

Environmental Baseline Contamination Assessment

Osborne Nuclear-Powered Submarine Construction Yard

26-Feb-2025

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Environmental Baseline Contamination Assessment – Osborne Nuclear-Powered
Submarine Construction Yard

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Osborne Nuclear-Powered Submarine Construction Yard

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Executive Summary

To support the Commonwealth in establishing an environmental baseline for the Nuclear-Powered Submarine Construction Yard (NPSCY), in Osborne, South Australia, AECOM Australia Pty Ltd (AECOM) was engaged by the Australian Submarine Agency to conduct an Environmental Baseline Contamination Assessment ('the Project') at the Site.

The 'Site' has been defined as the location selected for the activities associated with the NPSCY (Areas 1, 2 and 3 and the Shipyard carpark), as well as surrounding areas including Falie Reserve, Mutton Cove Conservation Park and Biodiversity Park, and a control location situated across Port Adelaide River, north of the old quarantine station on Torrens Island. Nearby areas to the NPSCY were included in the Site to provide comparative analysis of conditions surrounding the NPSCY.

The purpose for the Project is to support the Commonwealth in determining an environmental baseline for the Site prior to the establishment of the NPSCY, which will in turn inform a continuous environmental monitoring programme over the life of the Nuclear-Powered submarines (NPS) program. The primary objective of the Project is the sampling and analysis of Site contaminants and radionuclides within various environmental media across the Site area.

Specific functional objectives of the works to achieve these primary objectives include:

- Collection of environmental samples from terrestrial soil and sediment, marine waters, marine sediments and groundwater with analysis of Site contaminants of potential concern (CoPC) and radionuclides to establish baseline environmental conditions.
- Establishment of background levels of surface radiation through a surface gamma radiation survey (conducted by Defence).

The environmental baseline sampling activities consisted of the collection of environmental samples for both chemical and radiological analysis across the Site:

- 145 terrestrial soils and sediments samples (one event).
- Eight marine sediment samples (two biannual events)
- Eight marine water samples (four quarterly events)
- Six groundwater samples (one event)

In addition, background levels of surface radiation established through a surface gamma radiation survey and an aerial radiometric survey conducted by Defence across Areas 1, 2, and 3 and the shipyard carpark was undertaken during this phase of work.

Key findings

Contaminants of potential concern associated with the surrounding industrial land uses and known use of fill materials were reported at minor concentrations across all environmental media samples, noting:

- Perfluoroalkyl and polyfluoroalkyl substances (PFAS) (primarily perfluorooctane sulfonate (PFOS)) have been identified in all media sampled at low concentrations likely associated with off-site industrial practices and migration via the Port River.
- Elevated metals were identified across all media with this being noted as primarily a result of background conditions with the exception of:
 - elevated metals in marine sediments associated with the Bolivar Wastewater Treatment Plant Outfall (copper) and Mutton Cove Conservation Park (arsenic, lead, nickel)
 - elevated metals in marine waters at the Bolivar Wastewater Treatment Plant Outfall
- Elevated ammonia in marine waters (four of the eight locations).

The radionuclide analysis conducted on environmental media samples reported naturally occurring isotope concentrations that were low and consistent with expected natural background levels (as identified from IAEA Marine Radioactivity Information System (MARIS) 2024).

No artificial isotopes were detected other than Iodine-131 (I-131) in marine waters, Caesium-137 (Cs-137) in soils, Plutonium-239/240 (Pu-239/240) in one soil sample, and low-level traces of Strontium-90 (Sr-90) in soils.

- I-131 was detected at the sample location near the Bolivar Wastewater Treatment Plant outfall, which receives sewage from the majority (70%) of metropolitan Adelaide, including Osborne. I-131 is a medical isotope and thus may continue to be detected in future sampling events.
- Cs-137 was detected in soil samples collected north of the Torrens Island Quarantine site and the Mutton Cove Conservation Park site. These are less disturbed sites and the Cs-137 is likely present as a result of global nuclear weapons testing. The Cs-137 concentrations detected at these sites is well within the expected anthropogenic background from atomic weapons testing. It is noted that there are pending radiological results that will be provided in a revised version of this report including four deep soil samples collected from the deep boreholes at Area 3 (boreholes BH302 and BH304), samples of the newly installed groundwater monitoring wells, and a range of inter-laboratory samples.
- Pu-239/240 was detected in one soil sample from the North Quarantine site. Plutonium isotopes may be present from atmospheric weapons testing fallout with Plutonium-238 (Pu-238) less prevalent compared to Pu-239/240. Pu-238 was not detected in soils.
- There were low-level detections of Sr-90 in three soil samples although the reported concentrations were associated with considerable uncertainties (greater than +/- 50%).

No Tritium (H-3) was detected in water marine water or groundwater. The H-3 analyses by liquid scintillation counting resulted in detection limits that were well above typical background concentrations. The detection limits were about 4 Bq/kg, which is much higher than typical environmental levels, which are in the order of 0.5 Bq/kg or less.

The radiometric survey reported limited quantitative data but did identify Plutonium-239 (Pu-239) as potentially present at several locations. Pu-239 could be present in soil from atomic weapons testing as noted above. However, quantification of low-energy gamma radiation emitting isotopes such as Pu-239 with in situ gamma spectroscopy comes with high levels of uncertainty and the reported data should be considered as such.

The radiometric survey does provide valuable baseline data and demonstrates that there are no areas of gamma radiation that might be considered as radiation anomalies. The reported data presented in counts per second (cps) are dependent on detector type and detector size. However, these data should be normalised to an air dose rate in millisievert per hour (mSv/hr) to be able to combine or compare the fly-over and walk-over surveys and compare the baseline survey results to future surveys.

Data gaps

The key findings of this assessment were that the baseline data collected to date is considered inadequate in establishing baseline conditions to develop an ongoing monitoring programme for the life of the NPS program. The following data gaps have been addressed as part of the concurrent Siting and Site Evaluation project:

- Groundwater information from Areas 2 and 3
- Deeper soil information from Areas 2 and 3
- Concentrations of radionuclides in ambient air

The following additional data gaps have been identified, of which are expected to be addressed prior to the NPSCY construction commencing:

- determination of contaminants (including radionuclides) of potential concern for the construction and operational phases
- upon completion of site works and filling, collection of surface soils from across Areas 2 and 3 for testing. Fill materials may also be sampled and tested at their sources prior to their import to and placement on the Site

- terrestrial sediment sampling upon the establishment of stormwater drainage infrastructure within and surrounding Areas 2 and 3
- marine water and sediment samples from the Port River adjacent to, upstream and downstream of Area 3 following capital dredging works
- environmental area dosimeters and radon and thoron passive samplers installed outdoors and indoors upon completion of the construction (filling, pavements and buildings) and prior to the importation of nuclear materials to the Site. It is also noted that for the aerial radiometric survey to be useful for future radiological impact assessment, the gamma count rates data for the two detectors used by the Department of Defence should be normalised to an air dose rate in mSv/hr and re-reported to be able to compare the results to future surveys
- a range of other media including terrestrial and marine biota, rainwater, biosolids, recycled wastewater and produce (i.e. food stuffs) may potentially be sampled and tested for radionuclides in future, subject to consideration of:
 - the outcomes of the radiological dispersion and dose assessment modelling of operational and accidental releases
 - the presence, distance to, sensitivity of and potential impact to receptors from operational and accidental release scenarios
 - the outcomes from consultation and engagement with stakeholders

The summary presented in this Executive Summary is given strictly in accordance with, and subject to the limitations outlined in **Section 8.0**.

Acronyms

Acronym	Description
ACM	Asbestos containing materials
AECOM	AECOM Australia Pty Ltd
ALS	Australian Laboratory Services Pty Ltd
ANI	Australian Naval Infrastructure
ANSTO	Australia's Nuclear Science and Technology Organisation
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZG	Australian & New Zealand Guidelines
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
ASC NEPM	National Environment Protection (Assessment of Site Contamination) Measure
BTEXN	benzene, toluene, ethylbenzene, xylenes, naphthalene
CoC	Chain of custody
CoPC	Contaminant of potential concern
CRC CARE	Cooperative Research Centre for Contamination Assessment and Remediation of the Environment
DCARM	Directorate of Contamination Assessment, Remediation and Management
DCMM	Defence Contamination Management Manual
Defence	Department of Defence
DO	dissolved oxygen
DQIs	Data quality indicators
DQOs	Data quality objectives
EC	electrical conductivity
EHM	Environment and Heritage Manual
EPA	Environment Protection Authority
EPBC	Environment Protection and Biodiversity Conservation Act 1999
EPP	Environment Protection (Water Quality) Policy 2015
EIL	Ecological investigation level
ERIK	Estate Resource Information Kiosk
ESL	Ecological screening level
GAR	SA EPA Guideline for the assessment and remediation of site contamination

Acronym	Description
GPS	global positioning system
HDPE	High Density Polyethylene
HEPA	Heads of EPAs of Australia and New Zealand
HIL	Health investigation level
HSL	Health screening level
IAEA	International Atomic Energy Agency
IP	interface probe
LOCR	Legal Obligations Compliance Register
LOR	Limit of reporting
MARIS	Marine Radioactivity Information System
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDA	minimum detectable activities
NATA	National Association of Testing Authorities
NEMP	National Environment Management Plan
NEPC	National Environment Protection Council
NHMRC	National Health and Medical Research Council
NPS	Nuclear-powered submarines
NPSTF	NPS Task Force
NRC	US Nuclear Regulatory Commission
NWQMS	National Water Quality Management Strategy
OCP	organochlorine pesticides
OPP	organophosphorus pesticides
PAHs	polycyclic aromatic hydrocarbons
PFAS	per- and polyfluoroalkyl substances
PFHxS	perfluorohexane sulfonic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
PID	photoionisation detector
PPMM	Pollution Prevention Management Manua
QA	quality assurance
QC	quality control

Acronym	Description
RPD	relative percentage difference
RSL	Regional screening level
SA EPA	South Australian Environment Protection Authority
NPSCY	Submarine Construction Yard
SPOCAS	Suspension Peroxide Oxidation Combined Acidity and Sulphur
TBT	tributyl-tin
TDS	total dissolved solids
TENORM	technologically enhanced naturally occurring radioactive materials
TOC	total organic carbon
TRH	total recoverable hydrocarbons
TU	Tritium Units
UK EA, SEPA & FSA	United Kingdom Environment Agency and Scottish Environment Agency and United Kingdom Food Standards Agency
US EPA	United States Environmental Protection Agency
VOC	volatile organic compounds
WA DoH	Department of Health (WA)
WHS	Work Health and Safety Act 2011
WQEPP	SA EPA Environment Protection (Water Quality) Policy

1.0 Introduction

1.1 Background

In September 2021, Australia, the United Kingdom and the United States embarked on a trilateral effort to define the Optimal Pathway for Australia's acquisition of conventionally-armed, nuclear-powered submarines (NPS). The project is Australia's largest infrastructure project and largest capability project. The submarine capability is essential for Australia's strategic interests and was addressed through the 2023 Defence Strategic Review. This project will be delivered over a long-term delivery period, however, infrastructure elements are required urgently to enable the commencement of construction of the new nuclear boats, as well as the home porting of three (3) Virginia class SSN boats to be procured by Australia, and the porting of visiting US and UK boats.

