walker

TOONDAH HARBOUR

APPENDIX 2 - B

SEDIMENT SAMPLING
AND ANALYSIS REPORT
- CONTAMINATED LAND
COMPARISON

saunders havill group

Toondah Harbour

Contaminated Land Sampling and Analysis 2019

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freshwater estuarine marine

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Summary

Toondah Harbour is an existing marine facility in the suburb of Cleveland in Redland City, approximately 30 kilometres south of Brisbane. Maintenance and capital dredging of approximately 500,000 m^3 of marine sediment to widen and lengthen Fison Channel to meet the minimum requirements for safe navigation set out in the PIANC (2014) Harbour Approach Channels Design Guidelines and Australian Standard 3962 – 2001 Guidelines for the Design of Marinas is proposed. It is proposed that all the dredge material will be beneficially reused to reclaim land for development such as high-rise residential buildings, public open space and commercial premises.

As excavated dredge spoil is proposed to be used for land reclamation purposes, dredged material was assessed for contamination in accordance with the National Environment Protection (Assessment of Site Contamination) Measure 1999 (ASC NEPM; Australian Government 2013) soil guidelines. Where excavated and unexcavated sediment exceeds the ASC NEPM's soil guideline values and is considered contaminated, dredge spoil should not be used for land reclamation without appropriate management, which may include treatment. The results of the analysis of potential contaminants in accordance with the ASC NEPM soil guidelines are summarised here. Assessment of sediment according to the National Assessment Guidelines for Dredging (NADG) is presented in a separate section of the EIS.

Cores were collected with a vibracore to a depth of 0.5 m below the maximum dredge depth, with the exception of cores at sites CBH1, CBH2, CBH3, CBH4 and REC1–3 which were collected to refusal. Each core was subsampled with depth, with all subsamples analysed for a targeted suite of parameters, and some subsamples analysed for an additional suite of parameters (the comprehensive suite).

Clay and silt dominated the sediments in the proposed dredge area, with varying amounts of sand and gravel. In the reclamation area, particle size distribution was more varied in surface and middle subsamples at sites furthest from the shoreline, with clay dominating the bottom layers.

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 Health Investigation Level (HIL), Health Screening Level (HSL), Ecological Investigation Level (ESL) and Management Limits (ML) (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

concern. In accordance with the flowchart for the assessment of site contamination, no further action is required.

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.

1 Introduction

Toondah Harbour is an existing marine facility located in the suburb of Cleveland in Redland City, approximately 30 kilometres south of Brisbane. Maintenance and capital dredging of approximately 500,000 m^3 of marine sediment to widen and lengthen Fison Channel to meet the minimum requirements for safe navigation set out in the PIANC (2014) Harbour Approach Channels Design Guidelines and Australian Standard 3962 – 2001 Guidelines for the Design of Marinas is proposed.

A barge mounted backhoe dredge or similar will be used to dredge the material and the material will be transported to the reclamation areas via hopper or flat top barges and unloaded at a temporary dock constructed specifically to unload dredged material. Dredged material would be disposed of within two bunded reclamation areas: the northern and southern reclamation areas. It is proposed that all the dredge material will be beneficially reused to reclaim land for development such as high-rise residential buildings, public open space and commercial premises.

Perimeter bunds will be established around the reclamation areas to contain the dredged material and limit indirect impacts outside of the development footprint. The bunds will comprise an inter-locking sheet piling cut-off wall, vibrated into place, within a rock revetment bund capped by a trafficable gravel vehicle and machinery access at a level above HAT. The depth of excavation in the bunded area will extend to approximately -3.5 m LAT in areas that will ultimately become channels and berths for recreational boats. No material will be removed from the bunded area.

As excavated dredge spoil is proposed to be used for land reclamation purposes, dredged material was assessed for contamination in accordance with the National Environment Protection (Assessment of Site Contamination) Measure 1999 (ASC NEPM; Australian Government 2013) soil guidelines. Sediment in the reclamation area was also assessed. Where sediment exceeds the ASC NEPM's soil guideline values and is considered contaminated, dredge spoil should not be used for land reclamation without appropriate management, which may include treatment.

The results of the analysis of potential contaminants in accordance with the ASC NEPM soil guidelines are summarised here. Assessment of sediment according to the National Assessment Guidelines for Dredging (NADG), including the SSAP, core logs and laboratory results, is presented in a separate section of the EIS.

2 Methods

Sediment samples were collected according to the Sediment Sampling and Analysis Plan for Toondah Harbour (the SSAP) that was prepared in accordance with the National Assessment Guidelines for Dredging (the NADG). This sampling strategy also complies with the sampling requirements of the ASC NEPM.

2.1 Timing

Sediment was sampled in the proposed dredging and reclamation areas from 6 – 14 November 2019.

2.2 Sites Surveyed

Cores were sampled as close as practical to the locations proposed in the Sediment Sampling and Analysis Program (SSAP) (Table 2.1, Map 1). Field triplicate cores for QAQC were collected from sites CBH 1 and CBH 10, and the split subsamples from sites CBH 6 and CBH 13 (Figure 2.2).

Table 2.1 Sediment sampling sites

Site	Easting (GDA)	Northing (GDA)
CBH 1	528193	6954988
CBH 2	528116	6954837
CBH 3	528231	6954670
CBH 4	528366	6954553
CBH 5	528858	6954434
CBH 6	529051	6954401
CBH 7	529066	6954263
CBH 8	529247	6954190
CBH 9	529186	6954092
CBH 10	529408	6953964
CBH 11	529444	6953809
CBH 12	529613	6953827
CBH 13	529727	6953716
CBH 14	530086	6953611
REC 1	528376	6955544
REC 2	528605	6955343
REC 3	528451	6955185
REC 4	528552	6954836

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Toondah Harbour: Contaminated Land Sampling and Analysis 2019

Map 1: Sediment sampling sites.

SOURCES

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LEGEND

Sample Sites
- Capital
- Reclamation

Proposed navigation channel
Reclamation Area
Existing navigation channel
Watercourse

Road Network
- Main Road
- Local Road
- Track

N

SCALE

0 50 100 200 300 400 500
Meters

Scale: 1:10,000 @ A3

PROJECTION
Coordinate System: GCS GDA 1994
Datum: GDA 1994
Units: Degree

DATE
2022-02-09

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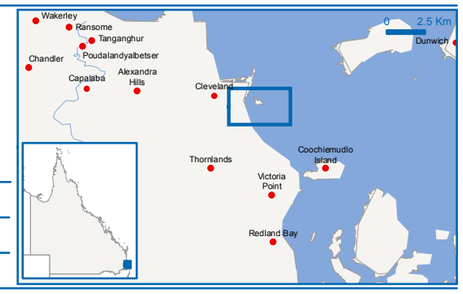

2.3 Sample Collection

Sediment was sampled by frc environmental under Moreton Bay Marine Park permit QS2018/CVL125 in accordance with the:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018)
- National Assessment Guidelines for Dredging 2009 (the NADG, DEWHA 2009)
- National Environment Protection (Assessment of Site Contamination) Measure 1999 (ASC NEPM; Australian Government 2013)
- National acid sulfate soils sampling and identification methods manual (Sullivan et al. 2018b)
- National acid sulfate soils identification and laboratory methods manual (Sullivan et al. 2018a)
- Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils (ASS) in Queensland (Ahern et al. 1998)
- Queensland Acid Sulfate Soil Technical Manual Soil Management Guidelines v. 4.0 (Dear et al. 2014)
- State Planning Policy 2/02 – Guideline: Acid Sulfate soil (DNRM 2002), and the
- Sediment Sampling and Analysis Plan for Toondah Harbour (the SSAP).

Each sediment core was divided into the following sections:

- 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
- the bottom 0.5 m of the core (subsample C), extending from the maximum dredge depth to 0.5 m below maximum dredge depth.

