January 2018

AMERICA'S CUP 36, AUCKLAND 2021

Assessment of Coastal Environmental Effects Associated with the Development of AC 36 Facilities

For Resource Consent Application, Wynyard Basin and Ferry & Fishing Industry Relocation Facility

Submitted to:
Panuku Development Auckland

Report Number: 1790454-004-Rev0

REPORT

Golder Associates

Executive Summary

Viaduct Basin

Environment

1) The Wynyard Basin is completely surrounded by man-made structures (concrete and wooden piles, wave barriers and floating pontoons) and constructed shore (sloping reclamation and vertical concrete walls). The seabed in the basin supports a relatively simple faunal community with differences between open water and the areas beneath existing wharf structures (where light is reduced). The sediment fauna includes some non-indigenous species, predominantly bivalves.

2) The man-made intertidal structures provide intertidal and subtidal habitat which supports a wide range of species including a significant non-indigenous component. The communities present do not contain any species of high conservation value.

3) A number of coastal bird species of high conservation value (e.g., red-billed gull and white-fronted tern) utilise the Wynyard Basin but the basin does not provide any specific roosting or nesting sites for those species. A range of fish species that are present within the Waitemata Harbour are present within Wynyard Basin.

4) Surface and deeper sediments within the Viaduct Basin, in areas where dredging and construction works are proposed, were dominated by mud with lesser proportions of clay and fine sand. The sediments close to North Wharf contained more coarse material presumably because of the proximity of storm water outfalls and or other historic activities. Sediment quality within the open water areas of Wynyard Basin and in the Outer Viaduct Harbour is considered to be good. All sediments contain a low level of mercury, which is associated with the fine sediments from the lower Waitemata Harbour. Sediment collected adjacent to North Wharf contained elevated concentrations of the contaminants lead, zinc and tributyl-tin (TBT).

5) Water quality measured in both the Inner/Outer Viaduct Basin and Wynyard Basin during November - December 2017 was similar to that reported for the Chelsea monitoring site in the mid-Waitemata Harbour. This suggests that, based on the current short duration survey, the water quality in the Viaduct Basin is of similar "excellent" quality and reflects the quality of the water entering the Viaduct Basin on the flood tide from the at Waitemata Harbour.

Environment and effects

6) The construction works in the Viaduct Basin will produce structures similar to those present today. These will develop intertidal and subtidal biological communities similar to those present on existing structures.

7) It is expected that the construction of additional decking north of Western Viaduct Wharf may change the biological community present in the underwharf sediment due to changes in the amount of light reaching the seabed. The effect is considered to be no more than minor.

8) Some intertidal shore will be covered by new wharf decking over at the south end of Wynyard Wharf. The effect is considered to be no more than minor.

9) Dredging will occur in several areas to ensure adequate water depth for AC36 boats and visiting yachts. The dredging is not likely to have any adverse effect on local ecology, as the seabed community is considered to have low ecological value.

10) Piling activity will not result in adverse seabed disturbance or generation of suspended solids.

11) Dredging will result in localised increases in suspended solids concentrations, which are not expected to result in measureable changes in water clarity or sediment deposition in a down current direction.

12) Sediment disturbance will result in some dissolved contaminants entering the water column. Although elevated concentrations of TBT, polyaromatic hydrocarbons lead and mercury were identified in North Wharf sediment samples, concentrations were non-detectable or low in elutriate. All elutriate concentrations were below ANZECC (2000) trigger values for protection of marine biota. Although tributyl tin was not detectable in all elutriate samples, the detection limit was higher than the trigger value. However, should tributyl tin concentrations exceed the trigger value, only a small amount of dilution at the point of disturbance would reduce concentrations below the trigger value.

13) As the sediment to be dredged contains elevated concentrations of several contaminants and this is likely to restrict its offsite management and disposal. Proposed dredging will be managed through a dredging management plan.

14) The construction required in Wynyard Basin (wharf piles and breakwater) will result in an increase in the e-folding time within the southern parts of Wynyard Basin (e.g., inside the new breakwaters) and at sites at the ‘far ends’ of the Inner Viaduct Harbour (e.g., the Lighter Basin). Although the modelled e-folding times increased by up to a day at several points, a number of physical characteristics indicate that the water quality should still be ‘fair’ in the inner harbour. As the hydrodynamic changes are quite complex, a monitoring program has been recommended to confirm predictions on water quality and ecology within the Wynyard Basin and Viaduct Harbour.

15) Storm water will be generated from the new wharfs and buildings. Although the locations are not considered high contaminant generating surfaces, wharf deck storm water will be collected and passed through treatment devices (located under-wharf) to remove at least 75 % of particulates and associated contaminants. The discharge from the wharf storm water treatment systems will not have adverse effects, following reasonable mixing.

Monitoring and mitigation

16) A Viaduct Harbour water quality and ecological monitoring programme is recommended to collect information on both the water quality and ecology (inter and sub-tidal) prior to and after the completion of the new wharfs and breakwaters in the Wynyard Basin. The purpose of the programme will be to identify whether the additional structures have resulted in any measureable changes to water quality or ecology within the inner Viaduct Harbour.

17) Monitoring of dredging activity is also proposed. For the Wynyard Basin and Outer Viaduct Harbour areas it has been recommended that this comprises observation and photographic information collection. For the dredging required at North Wharf, down-current water sampling is recommended (for suspended solids and turbidity) with monitoring continuing at other locations to be dredged if the monitoring threshold is exceeded. If no significant sediment plumes are identified, monitoring will continue based on photographic record.

18) Storm water treatment will be installed on the new wharf structures being constructed in Wynyard Basin. Due to the anticipated large population visiting the Wynyard Basin during the AC36 event, rubbish and debris, including plastics, will be a key contaminant that requires active management. The proposed treatment system along with on-wharf management will provide effective control.

19) Given the presence of a wide range of non-indigenous organisms in the Wynyard Basin, a Biosecurity Risk Management Plan will be prepared to ensure that vessels used during the construction and dredging phase do not pose any biosecurity risks and that any identified risks are mitigated or managed when any demolition or decommissioning is carried out post the event.

Ferry and Fishing Industry Relocation Facility (FFIRF)

Environment

20) The intertidal shore along the FFIRF area is entirely man-made and comprises a range of materials. The hard shore at the location was relatively depauperate and did not support a community of high value. Although no sub-tidal benthic biology examination was carried out, information from adjacent areas provides general indication as to the composition of that community. The community would be expected to be of low ecological value containing common species.

21) The local shoreline provides roosting and nesting sites for two regionally important coastal birds, the white fronted tern and re-billed gull. The former are present as a small number of nests (with chicks) and the latter a very large roosting colony with a large number of nests and chicks. The fish fauna is expected to comprise a range of common Waitemata Harbour species.

22) FFIRF sediments were sandier (~50 %) than sediments within the Viaduct Harbour. Sediments sampled did not contain identifiable man-made materials in the coarse (>2 mm) fraction.

23) Sediments contained low concentrations of organic carbon and total petroleum hydrocarbons. A number of trace elements (copper, lead, mercury and zinc) were present in elevated concentrations but only mercury was present consistently above its sediment quality guideline value (SQGV). Lead concentrations exceeded the SQGV in two samples with one exceeding its sediment quality guideline-High (SQG-High). Tributyl-tin was present at variable and elevated concentrations including two samples that exceeded the SQG-High. A number of persistent organic compounds were detected at low concentrations. Polyaromatic hydrocarbons were the most common organic compound group measured. Concentrations of PAHs were below the SQGV in all but one sample but the concentration did not exceed the SQG-High.

Environment and effects

24) No ecological effects have been identified in relation to dredging and construction of shore and wharf related facilities.

25) Sediment to be dredged contained elevated concentrations of several contaminants and this is likely to restrict its offsite management and disposal.

26) Lighting controls may be required to minimise lighting related disturbance of bird species occupying a site at the southern end of the proposed development.

27) The construction required at the FFIRF area (wharf piles and breakwater) will have little effect on the e-folding time within Westhaven Marina or the general area close to the proposed facilities. As such, the new facilities should not have any measurable effects on water quality or ecological resources in areas adjacent to the development or within Westhaven Marina.

28) Elutriate testing of FFIFR area sediments has shown that, when disturbed or dredged, the sediment will release some constituents to seawater. Of the constituents measured ammoniacal-nitrogen and dissolved arsenic were released into the water at measureable concentrations. Ammoniacal-nitrogen concentrations required only a small amount of dilution to reduce concentrations below the marine water quality trigger. Although no tributyl-tin was detected in elutriate, the detection limit is higher than the ANZECC trigger value. Should tributyl-tin concentrations be between the detection limit and the trigger value then only a small amount of dilution would be required to ensure concentrations were below trigger values. Overall, no water borne toxicity concerns associated with seabed disturbance were identified from this study.

Monitoring and mitigation

29) An observational monitoring programme has been recommended to obtain further information on the numbers of birds utilising the Vos slipway area. This will provide information on variation in bird numbers leading up to the start of construction.

30) Although it appears that the two bird species present at the roost site are exposed to some disturbance, it has been recommended that some barrier material (e.g., fence) be installed on the wharf at the closest point to the roost site. This may assist in reducing disturbance especially following the start of normal activity at the wharf.

31) It is recommended that options for enhancing high tide roosting and nesting opportunity for coastal bird species within the Waitemata Harbour or providing positive mitigation at other red-bill gull roost and nest locations in the Auckland region be examined.

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APPENDICES

1.0 INTRODUCTION

1.1 Background

This report and assessment is submitted in support of the following resource consent applications to Auckland Council for:

1) The syndicate base infrastructure and event infrastructure for the 36th America's Cup regatta, by Panuku Development Auckland (Panuku).
2) The relocation of the Ferry and Fishing Industry to a new facility within the Wynyard Quarter, by Panuku.

Base infrastructure and event infrastructure

In 2017, Emirates Team New Zealand (ETNZ) defeated Oracle Team USA 7 – 1 in the 35th America's Cup regatta in Bermuda. The 36th America's Cup regatta (AC36) is scheduled to be held in Auckland in 2021. It is proposed to establish the Americas Cup bases in and around Wynyard Basin, which is located along part of Auckland's City Centre waterfront. This includes Hobson Wharf, the Halsey Street Extension Wharf and Wynyard Wharf, including the surrounding water space (Figure 1). ETNZ have indicated that up to eight syndicates will compete for the America's Cup in Auckland. Five of the bases will be double bases (two boats) and three of the bases will be single bases (one boat). The bases consist of a 15 m high building over approximately half of the base area and an area of hardstand over the other half. The dimensions of the bases vary in size, with the single bases being generally 85 m x 35 m and the double bases being a variety of sizes. The base sizes and locations are identified on the plans attached to the resource consent application. Figure 1 shows the key components of the proposed AC36 development.

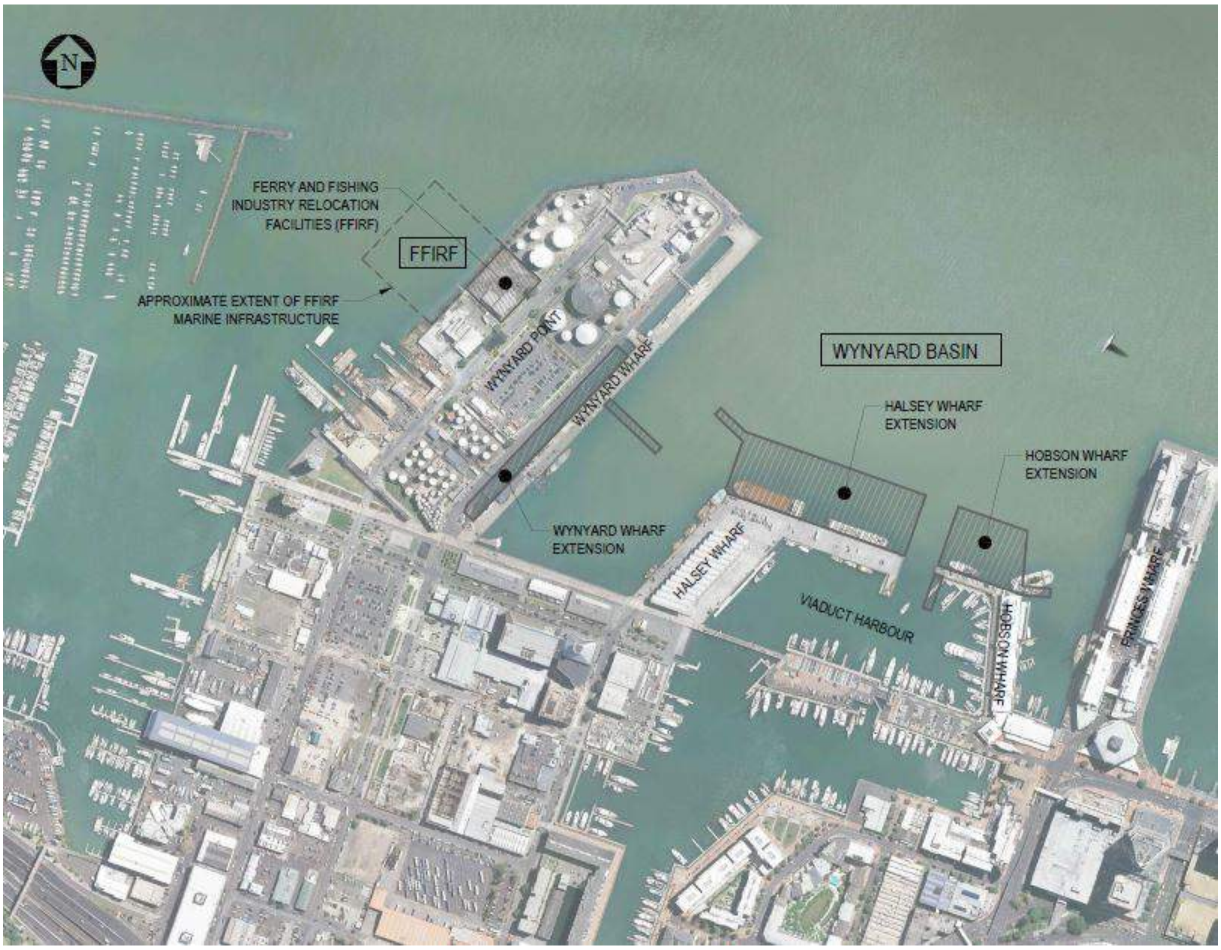


Figure 1: Key locations mentioned within this report.

In order to facilitate five of the bases, an extension to Hobson Wharf and the Halsey Street Extension Wharf/western Viaduct Wharf will be required. Part of the waterspace between Wynyard Wharf and Bringham Street will also be covered by a wharf extension (part temporary and part permanent) in order to facilitate the other three bases. All of the base buildings will be temporary with the exception of the Base 1, which is proposed to be located on the Hobson Wharf extension (Figure 2 shows the key components of AC36 in the Wynyard Basin). Permanent wharf areas 'post event' are anticipated to provide for a range of marine and public uses.

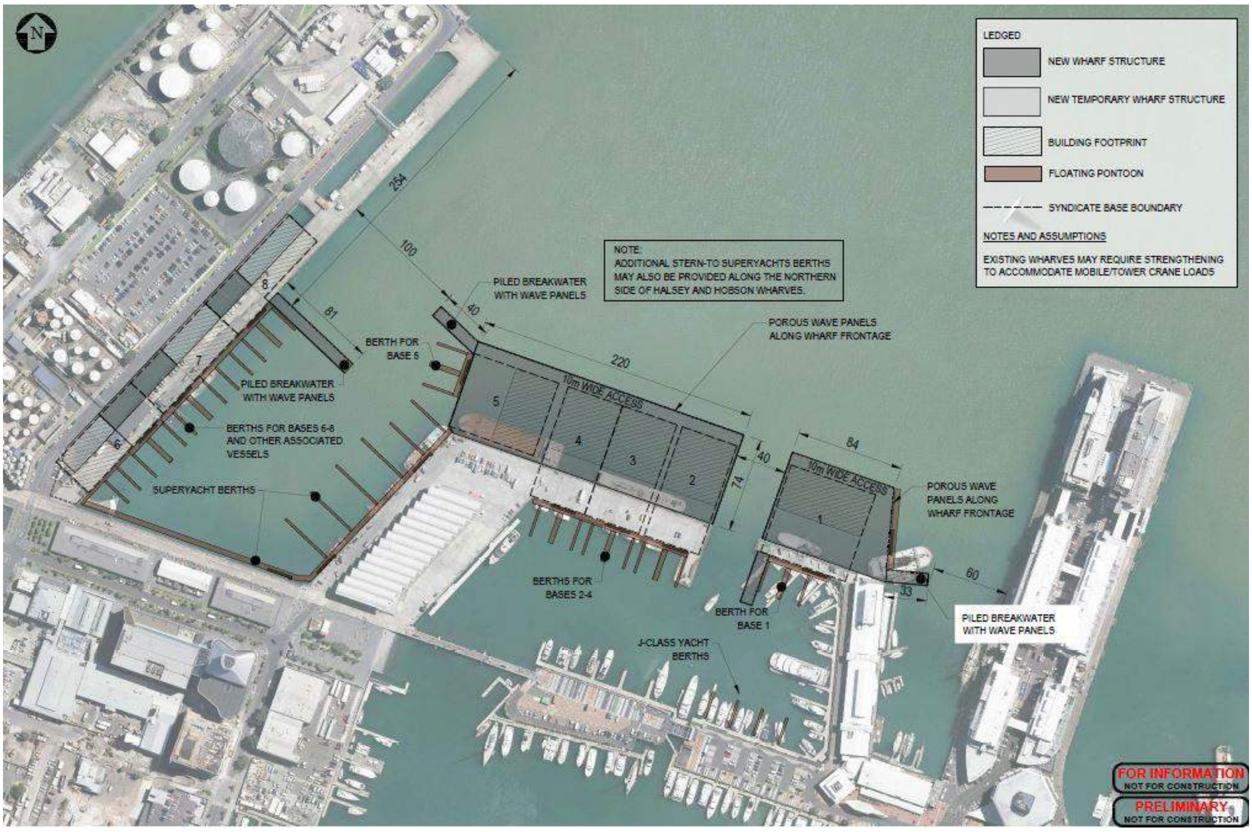


Figure 2: Wynyard Basin layout.

The resource consent for the syndicate base infrastructure and event infrastructure applications will seek approval for and developments associated with enabling the AC36 Base infrastructure.

The 'event' period associated with the AC36 will take place over six months commencing December 2020 and culminating in May 2021. This event period will include a challenger series (such as the Prada Cup) and supporting and complimentary regatta with the AC36 races held in March 2021. During the event, additional signage, lighting, live music and supporting structures will be located within the Viaduct and Wynyard area. Resource consent is sought for the event envelope and effects including traffic, lighting, noise, additional structures and the management of public spaces within the Wynyard and Viaduct areas in the immediate vicinity of the AC36 bases. These are addressed in the relevant sections of the application material.

In addition to the planning Assessment of Environmental Effects, multiple technical reports have been prepared in order to outline and assess the matters relevant to this application, this report should be read alongside the other complimentary assessments provided as part of the application material. These are identified within the Application document.

The above activities will occur within the Wynyard Quarter Precinct, the Viaduct Harbour Precinct and the City Centre/General Coastal Marine Zones. The proposal will also require various consents under the overlays and Auckland-wide provisions of the Auckland Unitary Plan. It is noted that a number of the proposed activities are permitted in some areas under the Auckland Unitary Plan and these are outlined in detail in the planning Assessment of Environmental Effects.

Ferry and fishing industry relocation facility (FFIRF)

The Auckland Fishing Fleet and Sanford's (collectively termed the Fishing Industry) and Sealink currently operate from existing facilities located on Wynyard Wharf, Halsey Street Extension Wharf and Western Viaduct Wharf. A new facility for the Fishing Industry and Sealink is proposed to be established on the western side of Wynyard Point.

The new facility will involve the construction of a purpose-built facility on land and within the coastal marine area adjacent to at 108 Hamer Street (referred to as the Hamer Street Yard) (Figure 3). Resource Consent is sought for the infrastructure and enabling works.

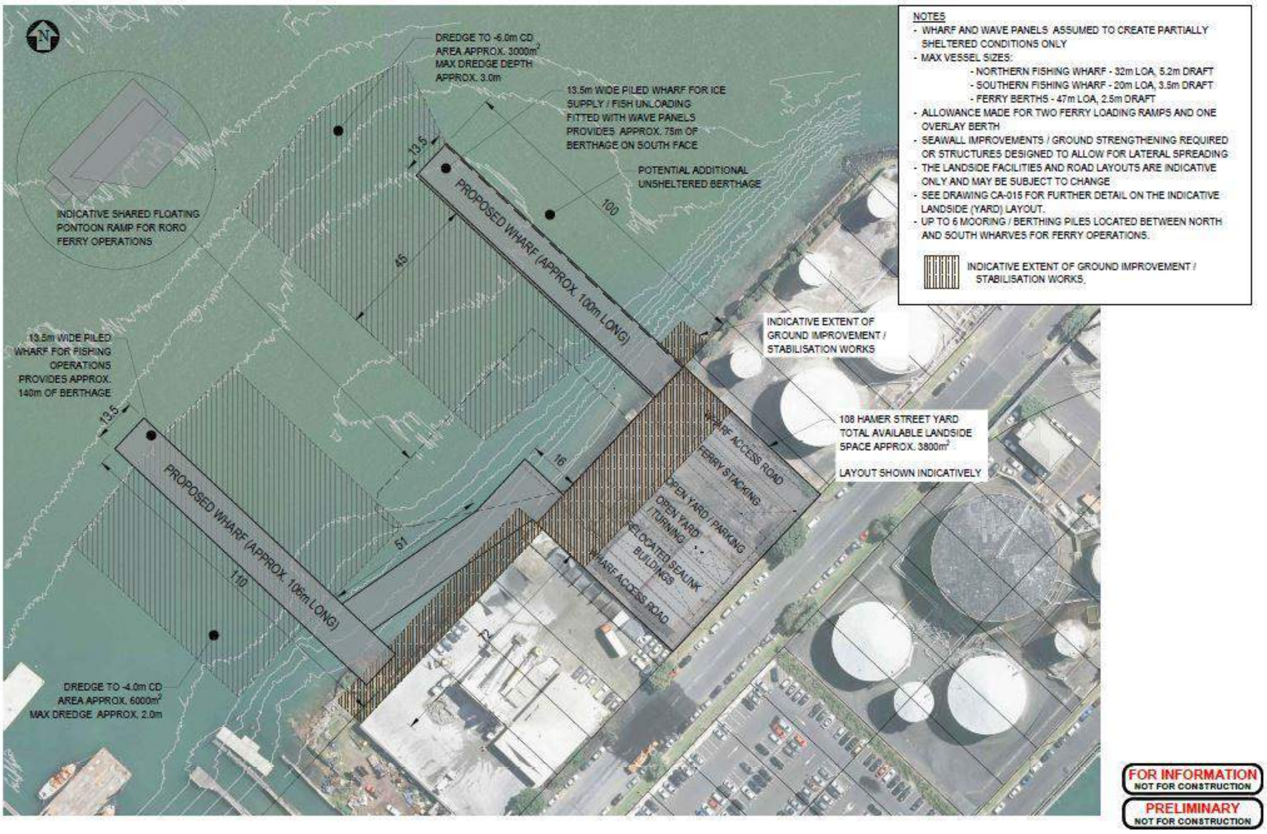


Figure 3: Ferry and fishing relocation area layout.

The FFIRF will provide for fishing vessel berthage and 'alongside' access to enable loading and unloading of vessels. The landward facilities will include associated parking and servicing areas to support this maritime use. The Sealink Facility provides for berthage and loading and unloading facilities for three vessels, associated maritime passenger facility and vehicle queuing, and manoeuvring areas. Access to FFIRF will be provided from Hamer Street.

1.2 The Assessment

This report, prepared by Golder Associates (NZ) Limited (Golder), summarises the nature of the existing environment associated with the development of facilities for the AC36. This assessment describes the physical and biological environment as well as examines any potential effects that may arise as a consequence of the construction activity required to develop the AC36 facilities. The assessment also provides information on the operational environmental effects. Table 1 identifies the key sections of this document and their associated appendices.

Table 1: Key report contents.

Topic	Section number	Supporting information
Physical environment, sediments, geology	2	
Intertidal habitat and ecology	3.2	Appendix A, NIWA (2017)
Subtidal habitat and ecology	3.3	Appendix A, NIWA (2017)
Seabirds	3.4	Appendix B
Fisheries	3.5	
Marine mammals	3.6	
Conservation values	3.8	
Sediment textures	2 and 4.4	Appendix C and D Cores and laboratory reports
Sediment quality	4	Appendix C Laboratory reports
Water quality	5	Appendix E Laboratory reports
Effects of Development	6	
Mitigation and monitoring	7	

2.0 PHYSICAL ENVIRONMENT

2.1 The Basin Environment

The main body of the proposed AC36 development sits in the northern, more exposed area outside of the Viaduct Basin between Princes Wharf and Wynyard Wharf and on the western side of the Western Reclamation, south of Wynyard Point. The shorelines in these areas are highly modified with the majority of exposed surfaces and "shores" consisting of wharves and supporting structures including concrete slabs, wood, concrete and steel piles (further detail is provided in Section 3.3) extending approximately 5.0 m above and 4.5 m below low tide level. The other key artificial habitat types in the immediate vicinity of the proposed development are floating marina berths.

The Waitemata Harbour shoreline near the Viaduct Basin has undergone considerable change since the establishment and development of Auckland City. The original shoreline is shown in Figure 4. Reclamation activity commenced about 1876 with Victoria Park being reclaimed between 1886 and 1901 with sediment dredged from the harbour. The area beside Hobson Wharf was reclaimed using refuse in 1902-1908. The area west of the Viaduct Basin was reclaimed between 1905-1907 using Waitemata series rock and dredged sediment. The area known as the western reclamation west of Wynyard Wharf was constructed in 1923-1930 using a combination of waste material derived from the Victoria Park gas works and marine dredged material. More recently, in 2003, the Inner Viaduct Basin was substantially redeveloped and the Halsey Wharf constructed. Figure 4 shows the old shoreline relative to the current shore.

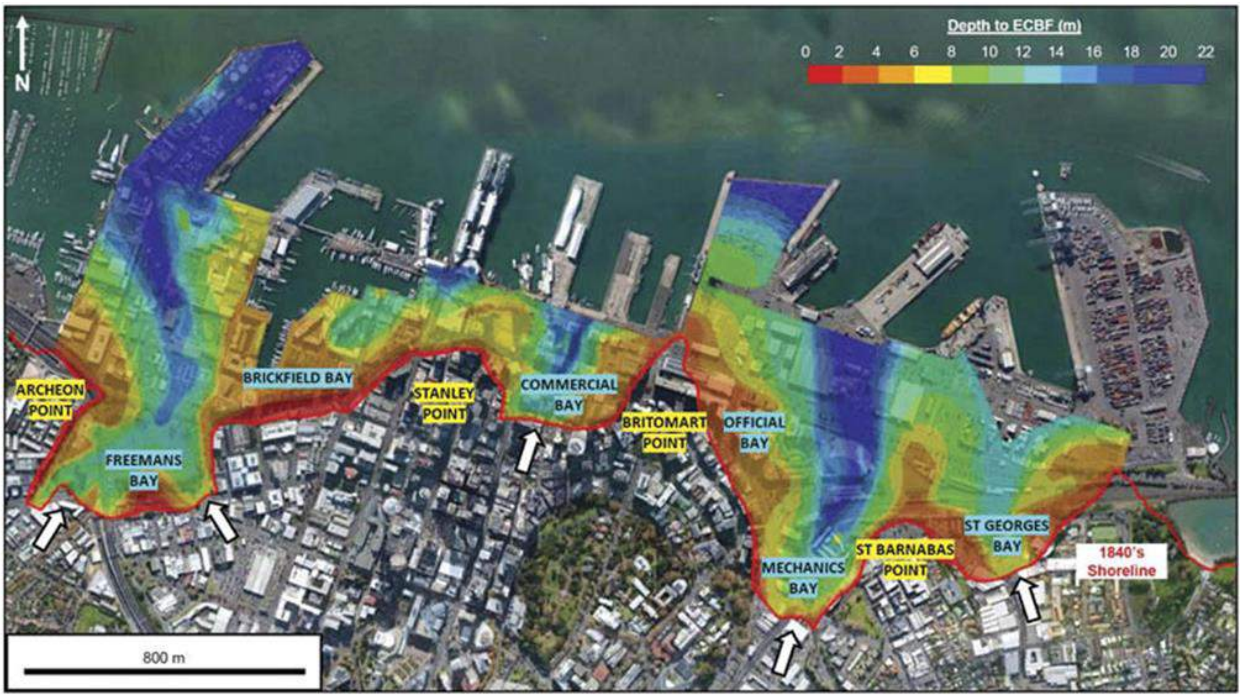


Figure 4: Auckland City original shoreline and depth to East Coast Bays Formation surface (from Wotherspoon & Lee 2016).

2.2 Sediment and Underlying Materials

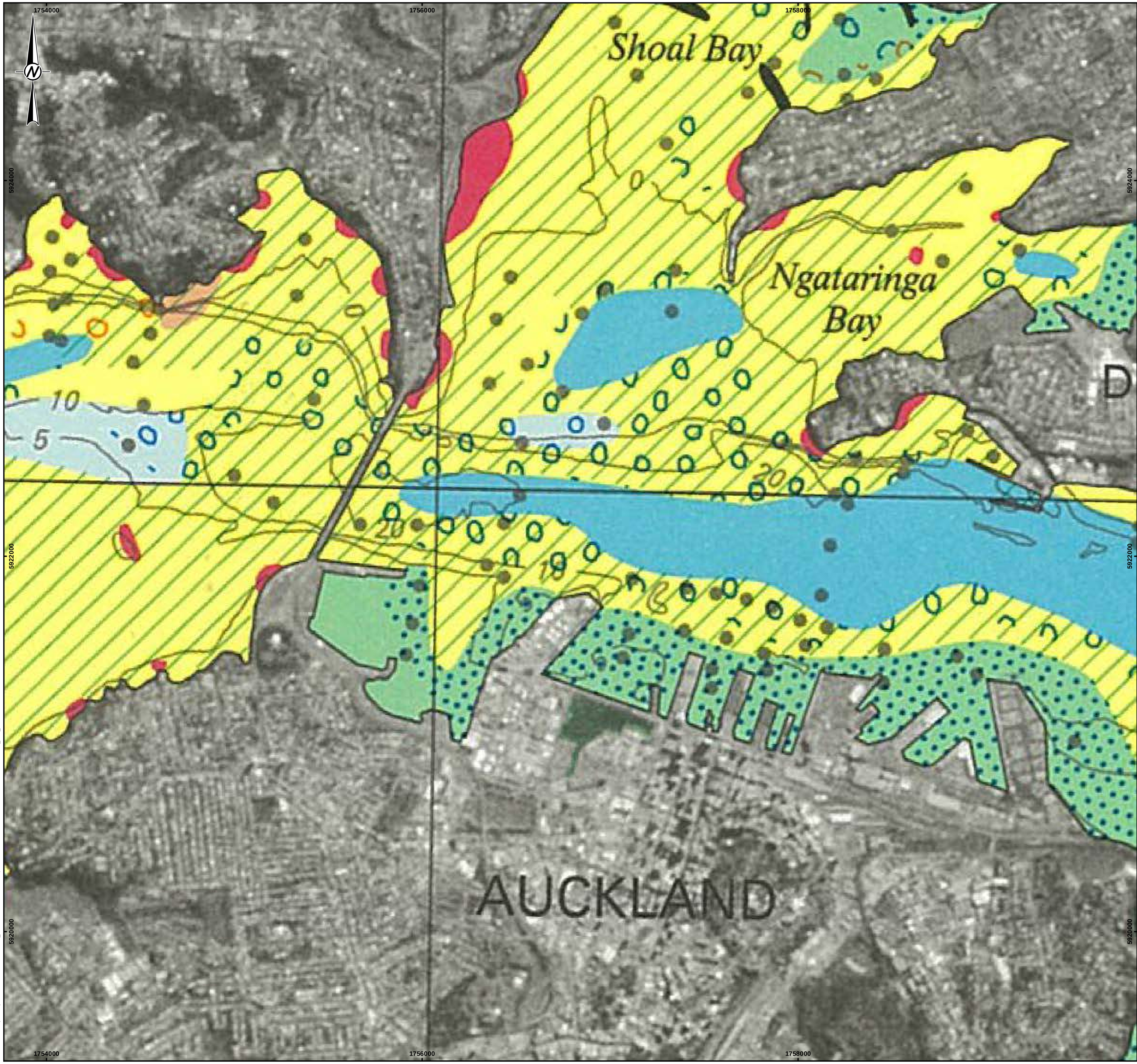
Sediments within the Waitemata Harbour have been described by Gregory & Thomson (1973) and also by Gregory et al. (1994). Figure 5 illustrates the broad characteristics of sediments within the mid and lower Waitemata Harbour.

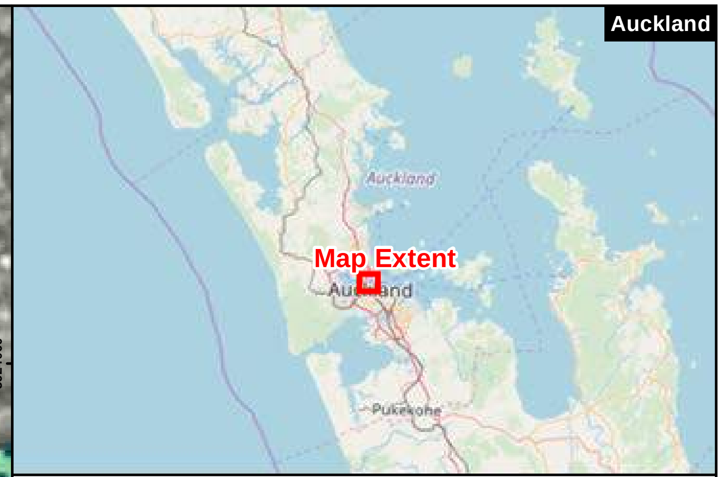
The area of the Waitemata Harbour where the proposed works will occur is located within the Port of Auckland. The wharves provide shelter from wind and waves and results in reduced tidal velocities. The reduced tidal velocities in the immediate vicinity. This reduced tidal velocity and calmer water results in the deposition of fine sediments (muds) under and between the wharves in the basins.

The general trend in seabed sediment characteristics from the outer Viaduct Basin into the main channel is an increase in the proportion of sand and shell gravel and a decrease in proportion of mud. This trend has been seen in samples collected from west of the Fergusson Container Terminal (at the eastern end of the Port). Section 4.4 provides site specific information on sediment physical characteristics.

Sediments sit on Tauranga Group sandstone at various depths. The underlying materials are an extension of the materials present in the ridges and valleys that lie immediately to the south of the Viaduct Basin. The materials have been extensively studied during the various drilling programmes undertaken as part of infrastructure projects, over the years, such as the City Rail Link. Within the Viaduct Basin, drilling was undertaken as part of investigations into the redevelopment of the Viaduct Basin (Terra Aqua (1989)). Three drill-holes were located immediately south of the Te Wero Bridge. The findings of the three dill holes (numbers 2, 4 and 5 in Terra Aqua 1989) were 0.3 to 2.8 m of soft mud overlying 4.9 to 12 m of Waitemata Group materials. Terra Aqua (1989) described the muds as being “very weak, soft to firm and non to slightly cohesive’.

The valleys and basins have filled in over time from prior to the man-made shoreline modification to the present day. The Port and ancillary areas are dredged when required to maintain navigable depths. In the outer Viaduct Basin, only Wynyard Wharf is dredged on a routine basis as depths are required for vessels that berth regularly at the wharf.





LEGEND

		< 50% Calcium Carbonate in gravel fraction		> 50% Calcium Carbonate in gravel fraction
G		gravel		calc-gravel
g		gravelly		calc-gravelly
		< 50% Calcium Carbonate in sand fraction		> 50% Calcium Carbonate in sand fraction
S		sand		calc-sand
s		sandy		calc-sandy
		< 50% Calcium Carbonate in mud fraction		> 50% Calcium Carbonate in mud fraction
M		mud	†	calc-mud
m		muddy	†	calc-muddy
		rock outcrop		

INTERPRETATION OF SEDIMENT CHART

1. Background colour shows primary constituents, e.g.

Sand. The sediment contains <5% gravel and, because there is no mud overlay, >90% sand in the fraction finer than 2 mm. Sand contains <50% carbonate.

2. Overlay shows subdominant constituents, e.g.

Muddy sand. Contains <5% gravel and, because there is a mud overlay, 50-90% sand.

NOTES

1. Map scanned: M.R. Gregory, N.A. Blacksmore, G.P. Glasby and N.W. Burrows - New Zealand Oceanographic Institute, 1994, Miscellaneous Series No. 70 - Manukau and Waitemata Harbours Sediments [1:75000]

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REFERENCE SCALE: 1:20,000 (at A3)

PROJECTION: NZGD 2000 New Zealand Transverse Mercator

CLIENT
PANUKU DEVELOPMENT AUCKLAND

PROJECT
AMERICAS CUP 36

TITLE
WAITEMATA HARBOUR SEDIMENT MAP

CONSULTANT	YYYY-MM-DD	2018-01-10
Golder Associates	PREPARED	RK
	CHECKED	KC
	REVIEWED	ED
	APPROVED	PK

PROJECT NO.	REPORT	REV.	FIGURE
1790454	001	0	**05**

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3.0 BIOLOGICAL ENVIRONMENTS

3.1 Introduction

This section provides a summary of information on the key biological environments and habitat that are located within the primary areas associated with the AC36 development. These areas are:

- The outer Viaduct Basin immediately inside and north of the Halsey Street Extension Wharf and Western Viaduct Wharf (dredging and construction).
- The area immediately alongside the southern section of Wynyard Wharf where bases are proposed (construction), alongside North Wharf and alongside the west side of Halsey Street Extension Wharf beside the event centre (dredging and construction).
- The waters alongside the western reclamation in Westhaven north of the Vos slipway and south of Wynyard Point (dredging and construction).

In the following sections, information is presented in relation to these three areas.

3.2 Information Collected

Subtidal seabed ecology

The work undertaken provided information in relation to epibenthic ecology (organisms on the seabed surface), infaunal ecology (biota inhabiting seabed sediment), fauna inhabiting the varied man-made structures within the outer Viaduct Basin, the shore of the south section of Wynyard Wharf. On 16th, 17th and 22nd November 2017. Sediment cores and video transects were taken at four locations to describe the epifauna and benthic infauna within the survey area comprising:

- The Viaduct Harbour (three stations approximately 30-35 m apart).
- Beneath the Viaduct Event Centre (three stations approximately 25-30 m apart).
- The area north of Western Viaduct Wharf (nine stations, approximately 50-60 m apart and the outermost sites 200 m off the entrance to the Viaduct Basin).
- The North Wharf/Wynyard Wharf corner (one 30 m continuous video transect only).

Further detail regarding sampling, methods and sampling locations (Figure 2-1) can be found in Appendix A.

Intertidal structures and shoreline

On the 16th and 22nd November 2017, fouling assemblages were surveyed on wharf piles and floating structures at 2 locations:

- The Outer Viaduct Basin (nine stations).
- Wave panels facing open water, adjacent to the entrance to the Viaduct Basin (three stations).

Four wharf piles (two outer wharf piles receiving sunlight, and two inner, shaded piles) were surveyed at each station in the Outer Viaduct Basin (Stations 1-6). A continuous video transect was recorded of assemblages on each pile from ~MHWS to 5 m below MHWS. At stations 7-9, pontoons (shaded underside) and fixed concrete wall structures (receiving full sunlight) were surveyed.

Concrete wave panels on the outer side of the Viaduct Basin were also surveyed. The panels consisted of flat, vertical concrete surfaces designed to attenuate wave action under the wharf and into the Viaduct Basin. Panels were approximately 4 m wide and between 2-5 m deep (depending on whether the panel was attached to the outside or inside of the wharf piles). Panels ran the length of the outer surface of the Wharf. Only wave panels which were on the outside of the wharf piles were surveyed, these panels were attached down to the sea floor (5 m). Three stations (from three different panels) were surveyed, each station consisting of two vertical transects.

Photographs were taken of the shoreline along a reclamation wall located on the Westhaven side of the Western Reclamation. Four transects were surveyed perpendicular to the shoreline from the high tide (top of the barnacle zone), to the low tide line (water's edge at low tide). Dominant organisms were identified and relative abundances estimated.

3.3 Habitat

The nature of the natural and artificial habitat determines the type and extent of biological community present on it. As the shore line changes in character, the marine biological communities present also change. There is no natural shoreline remaining along the southern shores of the mid-Waitemata Harbour from the Auckland Harbour Bridge in the west to the Fergusson Container terminal in the east. The artificial shoreline now present comprises a range of man-made structures as summarised in Table 2.

Table 2: Summary of man-made features and structures in existing areas of the proposed AC36 project area.

Location	Physical habitat	Images in Figure 6
Wynyard Wharf	Cement piles and cross beams, wooden facing piles. Southern under-wharf dominated by artificial sand and rock beach, changing to rock revetment behind northern section of Wynyard wharf.	6a, 6b
North Wharf	Cement piles and cross beams, wooden facing piles, rock revetment at rear of under-wharf area...	6c
Existing outside Halsey Wharf extension	Concrete piles and cross beams, wooden outer facing piles, and concrete wave protection panels along outer sections of Wharf.	6d
Inner Halsey Wharf extension	As above.	6e
Te Wero Island	As above.	
Inner Hobson Wharf	As above.	
Outer Hobson Wharf	As above.	6f
Princes Wharf	Concrete piles and cross beams, wooden outer facing piles.	
Western reclamation	Rock/rubble facing wave protection to below low tide.	

3.4 Intertidal Environment

3.4.1 Introduction

The structures in the immediate vicinity of the proposed development area are relatively recent additions to the Viaduct Basin having been built in 1998 as part of the development for the 30th Americas Cup held in Auckland in 2000. To fully assess intertidal community patterns and long term colonisation of structures, the newer structures and older more established concrete structures associated with Wynyard Wharf to the west of the Halsey Street Wharf, as well as the wooden piles within the Outer Viaduct Basin were examined.

3.4.2 Wynyard Basin and outer Viaduct Harbour

The visible structures on the eastern side of the outer Viaduct Basin (Princes Wharf, Hobson and Halsey Wharf) do not have hard "shores" behind them. The structures all have internal concrete piles with wooden piles on the external faces and wave panels along the northern faces of Hobson and The Halsey Extension, along the west side of Halsey Wharf and also on the north side of the Outer Viaduct Basin.

6a

6b

6c

6d

6e

6f

Figure 6: Physical environments in the Wynyard Basin and Outer Viaduct Basin.

The November 2017 investigation identified 27 dominant biofouling organisms from the samples removed from wharf piles, pontoons, walls and wave panels (Appendix A).

Piles and wave panels

Intertidal fouling communities were surveyed based on substrate type within the Outer Viaduct Basin (i.e. new piles located under the Viaduct Event Centre, old piles located underneath the Maritime museum, pontoons and walls within the Viaduct basin, and the externally facing wave attenuation panels.

Biofouling assemblages on the pontoons in the Viaduct Basin were also compositionally distinct from those on the piles and wave panels and from assemblages on the outer Viaduct Basin wall that was examined. There was no significant difference between the biota on the older piles beneath the Maritime Museum and the wave panels (outer).

The identified differences were related to the abundance of key taxa. The Event Centre (new piles), Maritime Museum (old piles) and outer wave panels all had high abundances of the barnacle *Austrominius modestus*. *A. modestus* was absent from the Viaduct Basin wall (and Viaduct Basin pontoon sites). Conversely, the Viaduct Basin wall (and Viaduct Basin pontoon sites) had large densities of the Pacific oyster, *Magallana* (*Crassostrea) gigas*, which was only present in small numbers at the Event Centre (new piles), Maritime Museum (old piles) and wave panel sites.

Floating pontoons

Floating pontoons are non-tidal structures that allow subtidal biota to be present at the water surface while remaining submerged over the full tide cycle. Biota occupying pontoons in the Viaduct Basin was originally described by Kingett Mitchell (2003). At the time of that survey, the communities were dominated in the upper surfaces by paddleweed (*Ecklonia radiata*) and filamentous green algae, which formed dense mats over all available surfaces. Tube worms (*P. caeruleus*) were present in close proximity to the water surface, while small mussels (*Perna canaliculus*) and oysters (*Crassostrea spp*) were present in low densities.

On the underside of the berths, sea squirts (*Cnemidocarpa bicornuata* and *Corella eumyota*) dominated the faunal community. Occasional yellow and red golf-ball sponges (*Tethya spp*) were also present towards the deeper edges of the berths. In shaded areas between individual berths, green filamentous algal abundance decreased while sea squirt abundance increased. Colonial bryozoans and hydrozoans were also observed in these areas.

In the 2017 survey, biofouling assemblages were significantly different on the pontoons located in the outer Viaduct Basin, compared with wharf piles, walls or wave panels. At 0 m (MHWS) and 2 m, the wall and pontoon sites in the Viaduct Basin had the highest species abundance and the pontoons had the highest species richness. However at 5 m, all the substrate types (i.e., locations – new piles under the Event Centre, old piles under the Maritime Museum, pontoons and walls in the Viaduct Basin, and the outer facing wave panels) had relatively high abundance, species richness and diversity.

3.4.3 Inner Viaduct Basin

Visual inspection of pontoons and the intertidal concrete walls of the Inner Viaduct Basin showed a dominance of oysters through entire Basin with some differences in density depending on age of the wall. Lesser dominant species in the intertidal and subtidal regions included barnacles, chitons and at the lower tide, tube worms.

On pontoons in the Inner Viaduct Basin, a biofouling community dominated on the near surface concrete sides (some 30 cm depth) and the pontoon underside. Both surfaces can support substantive communities and biomass as can be seen in Figure 7. On the western side of the Inner Basin, prior to the Lighter Basin and along the eastern side of the Lighter Basin, both the extent and percentage cover of macroalga (e.g., *Ecklonia* sp.) varied, with increased biomass typically occurring towards the end of the pontoons. Differences in observed biomass may be partly related to the pontoon’s proximity to the main channel of the Lighter Basin and whether the berth has regular vessel use.

3.4.4 North Wharf and Southern Wynyard Wharf

North wharf is backed by the reclamation carried out for the first Americas Cup (this is located under North Wharf) which abuts onto the western reclamation at the southern end of Wynyard Wharf. At the southern end, oysters are encrusted on the artificial sand and rock beach as well as the deeper rock armour (refer Figure 2-2 in Appendix A). A variety of substrates were present under the wharf. Few invertebrate burrows were seen in transects examined in this area.

3.4.5 Ferry and Fishing Relocation area (Western Reclamation shore)

The shoreline of the proposed ferry and fishing industry relocation is comprised of decant reclamation wall with a relatively smooth, flat basalt rocky surface. Artificial concrete slabs are also present over an intertidal distance of ~ 10-15 m. This shoreline is exposed to waves because of the prevailing wind, long fetch and vessel traffic. A clear zonation was present along the shoreline, although the littoral fridge was relatively barren.

Pontoon (mid) east side Lighter Basin.

Pontoon (outer section) east side Lighter Basin.

Pontoon north side - east arm Inner Viaduct Basin.

Pontoon by lift bridge, Inner Viaduct.

Figure 7: Inner Viaduct Basin pontoons.

There was a clear vertical zonation visible on the rocky shoreline, with fouling assemblages largely dominated by the Pacific oyster. There was no flora or fauna located in the upper littoral zone, a zone which was characterised predominantly by concrete slabs.

The midshore zone was dominated by oysters, while barnacles were present towards the upper boundaries of this zone. Smaller invertebrates such as molluscs (*Sypharochiton pelliserpentis*) and gastropods (*Nerita melanotragus*) were present between the dense clumps of oysters. A range of macroalgae were present in small quantities towards the sublittoral fringe including the red macroalgal species *Corralina officianalis*, *Gelidium caulacantheum* and *Apophlaea sinclairii*, the brown macroalgal species *Hormosira banksia* and *Scytothamnus australis* and the green macroalga *Codium convolutum*. Below the waterline, the brown macroalga *Carpophylum maschalocarpum* was present.

3.4.6 Overview

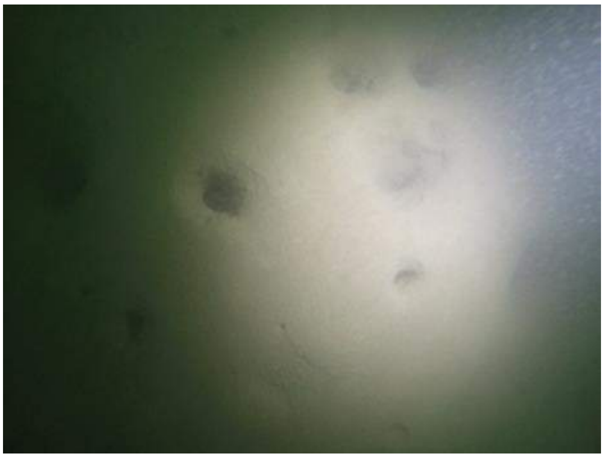
Comparisons between the present surveys and previous studies in this area showed that over the past 30 years, similar community zonation patterns have persisted on the wharf piles in the Waitemata Harbour (Morton & Miller 1967, Larcombe 1973, Kingett Mitchell 1996 - 2003). The intertidal fauna is strongly influenced by the nature of man-made surfaces and activities along with a significant component of introduced organisms.

3.5 Subtidal Environment

3.5.1 Wynyard Basin and outer Viaduct Harbour seabed

No systematic examination of epibenthos have previously been carried out in the Viaduct Basin or adjacent areas of the Port. Observations and photographs have shown that in areas of soft sediment, the surface can be mobile due to being easily disturbed. Figure 8 shows an image taken from the November 2017 video surveys and a comparative image taken from Princes Wharf east in 1989.

The dominant sediment type at each of the locations (Viaduct Basin, open water adjacent to Viaduct entrance, North Wharf (and under the Event Centre) consisted of soft, silty mud, with invertebrate burrows and holes the most dominant sign of animal life (Figure 8). In contrast, the North Wharf site located at the corner of Wynyard Wharf and North Wharf (underneath a wharf and against a rock wall, Figure 2 in Appendix A) was quite different, consisting mainly of broken rubble, some patches of course sediment and broken rock (refer Appendix A for more detail).



Station 6 outer Halsey Basin, November 2017

Princes Wharf east, 1989.

Figure 8: Soft sediment showing burrows.

The subtidal environment in the Viaduct Basin comprises predominantly soft sediments, limited areas of coarser material (which includes shell debris near structures) and the underwater piles and wave panels associated with the wharfs.

Subtidal sediments sites in open water areas were characterised by soft, silty mud with invertebrate burrows and few mobile or epibenthic fauna. There was a significantly higher number of burrows at the open water sites, compared with underneath the Event Centre and the Viaduct Basin (refer Appendix A). Macrofaunal community composition was significantly different between sites located under the Event Centre and those in open water or the Viaduct Basin (refer Appendix A). Species diversity was significantly different underneath the Event Centre compared to both the Viaduct Basin and open water sites.

