KENNEDY ENVIRONMENTAL LIMITED

Quality of sediments in the Waitematā Navigation Channel Precinct (Rangitoto Channel and Fergusson North berth and approaches)

Prepared for Ports of Auckland Limited

January 2020

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Abbreviations and Units

ANZECC	Australian and New Zealand Environment & Conservation Council
APPs	Antifouling paint particle
CDS	Cuvier Disposal Site
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DGV	Default Guideline Value (ANZECC 2018)
EPA	Environmental Protection Authority
FNB	Fergusson North berth
FNBA	Fergusson North berth approaches
GV-high	Guideline Value - high (ANZECC 2018)
g/m^3	Grams per cubic metre
MDC	Marine Dumping Consent
mg/L	milligrams per litre (water)
mg/kg	milligrams per kilogram (sediment)
MSA	Maritime Safety Authority
OCP	Organochlorine pesticide
PAH	Polyaromatic hydrocarbon
PCB	Polychlorinated biphenyl
POA	Port of Auckland
POAL	Port of Auckland Limited
SVOC	Semi volatile organic compounds
SPLP	Synthetic precipitation leaching procedure
TBT	Tributyl tin
TOC	Total organic carbon
TPH	Total petroleum hydrocarbons
µg/kg	micrograms per kilogram
$µg/m^3$	micrograms per cubic metre
USACOE	United States Army Corps of Engineers

USEPA	United States Environmental Protection Agency
WNCP	Waitematā Channel Navigation Precinct

1 INTRODUCTION

1.1 Background

Ports of Auckland (POAL) have applied to Auckland Council to undertake capital dredging and on-going maintenance dredging activities within the Waitematā Navigation Channel Precinct (WNCP) and Port Precinct (Bentley 2019). As part of the supporting documentation, KEL (2019) described sediments and sediment quality within the WCNP. The information was based on sediment samples collected and described in Kingett Mitchell (2001). That study was undertaken as part of the Application that preceded capital dredging undertaken over 2004-2007 within the WCNP (POAL 2001).

A sediment quality sampling programme was described in KEL (2019). This programme was developed as a requirement of the disposal consent that POAL has for the dumping of dredged material at the Cuvier Disposal Site (CDS) (Marine Dumping Consent EEZ400011). Dredged material cannot be dumped until a sediment quality sampling plan is first approved and until the post sampling evaluation has been undertaken and approved by the Environment Protection Authority (EPA). This sampling programme will be undertaken during 2020. The sampling carried out in the WCNP during December 2019 was undertaken to characterise the sediment for a wide range of constituents and potential contaminants to confirm the overall sediment quality and define the level of contamination impacting on channel sediments.

1.2 Report Contents

The data presented in this report supplements that presented in KEL (2019). To assist the reader, relevant information from KEL (2019) is re-presented in this report to minimise the need to cross-reference to KEL (2019).

- Section 2 describes the sediments to be dredged.
- Section 3 provides a summary of the proposed dredging and background information that determines what analysis and sampling has been undertaken.
- Section 4 describes methods of sampling undertaken.
- Section 5 describes the physical characteristics of sediments in the WCNP.
- Section 6 describes previous sediment quality characterisation.
- Section 7 describes the chemical characteristics of sediments collected from the WCNP in December 2019.
- Section 8 discusses the results obtained in relation to proposed dredging.
- Section 9 provides a summary and conclusions.

2 SEDIMENTS TO BE DREDGED

2.1 Areas to be Dredged

POAL plans to undertake capital works dredging within the WNCP in two stages (Stage 1 and Stage 2). Dredging is proposed in the following areas:

- The pocket berth immediately adjacent the Fergusson North berth (FNB) (the yellow rectangle adjacent to the berth in Figure 1 and Appendix A). The FNB pocket will be dredged to its full depth in stage one and it is not proposed to be dredged further in stage 2.
- The Fergusson North Berth approaches (FNBA) which comprise those areas outside the "berth" area where the vessel approaches the berth. The areas that require to be dredged in stage 1 are shown in Figure 1 (and Appendix A). The full dredging depths (Stage 1 and 2 combined can be found in Beca 2019).
- The Navigation Channel within the Rangitoto Channel (Figure 2). POAL divides the Navigation Channel into five sections labelled A to E in a seaward direction from the harbour. Area A does not require to be dredged in Stage 1. The stage 1 dredging areas can be seen in Figure 2 (and Appendix A) and the total area dredged in both stages in Beca (2019).

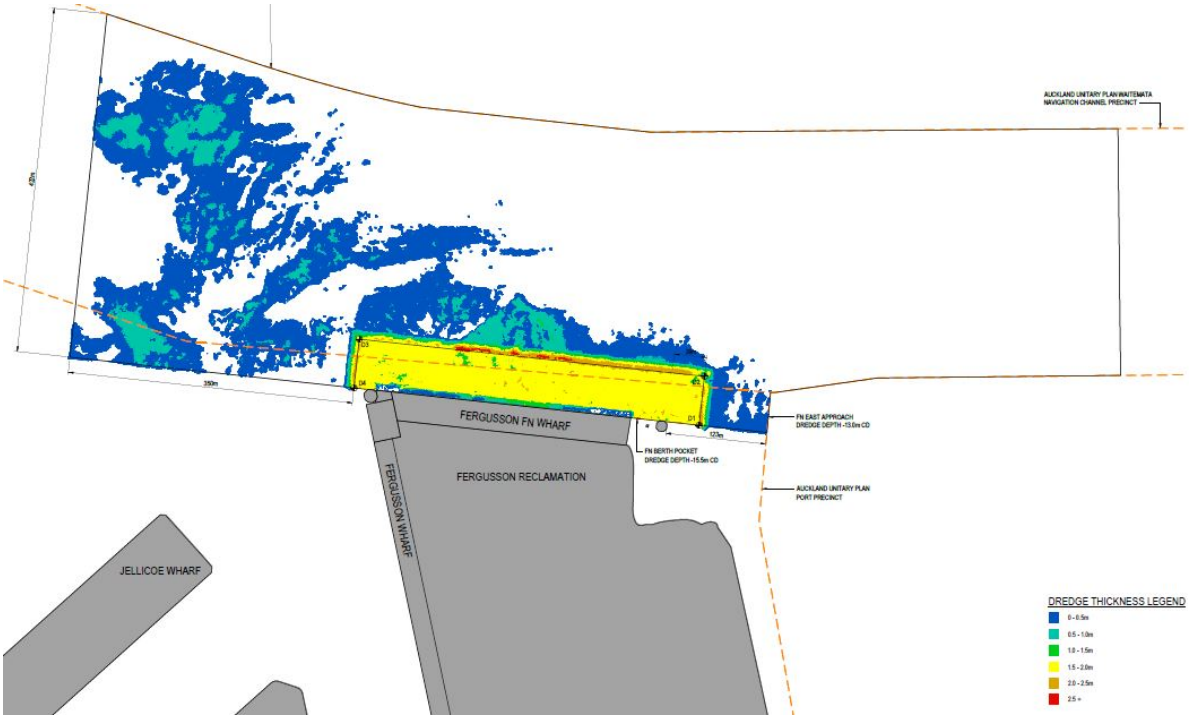


Figure 1: Dredging areas (Stage 1) adjacent to the Fergusson North berth.

It should be noted that the southern area of dredging within the pocket berth and the Approaches falls within the Port Precinct (the red dotted line in Figure 1 identifies the boundary between the WCNP and the Port Precinct). For the purpose of this assessment, the area that falls into the Port Precinct is considered to be similar to that within the area falling within the WCNP (in terms of physical environment).

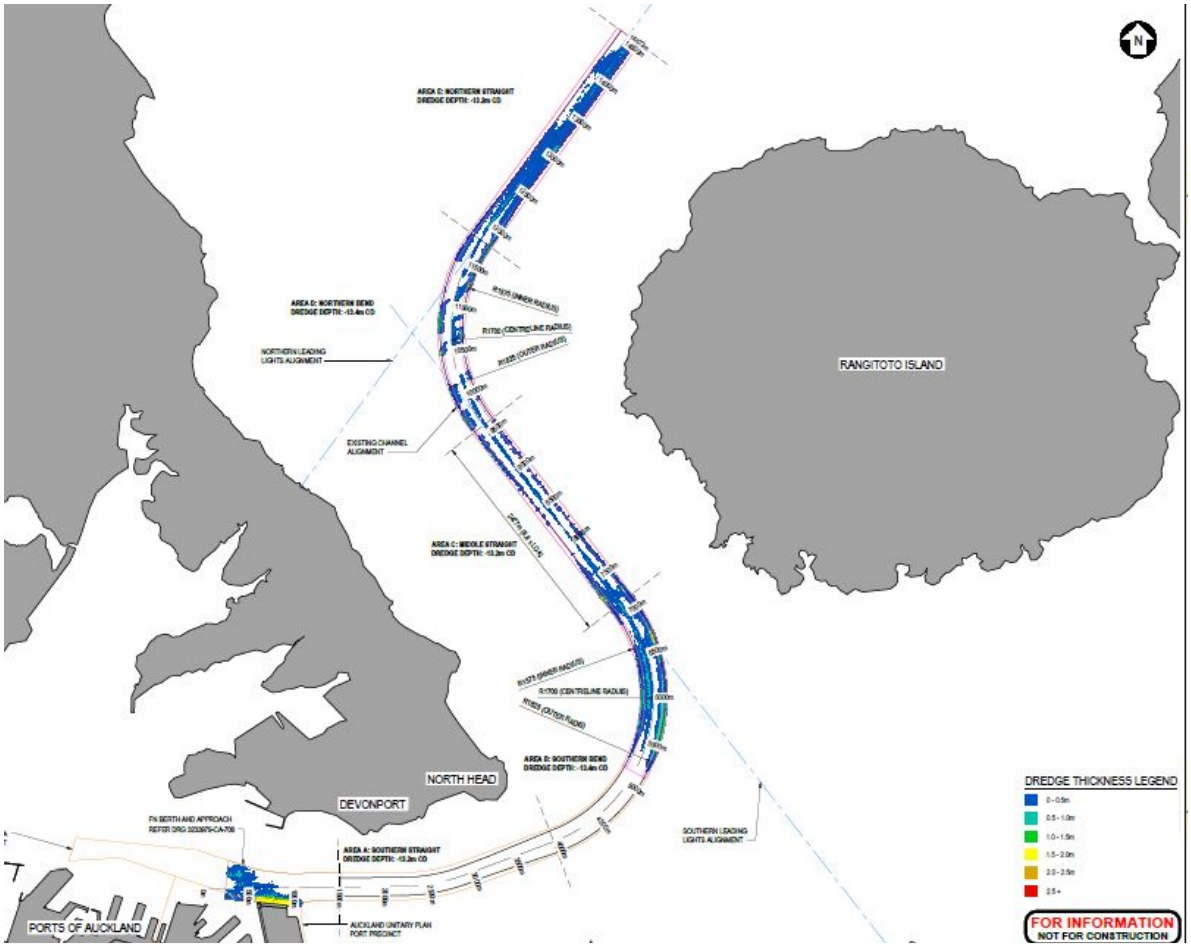


Figure 2: Dredging areas (Stage 1) with the Rangitoto Channel.

2.2 Dredging Depths

Depths for Stage 1 dredging are shown on Figures 1 and 2 and the full figures in Appendix A. Stage 2 dredging depths will be re-checked following the completion of the Stage 1 dredging. The dredging depth data for the FNB and FNBA provides the following information:

- At the FNB, all dredging away from the berth pocket is to a maximum depth of 1.0 m below seabed. Over 50 % of the FNBA is dredged to 0.5 m.
- The berth pocket will require dredging of 1.5-2.0 m sediment over most of the pocket area. A very narrow strip (a ridge) at the seaward side of the pocket requires 2.5 m of sediment to be dredged.

Within the Rangitoto Channel, dredging will be carried out to a maximum depth of 2.5 m. Those locations which are identified as being deeper than 1.0-1.5 m are often mound features (wave bedforms). Dredging to a depth of 2.5 m in a location takes the channel bed to the same level as an adjacent area dredged for example to a depth of 1.5 m. Within the four sections (B, C, D and E) of the channel to be dredged in Stage 1:

- Within Section B on the southern bend of the channel, no dredging will be carried out in Stage 1 from 4,000 m to 5,000 m. Nearly all dredging will be carried out to depths of 1.0-1.5 m, with one small area at 6,500 m on the outer east side will be dredged to between 1.5 and 2.0 m and 2.0 and 2.5 m. The mound at the edge of the channel in Section B at location 6,500 m is approx. 20 m across and 160 m long.
- Less than 30 % of Section C will be dredged with most occurring at the southern part of the Area. One small part of the Section C on the west side at 7,200 m will be dredged to 2.0 m.
- About 30 % of Section D will be dredged, with most of that area being dredged to a depth of 1.0-1.5 m. Two points on the edge of the channel in this section (at 10,500 m and 11,300 m) will be dredged to 2.0 m.
- About 70 % of Section E will all be dredged, to a depth of 1.0 m or less.

More detail on Stage 1 and 2 dredging depths can be found in KEL (2019) and Beca (2019).

3 SOURCE SITE INFORMATION RELEVANT TO SAMPLING & ASSESSMENT

3.1 Sources of Sediment Contamination

Potential sources of contamination are reviewed prior to sampling to assist in identifying the contaminants to be analysed on sediment samples collected. A primary set of key (common contaminants and environmentally significant contaminants) is included in analysis undertaken. These constituents have been included in analysis previously undertaken on port and waterfront sediments. As described in section 7.1, the contaminants that should be considered for inclusion are set out in a range of advisory documents (e.g., MSA 1999).

The lower Waitematā Harbour has a very large urbanised and rural catchment and below the Auckland Harbour Bridge the harbour receives drainage from the Auckland City commercial catchments. When sediment is discharged in stormwater to the port and waterfront areas, the coarse (heavy) material in the stormwater settles close to the outfalls. The fine material which is in freshwater interacts with seawater and much of the fine material is deposited in the deposition areas (berths and basins) adjacent to the outfalls where currents are weak. Some fine sediment will disperse to the main harbour but much is trapped close to the outfalls. What happens within these catchments influences water and sediment quality within the harbour. Quality is determined by activities on roads, washoff from buildings and a wide range of activities and incidents (vehicle accidents, spills, fires etc.).

In October 2019, a large fire occurred at the Sky City Convention Centre. Water from the fire, discharged to the stormwater system that then discharged to Freemans Bay at Daldy St.). Concerns were raised (generally and in the media) regarding the contaminants present in the drainage water from the fire and its effects on harbour water and sediment. These concerns extended to comments on its effect on any sediment that might be dredged.

Auckland Council undertook sampling of stormwater and water generated by the fire. That analysis showed that the key trace elements present in runoff were dissolved arsenic,

chromium, copper and zinc. Sampling was undertaken by Auckland Council and Watercare with results) including toxicity testing, being reported in the media. Section 7.1 describes additions which were made to the analysis undertaken on sediment samples from the FNBA

3.2 Fergusson North berth and Approaches

The FNB has been recently constructed. Prior to 2001 when the extension to the container terminal berth was commenced, the area was part of the main body of the harbour and unaffected by shipping activities. The berth was completed in 2018 and the berth pocket dredged to a depth of 13.5 m as part of this completion. Vessels have only recently commenced berthing at the FNB but the berth has not been commissioned yet. As such, the sediment at the berth has not been subject to any direct vessel related potential contaminant exposure. Examination of recent photographs of the seabed at the berth and within the adjacent approaches, does not show any accumulation of fine sediment. The seabed along the length of the berth is subject to strong tidal currents and as such the area appears to be an erosional environment (i.e., not a depositional area). The area adjacent to the FNB and part of the FNBA was previously dredged in 2004-2007 as part of the last capital dredging (Figure 3).

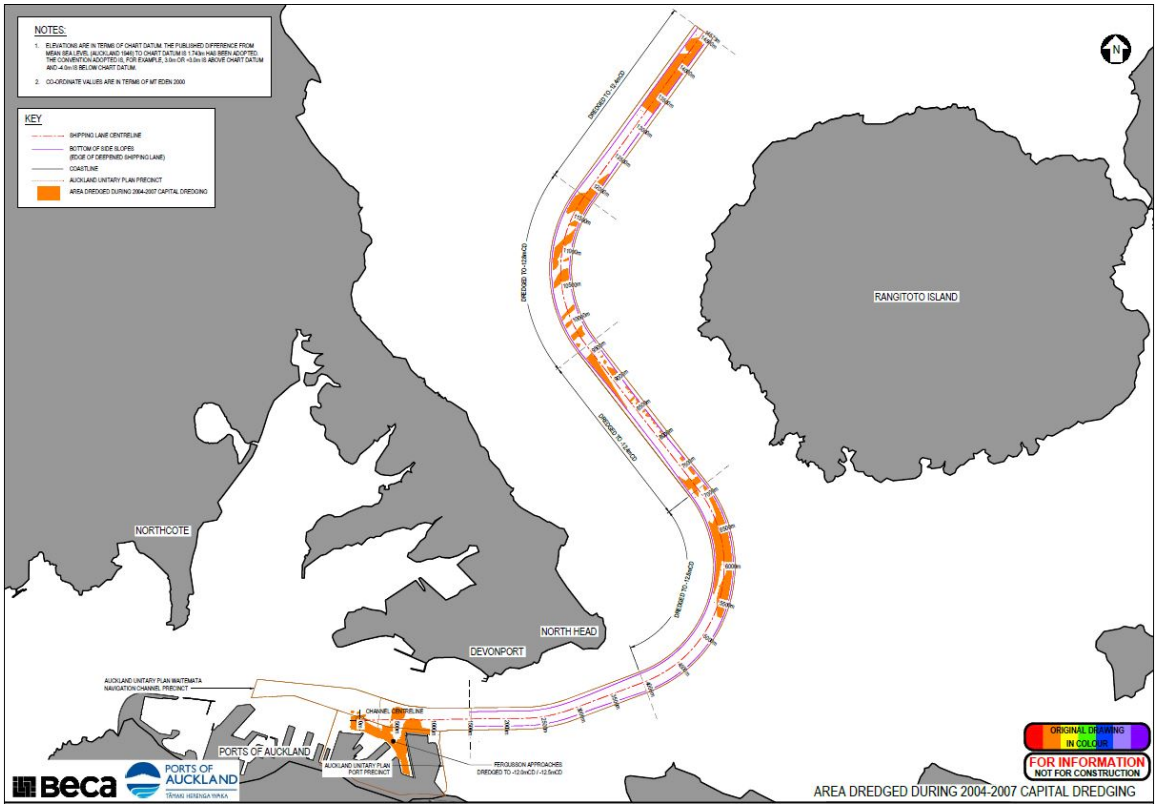


Figure 3: Areas dredged in 2004-2007 (Refer Appendix a of Beca (2019) for full figure).

Any fine sediment that may have been deposited/incorporated into surface sediment would be expected to come from within the POA and from the general Waitematā Harbour. A

precautionary approach would suggest that any finer sediment present at and adjacent to the berth has potential to contain concentrations of contaminants at higher concentrations than would be expected within the wider WHNP.

3.3 Rangitoto Channel

The Rangitoto Channel is not subject to any direct sources of contaminants (e.g., discharges and stormwater). The channel is subject to diffuse/indirect sources of contaminants through, the ebb tidal discharge from the Waitematā Harbour, atmospheric deposition and any litter discharged from commercial and recreational vessel traffic within the channel.

No specific contaminants have been identified (arising from specific sources) that require specific inclusion in the contaminant characterisation program (Section 6). Although the Rangitoto Channel is not "pristine" it is considered essentially uncontaminated in terms of sediment quality assessment as the subsurface sediment was deposited prior to human arrival in New Zealand.

As described in Section 5.4.1, the channel contains wave bedforms. For the purpose of assessing sediment quality, it is assumed that these features are younger than the underlying sediments. The source of contaminants associated with fine sediment within the bedforms remain the same as for general surface sediments, however sediment within the wave bedforms may be slightly older that current surface sediments (but younger than the date they started to form (e.g., some are expected to have formed post 2004-2007).

Dredging has been carried out in the Rangitoto Channel several times over the last 50 years, with older-pre-European sediment becoming the surface sediments. The most recent dredging carried out in the channel was capital dredging over the period 2004-2007 shown in Figure 3 and localised maintenance dredging since 2007.

3.4 Summary

The WCNP is located away from the depositional areas of the port and waterfront area. The port and waterfront receive stormwater from the city commercial catchments resulting in a range of contaminants being carried into the coastal environment. Physico-chemical processes plus the very slow currents adjacent to most stormwater discharge points results in sediment and associated contaminants being deposited close to the outfalls. Although sediment transport out of the harbour results in fine sediment being incorporated into surface sediment within the WCNP, the WCNP is not a depositional environment (hence the sandier and shelly nature of the sediment as described in the following sections).

Much of the area within the WCNP proposed to be dredged was dredged in 2004-2007. This removed the surface sediment present at that time. Surface sediment quality will be influenced by catchment based contaminant sources but underlying sediment is considered to be older, pre-European in age and not impacted by man-made anthropogenic sources (in New Zealand) of contaminants.

4 SEDIMENT SAMPLING

4.1 Introduction

The purpose of the sampling undertaken on 11 December 2019, was to provide additional information on the levels of contaminants in the surface sediments of the WCNP as part of the assessment of effects related to the capital dredging application made by POAL (Bentley 2019).

As noted earlier, disposal of any dredged material at the CDS will require approval by EPA and this will require a separate sediment sampling programme and assessment. That work is underway and while related, is not necessary for the assessment of this dredging consent application.

4.2 Sample Sites

To identify sample locations the overall dredging area was divided into three sub-areas. These comprised:

- The FNB (pocket berth).
- The FNBA.
- The Rangitoto Navigation channel over Sections B through E (for Stage 1). Each section of the Rangitoto Channel dredging is 2,500 m long. The Sections within the channel comprise:
    - Sections B and D which are bends (Appendix A)
    - Sections C and E are straight sections (Appendix A).

For the purpose of identifying sampling locations, a grid was overlain within each area:

- Within the FNB and FNBA, a grid of 20 x 20 m was overlain (to accommodate the scale of the FNB) and cells randomly chosen to provide three samples from the FNB and FNBA. To achieve some spatial separation of sample locations, the following rules applied to selecting grid squares for sampling:
    - There must be at least two cells separating each random sample location.
- Within the Rangitoto Channel, a grid of 50 x 50 m was overlain and cells randomly chosen from within the sub-sections to identify three sample locations within each of sections B through E of the channel. The same rules applied to random location selection.
    - Only one sample per set of cells along the channel (i.e., the cells across the channel).
    - There must be at least two cells separating each sample location.

The random sample locations for the FNB, FNBA and Sub-Sections B through E in the Rangitoto Channel are shown on the grid overlays provided in Appendix A.

All samples were collected within pre-identified cells except one location within the channel which required sampling in an adjacent cell due to repeated non-recovery of a sample by the grab (due to hard surface or large shells).

4.3 Sediment Sampling

Sediment samples were collected using a van Veen grab (provided by Cawthron Institute) mounted in a weighted frame (Figure 4). GPS co-ordinates for the sample locations were pre-determined and used to position the sample location. Upon retrieval of the grab, a photograph was taken of the grab contents (sample photographs are provided in Appendix C). Sediment was sampled from within the grab using a plastic scoop. Samples were taken to a depth of 100 mm with the exception of sample one (which was taken to a depth of 50 mm). Due to the coarse shell nature of the sediment, precise removal of sediment from within the grab was not possible hence the change in sampling method to 100 mm.

Figure 4: Cawthron van Veen grab (image taken from Sneddon 2019).

4.4 Field and Sample Management

Samples were placed directly into new zip-lock plastic bag (double bagged) and placed into a chilly bin containing ice. Following transfer of the sediment the grab and the sample scoop were washed using seawater to remove all residual sediment. The grab was inspected to ensure residual sediment was removed.

No volatile organic compounds were included in the analysis, which would have required glass or non-permeable sample containers (no sample locations were in proximity of sites where volatile contaminants might be generated that could contaminate sediment).

Samples were delivered to Hill Laboratories in Parnell, Auckland at the end of the day of sampling with Chain of Custody.

5 SEDIMENT PHYSICAL CHARACTERISTICS

5.1 Introduction

This section describes the physical characteristics of sediments sampled within the WCNP from areas that dredging is proposed. Within this section, the following information is provided:

- A summary of studies undertaken historically (re-presented from KEL 2019).
- Data obtained from surface sediment samples collected in 2019 as part of ecological sampling (Marlow 2019).
- Further data collected from the FNB, FNBA and the Rangitoto Channel in December 2019 (as part of sediment quality characterisation). Location and sampling methods are described in Section 4).

Information presented below was presented in KEL (2019) and also in Beca (2019) (and associated appendices).

5.2 Nature of Sampling Environment

The Rangitoto Channel and FNBA have been extensively studied. The Fergusson North area was essentially part of the centre of the lower Waitematā Harbour prior to the construction of the Fergusson Container terminal (which was constructed in stages from 1965 following initial port works in this area in 1924 (POAL 1996)).

The WCNP has had extensive bathymetric data as it is the navigation channel to the POA. The nature of the seabed has been examined through surface seabed sampling and geotechnical coring that has been undertaken for construction activity within the POA and the previous navigation channel deepening.

The geology of the lower Waitematā Harbour has been described by Gregory & Thomson (1973a) and the sediments by Gregory & Thomson (1973b) and mapped by Gregory et al. (1994). Much of the available information is summarised in two POAL documents:

- POAL (1996) describes the environment adjacent to the Fergusson Container Terminal (Assessment of Environmental Effects for development of the Fergusson Container Terminal).
- POAL (2001) describes the environment of the navigation channel (the current Navigation Precinct).

Boreholes drilled for the design of the extended Fergusson reclamation and FNB construction (POAL 1996) and earlier, showed that the reclamation is located on a ridge of Waitematā sandstone extending north into the Waitematā Harbour. At the end of the reclamation, marine sediment lies on a sandstone/siltstone surface located at a depth of about 24 m with variable depths of weathered material above that. The weathered Waitematā materials are interbedded and contain some fibrous wood materials. The infilling of the Waitematā River valley occurred as a result of sea-level rise 8,500-16,000 years ago. As such, the sub-surface sedimentary deposits pre-date human arrival in New Zealand.

The majority of the Rangitoto Channel contains sandy mud deposits (varying clay and silt) overlain with shell deposits. Boreholes within the channel have shown that these sediments occur to a depth of 3 m. Seismic reflection survey work carried out by the Institute of Geological and Nuclear Sciences Ltd (IGNS) in 2000 showed that sediments extend to depths of 15 m below seabed where they meet Waitematā Group sandstones and siltstones (Beca 2001a). At the southern end of the channel near number 3 buoy, the Waitematā materials rise close to the seabed. Adjacent to this, an area of Parnell Grit has been identified. The Parnell Grit beds comprise basaltic to andesitic lava and pumice clasts set in a matrix of crystal-rich sand and clay (Allen 2004). These areas are shown in Appendix A and D of Beca (2019)

As with the sediments off the FNB, the area of the Rangitoto Channel was infilled with sediment following the post glacial rise in sea level. At that time, Rangitoto Island had not been formed. The formation of Rangitoto Island from basaltic magma during two eruptions some 600-700 years ago, created the physical Rangitoto Channel. Although the sediments discharged from the Waitematā Harbour are derived from catchment erosion (refer Hume 1983), and these will contribute both sand and fine sediments to the lower harbour and channel environment, the Rangitoto Island shoreline would be expected to contribute some basaltic sand to channel sediment (refer following section).

5.3 Sediment Physical Characterisation Studies

5.3.1 Surface sediment

A range of surface sediment samples have been collected historically from the WCNP and port approaches including:

- Early sampling by Gregory & Thompson (1973a) in the lower Waitematā Harbour and the Rangitoto Channel.
- Sediment samples collected on the eastern edge of the navigation channel and around the northwest shore of Rangitoto Island by POAL (1989a).
- Sampling and sediment physical analysis of 160 surface samples from the Rangitoto Channel (North Shore to Rangitoto Island) and interpretation of sediment processes (Coastal Consultants 2001).
- Consideration of 1997 sampling and analysis of 90 samples from the lower Waitematā Harbour (Coastal Consultants 2001).
- Physical characterisation of four samples from the Port approaches and 23 from the Rangitoto Channel (Kingett Mitchell 2001).
- In 2003-2004 and 2007-2013, surface sediment samples were collected from three locations in the channel as part of monitoring related to studies of seabed recolonisation (Golder 2013).
- Dodds (2009) undertook sampling within and either side of the Rangitoto Channel.
- Sediment samples were collected in 2019 as part of ecological sampling by Marlow (2019) at nine locations (five replicates at each site) in the WCNP (this Application).

- 18 surface samples were collected from the WCNP in December 2019 (described in this report).

5.3.2 Sub-surface sediment

Sub-surface sediment characteristics have been obtained from drilling carried out within the Port approaches and the Channel over the last 25 years and some test pits (Beca 2019a, Appendix D). A seismic reflection survey of the navigation channel was carried out by IGNS (2000). The following sub-surface investigation work has previously been carried out.

- Ten bore holes were drilled in 1993 north of Bledisloe Wharf and Fergusson Container Terminal to depths of between 12 and 20 m below seabed in Waitematā Group materials.
- Four bore holes were drilled near Fergusson Container Terminal to depths of 2 to 4 m below seabed. Seven bore holes were drilled north of Fergusson Container Terminal to depths of 12 to 18 m into Waitematā Group materials.
- Eighteen bore holes were drilled in the Rangitoto Channel in 2000 and 2001. The holes were drilled to depths of 2 to 4 m below sea-bed. Nine test pits were excavated in the Rangitoto Channel seabed to a depth of 1.7 m below seabed.

Nine sub-surface samples were taken from the Rangitoto Channel cores collected in 2000-2001 and examined (for physical and chemical data) by Kingett Mitchell (2001).

5.4 WCNP 2019 Surface Sediment Characteristics

5.4.1 Introduction

Surface sediment characteristics within the areas sampled are determined by local hydrodynamic factors (tidal currents) and water depth:

- From the berth ends northwards to the main Waitematā Harbour Channel, sediments are comprised of more sand and contain more shell material.
- Within the Rangitoto Channel, sediment texture is generally sandy with variable proportions of shell hash at the surface (Kingett Mitchell 2001, Golder 2013).
- Towards the north end of the channel (heading into the Hauraki Gulf, beyond section E within the channel), sediment contain a higher proportion of mud.