No distinct strata over 50 cm was observed in any of the cores, and hence separate sub-sampling of distinct strata was not required.

Cores were collected to a depth of 0.5 m below the maximum dredge depth, except for cores at sites CBH1, CBH2, CBH3, CBH4 and REC1–3 which were collected to refusal, which ranged from -1.25 m to -2 m depth (LAT) (Figure 2.1 and Figure 2.2).

In accordance with QA/QC procedures outlined in the SSAP:

- triplicate cores were collected at sites CBH 1 and CBH 10 (i.e. three separate cores were collected from these sites)
- split sub-samples were collected from sites 6 and 13 (i.e. the surface subsample from these cores was homogenised and split into three subsamples, with two subsamples analysed by the primary laboratory, and one by a secondary laboratory)
- a blank sample was collected at site 14, and
- samples analysed in previous batches were re-analysed to measure analytical variation between batches[1].

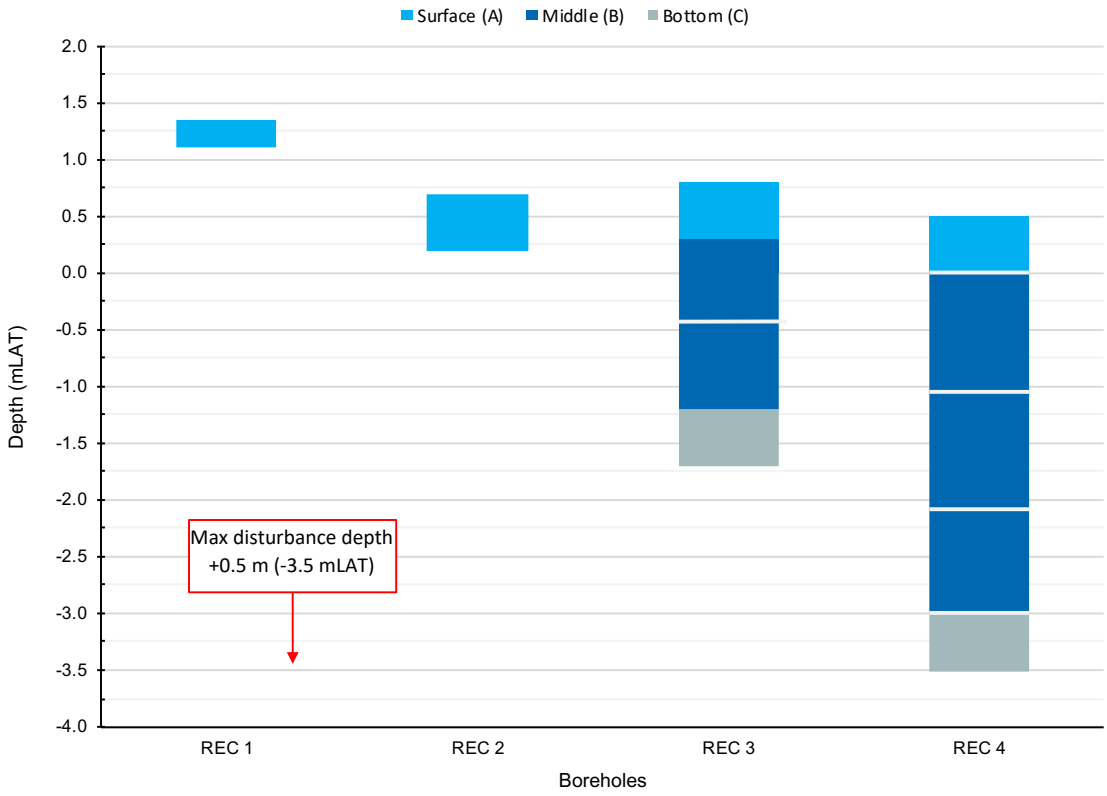

Figure 2.1 Subsampling regime for samples collected in the proposed reclamation area.

[1] To comply with holding times for analyses, the samples were sent to the laboratory in separate batches as required. Samples CBH5_A and CBH2_B1 were re-analysed to comply with QA/QC NAGD guidelines.

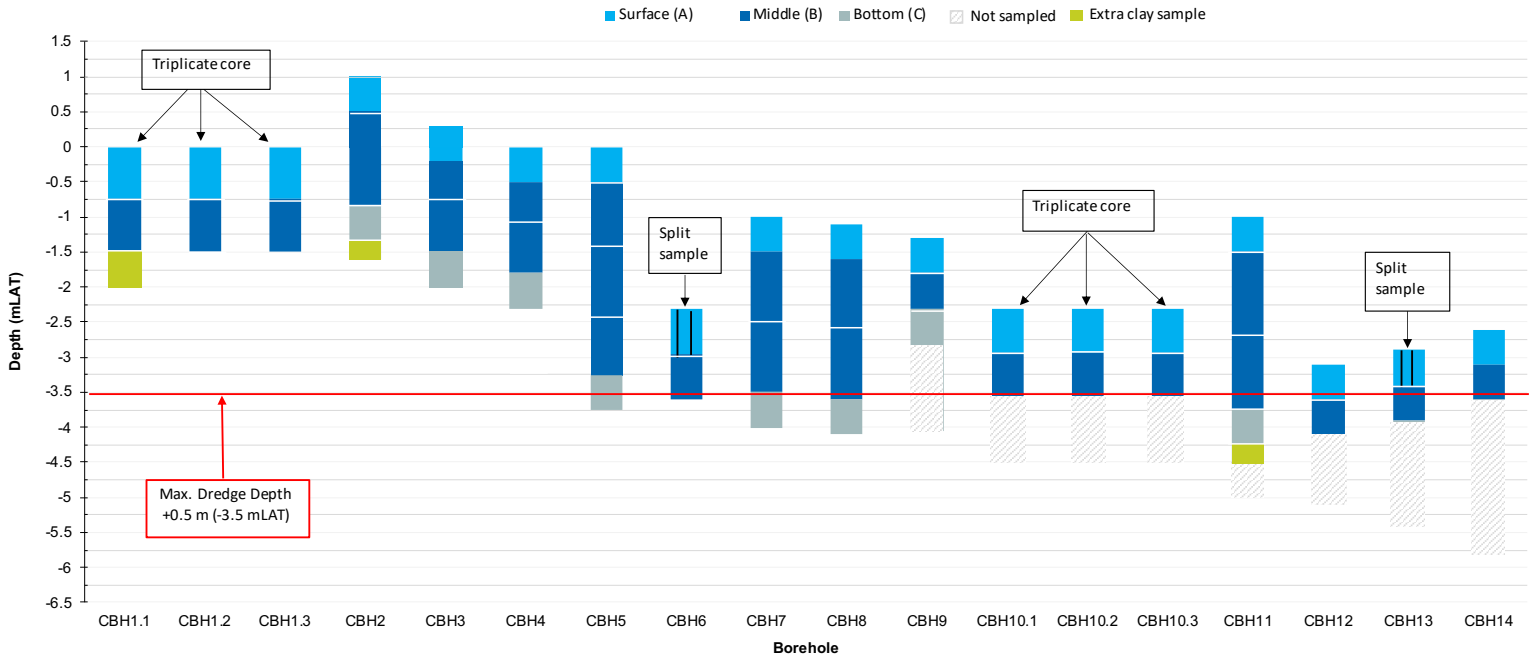

Figure 2.2 Subsampling regime for samples collected in the proposed dredge area.[2]

Where the middle section of the cores was over 1 m long, it was divided into subsamples a maximum of 1 m long.

[2] At site CBH9 subsamples were collected according to the specifications in the SSAP, but not to the maximum dredge depth due to an error in field calculations.