The Department of Defence (Defence) led Nuclear Powered Submarine Taskforce (NPSTF) identified the current Australian Naval Infrastructure (ANI) site, owned by the South Australian Government and located in Osborne, South Australia as the preferred site for the construction of NPS – NPS Submarine Construction Yard (NPSCY). The selection of the NPSCY location followed a number of feasibility assessments, due diligence activities and a comparative analysis of available land in and around the LeFevre Peninsula.

Given the construction activities to take place as well future use of nuclear reactor modules and installations for the NPS, the due diligence activities undertaken for the NPSCY site selection process identified the need to undertake an environmental baseline contamination assessment (including radiological assessment) of the Site (this Project) with considerations to the social, human health, and ecological risks posed by the NPS, current knowledge gaps in baseline conditions and the urgency of the work.

AECOM Australia Pty Ltd (AECOM) was engaged by Australian Submarine Agency (ASA) to conduct an Environmental Baseline Contamination Assessment (the Project) at the 'Site' comprising of the NPSCY comprising Areas 1, 2 and 3 and the ANI Shipyard carpark, as well as surrounding areas including Falie Reserve, Mutton Cove Conservation Park and Biodiversity Park, and a control location situated across Port Adelaide River, north of the old quarantine station on Torrens Island. Nearby areas to the NPSCY were included in the Site to provide comparative analysis of conditions surrounding the NPSCY. The Project location is shown on **Figure F1, Appendix A** and in the figure below.



Figure 1-1 Location of the preferred NPSCY, LeFevre Peninsula

As part of this engagement, AECOM prepared a Program Plan (AECOM, 2023) to document the sampling, analysis and quality plan for the Project.

1.2 Objectives

The purpose for the Project was to support the Commonwealth in determining an environmental baseline for the Site prior to the establishment of the NPSCY, which will in turn inform a continuous environmental monitoring programme over the life of the NPS program.

The primary objective of the Project is the sampling and analysis of Site contaminants and radionuclides within various environmental media across the Site area.

Specific functional objectives of the works to achieve these primary objectives include:

- Collection of environmental samples from terrestrial soil and sediment, marine waters, marine sediments and groundwater with analysis of Site contaminants of potential concern (CoPC) and radionuclides to establish baseline environmental conditions.
- Establishment of background levels of surface radiation through a surface gamma radiation survey (conducted by Defence).

1.3 Data quality objectives

Setting data quality objectives (DQOs) is a process used to define the type, quantity and quality of data needed to support decisions relating to the environmental condition of a site.

The process of establishing appropriate DQOs is defined by the seven-step planning approach presented in the NEPM.

The Program Plan (AECOM, 2023) presented a sampling plan and methodology which was designed to meet the objectives for the baseline sampling program and to achieve the nominated DQOs. The DQO review process is presented in **Table 1-1**.

Table 1-1 Outputs from the DQO review process

Step	DQO	Outcome
1	<i>State the Problem</i>	Baseline contamination and radiological information was required to be collected from across the Site and within various media prior to the establishment of the Site for the NPSCY.
2	<i>Identify the Goal of the Study</i>	The primary objective of the works was to determine an environmental baseline for the Site by undertaking sampling and analysis of Site contaminants and radionuclides, to inform a continuous environmental monitoring programme over the life of the NPS program and provide data for other requirements as part of the wider program. Specific functional objectives of the works to achieve these primary objectives included: - Collection of environmental samples from terrestrial soil and sediment, terrestrial groundwater, marine sediments and marine waters with analysis of Site contaminants of potential concern (CoPC) to establish baseline environmental conditions, and - Concurrent collection and submission of samples for radionuclide testing.
3	<i>Identify Information Inputs</i>	To meet the objectives of the works, various inputs were considered as follows: - Results of previous environmental and/or contamination assessments across the Site area - Visual observations and field measurements made during the sampling program - Laboratory analytical data from field samples - Analytical data comparisons with screening criteria appropriate for the Site land use.
4	<i>Define the Boundaries of the Study</i>	The lateral extent of the study area is defined by the Site boundary as shown on Figure F1, Appendix A. The temporal boundaries of the study included the following over an approximate 10-month period: - One terrestrial soil and sediment sampling event - One terrestrial groundwater sampling event - Four marine waters sampling events - Two marine sediments sampling events The target population included human health and ecological receptors on and adjacent to the Site.
5	<i>Develop the Analytical Approach</i>	The analytical approach included the following: - A quality assurance/quality control (QA/QC) assessment was undertaken in accordance with the NEPM and NEMP to indicate that the data is of an acceptable accuracy and precision for its intended use. - An assessment of reported chemical concentrations in comparison to published data.

Step	DQO	Outcome
		Decisions were made with full consideration of field and laboratory QA/QC processes and data quality review.
6	Specify Performance or Acceptance Criteria	Data validation was performed by an in-house review following ASC NEPM and NEMP guidance. Experienced field staff followed standard field procedures appropriate for the tasks undertaken and kept appropriate documentation.
7	Develop the Plan for Obtaining Data	The scope and methodology presented was designed to meet the program objectives and to achieve the nominated DQOs. The scope of works was carried out to a level of accuracy and confidence presented in the NEPM and NEMP.

1.4 Scope of works

As detailed in the Program Plan (AECOM, 2023), the scope of works that form the engagement for the Project is detailed below in **Table 1-2**. The sample numbers, locations and analysis for media was prescribed by ASA. The scope of works was completed between August 2023 and July 2024.

The field methodology employed for the scope of works is detailed in **Section 3.0**. Sample locations are shown on the figures in **Appendix A**.

Department of Defence conducted a radiometric survey, targeted at certain areas of the Site (Areas 1, 2, 3 and the shipyard carpark) in March 2023. The report documenting this survey is provided as **Appendix B**.

Table 1-2 Scope of works completed

Media	Task	Events	CoPC analysis	Radionuclide analysis
Terrestrial soil and sediment Figures F2A – F2H, Appendix A	Collection of a total of 145 samples from the top 10 cm of the soil profile across the whole Site: 10 within Area 1 20 within Area 2 20 within Area 3 10 within the shipyard carpark 5 within Falie Reserve 30 within Biodiversity Park 40 within Mutton Cove Conservation Park 10 within North Quarantine (on Torrens Island)	One	Total of 67 primary samples: - metals and metalloids¹ - polycyclic aromatic hydrocarbons (PAHs), benzene, toluene, ethylbenzene, xylenes & naphthalene (BTEXN), and total recoverable hydrocarbons (TRH) - per-and poly-fluoroalkyl substances (PFAS) Five primary samples: - site-specific physical properties Two primary samples: - Suspension Peroxide Oxidation Combined Acidity and Sulphur (SPOCAS)	96 samples: - artificial gamma suite 105 samples: - natural gamma suite 111 samples: - Strontium-90 (Sr-90) and actinides
Marine sediment Figure F4, Appendix A	Collection of eight sediment samples (below tideline sediment) across the Site from the top 10 cm of the sediment profile	Biannual (2) (total 16 samples)	- metals and metalloids¹ - PFAS Four primary samples: - tributyltin (TBT) - total organic carbon (TOC)	- artificial gamma suite - natural gamma suite - Sr-90 and actinides Four samples:

¹ Na, Mg, Al, Ca, Se, V, Cr, Mn, Co, Ni, Cu, Zn, As, Sr, Mo, Ag, Cd, Sb, Ba, La, Eu, Ho, Yb, Tl, Pb, Th, Ur, Cs

Media	Task	Events	CoPC analysis	Radionuclide analysis
				Iron-55 (Fe-55) and Nickel-63 (Ni-63)
Marine water Figure F4, Appendix A	Collection of eight surface water samples across the Site	Quarterly (4) (total 32 samples)	- metals and metalloids² - PFAS - PAHs, TRH, BTEXN, phenols - volatile organic compounds (VOCs) - organochlorine pesticides (OCPs), organophosphorus pesticides (OPPs) - ammonia and cyanide - major cations and anions - amino aliphatics & aromatics, anilines - carbamates & fungicides	- artificial gamma suite - natural gamma suite - Sr-90 and actinides - Polonium-210 (Po-210), Fe-55 and Ni-63 - Tritium (H-3)
Groundwater Figure F3A, Appendix A	Collection of groundwater samples from ten nominated groundwater monitoring wells: - Three within Site 3 - Three off-site to the north west within the Engie property - Four off-site to the west associated with the Quantem Terminal	One event	- metals and metalloids¹ - chlorinated alkenes, chlorobenzenes and chloronaphthalenes, chloroethanes, chloromethanes, chloropropenes - OCPs, OPPs - ammonia, cyanide - PAHs - PFAS	Six monitoring well locations: - artificial gamma suite - natural gamma suite - Sr-90 and actinides - H-3 - Fe-55, Ni-63

² Na, Mg, Al, Ca, Se, V, Cr, Mn, Co, Ni, Cu, Zn, As, Sr, Mo, Ag, Cd, Sb, Ba, La, Eu, Ho, Yb, Tl, Pb, Th, Ur, Cs

2.0 Regulatory and policy framework

Key guidelines and legislation applicable to the baseline assessment are summarised below.

2.1 Defence environmental management framework

2.1.1 Environmental policy and strategic aims

The Defence Environmental Vision provided in the Environmental Policy (<http://www.defence.gov.au/estatemangement/Governance/Policy/Environment/Policy/EnvironmentalPolicy2016.PDF>) states: *Defence will be a leader in sustainable environmental management to support the ADF capability to defend Australia and its national interests*".

Defence's Vision is underpinned by five (5) strategic aims, including Strategic Aim 3 which states that *"Defence will minimise future pollution risks and manage existing contamination risks"*. The strategic aims are detailed in the Environmental Strategy 2016 – 2036.

