TOONDAH HARBOUR

CHAPTER 7

SOILS, SEDIMENTS AND CONTAMINATED LAND

7. Soils, Sediments, and Contaminated Land

7.1. Introduction

The sediment quality technical studies were completed by frc environmental (FRC) and summarised for the EIS by SHG. Details of the key personnel involved in the studies are provided in Appendix 1-F. The full technical report is included as Appendix 2-A. An additional report assessing the results of sediment analysis against terrestrial contaminated land trigger criteria is include as Appendix 2-B.

A contaminated land preliminary site investigation (PSI) was completed by Environmental Earth Sciences International (EESI) and summarised for the EIS by SHG. The full technical report is included as Appendix 2-C with historical reports by Golder and GHD utilised for the PSI included as Appendix 2-D. Key personnel are included in Appendix 1-F.

7.1.1 Scope of Study

The EPBC Act Draft EIS guidelines contain the following requirements in relation to potential contamination of soils and marine sediments:

- Assess sediment according to the National Assessment Guidelines for Dredging (NAGD) 2009 (Commonwealth of Australia, 2009) – this must include an assessment of the suitability of this material for reclamation;
- Assessment of the risk and potential impacts of ASS and potential acid sulfate soils (PASS);
- Consideration of potential impacts of mobilised sediments (e.g., metal or contaminant release);
- Detail of any known or potential sources of contaminated land in the vicinity of the site and the potential for the Project to disturb contaminated land; and
- Describe the risk of the development activities leading to land becoming contaminated.

Sediment analysis was carried out in the dredge channel in accordance with the NAGD to assess potential contaminant levels. Sampling of a number of sites was also carried out within the reclamation area to characterise sediment chemistry. As sediments within the dredge and reclamation areas will be beneficially reused for the reclamation, they were assessed against the National Environment Protection (Assessment of Site Contamination) Measure 1999 (ASC NEPM) (Australian Government 2013) soil guidelines. If sediments exceed the ASC NEPM's soil guideline values, they will require management and treatment prior to being used within the reclamation.

A PSI was completed to determine the risk of contamination associated with the planned works at GJ Walter Park and Toondah Harbour and develop a conceptual site model (CSM) of the site in accordance with the methodology outlined in the NEPM (NEPC, 2013). The PSI determined further works that will be required to ensure compliance with relevant contaminated land legislation and mitigate the risk of impacts associated with contaminated material. The Project will result in minimal disturbance of terrestrial areas, such as GJ Walter Park, and therefore the risk of contaminated land area being directly disturbed is low. Impacts due to contaminated land have more potential to occur through changes in the groundwater regime. These issues are addressed in Chapter 10.

Importantly, this section addresses the chemical properties of the dredge material only. Physical properties and engineering suitability of the material for reclamation is summarised in Section 2.4.2 and the full geotechnical report is included as Appendix 1-J. Engineering assessment concluded that sediments within the dredge and reclamation areas are suitable to be used for engineering fill once treated to remove the high moisture content.

7.1.2 Activities that May Result in Impacts

Contaminated sediments and soils could be mobilised through a number of Project activities. These include:

- Reclamation and maritime construction works:
  - Excavation of mud, sheet piling and placement of rock to construct the bund walls could mobilise contaminated sediments which may then impact on water quality and surrounding habitats;
  - Installation of permanent and temporary sheet piling for the bund walls could result in changes to groundwater interaction between terrestrial areas and Moreton Bay;
  - Release of contaminants and nutrients into the water column from sediments disturbed by the reclamation process. While this water will be collected and re-used on site for dust suppression, there is some potential for it to be released into the surrounding environment in large storm events;
  - Potential for spills of fuel and other chemicals to cause localised contamination.

- Dredging:
  - Release of contaminants and nutrients including ASS into the water column from sediments disturbed by the dredging process which may impacts on water quality and habitats outside of the Project footprint;
  - Potential for spills of fuel and other chemicals to cause localised contamination.

- Building and civil works (onshore and within the reclamation):
  - Disturbance of potentially contaminated materials within the Project footprint, such as the historical landfill areas under sections of GJ Walter Park and the disused maintenance dredge material disposal pond to the south of the existing boat ramp;
  - Potential for spills of fuel and other chemicals to cause localised contamination.

- Ongoing use of the ferry terminal, marina and urban development:
  - Potential for spills of fuel and other chemicals to cause localised contamination.

7.2. Assessment Methodology

7.2.1 Sediment Analysis

A sediment sampling and analysis plan (SSAP) was developed in consultation with the Department of Climate Change, Energy, the Environment and Water (DCCEEW) and in accordance with the sediment analysis process set out in Phase I and II of the NAGD. This sampling strategy also complies with the sampling requirements of the ASC NEPM. The NAGD set out the framework for environmental impact assessment and permitting of the ocean disposal of dredged material. The process entails evaluating alternatives to ocean disposal, assessing loading and disposal sites, assessing potential impacts on the marine environment and other users and determining management and monitoring requirements.

The SSAP is included as an attachment to Appendix 2-A and in summary required that:

- The material to be dredged is assessed according to the NAGD, with potential contaminants assessed against the sediment quality guidelines in the NAGD;
- The dredged material is proposed to be used for land reclamation purposes, therefore requires assessment against the ASC NEPM soil guidelines;
- The selection of sampling locations is based on the potential occurrence of contaminants and the volume of material that may be disturbed;
- Samples are collected from 14 sites in the turning basin, Fison Channel (inner channel and outer channel), and from four sites in the reclamation area;
- Sediment cores are subsampled where possible as follows:
  - the upper 0.5 m of the core (subsample A);

  - the middle section of the core (subsample B), extending from 0.5 m to the maximum dredge depth—where this section is over 1 m long or there are distinct changes in sediment composition, this sample will be divided accordingly;
  - the bottom 0.5 m of the core (subsample C), extending from the maximum dredge depth to 0.5 m below the maximum dredge depth;
- For sampling and laboratory quality assurance purposes:
  - Triplicate cores are collected at two sites, with each of the three cores sub-sampled and analysed for all parameters;
  - Two sub-samples are split into three, with each of the three sub-samples analysed for all parameters, and one sample analysed at a second laboratory;
  - A blank sample is collected for quality assurance / quality control (QA/QC);
- All subsamples are analysed for particle size distribution (PSD), carbon, metals, hydrocarbons, organotins, benzene, toluene, ethylbenzene, p-xylene and naphthalene (BTEXN), phenolics, ASS and chromium test;
- Half of all samples collected within the reclamation area are analysed for the 'targeted suite', with the remaining samples sent to the lab and stored appropriately so that they can be used for further analysis if required.

The intent of the NAGD is to assess whether dredged material is suitable for unconfined ocean disposal. As disposal of the material will not be unconfined, but will be confined within a containment bund, the approach taken to sediment sampling and analysis for the Project is considered to be highly conservative. The focus is on identifying contaminants that may become re-suspended in the water column and require management during the construction process.

7.2.1.1 *Sediment Survey Locations and Collection*

Sediment was sampled in the proposed dredge and reclamation areas from 6 - 14 November 2019. Samples were collected from 14 sites in the turning basin, inner channel and outer channel, and from four sites in the reclamation area (Figure 7-1). Cores were sampled as close as practical to locations proposed in the SSAP.

Figure 7-1: Sediment Sampling Locations

Legend

- Toondah Harbour PDA (Project Area)
- Qld DCDB
- Dredge Area
- Reclamation Area

Bore Hole Locations

- Dredge Area Bore Hole
- Reclamation Area Bore Hole

TOONDAH HARBOUR

walker

0 100 200 300 400 m

GDA 1994 MGA zone 56

Scale (A3): 1:9,000

N

DATE: 12/04/2022

Layer Source: © State of Queensland Datasets (Department of Resources 2022), Aerial Imagery (Nearmap.com 2020)

FILE REF. 9858 E Figure 7 1 Sediment Sample Locations B

7.2.1.2 *Sediment Laboratory Analysis*

All samples were analysed by a NATA-accredited laboratory in accordance with the requirements of the NAGD, including quality control procedures and practical quantification limits (PQL). Analytes tested are listed in Table 7-1.