2.4 Parameters Assessed

Field logs were completed at each site for each core with the following recorded:

- the position of the site (latitude and longitude)
- time and date of sampling
- name of the sample collector
- weather conditions at the time of sampling
- sea state at the time of sampling
- general comments (e.g. on wind speed and amount of shipping traffic)
- observations on the type and quantity of litter present (if any)
- water depth at core site
- tide and derived LAT height of core at defined reference point
- height of the top and bottom of each core, relative to LAT
- core length, and
- type of corer used.

At 0.25 m intervals, or before and after any discontinuities, the following observations of the sediment were recorded:

- the distance from the top of the core
- colour
- approximate particle size
- field texture
- mottles
- plasticity
- odour, and the
- presence of shell or carbonate material, along with a measure or estimate of their abundance and size distribution.

All samples were analysed by a NATA accredited laboratory for parameters listed in Table 2.2.

Table 2.2 Sediment quality parameters for analysis and practical quantitation limits

Parameter	Units	PQL	Suite *
Particle Size Distribution	%	NS	C, B
Moisture Content	%	0.1	C, B
Metals and Inorganics			
Aluminium	mg/kg	200	C, T
Antimony	mg/kg	0.5	C, T
Arsenic	mg/kg	1	C, T
Cadmium	mg/kg	0.1	C, T
Chromium	mg/kg	1	C, T
Cobalt	mg/kg	0.5	C, T
Copper	mg/kg	1	C, T
Iron	mg/kg	100	C, T
Lead	mg/kg	1	C, T
Manganese	mg/kg	10	C, T
Mercury	mg/kg	0.01	C, T
Nickel	mg/kg	1	C, T
Selenium	mg/kg	0.1	C, T
Silver	mg/kg	0.1	C, T
Vanadium	mg/kg	2	C, T
Zinc	mg/kg	1	C, T
Cyanide	mg/kg	2	C
Polycyclic Aromatic Hydrocarbons (PAHs)			
Carcinogenic PAHs	mg/kg	0.005	C, B
Total PAHs	mg/kg	0.1	C, B
Phenols			
Phenol	mg/kg	0.5	C, B
Pentachlorophenol	mg/kg	2	C, B
Chlorobenzenes	mg/kg	0.05	C
Organochlorine Pesticides			
DDT+DDE+DDD	mg/kg	0.5	C
Aldrin and Dieldrin	mg/kg	0.5	C

Parameter	Units	PQL	Suite *
Chlordane	mg/kg	0.5	C
Endosulfan	mg/kg	0.5	C
Endrin	mg/kg	0.5	C
Heptachlor	mg/kg	0.5	C
Hexachlorobenzene (HCB)	mg/kg	0.5	C
Methoxychlor	mg/kg	0.5	C
Herbicides			
2,4,5-T	mg/kg	0.02	C
2,4-D	mg/kg	0.02	C
MCPA	mg/kg	0.02	C
MCPB	mg/kg	0.02	C
Mecoprop	mg/kg	0.02	C
Picloram	mg/kg	0.02	C
2,4,5-T	mg/kg	0.02	C
Other Pesticides			
Chlorpyrifos	mg/kg	0.01	C, T
Bifenthrin	mg/kg	0.05	C, T
Other Organics			
Total Polychlorinated biphenyls (PCBs)	mg/kg	0.005	C
BTEXN			
Toluene	mg/kg	0.5	C, B
Ethylbenzene	mg/kg	0.5	C, B
Xylenes	mg/kg	0.5	C, B
Naphthalene	mg/kg	1	C, B
Benzene	mg/kg	0.2	C, B
F1[1]	mg/kg	10	C, B
F2[2]	mg/kg	3	C, B
F3 >C_{16}-C_{34}	mg/kg	3	C, B
F4 >C_{34}-C_{40}	mg/kg	5	C, B

* C = Comprehensive suite; T = Targeted suite

1 F1 = C_6-C_{10} fraction minus total BTEX concentrations

2 F2 = >C_{10}-C_{16} fraction minus naphthalene

2.5 Data Analysis

Comparison with Contaminated Land Guidelines

ASC NEPM

The National Environment Protection (Assessment of Site Contamination) Measure 1999 (ASC NEPM; Australian Government 2013) provides a flowchart for the assessment of site contamination, comprised of the following stages (Figure 2.3):

- Tier 1 Preliminary site investigation
- Tier 1 Detailed site investigation, and
- Tier 2 or 3 Site specific risk assessment.

In the Tier 1 Preliminary Site Investigation stage, the concentrations of contaminants identified in the Conceptual Site Model (CSM) are compared to investigation levels and screening levels relevant for the intended land use (i.e. human activity).

As dredged material is proposed to be reclaimed for human activity (i.e. residential and commercial development), Health Screening Levels (HSL) and Health Investigation Levels (HIL) 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. A list of applicable HSLs and HILs are listed in Table 2.3 and Table 2.4. The ASC NEPM provides a flowchart approach for a Tier 1 Health Risk Assessment of petroleum hydrocarbon contamination (Figure 2.4), with Ecological Screening Levels (ESLs) and Management Limits (MLs) also considered (Table 2.4).

The contaminant range, median, arithmetic/geometric mean, standard deviation and 95% upper confidence limit (UCL) of each contaminant was calculated, with the maximum and the 95% UCL of the arithmetic mean compared to the relevant Tier 1 HSL and HIL. Where the maximum concentration complies with the relevant HSL or HIL, it provides a highly conservative assessment of exposure and recognises the site as suitable for use under the CSM. However, the maximum concentration may result in an overestimation or underestimation of risk (e.g. where sample size is insufficient), and therefore a comparison of the 95% UCL of the arithmetic mean is recommended as a suitable measure for the assessment of risk from site contamination. The results are also expected to meet the following criteria:

- the standard deviation of the results is less than 50% of the relevant investigation or screening level, and
- no single value exceeds 250% of the relevant investigation or screening level.

Where exceedance of Tier 1 HILs and HSLs indicates that there is a likelihood of an adverse impact on human health for the reclamation area, a site-specific health risk assessment (Tier 2 or 3) is required. This site-specific risk assessment must consider the magnitude of any exceedance and whether the exposure pathway is plausible and will result in harm to human health.