The priorities of Strategic Aim 3 are to:

1. *Minimise future pollution and contamination risks both in Australia and overseas operations;*
2. *Understand emerging contamination risks and advances in remediation and management approaches;*
3. *Apply a risk-based approach to managing contaminated sites, including unexploded ordnance, to reduce impacts on human health and the natural environment and maintain public access to key information about these risks; and*
4. *Manage contaminated sites and potential pollutants in accordance with relevant legislative obligations and standards.*

The actions, accountabilities and timeframes to achieve these priorities are provided in the Defence Environmental Plan.

2.1.2 Environment and Heritage Manual

The Environment and Heritage Manual (EHM) (2019) describes the agreed approach to enabling Defence capability through long-term sustainable management of the environment. The EHM provides instruction and policy guidance for all Defence personnel and contractors on Defence's legislative obligations and stewardship goals in line with the Defence Environmental Policy and Environmental Strategy 2016-2036.

The EHM is divided into 13 chapters that link back to a Strategic Aim of the Defence Environmental Policy and provide supporting documentation to support the implementation of the policy.

2.1.3 Contamination guidelines and policy

Defence has developed numerous guidelines and policies in relation to the management of land across the Estate.

The Defence Pollution Prevention Management Manual (PPMM) (2017) within the Defence Estate Resource Information Kiosk (ERIK) provides the framework for pollution prevention to assist in the environmental management of the Defence Estate. The PPMM relates to Chapter 6 (soil management), Chapter 8 (pollution prevention) and Chapter 12 (waste minimisation and management) of the EHM (2019).

The Defence Contamination Management Manual (DCMM) (2021) provides the framework and technical guidance for the management of contamination related to Defence activities. The Directives set out mandatory requirements and are updated / amended as required. The DCMM relates to Chapter 6 (soil management) and Chapter 9 (site contamination management) of the EHM (2019).

The PPMM, DCMM and policy are available on the Defence website:

<https://www.defence.gov.au/business-industry/industry-governance/industry-regulations?keywords=&type=1125®ulator=All&page=0>

2.2 Commonwealth legislation, policies and guidelines

Defence and its contractors must operate to comply with all Commonwealth legislation. Reference can be made to the Defence Legal Obligations Compliance Register (LOCR).

2.2.1 *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)*

The EPBC Act is the Australian Government's central piece of environmental legislation.

Under the EPBC Act, any activity which is likely to have a significant impact on the environment, or on matters of national environmental significance, requires the approval of the Commonwealth Minister for the Environment and Energy. Under the Act, 'environment' is defined broadly and includes, but is not limited to, ecosystems and their constituent parts, people and communities, natural and physical resources and the heritage values of places. Non-compliance can result in penalties for both individuals and the organisation.

2.2.2 *National Environment Protection (Assessment of Site Contamination) Measure 1999 as amended in 2013*

National Environment Protection Measures (NEPMs) are developed by the National Environment Protection Council (NEPC) to protect or manage particular factors of the environment.

NEPMs establish a nationally consistent approach to the assessment of site contamination to ensure sound environmental management practices. The *National Environment Protection Measures (Implementation) Act 1998* (the Implementation Act) gives the Australian Government the power to implement NEPMs on its own land and for its own activities.

2.2.3 *Workplace Health and Safety Act 2011 (WHS Act)*

Defence operates within the Commonwealth Workplace Health and Safety (WHS) jurisdiction, however due to the nature of its business and operations there may be legislative touch points from time to time with State and Territory legislative requirements. The model WHS legislative framework consists of the WHS Act, Work Health and Safety Regulations 2012 (WHS Regulation) (both being statutory instruments), supported by advisory Codes of Practice (Safe Work Australia). In addition to these National Codes of Practice, regulatory compliance may also be demonstrated by following technical or industry standards (such as the Australian Standards) where they provide a standard of work health and safety equivalent to, or higher than, the Code of Practice.

Comcare, the national authority for work health and safety, and workers' compensation, while established under the *Safety, Rehabilitation and Compensation Act 1988 (SRC Act)* has functions and responsibilities under the WHS Act and as a government regulator, aims to:

- minimise the impact of harm in the workplace
- improve recovery at work and return to work
- promote the health benefits of good work

All controls required during on-site work involving the handling of potentially contaminated materials will be implemented in accordance with the Defence *WHS Manual*.

2.2.4 *Australian Radiation Protection and Nuclear Safety Act 1998*

The *Australian Radiation Protection and Nuclear Safety Act 1998* (the Act) provides a legal framework for the protection of the health and safety of the public and the environment from the harmful effects of radiation and establishes the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) as the national regulatory body with the *Australian Radiation Protection and Nuclear Safety Regulations 2018* (the Regulations) supporting the Act.

2.2.5 *National Water Quality Management Strategy 2000 (updated in 2018)*

Prepared by the Australian Government, the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG) as part of the National Water Quality Management Strategy (NWQMS), provide a framework for a nationally consistent approach to the protection of fresh and marine water quality. Specifically, the framework provides guidance for selecting and implementing water quality management objectives to improve and maintain water quality.

Whilst the framework provides a ten step process for implementation of the NWQMS, the trigger values to be applied are derived from the Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) revised ANZG for Fresh and Marine Water Quality (2018). The guidelines provide trigger values for assessing water quality, including physical, chemical and biological characteristics of a waterway to support the identified community environmental values. Environmental values include protection of aquatic ecosystems, primary industry, recreation and aesthetics, drinking water, industrial water (no water quality guidelines) and cultural and spiritual values (no water quality guidelines).

2.2.6 Heads of EPAs Australia and New Zealand 2020 PFAS National Environment Management Plan

The Heads of EPAs Australia and New Zealand (HEPA) put together a National Environment Management Plan (NEMP) to provide guidance including screening guideline values for soil and groundwater about PFAS referred to as perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and perfluorohexane sulfonate (PFHxS), and their direct and indirect precursors, as these are the most widely studied PFAS substances.

2.3 South Australian legislation, policies and guidelines

2.3.1 SA Regulatory system overview

The *Environment Protection Act 1993* (the EP Act) and the Environment Protection Regulations 2023³ set the regulatory framework for the investigation and management of contaminated land and water in South Australia.

The Environment Protection (Water Quality) Policy (EPP) (2015) provides detail to support the EP Act and provides the structure for regulation and management of water quality in South Australian inland surface waters, marine waters and groundwaters. The EPP (2015), which came into force on 1 January 2016 replacing the now revoked Environment Protection (Water Quality) Policy 2003 (EPP (2003)), also provides information on:

- what constitutes environmental harm (section 5 in the Act)
- what are the general environmental duty requirements (section 25 in the Act)
- what are the mandatory provisions which constitute offences (section 34 in the Act).

In November 2019, the SA EPA issued its revised Guidelines for the assessment and remediation of site contamination (GAR) which describes the legislative and policy approach to risk-based assessment and remediation of site contamination and supports the objects of the EP Act.

The SA EPA GAR (2019) details published criteria deemed as appropriate by the SA EPA for assessment of chemical impacts to groundwater, including determination of whether chemical impacts to groundwater represent 'actual or potential harm' and are 'not trivial' with respect to Section 5B(1)(c) of the EP Act. These referenced criteria are consistent with the approach outlined in the ASC NEPM and EPP; the process described in the GAR is adopted for derivation of screening levels for sites in SA. Under this process, determination of actual or potential harm to groundwater takes into account the applicable environmental values of groundwater.

2.4 Standards and guidance documents

Guidance provided in the following documents was referenced during the baseline sampling program:

Radiological Assessment and Monitoring

- Current relevant International Atomic Energy Agency (IAEA) guidelines including:
 - Guidelines on Soil and Vegetation Sampling for Radiological Monitoring, Radiation Safety Guide No. 486 2019

³ Environment Protection Regulations, 2009 was updated to Environment Protection Regulations, 2023 on 1 April 2024

- Environmental and Source Monitoring for Purposes of Radiation Protection, Radiation Safety Guide No. RS-G-1.8, 2005
- Monitoring and Surveillance of Radioactive Waste Disposal Facilities, Specific Safety Guide No. SSG-31, 2014
- Chamber of Minerals and Energy of Western Australia (WACME) (2010) Managing naturally occurring radioactive material in mining and mineral processing - 3.1 pre-operational monitoring requirements
- UK EA, SEPA and FSA (2010) Radiological monitoring technical guidance note 2: Environmental radiological monitoring, United Kingdom Environment Agency and Scottish Environment Agency and United Kingdom Food Standards Agency

Contamination assessment and monitoring

- Department of Defence (2021) Defence Contamination Management Manual (DCMM), *Annex B – Investigations, Remediation and Management*, March 2018, amended June 2021
- Department of Defence (2021) DCMM, *Annex L – Data Management*, March 2018, amended June 2021
- Department of Defence (2021) DCMM, *Annex K – Management of PFAS Contamination*, June 2018, amended June 2021
- National Environment Protection (Assessment of Site Contamination) Measure (1999) (as amended in 2013) Schedule B2: Guideline on Site Characterisation (NEPM)
- Heads of EPAs Australia and New Zealand (2020) PFAS National Environmental Management Plan (NEMP) Version 2, January 2020
- WA Department of Health (DoH) (2021) Guidelines for the assessment, remediation and management of asbestos contaminated sites
- Current relevant South Australian Environment Protection Authority (SA EPA) guidelines including:
 - SA EPA (2007) Guidelines for regulatory monitoring and testing – Groundwater sampling, South Australian Environment Protection Authority, revised April 2019
 - SA EPA (2018) Site Contamination: Guidelines for the assessment and remediation of site contamination (GAR), revised November 2019
 - South Australian Environment Protection (Water Quality) Policy (EPP) 2015

Environmental media sampling

- Standards Australia (AS/NZ 5667:1998) Water Quality – Sampling – Guidance on sampling of groundwaters
- Standards Australia (AS/NZ 5667:1998) Water Quality – Sampling – Guidance on sampling from marine waters
- Standards Australia (AS/NZ 5667:1998) Water Quality – Sampling – Guidance on sampling from bottom sediments

3.0 Site setting

3.1 Overview

The Site is located on the northern end of the Le Fevre Peninsula in Osborne, on the western bank of the estuarine Port Adelaide River.

The surrounding land use is predominantly industrial with facilities such as a peaking gas-fired power plant to the north and north-west, grain storage and handling to the west, freight rail and a fuel terminal to the west, the Mutton Cove Conservation Reserve directly south or east, and the existing Osborne Naval Shipyard further to the south. There are no existing built structures within Areas 2 and 3, except for a private battery manufacturing facility in the southern section of Area 2, and Area 1 comprises of commercial buildings in the northern portion.

