total PAH is therefore not applicable and the material is considered to be *General Solid Waste*.

5.3.4 Asbestos Results

During the waste classification assessment no visible asbestos containing materials was identified on the site. Therefore no classification of the material as *Special Waste – Asbestos* is required.

5.4 Comparison of Statistical Data to Site Assessment Criteria

Radiological

As the majority of samples from the site exceeded the relevant *General Solid Waste* criteria, statistical assessment was performed on the primary samples analysed. A statistical assessment of radiological data was undertaken for the site using guidance from the *EPA Sampling Design Guidelines* (1995) and *US EPA Multi-Agency Radiation Survey and Site Investigation Manual, August 2000 (MARSSIM).* Area C was not assessed as no samples were taken for radiological analysis, only for chemical analysis.

In accordance with *NSW EPA Sampling Design Guidelines*, the dataset was initially assessed using Procedure D to determine the 95% UCL value applied. Normal distribution provides a representative description of data that is centred on the mean. It is the preferred distribution due to the high probability that the statistical result represents the actual data.

As the identification and a reduction in the potential size of the radiological hotspots on the site comprising of heterogeneously distributed fill material can be achieved by the continuous walk over radiological survey of the site (unlike in chemical analysis), the statistical Sign Test as outlined in MARSSIM was also utilised during the analysis of the data.

Summary tables presenting the statistical assessment for the site reporting criteria exceedances are including in **Appendix I.**

5.4.1 Collective area (LG1 and LG2) – Statistical Data Assessment – Radiological

A statistical data assessment for total activity that exceeded the adopted assessment criteria for samples collected within the site is summarised below:

Total Activity – The Coefficient of Variation (CV) was calculated for the samples in areas LG1 and LG2 as 0.69. This result for the CV supports the use of the methodology

in Procedure D of the NSW EPA Contaminated Sites Sampling Design Guidelines to calculate the 95% UCL. This methodology was used to calculate the 95% UCL value of 77 Bq/g, which is below the criteria limit for *Restricted Solid Waste* (100 Bq/g). This figure is primarily due to the high standard deviation of 71 Bq/g against the median activity of 23 Bq/g (average activity 49 Bq/g).

In accordance with MARSSIM, statistical analysis using the Sign Test was also utilised as an additional test. Of the 20 samples from the collective site, 16 of the samples were less than the criteria limit for *Restricted Solid Waste*, which meets the requirements of the Sign Test. Further analysis was undertaken using the Sign Test of all of the samples analysed, including where multiple samples were taken from the same bore hole. Of the total number of samples analysed (28), 22 of the samples were less than the criteria limit for *Restricted Solid Waste*, which meets the requirements of the Sign Test. From the 95% UCL result, supported by the results of the Sign Tests and the continuous walk over radiological survey, the collective site meets the requirements to be classified as *Restricted Solid Waste*.

5.4.2 LG4 – Statistical Data Assessment – Radiological

Area LG4 was not assessed for radiological material during this assessment. This area has previously been classified as *Restricted Solid Waste* by a Site Auditor during a previous study of the area.

5.5 Data Quality Assessment

Data Quality Indicators (DQIs) were developed as part of the DQO process to provide goals for the quality of data required to achieve the objectives of the assessment. Details on the DQIs and data quality assessment adopted for the chemical and radiological analytical results are provided in **Appendix B**.

An assessment of the quality of the chemical data against data quality indicators (DQIs) indicated that although there were a small number of non-conformances, the majority of the DQIs were achieved. Based on the conclusions of the quality review, CH2M HILL considers that the chemical data supplied for the Site meets the objectives of the Precision, Accuracy, Representativeness, Completeness and Comparability (PARCC) criteria. Therefore, CH2M HILL and ANSTO consider that the chemical data set is of acceptable quality to meet the objectives of this waste classification program.

An assessment of the quality of the radiological data against data quality indicators (DQIs) indicated that although there were a small number of non-conformances, the majority of the DQIs were achieved. Based on the conclusions of the quality review, ANSTO considers that the radiological data supplied for the Site meets the objectives of the Precision, Accuracy, Representativeness, Completeness and Comparability (PARCC) criteria. Therefore, ANSTO considers that the radiological data set is of acceptable quality to meet the objectives of this waste classification program.

5.6 Summary of Chemical Waste Classification

The waste classification of the material in each LG is based on chemical results and is discussed in the following sections.

5.6.1 LG1 – Waste Classification

CoPCs detected at concentrations greater than the CT values specified in **Section 3.3.2** included arsenic, lead, mercury, total PAH and BaP. Samples representative of the foreshore area indicate no exceedances of the maximum allowable leachate concentration (TCLP1) or specific contaminant concentrations (SCC1) for *General Solid Waste*, with the exception of total PAH. Statistical assessment of the data resulted in a 95% UCL value less than the SCC1 criterion of 200 mg/kg. Therefore, the material in LG1 is classified as *General Solid Waste.*

5.6.2 LG2 –Waste Classification

CoPCs detected at concentrations greater than the CT values specified in **Section 3.3.2** included arsenic, lead and BaP. Samples representative of the LG2 area indicate no exceedances of the maximum allowable leachate concentration (TCLP1) or specific contaminant concentrations (SCC1) for *General Solid Waste.* Therefore the material in LG2 is classified as *General Solid Waste.*

5.6.3 LG4 –Waste Classification

CoPCs detected at concentrations greater than the CT values specified in **Section 3.3.2** included arsenic, lead, BaP and total PAH.

TCLP results obtained for BaP in select samples collected from within LG4 indicate low leaching potential, however, two samples (C1-1 and C4-1) reported concentrations of total PAH and BaP greater than the SCC1 criterion. In addition, the total concentration of BaP in sample C1-1 also exceeds the SCC2 criterion.

Under the DECC *1999/05 General Approval of the Immobilisation of Contaminants in Waste,* 1999, the material representative of sample C1-1, located in the south east corner of LG4, has been classified according to TCLP results alone. Under the DECC 1999/05 approval notice this material is classified as *General Solid Waste.*

Material representative of sample C4-1, located in the central western portion of LG4, is classified as *Restricted Solid Waste.*

The remaining material in LG4, excluding location C4, is classified as *General Solid Waste.*

5.7 Summary of Radiological Waste Classification

The waste classification of the material for the site collectively is based on radiological results and is discussed in the following sections.

5.7.1 Collective Areas LG1 and LG2 – Radiological Waste Classification

Radioactive material was detected at varying concentrations across the site. Of the 20 samples collected,18 of the samples exceeded the criteria for classification as *General Solid* Waste and 4 of the samples exceeded the criteria for *Restricted Solid Waste* specified in **Section 3.3.1**.

Statistical assessment of the data resulted in a 95% UCL value less than the criterion of 100 Bq/g total activity. Therefore, the material in the collective area is classified as *Restricted Solid Waste.*

5.7.2 LG4 – Radiological Waste Classification

Radioactive material in area LG4 has been previously assessed for radiological material in a separate assessment, and does not form part of the assessment of this report. The previous assessment of this area by the site auditor was that the area is classified as *Restricted Solid Waste*.

5.8 Summary of Asbestos Waste Classification

During the waste classification assessment no visible asbestos containing materials was identified on the site. Therefore no classification of the material as *Special Waste – Asbestos* is required.

6. Conclusions and Recommendations

The following conclusions and recommendations are provided based on the chemical and radiological results reported in this investigation.

6.1.1 Chemical Waste Classification

The nature of the fill materials across the Site appear to be consistent. Field observations indicated that the only visual contamination is attributed to pockets of ash, charcoal and suspected coking waste. Chemical results show that elevated concentrations of heavy metals, BaP and Total PAH tend to correlate with these isolated pockets of visually contaminated material.

Through an assessment of both total contaminant concentrations and TCLP results and consideration of the DECC *1999/05 General Approval of the Immobilisation of Contaminants in Waste,* 1999, the following waste classifications have been determined:

- **LG1 and LG2** = *General Solid Waste*
- **LG4** = Material representative of C4-1 is classified as *Restricted Solid Waste.* The remaining material in LG4 is classified as *General Solid Waste.* However, should there be evidence of PAH related contaminants not associated with coal and ash material (such as free tars), such materials will need to be classified and handled as separate waste streams.

6.1.2 Radiological Waste Classification

The nature of the fill materials across the site with regard to radiological content is variable across the site. Localised concentrations of elevated radioactivity are present on the site, often where historical back-filling behind walls has occurred. The spatial extent of these hot spots has been qualified by the use of continuous walk over radiological surveying. Through an assessment of total radioactive concentrations the following waste classifications have been determined:

- **Collective area (LG1, LG2 and LG5)** = *Restricted Solid Waste*

6.1.3 Collective (Radiological and Chemical) Waste Classification

Based upon the results of both the chemical and radiological results, and upon previous radiological waste classification of area LG4 (Area C), for remediation purposes, the entire site, can be classified as *Restricted Solid Waste.*

7. References

ANSTO, *Radiological survey of Nelson Parade, Hunters Hill – Stages 1 and 2*, June 2009

ANSTO, *Sampling and Analysis Quality Plan, In-Situ Classification of Fill Materials at Nos 5 to 15 Nelson Parade, Hunters Hill for the Purpose of Waste Classification for State Property Authority* NSW, 2010

GHD, *Report for Foreshore Land Fronting 5 and 13 Nelson Parade, Hunters Hill, NSW, Contamination Assessment*, June 2009

MARSSIM, *Multi-Agency Radiation Survey and Site Investigation Manual*, August 2000.

NEPC, *National Environment Protection Measure Schedule B(2) Guidelines on Data Collection, Sample Design and Reporting*, 1999

NSW Department of Health, Radiation Branch, *radiation survey*, 1966

NSW Department of Mineral Resources, *Geological Series Sheet 9029-9129, Wollongong-Port Hacking*, 1985

NSW DEC, *Contaminated Sites: Guidelines for the NSW Site Auditor Scheme (2nd edition)*, April 2006

NSW EPA, *Contaminated Sites: Sampling Design Guidelines*, September 1995.

NSW EPA, *Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites*, November 1997

NSW DECC, General Approval of the Immobilisation of Contaminants in Waste, 1999/05, 1999

NSW DECC, *Waste Classification Guidelines, Part 1: Classifying Waste*, 2008

NSW DECC, *'Waste Classification Guidelines, Part 3: Waste Containing Radioactive Material'* (October 2008)

Scott, B. W., *Investigation of Radioactive contamination at Nelson Parade Woolwich*, September 1977