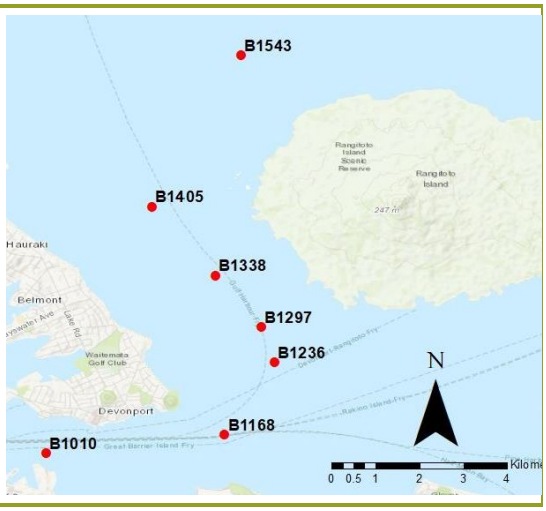
Coastal Consultants (2001) provides background information on the physical processes within the lower harbour and the channel (this report is provided in full as Appendix F of Beca 2019). That study carried out extensive sampling across the entire Rangitoto Channel and adjacent seabed to adjacent shores. The study identified channel wave bedforms (average height 1.37 m) noting that shell material was concentrated on bedform crests interspersed with discrete areas of cohesive fine sand and mud (with less shell) between.

Table 1 provides a summary of the broad textural classes examined in the surface sediment samples collected by Morley (2019). The laboratory report for the recent sampling (December 2019) included in Appendix B, provides the % data for all sand fractions shown in Figure 5 below.

Overall, textural components of the sediments were dominated by coarse shell debris (described further in the following sections) and mud in a small proportion of samples.

Table 1. Sediment textures for surface sediments collected by Marlow (2019).

Site	Mud %	Sand % (dominant sand size)	Gravel % (shell)
1010	20.1 ± 1.5	41.4 (FS and VFS)	28.9 ± 7.9
1168	33.2 ± 6.2	66.5 (VFS)	0.3 ± 0.25
1236	35.9 ± 7.4	47.7(VFS)	16.4 ± 6.8
1297	16.9 ± 2.6	43.6 (FS and VFS)	39.5 ± 11.8
1338	10.0 ± 6.9	61.8 (FS 2 samples)	28.2 ± 27.3
1405	22.7 ± 11.4	52.6 (FS and VFS)	24.7 ± 6.4
1543	28.7 ± 9.8	64.2 (FS and VFS)	7.1 ± 4.2



Notes: All data wt %. N=5 for all locations. Mean mud % determined by difference. Sand five sieve classes, 0.063-0.125 mm (VFS = very fine sand), 0.125-0.250 mm (FS = fine sand), 0.250-0.5 mm, 0.5-1.0 mm, 1-2 mm.

Table 2. Mud, sand and gravel content of sediments from Port approaches and Rangitoto Channel.

	Mud %	Sand %	Gravel %	N
Rangitoto Channel[1]	23.7 ± 13.3 (13.6-57.9)	48.2 ± 14.1 (29.8-48.2)	28.1 ± 18.3 (0.1-53.9)	12
Rangitoto Channel [2]	17.4 ± 15.7 (0.03-64.4)	51.1 ± 21.3.15 (3.6-95.1)	31.5 ± 26.3 (0.03-96.32)	40
FNBA	19.6 ± 18.5 (5.8-40.6)	34.4 ± 10.0 (22.9-40.8)	46.0 ± 25.8 (19.8-71.3)	3
FNB	52.6 ± 28.5 (26-82.7)	28.9 ± 0.0 (14.9-43.7)	18.5 ± 14.4 (2.4-30.3)	3

Notes: All data weight %. 1 – This study; 2 – Kingett Mitchell (2001).[2]

5.4.2 Gravel

As described by Kennedy et al. (2001) (Appendix D of Kingett Mitchell 2001) shells and shell fragments are an important component of the material that has been deposited over time to form the sediment within the channel. KEL (21019) presented photographs of the coarse material (>2 mm) from the sediments collected from the ecological stations by Morley (2019) (locations shown in Table 2 along with a summary of the data). Table 3 identifies gravel content of the 18 samples collected from the three areas sampled and the data from Kingett Mitchell (2001). The coarse material (larger than sand) within the sediment is dominated by shell and other non-mollusc carbonate materials. The shells within the channel are worn and comprise a wide range of mollusc species

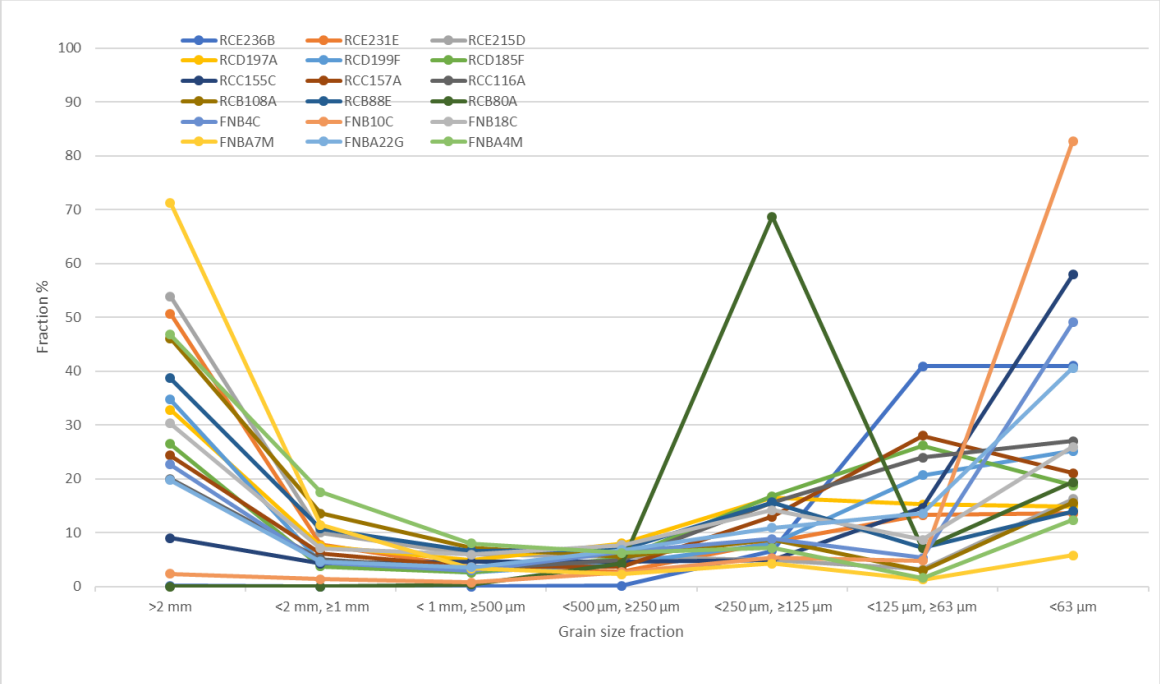


Figure 5: Sediment grain size fractions over the seven fractions examined.

Photographs of the nature of the shell material in the coarse fractions (gravel and coarse sand) are provided in Appendix D and described further in Section 5.6. As shown in Figure 5, the proportion of material >2 mm in size varied from <10 % to over 50 % with 12 of 18 samples having between 20 and 50 % very coarse shelly material.

5.4.3 Sand

Table 1 and 2 summarises sand content of the 18 samples collected from the three sub-areas and for the ecological samples reported in Marlow (2019). Figure 5 shows that medium and coarse sand were minor components of the sediment with fine and very fine sand being more important. One sample located within the south bend (RCB80A) contained a significant proportion of fine sand compared to all other samples. It is assumed that this difference may have arisen from local particle sorting mechanisms.

5.4.4 Mud

Table 2 summarises the mud (silt+clay) content of the 18 samples collected from the three sub-areas. Table 3 summarises sediment textures for surface ecological samples reported in Marlow (2019). At the seven locations samples and reported in Morley (2019), the average mud % ranged from 10-36 %. In the 12 samples collected from the channel in December 2019, the median mud content was 17.4 %.

5.4.5 Summary

Surface sediments within the FNBA, FNB and Rangitoto Channel are dominated by coarse shell material (and some lithic materials). As the approaches and channel are subject to relatively strong currents, the sediments have low proportions of mud. Proportions of mud are higher near the FNBA within the port basins where currents are low (and the area is a depositional environment) and further out within the Hauraki Gulf (beyond Section E of the channel) (where water is deeper and the environment is more depositional).

Overall, sediments to be dredged are predominantly shelly and sandy in nature. One sediment sample from the FNB contained a high proportion of mud compared to other samples collected.

5.5 Subsurface Sediments

5.5.1 Waitematā materials

Logs of drilled sediment cores drilled within the Rangitoto Channel, are provided in BCHF (2001a). Surface sediments to depths of 1 to 2 m were described as Pleistocene sediments (BCHF 2001a; Appendix E1 of POAL 2001). These sediments correspond to the material to be dredged within the channel.

As noted in Section 3.1 and 3.3, the geology of the Waitematā Harbour has been well studied. Waitematā group rocks underlie sediments in the harbour and channel. The depth to this material is dependent on the underlying landform. The material is mainly weak Waitematā Series siltstone and sandstone (Balance 1964) with zones of Parnell grit (coarser sandstone or fine conglomerate). The sandstone and siltstone of the Waitematā Series are the predominant regional geology and dominate sediment geochemistry. The Parnell grit are volcanic in origin and are found throughout the Auckland area. The deposits contains volcanic material, pumice clasts, sedimentary debris (Allen 2004).

In the 2000-2001 investigations, rock was encountered in two sections of the Rangitoto Channel at depths which will be reached during the Stage 1 and Stage 2 dredging. Further investigation in 2019 by Beca (Beca 2019a, Appendix D), confirmed that there are two areas within the channel where Waitematā Series material will be excavated by the dredger. Beca (2019, Appendix D) illustrates the locations of Waitematā Series material in plan and long section.

5.5.2 Sampled materials

As shown in Table 3, the 2001 core sediment samples had variable textures ranging from fine through to coarse material. The data provided in Table 3 is for ‘sediment’ not sandstone and other geological material such as Parnell grit. Although there is grain size data for sandstone, the disaggregated particulate sizes do not apply to the in-situ materials post dredging.

Shell gravel content in the sub-surface sediment samples from the channel (max 18.5 %) was lower than the surface sediment average (28.1 %) from the December sampling and average (31.5 %) from the 2001 sampling.

Table 3. Sediment textures in sub-surface cores from the Rangitoto Channel (from Kingett Mitchell 2001).

	Rangitoto Channel core sediment samples (categorised by mud content)		
	Coarse material	**Intermediate**	**Fine material**
Mud %	15.61 (13.54-18.59)	34.6 (29.51-38.96)	75.69 (71.81-79.57)
Sand %	77.3 (73.41-80.13)	54.84 (42.58-66.94)	23.19 (19.32-27.05)
Gravel %	7.3 (3.06-13.45)	10.57, (3.32-18.47)	1.12 (1.11-1.13)
No. samples	3	4	2

Notes: All data, % dry weight. The 2001 samples were grouped into fine and coarse samples based on mud percentage with coarse material having low mud and high sand percentages and fine sediments having high mud and low sand percentages. The proportion of coarse material (mostly shell) varied between samples.

5.5.3 Summary

Overall, subsurface materials within the WCNP have variable physical characteristics based on the Kingett Mitchell (2001) assessment. Samples were both shelly and muddy reflecting the variability seen in surface sediments over time.

5.6 Nature of Coarse Material

5.6.1 Gravel fraction

The gravel fraction (>2 mm) and the very coarse sand fraction (1-2 mm) of each sediment sample was examined to provide information on the nature of the coarse material in the sample and to identify whether man-made objects contributed to the nature of that material. Appendix D provides photographs of the >2 mm (gravel) and Appendix E photographs of the 1-2 mm fraction of the samples collected in December 2019.

The material found in the December 2019 sediment samples and those described in KEL (2019) are almost entirely natural, comprising mainly of shell but with occasional to common geological material (sand and fine gravel sized materials) as shown in Figure 5 and described below. Most samples did not contain any readily identifiable man-made material (e.g., glass, tin-foil, plastic fragments and pieces).

- The larger (>2 mm) coarse shell material comprises a wide variety of bivalve and gastropod mollusc shell along with carbonate skeletal material from other biota (echinoderm tests, coraline species etc.). The material includes whole valves of fragile shells, relatively worn and very old weathered whole and nearly whole shells of various sizes. Non-shell material from the Rangitoto Channel also contains gravel sized material most of which appears to be of volcanic origin. In the FNB and FNBA samples, well rounded and angular sedimentary gravel is present. It is likely that this material has been derived from exposed harder sandstone Waitematā material that has become rounded by local movement along the seabed. This material is also bored by benthic biota. A few sedimentary gravel pieces appeared darker (grey to brown) (e.g., sample 18) and their geological source (natural or man-made) was not confirmed.

- No significant numbers of man-made materials were identified in the >2 mm fraction. No glass or plastic was seen. Several samples had fragments of what was classified as “coal” or “smelter” type”. The former typically angular and shiny and the latter (e.g., sample 8 (Figure 6 and detail of material in Appendix D)), globular. Sample 15 (from the FNB) contained the only unidentified object (non-metallic) which was considered to be man-made.

Sample 2

Sample 8

Sample 18

Sample 13

Figure 6. Examples of >2 mm fractions from the Rangitoto Channel and off the FNB (refer Appendix D for all photographs).

Although not identified in the surface samples collected some man-made glass fragments might be expected along with heavy man-made objects such as ceramic, pottery and metal. Muller-Karanosso et al. (2019) visually identified antifouling paint particles (APPs) amongst coarse particles >2 mm in size from estuaries in south-west England (Plym estuary and other sites).

5.6.2 Coarse sand fraction

As shown in the photographs in Appendix F, (defined as 1-2 mm noting that fragments with at least one dimension smaller than 2 mm will pass through the mesh with the other dimension being longer)

- The coarse sand sized material in all samples comprised whole single valves (from bivalves) or whole small gastropod shells and shell fragments. These can be seen in the example images provided in Appendix E.
- The RC samples contained occasional to frequent volcanic rock grains.
- The FNB and FNBA samples (13-18) contained coarse sand sized Waitematā materials along with some volcanic grains.
- The only presumed man-made objects were seen in sample 2 from the northern section of the channel (a smelter type globular object) and sample 16 from the FNBA (an angular green 'plastic or foil" material).

In the Plym estuary study noted above, a greater number of APPs were seen in 1-2 mm fraction of sediment compared to particles above 2 mm in size. No APPs were seen in any of the samples visually examined from the WCNP providing a general indication of the rarity of such material in the larger sand fractions.

5.6.3 Plastics in New Zealand

The distribution of man-made objects especially plastics in intertidal sediments has been described in New Zealand. Plastic granules on New Zealand Beaches were examined by Gregory (1978), microplastics on Canterbury beaches (>0.032 mm, Clunies-Ross et al. 2016) and Auckland beaches (Parker et al. 2019). Both recent studies identified a range of fibre and fragment/bead shaped plastics. Plastics are seen more commonly in intertidal sediment due to their low specific gravity (compared to seawater).

Subtidal sediments in the Waitematā and Hauraki Gulf have been examined for man-made objects in previous POAL studies. Sediments examined from Mechanics Bay (area on east side of Fergusson container terminal) by POAL (1989b) were found to contain some coal and clear/coloured glass and occasional paint flake in the >2 mm fraction. Examination of subtidal sediment around the Rangitoto shores samples identified a range of man-made objects (POAL 1989a). Some sediments in the Hauraki Gulf (POAL 1992), were found to contain coal and clinker (welded appearance) fragments in the coarse and fine sand fractions.

5.6.4 Sub-surface sediment

There is little likelihood that the sub-surface sediments dredged from the WNCP (which will constitute the bulk of the capital works) contain anthropogenic objects as the sediment pre-dates arrival of Europeans in New Zealand.

5.6.5 Summary

Overall, the sediments sampled from the navigation channel section of the WNCP contains little anthropogenic debris. Few large man-made objects were identified. Although not identified in samples collected some man-made materials such as glass, ceramic, pottery and metal might be expected to be present.

5.7 Summary

Surface sediments within the WCNP are dominated by coarse shell material (and some lithic materials). As the approaches and channel are subject to relatively strong currents, the sediments have low proportions of mud. Proportions of mud are higher near the FNBA within the port basins where currents are low (and the area is a depositional environment) and further out within the Hauraki Gulf (beyond Section E of the channel) (where water is deeper and the environment is more depositional). The coarse sand fraction is dominated by very small whole shells and fragments. Overall, sediments from the WCNP to be dredged are predominantly shelly and sandy in nature. One sediment sample from the FNB contained a high proportion of mud compared to other samples collected.

Overall, surface sediments from the navigation channel section of the WNCP contains predominantly coarse shell material, which also makes up a significant part of the sand fraction (refer section 5.4) and little anthropogenic debris. Although not identified in samples collected some man-made materials such as glass, ceramic, pottery and metal. . In the coarse sand fraction, the only presumed man-made objects were a smelter type globular particle and a, angular green 'plastic or foil" object.

6 PREVIOUS SEDIMENT QUALITY ASSESSMENT

6.1 Introduction

Historical sediment sampling and contaminant characterisation has been summarised by Golder (2018). The previous sampling, physical and chemical characterisation within the proposed dredging area was carried out in 2001 by Kingett Mitchell (2001). Limited sampling was also carried out by POAL (1989a) but that information is not reviewed in this report. The Kingett Mitchell (2001) sampling included surface sediment sampling (depth about 150 mm) and a series of samples obtained from geotechnical cores obtained from the Rangitoto Channel at depths to 3 m (exact depths of samples not reported in Kingett Mitchell 2001). Figure 7 shows the location of the transects sampled (for ecology) by Kingett Mitchell (2001).

The four samples which had data from Transects A and B (no data for transect C), are technically within the Port Precinct rather than the WCNP. Table 4 provides a summary of the combined surface and sub-surface data collected previously from the Rangitoto Channel. Some of this data was summarised in KEL (2019). In this section the data is re-presented with some additional interpretation.

6.2 Rangitoto Channel

Surface sediment samples collected by Kingett Mitchell (2001) were to a depth of 150 mm. Ecological sample locations (not all were used for sediment quality analysis) are shown in Figure 7. The 2001 sediment quality results showed that all trace element concentrations were below the ANZECC (2018) DGV except for:

- Two surface sediment samples from a transect (transect I in Kingett Mitchell 2001, Figure 7) off Rangitoto which contained 32 and 34 mg/kg Ni (above the DGV of 21 mg/kg). The cause of the elevated nickel concentrations was not identified at the time but was considered to have arisen from volcanic sand in the sample (discussed again in Section 7.3.10).
- One surface sample from transect K which contained 0.18 mg/kg mercury (DGV 0.15 mg/kg). The cause of the elevation was unknown.

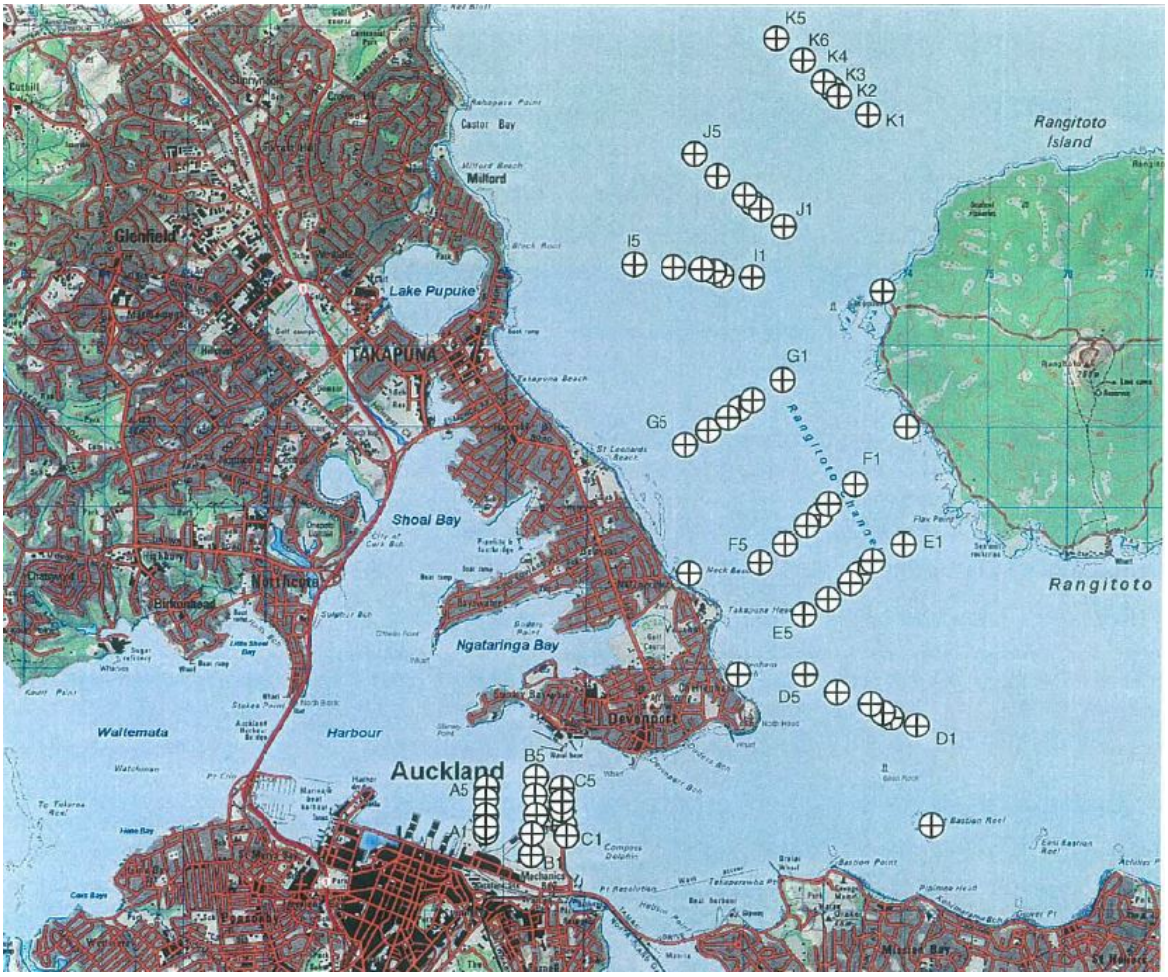


Figure 7: Transects sampled by Kingett Mitchell (2001).

- Concentrations of organochlorine pesticides (OCP) in composite samples (three surface and one sub-surface) were low and typically non-detectable with total PCB <3 µg/kg and all organochlorine pesticides <0.1 µg/kg. The only exception was detectable concentrations of 4,4' DDT in the transect K composite (0.3 µg/kg) which was lower than the DGV of 1.2 µg/kg. 4,4' DDD was detected in composite samples from transect F (0.2 µg/kg) and K (0.7 µg/kg) but below the ANZECC (2018) DGV of 3.5 µg/kg.
- Concentrations of individual PAH compounds in four composite samples (thee channel and one approaches) were reported as <0.01 mg/kg in the 2001 study. When compared to other data, the concentrations reported appear low and are not discussed further.
- No TBT analysis were undertaken in the 2001 examination of channel sediment samples.

6.3 Port Approaches

Kingett Mitchell (2001) reported data for sediment samples collected in the berth approaches between Fergusson Terminal and Bledisloe Wharfs but not specifically within the area of proposed dredging off the FNB. This location is however considered likely to be very similar to the sediment within the area proposed to be dredged off the FNB.

Table 4. Summary of previous sediment quality analysis from the Rangitoto Channel & Port Approaches (From Kingett Mitchell 2001).

Constituent		Mean	Range	Number of samples	ANZECC (2018) DGV
Arsenic	Surface	5.1	3.9-6.2	11	20
	Sub-Surface	6.7	5.7-7.7	3	
Cadmium	Surface	<0.2	-	11	1.5
	Sub-Surface	<0.2	-	3	
Chromium	Surface	18.8	14-25	11	80
	Sub-Surface	19	16-24	3	
Copper	Surface	7.2	3-23	27	65
	Sub-Surface	5.1	3.8-6.6	9	
Lead	Surface	13.3	2.1-43	27	50
	Sub-Surface	5.8	3.7-12	9	
Mercury	Surface	0.10	<0.05-0.27	11	0.15
	Sub-Surface	<0.05	-	3	
Nickel	Surface	12.6	6.1-33	11	21
	Sub-Surface	8.6	7.4-9.8	3	
Zinc	Surface	56.2	34-111	27	200
	Sub-Surface	40.8	33-53	9	

Notes: Blue highlights indicate individual concentrations that exceed the ANZECC (2018) DGV. The 11 samples includes 7 samples from transects D through K and 4 samples from Transects A (A1 and A2) and B (B1 and B2) within the Port (Figure 6). Sub-surface samples are from within the Rangitoto Channel.

The four surface sediment samples analysed comprised two sandy samples (~17 % mud) and two muddy samples (89 % mud). The muddy samples are likely to be more representative of the immediate berth areas (within the Freyberg – Fergusson Container Terminal) than the approaches further out into the harbour (being dredged in the proposed capital works). The results of the analysis of the four surface sediment samples collected from this area were:

- All trace element concentrations were below the ANZECC (2018) DGV apart from one surface sediment (sample 1 from Transect B in Kingett Mitchell 2001) which contained 0.27 mg/kg mercury (average concentration for the four approaches samples was 0.13 mg/kg (0.06, 0.09, 0.11 mg/kg plus the sample with 0.27 mg/kg).
- The muddy sample B1 contained higher zinc concentration (111 mg/kg) compared to the other three samples (52, 91 and 91 mg/kg). All concentrations were below the DGV of 200 mg/kg. Sample B1 also contained a higher copper concentration (23 mg/kg) compared to the other three samples from that area (11-13 mg/kg). All copper concentrations were below the DV of 65 mg/kg. The higher concentrations in sample B1 from 2001 are more representative of soft sediment within the berth areas rather than the approaches.

- Concentrations of PCBs and organochlorine compounds were examined in one composite sample (Transect B in Kingett Mitchell 2001).
- Total PCB <3 µg/kg and all organochlorine pesticides including DDT congeners <0.1 µg/kg were lower than their DGV concentrations.
- .

Overall, sediment sampled from the Rangitoto Channel in 2001 (Kingett Mitchell 2001) contained low concentrations of most trace elements. A few samples contained elevated nickel concentrations which were considered natural and one sample contained an elevated mercury concentration of unknown cause. The 2001 samples collected away from the berth areas contained low concentrations of trace elements.

7 WCNP 2019 SEDIMENT QUALITY

7.1 Introduction

Sediment quality physical and chemical analysis follows historical analysis undertaken by POAL within the port and within the Rangitoto Channel. It follows the requirements of Appendix 1 of MDC EEZ400011 and the requirements of MSA (1999). Sediment quality characterisation should be sufficient to account for any known or suspected sources of contamination and the contaminants associated with the (historic and current). Table 5 provides a summary of analysis undertaken on samples collected compared to the recommendations of MSA (1999) and requirements of the MDC. The table also identifies parameters that have ANZECC (2018) sediment quality guidelines.

Some additional analysis was undertaken on the six sediment samples from FNB and FNBA as a result of queries raised in relation to the effect of key “events” within the city stormwater catchment (and what effect they may have on sediment quality). Analysis included a range of semi-volatile organic compounds including phenols and phthalates. The area of dredging within the FNBA is some 1,500 m away from the point of stormwater discharge (during the Sky City fire).

7.2 Total Organic Carbon

Total organic carbon (TOC) concentrations were not measured in sediment from the channel by either POAL (1989a) or Kingett Mitchell (2001). TOC is generally well correlated to particle size with muds having the highest TOC concentrations. Sandy sediments within the lower Waitematā Harbour have concentrations of TOC of around 0.5 % with concentrations increasing to about 2.0 % in the Hauraki Gulf (POAL 1990, 1992). Sediments sampled within the Port which have mud concentrations of the order of 85 %, have TOC concentrations of about 1.5 % (Golder 2018a). More variability is expected in surface sediments where some natural organic detritus may be incorporated compared to sub-surface sediments.

Table 5. Summary of non-toxicant and toxicant analysis considered and proposed for sediments sampled from Fergusson North berth and Rangitoto Channel.

MSA (1999) action list	ANZECC (2018) toxicants (guidance)	MDC Appendix 1 Minimum requirements	Analysis carried out on WNCP sediment samples.
Non-toxicants			
Total organic carbon (TOC)	No	Yes	Yes
Trace elements			
Antimony	Yes	No	No
Arsenic	Yes	Yes	Yes
Cadmium	Yes	Yes	Yes
Chromium	Yes	Yes	Yes
Copper	Yes	Yes	Yes
Lead	Yes	Yes	Yes
Mercury	Yes	Yes	Yes
Nickel	Yes	Yes	Yes
Silver	Yes	No	No
Zinc	Yes	Yes	Yes
Hydrocarbons			
Total petroleum hydrocarbons	Yes	Yes	Yes, as C7-C44 in seven bands.
Polycyclic aromatic hydrocarbons (13 individual PAHs)	Yes (Total PAH only)	Yes	Yes, 18 individual PAH [plus two methylated naphthalene's] as per Simpson et al. (2013).
Organochlorine compounds[1]			
Polychlorinated biphenyls (PCB)	Yes (Total PCB)	Yes	Yes, 35 congeners.
Organochlorine pesticides[1]		No	
Hexachlorobenzene	-	-	Yes
p,p' DDD	Yes	-	Yes
o,p'+p,p' DDE	Yes	-	Yes
Total DDT	Yes	-	Yes
Dieldrin	Yes	-	Yes
Chlordane	Yes	-	Yes
Lindane	Yes	-	Yes
Heptachlor	-	-	Yes
Aldrin	-	-	Yes
Endrin	Yes	-	Yes
Other Organic compounds			
Phthalates	No	No	Yes (FNB approaches only)
Tributyl tin (TBT)	Yes	Yes	Yes
Radionuclides	No	No	No

Notes: 1 - Organochlorine pesticides also includes endosulfan (1,2 and sulphate), endrin aldehyde and ketone, heptachlor epoxide, methoxychlor as part of broad OCP analytical suite provided by laboratory.

The mean TOC concentration in the 18 sediment samples from the WCNP was 0.465 % (range 0.2-0.99 %). Overall, the amounts of organic matter (or TOC) present appear typical of the type of sediment. The coarse components of the sediment contain minimal to no particulate organic matter organic matter apart from living biota. The sediment does not show any indication of containing excess due to addition of organic matter from sources such as stormwater and wastewater.