Two different lists of analytes were adopted for the testing of turning basin and channel sediments, comprising 'comprehensive' and 'targeted' lists of analytes. The comprehensive list of analytes is the complete list of parameters from the NAGD, with the exception of dioxins, furans and radionuclides, which are extremely unlikely to be found in any sediments in western Moreton Bay. The targeted list of analytes includes those that have been found by previous sediment analysis at Toondah Harbour as well as those known to be present in western Moreton Bay.

All samples were analysed for PASS using field pH tests and the chromium reducible sulfur (CRS) method as detailed in the National acid sulfate soils identification and laboratory methods manual (Sullivan *et al*. 2018a).

Table 7-1: Sediment Quality Parameters for Analysis and Practical Quantitation Limits (Excluding PASS).

Parameter	Units	PQL (NAGD)	Suite [1]
Particle Size Distribution	%	NS	C, T
Moisture Content	%	0.1	C, T
pH (f) and pH (fox)	pH units	NS	C, T
Chromium Reducible Sulfur (S_{CR})	NS	NS	C, T
Total Carbon	NS	NS	C, T
Total Inorganic Carbon	NS	NS	C, T
Total Organic Carbon	%	0.1	C, T
Total Petroleum Hydrocarbons			
C6-C9 fraction, C10-C14 fraction, C15-C28 fraction, C10-C36 fraction (sum)	mg/kg	100	C, T
Organochlorine Pesticides			
Aldrin, BHC (alpha, beta, delta), chlordane, endrin, dieldrin, DDD, DDE, DDT, oxychlordane, heptachlor, endulsofan, hexachlorobenzene, methoxychlor	µg/kg	1	C
Polychlorinated biphenyl	µg/kg	5	C
Other Organic Compounds			
Phenolics	mg/kg	1	C, T
Polycyclic Aromatic Hydrocarbons	µg/kg	5	C, T

Parameter	Units	PQL (NAGD)	Suite [1]
Sum of PAHs	µg/kg	100	C, T
Chlorobenzenes	mg/kg	0.05	C
BTEXN	µg/kg	200	C, T
Organotin Compounds			
Tributyltin as Sn	µgSn/kg	1	C, T
Organophosphorus Pesticides			
Bromophs-ethyl, carbophenothion, chlorfenvinphos (Z & E), chlorpyrifos, chlorpyrifos-methyl, demeton-s-methyl, diazinon, dichlorvos, dimethoate, ethion, fenamiphos, fenthion, malathion, azinphos methyl, monocrotophos, parathion, parathion-methyl, primphos-ethyl, prothiofos	µg/kg	10-100	C, T
Non-organochlorine Pesticides			
Pyrethroids	mg/kg	0.01-0.1	C
Carbamates	mg/kg	0.01-0.1	C
Phenoxy-acid Herbicides	mg/kg	0.01-0.1	C
Metals and Metalloids			
Copper	mg/kg	1	C, T
Lead	mg/kg	1	C, T
Zinc	mg/kg	1	C, T
Chromium	mg/kg	1	C, T
Nickel	mg/kg	1	C, T
Cadmium	mg/kg	0.1	C, T
Mercury	mg/kg	0.01	C, T
Arsenic	mg/kg	1	C, T
Silver	mg/kg	0.1	C, T
Manganese	mg/kg	10	C, T

Parameter	Units	PQL (NAGD)	Suite [1]
Aluminium	mg/kg	200	C, T
Cobalt	mg/kg	0.5	C, T
Iron	mg/kg	100	C, T
Vanadium	mg/kg	2	C, T
Selenium	mg/kg	0.1	C, T
Antinomy	mg/kg	0.5	C, T
Nutrients			
Total phosphorus	mg/kg	0.1	C
Total nitrogen	mg/kg	0.1	C
Nitrate and nitrite	mg/kg	0.1	C
Total Kjeldahl nitrogen	mg/kg	0.1	C
Other Inorganics			
Cyanide	mg/kg	0.25	C
Ammonia	mg/kg	0.1	C

[1]C = Comprehensive suite; T = Targeted suite

7.2.1.3 *Sediment Data Analysis*

The results of the sediment and soils analysis were compared to a number of guidelines including the NAGD, Australian Water Quality Guidelines, various state and national guidelines for ASS and the NEPM health investigation and screening levels.

The NAGD provides a decision tree approach for the assessment of sediment for disposal at sea. In Phase II of this process, the concentrations of potential contaminants are compared to screening levels. The screening level is the concentration of a substance in the sediment, below which toxic effects on organisms are not expected. The upper 95% confidence limit of the mean (95% UCL) for all results is used to determine compliance with the screening levels.

Where the 95% UCL of all potential contaminants are below the screening levels, it is considered that the material is not contaminated, and is suitable for disposal at sea. Where the 95% UCL are above screening levels, further investigation is required.

The NAGD also provides sediment quality high values (SQG-High values). Where one or more analytes in a given category exceed the SQG-High values, and this is not considered to be due to natural causes, there may be a risk of very significant contamination. Where one or more analytes are between the screening level and the SQG-High values, and this is not considered to be due to natural causes, there may be a risk of significant contamination.

The Australian and New Zealand guidelines for fresh and marine water quality (2018) also provide guidelines for the assessment of sediment toxicity. Where concentrations are below default guideline values (DGV), there is a low risk of unacceptable effects. The upper guideline values (GV-High) provide an indication of concentrations at which there may be toxicity-related adverse effects.

Where parameters exceeded screening values, they were also compared to the SQG-High, GV-High and previous data collected from Toondah Harbour and the Fison Channel.

As dredged material is proposed to be reclaimed for human activity (i.e., urban development), health screening levels (HSL) and health investigation levels (HIL) as outlined in the Guideline on Investigation Levels for Soils and Groundwater (ASC NEPM 2013 Schedule B1) are applicable for assessing human health risk via all relevant pathways of exposure. Specifically, HILs are applicable for assessment from a broad range of metals and organic substances in all soil types, and generally apply to a depth of 3 m. By comparison, HSLs are applicable for assessment of risk from selected petroleum compounds and fractions, and depend on specific soil physicochemical properties, land use scenarios, and the characteristics of building structures. They are applicable to different soil types and depths below surface up to 4 m.

Although the primary concern in most site assessments is protection of human health, the Guideline on Investigation Levels for Soils and Groundwater also outlines how assessments in environmentally sensitive areas should consider ecological risks and protection of groundwater resources that may result from site contamination. Ecological investigation levels (EILs) and Ecological screening levels (ESLs) have been derived for common a range of common contaminants in soil including metals, naphthalene and DDT, petroleum hydrocarbons fractions, BTEX and benzo(a)pyrene.

The results of the sediment analysis have been compared against the various screening and investigation levels outlined in the Guideline on Investigation Levels for Soils and Groundwater to assess risk to human health and the surrounding environment for sediments within the reclamation. Further detail on the assessment against the various health and environmental screening levels can be found in Appendix 2-B.

7.2.1.4 *Potential Acid Sulfate Soils*

Field pH testing is used as an exploratory tool to indicate whether sediment may be PASS. The results of a combination of the following three factors are used to arrive at a "positive field sulphide identification":

- The reaction with hydrogen peroxide, with a stronger reaction indicating PASS are more likely;
- The actual value of pH_{FOX}, if pH_{FOX} is < 3, and there is a strong reaction with hydrogen peroxide, then PASS is likely;
- A much lower pH_{FOX} (peroxide pH test) than the pH_F (field pH).

The actual acidity (TAA), and the existing acidity plus potential acidity for chromium reducible sulfur (CRS) were compared to the action criteria outlined in the State Planning Policy 2/02, and according to the latest ASS Management Guideline (Sullivan *et al*. 2018a).

7.2.2 Terrestrial Contaminated Land

The following scope of work was undertaken as part of the PSI (Appendix 2-C):

- Desktop assessment of the physical and environmental setting of the Project footprint and surrounding area;
- Desktop review of the site history of the Project footprint and surrounds to identify land uses and activities with the potential to result in contamination, including review of available reports and data;
- Site inspection to complement the findings of the desktop assessment and to identify any additional relevant site information;

- Preparation of a report detailing the works undertaken and recommendations for further investigation, management or remediation works (if required) to ensure the development meets relevant.