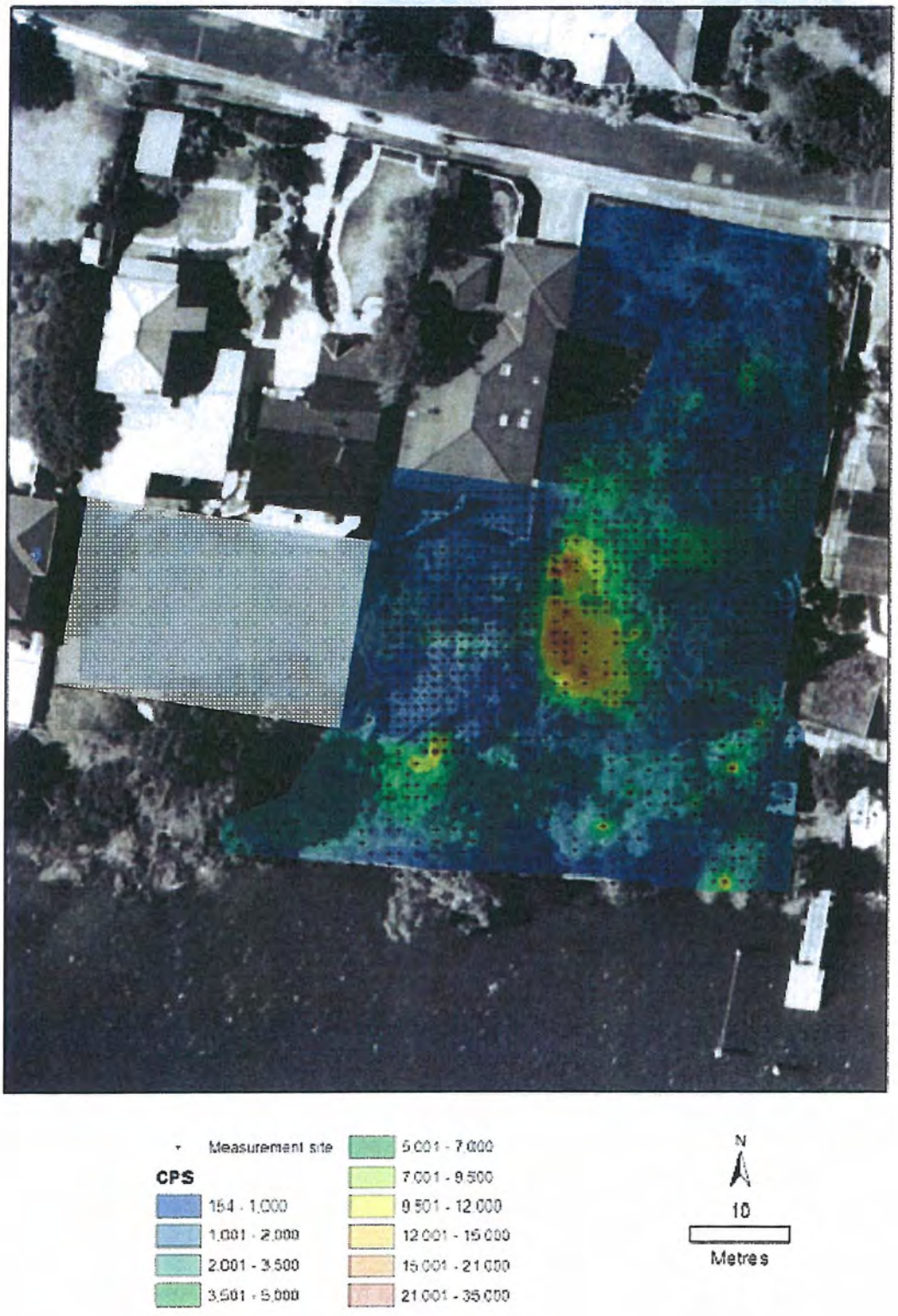
Sinclair Knight and Partners, *Radium waste clean up Nelson Parade, Hunters Hill, Review of Environmental Factors*, August 1987

US EPA, *Calculating Upper Confidence Levels for Exposure Point Concentrations at Hazardous Waste Sites*, December 2002

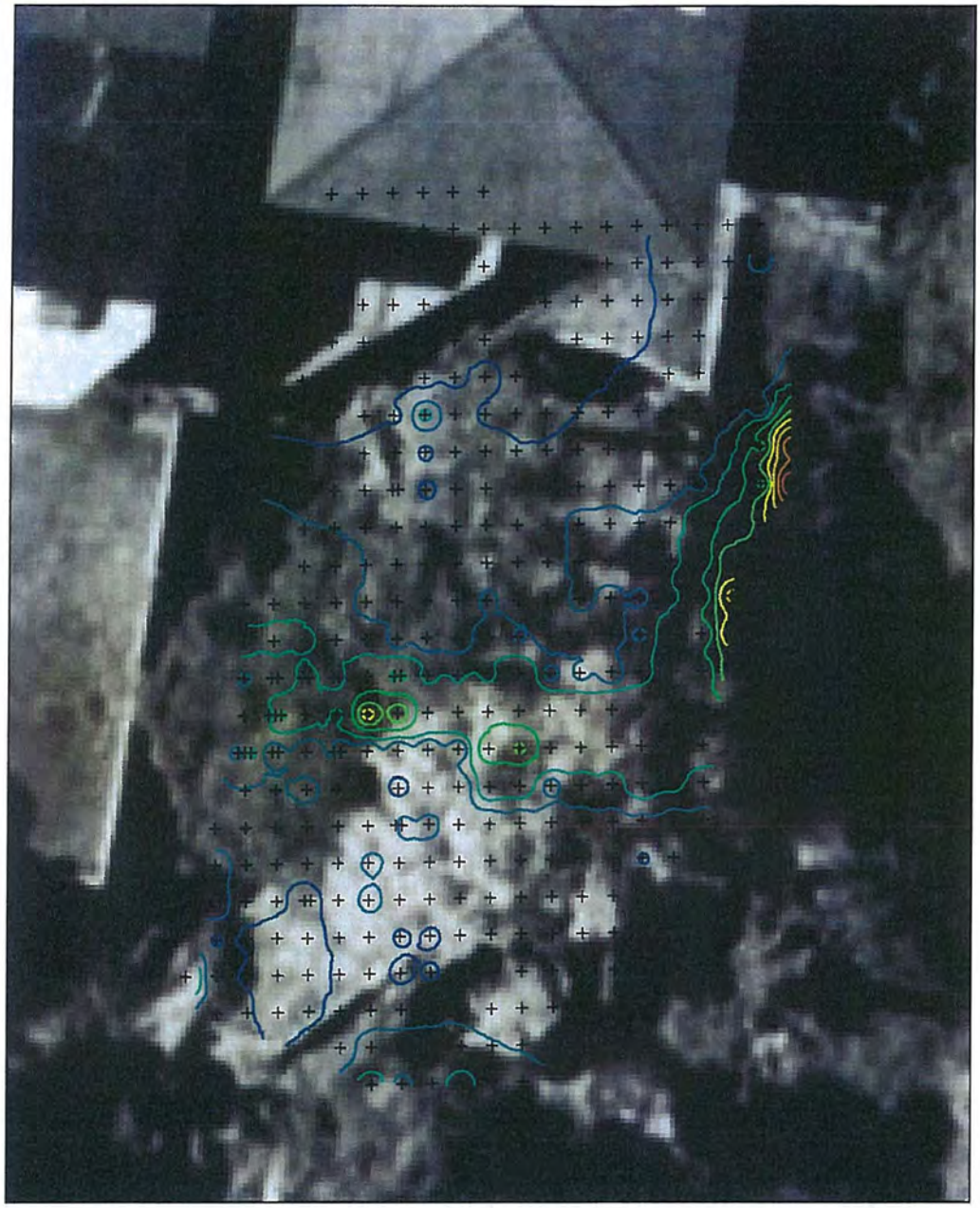
U.S. Nuclear Regulatory Commission, *A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys, NUREG-1505, Rev. 1*, 1998

8. Appendix A – Spatial Distribution of radioactive material

Composite relative spatial distribution across the site

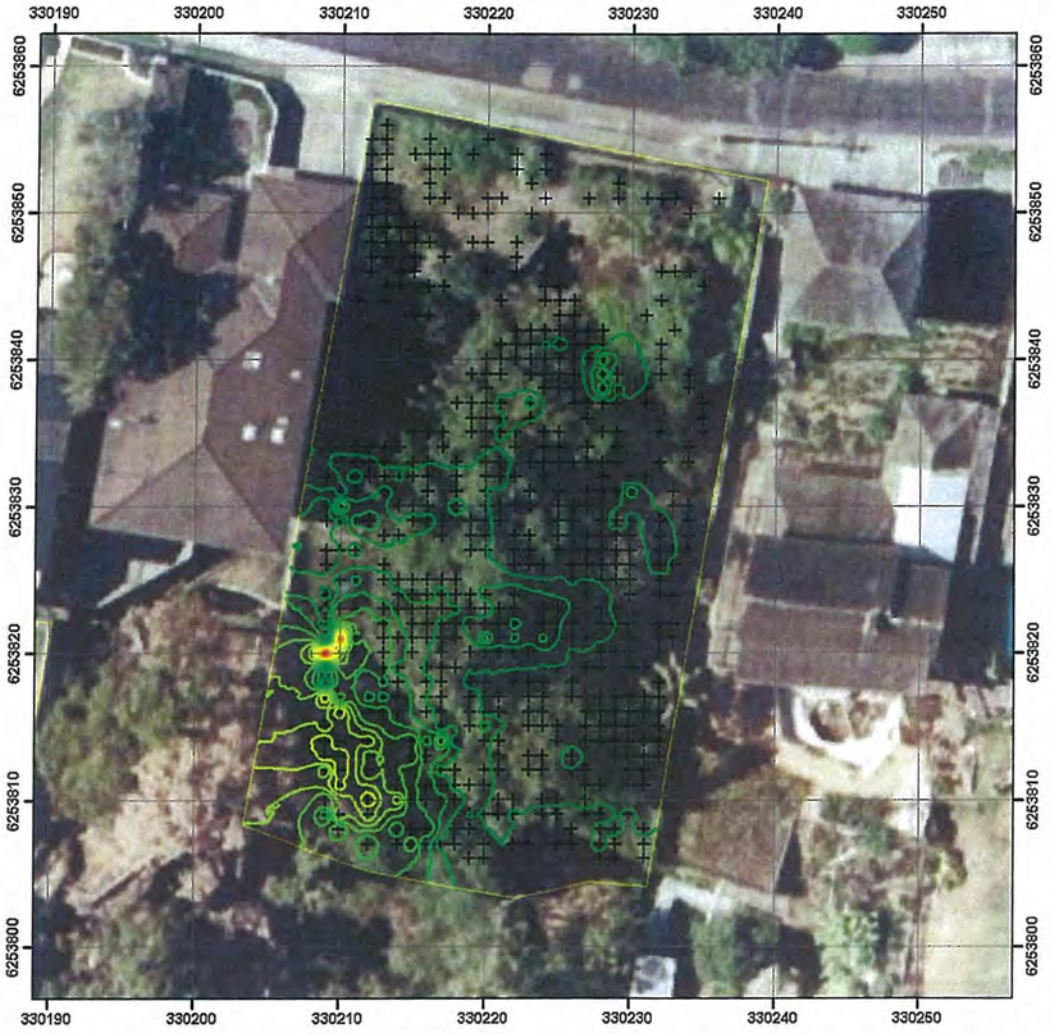


Area B: No11 Nelson Parade Backyard



Note: Contour scaling customised for this map to highlight variations in relative activity

Area C: No7 and No9 Nelson Parade



Area C - 2000 CPS Contour Interval

CPS

2000	14000	26000
4000	16000	28000
6000	18000	30000
8000	20000	32000
10000	22000	34000
12000	24000	

N

10

Meters

Note: Contour scaling customised for this map to highlight variations in relative activity

9. Appendix B – QA/QC Assessment

Chemical

Quality Assurance/Quality Control (QA/QC) Procedures

A review of the quality of data has been based on the following:

- Review of the findings of sample analyses against field observations and measurements;
- Review of data quality based on the verification of field QA/QC procedures, evidence of the proper transference of samples (chain-of-custody documentation), sample analysis (and extraction) within the recommended holding times;
- Analysis of duplicate samples at the project laboratory ('blind duplicates');
- Analysis of a duplicate sample by an independent laboratory ('split duplicates'); and
- Internal laboratory QA/QC analyses including analysis of reagent blanks, spike recoveries and duplicates.

These requirements are defined in NSW DECCW guidance documents and Australian Standard AS4482.

Eight field blind duplicate soil samples and six field split duplicate soil samples were collected for analyses during the field program. Quality assurance and quality control criteria are summarised in **Table 1.1** below, together with an assessment of whether these criteria have been met.

Table 1.1

Summary of Quality Assurance / Quality Control Criteria

Waste Classification Report

Item	Objective	Reference	Summary of Results	Compliance
Comparison of field and analytical data	Agreement between visual, olfactory & PID measurements with laboratory results		Observations of ash pockets present in soil at certain sample locations correlate with detections of B(a)P and total PAH.	Yes
Chain of Custody documentation	Completed		Completed in full.	Yes
Analysis of field blind duplicate samples	RPDs within <30-50%	AS4482	Heavy metal, PAH and TPH concentrations resulted in RPD exceedances.	*Note 1*
Analysis of field split duplicate samples	RPDs within <30-50%	AS4482	Heavy metal, PAH, TPH and OCP detected concentrations resulted in RPD exceedances.	*Note 2*
Analysis of field blanks, including trip and equipment blanks as appropriate	No contamination of blanks		No detection in blanks	Yes
Analysis of field spikes	RPD 70-130%	AS4482	All within 70-130%	*Yes*
Analysis of laboratory method blanks	No contamination of blanks		All non-detects	Yes

Table 1.1

Summary of Quality Assurance / Quality Control Criteria

Waste Classification Report

Item	Objective	Reference	Summary of Results	Compliance
Analysis of spike recoveries	Recoveries 70-130%		Matrix spike recovery < 70%	*Note 3*
Analysis of laboratory control samples	Recoveries 70-130%		Control spike recovery < 70%	*Note 4*
Sample analysis and extraction holding times	Comply with holding time guidelines.	AS4482	Conform with guidelines	*Note 5*
Analysis of laboratory duplicates	RPDs <50%		All within RPD criteria	Yes
Calibration of field instruments	Meet calibration specifications	AS4482	PID calibrated	Yes

Note 1:

Mercury in ALS-DUP-006 and Lead in ALS-DUP-008 *exceeded the data quality indicators for field blind RPD values. RPD calculations are sensitive at concentrations close to the analytical limit of reporting (LOR). The RPD exceedances for nickel and zinc are considered a result of variations of low contaminant concentrations therefore resulting in high RPDs.*

A ***range of PAH compounds*** *exceeded the data quality indicators for field blind RPD values. It is likely that these RPD exceedences are attributed to the heterogeneity of the fill material encountered during the investigation. In addition, the majority of the contaminants were reported at low concentrations in comparison to the LOR and therefore contaminants within the same order of magnitude can exhibit high RPDs.*

Note 2:

A number of heavy metals detected in field split duplicate samples resulted in RPD exceedance. It is likely that these RPD exceedences are attributed to the heterogeneity of the fill material encountered during the investigation. The RPD exceedances are therefore not considered likely to affect the validity of the data set.