The November 2017 survey identified a total of 33 macrofaunal organisms associated with the sediment cores. Across the 12 locations in Halsey Basin (Refer Appendix A) polychaetes were the dominant taxa, comprising about 70 % of the individual organisms in each sample. Less frequently occurring species included bivalves, as well as small crustaceans (amphipods, ostracods and isopods and crabs.

There was no significant difference in the mean number of individuals or the species richness at the Event Centre, open water, or Viaduct Basin sites (note: no sediment cores were taken from the North Wharf site) (refer Appendix A). However, the diversity of species between the three locations was significantly greater at the open water site. There was no significant difference in species diversity between the Event Centre or Wynyard Basin/Viaduct Basin sites.

Bivalves were mostly represented by the non-indigenous species *Theora lubrica*. This species is a common inhabitant of soft sediment in the Waitemata Harbour, having arrived over 40 years ago (arrived in New Zealand in 1972, Dromgoole & Foster 1983). *Theora lubrica* was present in smaller densities within stations in Viaduct Basin and outside the entrance to the Viaduct Basin. The only gastro*pod* identified from the samples was the non-indigenous Australian dog whelk *Nassarius burchardi* which is now regarded as being quite common in the Waitemata Harbour (ref needed). The dog welk also occurred in greater abundance beneath the Event Centre and was almost absent from the open water or Viaduct Basin sites. The most dominant polychaete species was *Heteromastus filiformis*. *H. filiformis* is widely distributed through New Zealand, colonising many different coastal sediment environments.

Examination of the infaunal data revealed that there were no significant differences between the species densities between the sampling locations (Appendix A). Species richness (the number of species within a community or ecosystem) did not differ significantly between the locations. Species diversity differed under the Event Centre compared to that in the open water areas of Wynyard Basin/outer Viaduct Harbour which did not differ from each other (refer Appendix A). Differences in communities are likely to relate to different environmental conditions, particularly available light.

The outer Viaduct Basin (corresponding to the Inner and Outer Halsey Basin) was sampled as part of investigations for the previous America's Cup development. In 1996, 29 invertebrate species (16 species of polychaete worm, six crustacean species, four bivalve mollusc species, and single gastropod, hydrozoan and holothuroid species) were recorded by Kingett Mitchell (1996) from the inner and outer Viaduct Basin. This is similar to those recorded during the present survey. Locations where biota were sampled in 1996 are shown in Figure 11. In the 1996 survey, the bivalve *T. lubrica* and polychaete worms dominated the community.

The deposit feeding communities found in the Viaduct Basin were considered to be fairly typical of the soft sediment environment between the wharfs in the Port. Similar communities have been found at the nearby Princes, Jellicoe and Fergusson wharves. At locations such as Jellicoe and Princes wharves, the abundance of organisms is generally low with the most abundant species being the bivalve *T. lubrica*,

Although surveys have been 30-40 years apart, they have identified similar infaunal communities in the soft sediments through the Inner and outer Halsey Basin. Although data is limited, it appears that introduced species (polychaetes and molluscs) have become part of the soft sediment community. Overall, the community present reflects the soft nature of the seabed habitat and likely the ongoing disturbance by vessels of surface sediments.

3.5.2 Western Reclamation (ferry and fishing relocation area)

No benthic subtidal survey was undertaken within the FFIRF area as it was not considered warranted based on general knowledge of community expected. The sediment sampling survey did not identify any identifiable changes in seabed physical characteristics across the area. Examination of sediment cores collected for sediment quality found an absence of invertebrates in this location. The fauna of subtidal sediments has been examined within Westhaven Marina in studies from Bioresearches (1989) through to Bioresearches (2016). The early study identified a community not too dissimilar to that described for the soft sediments within the Viaduct Basin. Infauna was dominated by the bivalve *T. lubrica* along with crabs, amphipods and polychaete worms including Heteromastus also a key species in the Viaduct Basin. Snapping shrimps and their burrows were observed in various locations.

Bioresearches (2016) examined benthic fauna inside the breakwater at the entrance to Westhaven Marina. They found a generally similar community with a reasonable number of species present. The composition was dominated by Heteromastus and *T. Lubrica*. The 2016 assessment concluded that the biota present was not of high value and the species identified were common in the nearby areas.

Overall, it is considered that the infauna is comprised of common Waitemata Harbour invertebrate species and the community present here is expected to be is typical of similar areas in adjacent Westhaven and through the Harbour.

3.6 Seabirds

3.6.1 Introduction

Information on bird species utilising the coastal environment within the working areas of the Port and Westhaven have come from a range of observations made over the last 20-30 years. As noted earlier the shoreline is man-made and there are no natural intertidal shores or intertidal mudflats. Other areas of the Waitemata Harbour supporting coastal bird species are described in Section 3.10. Larcombe (1973) described the birds that utilise the coastal marine areas of the Waitemata Harbour, while Bioresearches (1989) provided a description of the birds using the outer Viaduct Basin and Westhaven Marina. Although nearly 30 years have passed since those observations were made, the birds using the area were typically the same species. These include species summarised in Table 3. Gaskin & Raynor (2013) and Hauraki Gulf Forum (2014) provide information on seabird populations and breeding sites within the wider Hauraki Gulf area and Aguirre et al. (2016) provides an overview of the key avifaunal values of the Waitemata Harbour.

Table 3: Bird species seen in the Wynyard and Westhaven sections of the Waitemata Harbour.

Common name	Species name	Notes/Conservation significance
White-fronted tern	*Sterna striata*	At risk – declining (data poor)
Pied shags	*Phalacrocorax varius*	At risk – recovering
Little shag	*Phalacrocorax melanoleucos brevirostris*	Not threatened
Black-backed gull	*Larus dominicanus*	Not threatened
Red-billed gull	*Larus novaeholandiae scopulinus*	At risk – declining
Australasian gannet	*Sula serrator*	Not threatened
Variable Oystercatchers	*Haematopus unicolor*	At risk – recovering
New Zealand dotterel	*Charadrius obscurus aquilonius*	At Risk – recovering

Notes: Conservation significance from Robertson et al. (2016).

3.6.2 Outer Viaduct Basin

The low numbers of coastal bird species observed in the area between Princes and Wynyard wharves is most likely a reflection of the low amount of suitable habitat present, as well as the disturbance from people and vessel movement. The Viaduct area provides some limited roosting sites (e.g., on bollards) for birds. The six open water birds in Table 3 can be seen in the outer Viaduct Basin at various times. The Viaduct Basin area is part of a wider habitat in the Waitemata Harbour used by these bird species.

Overall, bird species typical of the lower Waitemata Harbour use the area of the outer Viaduct Basin. There are limited roost sites and no nest sites were known. As identified in Table 3, some of the bird species seen using the waters between Princes and Wynyard wharves are identified as being At Risk (refer above) and these wharves are part of the wider Waitemata Harbour environment used by these species. The intertidal wader birds do not utilise this area.

3.6.3 Western Reclamation shore (ferry and fishing industry relocation area)

Along the shoreline of the Western Reclamation immediately north of the Vos Slipway the shore is utilised as a high tide roosting area by red-billed gull and white fronted terns utilise most of the old wharf piles along the shore as nest sites (Figure 9). Other bird species listed in Table 3 are also seen in the general Westhaven Marina area. Additional information about the three key bird species known to be present in the area of the ferry and fishing industry relocation area is provided in Appendix B and is discussed further below.

New Zealand dotterel

A pair of New Zealand dotterel were identified as nesting on 'vacant' land within a boat building yard (164-188 Beaumont St) and it is understood that they have raised chicks over the past five years including the present breeding season. This site is not anticipated to be involved in any Americas Cup activities identified in this application. Dotterels are known to nest on land of this type at a variety of locations in the Auckland region. Dotterel are not discussed further.

White fronted terns

The white fronted terns utilise nest sites that offer safety from predation. In December 2017, most of the old wharf piles north of the Vos Slipway were occupied by nests (at least eight) with at least one chick (Figure 9).

Figure 9: High tide roosting site (left) and white fronted tern nest (right) north of the Vos Slipway.

Red billed gulls

It is understood that the red-billed gull colony has been present in the ferry-fishing fleet relocation area for a number of years. Red-billed gulls return to the same colony that they are hatched at. In December 2017, the numbers present were estimated at about 600 and a number of nests were present on the ground at the roost. Appendix B provides a number of photographs of the roost and nest site.

Overview

Overall, a number of bird species typical of the lower Waitemata Harbour use the area of the outer Viaduct Basin. There are limited roost sites and no known nest sites. None of the observed species utilise the Viaduct environment as a unique habitat, with all species using this area as part of their wider habitat in the Waitemata Harbour. Along the shore between the Vos slipway and Wynyard Point, the northern section of shore does not provide any suitable habitat for coastal bird species of any note. Just to the south of the relocation area, the shore and old wharf piles provide suitable sites for a small number of nesting white faced terns and a large roosting and nesting colony of red-billed gull.

3.7 Fisheries

There is limited information on fish species utilising the habitat within the outer Viaduct Basin and Westhaven Marina. Larcombe (1973) provides one of the earliest descriptions of fish utilising the Port area of the Lower Waitemata Harbour. Larcombe (1973) reported that little is known of the fish in the area but that several species were caught by line fishing including snapper (*Chysophrys auratus*), kahawai (*Arripis trutta*), yellow-eyed mullet (*Aldrichetta forsteri*), and koheru (*Decapterus koheru*).

Fish species commonly inhabiting other areas of the Waitemata Harbour have been documented and include yellowbelly flounder (*Rhombosolea leporina*), sand flounder (*Rhombosolea plebeia*), smoothhound (*Mustelus lenticulatus*), parore (*Girella tricuspidata*), paketi/spotty (*Notolabrus celidotus*), jack mackerel (*Trachurus declivis*), grey mullet (*Mugil cephalus*), school shark (*Galeorhinus australis*), anchovy (*Engraulis australis*), common sole (*Peltorhamphus novaezelandiae*), and eagle ray (*Myliobatus tenuicaudatus*) (Briggs 1980).

Although habitat within the Viaduct Basin for fish is limited, the area is thought to be utilised by a variety of fish found in the Waitemata Harbour. As part of the biosecurity surveys undertaken in the Port (which included the area between Princes and Wynyard wharfs), Inglis et al. (2000) reported eel (*Anguilla australis*), congor eel (*Conger wilsoni*), snapper, yellow eyed mullet, mackerel, koheru and spotty (*Notolabrus celidotus*). Inglis et al. (2000) identified the introduced bridled goby (*Arenigobius bifrenatus*) (first found in New Zealand in 1998) at a number of locations along Wynyard Wharf and Princes Wharf. Westhaven marina also provides a range of habitat and food sources for fish.

Overall, both the Viaduct basin and the Relocation area in Westhaven Marina provide habitat for a range of fish species, including artificial (manmade) habitat. The fish species recorded in these areas are present through the Waitemata Harbour. There is no information to suggest that either area is specifically utilised by a particular fish species to the extent that the species is dependent upon the habitat.

3.8 Marine Mammals

At least 27 cetacean and two pinniped species have stranded or been sighted along the north eastern coastline of the North Island. More than 22 species of whales and dolphins have been recorded in the Hauraki Gulf while only a smaller number of these species find their way from the Gulf into the Waitemata Harbour (Table 4).

Common and bottlenose dolphins are sighted and Orca (killer whales) (seen in the Gulf in small pods) are known to enter the Waitemata Harbour. Leopard seals are uncommon although in 2017 two have been visiting Westhaven marina. One of the seals has been a regular visitor to Westhaven Marina and other locations in the upper Waitemata Harbour since 2015 and was seen during field work for this assessment in the marina.

Table 4: Marine mammals in the Hauraki Gulf and Waitemata Harbour.

Common name	Scientific name	Seen in Waitemata Harbour
Whales and dolphins		
Arnoux's beaked whale	*Berardius arnouxi*	
Gray's beaked whale	*Mesoplodon grayi*	
Common dolphin	*Delphinus delphis*	Yes
Bottlenose dolphin	*Tursiops truncatus*	Yes
Dusky dolphin	*Lagenorhynchus obscurus*	
Hector's dolphin	*Cephalorhynchus hectori*	
False killer whale	*Pseudorca crassidens*	
Killer whale	*Orcinus orca*	Yes
Pilot whale	*Globicephala sp*	
Pygmy sperm whale	*Kogia breviceps*	
Sperm whale	*Physeter macrocephalus*	
Humpback whale	*Megaptera novaeangliae*	
Southern right whale	*Eubalaena australis*	
Minke whale	*Balaenoptera sp*	
Bryde's whale	*Balaenoptera edeni/brydei sp*	
Fin whale	*Balaenoptera physalus*	
Sei whale	*Balaenoptera borealis*	
Blue whale	*Balaenoptera musculus sp*	
Seals		
New Zealand fur seal	*Actocephalus forsteri*	Yes
Leopard seal	*Hydrurga leptonyx*	Yes

3.9 Biosecurity Information

About 260 non-indigenous marine species have been identified in New Zealand and some 141 species have been identified in the Hauraki Gulf (Hauraki Gulf Forum 2014). Areas such as the Port of Auckland and marinas are focal points for marine introductions. The port has been surveyed on a regular basis as part of national biosecurity surveys on behalf of MPI (e.g., Inglis et al. 2000 and more recent surveys). The Viaduct Basin is part of this program and, as such, has extensive data on the presence of introduced species within the marine communities in the basin.

There has been a substantial increase in the number of non-indigenous species present in the Waitemata Harbour, including the Viaduct Basin. A range of non-indigenous species were identified during the ecological surveys for this assessment and further information can be found in Appendix A. A large proportion of non-indigenous and cryptogenic species were identified from the intertidal sites compared with indigenous species (i.e., wharf piles, pontoons, walls and wave panels) (Table 3-1). As these structures are associated with vessel movements within the Viaduct Harbour, they can act as hotspots (concentrated areas) for colonisation, act as stepping stones or even corridors for some non-indigenous species (Mineur et al. 2012, Lambert & Lambert 2003). In addition, due to the introduction of new species from vessels, the existing fouling communities and suitable uncolonised substrate that provides a refuge from native predators, a greater number of non-native species are found on artificial structures compared to nearby natural substrates (Mineur et al. 2012).

3.10 Conservation Values

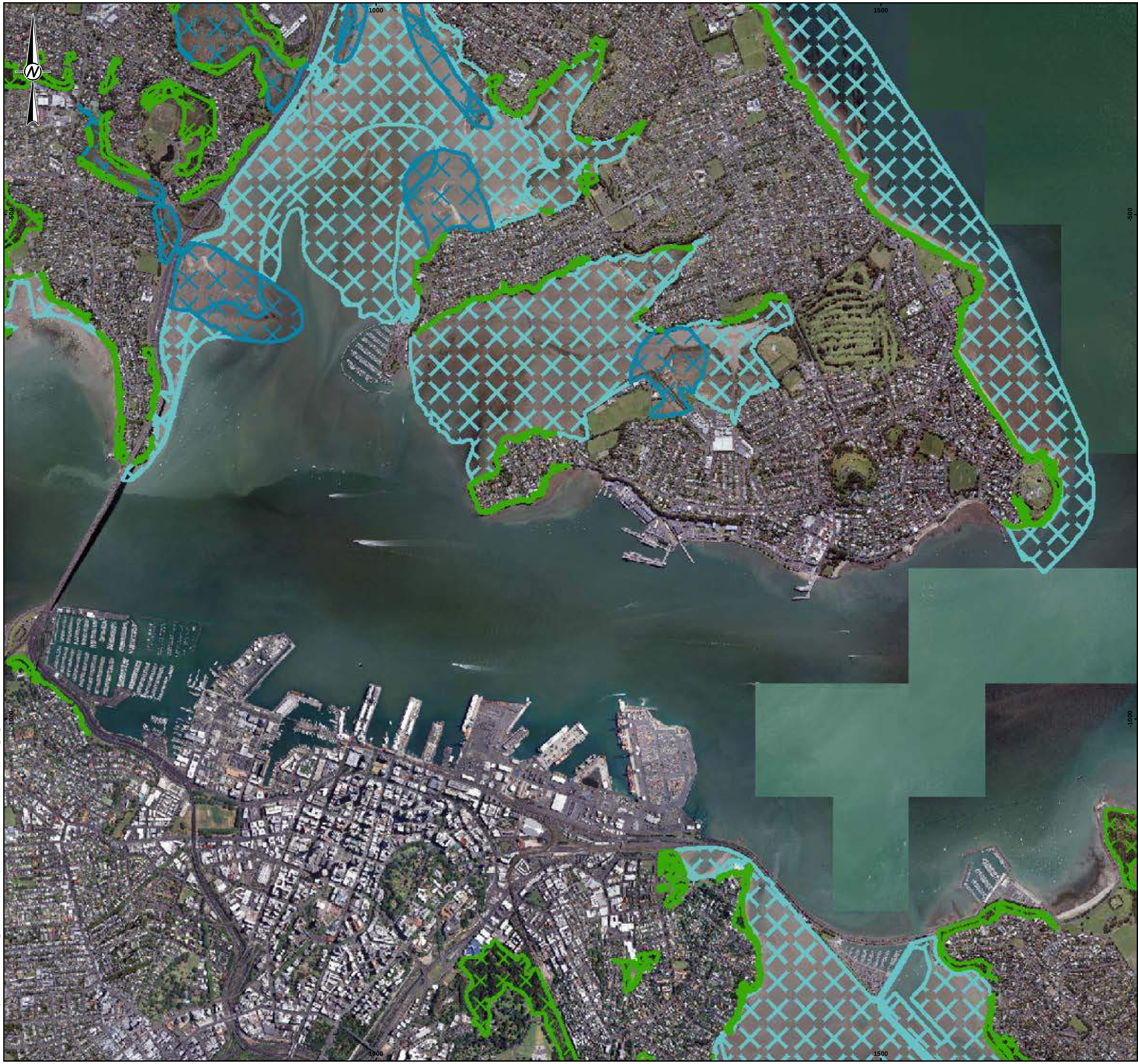
No areas of conservation value are located within, or immediately adjacent to, the outer Viaduct Basin, or the proposed ferry and fishing relocation areas. A number of areas of conservation and ecological significance (as recognised in the Unitary Plan (Schedule 4)) are present in the mid and lower Waitemata Harbour. Areas of significance are summarised in Table 5 and shown on Figure 10. These areas are located in Shoal and Ngataringa Bays on the northern side of the Waitemata Harbour from the Viaduct and Westhaven Marina relocation site. To the west, up-harbour is the Meola Reef intertidal area of significance. All identified area are several kilometres from the development area.

Table 5: Examples of areas of ecological significance in the lower and mid Waitemata Harbour.

ID	Name/Location	Values of area	SEAM type
51a, b	Orakei Basin and Hobson Bay	This area is a breeding area for a variety of shag species. Orakei Basin and Hobson Bay are feeding areas used by these birds along with a variety of other coastal and wading birds, including whitefronted terns ('at risk, declining'), gulls, kingfishers, whitefaced herons, pied stilts ('at risk, declining').	SEAM 2
52 Te Tokoroa Reef			
52a	Te Tokoroa Reef saline vegetation	Te Tokoroa Reef is a basaltic lava flow which extends into the Waitemata Harbour and provides a range of habitats and flora and fauna which is unique both within the Waitemata Harbour and throughout New Zealand. The reef is a significant area for wading birds. There are extensive salt marshes and mangrove communities associated with the reef.	SEAM 1
60 Shoal Bay – Ngataringa Bay			
60a, b	Shoal Bay intertidal area, Ngataringa Bay intertidal area	Shoal Bay, north of a line east of the Northcote motorway interchange, is an important feeding and roosting area. Caspian tern, New Zealand dotterel, pied stilt, white-faced heron, pukeko, kingfisher and gulls can be seen in the area. Within this area are extensive areas of shell banks and intertidal sand and mud, which together form a complex habitat for a variety of animal and plant communities. The intertidal area (60a, 60b) is an important wading bird feeding ground.	SEAM 2
60c, d, e, g	Shell banks	Associated shell banks (60c, 60d, 60e, 60g) are used as a high tide roost by wading birds and a variety of coastal birds. The City of Cork shell banks and the reconstructed shell banks created as part of the North Shore Busway are used as a breeding site for New Zealand dotterel. The shell banks beside the motorway are the only roosting area used by the New Zealand dotterel between Traherne Island and Browns Island, and is a nesting area for the New Zealand dotterel, Caspian tern and pied stilt.	SEAM 1

Note: SEAM – Significant Ecological Area – Marine.

In summary, although there are areas of subtidal and intertidal ecological resources of conservation significance located in the lower Waitemata Harbour, none are located close to the proposed areas of development for AC36 facilities or the FFIRF development.



LEGEND

Significant Ecological Areas Overlay

TYPE

- Terrestrial [rp/dp]
- Marine 1 [rcp]
- Marine 2 [rcp]

NOTES

1. Aerial and map services from Auckland Council, CC-BY-3.0-NZ.
2. Map image: © OpenStreetMap (and) contributors, CC-BY-SA
3. Schematic only, not to be interpreted as an engineering design or construction drawing.

REFERENCE SCALE: 1:48000

PROJECTION: NZGD 2000 New Zealand Transverse Mercator

CLIENT
PANUKU DEVELOPMENT AUCKLAND

PROJECT
AMERICAS CUP 36

TITLE
COASTAL AREAS OF CONSERVATIONS SIGNIFICANCE

CONSULTANT		
Golder Associates	YYYY-MM-DD	2018-01-11
	PREPARED	RK
	CHECKED	KC
	REVIEWED	ED
	APPROVED	PK

PROJECT NO.	REPORT	REV.	FIGURE
1790454	001	0	**10**

4.0 SEDIMENT QUALITY

4.1 Introduction

Sediment quality is important as it will determine a number of key aspects of environmental quality during the construction phase of the proposed project. The key potential issues being the off-site transport of sediment to other areas in the Waitemata Harbour through seabed disturbance and the effects that construction activity may have on water quality downstream of the works. Background information on the nature of the current sediment quality allows for an assessment of any potential effects as a result of the proposed construction. The effects of movement and deposition of sediments as well as the potential changes in water quality are dealt with in Sections 6.4 and 6.5.

4.2 Sediment Sampling and Analysis

4.2.1 Sampling

Historical sampling

Sediment samples have been collected previously from the outer Viaduct Basin on a number of occasions as summarised in Table 6. The coastal area on the west side of the western reclamation (mainly within Westhaven Marina) was sampled as early as 1996 during work for the first AC in New Zealand. However, there is little published sediment quality data close to the areas of proposed dredging and construction in the latter area.

Table 6: Historical sampling in the Outer Viaduct Basin and Westhaven.

Location	Date	Sampling	Number of samples	Reference
Westhaven	1989	Cores	4	Bioresearches (1989)
Inner and Outer Viaduct	1989	Cores	10	Bioresearches (1989)
Outer Viaduct	1996	Cores	15	Kingett Mitchell (1996)
Outer Viaduct	2002/3	Surface and cores	6	Kingett Mitchell (2003)
Wynyard wharf*	1988-2016	Cores	3 per survey	Golder (2011)

Notes: * Five yearly surveys from 1988 to 2016.

The 1996 sampling reported in Kingett Mitchell (1996) was in a very similar area to that sampled in the 2017 survey (see Figures 11 & 12 for comparison). Where appropriate, the 1996 data is compared with the data from the present survey.

2017 Sampling

Sediment sampling was undertaken in two areas during November 2017. Figures 12 and 13 show the location of all sites sampled in the Viaduct Basin and in the FFIRF area, respectively. Table 7 provides information on the site location, the samples collected and identification codes. At each site, three randomly located core samples were collected using a pre-determined random set of sample locations from a central dive location. Surface sediment were collected using 150 mm deep cores (130 mm diameter) while sediment cores were collected using 1 m long 60 mm diameter perspex push tubes. The length of core collected was measured and cores were extruded from tubes into plastic trays. A photograph of each core was taken (see Appendix C) prior to the sediment from the core being mixed and transferred to clean zip-lock plastic bags prior to being transported chilled to the laboratory under chain of custody.

Table 7: Summary of sediment samples collected in AC36 survey.

Site	No. Samples	Sample codes	Figure
Western Viaduct Wharf	9 surface samples 6 cores	HWS1-9 HWC 4-9	11
Viaduct Harbour	3 surface samples 3 cores	HWS 10-12 HWC 10-12	11
North Wharf	3 cores	NW 1-3	11
Wynyard Wharf	3 cores	WW 1-3	11
FFIRF area (Westhaven)	12 cores	WH 1-12	12

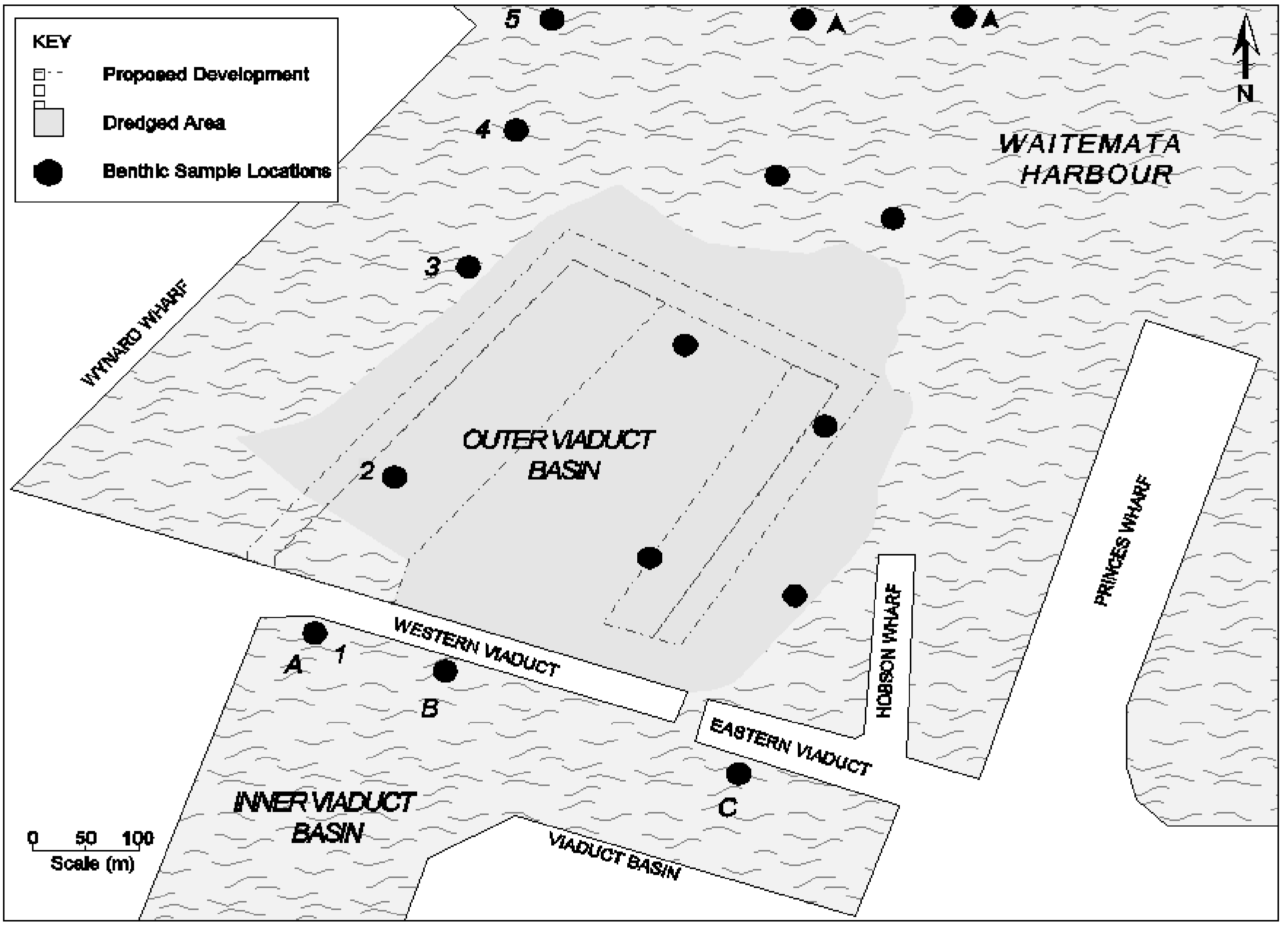


Figure 11: Sites sampled by Kingett Mitchell (1996) (outline of proposed Halsey Wharf in 1996 shown).

4.2.2 Analysis

Table 8 summarises analytical methods used for parameters determined and reported as part of the sediment quality surveys. All laboratory reports are provided in Appendix D.

Table 8: Summary of key analytical methods for sediment samples collected in this study.

Analysis	Methods
Total organic carbon (TOC)	Acid pre-treatment to remove carbonates present followed by Catalytic Combustion (900°C, O_2), separation, Thermal Conductivity Detector [Elementar Analyser].
Trace elements	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2
Total petroleum hydrocarbons (TPH)	Sonication extraction, Silica cleanup, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines. Tested on as received sample
Organochlorine compounds/Polychlorinated biphenyls (PCB)	Sonication extraction, SPE cleanup, GC & GC-MS analysis. Tested on dried sample
Polycyclic aromatic hydrocarbons (PAH)	Sonication extraction, SPE cleanup, GC-MS SIM analysis US EPA 8270C. Tested on as received sample
Tributyl tin (TBT)	Solvent extraction, ethylation, SPE cleanup, GC-MS SIM analysis. Tested on dried sample
Elutriation	Extraction with 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".
Marine textures (key fractions)	Wet sieving with dispersant, 2.00 and 0.063 mm sieves, gravimetry and by difference.
Marine textures (Mastersizer)	

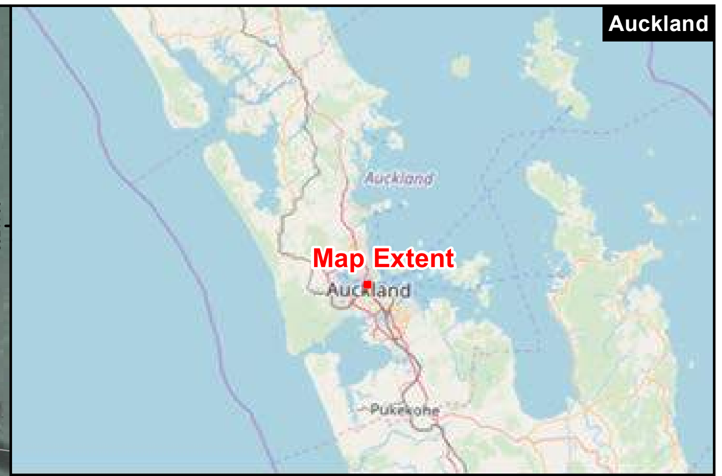
Notes: For further detail including method detection limits and specific methods for analysis of trace elements in elutriate refer Appendix C.

4.3 Sediment Quality Guidelines

The concentrations of key constituents are compared with sediment quality guidelines to assist in assessing the potential environmental issues associated with the exposure of benthic organisms in-situ and the disturbance and transport offsite of sediment during dredging and construction. The primary international guidelines utilised in Australasia are the interim ANZECC (2000) sediment quality guidelines (ISQG).

The ANZECC (2000) approach provided two sediment quality guideline values (SQGV) following the approach to guideline derivation (refer Batley et al. 2005). The lower SQGV (the Interim Sediment Quality Guideline Low (ISQG-Low), equivalent to the effects range low value used by Long & Morgan (1990)), represents the threshold for potential effects to occur while the upper guideline (The Interim Sediment Quality Guideline High (ISQG-High) equivalent to the effect range median of Long & Morgan (1990)) represents a point where a high probability of effects is possible.

The ISQG values were reviewed by Simpson et al. (2013) and with the exception of PAHs and TBT, remain unchanged for the revised ANZECC (2000) ISQG-Low and ISQG-High values for the parameters identified in Table 9.



LEGEND

- Core sediment sample locations
- Surface sediment sample locations
- Parcel boundary

NOTES

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0 50 100 METRES

REFERENCE SCALE: 1:2,500 (at A3)

PROJECTION: NZGD 2000 New Zealand Transverse Mercator

CLIENT
PANUKU DEVELOPMENT AUCKLAND

PROJECT
AMERICAS CUP 36 ENVIRONMENTAL WORK

TITLE
SEDIMENT SAMPLING LOCATIONS – HALSEY BASIN

CONSULTANT
Golder Associates

YYYY-MM-DD	2018-01-11
PREPARED	RK
CHECKED	KC
REVIEWED	ED
APPROVED	PK

PROJECT NO.	REPORT	REV.	FIGURE
1790454	001	0	12

LEGEND

- Sediment sampling locations
- Dredging Areas
- Parcel boundary

NOTES

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0 20 40 METRES

REFERENCE SCALE: 1:1,000 (at A3)

PROJECTION: NZGD 2000 New Zealand Transverse Mercator

CLIENT
PANUKU DEVELOPMENT AUCKLAND

PROJECT
AMERICAS CUP 36 ENVIRONMENTAL WORK

TITLE
SEDIMENT SAMPLING LOCATIONS – WESTERN RECLAMATION

CONSULTANT: Golder Associates

YYYY-MM-DD	2018-01-11
PREPARED	RK
CHECKED	KC
REVIEWED	ED
APPROVED	PK

PROJECT NO.	REPORT	REV.	FIGURE
1790454	001	0	13

Table 9: Sediment quality guidelines.

Parameter	Revised ANZECC (2000)*	
	SQGV[A]	SQG-High[B]
Arsenic	20	70
Cadmium	1.5	10
Chromium	80	370
Copper	65	270
Lead	50	220
Mercury	0.15	1.0
Nickel	21	52
Zinc	200	410
TPH	280	550
Organic compounds (µg/kg dry weight, 1 % TOC)		
Total PAH c	10,000	50,000
Total PCB	34	280
DDT	1.2	5
Tributyl tin (µg Sn/kg)	9	70

Notes: All units mg/kg dry weight (dw); *Simpson et al. (2013); [A] Sediment quality guideline values; and [B] Sediment quality guidelines – High value. c Normalised to 1% TOC within the limits of 0.2 to 10 % TOC. Thus if a sediment has (i) 2% OC, the '1% normalised' concentration would be the measured concentration divided by 2, (ii) 0.5% OC, then the 1% normalised value is the measured value divided by 0.5, (iii) 0.15% OC, then the 1% normalised value is the measured value divided by the lower limit of 0.2.

Simpson et al. (2013) adjusted the naming of the guidance values to SQGV and SQG-High. Simpson et al. (2013) also provided a SQGV for TPH. In relation to the PAH and TPH guideline values:

- The revised SQGV and SQG-High values for total PAHs (sum of PAHs) described in Simpson et al. (2013) include the 18 parent PAHs: naphthalene, acenaphthylene, acenaphthene, fluorene, anthracene, phenanthrene, fluoranthene, pyrene, benzo[a]anthracene, chrysene, benzo(a)pyrene, perylene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(e)pyrene, benzo(ghi)perylene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. The total PAH concentrations determined for this work (adjusted to 1 % TOC) are compared directly with the guidelines.

- Toxicity studies of hydrocarbons in sediments have identified a range of concentrations at which chronic and other effects might be elicited in benthic fauna. Generally, TPH concentrations are reported in bands typically reported as C6-C9, C10-C14, C15-C28, C29-C36 and C37-C44 TPH. Simpson et al. (2013) recommended SQGV of 280 mg/kg and a SQG-High of 550 mg/kg across all the TPH bands to be included in the revised ANZECC (2000) guidelines.

In assessing the potential effects of sediment disturbance as part of this assessment, the guidelines are utilised as first level screening tool. The concentrations measured (e.g., for trace element, extracted using a strong acid), are compared to the SQGV and concentrations measured below the SQGV are considered low risk. As concentrations approach the SQG-High, there is a higher probability of effects occurring. As described in Simpson et al. (2013) and ANZECC (2000), the identification of concentrations above the SQGV initiates a hierarchical assessment process to determine if effects are present.

4.4 Sediment Physical Characteristics

4.4.1 Introduction

The surface sediments of the Waitemata Harbour have been previously described by Gregory & Thompson (1973) and Gregory et al. (1994). Figure 5 shows a section of the mid-Waitemata Harbour adjacent to the outer Viaduct Basin from the sediment map prepared by Gregory et al. (1994). Overall, the sediments within the basins (between the wharfs) that are located in and around the Port of Auckland, including those in the Viaduct Basin, are predominantly sandy muds (with varying amounts of shell material). As water depth increases out into the harbour and the tidal currents are faster, the seabed become dominated by muddy sands with more coarse material (shell-gravel), whereas the centre of the channel is dominated by a greater shell-gravel component. This reflects the nature of water movement patterns, tidal currents and deposition zones typical of harbour basins.

4.4.2 Viaduct Basin

Table 10 provides a summary of sediment textural data for samples collected within the area between Wynyard Wharf and Princes Wharf, including the Viaduct Harbour Basin. The laboratory results for these tests are presented in Appendix C, while Appendix D provides a record of sediment core information by location.

Table 10: Sediment textures for samples collected from the outer Viaduct Basin and Wynyard Wharf area (all data % dry wt.).

Location	Sample type	Year	Samples	Gravel	Sand	Mud (silt + clay)
Western Viaduct Wharf	surface	2017	5	0.0	24.2 ± 6.2	75.7 ± 6.2
	cores	2017	6	0.1 ± 0.1	32.8 ± 8.9	67.2 ± 5.5
Viaduct Harbour	surface	2017	3	0.0	8.3 ± 0.9	91.7 ± 0.9
	cores	2017	3	0.2 ± 0.2	26.3 ± 0.6	73.5 ± 0.5
North Wharf	cores	2017	3	2.3 ± 0.8	43.0 ± 8.6	54.0 ± 10.3
Wynyard-Halsey Wharf	cores	2017	3	0.1 ± 0.1	30.9 ± 8.9	69.0 ± 8.9
Comparative data						
Outer Viaduct*	cores	1996	3	<0.1	25.6 ± 11.4	74.4 ± 11.5
Outer Viaduct Basin**	cores	1989	3	0.6	32.9	85.1
Wynyard Wharf***	cores	2011	3	5.0 ± 8.5	16.7 ± 7.0	78.3 ± 7.2

Notes: * ** Bioresearches (1989), *** - Golder (2011).

The surface sediments from the Wynyard Basin (beyond Western Viaduct Wharf) contained an average of 76 % mud with little or no gravel sized material. Samples collected in the same area by Kingett Mitchell (1996) had a similar percentage of mud. The surface samples from both outside and inside the Outer Viaduct Harbour had higher mud % than cores from the same locations implying that the at-depth material is somewhat sandier or the surface sediment contains more silt and clay due to a number of factors (e.g., disturbance and settling). The higher average mud % in the surface sediments within the basin compared to outside the basin may also reflect the calmer conditions within the sheltered basin.

Sediments collected from adjacent to North Wharf comprised of a higher proportion of sand than other locations, while those samples collected further out from North Wharf (the WW samples, refer Figure 10) had mud % similar to the outer Viaduct core samples.

Additional analysis of six sediment samples (HWC-4 to HWC-9) collected from the area of the Outer Viaduct Basin, immediately north of the Western Viaduct Wharf showed that:

- The samples had a median diameter (the Dv(50)) of 14.5 µm (range 13.4 to 20.3 µm).
- The fine sediment fractions were comprised of 21.7 ± 1.2 % clay and 56.7 ± 2.0 % silt (78.4 % silt + clay).
- The sand component (21.6 ± 3.0 %) was comprised of 14.1 ± 1.6 % very fine sand, 6.7 ± 1.9 % fine sand and no coarse sand.

The clay and silt proportions are similar to that reported for five sediment samples for the Port in POAL (1989) which contained on average 36 % clay and 32 % silt (68 % silt + clay).

4.4.3 FFIRF area

Table 11 summarises sediment textural data for the four areas sampled adjacent to the Western Reclamation in Westhaven (Figure 11). Samples contained little material over 2 mm in size and across all samples close to 50 % silt + clay and 50 % clay. Overall, the FFIRF area sediments were sandier than those in the outer Viaduct Basin.

Table 11: Sediment textures for core samples collected from the FFIRF area in December 2017 (all data % dry wt).

	Samples	Gravel	Sand	Mud (silt + clay)
South area	3	<0.1 – 0.5	48.0 ± 7.3	51.7 ± 7.6
South-mid	3	<0.1 – 0.7	53.5 ± 10.9	46.3 ± 11.3
North mid	3	<0.1 – 0.25	46.3 ± 4.3	53.7 ± 4.2
North area	3	<0.1 – <0.1	52.6 ± 2.8	47.4 ± 2.8
All samples	12	<0.1 - 0.7	50.1 ± 6.8	49.3 ± 6.5

4.4.4 Man-made objects

The sediment cores contained little coarse material. The presence of man-made material in sediment samples provides information about the potential sources of contaminants. Examination of the >2 mm fractions of the samples was undertaken following the textural characterisation. This assists in determining whether there are any gross factors that may explain unusual contaminant results.

Most samples contain no coarse material or minor amounts of degraded terrestrial organic matter. Samples NWC1 and NWC3 were the only two samples from the Viaduct Basin that contained moderate amounts of coarse material. In sample C1, this comprised pieces of organic matter, small gravel and some mussel shell fragments. Sample C3 contained a small amount of organic matter but consisted mainly of small gravel including sandstone and possibly burnt material/clinker and a single small green tinged unidentified fragment. Overall, the samples did not contain any material >2 mm in size that would reflect significant extraneous sources of material.

In the Kingett Mitchell (1996) sampling, one sample in the outer Basin (4A in Figure 9)) contained unusual coarse matter - charcoal, while the Inner Viaduct (Halsey Basin) (sample 1C) contained paint fragments and charcoal. Other samples did contain 'natural' materials such as shell and sandstone fragments, wood and bark fragments (noting that logs used to be stored adjacent to the inner basin). Inside the Viaduct Basin, the sediment at that time was found to contain man-made materials such as paint, fibreglass, coal / clinker as well as fish vertebrate and gravel aggregate.

4.4.5 Overview

Overall, both the surface and deeper sediments within the Viaduct Basin, in areas where dredging and construction works are proposed, are dominated by mud with lesser proportions of clay and fine sand. The sediments close to North Wharf contained more coarse material presumably because of the proximity of storm water outfalls and or due to other historic activities. FFIRF sediments were sandier than those within the Viaduct basin. The sediments sampled did not contain identifiable man-made materials in the coarse (>2 mm) fraction.

4.5 Sediment Quality

4.5.1 Introduction

Sediment samples were examined upon collection in the field. No cores contained marked redox discontinuities or textural layering. Colours were also relatively similar in many cores with the primary Munsell colours being dark greenish grey (7.5 Y 4/1 and 5G 4/1). Only one core (site WHC04 in the FFIRA) contained a small area of distinctly black sediment (10BG2/1, bluish black), which was odourless.

4.5.2 Viaduct Basin

The various analytical results for sediment cores collected from the four areas (refer Figure 9) within the Viaduct Basin are summarised in Tables 12 to 20. The results obtained are summarised below.

- Table 12 shows that the total organic carbon (TOC) concentrations in sediment from the open water surface and core samples were relatively similar and related to the % mud. Figure 14 shows that the three samples collected from adjacent to North Wharf contain more TOC than expected based on their mud %. The linear relationship arises as the bulk of the organic carbon (=organic matter) present is associated with the particle surfaces, so the more silt and clay, the greater the TOC within a general range. The North Wharf samples are likely to contain additional particulate organic matter, relative to the other sites, most probably due to input from the adjacent storm water outfalls. Overall, the TOC concentrations are similar to muddy sediments sampled from basins within the Port of Auckland. The sediments do not contain significant organic carbon.

- Table 13 provides a summary of trace element concentration from the four sites sampled. Within the table, the individual and location average concentrations have been compared with sediment quality guidelines (as described in Section 4.3). Those results (either individual results or site average concentrations) that are higher than the SQGV or SQG-High are indicated by highlighter.

- Concentrations of arsenic, chromium and nickel were generally consistent and fell within relatively narrow ranges (Table 13). Concentrations were similar between surface and core samples in the inner and outer Viaduct Harbour. Concentrations of chromium in the outer Viaduct Basin (north of Western Viaduct Wharf) were similar to those measured in 2003 (Table 13). Concentrations of all three elements in all samples collected were lower than the ANZECC (2000) SQGV.

Table 12: TOC in sediments.

Location	Sample type	Year	Samples	Concentration
Western Viaduct Wharf	Cores	2017	6	1.19 ± 0.04
	Surface	2017	6	1.21 ± 0.12
Viaduct Harbour	Cores	2017	3	1.28 ± 0.08
	Surface	2017	3	1.49 ± 0.05
North Wharf	Cores	2017	3	1.71 ± 0.25
Wynyard-Halsey Basin	Cores	2017	3	1.50 ± 0.28
FFIRF area	Cores	2017	12	0.98 ± 0.17
Comparative data				
Wynyard Wharf*	Cores	2016	1	1.59

Notes: all data wt % dry weight. * Golder (2011).

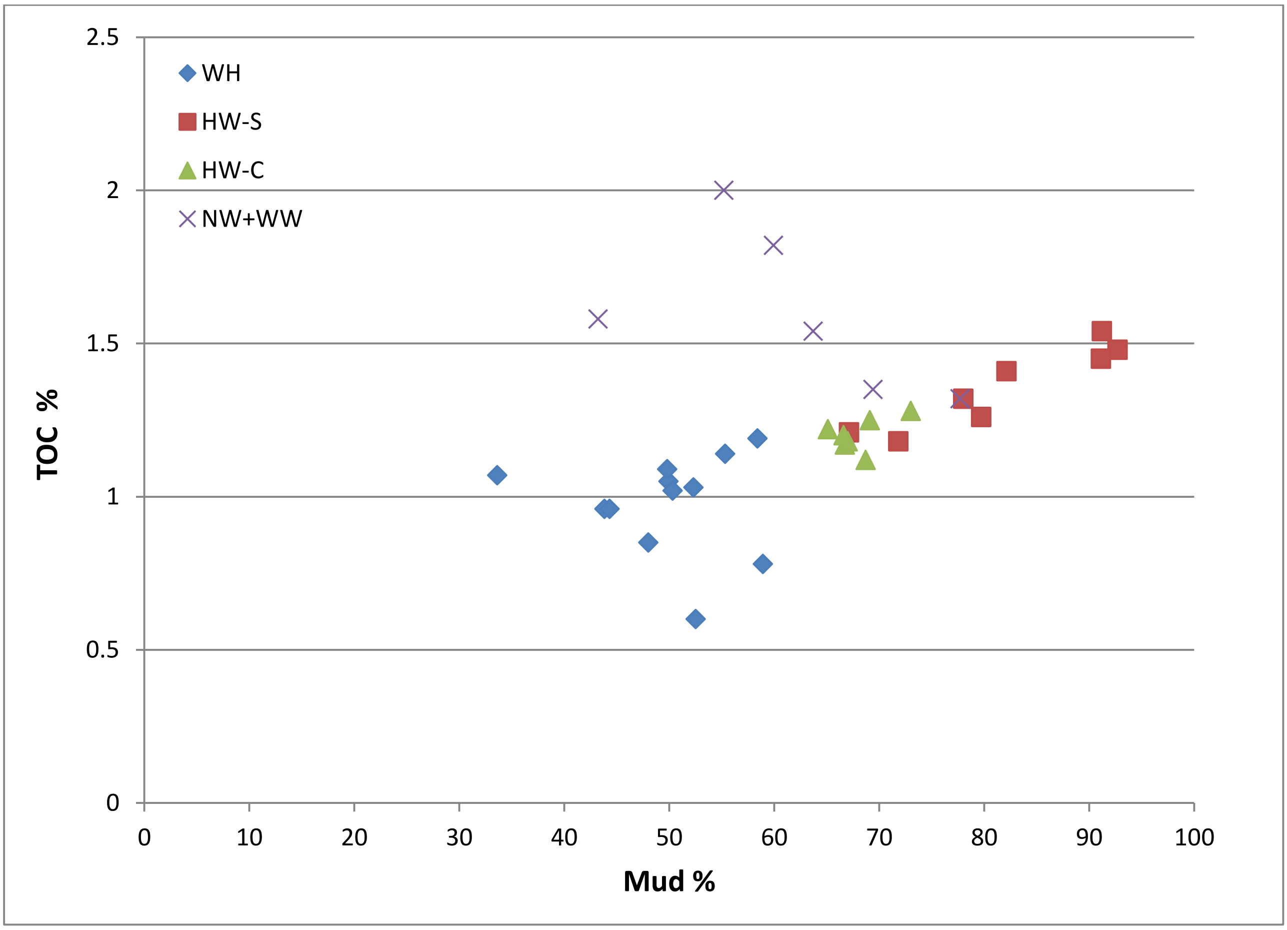

Figure 14: Mud and TOC relationship in Viaduct and FFIRF sediment samples (HW = Halsey Wharf, NW = North Wharf, WH=FFIRF).

Table 13: Trace elements in sediments (all data mg/kg dry weight).

Element	Wynyard Basin (north of Western Viaduct Wharf) (sample code HW)		Outer Viaduct Harbour (HW		North Wharf (NW)	Wynyard Halsey Basin (WW)	FFIRF area (WH)	ANZECC (2000)	
	Surface	Cores	Surface	Cores	Cores	Cores	Cores	**SQGV**	**SQG-High**
Samples	9	6	3	3	3	3	12		
Arsenic	-	7.4 ± 0.7 (6.8-8.4)	-	7.0 ± 0.1 (6.9-7)	12.9 ± 2.3 (11.2-15.5)	9.1 ± 1.3 (8.3-10.6)	8.1 ± 0.9 (7.1-9.9)	20	70
Cadmium	-	0.064 ± 0.018 (0.041-0.098)	-	0.066 ± 0.018 (0.051-0.085)	0.208 ± 0.076 (0.139-0.29)	0.114 ± 0.088 (0.037-0.21)	0.063 ± 0.019 (0.035-0.113)	1.5	10
Chromium	-	25 ± 1 (24-27)	-	27 ± 0 (27-27)	28 ± 4 (23-31)	27 ± 1.5 (25-28)	19.8 ± 2.7 (14.8-23)	80	370
Copper	16.0 ± 1.6 (13.4-18.5)	21.2 ± 2 (18-24)	28 ± 1 (27-29)	27 ± 2 (25-29)	61 ± 5 **(**57-**67)**	32 ± 14 (21-48)	33.4 ± 28.5 (9-**116**)	65	270
Lead	23 ± 1.1 (22-25)	30 ± 3 (27-33)	28 ± 1 (28-29)	36 ± 4 (31-39)	**201 ± 117 (103-330)**	50 ± 28 **(**26-**80)**	38 ± 13 (16.4-**67**)	50	220
Mercury	-	**0.19 ± 0.03 (0.16-0.24)**	-	**0.20 ± 0.03 (0.17-0.23)**	**0.28 ± 0.02 (0.26-0.29)**	**0.28 ± 0.05 (0.23-0.32)**	**0.39 ± 0.17 (0.21-0.69)**	0.15	1
Nickel	-	9.1 ± 0.3 (8.8-9.6)	-	9.9 ± 0.2 (9.7-10)	16.9 ± 0.7 (16.3-17.7)	11.9 ± 2.5 (10-14.8)	8.95 ± 1.2 (6.6-10.8)	21	52
Zinc	88 ± 3.2 (85-95)	104 ± 6.2 (96-110)	117 ± 7 (111-124)	119 ± 3.8 (115-122)	**227 ± 21 (210-250)**	138 ± 43 (100-184)	96 ± 30 (42-150)	200	410

Notes: Bold numerals indicate sample exceedance of SQGV, orange shading indicates location mean exceeds SQGV, red numeral indicates sample exceedance of SQG-High.