7.3 Trace Elements

7.3.1 Introduction

Trace element concentrations have been measured previously in surface sediment in the Waitematā Harbour and Rangitoto Channel (refer Section 3.2), in the Hauraki Gulf. In KEL (2019) some of this data was summarised. In this section the data is re-presented with some additional interpretation. When comparing trace element concentrations between studies, the data needs to have been obtained using the same or similar extraction techniques and the same grain size fraction should have been used (e.g., <2 mm, <0.5 mm or <0.063 mm). For the study data compared in this section:

- The December 2019 survey samples were digested using US EPA Method 200.2 (nitric/hydrochloric acid). Samples were air dried at 35°C and <2 mm fraction used.
- The Kingett Mitchell (2001) sediment samples from the Rangitoto Channel were examined on <2 mm fraction with extraction using US EPA method 3112 (modified) using nitric acid/hydrogen peroxide digestion (high pressure microwave US EPA method 30151).
- The POAL February 1991 samples (POAL 1992) from the Hauraki Gulf were examined on <2 mm fraction, air dried, with copper, lead and zinc analysed after extraction using nitric and perchloric acid digestion. Mercury was extracted using as received sediment and nitric/sulphuric/permanganate/persulphate digestion. Other elements were determined using a dilute acid extraction and as such that data is not utilised for comparison.
- The POAL April 1990 samples (POAL 1990) from the Hauraki Gulf were examined on <2 mm fraction, air dried, with aluminium and trace elements analysed after extraction using nitric and perchloric acid digestion. Mercury was examined with a lower precision and is not reported here. Cadmium and chromium data results do not appear 'comparable' and are not reported here. The cause of the relative difference is not known.
- POAL (1989a) examined sediments within and adjacent to the Rangitoto Channel. All trace element analysis with the exception of mercury was undertaken using dilute acid extraction. Mercury was determined as per the POAL (1991) survey samples.

7.3.2 Assessing contaminant concentrations

In the following sections, the concentration of trace elements in the 18 sediment samples collected in December 2019 are summarised and discussed. In the absence of contamination, the concentration of any given element in the sediment is influenced by a range of factors. Grain size distribution (proportions of clay, silt, sand and the distribution of different size classes

of sand) has a key influence on concentration with concentration of many elements increasing naturally as the proportion of silt and clay increase in the sediment.

Over this primary influence mineralogical factors have additional influences. For example, some heavy minerals can be found in particular sand sized particles (which are influenced by particle sorting) and this may increase the concentration of some elements in the sand fraction and the amount of quartz in the sand fraction may reduce the concentration of some elements. In sediments with abundant shell (as in the sampled sediments), the presence of shell carbonate in the material finer than 2 mm will also introduce variability to measured concentrations.

For many elements the concentration is typically low in the shell compared to the sediment so the shell dilutes the whole sample concentration producing lower concentrations in the sample. Data for trace elements in mollusc shell, indicates that natural incorporation of trace elements is dependent on ionic radius (the calcium in aragonite has 9 fold co-ordination compared to 6 fold in calcite and this influences what elements are incorporated into the matrix (Piwoni-Piorewicz et al. 2019)). This allows larger cations (such as strontium and manganese) to become incorporated but smaller cations such as copper and zinc to a lesser extent (Onuma et al. 1979). Carbonate is discussed in section 6.3.3 below.

For each element, the concentration is plotted against the mud content % and the aluminium concentration. For each element, the comparative information included in each graphic differs depending upon the available information. Aluminium concentration data was only available for a number of the studies reducing the number of data sets that could be included when aluminium was used as the normalising element. Aluminium concentrations were available for the Hauraki Gulf data set (POAL 1990) used in the graphics (for other elements) where concentrations are compared to mud %, however, the aluminium concentrations in these muddy sediments are much higher than in other more recent data due to the different acid extraction utilised.

Figure 8 shows the relationship of mud % and aluminium in the samples collected in December 2019 along with samples collected from the port over 2016-2017 (Golder 2018). In the following figures the sediments sampled from the WCNP are presented on graphics so the three sub-groups of sediments (FNB, FNBA and RC can be seen).

Data for sediments sampled within the port berths from sampling carried out over 2016-2017 is included for a number of elements that are not considered to be elevated due to catchment activities (hence these results are not included in the graphics for cadmium, copper, lead, mercury and zinc).

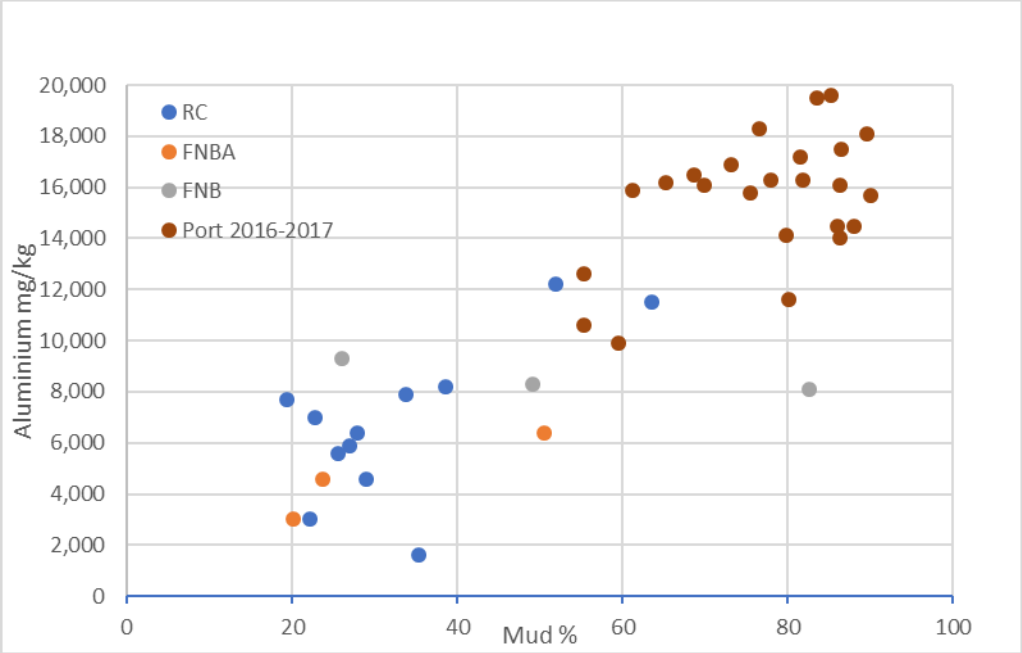


Figure 8: Relationship between aluminium and the mud (silt + clay) content of sediment samples.

7.3.3 Carbonate content

As described in Section 4 the sediment samples contain significant amounts of shell material. Analysis of carbonate-content (by acid-dissolution) was carried out (on the <2 mm fraction) to provide information that might assist interpretation of any lower element concentrations in the data set. The analysis (data is provided in Appendix B) showed that the mean and median concentrations were 38.4 % and 32.5 % respectively (range 5.8-80.0 %).

Although a visual examination of the amount of carbonate in the <2 mm fraction (all sand) and the total amount of sand or mud suggested a poor relationship (Figure 9), the correlation (positive) for sand/carbonate was significant (Pearsons R, $p<0.05$). The correlation (negative) for aluminium/carbonate was also significant.

For the elements measured in this assessment, examination of the carbonate and trace element relationship did not reveal any obvious influences. Most elements displayed a graphical distribution with lower and high concentrations in samples containing <20 % carbonate and lower concentrations in the three samples containing carbonate >70 %. It is likely another unaccounted for factor is reducing or increasing the concentration of some elements in the sand fraction.

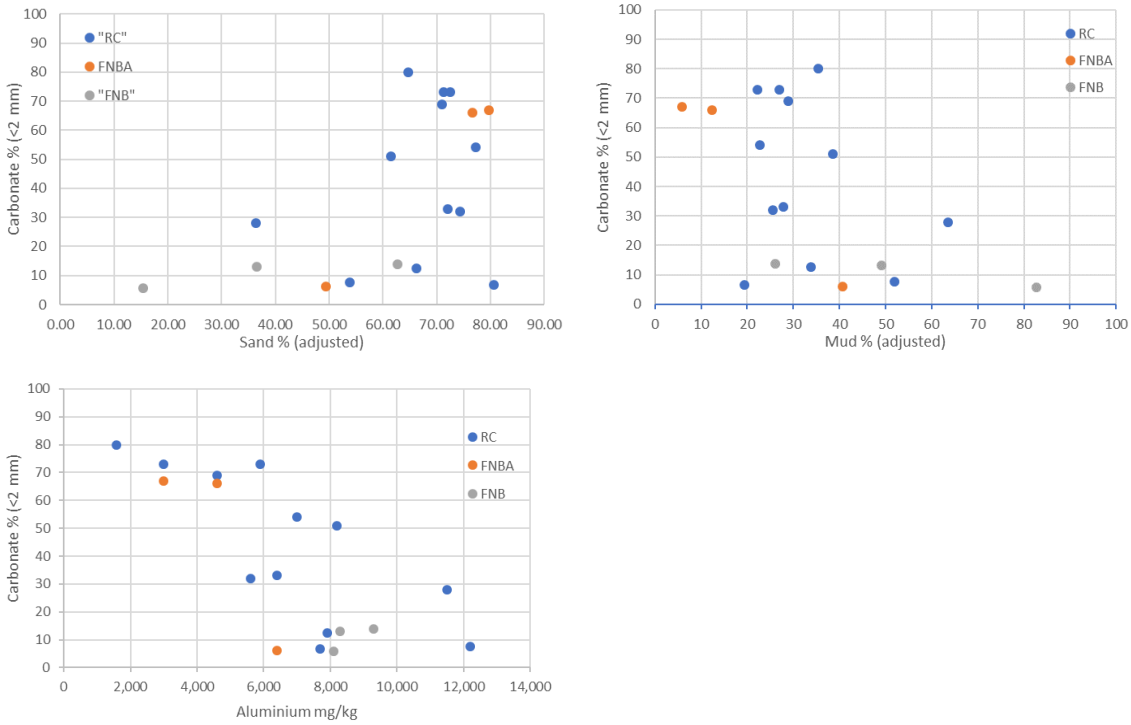


Figure 9: Carbonate concentrations in WCNP sediment.

7.3.4 Arsenic

Figure 10 illustrates arsenic concentrations in the three areas of Navigation precinct sediments plotted against their adjusted mud content (the % mud is the % in the sediment fraction <2 mm in size, the grain size used in the analysis) and aluminium concentration. Mean concentration of arsenic in the 18 samples collected in December 2019 was 5.0 mg/kg (range 1.3-8.1 mg/kg). Plots of arsenic and aluminium provide a good visual indication that the concentrations do not reflect any significant anthropogenic additions. All concentrations of arsenic were below the ANZECC (2018) DGV of 20 mg/kg.

7.3.5 Cadmium

Figure 11 illustrates cadmium concentrations in the three areas of Navigation Precinct sediments plotted against their adjusted mud content and aluminium concentrations. Mean concentration of cadmium in the 18 samples collected in December 2019 was 0.022 mg/kg (range 0.010-0.045 mg/kg). Concentrations of cadmium were low in all samples and below the ANZECC (2018) DGV of 1.5 mg/kg.

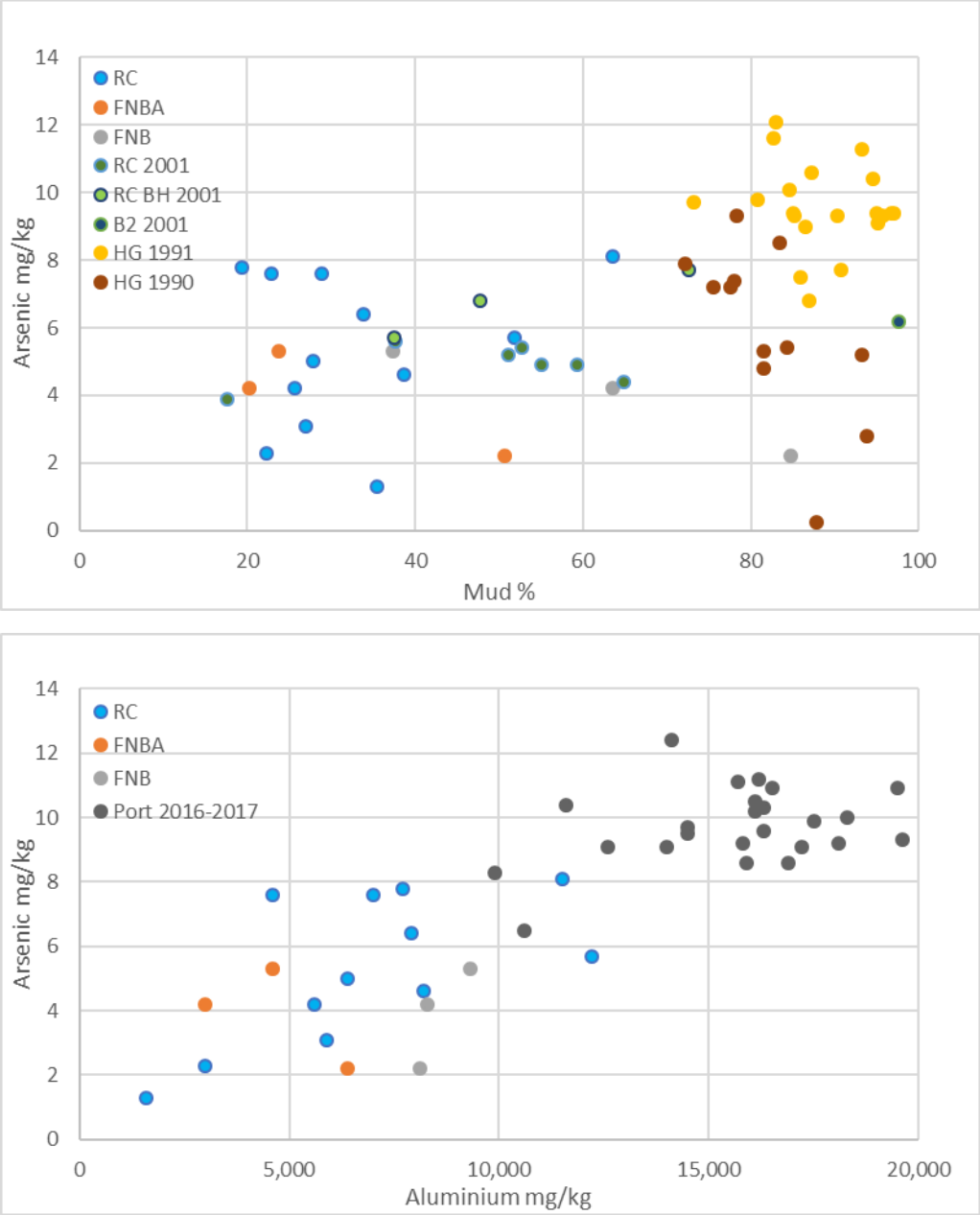


Figure 10: Arsenic concentrations in WCNP sediment samples and comparative information.

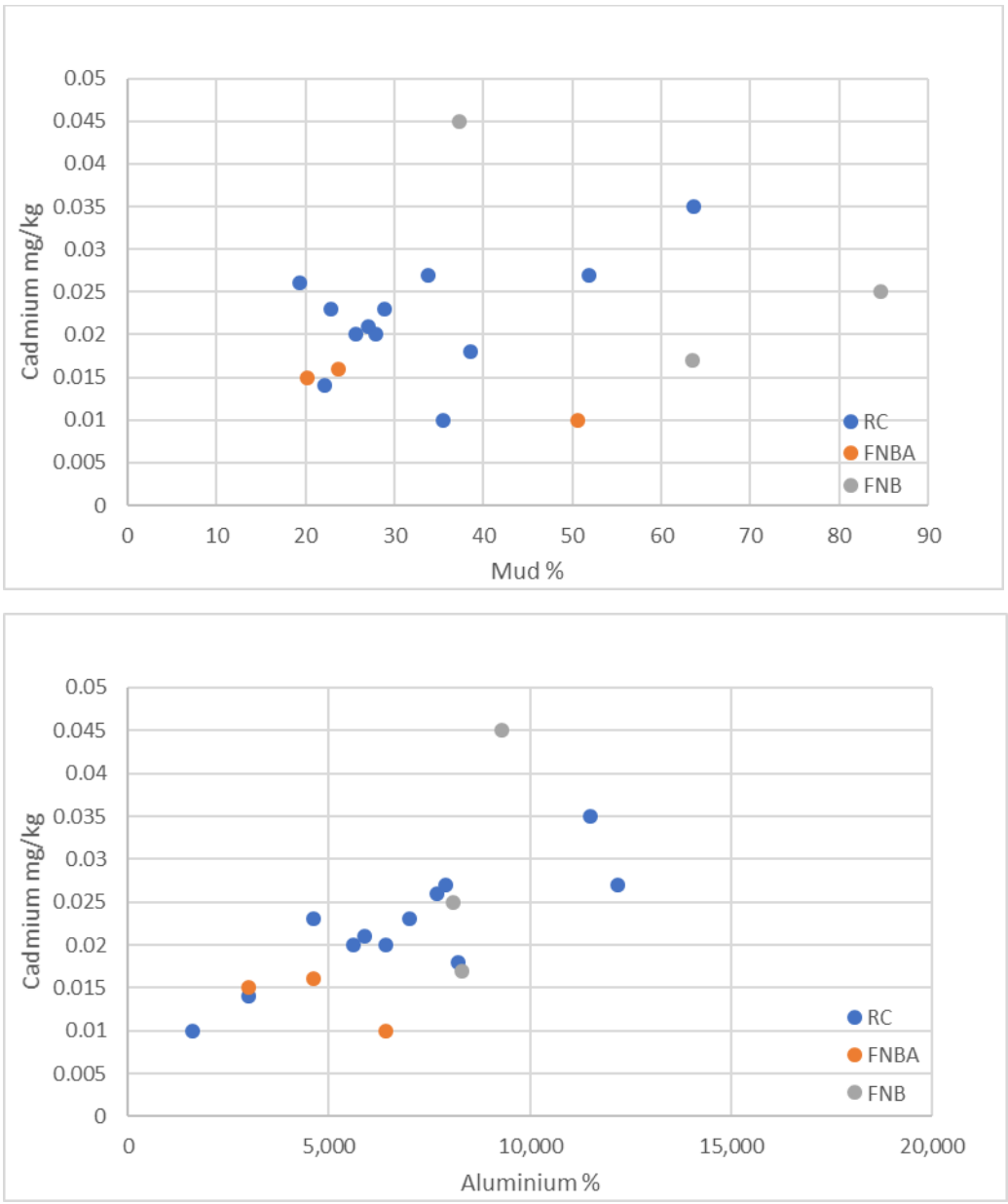


Figure 11: Cadmium concentrations in WCNP sediment samples.

7.3.6 Chromium

Figure 12 illustrates chromium concentrations in the three areas of Navigation Precinct sediments plotted against their adjusted mud content and aluminium concentrations. Mean concentration of chromium in the 18 samples collected in December 2019 was 9.9 mg/kg (range 3.5-15.0 mg/kg). It is likely that chromium concentrations vary with lower concentrations in sandy sediment and higher concentrations in muddy sediment. It is likely that there is little anthropogenic chromium in the sediment samples. All concentrations were below the ANZECC (2018) DGV of 80 mg/kg.

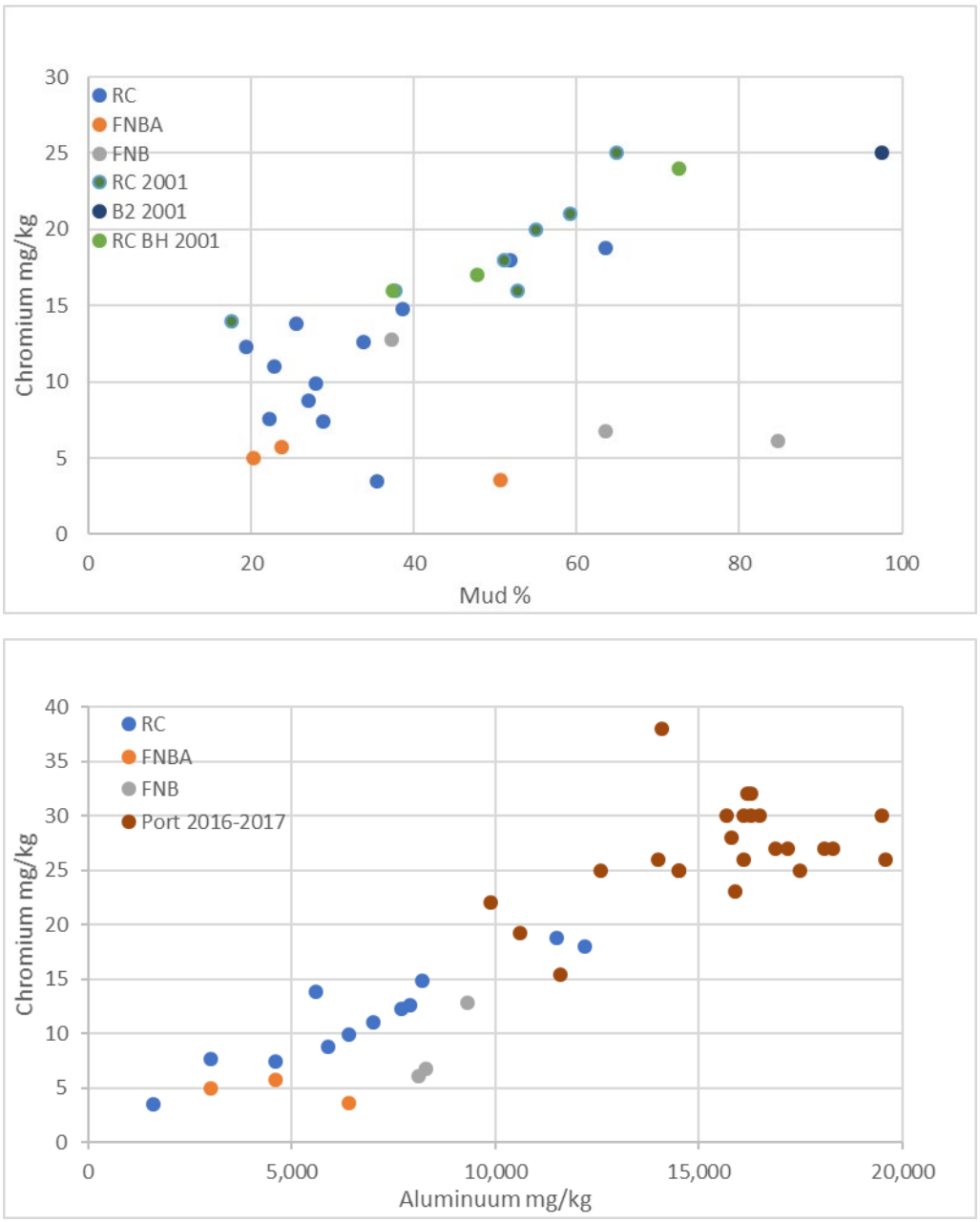


Figure 12: Chromium concentrations in WCNP sediment samples and comparative information.

7.3.7 Copper

Copper is a common metal in urban environments and in stormwater. Figure 13 illustrates copper concentrations in the three areas of WCNP sediments plotted against their adjusted mud and aluminium concentrations. Mean concentration of copper in the December 2019 samples was 4.4 mg/kg (range 1.2-8.1 mg/kg). Examination of the concentration data in Figure 12 includes concentrations for sediment samples collected in the Waitematā and Gulf since 1990 provides an indication that much of the copper in the sediment is natural with higher concentrations in muddy sediment and lower concentrations in sandy sediments. Given the prevalence of copper in stormwater and stormwater sediments along with its use in

antifoulants, some anthropogenic copper is likely to be present in surface sediments. All concentrations in surface sediments were lower than the AZECC (2018) DGV of 65 mg/kg.

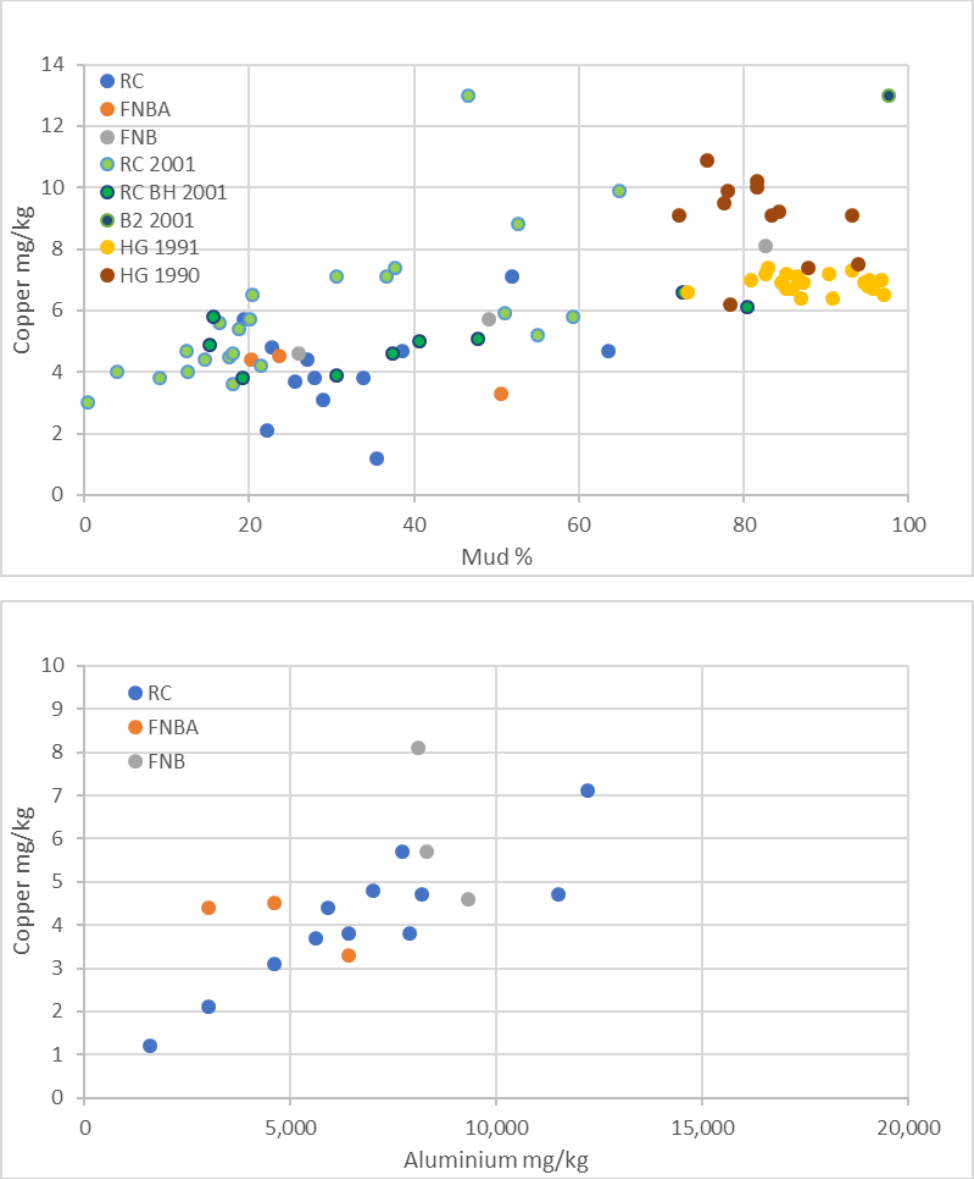
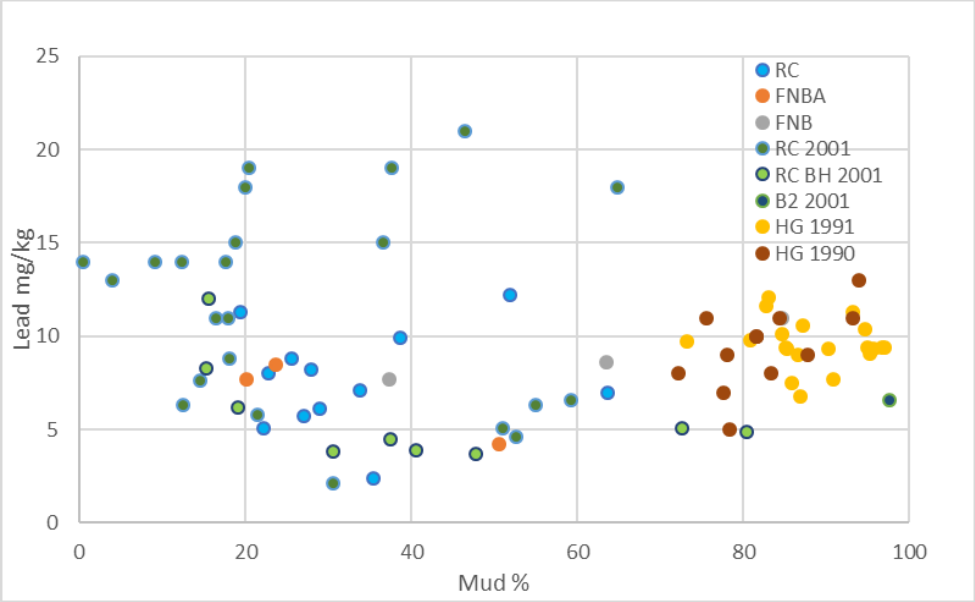


Figure 13: Copper concentrations in WCNP sediment samples and comparative information.

7.3.8 Lead

Figure 14 illustrates lead concentrations in the three areas of WCNP sediments plotted against their adjusted mud content and aluminium concentrations. Mean concentration of lead in the sediment samples was 7.8 mg/kg (range 2.4-12.2 mg/kg).