A ***range of PAH and TPH compounds*** *exceeded the data quality indicators for field split duplicate RPD values. It is likely that these RPD exceedences are attributed to the heterogeneity of the fill material encountered during the investigation.*

Note 3:

A laboratory matrix spike result for 4.4'-DDT exceeded lower recovery limit with a result of 62.7 %. No 4.4'-DDT was detected in any of the samples analysed and the exceedance is therefore not considered to influence the validity of the data set.

Note 4:

Laboratory control spike recoveries were recorded at 63.3% for both Heptachlor and Endrin Ketone. None of these compounds were detected in soil samples collected at the site and the criteria exceedance is therefore not considered to influence the validity of the data set.

Note 5
TCLP analysis for mercury at I4-1 exceeded the required holding time. As mercury is not a volatile contaminant this exceedance is not considered likely to affect the validity of the dataset.

Generally, QC requirements are considered to be met if less than 10% of the RPD values calculated exceed the nominated acceptance criteria. The validation of data was considered to be acceptable. Although there were some minor non-conformances the majority of the indicators were within the specified Recovery Limits and below the recommended RPDs and therefore, overall, the data is considered to be of sufficient quality to meet the objectives of the waste classification assessment.

Radiological

Quality Assurance/Quality Control (QA/QC) Procedures

A review of the quality of data has been based on the following:

- Review of the findings of sample analyses against field observations and measurements;
- Review of data quality based on the verification of field QA/QC procedures, evidence of the proper transference of samples (chain-of-custody documentation), sample analysis (and extraction) within the recommended holding times;
- Analysis of duplicate samples at the project laboratory ('blind duplicates');

These requirements are defined in NSW DECCW guidance documents and Australian Standard AS4482.

Three field blind duplicate soil samples were collected for analyses during the field program for radiological analysis. Each field blind duplicate sample was compared to the corresponding soil sample for the U-238 decay chain (using Pb-210 results), the Th-232 decay chain (using Bi-212 results), the U-235 decay chain and for Total Activity (total of 16 RPD analyses). Quality assurance and quality control criteria are summarised in **Table 1.1** below, together with an assessment of whether these criteria have been met.

Table 1.1

Summary of Quality Assurance / Quality Control Criteria

Waste Classification Report

Item	Objective	Reference	Summary of Results	Compliance
Chain of Custody documentation	Completed		Completed in full.	Yes
Analysis of field blind duplicate samples. Note blind duplicate samples analysed separately for U-238 decay chain, Th-232 decay chain, U-235 decay chain and Total Activity	RPDs within <30-50%	AS4482	Single result for Th-232 decay chain resulted in RPD exceedance.	*Note 1*
Analysis of laboratory duplicates	RPDs <50%		All within RPD criteria	Yes
Calibration of field instruments	Meet calibration specifications	AS4482	All field instruments calibrated	Yes

Note 1:

Bi-212 (Th-232 decay chain) results for sample location H-1 *exceeded the data quality indicators for field blind RPD values (74% RPD). All other RPD calculations for other decay chains present in the same sample were within data quality indicators.*

Generally, QC requirements are considered to be met if less than 10% of the RPD values calculated exceed the nominated acceptance criteria. The validation of data was considered to be acceptable. Although there were some minor non-conformances the majority of the indicators were within the recommended RPDs and therefore, overall, the data is considered to be of sufficient quality to meet the objectives of the waste classification assessment.

10. Appendix C – Soil Borehole Logs

CH2M HILL

CH2M HILL AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. BI

BI

Sheet 1 of 1

Project No:	406484	Excavation Equip.:	HAND AUGER	Contractor:	CH2M HILL
Project:	ANBIO HUNTERS HILL	Easting:	–	Logged By:	RICHARD HAYES
Site:	11 NELSON PARADE	Northing:	–	Project Manager:	REN FARQUE
Date:	24/08/2020	Elevation (mAHD):	–	Checked By:	[signature]
Weather:	CLEAR BLUE SKY, SUNNY, 20°C	Water Level (mbgl):	–		
		Final Depth (mbgl):	0.10m		

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
		0.0	BI-1		Sandy topsoil, dark brown, loose, moist, sand is fine and @ approx 45%. Frequent rootlets.	Sample: BI-1 = 0.10mbgl	
0.10	No				End OF HOLE @ 0.10mbgl.	Sandstone outcrop hit @ 0.10mbgl	

Notes

mAHD: metres Australian Height Datum

mbgl: metres below ground level

Water Found

- ⇩ Water Level
- ⇨ Water Inflow
- ⇦ Water Outflow
- GNE Groundwater Not Encountered

Monitoring Bore Details

Backfill, Bentonite Pellets, Cement, Gravel, Bentonite, Sand, Standpipe, Slotted Screen

Other Details/Comments

N/A

CH2M HILL

CH2M HILL AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. B2

Sheet 1 of 1 B2

Project No:	406484	Excavation Equip.:	HAND AUGER
Project:	ANSTO HUNTERS HILL	Easting	
Site:	11 MESSOR PLACE	Northing	
Date:	23/08/2010	Elevation (mAHD):	
Weather:	CLEAR, NO RAIN	Water Level (mbgl):	
		Final Depth (mbgl):	1.0M
Contractor:	CH2M HILL		
Logged By:	RICARDO PAES		
Project Manager:	R. EARLES		
Checked By:			

Depth (m)	Water Found	PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contam noted, odour, soil collapse, etc.)	Monitor. Bore Details
0.2					Sand and silt topsoil fill, brown, loose, slightly moist. Sand is at 65% and fine. Rare rootlets.	Sample B2-1 taken at 0-4mbgl	
0.4	No	0.1	B2-1	0		B2-2 = ~~0-0mbgl~~ 0.90 to 1.0mbgl	
0.6					0-50M → light brown, sandy clay, moist-stiff. Occasional fine angular gravel		
0.8					0-50M → dark brown, stiff, moist, silty sand. Sand is at 60% and fine.		
1.0		0.0	B2-2 @ Taken at 0.90 to 1.0mbgl		REFUSAL @ 1.0M as light light brown sandstone.		
.0							
.0							
.0							
.0							

Notes

mAHD: metres Australian Height Datum
mbgl: metres below ground level

Water Found

- Water Level
- Water Inflow
- Water Outflow
- GNE: Groundwater Not Encountered

Monitoring Bore Details

- Backfill
- Bentonite Pellets
- Cement
- Gravel
- Bentonite
- Sand
- Standpipe
- Slotted Screen

Other Details/Comments

CH2M HILL
CH2M HILL AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. B3

Sheet 1 of 1 B3

Project No: 406484	Excavation Equip.: HAND AUGER	Contractor: CH2M HILL	
Project: ANGLO HUNTERS HILL	Easting: —	Logged By: RICHARD HAAS	
Site: 11 NELSON AVENUE	Northing: —	Project Manager: BEN TRENGE	
Date: 24/05/2010	Elevation (mAHD): —	Checked By: Ben Trenge	
Weather: SUNNY, BLUE SKIES, 20°C	Water Level (mbgl): —		
	Final Depth (mbgl): 0.70 mbgl		

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
0.1					Silty sand, light brown, moist, loose, medium & fine grained sand. Sand is 75 to 80 %. Rare rootlets.	B3-1 = 0.30 mbgl B3-2 = 0.60 mbgl NOTE: Scale change on depth at 0.40mbgl.	
0.2							
0.3		0.0	B3-1		0.30mbgl = Sand with slight silt content, orange/brown, moist, dense, medium to fine sand at 90%. Rare light brown sand lenses.		
0.4	No						
0.6		0.0	B3-2				
0.8					REFUSAL ON SANDSTONE BOULDER AT 0.70 mbgl END OF HOLE		
.0							
.0							
.0							

Notes

mAHD: metres Australian Height Datum
mbgl: metres below ground level

Water Found

- Water Level
- Water Inflow
- Water Outflow
- GNE: Groundwater Not Encountered

Monitoring Bore Details

- Backfill
- Bentonite Pellets
- Cement
- Gravel
- Bentonite
- Sand
- Standpipe
- Slotted Screen

Other Details/Comments

CH2M HILL
CH2M HILL AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. B4
Sheet 1 of 1 B4

Project No:	L100484	Excavation Equip.:	Hand Auger	Contractor:	CH2M HILL
Project:	ANSTO HUMES HILL	Easting	—	Logged By:	Richard Hills
Site:	11 Nelson Parade	Northing	—	Project Manager:	Ben Frewer
Date:	24/08/2010	Elevation (mAHD):	—	Checked By:	[illegible signature]
Weather:	Sunny, Blue Skies, 20°C	Water Level (mbgl):	—		
		Final Depth (mbgl):	0.30 mbgl		

Depth (m)	Water Found	PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
0.00–0.30					Sand and silt, topsoil, brown, dry, loose, sand is 50-60% and medium to fine grained. Occasional rootlets.	B4-1 = 0.20 mbgl	
0.10							
0.20	No	0.0	B4-1				
0.30					END OF HOLE AT 0-30mbgl ON SANDSTONE OUTCROP		
.0							
.0							
.0							
.0							
.0							
.0							

Notes

mAHD: metres Australian Height Datum
mbgl: metres below ground level

Water Found

⇩ Water Level
⇨ Water Inflow
⇤ Water Outflow
GNE Groundwater Not Encountered

Monitoring Bore Details

Backfill
Bentonite Pellets
Cement
Gravel
Bentonite
Sand
Standpipe
Slotted Screen

Other Details/Comments

CH2M HILL

CH2M HILL AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. B6

Sheet 1 of 1 B6

Project No:	406484	Excavation Equip.:	Hand Auger
Project:	ANSTO TOWERS 10th	Easting	—
Site:	11 NELSON AVENUE	Northing	—
Date:	14/08/2020	Elevation (mAHD):	—
Weather:	Sunny, blue skies, 20°C	Water Level (mbgl):	—
		Final Depth (mbgl):	0.20 mbgl
Contractor:	CH2M HILL		
Logged By:	RICHARD LOWE		
Project Manager:	BEN FRYER		
Checked By:	[signature]		

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
0.10	NO	0.0	B6-1		Sand and silt topsoil, light brown dark brown, moist, sand is fine to medium. Occasional angular sandstone progments and rare rootlets.	B6-1 = 0.10 mbgl	
0.15					Weathered sandstone, light brown dry, sand is medium to coarse		
0.20					END OF HOLE AT 0.20 mbgl as hit sandstone.		