- Cadmium concentrations were similar between surface and core samples in the outer Viaduct Basin and the inner Viaduct Basin with all concentrations <0.10 mg/kg. Higher concentrations were measured in 4 out of 6 samples collected out from North Wharf (NW and WW samples). The concentrations in the four samples ranged from 0.139 to 0.29 mg/kg. All concentrations were all lower than the ANZECC (2000) SQGV.
- Copper, lead and zinc concentrations in samples collected north of the Halsey extension and in the Halsey Basin were consistent across sites and below the ANZECC (2000) SQGV. Concentrations measured in all North Wharf sediment samples were higher than those measured in the Wynyard samples located further out from North Wharf (Table 13) and 2/3 of these were similar to those samples collected off the Western Viaduct Wharf. The higher concentration in the North Wharf samples is most likely to be a result of storm water inputs in this area. Concentrations were also lower in surface sediments compared to cores, possibly reflecting the continued decline in lead concentrations in the environment post removal of lead from petrol.
- Copper concentrations were all (bar a single sample) lower than the SQGV, with the exception of one sample.
- Lead concentrations were lower than the SQGV in all sites except the North Wharf and Wynyard samples. In the Wynyard samples, only one out of three samples was above the SQGV. In the North Wharf samples, the location average was over the SQGV and one sample was above the SQG-High.
- Mercury concentrations in sediments from the outer Viaduct Basin were low (average 0.2 mg/kg) across sites sampled (Table 13) when compared to fine sediments sampled in parts of the lower Waitemata Harbour. Sediment samples from both North Wharf and off North Wharf in the Wynyard Basin had higher mercury concentrations with all samples exceeding the SQGV but not the SQG-High limits (Table 13). Median concentration measured in the Wynyard Basin by Kingett Mitchell (2003) was 0.48 mg/kg.
- Zinc concentrations in the North Wharf samples exceeded the SQGV but not the SQG-High. All other zinc concentrations at all other sampled sites were below the SQGV.
- TPH concentrations are summarised in Table 14. No TPH were detected in the surface sediment samples from the Wynyard Basin or outer Viaduct Basin. TPH was detected in the samples taken at North Wharf. Historically, concentrations were typically in the 100 - 300 mg/kg range. Low concentrations have been measured in Port surveys (e.g., Golder 2011) and in the outer Viaduct Harbour in past surveys (Table 14).

Table 14: TPH in sediments (all data mg/kg dry weight).

Location	Sample type	Year	Samples	Concentration
Western Viaduct Wharf	Cores	2017	6	<110-<120
Viaduct Basin	Cores	2017	3	<100-<120
North Wharf	Cores	2017	3	133-290
Wynyard-Halsey Basin	Cores	2017	3	<110-320
FFIRF area	Cores	2017	12	<90-184
Comparative data				
Wynyard Wharf*	Cores	2011	3	<100-<300
Outer Viaduct Basin**	Cores	1989	4	147 ± 29
SQGV/SQG-High	-	-		130/550

Notes: * - Golder (2011), ** Bioresearches (1989).

- A total of 18 individual PAHs were included in the analysis of sediments collected from the four areas in 2017. Table 15 provides a summary of the total summed PAH concentrations for the five sample areas. Table 15 also presents the TOC adjusted concentration (as the SQGV is based upon normalising the concentration to 1 % TOC). All concentrations in samples collected from the Wynyard Basin were below the modified SQGV (Simpson et al. 2013).

- The individual PAH concentrations and the ratio between specific compounds were examined to provide information on the potential origins of the elevated PAHs seen in the North Wharf sediment samples (i.e., whether the PAHs were sourced from pyrogenic or petroleum sources). Figure 15 shows that the ratio of PAHs in sediments within the Wynyard Basin were all very similar. The ratio of key PAH concentrations shows that the PAHs are likely of pyrogenic and mixed pyrogenic/petrogenic sources (i.e., the PAHs are probably sourced from storm water as they appear to be mainly pyrogenic). Storm water contributes PAHs from sources such as vehicle fuel combustion products, rubber tyre particles, lubricants, etc. (refer Kennedy et al. 2016). The two key PAHs seen in storm water sediments, fluoranthene and pyrene are common PAHs in urban street dust and storm water (Stogiannidis & Laane 2015).

Table 15: Total PAH in sediments (all data mg/kg dry weight).

Location	Sample type	Year	N	Concentration*	Adjusted concentration (1 % TOC)
Western Viaduct Wharf	Cores	2017	6	1.662 ± 0.406 (1.12-1.22)	1.907 ± 0.285 (0.954-1.949)
	Surface	2017	2	1.702, 1.160	1.53, 0.892
Outer Viaduct Basin	Cores	2017	3	2.008 ± 0.385 (1.638-2.406)	1.907 ± 0.285 (1.204-1.88)
	Surface	2017	1	1.286	0.863
North Wharf	Cores	2017	3	7.65 ± 3.88 (4.42-11.953)	4.574 ± 2.598 (2.87-7.565)
Wynyard-Halsey Basin	Cores	2017	3	3.479 ± 2.962 (1.418-6.873)	2.147 ± 1.434 (1.074-3.776)
FFIRF area	Cores	2017	11	4.807+ ± 1.986 (2.538-8.237) 52.369)	4.972 ± 1.786 (2.555-7.225) (**48.943**)
Comparative data					
Wynyard Wharf**	Cores	2011	1	1.996	1.25
Outer Viaduct Basin**	Cores	1989	4	0.389 ± 0.132*	-
SQGV/SQG-High	-	-			10/50

Notes: Total PAH presented as the sum of measured concentrations and half detection limits for all compounds below detection limit. * - total based on nine individual PAHs. Concentrations not adjusted to 1 % TOC. ** - Golder (2011), ** Bioresearches (1989). + mean excludes maximum value. Bold concentration greater than SQGV.

- Table 16 summarises data for PCBs in the sediments collected in the 2017 survey. There are a total of 209 different PCB congeners present in PCB formulations. One sample from the North Wharf area contained detectable congeners. The range of congeners display toxicity that relates to their structure. Those of environmental significance have dioxin-like toxicity (these congeners have no more than one chlorine atom at the ortho-position (polychlorinated non-ortho and mono-ortho biphenyls)). There are 12 key congeners that fall into the dioxin-like toxicity group, although there are a range of other congeners that do not display this dioxin-like toxicity (Berg et al. 2006). The total PCB congener concentrations in all samples from the Viaduct Basin area were below the SQGV (Table 16). Table 17 summarises the detected congeners in the composite samples. Seven congeners made up most of the concentrations detected. Of these, only one (PCB 118) was in the group of 12 dioxin related congeners. Low concentrations of PCBs are often measured in estuarine and coastal sediments, often as a result of urban storm water run-off (ARC 1992).

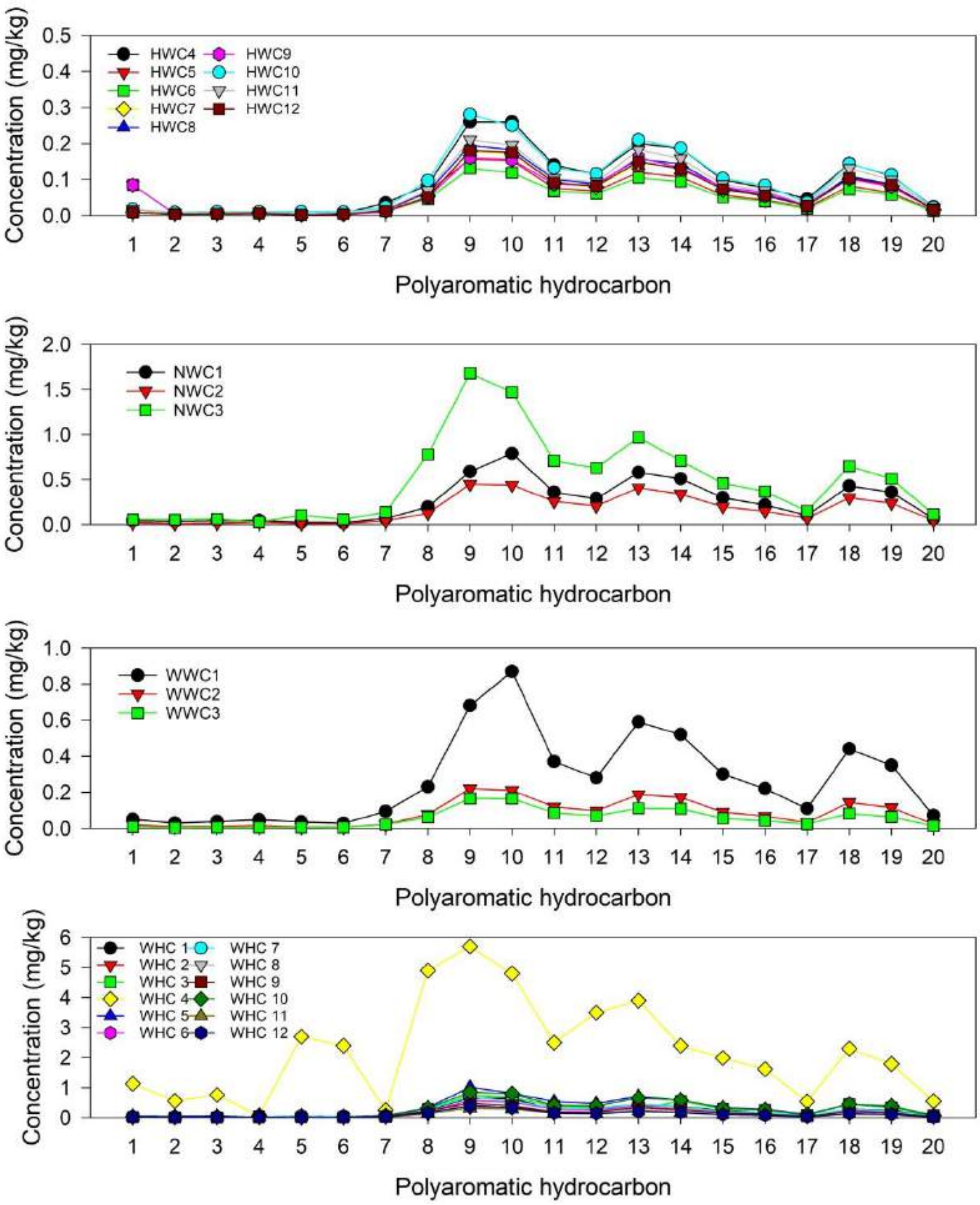

Figure 15: Comparison of PAH data between locations (note difference scale bar between graphs).

Key for the PAHs in Figure 14.

1	Naphthalene	11	Benzo[a]anthracene
2	1-Methylnaphthalene	12	Chrysene
3	2-Methylnaphthalene	13	Benzo[b]fluoranthene + Benzo[j]fluoranthene
4	Acenaphthylene	14	Benzo[a]pyrene (BAP)
5	Acenaphthene	15	Benzo[e]pyrene
6	Fluorene	16	Benzo[k]fluoranthene
7	Anthracene	17	Perylene
8	Phenanthrene	18	Indeno(1,2,3-c,d)pyrene
9	Fluoranthene	19	Benzo[g,h,i]perylene
10	Pyrene	20	Dibenzo[a,h]anthracene

- A range of persistent organochlorine pesticide (OCP) compounds were measured in sediments. These included the historical insecticide DDT (1,1,1-trichloro-2,2,bis[p-chlorophenyl]ethane) and its metabolites and dieldrin and chlordane. Table 18 summarises data for total DDT in the sediments collected in the 2017 survey and previously in earlier sediment quality studies. DDT concentrations were <0.006 mg/kg in surface and core sediment samples from the outer Viaduct Basin, Viaduct Basin and North Wharf cores. Low concentrations of 4,4 isomers of DDD, DDE and DDT were detected in the Outer Viaduct Basin surface samples (up to 0.0022 mg/kg). Dieldrin and chlordane were not detected (<0.001 mg/kg and <0.002 mg/kg respectively) in the 2017 samples from Viaduct Harbour and the outer Viaduct Basin
- Table 19 summarises concentrations of total TBT in sampled sediments. Appendix C contains all laboratory reports that provide the analytical data for the individual TBT compounds mono, di and tri-butyl tin plus tri-phenyl tin. In surface samples and core samples from both the outer Viaduct Basin and the Inner Viaduct Harbour, TBT was below detection limits in seven out of the nine samples, while the other two samples were below the SQGV (Table 19). In the six core samples from North Wharf and from between Wynyard and Halsey Wharf, TBT concentrations were higher compared to the Viaduct Harbour, although only one sample was above the SQGV. In the North Wharf samples, all three samples were over the SQGV and one sample contained a TBT concentration above the SQG-High (Table 19).

Table 16: Total PCBs in sediments (all data mg/kg dry weight).

Location	Sample type	Year	Samples	Concentration
Western Viaduct Wharf	Cores	2017	2	<0.04*
	Surface	2017	2	<0.04
Viaduct Basin	Cores	2017	1	<0.04
	Surface	2017	1	<0.04
North Wharf	Cores	2017	1	<0.04
Wynyard-Halsey Wharf	Cores	2017	1	<0.04
FFIRF area	Cores	2017	4	<0.04 and 0.09 (composite 4/5/6)
Comparative data				
Wynyard Wharf*	Cores	2011	3	<0.04
Outer Viaduct Basin**	Cores	1989	4	0.017 ± 0.004
SQGV/SQG-High	-	-		0.034/0.280

Notes: Total PCB presented as the sum of measured concentrations and half detection limits for all compounds below detection limit. * Individual congener detection limit <0.001 mg/kg. *Golder (2011), ** Bioresearches (1989).

Table 17: PCB congeners in samples with detectable PCBs (all data mg/kg dry weight).

PCB IUPAC No		NW	WH2	WH3	WH4
PCB-44	2,2',3,5'-Tetrachlorobiphenyl		0.0022		
PCB-49	2,2',4,5'-Tetrachlorobiphenyl		0.0018		
PCB-52	2,2',5,5'-Tetrachlorobiphenyl		0.0038		0.0017
PCB-101	2,2',4,5,5'-Pentachlorobiphenyl		0.0111	0.0029	0.0037
PCB-105	2,3,3',4,4'-Pentachlorobiphenyl		0.0026		0.0012
PCB-110	2,3,3',4',6-Pentachlorobiphenyl	0.0014	0.0088	0.002	0.003
PCB-118	2,3',4,4',5-Pentachlorobiphenyl	0.0012	0.0076	0.002	0.0028
PCB-128	2,2',3,3',4,4'-Hexachlorobiphenyl		0.0022		
PCB-138	2,2',3,4,4',5'-Hexachlorobiphenyl	0.0024	0.0124	0.0033	0.0028

PCB IUPAC No		NW	WH2	WH3	WH4
PCB-141	2,2',3,4,5,5'-Hexachlorobiphenyl		0.0022		
PCB-149	2,2',3,4',5',6-Hexachlorobiphenyl	0.0019	0.0078	0.0022	0.0016
PCB-151	2,2',3,5,5',6-Hexachlorobiphenyl		0.0022		
PCB-153	2,2',4,4',5,5'-Hexachlorobiphenyl	0.0021	0.0093	0.0028	0.002
PCB-156	2,3,3',4,4',5-Hexachlorobiphenyl		0.0015		
PCB-170	2,2',3,3',4,4',5-Heptachlorobiphenyl		0.0034	0.0011	
PCB-180	2,2',3,4,4',5,5'-Heptachlorobiphenyl	0.0013	0.0049	0.0014	
PCB-194	2,2',3,3',4,4',5,5'-Octachlorobiphenyl		0.0011		

Notes: All congeners sit within homologue groups tetra (congeners 40 to 81) through to octa (congeners 194 to 205) coloured to highlight homologue groups. Yellow highlighted PCBs are those that belong to the 12 key dioxin like congeners.

Table 18: Total DDT in sediments (all data mg/kg dry weight).

Location	Sample type	Year	Samples	Concentration
Outer Halsey Wharf	Cores	2017	2	<0.006
	Surface	2017	2	<0.006
Inner Halsey Wharf basin	Cores	2017	1	<0.006
	Surface	2017	1	<0.006
North Wharf	Cores	2017	1	<0.006
Wynyard-Halsey Wharf	Cores	2017	1	<0.006
FFIRF area	Cores	2017	4	<0.006-0.016
Comparative data				
Wynyard Wharf*	Cores	2011	3	<0.003
Outer Viaduct Basin**	Cores	1989	4	0.017 ± 0.004
SQGV/SQG-High	-	-		0.034/0.280

Notes: Total DDT presented as the sum of measured concentrations and half detection limits for all compounds below detection limit Golder (2011), ** Bioresearches (1989). DDT = .1,1,1-trichloro-2,2,bis[p-chlorophenyl]ethane.

- At North Wharf, TBT comprised the largest part of the organo-tin compounds. The amount of DBT present varied but ranged from 7 % to 55 % of the combined DBT and TBT. This ratio of degradation product to original TBT suggests variable ages of TBT addition. Given that the NW and WW samples are cores, it is likely that the cores contain a range of DBT and TBT concentrations depending upon the time of the addition and sediment depth. TBT has a half-life of ~ 2.5-3.5 years in sediments (Batley 1995, de Mora et al. 1996). TBT was banned for use within New Zealand, with the full ban taking effect in 1993, however, this ban did not cover its use on foreign vessels arriving in New Zealand (Smith1996).
- Analytical results for the three antifouling co-biocides are provided in Appendix D. Co-biocides are broad spectrum herbicides present in most antifoulant paints. The three cobiocides were not detected in surface sediments from the four locations (HW outer and HW inner basin, NW and WW) where samples were analysed (<0.01 mg/kg). The co-biocides have not been measured in sediments previously in the Viaduct or in Port sediments.

Table 19: Tri-butyl tin (as Sn) in sediments (all data mg/kg dry weight).

Location	Sample type	Year	Samples	TBT
Western Viaduct Wharf	Cores	2017	3	0.003-<0.004
	surface	2017	2	<0.004
Viaduct Basin	Cores	2017	3	<0.004-0.007
	surface	2017	1	<0.004
North Wharf	Cores	2017	3	**0.037**, **0.010**, 0.290
Wynyard-Halsey Wharf	Cores	2017	3	**0.022**, 0.005**,** <0.004
FFIRF area	Cores	2017	12	**0.025** ± 0.016 (<0.004-0.046) excluding 0.190, 0.400; mean of all data 0.069.
Comparative data				
Wynyard Wharf	Cores	2011	3	<0.003
Outer Viaduct Basin	Cores	1989	4	0.006-**0.038**
SQGV/SQV-High				0.009/0.070

Notes: * - composite of samples HW-S4/5/6; ** - composites of samples HW-S7/8/9; + TBT mean derived from half detection limits and concentrations over detection limit.

4.5.3 FFIRF area

Sediment quality information for the 12 locations sampled in the area of Westhaven potentially occupied by the FFIRA is summarised in Tables 12 -19.

- Concentrations of TOC in sediments from the FFIRF area were lower (concentrations typically <1 %) than all other locations (Figure 13). The difference is considered to be a result of the higher proportion of sand in the sediments in this location.
- Arsenic, chromium and nickel concentrations fell within relatively narrow ranges (Table 12). Concentrations of all three elements were lower than the ANZECC (2000) SQGV.
- Cadmium concentrations were <0.1 mg/kg with the exception of sample WH10 (0.113 mg/kg). Concentrations were all lower than the ANZECC (2000) SQGV.
- Copper concentrations were variable ranging from 9 to 116 mg/kg. One sample (WH4) had a concentration higher than the SQGV.
- Lead concentrations ranged from 16.4 to 67 mg/kg with two samples exceeding the SQGV (WH4 and WH5).
- Mercury concentrations in sediments from the FFIRF area were elevated (0.21 – 0.69 mg/kg) when compared to the results from the Viaduct Basin (Table 12). All results exceeded the SQGV but none exceeded the SQG-High.
- Zinc concentrations ranged from 42 mg/kg to 150 mg/kg. All results were below the SQGV.
- TPH was detected at one site, WH10, but was below the proposed upper guidance value set out by Simpson et al. (2013).
- PAH concentrations were measured at all WH sites with the average concentration similar to that measured in the North Wharf samples. One of the 12 sites (WH4) had a total PAH concentration of 52.369 mg/kg which, when adjusted to 1 % TOC, was 48.943 mg/kg (Table 17). This was the only

concentration over the SQGV but was below the SQG-High. Sample WH4 was the only location within the FFIRF area where a core contained noticeable black discoloration in a localised area of subsurface core. The PAH profile differed to all other samples examined with elevated concentrations of acenaphthene and fluoranthene. The higher concentrations are likely to suggest a petrogenic source in this area of sediment.

- The OCPs dieldrin and chlordane were not detected (<0.001 mg/kg and <0.002 mg/kg, respectively) in the samples from the FFIRF area. DDT was detected at low concentrations (below the SQGV) in three of four composite samples (Table 18). Total PCB concentrations were lower than the SQGV (Table 19).
- Table 19 summarises concentrations of total TBT measured in sediments from the FFIRF area. Appendix C contains the laboratory reports that provide the analytical data for the individual TBT compounds. The average TBT concentration for 10 of the 12 site exceeded the SQGV. Two samples were measured above the SQG-High (WH4 and WH5).
- The three antifoulant cobiocides were not detected in surface sediment composites from the FFIRF area.

4.6 Overview

Overall, the sediments sampled from the four areas did not display any unusual physical characteristics. No excessive organic matter (as determined by TOC) was measured in any of the samples collected.

The comparison of sediment quality results with the ANZECC (2000) / Simpson et al. (2013) modified SQGVs identified a limited number of samples where SQGVs were exceeded (Table 20). In Table 20, if any individual sample concentrations exceed the SQGV they are identified with a bold black x (and if more than three the number is identified). If a value exceeds the SQG-H the x is in identified red. If the mean of the location data exceeds the SQGV the cell is highlighted yellow. No mean concentration for any location exceed the SQG-H.

Table 20: Summary of contaminant concentrations in key AC36 areas and comparison with ANZECC sediment quality guidelines (updated from Simpson et al. 2013).

Contaminant\ sampling area	HWC4-9 and 10-12	NW	WW	FFIRF	ANZECC (2000) guideline	
					SQGV	SQG-High
Samples	6,3	3	3	12		
Arsenic					20	70
Cadmium					1.5	10
Chromium					80	370
Copper		**x**		**x**	65	270
Lead		**xx x**	**x**	**xx**	50	220
Mercury	**6x** and **xxx**	**xxx**	**xxx**	**12x**	0.15	1
Nickel					21	52
Zinc		**xxx**			200	410
Total PAHs				**x**	10	50
Total PCBs					34	280-
TBT		**xx x**	**x**	**8x xx**	9	70

Notes: Bold x indicates a sample exceeds the SQGV. Yellow shading equates to the mean site concentration exceeding the SQGV. Red x indicates a sample exceeds the SQG-H, red. HW surface sample data for Cu, Pb, Zn not shown as data was all lower than SQGV.

For PAHs in samples from the FFIRF area, sample WHC-4 contained a total concentration above the SQG-H but when adjusted for the TOC concentration the total adjusted concentration was below the SQG-H concentration. Mean values exceed the SQGV the cells are highlighted yellow.

5.0 WATER QUALITY

5.1 Historical Information

Historical water quality data within the immediate vicinity of the AC36 project area is very limited. In 1989, Bioresearches (1989) undertook a one-off water quality sampling at five stations in the Viaduct Basin and four stations in the outer Viaduct Basin. Total Kjeldahl nitrogen (TKN), total and dissolved phosphorus, trace elements and faecal coliforms were measured and the mean values of these parameters are reproduced in Table 21.

Table 21: Summary of water quality information from Bioresearches (1989) (all data g/m^3).

Parameter	Inner Viaduct Basin	Outer Viaduct Basin
TKN	0.23	0.13
Total phosphorus)	0.024	0.022
Dissolved reactive phosphorus	0.0072	<0.007
Iron	0.098	0.14
Copper	0.0012	0.0013
Lead	<0.0012	<0.0015
Zinc	0.0082	0.0065

Bioresearches (1989) noted that water quality parameters were similar to those recorded at Westhaven during the same sampling period, suggesting a good exchange of water in the Viaduct Basin with the greater Harbour.

5.2 Sampling

Water quality sampling was undertaken on five occasions during November and December 2017 at two sites within the inner Viaduct Basin and two sites within the outer Viaduct Basin (Figure 16).

On each occasion, water samples were collected for measurement of turbidity, total suspended solids (TSS), major nutrients (nitrogen and phosphorus), chlorophyll-*a* and dissolved trace element concentrations. Water quality in the Inner and Outer Viaduct Basin (labelled as Halsey Basin in Figure 16) was compared to the water quality results for the Auckland Regional Council's long term monitoring site at Chelsea up-harbour from the Auckland Harbour Bridge. The Chelsea Site is the closest regional marine water quality monitoring site to the Viaduct Basin. Water quality at the Chelsea Site is regarded as being in an 'excellent' state (Williams et al. 2017).

5.3 Water Clarity

Visual clarity, as determined by Secchi depth, was measured on site at each station. Mean Secchi depth was higher at the inner Viaduct Basin sites compared to the outer Viaduct Basin sites (Table 22), meaning that water in the inner Viaduct Basin was more clear than the outer Viaduct Basin. Similarly, turbidity was lower at the inner Viaduct Basin sites compared to the outer Viaduct Basin sites, ranging from 1.5 - 3.2 NTU in the inner Viaduct Basin to 3.5 - 6.0 in the outer Viaduct Basin. Turbidity at all four sites was similar to that reported for the Chelsea site during the 2015 monitoring period (range 1.90 - 5.60; Williams et al. 2017).

Figure 16: Water quality sampling locations.

TSS ranged from <3 to 36 g/m^3 in the inner Viaduct Basin and from 8 to 36 g/m^3 in the Outer Viaduct Basin (Table 22). The mean TSS at all four sites was similar to the mean TSS reported for Chelsea during 2015 (mean 10.93 g/m^3; range 4.8 - 20.0 g/m^3; Williams et al. 2017). A substantial amount of suspended sediment concentration data has been collected during water quality monitoring activity in the port areas of the Waitemata Harbour (as part of construction and dredging activity). This information is summarised in Appendix F and Table 23. The long term port and harbour TSS concentrations were similar to those measured during the current sampling.

Table 22: Water clarity, as determined by Secchi depth, turbidity and total suspended solids at the four monitoring sites during November - December 2017 (data is mean ± standard deviation).

Station	Secchi depth (m)	Turbidity (NTU)	Total suspended solids (g/m^3)
IV1 Inner Viaduct	1.88 ± 0.01	2.0 ± 0.6	10.1 ± 14.5
IV2 Inner Viaduct	1.82 ± 0.14	2.4 ± 0.7	12.5 ± 15.7
HB1 Outer Viaduct	1.38 ± 0.28	4.3 ± 0.7	12.4 ± 12.1
OVB Wynyard Basin	1.23 ± 0.27	4.7 ± 8.0	14.4 ± 12.1

Notes: Mean and standard deviation based on five surveys.

Table 23: Summary of historical suspended solids monitoring data for the Port and Viaduct Basin area (all data mean ± standard deviation, g/m^3).

Site	Year/date	Flood tide	Ebb tide
Wynyard Wharf	2001	4.6	
Queens Wharf	2000-2001	6.9 ± 2.3	
Queens Wharf mid-eastern side		5.7 ± 2.4	5.6 ± 2.5
Queens Wharf north east side		8.2 ± 6.1	9.2 ± 5.3
Captain Cook Wharf, mid-western side		9.3 ± 6.5	6.6 ± 2.7
Captain Cook Wharf, mid-eastern side		12.3 ± 5.8	6.1 ± 3.1
Marsden Wharf		6.7 ± 3.1	6.6 ± 3.2
Bledisloe Wharf	2001		21.0 ± 7.3
Bledisloe Terminal		7.9 ± 3.4	8.5 ± 4.8
Bledisloe Wharf East	2008	8.4	9.2
Berth Jellicoe Wharf	1997-2005	7.1 ± 3.2	3.0 ± 0.6
Freyberg Wharf East	2008	7.9	8.5
Berth Freyberg Wharf	2000-2002	7.6 ± 5.4	8.8 ± 6.0
Berth Fergusson Wharf	1998-2002	4.4	
Fergusson Wharf dredging	2015 - 2017	7.1 ± 3.8	15.0 ± 13.5
Fergusson Wharf Western	2011	5.4 ± 3.3	
Port Approach Jellicoe Wharf	2005-2007	3.4 ± 2.6	11.2 ± 6.1
Port Approach Jellicoe Wharf	2005-2007	3.4 ± 2.6	11.2 ± 6.1

Overall, the results from the recent Viaduct /Wynyard Basin water quality sampling indicate that the water clarity in the Inner Viaduct Basin is slightly better than that measured in the Outer Viaduct and Wynyard Basin. Water clarity in the Wynyard Basin was similar to that recorded in the main body of the Waitemata Harbour.

5.4 Nutrients

Nitrogen

Total nitrogen (TN), comprised of both particulate and dissolved fractions, ranged from 0.152 - 0.430 g/m^3 in the inner Viaduct Basin and from 0.156 - 0.230 g/m^3 in the outer Wynyard Basin (Table 24). TN in the Viaduct/Wynyard Basin was higher than that reported for the Chelsea site during the 2015 monitoring period (range 0.005 - 0.150 g/m^3; Williams et al. 2017).

For the dissolved fractions of nitrogen, ammoniacal-N concentrations ranged from 0.009 - 0.038 g/m^3 in the inner Viaduct Basin and from 0.010 - 0.021 g/m^3 in the outer Viaduct Basin. This was similar to the range reported for the Chelsea site during the 2015 monitoring period (range 0.003 - 0.026 g/m^3; Williams et al. 2017). Nitrate concentrations ranged from 0.0043 - 0.0186 g/m^3 in the inner Viaduct Basin and from <0.001 - 0.0089 g/m^3 in the outer Viaduct Basin, while nitrite ranged from < 0.001 - 0.0015 g/m^3 in the inner Viaduct Basin but was below detection limits (<0.001) in the outer Viaduct Basin. This was similar to the range reported for the Chelsea site during the 2015 monitoring period, with nitrate ranging from 0.001 - 0.043 g/m^3 while nitrite was below detection limits (Williams et al. 2017).

Table 24: Total and dissolved nitrogen and DRP concentrations at the four monitoring sites during November - December 2017 (data is g/m^3, mean ± standard deviation).

Station	Nitrate-N	Nitrite-N	Ammoniacal-N	Total-N	DRP
IV1	0.008 ± 0.004	0.001 ± 0.000	0.016 ± 0.003	0.20 ± 0.04	0.015 ± 0.002
IV2	0.008 ± 0.006	0.001 ± 0.000	0.019 ± 0.011	0.24 ± 0.11	0.013 ± 0.004
HB1	0.004 ± 0.002	<0.001	0.020 ± 0.009	0.19 ± 0.02	0.015 ± 0.002
OVB	0.003 ± 0.002	<0.001	0.015 ± 0.003	0.19 ± 0.03	0.013 ± 0.001

Notes: mean and standard deviation based on five surveys.

Phosphorus

Dissolved reactive phosphorus (DRP) ranged from 0.006 - 0.017 g/m^3 in the inner Viaduct Basin and from 0.012 - 0.018 g/m^3 in the outer Viaduct Basin over the five sampling occasions (Table 24). DRP concentrations in the Viaduct Basin were within the range reported for the Chelsea site during the 2015 monitoring period (range 0.007 - 0.020 g/m^3 (Williams et al. 2017)).

5.5 Chlorophyll-a

Chlorophyll *a* is an approximate measure of microalgal (or phytoplankton) biomass. Chlorophyll *a* concentrations ranged from <0.001 - 0.003 g/m^3 in the Inner and Outer Viaduct Basin and from 0.001 - 0.002 g/m^3 in the Wynyard Basin, over the five sampling occasions (Table 26). Chlorophyll a concentrations were similar to those reported for the Chelsea Site during the 2015 monitoring period (ranged <0.001 - 0.002 g/m^3; Williams et al. 2017).

Table 25: Chlorophyll-a concentrations at the four monitoring sites during November - December 2017 (data is mean ± standard deviation, g/m^3.

	Chlorophyll *a*
IV1	0.0020 ± 0.0006
IV2	0.0020 ± 0.0010
HB1	0.0019 ± 0.0007
OVB	0.0020 ± 0.0009

Notes: mean and standard deviation based on five surveys.

5.6 Trace Elements

Dissolved copper, lead and zinc were measured during the November and December 2017 sampling period. For the inner Viaduct Basin, dissolved copper ranged from 0.003 - 0.005 g/m^3 and from <0.001 - 0.02 g/m^3 in the outer Viaduct Basin. Dissolved zinc ranged from 0.004 - 0.008 g/m^3 in the Inner and Outer Viaduct Basin and from <0.004 - 0.011 g/m^3 in the Wynyard Basin (Table 26). Dissolved lead was below the laboratory detection limits at all sites (Table 26). Trace elements are not routinely monitored by the Auckland Regional Council at the Chelsea site.

Table 26: Trace element concentrations measured at the four monitoring sites during November - December 2017 (data is mean ± standard deviation, g/m^3).

	Dissolved copper	Dissolved lead	Dissolved zinc
IV1	0.0036 ± 0.0008	<0.001	0.006 ± 0.003
IV2	0.0031 ± 0.0006	<0.001	0.004 ± 0.004
HB1	0.0075 ± 0.0109*	<0.001	0.003 ± 0.002
OVB	0.0010 ± 0.0008	<0.001	0.005 ± 0.005

Note: * - Includes a single value of 0.020 g/m^3. Mean and standard deviation based on five surveys.

5.7 Organic Carbon and Dissolved Oxygen

The mean dissolved organic carbon concentration was 1.7 g/m^3 at Site IV1 (inner Viaduct Harbour) and 2.0 g/m^3 at Site HB1 in the Outer Viaduct Harbour (range 1.4-2.4 g/m^3). Concentrations measured during November-December were typically low and are not considered likely to exert oxygen demand.

In mid-December a dissolved oxygen (DO) survey was carried out over five days from 18 to 22 December 2017 by Beca Ltd. The measurements were all above 6 g/m^3, with a maximum concentration of 8.4 g/m^3 (water temperature 21.1 to 22.9 ^{o}C), which was within the range recorded at Chelsea Wharf through 2015 (mean 7.4 g/m^3, range 6.46 – 8.24 g/m^3). DO percentage saturation at the outer Wynyard Basin site ranged from 87 to 96 %. The Inner Basin DO percentage saturation values were generally over 80 % except on 19 December when saturation values ranged between 70 and 74.5 %. No cause for the lower values on that day was identified.

5.8 Summary

Water quality parameters measured in both the Inner/Outer Viaduct Basin and Wynyard Basin during the November - December 2017 monitoring period was similar to that reported for the Chelsea monitoring site in the mid-Waitemata Harbour.

Based on the current short duration survey, the water quality in the Viaduct Basin is of similar “excellent” quality and reflects the quality of the water entering the Viaduct Basin on the flood tide from the at Waitemata Harbour.

6.0 ENVIRONMENTAL EFFECTS

6.1 Introduction

The key elements of the AC36 project (Beca 2018a) that are discussed within this section are:

Viaduct Basin

- The construction of a northward extension to the existing Western Viaduct Wharf extension and to Hobson Wharf which will house team bases (Figure 2).
- The construction of new wharf structures at the southern end of Wynyard Wharf which will provide a platform for team bases.
- The construction of wave reduction breakwaters to the west of Halsey Street Extension Wharf and east of Wynyard Wharf within the outer Viaduct Basin (Figure 2).
- The installation of pontoons for super yacht berths in the outer Viaduct Basin.
- Dredging to meet the needs of new berths and new facilities at three locations of the Viaduct Basin (Outer Western Viaduct Wharf, between Wynyard Wharf and Halsey Street Extension Wharf and in the Viaduct harbour on the south side of the Western Viaduct Wharf).

The operation of the proposed facilities will require a number of environmental matters to be managed. These are discussed in the following sections.

FFIRF

- The construction of a new wharf, vehicle loading ramps for a relocated ferry service along with floating pontoons to provide berths for relocated fishing vessels. The new facilities will be located on the western side of the western reclamation immediately between the Vos Slipway and Wynyard Point (Figure 3).
- Dredging to meet the needs of new facilities along shore of the western reclamation.

The operation of the proposed facilities will require a number of environmental matters to be managed. These are discussed in the following sections.

6.2 Dredging

6.2.1 Dredging requirements

The dredging and hydraulic environment in both the Viaduct and in the FFIRF areas is described in Beca (2018b). Dredging is required in three areas in the Viaduct Basin and one area in Westhaven Marina as shown in Appendix G.

Viaduct Basin (refer figure in Appendix G)

- Dredging immediately north of the entrance to the Outer Viaduct Basin to provide an entrance channel to AC36 berths in the Outer Viaduct Harbour. The area requiring dredging is a shoal of soft sediment with dredging to occur through one to two metres in depth (of sediment). The total volume of dredging is expected to amount to 30,000 m^3.
- Dredging in the Outer Viaduct Harbour (30,000 m^3).
- Dredging in the area between Wynyard Wharf and Halsey Street Extension Wharf extension (Wynyard Basin). One area abuts north wharf (5,000 m^3) and a second area occurs between Wynyard and Halsey (10,000 m^3). Dredging is expected to be 1 m in depth.

FFIRF (refer figure in Appendix G)

- Dredging associated with the FFIRF area in Westhaven Marina (10,000 m^3). Dredging is expected to be 1 m in depth.

6.2.2 Dredging methods

As described by Beca (2018b) all dredging will be carried out using barge mounted excavator. This has been the method utilised for all maintenance dredging and capital works dredging across the port and associated facilities for a number of years. As described, the methods used and equipment will be very similar if not the same as the equipment previously utilised.

Beca (2018b) describes the currents and tidal water movement within the Viaduct Basin and FFIRF area. The tidal velocities and movement will influence the dispersion of any particulate material that enters the water column during dredging.

6.2.3 Environmental issues

Table 26 provides a summary of the key environmental issues associated with dredging. These issues are discussed in the following sections. Parts of the Wynyard Basin have had dredging previously and at low tide, vessels with the basin can disturb seabed sediment creating visible sediment plumes around the point of disturbance.

Table 27: Summary of key environmental issues associated with dredging.

Water quality	Effects on benthic and pelagic ecology
Reduction in water clarity resulting from an increase in suspended solids concentrations (Section 6.4.3).	Loss of benthic habitat and changes in the physical nature of habitat (Section 6.3)
Changes to water quality resulting from the release of interstitial water during dredging and from the de-sorption of constituents on suspended particulates (Section 6.4.4).	The potential for sediment released from the area of dredging to be deposited 'downstream' and exerting physical and toxic effects on benthic biota (Section 6.4.3).
	Physical effects of sedimentation on ‘downstream’ benthic communities (Section 6.4.3).

6.3 Loss and Changes in Habitat

6.3.1 Wynyard Basin

Loss of benthic habitat

The dredging and works associated with the AC36 project will result in immediate changes in the habitat at the site of dredging. The immediate change is a loss of the existing habitat and associated biological community when sediment is excavated.

The dredging of the seabed will leave a new seabed surface relatively similar to what was there prior to dredging. It is likely that the surface sediment will be firmer that the surface of the prior seabed as the surface typically has a softer, less dense sediment (higher water content) due to relatively frequent disturbance (by vessels at low tide).

Following dredging, the process of recolonisation commences relatively quickly (depending upon the seasonal movement of biota from adjacent areas and from the larvae in the tidal waters which may settle in the area). Colonisation commences with opportunistic species that may form ‘boom’ communities due to lack of local competition but gradually the diversity increases and the bed community moves towards a typical stable community (similar to that seen in the samples collected). To reach a stable state community similar to that currently present, it will take at least several seasonal cycles but can take longer (Golder 2013).

Overall, it is likely that new open water seabed infaunal communities will continue to be dominated by a community considered to have low ecological value, consisting of introduced bivalves and polychaete species. The seabed in areas such as the Viaduct Basin is part of the overall Waitemata Harbour ecosystem and provides ecosystem services to the local area. Due to activities such as vessel movement the seabed in shallow waters is subject to disturbance which results in maintenance of the soft sediment and limited species diversity, favouring those that are disturbance tolerant.

Areas of seabed will also be lost through the installation of wharf piles and breakwater support piles in the Viaduct Basin. The area lost will be proportional to the number of piles in a given area. As described by Beca (2018a):

- Hobson Wharf extension will have 150 piles and occupy an area of 170 m^2.
- Halsey Wharf extension will have 340 piles and occupy an area of 390 m^2.
- Wynyard Wharf infill will have 40 permanent piles and occupy an area of 50 m^2. It will also have 80 temporary piles that occupy 25 m^2 of seabed.
- Breakwaters in the Wynyard Basin will have 60 piles occupying 30 m^2 of seabed.
- Pontoons will have 160 piles that occupy 50 m^2 of seabed.

In terms of EIANZ criteria to assess the nature of effects, the ecological value is considered “Low” and the magnitude of effects is considered to be “Moderate” as the existing community will be impacted in the short term but recovery of the community to the pre-disturbance level is anticipated. This identifies an overall effects rating of VERY LOW (refer Appendix B for EIANZ assessment tables).

Changes in benthic habitat

Changes in benthic habitat can potentially arise through a change in substrate composition or through change in available light.

In relation to changes in substrate, the new seabed is expected to have similar physical characteristics to the existing seabed. As such, the overall change in seabed character will be no more than minor. Where piles are installed there will be a change in habitat. The installation will create new vertical habitat which will be colonised by biota. The nature of the change will depend on the location of the new piles (on the outside of the wharf where there is more light or under the wharf). Overall, the new piles in the Wynyard Basin will result in the replacement of sediment with 715 m^2 of concrete. This area represents about 20 % of the area of new wharf decking (3,200 m^2) to be constructed.

As described in Section 5, in-water clarity in November-December can be up to 2 m. However, as light passes through the water column to the sea bed, it is considerably reduced due to absorption by the suspended sediments. The construction of new wharf structures will reduce the under-wharf environment light (in those areas) as the wharf acts as a light barrier. Under the Event Centre on the Halsey Extension Wharf, there is no light at the seabed. As such, a similar reduction in the available light is expected under the Halsey Wharf extension and Hobson Wharf extension decks and the new decks constructed on the southern section of the existing Wynyard Wharf.

The comparison of the fauna inhabiting the seabed in the outer Viaduct Basin and under the Event Centre described in Section 3.5.3 and Appendix A showed that the change in light environment appears to result in a change in community composition (with sediment type being similar). The primary characteristic that changed was species diversity with a change in the key species present. The key species in the under-wharf community were the bivalve Theora along with ostracods. The differences are considered to relate to the shading that occurs under the Event Centre (and the loss of algal communities), which provides a source of food for some species. Based on this information, it is likely that the fauna under the new deck structures in the outer Viaduct basin will change from what is typically present in the open water areas to a fauna akin to that seen under the Event Centre.

In terms of EIANZ (Environmental Institute of Australia and New Zealand) criteria to assess the nature of effects, the ecological value is considered Low and the magnitude of effects is considered to be Low as some elements of the existing community will change, but many elements will remain. This identifies an overall effects rating of VERY LOW.

Changes and creation of new intertidal habitat

A range of new intertidal structures will be constructed and installed within the Viaduct Basin. These include concrete and wooden piles and wave panels. These new structures will be colonised over time and will support vertical communities similar to those seen on the present day structures. Those current external piles will become inner piles and their vertical community will shift to that of a shaded community. These changes will affect the piled areas of the Western Viaduct wharf and the adjacent Hobson Wharf extension.

At Wynyard Wharf, there will be an increase in the number of piles but no substantive change in the existing underwharf shore. The shore will experience greater shading from the new wharf decking but given the Low value of the ecological community at this location, this is not considered significant.

The installation of floating pontoons creates some local shading. It also creates non-tidal habitat for a variety of macroalgal species and a range of fauna. The habitat is all new and should be similar to what is currently seen on floating structures in the Viaduct Basin (refer Section 3.4.5 and Appendix A). The pontoons will result in additional shading from vessels that berth. The change in light climate has not been quantified but is expected to be moderate to significant in local areas where additional berthing occurs. The additional habitat created by the pontoons in the upper water column is considered to provide some compensation.

Overall, based on EIANZ ranking, the intertidal habitat effects in the new Halsey Extension and Hobson Wharf Extension, and Wynyard Wharf areas are considered to have an overall rating of Low.

6.3.2 FFIRF area

Loss of habitat

No significant loss of habitat is expected. No loss of intertidal habitat is expected. Dredging will not result in a loss of sub-tidal habitat as seabed sediment characteristics post dredging will be similar to that present. Minor loss of benthic habitat will occur through the installation of piles for wharf structures and pontoons. The introduction of new sub-tidal and intertidal habitat (piles and pontoons) will add some local habitat diversity.

Changes in benthic/sub-tidal habitat

No significant changes in the nature of benthic habitat are expected. Dredging will result in short term changes when the new sediment surface is exposed.

Longer term changes will involve regular sediment disturbance in areas where ferry and fishing vessels berth. This disturbance is not considered significant given the values of the local ecological community.

As noted above, construction will introduce new vertical habitat (mainly wharf piles). This habitat will become colonised over time by a range of common hard substrate species already seen on existing structures.

Changes and creation of new intertidal habitat

At the FFIRF area, no significant changes to existing intertidal habitat are expected as no major construction works are proposed on the man-made intertidal shore that forms the edge of the Western Reclamation. The construction of floating pontoons and the installation of piles to support wharf structures will add intertidal and non-tidal (floating) habitat. This will increase the amount of habitat in the immediate area.

Overall, based on EIANZ ranking, the intertidal habitat effects in the FFIRF area are considered to have an overall rating of Low.

6.4 Sediment Disturbance During Construction

6.4.1 Sources of water quality changes

There are several components of construction that will result in seabed disturbance. This includes, dredging, installation of piles and the movement of construction vessels. Sediment disturbance results in:

- The suspension and transport away from the site of solids which has the potential to also transport contaminants from the site.
- The release of pore water during excavation and disturbance.
- The desorption of contaminants from sediment when suspended in the water column.

These are considered in the following sections.

6.4.2 Pile installation and construction

Beca (2018a, Section 4.2) describes the preliminary engineering design and likely construction approach. The majority of piles installed for the Viaduct Basin wharf construction will be pre-cast concrete piles. Sea facing piles are expected to be larger and rectangular to allow wave panels to be attached.

Piles will be installed into underlying ECBF materials where required. Drilling will be carried out within a casing and all sediment and siltstone/sandstone will be retrieved. The level of disturbance during placement of the casing is expected to be minor. It is proposed that the sediment and rock fragments be taken off site.

The pre-cast piles will be set into their holes with concrete. Concrete and concrete waste will be managed to minimise loss to the environment. No significant water quality issues are expected during this work.

The introduction of cement into the marine environment has the potential to raise the local seawater pH (however less so than in freshwater). Any change is, however, dependent on the area of exposed cement, and the water movement above the cement (i.e., the release rate versus the flushing effect). Some information on the effects of using cement in mudcrete in the marine environment was presented by ARST (1996). Adverse pH changes are not expected and the release of any other constituents (e.g., soluble trace elements are expected to be minor and rapidly diluted in overlying seawater.

6.4.3 Effects of off-site sediment loss from sediment disturbance

Activities in the coastal marine area such as dredging and piling will results in the disturbance of sediment and local increases in suspended particulates in the water column. This potentially can result in temporary increases in suspended solids concentrations and the deposition of sediment in areas away from the site. Piling activity results in disturbance at the seabed and disturbs relatively small areas of bed even when casings are being used. Piling is typically a single location activity that disturbs a very small area of seabed. As such, the sediment loss to water column is expected to be small and this source is not considered further.

Dredging using mechanical methods such as a back-hoe excavator will result in sediment disturbance during the excavation, some loss of sediment during the retrieval especially when open buckets are utilised, some losses from bucket movement out of the water and potentially some bed disturbance during the repositioning of the excavator platform and barge. In the Port area and marinas in the Auckland area, maintenance dredging is commonly carried out using a back-hoe excavator and barge.

Suspended solids

Monitoring of water quality during other dredging activities in the harbour has been carried out on numerous occasions. Results of past monitoring have been summarised by Priestley (1995, 1997) and in Appendix B of Beca (2001). Monitoring of local harbour dredging has shown that TSS concentration increases are relatively small with Beca (2001) reporting 5 g/m^3 at 200 m distance. It should be noted that the bed disturbance by vessels operating within the Viaduct Basin is another source of suspended solids.

The amount of TSS in suspension is dependent upon the sediment grain size characteristics (and their settling velocities), the rate of dredging and the local hydrodynamics. In the Viaduct basin, tidal currents are low and only a fraction of the tidal velocities at the edge of the main Harbour channel (e.g., at the end of princes Wharf). It should be noted that not all sediment disturbed or lost during dredging is present as single particles and as such larger materials, or clumps, will settle out of the water column close to the point of dredging. Beca (2001) also report on settling velocities of fine sediments within the port. Following re-suspension and the settlement of the larger lumps and particles, the remaining suspended sediment is carried away from the dredging site by water movement. Settling velocities are determined by Stokes Law. As described by Beca (2001) particle settlement velocities are higher in sediment clouds with high concentrations of particles. Examination of sediment settling velocities using Rangitoto Channel sediments showed that 10 % of the sediment had settling velocities of less than 0.01 cm/sec and 25 % less than 0.30 cm/sec. In 6 m of water, even the faster settling velocities will allow small suspended particles to travel a significant distance before settling.

Sediment in suspension within the Outer Basin (or FFIRF area) will be transported by tidal currents. In the Outer Viaduct harbour these will be of the order of 0.1 m/s resulting in travel distance of up to 360 m/hour. Given that the finer silts and clays will have settling times of hours, any very fine sediment moving on the ebb tide will likely leave the Viaduct Basin and potentially re-settle within the Port basins.

Overall, historical monitoring of dredging in the harbour shows that elevated TSS can occur close to the dredger but downstream (200 m away from the dredging site) concentrations are similar to those measured upstream. Water quality monitoring in December 2017 identified TSS concentrations of just under 10 g/m^3 in the outer Viaduct. These concentrations are similar to the average harbour TSS concentration of 12 g/m^3 identified in the monitoring publications identified above and 10 g/m^3 at the Council Chelsea monitoring site in 2015. Significant off-site changes in water clarity are not expected.