Schedule A—Recommended general process for assessment of site contamination

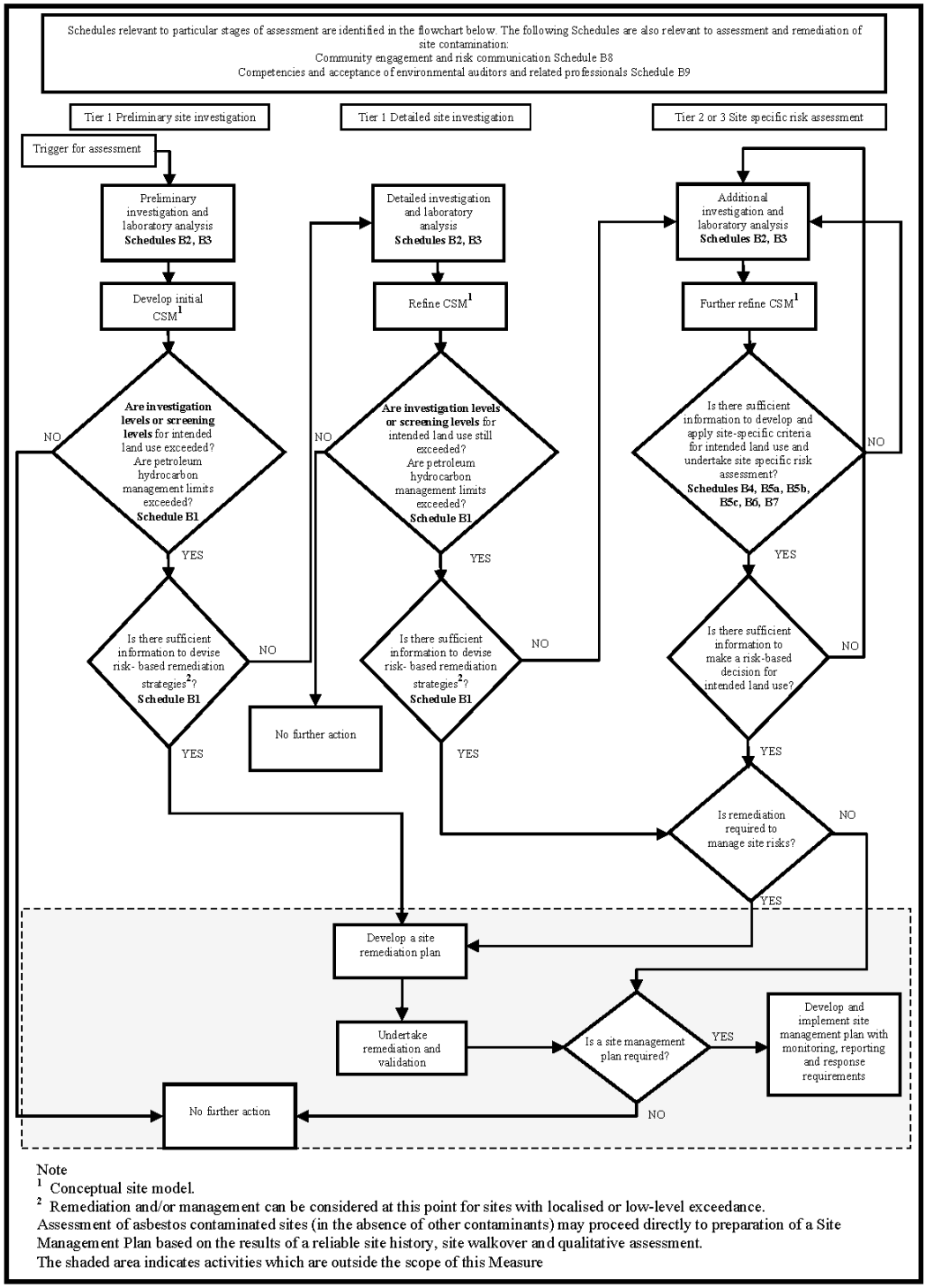

Figure 2.3 ASC NEPM flowchart for the assessment of site contamination

Table 2.3 Health Investigation Levels for soil contaminants

Parameter	Units	Residential (HIL/HSL B)	Recreational (HIL/HSL C)	Commercial/ Industrial (HIL/HSL D)
Particle Size Distribution	%	–	–	–
Moisture Content	%	–	–	–
Metals and Inorganics				
Aluminium	mg/kg	–	–	–
Antinomy	mg/kg	–	–	–
Arsenic	mg/kg	500	300	3,000
Cadmium	mg/kg	150	90	900
Chromium	mg/kg	500	300	3,600
Cobalt	mg/kg	600	300	4,000
Copper	mg/kg	30,000	17,000	240,000
Iron	mg/kg	–	–	–
Lead	mg/kg	1,200	600	1,500
Manganese	mg/kg	14,000	19,000	60,000
Mercury	mg/kg	120	80	730
Nickel	mg/kg	1,200	1,200	6,000
Selenium	mg/kg	1,400	700	10,000
Silver	mg/kg	–	–	–
Vanadium	mg/kg	–	–	–
Zinc	mg/kg	60,000	30,000	400,000
Cyanide	mg/kg	300	240	1,500
Polycyclic Aromatic Hydrocarbons (PAHs)				
Carcinogenic PAHs	mg/kg	4	3	40
Total PAHs	mg/kg	400	300	4,000
Phenols				
Phenol	mg/kg	45,000	40,000	240,000
Pentachlorophenol	mg/kg	130	120	660
Organochlorine Pesticides		–	–	–
DDT+DDE+DDD	mg/kg	600	400	3,600
Aldrin and Dieldrin	mg/kg	10	10	45

Parameter	Units	Residential (HIL/HSL B)	Recreational (HIL/HSL C)	Commercial/ Industrial (HIL/HSL D)
Chlordane	mg/kg	90	70	530
Endosulfan	mg/kg	400	340	2,000
Endrin	mg/kg	20	20	100
Heptachlor	mg/kg	10	10	50
Hexachlorobenzene (HCB)	mg/kg	15	10	80
Methoxychlor	mg/kg	500	400	2,500
Herbicides				
2,4,5-T	mg/kg	900	800	5,000
2,4-D	mg/kg	1,600	1,300	9,000
MCPA	mg/kg	900	800	5,000
MCPB	mg/kg	900	800	5,000
Mecoprop	mg/kg	900	800	5,000
Picloram	mg/kg	6,600	5,700	35,000
Other Pesticides				
Chlorpyrifos	mg/kg	340	250	2,000
Bifenthrin	mg/kg	840	730	4,500
Other Organics				
Total Polychlorinated biphenyls (PCBs)	mg/kg	1	1	7

Bold values indicate the most conservative HIL or HSL for the parameter

Soil HSLs listed for silt soil type at a depth of 0 m to <1 m

[1] F1 = C_6-C_{10} fraction minus total BTEX concentrations

[2] F2 = >C_{10}-C_{16} fraction minus naphthalene

– no applicable HIL or HSL

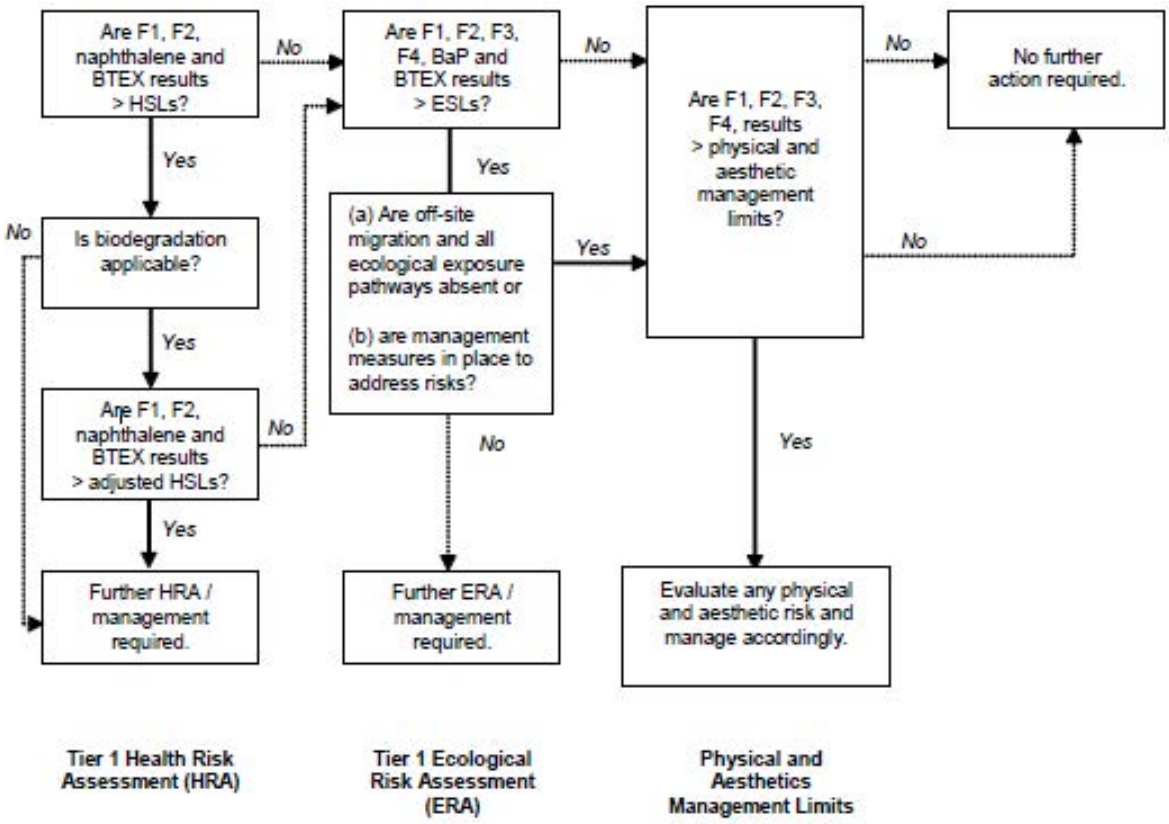

Figure 2.4 Flowchart for Tier 1 human and ecological risk assessment of petroleum hydrocarbon contamination