The Port River has been used for the Port of Adelaide since the middle of the nineteenth century, changing from an estuary⁴ to a shipping channel which involved significant geomorphological modification. The banks and shorelines of the Port River were formalised and hardened, extensive plots of land were reclaimed, training walls were built along the mouth of the Port River (complete in 1905 - extending from Torrens Island into the Gulf St Vincent) and dredging activities within the main channel (starting from the mid-1800s) occurred to deepen the channel for shipping.

The Site is located in a low-lying area adjacent to the Port Adelaide River approximately 5 km from where it meets the ocean. The terrain is generally flat, with an elevation of 2 – 3 m Australian Height Datum (AHD), other than in areas where up to 4 m high stockpiles of river dredge material has been placed.

The site experiences a warm temperate climate⁵ with warm, dry summers and mild winters. Summer monthly mean maximum temperatures range between 26 °C and 28 °C, and winter mean maximums range between 15 °C and 16 °C. The average annual rainfall is 440 mm/year⁶.

Occasionally the region experiences extreme weather events including flooding from intense rainfall events and storm surge, and extreme temperatures and heatwaves⁷. Droughts also impact the greater Adelaide region.

The Site is underlain by the St Kilda Formation which consists of a variety of sedimentary materials derived from marine beach, coastal dune, estuarine and backbarrier lagoonal environments of deposition. Estuarine deposits around the Port Adelaide River and Torrens Island, on LeFevre Peninsula are highly variable and range from sands, silts, clays and muds to variants rich in organics and shells. The St Kilda Formation is underlain by the Glanville Formation, consisting of coastal sediments including silt, sand and clay, often with shell inclusions (Department of Mines SA, 1969).

Soil conditions across the Site area generally consist of unconsolidated sands and clays associated with the land reclamation and infilling activities conducted across the LeFevre Peninsula. Material used was dredged from the Port Adelaide River as well as industrial wastes from the defunct Penrice soda plant (ash, cinder, iron pyrite and calcium rich grit) and Snowdens Beach sulphuric acid plant which sourced pyrite from Brukunga in the Adelaide Hills. The Brukunga pyrite is rich in other heavy metal constituents, notably including arsenic, with the result that these other metals are commonly found in association with deposits of the Snowdens Beach sulphuric acid plant wastes. As a result, the soil conditions across the Site area have the potential for the formation of acid sulfate soils due to the disposed materials (namely pyrite). In addition, the natural underlying St Kilda formation has the potential for formation of acid sulfate soils due to the presence of a variety of sedimentary materials derived from marine beach, coastal dune, estuarine and backbarrier lagoonal environments of deposition which create reduced inorganic sulfur (RIS), predominantly as pyrite (FeS₂)

⁴ <https://www.estuary.org.au/the-estuary/>

⁵ Australian Building Code Board, 2024, *Climate Zone Map*, <https://www.abcb.gov.au/resources/climate-zone-map> accessed 16 April 2024.

⁶ Historical climate data relating to observations at Adelaide Airport between 1955 and 2024, sourced from the Bureau of Meteorology, www.bom.gov.au/climate/averages/tables/cw_023034.shtml accessed 16 April 2024.

⁷ AdaptWest, 2016, *Western Adelaide Region Climate Change Adaptation Plan*

Mutton Cove Conservation Reserve, located to the east of Area 2 and south of Area 3, has not been reclaimed and consists of mangrove and salt marsh wetlands, which are exposed to tidal flows.

Shallow groundwater is encountered beneath the Site within the St Kilda formation, and a deeper aquifer is encountered beneath within the Hindmarsh Clay, a regional confining layer for the uppermost quaternary (Q1) aquifer system.

3.2 Previous environmental assessments

A number of environmental assessments are available for the Site as well as land parcels to the south associated with the expansion of the existing Osborne Naval Shipyard, the north associated with the Engie Pelican Point and Nexif Snapper Point power station and the west associated with the Quantem Terminal.

TetraTech Coffey conducted land due diligence assessment of the Site in 2023 (Tetra Tech Coffey, 2023a) (Tetra Tech Coffey, 2023b) (Tetra Tech Coffey, 2023c), which summarised a number of assessment reports, site history and ground conditions encountered across Sites 2 and 3.

JBS&G (JBS&G, 2023) conducted a land contamination assessment across the Site which also summarised site history and included a limited soil investigation. Key information for the Site from these reports as well as others is described in **Table 3-1** below.

Table 3-1 Existing conditions overview, contaminated land

Item	Summary description
Depth and type of fill	Ground improvements have been conducted across Area 1 & 2 comprising a blend of St Kilda sands with clayey silts of surplus site material and imported materials, validated to meet Waste Fill criteria in accordance with the SA EPA (2013) Waste Derived Fill standard. This material generally extends to 1 m below the ground level (bgl). Fill associated with Penrice Soda Products Pty Ltd also occurs in that area as white, hard and cemented silt and/or sand material comprising calcium oxide/hydroxide and calcium carbonate extend to a maximum of 3 m bgl. Material produced from the Penrice Soda operations was used as fill as part of reclamation activities, is encountered as the hard white material and sits below the overlying recent fill material. Fill materials also include ash and cinders associated with reclamation activities and some imported gravels and unconsolidated material dredged from the Port River. Surficial asbestos has been encountered on the Mutton Cove Conservation Park boundary.
Depth to groundwater	Between 1.7 and 4.6 m bgl and +2.1 m to -1.5 m relative to Australian Height Datum (AHD) within the St Kilda Formation. Flow to the west noting the two wells located closest to the Port Adelaide River show tidal influence.
Contaminants of potential concern (CoPCs)	Some metals have been identified above ecological screening criteria in fill materials (arsenic, chromium, copper, lead and zinc). In groundwater, polycyclic aromatic hydrocarbons (PAHs), arsenic, chromium VI, cyanide and mercury have been reported above the marine ecosystem protection criteria as well as acetone and total recoverable hydrocarbons (TRH) above the laboratory detection limits. Other CoPCs below laboratory limits of reporting include per- and polyfluoroalkyl substances (PFAS) and pesticides. Potential acid sulfate soils have not been identified in the assessments undertaken.
Marine	No information about the contaminated land status is available for the marine area adjacent to Area 3. It is acknowledged the area was subject to land reclamation dredging activities. Given the known contamination impacts to the water and sediments of the Port Adelaide River⁸ it is considered likely this area is contaminated.

⁸ https://www.epa.sa.gov.au/environmental_info/water_quality/programs/port_waterways

4.0 Methodology

The following methodology was completed in reference to the scope of works in Section 1.4 and in accordance with the Program Plan (AECOM, 2023) for fieldworks completed. Field sheets and calibration certificates are in **Appendix C**.

4.1 Terrestrial soil and sediment sampling

For terrestrial soil and sediment sampling, the following methodology was employed.

Table 4-1 Terrestrial soil and sediment field sampling methodology

Activity	Methodology
Sample locations	- The coordinates of each location were recorded using a global positioning system (GPS). The spatial accuracy of the GPS equipment will also be recorded - All sediment locations were collected above the low tide mark and from the top 10 cm from the surface - Shallow soil samples were collected from the top 10 cm from the surface
Sediment and soil sampling	- All soil and sediment samples were collected using a clean pair of disposable nitrile gloves, with a trowel and transferred directly into laboratory-supplied sample containers and/or double zip locked bags - A minimum of 1 kg was collected at each sample location for radionuclide analysis, and 250 g for chemical analysis - Samples were placed on ice and kept at a maximum of 4°C on storage and transport to the analytical laboratories under chain of custody (CoC) protocols - The analytical laboratory for radionuclide analysis dried and sifted the samples as required to meet 500 g <2 mm and dry mass equivalent
Sediment and soil sample description	- All soil and sediment returns were logged in accordance with the AS1726:2017 Geotechnical Site Investigations - Depth of samples was logged and recorded - Observation of anthropogenic materials and visual and olfactory evidence of contamination (i.e. staining and/ or odour), where present, was noted on the field sampling sheets - Observations of potential acid sulfate soils (such as black odorous soils, organic content and presence of shells) was noted on sampling sheets - Each location was recorded with a photograph.
Equipment decontamination	- Re-usable sampling equipment, such as the trowel, was decontaminated using a solution of Liquinox, followed by rinsing in potable water between locations. - Decontamination procedures were performed before initial use of re-useable equipment, and after each subsequent use.
Waste management	No soil or sediment waste was generated during the field program.

4.2 Marine sediment and waters sampling

For marine sediment and marine water sampling works, the following methodology was employed.

Table 4-2 Marine sediment and waters sampling methodology

Activity	Methodology
Sample locations	- Prior to field works, locations for marine sediment and water sampling were georeferenced on field plans to ensure correct locations. - The location coordinates of each sample location were recorded on the Sample Register using a handheld GPS device with ± 2 m accuracy.
Sediment sampling	All sediment samples were collected from the top 10 cm of the surface using a clean pair of disposable nitrile gloves, with a grab sampler (i.e. Ekman) from a boat and

Activity	Methodology
	transferred directly into laboratory supplied sample containers and double zip locked bags • Sediment samples were collected following collection of co-located marine water samples to prevent cross contamination of marine water samples with mobilised sediments • A minimum of 1 kg was collected at each sample location for radionuclide analysis, and 250 g for chemical analysis • Samples were placed on ice and kept at a maximum of 4°C on storage and transport to the analytical laboratories under CoC protocols • The analytical laboratory for radionuclide analysis dried and sifted the samples as required to meet 500 g <2 mm and dry mass equivalent
Sediment sample description	• All sediment returns were logged in accordance with the AS1726:2017 Geotechnical Site Investigations • Observation of visual and olfactory evidence of contamination (i.e. staining and/ or odour), or the potential presence of acid sulfate soils (i.e. high organic content, seashells), was noted on the sampling sheets • The coordinates of each location were recorded using a handheld GPS and photographed.
Marine water collection	• Marine water samples were collected from below the surface of the water between 0.25 and 0.5 m, from a boat with sample depth recorded. • Samples were collected with a surface water sampler away from the sediment. • A total of 10 L per location was collected for radionuclide analysis, with 5 L of 0.45 µm filtered sample and 5 L of unfiltered sample. Both filtered and unfiltered samples were acidified to pH<2 using analytical grade nitric acid and placed into 5 L pre-rinsed laboratory supplied High Density Polyethylene (HDPE) containers • Additional filtered marine water samples were collected for H-3 analysis into a separate laboratory-supplied sample container, not preserved • Additional marine water samples were collected for chemical analysis (filtered and unfiltered) and transferred into laboratory-supplied sample containers (as required for the analysis) • All samples were held in chilled conditions meeting 4°C pending and during transport to the analytical laboratories under CoC protocols.
Marine water quality measurements and sample description	• Field parameters of temperature, pH, electrical conductivity (EC), dissolved oxygen (DO) and redox potential were recorded at each marine water location using a calibrated water quality meter (WQM) • Recording of the characteristics of the marine water samples including observations of any visual and/or olfactory observations (i.e. colour, turbidity and/ or odour) will be noted on the field sampling sheets • The coordinates of each location were recorded using a handheld GPS photographed.
Equipment decontamination	• Re-usable equipment was decontaminated using a solution of Liquinox, followed by rinsing in potable water between locations. • Decontamination procedures were performed before initial use of re-useable equipment, and after each subsequent use.
Waste management	• No marine water or sediment waste was generated during the field program.