Marine sediment deposition

Off-site sediment movement can result in deposition. The effects of sediment deposition on the benthic fauna inhabiting the seabed in the outer parts of the outer Viaduct Basin will be dependent on:

- How much sediment is transported out of the dredging area.
- How it is dispersed.
- What the overall loading is on any particular benthic or intertidal community.
- The tolerance of the biota to smothering, should it occur.

Beca (2018b) provides an assessment of potential down-current sedimentation during dredging. Filter feeding shellfish and sedentary infauna may be affected outside of the dredging area should sedimentation occur. However, burial would need to be in the order of a few centimetres over a short time period to cause an adverse effect. The low tidal velocities in parts of the outer Basin could promote sedimentation of larger particulate material close to the dredging. However, as described in Section 3.5, the biological community present in the typically soft sediment is considered to contain species tolerant of disturbance. There does not appear to be a significant sessile particulate sensitive species present.

The species present are fairly typical of the rest of the port and are subject to both vessel and dredging disturbance. Much of any local deposition is likely to occur within the local area being dredged.

Marine sediment bound contaminants

The settlement of suspended particles off site has the potential to change the quality of off-site sediments if there is a significant difference in the concentration of contaminants between the settling and in-situ sediments. Based on the work of Beca (2001), the long-term fate of sediment transported off site is to be deposited in depositional areas such as the Port. If suspended sediment is deposited it will have little influence on the quality of sediment within the Port as any changes are a function of the deposition rate of the material from this dredging operation returning to the Port versus the rate of deposition on daily basis and the quality of the two sources.

As described in Section 4, the concentration of contaminants in the sediments to be dredged are generally below their ANZECC (2000) SQGV. Elevated concentrations of three groups of contaminants were identified. These were:

- Elevated concentrations of elements such as lead in North Wharf (NW) (including one concentration above the SQG-H) and adjacent Wynyard-Halsey sediment samples (WW), zinc in North Wharf sediments.
- Variable concentrations of TBT in North Wharf sediments including one sample above the SQG-High.
- Elevated concentrations of mercury above the SQGV in sediments from through the Wynyard Basin and FFIRF area.
- Elevated concentrations of PAHs (but below the SQGV).

As noted in Section 4 the variability in TBT concentrations suggested that the source may be paint fragments (although no information is available to confirm at this stage). It is unlikely that the transport of sediment from a location such as North Wharf would result in significant adverse sediment quality changes off site, the transport of sediment to an adjacent area would potentially result in small increases in the concentration of PAHs and TBT. At an off-site sediment contribution of 1:100 the concentration changes would not be significant (e.g., +0.1 mg/kg total PAH, 0.002 mg/kg TBT and 2 mg/kg zinc).

6.4.4 Effects of dissolved contaminants released during sediment disturbance

6.4.4.1 Elutriate Testing

During sediment disturbance (e.g., during dredging or dredged material disposal), trace elements, nutrients and any other constituent in interstitial water or adsorbed to sediment may be released to the water column. The potential for the release of nutrients and contaminants during the dredging is typically assessed using the standard U.S. Army Corps of Engineers - USEPA - elutriate test (Ludwig et al. 1989).

Elutriate testing was carried out on a sub-set of sediment samples from each of the key areas sampled and the early sediment quality data for the samples collected. In this assessment the elutriation data also provides information of what may be released from the sediment when disturbed (e.g., pore water) and when the sediment is released into the water column and particulates react with seawater and desorption process occur. The data is compared with other elutriate data obtained on harbour, marina and ports sediment samples collected within the Auckland region. The elutriate was analysed primarily for ammoniacal-nitrogen, trace elements and TBT based on past elutriate testing of port and marina sediments in the Auckland region. These data are discussed below.

Elutriate testing has been carried out for a range of inorganic and organic constituents in sediments from the outer Viaduct Basin and Westhaven Marina (Bioresearches 1989), sites around the Port of Auckland (POAL 1989) and at Hobsonville Point (Golder 2017).

6.4.4.2 Wynyard Basin and Outer Viaduct Basin

Ammoniacal nitrogen

Dissolved inorganic nitrogen in the form of ammoniacal-nitrogen (as sediment pore water is typically reduced) is the main form of dissolved inorganic nitrogen released during the disturbance of sediment (e.g., during dredging). The ammoniacal nitrogen concentrations present in the sediment are ‘natural’ and can be present in quite high concentrations. Concentrations will vary depending on factors such as the redox state of the sediment (i.e., how anoxic the sediment is), the amount and age of organic matter present and the degree of seabed disturbance and near bed water movement.

Based on historical data, sediments such as those in the Viaduct Basin (with relatively low levels of TOC) would be expected to release moderate concentrations of ammoniacal-nitrogen. As summarised in Table 28, ammoniacal-nitrogen concentrations had a range of 1.66 to 8.8 g/m^3 with an average of 5.1 g/m^3. The lower ammoniacal-nitrogen concentrations measured are similar to those measured in port sediments.

Table 28: Elutriate ammoniacal-nitrogen and trace element concentrations – Viaduct Basin.

	Amm-N+	NPOC	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn
NW-1	8.6	5.1	7.8	<0.21	<1.1	<1.1	<1.1	<0.08	<7	16.3
NW-2	3.7	4.6	24	<0.21	<1.1	<1.1	<1.1	<0.08	<7	<4.2
NW-3	1.66	3.0	12.2	<0.21	<1.1	<1.1	<1.1	<0.08	<7	<4.2
WW-1	8.8	5.2	21	<0.21	<1.1	<1.1	<1.1	<0.08	<7	<4.2
WW-2	2.2	3.2	14.6	<0.21	<1.1	<6.6	<1.1	<0.08	<7	<4.2
WW-3	5.7	3.8	15.6	<0.21	<1.1	<1.1	<1.1	<0.08	<7	<4.2
Seawater	0.017	-	<4.2	<0.21	<1.1	<1.1	<1.1	<0.08	<7	<4.2
Basin water	0.016	2.0	-	-	-	1	<1	-	-	3
ANZECC (2000) 95 %	0.91	NTV	NTV	5.5	4.4	1.3	4.4	0.4	70	15
USEPA (2017)	1.0	NTV	36	7.9	50	3.1	8.1	0.94	8.2	81

Notes: All concentrations mg/m^3 except ammoniacal-nitrogen which are g/m^3. + Amm-n = ammoniacal-nitrogen. pH 8.2, 15ºC. As – arsenic, Cd – cadmium, Cr – chromium, Cu – copper, Pb – lead, Hg – mercury, Ni – nickel, Zn – zinc.

However, several samples produced concentrations higher than measured previously in elutriates from port core samples The concentrations in the elutriate appeared to be related to the concentration of dissolved organic carbon (measured as NPOC) in the elutriate (potentially reflecting the redox potential of the overall core sample). Similar concentrations of ammoniacal-nitrogen have been measured in fine sediment from the Waitemata Harbour (Table 29) including:

- The Port of Auckland (1.5 ± 1.3 g/m^3) (POAL 1989).
- Sediments from Hobsonville Point in the Upper Waitemata Harbour (<0.01-0.33 g/m^3 (n=4) and 2.5 g/m^3 (Golder 2017).
- Sediment samples from Lucas Creek in the Waitemata Harbour 0.35 and 0.37 g/m^3 (POAL 1989).

The maximum concentration of 8.8 g/m^3 would require less than ten-fold dilution to bring the concentration below the ANZECC (2000) 95 % protection trigger value (0.91 g/m^3). This is likely to occur very close to the point of disturbance.

Trace elements

Table 28 summarises trace element concentrations in elutriate from the North Wharf and Wynyard Basin (between Wynyard and Halsey Wharfs) sediment samples. Concentrations of cadmium, chromium, lead, mercury, nickel and zinc were below detection in the six samples and the detection limit was in each case below the ANZECC (2000) marine 95 % trigger value. As such, no waterborne toxicity related effects would be expected as a result of the mixing of sediment and seawater. In relation to the other elements:

- Arsenic concentrations ranged from <4.2 to 24 mg/m^3. Arsenic is often measured in concentrations above detection limit in coastal sediments as arsenic mobility is influenced by anaerobic conditions. Concentrations are similar to those measured previously in sediment from Half Moon Bay Marina (6.3 to 9.8 mg/m^3 (n=3), Golder 2013) and Hobsonville Point (<4.2 to 10.9 mg/m^3 (n=5), (Golder 2017).
- Although copper was measured in elevated concentrations in the sediment, it was not detected in elutriate obtained from sediment samples from North Wharf. In other previous elutriate testing, copper was either not detected or measured at low concentrations (Table 28).

Table 29: Comparison of study elutriate data with historic elutriate data.

Element	North Wharf in Wynyard Basin (NW)	Wynyard Wharf (WW) (between WW and Halsey Wharf)	FFIRF area (WH)	Hobsonville Point	Port of Auckland	Viaduct Harbour (Wynyard Basin)	Westhaven Marina	ANZECC (2000) water quality trigger values
	2017	2017	2017	2017	1989	1989	1989	
	This survey	This survey	This survey	Golder (2017)	POAL (1989)	Bioresearches (1989)	Bioresearches (1989)	
Samples	3	**3**	**6**	4	15	4	4	
Arsenic	14.7 (7.8-24)	17.1 (14.6-21)	11.8 (6.5-19.8)	7.5 (5.2-10.9)	-	-	-	NTV
Cadmium	<0.21	<0.21	<0.21	<0.21	-	<0.1	<0.1	5.5
Chromium	<1.1	<1.1	<1.1	<1.1	-	<1	<1	4.4
Copper	<1.1	<1.1	<1.1	<1.1-2.1	1 (<1-2)	<1	<1	1.3
Lead	<1.1	<1.1	<1.1	<1.1	< (<1-3)	<2	<2	4.4
Mercury	<0.08	<0.08	<0.08	<0.08	-	<0.1	<0.1	0.4
Nickel	<7	<7	<7	<7	-	NM	NM	70
Zinc	<4.2, 16.3	<4.2, 16.3	<4.2	<4.2	14 (9-38)	<1	<1	15
Ammoniacal-N	4.65 (1.66-8.6)	5.6 (2.2-8.8)	3.7 (2.3-5.3)	0.37 (0.24-2.5)	1.78 (<0.02-5.16)	9.5 (7.9-12.3)*	2.4 (1.4-3.6)*	0.9
TBT (as Sn)	<0.05	<0.05	<0.05	<0.05	-	<0.05 (<0.02-0.15)	<0.05 (<0.02-0.10)2	0.006

Notes: All concentrations mg/m^3 except ammoniacal-nitrogen which are g/m^3. ++ USEPA (1989), pH 8.2, 15^{o}C. * - Measured as TKN.

Overall, there is no indication that the quality (trace element concentration) of sediments from the locations where dredging will be carried in the Wynyard Basin would have any adverse effect on water quality that might result in water column toxicity issues (following minor amounts of mixing). In this assessment acute effects have not been considered, only “no effects” (ANZECC (2000).

PAHs

Elutriate from select sediment samples with elevated PAH concentrations was analysed for PAHs. Result are provided in Appendix C. The analysis showed that PAH concentrations in the elutriate were low. Most PAHs were not detected at the following detection limits.

- Naphthalene <0.04 mg/m^3 (NW3, WW1, WH04) and <0.001 mg/m^3 (WW3).
- Acenaphthene, acenaphthylene, anthracene, benzo[a]anthracene, benzo[a]pyrene (BAP), benzo[b]fluoranthene + Benzo[j]fluoranthene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, dibenzo[a, h]anthracene, fluoranthene, fluorine, indeno(1,2,3-c,d)pyrene, phenanthrene <0.008 mg/m^3 (NW3, WW1 and WH04) and <0.019 mg/m^3 (WW3). Pyrene was not detected in NW3 and WW3 at <0.008 mg/m^3 but was detected in WW1 and WH04 at 0.042 and 0.009 mg/m^3 respectively.

There are no ANZECC (2000) trigger values for individual PAH compounds. USEPA have no marine water criteria for individual PAHs. Other regulatory bodies have freshwater criteria/guidelines for individual PAHs. CCME (1999) has a freshwater guideline for pyrene of 0.025 mg/m^3. A small amount of dilution of elutriate would reduce an individual PAH concentration for pyrene to below the guidance value.

TBT

Elutriate from the North Wharf and Wynyard Wharf sediment samples (which the sediment itself contained variable amounts of TBT) contained no detectable TBT species (refer Appendix C). The sediment samples examined contained a range of TBT concentrations including one North Wharf sample containing TBT concentrations above the SQG-H concentration (refer Table 19).

The ANZECC (2000) 95 % marine water quality protection trigger value is 0.006 mg/Sn/m^3. This value is below the laboratory detection limit. However, a dilution of at least 10 times would be required to be assured that the detection limit concentrations would be diluted below the trigger value. It is considered that this level of dilution will occur naturally, due to the large volume of water present, near the points of disturbance.

Overall, no acute or chronic effects are expected from the concentrations of TBT released in dissolved form from sediment during disturbance associated with construction activity and dredging.

Summary

Elutriate testing of Outer Viaduct Basin sediments (from North Wharf and between Wynyard and Halsey Wharfs) has shown that, when disturbed or dredged, the sediment will release some constituents to seawater. The most significant constituent to be released will be ammoniacal-nitrogen. A low amount of dilution (naturally occurring near to the source of release) will result in the ammoniacal-nitrogen concentrations falling well below the ANZECC (2000) marine trigger values.

Although elevated concentrations of TBT, lead and mercury were identified in North Wharf sediment samples, concentrations were non-detectable in elutriate. All elutriate concentrations were below ANZECC (2000) trigger values for protection of marine biota. Although TBT was not detectable in all elutriate samples, the detection limit was higher than the trigger value. However a small amount of dilution at the point of disturbance would ensure rapid dilution of any concentration that was below the detection limit but above the trigger value.

6.4.4.3 FFIRF Area

Ammoniacal nitrogen

Concentrations of ammoniacal-nitrogen in elutriate samples were lower than measured in North Wharf samples. All concentrations were higher than the ANZECC (2000) trigger value (Table 30) but with a small amount of dilution (~five times) near the point of sediment disturbance, the concentrations would be below the 95 % protection trigger value.

Table 30: Elutriate ammoniacal-nitrogen and trace element concentrations – FFIRF area.

	Amm-N+	NPOC	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn
WH-1	4.4	4.2	13	<0.21	<1.1	<1.1	<1.1	<0.08	<7	<4.2
WH-2	5.1	3.6	19.4	<0.21	<1.1	<1.1	<1.1	<0.08	<7	<4.2
WH-3	2.3	3.4	6.9	<0.21	<1.1	<1.1	<1.1	<0.08	<7	<4.2
WH-4	1.2	3.0	<4.2	<0.21	<1.1	<1.1	<1.1	<0.08	<7	<4.2
WH-7	2.7	3.7	11.5	<0.21	<1.1	<1.1	<1.1	<0.08	<7	<4.2
WH-8	3.1	3.9	6.5	<0.21	<1.1	<1.1	<1.1	<0.08	<7	<4.2
WH-9	4.7	4.9	19.8	<0.21	<1.1	<1.1	<1.1	<0.08	<7	<4.2
Mean	3.4	3.8	11.8	<0.21	<1.1	<1.1	<1.1	<0.08	<7	<4.2
Seawater	0.017	-	<4.2	<0.21	<1.1	<1.1	<1.1	<0.08	<7	<4.2
Basin water	0.016	2.0	-	-	-	1	<1	-	-	3
ANZECC (2000) 95 %	0.91		NTV	5.5	4.4	1.3	4.4	0.4	70	15
USEPA CCC (2017)	1.0++		36	7.9	50	3.1	8.1	0.94	8.2	81

Notes: All concentrations mg/m^3 except ammoniacal-nitrogen which are g/m^3. + Amm-n = ammoniacal-nitrogen. ++ USEPA (1989), pH 8.2, 15ºC. As – arsenic, Cd – cadmium, Cr – chromium, Cu – copper, Pb – lead, Hg – mercury, Ni – nickel, Zn – zinc.

Trace elements

Measured cadmium, chromium, copper, lead, mercury, nickel and zinc were all below the laboratory detection limits. All detection limited were lower than their corresponding ANZECC (2000), 95 % trigger values for marine waters (Table 30). Arsenic was detected in all elutriate samples at concentrations (6.5-19.8 mg/m^3) above the concentration normally found in seawater but below the USEPA (1995) arsenic chronic criteria. Cadmium concentrations were similar to those measured in elutriate from Viaduct Basin sediments (refer previous section).

TBT

Elutriate from sediment samples collected in the FFIRF area contained no detectable organo- tin species. The sediment samples contained a range of TBT concentrations including samples with TBT concentrations above the SQG-High concentration. As discussed in the previous section, although the detection limit is above the ANZECC (2000) 95 % protection trigger value of 0.006 $mg/Sn/m^3$, a low level of dilution ensures that any concentration between the detection limit and trigger value would be diluted below the trigger value.

Summary

Elutriate testing of FFIFR area sediments has shown that when disturbed or dredged the sediment will release some constituents to seawater. Of the constituents measured, ammoniacal-nitrogen and dissolved arsenic were released into the water at measureable concentrations. Released arsenic concentrations were below the ANZECC trigger value. Ammoniacal nitrogen concentrations would require a small amount of dilution to reduce concentrations below the marine water quality trigger. Although no TBT was detected in elutriate, the detection limit was higher than the ANZECC 95 % protection trigger value. A small amount of dilution is required (as the actual concentrations will have been between the detection limit and the trigger value. Dilution of this order will occur close to the due to the large body of water present and would not require any intervention. Overall, no water borne toxicity concerns derived from seabed disturbance were identified.

6.5 Management of Dredged Materials

As described in Section 6.2.1, dredging is required at four locations. Three within the Viaduct Basin and one in Westhaven Marina. Beca (2018b) describes options for dredged sediment management.

Viaduct and Wynyard Basin

Based on sediment quality data collected as part of this assessment (Section 4.5.2), sediment dredged from Outer Viaduct Basin and the Inner Viaduct Basin entrance channel is likely to be suitable for open water disposal to a permitted offshore marine disposal site (Table 31).

The sediments to be dredged within Wynyard Basin were sampled in two groups (Figure 11). Part of the dredging involves an area alongside North Wharf. The quality of sediment from that area indicates that it has been directly affected by the discharge of urban storm water, vessel management and may also be influenced by discharges from the historic reclamations south of North Wharf.

Elevated concentrations of lead, mercury, zinc and TBT (Section 5.6) combined provide an initial indication that the sediment may not be suitable for open water disposal without further investigation as to the potential impacts of the elevated concentrations of contaminants.

FFIRF

The sediments to be dredged from the FFIRF area within Westhaven Marina were sampled along four transects (Figure 12). The quality of sediment indicates that it may have been has been directly affected by the management and maintenance of vessels alongshore (principally paint sources). The elevated concentrations of mercury and TBT (Section 5.6) combined provide an initial indication that the sediment may have been influenced by historic ship maintenance activities and is not likely to be suitable for open water disposal without further investigation as to the potential impacts of the elevated concentrations of contaminants (Table 31).

Table 31: Summary of dredged sediment management options*.

Location	**Volume**	**Management options**			
		Offshore disposal	**Reclamation**	**Mudcrete reclamation or other use**	**Landfill**
Wynyard Basin (entrance channel to Outer Viaduct))	30,000 m^3	**YES**	YES	YES	YES
Outer Viaduct Harbour	30,000 m^3	**YES**	YES	YES	YES
North Wharf, Wynyard Basin	5,000 m^3	NO	POSS**	**YES**	**YES**
FFIRF	15-20,000 m^3	NO	POSS**	**YES**	**YES**

Notes: Based upon bulk sediment quality only. ** - assuming no treatment. Bold – preferred yes,

6.6 Effects of New Structures (Post-construction) on Water Quality

6.6.1 Predicted changes

Both Tonkin & Taylor (2017) and Beca (2018b) examined the effects that the new structures (wharfs and breakwaters etc.) could have on the circulation of tidal waters through the Viaduct Basin and Westhaven Marina. Ideally the characteristics of enclosed marina and harbour areas should allow for good water movement and exchange. Poor exchange can result in a variety of environmental concerns including increased sedimentation, decreased dissolved oxygen, decreased flushing of nutrients and contaminants and as well as odours. For harbour and marina construction, PIANC (2008) identify that the concentration of any constituent should decrease to 37 % within four days to maintain good water quality and 10 days to maintain fair water quality. The two independent assessments of the effects of proposed structures on water circulation and exchange provide generally similar results. In general the Beca (2018b) results show a lesser effect than that presented by Tonkin & Taylor (2017).

6.6.2 Effects on water quality in Wynyard Basin

Water quality in enclosed areas like the Inner Viaduct Basin is determined by the quality and quantity of flood tide waters from the harbour relative to sources entering within the Inner Basin. Contributions include storm water, discharges from boats (e.g., bilge discharges) using and berthed within the Inner and Outer Viaduct Basin. There may be some contribution from groundwater derived from within the reclamations. In Section 5 recent water quality data from two sites in the Inner Viaduct Basin were presented.

As described by Tonkin & Taylor (2017), prior to the 2000 redevelopment of the Viaduct Basin, storm water (containing wastewater overflows) were re-routed from the Inner Viaduct Harbour, Storm water from the Freemans Bay subcatchment discharges in the south-west corner of Wynyard Basin through the Daldy Street outfall. Subsequently, storm water from the redeveloped Halsey Street is discharged to the Inner Viaduct Harbour through an outlet along Halsey Street.

Although the AC36 project results in no change (volume or quality) to the two key storm water discharges, the results of modelling of flushing time (the movement and exchange of tidal waters on each tide) showed that the additional structures altered the movement of water and consequently reduced the flushing in different parts of the Viaduct Basin. The effects of these physical changes have been reviewed (by Beca and Tonkin & Taylor) to identify whether the changes result in any general changes in water quality and if it will alter the current effects that storm water discharges may have on the Inner Viaduct Basin and Wynyard basin.

Model simulations were carried out through seven tides. Flushing characteristics are described in terms of the e-folding time = the time that it takes for water to be diluted/exchanged such that a constituent had been diluted to 37 % of its original condition. Figure 17 identifies the locations that flushing characteristics were assessed for.

The modelling of e-folding times (Tonkin & Taylor 2017) showed that for sites 7 to 10 (outside the inner Viaduct Basin) the time was relatively short (i.e., the area has rapid exchange). The e-folding time increased with the proposed structures (breakwaters and piles) in place but was still well within the good category.

At Site 11, just inside the Inner Viaduct Basin, the e-folding times increased but was still within the good category under spring tides but decreased into the fair category under neap tides. In the southern section of the Basin (the Lighter basin), at Sites 13 and 14, the e-folding time increased but remained within the fair category. Having noted the potential increases in e-folding time under neap tide conditions it should be noted that neap tide conditions only occur twice a month. As such for most of the month the predicted changes should be less than identified.

Overall, although the water exchange characteristics change due to decreased water movement, the e-folding time remain within the fair category within the Inner Viaduct Basin. The implications of the modelled changes are discussed below in relation to nutrients and algal growth in the inner Basin and the discharge of storm water from Halsey Street between points 11 and 13 and from Daldy Street adjacent to site 10 (Figure 17).

Time (in hours) for 37 % of "initial concentration" to be reached (current/proposed under spring and neap tides).		
Site	**Spring**	**Neap**
7	6.5 / 18.8	8.0 / 38.2
8	13.5 / 26.5	12.0 / 51.3
9	38.5 / 63.3	38.8 / 111.5
10	27.7 / 17.8	21.7 / 21.8
11	50 / 75.7	64.3 / 126.3
12	47.3 / 66.8	64.5 / 127.8
13	100.7 / 135.8	125.8 / 188.2
14	81.3 / 145.2	145.2 / 211.8

Figure 17: Locations in the Viaduct basin modelled for changes in flushing characteristics.

Storm water

Urban storm water contains a variety of 'contaminants' including dissolved trace elements copper and zinc (derived from urban buildings, galvanised infrastructure and motor vehicle tyres) and bacteria which are used here to discuss potential changes in water quality arising from the predicted e-folding changes.

Historically, a greater volume of untreated storm water was discharged into the inner Viaduct Basin. Following the reconstruction on the Inner Viaduct Basin, storm water was re-directed to the foot of North Wharf. With the recent revitalisation of the western reclamation the storm water system has been reconstructed and treatment has been added (rain gardens and tree pits). To manage flows due to the increase in building storm water, the treated storm water from Halsey Street was redirected back into the Viaduct Basin at a point at the southern end of the Park Hyatt site.

Tonkin & Taylor (2017) have carried out modelling of the discharges (from the Freemans Bay sub-catchment) to the Wynyard Basin through the Daldy Street discharge adjacent to North Wharf and from the Halsey Street discharge into the Inner Viaduct Harbour.

Results for a relative assessment modelling 200 L/s of discharge from the Daldy Street outfall over 24 hours show that rather than being flushed offshore into the main Waitemata Harbour channel, discharge flows remain in Wynyard Basin and are more efficiently transported into the Outer Viaduct Harbour. The Tonkin & Taylor modelling identified a primary dilution of some 71 times within the immediate new Wynyard Basin area (the area enclosed by the new breakwaters and the existing Halsey wharf). Over the subsequent 24-48 hours much of the discharge remaining within the area has been diluted by a factor of 200 times. Modelling 100 L/s of storm water discharge from the Halsey outfall over 24 hours shows similar patterns of longer residence time within the Inner Viaduct Harbour before discharge flows are flushed into the main Waitemata Harbour.

To assess possible effects of current and post construction effects a nominal concentration of copper, zinc and numbers of bacteria were examined using the modelled output from Tonkin & Taylor (2017). The evaluation assumes a moderate degree of treatment for the Halsey Street discharge and no treatment for the Daldy Street discharge. For this assessment, urban storm water data from the NIWA URQIS database was utilised in absence of site specific data for the two outfalls. The data utilised was:

- Treated and untreated median TSS concentrations of 18 and 46 g/m^3, respectively. Raingardens used for the treatment of road and pavement storm water along Halsey Street can be effective in the removal of TSS as they are filtration devices. There is little published data for TSS output from working raingardens in New Zealand but TSS concentrations would be low as reported in the single data point of 2 g/m^3 in Trowsdale & Simcock (2008).
- Treated and untreated dissolved copper concentrations of 0.0052 and 0.0081 g/m^3, respectively.
- Treated and untreated dissolved zinc concentrations of 0.0086 and 0.220 g/m^3, respectively.
- Untreated enterococci numbers of 14,100/100 mL. A nominal 1,400 MPN/100 mL was used for treated storm water.

Concentrations of TSS from the Halsey outfall should not result in prolonged water clarity changes within the Inner Viaduct Basin. The discharge will have a poor clarity compared to the water in the basin but this will dissipate due to settling and dilution. However, a very large storm water event is likely to result in some clarity changes over a period of 24 hours or more. At the Daldy Street outfall, the storm water is untreated and known to have poor clarity at times. Currently, following a period of mixing, it is likely that some clarity changes will persist off North Wharf and alongside Wynyard Wharf within the Wynyard Basin. Following construction, prolonged clarity changes will be expected within the Wynyard Basin for a period of at least 24 hours.

In relation to copper and zinc, the water quality assessment identified concentrations of 0.0036 and 0.001 g/m^3 in the inner Viaduct and the outer Viaduct Basin, respectively. Based on the standard e-folding time, it is assumed that moderate mixing of a storm water discharge would result in concentrations of 0.001-0.002 g/m^3 copper which is not dissimilar to that present in Viaduct Harbour waters. Concentrations of zinc derived from storm water would following modelled mixing result in additive concentrations of <0.001 g/m^3 from the Halsey Street discharge and 0.003 g/m^3 from the Daldy Street discharge. In both cases, the concentrations decline to below the ANZECC (2000) 95 % protection marine trigger values. Overall, depending on the scale of storm water event, there will be localised areas of both the inner and outer basins that have elevated concentrations of both dissolved elements for periods of time. However, the concentrations are not expected to have adverse effects.

Discharge of storm water containing bacteria (e.g., enterococci), will require dilution to reduce bacterial numbers (e.g., to meet recreational marine water quality (green mode) guidelines (e.g., no single sample above 140 MPN/100 mL)). The Halsey Street outfall would be expected to have a better quality (i.e. lower bacteria numbers) than the Daldy discharge. In the Halsey Street discharge, enterococci would be expected to be sourced from birds and dogs (the most likely faecal sources) with no human faecal source. The Daldy Street discharge would contain enterococci from dogs and birds and also human sources as the discharge receives combined sewer overflow from a wider catchment.

Based on the indicative bacterial numbers noted above and the modelling undertaken, bacterial numbers are expected to decline to satisfactory numbers relatively quickly adjacent to the Halsey outfall (i.e., <20/100 mL). However at Daldy St, it is likely that any significant storm water event would result in exceedance of the MfE (2003) green mode guidance (140/100 mL) and quality being categorised as amber mode (single sample exceeds 140/100 mL). Modelling predicts moderate dilution over the first 24 hours as storm water affected water is carried to the outer Viaduct Harbour and potentially into the Inner Viaduct. At this point, bacterial numbers may have declined to less than the alert guidance. However, as the Daldy Street discharge may contain human wastewater at times, it should be assumed that post discharge waters exceed the Alert level within Wynyard Basin and around to Karanga Steps at the entrance to the Inner Viaduct Basin for at least 48 hours.

Overall, no significant changes in microbiological water quality are expected within the Inner Viaduct Basin from discharges from the Halsey Street outfall. Discharge from the Daldy Street discharge currently results in poor microbiological water quality in the area of North Wharf north along Wynyard Wharf. Post construction, the creation of Wynyard Basin results in increased 'containment' of the Daldy Street storm water discharge. As a consequence, there is some movement of diluted storm water east to the Outer Viaduct Harbour. As this assessment is based upon conservative modelling (i.e., dilution only) and an assumed average microbiological quality, it should be assumed that some poor quality water may reach Karanga Steps within the Inner Basin. Water quality in this area should be considered to be poor quality for 24-48 hours following a storm discharge from the Daldy Street outfall. Additional water quality monitoring in the area of the Wynyard Basin and within the inner Viaduct basin have been recommended (refer Section 7.1).

Phytoplankton growth

Chlorophyll *a* concentration, a pigment found in all algae and cyanobacteria, is used as a proxy measurement of phytoplankton (or free-floating algae) biomass. Measured chlorophyll *a* concentrations in the inner Viaduct Basin during November - December 2017, indicate that the basin is moderately productive (Table 25). These concentrations in the inner harbour are affected by both the phytoplankton growth rate and the flushing rate, which effectively dilutes the phytoplankton biomass. Decreased water exchange in the inner Viaduct Basin, particularly at Sites 13 and 14, would most likely result in an increase in phytoplankton biomass due not only to decreased dilution but also due to increased residence time, allowing the phytoplankton within the Inner Basin more time to grow. With the limited data available it is difficult to make an accurate prediction on the anticipated phytoplankton biomass as a result of the increased e-folding time at sites 11 to 14 summarised in Figure 15. However, taking a highly conservative approach and assuming that measured chlorophyll *a* is a product of both dilution and time to grow, then anticipated chlorophyll *a* would be ~ 0.0024 g/m^3. This chlorophyll a concentration is within the range reported for New Zealand harbours (<0.004 g/m^3; Innes et al. 2010) and the increase in biomass is not anticipated to be observable to the casual observer.

Changes in ecological well-being of the Inner Viaduct Basin

The overall ecology (and its well-being) of the inner Viaduct Basin, is influenced by a range of factors some directly or indirectly linked to water circulation and water quality. As such there is a general gradient within the Inner Viaduct that focuses on the area within the Lighter Basin and the eastern end of the Inner Viaduct which have less water movement and calmer surface waters than other parts of the basin. These areas are more sheltered and as a consequence:

- Have a propensity to hold floatables for longer than other areas. This includes plastics and hydrocarbon sheens when they occur.
- Have less tidal and wind driven water movement/surface water disturbance.
- Will hold water for longer and if that water quality changes, may have a greater influence on the composition of communities on intertidal and sub-tidal structures.

These factors can lead to accumulation of rubbish/organic matter on the water surface and seabed in the Inner Basin (which can lead to increased aesthetic issues and occurrence of anaerobic sediment, potentially reduced oxygen in waters). The changes in water movement can potentially influence the composition of biological communities on basin walls, piles and floating pontoons. A walk around the Inner Basin suggests visually some changes in the pontoon communities going from more exposed outer areas of the Basin to the southern end of the Lighter basin where waters are relatively calm.

The assessment of changes in circulation and e-folding time has shown that sections of the Inner Viaduct Basin will have increased water retention times. Although the post construction e-folding times are all within what is classed as a 'fair' category (in terms of water quality), it has been recommended that additional ecological and water quality monitoring be carried out as part of an "**Inner Viaduct Basin Monitoring and Management Plan**". This is discussed further in Section 7.2.

6.6.3 Predicted changes in the FFIRF area

Beca (2018b) modelled the effects of the proposed FFIRF structures (wharf and breakwater) on water circulation in Westhaven Marina. The modelling showed that the narrowing of the eastern entrance to Westhaven resulted in an increase of mean current speeds within the entrance. The e-folding times within Westhaven marina tend to decrease with the narrowing of the eastern entrance except for minor increases within the southern portion of Westhaven Marina and St Mary's Bay. Overall, the changes were minor and resulted in no change in the PIANC (2008) categories with most of the marina being good and only some sites (e.g., south-eastern corner of Westhaven) being categorised as fair.

Overall, the construction required at the FFIRF area (wharf piles and breakwater) will have little effect on the e-folding time within Westhaven Marina or the general area close to the proposed facilities. As such the new facilities should not have any effects on water quality or ecological resources in areas adjacent to the development or within Westhaven Marina.

6.7 Effects of Construction on Terrestrial Resources

6.7.1 Viaduct Basin

Although the proposed construction activity discussed in this assessment is coastal in nature, some works associated with the Wynyard Basin will occur on reclaimed land. This includes the construction of the structures to support the bases at the south end of Wynyard Wharf. No terrestrial ecological resources are known from these areas.

6.7.2 FFIRF area

The proposed FFIRF area will occupy shoreline from the Vos Slipway north towards Wynyard Point. The shoreline is entirely man-made and no significant ecological resources have been identified along the immediate shoreline. New Zealand dotterel are known to be present and nest at a location south of Silo Park. This area is unaffected by AC36 construction activity

As discussed in Section 3.6 and Appendix B, the area adjacent to the Vos Slipway provides roosting and nesting sites for white fronted terns and red-billed gull. The closest tern nesting sites and red-billed gull roosting occurs within 25 m of the proposed southern wharf structure.

It is likely that many of the old wooden piles utilised by the terns for nest sites will remain in-place. However, should any existing pile nest sites be lost, the loss could be mitigated by placing some equivalent pile structures as nest sites for terns in a suitable area.

The red-bill gull high tide roost and nesting site supports a large number of birds and a solution to assist the red-bill population, should the birds be disturbed by the construction work, is more complex. Although the birds are currently subjected to disturbance due to present activity on the site, it is considered that additional disturbance may be possible and some mitigation is discussed in Section 7.

6.8 Biosecurity Matters

The ecological survey carried out for this assessment confirmed that (as seen in regular biosecurity monitoring surveys) within this area of the Port of Auckland, there are a high number of non-indigenous species present. Nearly all of these species are present on structures (e.g., piles and pontoons) with few present on the seabed.

No specific biosecurity issues have been identified as part of the dredging and construction works as no biosecurity threat species has been identified (i.e., a species not known from any adjacent area). However, during decommissioning of any structures post AC36, the potential transfer of threat species off site will need to be considered. The preparation of a decommissioning management plan to minimise biosecurity issues that may arise is identified in Section 7.2.

6.9 Other Construction Related Matters

6.9.1 Viaduct Basin

Earthworks

Beca (2018a) describes the nature of ground improvement and earthworks associated with proposed construction works to provide a platform for bases along the southern 270 m of Bringham Street at Wynyard Wharf (Refer Figure 3). It is likely that ground improvement for the structures will involve ground improvement in the form of cement-stabilised or stone columns or piling for the main structures, minor earthworks at a number of locations along Hamer Street; south of Brigham Street/Jellicoe Street West; Jellicoe Street East/Halsey Street North/ Karanga Plaza; and Hobson Street/Quay Street/Eastern Viaduct which may include. These minor works may be required for pre-investigation, works associated with services investigation and installation. Beca (2018a) note that innovative solutions may be required for some works to overcome ground instability problems.

Any work will be carried out in accordance to a remediation (ground) Action Plan. Apart from the foundation works, most work is considered to be relatively minor in terms of earthworks volumes. All services works are considered minor and similar to other works already completed on the Western Reclamation. As such, all works would be subject to sediment controls to ensure no loss of sediment to road surfaces and to the storm water system. The Remediation Action plan will set out the sediment control tools that will available/used to control sediment loss and storm water quality during works. Earthworks controls will be equivalent to those used for street redevelopment and site works on the Western Reclamation to-date.

Beca (2018a) have identified that, as part of ground improvement works, mudcrete may be used to improve ground-conditions in areas where the services are being installed. The mudcrete can be prepared utilising some of the material dredged or recovered during piling as this material will need to be disposed to landfill or another approved disposal option. Based on the quality of sediment in the Wynyard Basin, sediment dredged from the entrance channel or excavated and removed from the foundation hole for new wharf piles would be most suited for mudcrete. The mudcrete from these sources would not result in addition of unacceptable levels of contaminants and would not contribute to adverse changes in ground water quality.

Underwharf repair work

It is expected that some under-wharf repair work will be required on Hobson and Halsey Street Extension Wharves during the new wharf construction. This work involves the removal of deteriorated concrete on beams and piles using high pressure water. The loose concrete is collected under-wharf and the waste material disposed to landfill.

Hydrocarbon management

Spills of hydrocarbons or other environmentally hazardous substances during construction are a potential risk, which may affect the quality of water in the surrounding environment. A **Spill Response Pla**n is to be developed as part of the Construction Environmental Management Plan outlining spillage procedures for the construction sites (Beca 2018a).

6.9.2 FFIRF area

Earthworks

Beca (2018a) has identified that some site clearance works will be required as well as ground improvement works. It has also been identified that some site improvement and shoreline improvement works will be required. It has been identified that ground improvement works (e.g., raising the site level) could be carried out using dredged sediment and / or material excavated during the installation of wharf piles. As noted above, the use of mudcrete is not expected to result in any water quality concerns associated with storm water or discharge to ground (primarily as the receiving environment for any discharges is coastal waters).

As noted above, a **Remedial Action Plan** will document site management measures such as soil excavation, disturbance and disposal procedures. This will also include an **Erosion and Sediment Control Plan** that will document management for all earthworks and storm water generated during construction.

Shoreline works

Remedial works to the shoreline at the FFIRF will involve the removal of existing shoreline protection materials to provide a rebuilt stable shoreline. At the southern end of the development, this will involve the removal of a variety of rubble and fill. This is likely to require new founding material for the seawall. The work would be undertaken at low tide or it may be undertaken behind a temporary structure that provides a non-tidal work environment. If the area is isolated, it is unlikely that the works will result in sediment entering the immediate coastal environment. The work may be undertaken with rock and concrete armour units or mudcrete overlain by rock armour (refer Beca 2018a for more detail).

Extensive mudcrete placement has occurred at Fergusson Container terminal in the Port of Auckland and was previously used in the construction of the Viaduct Basin. Mudcrete is formed by the addition of cement to sediment (at a pre-defined ratio) which is mixed together prior to being placed. The amount of cement added is dependent upon the end use of the mudcrete and the nature/concentration of any contaminants present. For example, the mobilisation of TBT in the sediment can be reduced by adding a small amount of activated carbon to the mix (Port Nelson 2016).

Monitoring and mudcrete-leachate trials (e.g., Port Nelson 2016) have shown that leachate through contact with seawater is not likely to result in elevated concentrations of contaminants in adjacent seawater due to the immobility of contaminants in conjunction with the small depth of interaction (low diffusion rate into seawater). Following reasonable mixing close to the mudcrete surface, no water borne toxicity effects are expected.

Hydrocarbon management

As described above, the Construction Management Plan's **Spill Response Plan** will address both marine and land based hydrocarbon management and storage. It will also address the response to all land and marine based spills.

6.10 Storm Water Management

6.10.1 Viaduct Basin

Currently, storm water is discharged into the Wynyard Basin from the storm water network at a variety of locations. As described earlier, road storm water discharged to the Inner Viaduct Basin at Halsey Street is treated (via raingardens). As the western reclamation is progressively redeveloped, road storm water will be treated prior to discharge by passing the storm water through devices such as raingardens.

Beca (2018c) describes the management of storm water on all new constructed impervious surfaces as part of the AC36 development. It is proposed that storm water on all new wharf surfaces be collected and treated in underwharf filtration systems. Wharf structures built for the previous Americas Cup did not provide storm water quality improvements.

Wharf decks will be graded to collect storm water via grates and underwharf pipework draining to proprietary treatment devices that will be accessible for maintenance. The treated storm water will be discharged directly into the harbour. The treatment devices (e.g., StormFilter, Jellyfish etc.) designed to remove 75 % of suspended sediment discharges.

The wharf surfaces are considered to be relatively low trafficked areas compared to roads within the Wynyard Basin catchment. However, the use of the new wharf structures for large population events will generate significant debris (paper, plastic, metal fragments etc.) that will need to be removed using on wharf management and cleaning strategies (bins, vacuum cleaning etc.) or removed from the storm water prior to discharge.

Other aspects of storm water management will be dealt with through the ITA Environmental and Hazardous Substances Management Plans and Emergency Spill Response Plans.

A further improvement to storm water discharges into the Wynyard basin is recommended. By the time the lead-up events commence for AC36, a good proportion of re-developed streets up to Silo Park will have upgraded storm water/treatment systems. It is recommended that in those remaining streets that drain into the Wynyard Basin, for the duration of the AC36 event, additional treatment is added to the inlets that feed to the storm water system draining to the Basin. The purpose of the treatment would be to remove gross pollutants (litter) and large particulates via filtration (using a simple inlet filter systems) prior to entry. This would be supplemented by street sweeping in those streets during the event.

Overall, the addition of non-roof storm water collection and treatment supplemented with on-wharf litter and debris collection will reduce particulate discharges along with particle associated contaminants (TPH and total copper and zinc) to Wynyard Basin.

6.10.2 FFIRF area

The FFIRF area will have a standard storm water management system for all hardstand areas. The storm water system will collect and treat (removing 75 % of particulate material) prior to marine discharge.

Overall, the addition of non-roof storm water collection and treatment supplemented with litter and debris collection will reduce particulate discharges along with particle associated contaminants (TPH and total copper and zinc) to Westhaven Marina.

6.11 Lighting

Wynyard Basin

No lighting concerns in relation to ecological resources have been identified within the Wynyard Basin. It is assumed in this area that lighting management to meet the requirements of the human environment will also minimise lighting effects on any local biota.

FFIRF area

Birds are present at the southern end of the FFIRF area and they are potentially close enough to be disturbed during construction and operation. Lighting may be required during construction period and where it is required it may need to be directed away from the specific area of shore.

6.12 Overview of Environmental Issues Arising From Development of AC36 Facilities

The review of proposed construction activity in the Viaduct Basin and FFIRF area has shown:

Viaduct Basin

- The construction works in the Viaduct Basin will generate structures similar to those present today. These will develop intertidal and subtidal biological communities similar to those on existing structures.
- The construction of additional decking north of Western Viaduct Wharf may change the biological community present in the sediment under the new wharf structures due to changes in the light climate reaching the seabed. The effect is considered to be no more than minor.
- Some intertidal shore will be covered over by new wharf decking at the south end of Wynyard Wharf. This is not considered to be ecologically important.
- Dredging will occur in several areas to ensure adequate water depth for AC36 boats and visiting yachts. The dredging is not likely to have any adverse effects on local ecology as the seabed community is considered to have low value.
- Piling activity will not result in adverse seabed disturbance or generation of suspended solids.

- Dredging will result in local increases in suspended solids concentrations which are not expected to result in significant changes in water clarity or sediment deposition in a down current direction.
- Sediment disturbance will result in some dissolved contaminants entering the water column. Ammoniacal-nitrogen, TBT and total PAH were identified as the contaminants with the highest potential to increase down-current concentrations. Assessment of in-water concentrations and likely dilution indicates that concentrations should not have adverse effects on water column biota. As the sediment to be dredged contains elevated concentrations of several contaminants and this is likely to restrict its offsite management and disposal, proposed dredging will be managed through a dredging management plan.
- Modelling has shown that construction of new wharves and breakwaters in the Wynyard Basin will increase the e-folding time in parts of Viaduct Harbour. The key changes occur within the Inner Basin and in particular within the Lighter Basin. Water quality based on current data is good. During wet weather storm water discharges will change local water quality. This has been modelled but further field data is required to confirm the extent of local water quality changes during and after storm water discharges (especially at Daldy St) (refer Section 7.1 and 7.2 below).

FFIRF area

- No ecological effects have been identified in relation to dredging and construction of shore and wharf related facilities.
- Sediment to be dredged contains elevated concentrations of several contaminants and this is likely to restrict its offsite management and disposal. This can be dealt with through a dredging management plan.
- Lighting controls may be required to minimise lighting related disturbance of bird species occupying a site at the southern end of the proposed development.
- The construction required at the FFIRF area (wharf piles and breakwater) will have little effect on the e-folding time within Westhaven Marina or the general area close to the proposed facilities. As such, the new facilities should not have any effects on water quality or ecological resources in areas adjacent to the development or within Westhaven Marina.

7.0 MITIGATION & MONITORING

7.1 Monitoring

Inner Viaduct water quality monitoring

Preliminary water quality monitoring has been carried out (Section 5) in the Viaduct Basin to inform the environmental assessment. It is recommended that ongoing water quality monitoring be carried out to inform assessment of the water quality in the Inner Viaduct Basin. The primary purpose of the water quality survey would be to identify whether there are any changes in water quality prior to and post construction. The following monitoring is recommended.

- Sampling to be carried out at six sites comprising the four sites described in Section 5 plus a site located in the Lighter Basin and a site in the Wynyard Basin (50 m off Daldy Street outfall).
- Field measurements of temperature and dissolved oxygen to be taken just below the water surface (~0.2m depth) and just above the seabed, as well as Secchi disc depth.
- Water samples to be collected monthly just below the water surface and analysed for:
  - Turbidity.
  - Total suspended solids (TSS).

- Dissolved nutrients (nitrate-nitrogen, nitrite-nitrogen, ammoniacal-nitrogen, and dissolved reactive phosphorus).
- Enterococci counts.
- Dissolved copper and zinc.

- At least three sets of post storm samples should be collected (when Daldy Street outfall has been discharging).
- Sampling to be undertaken by a qualified water quality scientist and samples to be analysed in a suitably accredited laboratory.

The monitoring will allow data to be collected over a period prior to the construction being completed. Sampling should also continue for at least 12 months following completion of construction, with the period of sampling to be reviewed following data analysis. Following the completion of the programme, the results will be assessed and provide information for the Viaduct Basin Environmental Management Plan (refer also Section 7.2)

The final details of the water quality monitoring programme will be set out in a Viaduct Basin Water Quality Monitoring Programme Sampling Plan which should be a subcomponent of an overarching **Environmental Monitoring Plan** (EMP) and part of **Inner Viaduct Basin Environmental Management Plan** (refer Section 7.2 below) . This monitoring programme and plan have been included in recommended conditions. No water quality monitoring is considered necessary for the FFIRF area.

Dredging water quality monitoring

It is recommended that water quality monitoring be undertaken during the dredging of sediment from the North Wharf area. Monitoring should include the following components:

- Near surface water quality samples should be collected on down-current on the ebb tide at least 50 and 200 m from the point of dredging.
- Water quality samples should be collected at a ‘control’ site (e.g., in the east side of the outer Viaduct Basin).
- Samples should be collected at least once a week.
- TSS or turbidity should be <50 g/m^3/NTU above the control site at 200 m down-current.

Should monitoring identify a breach of TSS / turbidity limits an investigation identifying potential reasons for such an increase should be undertaken as soon as practical. The activity causing of the breach of TSS / turbidity should be assessed and modified, where appropriate, to reduce off-site water clarity. The monitoring has been included in recommended consent conditions and would form part of the overall EMP.

Bird monitoring

As noted above, monitoring of bird numbers at the red-billed gull colony may assist in determining whether numbers change during construction. It is recommended that, over the nesting season, a monthly visit during high tide to the roosting site be carried out to record:

- Numbers of red-billed gulls roosting
- Numbers of red-billed gulls nesting and status of any chicks present.
- Numbers of white fronted terns present and nesting.

7.2 Management and Mitigation

Inner Viaduct Basin water quality management

There has been considerable discussion in relation to water quality within the Inner Viaduct Basin. It is recommended that an **Inner Viaduct Basin Environmental Management Plan** be prepared. The Plan should include the following:

- Identification of key ecological communities within the Inner Basin and the establishment of fixed photo-quadrats on floating pontoons, basin walls and piles. Ecological monitoring of the fixed monitoring points to be undertaken once every 12 months, at the same time each year.
- Water quality monitoring (covered under the EMP) and aesthetic observations (Munsell colour observations, identification of sheens, floatables, rubbish) (refer water quality notes in Section 7.1 above).
- Aesthetic monitoring to be carried out monthly along with photographic record.
- Sampling following at least three significant storm events corresponding for example to more than 2 mm in an hour minute period to a
- Confirmation of sediment quality at water quality monitoring locations. Sediment quality characterisation to include sediment core photographs, TOC, redox, TPH, copper, lead and zinc.

The ecological information collected should be sufficient to identify whether the current ecological communities are influenced by the existing circulation within the Inner Basin (e.g., is the Lighter Basin different to the rest of the Inner Basin).

The Plan should include and assess the following matters:

- What storm water events result in wastewater overflows (their scale and frequency)?
- Is water quality in the Inner Basin suitable for contact recreation?
- Does the status of contact recreation change in response to storm events?
- Does storm water discharge to the Inner Viaduct Basin result in water quality changes?

The plan will include Panuku support for wider Council group initiatives with Freemans Bay catchment storm water improvement (e.g., Central interceptor, site management including storm water and ITA awareness for Wynyard Quarter industries/businesses etc.).

Following the completion of the monitoring programme described in Section 7.1, the results will be reviewed to determine if there have been any measureable changes in the quality of the Inner Viaduct Basin environment. Should any negative changes be identified, a review would be initiated in relation to the options available to improve circulation/flushing in the Inner Basin (e.g., modifications to under-wharf wave panels post the Event).

Storm water discharges to Wynyard Basin

It is recommended that any remaining streets draining to the Wynyard Basin that do not have upgraded storm water treatment systems prior to the commencement of the AC36 event have additional treatment added to the catchpit inlets. The purpose of the treatment would be to remove gross pollutants (litter) and large particulates via filtration (using a simple inlet filter type device). This treatment would be for the duration of the AC36 Event.

Coastal birds

As identified in Section 6.5, there are key coastal bird species immediately adjacent to the proposed FFIRF area.