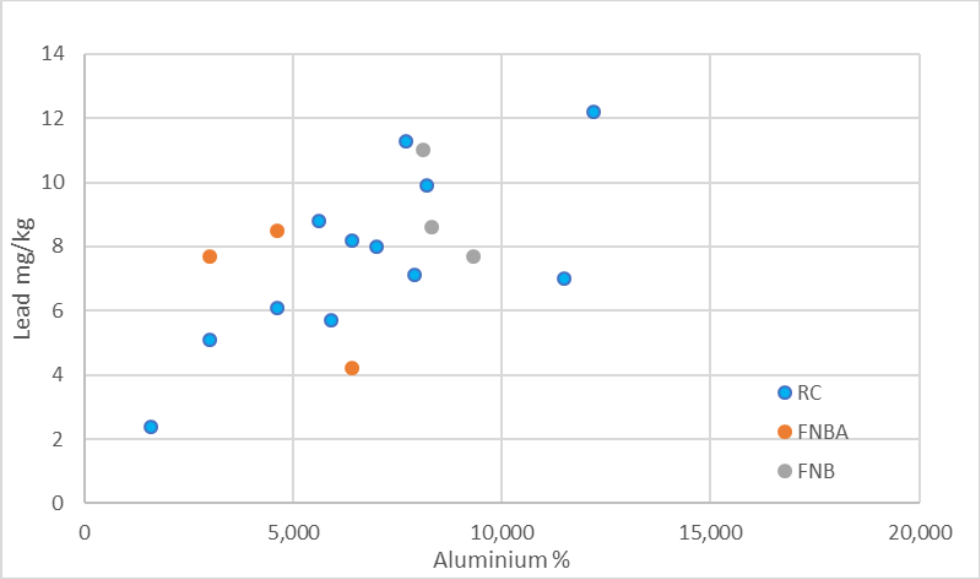


Figure 14: Lead concentrations in WCNP sediment samples and comparative information.

Examination of the concentration data in Figure 14 shows that the concentration of the surface sediment collected in December 2019 is lower (lowered by 40 %) than that collected in 2001 from the Rangitoto Channel in 2001 when the mean concentration was 13.3 mg/kg. A similar decrease has been seen in the muddy sediments within the port and waterfront areas (POA five yearly surveys). The historic use of lead (in vehicle fuels and historic uses) has left an imprint in remote locations globally and in seabed sediments in the Auckland region. All concentrations in surface sediment within the three areas sampled were lower than the ANZECC (2018) DGV of 50 mg/kg.

7.3.9 Mercury

Figure 15 illustrates mercury concentrations in the three areas sampled plotted against their adjusted mud content and aluminium concentration.

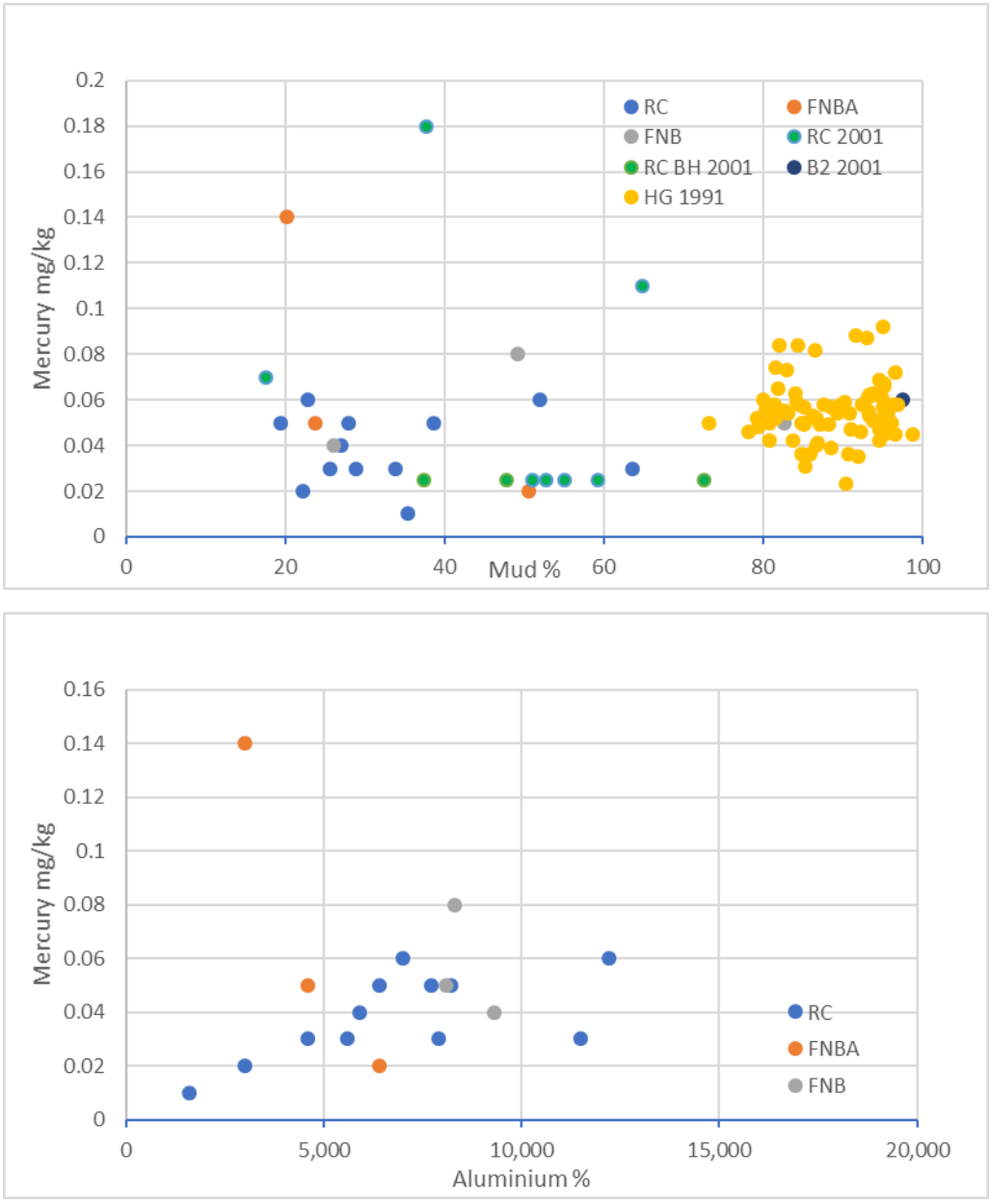


Figure 15: Mercury concentrations in WCNP sediment samples.

Mean concentration in the sediment samples collected in December 2019 was 0.049 mg/kg (range <0.02-0.14 mg/kg). There was some uncertainty regarding the result of sample 16, reported as 0.14 mg/kg. The result has remained as determined by the laboratory as repeat replicated analysis was not undertaken.

Kingett Mitchell (2001) reported mercury data for eight surface and three subsurface samples collected in similar areas of the channel. Seven samples contained <0.025 mg/kg and one

sample had a concentration of 0.18 mg/kg. Concentrations of mercury in muddy sediment from the Hauraki Gulf (POAL 1991) were all below 0.010 mg/kg.

Mercury is contributed to the environment in New Zealand by natural volcanic emissions and by a variety of anthropogenic sources. Elevated concentrations have been measured in muddy sediments within the waterfront area due to both historical contributions and continued discharge in urban stormwater.

Overall, all mercury concentrations measured in the December 2019 surface sediment samples from the three areas of WCNP sediment were lower than the ANZECC (2018) DGV of 0.15 mg/kg.

7.3.10 Nickel

Figure 16 illustrates nickel concentrations in the three areas of Navigation precinct sediments plotted against their adjusted mud content and aluminium concentrations. Mean concentration in the 18 samples collected in December 2019 was 10.7 mg/kg (range 1.7-31 mg/kg).

The ANZECC (2018) DGV for nickel is 21 mg/kg. Two sediment samples exceeded the DGV in the 2001 Rangitoto Channel sediments (transect I in that survey) and in two samples from the 2019 samples (Section D of the channel). All four samples were collected in the same section of channel. The third sample from Section D of the channel also contains a higher concentration of nickel (18.7 mg/kg) for its low mud %. It was considered in 2001 that the elevated nickel concentrations may be derived from a contribution of volcanic sands in that area.

This conclusion is reinforced by the consistent low concentration of nickel in lower Waitematā Harbour Waterfront sediments which suggests that compared to contaminants such as copper, lead and zinc the proportion of anthropogenic nickel in the waterfront sediments (and sediments within the lower harbour and channel) is low.

Overall, the probability that the elevated nickel in this part of the channel over two surveys 20 years apart is due to local contaminant contribution is considered remote.

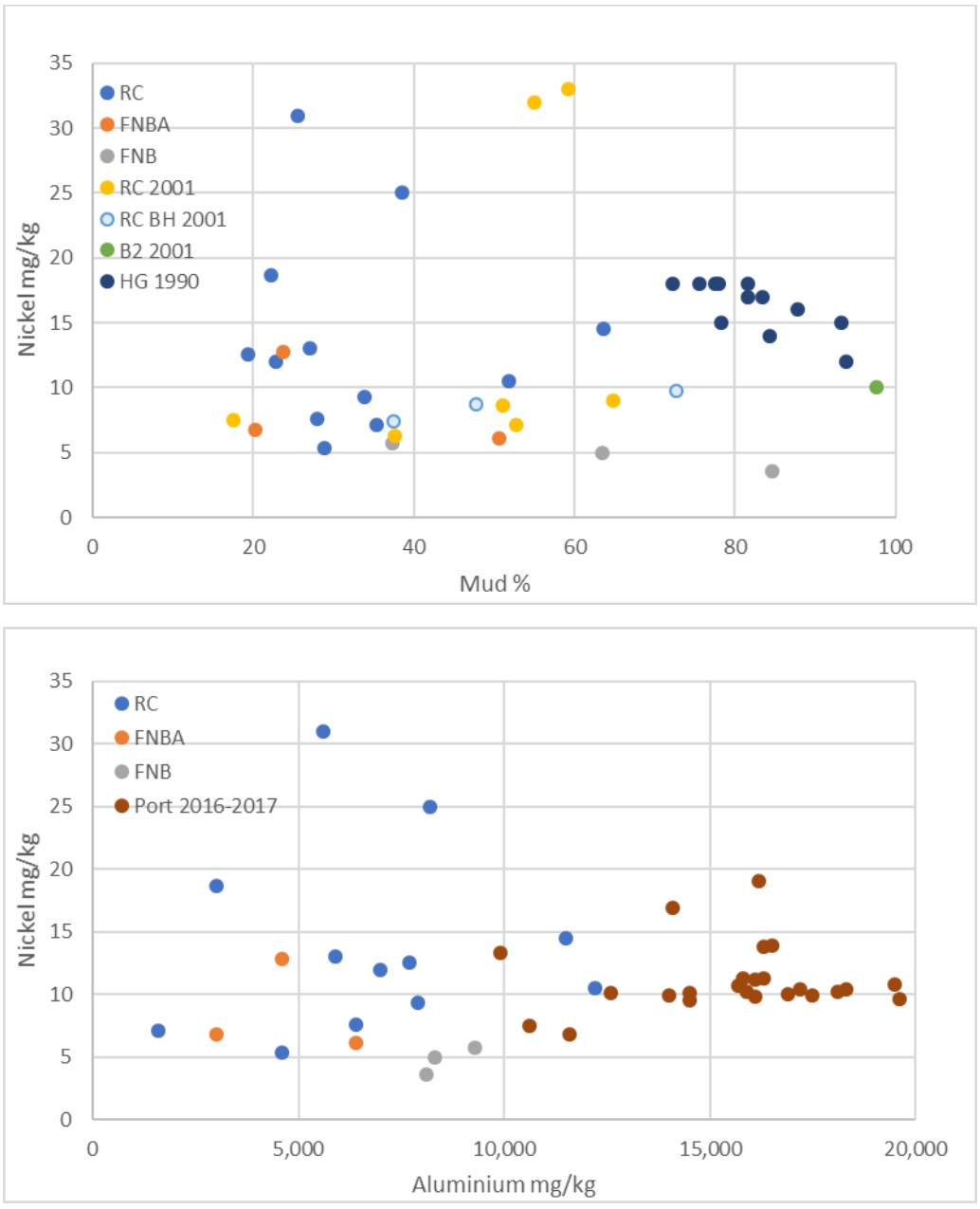


Figure 16: Nickel concentrations in WCNP sediment samples and comparative information.

7.3.11 Zinc

Zinc is a very common urban metal as it is widely used and emitted in urban areas. Figure 17 illustrates zinc concentrations in the three areas of Navigation precinct sediments plotted against their adjusted mud content and aluminium concentrations.

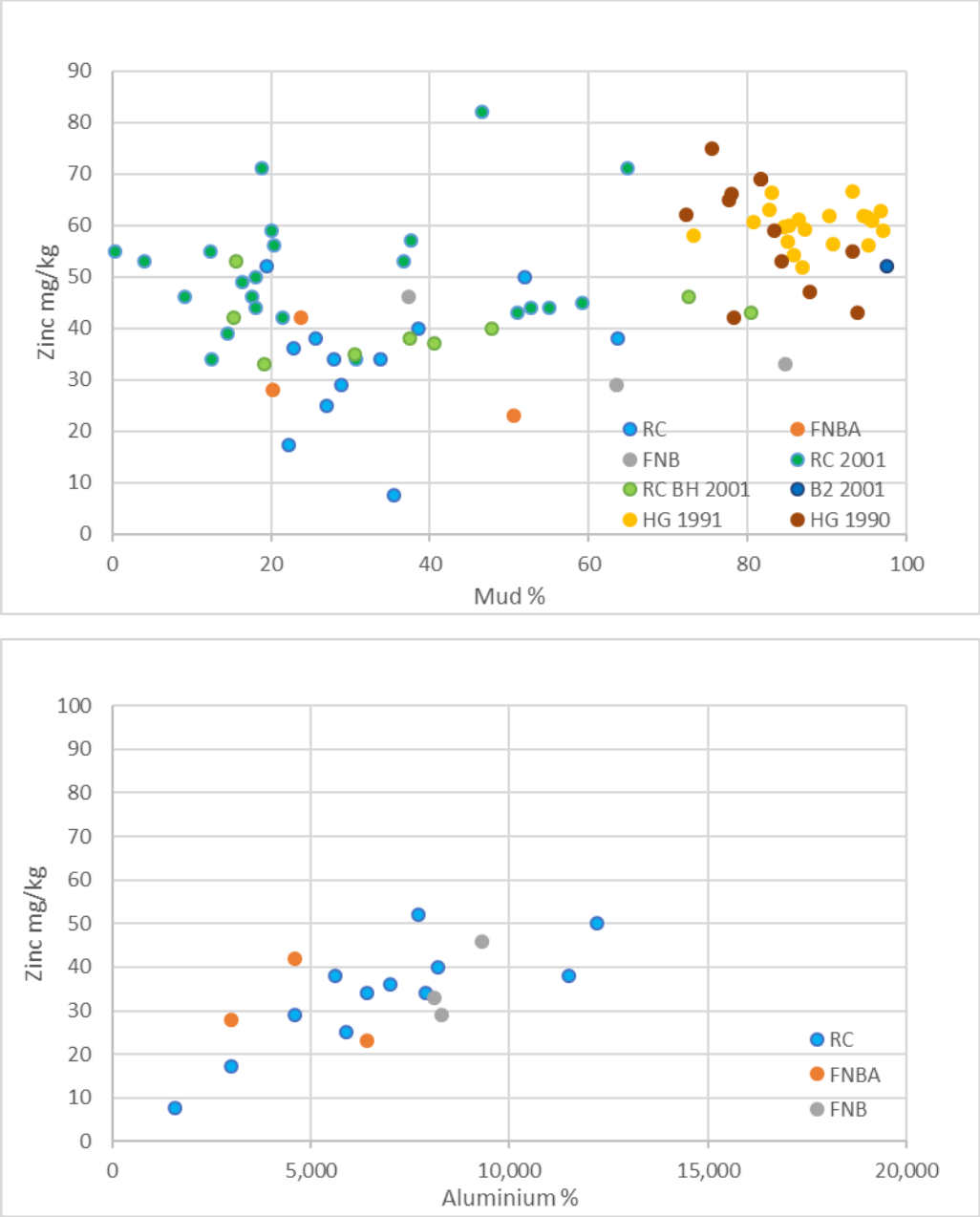


Figure 17: Zinc concentrations in WCNP sediment samples and comparative information.

Mean concentration of zinc in the 18 samples collected in December 2019 was 33.4 mg/kg (range 7.6-52 mg/kg). The concentration range seen in the 18 samples is very similar to that reported for sediments off New Brighton (median 35 mg/kg) and in Pegasus Bay (Golder 2012).

Zinc concentrations typically increase as sediments become finer (both naturally and when zinc adsorbs to finer sediment). Although there is variability within the concentration data set in Figure 14, the concentrations show a general increase from about 40 to 60 mg/kg across the range of mud %. Three surface samples collected in 2001 contained concentrations between 71 and 82 mg/kg. As noted above, the maximum concentration measured in the 2019 samples was 52 mg/kg.

All concentrations measured in the 2001 and 2019 survey were below the ANZECC (2018) DGV of 200 mg/kg.

7.3.12 Subsurface sediments

The preceding sections described trace element concentrations in surface sediments. Samples collected and analysed included sediment material to a maximum depth of 100 mm. Given minimum dredging depth is 500 mm, the sampled sediment represents 20 % of the minimum dredging depth in stage 1.

Surface sediment includes sediment particles settling from other locations that may be carrying anthropogenic contaminants. This material can only be incorporated deeper into the sediment through processes such as bioturbation (to depths of 150 mm) or in some locations through disturbance where the sediment to depth is able to be suspended. Sub-surface concentrations would be expected to be similar with lead expected to be lower.

As described in Section 5.5, the subsurface sediment within the areas sampled in non-bedform areas and to be dredged below the 100 mm sampled is geologically historic and has not been directly exposed to contaminants that have been transported to the area.

Concentrations of trace elements in bed-form features are expected to be similar to those measured in surface sediment and deeper sediment would be expected to have natural concentrations of trace elements. Further sub-surface sediment sampling and analysis is to be carried out as a requirement of MDC EEZ400011 prior to any dumping occurring at the CDS. This will confirm results obtained before and quality expectations as the sediment pre-dates European arrival (and industrialisation) in New Zealand.

7.3.13 Summary

Table 6 provides a summary of all trace element concentrations within each of the three areas sampled in December 2018.

All concentrations of arsenic, cadmium, chromium, copper, lead, mercury and zinc were below their ANZECC (2018) DGV concentrations.

For nickel two samples in the Rangitoto Channel had concentrations above the DSGV but below the GV-high. Both concentrations are considered to be natural.

7.4 Hydrocarbons

7.4.1 Total petroleum hydrocarbons

Total petroleum hydrocarbons were not measured in previous sampling in the Rangitoto Channel (Kingett Mitchell 2001) but has been included in all POAL port studies (e.g., Golder 2018) where elevations in TPH concentration have a higher probability of being detected) and other sediment quality assessments that have been undertaken in the various Waterfront precincts (e.g., in Westhaven, Outer Viaduct Harbour etc.).

Table 6. Summary of trace element concentrations in sediments from the WNCP sampled in December 2019.

Constituent	Rangitoto Channel (RC)	Fergusson North berth (FNB)	FNB Approaches	ANZECC (2018) DGV
No samples	12	3	3	
Arsenic	5.3 (1.3-8.1)	4.8 (3.0-8.1)	3.9 (2.2-5.2)	20
Cadmium	0.022 (0.01-0.035)	0.029 (0.017-0.045)	0.014 (<0.01-<0.03)	1.5
Chromium	11.5 (3.5-18.8)	8.6 (6.1-12.8)	4.6 (3.6-5.2)	80
Copper	4.1 (1.2-7.1)	6.1 (4.6-8.1))	3.8 (3.3-4.4)	65
Lead	7.7 (2.4-12.2)	9.1 (7.7-11))	6.5 (4.2-7.7)	50
Mercury	0.038 (0.01-0.06)	0.057 (0.04-0.08))	0.07 (0.02-0.14)	0.15
Nickel	13.9 (5.4-31)	5.4 (4.1-6.4)	2.7 (1.7-3.4)	21
Zinc	33.4 (7.6-52)	36 (29-46)	29 (23-35)	200

Notes: All results mg/kg.

The 18 surface sediment samples collected from the Navigation Precinct in December 2019 were examined for TPH in seven carbon bands covering C7-C44 carbon numbers. Total TPH ranged from <70 to <100 mg/kg. No hydrocarbons were detected in any bands in the 12 samples from the Rangitoto Channel. No hydrocarbons were detected in the three samples from the FNB area. In the FNBA samples, two samples (4M and 7M) contained no detectable hydrocarbons. Sample 22G from the approaches area contained low concentrations of hydrocarbons in bands C21-C29 (14 mg/kg) and C30-C44 (28 mg/kg). The detected concentrations and the overall total concentrations (reported as less than concentrations) were lower than the ANZECC (2018) DGV concentration of 280 mg/kg.

Concentrations in sub-sub-surface sediments within the channel and approaches would be expected to be non-detectable as sub-surface sediments have not been exposed to man-made petroleum hydrocarbons.

7.4.2 Polyaromatic hydrocarbons

PAHs are a large group of aromatic compounds widely present in coastal sediments derived from atmospheric deposition and urban stormwater and sourced principally from combustion (pyrogenic) processes (burning of coal, timber, oil and vehicle fuels etc.) and from petroleum sources (loss of oil, gas work waste etc.). A subset of parent PAH compounds have been utilised to provide an indication of the overall presence of PAH compounds. Simpson et al. (2013) reviewed PAH and sediment quality guidance concluding that when comparing total PAH concentrations with the DGV that 18 parent PAHs should be used and that concentrations should be normalised to 1 % TOC. In situations where PAHs are a dominant component of the contaminants present then the equilibrium sediment benchmark approach (ESB) should be used

in conjunction with a further 16 alkylated PAHs. In this assessment all of the 18 PAHs identified by Simpson et al. (2013) are measured.

Table 7 provides a summary of the PAH concentrations measured within the three areas sampled in the Navigation Precinct. All total PAH concentrations (unadjusted to 1 % TOC) were lower than the ANZECC (2018) DGV of 10 mg/kg and the GV-high of 50 mg/kg. The highest TOC adjusted total PAH concentration in the sediment sample was 0.625 mg/kg (sample RCD-197A). Overall, surface sediments contain PAHs but at a concentration <10 % of the DGV.

Table 7. Summary of WCNP sediment sample PAH concentrations.

PAH	No. Rings	RC	FNB	FNBA
Number samples	-	12	3	3
Naphthalene	2	<0.01-<0.015	<0.012	<0.01-<0.015
1-Methylnaphthalene	2	<0.002-0.005	<0.003	<0.002-0.007
2-Methylnaphthalene	2	<0.002-0.003	<0.003	<0.002-0.011
Acenaphthylene	3	<0.002-<0.003	<0.003-0.003	<0.002-<0.003
Acenaphthene	3	<0.002-0.007	<0.003-0.003	<0.002-<0.003
Fluorene	3	<0.002-0.007	<0.003-0.003	<0.002-<0.003
Phenanthrene	3	<0.002-0.032	<0.003-0.015	<0.002-<0.003
Anthracene	3	<0.002-0.014	<0.003	<0.002-<0.003
Fluoranthene	4	0.005-0.103	<0.003-0.014	0.004-0.013
Pyrene	4	0.005-0.090	<0.003-0.014	0.005-0.014
Benzo[a]anthracene	4	0.002-0.056	0.003-0.006	<0.002-0.006
Chrysene	4	0.003-0.041	<0.003-0.006	<0.002-0.006
Benzo[b]fluoranthene + Benzo[j]fluoranthene	5	0.003-0.074	<0.003-0.009	0.003-0.010
Benzo[k]fluoranthene	5	<0.003-0.029	<0.003-0.007	<0.002-0.005
Perylene	5	<0.002-0.016	0.006-0.046	<0.002-0.006
Benzo(e)pyrene	5	<0.003-0.027	<0.003-0.004	<0.002-0.007
Benzo[a]pyrene (BAP)	5	0.003-0.062	<0.003-0.009	0.003-0.009
Dibenzo[a,h]anthracene	5	<0.002-0.008	<0.003	<0.002-<0.003
Indeno(1,2,3-c,d)pyrene	6	<0.003-0.044	<0.003-0.006	0.002-0.006
Benzo[g,h,i]perylene	6	<0.003-0.042	<0.003-0.006	<0.002-0.006
Total PAH mean	-	0.152	0.095	0.042
Total PAH range	-	0.015-0.624	0.023-0.206	0.03-0.058

Notes: Total PAH, sum of individual PAH using detection limit at limit of detection.

As described in KEL (2019), sediment samples collected north of the channel in the Hauraki Gulf (POAL 1990) contained a mean concentration of total PAH of 0.135 mg/kg (range 0.087-0.168 mg/kg).

The individual PAH concentrations for each sample are shown in Figure 18. The figure illustrates the similarity of the relative individual PAH concentrations between samples. The figure also shows the low concentrations of the lighter 2-3 ring PAHs. These have higher volatility and as such do not remain associated with water or sediment. The ratio between specific PAHs provides general information on the potential origins of the PAHs seen in the sediment samples

(i.e., whether the PAHs present were derived from pyrogenic or petroleum sources). The ratio of key PAHs indicates that the PAHs present are predominantly of pyrogenic origin. This reflects atmospheric deposition and stormwater as the key source. Storm water contributes PAHs from sources such as vehicle fuel combustion products, rubber tyre particles, lubricants, etc. (refer Kennedy et al. 2016). Due to their hydrophobic characteristics PAHs attach to particles resulting in concentrations declining (through settlement and dispersion/dilution) from the source.

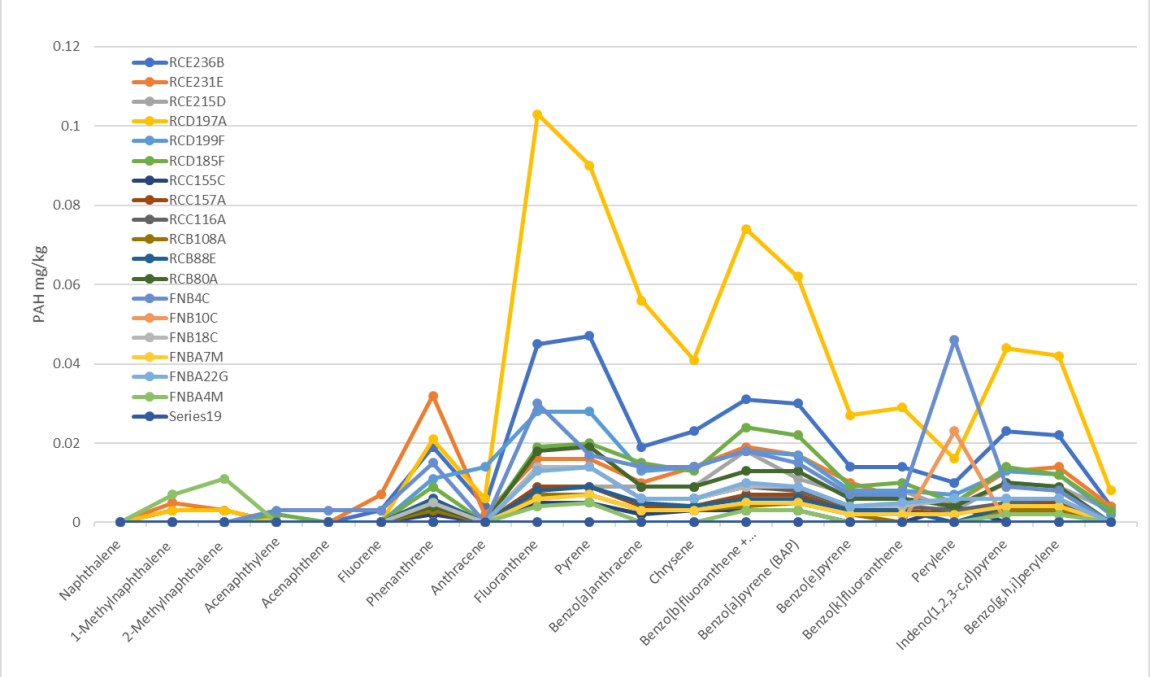


Figure 18: PAH concentrations in WCNP sediment samples.

Overall, PAHs are present in the surface sediments. This group of hydrocarbons are ubiquitous and widely distributed. Concentrations in surface sediments sampled are lower than the DGV concentration. Concentrations are expected to be much lower in sub-surface sediments but may be present as PAHs are released during vegetation burning.

7.5 Organochlorine pesticides

A range of organochlorine pesticides (OCPs)were analysed in the Navigation Precinct sediment samples (Table 8). The OCPs in Table 8 were deregistered in 1992 and no longer used in agriculture, industry or horticulture (MfE 2006).

No OCP compounds were detected (at a detection limit of 0.001 mg/kg). Table 8 also identifies the ANZECC (2018) DGV and GV-high concentrations (set for 1 % TOC). DDT isomers and total DDT were non-detectable (detection limits are being evaluated with the aim of undertaking analysis to a lower detection limit in the sampling proposed during 2020).

Table 8. Summary of organochlorine pesticide concentrations in WCNP sediment samples.

Organochlorine pesticide	RC	FNB	FNBA	ANZECC (2018) DGV	History of use*
Number of samples	12	3	3		
Aldrin	<0.001	<0.001	<0.001		Control of sheep ectoparasites and household pests. Use stopped about 1989.
Alpha-BHC	<0.001	<0.001	<0.001		Lindane is used to control lice, keds and blowflies on cattle and sheep, and grass grub in pasture and for household control of winged insects. Lindane is still approved as a treatment for scabies and lice in humans.
Beta-BHC	<0.001	<0.001	<0.001		
Delta-BHC	<0.001	<0.001	<0.001		
Gamma-BHC (lindane)	<0.001	<0.001	<0.001	0.9/1.4	
Cis-chlordane	<0.001	<0.001	<0.001		Used to control agricultural pests; timber treatment. Use in timber treatment ceased in 1989.
Trans-chlordane	<0.001	<0.001	<0.001		
Total chlordane	<0.002	<0.002	<0.002	4.5/9.0	
2,4'-DDD	<0.001	<0.001	<0.001	3.5/9.0	Used to control grass grub and porina caterpillars in pasture and grass on farms, gardens and parks. DDT breaks down to dichlorodiphenyltrichloroethylene (DDE) and dichlorodiphenyldichloroethane (DDD).
4,4'-DDD	<0.001	<0.001	<0.001		
2,4'-DDE	<0.001	<0.001	<0.001		
4,4'-DDE	<0.001	<0.001	<0.001	1.4/7.0	
2,4'-DDT	<0.001	<0.001	<0.001	1.2/5.0	
4,4'-DDT	<0.001	<0.001	<0.001		
Total DDT	<0.006	<0.006	<0.006		
Dieldrin	<0.001	<0.001	<0.001	2.8/7.0	Is also a breakdown product of dieldrin. Used for timber treatment and carpet treatment. Use stopped about 1989.
Endosulfan 1	<0.001	<0.001	<0.001		Used on plants and turf. Import stopped in 2008.
Endosulfan 2	<0.001	<0.001	<0.001		
Endrin	<0.001	<0.001	<0.001	2.7/60	Used as an insecticide, rodenticide, and avicide to control a range of pests on crops. Endrin is a stereoisomer of dieldrin. Very little endrin was used in New Zealand. Endrin aldehyde and endrin ketone occur as impurities or degradation products of endrin.
Endrin aldehyde	<0.001	<0.001	<0.001		
Endrin ketone	<0.001	<0.001	<0.001		
Heptachlor	<0.001	<0.001	<0.001		Control of household insects. Not used much in NZ but was also a contaminant in chlordane.
Heptachlor epoxide	<0.001	<0.001	<0.001		
Hexachlorobenzene	<0.001	<0.001	<0.001		Used 1970-1972 as fungicide; was also an impurity in solvent manufacture
Methoxychlor	<0.001	<0.001	<0.001		Used as an insecticide for a range of pests (e.g., houseflies, mosquitoes, cockroaches) in crops, stored grain, livestock and domestic pets. Little information on the use of methoxychlor in New Zealand, though it was apparently used in sheep dipping and its use was banned in 1961 along with DDT, dieldrin, aldrin, and lindane.