Notes

mAHD: metres Australian Height Datum

mbgl: metres below ground level

Water Found

- Water Level
- Water Inflow
- Water Outflow
- GNE: Groundwater Not Encountered

Monitoring Bore Details

Backfill, Bentonite Pellets, Cement, Gravel, Bentonite, Sand, Standpipe, Slotted Screen

Other Details/Comments

CH2M HILL

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GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. B8

Sheet 1 of 1

B8

Project No:	406484	Excavation Equip.:	HAND AUGER	Contractor:	CH2M HILL
Project:	ANSTO MINERALS HILL	Easting	—	Logged By:	RICHARD MATES
Site:	11 NELSON PARADE	Northing	—	Project Manager:	BEN FARMER
Date:	24/08/2020	Elevation (mAHD):	—	Checked By:	
Weather:	Sunny, blue skies, 20°C	Water Level (mbgl):	—		
		Final Depth (mbgl):	0.30 mbgl		

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
0.1					Sandy topsoil, light brown, dry, loose. Sand is fine. Occasional pellets. (FILL MATERIAL IN RAISED GARDEN BED.). Rare coarse, angular gravel.	B8-1 = 0.20 mbgl	
0.2	ND	0.0	B8-1				
0.3					REFUSAL @ 0.30 mbgl, potential concrete upturn or sandstone causing refusal.		
0.4							
0.5							
.0							
.0							
.0							
.0							

Notes

mAHD: metres Australian Height Datum
mbgl: metres below ground level

Water Found

⇓	Water Level
⇒	Water Inflow
⇐	Water Outflow
GNE	Groundwater Not Encountered

Monitoring Bore Details

Backfill
Bentonite Pellets
Cement
Gravel
Bentonite
Sand
Standpipe
Slotted Screen

Other Details/Comments

CH2M HILL

CH2M HILL AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. C1

Sheet 1 of 1

Project No:	406454	Excavation Equip.:	HA	Contractor:	CH
Project:	ANSTO	Easting	–	Logged By:	BF
Site:	Hunters Hill	Northing	–	Project Manager:	BF
Date:	23.8.10	Elevation (mAHD):	–	Checked By:	[signature]
Weather:	Cloudy	Water Level (mbgl):	–		
		Final Depth (mbgl):	1.40m		

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
0.10					Sand and silt topsoil, brown, ~~moist~~ dry, soft. Sand is fine and at 45%. Occasional angular hard charcoal fragments. Coarse.	C1-1 = 0.20mbgl, Includes: ALS-DP-003, EU-DUP-003, ANSTO DUPLICATE = ANS-DUP-001	
0.20		0.1	C1-1				
0.30					Light brown sandstone at 0.30m, soft.	Note – Change in depth scale at 0.40m	
0.40	No				Light brown sandy topsoil fill, moist with occasional sandstone fragments and angular coal fragments.	C1-2 = 1.0m; C1-3 = 1.40m	
0.60							
0.80						1.40m = Refusal in coarse, angular gravel (could be one off cobble/boulder)	
1.0		0.1	C1-2				
1.20					– Contain angular, coarse gravel and rare slag fragments.		
1.40		0.1	C1-3			PID in hole = 0.7ppm	

Notes

mAHD: metres Australian Height Datum

mbgl: metres below ground level

Water Found

- Water Level
- Water Inflow
- Water Outflow
- GNE Groundwater Not Encountered

Monitoring Bore Details

Backfill, Bentonite Pellets, Cement, Gravel, Bentonite, Sand, Standpipe, Slotted Screen

Other Details/Comments

No installation.

CH2M HILL

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GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. C2

Sheet 1 of 1

Project No: 406484	Excavation Equip.: HA	Contractor: CH	
Project: ANSTO	Easting: –	Logged By: RM	
Site: Munters Hill	Northing: –	Project Manager: BF	
Date: 23.8.10	Elevation (mAHD): –	Checked By:	
Weather: cloudy	Water Level (mbgl): –		
	Final Depth (mbgl): 0.40m		

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
0.20		0.0	C2-1		Sand and silt topsoil fill, brown, loose, moist, sand is 60% and fine. Occasional rootlets.	C2-1 = taken at 0-30mbgl. Sandstone caused refusal @ 0.40m	
0.40	No				Light brown, yellow sandstone Refusal and End of boring @ 0.40m		

Notes

mAHD: metres Australian Height Datum
mbgl: metres below ground level

Water Found

⇩	Water Level
⇨	Water Inflow
⇦	Water Outflow
GNE	Groundwater Not Encountered

Monitoring Bore Details

Backfill
Bentonite Pellets
Cement
Gravel
Bentonite
Sand
Standpipe
Slotted Screen

Other Details/Comments

CH2M HILL
CH2M HILL AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. C3

Sheet 1 of 1 C3

Project No: 406484	Excavation Equip.: HAND AUGER	Contractor: CHM HILL	
Project: ANSTO HUNTERS HILL	Easting: —	Logged By: RICHARD HAYES	
Site: 11 NELSON PARADE	Northing: —	Project Manager: BF	
Date: 23/08/2010	Elevation (mAHD): —	Checked By:	
Weather: SUN C10	Water Level (mbgl): —		
	Final Depth (mbgl): 1.70 mbgl		

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
0.2		0.0	C3-1		Silt and sand topsoil, brown, moist, loose, sand is fine to medium, occasional rootlets.	C3-1 = 0-30 mbgl C3-2 = 0.70 mbgl	
0.4					Sandy clay, light yellow brown, moist, soft. Clay is 55%, sand is 45%		
0.6							
0.8		0.0	C3-2				
1.0	No						
1.2					- @ 1.20 sand content increases to 65-70% with lenses of fine, moist, white/light brown sand.		
1.4							
1.6		0.0	C3-3				
1.7					minor ironstone from 1.5m. EOH @ 1.7m : Refusal on S/S		

Notes

mAHD: metres Australian Height Datum
mbgl: metres below ground level

Water Found

⇓	Water Level
⇨	Water Inflow
⇦	Water Outflow
GNE	Groundwater Not Encountered

Monitoring Bore Details

Backfill
Bentonite Pellets
Cement
Gravel
Bentonite
Sand
Standpipe
Slotted Screen

Other Details/Comments

CH2M HILL

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GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. C4

Sheet 1 of 1 C4

Project No:	408284	Excavation Equip.:	HAND AUGER
Project:	ANSTO HUNTERS HILL	Easting	—
Site:	11 MASONS PARADE	Northing	—
Date:	23/08/2010	Elevation (mAHD):	—
Weather:	SEE LOG FOR C-10	Water Level (mbgl):	—
		Final Depth (mbgl):	0.2
Contractor:	CH2M HILL		
Logged By:	RICHARD HAINES		
Project Manager:	BEN FARMER		
Checked By:			

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
0.1					Silty Sand. Brown. minor rootlets. Slight moisture. Small sandstone fragments. Loose.	n/o n/d	
0.2		0.0	C4-1	0.0			
					END @ 0.2 m bgl. Refusal on sandstone.		
.0	No						
.0							
.0							
.0							
.0							
.0							
.0							

Notes:

mAHD: metres Australian Height Datum

mbgl: metres below ground level

Water Found

- Water Level
- Water Inflow
- Water Outflow
- GNE Groundwater Not Encountered

Monitoring Bore Details

- Backfill
- Bentonite Pellets
- Cement
- Gravel
- Bentonite
- Sand
- Standpipe
- Slotted Screen

Other Details/Comments

N/A

CH2M HILL
CH2M HILL AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. C5

Sheet 1 of 1

Project No:	400484	Excavation Equip.:	HA	Contractor:	CH2M HILL
Project:	ANSTO Hunters Hill	Easting	-	Logged By:	BF
Site:	11 Nelson Parade	Northing	-	Project Manager:	BP
Date:	23.9.10	Elevation (mAHD):	-	Checked By:	
Weather:	cloudy/rainy	Water Level (mbgl):	-		
		Final Depth (mbgl):	0.70		

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
0.1	NO	0.0	CS-1	0-70 mbgl	Sand + Silt topsoil, moist/loose, sand is fine and 70%.	REFUSAL @ 0.70 mbgl	
					Light brown, moist, sand and sandstone. Sand is fine.	Sample CS-1 taken @ 0-70 mbgl	
0.2					End of Hole @ 0.70 mbgl		
0.3							
0.4	NO						
0.5							
.0							
.0							
.0							
.0							

Notes

mAHD: metres Australian Height Datum
mbgl: metres below ground level

Water Found

⇓	Water Level
⇨	Water Inflow
⇦	Water Outflow
GNE	Groundwater Not Encountered

Monitoring Bore Details

Backfill
Bentonite Pellets
Cement
Gravel
Bentonite
Sand
Standpipe
Slotted Screen

Other Details/Comments

NO INSTALLATION, HAND AUGER ONLY.

CH2M HILL

CH2M HILL AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. C6

Sheet 1 of 1 C6

Project No: 406484	Excavation Equip.: HAND AUGER	Contractor: CH2M HILL	
Project: HUNTERS HILL STP	Easting: —	Logged By: RICHARD HINES	
Site: HUNTERS HILL, 11 N PARADE	Northing: —	Project Manager: BEN EXCELL	
Date: 23/03/2010	Elevation (mAHD): —	Checked By:	
Weather: SEE LOG FOR C-10	Water Level (mbgl): —		
	Final Depth (mbgl): 0-20 mbgl		

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
0-1.0					Silt and sand TOPSOIL, Brown, moist, dense. Silt is 40%, Sand is 60%. Sand is fine.	REFUSAL @ 0-20m	
0-2.0		0.0	C6-1	0.0			
					END OF HOLE AT 0-2m		
.0	No						
.0							
.0							
.0							
.0							
.0							

Notes

mAHD: metres Australian Height Datum
mbgl: metres below ground level

Water Found

- Water Level
- Water Inflow
- Water Outflow
- GNE: Groundwater Not Encountered

Monitoring Bore Details

- Backfill
- Bentonite Pellets
- Cement
- Gravel
- Bentonite-Sand
- Standpipe
- Slotted Screen

Other Details/Comments

N/A

CH2M HILL

CH2M HILL AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. ~~C7~~ C7

Sheet 1 of 1

Project No:	405484	Excavation Equip.:	HAND AUGER	Contractor:	CH2MHILL
Project:	HUNTERS HILL SOIL	Easting	—	Logged By:	RICHARD HAYES
Site:	HUNTERS HILL, 11N PARK	Northing	—	Project Manager:	R. FOSTER
Date:	23/08/2020	Elevation (mAHD):	—	Checked By:	[signature]
Weather:	SEE EIO LOG	Water Level (mbgl):	—		
		Final Depth (mbgl):	0.3		

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
					Silty sand. Brown. Moist. Minor rootlets. Sand 70%, silt 30%	n/o n/l	
0.1							
0.2		~~C7-1~~ 0.0	C7-1				
0.3							
					EOH @ 0.3m. Refusal on sandstone.		
.0	No						
.0							
.0							
.0							
.0							
.0							

Notes

mAHD: metres Australian Height Datum
mbgl: metres below ground level

Water Found

- ⇩ Water Level
- ⇨ Water Inflow
- ⇦ Water Outflow
- GNE Groundwater Not Encountered

Monitoring Bore Details

Backfill
Bentonite Pellets
Cement
Gravel
Bentonite
Sand
Standpipe
Slotted Screen

Other Details/Comments

N/A

CH2M HILL
CH2M HILL AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. C8

Sheet 1 of 1 C8

Project No: 466484	**Excavation Equip.:** HAND AUGER	**Contractor:** CH2M HILL	
Project: HUNTERS HILL SOIL	**Easting** —	**Logged By:** RICHARD HARE	
Site: HUNTERS HILL, 11 N PARADE	**Northing** —	**Project Manager:** RYAN FARLOW	
Date: 23/08/2010	**Elevation (mAHD):** —	**Checked By:**	
Weather: SEE C10	**Water Level (mbgl):** —		
	Final Depth (mbgl): 0.20mbgl		

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
0.1					Brown, moist, silt and sand TOPSOIL with fine rootlets and occasional light brown sandstone fragments, Silt is <10%, sand is ~50%. Sand is fine.	C8-1 @ 0-20mbgl	
0.2		0.0	C8-1			REFUSAL @ 0-20mbgl	
.0	No						
.0							
.0							
.0							
.0							
.0							

Notes

mAHD: metres Australian Height Datum
mbgl: metres below ground level

Water Found

⇩	Water Level
⇨	Water Inflow
⇦	Water Outflow
GNE	Groundwater Not Encountered

Monitoring Bore Details

Backfill
Bentonite Pellets
Cement
Gravel
Bentonite
Sand
Standpipe
Slotted Screen

Other Details/Comments

NO INSTALLATION DUE TO AUGER + REFUSAL

CH2M HILL

CH2M HILL AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. C9

Sheet 1 of 1

Project No: 406491	Excavation Equip.: HAND AUGER	Contractor: CH2M HILL	
Project: HUNTERS HILL SCH.	Easting: —	Logged By: R. HAYES	
Site: HUNTERS HILL, 11 N PARK	Northing: —	Project Manager: R. RAMAGE	
Date: 23/02/2010	Elevation (mAHD): —	Checked By:	
Weather: AS AT C20 LOG	Water Level (mbgl): —		
	Final Depth (mbgl): 0.35 mbgl		

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
0.2	N/A	0.0	C9-1		brown (dark), loose, moist, sand and silt topsoil with rare rootlets. Sand is 70%, silt is 30%	REFER TO 0-35 mbgl AS FILL STOCKPILE.	
0.4					REFER @ 0.35 mbgl		
0.6	No						
.0							
.0							
.0							
.0							
.0							

Notes

mAHD: metres Australian Height Datum
mbgl: metres below ground level

Water Found

⇓	Water Level
⇨	Water Inflow
⇦	Water Outflow
GNE	Groundwater Not Encountered

Monitoring Bore Details

Backfill
Bentonite Pellets
Cement
Gravel
Bentonite
Sand
Standpipe
Slotted Screen

Other Details/Comments

NO INSTALLATION.