If it is confirmed that some displacement of white fronted tern nest sites occurs it was identified that mitigating the loss of nest sites may be possible through direct replacement of sites with structures similar to those present today (e.g., wooden piles suitable for nesting).

Some disturbance of red-billed gull may also occur (potentially during construction and post construction). A number of mitigation options to minimise potential effects to the red-billed gull colony have been identified. These include:

- Management of pests in the immediate vicinity of the colony may enhance survival of chicks.
- Creating a visual barrier on the southern nearshore side of the proposed new southern wharf may be of value. The purpose of the visual barrier (which may comprise an open panel wooden fence along a short section of wharf) would be to reduce the effect on movement along the inshore section of the new wharf.
- Enhancing high tide roosting and nesting opportunity for coastal bird species within the Waitemata Harbour or providing positive mitigation at other red-bill gull roost and nest locations in the Auckland region.

Biosecurity

Biosecurity monitoring of the Viaduct Harbour Marina has shown that the subtidal structures support a significant number of exotic species. Some of these species pose potential biosecurity issues and, as such, it is recommended that any decommissioning of structures carried out post AC36 should be carried out under a **Decommissioning Biosecurity Management Plan**. This Plan, which is likely to be a component of a Decommissioning Management Plan, will need to be prepared and approved at least six months prior to any works being carried out.

8.0 SUMMARY AND CONCLUSIONS

8.1 Viaduct Basin

Environment

- The Wynyard Basin is completely surrounded by man-made structures (concrete and wooden piles, wave barriers and floating pontoons) and shorelines (sloping reclamation and vertical concrete walls). The seabed in the basin supports a relatively simple faunal community with differences between open water and the areas beneath existing wharf structures (where light is reduced). The sediment fauna includes some non-indigenous species such as the small bivalve Theora.
- The physical structures through-out the basin provide intertidal and subtidal habitat which supports a wide range of biota. The communities present do not contain any species regarded to have high conservation value and contain a predominantly non-indigenous component. A number of species present are considered to be marine biosecurity threats.
- A number of coastal bird species of high conservation value (e.g., red-billed gull and white-fronted tern) utilise the Wynyard Basin but the basin does not provide any specific roosting or nesting sites for those species.
- A range of fish species that are present within the Waitemata Harbour are present within Wynyard Basin. This includes some species such as parore and spotty that are resident around piles and pontoons. There are species that are considered to be transient and will come into the Wynyard Basin and also Viaduct Harbour at times. These include mullet, sting-rays and flounder amongst others.

- Surface and deeper sediments within the Viaduct Basin in areas where dredging and construction works are proposed are dominated by mud with lesser proportions of clay and fine sand. The sediments close to North Wharf contained more coarse material presumably because of the proximity of storm water outfalls and or other historic activities. Sediments sampled did not contain identifiable man-made materials in the coarse (>2 mm) fraction.
- Water quality parameters measured in both the Inner/Outer Viaduct Basin and Wynyard Basin during the November - December 2017 monitoring period was similar to that reported for the Chelsea monitoring site in the mid-Waitemata Harbour. This suggests that, based on the current short duration survey, the water quality in the Viaduct Basin is of similar "excellent" quality and reflects the quality of the water entering the Viaduct Basin on the flood tide from the at Waitemata Harbour.
- Sediment quality within the open water areas of Wynyard Basin and in the Outer Viaduct Harbour is considered to be good. All sediments contain a low level of mercury which is seen in fine sediments from the lower Waitemata Harbour. Sediment collected adjacent to North Wharf contained elevated concentrations of some contaminants. These included lead, zinc and TBT.

Environment and effects

- The construction works in the Viaduct Basin will produce structures similar to those present today. These will develop intertidal and subtidal biological communities similar to those present on existing structures.
- The construction of additional decking north of Western Viaduct Wharf may change the biological community currently present due to changes in the amount of light reaching the seabed. The effect is considered to be no-more than minor.
- Some intertidal shore will be covered by new wharf decking over at the south end of Wynyard Wharf. This is not considered to be of ecological importance.
- Dredging will occur in several areas to ensure adequate water depth for AC36 boats and visiting yachts. The dredging is not likely to have adverse effects on local ecology as the seabed community is considered to have low ecological value.
- Piling activity will not result in adverse seabed disturbance or generation of suspended solids.
- Dredging will result in local increases in suspended solids concentrations which are not expected to result in measureable changes in the long-term water clarity or sediment deposition in a down current direction.
- Sediment disturbance will result in some dissolved contaminants entering the water column. Ammoniacal-nitrogen, TBT and total PAH were identified as the contaminants with the highest potential to increase down-current concentrations. Assessment of in-water concentrations and likely dilution indicates that concentrations should not have adverse effects on water column biota. As the sediment to be dredged contains elevated concentrations of several contaminants and this is likely to restrict its offsite management and disposal, proposed dredging will be managed through a dredging management plan.
- The construction required in Wynyard Basin (wharf piles and breakwater) will result in an increase in the e-folding time within the southern parts of Wynyard Basin (e.g., inside the new breakwaters) and at sites at the 'far ends' of the Inner Viaduct Harbour (e.g., the Lighter Basin). Although the e-folding times increase by a day at several points, a number of physical characteristics indicate that the water quality would still be 'fair' in the inner harbour. As the hydrodynamic changes are quite complex, a monitoring program has been recommended to provide information to confirm predictions of water quality and ecology within the Wynyard Basin and Viaduct Harbour.

- Elutriate testing of Outer Viaduct Harbour sediments (from North Wharf and between Wynyard and Halsey Wharfs) has shown that when disturbed or dredged the sediment will as expected release some constituents to seawater. The most significant constituent to be released will be ammoniacal-nitrogen but low levels of dilutions close to source release would result in concentrations being below the ANZECC (2000) marine trigger values.
- Although elevated concentrations of TBT, lead and mercury were identified in North Wharf sediment samples, concentrations were non-detectable in elutriate. All elutriate concentrations were below ANZECC (2000) trigger values for protection of marine biota. Although TBT was not detectable in all elutriate samples, the detection limit was higher than the trigger value. However a small amount of dilution at the point of disturbance would reduce any concentration that was between the detection limit and the trigger value.
- Storm water will be generated from the new wharfs and buildings. Although the locations are not considered high contaminant generating surfaces, wharf deck storm water will be collected and passed through treatment devices (located under-wharf) to remove at least 75 % of particulates and associated contaminants. The discharge from the wharf storm water treatment systems will not have adverse effects on water quality or aesthetic values, following reasonable mixing.

Monitoring and mitigation

- A Viaduct Harbour water quality and ecological monitoring programme is recommended to monitor water quality and ecology (inter and sub-tidal) prior to, during, and after the completion of the new wharfs and breakwaters in the Wynyard Basin. The purpose of the programme will be to confirm predictions of less than minor effects on water quality or ecology, especially within the inner Viaduct Harbour.
- Monitoring of dredging activity is also proposed. For the Wynyard Basin and Outer Viaduct Harbour areas, it has been recommended that this comprises observation and photographic information collection. For the dredging required at North Wharf, down-current water sampling is recommended (for TSS and turbidity) with monitoring continuing at other locations to be dredged, if the monitoring threshold is exceeded. If no significant sediment plumes are identified, monitoring will continue based on photographic record.
- Storm water treatment will be installed on the new wharf structures being constructed in Wynyard Basin. Due to the large population visiting the Wynyard Basin during the AC36 event, rubbish and debris including plastics will be a key contaminant requiring management. The proposed treatment system along with on-wharf management will provide effective control. There has been progressive improvement of storm water treatment during the redevelopment of the Western Reclamation. There are likely to be some street areas on the northern reclamation that will not have any treatment prior to AC36. It is proposed that during the event, these areas have storm water treatment enhanced through a number of management tools including installation of grate filter system.
- Given the presence of a wide range of non-indigenous organisms in the Wynyard Basin, a Biosecurity Risk Management Plan will be prepared to ensure that vessels used for construction and dredging do not pose any biosecurity risks and that risks are managed or mitigated when any demolition or decommissioning is carried out post the event.

8.2 FFIRF Area

Environment

- The intertidal shore along the FFIRF area is entirely man-made and comprises a range of materials. The hard shore at the location was relatively depauperate and did not support a community of value. Although no sub-tidal benthic biology examination was carried out, information from adjacent areas provides general indication as to the composition of that community. The community would be expected to be of low ecological value containing common species.

- The local shoreline provides roosting and nesting sites for two regionally important coastal birds, the white fronted tern and re-billed gull. The former are present as a small number of nests (with chicks) and the latter a very large roosting colony with a large number of nests and chicks. The fish fauna is expected to comprise a range of common Waitemata Harbour species.
- FFIRF sediments were sandier (~50 %) than sediments within the Viaduct Harbour. Sediments sampled did not contain identifiable man-made materials in the coarse (>2 mm) fraction.
- Sediments contained low concentrations of organic carbon and TPH. A number of trace elements (copper, lead, mercury and zinc) were present in elevated concentrations but only mercury was present consistently above its SQGV. Lead concentrations exceeded the SQGV in two samples with one exceeding its SQG-High. TBT was present at variable and elevated concentrations including two samples that exceeded the SQG-High. A number of persistent organic compounds were detected at low concentrations. PAHs were the most common organic compound group measured. Concentrations were below the SQGV in all but one sample but the concentration did not exceed the SQG-High.

Environment and effects

- No ecological effects have been identified in relation to dredging and construction of shore and wharf related facilities.
- Sediment to be dredged contains elevated concentrations of several contaminants and this is likely to restrict its offsite management and disposal.
- Lighting controls may be required to minimise lighting related disturbance of bird species occupying a site at the southern end of the proposed development.
- The construction required at the FFIRF area (wharf piles and breakwater) will have little effect on the e-folding time within Westhaven Marina or the general area close to the proposed facilities. As such, the new facilities should not have any measureable effects on water quality or ecological resources in areas adjacent to the development or within Westhaven Marina.
- Elutriate testing of FFIFR area sediments has shown that, when disturbed or dredged, the sediment will release some constituents to seawater. Of the constituents measured, ammoniacal-nitrogen and dissolved arsenic were released into the water at measureable concentrations. Arsenic concentrations are lower than the ANZECC trigger value. Ammoniacal-nitrogen concentrations required a small amount of dilution to reduce concentrations below the marine water quality trigger. Although no TBT was detected in elutriate, the detection limit is higher than the ANZECC trigger value. Should TBT concentrations be between the detection limit and the trigger value then only a small amount of dilution would be required to ensure concentrations were below trigger values. Overall, no water borne toxicity concerns associated with seabed disturbance were identified from this study.

Monitoring and mitigation

- An observational monitoring programme has been recommended to obtain further information on the numbers of birds utilising the Vos slipway area. This will provide information on variation in bird numbers leading up to the start of construction.
- Although it appears that the two bird species present at the roost site are exposed to some disturbance, it has been recommended that some barrier material (e.g., fence) be installed on the wharf at the closest point to the roost site. This may assist in reducing disturbance especially following the start of normal activity at the wharf.
- It is recommended that options for enhancing high tide roosting and nesting opportunity for coastal bird species within the Waitemata Harbour or providing positive mitigation at other red-bill gull roost and nest locations in the Auckland region be examined.

9.0 LIMITATIONS

Your attention is drawn to the document, “Report Limitations”, as attached. The statements presented in that document are intended to advise you of what your realistic expectations of this report should be, and to present you with recommendations on how to minimise the risks to which this report relates which are associated with this project. The document is not intended to exclude or otherwise limit the obligations necessarily imposed by law on Golder Associates (NZ) Limited, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing

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APPENDIX A

Intertidal and Subtidal Ecology

Ecological assessment of marine assemblages of the Halsey Street Wharf and Viaduct Harbour

Prepared for Paul Kennedy
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December 2017

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Contents

Tables

Figures

Executive summary

An ecological assessment was undertaken of the subtidal and intertidal marine environments in Viaduct Harbour, North Wharf, Halsey Street Wharf and Wynyard reclamation, Waitemata Harbour to describe the structure and composition of biological assemblages present within them. The assessment was required to inform an Environmental Impact Assessment being prepared by Golder Associates (NZ) Ltd. NIWA was contracted to implement a marine survey of biofouling assemblages on wharf piles and other structures within the study area and to describe faunal assemblages in sea-floor sediments in areas proposed for wharf development.

Epibenthic assemblages on the seafloor were described using video imagery. Sediment cores were used to sample the benthic infauna. High resolution video imagery were used to describe the composition of biofouling assemblages on wharf piles, pontoons and permanent wharf structures, and to assess the relative abundance of dominant functional groups of organisms.

Viaduct Basin and surrounding environments (including open water adjacent to the Viaduct Basin entrance and sites located underneath the Viaduct Event Centre):

- Subtidal sediments sites were characterised by soft, silty mud with invertebrate burrows and few mobile or epibenthic fauna. There was a significantly higher number of burrows at the open water sites, compared with underneath the Event Centre, particularly in the Outer Viaduct Basin. Macrofaunal species diversity and richness was significantly higher at the stations located in open water adjacent to the entrance to the Viaduct Basin.

- Biofouling assemblages were significantly different on the pontoons located in the Viaduct Basin, compared with wharf piles, walls or wave panels. At 0 m (MHWS) and 2 m, the wall and pontoon sites in the Viaduct Basin had the highest species abundance and the pontoons had the highest species richness. However at 5 m, all the substrate types (i.e. locations – new piles under the Event Centre, old piles under the Maritime Museum, pontoons and walls in the Viaduct Basin, and the outer facing wave panels)) had relatively high abundance, species richness and diversity.

Wynyard Wharf/North Wharf corner:

- Video transects taken underneath the existing wharf indicated the seabed was composed of anthropogenic rubble, brick and rock with some shell hash. The substrate was dominated by soft silty mud, however relatively few invertebrate burrows were observed.
- The number of burrows present at the North Wharf/Wynyard wharf transect site was significantly higher than any of the other sediment sites. Macrofaunal community composition was not significantly different to the open water or Viaduct Basin sites, but was significantly different to sites located underneath the Event Centre. Species diversity at the North Wharf site was not significantly different to the Viaduct Basin or open water sites, but was different to the Event Centre.

Wynyard wharf reclamation:

-There was a clear vertical zonation visible on the rocky shoreline, with fouling assemblages largely dominated by the Pacific oyster *Magallana (Crassostrea) gigas*. There was no flora or fauna located in the upper littoral zone, a zone which was characterised predominantly by concrete slabs.

1 Introduction

1.1 Objectives

The specific objectives of the assessment were to provide information on:

1. The relative abundances and percentage cover of marine organisms fouling wharf piles, pontoons and permanent wall structures and wave panels in the Outer Viaduct Harbour (referred to as Viaduct Basin in this report).
2. The structure and composition of macrofaunal assemblages in sediments ('infauna') on the seafloor of the Viaduct Basin, in the area immediately outside the entrance to Viaduct Harbour, at North Wharf/Wynyard wharf and underneath the Event Centre.
3. A basic description of the marine community's present between Extreme High Water Springs and Extreme Low Water Spring tide along the Westhaven Reclamation Wall (located between Silo Marina and Wynyard Point).
4. A description of the seabed and communities present in the North Wharf/Wynyard Wharf corner.

1.2 Background

The Waitemata Harbour is a deeply embayed inlet of Hauraki Gulf (Thompson 1981). The central city of Auckland extends along the southern shoreline of the harbour. The harbour is approximately 20 km long from North Head to the upper harbour bridge. Much of the harbour area is less than 5m deep and is composed of mud and fine sand, with a few small areas of course sand/shell/gravel near the centre of the harbour (Hayward et al. 1997). The commercial port is dredged annually (approximately 30,000 cubic meters) to maintain safe passage for merchant shipping.

The Port of Auckland is the largest in New Zealand with continuous wharves and jetties spanning over 2.5 km of the coastline (Inglis et al. 2006a). Westhaven Marina, situated immediately west of the main commercial port, is one of the largest marinas in the southern hemisphere. The Viaduct Harbour (incorporating Hobson West Marina) is nestled within the commercial port area of Freeman's Bay. It includes of a series of interconnected floating docks ('pontoons'), piles and finger piers.

Over recent years the Auckland waterfront has undergone significant development under the control of the Auckland Waterfront Development Agency (as part of the formation of the Auckland Council). These include the Rugby World Cup 2011, the opening of the Wynyard Quarter precinct and Queens wharf facilities, the Viaduct Events Centre and Wynyard Crossing.

This report summarises the results of the intertidal and subtidal surveys of the marine biological assemblages in and around the Viaduct Basin. It provides a description of the assemblages present in specific areas of interest that have undergone development previously and which may be subject to development in the future.

2 Methods

2.1 Subtidal ecology – sediment

2.1.1 Sediment sampling

Sediment cores (10 cm diam. x 15 cm deep) and video transects were taken at four locations (Figure 2-1) to describe the benthic infauna within the survey areas:

- The outer Viaduct Basin (Harbour) (3 stations approximately 30-35m apart),
- Beneath the Viaduct Event Centre (situated on the Halsey Street Extension Wharf) (3 stations approximately 25-30m apart),
- Adjacent to the entrance to the Viaduct Basin (Harbour), on the external side of the Western Viaduct Wharf, in open water (9 stations, approximately 50-60m apart and the outermost sites 200m off the entrance to the Viaduct Basin),
- The North Wharf/Wynyard Wharf corner (one 30 m continuous video transect only, no cores).

Choice of the four locations and sample stations within each was directed by Golder Associates Ltd. Field sampling was undertaken by SCUBA divers between the 16th-22nd November 2017.

Video transects were taken of the seabed at each station to characterise the habitat. Divers swam a complete circle around a central shot line, covering approximately 6 m of seabed. A continuous transect was filmed using a Go Pro 4 camera with video lights held at a fixed distance (20 cm) above the seabed. Five screen grabs were used during the analysis of the video to characterise the habitat. Where possible, digital photographs were also taken of the seabed. However exceptionally low visibility was problematic for the camera strobe.

A continuous horizonal 30 m video transect was also surveyed along the seabed at the North Wharf/Wynyard Wharf site, in an area pre-determined by the client (Figure 2-1). Divers used the same protocol as above, but swam along a transect following a fixed compass bearing. The video camera was held 10 cm above the seabed (10 cm). No digital photography with strobe was possible because of poor visibility.

Four replicate sediment cores were taken at each station (except North Wharf). Individual cores were spaced at least 1m apart on the sea floor. Corers were pushed into the sediment to a depth of 15cm, capped *in-situ* and then placed into a catch bag. Sediments were transferred from the cores into labelled plastic bags on the attending vessel and chilled until they could be processed in the laboratory. Rose Bengal (2%) was added to three samples from each station to stain the invertebrates and ease sorting. Sediments were then sieved using 1mm and 500 µm sieves with the 1 mm fraction retained for identification of macrofauna to the lowest practical level using an optical microscope. The 500 µm fraction was preserved in 50% isopropyl alcohol and stored. The fourth core sample from each station was used for sediment grain size analysis (undertaken by an independent contractor).

Three additional stations were surveyed in the North wharf/Wynyard Wharf location. These stations were included by the Client to characterise the seabed in that area, and note any observations or species of interest. The sites were only accessible by divers entering the water on the open water side of Wynyard Wharf, swimming underneath the Wharf and through to a rock/concrete reclamation wall behind the wharf (Figure 2-2). Divers were not able to exit the water once at the wall in order to characterise intertidal habitats using quadrats, so the transect started at MLWS (0 m).   Divers used the protocol described above, using continuous video held at a fixed distance (10 cm) from the seabed to record from the low tide mark, back underneath the wharf. Five screen grabs, spaced at approximately 2 m intervals, were used for the analysis.

Figure 2-1:   Sample locations for intertidal (wharf piles, pontoons, walls and wave panels), and subtidal surveys (sediment cores and video). Sediment stations were located under the Viaduct Event Centre on the Halsey Street Wharf Extension (Stations 1-3), in an area of open water in Freeman's Bay outside the entrance to the Viaduct Harbour (Stations 4-12), and in the Outer Viaduct Basin (Harbour) (Stations 13-15). An additional 30 m sediment transect was located in the corner of North Wharf and Wynyard Wharf. Intertidal Stations were located in the Outer Viaduct Basin (Harbour) on new wharf piles (Station 1-3), in the Viaduct Basin on old wharf piles (Stations 4-6), and in the Viaduct Basin on pontoons and walls (Stations 7-9). Wave panel sites were located on the external (open water side) of the Western Viaduct Wharf (Stations 1-3). Benthic habitat characterisation was located at the corner of North Wharf and Wynyard Wharf (Stations 1-3).

Figure 2-2: North Wharf / Wynyard Wharf benthic characterisation sites (3 stations) located underneath the Wynyard Quarter Wharf. Arrows indicate diver entry points. Photographs indicate the view from beneath the wharf looking shoreward.

2.2 Intertidal ecology – wharf piles

2.2.1 Intertidal ecology sampling

Fouling assemblages on wharf piles and floating structures were surveyed at 2 locations between the 16th and 22nd November 2017 (Figure 2-1):

- The Outer Viaduct Basin/Harbour (9 stations)
- Wave panels facing open water, adjacent to the entrance to the Viaduct Basin and attached to the Western Viaduct Wharf (3 stations)

Four wharf piles (2 outer piles receiving sunlight, and 2 inner, shaded piles) were surveyed at each station in the Outer Viaduct Basin (Stations 1-6). A continuous video transect was recorded of assemblages on each pile from ~MHWS to 5 m below MHWS. The video camera was held approximately 30 cm away from the wharf pile during recording, to maintain the same scale. Three still-photo quadrats (30 cm by 30 cm) were also sampled on the piles at 0 m (MHWS), 2 m and 5 m depth. Depths were calibrated using a tape measure, with 0 m set at MHWS (not diver depth gauge). Where visibility was low, a series of 4 sub-sample digital photographs was taken inside the PVC quadrat (i.e. approx. 6 cm by 6 cm). Representative samples of dominant taxa were scraped off the substratum and placed into labelled plastic bags by divers. Samples were kept chilled and transported to the laboratory, where they were preserved in either 80% ethanol or 10% formalin (depending on taxa) and identified.

Pontoons (shaded underside) and fixed concrete wall structures (receiving full sunlight) were surveyed at stations 7-9. Two 5 m horizontal transects underneath the pontoons and two 5 m vertical transects were assessed on the concrete walls, at each station. At 0 m, 2 m and 5 m, a 30 cm by 30 cm quadrat was placed on the substratum and digital photographs were taken along each transect (horizontally under the pontoons and vertically on the walls). Where visibility was too low, a series of smaller quadrats (as above) was taken. Video was taken along both the horizontal and vertical transects. Samples of dominant taxa were also taken for later identification (as above).

Concrete wave panels on the outer side of the Viaduct Basin were also surveyed (Figure 2-1). The panels consisted of flat, vertical concrete surfaces designed to attenuate wave action under the wharf and into the Viaduct Basin. Each panel was approximately 4 m wide and between 2-5 m deep (depending on whether it panel was attached to the outside or inside of the wharf piles). Panels ran the length of the outer surface of the Wharf. Only wave panels which were on the outside of the wharf piles were surveyed, these panels were attached down to the sea floor (~5 m). Three stations (from three different panels) were surveyed. Each station consisted of two vertical transects from MHWS to the 5 m below MHWS. Screen grabs were taken from each transect at 0 m, 2 m and 5 m. Representative samples of dominant species were scraped from the wall and placed into labelled bags underwater. Samples were kept chilled until transportation to the laboratory, where they were preserved with either 80% ethanol or 10% Formalin (depending on taxa) and identified.

2.3 Westhaven reclamation wall

Photographs were taken of the shoreline along a reclamation wall located on the western side of Wynyard Wharf (Figure 2-3). Four transects were run from the littoral zone (defined as the high shore area, Stephenson and Stephenson 1972), down the shore to the lower eulittoral zone (i.e., water's edge at low tide). A single 1m x 1m quadrat was sampled in the littoral zone (high), middle of the eulittoral zone (mid) and lower edge of the eulittoral zone (low) on the shore line. Dominant organisms were identified and relative abundances estimated by image analysis (Section 2.4).

Figure 2-3: Location of transects taken between Mean High Water Springs and Mean Low Water Springs, along the western side of the Wynyard reclamation wall.

2.4 Image analysis

Still-images were analysed with ImageJ 1.47h, a Java-based program that measures a user-defined selection of an area within an image. Where still-images were not available, frame grabs were taken from GoPro video transects using VLC media player 2.0.7 Twoflower. Frame grabs were analysed using the same ImageJ software. A frame grab was captured every 30 seconds within a video transect although this depended on video quality and diver swimming speed. If the quality of the image was poor, a frame grab 5 seconds before or after the 30-second mark would be assessed for suitability. A scale bar was set on ImageJ based on images where the 30 x 30 cm PVC quadrat was visible, or else an estimated distance was used when it was not possible to have the quadrat as a measurement tool due to limitations with water clarity. The total area of the still-images was measured once a scale bar was determined. Selected areas of interest (i.e., *in-situ* plants or animals) were then calculated based on the set scale. The percentage cover of determined taxa found on the still-images was calculated from the selected areas of interest and total area of the still-images.

2.5 Statistical Analysis

Multivariate analyses (PRIMER-E, Clarke and Warwick 2001) were carried out in order to identify whether the various pre-determined locations (and/or substrates) or depths had differing macrofaunal fouling assemblages (from intertidal stations). A non-multidimensional scaling (nMDS) plot of Bray Curtis similarities of log transformed data was used to give a two-dimensional representation of the relative similarities or dissimilarities of each sample site. The closer two sites are to each other in the plot the more similar they are with respect to community structure. The key taxa contributing to within group similarity and between group dissimilarity were identified using the SIMPER routine within E-PRIMER. An ANOSIM (analysis of similarity) routine within PRIMER-E tested for differences in assemblage structure between locations.

For macrofaunal stations, data were tested for homogeneity in sample variances using Cochran's C (a one-sided upper limit of variance outlier test). If heterogeneous, then the data was ln(x+1) transformed. A nested ANOVA was used for unequal samples in which Stations were nested within the Location factor (F-ratios are quasi F-values because of unbalanced samples). A Student-Newman-Keuls method was used to identify sample means (i.e., burrow numbers at Event Centre vs Viaduct Basin vs Outside Viaduct) which were significantly different from each other. SNK tests were not done on significant Station terms, since the stations were nested random factors.

3 Results

3.1 Intertidal Ecology – wharf piles, pontoons and walls

3.1.1 Biofouling identification

A total of 27 dominant biofouling organisms were identified from the samples removed from wharf piles, pontoons, walls and wave panels (Table 3-1). These species were recognisable from the image analysis and identifications were confirmed taxonomically from samples removed during the survey.

3.1.2 Abundant biofouling taxa

Barnacles

Autrominius modestus (Darwin, 1854) was the dominant barnacle present in all locations, on all substrate types (i.e. wharf piles, pontoons, walls and wave panels) and occupied between 70-100% of the available substrate in the 0 m quadrats on wharf piles within the Viaduct Basin and the wave panels. Widely distributed around New Zealand and Australia, this indigenous barnacle is often found in high densities on sheltered rocky shores and in ports and harbours (Carson and Morris 2017). *A. modestus* is able to survive in water with low current flow, low salinity and high turbidity. It readily settles on artificial substrates, wharf piles, pontoons and on other species such as oysters.

Bivalves

The dominant oyster was the non-indigenous *Magallana (Crassostrea) gigas* (Thunberg, 1793), occupying 100% of the available substrate on wharf piles and walls (mainly at 2 m and 5 m) in the Viaduct Basin and between 70-100% of the wave panel substrate within the 0 m and 2 m quadrats. This oyster is native to Japan and China Seas and the north-west Pacific. It has been introduced to the west coast of both North and South American the West Africa coast, the northeast Atlantic the Mediterranean, Australia, New Zealand, Polynesia and Micronesia. It is cryptogenic in Alaska. *Magallana (Crassostrea) gigas* will attach to almost any hard surface in sheltered waters. Whilst they usually attach to rocks, the oysters can also be found in muddy or sandy areas and will settle readily on other oysters of the same or different species. *M. gigas* has been present in New Zealand since the early 1960s, and little is known about the impacts of this species. However, it is now a dominant structural components of fouling assemblages (Inglis et al. 2006a). *M. gigas* was found in dense aggregations in the intertidal and shallow subtidal zones at all sites surveyed.

Sponges

A variety of sponges were identified from the intertidal surveys. The abundance of each species was variable, at both location and depth.

Haliclona parietalioides (Bergquist, 1961) is an intertidal sponge first described from the shores of Rangitoto Island, Hauraki Gulf. It is a relatively common species around northern New Zealand, and known from all the major North Island Harbours, and Picton in the South Island.

Mycale (*Carmia*) *tasmani* Bergquist & Fromont, 1988, was first described from the Maui A Platform near New Plymouth and has since been collected from most of the major ports and harbours around New Zealand. Both *M. tasmani* and *H. parietalioides* are considered indigenous to New Zealand. They have both been collected previously from Westhaven Marina and the Viaduct.

Haliclona n. sp. 3 (120-140, digitate), *Haliclona* n. sp. 5 (clubby fan, 100) and *Paraesperella* n. sp. 1 (thin encrusting), are undescribed species known from most of the major ports and harbours around New Zealand. They are considered indigenous to New Zealand and have been collected previously from Westhaven Marina and the Viaduct.

Callyspongia ramosa (Gray, 1843) is considered indigenous to New Zealand. *C. ramosa* is considered to be one of the most common sponges in New Zealand coastal waters and has also been recorded from southern parts of Australia.

Hymedesmia microstrongyla Bergquist & Fromont, 1988 was first described from the Waitemata Harbour. Like *C. ramosa*, it considered indigenous and is found predominantly around the North Island.

Toxadocia toxophora (Hentschel, 1912) was first described by Bergquist & Warne (1980) from Rangitoto Island in the Hauraki Gulf. The sponge is uncommon and has not been re-collected since it was first described. The sponge was originally described as *Gellius toxophorus* from Aru Island in the tropical Malay Archipelago by Hentschel (1912). However, the record from Rangitoto has most likely been incorrectly named as there are only a few deep-water New Zealand species that share a southeast Asian distribution. Species in family Chalinidae are difficult to differentiate because of the uniformity of several characters. We consider this specimen to be indigenous and until further work is carried out, this species is correctly identified as *Haliclona* (*Gellius*) '*toxophora'* (Hentschel, 1912) sensu Bergquist & Warne (1980).

Carmia macilenta (Bowerbank, 1866) was first described by Bergquist & Fromont (1988) from Muriwai Beach, West Coast of Auckland, and Ladies Bay in the Waitemata Harbour. We consider the New Zealand specimens named *Carmia macilenta* to be indigenous, and quite possibly synonymous with *Mycale* (*Carmia*) *tasmani*. Until further work is carried out, this species is correctly identified as *Mycale* (*Carmia*) '*macilenta'* (Bowerbank, 1866) sensu Bergquist & Fromont (1988).

Crella incrustans (Carter, 1885) sensu Bergquist & Fromont (1988) was first described from Port Philip Heads, South Australia, and is extremely common throughout New Zealand coastal waters in a range of habitats. It is known from a majority of the New Zealand ports and harbours but has not been collected in the Waitemata Harbour prior to this survey.

Ascidians

Two abundant solitary ascidian genera were recorded from the wharf piles, pontoons, wave panels and walls. These were the cryptogenic *Cnemidocarpa* sp. and *Pyura* sp. Cryptogenic species are those defined as species which have previously been recorded from New Zealand whose identity as either native or non-indigenous is ambiguous. In some cases, there is insufficient systematic or biogeographic information to determine whether New Zealand is within their native range. *Cnemidocarpa* sp. is in the family Styelidae, and two closely related species are present in this area, *C. nisiotus* and *C. bicornuta*. Both species are very common in ports, harbours and coastal environments and are known to co-occur together (Millar, 1982). *Pyura* sp. is a group of closely related species that cannot be easily distinguished in the field due to their physical similarity, belonging to the family Pyuridae. Species in this family include *P. rugata*, *P. subuculata* and *P. cancellata*. All 3 species can be found growing attached to shell debris, on the seabed, or fouling wharf piles, widely distributed around New Zealand. *Pyura* sp. can easily be confused for *Cnemidocarpa* sp.

One specimen of the indigenous solitary ascidian *Corella eumyota* Traustedt, 1882, was identified from a wharf pile. This species is found in shallow, subtidal environments attached to wharf piles, ropes and other submerged structures.

The most dominant colonial ascidian was the cryptogenic *Aplidium phortax* (Michaelsen, 1924). This creamy/yellow colonial ascidian is commonly found fouling wharf piles and structures in ports and harbours and occurs widely throughout New Zealand.

The non-indigenous *Symplegma brakenhielmi* (Michaelsen, 1904) was recorded from one concrete wall in the Viaduct Basin (approximately 5% cover). This colonial ascidian belongs to the family Styelidae and is an encrusting species. Native to the Pacific and Indian Oceans (Kott 1985), it has become widely established globally including Bermuda, U.S.A, Jamaica, Peurto Rico, Gua Guadeloupe, Mexico, Belize, Panama, Brazil, Senegal, Ghana, Hawaii, Guam, Arabian Gulf, Australia, New Caledonia and Israel. This species was first detected in New Zealand in 2015, from Marsden Cove and subsequently in Auckland in 2016. This species was recorded from several sites in the Viaduct Basin (inner and outer) and Wynyard Wharf area (and throughout the Waitemata) during MPI NIWA Marine High-Risk Site Surveillance Program during 2016-2017.

Colonial ascidians in the genus *Didemnum* were observed from wharf pile, pontoon and walls within the Viaduct Harbour. This species complex is a group of closely related species that cannot be easily distinguished in the field due to their physical similarity. Species in this complex may include *D. vexillum*, *D. incanum*, *D. maculatum* and *D. lambitum* (Kott 2001). This species complex commonly foul boat hulls, undersides of floating structures, marine farms, sea cages and wharf piles around New Zealand.

The colonial, cryptogenic ascidian *Botrylloides leachii* (Savigny, 1816) was recorded from the concrete walls and pontoons in the Viaduct Basin. This species is very common in ports and harbours throughout New Zealand, fouling wharf piles, pontoons and jetties. The colonies are easily distinguished by parallel systems of zooids and lighter pigmentation around the inhalant apertures (often giving the appearance of tiny star or flower shapes).

Hydroids

The non-indigenous hydroid, *Pennaria disticha* Goldfuss, 1820, was identified from underneath the pontoons in the Viaduct Basin. This hydroid forms large colonies and the branches are overgrown with diatoms and algae, making them appear muddy brown and tufty in appearance. *P. disticha* attaches to artificial substrates and is a very common fouling organism in ports and harbours. Native to the north east Atlantic, it now occurs in tropical and subtropical seas around the world (Cranfield et al. 1998), and has been present in the Waitemata harbour since at least 1928.

The endemic *Solanderia ericopsis* (Carter, 1873) was identified from a single wharf pile station. Commonly known as tree hydroids, this species can form very large colonies which are usually fan-shaped but can be bushy (Schuchert 1996).

Bryozoans

Bugula neritina (Linnaeus, 1758) was identified from both the wave panels, wharf piles and walls. This non-indigenous bryozoan has an erect, bushy form and typically red-purple-brown in colour. Native to the Mediterranean Sea, it has been introduced to most of North America, Hawaii, India, the Japan and China Seas, Australia and New Zealand. It is now one of the most common bryozoans in ports and harbours and forms an important part of the fouling community (Gordon and Matawari 1992).

Polychaetes

The Mediterranean fan worm *Sabella spallanzanii* (Gmelin, 1791) was recorded from wharf piles, pontoons, concrete walls and along the wave panels. This non-indigenous fan worm is widely distributed through the Waitemata Harbour and well established in the survey area. Native to the north eastern Atlantic Ocean and the Mediterranean Sea, it has spread globally to Europe, South America, South Africa, Australia and into New Zealand in 2008 (Read et al. 2011).

Table 3-1: Summary of species identified from wharf piles, pontoons, concrete walls and wave panels in the Viaduct Basin. Station codes are described in Figure 2-1.

Taxa	Taxon Information	Pile/pontoon/wall	Wave panel	Biosecurity Status
		Stations	Stations	
Cnemidocarpa sp. Huntsman, 1913	Ascidiacaea	1, 2, 3, 4, 5, 6, 7, 8, 9	1, 2, 3	Cryptogenic
Pyura sp. Molina, 1782	Ascidiacaea	1, 2, 3, 4, 5, 6		Cryptogenic
Aplidium phortax (Michaelsen, 1924)	Ascidiacaea	1, 2, 3, 4, 5, 6, 7, 8, 9	1, 2, 3	Cryptogenic
Didemnum sp. Savigny, 1816	Ascidiacaea	4, 6, 7, 8, 9,		Indeterminate
Corella eumyota Traustedt, 1882	Ascidiacaea	7		Indignous
Symplegma brakenhielmi (Michaelsen, 1904)	Ascidiacaea	7		Non-indigenous

Botrylloides leachii (Savigny, 1816)	Ascidiacaea	7, 8, 9		Cryptogenic
Colonial ascidian	Ascidiacaea		1, 2	Indeterminate
Magallana (Crassostrea) gigas (Thunberg, 1793)	Bivalvia	1, 2, 3, 4, 5, 6, 7, 8, 9	1, 2, 3	Non-indigenous
Bugula nertina (Linnaeus, 1758)	Bryozoa	3, 7, 9	3	Non-indigenous
Austrominius modestus (Darwin, 1854)	Cirrpedia	1, 2, 3, 4, 5, 6, 7, 9	1, 2, 3	Indigenous
Haliclona n sp. 3	Demospongiae	1, 2, 3, 4, 5, 6, 7, 8, 9	3	Cryptogenic
Haliclona n sp. 5	Demospongiae	2, 3, 4, 5		Cryptogenic
Hymedesmia microstrongyla Bergquist & Fromont, 1988	Demospongiae	1, 2, 3, 5, 6, 7, 8, 9		Indigenous
Crella incrustans (Carter, 1885)	Demospongiae	1, 2, 3, 4, 5, 6, 7, 8, 9		Cryptogenic
Mycale (Carmia) macilenta (Bowerbank, 1866) sensu Bergquist & Fromont (1988).	Demospongiae	3, 5, 6, 7, 8, 9	3	Non-indigenous
Haliclona parietalioides (Bergquist, 1961)	Demospongiae	3, 6, 7, 8, 9,	1, 2, 3	Indigenous
Chondropsis sp. Carter, 1886	Demospongiae	4, 5, 6, 9		Indeterminate
Clathrina sp. Gray, 1867	Demospongiae	6, 7, 8		Indeterminate
Callyspongia ramosa (Gray, 1843)	Demospongiae		1, 3	Indigenous
Mycale (Carmia) tasmani Bergquist & Fromont, 1988	Demospongiae		1, 2, 3	Indigenous
Halichondria (Gellius) 'toxophora' (Hentschel, 1912) sensu Bergquist & Warne (1980).	Demospongiae		3	Non-indigenous
Paraesperella n sp 1	Demospongiae		3	Cryptogenic

Solanderia ericopsis (Carter, 1873)	Hydrozoa	6		Indignous
Pennaria disticha Goldfuss, 1820	Hydrozoa	7, 8		Non-indigenous
Sabella spallanzanii (Gmelin, 1791)	Polychaeta	1, 2, 3, 7, 8, 9	1, 2, 3	Non-indigenous
Red algae	Rhodophyceae	4		Indeterminate

3.1.3 Image analysis

Intertidal fouling communities were surveyed based on substrate type within the Outer Viaduct Basin (i.e. new piles located under the Viaduct Event Centre ('new piles'), old piles located underneath the Maritime museum ('old piles'), pontoons and walls within the Viaduct basin ('pontoons and walls'), and the externally facing wave attenuation panels ('outer wave panels'). The fouling communities were assessed (percentage cover) at three depths (0m, 2m, and 5m below MHWS).

Multivariate analyses (PRIMER-E, Clarke & Warwick 2001, Clarke and Warwick 1994) were carried out in order to identify trends in macrofaunal assemblages between locations/substrates and depths. An ANOSIM routine showed significant differences between fouling assemblages at different locations, substrates and depths (Global R = 0.097 (0.1%), 0.123 (0.1%), and 0.48 (0.1%) respectively). Due to the differences between depths, the fouling assemblages at and between each location/substrate have been described separately for each depth.

Analysis of community assemblage by depth – 0 m (MHWS)

At 0 m MHWS, the wall and pontoon sites (in the Outer Viaduct Basin) had the highest abundance (percentage cover), and the pontoons had both the highest species richness (S) and diversity (Figure 3-1). The lowest species richness was recorded underneath the Event Centre, the old piles under the Maritime Museum, the wall in the Viaduct Basin, and the wave panels.

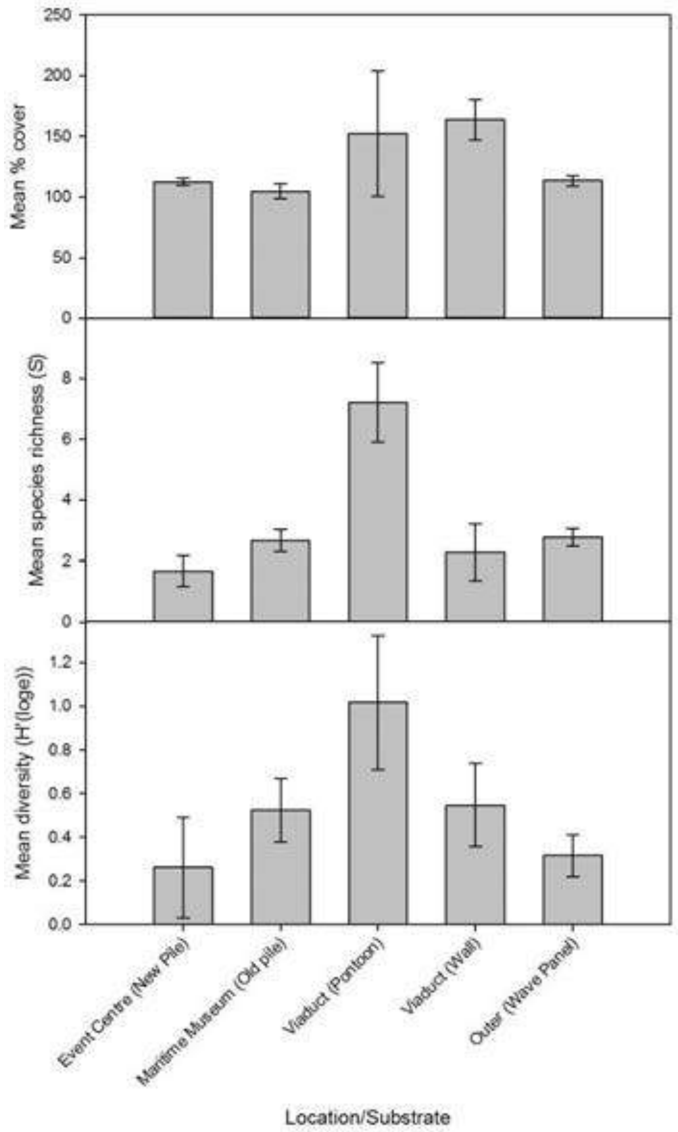


Figure 3-1: Mean percentage cover, species richness and Shannon diversity (H') of intertidal fouling at the sample locations at 0 m (MHWS). Error bars represent 95% confidence intervals.

An nMDS plot of Bray Curtis similarities of log transformed data (Figure 3-2) gives a two-dimensional representation of the relative similarities or dissimilarities of the community structure from selected locations/substrates. Data points are colour coded for substrate type. The plot shows that wall and pontoon substrates support quite different community assemblages to the other substrates (new piles, old piles, wave panels at Event centre, Maritime museum and Outer locations respectively).

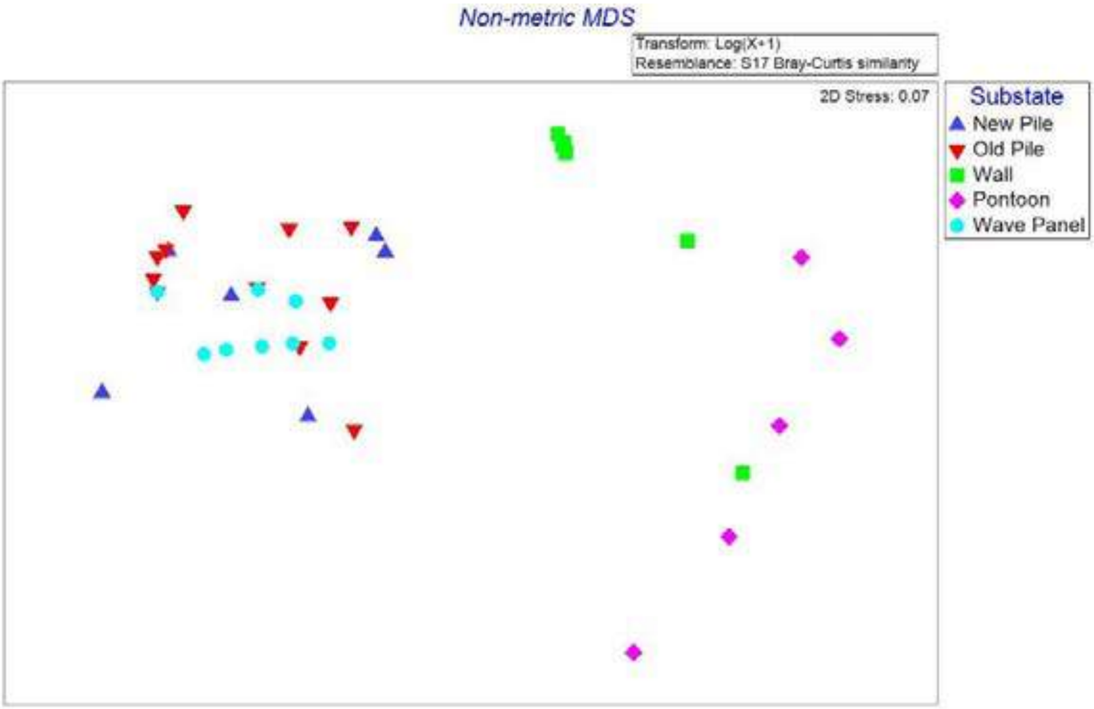


Figure 3-2: Nonmetric multidimensional scaling (nMDS) ordination of the intertidal fouling assemblages on each of the sample substrates at 0 m (MHWS). Substrates were correlated with location. New pile, the Event Centre; Old pile, under the Maritime Museum; Wall, permanent concrete wall structures in the Viaduct Basin; Pontoon, floating pontoons located in the Viaduct Basin; Wave panel, externally facing concrete wave panels exposed to the open water.

An ANOSIM routine showed significant differences between fouling assemblages at different locations/substrates at depth = 0 m (Global R = 0.595 (0.1%). The greatest differences in community structure were between assemblages on the Viaduct Basin wall and those on piles (Event Centre and Maritime Museum) and wave panels (Outer) (Table 3-2). Biofouling assemblages on the pontoons in the Viaduct Basin were also compositionally distinct from those on the piles and wave panels and from assemblages on the Viaduct Basin wall. There was no significant difference between the biota on the older piles beneath the Maritime Museum and the wave panels (outer).

Table 3-2: Pairwise comparisons of fouling assemblages on old piles, new piles, pontoons, walls and wave panels at 0 m depth (MHWS). Data are R-values from an Analysis of Similarities (ANOSIM) of the sites. Values of R range from 0 (100% similarity) to 1 (100% dissimilarity). Permutated significance levels for the R statistics (%) are depicted in brackets, with significantly different assemblages (at 0.1%) indicated by asterisks.

Depth 0 m **R = 0.595 (0.1%)**				
	Event centre (new pile)	Maritime Museum (old pile)	Viaduct Basin (wall)	Viaduct Basin (pontoon)
Maritime Museum (old pile)	0.299 (0.3)			
Viaduct Basin (wall)	0.917 (0.1)	0.949 (0.1)		
Viaduct Basin (pontoon)	1 (0.1)	1 (0.1)	0.762 (0.1)	
Outer (wave panel)	0.292 (0.7)	0.085 (11)	0.954 (0.1)	1 (0.2)

The key taxa contributing to differences between the biotic assemblages at the difference locations are presented in Figure 3-3. The Event Centre (new piles), Maritime Museum (old piles) and outer wave panels all had high abundances of the barnacle *Austrominius modestus*. *A. modestus* was absent from the Viaduct Basin wall and Viaduct Basin pontoon sites. Conversely, the Viaduct Basin wall and Viaduct Basin pontoon sites had large densities of the Pacific oyster, *Magallana* (*Crassostrea) gigas*, which was only present in small numbers at the Event Centre (new piles), Maritime Museum (old piles) and wave panel sites. The solitary ascidian *Cnemidocarpa* sp., colonial ascidians *Aplidium phortax* and *Botrylloides* sp., and sponges *Haliclona* n sp. 3 and *Mycale macilenta* were only present on the pontoons.

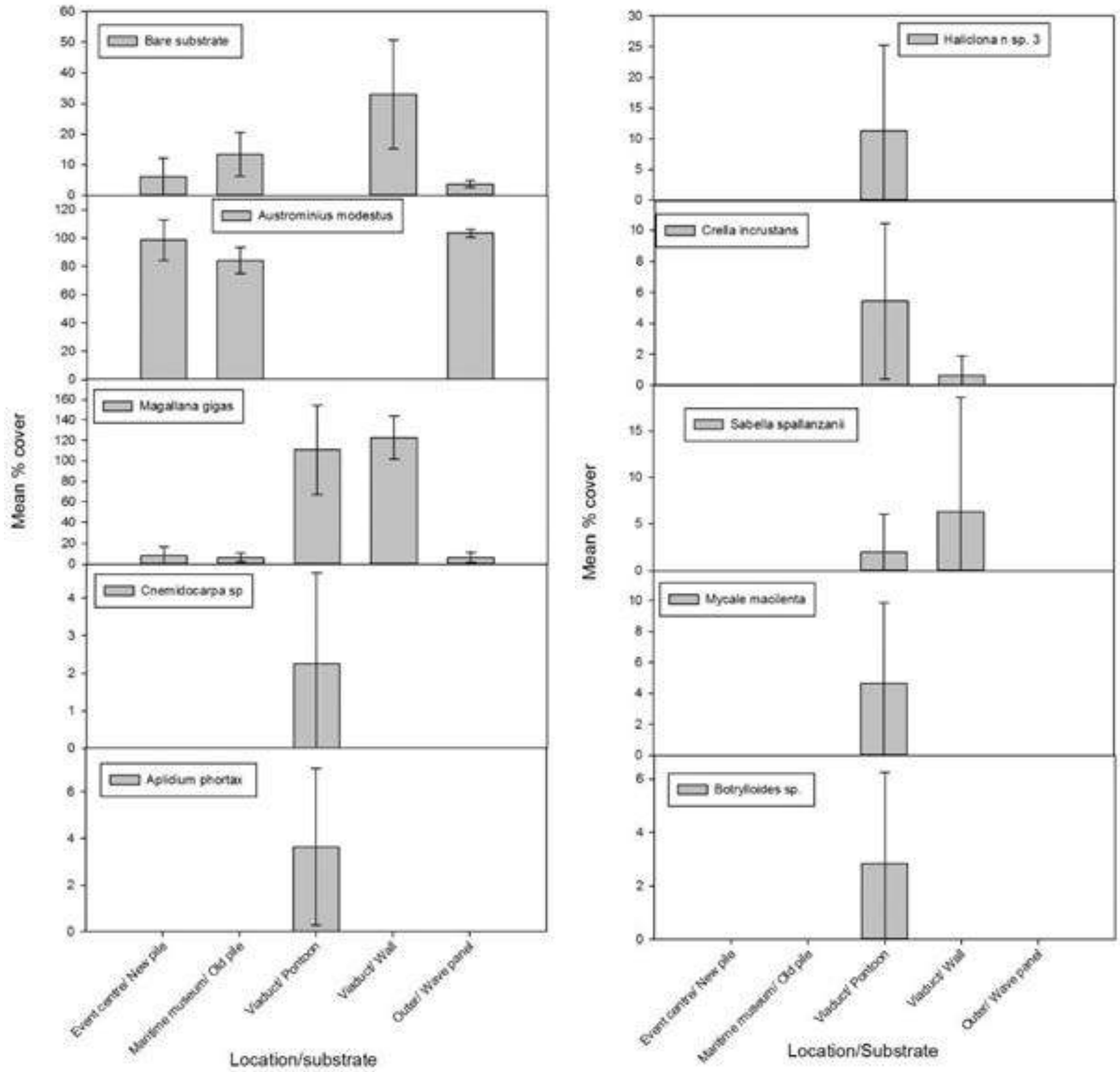


Figure 3-3: Mean (+ 95% C.I.) abundance of species that contributed most to differences among locations at 2 m depth. Dominant taxa within each location and those that contributed >5% dissimilarity among locations are included.