Notes: All WCNP sample data are mg/kg (<0.001 mg/kg = 1 µg/kg). ANZECC (2018) DGVs are µg/kg. * From MfE (2006).

Analysis of four surface and one boreholes sample by Kingett Mitchell (2001) found that most isomers of the three DDT group compounds were <0.1 µg/kg. p,p' DDD was the only isomer detected at 0.2 and 0.7 µg/kg. For DDE and DDT the 2001 samples indicate that the concentration is of the order of 0.1 µg/kg, well below the DGV (1.7 and 1.2 µg/kg respectively) even when adjusted for TOC (the mean TOC concentration for all 18 samples was 0.47 %,

representing an adjustment factor of 2.1 to convert the data to 1 % TOC equivalent). At half detection limit, this would produce 4,4'-DDE and DDT isomer concentrations on average of 0.0011 mg/kg. Given the uncertainties of concentrations at the detection limits (and the lower non-detectable concentrations measured in 2001), the current 2019 concentrations are considered to be at or below the DGV. Sub-surface concentrations should not contain any DDT as DDT was used from the 1940s (refer .

7.6 Polychlorinated biphenyls

PCBs are a large group of synthetic organic chemicals comprising 209 congeners that have historically had a wide range of uses in product from transformer oil and insulating materials. PCBs were banned from manufacture in the US in 1977. New Zealand signed the Stockholm Convention in 2001 and all PCBs were to be withdrawn from use and destroyed no later than 2016 (MfE 2006).

Different PCB congeners exert different toxic effects due to their structure (chlorine substitution). Of the 209 congeners there are a smaller subset that are regarded as being more significant as they exhibit dioxin like properties and have been assigned toxicity equivalent factors. All of these congeners are included in the analysis undertaken (Table 9).

The analysis undertaken of the 18 surface sediments from the three areas sampled did not detect any PCB congeners at a detection limit of 0.001 mg/kg. Based on the 35 non detected congeners the laboratory assigns a summed total concentration based on the congeners analysed of <0.04 mg/kg (Table 9).

The ANZECC (2018) DGV is 0.034 mg/kg and the GV-high is 0.280 mg/kg. The ANZECC (2018) sediment guidance values are set for a TOC concentration of 1 %. As concentration were below detection limit, detection limits were not adjusted for TOC. Although the total PCB concentration (based on detection limits) is higher than the DGV, the total concentration is not considered to be above the DGV.

Previous PCB analysis of surface sediments (3 samples from Transect K) and three subsurface borehole samples from the Rangitoto Channel by Kingett Mitchell (2001) did not detect PCBs (28 congeners) at a detection limit of <0.0001 mg/kg (total <0.003 mg/kg) (ten fold lower than the current study).

Overall, PCB concentrations are not detectable in surface sediments and considered to be below the DGV. Subsurface sediments are expected to contain no PCB based on sub-surface sediment analysis in 2001 and PCB use in New Zealand commencing in the early 1900s.

Table 9. Summary of PCB concentrations in WCNP sediment samples.

		Location		
IUPAC congener number	**Name**	**RC**	**FNB**	**FNBA**
Number of samples		12	3	3
PCB-18	2,2',5-Trichlorobiphenyl	<0.001	<0.001	<0.001
PCB-28	2,4,4'-Trichlorobiphenyl	<0.001	<0.001	<0.001
PCB-31	2,4',5-Trichlorobiphenyl	<0.001	<0.001	<0.001
PCB-44	2,2',3,5'-Tetrachlorobiphenyl	<0.001	<0.001	<0.001
PCB-49	2,2',4,5'-Tetrachlorobiphenyl	<0.001	<0.001	<0.001
PCB-52	2,2',5,5'-Tetrachlorobiphenyl	<0.001	<0.001	<0.001
PCB-60	2,3,4,4'-Tetrachlorobiphenyl	<0.001	<0.001	<0.001
PCB-77	3,3',4,4'-Tetrachlorobiphenyl	<0.001	<0.001	<0.001
PCB-81	3,4,4',5-Tetrachlorobiphenyl	<0.001	<0.001	<0.001
PCB-86	2,2',3,4,5-Pentachlorobiphenyl	<0.001	<0.001	<0.001
PCB-101	2,2',4,5,5'-Pentachlorobiphenyl	<0.001	<0.001	<0.001
PCB-105	2,3,3',4,4'-Pentachlorobiphenyl	<0.001	<0.001	<0.001
PCB-110	2,3,3',4',6-Pentachlorobiphenyl	<0.001	<0.001	<0.001
PCB-114	2,3,4,4',5-Pentachlorobiphenyl	<0.001	<0.001	<0.001
PCB-118	2,3',4,4',5-Pentachlorobiphenyl	<0.001	<0.001	<0.001
PCB-121	2,3',4,5',6-Pentachlorobiphenyl	<0.001	<0.001	<0.001
PCB-123	2,3',4,4',5'-Pentachlorobiphenyl	<0.001	<0.001	<0.001
PCB-126	3,3',4,4',5-Pentachlorobiphenyl	<0.001	<0.001	<0.001
PCB-128	2,2',3,3',4,4'-Hexachlorobiphenyl	<0.001	<0.001	<0.001
PCB-138	2,2',3,4,4',5'-Hexachlorobiphenyl	<0.001	<0.001	<0.001
PCB-141	2,2',3,4,5,5'-Hexachlorobiphenyl	<0.001	<0.001	<0.001
PCB-149	2,2',3,4',5',6-Hexachlorobiphenyl	<0.001	<0.001	<0.001
PCB-151	2,2',3,5,5',6-Hexachlorobiphenyl	<0.001	<0.001	<0.001
PCB-153	2,2',4,4',5,5'-Hexachlorobiphenyl	<0.001	<0.001	<0.001
PCB-156	2,3,3',4,4',5-Hexachlorobiphenyl	<0.001	<0.001	<0.001
PCB-157	2,3,3',4,4',5'-Hexachlorobiphenyl	<0.001	<0.001	<0.001
PCB-159	2,3,3',4,5,5'-Hexachlorobiphenyl	<0.001	<0.001	<0.001
PCB-167	2,3',4,4',5,5'-Hexachlorobiphenyl	<0.001	<0.001	<0.001
PCB-169	3,3',4,4',5,5'-Hexachlorobiphenyl	<0.001	<0.001	<0.001
PCB-170	2,2',3,3',4,4',5-Heptachlorobiphenyl	<0.001	<0.001	<0.001
PCB-180	2,2',3,4,4',5,5'-Heptachlorobiphenyl	<0.001	<0.001	<0.001
PCB-189	2,3,3',4,4',5,5'-Heptachlorobiphenyl	<0.001	<0.001	<0.001
PCB-194	2,2',3,3',4,4',5,5'-Octachlorobiphenyl	<0.001	<0.001	<0.001
PCB-206	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	<0.001	<0.001	<0.001
PCB-209	Decachlorobiphenyl	<0.001	<0.001	<0.001
Total		<0.04	<0.04	<0.04

Notes: Key congeners with WHO toxicity equivalent factors are colour coded. Yellow are non-ortho substitute PCBs, green are mono-ortho substituted and orange are Di-ortho substituted.

7.7 Antifoulants

The key antifoulant tributyl tin (TBT) is measured in Port Precinct sediment quality surveys and has been detected in some port berth sediment samples (Golder 2018a,b).

As KEL (2019) noted, the FNB has only been recently constructed and the berth has only been occupied a few times. The berth is expected to become fully operational in 2020. Following this capital works dredging assessment, the pocket berth will be part of the maintenance dredging sediment quality assessment programme. As noted earlier, the FNBA were dredged as part of the 2004-2007 capital works dredging program. Any TBT present in FNB approaches and channel sediments will be derived from the transport of sediment particles out of the port and waterfront (and other locations such as the four marinas in the lower harbour and the Devonport Naval Base).

Measurement of TBT compounds carried out on the 18 surface sediment samples collected in December 2019, did not detect any butyl tin compounds in 16 samples (<0.004 mg/kg) (Appendix B). TBT (along with DBT) was detected in samples FNBA-7M and 4M (Table 10). Following receipt of the analysis, two repeat analysis (using fresh sediment sub-samples from the sample) were carried out. The repeat analysis from both samples identified no detectable TBT in any of the repeat analysis.

Table 10. Summary of TBT analysis of two sediment samples from FNBA.

TBT	FNBA-7M	FNBA-7M replicate 1	FNBA-7M replicate 2	FNBA-4M	FNBA-4M replicate 1	FNBA-4M replicate 2
Dibutyltin	0.007	<0.005	<0.005	0.008	<0.005	<0.005
Monobutyltin	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Tributyltin	0.051	<0.004	<0.004	0.053	<0.004	<0.004
Triphenyltin	<0.003	<0.003	<0.003	0.004	<0.003	<0.003

Notes: All results mg/kg (as Sn), not-adjusted to 1 % TOC. Blue concentrations are above the DGV but below GV-high.

The analysis indicates that there is likely to be marine paint fragments in the sediment. The detected concentrations are above the DGV and adjusted concentrations above the GV-high (0.070 mg/kg). The adjusted concentrations assumes that the TBT is associated with organic matter/carbon and not present as paint flakes. The average concentrations for the samples based on the three results are above the DGV but lower than the GV-high concentration. No paint fragments were identified in an examination of the coarse sand fraction of the sediment sample.

To determine an "average" concentration for the two samples with repeat analysis is "difficult" as the data is skewed and two of the three data for each sample are less than detect. The results for the two samples were

- For sample 16 (FNBA-7M), the mean and geometric mean concentrations were 0.0183 and 0.0059 mg/kg respectively using half detection limit values.

- For sample 18 (FNBA-4M), the mean and geometric mean concentrations were 0.019 and 0.006 mg/kg respectively using half detection limit values.

TBT only became popular as a marine antifoulant in the 1960s. In 1989, New Zealand banned application of TBT as an antifoulant on hulls of vessels less than 25 m in length (Pesticides (Antifouling Paints) Order 1989, noting that vessels with aluminium hulls were exempt). In 1993, application of any organotin-containing paint to any vessel was prohibited (The Pesticides (Organotin Antifouling Paints) Regulations 1993). This ban did not cover its use on foreign vessels arriving in New Zealand (Smith1996). In 2001 the global ban by the IMO (International Convention on the Control of Harmful Anti-fouling Substances) was adopted. The IMO ban came into force in September 2008.

The results obtained reflect an expectation that TBT should be non-detectable in sediments. Given, the IMO ban, TBT would not be expected to be in use on foreign vessels. However, it has been noted for example in the case of the Rena wreck (2011) that TBT was still present in hull paint under layers of current paint. It is possible the TBT is legacy TBT (re-mobilised TBT paint fragments from another location) or TBT paint fragments derived from a vessel that has been in the port in recent years. Further TBT analysis will be undertaken during 2020 as a requirement of the MDC to provide further detail with regard to the TBT concentrations.

7.8 Other Organic Compounds

As identified in Section 3.1, analysis of sediment samples from FNB and FNBA were carried out for SVOCs. This allowed a high level analysis to assess the presence of phthalates a common group of compounds (associated with plastics). The summary of analysis in Table 11 shows that phthalates were not detected at a typical detection limit of <0.2 mg/kg. The only compounds detected were two phenol group compounds which were detected in one of the three samples from the FNBA.

Phthalates were measured in port berth sediments by POAL (1995). That analysis detected phthalates in most sediment samples. The more common phthalates were bis(2-ethylhexyl)phthalate and diethylphthalate which had mean concentrations of 2.0 and 1.12 mg/kg respectively.

Chlorophenols have and had a wide range of uses as fungicides and insecticides especially in the timber industry and have had a use in antifoulant paints. There are seven more common chlorophenols which are identified in Table 10. Low concentrations have been detected in port sediments (POAL 1989a) with total phenol concentrations from 0.031-0.046 mg/kg with pentachlorophenol making up much of the total. POAL (1995) did not detect any chlorophenol compounds in port sediments above a detection limit of <0.015 mg/kg. Low concentrations of two common phenols were detected in the FNBA sediments (Table 11)

Table 11. Phthalate concentrations and other organic compounds in FNB and FNBA sediment samples.

Compound	FNB	FNBA	
Number of samples	3	3	
Phthalates			
Bis(2-ethylhexyl)phthalate	<0.5	<0.5	
Butylbenzylphthalate	<0.2	<0.2	
Di(2-ethylhexyl)adipate	<0.2	<0.2	
Diethylphthalate	<0.2	<0.2	
Dimethylphthalate	<0.2	<0.2	
Di-n-butylphthalate	<0.2	<0.2	
Di-n-octylphthalate	<0.2	<0.2	
Phenols			
4-Chloro-3-methylphenol	<0.5	<0.5	
2-Chlorophenol	<0.2	<0.2	
2,4-Dichlorophenol	<0.2	<0.2	
2,4-Dimethylphenol	<0.4	<0.4	
3 & 4-Methylphenol (m- + p-cresol)	<0.4	<0.4-0.9	
2-Methylphenol (o-Cresol)	<0.2	<0.2	
2-Nitrophenol	<0.4	<0.4	
Pentachlorophenol (PCP)	<6	<6	
Phenol	<0.2	<0.2-3.6	
2,4,5-Trichlorophenol	<0.2	<0.2	
,4,6-Trichlorophenol	<0.2	<0.2	
Other halogenated compounds			
Hexachloroethane	<0.19	<0.19	
1,3-Dichlorobenzene	<0.19	<0.19	
1,4-Dichlorobenzene	<0.19	<0.19	
Hexachlorobutadiene	<0.19	<0.19	
1,2,4-Trichlorobenzene	<0.10	<0.10	

Notes: For full SVOC analytical results refer to Appendix A.

7.9 Summary

The examination of 18 surface sediment samples from the WCNP has shown:

- All concentrations of arsenic, cadmium, chromium, copper, lead, mercury and zinc were below their ANZECC (2018) DGV concentrations. For nickel two samples in the Rangitoto Channel had concentrations above the DSGV but below the GV-high. Both concentrations are considered to be natural.
- TPH concentrations were below the DGV and all total PAH concentrations were below the DGV.
- No individual PCB congeners were detected in any samples collected in 2019 above a detection limit of 0.001 mg/kg.

- No organochlorine pesticide compounds were found above a detection limit of 0.001 mg/kg.
- No detectable concentrations of phthalate compounds were measured in sediments from the FNB or FNBA. Low concentrations of two phenol compounds were detected in FNBA sediments.
- No TBT was detected in 16 of 18 samples. Two samples from the FNBA contained unadjusted TBT concentrations above the DGV. Analysis of two independent repeat sub-samples from each of the samples failed to identify any TBT above detection limit.

8 SEDIMENT QUALITY EVALUATION

8.1 Introduction

The assessment of effects during dredging relating to sediment quality relate to:

- The release of contaminants in a dissolved phase to the water during dredging.
- The transport of sediment off-site to other localities where the sediment may change the quality at that location when deposited.

Based on the approach used by MSA (1999) to assess likely effects of dredging, the following approach was utilised in relation to the sediment data:

- Compare concentrations obtained and compare to sediment quality guideline concentrations (ANZECC 2018).
- For any sediment samples with concentrations above DGV concentrations, undertake elutriate to assess the potential release from suspended sediment.
- For any sediment samples where elutriate concentrations exceed DGV, consider undertaking toxicity testing.
- Where sediments have concentrations that exceed the DG-high, review potential for bioaccumulation.

8.2 Concentrations and Guidelines

Table 12 summarises concentration data for a range of key contaminants in 2019 sediments with ANZECC (2018) DGV concentrations. In addition to comparing the individual data with guidance, the 95 % upper confidence limit for the data sets was also calculated. In relation to contaminant concentrations, the sediment quality data tells us that:

- For all elements except nickel, concentrations were below the DGV.
- For nickel, two individual sediment samples had elevated concentrations (compared to other samples) and were above the DGV (the concentrations were considered natural). The 95 % UCL concentration for the 18 samples was below the DGV. For the Rangitoto channel samples on their own, the 95 % UCL was 17.8 and below the DGV.
- All PAH concentrations were below the DGV and the 95 % UCL was lower than the DGV. All OCP and PCB concentrations are considered to be below their respective DGVs.

- For TBT, the majority of data was below detection limit. This did not allow the normality of the data to be assessed apart from identifying that the data was not normally distributed. Two examples of UCL values are given but they are indicative only (i.e., because of the nature of the data, there is low confidence in predicting the upper TBT concentration confidence limit). Based on the available data (for the 18 samples, using the mean values calculated for the two samples from the FNBA discussed in Section 7.7), the upper 95 % UCL concentration is likely to site between 0.003 and 0.005 mg/kg.

Table 12. Summary of key contaminant concentrations and December 2019 sediment dataset upper confidence limits and ANZECC DGVs.

Constituent	Mean	GM	Max	Normality	95 % UCL	ANZECC (2018) DGV
Arsenic	4.9	4.3	8.1	Normal	5.8	20
Cadmium	0.022	0.020	0.045	Normal	0.025	1.5
Chromium	9.9	8.8	18.8	Normal	11.8	80
Copper	4.4	4.1	8.1	Normal	5.1	65
Lead	7.7	7.2	12.2	Normal	8.7	50
Mercury	0.05	0.04	0.14	Non normal	0.066 (gamma)	0.15
Nickel (all)	10.6	8.2	31	Normal	13.8	21
Nickel (RC only)	13.9	12.3	31	Normal	17.8	21
Zinc	33.1	30.7	52	Normal	38.0	200
Total PAH (UA)	0.123		0.617	Non-normal	0.201 (gamma)	10
TBT (UA) (DL)	0.0046	0.0044	0.0095	Non-normal	0.005 (gamma) 0.005(non para)	0.007
TBT (UA) (half DL)	0.0026	0.0024	0.006	Non-normal	0.003 (gamma) 0.003 (non para)	0.007

Notes: All results mg/kg. UA – unadjusted. DL – detection limit. 95 % UCL values calculated using ProUCL V5.1; Normal (at 5 % significance level), UCL = 95 % Students-t Upper confidence limit;. Gamma = Gamma distributed (95 % adjusted Gamma UCL). Non-para – Non parametric distribution.

Table 13 provides a summary of data for organic compounds. 95 % upper confidence limits (UCL) were not able to be calculated as the majority of the data (e.g., DDT compounds and others) were detection limit (and identical). For those such as total PAH where the 95 % UCL could be calculated the 95 % UCL was below the DGV for total PAHs (ANZECC 2018) (Table 12).

8.3 Elutriate Testing

8.3.1 Testing

A standard elutriate test (USEPA 1991) is carried out to assess the potential release of contaminants to seawater during dredging. Elutriate testing was discussed in Section 8.4 of KEL (2019). All elutriate extractions are typically undertaken within four weeks of sample collection. Due to the timing of the sediment sampling in December 2019, elutriate extraction was not able

to be carried out until 48 days after sampling. It is recognised that this timing is outside the normally accepted period. All samples had been held at 4°C during that time.

Table 13. Summary of organic compounds with ANZECC (2018) sediment quality guidance concentrations.

Constituent	Mean	Max	ANZECC (2018) DGV	ANZECC (2018) DG-high
TPH (mg/kg)	<70-<100	-	280	550
Total PAH*	15-152	624	10,000	50,000
Total DDT	<2**	<2**	1.2	5.0
p,p' DDE	<1	<1	<1	7.0
o,p'+p,p' DDD	<2**	<2**	3.5	9.0
Chlordane	<2	<2	4.5	9.0
Dieldrin	<1	<1	2.8	7.0
Endrin	<1	<1	2.7	60
Lindane	<1	<1	0.9	1.4
Total PCB	<40	<40	34	280

Notes: All results µg/kg unless stated. * 95 % UCL for PAHs is provided in Table 11. ** individual isomers <1 µg/kg.

As identified in the previous section sediment samples with contaminant concentration exceedances above the DGV included four separate samples for nickel and TBT. The elutriate testing for nickel was carried out even though the nickel was considered to be of natural geologically origin.

Overall, the DGV comparison for the December 2019 sediment samples (supported with data for some constituents collected in 2001) indicated that only nickel and TBT needed to be considered further in the following assessment sections.

8.3.2 Reasonable mixing

Elutriate contaminant concentrations are compared with relevant marine water quality trigger values/water quality criteria (ANZECC 2018) 95 % protection and or USEPA where relevant). If any contaminant concentrations in elutriate exceed guidance values, dilution following reasonable mixing will be considered as set out below. The elutriation incorporates a basic initial dilution within the test (1:4 times). Beca (2001b) discuss changes in TSS during plume development during dredging. That data indicated that TSS changes from close to dredging to a point 200 m downstream are of the order of provides a six fold dilution. That figure is utilised to undertake a screening comparison with water quality guidelines where required.

8.3.3 Nickel

As identified above, two samples from the Rangitoto Channel contained nickel concentrations that were higher than those present in other samples collected (Figure 15). In 2001, two

samples also contained a higher concentration of nickel and the concentrations were considered to be natural and geologically determined.

Figure 16 below provides a summary of nickel concentrations that have been measured in sediment samples collected from the lower Waitematā Harbour including the port and waterfront areas. The data for the 2001 and 2019 'channel' samples are also shown. The third set of data is from 25 samples collected with the waterfront area within the port, Freemans Bay and Westhaven between 2017 and 2019. Elutriate was extracted from all of these samples in the various studies and all contained <0.007 g/m^3 nickel. The relatively high detection limit concentration is a methodology limitation as elutriate samples are seawater.

Golder (2018) reported on the concentration of nickel in a SPLP (Synthetic precipitation leaching procedure) extraction of nine samples from the port. These samples are a subset of the waterfront sediments shown in Figure 16 and had an average nickel concentration of 12.7 ± 3.8 mg/kg (range 9.6-19.6 mg/kg) and a SPLP nickel extract nickel concentration of 1.03 ± 0.13 µg/m^3 (range 1.03-1.47 µg/m^3). Nickel is poorly extractable in the waterfront sediments. POAL (1990) identified that weak acid extraction (0.5 M hydrochloric acid) removed 26 % of that extracted using strong acid (nitric/perchloric) (2.6 mg/kg compared to an average of 10 mg/kg).

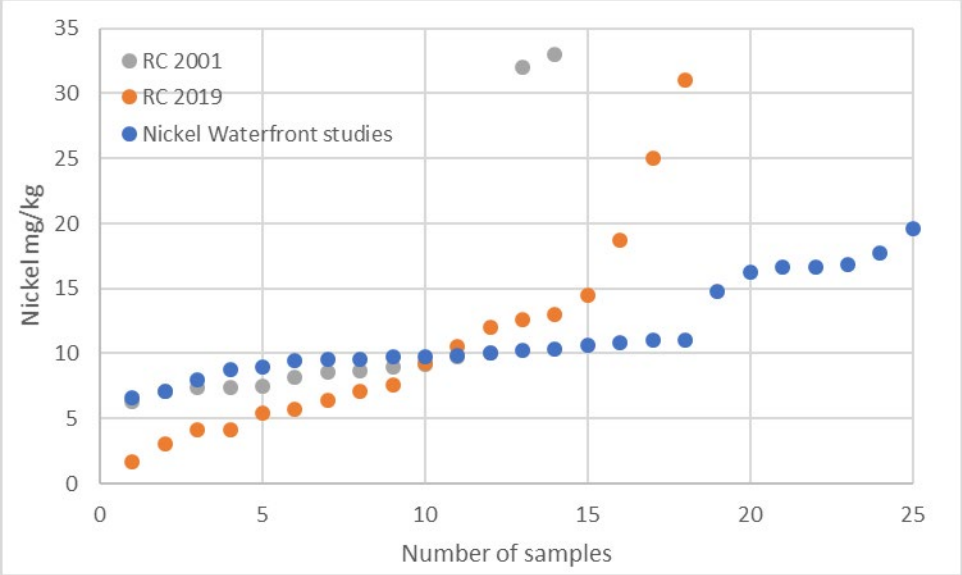


Figure 19: Nickel in Waitematā (Rangitoto channel and waterfront) sediments.

Overall, across the set of 25 sediment samples from the lower Waitematā Harbour and Rangitoto Channel, nickel concentrations in elutriate were all below a detection limit of <0.007 g/m^3. Analysis of the elutriate from the two samples (with elevated nickel) from Rangitoto Channel had no detectable nickel in elutriate.

The ANZECC (2018) default guideline value for nickel at 95 % level of species protection is 0.07 g/m^3. Concentration in the two elutriates were below the DGV. The slight elevation in natural nickel concentrations seen in a proportion of sediment samples from the Rangitoto Channel will not result in any waterborne toxicity downstream of dredging.

8.3.4 TBT

As noted in section 7.7, two surface sediment samples from FNBA contained detectable TBT which exceeded the GV-high when corrected for TOC concentrations. Resampling and analysis of both samples did not detect any TBT in the sediment. The mean TBT concentration in the two samples is below and above the DGV depending on the manner in which the mean is calculated. Figure 19 provides a summary of the concentration of TBT in samples of sediment collected from the waterfront and port area.

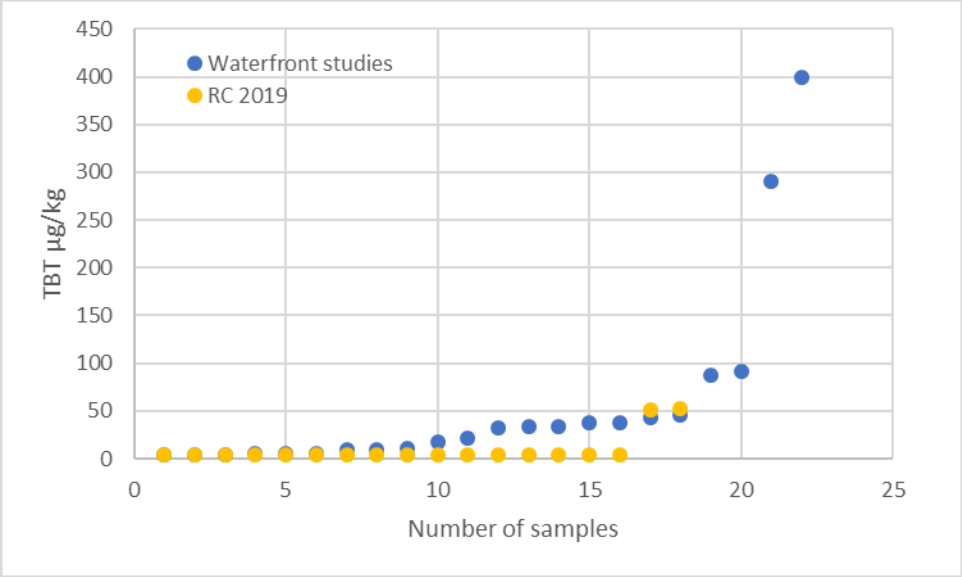


Figure 20: TBT in Auckland waterfront sediments.

Elutriates have been undertaken on 19 sediment samples and three composite sample elutriates collected from the waterfront and port comprising:

- Three composite samples from the port (Golder 2018) which had TBT (as tin) concentrations all below a detection limit of <0.00005 g/m^3 (0.05 mg/m^3).
- Three samples from borehole samples in Freemans Bay were found to have TBT concentrations below detection limit.
- Six samples from off North Wharf in Freemans Bay were found to have TBT concentrations below detection limit.
- Seven samples collected prior to the construction of the new Sealink ferry terminal (north of Silo Park marina) also contained TBT below detection limit of <0.00005 g/m^3.

Overall, no TBT has been detected (above the method detection limit) in elutriate derived from sediments containing TBT. Analysis of the two samples from FNBA also had no detectable TBT in elutriate.

Although no TBT was detected in elutriate, the detection limit as measured in the elutriate (<0.05 mg/m^3) is higher than the ANZECC 95 % protection trigger value of 0.006 mg/m^3. A small amount of dilution (<10 times) is theoretically required to reduce the detection limit concentration to the DGV. This occurs (refer section 8.3.2) within a zone close to the dredging.

8.3.5 Biouptake

A number of contaminants present in coastal sediment have greater potential for uptake by biota (through water borne or sediment sources). These contaminants include lead, mercury, TBT and organochlorine compounds. The degree of uptake is dependent on a variety of factors (species, whether the contaminant is in water, associated with sediment, organic matter in living biological material). Of the two contaminants that were examined for elutriate (nickel and TBT) neither were found to be waterborne at measurable concentrations.

Dredging results in the off-site transport of sediment. As described in KEL (2019), most sediment falls adjacent to the site of dredging but some is transported off-site to settle in depositional areas relatively close to the areas of dredging. As described (refer Beca 2001) these depositional areas are principally within the waterfront area and in the area just north of the seaward end of the navigation channel. Down-current particle sedimentation concentrations will not result in any changes in nickel concentration. The analysis for TBT did identify inhomogeneous presence of TBT in two samples from near the FNB suggesting possible presence of paint fragments in the surface layer of sediment. Disturbance during dredging will result in off-site movement of particulates, with past monitoring indicating that this is detectable at a distance of about 200 m. Although TBT is known to be taken up by biota, the average (unadjusted for TOC) concentration in the FNBA area was below the DGV. The dredging is not expected to alter the overall accessibility of TBT (to biota) within this area. Further sediment sampling which will include TBT analysis is to be carried out in the 2020 survey (for disposal). This will provide additional information on TBT concentration variability.