CH2M HILL
CH2M HILL AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. C-10

Sheet 1 of 1

Project No: 406484	Excavation Equip.: HAND AUGER	Contractor: CH	
Project: Hunters Hill Soil	Easting: —	Logged By: R. Brouwer + R. Hayes	
Site: Hunters Hill, 11 N Parade	Northing: —	Project Manager: B. Brouwer	
Date: 23/8/2010	Elevation (mAHD): —	Checked By: [signature]	
Weather: Drizzle, Overcast, 15°C	Water Level (mbgl): —		
	Final Depth (mbgl): 0-50m		

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
0.2					Brown, loose, sandy, silty topsoil fill with occasional pebbles. Sand is 70%, silt is 30%	Refusal at 0.50m hit sandstone bedrock. C10-1 = 0.50m	
0.4							
	NO	0.0	C10-1		End of hole at 0.50m		
0.6							
0.8							
1.0							
.0							
.0							
.0							
.0							

Notes
mAHD: metres Australian Height Datum
mbgl: metres below ground level

Water Found
Water Level
Water Inflow
Water Outflow
GNE Groundwater Not Encountered

Monitoring Bore Details
Backfill
Bentonite Pellets
Cement
Gravel
Bentonite
Sand
Standpipe
Slotted Screen

Other Details/Comments
No installation.

CH2M HILL
CH2M HILL AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. F1

Sheet 1 of 1 F1

Project No: 406484	Excavation Equip.: HAND AUGER	Contractor: CH2M HILL	
Project: HUNTERS HILL, ANSTO	Easting: —	Logged By: RICHARD HYNES	
Site: 11 NELSON PARADE	Northing: —	Project Manager: BEN FRASER	
Date: 25/08/2020	Elevation (mAHD): —	Checked By:	
Weather: Sunny, 20°C	Water Level (mbgl): —		
	Final Depth (mbgl): 1.40		

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, sidewall collapse, etc.)	Monitor. Bore Details
0.20					Sand and silt topsoil, dark and light brown (variable). occasional rootlets, dry, sand is medium to fine. Occasional medium to coarse, sandstone gravels	F1-1 = 0.40m F1-2 = 0.90m F1-3 = 1.40m	
0.40		2.3	F1-1		0.30m = Sand and gravel, orange brown, moist, loose, sand is medium gravel is medium and sub-rounded. 75% sand.		
0.60					0.50m = Sand, light brown, moist, sand is medium to coarse and loose.		
0.80							
1.00		0.1	F1-2				
1.20					→ Becomes wet @ 1.20mbgl		
1.40		0.0	F1-3		SANDSTONE – REFUSAL: END OF HOLE AT 1.40mbgl		
.0							
.0							

Notes

mAHD: metres Australian Height Datum
mbgl: metres below ground level

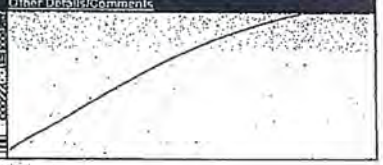
Water Found

⊻	Water Level
⊂)	Water Inflow
⊏	Water Outflow
GNE	Groundwater Not Encountered

Monitoring Bore Details

Backfill
Bentonite Pellets
Cement
Gravel
Bentonite
Sand
Standpipe
Slotted Screen

Other Details/Comments



CH2M HILL
CH2M HILL AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. G1
Sheet 1 of 1 G1

Project No:	406484	Excavation Equip.:	HAND AUGER	Contractor:	CH2M HILL
Project:	ANSTO, HUNTERS HILL	Easting	—	Logged By:	RICHARD HAMES
Site:	11 NELSON PARADE	Northing	—	Project Manager:	RON KRAMER
Date:	25/08/2010	Elevation (mAHD):	—	Checked By:	[signature]
Weather:	SUNNY, 20°C	Water Level (mbgl):	—		
		Final Depth (mbgl):	0.30 mbgl		

Depth (m)	Water Found	PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
0.0–0.30					Sand and silt topsoil, dark brown, rare roots, occasional fine angular gravel. Sand is medium and at 45%	G1-1 = 0.30 mbgl	
0.10							
0.20							
0.30		0.0	G1-1				
					REFUSAL ON SANDSTONE OUTCROP AT 0.30 mbgl		
.0							
.0							
.0							
.0							
.0							
.0							

Notes
mAHD: metres Australian Height Datum
mbgl: metres below ground level

Water Found
⇩ Water Level
⇨ Water Inflow
⇤ Water Outflow
GNE Groundwater Not Encountered

Monitoring Bore Details
Backfill
Bentonite Pellets
Cement
Gravel
Bentonite
Sand
Standpipe
Slotted Screen

Other Details/Comments

CH2M HILL
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GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. G2
G2
Sheet 1 of 1

Project No:	406484	Excavation Equip.:	HAND AUGER	Contractor:	CH2M HILL
Project:	AUSTIN MINTERS HILL	Easting	—	Logged By:	RICHARD MILES
Site:	H NELSON PARK	Northing	—	Project Manager:	BEN FRANKE
Date:	25/08/2010	Elevation (mAHD):	—	Checked By:	[signature]
Weather:	Sunny, 20°C	Water Level (mbgl):	—		
		Final Depth (mbgl):	1.0 mbgl		

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc)	Observation/Comments (visual contamination, odour, side collapse, etc)	Monitor. Bore Details
					Sand and silt topsoil, dark brown, moist, loose; sand is fine to medium, occasional rootlets.	G2-1 = 0.50 mbgl G2-2 = 1.0 mbgl	
0.20							
0.40							
		0.1	G2-1				
0.60					Sand, light brown, loose, moist, occasional angular gravel, inclusions of glass and ash FILL		
0.80							
1.0		0.0	G2-2		→ Introduction of sandstone fragments at 1.0mbgl, angular.		
					1.0mbgl = REFUSAL on COARSE, ANGULAR SANDSTONE (WEATHERED) COBBLES		
.0							
.0							
.0							
.0							

Notes
mAHD: metres Australian Height Datum
mbgl: metres below ground level

Water Found
Water Level
Water Inflow
Water Outflow
GNE Groundwater Not Encountered

Monitoring Bore Details
Backfill
Bentonite Pellets
Cement
Gravel
Bentonite
Sand
Standpipe
Slotted Screen

Other Details/Comments

CH2M HILL

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GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. G3

Sheet 1 of 1 G3

Project No: 446484	Excavation Equip.: HAND AUGER	Contractor: CH2M HILL	
Project: AMCO HUNTERS HILL	Easting: —	Logged By: RICHARD HAYES	
Site: 11 NELSON AVENUE	Northing: —	Project Manager: RON BROWN	
Date: 25/08/2010	Elevation (mAHD): —	Checked By: RH	
Weather: SUNNY 20°C	Water Level (mbgl): —		
	Final Depth (mbgl): 0.9		

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
0.20	NO				Sand and silty ptld, brown, loose, moist. Contains small angular gravel.	G3-1 = 0.50m G3-2 = 0.90m	
0.40		0.0	G3-1		No change		
0.60							
0.80		0.0	G3-2				
1.00					End of hole @ 0.90 mbgl due to refusal on sandstone cobbles.		

Notes

mAHD: metres Australian Height Datum
mbgl: metres below ground level

Water Found

⇓	Water Level
⇨	Water Inflow
⇦	Water Outflow
GNE	Groundwater Not Encountered

Monitoring Bore Details

Backfill
Bentonite Pellets
Cement
Gravel
Bentonite
Sand
Standpipe
Slotted Screen

Other Details/Comments

CH2M HILL

CH2M HILL AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. H1

Sheet 1 of 1

Project No:	408484	Excavation Equip.:	HA	Contractor:	CH2M HILL
Project:	ANSTO	Easting		Logged By:	BF
Site:	Hunters Hill	Northing		Project Manager:	BF
Date:	25.8.10	Elevation (mAHD):		Checked By:	
Weather:	sunny	Water Level (mbgl):			
		Final Depth (mbgl):			

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
					silty sand. brown. loose. minor rootlets and gravel.	n/o n/o	
0.1		0.3	H1-1 DUP		EOH @ 0.1m. Refusal on sandstone gravel. Attempt re-drill 5 times with same shallow refusal		

Notes

mAHD: metres Australian Height Datum
mbgl: metres below ground level

Water Found

⇩	Water Level
⇨	Water Inflow
⇦	Water Outflow
GNE	Groundwater Not Encountered

Monitoring Bore Details

Backfill
Bentonite Pellets
Cement
Gravel
Bentonite
Sand
Standpipe
Slotted Screen

Other Details/Comments

CH2M HILL

CH2M HILL AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. H2

Sheet 1 of 1

Project No:	406484	Excavation Equip.:	HA	Contractor:	CH2M HILL
Project:	ANSTO	Easting		Logged By:	BF
Site:	Hunters Hill	Northing		Project Manager:	B.F.
Date:	25.8.10	Elevation (mAHD):		Checked By:	
Weather:	Sunny	Water Level (mbgl):	–		
		Final Depth (mBgl):	0.5		

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
0.2					silty sand topsoil. Black. Loose. mine. gravel and rootlets.	n/o n/d.	
0.1		0.1	H2-1			H2-1 @ 0.4mbgl	
0.5					EOH @ 0.5m. Refusal on sandstone bedrock.		

Notes

mAHD: metres Australian Height Datum
mbgl: metres below ground level

Water Found

- ⇩ Water Level
- ⇨ Water Inflow
- |⇦ Water Outflow
- GNE Grouridwater Not Encountered

Monitoring Bore Details

- Backfill
- Bentonite Pellets
- Cement
- Gravel
- Bentonite
- Sand
- Standpipe
- Slotted Screen

Other Details/Comments

CH2M HILL

CH2M HILL AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. H3

Sheet 1 of 1

Project No:	406487	Excavation Equip.:	HA	Contractor:	CH2M HILL
Project:	ANSTO	Easting	–	Logged By:	BF
Site:	Hunters Hill	Northing	–	Project Manager:	RM
Date:	25.8.10	Elevation (mAHD):	–	Checked By:	
Weather:	Sunny	Water Level (mbgl):	–		
		Final Depth (mbgl):	0.3		

Depth (m)	Water Found	PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor Bore Details
0.1					Silty sand topsoil. dark brown. loose. gravel and rootlets. sandstone fragments.		
0.2			H3-1			n/o n/d H3-1 @ 0.2m	
0.3					EOH @ 0.3m. Refusal on sandstone cobbles. Attempt BH at 3 locations. Similar refusal in each.		