Analysis of community assemblage by depth – 2 m below MHWS

At 2m depth, the greatest percentage cover was recorded from the pontoon stations. Assemblages on the pontoons had the highest species richness (S) and diversity (Figure 3-4).

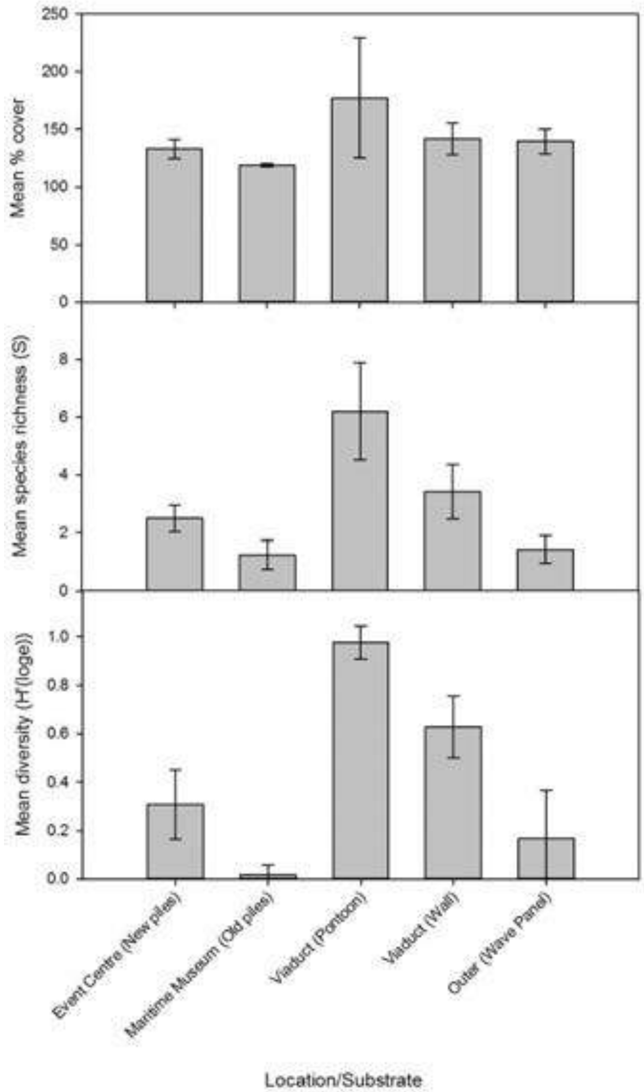


Figure 3-4: Mean percentage cover, species richness and Shannon diversity (H') of intertidal fouling at the sample locations at 2 m depth. Error bars represent 95% confidence intervals.

An nMDS plot of Bray Curtis similarities of log transformed data (Figure 3-5) showed that the community structure diverged between the four locations sampled. There were significant differences in assemblage structure between all pairs of locations, except between the Event centre (new piles) and the wave panels (outer) (Table 3-3).

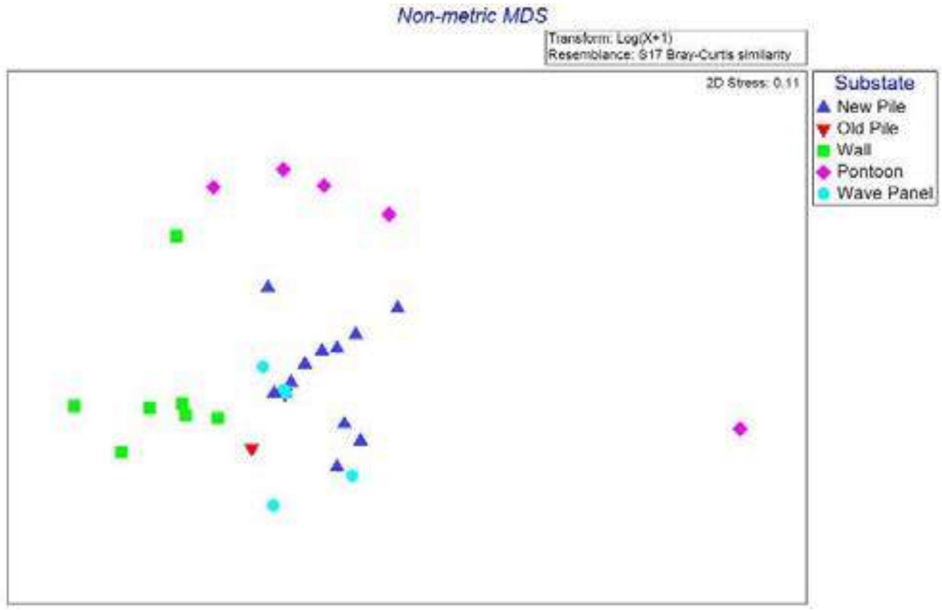


Figure 3-5: Nonmetric multidimensional scaling (nMDS) ordination of the intertidal fouling at each of the sediment sample stations at 2 m depth. Sites were located underneath the Event Centre, in Open Water adjacent to the Viaduct Basin entrance, and within the Viaduct Basin.

Table 3-3: Pairwise comparisons of fouling assemblages on old piles, new piles, pontoons, walls and wave panels at 2 m depth. Data are R-values from an Analysis of Similarities (ANOSIM) of the sites. Values of R range from 0 (100% similarity) to 1 (100% dissimilarity). Permutated significance levels for the R statistics (%) are depicted in brackets, with significantly different assemblages (at 0.1%) indicated by asterisks.

Depth 2 m **R = 0.484 (0.1%)**				
	Event centre (new pile)	Maritime Museum (old pile)	Viaduct Basin (wall)	Viaduct Basin (pontoon)
Maritime Museum (old pile)	0.246 (0.1)			
Viaduct Basin (wall)	0.723 (0.1)	0.826 (0.1)		
Viaduct Basin (pontoon)	0.806 (0.1)	0.916 (0.1)	0.69 (0.1)	
Outer (wave panel)	0.037 (24)	0.439 (0.1)	0.627 (0.1)	0.853 (0.2)

ANOSIM pairwise tests

The mean abundances of key taxa that contributed to these differences among the locations are presented in Figure 3-6. The Pacific oyster, *M. gigas*, was abundant at all locations, but densities were more variable within the sites in Viaduct (walls or pontoons). The ascidian *Cnemidocarpa* sp. was only present at the Viaduct sites (wall and pontoon). The sponges *Haliclona* n sp. 3, *Hymedesmia microstrongyla* and *Mycale macilenta* were dominant on the pontoon, compared with other substrates. The ascidian *Cnemidocarpa* sp. was present on both the pontoons and walls, and *Aplidium phortax* were present on the pontoons and the new piles. The Viaduct wall was the only site to have bare substrate, though this was heavily fouled with mud and silt.

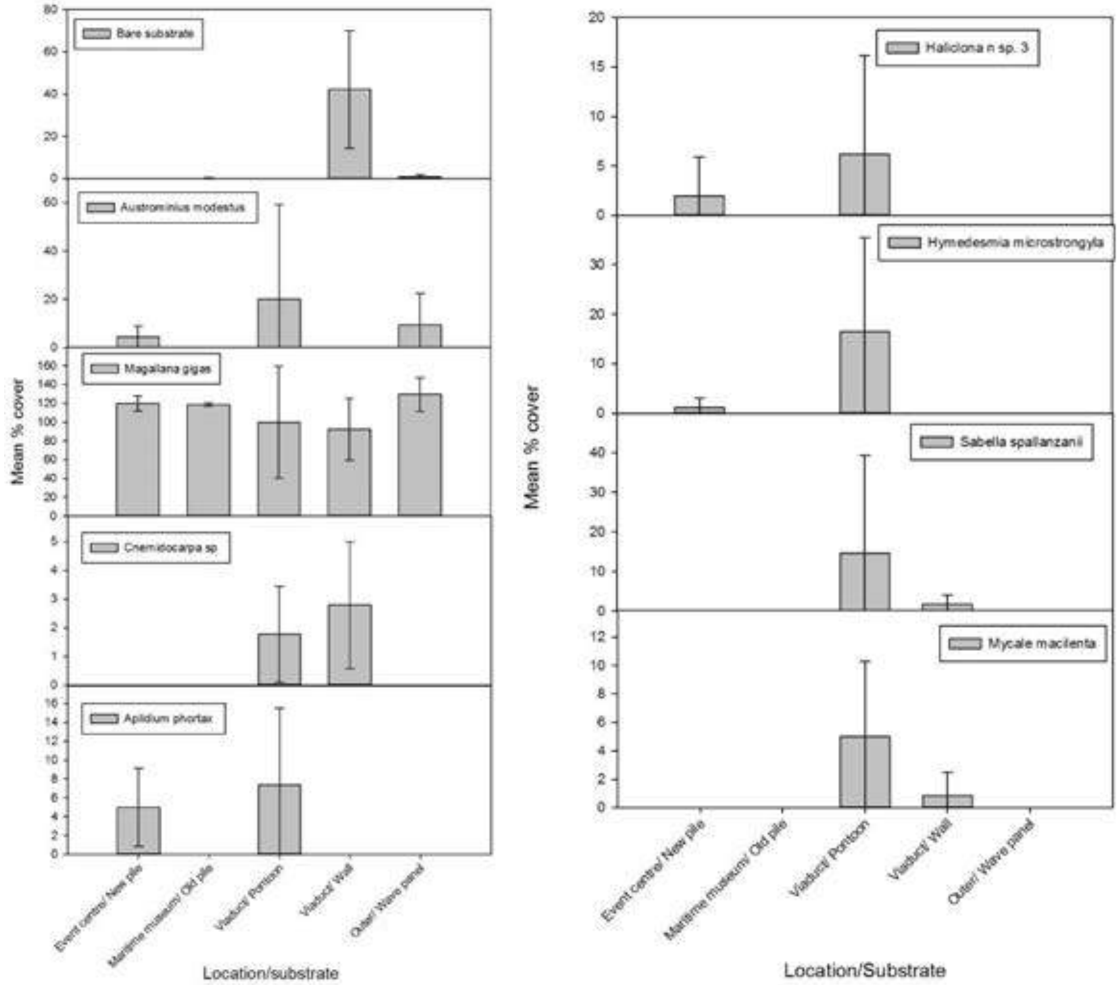


Figure 3-6: Mean (+ 95% C.I.) abundance of species that contributed most to differences among locations at 2 m depth. Dominant taxa within each location and those that contributed >5% dissimilarity among locations are included.

Analysis of community assemblage by depth – 5 m

At 5 m, all location/substrate groups had high percentage cover, with no bare substrate. (Figure 3-7). The viaduct wall and outer wave panels had significantly lower N than the new piles and old piles (CHECK with ANOVA) and the Outer wave panel had a significantly lower diversity (H'(loge)) than the other locations/substrates. (CHECK WITH ANOVA).

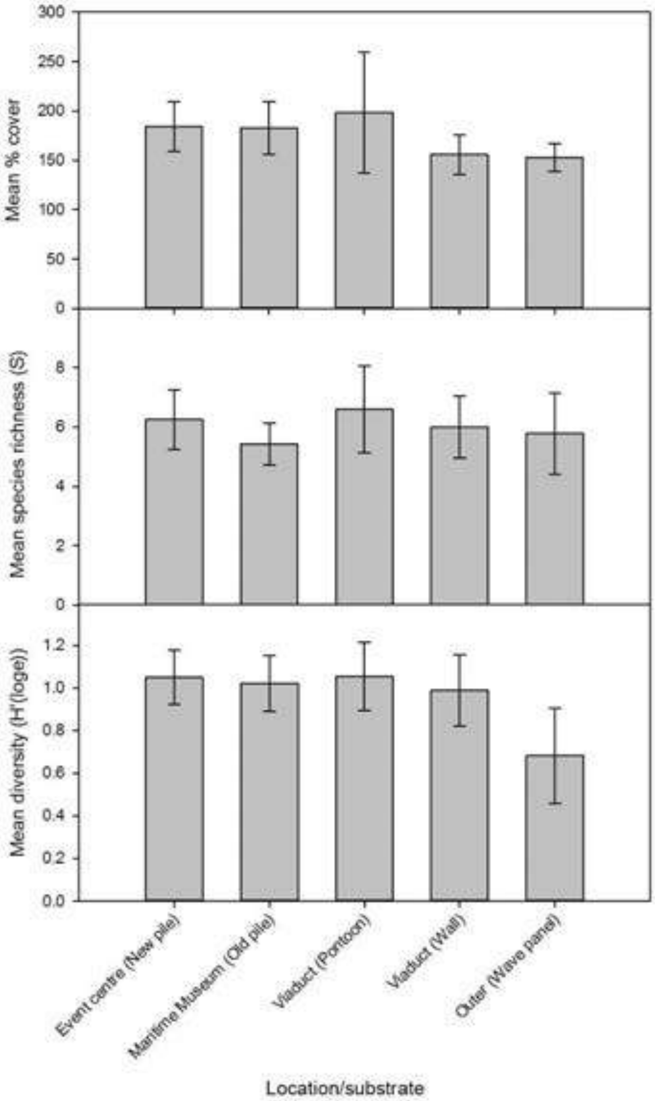


Figure 3-7: Mean percentage cover, species richness and Shannon diversity (H') of intertidal fouling at the sample locations at 5 m depth. Error bars represent 95% confidence intervals.

An nMDS plot (Figure 3-8) shows the relationship between the community structure at each location/substrate data point. Wall (Viaduct), wave panel (Outer) and new pile (Event centre) all cluster relatively tightly, with old pile (maritime museum) and pontoon (Viaduct) more scattered throughout the plot.

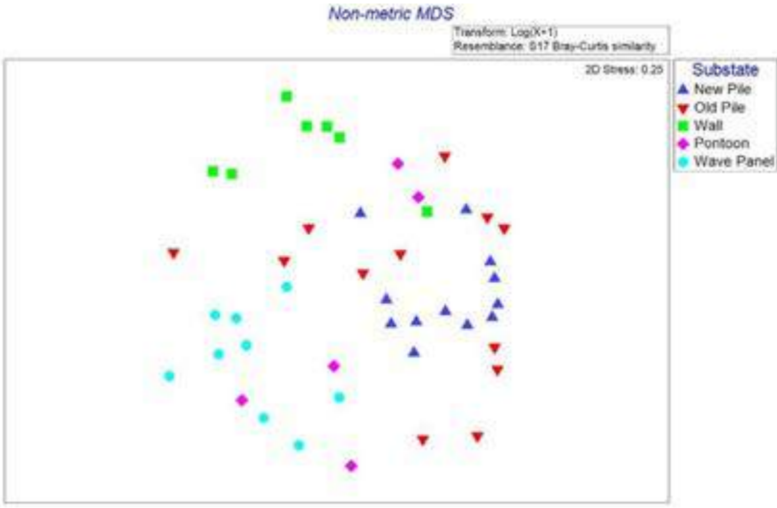


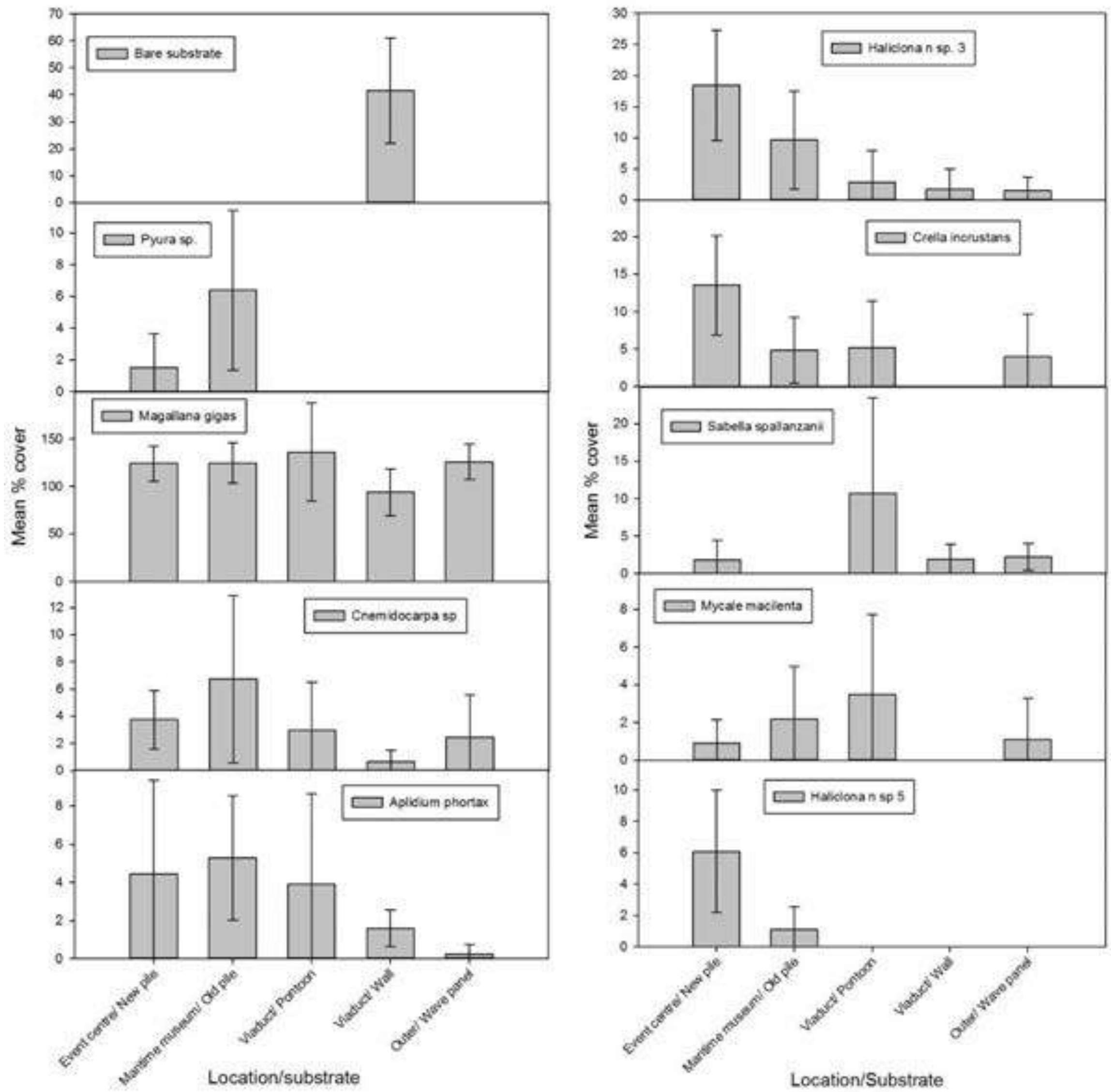
Figure 3-8: Nonmetric multidimensional scaling (nMDS) ordination of the intertidal fouling at each of the sediment sample stations at 5 m depth. Sites were located underneath the Event Centre, in Open Water adjacent to the Viaduct Basin entrance, and within the Viaduct Basin.

An ANOSIM routine showed significant difference between substrates/locations (Global R = 0.6 (0.1%)). Pairwise tests (Table 3-4) show all pairs to be significantly different except for viaduct/pontoon vs outer/wave panel. The greatest differences were between new pile (event centre) and wall (viaduct), new pile and wave panel (outer), and wall and wave panel.

Table 3-4: Pairwise comparisons of fouling assemblages on old piles, new piles, pontoons, walls and wave panels at 5 m depth. Data are R-values from an Analysis of Similarities (ANOSIM) of the sites. Values of R range from 0 (100% similarity) to 1 (100% dissimilarity). Permutated significance levels for the R statistics (%) are depicted in brackets, with significantly different assemblages (at 0.1%) indicated by asterisks.

Depth 5 m **R = 0.6 (0.1%)**				
	Event centre (new pile)	Maritime Museum (old pile)	Viaduct Basin (wall)	Viaduct Basin (pontoon)
Maritime Museum (old pile)	0.354 (0.1)			
Viaduct Basin (wall)	0.835 (0.1)	0.681 (0.1)		
Viaduct Basin (pontoon)	0.596 (0.1)	0.356 (0.3)	0.567 (0.4)	
Outer (wave panel)	0.823 (0.1)	0.614 (0.1)	0.836 (0.2)	0.48 (1)

The mean abundances of key characterising taxa, identified using a SIMPER routine, are given in Figure 3-9. All groups had relatively high mean abundances of the oyster *M. gigas*. Unlike at the 2m depth strata, *Cnemidocarpa* sp. was present in all groups, and with a highest abundance at the maritime museum/old piles. The ascidian *Pyura* sp and the sponge *Haliciona* n sp. 5 were only present on the new and old piles at the event centre and maritime museum respectively and the viaduct wall was the only group to have bare substrate within the transects. Unlike the 0 m and 2 m depths, *Cnemidocarpa* sp., *A. phortax* and *Haliclona* n sp. 3, was present on all the substrates. The sponges *Crella incrustans* and *Mycale macilenta* were present on all the substrates except the Viaduct wall and *Haliclona* n sp. 5 was abundant on the new piles. The fan worm *Sabella spallanzanii* was present on all substrates except the old piles.



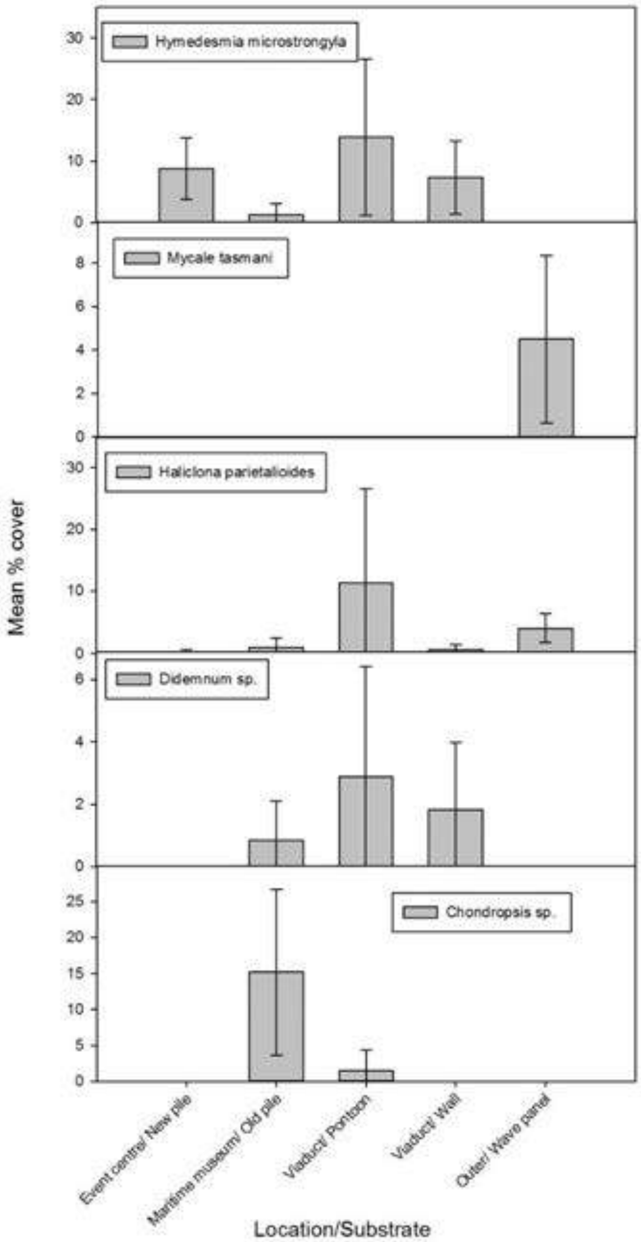


Figure 3-9: Mean (+ 95% C.I.) abundance of species that contributed most to differences among locations at 5 m depth. Dominant taxa within each location and those that contributed >5% dissimilarity among locations are included.

3.2 Subtidal Ecology – sediments

3.2.1 Image Analysis

Sediment stations

The dominant sediment type at each of the locations (Outer Viaduct Basin, open water adjacent to Viaduct Basin entrance, North Wharf/Wynyard Wharf transect site (as shown in Figure 2-1) and under the Viaduct Event Centre) consisted of soft, silty mud, with invertebrate burrows and holes the most dominant sign of animal life. In contrast, the North Wharf site located at the corner of Wynyard Wharf and North Wharf (underneath a wharf and against a rock wall, Figure 2-2) was quite different, consisting mainly of broken rubble, some patches of sand, and broken rock.

The mean density of burrows at each location (Event Centre, Viaduct basin, open water adjacent to Viaduct entrance, and at North Wharf) was standardised per 0.067 m^2 and plotted (Figure 3-10). Results indicated there were significantly more burrows present in the open water sites (i.e. the open water adjacent to the Viaduct Basin entrance, the Viaduct Basin and at the North Wharf/Wynyard Wharf) compared to underneath the Event Centre. However, there was a significantly greater number of burrows at the North Wharf site compared to any of the other sites (Table 3-5).

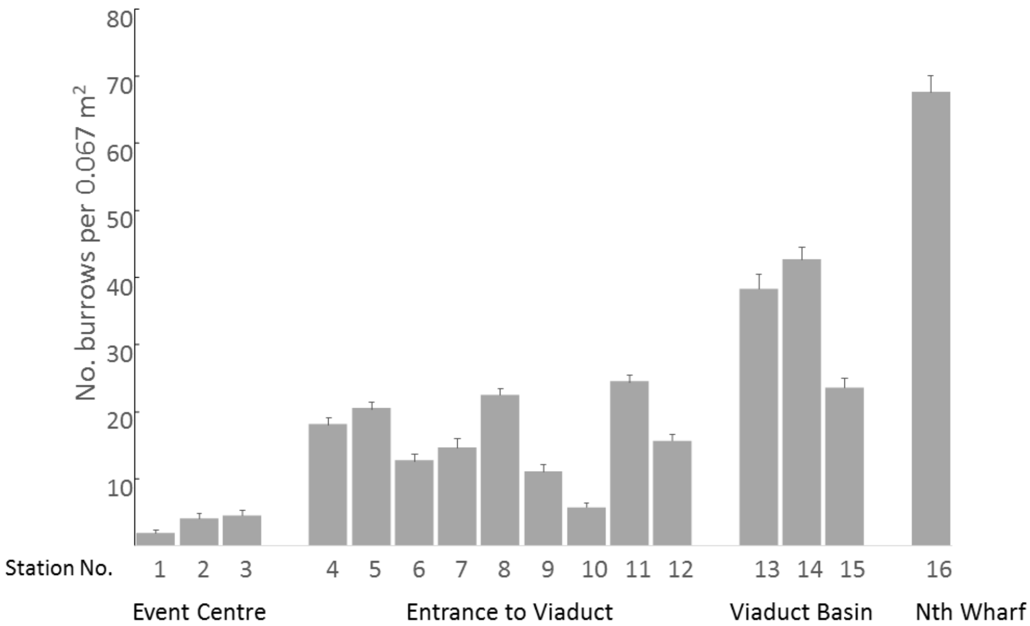


Figure 3-10: Mean number of burrows standardised per 0.067m^2. Error bars represent 95% confidence intervals.

Table 3-5: **Homogeneity of variance test for number of invertebrate burrows.**

	Sum of squares	d.f.	Mean square	Fs	P
Locations: L	36.7754	2	18.3877	23.2200	**0.000075**
Stations(L)	9.5027	12	0.7919	3.2951	**0.001058**
Residual	14.4192	60	0.2403		
total	60.6973	74			

Results from a Student-Newman-Kuels Test showed that there also a significant difference in burrow number between stations. There were significantly less burrows at the Event Centre stations compared to the open water adjacent to the Viaduct entrance, but the Viaduct Entrance was not significantly different to the Viaduct Basin.

There were no significant differences in the numbers of epibenthic fauna, opal fish *Hemerocoetes monopterygius* Schneider, 1801, starfish *Coscinasterias muricata* Verrill, 1867, or fan worm *Sabella spallanzanii* (Gmelin, 1791) between the stations due to the low numbers of these species recorded at the different stations (Figure 3-11). The opal fish was tentatively identified from images as a specimen could not be obtained.

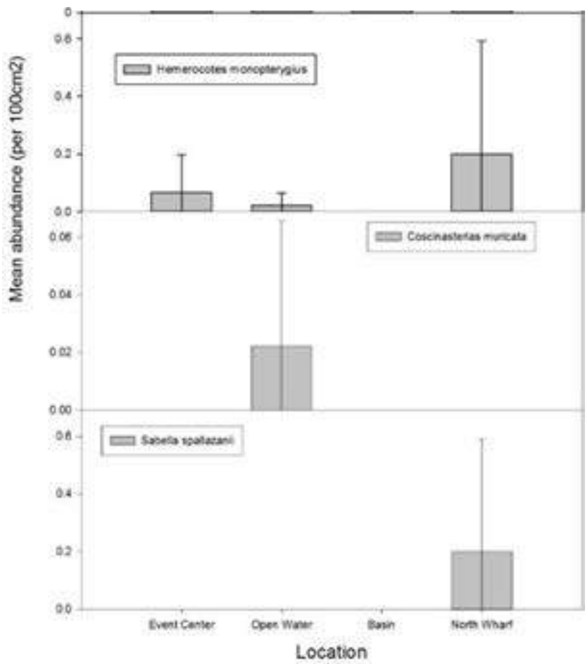
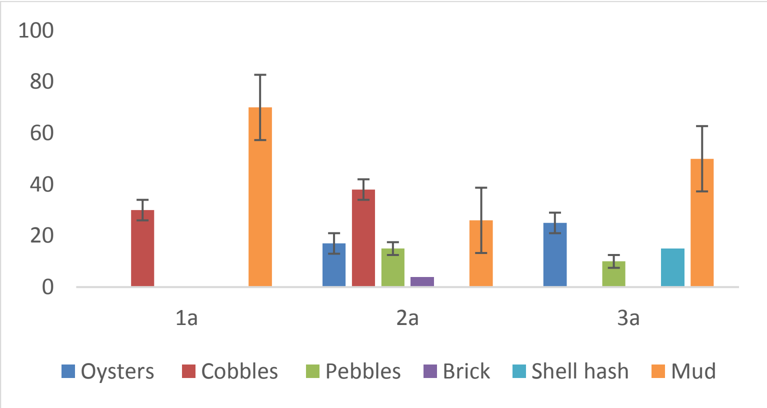
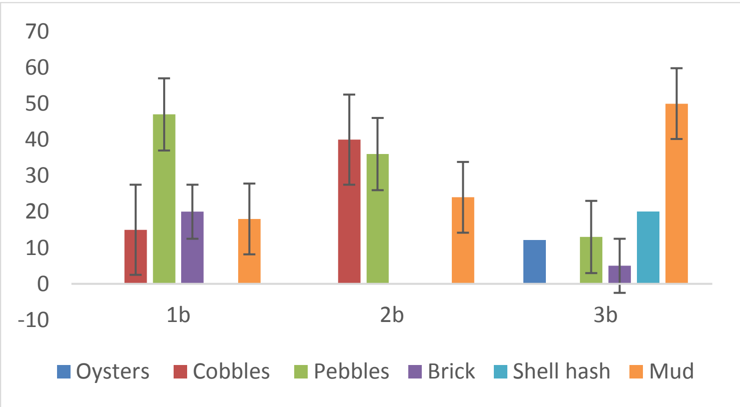


Figure 3-11: Mean densities of abundant epibenthic species at each location. Error bars represent 95% confidence intervals.

Image Analysis - North wharf/Wynyard Wharf Corner

Three horizontal transects were surveyed in the corner of the North Wharf/Wynyard Wharf (Figure 3-12). Oysters heavily fouled the rocks along the intertidal (between 50 and 80% cover). At 0 m (quadrat a), the dominant substrate was mud at each of the transect sites, however cobbles, oysters, pebbles, shell hash and brick were also recorded (Figure 3-12). At 2 m (quadrat b), the substrate was dominated by pebbles at transect 1, pebbles and cobbles on transect 2 and predominantly mud at transect 3. At 4 m (quadrat c), mud was the dominant substrate at each of the three transect, with brick also present at transect 1. Invertebrate burrows were recorded at transect 2 and 3. At 6 m (quadrat d), all transects were comprised of mud, with a few pebbles, one small piece of brick and two invertebrate burrows at transect 3. At 8 m (quadrat e), mud was the dominant substrate at each of the transects, with pebbles also recorded at transect 2. A single invertebrate burrow was recorded from transect 3.





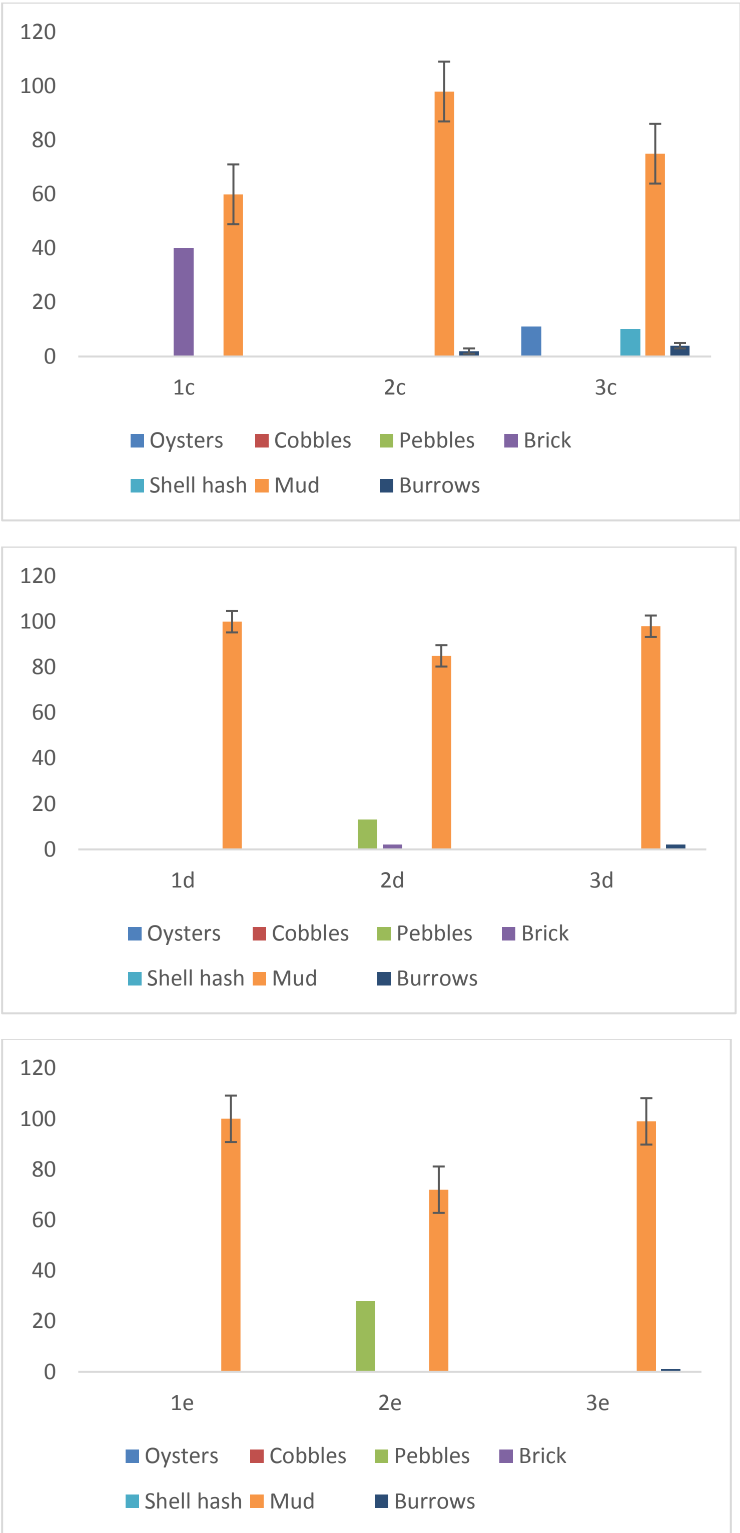


Figure 3-12: Seabed composition (% cover) along three transects (1-3). Quadrat 'a' was a screen grab taken at 0 m (low tide line), 'b' was 2 m below the low tide line, 'c' was 4 m below the low tide line, and 'd and e' were 6 m and 8 m below the low tide line respectively. Quadrats 'c-e' were located underneath the Wynyard Wharf.

3.2.2 Macrofauna identification

A total of 33 macrofaunal organisms were identified from the sediment cores (except Stations 4, 9 and 10 which were not identified at the Clients request). Not all could be identified to species level due to incomplete or damaged specimens, or an absence of diagnostic morphological features.

Polychaetes were the dominant taxa across all stations. On average, they comprised approximately 76% of the total number of individuals collected at each station (Figure 3-13 and Table 3-6). Bivalves represented approximately 12% of fauna in the samples, oligochaetes 6%, with other small crustaceans (amphipods, ostracods and isopods and crabs) making up ~4% collectively. Nemerteans, a single ascidian and a barnacle comprised less than 2% collectively.

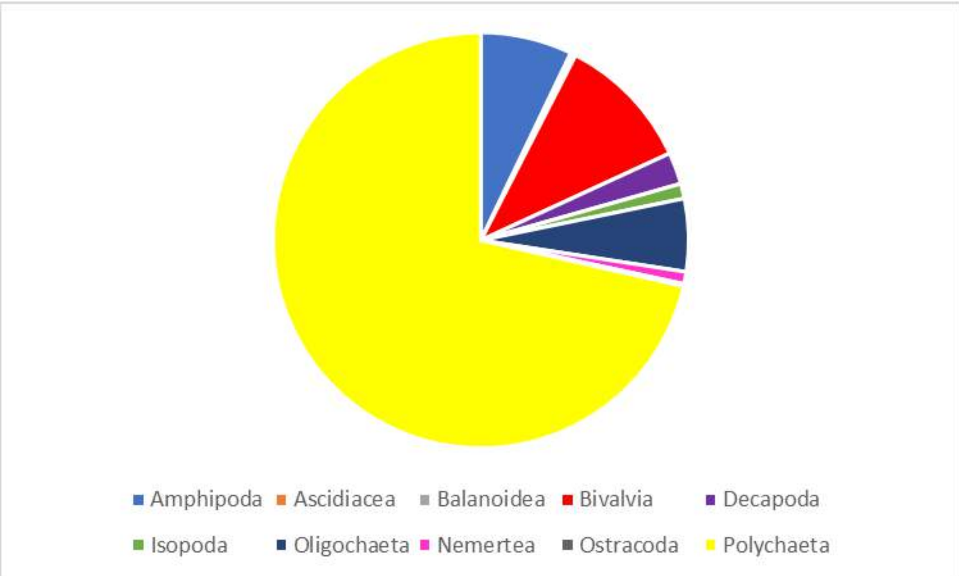


Figure 3-13: Overall taxonomic composition (%) of the benthic assemblages by numbers of individuals.

The most abundant of the polychaetes was the cryptogenic species, *Heteromastus filiformis* (Claparède, 1864), (Table 3-7). *H. filiformis* is widely distributed in New Zealand in the intertidal, soft shore, enclosed harbours, and sheltered bays (Read 1984).

The non-indigenous polychaete, *Leonnates stephensoni* Rullier, 1965*,* was identified from Stations 8, 11 and 13 (open water adjacent to the entrance to the Viaduct Basin). This species was first described in New Zealand in November 2017, from Henderson Creek intertidal flat, Waitemata Harbour. These records are the first for the Viaduct/Freemans Bay area. *Leonnates stephensoni* is native to Australia on western, northern and eastern coasts, with the southernmost record from near Sydney. Although not exclusive to disturbed habitats the surface deposit feeders are also characteristic in urbanised mangrove areas (Metcalfe and Glasby, 2008).

A single specimen of the non-indigenous polychaete *Pseudopolydora paucibranchiata* (Okuda, 1937) was also recorded from station. *P. paucibranchiata* is a tube-building spionid polychaete native to Japan, Hong Kong and the Kuril Islands. However, introduced populations are known from the Northeast Pacific, Southwest Pacific (including Australia and New Zealand) and the Northeast Atlantic. It is commonly found in shallow intertidal mudflats, harbour pilings and oyster beds. NIWA first recorded this species during baseline port surveys in Auckland in 2005 (Inglis et al. 2010).

However, the earliest record of this species was by Read (1975) from Wellington Harbour and then Inglis et al. (2006b), from Whangarei Harbour.

Bivalves were mostly represented by the non-indigenous *Theora lubrica* Gould, 1861*,* a small thin shelled bivalve. *T. lubrica* is native to Japan and China Seas and subsequently introduced to the USA, Australia and New Zealand, since at least 1971 (Cranfield et al. 1998, Inglis et al. 2006a). Typically found in muddy sediments, *T. lubrica* is an indicator species for eutrophic and anoxic areas.

The only gastropod identified from the samples was the non-indigenous Australian dog whelk, *Nassarius (Plicarcularia) burchardi* (Dunker in Philippi, 1879). Commonly found on sand and mud flats, in lagoons and estuaries and the intertidal area, *N. burchardi* was first detected in New Zealand from the Waitemata Harbour in 2009 and now well established (Townsend et al. 2010).

Although not identified from the sediment cores, the Mediterranean fan worm *Sabella spallanzanii* (Gmelin, 1791) was identified in images from North Wharf/Wynyard Wharf.

Table 3-6: Summary of macrofaunal species identified from the sediment samples.

Taxa	Taxon Information	Stations	Biosecurity Status
Exoedicerotidae	Amphipoda	7, 8, 15	Indeterminate
Phoxocephalidae	Amphipoda	2, 5, 7, 11, 12, 13, 14, 15	Indeterminate
Torridoharpinia hurleyi (J.L. Barnard, 1958)	Amphipoda	5, 7, 11	Indigenous
Tunicata	Ascidiacea	1	Indeterminate
Austrominius modestus (Darwin, 1854)	Balanidae	1	Indigenous
Arthritica bifurca (Webster, 1908)	Bivalvia	3	Indigenous
Nucula nitidula A. Adams, 1856	Bivalvia	1	Indigenous
Theora lubrica Gould, 1861	Bivalvia	1, 2, 3, 5, 6, 7, 8, 11, 12, 13, 14, 15	Non-indigenous
Halicarcinus whitei (Miers, 1876)	Decapoda	15	Indigenous
Hemiplax hirtipes Heller, 1865	Decapoda	5, 7, 8, 11	Indigenous
Nassarius burchardi (Dunker in Philippe, 1879)	Gastropoda	1, 2, 3, 14	Non-indigenous
Anthuridae	Isopoda	1	Indeterminate
Ostrocod	Ostracoda	1, 2, 3, 5, 6, 7, 8, 12, 13, 15	Indeterminate
Aglaophamus macroura (Schmarda, 1861)	Polychaeta	11	Indigenous
Maldane theodori (Augener, 1926)	Polychaeta	3, 13	Indigenous

Ceratonereis sp. Kinberg, 1865	Polychaeta	2	Indeterminate
Cirratulidae	Polychaeta	1, 6, 7, 8, 11, 12, 13, 14, 15	Indeterminate
Cossura consimilis Read, 2000	Polychaeta	1, 3, 6, 7	Indigenous
Exogoninae	Polychaeta	1	Indeterminate
Glycera ovigera Schmarda, 1861	Polychaeta	5, 13, 14, 15	Indigenous
Glycinde trifida (McIntosh, 1885)	Polychaeta	13	Indigenous
Heteromastus filiformis (Claparède, 1864)	Polychaeta	1, 2, 5, 6, 7, 8, 11, 12, 13, 14, 15	Cryptogenic
Labiosthenolepis	Polychaeta	1, 2, 5, 6, 8, 11, 12, 13, 14	Indeterminate
Leonnates stephensoni Rullier, 1965	Polychaeta	8, 11, 13	Non-indigenous
Levinsenia gracilis (Tauber, 1879)	Polychaeta	2, 5, 7, 8, 11, 12, 14	Cryptogenic
Lumbrineridae	Polychaeta	3, 5, 6, 8, 12, 13	Indeterminate
Nemertea	Nemertea	3, 13	Indeterminate
Oligochaeta	Clitellata	1, 2, 5, 6, 7, 8, 11, 13, 14	Indeterminate
Paradoneis lyra (Southern, 1914)	Polychaeta	1, 2, 3, 5, 6, 8, 11, 12, 13, 14, 15	Cryptogenic
Phylo sp. Kinberg, 1866	Polychaeta	1, 2, 3, 5, 6, 7, 8, 11, 14	Indeterminate
Prionospio yuriel Wilson, 1990	Polychaeta	5, 6, 7, 8, 11, 12, 13, 15	Indigenous
Pseudopolydora paucibranchiata (Okuda, 1937)	Polychaeta	2	Non-indigenous
Terebellidae	Polychaeta	3	Indeterminate

Table 3-7: Composition of the subtidal macrofauna as a percentage of the total number of individuals recorded at each station from the three cores. A complete table of the data can be found in Appendix 1.

Stations	1	2	3	5	6	7	8	11	12	13	14	15
Amphipod	7	3	8	22	0	19	6	3	8	3	8	4
Ascidian	2	0	0	0	0	0	0	0	0	0	0	0
Balanid	0	3	0	0	0	0	0	0	0	0	0	0
Bivalve	2	3	4	14	18	17	17	10	11	19	13	7
Decapod	2	6	0	3	0	4	6	7	0	0	0	4
Isopod	0	0	4	3	0	0	0	0	0	0	8	0
Oligochaeta	11									1		

Nemertea	1											
Ostracod	2	0	0	0	0	0	0	0	0	0	0	0
Polychaete	85	85	80	58	81	60	69	78	78	77	73	86
Total Number of individuals	**43**	**35**	**25**	**32**	**19**	**27**	**32**	**29**	**18**	**32**	**13**	**28**
Number of Taxa	**15**	**12**	**12**	**15**	**11**	**13**	**14**	**13**	**10**	**14**	**11**	**9**

3.2.3 Macrofauna comparison between locations

There was no significant difference in the mean number of individuals or the species richness at the Event Centre, open water, or Viaduct Basin sites (note: no sediment cores were taken from the North Wharf site). (Figure 3-14). However, the diversity of species between the three locations was significantly greater at the open water site (Figure 3-14). There was no significant difference in species diversity between the Event Centre or Viaduct Basin sites.

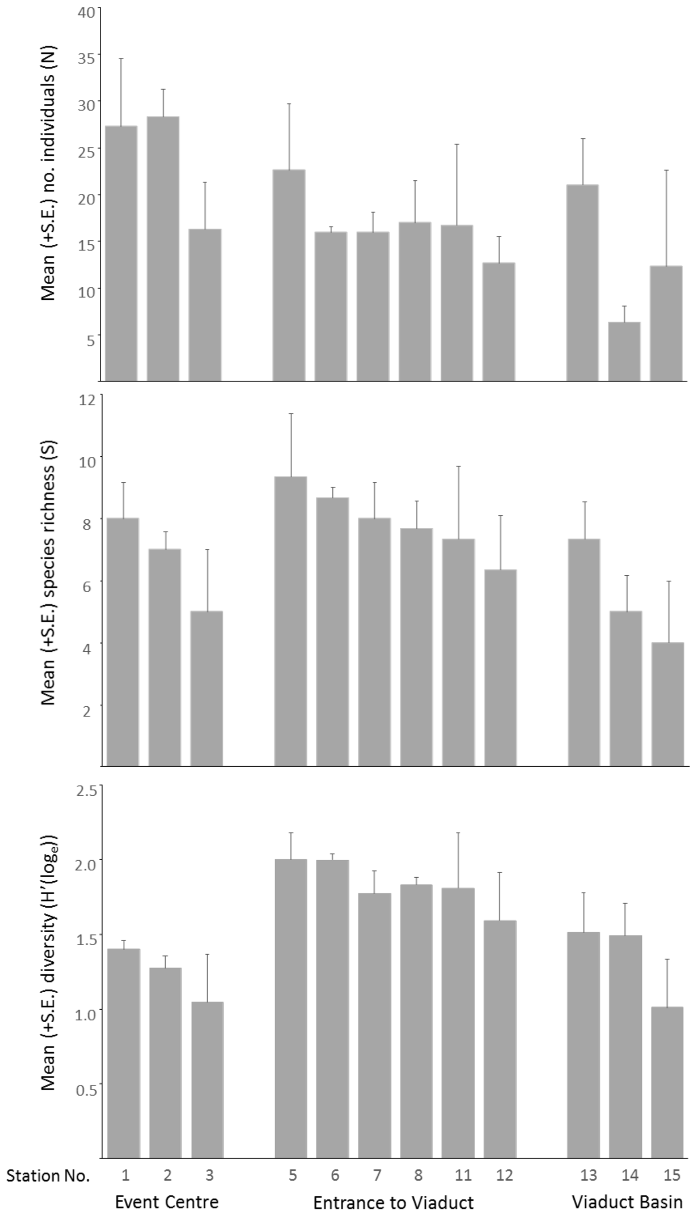


Figure 3-14: Mean number of individuals, species richness and Shannon diversity (H') of macrofaunal at the Viaduct Event Centre, entrance to the Viaduct basin in the Outer Viaduct basin.

A non-multidimensional scaling (nMDS) plot of Bray Curtis similarities of log transformed data gives a two-dimensional representation of the relative similarities or dissimilarities of each sample site (Figure 3-15). The closer two sites are to each other in the plot the more similar they are with respect to community structure. Each sample site has been colour coded to represent which location that sediment core was taken from. The stress value (degree of correspondence between the distances among points reflects the similarity to other points/samples) of 0.19 corresponds to the data having good ordination in 2-dimensional space, as stated in Clarke and Warwick (1994). The results indicated that the Event Centre sites clustered more closely than the Open Water or Viaduct Basin sites.