4.3 Groundwater monitoring

For the groundwater monitoring event, the following methodology was employed.

Table 4-3 Groundwater sampling methodology

Activity	Methodology
Groundwater gauging	All groundwater monitoring wells were gauged for depth to water and total depth from a clearly marked and designated point at the top each well casing using an interface probe (IP).
Groundwater purging and sampling	- Purging and sampling of the groundwater was conducted using low-flow sampling techniques. The low-flow micropurge pump was set at a consistent depth above the base of each well, within the well screen, to ensure samples collected were representative of the surrounding aquifer - A total of 10 L per location was collected for radionuclide analysis, with 5 L of 0.45 µm filtered sample and 5 L of unfiltered sample. Both filtered and unfiltered samples were acidified to pH<2 using analytical grade nitric acid and placed into 5 L pre-rinsed HDPE laboratory-supplied containers - Additional filtered groundwater samples were collected for H-3 analysis into a separate laboratory-supplied sample container, not preserved - Additional groundwater samples were collected for chemical analysis (filtered and unfiltered) and transferred into laboratory-supplied sample containers for the analysis required - All groundwater samples were collected using a clean pair of disposable nitrile gloves and held in chilled conditions meeting 4°C pending and during transport to the analytical laboratories under CoC protocols.
Water quality measurements and sample description	- Field parameters of temperature, pH, EC, DO and redox potential were recorded at the time of sample using a WQM - Recording of the characteristics of the groundwater samples including observations of any visual and/or olfactory observations (i.e. turbidity, colour and/ or odour) was noted on field sampling sheets.
Equipment decontamination	All re-usable equipment including the IP, low-flow pump, WQM were decontaminated using a solution of Liquinox, followed by rinsing in potable water between locations.
Waste management	Purged groundwater was returned to ground.

4.4 Field QA/QC program

The following QA/QC sampling has been employed for all media.

Table 4-4 QA/QC sampling methodology

Activity	Methodology
Quality control sampling	- Field duplicate pairs were prepared in the field by splitting samples. - Intra-laboratory and inter-laboratory duplicate samples were collected at a frequency of one each per 20 primary samples for chemical analysis and at a frequency of one each per 10 primary samples analysed for PFAS. - Rinsate blanks were collected at a frequency of one per day of sampling, per set of sampling equipment, by passing laboratory supplied rinsate water over dedicated sampling equipment following decontamination. A trip blank was collected at a frequency of one per cooler where sampling from zones with potential volatile contamination is relevant. Trip blanks are analysed for volatile hydrocarbons (C₆ to C₁₀ TRH fraction) and VOCs to assess the potential for cross contamination during sample collection and transport. - Field blanks were collected at a rate of one per day of sampling. The field blanks will be placed on hold at the analytical laboratory and only analysed if cross contamination is suspected.

4.5 Analytical data validation

Analytical data validation is the process of assessing whether data is in compliance with method requirements and project specifications. The primary objectives of this process were to ensure that data of known quality are reported, and to identify if the data can be used to fulfil the overall project objectives.

The data validation guidelines that are adopted provide a consistent approach for the evaluation of analytical data. These guidelines are based upon data validation guidance documents:

- USEPA (2017) Contract Laboratory Program National Functional Guidelines for Organic Superfund Methods Data Review, EPA-540-R-2017-002, January 2017.
- USEPA (2017) Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Methods Data Review, EPA 540-R-2017-001, January 2017.
- NEPC (1999) National Environment Protection (Assessment of Site Contamination) Measure. Schedule B3.

A range of quality control tests are conducted and reported by the analytical laboratories to enable an assessment of the accuracy, precision and reliability of the project analytical data generated. Accuracy and precision can be defined as follows:

Accuracy - the degree of agreement of a measurement (or an average of measurements) with the accepted reference or true value. Analytical accuracy is analyte and matrix dependent.

Precision - the degree to which data generated from replicate or repetitive measurements differ from one another.

Specific elements that have been checked and assessed for this project are:

- a comparison of field data to laboratory data.
- preservation and storage of samples upon collection and during transport to the laboratory.
- sample holding times.
- use of appropriate analytical procedures.
- required limits of reporting (check to ensure below the adopted assessment criteria).
- frequency of conducting quality control measurements.
- laboratory blanks (enables the measurement of incidental or accidental contamination within the laboratory).
- laboratory duplicates.
- field duplicate and triplicates.
- matrix spikes/matrix spike duplicates (MS/MSDs).
- laboratory control spikes.
- surrogates (or System Monitoring Compounds) to assess the performance of individual organic analyses that involve chromatographic techniques).
- the occurrence of apparently unusual or anomalous results, e.g. laboratory results that appear to be inconsistent with field observations or measurements.

The validation summary report and table of relative percentage difference (RPD) calculations for field duplicates that have been completed at the time of issue of this report are provided as **Appendix F** for chemical data only.

5.0 Results

5.1 Assessment criteria

Defence and its contractors must operate to comply with all Commonwealth legislation, including the Work Health and Safety Act 2011 (WHS Act), Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and the NEPM. Reference can be made to the Defence Legal Obligations Compliance Register. Defence may not be subject to State and Territory law in all situations. Whether or not Defence is bound by State and Territory law is a complex issue and legal advice must be obtained to confirm whether a particular State or Territory law is applicable to Defence. However, as stated in the Defence Environmental Policy (Defence, 2016), Defence complies with its legislative and regulatory obligations regardless of where it operates and complies with the spirit and intent of state and territory environmental management legislation where it does not conflict with Commonwealth legislation. Defence contractors must comply with relevant State or Territory laws.

5.1.1 Terrestrial soils and sediment

The primary reference for environmental site assessment in Australia is the National Environment Protection (Assessment of Site Contamination) Measure 1999 (ASC NEPM), amended in 2013 (NEPC, 2013). This document provides health-based investigation screening levels (HILs), health screening levels (HSLs) for various exposure settings for some chemicals.

In addition, the CRC CARE (2011) direct contact and vapour intrusion HSLs have been applied. These screening assessment criteria are applied to assess the top 2 m of soil for potential risks associated with dermal contact with petroleum hydrocarbons and vapour intrusion for maintenance workers.

The ASC NEPM (NEPC 2013) requires consideration of Ecological Investigation Levels (EILs) and Ecological Screening Levels (ESLs) on sites (relevant to soils that will be within 2 m of the surface).

As PFAS is analysed in soil samples, the PFAS NEMP was adopted for human health and ecological receptors. Where applicable screening criteria cannot be determined from Australian guidance, the US EPA Regional Screening Levels (RSL) (2024) has been adopted.

Data from terrestrial soils was also screened against published background levels for radionuclides, metals and metalloids in Australian soils such as Kleinschmidt (2017).

Applicable screening criteria are as follows:

- ASC NEPM (NEPC 2013) HILs, Commercial/Industrial HIL D and Public Open Space HIL C
- ASC NEPM (NEPC 2013) HSLs, petroleum hydrocarbons for vapour intrusion, Commercial/Industrial HSL D (sand) and Recreational/Open Space HSL C (sand)
- CRC CARE (2011) HSLs for Direct Contact, Commercial/Industrial HSL D, Recreational/Open Space HSL C and intrusive workers (sand)
- CRC CARE (2011) HSLs for intrusive maintenance workers (shallow trench) (sand)
- ASC NEPM (NEPC 2013) EILs Commercial/Industrial and Urban Residential/Public Open Space – calculated where available using site-specific data collected
- ASC NEPM (NEPC 2013) ESLs Commercial/Industrial and Urban Residential/Public Open Space
- US EPA (2024) RSL, Industrial Soil
- PFAS NEMP (2020) Human health commercial/industrial and open space; ecological direct and indirect exposure
- National Council on Radiation Protection (1999) Recommended screening limits for contaminated surface soil
- US EPA (2007) Soil Screening Guidance for Radionuclides

5.1.2 Marine sediment

All marine sediments collected have been screened for chemical assessment against the relevant species protection level guideline values in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018).

As no radionuclide guideline values are present for sediments within the Australian guidance, the screening levels for soils from the National Council on Radiation Protection (1999) Recommended screening limits for contaminated surface soil and US EPA (2007) Soil Screening Guidance for Radionuclides will be reviewed for appropriate screening of sediment values on receiving radionuclide data for this media.

5.1.3 Marine water

All water samples collected are screened for chemical assessment against the relevant species protection level guideline values in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018).

Results are also screened against the PFAS NEMP for the screening of PFAS.

The NHMRC (2011) Australian drinking water guidelines are adopted for the screening values for gross alpha and beta. The NHRMC (2008) Guidelines for Managing Risks in Recreational Water are also adopted given the location of the site.

5.1.4 Groundwater

The ASC NEPM provides direction as to groundwater screening criteria for assessment of human health risk and ecological protection, drawn from other national guidance documents including the *Australian Drinking Water Guidelines* (NHMRC 2011) and the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ, 2000 & ANZG 2018). The SA EPA Environment Protection (Water Quality) Policy (WQEPP) (2015) refers to the same national guidance documents (as well as referencing the *Guidelines for Managing Risks in Recreational Waters* (NHMRC 2008) in stipulating guideline values for contaminants in waters.

The SA EPA Guideline for the assessment and remediation of site contamination (GAR) (2019) details published criteria deemed as appropriate by the SA EPA for assessment of chemical impacts to groundwater, including determination of whether chemical impacts to groundwater represent 'actual or potential harm' and are 'not trivial' with respect to Section 5B(1)(c) of the EP Act. These referenced criteria are consistent with the approach outlined in the ASC NEPM and WQEPP; the process described in the GAR is adopted for derivation of screening levels for sites in South Australia. Under this process, determination of actual or potential harm to groundwater considers the applicable environmental values of groundwater.