Notes

mAHD: metres Australian Height Datum
mbgl: metres below ground level

Water Found

- Water Level
- Water Inflow
- Water Outflow
- GNE: Groundwater Not Encountered

Monitoring Bore Details

- Backfill
- Bentonite Pellets
- Cement
- Gravel
- Bentonite
- Sand
- Standpipe
- Slotted Screen

Other Details/Comments

CH2M HILL
CH2M HILL AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. H4

Sheet 1 of 1 H4

Project No: LyN6482	Excavation Equip.: Hand Auger	Contractor: CH2M Hill
Project: ANSTO Hunters Hill	Easting: —	Logged By: B Fraser
Site: 11 Nelsons Parade	Northing: —	Project Manager: BF
Date: 25/08/2010	Elevation (mAHD): —	Checked By: [signature]
Weather: Sunny, 20°C	Water Level (mbgl): —	
	Final Depth (mbgl): 0.1	

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
		0.1	H4-1		silty sand. topsoil. minor gravel and rootlets. black. slight moisture. loose.	n/v n/d	
					EOHD 0.1 m. Refusal on sandstone.		
0.2 .0							
0.4 .0							
0.6 .0							
0.8 .0							
1.0 .0							
.0							
.0							
.0							
.0							

Notes
mAHD: metres Australian Height Datum
mbgl: metres below ground level

Water Found
- Water Level
- Water Inflow
- Water Outflow
- GNE Groundwater Not Encountered

Monitoring Bore Details
- Backfill
- Bentonite Pellets
- Cement
- Gravel
- Bentonite
- Sand
- Standpipe
- Slotted Screen

Other Details/Comments

CH2M HILL
CH2M HILL AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. I1

Sheet 1 of 1

Project No:	405484	Excavation Equip.:	HAND AUGER	Contractor:	CH2M HILL
Project:	ANSTO, HUMES HILL	Easting	—	Logged By:	R-Hayes
Site:	11 NELSON PARADE	Northing	—	Project Manager:	R-[illegible]
Date:	27/05/20	Elevation (mAHD):	—	Checked By:	[signature]
Weather:	SUNNY, 20°C	Water Level (mbgl):	—		
		Final Depth (mbgl):	0.2		

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
0.1.0 / 0.2.0		0.0	I1-1		Silty sand topsoil. Dark brown with minor gravel and rootlets. Significant sandstone cobbles. Loose. Dry.	I1-1 @ 0.2mbgl n/o n/d	
.0 / .0 / .0 / .0 / .0 / .0 / .0					EOH @ 0.2 mbgl. Refusal on sandstone cobbles. Attempt 3x redrill with same refusal depth.		

Notes

mAHD: metres Australian Height Datum
mbgl: metres below ground level

Water Found

- Water Level
- Water Inflow
- Water Outflow
- GNE Groundwater Not Encountered

Monitoring Bore Details

Backfill
Bentonite Pellets
Cement
Gravel
Bentonite
Sand
Standpipe
Slotted Screen

Other Details/Comments

CH2M HILL

CH2M HILL AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. 12

Sheet 1 of 1

Project No:	400454	Excavation Equip.:	MA	Contractor:	CH
Project:	ANSTO	Easting	—	Logged By:	RM
Site:	Hunters Hill	Northing	—	Project Manager:	BF
Date:	25.8.10	Elevation (mAHD):	—	Checked By:	
Weather:	Sunny.	Water Level (mbgl):	—		
		Final Depth (mbgl):	0.60		

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
0.1	ND				Sandy topsoil, dark brown, dry, loose, grasses rootlets, occasional medium angular gravel.	12-1 = 0.0 mbgl	
0.2							
0.3		0.0	12-1		Ash, sand and gravel fill. Dark brown/black, gravel is coarse and sub-rounded to angular. Rare rootlets. Sand is medium.		
0.4						PID = 0.2 in borehole cavity.	
0.5					END OF HOLE AT 0.60m DUE TO REFUSAL. POTENTIALLY SHALLOW ROCK.		
.0							
.0							
.0							
.0							

Notes

mAHD: metres Australian Height Datum

mbgl: metres below ground level

Water Found

- Water Level
- Water Inflow
- Water Outflow
- GNE: Groundwater Not Encountered

Monitoring Bore Details

- Backfill
- Bentonite Pellets
- Cement
- Gravel
- Bentonite
- Sand
- Standpipe
- Slotted Screen

Other Data to/Comments

CH2M HILL

CH2M HILL AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. I3

Sheet 1 of 1

Project No: 405484	Excavation Equip.: HAND AUGER	Contractor: CH2M HILL	
Project: ANSTO, LUCAS MILL	Easting: —	Logged By: R.HAYES	
Site: 11 MELSON PARADE	Northing: —	Project Manager: B.GAGNON	
Date: 27/08/2010	Elevation (mAHD): —	Checked By:	
Weather: SUNNY, 20°C	Water Level (mbgl): —		
	Final Depth (mbgl): 0.3		

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
0.1					Silty sand. Dark brown moist. Clay/compost. Black organic mud material and frequent rootlets.	n/d natural slight organic odour. (swampy).	
0.2		0.2	I3-1			I3-1 @ 0.2 mbgl	
0.3					EOH @ 0.3 mbgl. Refusal on sandstone cobbles.		
0.4							
0.5							
0.6							
0.7							

Notes

mAHD: metres Australian Height Datum
mbgl: metres below ground level

Water Found

- Water Level
- Water Inflow
- Water Outflow
- GNE Groundwater Not Encountered

Monitoring Bore Details

- Backfill
- Bentonite Pellets
- Cement
- Gravel
- Bentonite
- Sand
- Standpipe
- Slotted Screen

Other Details/Comments

N/A

CH2M HILL

CH2M HILL: AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. I4

Sheet 1 of 1

Project No: 405484	Excavation Equip.: HAND AUGER	Contractor:	CH2M HILL
Project: ANSO HUNTER HILL	Easting: —	Logged By:	R. HAYES
Site: 11 NELSON PREMISES	Northing: —	Project Manager:	R. FARQUHAR
Date: 27/08/2020	Elevation (mAHD): —	Checked By:	
Weather: SUNNY 20°C	Water Level (mbgl): —		
	Final Depth (mbgl): 0.30 mbgl		

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
0.10					Sand and silt fill, dark brown, dry, loose, frequent inclusion of fine ash fragments. Occasional rubbles.	I4-1 = 0.20 mbgl	
0.20		1.6	I4-1				
0.30					→ Included solidified coking waste (suspected). 0.30 mbgl = END OF HOLE @ 0.30 on suspected sandstone outcrop.		

Notes

mAHD: metres Australian Height Datum
mbgl: metres below ground level

Water Found

⇓	Water Level
⇨	Water Inflow
⇦	Water Outflow
GNE	Groundwater Not Encountered

Monitoring Bore Details

Backfill
Bentonite Pellets
Cement
Gravel
Bentonite
Sand
Standpipe
Slotted Screen

Other Details/Comments

CH2M HILL

CH2M HILL AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. IS

Sheet 1 of 1

Project No: 408484	Excavation Equip.: HA	Contractor: CH2M HILL	
Project: ANSTO	Easting: —	Logged By: BF	
Site: Hunters Hill	Northing: —	Project Manager: BF	
Date: 27.8.10	Elevation (mAHD): —	Checked By:	
Weather: Sunny	Water Level (mbgl): —		
	Final Depth (mbgl): 0.20		

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
					Fill: Silty/sandy topsoil, dark brown, moist, loose, occasional angular gravel and organics/rubble	IS-1 = 0.20 mbgl	
0.10					Silty sandy to pill, light to dark brown (variable), moist, loose, occasional medium, angular ash fragments and sandstone.		
0.20		0.0	IS-1		REFUSAL @ 0.2 mbgl on suspected sandstone outcrop.		
.0							
.0							
.0							
.0							
.0							
.0							

Notes

mAHD: metres Australian Height Datum

mbgl: metres below ground level

Water Found

⇩	Water Level
⇨	Water Inflow
⇦	Water Outflow
GNE	Groundwater Not Encountered

Monitoring Bore Details

- Backfill
- Bentonite Pellets
- Cement
- Gravel
- Bentonite
- Sand
- Standpipe
- Slotted Screen

Other Details/Comments

CH2M HILL

CH2M HILL AUSTRALIA Pty Ltd

GROUNDWATER MONITORING BORE LOG

Monitoring Bore No. 14

Sheet 1 of 1

Project No:	406484	Excavation Equip:	HA
Project:	ANCTO	Easting	–
Site:	Mantpis Hill	Northing	–
Date:	26.6.10	Elevation (mAHD):	–
Weather:	Sunny	Water Level (mbgl):	–
		Final Depth (mbgl):	1.0
Contractor:	CH2M HILL		
Logged By:	BF		
Project Manager:	BF		
Checked By:	[illegible]		

Depth (m)	Water Found	Sample PID	Sample No.	Graphic Log	Soil Description (soil type, colour, moisture content, plasticity, grain size, stiffness, etc.)	Observation/Comments (visual contamination, odour, side collapse, etc.)	Monitor. Bore Details
					Pooh concrete edge		
0.2					Air void		
0.4							
0.6							
0.8							
1.0		0.2	J4-1		Sandstone fragments and sand. Top of bedrock. Light brown. Loose. Dry	~10 ~20 J4-1 @ 0.9m bgl (although sample at 0.0-0.1 of formation)	
1.2					EOH @ 1.0m bgl Refusal on sandstone.		

Notes

mAHD: metres Australian Height Datum
mbgl: metres below ground level

Water Found

- Water Level
- Water Inflow
- Water Outflow
- GNE Groundwater Not Encountered

Monitoring Bore Details

- Backfill
- Bentonite Pellets
- Cement
- Gravel
- Bentonite
- Sand
- Standpipe
- Slotted Screen

Other Details/Comments

N/A

11. Appendix D – Site Photographs

Photo 1: Historic photo of radium extraction plant

Photo 2: Upper terraces of the site

Photo 3: Middle terraces of the site

Photo 4: Middle terraces on the site

Photo 5: Middle terraces beside

Photo 6: Foreshore of No9 and 7 Nelson Pde

Photo 7: Foreshore of No5 Nelson Pde

Photo 8: Cliff line from foreshore

Photo 9: Foreshore area of site

Photo 10: Seawall on boundary

Photo 11: Caves at base of cliff line

Photo 12: Walkover survey

Photo 13: Elevated radioactive hotspot on foreshore

Photo 14: Borehole markers

Photo 15: Soil sampling of upper terraces

Photo 16: Soil sampling of No5 Foreshore

Photo 17: Soil sampling beside foreshore shed

Photo 18: Soil sampling through path at No11 Nelson Pde

Photo 19: Borehole

Photo 20: Soil sample from middle terrace area

12. Appendix E – Radiation Field Instruments Used

The Health Physics measurements, analysis and survey work was conducted using a number of different systems to measure the different types of radiation emissions. These detection systems are calibrated annually at ANSTO's dedicated instrument calibration facility. These calibrations are traceable to primary and secondary standards. The following table details the instruments used by ANSTO for the work.

Instrument	MTE / Serial No.	Detector	Use
Eberline E-600	2904 Calibration Due 2/3/2012	SSPA-3 High sensitivity γ detector, 2 x 2" NaI(Tl) detector	High sensitivity gamma measurements, for identifying localised elevated areas in the γ energy range from 60 keV to 2 MeV
Eberline E-600	2568 Calibration Due 25/5/2011	SSPA-3 High sensitivity γ detector, 2 x 2" NaI(Tl) detector	High sensitivity gamma measurements, for identifying localised elevated areas in the γ energy range from 60 keV to 2 MeV
Eberline E-600	2903 Calibration Due 2/3/2012	SSPA-3 High sensitivity γ detector, 2 x 2" NaI(Tl) detector	High sensitivity gamma measurements, for identifying localised elevated areas in the γ energy range from 60 keV to 2 MeV
NE Electra	1971 Calibration Due 1/3/2012	DP2/R4-A Scintillation detector - calibrated in cps	Contamination monitoring and for detecting a wide range of radiations. Used to initially identify areas of interest above background and for self-monitoring for loose particles
Rotem R-200	2591 Calibration due 1/3/2012	GM type	Measures ionising radiation, (including X-Rays) from 30keV to 2 MeV, over the range of 0.1μSv/h to 1000mSv/h
Mini Instruments	2386 Calibration due 14/3/2012	GM Environmental probe	Environmental dose rate meter sensitive to γ energy with extendable count time
Eurisys Mesures Radiagem 2	1755 Calibration Due 3/11/2012	G.M. type (small tube-good for high intensity beams)	Measures ionising radiation, (including X-RAYS) from 30keV to 2 MeV, over the range of 0.1μSv/h to 100mSv/h
Target Identifier	2327 Calibration due 1/3/2012	1" NaI detector and GM tube	Analysing gamma energies for comparison against internal libraries to determine radionuclide identity. Effective from 30keV to 1.5MeV
Sv Bleeper	3041 Calibration due 4/1/2012	GM Tube	Used for recording real time radiation exposures to staff, and early warning of hazardous levels.
Sv Bleeper	3036 Calibration	GM Tube	Used for recording real time radiation exposures Calibration due, and early

	due 4/1/2012		warning of hazardous levels.
Sv Bleeper	3038 Calibration due 4/1/2012	GM Tube	Used for recording real time radiation exposures to staff, and early warning of hazardous levels.
Sv Bleeper	3033 Calibration due 1/3/2012	GM Tube	Used for recording real time radiation exposures to staff, and early warning of hazardous levels.
Sv Bleeper	3042 Calibration due 1/3/2012	GM Tube	Used for recording real time radiation exposures to staff, and early warning of hazardous levels.
Sv Bleeper	3039 Calibration due 4/1/2012	GM Tube	Used for recording real time radiation exposures to staff, and early warning of hazardous levels.