An ANOSIM (analysis of similarity) routine within PRIMER-E tested for differences in assemblage structure between locations. There was a significant difference between locations ($p < 0.01$, Global R = 0.419). There was a greater difference in structure between the Event Centre community and the

Open Water community than between either the Open Water vs Basin or the Event Centre vs Basin. To determine which species were driving the differences among locations, group similarity and dissimilarity was explored using the SIMPER routine (PRIMER-E). Differences in similarity between locations and similarity within locations can be explained by the community assemblages identified in each location, and the relative contribution of characterising taxa (

Table 3-8, Figure 3-16).

Within locations, there were dominant species (mean abundances) which explained the dissimilarity between locations (Figure 3-16). Stations located under the Event Centre were dominated by the non-indigenous bivalve, *Theora lubrica*, Oligochaetes, the non-indigenous gastropod *Nassarius burchardi*, and ostracods. *Theora lubrica* was present in smaller densities within stations in Viaduct Basin and outside the entrance to the Viaduct Basin. The gastropod *Nassarius burchardi* also occurred in greater abundance beneath the Event Centre and was almost absent from the Open water or Viaduct Basin sites. The polychaete worm *Prionospiro yuriel* was absent from the Event Centre stations. Differences in species between locations and stations was tested using ANOVA analysis on ln(x+1) transformed data. There was a significant difference in the mean number of individuals per core between locations for *T. lubrica, N. burchardi* and *Prionospiro yuriel*. There was a significant difference in the mean number of individuals per core between stations for *T. lubrica, N. burchardi,* Curratulidae and *Phylo* sp. (summary table given in Appendix 5).

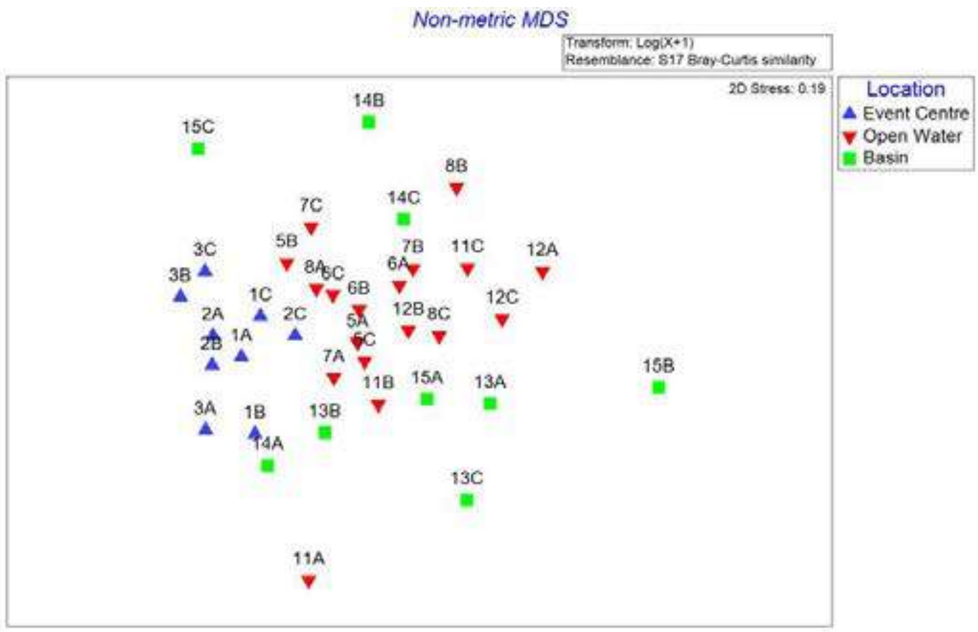


Figure 3-15: Nonmetric multidimensional scaling (nMDS) ordination of the subtidal infauna at each of the sediment sample stations. Sites were located underneath the Event Centre, in Open Water adjacent to the Viaduct Basin entrance, and within the Viaduct Basin.

Table 3-8: Similarity (%) among the infaunal assemblage sampled beneath the Event Centre, within Viaduct Basin and outside the entrance to Viaduct (Open Water).

Event Centre (53.59%)		Open Water (43.31%)		Basin (25.06%)	
Species	**% Contr.**	**Species**	**% Contr.**	**Species**	**% Contr.**
Theora lubrica	59.3	*Theora lubrica*	18.07	*Theora lubrica*	29.05
Ostrocod	17.52	*Prionospio yuriel*	17.97	*Heteromastus filiformis*	22.16
		Cirratulidae	15.33	*Paradoneis lyra*	16.13
		Heteromastus filiformis	10.79	Cirratulidae	12.67
		Phylo sp.	9.55		

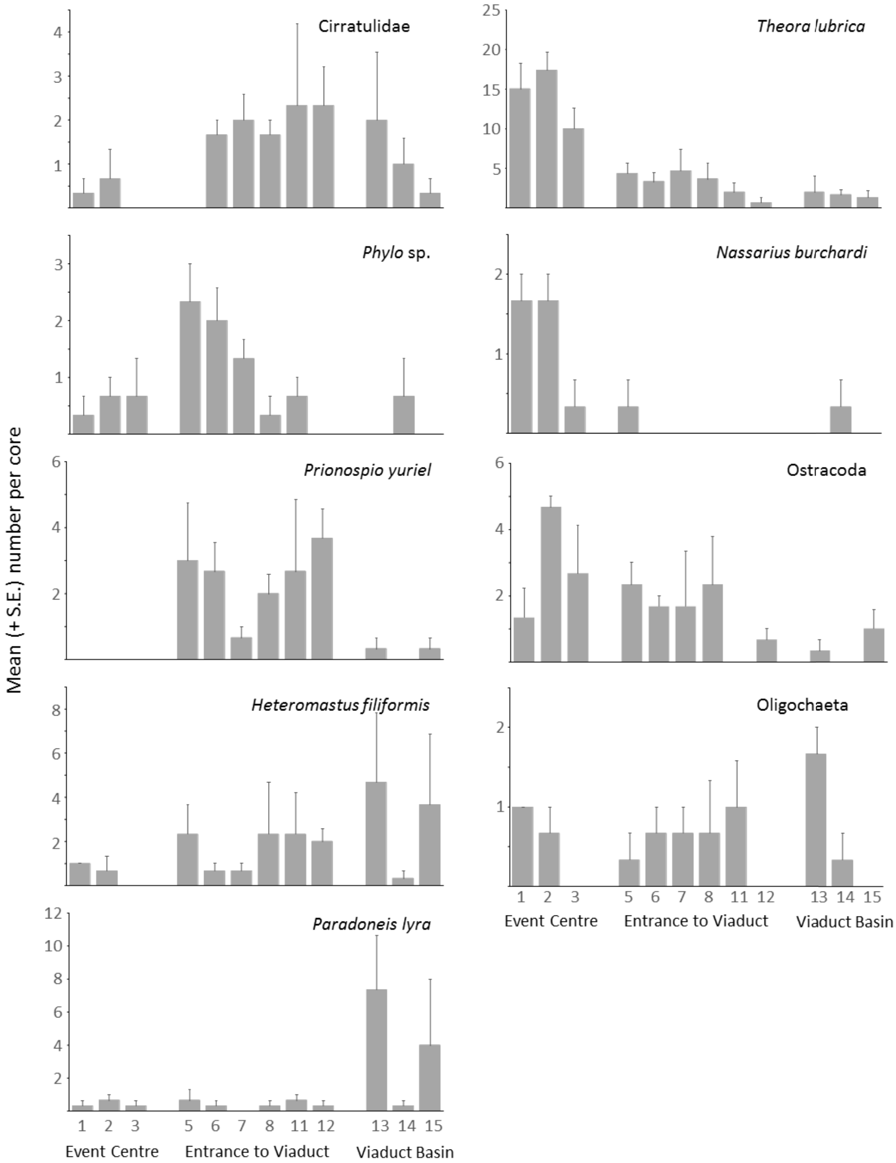


Figure 3-16: Mean (+S.E) abundance of species that contributed most to differences among locations.

3.3 Westhaven Reclamation Wall

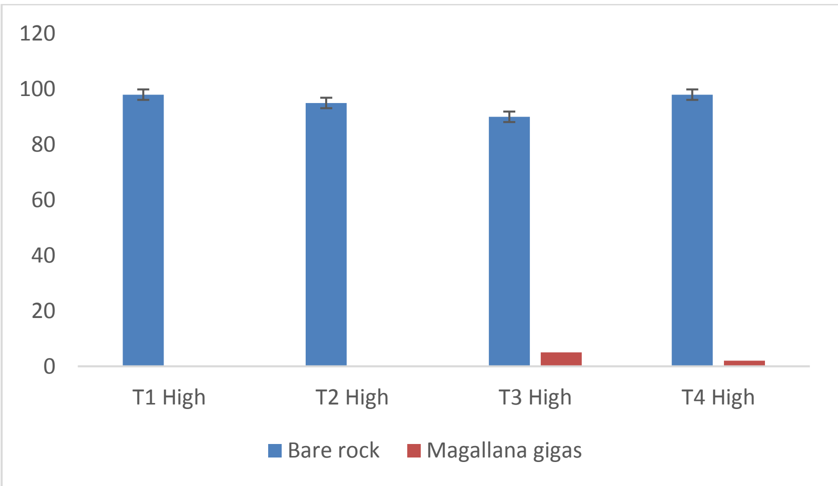
The reclamation wall consisted of relatively smooth, flat basalt rock surfaces, with artificial concrete slabs that formed part of the rock platform structure (Figure 3-17). Towards the waterline, the rocks were split and eroded from wave action, forming deep crevices. The distance between low and high tide line was ~ 10-15 m.

This site was inaccessible by foot due to high currents and wind chop, making it difficult to approach in the research vessel. The reclamation wall faces North West and is exposed to waves from the large fetch across the Waitemata Harbour during northerly and north-easterly winds. Vessel traffic in this area is also high, with vessel wake contributing to the wave climate.

Figure 3-17: The shoreline of the western Wynyard reclamation area facing north (toward the locations of Transects 1-3) and south toward the location of Transect 4.

A clear vertical zonation was visible on the rocky shoreline. There was no marine flora or fauna present on the concrete slabs in the high littoral zone. Storm water drains were present along the upper concrete retaining wall.

The eulitoral (midshore) zone was dominated by rock oysters *Magallana* (*Crassostrea) gigas*; (~95% cover), with low densities (~ 5%) of barnacles (*Austrominius modestus*) present towards the upper boundaries of this zone (Figure 3-18). Smaller invertebrates such as chitons (*Sypharochiton pelliserpentis* (Quoy and Gaimard, 1835)) and limpets (*Nerita melanotragus* E.A. Smith, 1884) were present towards the lower sublittoral fringe, scattered between the heavy clumps of oysters (but were not included in the image analysis as they were mobile species). The red algae, *Corallina officianalis* Linnaeus, 1758, *Gelidium caulacantheum* J.Agardh and *Apophlaea sinclairii* J.Agardh J.D.Hooker & Harvey, the brown algae *Hormosira banksii* (Turner) Decaisne and *Scytothamnus australis* (J.Agardh) J.D.Hooker & Harvey and green algae *Codium convolutum* (Dellow) P.C.Silva were present in small quantities towards the sublittoral fringe. Below the waterline, the brown algae *Carpophyllum maschalocarpum* (Turner) Grev. was present, though was not quantified because divers could not access the water at this site.



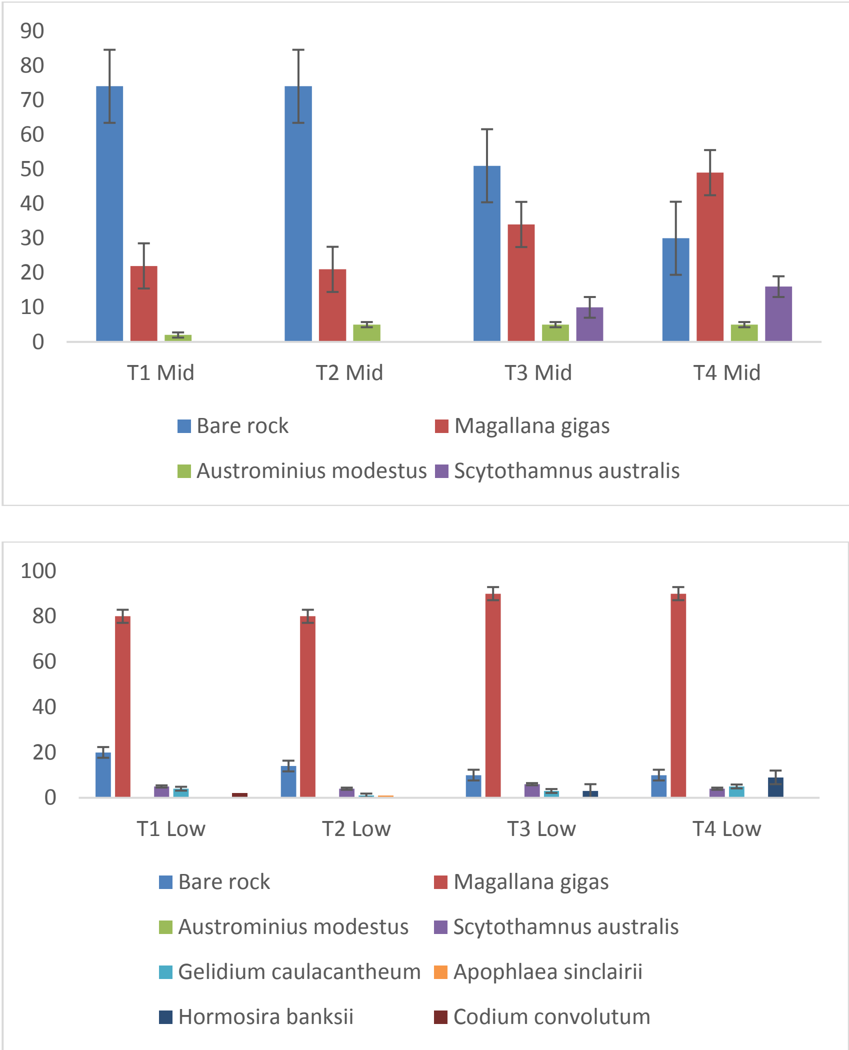


Figure 3-18: Percentage cover of dominant organisms within marine assemblages on the western side of the Wynyard reclamation wall, between Silo Marina and Wynyard Point. T1, transect 1; T2, transect 2; T3, transect 3; T4, transect 4. High was defined as the upper littoral zone, Mid was the middle of the eulittoral zone, Low was the low tide mark, 1 m above MLWS.

4 Discussion

Benthic assemblages located beneath the Viaduct Event Centre differed significantly from those sampled from the sea floor within the Outer Viaduct Basin or immediately outside it. The Event Centre site is permanently shaded and light levels beneath the water and at the seabed are exceptionally low. Water currents and wave action are reduced due to externally facing wave attenuation panels. These stations were dominated by the bivalve *Theora lubrica,* the gastropod *Nassarius burchardi* and ostracods. These species were only present in low numbers at the Open water, Viaduct Basin or North Wharf sites. Building structures over or onto soft sediments has multiple implications (Bulleri 2005). Overhanging structures such as docks, pontoons and wharves cause shading and reduced illumination, may alter water movement and sedimentation rates (Glasby 1999a, b, Bertasi et al. 2007, Lindegarth 2001, Martin et al. 2005). In addition, fouling organisms on surrounding wharf piles or infrastructure which become dislodged or die and fall to the seabed may alter the benthic habitat and community composition.

There was a significant difference in the number of invertebrate burrows between the open water sites (i.e. the open water adjacent to the Viaduct Basin entrance, the Viaduct Basin and at the North Wharf/Wynyard Wharf) compared to underneath the Event Centre. However, there was a significantly greater number of burrows at the North Wharf site compared to any of the other sites. There was also a significant difference in burrow number between stations at each site.

The most obvious physical difference between the Event Centre site is the presence and proximity to artificial structures such as wharf piles, pontoons and overhanging wharves which might impede water flow and cause increased sedimentation and shading. The construction and maintenance of macrofaunal burrows has implications for the microbiology and biogeochemistry of marine sediments. Evidence suggests the activity and abundance of microbes are elevated around burrows (Kristensen and Kostka 2005) and the presence of burrows may serve as an indicator of ecosystem function and health. The open water sites (i.e., adjacent to the entrance to the Viaduct Basin, the Viaduct Basin and at North Wharf) had significantly more burrows than the sites located inside underneath the Event Centre, suggesting a more suitable habitat for burrow-dwelling invertebrates.

A large proportion of non-indigenous and cryptogenic species were identified from the intertidal sites compared with indigenous species (i.e. wharf piles, pontoons, walls and wave panels) (Table 3-1). Because these structures are associated with vessel movements within the Viaduct Harbour, they can act as hotspots (concentrated areas) for colonisation, act as stepping stones or even corridors for some non-indigenous species (Mineur et al. 2012, Lambert and Lambert 2003). In addition, due to the introduction of new species from vessels, the existing fouling communities and suitable uncolonized substrate that provides a refuge from native predators, a greater number of non-native species are found on artificial structures compared to nearby natural substrates (Mineur et al. 2012).

In terms of substrate type (location), there were significant differences in community assemblage at pontoons located inside the Outer Viaduct Basin. The pontoons were horizontal concrete slabs with shaded, permanently submerged bases which were heavily fouled. There were no significant differences in communities on new wharf piles (under the Event Centre), old wharf piles (under the Maritime Museum), concrete walls, or the externally located concrete wave panels. Partially enclosed marinas and basins provide optimal conditions for the recruitment and retention of fouling organisms (Floerl and Inglis 2003) and over time we would expect the community assemblage to be similar across sites. The new wharf piles were built during the 1990's when the Viaduct was redeveloped for the America's Cup defence. It appears that the fouling communities on the newer piles is not significantly different to the older piles which are located underneath the Maritime Museum and community richness, diversity and abundance is quite consistent between the sites (except the pontoons). Increasing demand for urban infrastructure to sustain commercial, residential and tourist activities, results in marine urban ecosystems where community assemblage and diversity is driven by marine urban ecosystems (Bulleri and Chapman 2010). We do not have the date of installation of the externally facing wave panels, however the mean number of individuals (across all depths) were not significantly different than the new piles, old piles or pontoons. The mean species richness or diversity was not significantly different on the wave panels compared with the new piles, old piles, or viaduct wall. The wave panels are exposed to environmental factors including wave action, wind and vessel wake. However, there are often large vessels or barges moored for extended periods of time alongside the panels and this would reduce the effects of the wind and waves.

The Wynyard Wharf reclamation wall was composed of basaltic rock and concrete slabs, largely encrusted by the non-indigenous Pacific oyster, *Magallana (Crassostrea) gigas*. This oyster was a dominant structural component of the fouling assemblages recorded along the reclamation wall. Although vertical zonation was observed along this wall, there was a marked absence of flora and fauna in the upper littoral zone. This may be explained by the substrate type (which was predominantly concrete) and possible freshwater input from storm water pipes located at the base of the vertical section of the wall. The influx of anthropogenic infrastructure, such as reclamation walls, and other mechanisms to help curb erosion and promote human use, can modify marine environments (Bulleri and Chapman 1994, 2010, Chapman and Underwood 2011).

The benthic habitat at the North Wharf/Wynyard Wharf corner was also characterised largely by mud, bricks, rubble and rocks of terrestrial origin. This area was characterised as having high sedimentation (as evidenced by mud being the dominant substrate) and large proportion of the first 2 m, consisting of debris. Although oysters were observed in the intertidal, above the waterline, they did not cover a high percentage of the rocky substrate below the water line (as recorded from the wharf piles, walls and pontoons). It was not clear whether the rubble was discarded in this area or used as part of a the substrate during wharf construction.

5 Acknowledgements

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Appendix A Macrofauna from subtidal sites

Station		1			2			3			5			6			7			8			11			12			13			14			15		
Core		i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii
Amphipoda	Exoedicerotidae																1		1			2														1	
Amphipoda	Phoxocephalidae				1						6		4				3							1			2	1			1	1					
Amphipoda	Torridoharpinia hurleyi										2		2				1		1					2													
Ascidiacea	Tunicata		1																																		
Balanidae	Austrominius modestus	0	11	0																																	
Bivalvia	Arthritica bifurca									1																											
Bivalvia	Nucula nitidula		1																																		
Bivalvia	Theora lubrica	9	20	16	22	15	15	5	14	11	7	3	3	1	4	5	10	3	1	7		4		2	4		2			6		3	1	1	3		1
Decapoda	Halicarcinus whitei																																		1		
Decapoda	Hemiplax hirtipes										1								1	2					2												
Gastropoda	Nassarius burchardi	2	2	1	2	1	2			1	1																					1					
Isopoda	Anthuridae	1																																			
Ostracoda	Ostrocod	1		3	5	5	4		3	5	1	3	3	1	2	2			5	5	2						1	1	1						2		1
Polychaeta	Aglaophamus macroura																							1													
Polychaeta	Asychis theodori									1																				1							
Polychaeta	Ceratonereis sp.				1																																
Polychaeta	Cirratulidae		1				2							2	1	2	2	3	1	2	2	1		1	6	4	1	2	5	1			1	2	1		

Station		1			2			3			5			6			7			8			11			12			13			14			15		
Core		i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii	i	ii	iii
Polychaeta	Cossura consimilis			3					1							1			1																		
Polychaeta	Exogoninae		1																																		
Polychaeta	Glycera ovigera											1																		1		1			3		
Polychaeta	Glycinde trifida																													1							
Polychaeta	Heteromastus filiformis	1	1	1			2				5	1	1	1	1		1	1				7		1	6	1	2	3	11	1	2			1	10	1	
Polychaeta	Labiosthenolepis			1						1	1	1		3	1						1	1			3		1		1				1	1			
Polychaeta	Leonnates stephensoni																			1	1	1			2					1							
Polychaeta	Levinsenia gracilis				1						1							4			1			1	3			1				1					
Polychaeta	Lumbrineridae							1			1		1	1	2	1						1					1	3	1								
Polychaeta	Nemertea									1																			1								
Polychaeta	Oligochaeta	1	1	1	1	1					1			1		1	1		1	2			1	2					2	2	1	1					
Polychaeta	Paradoneis lyra		1			1	1	1					2		1							1	1	1			1		9	1	12	1			12		
Polychaeta	Phylo sp.			1	1		1			2	3	3	1	1	3	2	1	1	2	1			1	1										2			
Polychaeta	Prionospio cirrifera										6		3	4	1	3		1	1	2	1	3		1	7	2	5	4			1				1		
Polychaeta	Pseudopolydora paucibranchiata					1																															
Polychaeta	Terebellidae									1																											

Appendix B Biofouling organisms from piles, pontoons, walls and wave panels

Percentage cover (non-standardized) of key fouling species identified from wharf piles, pontoons, wave panels and wall structures in the Viaduct Harbour. AM, *Austrominius modestus*; MG, *Magallana (Crassostrea) gigas*; C sp., *Cnemidocarpa* sp.; AP, *Aplidium phortax*; P sp, *Pyura* sp. complex, H n sp 3, *Haliclona* n sp 3; H n sp 5, *Haliclona* n sp 5; HM, *Hymedesmia microstrongyla*; CI, *Crella incrustans*; SS, *Sabella spallanzanii*; Nu, nudibranch egg; Ch, chiton; MM, *Mycale macilenta*; HP, *Haliclona parietioides*; D sp, *Didemnum* sp.; Ra, red algae; Ch sp, *Chondropsis* sp., Cl sp., *Clathrina* sp., SE, *Solanderia ericopsis*; BN, *Bugula neritina*; PD, *Pennaria ditschia*; CE, *Corella eumyota*; SB, *Symplegma brakenhielmi*; B sp., *Botrylloides* sp.; C AN, colonial ascidian; CR, *Callyspongia ramosa*; MT, *Mycale tasmani*; P n sp., *Paraesperella* n sp 1.

Station	Area (m2)	Bare wall	AM	MG	C sp.	AP	P sp.	H n sp 3	H n sp 5	HM	CI	SS	Nu	Ch	MM	HP	D sp	Ra	C sp	C sp
Piles																				
1-1a	0.9		100	0																
1-1b	0.84			100																
1-1c	0.78			100	7	3				25										
1-2a	0.9		100	0																
1-2b	0.85			100		0.3														
1-2c	0.7			100	2			13			9									
1-3a	0.9		100	0																
1-3b	0.83		9	100		1														
1-3c	0.72			100	7	0.2				7	27									
1-4a	0.9		100	0																
1-4b	0.83		14	100						2										
1-4c	0.8			100	6	3				14	23	13								
2-1a	0.9		100	0																

Station	Area (m2)	Bare wall	AM	MG	C sp.	AP	P sp.	H n sp 3	H n sp 5	HM	Cl	SS	Nu	Ch	MM	HP	D sp	Ra	C sp	C sp
2-1b	0.84			100			1													
2-1c	0.58			100		4		20	5	5	9		2							
2-2a	0.9		100	0																
2-2b	0.75		18	100										1						
2-2c	0.61			100		19		5	10	6										
2-3a	0.9		100	15																
2-3b	0.69			100			3			8				1						
2-3c	0.75			100	2			30	10	2	14									
2-4a	0.9		100	0																
2-4b	0.83			100		12														
2-4c	0.86			100	6	2	0.2	28			19	2								
3-1a	0.9	20	40	40																
3-1b	0.82			100		2														
3-1c	1.3			100	1	3		10	5	10	16				5	3				
3-2a	0.9	30	40	30																
3-2b	0.84			70		17		20												
3-2c	1.3			100				43	2	2	6									
3-3a	0.9	10	90	0																
Station	Area (m2)	Bare wall	AM	MG	C sp.	AP	P sp.	H n sp 3	H n sp 5	HM	Cl	SS	Nu	Ch	MM	HP	D sp	Ra	C sp	C sp
piles																				
3-3b	0.83			100		5														

3-3c	1.3			100		3	7	15	20	10	4	4								
3-4a	0.9	5	95	2																
3-4b	0.86			100		13														
3-4c	0.72			100	4	0.3	9	25	10	6	5				5					
4-1a	0.9	36	50	14																
4-1b	0.86	2	0.6	95			2													
4-1c	0.87			100		4	16	5			16							5		
4-2a	0.9	25	70	5																
4-2b	0.85			100																
4-2c	0.8			100		11		29	5								6			
4-3a	0.9	5	75	20																
4-3b	0.83			100																
4-3c	0.69			100	11	4.3		25												
4-4a	1	5	91	4																
4-4b	0.85			100																
4-4c	0.85			100	2	5													59	
5-1a	0.9	5	95	0																
5-1b	0.85			100																
5-1c	0.66			100		2	18			6									19	
Station	**Area (m2)**	**Bare wall**	**AM**	**MG**	**C sp.**	**AP**	**P sp.**	**H n sp 3**	**H n sp 5**	**HM**	**Cl**	**SS**	**Nu**	**Ch**	**MM**	**HP**	**D sp**	**Ra**	**C sp**	**C sp**
piles																				
5-2b	0.85			100																

5-2c	0.73			100			8		5		6				5				20	
5-3a	0.97	2	88	10																
5-3b	0.83			100																
5-3c	0.65			100	7	0.7		5											7	
5-4a	1.3	2	80	18						9										
5-4b	0.82			100																
5-4c	0.67			9	6	2										6			5	
6-1a	1.1	10	90																	
6-1b	0.86			100																
6-1c	0.69			100	4		2				14				2				16	8
6-2a	1.1	9	91																	
6-2b	0.81			100																
6-2c	0.68			100	25	13										2				
6-3a	0.82	6	94																	
6-3b	0.83			100																
6-3c	0.9			100		1	8	7			10									
6-4a	0.9	19	81																	
6-4b	0.84			100																
6-4c	0.73			100		4	6	16		5					12		2		11	
Station	**Area (m2)**	**Bare wall**	**AM**	**MG**	**C sp.**	**AP**	**P sp.**	**H n sp 3**	**H n sp 5**	**HM**	**CI**	**SS**	**Nu**	**Ch**	**MM**	**HP**	**D sp**	**Ra**	**C sp**	**C sp**
7-1a	0.69	37		87																
7-1b	0.8	31		64	5															
7-1c	0.71	47		50		0.5										2				

7-2a	0.68	25		75																
7-2b	0.81	20		80								1								
7-2c	0.68	40		40		0.7				14						1				
7-3a	0.64			16		5		2							0.6		0.9			
7-3b	0.68			39		2		1				1			4		1			
7-3c	0.68			26	5	8		0.8		20										
7-4a	0.67			83	4	5					3				7					
7-4b	0.68		68			16				37										
7-4c	0.67			100	5					19	8	18				4	1			1
8-1a	0.67	25		75																
8-1b	0.67	60		22	5							1								
8-1c	0.68	47		53		2				1										
8-2a	0.68	30		70																
8-2b	0.73	72		28	1															
8-2c	0.68	25		71	1			0.3				5								3
8-3a	0.89			100				2		6	11						0.8			
8-3b	0.68			100	3			2		8		44			3					
8-3c	0.5			100							7				5	21	5			
Station	**Area (m2)**	**Bare wall**	**AM**	**MG**	**C sp.**	**AP**	**P sp.**	**H n sp 3**	**H n sp 5**	**HM**	**CI**	**SS**	**Nu**	**Ch**	**MM**	**HP**	**D sp**	**Ra**	**C sp**	**C sp**
piles																				
8-4b	0.68			100	1	4		18		5	9	5								
8-4c	0.68			100		5		9		8						1	1			
9-1a	0.58			100																

9-1b	0.68	20		80	1															
9-1c	0.67	30		86		0.4				3							3			
9-2a	0.68	40		60																
9-2b	0.68	10		90																
9-2c	0.68	10		47	2	2				7		2					5			
9-3a	0.68			100						2	3	30					4			
9-3b	0.68			100	2						8	6			4	1				
9-3c	0368		10	100		2		8		10		2					0.6			
9-4a	0.69			100	0.6	2		9		1		7				0.3	2			
9-4b	0.68			100	2	3				6					10	2				
9-4c	0.68			100		0.3						18			5	5	1		5	
Station	**Area (m2)**	**Bare wall**	**AM**	**MG**	**C sp.**	**AP**	**P sp.**	**H n sp 3**	**H n sp 5**	**HM**	**CI**	**SS**	**Nu**	**Ch**	**MM**	**HP**	**D sp**	**Ra**	**C sp**	**C sp**
Wave panel																				
1-1a	0.9	5	95																	
1-1b	0.9	5	25	70																
1-1c	0.9		20	60	2						10	5				4				
1-2a	0.9	2	98	1																

1-2b	0.9		51	84																
1-2c	0.68			100												0.4				
1-3a	0.9	5	95																	
1-3b	0.68			100																
1-3c	0.68			100								2				6				
2-1a	0.9	2	93	5																
2-1b	0.9			100																
2-1c	0.68			100	2						17					7				
2-2a	0.9	5	91	4																
2-2b	0.68			100																
2-2c	0.68			100	10											3				
2-3a	0.9	2	96	2																
2-3b	0.68			100																
2-3c	0.68			100								4				2				
3-1a	0.9	2	90	8																
Station	**Area (m2)**	**Bare wall**	**AM**	**MG**	**C sp.**	**AP**	**P sp.**	**H n sp 3**	**H n sp 5**	**HM**	**Cl**	**SS**	**Nu**	**Ch**	**MM**	**HP**	**D sp**	**Ra**	**C sp**	**C sp**
Wave panel																				
3-1c	0.9			100											9	2				
3-2a	0.9	5	85	10																
3-2b	0.68			100																
3-2c	0.9			100								5				2				
3-3a	0.9	2	95	21																
3-3b	0.68			100																

3-3c	0.9			100	2	2										0.7				

Piles	SE	BN	PD	CE	SB	B sp	C AN	CR	MT	HT	P n sp 1	Remarks
1-1a,b,c 1-2a,b,c 1-3a,b,c 1-4a,b,c												New piles under event center
2-1a,b,c 2-2a,b,c 2-3a,b,c 2-4a,b,c												New piles under event center
3-1a,b,c 3-2a,b,c 3-3a,b,c 3-4a,b,c												New piles, around top edge of viaduct basin
4-1a,b,c 4-2a,b,c 4-3a,b,c 4-4a,b,c												New piles, around top edge of viaduct basin
5-1a,b,c 5-2a,b,c 5-3a,b,c 5-4a,b,c												New piles, around top edge of

												viaduct basin
6-1a,b,c 6-2a,b,c 6-3a,b,c												New piles, around top edge of viaduct basin
6-4a	20											New piles, around top edge of viaduct basin
6-4b												New piles, around top edge of viaduct basin
6-4c												New piles, around top edge of viaduct basin
7-1a												Wall
7-1b												Wall
7-1c												Wall

7-2a						1						Wall
7-2b												Wall
7-2c												Wall
7-3a					5	1						Pontoon
7-3b		11	3	1								Pontoon
Piles	**SE**	**BN**	**PD**	**CE**	**SB**	**B sp**	**C AN**	**CR**	**MT**	**HT**	**P n sp 1**	**Remarks**
7-3c		6										Pontoon
7-4a												Pontoon
7-4b												Pontoon
7-4c												Pontoon
8-1a						1						Wall
8-1b												Wall
8-1c												Wall
8-2a												Wall
8-2b												Wall
8-2c												Wall
8-3a												Pontoon
8-3b			2			8						Pontoon
8-3c												Pontoon
8-4a												Pontoon
8-4b						3						Pontoon
8-4c												Pontoon

9-1a						9						Wall
9-1b												Wall
9-1c												Wall
9-2a												Wall
9-2b												Wall
9-2c												Wall
9-3a						2						Pontoon
9-3b												Pontoon
9-3c												Pontoon
9-4a												Pontoon
9-4b						0.5						Pontoon
9-4c		1				2						Pontoon
Station	**SE**	**BN**	**PD**	**CE**	**SB**	**B sp**	**C AN**	**CR**	**MT**	**HT**	**P n sp 1**	**Remarks**
Wave panels												
1-1a												Wave panel
1-1b												Wave panel
1-1c							1		1			Wave panel
1-2a												Wave panel

1-2b												Wave panel
1-2c							0.03		7			Wave panel
1-3a												Wave panel
1-3b												Wave panel
1-3c							0.4	2				Wave panel
2-1a												Wave panel
2-1b												Wave panel
2-1c							1					Wave panel
2-2a												Wave panel
2-2b												Wave panel
2-2c									7			Wave panel
2-3a												Wave panel
2-3b												Wave panel
2-3c												Wave panel

3-1a												Wave panel
3-1b									2			Wave panel
3-1c									14		1	Wave panel
3-2a												Wave panel
3-2b												Wave panel
3-2c		7						2	1	2	2	Wave panel
3-3a												Wave panel
3-3b												Wave panel
3-3c								10	2	5	2	Wave panel

Appendix C Location of samples

Sample	Substrate	Sample type	Station	Date sampled	Lat	Long	Comments
Subtidal	Sediment	Cores + video	1	16/11/2017	36.84073	174.75962	Under event centre
			2	16/11/2017	36.84068	174.75969	Under event centre
			3	16/11/2017	36.8406	174.75982	Under event centre
			4	17/11/2107	36.83889	174.7634	Outside entrance to Viaduct
			5	17/11/2107	36.83949	174.7632	Outside entrance to Viaduct
			6	17/11/2107	36.84015	174.76295	Outside entrance to Viaduct
			7	17/11/2107	36.83996	174.76219	Outside entrance to Viaduct
			8	17/11/2107	36.83924	174.76239	Outside entrance to Viaduct
			9	17/11/2107	36.83871	174.76261	Outside entrance to Viaduct
			10	17/11/2107	36.83832	174.76159	Outside entrance to Viaduct
			11	17/11/2107	36.83893	174.76146	Outside entrance to Viaduct
			12	17/11/2107	36.8396	174.76121	Outside entrance to Viaduct
			13	22/11/2017	36.84105	174.76179	Outer viaduct basin
			14	22/11/2017	36.84099	174.76125	Outer viaduct basin
			15	22/11/2017	36.84069	174.76088	Outer viaduct basin
		Video	North Wharf	22/11/2017	Start		North wharf 30m transect
					36.8406	174.75855	
					Finish		
					36.84041	174.75883	
Intertidal	Wharf Piles	Video + samples	1	16/11/2017	36.84784	174.7598	New piles under event center

Sample	Substrate	Sample type	Station	Date sampled	Lat	Long	Comments
			2	16/11/2017	36.84025	174.76044	New piles under event center
			3	16/11/2017	36.84022	174.76059	New piles, around top edge of viaduct basin
			4	16/11/2017	36.84105	174.76309	Old piles under maritime museum
			5	16/11/2017	36.84105	174.7632	Old piles under maritime museum
			6	16/11/2017	36.84115	174.76316	Old piles under maritime museum
			7	16/11/2017	36.84199	174.76297	Pontoon and wall
			8	16/11/2017	36.84194	174.76279	Pontoon and wall
			9	16/11/2017	36.84188	174.76271	Pontoon and wall
	Wave panels	Video + samples	1	22/11/2017	36.84035	174.76203	Wave panel closest to Viaduct entrance
			2	22/11/2017	36.84018	174.76138	Wave panels between barges
			3	22/11/2017	36.83978	174.75983	Wave panel closet to North Wharf
	North Wharf	Video	1	22/11/2017	36.83978	174.75716	Corner North Wharf, behind sea plane
			2	22/11/2017	36.83953	174.75744	In front of sea plane
			3	22/11/2017	36.83849	174.75858	In front of Arctic Expedition vessel
	Reclamation Wall	Video	1	22/11/2017	36.83679	174.75714	Reclamation wall
			2	22/11/2017	36.83707	174.75679	Reclamation wall
			3	22/11/2017	36.83742	174.75642	Reclamation wall
			4	22/11/2017	36.83767	174.75615	Reclamation wall

Appendix D Representative photos

1. Wharf piles

Representative photos from wharf piles underneath the Event Center. A, quadrat a was at MHWS (as defined by the upper limit of barnacles on the pile). B, quadrat b was 2 m below MHWS and characterised as dominant oyster, *Magallana gigas*, cover. C, quadrat c was 5 m below MHWS.

2. Walls

Representative photos from concrete walls in the Outer Viadict Basin. A, quadrat a was at MHWS (as defined by the upper limit of oysters, *Magallana gigas*, on the pile). B, quadrat b was 2 m below MHWS. C, quadrat c was 5 m below MHWS.

3. Pontoons

Representative photos from the underside of pontoons in the Outer Viadict Basin. A, quadrat a was at 0 m on a horizontal transect. B, quadrat b was 2 m and C, quadrat c was 5 m.

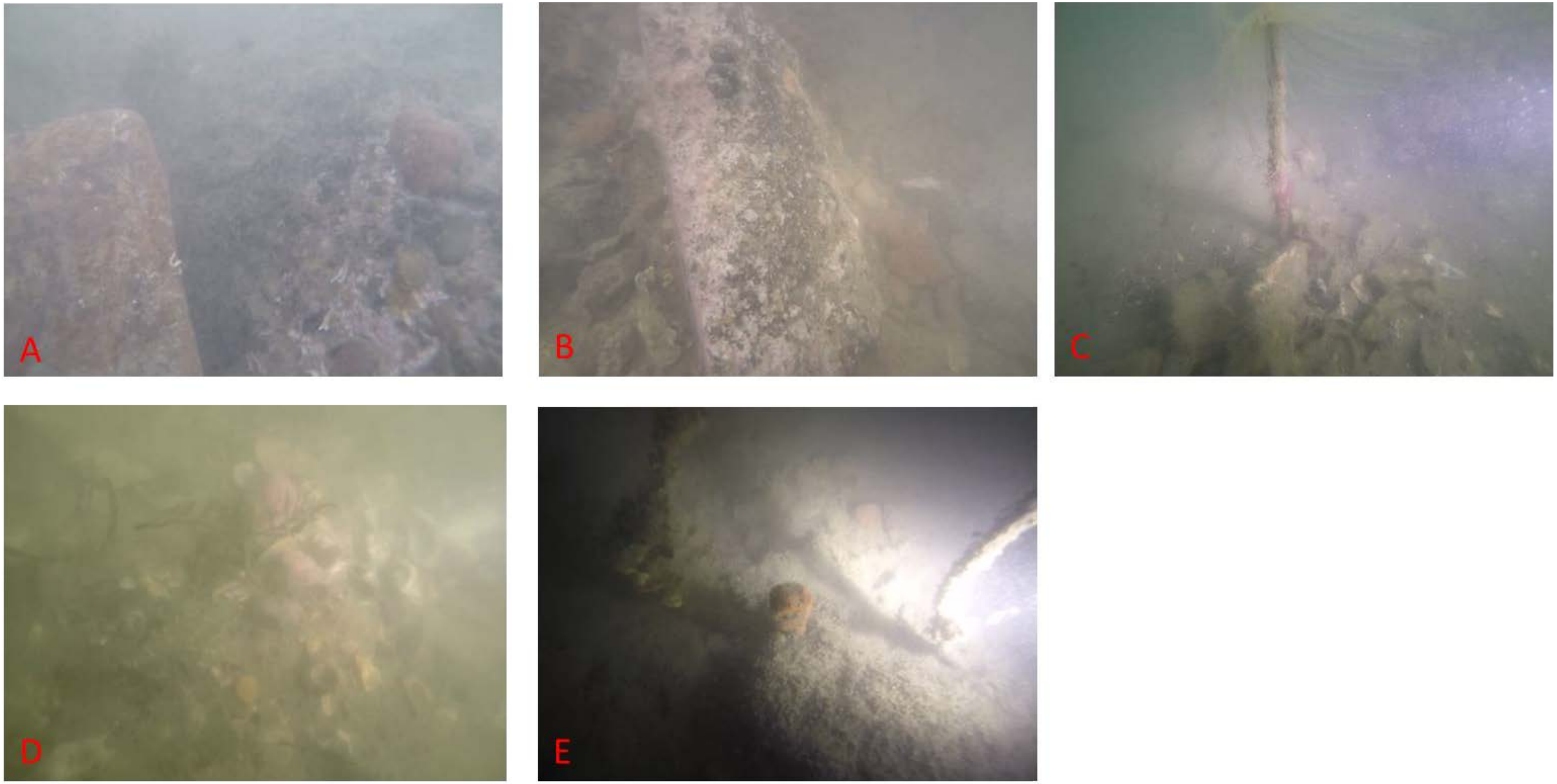
4. Wave panels

Representative photos from wave panels located on the Western Viaduct Wharf, seaward facing. A, quadrat a was at MHWS (as defined by the upper limit of barnacles on the pile). B, quadrat b was 2 m below MHWS and characterised as dominant oyster, *Magallana gigas*, cover. C, quadrat c was 5 m below MHWS.

5. Reclamation wall

Representative photos from the reclamation wall located between Silo Marina and Wynyard Point. A, quadrat a was at MHWS (as defined by the upper littoral zone). B, quadrat b was approximately 5 m below MHWS and characterised as dominant oyster, *Magallana gigas*, cover. C, quadrat c was MLWS.

6. North Wharf/Wynyard Wharf corner



Representative photos from the corner of North Wharf and Wynyard Wharf. A, quadrat a was at MLWS (approximately 0.5 m depth at low tide). B, quadrat b was approximately 2 m below MLWS, on a horizontal transect along the seabed. C, quadrat c was approximately 4 m below MLWS. D, quadrat D was approximately 6 m below MLWS. E, quadrat e was approximately 8 m below MLWS.

7. Sediment stations

Representative photos from sediment stations showing invertebrate burrows. approximately 2 m below MLWS, on a horizontal transect along the seabed. C, quadrat c was approximately 4 m below MLWS. D, quadrat D was approximately 6 m below MLWS. E, quadrat e was approximately 8 m below MLWS.

Appendix E ANOVA Summary for sediment macrofauna

Significant differences in bold.

		No. individuals		Richness		Shannon's H'		*Theora lubrica*		*Nassarius burchardi*		Ostracoda	
	d.f.	*F*	*P*	*F*	*P*	*F*	*P*	*F*	*P*	*F*	*P*	*F*	*P*
Locations: L	2, 9	3.304	0.084	3.466	0.076	11.796	**0.003**	34.026	**0.000**	9.894	**0.005**	3.898	0.060
Stations(L)	9, 24	0.877	0.558	0.781	0.636	0.722	0.684	1.190	0.345	3.244	**0.010**	1.558	0.185

		Oligochaeta		Cirratulidae		*Phylo* sp.		*Prionospio yuriel*†		*Heteromastus filiformis*		*Paradoneis lyra*†	
	d.f.	*F*	*P*	*F*	*P*	*F*	*P*	*F*	*P*	*F*	*P*	*F*	*P*
Locations: L	2, 9	0.047	0.954	2.982	0.101	1.644	0.246	20.266	**0.000**	2.581	0.130	3.409	0.079
Stations(L)	9, 24	2.461	**0.038**	0.889	0.549	2.844	**0.020**	0.824	0.600	0.593	0.790	1.221	0.328

†Analysis on ln(x+1) transformed data

APPENDIX B

Seabirds

Boffa Miskell

Memorandum

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Attention:	Paul Kennedy
Company:	Golder Associates
Date:	12/12/2017
From:	Lee Shapiro
Message Ref:	Avifauna surveys western reclamation
Project No:	A17217

Purpose

The proposed location of Americas Cup 36 land-based elements utilises the existing wharves and adjacent water space of Freemans Bay between the eastern side of Wynyard Wharf and the western side of Princes Wharf. Several businesses currently utilising the site will need to be relocated and this includes the Sealink Wynyard Wharf Terminal located at 11 Brigham St. The proposed relocation site put forward is located on the western side of the of the Wynyard reclamation and referred to as Option 3.4 Decant Facilities 2. The site is directly adjacent and South West of the existing Firth Concrete site.

An assessment of potential impacts on avifauna was undertaken as part of the assessment of effects for the overall project including the potential relocation of the Sealink Terminal. The assessment included a desktop review of known bird records for the area as well as a site survey of the coastal margins of the Wynyard Wharf.

Avifauna values

The Waitemata Harbour is home to a diverse range of native and introduced avifauna including several At Risk species (including NZ dotterel, variable oyster catchers, white-fronted terns and red-billed gulls) that utilise the coastal habitat, sandspits and mudflats for feeding, roosting and breeding.

Red-billed gulls

The Wharf provides a mix of potential habitat for birds in what is largely an industrial use area. During survey work looking at potential marine effects of the development (undertaken from a boat) a large number of red-billed gulls (At Risk – declining) were observed at one site along the western coast of Wynyard Wharf. A review of the literature on red-billed gulls identified records of a well-established red-billed gull colony located within the Sanford's slipway and yards at 56 Hamer St (Wynyard Wharf), and during the 2014-2016 national red-billed gull colony survey this was classified as a medium to large colony (Frost & Taylor 2016). During a visit to this site (6th December 2017) approximately 600 red-billed gulls were recorded and this consisted of nesting and non-nesting adults and juveniles (Figure 1). A large number of nests, eggs and juveniles were observed (Figure 2).

Figure 1: Red-billed gull colony at Sanford's slipway and yards at 56 Hamer St

Figure 2: Nesting red-billed gulls, juveniles and eggs

White-fronted tern

White-fronted tern (At Risk – declining) were also observed at this site utilising wooden wharf piles (several metres offshore from the slipway) for roosting and nesting (Figure 3). Eight individual nests (each on a single wooden pile) were observed during the site survey.

North Island NZ Dotterel

Approximately 300 m south of the red-billed gull colony on Wynyard Wharf, a pair of NZ dotterel (At Risk – recovering) have made use of a small grassed area within a boat building yard (164-188 Beaumont St) to nest and successfully fledge chicks over the past five years. During the visit to this site (6th December 2017) both adults and three chicks were observed sheltering under a large boat mast. This site is not part of the redevelopment for the Americas Cup but it is noteworthy in terms of an At Risk species successfully utilising habitat in close vicinity and the need to consider the timing of works for the wider site around breeding times.

Figure 3: White-fronted terns roosting and nesting on wharf piles at 56 Hamer St

Other species of interest

Several other bird species including a single pied shag and two variable oyster catchers (both species At Risk – recovering) were seen moving across the channel adjacent to this site but appeared to be using the Westhaven seawall on the opposite side of the channel for roosting. Black-backed gulls (not threatened) were observed raiding red-billed gull nests within the colony and returning to the Westhaven seawall where black-backed gulls appeared to be nesting.

Context for threat classifications of observed avifauna

Red-billed gulls

The red-billed gull is the commonest gull species found on the New Zealand coast, however, their threat classification of 'At Risk' – Declining (Robertson et al. 2017) is due to recent concern at the marked decline in numbers nationally, especially at some of the historically largest colonies (Frost & Taylor 2016). Red-billed gulls have a long breeding season that can stretch between September and January and breeding occurs in large densely packed colonies. Adults and juveniles display considerable site fidelity to colonies and at most colonies adults and chicks return to the same colony in which they previously bred or were hatched (Mills 2013).

There are a number of factors potentially adversely influencing the red-billed gull population, including predation and disturbance at breeding colonies, however, these may be less important than changes in food availability offshore during the breeding season (Frost & Taylor 2016). Red-billed gulls are dependent upon an abundant and regular supply of the surface-swarming planktonic euphausiid *Nyctiphanes australis* for successful breeding (Mills et al. 2008).

The colony located at the Sanford's slipway was classified as a medium – large colony (100<500 pairs) in the 2014-2016 national red-billed gull colony survey. During this survey three other medium – large colonies were recorded in the Hauraki Gulf at Koi Island, The Needles Rocks and on Tiritiri Matangi Island and a further six small – medium colonies (10<100 pairs) were also recorded within the Hauraki Gulf.

White-fronted tern

White-fronted tern are the most abundant and widespread tern in New Zealand. Most white-fronted terns breed colonially on rocky offshore islands and stacks, ledges on cliffs and on sand spits in estuaries and along the coast. Breeding generally occurs between October and January inclusive. A small number of white-fronted terns also nest on groynes and harbour piles (Frost 2017) as observed by the slipway at the red-billed gull colony at 56 Hamer St. White-fronted terns roost and nest at a number of locations within the Waitemata Harbour including on disused wooden wharf piles along St Marys Bay and within Westhaven Marina as well as on several of the shell barrier beaches within Shoal Bay.

North Island NZ dotterel

The North Island NZ dotterel is almost entirely coastal and typically breeds on sandy beaches, sand spits and shell banks (Dowding & Davis 2007). In urban or developed areas it will also nest on grassed areas or bare earth including building sites, spoil heaps, quarries, golf courses and airport margins (Dowding & Davis 2007). The main breeding period is between September and January.

There are a number of factors that currently adversely impact Northern NZ dotterel. These include predation by mammalian pests, particularly of chicks and eggs as well as human activities in the coastal zone which can result in loss or degradation of habitat and high levels of disturbance in some areas during the breeding season (Dowding & Davis 2007; Dowding 2014).