Table 2.4 Health Screening Levels (HSL), Ecological Screening Levels (ESL) and Management Limits (ML) for Soil contaminants

Parameter	Units	Urban Residential and Public Open Space	Commercial and Industrial
HSLs for Soil*			
Toluene	mg/kg	390	–
Ethylbenzene	mg/kg	–	–
Xylenes	mg/kg	95	–
Naphthalene	mg/kg	4	–
Benzene	mg/kg	0.6	4
F1[1]	mg/kg	40	250
F2[2]	mg/kg	230	–
ESLs for Soil			
F1 C_6-C_{10}	mg/kg	180	215
F2 >C_{10}-C_{16}	mg/kg	120	170
F3 >C_{16}-C_{34}	mg/kg	1,300	2,500
F4 >C_{34}-C_{40}	mg/kg	5,600	6,600
Benzene	mg/kg	65	95
Toluene	mg/kg	105	135
Ethylbenzene	mg/kg	125	185
Xylenes	mg/kg	45	95
Benzo(a)pyrene	mg/kg	0.7	0.7
Management Limits for Soil			
F1 C_6-C_{10}	mg/kg	800	800
F2 >C_{10}-C_{16}	mg/kg	1000	1000
F3 >C_{16}-C_{34}	mg/kg	3,500	5,000
F4 >C_{34}-C_{40}	mg/kg	10,000	10,000

* Soil HSLs listed for silt soil type at a depth of 0 m to <1 m

Bold values indicate the most conservative ESL for the parameter

3 Results of QA/QC Assessments

3.1 Relative Percent Difference & Relative Standard Deviation

The ASC NEPM provide guidance on acceptable relative percent differences (RPD) and relative standard deviations (RSD) between QA/QC samples (DEWHA 2009). RPD/RSD were calculated for differences between:

- cores collected from the same site
- subsamples collected from the same site
- subsamples analysed by different laboratories
- samples analysed in different batches by the same laboratory, and
- laboratory duplicates, blanks and spikes.

RPD and RSD were not calculated where concentrations were below the LOR, as this does not provide a true indication of variation. A detailed assessment of RPD and RSDs between QA/QC samples is provided in the NAGD report (REFERENCE NAGD Report), with a summary provided below.

Between Cores at the Same Site (RSD)

The concentration of a parameter in three or more samples taken at the same location should agree with a relative standard deviation (RSD) of ± 30%, except where sediments are very heterogeneous or there are substantial differences in grain size (Australian Government 2013).

There were substantial differences in grain size for sediments collected in triplicate cores from sites CBH1 and CBH10, resulting in some variation for chromium and total PAHs at these sites. However, the concentration these parameters were below the ASC NEPM investigation and screening limits (Section 4.2), so these QA/QC results are not considered to be a concern.

Between Subsamples from the Same Site (RPD)

The concentration of subsamples from the same site should have an RPD ± 30% (Australian Government 2013). The RPD for all parameters was less than ± 30% except for:

- total recoverable hydrocarbons (TRH) C16–C34 fraction in sample CBH6_A, and
- particle sizes +75µm and +150µm, aluminium and iron in sample CBH13_A.

These QA/QC results are not of concern as none of the results exceeded the investigation or screening levels (Section 4.2).

Between Laboratories (RPD)

The RPD between samples analysed by different laboratories exceeded the recommended ASC NEPM criteria (± 30%) for

- the percentage of clay, aluminium, iron, chromium, manganese, nickel and zinc in sample CBH6_A, and
- the percentage of sand, aluminium, iron and nickel in sample CBH13.

Results for these parameters are hence considered estimates rather than precise values. However, the concentration of these parameters did not exceed the ASC NEPM investigation or screening levels and were therefore not of concern. Between Batches (RPD)

There were some differences in particle size distribution (clay, sand and gravel) in samples from CBH5_A and several PAHs in samples from CBH5_A, when analysed by the same laboratory in different batches. All concentrations of PAH were below the ASC NEPM investigation and screening levels, and consequently this QA/QC result is not considered to be of concern.

Within Laboratory

In batches EB1929953 and EB1929954, all duplicate samples were within RPD limits, however for batch EB1929789, the RPD for aluminium, iron, chromium, cobalt, vanadium exceeded the laboratory limit.

Blank sample results for all batches were below the LOR for each parameter and LCS recovery was within the acceptable recover range.

MS recovery of arsenic in batch EB1929789 was below recovery range, due to a matrix interference in the analyses.

While the results for these parameters should be considered as estimates rather than precise values for their corresponding batches, concentrations of these parameters were below the ASC NEPM investigation and screening levels, and are consequently the results of these QA/QC tests are not considered to be of concern.

3.2 Limit of Reporting (LOR)

The limit of reporting (LOR) achieved by the laboratory was below the applicable investigation or screening level for all parameters except for Naphthalene within the reclamation area (<5 mg/kg), which was higher than the ASC NEPM HIL (4 mg/kg). However as the concentration of Naphthalene was less than LOR at each site within the dredge area, and below the ASC NEPM HIL, the results not considered of concern.

4 Results and Discussion

4.1 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 area and reclamation area were dominated by clay and silt at all sites, except REC3 which was dominated by sand (54%, Figure 4.1, Figure 4.4). The highest proportions of gravel were at sites within the inner proposed dredge and reclamation area, with the highest proportions at sites 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 (Figure 4.2, Figure 4.5).

Bottom sediments were dominated by fines at all sites except CBH3, which was dominated by sand (45%) and gravel (41%) with no silt (Figure 4.3, Figure 4.5).

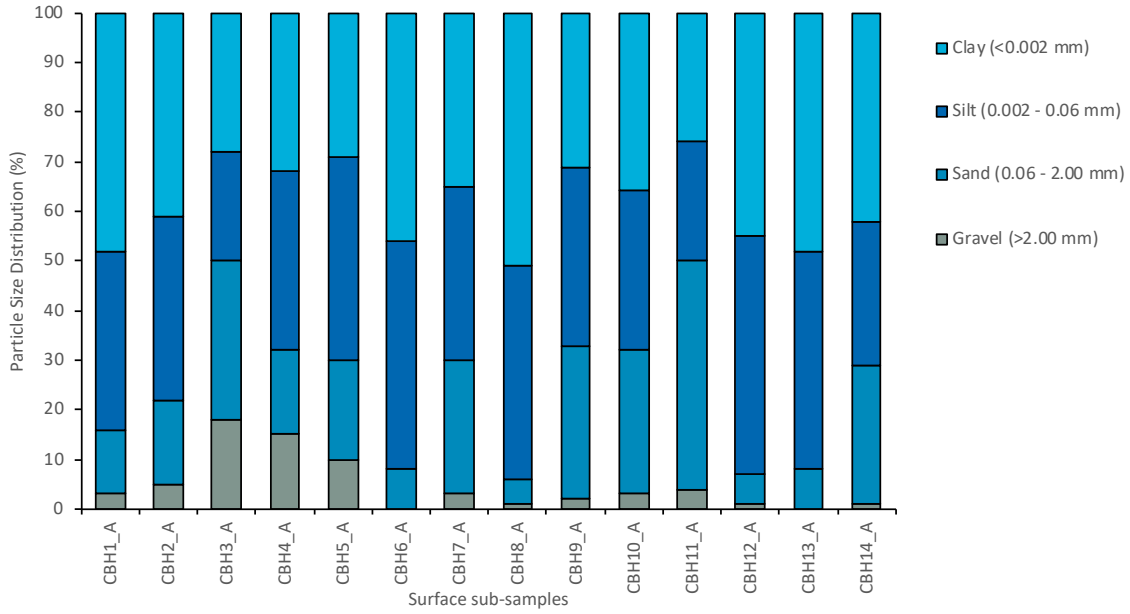

Figure 4.1 Particle size distribution for surface subsamples in the proposed dredge area.