A conceptual site model (CSM) can be formed by considering the geophysical characteristics at play at the site, the contaminant source, potential receptors and the pathways to the receptors. The CSM, as required by the NEPC (2013), is an iterative process constantly being updated during the investigation process as more information becomes available.

Prior to constructing the exposure component of the CSM, an evaluation of geophysical factors is required. This is achieved as follows:

- Define the known and potential sources of contamination;
- Predict the potentially affected media (e.g., soil, sediment, groundwater and surface water) based on the physical environment;
- Define the receptors that could be exposed on-site and
- Given the outcome of the first three steps, Determine the likelihood of exposure via the identified pathways.

The preliminary source-pathway-receptor (S-P-R) evaluation includes all potential S-P-R linkages, regardless of planned remediation or mitigation strategies. Development of the preliminary CSM allows data gaps to be identified to inform requirement for future investigation works on site. The additional information obtained can then be used to refine the CSM and the exposure pathway analysis.

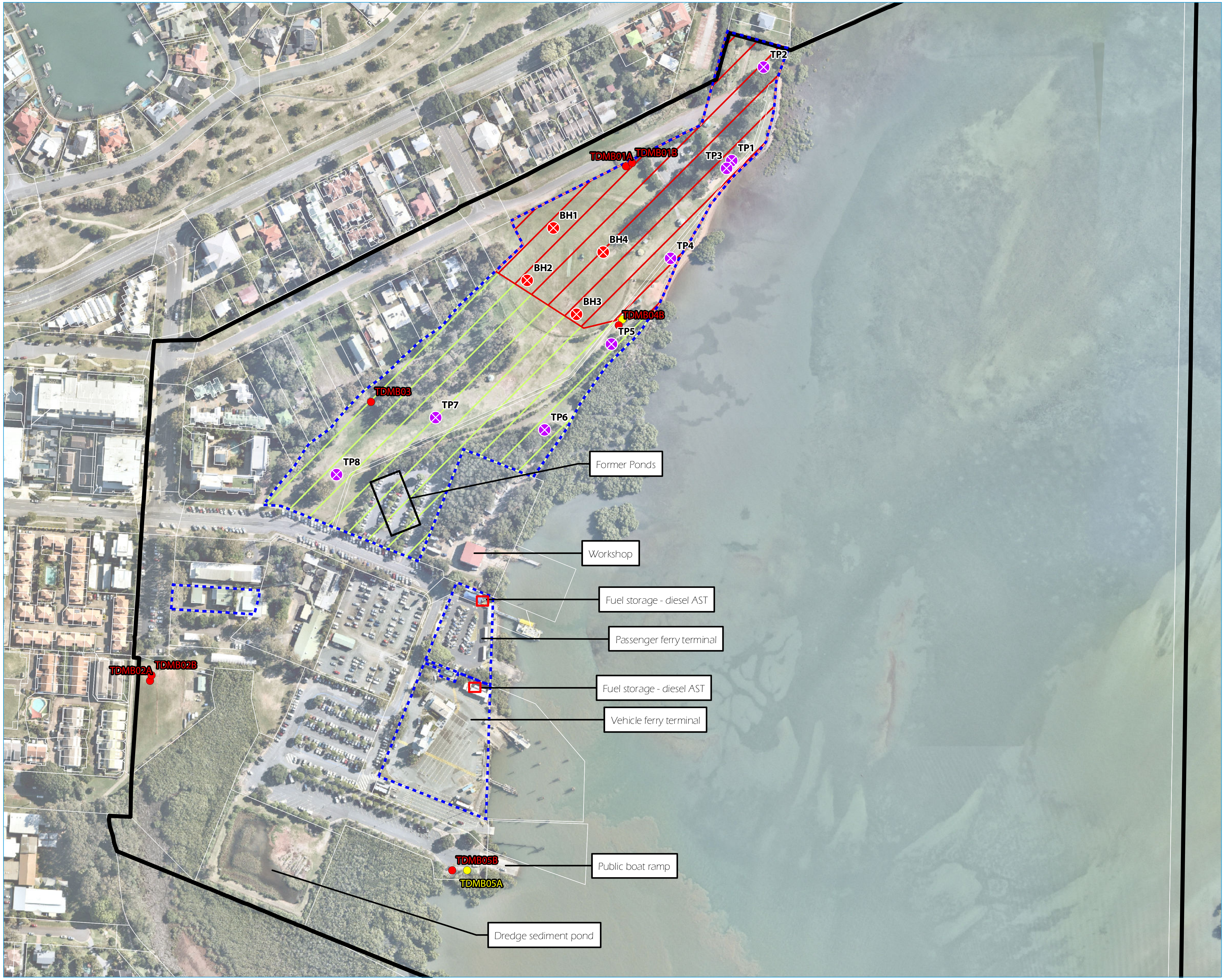
A number of studies have been previously completed at the site by Redland City Council (RCC) and were reviewed as part of the PSI. The only known contaminated land within the Toondah Harbour PDA is a section of GJ Walter Park which was historically used for landfill up until the 1970s. RCC commissioned a preliminary contaminated land assessment in 2013 by Golder Associates as well as a landfill gas risk assessment in 2011 by GHD. The full reports are provided in Appendix 2-D and the outcomes of the studies are summarised in the results section.

The investigation was undertaken in general accordance with and reference to, the following relevant state and federal guidelines:

- Australian and New Zealand Governments (ANZG) (2018) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. National Water Quality Management Strategy;
- Department of Environment and Science (DES) (2018) Queensland auditor handbook for contaminated land. *Module 6: Content requirements for contaminated land investigation documents, certifications and audit reports*. ESR/2018/4224 Version 7 February 2019;
- Heads of the Environmental Protection Authorities (HEPA) (2020) *PFAS National Environmental Management Plan (NEMP) – Version 2.0*. Heads of EPAs Australia and New Zealand, January 2020;
- National Environment Protection Council (NEPC), *National Environment Protection (Assessment of Site Contamination) Measure 1999*, as amended in 2013 (ASC NEPM, 2013);
- National Water Commission (2020) *Minimum Construction Requirements for Water Bores in Australia. 4th Edition;*
- New South Wales Environment Protection Authority (NSW EPA) (2020) *Assessment and management of hazardous ground gases*. December 2019, as amended in May 2020;
- Queensland Government (2010) *Environmental Protection (Water) Policy 2009: Moreton Bay environmental values and water quality objectives. Basin No. 144 (part) and adjacent basins 141, 142, 143, 145 and 146, including Moreton Bay, North Stradbroke, south Stradbroke, Moreton and Moreton Bay Islands*. July 2010;
- Standards Australia (AS4482.1-2005) *Guide to the sampling and investigation of potentially contaminated soil. Part 1: Non-volatile and semi-volatile compounds;*
- Australian Government (2018) *National Acid Sulfate Soils Guidance. National acid sulfate soils sampling and identification methods manual*. June 2018.

The investigation area for the PSI contaminated land assessment, including location of sampling carried out as part of historical investigations, is shown on Figure 7-2.

Figure 7-2: Contaminated Land Assessment Locations



Legend

- Toondah Harbour PDA
- Qld DCDB
- EMR listed lots
- Area where the presence of waste is unlikely
- Possble extension of the landfill
- Borehole Location (Golders 2013)
- Test Pit Location (Golders 2013)

Groundwater Monitoring Locations

- Petrie formation
- Quaternary sediments

0 20 40 60 80 m

GDA 1994 MGA zone 56

Scale (A3): 1:3,000

DATE: 12/04/2022

Layer Source: © State of Queensland Datasets (Department of Resources 2022), Aerial Imagery (Nearmap.com 2020), Golders (2013) Preliminary Environmental Investigation of a closed landfill GJ Walter Park, Cleveland

7.3. Existing Values

7.3.1 Sediment Analysis Results

Laboratory results for the various nutrients and contaminants tested are discussed below. Data summary tables are included in Appendix 2-A as tables 5.4 and 5.5. Results certificates from analysis carried out by the NATA accredited laboratory are also included as Attachment C to Appendix 2-A. Generally, the concentrations of nutrients and contaminants were lower than those previously recorded in sediment sampling programs carried out for maintenance dredging in Toondah Harbour and were well below NAGD screening levels. This is likely due to the nature of capital dredging, which includes the removal of pre-existing natural sediments that are less likely to include contaminants or organic material, compared to the recently deposited material removed through maintenance dredging which is likely to originate from rivers or other external sources.