As part of the Program Plan (AECOM, 2023) an assessment of environmental values for the groundwater system was undertaken and concluded that given the depth to groundwater, and the quality and the distance to the marine environment, the groundwater environment in the Site vicinity is considered to be required to be protected for marine ecosystems, recreation and aesthetics, and primary industries.

Applicable screening criteria are as follows:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG) (2018), marine ecosystem 95%
- NHMRC/NRMMC (2011), Australian Drinking Water Guidelines (ADWG)
- PFAS NEMP (2020) marine waters
- NHMRC (2008) Guidelines for Managing Risk in Recreational Waters
- WHO (2022) Guidelines for Drinking Water Quality

5.2 Field observations

Field sheets are provided in **Appendix C**.

5.2.1 Terrestrial soil and sediment

Surficial soils across the Site generally consisted of pale brown sandy silt / silty sands with some occurrences of coarse gravelly sand. No visual or olfactory observations were made during the field works that indicated potential contamination.

The terrestrial sediment samples collected from Mutton Cove Conservation Park reported dark grey/brown sandy silt/silty sands.

No observations of potential acid sulfate soils were noted in the terrestrial soils and sediments.

5.2.2 Marine sediments

Sediments were collected during the sampling events in October 2023 and May/June 2024 from the top 0.1 m of sediment depth. The sediments were generally observed as sandy silty material with shell grit and seagrass except for the sample collected from Mutton Cove Conservation Park (SD0007) which observed sandy medium plasticity clays. The Bolivar Outfall sample location (SD0008) observed a septic odour likely associated with the water treatment plant. No other visual or olfactory observations were made that indicated potential contamination.

No observations of potential acid sulfate soils were noted in the marine sediments.

5.2.3 Marine water

Marine waters were generally described as blue brown odourless water with medium turbidity, except for the water collected from the Bolivar Outfall (SW0007) which reported a septic odour within the green-brown, medium turbidity water which also contained some suspended grains of sand.

Field water quality results from the marine water samples collected reported:

- Dissolved oxygen between 3.6 and 7.5 mg/L
- Electrical conductivity between 37,446 and 69,582 mS/cm
- pH between 7.5 and 8.9
- temperature between 11.7 and 24.3°C

5.2.4 Groundwater

Groundwater elevations recorded during the sampling event conducted in January 2024 are tabulated in **Table 1, Appendix D**. Groundwater elevations have been corrected for salinity interference to ensure levels presented are representative of the groundwater system. The salinity corrections are shown in **Table 1B, Appendix D**. Inferred groundwater elevations are presented graphically on **Figure 3B, Appendix A**. Groundwater elevation data is summarised below:

- Depth to groundwater ranged from 1.532 m below top of casing (btoc) at MW201 (Site 3) to 3.489 m btoc at MW203 (Site 3)
- Salinity-corrected groundwater elevations ranged from 0.179 m Australian Height Datum (AHD) at MW4 (Engie) to 1.445 m AHD at MW3A (Quantem Terminal)
- Based on the groundwater elevations, the interpreted local groundwater flow is inferred to the north east to the river

Field parameters measured during sampling of groundwater wells are tabulated in **Table 1, Appendix D** and summarised below.

- DO ranged between 0.03 and 2.16 mg/L
- Electrical conductivity ranged between 10,332 and 96,400 µS/cm
- Calculated total dissolved solids ranged between 6,199 and 57,840 mg/L
- Redox potential (corrected) ranged between -210 and 8 mV

- Temperature ranged between 21.3 and 27.4 °C

It is noted that a number of the monitoring wells reported a field observation of an odour of hydrogen sulphide (sometimes described as rotten egg smell) at both groundwater monitoring events. No observations of light non aqueous phase liquid (LNAPL) was observed across both events at any wells.

Analytical tables for the chemical analysis of soils, marine sediments, marine waters and groundwater are presented in **Tables 2 to 5, Appendix D**. Laboratory certificates of analysis for chemical and radiological analysis is presented in **Appendix E**.

5.3 Analytical results

5.3.1 Chemical analytical results

5.3.1.1 Terrestrial soil and sediments

The terrestrial soils and sediments analytical results reported concentrations of CoPCs in the soil samples analysed below the laboratory limit of reporting (LOR) with the exception of:

- TRH >C₁₆-C₃₄ (430 mg/kg) above the ESL for urban residential/open space at one soil sample (SS119) within Mutton Cove Conservation Reserve
- Perfluorooctane sulfonate (PFOS) above the laboratory LOR but below the adopted screening criteria at a number of samples across the Site
- Isolated samples with concentrations of TRH above the laboratory LOR, below the adopted screening criteria
- Some metals above the laboratory LOR, below the adopted screening criteria and considered to be representative of background conditions

5.3.1.2 Marine sediments

The marine sediments analytical results reported concentrations of CoPCs in the samples collected below the laboratory LOR with the exception of:

- Copper (79 mg/kg) above the adopted screening assessment criteria at SD007
- Arsenic (23 mg/kg), lead (59 mg/kg), nickel (22 mg/kg) above the adopted screening assessment criteria at SD008
- PFOS above the laboratory LOR but below adopted screening criteria at SD004, SD007 and SD008
- Some metals above the laboratory LOR, below the adopted screening criteria and considered to be representative of background conditions

5.3.1.3 Marine water

The marine waters analytical results reported concentrations of CoPCs in the samples collected below the laboratory LOR with the exception of:

- Silver above the screening assessment criteria at all locations ranging from 0.003 to 0.068 mg/L
- Ammonia above the adopted screening assessment criteria at four locations ranging from 2,860 and 5,900 µg/L
- TRH >C₁₀-C₄₀ at one sample (SW007) between 80 and 680 µg/L
- Chromium total (0.01-0.074 mg/L), cobalt (0.004 mg/L), copper (0.004-0.141 mg/L), lead (0.014-0.015 mg/L) and zinc (0.018-0.234 mg/L) above the adopted screening assessment criteria at one sample (SW007)
- PFOS and PFHxS above the adopted screening criteria at one location (SW007) between 0.01 to 0.05 µg/L
- Some metals above the laboratory LOR, below the adopted screening criteria and considered to be representative of background conditions

5.3.1.4 Groundwater

The groundwater analytical results reported concentrations of CoPCs in the samples collected below the laboratory LOR with the exception of:

- PFOS above the adopted screening criteria at four samples ranging between 0.01 and 0.05 µg/L
- PFHxS above the adopted screening criteria at one sample (MW4) at 0.42 µg/L
- A number of metals above the adopted screening criteria and considered to be representative of background conditions with the exception of:
 - Arsenic at MW201 (on-site)
 - Antimony, arsenic, nickel and uranium at MW4 (Quantem Terminal off-site)
 - Chromium (total) and lead at MW9A & MW12 (Quantem Terminal off-site)
 - Nickel, silver and uranium at MW3A (Quantem Terminal off-site)
 - Selenium at MW12 (Quantem Terminal off-site)

5.3.2 Radiological analytical results

Analytical tables for the chemical analysis of soils, groundwater, marine sediments and marine waters are presented in ANSTO's report including the laboratory certificates of analysis, presented in **Appendix E**.

5.3.2.1 Terrestrial soil and sediment

Terrestrial soil and sediment samples were analysed for both natural and artificial isotopes. Of the artificial isotopes analysed, Caesium-137 (Cs-137) was the only radionuclide detected in any of the samples using gamma spectroscopy. These detects were in samples from the North Quarantine Station (Torrens Island) site (8 of 10 samples; range: 0.98 to 7.83 Bq/kg) and the Mutton Cove site (4 of 45 samples; range: 1.82 to 3.60 Bq/kg). The North Quarantine site is a relatively undisturbed site. Therefore, the high percentage of detectable Cs-137 in surface soil is likely from atmospheric fallout from global nuclear weapons tests. As the area is generally undisturbed and not subject to significant erosion, Cs-137 deposited on this area decades ago likely persists in the shallow soils (the half-life of Cs-137 is slightly more than 30 years and it binds strongly to soil, especially to clay and organic materials). Similarly, the Cs-137 detections in Mutton Cove are from samples from areas historically subject to less human disturbance and not subject to tidal inundation. The estimated concentrations of Cs-137 in the northern hemisphere range from 4 to 29 Bq/kg due to global fallout (Edomskaya et al. 2022). Concentrations in the southern hemisphere are generally lower than in the northern hemisphere where the majority of weapons test occurred.

During actinide analyses, one of 30 samples showed detectable Pu-239/240 and three of 30 samples reported traces amounts of Sr-90. The lone Pu-239/240 detection was in a sample from the North Quarantine site. Two samples from Biodiversity Park and one sample from the Shipyard Car Park had Sr-90 reported above detection limits. Pu-239/240 and Sr-90 could be present from nuclear weapons testing fall out. The Sr-90 detections are associated with considerable uncertainties (greater than +/- 50%).

Figure 5-1 provides a summary of the average naturally occurring radioactive isotopes reported for soil samples from the Study Area. Potassium (K-40), which is ubiquitous in the natural environment and present at higher concentrations is excluded from Figure 5-1 as including it in the chart would reduce the scale. The data is reported with the highest average Radium-226 (Ra-226) concentration to the left and decreasing to the right. There are two key points:

- the average Thorium-232 (Th-232) and Radium-228 (Ra-228) concentrations are very close for each area sampled. These isotopes are in the natural Th-232 decay chain and will typically be present, on average, in nature at equal concentrations
- the average Po-210 concentration is higher than the Ra-226 at seven of the eight areas (excluding Area 1). This difference is discussed in the paragraphs below.

- the range in the average naturally occurring radioactive isotope concentrations across the sites likely reflects the diverse geological origins of the materials sampled (e.g., fill, sediment, etc).

As shown in Figure 5-1, soil samples analysed by gamma spectroscopy show that the average Po-210 concentration is higher than the average Ra-226 concentration at each of the eight areas sampled except Area 1. At Area 1, the average Ra-226 concentration is approximately twice the Po-210 concentration. At the other areas, Po-210 concentrations are higher than Ra-226 concentrations. The latter relationship between Po-210 and Ra-226 is the more common and the expected condition. This is the expected condition because some radon-222 gas from the decay of Ra-226 will be released from soils, will further decay to solid elements (including Po-210), and then be deposited back on surface soils thus adding additional Po-210 to the soil. However, while Po-210 is typically greater than Ra-226 in surface soils, the opposite condition observed at Area 1 may also be demonstrating the natural variability in the concentration of naturally occurring radioactive isotopes and it should not be taken as an indicator of Ra-226 contamination.