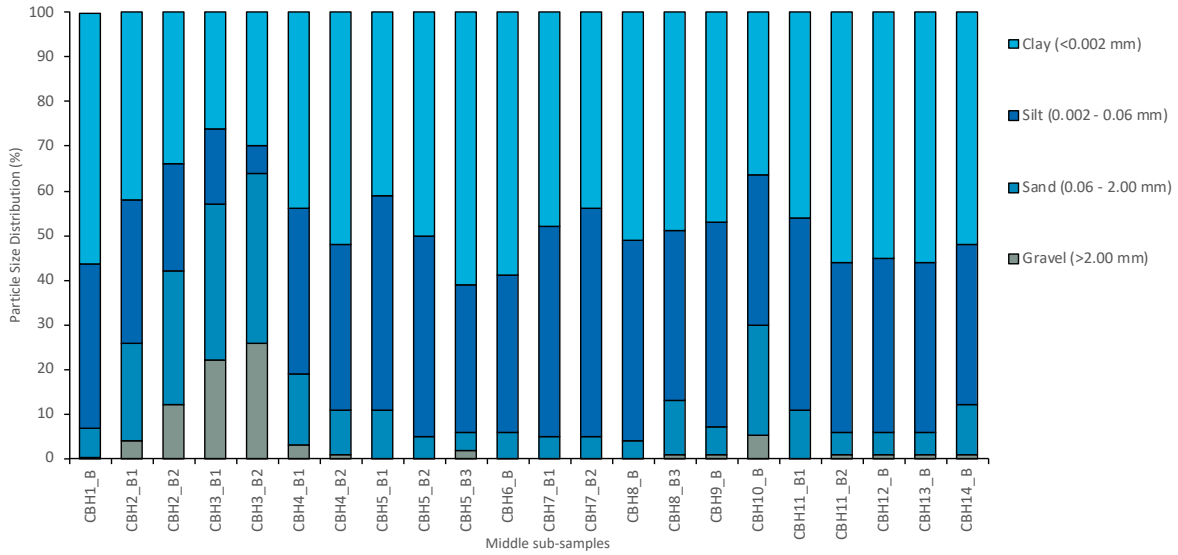

Figure 4.2 Particle size distribution for middle subsamples in in the proposed dredge area.

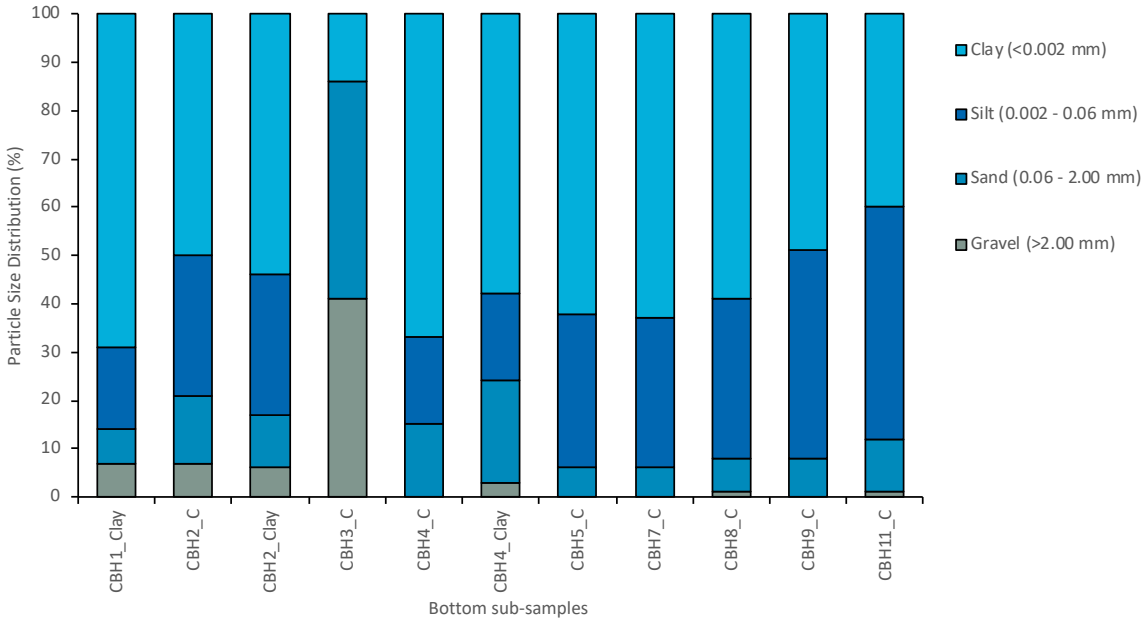

Figure 4.3 Particle size distribution for bottom subsamples in in the proposed dredge area.

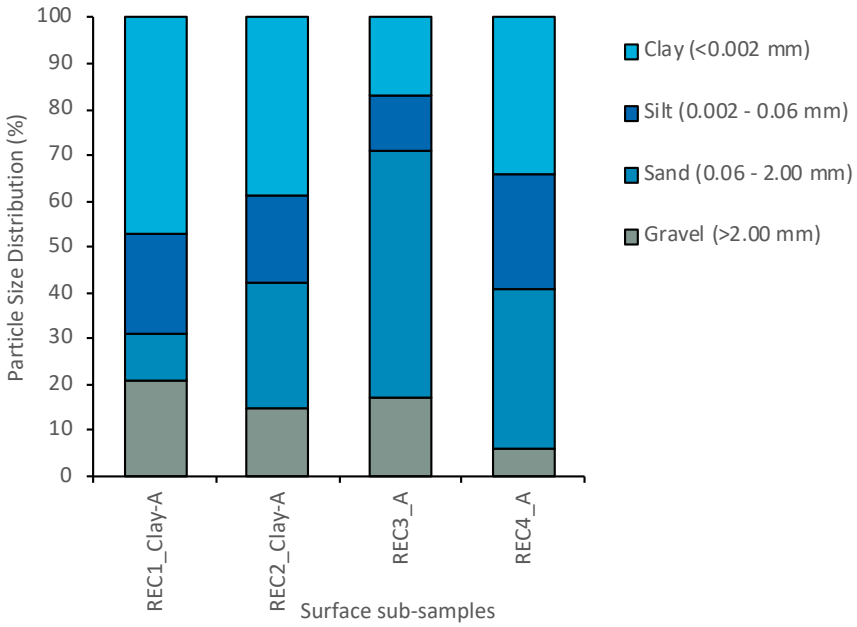

Figure 4.4 Particle size distribution for surface subsamples in the proposed reclamation area.