7.3.1.1 *Particle Size Distribution*

Sediments were generally dominated by silt and clay, with a mean of 80% of fines in all of the samples within the proposed dredge area and 61% of fines in samples within the reclamation area.

Surface sediments in the proposed dredge and reclamation areas were dominated by clay and silt at all sites, except REC3 which was dominated by sand (54%). The highest proportions of gravel were at sites within the inner proposed dredge and reclamation areas, namely REC1 (21%) and CBH3 (18%). Sediment in the middle layers was similarly dominated by fines in the outer section of the proposed dredge area, and at site CBH1 east of the ferry jetty. Sediment was dominated by sand and gravel at sites REC4 (63% sand), CBH2 and CBH3, with the proportion of sand and gravel increasing with depth in the two latter sites. Bottom sediments were dominated by fines at all sites except CBH3, which was dominated by sand (45%) and gravel (41%) with no silt.

7.3.1.2 *Nutrients*

Organic Carbon

There are no NAGD guidelines for the concentration of organic carbon in sediment. In the dredge area, the mean total organic carbon (TOC) concentration was 0.56% and 95% UCL was 0.71%. In the reclamation area, the mean TOC was 0.47% and 95% UCL was 0.64%. These concentrations are lower than those previously recorded at Toondah Harbour.

Nitrogen, Nitrates and Ammonia

There are no NAGD guidelines for the concentration of nitrogen, nitrates and ammonia in sediment. These parameters were only analysed in samples from the dredge area.

The mean concentration of total nitrogen was 875 mg/kg and the 95% UCL was 1332 mg/kg. The highest concentration of total nitrogen was in the middle layer of site CBH1 (2060 mg/kg), which was characterised by silty clay sediments. The mean concentration and 95% UCL of nitrates and nitrites were both below the limit of reporting (LOR) – the minimum concentration of a substance in a sample that can be reliably detected by a laboratory - and hence not of concern.

The mean concentration of ammonia was 12.5 mg/kg and 95% UCL was 128 mg/kg. The highest concentration of ammonia was at site CBH1 with a concentration of 218.3 mg/kg in the middle layer.

In previous assessments of the quality of sediment in Toondah Harbour, there was a concern that the concentration of ammonia in the pore water of the sediment may cause toxicity and make the sediment unsuitable for disposal at Mud Island (WBM 2006). As a result of this concern, there were extensive investigations consistent with the tiered approach in the NAGD. These investigations included:

- Determining the concentration of ammonia in the pore water of the sediments from Toondah Harbour, and Mud Island as a potential placement site;
- Numerical modelling to determine likely impacts to water quality;
- Monitoring the concentration of ammonia in the water column after placement at Mud Island; and
- Measuring the concentration of ammonia in the pore water five days after disposal.

These studies determined that (WBM 2005; 2006; BMT WBM 2013):

- The concentration of ammonia in the water column was close to background within 10 minutes, and at background levels within one hour of placement of the dredged material; and
- Sediment porewater ammonia concentrations at Mud Island were similar to baseline conditions within five days of placement.

The investigations concluded that the risk of porewater contamination from the disturbance of sediment in Toondah Harbour was low. The concentration of nitrogen, nitrates and ammonia identified in the sediment at Toondah Harbour is not considered to be of any environmental concern.

Phosphorus
There are no NAGD guidelines for the concentration of phosphorous in sediment. Mean and 95% UCL of total phosphorus were 394 mg/kg and 455 mg/kg respectively. These concentrations are lower than those previously recorded at Toondah Harbour.

The concentration of phosphorous in the sediment is not considered to be of any environmental concern.

7.3.1.3 *Potential Contaminants*

The mean, 95% UCL and maximum concentration of each parameter complied with the most conservative ASC NEPM HIL and HSL for sites within the dredge and reclamation areas. That is, the concentration of these parameters in the sediments of the dredge and reclamation areas are not of concern for the proposed land uses and will not result in any environmental or human health issues.

Metals & Metalloids
The 95% UCL of all metals and metalloids were below the NAGD screening level at every site in the dredge area. That is, the concentration of metals and metalloids in the sediment in the dredge area is not of concern and unlikely to result in any environmental impacts. In the proposed reclamation area, the 95% UCL for arsenic (27 mg/kg), chromium (119 mg/kg), lead (59 mg/kg), and nickel (43 mg/kg) exceeded the NAGD screening levels. This was primarily due to high concentrations of all these metals in one sample (the upper 0.5 m from site REC4). However, the concentrations of these metals were significantly lower than the SQG-High, GV-High, and similar to or within the range of concentrations in previous surveys of the channel.

The mean concentration of a number of parameters that do not have screening levels or HILs were above the LOR. This included cobalt, iron, manganese, selenium and vanadium in the dredge and reclamation areas, and aluminium in the reclamation area. These parameters were also above the LOR in previous surveys of Toondah Harbour (frc environmental 2018) and are likely to be associated with the local geology. Concentrations above the LOR mean these parameters were detected but does not imply there is any environmental risk.

The red earth soils typical of the surrounding area are noted for the inclusion of ironstone nodules (Bryan 1939, Beckman *et al*. 1987). Many of the rock platforms and hard intertidal and shallow subtidal areas in the Cleveland region are laterite, high in iron and aluminium oxides (Haldar 2013; Cooley 2017). This high concentration of metals in surrounding soils and geological formations is likely to have contributed to a higher-than-average concentration of metals in the sediment. Further, as the concentration of metals is higher in the nodules than in the surrounding sediment matrix, these sediments often have high variability.

The concentration of metals and metalloids in the sediment in the reclamation area are not considered to be of concern, given that all works will be carried out within a bunded area cut off from tidal interaction, therefore minimising potential for the release of contaminants.

Hydrocarbons

The 95% UCL of total petroleum, recoverable hydrocarbons, and total polycyclic aromatic hydrocarbons (PAH) in both the dredge and reclamation areas were below NAGD screening levels. The concentrations of BTEXN were below the LOR in every sample, although the naphthalene LOR for samples within the reclamation area was higher than the HSL. The concentration of naphthalene is unlikely to be of concern as:

- The LOR is only slightly higher than the HSL;
- All naphthalene results were less than LOR; and
- The sediments from the dredge area, where concentrations were below the HSL, is to be beneficially re-used within the reclamation area and therefore of focus for assessment of contamination.

In accordance with the flowchart for Tier 1 human and ecological risk assessment of petroleum hydrocarbon contamination, the concentrations were also compared to the applicable ecological screening level (ESL) and Management Limits (ML), of which each parameter was compliant therefore no further action is required. Concentrations of hydrocarbons are not of any environmental or health concern.

Herbicides and Pesticides

Concentrations of herbicides and pesticides were below the LOR in every sample. That is, the concentrations of herbicides and pesticides were very low, and not of concern.

Organotin

The 95% UCL of tributyltin (TBT) was below the LOR and the screening level and was not of concern.

Polychlorinated Biphenyls

Concentrations for polychlorinated biphenyls were below LOR in every sample, and hence not of concern.

7.3.1.4 *Potential Acid Sulfate Soils*

Field pH

Field pH tests give a preliminary indication of whether there may be PASS. The stronger the reaction with peroxide, the greater the difference between pH_F and pH_{FOX} and a low pH after peroxide oxidation (i.e., PH_{FOX} <3) the more likely the sediment is PASS.

The reaction with hydrogen peroxide in every sample from the dredge and reclamation areas was extreme, except the clay sample at CBH4 which had a strong reaction. pH_{FOX} was less than 3, and there was a large (>4.5) difference in pH at four sites in the dredge area, and one site in the reclamation area. This means sediments are likely to be PASS.

Chromium Tests

Testing for existing acidity was not required as no jarosite was observed in the samples, and the pH of each sample was well above 4.5. TAA of each sub-sample (<2 moles H+/tonne) was low.

Potential sulfidic acidity was high at all sites except REC1. The existing acidity plus potential acidity at this site was below the action criteria, and hence is not considered ASS. However, the remaining sub-samples at all sites have higher potential sulfidic acidity, and the existing acidity plus potential acidity were above action criteria in the Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils in Queensland 1998. Furthermore, net acidity of the samples increased with depth at most sites, with the highest net acidity approximately at or above 2 m depth, after which, net acidity dropped again.