13. Appendix F – Calibration Certificates

FWAO-02 CH2M HILL Equipment Calibration Daily Log Sheet

CH2MHILL

PID CALIBRATION (onsite only)

Calibration gas ppm?	100	DATE:	23.8.10
START OF DAY PID reading after calibration	99.8	**MIDDAY CHECK** PID reading with Cal gas	—
END OF DAY PID reading after calibration	99.7	PID Correction Factor Used	—
BACKGROUND READING:	0.0 ppm.		

Calibration gas ppm?	100	DATE:	24.8.10
START OF DAY PID reading after calibration	99.8	**MIDDAY CHECK** PID reading with Cal gas	—
END OF DAY PID reading after calibration	99.9	PID Correction Factor Used	—
BACKGROUND READING:	0.0 ppm		

Calibration gas ppm?	100	DATE:	25.8.10
START OF DAY PID reading after calibration	100	**MIDDAY CHECK** PID reading with Cal gas	—
END OF DAY PID reading after calibration	99.6	PID Correction Factor Used	—
BACKGROUND READING:	0.0 ppm		

Calibration gas ppm?	100	DATE:	26.8.10
START OF DAY PID reading after calibration	99.7	**MIDDAY CHECK** PID reading with Cal gas	—
END OF DAY PID reading after calibration	99.8	PID Correction Factor Used	—
BACKGROUND READING:	0.0		

PID CALIBRATION (onsite only)

Calibration gas ppm? 100 DATE: 27.8.10

START OF DAY
PID reading after calibration 99.9

MIDDAY CHECK
PID reading with Cal gas —

END OF DAY
PID reading after calibration —

PID Correction Factor Used —

BACKGROUND READING: 0.0 ppm

Calibration gas ppm? DATE:

START OF DAY
PID reading after calibration

MIDDAY CHECK
PID reading with Cal gas

END OF DAY
PID reading after calibration

PID Correction Factor Used

BACKGROUND READING:

Calibration gas ppm? DATE:

START OF DAY
PID reading after calibration

MIDDAY CHECK
PID reading with Cal gas

END OF DAY
PID reading after calibration

PID Correction Factor Used

BACKGROUND READING:

Calibration gas ppm? DATE:

START OF DAY
PID reading after calibration

MIDDAY CHECK
PID reading with Cal gas

END OF DAY
PID reading after calibration

PID Correction Factor Used

BACKGROUND READING:

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RENTALS

Equipment Report - MINIRAE 2000 PID

This PID has been performance checked / calibrated* as follows:

Calibration	Actual Value	Reading	Pass?		
Zero – fresh air	0.0 ppm	0.0 ppm	☑		
Span – Isobutylene	101 ppm	101 ppm	☑		
Set Alarm limits to	High	100 ppm	Low	50 ppm	
Operations Check					

☑	Performance Check (pump, lamp, sensor & battery voltage check)					
☑	Battery Charged	☑	Filters Check	☑	Spare battery Voltage (5.5v minimum)	6 V
☐	Electrical Safety Tag attached (AS/NZS 3760)	Tag No:.....		Valid to:.....		
☐	Bump test / Date: 20-08-10					

** Calibration gas traceability information is available upon request.*

This PID has been performance checked / calibrated* as follows:

Date: 11/08/2010 Checked by: MILENKO

Signed:

Please check that the following items are received and that all items are cleaned and decontaminated before return. A minimum $20 cleaning / service / repair charge may be applied to any unclean or damaged items. Items not returned will be billed for at the full replacement cost.

Sent	Returned	Item
☑	☐	MiniRae 2000 PID / Operational Check, plus Battery Voltage @ 5.7 V
☑	☐	Lamp Voltage @ 10.6 eV Compound Set to: ISOBUTYLENE factor: 1
☑	☐	Protective yellow rubber boot
☑	☐	Inlet probe (attached to PID)
☑	☐	Spare water trap filter(s) Qty 2
☑	☐	Charger 240V to 12V 500mA
☑	☐	Instruction Manual behind foam on the lid of case "
☑	☐	Quick Guide Sheet behind foam on the lid of case "
☑	☐	Spare Alkaline Battery Compartment with batteries
☐	☐	Inline Moisture trap Filter Guide Laminated
☐	☐	Calibration regulator & tubing (optional)
☑	☐	Carry Case
	☐	Check to confirm electrical safety (tag must be valid)
☐	☐	

Processors Signature/ Initials

EE Quote Reference	21152	Condition on return
Customer Ref	270036	
Equipment ID	PID MINSAF	
Equipment serial no.	110900781	
Return Date	20/08/10	

ThermoFisher SCIENTIFIC

RENTALS

Equipment Report - MINIRAE 2000 PID

This PID has been performance checked / calibrated* as follows:

Calibration	Actual Value	Reading	Pass?		
Zero – fresh air	0.0 ppm	0.0 ppm	☑		
Span – Isobutylene	101 ppm	101 ppm	☑		
Set Alarm limits to	High	100 ppm	Low	50 ppm	
Operations Check					

☑	Performance Check (pump, lamp, sensor & battery voltage check)					
☑	Battery Charged	☑	Filters Check	☑	Spare battery Voltage (5.5v minimum)	6 V
☐	Electrical Safety Tag attached (AS/NZS 3760)	Tag No:.....		Valid to:.....		
☐	Bump test / Date: 20-08-10					

** Calibration gas traceability information is available upon request.*

This PID has been performance checked / calibrated* as follows:

Date: 10/08/2010 Checked by: MILENKO

Signed:

Please check that the following items are received and that all items are cleaned and decontaminated before return. A minimum $20 cleaning / service / repair charge may be applied to any unclean or damaged items. Items not returned will be billed for at the full replacement cost.

Sent	Returned	Item
☑	☐	MiniRae 2000 PID / Operational Check, plus Battery Voltage @ 5-6v
☑	☐	Lamp Voltage @ 10-6eV Compound Set to: ISOBUTYLENE/factor: 1
☑	☐	Protective yellow rubber boot
☑	☐	Inlet probe (attached to PID)
☑	☐	Spare water trap filter(s) Qty 2
☑	☐	Charger 240V to 12V 500mA
☑	☐	Instruction Manual behind foam on the lid of case "
☑	☐	Quick Guide Sheet behind foam on the lid of case "
☑	☐	Spare Alkaline Battery Compartment with batteries
☐	☐	Inline Moisture trap Filter Guide Laminated
☐	☐	Calibration regulator & tubing (optional)
☑	☐	Carry Case
	☐	Check to confirm electrical safety (tag must be valid)
☐	☐	

Processors Signature/ Initials

EE Quote Reference	2452	Condition on return
Customer Ref	271024	
Equipment ID	PID MINSE	
Equipment serial no.	11000 3550	
Return Date	30 10/8/10	

Phone: (Free Call) 1300 735 295 | Environmental Assessment Technologies | Fax: (Free Call) 1800 657 123

Melbourne Branch, 5 Caribbean Drive, Scoresby 3179, Email: RentalsEnviroVIC@thermofisher.com
Sydney Branch, Level 1, 4 Talavera Road, North Ryde 2113, Email: RentalsEnviroNSW@thermofisher.com
Adelaide Branch, 27 Beulah Road, Norwood, South Australia 5067, Email: RentalsEnviroSA@thermofisher.com
Brisbane Branch, Unit 2/5 Ross St, Newstead 4006, Email: RentalsEnviroQLD@thermofisher.com
Perth Branch, 121 Beringarra Ave, Malaga WA 6090, Email: RentalsEnviroWA@thermofisher.com

14. Appendix G – CoC and Laboratory Reports

Note: The soil samples analysed were submitted as part of a larger program of soil analysis. Samples that are not relevant to this in situ waste classification report have been blacked out, to retain the integrity of the laboratory reports and Chain of Custody forms.

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 45034

Client:
CH2MHILL
PO Box 5392
Chatswood
NSW 1515

Attention: Ben Farmer

Sample log in details:

Your Reference:	**406484, Hunters Hill**
No. of samples:	1 Soil
Date samples received:	24/08/10
Date completed instructions received:	24/08/10

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:	31/08/10
Date of Preliminary Report:	Not Issued
Issue Date:	31/08/10

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This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025.
Tests not covered by NATA are denoted with *.

Results Approved By:

Giovanni Agosti
Technical Manager

Sandra Taylor
Senior Organic Chemist

vTPH & BTEX in Soil Our Reference: Your Reference Date Sampled Type of sample	UNITS ---------- ----------	45034-1 EVL-DUP-003 23/08/2010 Soil
Date extracted	-	25/08/2010
Date analysed	-	28/08/2010
vTPH C_6 - C_9	mg/kg	<25
Benzene	mg/kg	<0.5
Toluene	mg/kg	<0.5
Ethylbenzene	mg/kg	<1.0
m+p-xylene	mg/kg	<2.0
o-Xylene	mg/kg	<1.0
Surrogate aaa-Trifluorotoluene	%	93

sTPH in Soil (C10-C36) Our Reference: Your Reference Date Sampled Type of sample	UNITS ---------- ---------- 	45034-1 EVL-DUP-003 23/08/2010 Soil
Date extracted	-	25/8/2010
Date analysed	-	25/8/2010
TPH C_{10} - C_{14}	mg/kg	<50
TPH C_{15} - C_{28}	mg/kg	1,800
TPH C_{29} - C_{36}	mg/kg	1,200
Surrogate o-Terphenyl	%	#

PAHs in Soil		
Our Reference:	UNITS	45034-1
Your Reference	----------	EVL-DUP-003
Date Sampled	----------	23/08/2010
Type of sample		Soil
Date extracted	-	25/8/2010
Date analysed	-	26/8/2010
Naphthalene	mg/kg	1.4
Acenaphthylene	mg/kg	5.5
Acenaphthene	mg/kg	0.4
Fluorene	mg/kg	4.1
Phenanthrene	mg/kg	110
Anthracene	mg/kg	15
Fluoranthene	mg/kg	140
Pyrene	mg/kg	150
Benzo(a)anthracene	mg/kg	71
Chrysene	mg/kg	70
Benzo(b+k)fluoranthene	mg/kg	94
Benzo(a)pyrene	mg/kg	77
Indeno(1,2,3-c,d)pyrene	mg/kg	32
Dibenzo(a,h)anthracene	mg/kg	6.6
Benzo(g,h,i)perylene	mg/kg	23
Surrogate p-Terphenyl-d_{14}	%	83

Organochlorine Pesticides in soil Our Reference: Your Reference Date Sampled Type of sample	UNITS ---------- ---------- 	45034-1 EVL-DUP-003 23/08/2010 Soil
Date extracted	-	25/08/2010
Date analysed	-	26/08/2010
HCB	mg/kg	<1
alpha-BHC	mg/kg	<1
gamma-BHC	mg/kg	<1
beta-BHC	mg/kg	<1
Heptachlor	mg/kg	<1
delta-BHC	mg/kg	<1
Aldrin	mg/kg	<1
Heptachlor Epoxide	mg/kg	<1
gamma-Chlordane	mg/kg	<1
alpha-chlordane	mg/kg	<1
Endosulfan I	mg/kg	<1
pp-DDE	mg/kg	<1
Dieldrin	mg/kg	<1
Endrin	mg/kg	<1
pp-DDD	mg/kg	<1
Endosulfan II	mg/kg	<1
pp-DDT	mg/kg	<1
Endrin Aldehyde	mg/kg	<1
Endosulfan Sulphate	mg/kg	<1
Methoxychlor	mg/kg	<1
Surrogate TCLMX	%	101

PCBs in Soil Our Reference: Your Reference Date Sampled Type of sample	UNITS ---------- ----------	45034-1 EVL-DUP-003 23/08/2010 Soil
Date extracted	-	25/08/2010
Date analysed	-	26/08/2010
Arochlor 1016	mg/kg	<1
Arochlor 1221*	mg/kg	<1
Arochlor 1232	mg/kg	<1
Arochlor 1242	mg/kg	<1
Arochlor 1248	mg/kg	<1
Arochlor 1254	mg/kg	<1
Arochlor 1260	mg/kg	<1
Surrogate TCLMX	%	101

Acid Extractable metals in soil		
Our Reference:	UNITS	45034-1
Your Reference	----------	EVL-DUP-003
Date Sampled	----------	23/08/2010
Type of sample		Soil
Date digested	-	25/8/10
Date analysed	-	25/8/10
Arsenic	mg/kg	85
Cadmium	mg/kg	0.6
Chromium	mg/kg	18
Copper	mg/kg	32
Lead	mg/kg	450
Mercury	mg/kg	0.4
Nickel	mg/kg	11
Zinc	mg/kg	330

Moisture		
Our Reference:	UNITS	45034-1
Your Reference	----------	EVL-DUP-003
Date Sampled	----------	23/08/2010
Type of sample		Soil
Date prepared	-	25/8/2010
Date analysed	-	25/8/2010
Moisture	%	22

Method ID	Methodology Summary
GC.16	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.
GC.3	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-FID.
GC.12 subset	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS.
GC-5	Soil samples are extracted with dichloromethane/acetone and waters with dichloromethane and analysed by GC with dual ECD's.
GC-6	Soil samples are extracted with dichloromethane/acetone and waters with dichloromethane and analysed by GC-ECD.
Metals.20 ICP-AES	Determination of various metals by ICP-AES.
Metals.21 CV-AAS	Determination of Mercury by Cold Vapour AAS.
LAB.8	Moisture content determined by heating at 105 deg C for a minimum of 4 hours.