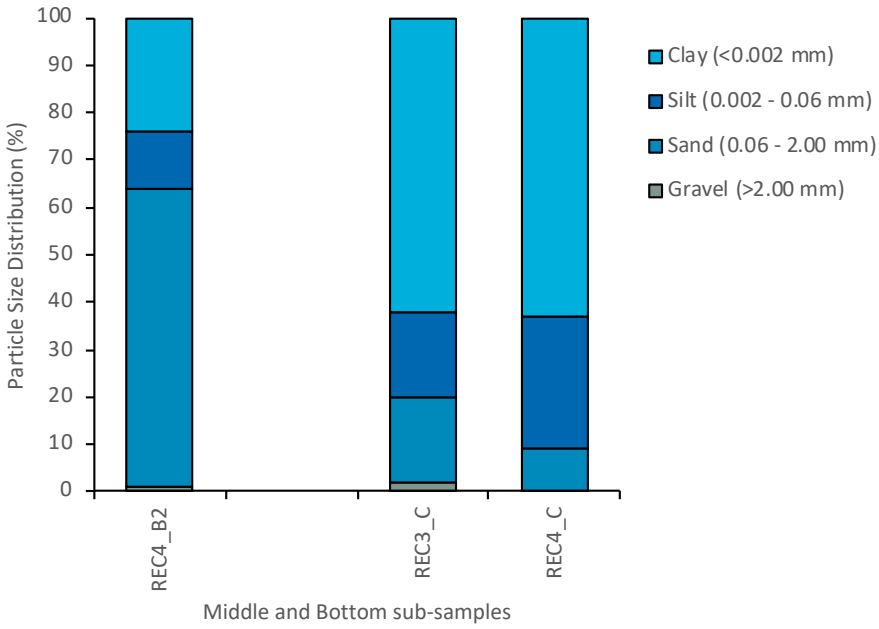

Figure 4.5 Particle size distribution for middle and bottom subsamples in the proposed reclamation area.

4.2 Health Investigation Levels

The mean, 95% UCL and maximum concentration of each parameter complied with the most conservative ASC NEPM HIL for sites within the dredge area and reclamation area (Table 4.1 and Table 4.2). That is, the concentration of these parameters in the soil of the proposed dredge area and reclamation area are not of concern for the proposed land-use. Further, the standard deviation for each parameter was less than 50% of the HIL.

The mean concentration of a number of parameters that do not have HILs were above the LOR (aluminium, iron and vanadium) (Table 4.1 and Table 4.2). 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 a risk.

Table 4.1 Summary of sample laboratory results from the proposed dredge area compared to the most conservative HIL

Parameter	Units	HIL	Mean[1]	SD[2]	95% UCL[3]	Max	Distribution
Metals and Inorganics							
Aluminium	mg/kg	–	10,664	2,616	12,757	18,200	N
Antinomy*	mg/kg	–	<0.5	0	–	<0.5	–
Arsenic	mg/kg	300	12	5	16	22	N
Cadmium	mg/kg	90	<0.1	1	–	<0.1	X
Chromium	mg/kg	300	47	2	48	321	X
Cobalt	mg/kg	300	8	2	9	37	X
Copper	mg/kg	17,000	7	1	9	23	X
Iron	mg/kg	–	37,364	1	37,365	99,000	L
Lead	mg/kg	600	7	2	9	12	N
Manganese	mg/kg	19,000	143	2	145	649	X
Mercury*	mg/kg	80	<0.01	2	–	0	X
Nickel	mg/kg	1,200	10	2	11	24	X
Selenium	mg/kg	700	0	1	2	1	X
Silver*	mg/kg	–	<0.1	1	–	<0.1	X
Vanadium	mg/kg	–	60	26	81	135	N
Zinc	mg/kg	30,000	14	3	17	53	X
Cyanide*	mg/kg	240	<1		–	1	X

Parameter	Units	HIL	Mean[1]	SD[2]	95% UCL[3]	Max	Distribution
Polycyclic Aromatic Hydrocarbons (PAHs)							
Carcinogenic PAHs*	mg/kg	3	<0.00968	0	–	0.01	N
Total PAHs*	mg/kg	300	<0.004	3	–	0.33	X
Phenols							
Phenol*	mg/kg	40,000	<0.5	0	–	<0.5	–
Pentachlorophenol*	mg/kg	120	<2	0	–	<2	–
Organochlorine Pesticides							
DDT+DDE+DDD*	mg/kg	400	<0.0005	0	–	<0.0005	–
Aldrin*	mg/kg	10	<0.0005	0	–	<0.0005	–
Dieldrin*	mg/kg	10	<0.0005	0	–	<0.0005	–
Chlordane*	mg/kg	70	<0.00025	0	–	<0.00025	–
Endosulfan*	mg/kg	340	<0.0005	0	–	<0.0005	–
Endrin*	mg/kg	20	<0.0005	0	–	<0.0005	–
Heptachlor*	mg/kg	10	<0.0005	0	–	<0.0005	–
Hexachlorobenzene (HCB)*	mg/kg	10	<0.0005	0	–	<0.0005	–
Methoxychlor*	mg/kg	400	<0.0005	0	–	<0.0005	–
Herbicides							
2,4,5-T*	mg/kg	800	<0.02	0	–	<0.02	–
2,4-D*	mg/kg	1,300	<0.02	0	–	<0.02	–
MCPA*	mg/kg	800	<0.02	0	–	<0.02	–
MCPB*	mg/kg	800	<0.02	0	–	<0.02	–
Mecoprop*	mg/kg	800	<0.02	0	–	<0.02	–
Picloram*	mg/kg	5,700	<0.02	0	–	<0.02	–
Other Pesticides							
Chlorpyrifos*	mg/kg	250	<0.01	0	–	<0.01	–
Bifenthrin*	mg/kg	730	<0.05	0	–	<0.05	–

Other Organics							
Total Polychlorinated biphenyls (PCBs)*	mg/kg	1	<0.005	0	–	<0.005	–

– calculation cannot be completed, NS not surveyed

* Parameters were below LOR in all samples or undetected in more than 75% of samples

N data normally distributed, L data log-normally distributed, X data neither normal nor log-normally or gamma distributed

[1] geometric mean presented for data log-normal (L) or neither normal nor log-normally distributed (X)

[2] geometric standard deviation presented for data log-normal (L) or neither normal nor log-normally distributed (X)

[3] 95% UCL – 95% upper confidence limit of the mean

Table 4.2 Summary of sample laboratory results from the proposed reclamation area compared to the most conservative HIL.

Parameter	Units	HIL	Mean[1]	SD[2]	95% UCL[3]	Max	Distribution
Metals and Inorganics							
Aluminium	mg/kg	–	9186	3743	11958	14700	N
Antinomy*	mg/kg	–	<0.5	–	–	<0.5	–
Arsenic	mg/kg	300	14	16.9	27	49	N
Cadmium	mg/kg	90	0.1	10.0	8	22	X
Chromium	mg/kg	300	80	53.6	119	178	N
Cobalt	mg/kg	300	10	3.0	12	93	X
Copper	mg/kg	17,000	5	4.5	9	95	L
Iron	mg/kg	–	41800	11827	50561	55600	N
Lead	mg/kg	600	9	3.8	12	130	L
Manganese	mg/kg	19,000	102	73.1	157	213	N
Mercury*	mg/kg	80	<0.01	1.3	–	<0.01	X
Nickel	mg/kg	1,200	9	3.6	12	93	L
Selenium	mg/kg	700	0.5	0.2	1	1	N
Silver*	mg/kg	–	<0.1	0.0	–	<0.1	–
Vanadium	mg/kg	–	76	1.4	77	152	L
Zinc	mg/kg	30,000	9	5.0	13	88	L
Cyanide	mg/kg	240	NS	NS	NS	NS	NS
Polycyclic Aromatic Hydrocarbons (PAHs)							
Carcinogenic PAHs*	mg/kg	3	<0.01	0.0	–	<0.01	–
Total PAHs*	mg/kg	300	<0.004	0.0	–	0.005	–
Phenols							
Phenol*	mg/kg	40,000	<0.5	0.0	–	<0.5	–
Pentachlorophenol*	mg/kg	120	<2	0.0	–	<2	–
Organochlorine Pesticides							
DDT+DDE+DDD	mg/kg	400	NS	NS	NS	NS	NS
Aldrin and Dieldrin	mg/kg	10	NS	NS	NS	NS	NS
Chlordane	mg/kg	70	NS	NS	NS	NS	NS