The acid neutralising capacity (ANC) of the sediment ranged from 38 to 7,090 moles H+/t in the proposed dredge area and 121 to 6,480 moles H+/t in the proposed reclamation area, which is considered very high. However, the latest national guidelines (Sullivan *et al*. 2018a) indicate that the acid neutralising capacity should not be considered when assessing management of ASS, as shell particles that contribute to acid neutralising capacity may be ground in the analysis resulting in an over estimation of neutralising capacity. Coatings can form over shell fragments, reducing their neutralising capacity; consequently, acid neutralising capacity can be overestimated.

Liming rates for each borehole, based on no acid neutralising capacity, are included in Appendix 2-A.

7.3.1.5 *Comparison of Dredged Sediment to Terrestrial Health and Environmental Investigation and Screening Limits*

The mean, 95% upper confidence limit (UCL) and maximum of all parameters in the proposed dredge area and reclamation area were below (and complied with) the ASC NEPM 2013 HILs, HSLs, ESLs and Management Limits (MLs) (where available) and in many instances were below the laboratory's detection limits. Of the parameters that do not have an ASC NEPM investigation or screening level, and that were above the LOR (i.e. were detected), the concentration was similar to previously recorded and is unlikely to be of any environmental or health concern. Comparisons of site data to the various screening and investigation levels are included in Appendix 2-B, Tables 4.1 to 4.4.

The soil in the proposed dredge and reclamation areas is not considered to be contaminated and is of low risk to human and ecological health, and therefore is appropriate for use as residential, public and/or commercial land-use, as proposed.

7.3.2 Terrestrial Contaminated Land

7.3.2.1 *Review of Historical Studies*

The following conclusions were drawn from the PSI carried out by Golders (2013):

- Fill was encountered at all sample locations. Fill was generally only soil in the northern half of GJ Walter Park while waste and rubbish material were encountered in the southern half. A capping layer was present across the site which was generally made up of medium to coarse grained material. While the capping layer is present, it would have been applied once landfill uses were halted in the 1970s and therefore does not meet contemporary requirements.
- Fibre cement material containing asbestos was found in the fill at one survey location (TP06). Any areas that may be disturbed will require a detailed site investigation (DSI) to delineate the extent of asbestos and management measures for removal. Areas that are not disturbed could be managed in situ through additional capping (where required) or use of other management measures such as a geo textile barrier.
- TPH was encountered within fill material at one survey location within GJ Walter Park (TP08). The level of contamination was low and not considered to pose a risk to people using the park. Protection measures would be required for any workers carrying out excavations in the area.
- ASS investigations were also carried out in GJ Walter Park and found some acid-generating potential in fill materials and minimal acid generating potential in the natural underlaying soils.

The landfill gas risk assessment carried out by GHD (2011) found that landfill gas was identified during monitoring at concentrations below trigger levels for action set out in various guidelines documents. Given the size and age of the site, landfill gas risks are considered low although cannot be entirely discounted. The report recommends all persons involved in the design, construction or maintenance of site features or facilities should be briefed on the potential presence of landfill gas and all design/construction/maintenance activities should be conducted to manage the risks associated with landfill gas.

7.3.2.2 *Environmental Management and Contaminated Land Register Searches*

A search of the Environmental Management Register (EMR) and Contaminated Land Register (CLR) was conducted as part of the PSI. Listings for lots with EMR listings are summarised in Table 7-2. The EMR/CLR certificates for all lots are presented in Appendix 2-B. No lots are listed on the CLR. None of the lots within the site are managed under a site management plan (SMP).

Table 7-2: EMR / CLR Search Results.

<table>
<tr><th>Lot on Plan</th><th>Site ID</th><th>EMR Result</th><th>CLR Result</th></tr>
<tr><td>66/SP115554</td><td>25281</td><td>LANDFILL - disposing of waste (excluding inert construction and demolition waste).</td><td>Not listed</td></tr>
<tr><td>79/SL7088</td><td>4646</td><td>PETROLEUM OR PETROCHEMICAL INDUSTRIES - including -
(a) operating a petrol depot, terminal or refinery; or
(b) operating a facility for the recovery, reprocessing or recycling of petroleum-based materials</td><td>Not listed</td></tr>
<tr><td>80/SL9713</td><td>4620</td><td rowspan="2">PETROLEUM PRODUCT OR OIL STORAGE - storing petroleum products or oil –
(a) in underground tanks with more than 200L capacity; or
(b) in above ground tanks with -
(i) for petroleum products or oil in class 3 in packaging groups 1 and 2 of the dangerous goods code - more than 2, 500L capacity;
or
(ii) for petroleum products or oil in class 3 in packaging groups 3 of the dangerous goods code - more than 5, 000L capacity; or
(iii) for petroleum products that are combustible liquids in class C1 or C2 in Australian Standard AS1940, 'The storage and handling of flammable and combustible liquids' published by Standards Australia - more than 25, 000L capacity</td><td>Not listed</td></tr>
<tr><td>35/C618</td><td>87806</td><td>Not listed</td></tr>
</table>

7.3.2.3 *Existing Environmentally Relevant Activities*

A review of the Queensland Department of the Environment (DES) Environmental Authority Locations Map (Qld Globe 2022) found two lots in the PDA are managed under Environmental Authority (EA) EPPR00618513. This EA is held by Redland City Council and the EA covers dredging activities for a number of sites along the Redlands coastline.

The lots and environmentally relevant activities (ERAs) relevant to the site are:

- Lot 79 on SL7088:
  - ERA 16 - Extraction and Screening, 1: Dredging, in a year, the following quantity of material, (b) more than 10,000t but not more than 100,000t
  - ERA 16 - Extraction and Screening, 3: Screening, in a year, the following quantity of material, (a) 5,000t to 100,000t
  - Adjacent to Lot: ERA 16 - Extraction and Screening, 1: Dredging, in a year, the following quantity of material, (a) 1000t to 10,000t
  - Adjacent to Lot: ERA 16 - Extraction and Screening, 2: Extracting, other than by dredging, in a year, the following quantity of material, (a) 5,000t to 100,000t
    - Adjacent to Lot: ERA 16 - Extraction and Screening, 1: Dredging, in a year, the following quantity of material, (c) more than 100,000t but not more than 1,000,000t; and

- Lot 20 on SP153278:
  - ERA 16 - Extraction and Screening, 1: Dredging, in a year, the following quantity of material, (b) more than 10,000t but not more than 100,000t
  - ERA 16 - Extraction and Screening, 3: Screening, in a year, the following quantity of material, (a) 5,000t to 100,000t
  - Adjacent to Lot: ERA 16 - Extraction and Screening, 1: Dredging, in a year, the following quantity of material, (a) 1000t to 10,000t
  - Adjacent to Lot: ERA 16 - Extraction and Screening, 2: Extracting, other than by dredging, in a year, the following quantity of material, (a) 5,000t to 100,000t
  - Adjacent to Lot: ERA 16 - Extraction and Screening, 1: Dredging, in a year, the following quantity of material, (c) more than 100,000t but not more than 1,000,000t.

7.3.2.4 *Summary of Site Conditions*

Utility infrastructure

Preferential contamination pathways can be created via utility trenches. A review of utility plans provided via a Dial Before You Dig (DBYD) search and RCC emapping was undertaken and the following was noted:

- Stormwater drainage runs along Shore Street East, Middle Street and Wharf Street. Discharge points to Moreton Bay are located at the north end of GJ Walter Park, adjacent to the passenger ferry terminal (Middle Street), adjacent to the public boat ramp (Emmett Drive) and into the mangroves south of trade college (Wharf Street).
- Sewers run along Shore Street East, Middle Street and Wharf Street, with a discharge point (overflow) at the north end of GJ Walter Park.
- Water mains run along Shore Street East, Middle Street and Wharf Street.
- Underground power lines run along Wharf Street, Middle Street, Emmett Drive and from Emmett Drive to the ferry terminals and car parks. The trade college is supplied via Wharf Street.
- Communications (Telstra, Optus, NBN, Uecomm), run along Shore Street East, Wharf Street, and Middle Street to supply the ferry terminal, trade college and residential areas.
- A high-pressure gas pipeline (APA Group) runs along Shore Street East, Wharf Street and Middle Street. The ferry terminals are not supplied with gas.