8.3.6 Summary

Analysis of 18 surface sediment samples collected from three areas within the WCNP, did not identify any significant contamination across the sediment samples.

Elevated nickel concentrations were measured in two samples, similar to samples previously collected from this location within the channel in 2001. The elevation was considered likely to be geologic in origin. No nickel was released in elutriate and consequently no environmental issues were identified in relation to the local difference in sediment quality.

Elevated concentrations of TBT were measured in two sediment samples from the FNBA. Repeat analysis of both samples failed to detect any TBT. The samples were subject to elutriate extraction which showed that the TBT was not detectable in the extract. It is possible that the measured TBT was present as isolated flakes rather than adsorbed to organic matter/sediment. As noted above, examination of coarse sediment particles did not identify any paint flakes in either sample.

9 SUMMARY & CONCLUSIONS

Sediment physical characteristics

Surface sediments within the WCNP (FNB, FNBA and Rangitoto Channel areas) are dominated by coarse shell material (and some lithic materials). As the approaches and channel are subject to relatively strong currents, the sediments have low proportions of mud. Proportions of mud are higher near the FNBA within the port basins (not part of this assessment) where currents are low (the area is a depositional environment) and further out within the Hauraki Gulf (beyond Section E of the channel) (where water is deeper and the environment is more depositional).

Sediments to be dredged are predominantly shelly and sandy in nature. One sediment sample from the FNB contained a higher proportion of mud compared to other samples collected. Subsurface materials within the WCNP have variable physical characteristics based on the Kingett Mitchell (2001) assessment. Those samples were both shelly and muddy reflecting the variability seen in surface sediments.

Coarse material characteristics

Shell makes up most of the material larger than sand (gravel size) and also virtually all of the coarse sand fraction (refer section 5.4). There is little man-made debris in the samples. Although not identified in samples collected some man-made materials such as glass, ceramic, pottery and metal might be expected. One unidentified non-metallic object was noted in the fraction >2 mm in size. In the coarse sand fraction, the only presumed man-made objects were a smelter type globular particle and a, angular green ‘plastic or foil” object.

General characteristics

The sediments contain about 0.5 % TOC which appears typical of sediments in the lower harbour. The sediment contains very little particulate organic matter (e.g., terrestrial organic matter such as seeds, wood fragments etc.) apart from living biota. The sediment does not show any indication of containing excess organic matter due to addition from sources such as stormwater and wastewater.

Trace elements

Concentrations of arsenic, cadmium, chromium, copper, lead, mercury and zinc in the sediment samples collected in December 2019 were below their ANZECC (2018) DGV concentrations.

For nickel two samples from the Rangitoto Channel had nickel concentrations above the DGV but below the GV-high. Both concentrations are considered to be natural. Similar higher concentrations have been noted previously in the same general area of the channel. Sub-surface concentrations would be expected to be similar with lead expected to be lower.

Hydrocarbons

The detected concentrations and the overall total concentrations (reported as less than concentrations) were lower than the ANZECC (2018) DGV concentration of 280 mg/kg.

Concentrations in sub-sub-surface sediments within the channel and approaches would be expected to be non-detectable as sub-surface sediments have not been exposed to man-made petroleum hydrocarbons.

PAHs are present in the surface sediments. This group of hydrocarbons are ubiquitous and widely distributed. Concentrations in surface are lower than the DGV concentration. Concentrations are expected to be much lower in sub-surface sediments but may be present as PAHs are released during vegetation burning (historical).

Organochlorine compounds

No compounds were detected (at a detection limit of 0.001 mg/kg). DDT isomers and total DDT were non-detectable. The non-detected concentration were not adjusted for TOC concentration. It is not possible based on the detection limit to identify whether an adjusted concentration of 4,4'-DDE in any of the samples would exceed the DGV concentration. Sub-surface concentrations should not contain any DDT as DDT was used from the 1940s onwards and residual DDT remains in the environment.

PCB concentrations were not detectable in surface sediments and are considered to be below the DGV. Subsurface sediments are expected to contain no PCB based on sub-surface sediment analysis in 2001 and PCB use in New Zealand commencing in the early 1900s (subsurface sediment pre-date European arrival in New Zealand).

TBT

Measurement of TBT compounds carried out on the 18 surface sediment samples collected in December 2019, did not detect any butyl tin compounds in 16 samples (<0.004 mg/kg). Dibutyl tin was detected in samples FNBA-7M and 4M at concentrations of 0.007 and 0.008 mg/kg respectively. Corresponding concentrations of tributyl tin were 0.051 and 0.053 mg/g. respectively. The unadjusted tributyltin concentrations in both samples are below the GV-high for TBT but the adjusted concentrations for both samples (0.113 and 0.147 mg/kg) are above the GV-high (0.070 mg/kg). Reanalysis of two independent subsamples from each sample did not detect any TBT. The results indicate that TBT is likely to be present in paint fragment form. However, examination of the coarse fractions of the samples did not identify the presence of paint fragments.

Other compounds

A range of other compounds were examined including phenols and phthalates (the latter sourced principally from plastics). Phthalates have been detected in sediments in historical sampling but were not detected in the FNB and FNBA samples.

Contaminants and dredging

The only contaminants that warranted follow up evaluation were nickel and TBT. Nickel was included for completeness even though, the elevations were considered likely to be geologic in origin. Analysis of elutriate from a wide range of sediments from the harbour has shown that nickel is not released when sediment interacts with seawater. No nickel was released in

elutriate from the two samples. No waterborne environmental issues were identified in relation to dredging associated with the local natural difference in sediment quality.

Elevated concentrations of TBT were measured in two sediment samples from the FNBA. Repeat analysis of both samples failed to detect any TBT. TBT has not been detected in elutriate from sediment containing TBT in the port and waterfront examined previously. The samples were subject to elutriate extraction which showed that the TBT was not detectable in the extract. It is possible that the measured TBT was present as isolated flakes rather than adsorbed to organic matter/sediment. As noted above, no paint flakes were identified in either sample.

Although the analytical detection limit (in the elutriate analysis) is higher than the ANZECC 95 % protection trigger value of 0.006 mg/m^3. A small amount of dilution (<10 times) is theoretically required to reduce the detection limit concentration to the DGV. This occurs within a zone close to the dredging. As such TBT in sediment is not likely to result in waterborne toxicity due to the release of TBT.

The sediment quality assessment included measurement of a range of contaminants that are known to be taken up by benthic biota (biota that live in or feed on the seabed). Although a number were detected, concentrations were low when compared to toxicity based sediment quality guidelines. Although TBT is known to be taken up by biota, the average (unadjusted for TOC) concentration in the FNBA area was below the DGV. The dredging is not expected to alter the overall accessibility of TBT (to biota) within this area.

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Appendix A: Stage 1 Dredging depths in WCNP and location of December 2019 samples in dredging areas.

NOTES:

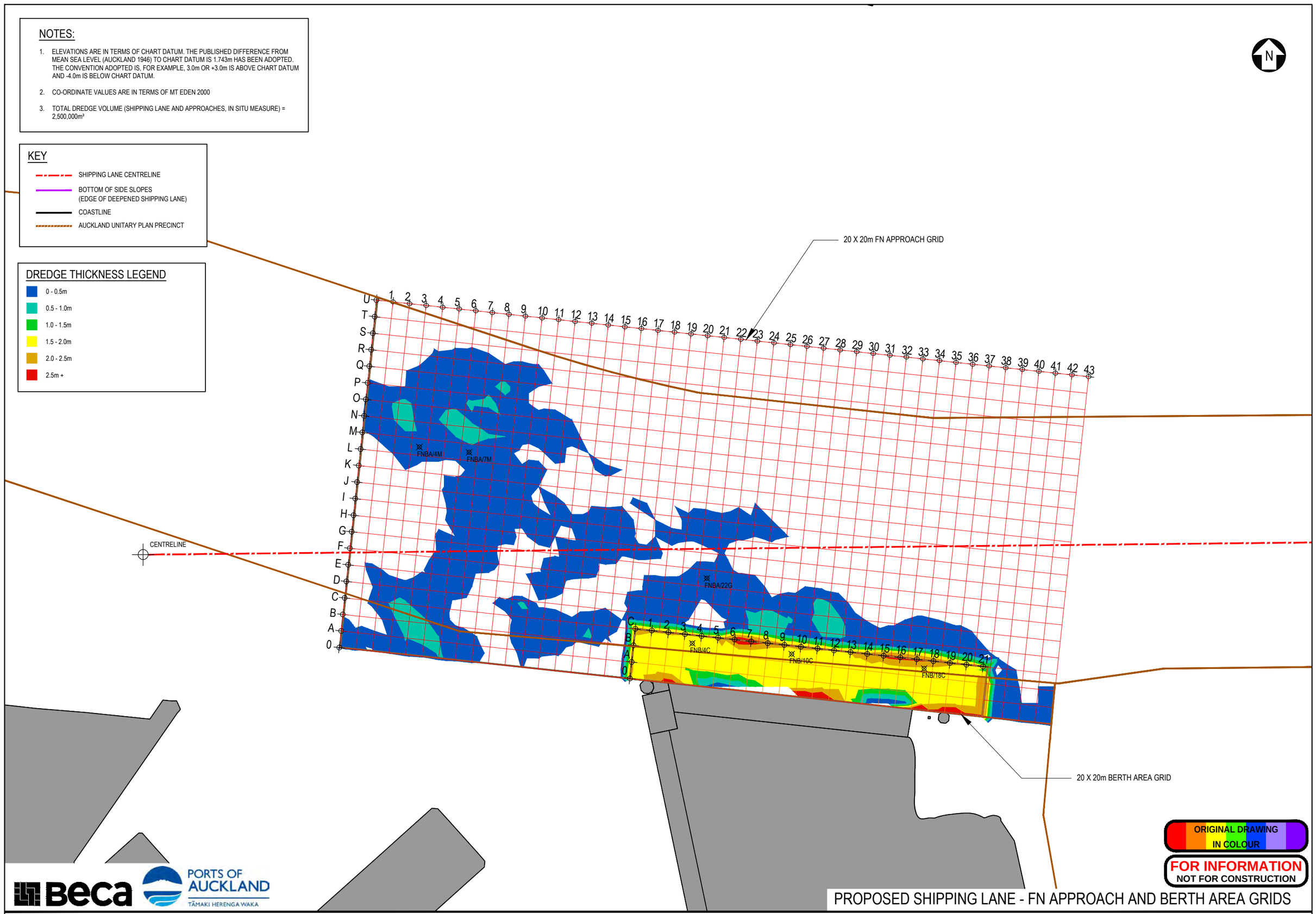
1. ELEVATIONS ARE IN TERMS OF CHART DATUM. THE PUBLISHED DIFFERENCE FROM MEAN SEA LEVEL (AUCKLAND 1946) TO CHART DATUM IS 1.743m HAS BEEN ADOPTED. THE CONVENTION ADOPTED IS, FOR EXAMPLE, 3.0m OR +3.0m IS ABOVE CHART DATUM AND -4.0m IS BELOW CHART DATUM.
2. CO-ORDINATE VALUES ARE IN TERMS OF MT EDEN 2000
3. TOTAL DREDGE VOLUME (SHIPPING LANE AND APPROACHES, IN SITU MEASURE) = 2,500,000m³

KEY

- SHIPPING LANE CENTRELINE
- BOTTOM OF SIDE SLOPES (EDGE OF DEEPENED SHIPPING LANE)
- COASTLINE
- AUCKLAND UNITARY PLAN PRECINCT

DREDGE THICKNESS LEGEND

- 0 - 0.5m
- 0.5 - 1.0m
- 1.0 - 1.5m
- 1.5 - 2.0m
- 2.0 - 2.5m
- 2.5m +



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PORTS OF AUCKLAND
TĀMAKI HERENGA WAKA

PROPOSED SHIPPING LANE - FN APPROACH AND BERTH AREA GRIDS

SCALE 1:500 (A1)
SCALE 1:1000 (A3)

SAMPLE LOCATIONS DECEMBER 2019 - FIGURE 1

NOTES:

1. ELEVATIONS ARE IN TERMS OF CHART DATUM. THE PUBLISHED DIFFERENCE FROM MEAN SEA LEVEL (AUCKLAND 1946) TO CHART DATUM IS 1.743m HAS BEEN ADOPTED. THE CONVENTION ADOPTED IS, FOR EXAMPLE, 3.0m OR +3.0m IS ABOVE CHART DATUM AND -4.0m IS BELOW CHART DATUM.
2. CO-ORDINATE VALUES ARE IN TERMS OF MT EDEN 2000
3. TOTAL DREDGE VOLUME (SHIPPING LANE AND APPROACHES, IN SITU MEASURE) = 2,500,000m³

KEY

- SHIPPING LANE CENTRELINE
- BOTTOM OF SIDE SLOPES (EDGE OF DEEPENED SHIPPING LANE)
- COASTLINE
- AUCKLAND UNITARY PLAN PRECINCT

DREDGE THICKNESS LEGEND

- 0 - 0.5m
- 0.5 - 1.0m
- 1.0 - 1.5m
- 1.5 - 2.0m
- 2.0 - 2.5m
- 2.5m +

NORTH HEAD

DEVONPORT

N

AREA A: SOUTHERN STRAIGHT
DREDGE DEPTH: -13.5m CD

F E D C B A

0 5 10 15 20 25 30 35 40 45 50 55

50 x 50m GRID

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PORTS OF AUCKLAND
TĀMAKI HERENGA WAKA

PROPOSED SHIPPING LANE - AREA A GRID

SCALE 1:250 (A1)
SCALE 1:500 (A3)

SAMPLE LOCATIONS DECEMBER 2019 - FIGURE 2

NOTES:

1. ELEVATIONS ARE IN TERMS OF CHART DATUM. THE PUBLISHED DIFFERENCE FROM MEAN SEA LEVEL (AUCKLAND 1946) TO CHART DATUM IS 1.743m HAS BEEN ADOPTED. THE CONVENTION ADOPTED IS, FOR EXAMPLE, 3.0m OR +3.0m IS ABOVE CHART DATUM AND -4.0m IS BELOW CHART DATUM.
2. CO-ORDINATE VALUES ARE IN TERMS OF MT EDEN 2000
3. TOTAL DREDGE VOLUME (SHIPPING LANE AND APPROACHES, IN SITU MEASURE) = 2,500,000m³

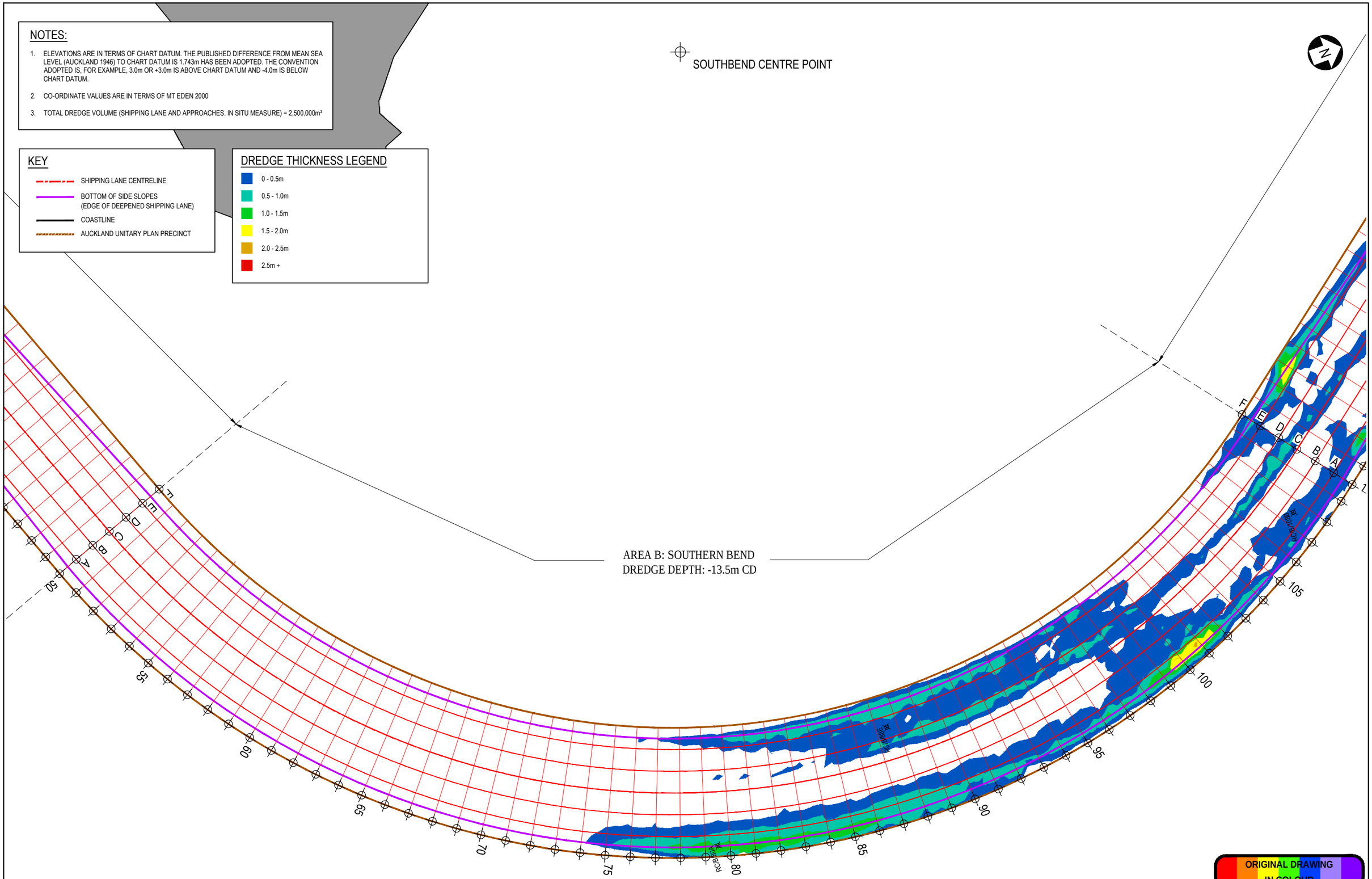
KEY

- SHIPPING LANE CENTRELINE
- BOTTOM OF SIDE SLOPES (EDGE OF DEEPENED SHIPPING LANE)
- COASTLINE
- AUCKLAND UNITARY PLAN PRECINCT

DREDGE THICKNESS LEGEND

- 0 - 0.5m
- 0.5 - 1.0m
- 1.0 - 1.5m
- 1.5 - 2.0m
- 2.0 - 2.5m
- 2.5m +

SOUTHBEND CENTRE POINT



AREA B: SOUTHERN BEND
DREDGE DEPTH: -13.5m CD

50 x 50m GRID

ORIGINAL DRAWING IN COLOUR

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PORTS OF AUCKLAND
TĀMAKI HERENGA WAKA

PROPOSED SHIPPING LANE - AREA B GRID

SCALE 1:250 (A1)
SCALE 1:500 (A3)

SAMPLE LOCATIONS DECEMBER 2019 - FIGURE 3

NOTES:

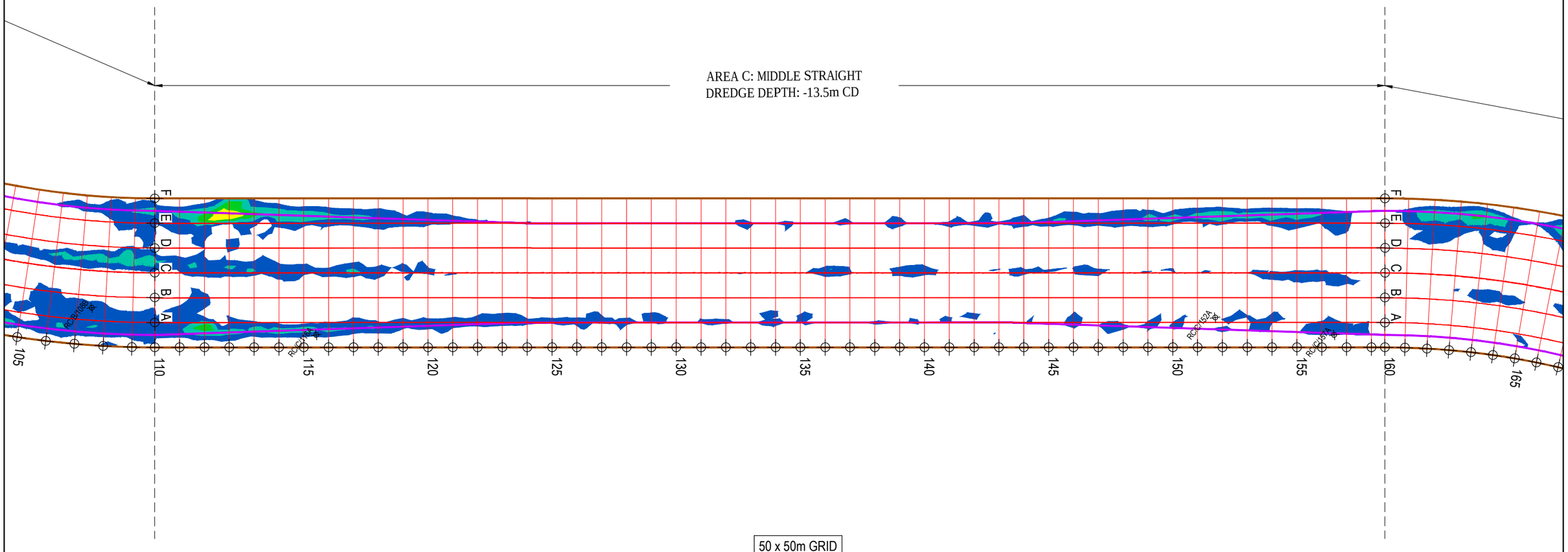
1. ELEVATIONS ARE IN TERMS OF CHART DATUM. THE PUBLISHED DIFFERENCE FROM MEAN SEA LEVEL (AUCKLAND 1946) TO CHART DATUM IS 1.743m HAS BEEN ADOPTED. THE CONVENTION ADOPTED IS, FOR EXAMPLE, 3.0m OR +3.0m IS ABOVE CHART DATUM AND -4.0m IS BELOW CHART DATUM.
2. CO-ORDINATE VALUES ARE IN TERMS OF MT EDEN 2000
3. TOTAL DREDGE VOLUME (SHIPPING LANE AND APPROACHES, IN SITU MEASURE) = 2,500,000m³

KEY

- SHIPPING LANE CENTRELINE
- BOTTOM OF SIDE SLOPES (EDGE OF DEEPENED SHIPPING LANE)
- COASTLINE
- AUCKLAND UNITARY PLAN PRECINCT

DREDGE THICKNESS LEGEND

- 0 - 0.5m
- 0.5 - 1.0m
- 1.0 - 1.5m
- 1.5 - 2.0m
- 2.0 - 2.5m
- 2.5m +



50 x 50m GRID

ORIGINAL DRAWING IN COLOUR

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PORTS OF AUCKLAND
TĀMAKI HERENGA WAKA

PROPOSED SHIPPING LANE - AREA C GRID

SCALE 1:250 (A1)
SCALE 1:500 (A3)

SAMPLE LOCATIONS DECEMBER 2019 - FIGURE 4

NOTES:

1. ELEVATIONS ARE IN TERMS OF CHART DATUM. THE PUBLISHED DIFFERENCE FROM MEAN SEA LEVEL (AUCKLAND 1946) TO CHART DATUM IS 1.743m HAS BEEN ADOPTED. THE CONVENTION ADOPTED IS, FOR EXAMPLE, 3.0m OR +3.0m IS ABOVE CHART DATUM AND -4.0m IS BELOW CHART DATUM.
2. CO-ORDINATE VALUES ARE IN TERMS OF MT EDEN 2000
3. TOTAL DREDGE VOLUME (SHIPPING LANE AND APPROACHES, IN SITU MEASURE) = 2,500,000m³

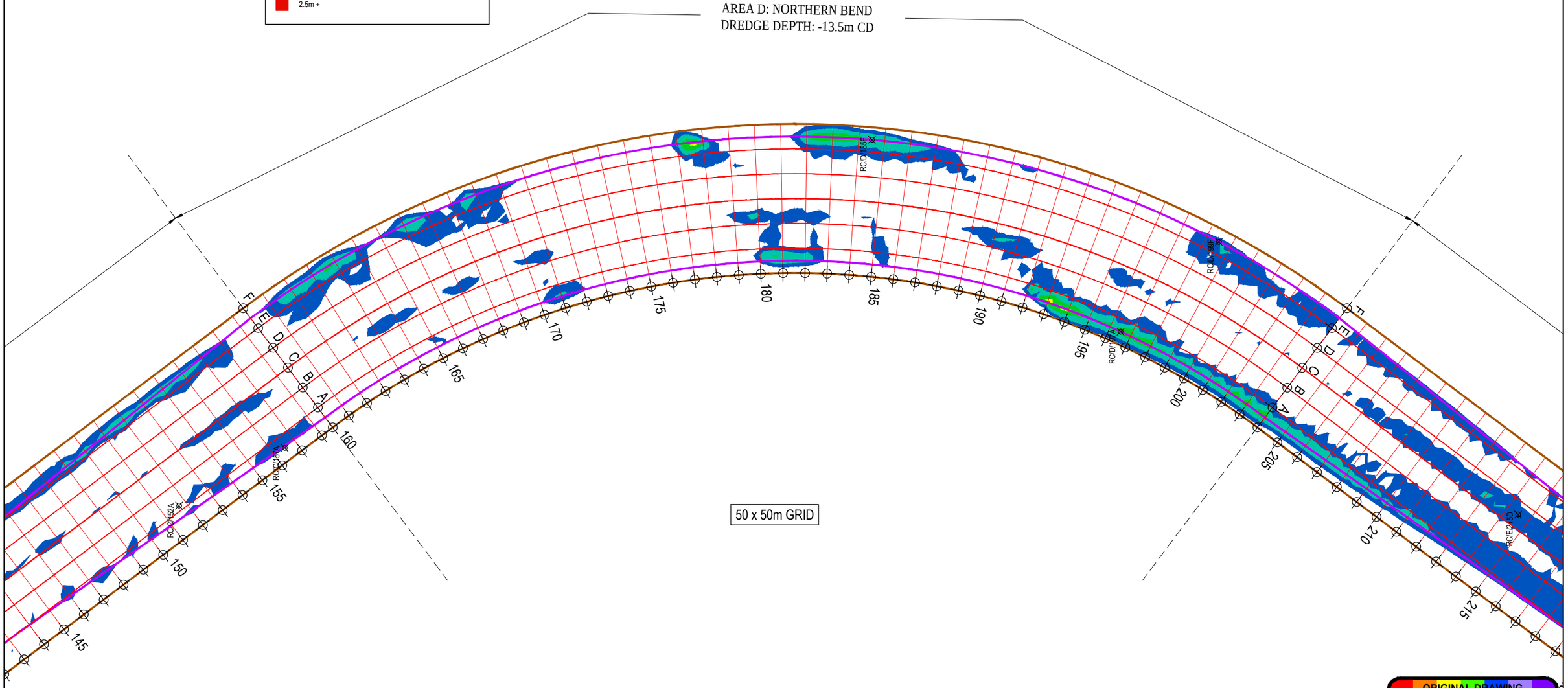
KEY

- SHIPPING LANE CENTRELINE
- BOTTOM OF SIDE SLOPES (EDGE OF DEEPENED SHIPPING LANE)
- COASTLINE
- AUCKLAND UNITARY PLAN PRECINCT

DREDGE THICKNESS LEGEND

- 0 - 0.5m
- 0.5 - 1.0m
- 1.0 - 1.5m
- 1.5 - 2.0m
- 2.0 - 2.5m
- 2.5m +

AREA D: NORTHERN BEND
DREDGE DEPTH: -13.5m CD



ORIGINAL DRAWING IN COLOUR

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PORTS OF AUCKLAND
TĀMAKI HERENGA WAKA

PROPOSED SHIPPING LANE - AREA D GRID

SCALE 1:250 (A1)
SCALE 1:500 (A3)

SAMPLE LOCATIONS DECEMBER 2019 - FIGURE 5

NOTES:

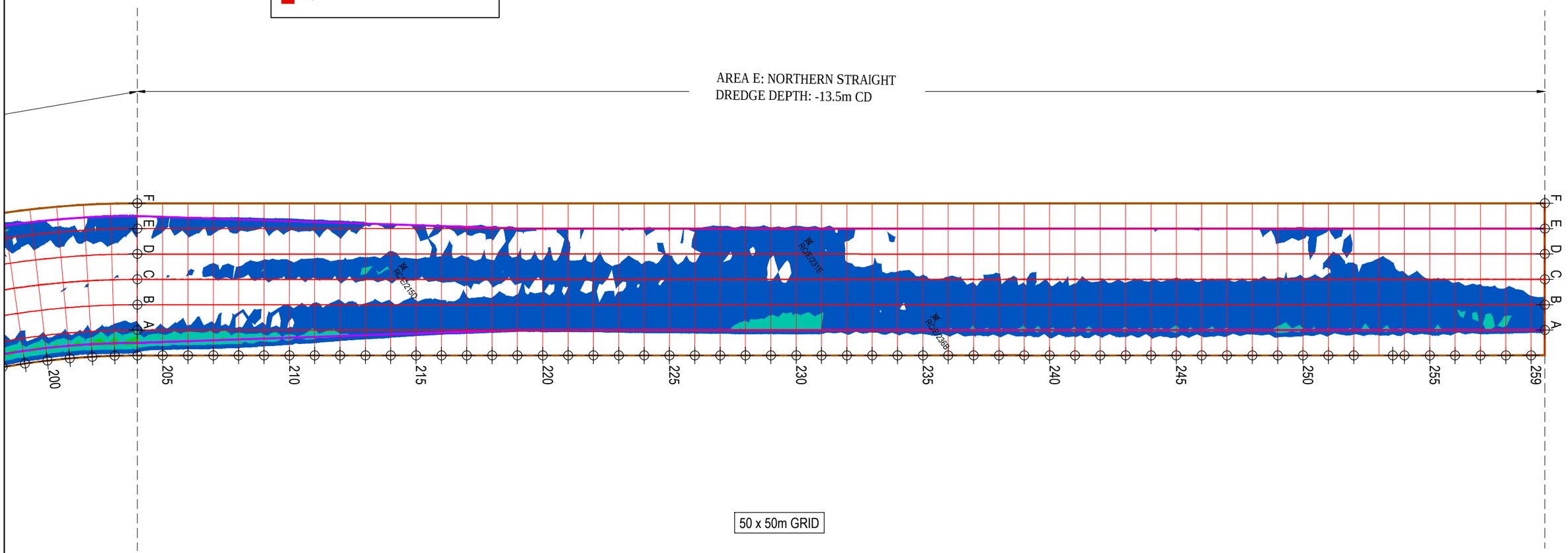
1. ELEVATIONS ARE IN TERMS OF CHART DATUM. THE PUBLISHED DIFFERENCE FROM MEAN SEA LEVEL (AUCKLAND 1946) TO CHART DATUM IS 1.743m HAS BEEN ADOPTED. THE CONVENTION ADOPTED IS, FOR EXAMPLE, 3.0m OR +3.0m IS ABOVE CHART DATUM AND -4.0m IS BELOW CHART DATUM.
2. CO-ORDINATE VALUES ARE IN TERMS OF MT EDEN 2000
3. TOTAL DREDGE VOLUME (SHIPPING LANE AND APPROACHES, IN SITU MEASURE) = 2,500,000m³