Parameter	Units	HIL	Mean[1]	SD[2]	95% UCL[3]	Max	Distribution
Endosulfan	mg/kg	340	NS	NS	NS	NS	NS
Endrin	mg/kg	20	NS	NS	NS	NS	NS
Heptachlor	mg/kg	10	NS	NS	NS	NS	NS
Hexachlorobenzene (HCB)	mg/kg	10	NS	NS	NS	NS	–
Methoxychlor	mg/kg	400	NS	NS	NS	NS	–
Herbicides							
2,4,5-T	mg/kg	800	NS	NS	NS	NS	–
2,4-D	mg/kg	1,300	NS	NS	NS	NS	–
MCPA	mg/kg	800	NS	NS	NS	NS	–
MCPB	mg/kg	800	NS	NS	NS	NS	–
Mecoprop	mg/kg	800	NS	NS	NS	NS	–
Picloram	mg/kg	5,700	NS	NS	NS	NS	–
Other Pesticides							
Chlorpyrifos	mg/kg	250	NS	NS	NS	NS	–
Bifenthrin	mg/kg	730	NS	NS	NS	NS	–
Other Organics			NS	NS	NS	NS	–
Total Polychlorinated biphenyls (PCBs)	mg/kg	1	NS	NS	NS	NS	–

– calculation cannot be completed, NS not surveyed

* Parameters were below LOR in all samples or undetected in more than 75% of samples

N data normally distributed, L data log-normally distributed, X data neither normal nor log-normally or gamma distributed

1 geometric mean presented for data log-normal (L) or neither normal nor log-normally distributed (X)

2 geometric standard deviation presented for data log-normal (L) or neither normal nor log-normally distributed (X)

3 95% UCL – 95% upper confidence limit of the mean

4.3 Health Screening Levels

The mean, 95% UCL and maximum concentration of each parameter complied with the most conservative ASC NEPM HSL for sites within the dredge area and reclamation area (Table 4.3 and Table 4.4). 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 soil from the dredge area, where concentrations were below the HSL, is to be re-purposed 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 (Figure 2.4), the concentrations were also compared to the applicable ESL and ML, of which each parameter was compliant. Therefore no further action is required.

Table 4.3 Summary of sample laboratory results from the proposed dredge area compared to the most conservative HSL, ESL and ML.

Parameter	Units	HSL/ESL/ML	Mean[1]	SD[2]	95% UCL[3]	Max	Distribution
HSLs for Soil							
Toluene*	mg/kg	390	<0.2	0	–	<0.2	–
Ethylbenzene*	mg/kg	–	<0.2	0	–	<0.2	–
Xylenes*	mg/kg	95	<0.5	0	–	<0.5	–
Naphthalene	mg/kg	4	1	1	2	3	–
Benzene*	mg/kg	0.6	<0.2	0	–	<0.2	–
F1[1]*	mg/kg	40	<10	0	–	<10	–
F2[2]*	mg/kg	230	<3	1	–	5	X
ESLs for Soil							
F1 C_6-C_{10}*	mg/kg	180	<10	0	–	<10	–
F2 >C_{10}-C_{16}*	mg/kg	120	<3	1	–	5	X
F3 >C_{16}-C_{34}*	mg/kg	1,300	5	7	10	39	N
F4 >C_{34}-C_{40}*	mg/kg	5,600	<5	1	–	22	X
Benzene*	mg/kg	65	<0.2	0	–	<0.2	–
Toluene*	mg/kg	105	<0.2	0	–	<0.2	–
Ethylbenzene*	mg/kg	125	<0.2	0	–	<0.2	–
Xylenes*	mg/kg	45	<0.5	0	–	<0.5	–
Benzo(a)pyrene*	mg/kg	0.7	<0.004	1.3	–	0.01	X
ML for Soil							
F1 C_6-C_{10}*	mg/kg	800	<10	0	–	<10	–
F2 >C_{10}-C_{16}*	mg/kg	1000	<3	1	–	5	X
F3 >C_{16}-C_{34}*	mg/kg	3,500	5	7	10	39	N
F4 >C_{34}-C_{40}*	mg/kg	10,000	<5	1	–	22	X

– calculation cannot be completed, NS not surveyed

* Parameters were below LOR in all samples or undetected in more than 75% of samples

N data normally distributed, L data log-normally distributed, X data neither normal nor log-normally

1 geometric mean presented for data log-normal (L) or neither normal, log-normally distributed (X)

2 geometric standard deviation presented for data log-normal (L) or neither normal nor log-normally distributed (X)

3 95% UCL – 95% upper confidence limit of the mean

Table 4.4 Summary of sample laboratory results from the reclamation area compared to the most conservative HSL, ESL and ML.

Parameter	Units	HSL/ESL/ML	Mean[1]	SD[2]	95% UCL[3]	Max	Distribution
HSLs for Soil							
Toluene*	mg/kg	390	NS	NS	NS	NS	–
Ethylbenzene*	mg/kg	–	NS	NS	NS	NS	–
Xylenes*	mg/kg	95	NS	NS	NS	NS	–
Naphthalene	mg/kg	4	<5	0	–	<5	–
Benzene*	mg/kg	0.6	NS	NS	NS	NS	–
F1[1]*	mg/kg	40	NS	NS	NS	NS	–
F2[2]*	mg/kg	230	<3	2	–	<3	–
ESLs for Soil							
F1 C_6-C_{10}*	mg/kg	180	NS	NS	NS	NS	–
F2 >C_{10}-C_{16}*	mg/kg	120	<3	2	–	<3	–
F3 >C_{16}-C_{34}*	mg/kg	1,300	<3	2	–	12	X
F4 >C_{34}-C_{40}*	mg/kg	5,600	<5	0	–	<5	–
Benzene*	mg/kg	65	NS	NS	NS	NS	–
Toluene*	mg/kg	105	NS	NS	NS	NS	–
Ethylbenzene*	mg/kg	125	NS	NS	NS	NS	–
Xylenes*	mg/kg	45	NS	NS	NS	NS	–
Benzo(a)pyrene*	mg/kg	0.7	<0.004	0	–	<0.004	–
ML for Soil							
F1 C_6-C_{10}*	mg/kg	800	NS	NS	NS	NS	–
F2 >C_{10}-C_{16}*	mg/kg	1000	<3	2	–	<3	–
F3 >C_{16}-C_{34}*	mg/kg	3,500	<3	2	–	12	X
F4 >C_{34}-C_{40}*	mg/kg	10,000	<5	0	–	<5	–

gold shading indicates where the result is less than LOR but the LOR is higher than the applicable HSL, ESL or ML

– calculation cannot be completed, NS not surveyed

* Parameters were below LOR in all samples or undetected in more than 75% of samples

N data normally distributed, L data log-normally distributed, X data neither normal nor log-normally

1 geometric mean presented for data log-normal (L) or neither normal nor log-normally distributed (X)

2 geometric standard deviation presented for data log-normal (L) or neither normal nor log-normally distributed (X)

3 95% UCL – 95% upper confidence limit of the mean

5 Conclusions

Clay and silt dominated the sediments in the proposed dredge area, with varying amounts of sand and gravel. In the proposed reclamation area, particle size distribution was more varied in surface and middle subsamples at sites furthest from the shoreline, with clay dominating the bottom layers.

The mean, 95% UCL and maximum of all parameters in the proposed dredge area and reclamation area were below (and complied with) the ASC NEPM HIL, HSL, ESL and ML (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 levels, and that were above the LOR, the concentration was similar to previously recorded and are unlikely to be of concern. In accordance with the flowchart for the assessment of site contamination, no further action is required.

Therefore, 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 consequently is appropriate for use as residential, public and/or commercial land, as proposed.

6 References

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