Chemical storage and transfer areas

Diesel above-ground storage tanks (ASTs) are located at the passenger and vehicle ferry terminals, as fuel supply for ferries. Location of fuel storage is shown on Figure 7-2. One lot within the trade college is also listed on the EMR for fuel storage. Both ferry terminals also have waste oil ASTs, which are located adjacent to the diesel ASTs.

The contaminated land assessment (EMR 2014) reported storage of minor quantities of paint and solvents at the passenger ferry terminal.

Product spills, losses, incidents, accidents, fires
No information has been provided regarding spills, losses, incidents, accidents or fires. The contaminated land assessment completed by EMR (2014) reported no fuel spills or leaks had occurred at the ferry terminals.

Discharges to land and water
Stormwater from the site and surrounding urban area discharges to Moreton Bay at four locations at the site. A sewer discharge point is located at the north end of GJ Walter Park.

Dredge material containing contaminants at levels higher than the NADG screening levels was previously placed at the maintenance dredge material disposal pond located south of the ferry terminals. It is noted that materials considered contaminated for placement in the marine environment are often still at levels on order of magnitude below contaminants that may impact on human health or terrestrial environments.

Two ponds were previously located in the car park area at the southern end of GJ Walter Park. It is not known what these ponds were used for.

Waste produced and waste storage areas, management practices and disposal areas
Intrusive investigations indicate that GJ Walter Park was historically used for waste disposal during the 1970s. It is not known whether the site operated as an official landfill, or whether waste was directed there as a means of filling the site.

The use of the ponds within the GJ Walter Park area is not known, however potential uses include liquid waste, nightsoil or dredge sediment disposal.

Dredge spoil was previously placed in the pond south of the ferry terminal from the late 1990s, for small amounts of material that contained contaminants above the NAGD screening levels. The majority of dredge spoil has historically been used for land reclamation along the adjacent foreshore, or ocean disposal (at Mud Island).

Details regarding current waste management practices at the existing ferry terminals or trade college are not known.

Historical earthworks and fill areas
The majority of the Toondah Harbour PDA has been subject to filling to raise the ground level from the historical intertidal zone. Specific sources of fill are not known, except that waste material is present within the GJ Walter Park area.

It is not known whether dredge spoil from the excavation of the Fison Channel and turning basin was used in filling the site.

Existing monitoring
A network of groundwater monitoring bores was installed at the site in early 2020 by AGE as part of the Toondah Harbour Project EIS investigations. These bores have been sampled as part of baseline assessment for the Project. No landfill gas bores are known to be present at the site.

7.3.2.5 *Conceptual Model*

Potential sources of contamination identified within the site area include:

- Potential for soil contamination:
  - Waste buried within the GJ Walter Park landfill area;

  - Contents of the two ponds in the south of the landfill area;
  - Diesel and waste oil ASTs within the ferry terminals (located adjacent to each other);
  - Fuel storage within the trade college;
  - Chemical storage within the ferry terminals, workshop area and trade college;
  - Uncontrolled fill used at the ferry terminals;
  - Historical dredge sediment in the old sediment pond;
  - ASS.
- Potential for groundwater contamination:
  - Leachate from waste within GJ Walter Park;
  - Leaking fuel storage and fuel lines within the ferry terminals and trade college;
  - Chemical storage within the ferry terminals, workshop area and trade college;
  - Uncontrolled fill used at the ferry terminals;
  - Oxidised ASS.
- Potential for marine environment contamination:
  - Mobilisation of contaminated sediment during dredging and reclamation activities;
  - Mobilisation of ASS-containing sediment during dredging and reclamation activities.
- Potential for hazardous building materials:
  - Asbestos in site buildings.

The potential pathways between the sources and human receptors have been identified as:

- Dermal/ inhalation/ ingestion exposure to contaminated soil materials when breaking ground during potential future works (includes below the concrete slab/ bitumen and unsealed portions of the site);
- Dermal/ inhalation/ ingestion exposure to contaminated soil materials for future residents, workers and visitors to the site;
- Dermal / ingestion exposure to contaminated sediment or marine water during primary or secondary recreation activities;
- Consumption of marine organisms impacted by contaminated sediment or water.

The potential pathways between the sources and environmental receptors have been identified as:

- Direct contact / contaminant uptake by flora or terrestrial fauna;
- Overland flow resulting in runoff to local soil and marine environment;
- Impacted groundwater discharging into the adjacent coastal environment;
- Direct contact / ingestion of contaminated sediment by marine organisms.

The nearest onsite and offsite human receptors of any potential land contamination are identified as:

- Residents of the site and surrounding areas;
- Current site workers and visitors;
- Future site workers involved with demolition and construction works;
- Future site residents, workers and visitors.

The closest environmental receptors are identified as:

- The terrestrial environments of the PDA;
- The marine environment of Moreton Bay within the PDA and the wider marine environment beyond the PDA;

Chemicals of potential concern (CoPC) associated with the identified sources include:

- Petroleum hydrocarbons (TRH) – with fuel and oil storage;
- BTEXN – fuel storage;
- Polycyclic aromatic hydrocarbons (PAH) – various oil products;
- Per- and polyfluoroalkyl substances (PFAS) – fire suppression and waste materials;
- Pesticides – pest control;
- Heavy metals – waste materials, workshops, batteries, antifouling, and degraded site infrastructure;
- Acids, alkalis, bleaches etc – disinfectants and cleaning agents;
- Volatile and semi-volatile organic compounds (VOCs/ SVOCs) – solvents, paints and other chemicals used in workshops and other site activities, liquid waste disposal;
- Asbestos in building materials and buried waste;
- Nutrients and leachate indicators – landfilling;
- ASS.

The PSI conceptual model identified the following data gaps:

- Extent of landfilling activities within GJ Walter Park, particularly in the southern part of the park;
- Types of waste disposed to GJ Walter Park, particularly in the southern part of the park;
- Use of the ponds in the landfill area within the current location of the southern car park;
- Contamination status of groundwater down gradient from landfilling areas and former ponds;
- Contamination status of soil or groundwater in vicinity of fuel storage and supply infrastructure;
- Contamination status of fill materials used in raising the level of the Toondah Harbour area;
- Contamination status of dredge material within the dredge sediment pond;
- Status of fuel storage (and other potentially contaminating activities) within the trade college lot;
- Extent, and neutralising capacity, of ASS materials beneath the site (covered natural material), within fill materials and in dredge spoil.

The assessment found that there are a range of high and moderate risk areas within the Project footprint, however at this stage the classification of risk and priority is focused on managing uncertainty regarding the status of potential contamination sources identified during this PSI, rather than any identified risk to human health or the surrounding environment. This means that a range of additional investigations are required prior to carrying out earthworks to allow risk to be better defined and management measures put in place to mitigate any risk.

Importantly, investigation completed within this PSI has not identified any risk to human health or the environment that could not be managed on site within the development process.

Locations within the Project footprint identified as having a high risk / priority, include GJ Walter Park, the workshop area, the existing passenger ferry terminal (fuel storage and delivery infrastructure), vehicle ferry terminal (fuel storage and delivery infrastructure), disused dredge sediment pond, the trade college (petroleum storage), and soils from the EMR-listed lots.

Locations within the Project footprint identified as having a moderate risk / priority are those where historical fill sources are unknown (existing passenger ferry terminal, vehicle ferry terminal, vehicle ferry ramp, car park, and public boat ramp and car park), and chemical storage activities at the workshop area, vehicle ferry terminal, and the trade college. Other sites identified as moderate risk include materials in site buildings at the trade college, dredged marine sediment, EMR-listed lots, and ASS materials requiring excavation.

7.4. Potential Impacts

7.4.1 Contaminants in Marine Sediments

During construction the key potential Project activities that may result in environmental impacts from marine sediments are:

- Excavation of mud, sheet piling and placement of rock to construct the bund walls mobilising contaminated sediments which may then impact on water quality and surrounding habitats;
- Dredging of the Fison Channel and turning basin causing an increase in suspended sediment and potential release of contaminants;
- Placement of material in the reclamation which may result in contaminants separating from the sediment and being released into the marine environment through tailwater release.