KEY

- SHIPPING LANE CENTRELINE
- BOTTOM OF SIDE SLOPES (EDGE OF DEEPENED SHIPPING LANE)
- COASTLINE
- AUCKLAND UNITARY PLAN PRECINCT

DREDGE THICKNESS LEGEND

- 0 - 0.5m
- 0.5 - 1.0m
- 1.0 - 1.5m
- 1.5 - 2.0m
- 2.0 - 2.5m
- 2.5m +



50 x 50m GRID

ORIGINAL DRAWING IN COLOUR

FOR INFORMATION
NOT FOR CONSTRUCTION

Beca

PORTS OF AUCKLAND
TĀMAKI HERENGA WAKA

PROPOSED SHIPPING LANE - AREA E GRID

SCALE 1:250 (A1)
SCALE 1:500 (A3)

SAMPLE LOCATIONS DECEMBER 2019 - FIGURE 6

Appendix B: Laboratory report

Hill Laboratories
TRIED, TESTED AND TRUSTED

R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Certificate of Analysis

Client:	Ports of Auckland Limited	**Lab No:**	2291701	SPv10
Contact:	Paul Kennedy C/- Kennedy Environmental Limited 1/9 Exmouth Road Northcote Auckland 0627	**Date Received:**	11-Dec-2019	
		Date Reported:	03-Feb-2020	**(Amended)**
		Quote No:	102550	
		Order No:	PO104715	
		Client Reference:		
		Submitted By:	Paul Kennedy	

Sample Type: Saline

Sample Name:	Gannet Rock Sea Water 21-Jan-2019				
Lab Number:	2291701.23				
Individual Tests					
Total Nickel g/m³	< 0.0070	-	-	-	-
Tributyl Tin Trace in Water samples by GCMS*					
Dibutyltin (as Sn)* g/m³	< 0.00006	-	-	-	-
Tributyltin (as Sn)* g/m³	< 0.00005	-	-	-	-
Triphenyltin (as Sn)* g/m³	< 0.00004	-	-	-	-

Sample Type: Sediment

Sample Name:	RCE-236B 11-Dec-2019 11:25 am	RCE-231E 11-Dec-2019 11:25 am	RCE-215D 11-Dec-2019 11:25 am	RCD-197A 11-Dec-2019 11:25 am	RCD-199F 11-Dec-2019 11:25 am
Lab Number:	2291701.1	2291701.2	2291701.3	2291701.4	2291701.5
Individual Tests					
Carbonate* g/100g as CO_2	7.6	73	80	73	51
Total Recoverable Aluminium mg/kg dry wt	12,200	5,900	1,590	3,000	8,200
Total Organic Carbon* g/100g dry wt	0.72	0.43	0.45	0.99	0.58
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg					
Total Recoverable Arsenic mg/kg dry wt	5.7	3.1	1.3	2.3	4.6
Total Recoverable Cadmium mg/kg dry wt	0.027	0.021	0.010	0.014	0.018
Total Recoverable Chromium mg/kg dry wt	18.0	8.8	3.5	7.6	14.8
Total Recoverable Copper mg/kg dry wt	7.1	4.4	1.2	2.1	4.7
Total Recoverable Lead mg/kg dry wt	12.2	5.7	2.4	5.1	9.9
Total Recoverable Mercury mg/kg dry wt	0.06	0.04	< 0.02	0.02	0.05
Total Recoverable Nickel mg/kg dry wt	10.5	13.0	7.1	18.7	25
Total Recoverable Zinc mg/kg dry wt	50	25	7.6	17.3	40
7 Grain Sizes Profile as received*					
Dry Matter of Sieved Sample* g/100g as rcvd	53	78	74	73	68
Fraction >/= 2 mm* g/100g dry wt	0.2	50.7	53.9	32.8	34.7
Fraction < 2 mm, >/= 1 mm* g/100g dry wt	< 0.1	7.8	10.0	7.6	4.5
Fraction < 1 mm, >/= 500 µm* g/100g dry wt	< 0.1	3.6	6.0	4.9	2.7
Fraction < 500 µm, >/= 250 µm* g/100g dry wt	0.2	2.8	5.6	8.0	4.3
Fraction < 250 µm, >/= 125 µm* g/100g dry wt	6.7	8.3	5.0	16.6	8.0
Fraction < 125 µm, >/= 63 µm* g/100g dry wt	40.9	13.3	3.2	15.3	20.7
Fraction < 63 µm* g/100g dry wt	51.9	13.6	16.3	14.9	25.2
Organochlorine Pesticides Trace in Soil					
Aldrin mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
alpha-BHC mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
beta-BHC mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
delta-BHC mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010

ilac-MRA IANZ ACCREDITED LABORATORY

This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.
The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.

Sample Type: Sediment						
Sample Name:		RCE-236B 11-Dec-2019 11:25 am	RCE-231E 11-Dec-2019 11:25 am	RCE-215D 11-Dec-2019 11:25 am	RCD-197A 11-Dec-2019 11:25 am	RCD-199F 11-Dec-2019 11:25 am
Lab Number:		2291701.1	2291701.2	2291701.3	2291701.4	2291701.5
Organochlorine Pesticides Trace in Soil						
gamma-BHC (Lindane)	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
cis-Chlordane	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
trans-Chlordane	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
2,4'-DDD	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
4,4'-DDD	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
2,4'-DDE	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
4,4'-DDE	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
2,4'-DDT	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
4,4'-DDT	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Total DDT Isomers	mg/kg dry wt	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Dieldrin	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Endosulfan I	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Endosulfan II	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Endosulfan sulphate	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Endrin	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Endrin aldehyde	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Endrin ketone	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Heptachlor	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Heptachlor epoxide	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Hexachlorobenzene	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Methoxychlor	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Total Chlordane [(cis+trans)* 100/42]	mg/kg dry wt	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Polycyclic Aromatic Hydrocarbons Trace in Soil						
Total of Reported PAHs in Soil	mg/kg dry wt	0.3	< 0.3	< 0.3	0.6	< 0.3
1-Methylnaphthalene	mg/kg dry wt	0.003	0.005	< 0.002	0.003	< 0.003
2-Methylnaphthalene	mg/kg dry wt	0.003	0.002	< 0.002	0.003	< 0.003
Acenaphthene	mg/kg dry wt	< 0.003	< 0.002	< 0.002	< 0.002	< 0.003
Acenaphthylene	mg/kg dry wt	< 0.003	< 0.002	< 0.002	< 0.002	< 0.003
Anthracene	mg/kg dry wt	0.004	0.002	< 0.002	0.006	0.014
Benzo[a]anthracene	mg/kg dry wt	0.019	0.010	0.009	0.056	0.013
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.030	0.017	0.011	0.062	0.017
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.031	0.019	0.018	0.074	0.018
Benzo[e]pyrene	mg/kg dry wt	0.014	0.010	0.007	0.027	0.008
Benzo[g,h,i]perylene	mg/kg dry wt	0.022	0.014	0.009	0.042	0.012
Benzo[k]fluoranthene	mg/kg dry wt	0.014	0.006	0.008	0.029	0.008
Chrysene	mg/kg dry wt	0.023	0.014	0.010	0.041	0.014
Dibenzo[a,h]anthracene	mg/kg dry wt	0.004	0.004	0.003	0.008	0.002
Fluoranthene	mg/kg dry wt	0.045	0.016	0.009	0.103	0.028
Fluorene	mg/kg dry wt	0.003	0.007	< 0.002	< 0.002	< 0.003
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.023	0.013	0.010	0.044	0.013
Naphthalene	mg/kg dry wt	< 0.015	< 0.010	< 0.010	< 0.010	< 0.011
Perylene	mg/kg dry wt	0.010	0.005	0.003	0.016	0.007
Phenanthrene	mg/kg dry wt	0.019	0.032	< 0.002	0.021	0.011
Pyrene	mg/kg dry wt	0.047	0.016	0.009	0.090	0.028
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES	mg/kg dry wt	0.044	0.026	0.018	0.092	0.025
Benzo[a]pyrene Toxic Equivalence (TEF)	mg/kg dry wt	0.043	0.026	0.018	0.091	0.025
Polychlorinated Biphenyls Trace in Soil*						
PCB-18	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-28	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-31	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-44	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010

Sample Type: Sediment						
Sample Name:		RCE-236B 11-Dec-2019 11:25 am	RCE-231E 11-Dec-2019 11:25 am	RCE-215D 11-Dec-2019 11:25 am	RCD-197A 11-Dec-2019 11:25 am	RCD-199F 11-Dec-2019 11:25 am
Lab Number:		2291701.1	2291701.2	2291701.3	2291701.4	2291701.5
Polychlorinated Biphenyls Trace in Soil*						
PCB-49	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-52	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-60	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-77	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-81	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-86	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-101	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-105	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-110	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-114	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-118	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-121	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-123	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-126	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-128	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-138	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-141	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-149	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-151	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-153	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-156	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-157	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-159	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-167	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-169	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-170	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-180	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-189	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-194	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-206	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-209	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Mono-Ortho PCB Toxic Equivalence (TEF)*	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Non-Ortho PCB Toxic Equivalence (TEF)*	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Total PCB (Sum of 35 congeners)	mg/kg dry wt	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Tributyl Tin Trace in Soil samples by GCMS						
Dibutyltin (as Sn)	mg/kg dry wt	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Monobutyltin (as Sn)	mg/kg dry wt	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
Tributyltin (as Sn)	mg/kg dry wt	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Triphenyltin (as Sn)	mg/kg dry wt	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Total Petroleum Hydrocarbons in Soil, GC						
C7 - C9	mg/kg dry wt	< 12	< 8	< 9	< 8	< 9
C10 - C11	mg/kg dry wt	< 12	< 8	< 9	< 8	< 9
C12 - C14	mg/kg dry wt	< 12	< 8	< 9	< 8	< 9
C15 - C20	mg/kg dry wt	< 12	< 8	< 9	< 8	< 9
C21 - C25	mg/kg dry wt	< 12	< 8	< 9	< 8	< 9
C26 - C29	mg/kg dry wt	< 12	< 8	< 9	< 8	< 9
C30 - C44	mg/kg dry wt	< 30	< 20	< 20	< 20	< 20
Total hydrocarbons (C7 - C44)	mg/kg dry wt	< 100	< 70	< 70	< 70	< 80

Sample Type: Sediment						
Sample Name:		RCD-185F 11-Dec-2019 11:25 am	RCC-155C 11-Dec-2019	RCC-157A 11-Dec-2019	RCC-116A 11-Dec-2019	RCB-108B 11-Dec-2019
Lab Number:		2291701.6	2291701.7	2291701.8	2291701.9	2291701.10
Individual Tests						
Carbonate*	g/100g as CO_2	32	28	33	12.6	69
Total Recoverable Aluminium	mg/kg dry wt	5,600	11,500	6,400	7,900	4,600
Total Organic Carbon*	g/100g dry wt	0.45	0.59	0.45	0.37	0.32
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	4.2	8.1	5.0	6.4	7.6
Total Recoverable Cadmium	mg/kg dry wt	0.020	0.035	0.020	0.027	0.023
Total Recoverable Chromium	mg/kg dry wt	13.8	18.8	9.9	12.6	7.4
Total Recoverable Copper	mg/kg dry wt	3.7	4.7	3.8	3.8	3.1
Total Recoverable Lead	mg/kg dry wt	8.8	7.0	8.2	7.1	6.1
Total Recoverable Mercury	mg/kg dry wt	0.03	0.03	0.05	0.03	0.03
Total Recoverable Nickel	mg/kg dry wt	31	14.5	7.6	9.3	5.4
Total Recoverable Zinc	mg/kg dry wt	38	38	34	34	29
7 Grain Sizes Profile as received*						
Dry Matter of Sieved Sample*	g/100g as rcvd	72	57	67	66	76
Fraction >/= 2 mm*	g/100g dry wt	26.5	9.0	24.4	20.0	46.1
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	3.8	4.3	6.2	5.1	13.6
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	2.6	4.6	3.7	3.2	7.3
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	5.2	4.7	3.7	5.0	5.6
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	16.8	4.9	13.0	15.6	8.7
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	26.2	14.7	28.0	24.0	3.0
Fraction < 63 µm*	g/100g dry wt	18.8	57.9	21.1	27.0	15.6
Organochlorine Pesticides Trace in Soil						
Aldrin	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
alpha-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
beta-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
delta-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
gamma-BHC (Lindane)	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
cis-Chlordane	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
trans-Chlordane	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
2,4'-DDD	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
4,4'-DDD	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
2,4'-DDE	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
4,4'-DDE	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
2,4'-DDT	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
4,4'-DDT	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Total DDT Isomers	mg/kg dry wt	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Dieldrin	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Endosulfan I	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Endosulfan II	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Endosulfan sulphate	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Endrin	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Endrin aldehyde	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Endrin ketone	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Heptachlor	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Heptachlor epoxide	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Hexachlorobenzene	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Methoxychlor	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Total Chlordane [(cis+trans)* 100/42]	mg/kg dry wt	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Polycyclic Aromatic Hydrocarbons Trace in Soil						
Total of Reported PAHs in Soil	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
1-Methylnaphthalene	mg/kg dry wt	< 0.002	< 0.003	< 0.002	< 0.002	< 0.002
2-Methylnaphthalene	mg/kg dry wt	< 0.002	< 0.003	< 0.002	< 0.002	< 0.002
Acenaphthene	mg/kg dry wt	< 0.002	< 0.003	< 0.002	< 0.002	< 0.002

Sample Type: Sediment						
Sample Name:		RCD-185F 11-Dec-2019 11:25 am	RCC-155C 11-Dec-2019	RCC-157A 11-Dec-2019	RCC-116A 11-Dec-2019	RCB-108B 11-Dec-2019
Lab Number:		2291701.6	2291701.7	2291701.8	2291701.9	2291701.10
Polycyclic Aromatic Hydrocarbons Trace in Soil						
Acenaphthylene	mg/kg dry wt	0.002	< 0.003	< 0.002	< 0.002	< 0.002
Anthracene	mg/kg dry wt	< 0.002	< 0.003	< 0.002	< 0.002	< 0.002
Benzo[a]anthracene	mg/kg dry wt	0.015	0.002	0.004	0.006	0.003
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.022	0.003	0.007	0.008	0.005
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.024	0.003	0.007	0.009	0.004
Benzo[e]pyrene	mg/kg dry wt	0.009	< 0.003	0.003	0.004	0.002
Benzo[g,h,i]perylene	mg/kg dry wt	0.012	< 0.003	0.005	0.006	0.003
Benzo[k]fluoranthene	mg/kg dry wt	0.010	< 0.003	0.003	0.004	< 0.002
Chrysene	mg/kg dry wt	0.013	0.003	0.004	0.006	0.003
Dibenzo[a,h]anthracene	mg/kg dry wt	0.003	< 0.003	< 0.002	< 0.002	< 0.002
Fluoranthene	mg/kg dry wt	0.019	0.005	0.009	0.014	0.007
Fluorene	mg/kg dry wt	< 0.002	< 0.003	< 0.002	< 0.002	< 0.002
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.014	< 0.003	0.005	0.005	0.003
Naphthalene	mg/kg dry wt	< 0.010	< 0.012	< 0.010	< 0.010	< 0.010
Perylene	mg/kg dry wt	0.005	0.004	0.002	0.003	< 0.002
Phenanthrene	mg/kg dry wt	0.009	0.002	0.003	0.005	0.003
Pyrene	mg/kg dry wt	0.020	0.005	0.009	0.014	0.007
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES	mg/kg dry wt	0.032	< 0.006	0.010	0.012	0.007
Benzo[a]pyrene Toxic Equivalence (TEF)	mg/kg dry wt	0.032	< 0.006	0.010	0.012	0.007
Polychlorinated Biphenyls Trace in Soil*						
PCB-18	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-28	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-31	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-44	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-49	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-52	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-60	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-77	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-81	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-86	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-101	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-105	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-110	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-114	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-118	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-121	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-123	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-126	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-128	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-138	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-141	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-149	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-151	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-153	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-156	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-157	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-159	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-167	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-169	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-170	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-180	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-189	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010

Sample Type: Sediment						
Sample Name:		RCD-185F 11-Dec-2019 11:25 am	RCC-155C 11-Dec-2019	RCC-157A 11-Dec-2019	RCC-116A 11-Dec-2019	RCB-108B 11-Dec-2019
Lab Number:		2291701.6	2291701.7	2291701.8	2291701.9	2291701.10
Polychlorinated Biphenyls Trace in Soil*						
PCB-194	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-206	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-209	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Mono-Ortho PCB Toxic Equivalence (TEF)*	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Non-Ortho PCB Toxic Equivalence (TEF)*	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Total PCB (Sum of 35 congeners)	mg/kg dry wt	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Tributyl Tin Trace in Soil samples by GCMS						
Dibutyltin (as Sn)	mg/kg dry wt	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Monobutyltin (as Sn)	mg/kg dry wt	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
Tributyltin (as Sn)	mg/kg dry wt	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Triphenyltin (as Sn)	mg/kg dry wt	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Total Petroleum Hydrocarbons in Soil, GC						
C7 - C9	mg/kg dry wt	< 9	< 11	< 9	< 9	< 8
C10 - C11	mg/kg dry wt	< 9	< 11	< 9	< 9	< 8
C12 - C14	mg/kg dry wt	< 9	< 11	< 9	< 9	< 8
C15 - C20	mg/kg dry wt	< 9	< 11	< 9	< 9	< 8
C21 - C25	mg/kg dry wt	< 9	< 11	< 9	< 9	< 8
C26 - C29	mg/kg dry wt	< 9	< 11	< 9	< 9	< 8
C30 - C44	mg/kg dry wt	< 20	< 30	< 20	< 20	< 20
Total hydrocarbons (C7 - C44)	mg/kg dry wt	< 70	< 90	< 80	< 80	< 70

Sample Name:		RCB-88E 11-Dec-2019	RCB-80A 11-Dec-2019 1:47 pm	FNB-4C 11-Dec-2019 2:25 pm	FNB-10C 11-Dec-2019 2:25 pm	FNB-18C 11-Dec-2019 2:25 pm
Lab Number:		2291701.11	2291701.12	2291701.13	2291701.14	2291701.15
Individual Tests						
Dry Matter	g/100g as rcvd	-	-	61	62	66
Carbonate*	g/100g as CO_2	54	6.7	13.1	5.8	13.9
Fraction >/= 2 mm*	g/100g dry wt	-	< 0.1	-	-	-
Total Recoverable Aluminium	mg/kg dry wt	7,000	7,700	8,300	8,100	9,300
Total Organic Carbon*	g/100g dry wt	0.40	0.33	0.51	0.20	0.48
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	7.6	7.8	3.0	3.2	8.1
Total Recoverable Cadmium	mg/kg dry wt	0.023	0.026	0.017	0.025	0.045
Total Recoverable Chromium	mg/kg dry wt	11.0	12.3	6.8	6.1	12.8
Total Recoverable Copper	mg/kg dry wt	4.8	5.7	5.7	8.1	4.6
Total Recoverable Lead	mg/kg dry wt	8.0	11.3	8.6	11.0	7.7
Total Recoverable Mercury	mg/kg dry wt	0.06	0.05	0.08	0.05	0.04
Total Recoverable Nickel	mg/kg dry wt	12.0	12.6	4.1	5.7	6.4
Total Recoverable Zinc	mg/kg dry wt	36	52	29	33	46
7 Grain Sizes Profile as received*						
Dry Matter of Sieved Sample*	g/100g as rcvd	75	69	65	63	66
Fraction >/= 2 mm*	g/100g dry wt	38.7	-	22.7	2.4	30.3
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	10.8	< 0.1	4.5	1.4	7.1
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	6.7	0.4	3.0	0.8	6.0
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	6.9	4.3	6.5	2.7	7.7
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	15.7	68.7	8.9	5.4	14.2
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	7.3	7.1	5.4	4.8	8.7
Fraction < 63 µm*	g/100g dry wt	14.0	19.4	49.1	82.7	26.0
Organochlorine Pesticides Trace in Soil						
Aldrin	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
alpha-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
beta-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010

Sample Type: Sediment						
Sample Name:		RCB-88E 11-Dec-2019	RCB-80A 11-Dec-2019 1:47 pm	FNB-4C 11-Dec-2019 2:25 pm	FNB-10C 11-Dec-2019 2:25 pm	FNB-18C 11-Dec-2019 2:25 pm
Lab Number:		2291701.11	2291701.12	2291701.13	2291701.14	2291701.15
Organochlorine Pesticides Trace in Soil						
delta-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
gamma-BHC (Lindane)	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
cis-Chlordane	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
trans-Chlordane	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
2,4'-DDD	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
4,4'-DDD	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
2,4'-DDE	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
4,4'-DDE	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
2,4'-DDT	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
4,4'-DDT	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Total DDT Isomers	mg/kg dry wt	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Dieldrin	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Endosulfan I	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Endosulfan II	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Endosulfan sulphate	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Endrin	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Endrin aldehyde	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Endrin ketone	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Heptachlor	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Heptachlor epoxide	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Hexachlorobenzene	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Methoxychlor	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Total Chlordane [(cis+trans)* 100/42]	mg/kg dry wt	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Polycyclic Aromatic Hydrocarbons Trace in Soil						
Total of Reported PAHs in Soil	mg/kg dry wt	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
1-Methylnaphthalene	mg/kg dry wt	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
2-Methylnaphthalene	mg/kg dry wt	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Acenaphthene	mg/kg dry wt	< 0.003	< 0.003	0.003	< 0.003	< 0.003
Acenaphthylene	mg/kg dry wt	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Anthracene	mg/kg dry wt	< 0.003	< 0.003	0.003	< 0.003	< 0.003
Benzo[a]anthracene	mg/kg dry wt	0.005	0.009	0.014	< 0.003	0.006
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.006	0.013	0.015	< 0.003	0.009
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.006	0.013	0.018	< 0.003	0.009
Benzo[e]pyrene	mg/kg dry wt	0.003	0.006	0.007	< 0.003	0.004
Benzo[g,h,i]perylene	mg/kg dry wt	0.004	0.009	0.008	< 0.003	0.006
Benzo[k]fluoranthene	mg/kg dry wt	0.003	0.006	0.007	< 0.003	0.004
Chrysene	mg/kg dry wt	0.004	0.009	0.014	< 0.003	0.006
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Fluoranthene	mg/kg dry wt	0.008	0.018	0.030	< 0.003	0.014
Fluorene	mg/kg dry wt	< 0.003	< 0.003	0.003	< 0.003	< 0.003
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.004	0.010	0.009	< 0.003	0.006
Naphthalene	mg/kg dry wt	< 0.011	< 0.012	< 0.012	< 0.012	< 0.012
Perylene	mg/kg dry wt	< 0.003	0.004	0.046	0.023	0.006
Phenanthrene	mg/kg dry wt	0.006	0.004	0.015	< 0.003	0.005
Pyrene	mg/kg dry wt	0.009	0.019	0.017	< 0.003	0.014
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES	mg/kg dry wt	0.009	0.019	0.022	< 0.006	0.013
Benzo[a]pyrene Toxic Equivalence (TEF)	mg/kg dry wt	0.009	0.019	0.022	< 0.006	0.013
Polychlorinated Biphenyls Trace in Soil*						
PCB-18	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-28	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-31	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010

Sample Type: Sediment						
Sample Name:		RCB-88E 11-Dec-2019	RCB-80A 11-Dec-2019 1:47 pm	FNB-4C 11-Dec-2019 2:25 pm	FNB-10C 11-Dec-2019 2:25 pm	FNB-18C 11-Dec-2019 2:25 pm
Lab Number:		2291701.11	2291701.12	2291701.13	2291701.14	2291701.15
Polychlorinated Biphenyls Trace in Soil*						
PCB-44	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-49	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-52	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-60	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-77	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-81	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-86	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-101	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-105	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-110	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-114	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-118	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-121	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-123	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-126	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-128	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-138	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-141	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-149	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-151	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-153	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-156	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-157	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-159	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-167	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-169	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-170	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-180	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-189	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-194	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-206	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PCB-209	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Mono-Ortho PCB Toxic Equivalence (TEF)*	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Non-Ortho PCB Toxic Equivalence (TEF)*	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Total PCB (Sum of 35 congeners)	mg/kg dry wt	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Haloethers Trace in SVOC Soil Samples by GC-MS						
Bis(2-chloroethoxy) methane	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Bis(2-chloroethyl)ether	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Bis(2-chloroisopropyl)ether	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
4-Bromophenyl phenyl ether	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
4-Chlorophenyl phenyl ether	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Nitrogen containing compounds Trace in SVOC Soil Samples, GC-MS						
N-Nitrosodiphenylamine + Diphenylamine	mg/kg dry wt	-	-	< 0.19	< 0.19	< 0.18
2,4-Dinitrotoluene	mg/kg dry wt	-	-	< 0.2	< 0.2	< 0.2
2,6-Dinitrotoluene	mg/kg dry wt	-	-	< 0.2	< 0.2	< 0.2
Nitrobenzene	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
N-Nitrosodi-n-propylamine	mg/kg dry wt	-	-	< 0.19	< 0.19	< 0.18
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Aldrin	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
alpha-BHC	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
beta-BHC	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10

Sample Type: Sediment						
Sample Name:		RCB-88E 11-Dec-2019	RCB-80A 11-Dec-2019 1:47 pm	FNB-4C 11-Dec-2019 2:25 pm	FNB-10C 11-Dec-2019 2:25 pm	FNB-18C 11-Dec-2019 2:25 pm
Lab Number:		2291701.11	2291701.12	2291701.13	2291701.14	2291701.15
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
delta-BHC	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
gamma-BHC (Lindane)	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
4,4'-DDD	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
4,4'-DDE	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
4,4'-DDT	mg/kg dry wt	-	-	< 0.2	< 0.2	< 0.2
Dieldrin	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Endosulfan I	mg/kg dry wt	-	-	< 0.2	< 0.2	< 0.2
Endosulfan II	mg/kg dry wt	-	-	< 0.5	< 0.5	< 0.5
Endosulfan sulphate	mg/kg dry wt	-	-	< 0.2	< 0.2	< 0.2
Endrin	mg/kg dry wt	-	-	< 0.19	< 0.19	< 0.18
Endrin ketone	mg/kg dry wt	-	-	< 0.2	< 0.2	< 0.2
Heptachlor	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Heptachlor epoxide	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Hexachlorobenzene	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Polycyclic Aromatic Hydrocarbons Trace in SVOC Soil Samples*						
Acenaphthene	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Acenaphthylene	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Anthracene	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Benzo[a]anthracene	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Benzo[a]pyrene (BAP)	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Benzo[g,h,i]perylene	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Benzo[k]fluoranthene	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
1&2-Chloronaphthalene	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Chrysene	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Dibenzo[a,h]anthracene	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Fluoranthene	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Fluorene	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
2-Methylnaphthalene	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Naphthalene	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Phenanthrene	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Pyrene	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	-	-	< 0.3	< 0.3	< 0.3
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	-	-	< 0.3	< 0.3	< 0.3
Phenols Trace in SVOC Soil Samples by GC-MS						
4-Chloro-3-methylphenol	mg/kg dry wt	-	-	< 0.5	< 0.5	< 0.5
2-Chlorophenol	mg/kg dry wt	-	-	< 0.2	< 0.2	< 0.2
2,4-Dichlorophenol	mg/kg dry wt	-	-	< 0.2	< 0.2	< 0.2
2,4-Dimethylphenol	mg/kg dry wt	-	-	< 0.4	< 0.4	< 0.4
3 & 4-Methylphenol (m- + p-cresol)	mg/kg dry wt	-	-	< 0.4	< 0.4	< 0.4
2-Methylphenol (o-Cresol)	mg/kg dry wt	-	-	< 0.2	< 0.2	< 0.2
2-Nitrophenol	mg/kg dry wt	-	-	< 0.4	< 0.4	< 0.4
Pentachlorophenol (PCP)	mg/kg dry wt	-	-	< 6	< 6	< 6
Phenol	mg/kg dry wt	-	-	0.3	< 0.2	< 0.2
2,4,5-Trichlorophenol	mg/kg dry wt	-	-	< 0.2	< 0.2	< 0.2
2,4,6-Trichlorophenol	mg/kg dry wt	-	-	< 0.2	< 0.2	< 0.2
Plasticisers Trace in SVOC Soil Samples by GC-MS						
Bis(2-ethylhexyl)phthalate	mg/kg dry wt	-	-	< 0.5	< 0.5	< 0.5
Butylbenzylphthalate	mg/kg dry wt	-	-	< 0.2	< 0.2	< 0.2
Di(2-ethylhexyl)adipate	mg/kg dry wt	-	-	< 0.2	< 0.2	< 0.2