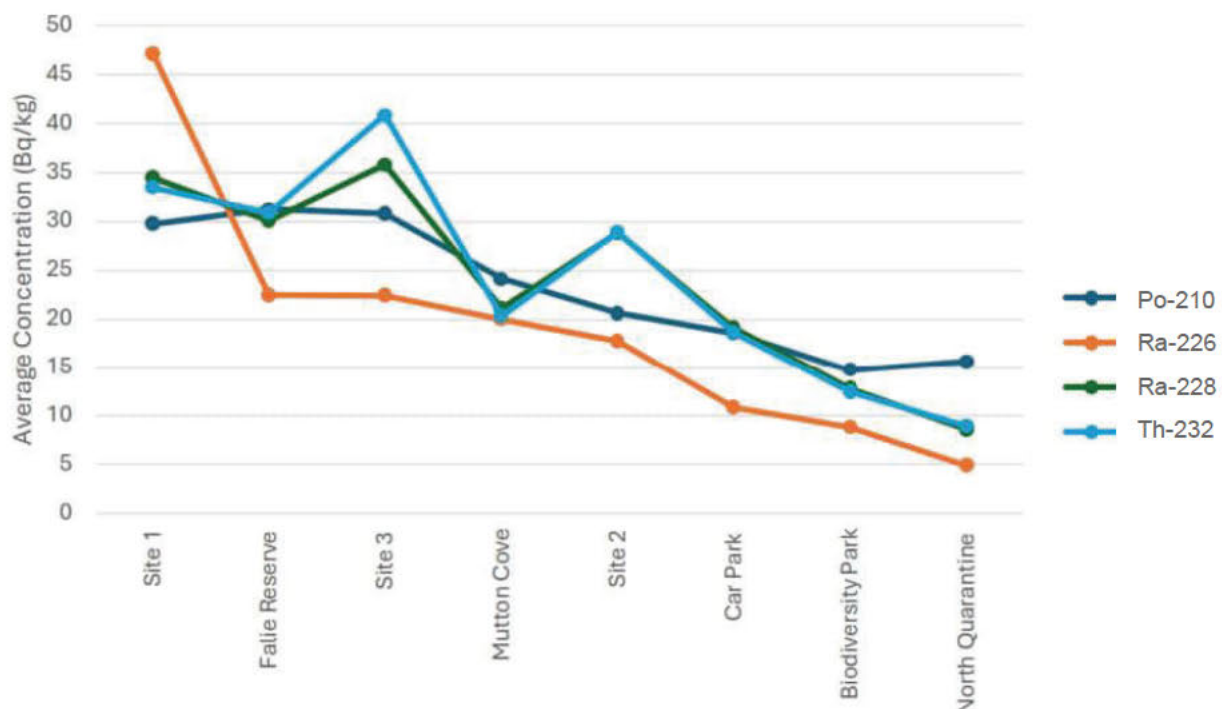


Figure 5-1 Average Po-210, Ra-226, Ra-228 and Th-232 soil concentrations

5.3.2.2 Marine sediment

The gamma spectroscopy results for naturally occurring isotopes in marine sediment samples show Lead-210 (Pb-210) concentrations in the SW006 sample (142 Bq/kg) and the SW001 sample (84.7 Bq/kg) are elevated above the other marine sediment samples. The ratios of the Pb-210 concentrations to the Ra-226 concentrations for the SW001 and SW006 samples are also inconsistent with other samples. However, these differences are consistent with natural variability.

The U-238, U-234, and Th-230 concentrations in marine sediments are consistent with the Ra-226 concentrations reported by gamma spectroscopy (all isotopes are in the U-238 decay chain). Similarly, Th-232 and Th-228 concentrations are consistent with the Th-232 and Ra-228 concentrations reported by gamma spectroscopy (all isotopes are in the Th-232 decay chain). All non-natural isotope concentrations (e.g. plutonium isotopes and Sr-90) were below detection limits. Fe-55 and Ni-63 were also not reported above the method detection limit for any of the samples analysed.

5.3.2.3 Marine water

Iodine-131 (I-131) was detected in both filtered and unfiltered samples from near the Bolivar Wastewater Treatment Plant Outfall (SW007) during 3 of 4 sampling events (not detected during the winter sampling event). Elevated I-131 could result from impacted sewage as I-131 is a common

radioisotope used in medicine to diagnose and treat thyroid disorders and other medical conditions. All other artificial radionuclides, including anthropogenic Cs-137, were below the minimum detectable activities (MDA).

Naturally occurring Pb-210, Ra-226, Ra-228, and Th-232 were detected using gamma spectroscopy analysis in two of eight October 2023 (Q1/R1) filtered and in two of eight Q1/R1 unfiltered samples. However, none were detected above MDAs in subsequent sample events. Naturally occurring Pb-210 was also detected in Q1/R1 samples, but not in subsequent sampling events. These data, and data from alpha spectroscopy analysis report naturally occurring uranium and thorium isotopes, are consistent with natural background levels. Uranium isotopes (U-238 and U-234) were detected at low concentrations in all samples. Naturally occurring thorium isotopes (Th-232, Th-230, and Th-228) were also detected in a few samples across the monitoring period.

While tritium (H-3) does occur naturally in the environment at low levels, none was detected above the detection limits in marine water samples collected during any of the sampling events. Currently, the levels of tritium in Australia are stabilising to around 2–3 Tritium Units (TU) increasing with latitude across the continent, suggesting that today the tritium in precipitation is predominantly natural⁹. A TU equals approximately 0.12 Bq/kg. The analytical detection limits for the H-3 analysis are greater than 4 Bq/kg (or greater than 33 TUs) limiting ability to determine H-3 levels as a baseline. The Adelaide Airport is shown as a sampling site between July 2005–June 2011 with a H-3 rainfall concentration of 2.4 to 2.8 TUs (Edomskaya et al. 2022). Furthermore, the reported detection limit for tritium (4.11 Bq/kg or 4.11 Bq/L) is well below the Australian Drinking Water Guideline value for tritium (76,000 Bq/L) and below the World Health Organisation recommended limit on tritium in drinking water of 10,000 Bq/L.

All samples were reported as less than MDA for Fe-55 and Ni-63. Neither Fe-55 nor Ni-63 are tracked by the IAEA 2024 Marine Radioactivity Information System (MARIS). No other artificial radionuclides were detected in marine waters.

5.3.2.4 Groundwater

No artificial isotopes, including I-131, Cs-137, Sr-90, or plutonium isotopes, were reported above detection limits in the groundwater samples analysed. Similarly, all groundwater samples reported concentrations of H-3, Fe-55 and Ni-63 less than their MDAs.

Concentrations of naturally occurring Th-228, U-238, U-234 were reported above their MDAs with average concentrations less than the average concentrations reported in marine water samples. Ra-226 was reported as less than MDA in all samples except the filtered and unfiltered samples from monitoring wells MW04 and MW05 located within the Engie property off-site. Th-228, U-238, U-234 were analysed for using alpha spectroscopy while Ra-226 was analysed for using the less sensitive method of gamma spectroscopy.

Table 5-1 provides the U-238 and Ra-226 concentrations from the MW04 and MW05 samples. When accounting for the reported uncertainty of the Ra-226 concentrations, the results from MW05 suggest that the U-238 and Ra-226, which are in the same decay chain, could be at approximately equal concentrations and consistent with background concentrations. Conversely, the Ra-226 results from MW04 are much higher and do not suggest that U-238 and Ra-226 are at equal concentration as would be expected in background samples. However, due to greater overall uncertainties with gamma spectroscopy analysis, the Ra-226 concentrations in MW04 samples are likely also at natural background levels.

Table 5-1 Detectable U-238 and Ra-226 concentrations in MW04 and MW05 groundwater samples (off-site)

Groundwater sample	U-238 by alpha spec. (Bq/kg)	Ra-226 by gamma spec. (Bq/kg)
MW04 – Filtered	< MDA (< 0.002)	0.67 +/- 0.08
MW04 – Unfiltered	0.004 +/- 0.001	0.60 +/- 0.08
MW05 – Filtered	0.017 +/- 0.002	0.16 +/- 0.10
MW05 – Unfiltered	0.020 +/- 0.002	0.07 +/- 0.06

⁹ <https://apo.ansto.gov.au/server/api/core/bitstreams/f1473c4c-e04c-4380-baae-a59c3cdc8dbe/content>

Like Ra-226, Po-210 is also within the U-238 decay chain and these isotopes could be expected to be in similar concentrations in background samples. However, soil and groundwater chemistry can disrupt this equilibrium. While Table 5-1 demonstrates potential disequilibrium between U-238 and Ra-226 in MW04 and MW05 samples (most prominently in MW04), Table 5-2 shows potential disequilibrium between Ra-226 and Po-210 in samples from MW04 and MW05 with the difference in reported concentrations being more significant in samples from MW04. Given that similar disequilibrium was observed in R1/Q1 marine water samples from two of eight sample locations and all U-238, Ra-226, and Po-210 concentrations are considered within the expected range of background concentrations, none of the Ra-226 or Po-210 sample results suggest the presence of contamination in the groundwater.

Table 5-2 Detectable Ra-226 and Pb-210 concentrations in MW04 and MW05 groundwater samples (off-site)

Groundwater Sample	Ra-226 by gamma spec. (Bq/kg)	Pb-210 by gamma spec. (Bq/kg)
MW04 – Filtered	0.67 +/- 0.08	< MDA (< 0.33)
MW04 – Unfiltered	0.60 +/- 0.08	< MDA (< 0.37)
MW05 – Filtered	0.16 +/- 0.10	2.31 +/- 0.97
MW05 – Unfiltered	0.07 +/- 0.06	3.17 +/- 0.83

5.4 Radiometric survey

The radiometric survey was conducted by Defence via a fly-over survey using a drone equipped with a 41 cm³ sodium iodide (NaI) gamma scintillation detector and a ground-level walk-over survey using a 208 cm³ NaI gamma scintillation detector across Areas 1, 2 and 3. A copy of this report is provided in **Appendix B**.

Neither the fly-over nor the walk-over surveys showed any significant gamma radiation anomalies within the survey areas. The surveys with the smaller drone-mounted detector had an average gamma count rate of 55.9 counts per second (cps) with a range of 34.4 to 136.8 cps. The surveys with the large ground-level detector had an average gamma count rate of 236.4 cps with a range of 123.0 to 370.4 cps. In the case of the drone surveys, the maximum reported gamma count rate is less than three times the mean count rate. For the walk-over surveys, the maximum reported gamma count rate is less than two times the mean count rate. These indicate a relatively tight data distribution and no outliers.