Potential for environmental impacts from these activities are considered minor for the Project as:

- Sediment analysis did not find any contaminants above NAGD screening levels within the dredge area. Some material in the reclamation area contained elevated concentrations of metals primarily due to high concentrations in one sample. The metals identified in higher concentrations (arsenic, chromium, lead, and nickel) are known to occur naturally in Moreton Bay. In addition, all works within the reclamation area will be separated from Moreton Bay by a sheet pile bund minimising the potential for any impacts outside of this area.
- Tailwater created through the process of treating sediments to remove moisture will be collected within the bunded area and re-used on site for dust suppression. The reclamation area will have sufficient bund capacity to provide long enough resident times for suspended sediments to settle out of the water column before re-use. Water quality monitoring of collected tailwater will also be carried out regularly to ensure no contaminants are present. If any contaminants are identified, water would be treated prior to re-use or transported offsite for disposal.

During operations, similar activities have the potential to impact on the surrounding environment, being the release of contaminants from sediment during maintenance dredging events and the release of tailwater from the on-land disposal facility for the material sourced from maintenance dredging of the marina coves and internal waterways. Maintenance dredging is expected to be carried out approximately every four to five years and would require approvals from the Queensland Government prior to commencing. As part of the approval process, sediment sampling and analysis would be conducted prior to any dredging event to test for contaminants. If contaminants were identified, management and monitoring measures would be required to address potential impacts.

In addition, improved environmental management proposed by the Project, such as incorporation of a stormwater treatment train and use of spill management kits on site, will reduce the risk of contaminants accumulating in the sediment for future maintenance dredging events.

Potential impacts to water quality as a result of turbidity plumes generated by dredging activities are addressed in Chapter 9. Potential impacts to marine flora and fauna as a result of dredging and reclamation activities are addressed in Chapter 16.

7.4.2 Acid Sulfate Soils

ASS can present a significant risk to coastal habitats if not properly managed. When exposed to air, the iron pyrite contained within the sediment oxidises to produce sulfuric acid. In the absence of neutralising agents, the oxidisation process would lower the in-situ pH and that of any groundwater and runoff. Potential impacts resulting from the oxidation of ASS include:

- Reduced water quality;

- Reduced productivity and health of aquatic life; and
- Impacts to surrounding flora and fauna.

Activities that may disturb PASS include removal of soft material for the reclamation area when creating the external bunds, scraping of material to create internal bunds and access roads, dewatering of soft sediment within the reclamation area and dredging and placement of PASS material into the reclamation area. Onshore works also have some potential to disturb PASS, although preliminary surveys showed acid-generating potential in these areas was low.

Dredge material will be treated with agents such as agricultural lime either within the barge or immediately after it is removed from barge minimising the risk of any PASS oxidising. An ASS monitoring and validation program will be implemented throughout the construction process to minimise potential for impacts. This program would include field oxidised pH and chromium testing and measures such as visual inspections of the reclamation and areas immediately surrounding it for evidence of acid leaching. Monitoring will also be carried out during civil works both in the reclamation area and in existing terrestrial areas.

Sediment testing for ASS would be progressively undertaken during the reclamation and dredging processes and lime will be applied using relevant guideline rates as required.

7.4.3 Contaminated Land

Potential impacts from existing contaminated areas are related to any excavation in areas identified as high risk by the PSI including GJ Walter Park, the workshop area, the existing passenger ferry terminal (fuel storage and delivery infrastructure), vehicle ferry terminal (fuel storage and delivery infrastructure), disused dredge sediment pond, the trade college (petroleum storage), and soils from the EMR-listed lots. Any potential impacts to the surrounding environment will be managed on site through more detailed assessment and identification of site and use-specific management and remediation requirements.

Site-specific contaminated land assessment and management plans will be developed for these areas prior to construction to minimise and address risk.

Potential impacts to water quality within and surrounding potentially contaminated land through changes in the groundwater regime are addressed in Chapter 10.

7.4.4 Fuel and Chemical Spills

A number of construction activities have the potential to impact on the land within the Project footprint and adjacent coastal waters. These include:

- Spills of fuels/oil and other contaminants to ground from machinery;
- Spills of fuels/oil and other contaminants to water from machinery and marine vessels;
- Leaks or spills of hazardous materials and/or dangerous goods;
- Imported contamination in soil and/or fill material.

Due to the necessity of using plant and equipment for construction of the Project, incidents involving fuels/oil spills and other contaminants may cause soil contamination or enter the marine waters. Appropriate siting of storage and handling areas and management of equipment and plant during construction will ensure that such risks are reduced. The ferry terminal and marina operators will need to obtain the relevant Environmental Authorities from the Department of Environment and Science in order to store and use fuel and chemicals on site. Any ongoing management requirements from the construction phase will be passed on to operators through contractual documentation provided in the handover process (refer to Section 28.2.5 of the Draft EIS).

7.5. Adaptive Management and Monitoring Measures

Where an activity is anticipated to have an impact on environmental values, mitigation measures are proposed in Table 7-3. Management measures will be reviewed at least annually to ensure they are achieving the best environmental outcomes. Where trigger criteria are exceeded or management outcomes are not achieved, management measures will be reviewed more frequently.

Table 7-3: Sediment and Contaminated Land Management Measures.

Potential impacts	Management and monitoring measures	Desired outcomes and effectiveness
Dredging resulting in the suspension of contaminated sediments into the water column	▪ Implement a water quality monitoring program to monitor dredge plumes and sensitive receptors. Additional management measure will be initiated in response to exceedances of impact criteria (refer to Chapter 9 for more detail on the proposed water quality monitoring program).	▪ Dredging will be managed so that there are no long-term impacts to habitats or fauna outside of the dredge area. ▪ Adaptive water quality monitoring programs have been implemented successfully for dredging operations at ports and harbour along the east coast (refer to DTMR Annual Maintenance Dredging Reviews 2019 and 2010), including previous maintenance dredging operations at Toondah Harbour. A site-specific monitoring program will be developed in accordance with relevant guidelines such as the NAGD. Effectiveness is therefore considered high.
Release of contaminants from dredge material and soft upper sediments within the reclamation area into tailwater	▪ Carry out water quality testing of tailwater regularly to ensure no contaminants are present prior to re-use on site. ▪ If contaminants are present above human health trigger levels use appropriate treatments to remove from the water prior to re-use or transport water from site for disposal in an appropriate facility.	▪ Tailwater will be managed within the bunded reclamation area with minimal releases so that there are no long-term impacts to habitats or fauna outside of the Project footprint. ▪ Low levels of contaminants in the sediments and adaptive water quality monitoring will result in high management effectiveness.
Oxidation of PASS in reclamation and other parts of the Project footprint where excavations occur	▪ Implement an ASS management plan in accordance with relevant State and Federal guidelines including a monitoring program for the dredging and reclamation processes. ▪ Keep sediments saturated during the dredging process until they have been treated for potential acidity and placed within the reclamation area.	▪ ASS will be monitored and managed in accordance with industry guidelines such as the Queensland ASS Technical Manual Soils Management Guidelines and National ASS Guidelines for the dredging of ASS sediments and associated dredge spoil management so that there are no