QUALITY CONTROL vTPH & BTEX in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			25/08/2010	[NT]	[NT]	LCS-6	25/08/2010
Date analysed	-			28/08/2010	[NT]	[NT]	LCS-6	28/08/2010
vTPH C_6 - C_9	mg/kg	25	GC.16	<25	[NT]	[NT]	LCS-6	102%
Benzene	mg/kg	0.5	GC.16	<0.5	[NT]	[NT]	LCS-6	100%
Toluene	mg/kg	0.5	GC.16	<0.5	[NT]	[NT]	LCS-6	99%
Ethylbenzene	mg/kg	1	GC.16	<1.0	[NT]	[NT]	LCS-6	103%
m+p-xylene	mg/kg	2	GC.16	<2.0	[NT]	[NT]	LCS-6	104%
o-Xylene	mg/kg	1	GC.16	<1.0	[NT]	[NT]	LCS-6	106%
Surrogate aaa-Trifluorotoluene	%		GC.16	102	[NT]	[NT]	LCS-6	119%

QUALITY CONTROL sTPH in Soil (C10-C36)	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			25/8/2010	[NT]	[NT]	LCS-6	25/8/2010
Date analysed	-			25/8/2010	[NT]	[NT]	LCS-6	25/8/2010
TPH C_{10} - C_{14}	mg/kg	50	GC.3	<50	[NT]	[NT]	LCS-6	90%
TPH C_{15} - C_{28}	mg/kg	100	GC.3	<100	[NT]	[NT]	LCS-6	90%
TPH C_{29} - C_{36}	mg/kg	100	GC.3	<100	[NT]	[NT]	LCS-6	94%
Surrogate o-Terphenyl	%		GC.3	80	[NT]	[NT]	LCS-6	82%

QUALITY CONTROL PAHs in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			25/8/2010	[NT]	[NT]	LCS-6	25/8/2010
Date analysed	-			25/8/2010	[NT]	[NT]	LCS-6	25/8/2010
Naphthalene	mg/kg	0.1	GC.12 subset	<0.1	[NT]	[NT]	LCS-6	107%
Acenaphthylene	mg/kg	0.1	GC.12 subset	<0.1	[NT]	[NT]	[NR]	[NR]
Acenaphthene	mg/kg	0.1	GC.12 subset	<0.1	[NT]	[NT]	[NR]	[NR]
Fluorene	mg/kg	0.1	GC.12 subset	<0.1	[NT]	[NT]	LCS-6	107%
Phenanthrene	mg/kg	0.1	GC.12 subset	<0.1	[NT]	[NT]	LCS-6	112%
Anthracene	mg/kg	0.1	GC.12 subset	<0.1	[NT]	[NT]	[NR]	[NR]
Fluoranthene	mg/kg	0.1	GC.12 subset	<0.1	[NT]	[NT]	LCS-6	99%
Pyrene	mg/kg	0.1	GC.12 subset	<0.1	[NT]	[NT]	LCS-6	101%

QUALITY CONTROL PAHs in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Benzo(a)anthracene	mg/kg	0.1	GC.12 subset	<0.1	[NT]	[NT]	[NR]	[NR]
Chrysene	mg/kg	0.1	GC.12 subset	<0.1	[NT]	[NT]	LCS-6	117%
Benzo(b+k)fluoranthene	mg/kg	0.2	GC.12 subset	<0.2	[NT]	[NT]	[NR]	[NR]
Benzo(a)pyrene	mg/kg	0.05	GC.12 subset	<0.05	[NT]	[NT]	LCS-6	124%
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	GC.12 subset	<0.1	[NT]	[NT]	[NR]	[NR]
Dibenzo(a,h)anthracene	mg/kg	0.1	GC.12 subset	<0.1	[NT]	[NT]	[NR]	[NR]
Benzo(g,h,i)perylene	mg/kg	0.1	GC.12 subset	<0.1	[NT]	[NT]	[NR]	[NR]
Surrogate p-Terphenyl-d_{14}	%		GC.12 subset	73	[NT]	[NT]	LCS-6	84%

QUALITY CONTROL Organochlorine Pesticides in soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			25/08/2010	[NT]	[NT]	LCS-6	25/08/2010
Date analysed	-			26/08/2010	[NT]	[NT]	LCS-6	26/08/2010
HCB	mg/kg	0.1	GC-5	<0.1	[NT]	[NT]	[NR]	[NR]
alpha-BHC	mg/kg	0.1	GC-5	<0.1	[NT]	[NT]	LCS-6	121%
gamma-BHC	mg/kg	0.1	GC-5	<0.1	[NT]	[NT]	[NR]	[NR]
beta-BHC	mg/kg	0.1	GC-5	<0.1	[NT]	[NT]	LCS-6	124%
Heptachlor	mg/kg	0.1	GC-5	<0.1	[NT]	[NT]	LCS-6	113%
delta-BHC	mg/kg	0.1	GC-5	<0.1	[NT]	[NT]	[NR]	[NR]
Aldrin	mg/kg	0.1	GC-5	<0.1	[NT]	[NT]	LCS-6	106%
Heptachlor Epoxide	mg/kg	0.1	GC-5	<0.1	[NT]	[NT]	LCS-6	115%
gamma-Chlordane	mg/kg	0.1	GC-5	<0.1	[NT]	[NT]	[NR]	[NR]
alpha-chlordane	mg/kg	0.1	GC-5	<0.1	[NT]	[NT]	[NR]	[NR]
Endosulfan I	mg/kg	0.1	GC-5	<0.1	[NT]	[NT]	[NR]	[NR]
pp-DDE	mg/kg	0.1	GC-5	<0.1	[NT]	[NT]	LCS-6	127%
Dieldrin	mg/kg	0.1	GC-5	<0.1	[NT]	[NT]	LCS-6	119%
Endrin	mg/kg	0.1	GC-5	<0.1	[NT]	[NT]	LCS-6	119%
pp-DDD	mg/kg	0.1	GC-5	<0.1	[NT]	[NT]	LCS-6	124%
Endosulfan II	mg/kg	0.1	GC-5	<0.1	[NT]	[NT]	[NR]	[NR]
pp-DDT	mg/kg	0.1	GC-5	<0.1	[NT]	[NT]	[NR]	[NR]
Endrin Aldehyde	mg/kg	0.1	GC-5	<0.1	[NT]	[NT]	[NR]	[NR]
Endosulfan Sulphate	mg/kg	0.1	GC-5	<0.1	[NT]	[NT]	LCS-6	114%
Methoxychlor	mg/kg	0.1	GC-5	<0.1	[NT]	[NT]	[NR]	[NR]
Surrogate TCLMX	%		GC-5	110	[NT]	[NT]	LCS-6	114%

QUALITY CONTROL PCBs in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			25/08/2010	[NT]	[NT]	LCS-6	25/08/2010
Date analysed	-			26/08/2010	[NT]	[NT]	LCS-6	26/08/2010
Arochlor 1016	mg/kg	0.1	GC-6	<0.1	[NT]	[NT]	[NR]	[NR]
Arochlor 1221*	mg/kg	0.1	GC-6	<0.1	[NT]	[NT]	[NR]	[NR]
Arochlor 1232	mg/kg	0.1	GC-6	<0.1	[NT]	[NT]	[NR]	[NR]
Arochlor 1242	mg/kg	0.1	GC-6	<0.1	[NT]	[NT]	[NR]	[NR]
Arochlor 1248	mg/kg	0.1	GC-6	<0.1	[NT]	[NT]	[NR]	[NR]
Arochlor 1254	mg/kg	0.1	GC-6	<0.1	[NT]	[NT]	LCS-6	134%
Arochlor 1260	mg/kg	0.1	GC-6	<0.1	[NT]	[NT]	[NR]	[NR]
Surrogate TCLMX	%		GC-6	110	[NT]	[NT]	LCS-6	109%

QUALITY CONTROL Acid Extractable metals in soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date digested	-			25/8/10	[NT]	[NT]	LCS-4	25/8/10
Date analysed	-			25/8/10	[NT]	[NT]	LCS-4	25/8/10
Arsenic	mg/kg	4	Metals.20 ICP-AES	<4	[NT]	[NT]	LCS-4	105%
Cadmium	mg/kg	0.5	Metals.20 ICP-AES	<0.5	[NT]	[NT]	LCS-4	104%
Chromium	mg/kg	1	Metals.20 ICP-AES	<1	[NT]	[NT]	LCS-4	104%
Copper	mg/kg	1	Metals.20 ICP-AES	<1	[NT]	[NT]	LCS-4	106%
Lead	mg/kg	1	Metals.20 ICP-AES	<1	[NT]	[NT]	LCS-4	102%
Mercury	mg/kg	0.1	Metals.21 CV-AAS	<0.1	[NT]	[NT]	LCS-4	102%
Nickel	mg/kg	1	Metals.20 ICP-AES	<1	[NT]	[NT]	LCS-4	105%
Zinc	mg/kg	1	Metals.20 ICP-AES	<1	[NT]	[NT]	LCS-4	105%

QUALITY CONTROL Moisture	UNITS	PQL	METHOD	Blank
Date prepared	-			25/8/2010
Date analysed	-			25/8/2010
Moisture	%	0.1	LAB.8	<0.10

Report Comments:

Total Petroleum Hydrocarbons in soil:# Percent recovery is not possible to report as the high concentration of analytes in the sample/s have caused interference.

OC/PCB's in soil: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:	Not applicable for this job
Asbestos ID was authorised by Approved Signatory:	Not applicable for this job
Asbestos counting was analysed by Approved Counter:	@ERROR
Asbestos counting was authorised by Approved Signatory:	@ERROR

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 batched of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

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

Envirolab Services Pty Ltd
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CERTIFICATE OF ANALYSIS 45067

Client:
CH2MHILL
PO Box 5392
Chatswood
NSW 1515

Attention: Ben Farmer

Sample log in details:

Your Reference:	**406484, Hunters Hill**
No. of samples:	2 Soils
Date samples received:	24/08/10
Date completed instructions received:	24/08/10

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:	1/09/10
Date of Preliminary Report:	Not Issued
Issue Date:	31/08/10

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

Results Approved By:

Giovanni Agosti
Technical Manager

Sandra Taylor
Senior Organic Chemist

Nancy Zhang
Chemist

vTPH & BTEX in Soil Our Reference: Your Reference Date Sampled Type of sample	UNITS ---------- ---------- -	45067-1 EVL-DUP-001 24/08/2010 Soil	45067-2 EVL-DUP-002 24/08/2010 Soil
Date extracted	-	26/08/25010	26/08/25010
Date analysed	-	28/08/25010	28/08/25010
vTPH C_6 - C_9	mg/kg	<25	<25
Benzene	mg/kg	<0.5	<0.5
Toluene	mg/kg	<0.5	<0.5
Ethylbenzene	mg/kg	<1.0	<1.0
m+p-xylene	mg/kg	<2.0	<2.0
o-Xylene	mg/kg	<1.0	<1.0
Surrogate aaa-Trifluorotoluene	%	105	102