The radiometric surveys provide valuable baseline data and demonstrates that there are no areas of gamma radiation that might be considered as radiation anomalies. However, the reported data presented in cps are dependent on detector type and detector size and the fly-over nor the walk-over survey data cannot be combined. Therefore, the data should normalised to an air dose rate in millisievert per hour (mSv/hr) so that the fly-over and walk-over surveys can be combined or compared against each other and so future surveys can be compared against these baseline surveys.

Gamma energy spectrum data from the fly-over SPIR-Explorer system was used to identify gamma radiations from anthropogenic radioactive materials. However, due to the sparsity and gain shift issues of the SPIR-Explorer, it was expected that the SPIR-Pack would provide better data for isotope identification at the cost of spatial resolution (i.e. a smaller detector footprint). The survey reports provide the following related to isotopes identified during the spectra evaluations:

A Ba-133 emission was reported but as there was no spatial correlation with other

Ba-133 identifications - it was observed in only a single measurement - and the match was of relatively low confidence, it is considered to be a spurious false positive identification.

There were also 19 spectra reported as containing Pu-239 emissions across both Area 2 and 3 (Figure 10), with an associated 'Low' to 'Fair' confidence; supporting the possible indication of the presence of this radioisotope.

The survey report concluded that the presence of Pu-239 in the northern sector of Area 3 could not be eliminated, although the confidence in the identification of Pu-239 from the radiometric survey data is 'Low' to 'Fair'. The report then recommended additional sampling and analysis for plutonium isotopes in the northern sector of Area 3 which the Project conducted subsequently from terrestrial soils and

groundwater (and is presented herein) . Pu-239 is a by-product of the nuclear fission process in nuclear reactors and in atomic weapons testing. It is created when Uranium-238 captures a neutron and transforms into Uranium-239, which then loses an electron to become Neptunium-239, and finally transforms into Plutonium-239¹⁰. Pu-239 was also identified at low levels in one of 30 soil samples taken across eight sites that were analysed for actinide series isotopes.

5.5 Quality of analytical data

Analytical data validation is the process of assessing if data are in compliance with method requirements and project specifications. The primary objectives of this process are to ensure that data of known quality are reported, and to identify if the data can be used to fulfil the overall project objectives. The analytical data validation for chemical data is shown in **Appendix F**.

No QA/QC issues were identified in the field or laboratory datasets that could have a material implication to decision-making on the project. The data is assessed to be of acceptable quality for reporting.

It is noted that the radiological data evaluation is contained within the ANSTO and Queensland Health laboratory reports in **Appendix E**.

¹⁰ [https://www.orano.group/en/unpacking-nuclear/all-about-plutonium#:~:text=Where%20does%20plutonium%20239%20come,into%20the%20oxide%20\(PuO2](https://www.orano.group/en/unpacking-nuclear/all-about-plutonium#:~:text=Where%20does%20plutonium%20239%20come,into%20the%20oxide%20(PuO2)

6.0 Discussion and summary

The Environmental Baseline Contamination Assessment conducted at the Osborne NPSCY and surrounds has been conducted to support the Commonwealth in determining an environmental baseline for the Site prior to the establishment of the NPSCY; and to inform a continuous environmental monitoring programme over the life of the NPS program via the sampling and analysis of Site contaminants and radionuclides within various environmental media across the Site area.

The field program has consisted of the collection of terrestrial soils and sediments and groundwater (one event), marine sediments (two events) and marine waters (four events) over a 11 month period, with analysis of both chemical and radionuclides.

Key findings

Contaminants of potential concern associated with the surrounding industrial land uses and known use of fill materials were reported at minor concentrations across all environmental media samples, noting:

- Perfluoroalkyl and polyfluoroalkyl substances (PFAS) (primarily perfluorooctane sulfonate (PFOS)) have been identified in all media sampled at low concentrations likely associated with off-site industrial practices and migration via the Port River.
- Elevated metals were identified across all media with this being noted as primarily a result of background conditions with the exception of:
 - elevated metals in marine sediments associated with the Bolivar Wastewater Treatment Plant Outfall (copper) and Mutton Cove Conservation Park (arsenic, lead, nickel)
 - elevated metals in marine waters at the Bolivar Wastewater Treatment Plant Outfall
- Elevated ammonia in marine waters (four of the eight locations).

The radionuclide analysis conducted on environmental media samples reported naturally occurring isotope concentrations that were low and consistent with expected natural background levels (as identified from IAEA Marine Radioactivity Information System (MARIS) 2024).

No artificial isotopes were detected other than Iodine-131 (I-131) in marine waters, Caesium-137 (Cs-137) in soils, Plutonium-239/240 (Pu-239/240) in one soil sample, and low-level traces of Strontium-90 (Sr-90) in soils.

- I-131 was detected at the sample location near the Bolivar Wastewater Treatment Plant outfall, which receives sewage from the majority (70%) of metropolitan Adelaide, including Osborne. I-131 is a medical isotope and thus may continue to be detected in future sampling events.
- Cs-137 was detected in soil samples collected north of the Torrens Island Quarantine site and the Mutton Cove Conservation Park site. These are less disturbed sites and the Cs-137 is likely present as a result of global nuclear weapons testing. The Cs-137 concentrations detected at these sites is well within the expected anthropogenic background from atomic weapons testing. It is noted that there are pending radiological results that will be provided in a revised version of this report including four deep soil samples collected from the deep boreholes at Area 3 (boreholes BH302 and BH304), samples of the newly installed groundwater monitoring wells, and a range of inter-laboratory samples.
- Pu-239/240 was detected in one soil sample from the North Quarantine site. Plutonium isotopes may be present from atmospheric weapons testing fallout with Plutonium-238 (Pu-238) less prevalent compared to Pu-239/240. Pu-238 was not detected in soils.
- There were low-level detections of Sr-90 in three soil samples although the reported concentrations were associated with considerable uncertainties (greater than +/- 50%).

No Tritium (H-3) was detected in water marine water or groundwater. The H-3 analyses by liquid scintillation counting resulted in detection limits that were well above typical background concentrations. The detection limits were about 4 Bq/kg, which is much higher than typical environmental levels, which are in the order of 0.5 Bq/kg or less.

The radiometric survey reported limited quantitative data but did identify Plutonium-239 (Pu-239) as potentially present at several locations. Pu-239 could be present in soil from atomic weapons testing as noted above. However, quantification of low-energy gamma radiation emitting isotopes such as Pu-239 with in situ gamma spectroscopy comes with high levels of uncertainty and the reported data should be considered as such.

The radiometric survey does provide valuable baseline data and demonstrates that there are no areas of gamma radiation that might be considered as radiation anomalies. The reported data presented in counts per second (cps) are dependent on detector type and detector size. However, these data should be normalised to an air dose rate in millisievert per hour (mSv/hr) to be able to combine or compare the fly-over and walk-over surveys and compare the baseline survey results to future surveys.

Data gaps

The key findings of this assessment were that the baseline data collected to date is considered inadequate in establishing baseline conditions to develop an ongoing monitoring programme for the life of the NPS program. The following data gaps have been addressed as part of the concurrent Siting and Site Evaluation project:

- Groundwater information from Areas 2 and 3
- Deeper soil information from Areas 2 and 3
- Concentrations of radionuclides in ambient air

The following additional data gaps have been identified, of which are expected to be addressed prior to the NPSCY construction commencing:

- determination of contaminants (including radionuclides) of potential concern for the construction and operational phases
- upon completion of site works and filling, collection of surface soils from across Areas 2 and 3 for testing. Fill materials may also be sampled and tested at their sources prior to their import to and placement on the Site
- terrestrial sediment sampling upon the establishment of stormwater drainage infrastructure within and surrounding Areas 2 and 3
- marine water and sediment samples from the Port River adjacent to, upstream and downstream of Area 3 following capital dredging works
- environmental area dosimeters and radon and thoron passive samplers installed outdoors and indoors upon completion of the construction (filling, pavements and buildings) and prior to the importation of nuclear materials to the Site. It is also noted that for the aerial radiometric survey to be useful for future radiological impact assessment, the gamma count rates data for the two detectors used by the Department of Defence should be normalised to an air dose rate in mSv/hr and re-reported to be able to compare the results to future surveys
- a range of other media including terrestrial and marine biota, rainwater, biosolids, recycled wastewater and produce (i.e. food stuffs) may potentially be sampled and tested for radionuclides in future, subject to consideration of:
 - the outcomes of the radiological dispersion and dose assessment modelling of operational and accidental releases
 - the presence, distance to, sensitivity of and potential impact to receptors from operational and accidental release scenarios
 - the outcomes from consultation and engagement with stakeholders

These findings and all information in this report is given strictly in accordance with, and subject to the limitations outlined in **Section 8.0**.

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8.0 Limitations

The information in this Report is provided strictly in accordance with and subject to the following limitations and recommendations:

- a. This Report has been prepared for the sole benefit of Australian Submarine Agency
- b. Except as required by law, no third party may use or rely on, this Report unless otherwise agreed by AECOM in writing other than the Department of Defence. Where such agreement is provided, AECOM will provide a letter of reliance to the agreed third party in the form required by AECOM.
- c. This Report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by AECOM for use of any part of this Report in any other context.
- d. This Report is dated 26 February 2025 and is based on the site investigations conducted, and information reviewed, from August 2023 to November 2024. AECOM accepts no responsibility for any events arising from any changes in site conditions or in the information reviewed that have occurred after the completion of the site investigations.
- e. The investigations carried out for the purposes of the Report have been undertaken, and the Report has been prepared, in accordance with normal prudent practice and by reference to applicable environmental regulatory authority and industry standards, guidelines and assessment criteria in existence at the date of this Report.
- f. Except as specifically stated above, AECOM makes no warranty, statement or representation of any kind concerning the suitability of the site for any purpose or the permissibility of any use, development or re-development of the site.
- g. Use, development or re-development of the site for any purpose may require planning and other approvals and, in some cases, environmental regulatory authority approval. AECOM offers no opinion as to whether the current use has any or all approvals required, is operating in accordance with any approvals, the likelihood of obtaining any approvals for development or redevelopment of the site, or the conditions and obligations which such approvals may impose, which may include the requirement for additional environmental works.
- h. AECOM makes no determination or recommendation regarding a decision to provide or not to provide financing with respect to the site.
- i. To the extent permitted by law, AECOM expressly disclaims and excludes liability for any loss, damage, cost or expenses suffered by any third party relating to or resulting from the use of, or reliance on, any information contained in this Report. AECOM does not admit that any action, liability or claim may exist or be available to any third party.
- j. Except as specifically stated in this section, AECOM does not authorise the use of this Report by any third party.
- k. It is the responsibility of third parties to independently make inquiries or seek advice in relation to their particular requirements and proposed use of the site.