Potential impacts	Management and monitoring measures	Desired outcomes and effectiveness
	▪ Apply additional treatment as required to dredge material and soft upper sediments within the reclamation area. ▪ Carry out daily inspections of the reclamation area to check for visual signs of oxidation. ▪ Carry out ASS and PASS sampling and analysis in accordance with relevant State and Federal guidelines prior to carrying out any on land works. Apply treatment as required to neutralise acid generating potential. ▪ Conduct an ASS weathering trial to determine rates of reaction and liming requirements for ASS containing sediment.	short or long-term impacts to habitats or fauna. ▪ Development of management and monitoring plans in accordance with industry standard guidelines will result in high management effectiveness.
Disturbance of existing contaminated land through construction activities adjacent to GJ Walter Park, existing ferry terminals, trade college and dredge sediment pond	▪ Carry out a DSI in accordance with relevant State and Federal guidelines prior to commencing works in areas identified as high or moderate risk by the PSI. ▪ As part of the DSI process develop a soil and groundwater investigation plan in consultation with relevant experts and regulatory authorities. ▪ Carry out groundwater monitoring during and post construction to check for changes in water chemistry (refer to Chapter 10 for more detail on the proposed groundwater monitoring program). ▪ Soil investigation to assess fill materials and underlying natural soil within GJ Walter Park, the ferry terminals and dredge sediment pond. Geotechnical assessment of soil in these areas to determine suitability of material to retain on site as part of site development. ▪ Carry out monitoring to assess the extent of asbestos present within the landfill site. ▪ Carry out a landfill gas assessment which may include installation of monitoring bores. The outcomes of the assessment are to be incorporated into the DSI including any required ongoing management.	▪ Contaminated land will be managed in accordance with relevant guidelines such as the National Environment Protection (Assessment of Site Contamination) Measure 1999 and Queensland Auditor Handbook for Contaminated Land so as to not impact on any sensitive environmental receptors, including Moreton Bay. ▪ Development of management and monitoring plans in accordance with industry standard guidelines will result in high management effectiveness.
Fuel or other chemicals spills to ground or water during the construction process and ongoing uses	▪ Store fuels and chemicals in appropriate areas away from sensitive receptors on site in accordance with relevant standards and guidelines. ▪ Retain appropriate spill response materials on site including booms and absorbent materials. Spill kits are to be kept nearby to any fuel or chemical storage area.	▪ Chemicals and fuels will be stored in accordance with relevant safety data sheets and Workplace Health and Safety Queensland's Managing risks of hazardous chemicals in the workplace. Storage and use will be carried out in accordance with site-specific environmental authorities.

Potential impacts	Management and monitoring measures	Desired outcomes and effectiveness
	▪ Installation and sampling of additional groundwater bores targeting the southern landfill area and fuel storages.	▪ Development of management and monitoring plans in accordance with industry standard guidelines will result in high management effectiveness.
Disturbance of EMR-listed lots	▪ Conduct a feasibility or cost/benefit analysis of EMR removal for each of the listed lots, with consideration of ongoing notifiable activities and intended future land use. ▪ Ensure all soil to be removed from EMR-listed lots is adequately assessed and removed under either a disposal permit or clean earth exemption.	▪ Contaminated land will be managed in accordance with relevant guidelines such as the NEPM Assessment of Site Contamination Measure 1999 and Queensland Auditor Handbook for contaminated land so as to not impact on any sensitive environmental receptors including Moreton Bay. ▪ Development of management and monitoring plans in accordance with industry standard guidelines will result in high management effectiveness.

7.5.1 Detailed Site Investigations

As identified in Table 7-3, Detailed Site Investigations (DSIs) will be carried out in all locations identified as having a high or moderate risk by the PSI. These locations are shown on Figure 7-2 and include:

- The southern end of GJ Walter Park;
- Chemical storage areas and historical landfill at the workshop area adjacent to the ferry terminal;
- Fuel and chemical storage and fill areas at the vehicle and passenger ferry terminals;
- Fill areas associated with the car park and public boat ramp;
- The disused dredge sediment pond; and
- Chemical and fuel storage areas within the trade college grounds.

A key area for future investigations will be the historical landfill area in the south of GJ Walter Park. Future investigations in this area will include, but not be limited to:

- Intrusive soil investigation to assess fill materials and underlying natural soil within GJ Walter Park. Soil sampling will also be carried out at locations in and around the ferry terminals and dredge sediment pond. This may include sampling in nearshore sediments.
- Installation and sampling of additional groundwater bores in areas downgradient of the historical landfill and fuel storages.
- Based on the outcomes of the assessment conduct a feasibility analysis of treatment options including removal of contaminated materials.

As part of the DSI process a soil and groundwater investigation plan will be developed in consultation with relevant experts and government authorities, including DES and DCCEEW. The plan will be implemented prior to commencing works in areas identified as high or moderate risk by the PSI and include a broad suite of analytes to ensure any potential contamination issues are identified.

Soil sampling locations will include areas in and adjacent to the potentially contaminated sites identified by the PSI. Groundwater bores will be installed downgradient of the investigation areas to identify whether contaminants are currently leaching into groundwater reserves and ultimately into Moreton Bay. The location of the monitoring bores will be included in the investigation plan and be selected in consultation with Project engineers to ensure they can be utilised before, during and after construction. This monitoring will be in addition to the broader groundwater monitoring program outlined in section 10.5.

Where required, management and remediation actions will be developed and implemented in response to the outcomes of the investigations.

Assessment will include a broad suite of analytes for both the soils and groundwater analysis. A preliminary set of analytes has been included in Table 7-4. Additional analytes may be added after consultation with relevant authorities.

Table 7-4: Preliminary Soil and Groundwater Investigation Sampling Analytes.

Analysis	**Description**
Soils/Sediment	
Heavy metals	May include - Arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, zinc, aluminium, antimony, barium, beryllium, boron, cobalt, iron, molybdenum, selenium, silver, strontium, thallium, tin, vanadium.
Organic and volatile compounds	Total recoverable hydrocarbons (TRH), Benzene, Toluene, Ethylbenzene, Xylenes and Naphthalene (BTEXN), Polycyclic aromatic hydrocarbons (PAH), phenolic compounds, volatile and semi-volatile scans (VOC/SVOC)
Organochlorine Pesticides (OCP)	Targeted suite based on historical site information
PFAS	Per and poly fluorinated Alkyl Substances
Asbestos	Friable asbestos and asbestos containing materials
Groundwater	
GP (General parameters)	pH, DO, Temp, EC, TDS, major cations, and anions (Na^+, Ca^{2+}, K^+, Mg^{2+}, Cl^-, SO_4^{2-}, HCO_3^-, CO_3^{2-}) Alkalinity.
Br	Bromide (using HPLC method).
Per and poly fluorinated Alkyl Substances (PFAS)	Per and poly fluorinated Alkyl Substances
Organochlorine Pesticides (OCP)	Targeted suite based on historical site information
Organic and volatile compounds	BTEX, phenolic compounds, polynuclear aromatic hydrocarbons (PAH), total petroleum hydrocarbons (TPH) and total recoverable hydrocarbons (TRH).
Metals	Arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, zinc, aluminium, antimony, barium, beryllium, boron, calcium, cobalt, iron, magnesium, molybdenum, potassium, selenium, silver, strontium, thallium, tin, vanadium.

Analysis	Description
Nutrients	Ammonia, nitrite, nitrate, total kjeldahl nitrogen, total phosphorus
Other parameters	Fluoride
SWLS	Standing water level data: Time-series groundwater levels. Corrected for barometric pressure effects.

7.6. Residual Risk of Impact

The risk of significant impacts to environmental values from sediment and contaminated land have been assessed following the methodology outlined in Section 6.1 of the EIS and are presented in Table 7-5.

Table 7-5: Sediment, ASS and Contaminated Land Risk Assessment of Key Activities.

Activity	Initial risk assessment					Mitigated risk assessment				
	Scale	**Duration**	**Impact**	**Likelihood**	**Risk**	**Scale**	**Duration**	**Impact**	**Likelihood**	**Residual risk**
Dredging resulting in the suspension of contaminated sediments into the water column	Local	Short	Low	Possible	**Low**	Local	Short	Low	Not likely	**Very Low**
Release of contaminants from dredge material and soft upper sediments within the reclamation area into tailwater	Local	Short	Low	Possible	**Low**	Local	Short	Low	Not likely	**Very Low**
Oxidation of PASS in reclamation and other parts of the Project footprint where excavations occur	Local	Medium	Medium	Likely	**High**	Local	Short	Low	Not likely	**Very Low**
Disturbance of existing contaminated land through construction activities adjacent to GJ Walter Park, ferry terminals, trade college and dredge sediment pond	Local	Medium	Medium	Possible	**Medium**	Local	Short	Low	Not likely	**Very Low**
Fuel or other chemicals spills to ground or water during the construction process	Local	Medium	Medium	Likely	**High**	Local	Medium	Medium	Not likely	**Low**
Disturbance of EMR-listed lots	Local	Medium	Medium	Possible	**Medium**	Local	Short	Medium	Not Likely	**Low**