Sample Type: Sediment						
Sample Name:		RCB-88E 11-Dec-2019	RCB-80A 11-Dec-2019 1:47 pm	FNB-4C 11-Dec-2019 2:25 pm	FNB-10C 11-Dec-2019 2:25 pm	FNB-18C 11-Dec-2019 2:25 pm
Lab Number:		2291701.11	2291701.12	2291701.13	2291701.14	2291701.15
Plasticisers Trace in SVOC Soil Samples by GC-MS						
Diethylphthalate	mg/kg dry wt	-	-	< 0.2	< 0.2	< 0.2
Dimethylphthalate	mg/kg dry wt	-	-	< 0.2	< 0.2	< 0.2
Di-n-butylphthalate	mg/kg dry wt	-	-	< 0.2	< 0.2	< 0.2
Di-n-octylphthalate	mg/kg dry wt	-	-	< 0.2	< 0.2	< 0.2
Other Halogenated compounds Trace in SVOC Soil Samples by GC-MS						
1,2-Dichlorobenzene	mg/kg dry wt	-	-	< 0.19	< 0.19	< 0.18
1,3-Dichlorobenzene	mg/kg dry wt	-	-	< 0.19	< 0.19	< 0.18
1,4-Dichlorobenzene	mg/kg dry wt	-	-	< 0.19	< 0.19	< 0.18
Hexachlorobutadiene	mg/kg dry wt	-	-	< 0.19	< 0.19	< 0.18
Hexachloroethane	mg/kg dry wt	-	-	< 0.19	< 0.19	< 0.18
1,2,4-Trichlorobenzene	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Other SVOC Trace in SVOC Soil Samples by GC-MS						
Benzyl alcohol	mg/kg dry wt	-	-	< 1.0	< 1.0	< 1.0
Carbazole	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Dibenzofuran	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Isophorone	mg/kg dry wt	-	-	< 0.10	< 0.10	< 0.10
Tributyl Tin Trace in Soil samples by GCMS						
Dibutyltin (as Sn)	mg/kg dry wt	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Monobutyltin (as Sn)	mg/kg dry wt	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
Tributyltin (as Sn)	mg/kg dry wt	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Triphenyltin (as Sn)	mg/kg dry wt	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Total Petroleum Hydrocarbons in Soil, GC						
C7 - C9	mg/kg dry wt	< 9	< 9	< 10	< 10	< 9
C10 - C11	mg/kg dry wt	< 9	< 9	< 10	< 10	< 9
C12 - C14	mg/kg dry wt	< 9	< 9	< 10	< 10	< 9
C15 - C20	mg/kg dry wt	< 9	< 9	< 10	< 10	< 9
C21 - C25	mg/kg dry wt	< 9	< 9	< 10	< 10	< 9
C26 - C29	mg/kg dry wt	< 9	< 9	< 10	< 10	< 9
C30 - C44	mg/kg dry wt	< 20	< 20	< 20	< 20	< 20
Total hydrocarbons (C7 - C44)	mg/kg dry wt	< 70	< 80	< 80	< 80	< 80

Sample Name:		FNBA-7M 11-Dec-2019 3:10 pm	FNBA-22G 11-Dec-2019 2:40 pm	FNBA-4M 11-Dec-2019 3:35 pm	FNBA-7M replicate 1	FNBA-7M replicate 2
Lab Number:		2291701.16	2291701.17	2291701.18	2291701.19	2291701.20
Individual Tests						
Dry Matter	g/100g as rcvd	80	50	75	-	-
Carbonate*	g/100g as CO_2	67	6.1	66	-	-
Total Recoverable Aluminium	mg/kg dry wt	3,000	6,400	4,600	-	-
Total Organic Carbon*	g/100g dry wt	0.45	0.29	0.36	-	-
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	4.2	2.2	5.2	-	-
Total Recoverable Cadmium	mg/kg dry wt	< 0.03	0.010	0.016 #2	-	-
Total Recoverable Chromium	mg/kg dry wt	5.0	3.6	5.2	-	-
Total Recoverable Copper	mg/kg dry wt	4.4	3.3	3.8	-	-
Total Recoverable Lead	mg/kg dry wt	7.7	4.2	7.6	-	-
Total Recoverable Mercury	mg/kg dry wt	0.14	0.02	0.05 #1	-	-
Total Recoverable Nickel	mg/kg dry wt	3.1	1.7	3.4	-	-
Total Recoverable Zinc	mg/kg dry wt	28	23	35	-	-
7 Grain Sizes Profile as received*						
Dry Matter of Sieved Sample*	g/100g as rcvd	80	56	77	-	-
Fraction >/= 2 mm*	g/100g dry wt	71.3	19.8	46.8	-	-
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	11.5	4.7	17.6	-	-
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	3.4	3.6	8.0	-	-
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	2.3	6.8	6.3	-	-

Sample Type: Sediment						
Sample Name:		FNBA-7M 11-Dec-2019 3:10 pm	FNBA-22G 11-Dec-2019 2:40 pm	FNBA-4M 11-Dec-2019 3:35 pm	FNBA-7M replicate 1	FNBA-7M replicate 2
Lab Number:		2291701.16	2291701.17	2291701.18	2291701.19	2291701.20
7 Grain Sizes Profile as received*						
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	4.3	10.9	7.2	-	-
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	1.3	13.6	1.6	-	-
Fraction < 63 µm*	g/100g dry wt	5.8	40.6	12.4	-	-
Organochlorine Pesticides Trace in Soil						
Aldrin	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
alpha-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
beta-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
delta-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
gamma-BHC (Lindane)	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
cis-Chlordane	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
trans-Chlordane	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
2,4'-DDD	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
4,4'-DDD	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
2,4'-DDE	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
4,4'-DDE	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
2,4'-DDT	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
4,4'-DDT	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
Total DDT Isomers	mg/kg dry wt	< 0.006	< 0.006	< 0.006	-	-
Dieldrin	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
Endosulfan I	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
Endosulfan II	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
Endosulfan sulphate	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
Endrin	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
Endrin aldehyde	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
Endrin ketone	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
Heptachlor	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
Heptachlor epoxide	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
Hexachlorobenzene	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
Methoxychlor	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
Total Chlordane [(cis+trans)* 100/42]	mg/kg dry wt	< 0.002	< 0.002	< 0.002	-	-
Polycyclic Aromatic Hydrocarbons Trace in Soil						
Total of Reported PAHs in Soil	mg/kg dry wt	< 0.3	< 0.3	< 0.3	-	-
1-Methylnaphthalene	mg/kg dry wt	< 0.002	< 0.003	0.007	-	-
2-Methylnaphthalene	mg/kg dry wt	< 0.002	< 0.003	0.011	-	-
Acenaphthene	mg/kg dry wt	< 0.002	< 0.003	< 0.002	-	-
Acenaphthylene	mg/kg dry wt	< 0.002	< 0.003	< 0.002	-	-
Anthracene	mg/kg dry wt	< 0.002	< 0.003	< 0.002	-	-
Benzo[a]anthracene	mg/kg dry wt	0.003	0.006	< 0.002	-	-
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.005	0.009	0.003	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.005	0.010	0.003	-	-
Benzo[e]pyrene	mg/kg dry wt	0.002	0.004	< 0.002	-	-
Benzo[g,h,i]perylene	mg/kg dry wt	0.004	0.006	0.002	-	-
Benzo[k]fluoranthene	mg/kg dry wt	0.002	0.005	< 0.002	-	-
Chrysene	mg/kg dry wt	0.003	0.006	< 0.002	-	-
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.002	< 0.003	< 0.002	-	-
Fluoranthene	mg/kg dry wt	0.006	0.013	0.004	-	-
Fluorene	mg/kg dry wt	< 0.002	< 0.003	< 0.002	-	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.004	0.006	0.002	-	-
Naphthalene	mg/kg dry wt	< 0.010	< 0.015	< 0.010	-	-
Perylene	mg/kg dry wt	0.002	0.006	< 0.002	-	-
Phenanthrene	mg/kg dry wt	< 0.002	< 0.003	< 0.002	-	-
Pyrene	mg/kg dry wt	0.007	0.014	0.005	-	-

Sample Type: Sediment						
Sample Name:		FNBA-7M 11-Dec-2019 3:10 pm	FNBA-22G 11-Dec-2019 2:40 pm	FNBA-4M 11-Dec-2019 3:35 pm	FNBA-7M replicate 1	FNBA-7M replicate 2
Lab Number:		2291701.16	2291701.17	2291701.18	2291701.19	2291701.20
Polycyclic Aromatic Hydrocarbons Trace in Soil						
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES	mg/kg dry wt	0.008	0.013	< 0.005	-	-
Benzo[a]pyrene Toxic Equivalence (TEF)	mg/kg dry wt	0.008	0.013	< 0.005	-	-
Polychlorinated Biphenyls Trace in Soil*						
PCB-18	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-28	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-31	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-44	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-49	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-52	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-60	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-77	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-81	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-86	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-101	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-105	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-110	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-114	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-118	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-121	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-123	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-126	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-128	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-138	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-141	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-149	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-151	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-153	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-156	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-157	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-159	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-167	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-169	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-170	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-180	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-189	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-194	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-206	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
PCB-209	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
Mono-Ortho PCB Toxic Equivalence (TEF)*	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
Non-Ortho PCB Toxic Equivalence (TEF)*	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	-	-
Total PCB (Sum of 35 congeners)	mg/kg dry wt	< 0.04	< 0.04	< 0.04	-	-
Haloethers Trace in SVOC Soil Samples by GC-MS						
Bis(2-chloroethoxy) methane	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
Bis(2-chloroethyl)ether	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
Bis(2-chloroisopropyl)ether	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
4-Bromophenyl phenyl ether	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
4-Chlorophenyl phenyl ether	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
Nitrogen containing compounds Trace in SVOC Soil Samples, GC-MS						
N-Nitrosodiphenylamine + Diphenylamine	mg/kg dry wt	< 0.14	< 0.3	< 0.16	-	-
2,4-Dinitrotoluene	mg/kg dry wt	< 0.2	< 0.3	< 0.2	-	-

Sample Type: Sediment						
Sample Name:		FNBA-7M 11-Dec-2019 3:10 pm	FNBA-22G 11-Dec-2019 2:40 pm	FNBA-4M 11-Dec-2019 3:35 pm	FNBA-7M replicate 1	FNBA-7M replicate 2
Lab Number:		2291701.16	2291701.17	2291701.18	2291701.19	2291701.20
Nitrogen containing compounds Trace in SVOC Soil Samples, GC-MS						
2,6-Dinitrotoluene	mg/kg dry wt	< 0.2	< 0.3	< 0.2	-	-
Nitrobenzene	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
N-Nitrosodi-n-propylamine	mg/kg dry wt	< 0.14	< 0.3	< 0.16	-	-
Organochlorine Pesticides Trace in SVOC Soil Samples by GC-MS						
Aldrin	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
alpha-BHC	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
beta-BHC	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
delta-BHC	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
gamma-BHC (Lindane)	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
4,4'-DDD	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
4,4'-DDE	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
4,4'-DDT	mg/kg dry wt	< 0.2	< 0.3	< 0.2	-	-
Dieldrin	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
Endosulfan I	mg/kg dry wt	< 0.2	< 0.3	< 0.2	-	-
Endosulfan II	mg/kg dry wt	< 0.5	< 0.5	< 0.5	-	-
Endosulfan sulphate	mg/kg dry wt	< 0.2	< 0.3	< 0.2	-	-
Endrin	mg/kg dry wt	< 0.14	< 0.3	< 0.16	-	-
Endrin ketone	mg/kg dry wt	< 0.2	< 0.3	< 0.2	-	-
Heptachlor	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
Heptachlor epoxide	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
Hexachlorobenzene	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
Polycyclic Aromatic Hydrocarbons Trace in SVOC Soil Samples*						
Acenaphthene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	-	-
Acenaphthylene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	-	-
Anthracene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	-	-
Benzo[a]anthracene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	-	-
Benzo[a]pyrene (BAP)	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
Benzo[g,h,i]perylene	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
Benzo[k]fluoranthene	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
1&2-Chloronaphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	-	-
Chrysene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	-	-
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
Fluoranthene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	-	-
Fluorene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	-	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
2-Methylnaphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	-	-
Naphthalene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	-	-
Phenanthrene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	-	-
Pyrene	mg/kg dry wt	< 0.10	< 0.10	< 0.10	-	-
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES*	mg/kg dry wt	< 0.3	< 0.3	< 0.3	-	-
Benzo[a]pyrene Toxic Equivalence (TEF)*	mg/kg dry wt	< 0.3	< 0.3	< 0.3	-	-
Phenols Trace in SVOC Soil Samples by GC-MS						
4-Chloro-3-methylphenol	mg/kg dry wt	< 0.5	< 0.5	< 0.5	-	-
2-Chlorophenol	mg/kg dry wt	< 0.2	< 0.2	< 0.2	-	-
2,4-Dichlorophenol	mg/kg dry wt	< 0.2	< 0.2	< 0.2	-	-
2,4-Dimethylphenol	mg/kg dry wt	< 0.4	< 0.4	< 0.4	-	-
3 & 4-Methylphenol (m- + p-cresol)	mg/kg dry wt	< 0.4	0.9	< 0.4	-	-
2-Methylphenol (o-Cresol)	mg/kg dry wt	< 0.2	< 0.2	< 0.2	-	-
2-Nitrophenol	mg/kg dry wt	< 0.4	< 0.4	< 0.4	-	-
Pentachlorophenol (PCP)	mg/kg dry wt	< 6	< 6	< 6	-	-

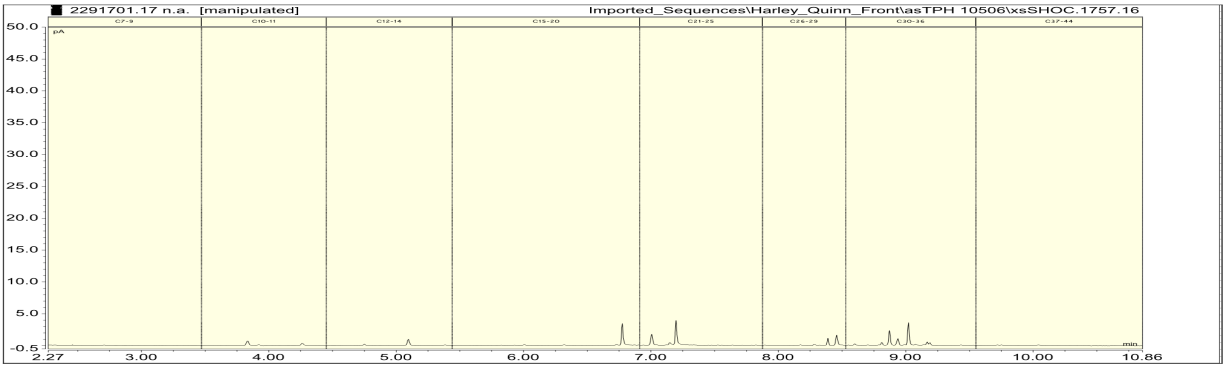
Sample Type: Sediment						
Sample Name:		FNBA-7M 11-Dec-2019 3:10 pm	FNBA-22G 11-Dec-2019 2:40 pm	FNBA-4M 11-Dec-2019 3:35 pm	FNBA-7M replicate 1	FNBA-7M replicate 2
Lab Number:		2291701.16	2291701.17	2291701.18	2291701.19	2291701.20
Phenols Trace in SVOC Soil Samples by GC-MS						
Phenol	mg/kg dry wt	< 0.2	3.6	< 0.2	-	-
2,4,5-Trichlorophenol	mg/kg dry wt	< 0.2	< 0.3	< 0.2	-	-
2,4,6-Trichlorophenol	mg/kg dry wt	< 0.2	< 0.3	< 0.2	-	-
Plasticisers Trace in SVOC Soil Samples by GC-MS						
Bis(2-ethylhexyl)phthalate	mg/kg dry wt	< 0.5	< 0.5	< 0.5	-	-
Butylbenzylphthalate	mg/kg dry wt	< 0.2	< 0.3	< 0.2	-	-
Di(2-ethylhexyl)adipate	mg/kg dry wt	< 0.2	< 0.2	< 0.2	-	-
Diethylphthalate	mg/kg dry wt	< 0.2	< 0.3	< 0.2	-	-
Dimethylphthalate	mg/kg dry wt	< 0.2	< 0.3	< 0.2	-	-
Di-n-butylphthalate	mg/kg dry wt	< 0.2	< 0.3	< 0.2	-	-
Di-n-octylphthalate	mg/kg dry wt	< 0.2	< 0.3	< 0.2	-	-
Other Halogenated compounds Trace in SVOC Soil Samples by GC-MS						
1,2-Dichlorobenzene	mg/kg dry wt	< 0.14	< 0.3	< 0.16	-	-
1,3-Dichlorobenzene	mg/kg dry wt	< 0.14	< 0.3	< 0.16	-	-
1,4-Dichlorobenzene	mg/kg dry wt	< 0.14	< 0.3	< 0.16	-	-
Hexachlorobutadiene	mg/kg dry wt	< 0.14	< 0.3	< 0.16	-	-
Hexachloroethane	mg/kg dry wt	< 0.14	< 0.3	< 0.16	-	-
1,2,4-Trichlorobenzene	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
Other SVOC Trace in SVOC Soil Samples by GC-MS						
Benzyl alcohol	mg/kg dry wt	< 1.0	< 1.2	< 1.0	-	-
Carbazole	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
Dibenzofuran	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
Isophorone	mg/kg dry wt	< 0.10	< 0.12	< 0.10	-	-
Tributyl Tin Trace in Soil samples by GCMS						
Dibutyltin (as Sn)	mg/kg dry wt	0.007	< 0.005	0.008	< 0.005	< 0.005
Monobutyltin (as Sn)	mg/kg dry wt	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
Tributyltin (as Sn)	mg/kg dry wt	0.051	< 0.004	0.053	< 0.004	< 0.004
Triphenyltin (as Sn)	mg/kg dry wt	< 0.003	< 0.003	0.004	< 0.003	< 0.003
Total Petroleum Hydrocarbons in Soil, GC						
C7 - C9	mg/kg dry wt	< 8	< 12	< 9	-	-
C10 - C11	mg/kg dry wt	< 8	< 12	< 9	-	-
C12 - C14	mg/kg dry wt	< 8	< 12	< 9	-	-
C15 - C20	mg/kg dry wt	< 8	< 12	< 9	-	-
C21 - C25	mg/kg dry wt	< 8	14	< 9	-	-
C26 - C29	mg/kg dry wt	< 8	< 12	< 9	-	-
C30 - C44	mg/kg dry wt	< 20	28	< 20	-	-
Total hydrocarbons (C7 - C44)	mg/kg dry wt	< 70	< 100	< 70	-	-

Sample Name:		FNBA-4M replicate 1	FNBA-4M replicate 1			
Lab Number:		2291701.21	2291701.22			
Tributyl Tin Trace in Soil samples by GCMS						
Dibutyltin (as Sn)	mg/kg dry wt	< 0.005	< 0.005	-	-	-
Monobutyltin (as Sn)	mg/kg dry wt	< 0.007	< 0.007	-	-	-
Tributyltin (as Sn)	mg/kg dry wt	< 0.004	< 0.004	-	-	-
Triphenyltin (as Sn)	mg/kg dry wt	< 0.003	< 0.003	-	-	-

Sample Type: Aqueous						
Sample Name:		RCD-199F [Elutriation extract]	RCD-185F [Elutriation extract]	FNBA-7M [Elutriation extract]	FNBA-4M [Elutriation extract]	
Lab Number:		2291701.24	2291701.25	2291701.26	2291701.27	
Individual Tests						
Total Nickel	g/m³	< 0.0070	< 0.0070	-	-	-

Sample Type: Aqueous						
Sample Name:		RCD-199F [Elutriation extract]	RCD-185F [Elutriation extract]	FNBA-7M [Elutriation extract]	FNBA-4M [Elutriation extract]	
Lab Number:		2291701.24	2291701.25	2291701.26	2291701.27	
Tributyl Tin Trace in Water samples by GCMS*						
Dibutyltin (as Sn)	g/m³	-	-	< 0.00006	< 0.00006	-
Tributyltin (as Sn)	g/m³	-	-	< 0.00005	< 0.00005	-
Triphenyltin (as Sn)	g/m³	-	-	< 0.00004	< 0.00004	-

2291701.17
FNBA-22G 11-Dec-2019 2:40 pm
Client Chromatogram for TPH by FID



Analyst's Comments

#1 It should be noted that the replicate analyses performed on this sample as part of our in-house Quality Assurance procedures showed greater variation than would normally be expected. This may reflect the heterogeneity of the sample. Replicate 1 = 0.016mg/kg, replicate 2 = 0.011mg/kg, replicate 3 = 0.011mg/kg, replicate 4 = 0.015mg/kg, replicate 5 = <0.010mg/kg, replicate 6 = <0.010mg/kg.

#2 It should be noted that the replicate analyses performed on this sample as part of our in-house Quality Assurance procedures showed greater variation than would normally be expected. This may reflect the heterogeneity of the sample. Replicate 1 = 0.054mg/kg, replicate 2 = 0.051mg/kg, replicate 3 = 0.044mg/kg, replicate 4 = 0.036mg/kg, replicate 5 = 0.051mg/kg, replicate 6 = 0.045mg/kg.

Amended Report: This certificate of analysis replaces an earlier report issued on 03 Feb 2020 at 11:50 am
Reason for amendment: The cadmium and mercury results for sample 2291701.18 have been reported to lower detection limits following a query by the client.

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Saline			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Individual Tests			
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E (modified) 23rd ed. 2017.	-	23-25
Total Nickel	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 23rd ed. 2017.	0.0070 g/m³	23-25
Tributyl Tin Trace in Water samples by GCMS*	Solvent extraction, ethylation, SPE cleanup, GC-MS SIM analysis	0.00003 - 0.00005 g/m³	23, 26-27

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Individual Tests			
Environmental Solids Sample Drying*	Air dried at 35°C Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-18

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-18
Non-Routine sample preparation. Air drying and 425 um sieving.*	Air dried and sieved, <425 um fraction. Used for sample preparation.	-	1-18
Soil Prep Dry for Organics,Trace*	Air dried at 35°C Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-22
Elutriation testing*	Extn with (client supplied) water, eg seawater, Sed:Water 1:4 by vol, mix 30 min, settle 1 hr, filtration or centrifugation. US EPA 503/8-91/001, "Evaluation of Dredged Material for Ocean Disposal".	-	5-6, 16, 18
Dry Matter (Env)	Dried at 103°C for 4-22hr (removes 3-5% more water than air dry) , gravimetry. (Free water removed before analysis, non-soil objects such as sticks, leaves, grass and stones also removed). US EPA 3550.	0.10 g/100g as rcvd	13-18
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-18
Carbonate*	Rapid titration method. BS 1377:Part 3:1990 section 6.3 (modified).	3.0 g/100g as CO_2	1-18
Total Recoverable Aluminium	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	10 mg/kg dry wt	1-18
Total Organic Carbon*	Acid pretreatment to remove carbonates present followed by Catalytic Combustion (900°C, O2), separation, Thermal Conductivity Detector [Elementar Analyser].	0.05 g/100g dry wt	1-18
Organochlorine/Polychlorinated biphenyls Trace in Soil	Sonication extraction, SPE cleanup, GC & GC-MS analysis. Tested on dried sample	0.0010 - 0.02 mg/kg dry wt	1-18
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, trace level.	0.010 - 0.4 mg/kg dry wt	1-18
Polycyclic Aromatic Hydrocarbons Trace in Soil	Sonication extraction, SPE cleanup, GC-MS SIM analysis US EPA 8270C. Tested on as received sample [KBIs:5784,4273,2695]	0.002 - 0.3 mg/kg dry wt	1-18
Semivolatile Organic Compounds Trace in Soil by GC-MS	Sonication extraction, GPC cleanup, GC-MS FS analysis. Tested on as received sample	0.002 - 6 mg/kg dry wt	13-18
Tributyl Tin Trace in Soil samples by GCMS	Solvent extraction, ethylation, SPE cleanup, GC-MS SIM analysis. Tested on dried sample	0.003 - 0.007 mg/kg dry wt	1-22
Total Petroleum Hydrocarbons in Soil, GC	Sonication extraction, Silica cleanup, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines. Tested on as received sample [KBIs:5786,2805,10734]	8 - 70 mg/kg dry wt	1-18
7 Grain Sizes Profile as received			
Dry Matter for Grainsize samples (sieved as received)*	Drying for 16 hours at 103°C, gravimetry (Free water removed before analysis).	0.10 g/100g as rcvd	1-18
Fraction >/= 2 mm*	Wet sieving with dispersant, as received, 2.00 mm sieve, gravimetry.	0.1 g/100g dry wt	1-18
Fraction < 2 mm, >/= 1 mm*	Wet sieving using dispersant, as received, 2.00 mm and 1.00 mm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-18
Fraction < 1 mm, >/= 500 µm*	Wet sieving using dispersant, as received, 1.00 mm and 500 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-18
Fraction < 500 µm, >/= 250 µm*	Wet sieving using dispersant, as received, 500 µm and 250 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-18
Fraction < 250 µm, >/= 125 µm*	Wet sieving using dispersant, as received, 250 µm and 125 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-18
Fraction < 125 µm, >/= 63 µm*	Wet sieving using dispersant, as received, 125 µm and 63 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-18
Fraction < 63 µm*	Wet sieving with dispersant, as received, 63 µm sieve, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-18

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Dates of testing are available on request. Please contact the laboratory for more information.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

This certificate of analysis must not be reproduced, except in full, without the written consent of the signatory.

Graham Corban MSc Tech (Hons)
Client Services Manager - Environmental

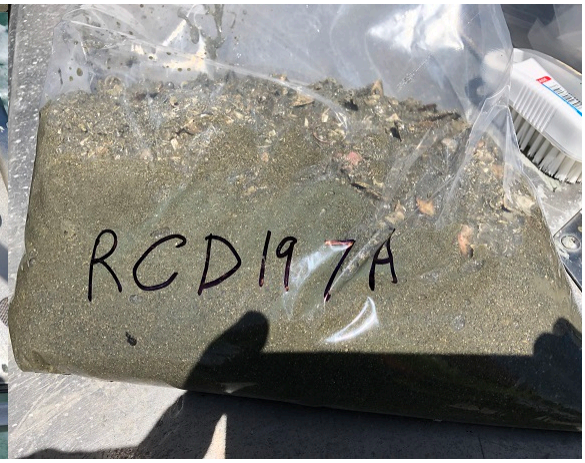
Appendix C: Grab sample photographs

Samples collected 11 December 2019. RC = Rangitoto Channel; FNB = Fergusson North berth; FNBA = Fergusson North berth approaches.

1 RCE-236B

2 RCE-231E

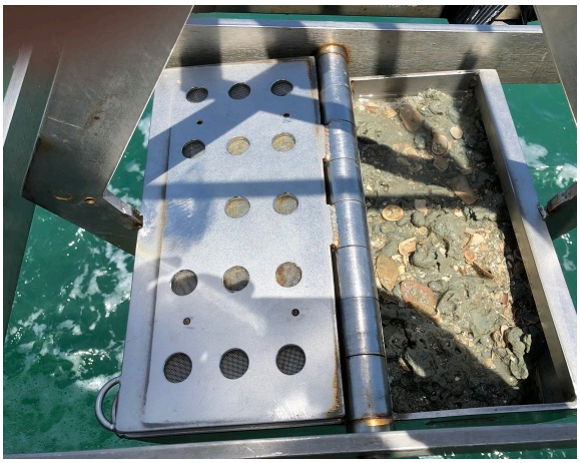
3 RCE-215D



4 RCD 197A

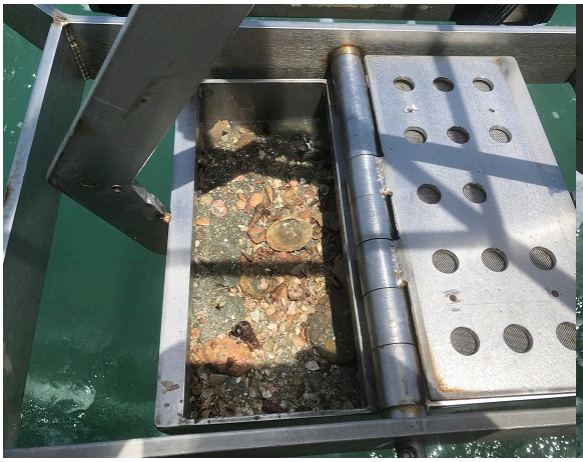
5 RCD-199F

6 RCD-185F



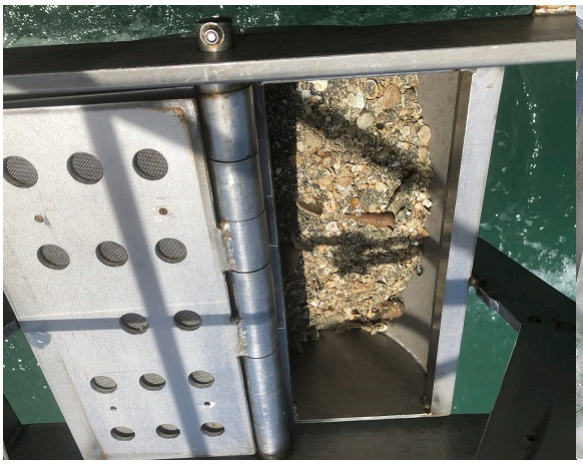
7 RCC-155C

8 RCC-157A



RCC-116A

J RCB-108B



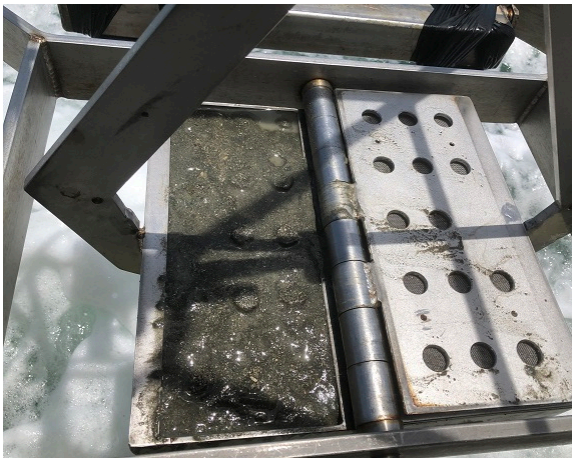
11 RCB-88E

12 RCB-80A

13 FNB-4C (no image)

14 FNB-10C

15 FNB-18C



16 FNBA-7M

17 FNBA-22G (no image)

18 FNBA-4M

Appendix D: Sediment > 2mm coarse material photographs

Samples (material larger than 2 mm in size (gravel) collected 11 December 2019. RC = Rangitoto Channel; FNB = Fergusson North berth; FNBA = Fergusson North berth approaches. Container scale top outside diameter 12 cm. detail image field of view ~22.5 mm.

1 RCE-236B (no coarse material)

2 RCE-231E

2 RCE-231E Non shell detail.

3 RCE-215D

4 RCD 197A

5 RCD-199F

6 RCD-185F

7 RCC-155C

8 RCC-157A

8 RCC-157A Non-shell detail.

9 RCC-116A

10 RCB-108B

11 RCB-88E

12 RCB-80A

13 FNB-4C

13 FNB-4C Non-shell detail.

14 FNB-10C

14 FNB-10C Non-shell detail.