Potential effects

The proposed site for relocating the Sealink terminal is located approximately 90 m North East of the red-billed gull colony. No native bird species were observed along the coastal fringe of this site when viewed from the seawall on the western boundary. The site has limited suitable habitat for shorebirds to feed and very little area for roosting exists between the high-tide line and the seawall.

The proposed terminal will include several floating pontoons and the construction of two wharfs. The wharf closest to the red-billed gull colony will be 96 m long and approximately 15 m from the colony at its closest point. The construction of this wharf would not impact the colony in terms of lost habitat, however, the close proximity of the south western wharf would create a disturbance effect both during construction and once operational. The main use of this wharf is proposed to be for commercial fishing vessels and this is likely to result in an increase in pest and scavenging species which potentially would increase the predation risk to nesting red-billed gulls, chicks and eggs. The proposed site would also possibly require the removal of old wharf piles currently being used by white-fronted terns for roosting and nesting.

Applying the EIANZ[1] criteria (outlined in Appendices 1 - 3) to assess the significance of ecological effects would result in a Low level of effect on red-billed gulls. This could possibly be further reduced to Very Low if several mitigation measures are implemented.

The potential removal of the several or all of the wharf piles at this site would remove this nesting habitat, however, these sites could easily be recreated at other points within close proximity. The removal of the wooden pylons would result in a loss of several individual nest sites for white-fronted tern and applying the EIANZ criteria a Very Low level of effect would result if these are removed.

Potential Mitigation

Red-billed gulls

The biggest impact on the red-billed gull colony is likely to disturbance from the construction of the 96 m long piled wharf on the south western end of the site. To minimise the level of disturbance the piling and construction of this wharf should be undertaken outside of the main breeding season for red-billed gulls (September to January inclusive). Once constructed there is likely to be a large amount of vehicle and foot

[1] Environmental Institute of Australia and New Zealand

traffic along this wharf, to reduce the disturbance on the colony it is recommended that screening is constructed along the section of this wharf that directly faces the colony.

The presence of commercial fishing vessels, their catch and any waste will be very attractive to a range of mammalian pest species including rats and feral cats. An effective mitigation measure to balance any potential increase in these predators would be ongoing trapping and toxic baiting targeting small mammals.

The red-billed colony does not appear to be significantly impacted from current disturbance levels at this site. The proposed development will increase the levels of disturbance and it will be important to assess the level of impact by monitoring the number of birds using the colony before, during and after construction. Considerable site fidelity to colonies is displayed by adult and juvenile red-billed gulls (Mills 2013) and monitoring has the potential to detect any significant short to medium term impacts from this development.

The Sanford's slipway red-billed gull colony is one of four medium – large colonies recorded in the Hauraki Gulf and if this development does have a significant disturbance effect then red-billed gulls may potentially use one of these other sites (or one of the six small – medium colonies) to breed instead. If this is the case, then further mitigation could be considered and this could include improving habitat quality at one or several of these other sites.

White-fronted tern

The removal of the wharf piles could be managed by ensuring that this in undertaken outside of the breeding season for white-fronted terns (October to January inclusive). Potential mitigation could include the replacement of the wharf piles with wooden piles to provide substitute nesting habitat in the general vicinity; or alternatively to provide offsite mitigation in the form of pest control at an established white-fronted tern breeding colony.

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Appendices

Appendix 1: EIANZ criteria to assess 'Ecological Value'.

Value	Explanation
Very High	Nationally Threatened species (Critical, Endangered or Vulnerable) found in the Zone of Influence or likely to occur there, either permanently or occasionally OR a habitat supporting more than one national priority vegetation type based on "Protecting Our Places" (MfE & DoC, 2007) OR rates High for all or most of the adopted assessment matters of representativeness, rarity, diversity and pattern and ecological context.
High	Nationally At Risk species (Declining) found in the Zone of Influence or likely to occur there, either permanently or occasionally OR a Nationally Uncommon ecosystem based on the threat categories in "Status Assessment of NZ's Naturally Uncommon Ecosystems" (Holdaway, Wiser & Williams, 2012) OR a Nationally recognised wetland OR a LENZ category of 20% or less remaining indigenous cover OR indigenous vegetation associated with sand dunes and wetlands OR indigenous vegetation associated with originally rare terrestrial ecosystems OR habitats of acutely and chronically threatened native species
Moderate-High	Species listed in any other category of At Risk category (Recovering, Relict or Naturally Uncommon) found in the Zone of Influence or likely to occur there, either permanently or occasionally.
Moderate	Locally uncommon/rare species but not Nationally Threatened or At Risk.
Low	Species Not Threatened nationally and common locally.

Appendix 2: EIANZ criteria to assess magnitude of effects

Magnitude	Description
Very High	Total loss or very major alteration to key elements/ features of the existing baseline conditions, such that the post development character/ composition/ attributes will be fundamentally changed and may be lost from the site altogether AND/OR loss of a very high proportion of the known population or range of the elements/feature.
High	Major loss or major alteration to key elements/ features of the baseline (pre-development) conditions such that post development character/ composition/ attributes will be fundamentally changed AND/OR loss of a high proportion of the known population or range of the elements/feature.
Moderate	Loss or alteration to one or more key elements/features of the baseline conditions such that post development character/composition/attributes of baseline will be partially changed AND/OR loss of a moderate proportion of the known population or range of the elements/feature.
Low/Minor	Minor shift away from baseline conditions. Change arising from the loss/alteration will be discernible but underlying character/composition/attributes of baseline condition will be similar to pre-development circumstances/patterns AND/OR having a minor effect on the known population or range of the elements/feature.
Negligible	Very slight change from baseline condition. Change barely distinguishable, approximating to the "no change" situation AND/OR having negligible effect on the known population or range of the elements/feature.

Appendix 3: EIANZ criteria to assess significance of ecological effects.

SIGNIFICANCE		Ecological &/or Conservation Value			
		Very High	**High**	**Medium**	**Low**
Magnitude	**Very High**	**Very High**	**Very High**	**High**	**Moderate**
	High	**Very High**	**Very High**	**Moderate**	**Low**
	Moderate	**Very High**	**High**	**Low**	**Very Low**
	Low	**Moderate**	**Low**	**Low**	**Very low**
	Negligible	**Low**	**Very Low**	**Very Low**	**Very Low**

APPENDIX C

Laboratory Reports – Sediment

Hill Laboratories
TRIED, TESTED AND TRUSTED

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ANALYSIS REPORT

Client:	Golder Associates (NZ) Limited	**Lab No:**	1879306 SPv3
Contact:	Mr P Kennedy	**Date Received:**	17-Nov-2017
	C/- Golder Associates (NZ) Limited	**Date Reported:**	14-Dec-2017
	PO Box 33849	**Quote No:**	88936
	Takapuna	**Order No:**	
	Auckland 0740	**Client Reference:**	Marine Sediment Samples
		Add. Client Ref:	1790454
		Submitted By:	Emanuelle Desrochers

Sample Type: Sediment

Sample Name:		Station 1	Station 2	Station 3	HW-S3	HW-S6
Lab Number:		1879306.1	1879306.2	1879306.3	1879306.4	1879306.5
Individual Tests						
Dry Matter	g/100g as rcvd	-	-	-	42	37
Dry Matter of Sieved Sample	g/100g as rcvd	35	36	33	-	38
Total Recoverable Copper	mg/kg dry wt	-	-	-	16.1	16.1
Total Recoverable Lead	mg/kg dry wt	-	-	-	24	22
Total Recoverable Zinc	mg/kg dry wt	-	-	-	89	85
Total Organic Carbon*	g/100g dry wt	-	-	-	1.26	1.26
3 Grain Sizes Profile						
Fraction < 2 mm, >/= 63 µm*	g/100g dry wt	14.9	17.2	12.9	-	20.3
Fraction < 63 µm*	g/100g dry wt	84.7	82.8	87.0	-	79.7
Total Petroleum Hydrocarbons in Soil, GC						
C7 - C9	mg/kg dry wt	-	-	-	< 15	< 16
C10 - C11	mg/kg dry wt	-	-	-	< 15	< 16
C12 - C14	mg/kg dry wt	-	-	-	< 15	< 16
C15 - C20	mg/kg dry wt	-	-	-	< 15	< 16
C21 - C25	mg/kg dry wt	-	-	-	< 15	< 16
C26 - C29	mg/kg dry wt	-	-	-	< 15	< 16
C30 - C44	mg/kg dry wt	-	-	-	< 30	< 30
Total hydrocarbons (C7 - C44)	mg/kg dry wt	-	-	-	< 110	< 120

Sample Name:		HW-S9	HW-S8	HW-S5	HW-S2	HW-S1
Lab Number:		1879306.6	1879306.7	1879306.8	1879306.9	1879306.10
Individual Tests						
Dry Matter	g/100g as rcvd	36	38	47	43	36
Dry Matter of Sieved Sample	g/100g as rcvd	36	37	-	42	37
Total Recoverable Copper	mg/kg dry wt	17.8	18.5	13.4	14.7	16.3
Total Recoverable Lead	mg/kg dry wt	24	25	24	23	22
Total Recoverable Zinc	mg/kg dry wt	91	95	85	87	86
Total Organic Carbon*	g/100g dry wt	1.41	1.32	1.00	1.21	1.21
3 Grain Sizes Profile						
Fraction < 2 mm, >/= 63 µm*	g/100g dry wt	17.9	21.8	-	32.9	-
Fraction < 63 µm*	g/100g dry wt	82.1	78.0	-	67.1	-
Total Petroleum Hydrocarbons in Soil, GC						
C7 - C9	mg/kg dry wt	< 17	< 16	< 13	< 14	< 17
C10 - C11	mg/kg dry wt	< 17	< 16	< 13	< 14	< 17
C12 - C14	mg/kg dry wt	< 17	< 16	< 13	< 14	< 17
C15 - C20	mg/kg dry wt	< 17	< 16	< 13	< 14	< 17
C21 - C25	mg/kg dry wt	< 17	< 16	< 13	< 14	< 17

Sample Type: Sediment						
	Sample Name:	HW-S9	HW-S8	HW-S5	HW-S2	HW-S1
	Lab Number:	1879306.6	1879306.7	1879306.8	1879306.9	1879306.10
Total Petroleum Hydrocarbons in Soil, GC						
C26 - C29	mg/kg dry wt	< 17	< 16	< 13	< 14	< 17
C30 - C44	mg/kg dry wt	< 30	< 30	< 20	< 20	< 30
Total hydrocarbons (C7 - C44)	mg/kg dry wt	< 120	< 120	< 100	< 110	< 130

	Sample Name:	HW-S4	HW-S7	Composite of HW-S4, HW-S5 and HW-S6	Composite of HW-S7, HW-S8 and HW-S9	STN 13 (HWS-12)
	Lab Number:	1879306.11	1879306.12	1879306.14	1879306.15	1879306.16
Individual Tests						
Dry Matter	g/100g as rcvd	43	40	43	38	33
Dry Matter of Sieved Sample	g/100g as rcvd	-	42	-	-	36
Total Recoverable Copper	mg/kg dry wt	14.9	16.0	-	-	28
Total Recoverable Lead	mg/kg dry wt	22	23	-	-	28
Total Recoverable Zinc	mg/kg dry wt	87	87	-	-	124
Total Organic Carbon*	g/100g dry wt	1.07	1.18	-	-	1.54
Antifouling cobiocides in sediment samples by LCMSMS						
Diuron*	mg/kg dry wt	-	-	< 0.010	< 0.010	-
Irgarol*	mg/kg dry wt	-	-	< 0.010	< 0.010	-
Isoproturon*	mg/kg dry wt	-	-	< 0.010	< 0.010	-
3 Grain Sizes Profile						
Fraction < 2 mm, >/= 63 µm*	g/100g dry wt	-	28.1	-	-	8.8
Fraction < 63 µm*	g/100g dry wt	-	71.8	-	-	91.2
Organochlorine Pesticides Trace in Soil						
Aldrin	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
alpha-BHC	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
beta-BHC	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
delta-BHC	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
gamma-BHC (Lindane)	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
cis-Chlordane	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
trans-Chlordane	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
2,4'-DDD	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
4,4'-DDD	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
2,4'-DDE	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
4,4'-DDE	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
2,4'-DDT	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
4,4'-DDT	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
Total DDT Isomers	mg/kg dry wt	-	-	< 0.006	< 0.006	-
Dieldrin	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
Endosulfan I	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
Endosulfan II	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
Endosulfan sulphate	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
Endrin	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
Endrin aldehyde	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
Endrin ketone	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
Heptachlor	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
Heptachlor epoxide	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
Hexachlorobenzene	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
Methoxychlor	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
Total Chlordane [(cis+trans)* 100/42]	mg/kg dry wt	-	-	< 0.002	< 0.002	-
Polycyclic Aromatic Hydrocarbons Trace in Soil						
1-Methylnaphthalene	mg/kg dry wt	-	-	0.005	0.004	-
2-Methylnaphthalene	mg/kg dry wt	-	-	0.004	0.004	-
Acenaphthene	mg/kg dry wt	-	-	0.005	< 0.004	-
Acenaphthylene	mg/kg dry wt	-	-	0.009	0.005	-
Anthracene	mg/kg dry wt	-	-	0.021	0.012	-

Sample Type: Sediment						
Sample Name:		HW-S4	HW-S7	Composite of HW-S4, HW-S5 and HW-S6	Composite of HW-S7, HW-S8 and HW-S9	STN 13 (HWS-12)
Lab Number:		1879306.11	1879306.12	1879306.14	1879306.15	1879306.16
Polycyclic Aromatic Hydrocarbons Trace in Soil						
Benzo[a]anthracene	mg/kg dry wt	-	-	0.103	0.069	-
Benzo[a]pyrene (BAP)	mg/kg dry wt	-	-	0.129	0.090	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	-	-	0.127	0.097	-
Benzo[e]pyrene	mg/kg dry wt	-	-	0.066	0.049	-
Benzo[g,h,i]perylene	mg/kg dry wt	-	-	0.071	0.054	-
Benzo[k]fluoranthene	mg/kg dry wt	-	-	0.049	0.036	-
Chrysene	mg/kg dry wt	-	-	0.088	0.059	-
Dibenzo[a,h]anthracene	mg/kg dry wt	-	-	0.014	0.010	-
Fluoranthene	mg/kg dry wt	-	-	0.22	0.141	-
Fluorene	mg/kg dry wt	-	-	0.009	0.004	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	-	-	0.078	0.059	-
Naphthalene	mg/kg dry wt	-	-	< 0.016	< 0.018	-
Perylene	mg/kg dry wt	-	-	0.029	0.022	-
Phenanthrene	mg/kg dry wt	-	-	0.104	0.047	-
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES	mg/kg dry wt	-	-	0.182	0.129	-
Benzo[a]pyrene Toxic Equivalence (TEF)	mg/kg dry wt	-	-	0.181	0.129	-
Pyrene	mg/kg dry wt	-	-	0.20	0.129	-
Polychlorinated Biphenyls Trace in Soil						
PCB-18	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-28	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-31	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-44	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-49	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-52	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-60	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-77	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-81	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-86	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-101	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-105	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-110	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-114	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-118	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-121	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-123	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-126	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-128	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-138	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-141	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-149	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-151	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-153	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-156	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-157	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-159	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-167	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-169	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-170	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-180	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-189	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-194	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
PCB-206	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-

Sample Type: Sediment

Sample Name:		HW-S4	HW-S7	Composite of HW-S4, HW-S5 and HW-S6	Composite of HW-S7, HW-S8 and HW-S9	STN 13 (HWS-12)
Lab Number:		1879306.11	1879306.12	1879306.14	1879306.15	1879306.16
Polychlorinated Biphenyls Trace in Soil						
PCB-209	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
Mono-Ortho PCB Toxic Equivalence (TEF)*	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
Non-Ortho PCB Toxic Equivalence (TEF)*	mg/kg dry wt	-	-	< 0.0010	< 0.0010	-
Total PCB (Sum of 35 congeners)	mg/kg dry wt	-	-	< 0.04	< 0.04	-
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	-
Total Petroleum Hydrocarbons in Soil, GC						
C7 - C9	mg/kg dry wt	< 14	< 15	-	-	< 18
C10 - C11	mg/kg dry wt	< 14	< 15	-	-	< 18
C12 - C14	mg/kg dry wt	< 14	< 15	-	-	< 18
C15 - C20	mg/kg dry wt	< 14	< 15	-	-	< 18
C21 - C25	mg/kg dry wt	< 14	< 15	-	-	< 18
C26 - C29	mg/kg dry wt	< 14	< 15	-	-	< 18
C30 - C44	mg/kg dry wt	< 20	< 30	-	-	< 30
Total hydrocarbons (C7 - C44)	mg/kg dry wt	< 110	< 110	-	-	< 140

Sample Name:		STN 14 (HWS-11)	STN 15 (HWS-10)	Composite of STN 13 (HWS-12), STN 14 (HWS-11) and STN 15 (HWS-10)		
Lab Number:		1879306.17	1879306.18	1879306.19		
Individual Tests						
Dry Matter	g/100g as rcvd	37	33	34	-	-
Dry Matter of Sieved Sample	g/100g as rcvd	37	34	-	-	-
Total Recoverable Copper	mg/kg dry wt	29	27	-	-	-
Total Recoverable Lead	mg/kg dry wt	29	28	-	-	-
Total Recoverable Zinc	mg/kg dry wt	117	111	-	-	-
Total Organic Carbon*	g/100g dry wt	1.48	1.45	-	-	-
Antifouling cobiocides in sediment samples by LCMSMS						
Diuron*	mg/kg dry wt	-	-	< 0.010	-	-
Irgarol*	mg/kg dry wt	-	-	< 0.010	-	-
Isoproturon*	mg/kg dry wt	-	-	< 0.010	-	-
3 Grain Sizes Profile						
Fraction < 2 mm, >/= 63 µm*	g/100g dry wt	7.3	8.9	-	-	-
Fraction < 63 µm*	g/100g dry wt	92.7	91.1	-	-	-
Organochlorine Pesticides Trace in Soil						
Aldrin	mg/kg dry wt	-	-	< 0.0010	-	-
alpha-BHC	mg/kg dry wt	-	-	< 0.0010	-	-
beta-BHC	mg/kg dry wt	-	-	< 0.0010	-	-
delta-BHC	mg/kg dry wt	-	-	< 0.0010	-	-
gamma-BHC (Lindane)	mg/kg dry wt	-	-	< 0.0010	-	-
cis-Chlordane	mg/kg dry wt	-	-	< 0.0010	-	-
trans-Chlordane	mg/kg dry wt	-	-	< 0.0010	-	-
2,4'-DDD	mg/kg dry wt	-	-	< 0.0010	-	-
4,4'-DDD	mg/kg dry wt	-	-	0.0010	-	-
2,4'-DDE	mg/kg dry wt	-	-	< 0.0010	-	-
4,4'-DDE	mg/kg dry wt	-	-	0.0016	-	-
2,4'-DDT	mg/kg dry wt	-	-	< 0.0010	-	-
4,4'-DDT	mg/kg dry wt	-	-	0.0022	-	-

Sample Type: Sediment						
Sample Name:		STN 14 (HWS-11)	STN 15 (HWS-10)	Composite of STN 13 (HWS-12), STN 14 (HWS-11) and STN 15 (HWS-10)		
Lab Number:		1879306.17	1879306.18	1879306.19		
Organochlorine Pesticides Trace in Soil						
Total DDT Isomers	mg/kg dry wt	-	-	< 0.006	-	-
Dieldrin	mg/kg dry wt	-	-	< 0.0010	-	-
Endosulfan I	mg/kg dry wt	-	-	< 0.0010	-	-
Endosulfan II	mg/kg dry wt	-	-	< 0.0010	-	-
Endosulfan sulphate	mg/kg dry wt	-	-	< 0.0010	-	-
Endrin	mg/kg dry wt	-	-	< 0.0010	-	-
Endrin aldehyde	mg/kg dry wt	-	-	< 0.0010	-	-
Endrin ketone	mg/kg dry wt	-	-	< 0.0010	-	-
Heptachlor	mg/kg dry wt	-	-	< 0.0010	-	-
Heptachlor epoxide	mg/kg dry wt	-	-	< 0.0010	-	-
Hexachlorobenzene	mg/kg dry wt	-	-	< 0.0010	-	-
Methoxychlor	mg/kg dry wt	-	-	< 0.0010	-	-
Total Chlordane [(cis+trans)* 100/42]	mg/kg dry wt	-	-	< 0.002	-	-
Polycyclic Aromatic Hydrocarbons Trace in Soil						
1-Methylnaphthalene	mg/kg dry wt	-	-	0.005	-	-
2-Methylnaphthalene	mg/kg dry wt	-	-	0.006	-	-
Acenaphthene	mg/kg dry wt	-	-	< 0.005	-	-
Acenaphthylene	mg/kg dry wt	-	-	0.006	-	-
Anthracene	mg/kg dry wt	-	-	0.011	-	-
Benzo[a]anthracene	mg/kg dry wt	-	-	0.069	-	-
Benzo[a]pyrene (BAP)	mg/kg dry wt	-	-	0.102	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	-	-	0.114	-	-
Benzo[e]pyrene	mg/kg dry wt	-	-	0.056	-	-
Benzo[g,h,i]perylene	mg/kg dry wt	-	-	0.067	-	-
Benzo[k]fluoranthene	mg/kg dry wt	-	-	0.041	-	-
Chrysene	mg/kg dry wt	-	-	0.063	-	-
Dibenzo[a,h]anthracene	mg/kg dry wt	-	-	0.013	-	-
Fluoranthene	mg/kg dry wt	-	-	0.137	-	-
Fluorene	mg/kg dry wt	-	-	< 0.005	-	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	-	-	0.083	-	-
Naphthalene	mg/kg dry wt	-	-	< 0.03	-	-
Perylene	mg/kg dry wt	-	-	0.024	-	-
Phenanthrene	mg/kg dry wt	-	-	0.045	-	-
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES	mg/kg dry wt	-	-	0.148	-	-
Benzo[a]pyrene Toxic Equivalence (TEF)	mg/kg dry wt	-	-	0.147	-	-
Pyrene	mg/kg dry wt	-	-	0.129	-	-
Polychlorinated Biphenyls Trace in Soil						
PCB-18	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-28	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-31	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-44	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-49	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-52	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-60	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-77	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-81	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-86	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-101	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-105	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-110	mg/kg dry wt	-	-	< 0.0010	-	-

Sample Type: Sediment						
Sample Name:		STN 14 (HWS-11)	STN 15 (HWS-10)	Composite of STN 13 (HWS-12), STN 14 (HWS-11) and STN 15 (HWS-10)		
Lab Number:		1879306.17	1879306.18	1879306.19		
Polychlorinated Biphenyls Trace in Soil						
PCB-114	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-118	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-121	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-123	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-126	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-128	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-138	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-141	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-149	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-151	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-153	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-156	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-157	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-159	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-167	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-169	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-170	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-180	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-189	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-194	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-206	mg/kg dry wt	-	-	< 0.0010	-	-
PCB-209	mg/kg dry wt	-	-	< 0.0010	-	-
Mono-Ortho PCB Toxic Equivalence (TEF)*	mg/kg dry wt	-	-	< 0.0010	-	-
Non-Ortho PCB Toxic Equivalence (TEF)*	mg/kg dry wt	-	-	< 0.0010	-	-
Total PCB (Sum of 35 congeners)	mg/kg dry wt	-	-	< 0.04	-	-
Tributyl Tin Trace in Soil samples by GCMS						
Dibutyltin (as Sn)	mg/kg dry wt	-	-	< 0.005	-	-
Monobutyltin (as Sn)	mg/kg dry wt	-	-	< 0.007	-	-
Tributyltin (as Sn)	mg/kg dry wt	-	-	< 0.004	-	-
Triphenyltin (as Sn)	mg/kg dry wt	-	-	< 0.003	-	-
Total Petroleum Hydrocarbons in Soil, GC						
C7 - C9	mg/kg dry wt	< 16	< 18	-	-	-
C10 - C11	mg/kg dry wt	< 16	< 18	-	-	-
C12 - C14	mg/kg dry wt	< 16	< 18	-	-	-
C15 - C20	mg/kg dry wt	< 16	< 18	-	-	-
C21 - C25	mg/kg dry wt	< 16	< 18	-	-	-
C26 - C29	mg/kg dry wt	< 16	< 18	-	-	-
C30 - C44	mg/kg dry wt	< 30	< 30	-	-	-
Total hydrocarbons (C7 - C44)	mg/kg dry wt	< 120	< 130	-	-	-

Analyst's Comments

Only plastic containers were supplied for the samples 1879306.4-12. Please note that glass containers should be used for TPHP/VOC/BTEX analysis to avoid loss of volatile's and possible plastic contamination.

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 clean 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.

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Individual Tests			

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Antifouling cobiocides suite in sediment by LCMSMS*	Ethyl acetate extraction, SPE cleanup, determination by LCMSMS.	-	14-15, 19
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%.	-	4-12, 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	4-12, 14-19
Dry Matter for Grainsize samples	Drying for 16 hours at 103°C, gravimetry (Free water removed before analysis).	0.10 g/100g as rcvd	1-3, 5-7, 9-10, 12, 16-18
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	4-12, 16-18
Composite Environmental Solid Samples*	Individual sample fractions mixed together to form a composite fraction.	-	4-12, 16-18
Total Recoverable Copper	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.2 mg/kg dry wt	4-12, 16-18
Total Recoverable Lead	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.04 mg/kg dry wt	4-12, 16-18
Total Recoverable Zinc	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, trace level. US EPA 200.2.	0.4 mg/kg dry wt	4-12, 16-18
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	4-12, 16-18
Antifouling cobiocides in sediment samples by LCMSMS*		0.010 mg/kg dry wt	14-15, 19
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	14-15, 19
3 Grain Sizes Profile*		0.1 g/100g dry wt	1-3, 5-7, 9, 12, 16-18
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 - 0.010 mg/kg dry wt	14-15, 19
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	14-15, 19
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	4-12, 16-18
3 Grain Sizes Profile			
Fraction < 2 mm, >/= 63 µm*	Wet sieving using dispersant, 2.00 mm and 63 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-3, 5-7, 9, 12, 16-18
Fraction < 63 µm*	Wet sieving with dispersant, 63 µm sieve, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-3, 5-7, 9, 12, 16-18

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

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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Client Services Manager - Environmental

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ANALYSIS REPORT

Client:	Golder Associates (NZ) Limited - Auckland	**Lab No:**	1882514 SPv9
Contact:	Emanuelle Desrochers	**Date Received:**	23-Nov-2017
	C/- Golder Associates (NZ) Limited - Auckland	**Date Reported:**	10-Jan-2018 **(Amended)**
	PO Box 33849	**Quote No:**	89156
	Takapuna	**Order No:**	
	Auckland 0740	**Client Reference:**	Sediment Quality Analysis
		Submitted By:	Mr P Kennedy

Sample Type: Saline

Sample Name:		Seawater (for elutriation extraction)				
Lab Number:		1882514.15				
Individual Tests						
Total Arsenic*	g/m³	< 0.0042	-	-	-	-
Total Cadmium*	g/m³	< 0.00021	-	-	-	-
Total Chromium*	g/m³	< 0.0011	-	-	-	-
Total Copper*	g/m³	< 0.0011	-	-	-	-
Total Lead*	g/m³	< 0.0011	-	-	-	-
Total Mercury*	g/m³	< 0.00008	-	-	-	-
Total Nickel*	g/m³	< 0.007	-	-	-	-
Total Zinc*	g/m³	< 0.0042	-	-	-	-
Total Ammoniacal-N	g/m³	0.017	-	-	-	-
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:		NWC1 23-Nov-2017	NWC2 23-Nov-2017	NWC3 23-Nov-2017	WWC1 23-Nov-2017	WWC2 23-Nov-2017
Lab Number:		1882514.1	1882514.2	1882514.3	1882514.4	1882514.5
Individual Tests						
Dry Matter	g/100g as rcvd	45	43	49	43	43
Dry Matter of Sieved Sample	g/100g as rcvd	46	44	53	44	40
Total Organic Carbon*	g/100g dry wt	2.0	1.54	1.58	1.82	1.35
Antifouling cobiocides in sediment samples by LCMSMS						
Diuron*	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Irgarol*	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Isoproturon*	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	11.2	11.9	15.5	10.6	8.5
Total Recoverable Cadmium	mg/kg dry wt	0.29	0.194	0.139	0.21	0.094
Total Recoverable Chromium	mg/kg dry wt	30	31	23	28	27
Total Recoverable Copper	mg/kg dry wt	59	67	57	48	26
Total Recoverable Lead	mg/kg dry wt	103	330	170	80	43
Total Recoverable Mercury	mg/kg dry wt	0.28	0.26	0.29	0.32	0.23
Total Recoverable Nickel	mg/kg dry wt	17.7	16.3	16.8	14.8	11.0
Total Recoverable Zinc	mg/kg dry wt	220	210	250	184	129

Sample Type: Sediment						
Sample Name:		NWC1 23-Nov-2017	NWC2 23-Nov-2017	NWC3 23-Nov-2017	WWC1 23-Nov-2017	WWC2 23-Nov-2017
Lab Number:		1882514.1	1882514.2	1882514.3	1882514.4	1882514.5
3 Grain Sizes Profile						
Fraction >/= 2 mm*	g/100g dry wt	2.7	1.3	4.8	0.1	< 0.1
Fraction < 2 mm, >/= 63 µm*	g/100g dry wt	42.2	34.9	52.0	40.0	30.5
Fraction < 63 µm*	g/100g dry wt	55.2	63.7	43.2	59.9	69.4
Polycyclic Aromatic Hydrocarbons Trace in Soil						
1-Methylnaphthalene	mg/kg dry wt	0.036	0.012	0.057	0.029	0.009
2-Methylnaphthalene	mg/kg dry wt	0.044	0.015	0.063	0.038	0.011
Acenaphthene	mg/kg dry wt	0.027	0.012	0.106	0.036	0.007
Acenaphthylene	mg/kg dry wt	0.049	0.033	0.031	0.048	0.016
Anthracene	mg/kg dry wt	0.070	0.043	0.139	0.094	0.022
Benzo[a]anthracene	mg/kg dry wt	0.36	0.26	0.71	0.37	0.119
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.51	0.34	0.71	0.52	0.172
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.58	0.41	0.97	0.59	0.187
Benzo[e]pyrene	mg/kg dry wt	0.30	0.20	0.46	0.30	0.090
Benzo[g,h,i]perylene	mg/kg dry wt	0.36	0.24	0.51	0.35	0.115
Benzo[k]fluoranthene	mg/kg dry wt	0.22	0.150	0.37	0.22	0.068
Chrysene	mg/kg dry wt	0.29	0.21	0.63	0.28	0.098
Dibenzo[a,h]anthracene	mg/kg dry wt	0.069	0.049	0.116	0.071	0.023
Fluoranthene	mg/kg dry wt	0.59	0.45	1.68	0.68	0.22
Fluorene	mg/kg dry wt	0.023	0.012	0.060	0.028	0.007
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.43	0.30	0.65	0.44	0.144
Naphthalene	mg/kg dry wt	0.045	0.023	0.058	0.050	0.019
Perylene	mg/kg dry wt	0.104	0.074	0.153	0.109	0.032
Phenanthrene	mg/kg dry wt	0.198	0.127	0.78	0.23	0.077
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES	mg/kg dry wt	0.74	0.51	1.12	0.76	0.25
Benzo[a]pyrene Toxic Equivalence (TEF)	mg/kg dry wt	0.74	0.51	1.11	0.76	0.25
Pyrene	mg/kg dry wt	0.79	0.44	1.47	0.87	0.21
Tributyl Tin Trace in Soil samples by GCMS						
Dibutyltin (as Sn)	mg/kg dry wt	0.013	0.009	0.022	0.005	0.006
Monobutyltin (as Sn)	mg/kg dry wt	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
Tributyltin (as Sn)	mg/kg dry wt	0.037	0.010	0.29	0.022	0.005
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	< 13	< 14	< 12	< 14	< 14
C10 - C11	mg/kg dry wt	< 13	< 14	< 12	< 14	< 14
C12 - C14	mg/kg dry wt	< 13	< 14	< 12	< 14	< 14
C15 - C20	mg/kg dry wt	35	31	45	58	< 14
C21 - C25	mg/kg dry wt	32	27	62	61	< 14
C26 - C29	mg/kg dry wt	33	26	73	58	< 14
C30 - C44	mg/kg dry wt	66	49	110	139	< 20
Total hydrocarbons (C7 - C44)	mg/kg dry wt	165	133	290	320	< 110

Sample Name:		WWC3 23-Nov-2017	Composite of NWC1, NWC2, NWC3	Composite of WWC1, WWC2, WWC3		
Lab Number:		1882514.6	1882514.7	1882514.8		
Individual Tests						
Dry Matter	g/100g as rcvd	37	-	-	-	-
Dry Matter of Sieved Sample	g/100g as rcvd	38	-	-	-	-
Total Organic Carbon*	g/100g dry wt	1.32	-	-	-	-
Antifouling cobiocides in sediment samples by LCMSMS						
Diuron*	mg/kg dry wt	< 0.010	-	-	-	-
Irgarol*	mg/kg dry wt	< 0.010	-	-	-	-
Isoproturon*	mg/kg dry wt	< 0.010	-	-	-	-

Sample Type: Sediment						
Sample Name:		WWC3 23-Nov-2017	Composite of NWC1, NWC2, NWC3	Composite of WWC1, WWC2, WWC3		
Lab Number:		1882514.6	1882514.7	1882514.8		
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	8.3	-	-	-	-
Total Recoverable Cadmium	mg/kg dry wt	0.037	-	-	-	-
Total Recoverable Chromium	mg/kg dry wt	25	-	-	-	-
Total Recoverable Copper	mg/kg dry wt	21	-	-	-	-
Total Recoverable Lead	mg/kg dry wt	26	-	-	-	-
Total Recoverable Mercury	mg/kg dry wt	0.30	-	-	-	-
Total Recoverable Nickel	mg/kg dry wt	10.0	-	-	-	-
Total Recoverable Zinc	mg/kg dry wt	100	-	-	-	-
3 Grain Sizes Profile						
Fraction >/= 2 mm*	g/100g dry wt	< 0.1	-	-	-	-
Fraction < 2 mm, >/= 63 µm*	g/100g dry wt	22.3	-	-	-	-
Fraction < 63 µm*	g/100g dry wt	77.7	-	-	-	-
Organochlorine Pesticides Trace in Soil						
Aldrin	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
alpha-BHC	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
beta-BHC	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
delta-BHC	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
gamma-BHC (Lindane)	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
cis-Chlordane	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
trans-Chlordane	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
2,4'-DDD	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
4,4'-DDD	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
2,4'-DDE	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
4,4'-DDE	mg/kg dry wt	-	0.0021	< 0.0010	-	-
2,4'-DDT	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
4,4'-DDT	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
Total DDT Isomers	mg/kg dry wt	-	< 0.006	< 0.006	-	-
Dieldrin	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
Endosulfan I	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
Endosulfan II	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
Endosulfan sulphate	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
Endrin	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
Endrin aldehyde	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
Endrin ketone	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
Heptachlor	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
Heptachlor epoxide	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
Hexachlorobenzene	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
Methoxychlor	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
Total Chlordane [(cis+trans)* 100/42]	mg/kg dry wt	-	< 0.002	< 0.002	-	-
Polycyclic Aromatic Hydrocarbons Trace in Soil						
1-Methylnaphthalene	mg/kg dry wt	0.004	-	-	-	-
2-Methylnaphthalene	mg/kg dry wt	0.005	-	-	-	-
Acenaphthene	mg/kg dry wt	0.006	-	-	-	-
Acenaphthylene	mg/kg dry wt	0.005	-	-	-	-
Anthracene	mg/kg dry wt	0.021	-	-	-	-
Benzo[a]anthracene	mg/kg dry wt	0.086	-	-	-	-
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.109	-	-	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.111	-	-	-	-
Benzo[e]pyrene	mg/kg dry wt	0.055	-	-	-	-
Benzo[g,h,i]perylene	mg/kg dry wt	0.064	-	-	-	-
Benzo[k]fluoranthene	mg/kg dry wt	0.042	-	-	-	-
Chrysene	mg/kg dry wt	0.069	-	-	-	-

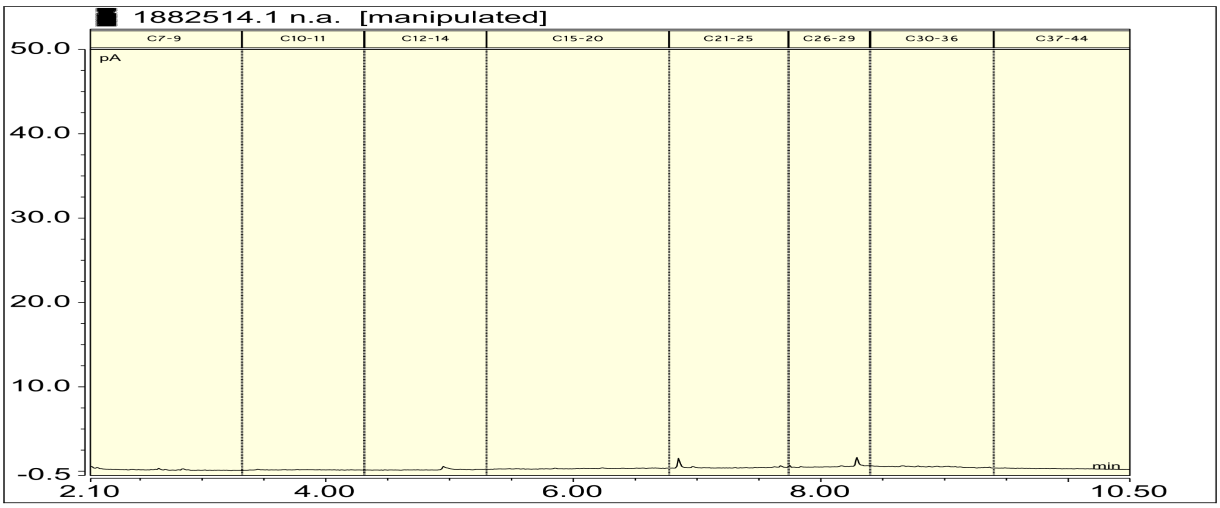
Sample Type: Sediment						
Sample Name:		WWC3 23-Nov-2017	Composite of NWC1, NWC2, NWC3	Composite of WWC1, WWC2, WWC3		
Lab Number:		1882514.6	1882514.7	1882514.8		
Polycyclic Aromatic Hydrocarbons Trace in Soil						
Dibenzo[a,h]anthracene	mg/kg dry wt	0.014	-	-	-	-
Fluoranthene	mg/kg dry wt	0.166	-	-	-	-
Fluorene	mg/kg dry wt	0.005	-	-	-	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.082	-	-	-	-
Naphthalene	mg/kg dry wt	< 0.019	-	-	-	-
Perylene	mg/kg dry wt	0.024	-	-	-	-
Phenanthrene	mg/kg dry wt	0.062	-	-	-	-
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES	mg/kg dry wt	0.157	-	-	-	-
Benzo[a]pyrene Toxic Equivalence (TEF)	mg/kg dry wt	0.157	-	-	-	-
Pyrene	mg/kg dry wt	0.165	-	-	-	-
Polychlorinated Biphenyls Trace in Soil						
PCB-18	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-28	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-31	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-44	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-49	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-52	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-60	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-77	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-81	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-86	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-101	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-105	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-110	mg/kg dry wt	-	0.0014	< 0.0010	-	-
PCB-114	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-118	mg/kg dry wt	-	0.0012	< 0.0010	-	-
PCB-121	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-123	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-126	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-128	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-138	mg/kg dry wt	-	0.0024	< 0.0010	-	-
PCB-141	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-149	mg/kg dry wt	-	0.0019	< 0.0010	-	-
PCB-151	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-153	mg/kg dry wt	-	0.0021	< 0.0010	-	-
PCB-156	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-157	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-159	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-167	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-169	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-170	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-180	mg/kg dry wt	-	0.0013	< 0.0010	-	-
PCB-189	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-194	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-206	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
PCB-209	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
Mono-Ortho PCB Toxic Equivalence (TEF)*	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
Non-Ortho PCB Toxic Equivalence (TEF)*	mg/kg dry wt	-	< 0.0010	< 0.0010	-	-
Total PCB (Sum of 35 congeners)	mg/kg dry wt	-	< 0.04	< 0.04	-	-

Sample Type: Sediment						
Sample Name:		WWC3 23-Nov-2017	Composite of NWC1, NWC2, NWC3	Composite of WWC1, WWC2, WWC3		
Lab Number:		1882514.6	1882514.7	1882514.8		
Tributyl Tin Trace in Soil samples by GCMS						
Dibutyltin (as Sn)	mg/kg dry wt	< 0.005	-	-	-	-
Monobutyltin (as Sn)	mg/kg dry wt	< 0.007	-	-	-	-
Tributyltin (as Sn)	mg/kg dry wt	< 0.004	-	-	-	-
Triphenyltin (as Sn)	mg/kg dry wt	< 0.003	-	-	-	-
Total Petroleum Hydrocarbons in Soil, GC						
C7 - C9	mg/kg dry wt	< 16	-	-	-	-
C10 - C11	mg/kg dry wt	< 16	-	-	-	-
C12 - C14	mg/kg dry wt	< 16	-	-	-	-
C15 - C20	mg/kg dry wt	< 16	-	-	-	-
C21 - C25	mg/kg dry wt	< 16	-	-	-	-
C26 - C29	mg/kg dry wt	< 16	-	-	-	-
C30 - C44	mg/kg dry wt	< 30	-	-	-	-
Total hydrocarbons (C7 - C44)	mg/kg dry wt	< 120	-	-	-	-

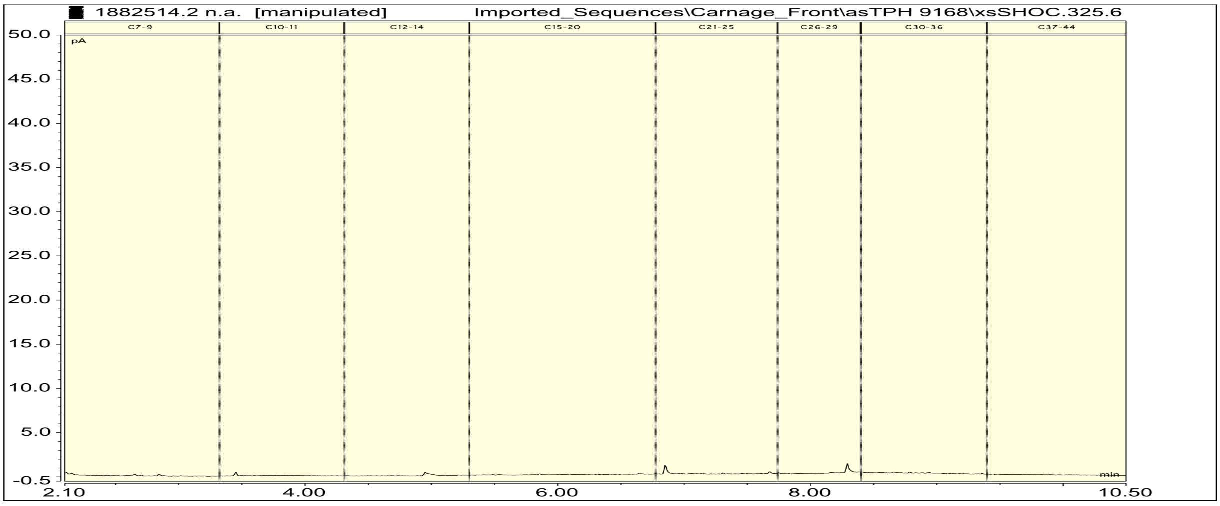
Sample Type: Aqueous						
Sample Name:		NWC1 [Elutriation extract]	NWC2 [Elutriation extract]	NWC3 [Elutriation extract]	WWC1 [Elutriation extract]	WWC2 [Elutriation extract]
Lab Number:		1882514.19	1882514.20	1882514.21	1882514.22	1882514.23
Individual Tests						
Total Arsenic*	g/m^3	0.0078	0.024	0.0122	0.021	0.0146
Total Cadmium*	g/m^3	< 0.00021	< 0.00021	< 0.00021	< 0.00021	< 0.00021
Total Chromium*	g/m^3	< 0.0011	< 0.0011	< 0.0011	< 0.0011	< 0.0011
Total Copper*	g/m^3	< 0.0011	< 0.0011	< 0.0011	< 0.0011	0.0066
Total Lead*	g/m^3	< 0.0011	< 0.0011	< 0.0011	< 0.0011	< 0.0011
Total Mercury	g/m^3	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008
Total Nickel*	g/m^3	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
Total Zinc*	g/m^3	0.0163	< 0.0042	< 0.0042	< 0.0042	< 0.0042
Total Ammoniacal-N	g/m^3	8.6	3.7	1.66	8.8	2.2
Non-Purgeable Organic Carbon (NPOC)*	g/m^3	5.1	4.6	3.0	5.2	3.2
Polycyclic Aromatic Hydrocarbons Trace in Water, By Liq/Liq						
Acenaphthene	g/m^3	-	-	< 0.000008	< 0.000008	-
Acenaphthylene	g/m^3	-	-	< 0.000008	< 0.000008	-
Anthracene	g/m^3	-	-	< 0.000008	< 0.000008	-
Benzo[a]anthracene	g/m^3	-	-	< 0.000008	< 0.000008	-
Benzo[a]pyrene (BAP)	g/m^3	-	-	< 0.000008	< 0.000008	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	g/m^3	-	-	< 0.000008	< 0.000008	-
Benzo[g,h,i]perylene	g/m^3	-	-	< 0.000008	< 0.000008	-
Benzo[k]fluoranthene	g/m^3	-	-	< 0.000008	< 0.000008	-
Chrysene	g/m^3	-	-	< 0.000008	< 0.000008	-
Dibenzo[a,h]anthracene	g/m^3	-	-	< 0.000008	< 0.000008	-
Fluoranthene	g/m^3	-	-	< 0.000008	< 0.000008	-
Fluorene	g/m^3	-	-	< 0.000008	< 0.000008	-
Indeno(1,2,3-c,d)pyrene	g/m^3	-	-	< 0.000008	< 0.000008	-
Naphthalene	g/m^3	-	-	< 0.00004	< 0.00004	-
Phenanthrene	g/m^3	-	-	< 0.000008	< 0.000008	-
Pyrene	g/m^3	-	-	< 0.000008	0.000042	-
Tributyl Tin Trace in Water samples by GCMS						
Dibutyltin (as Sn)	g/m^3	< 0.00006	< 0.00006	< 0.00006	< 0.00006	< 0.00006
Tributyltin (as Sn)	g/m^3	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Triphenyltin (as Sn)	g/m^3	< 0.00004	< 0.00004	< 0.00004	< 0.00004	< 0.00004

Sample Type: Aqueous						
Sample Name:		WWC3 [Elutriation extract]				
Lab Number:		1882514.24				
Individual Tests						
Total Arsenic*	g/m³	0.0156	-	-	-	-
Total Cadmium*	g/m³	< 0.00021	-	-	-	-
Total Chromium*	g/m³	< 0.0011	-	-	-	-
Total Copper*	g/m³	< 0.0011	-	-	-	-
Total Lead*	g/m³	< 0.0011	-	-	-	-
Total Mercury	g/m³	< 0.00008	-	-	-	-
Total Nickel*	g/m³	< 0.007	-	-	-	-
Total Zinc*	g/m³	< 0.0042	-	-	-	-
Total Ammoniacal-N	g/m³	5.7	-	-	-	-
Non-Purgeable Organic Carbon (NPOC)*	g/m³	3.8	-	-	-	-
Polycyclic Aromatic Hydrocarbons Trace in Water, By Liq/Liq						
Acenaphthene	g/m³	< 0.000019	-	-	-	-
Acenaphthylene	g/m³	< 0.000019	-	-	-	-
Anthracene	g/m³	< 0.000019	-	-	-	-
Benzo[a]anthracene	g/m³	< 0.000019	-	-	-	-
Benzo[a]pyrene (BAP)	g/m³	< 0.000019	-	-	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	g/m³	< 0.000019	-	-	-	-
Benzo[g,h,i]perylene	g/m³	< 0.000019	-	-	-	-
Benzo[k]fluoranthene	g/m³	< 0.000019	-	-	-	-
Chrysene	g/m³	< 0.000019	-	-	-	-
Dibenzo[a,h]anthracene	g/m³	< 0.000019	-	-	-	-
Fluoranthene	g/m³	< 0.000019	-	-	-	-
Fluorene	g/m³	< 0.000019	-	-	-	-
Indeno(1,2,3-c,d)pyrene	g/m³	< 0.000019	-	-	-	-
Naphthalene	g/m³	< 0.00010	-	-	-	-
Phenanthrene	g/m³	< 0.000019	-	-	-	-
Pyrene	g/m³	< 0.000019	-	-	-	-
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	-	-	-	-

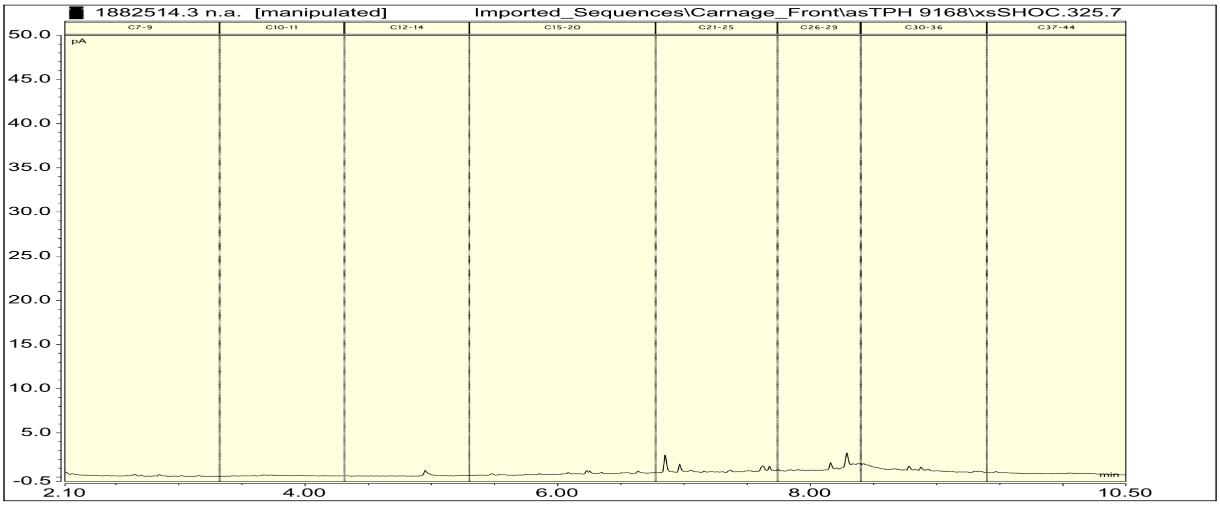
1882514.1
NWC1 23-Nov-2017
Client Chromatogram for TPH by FID



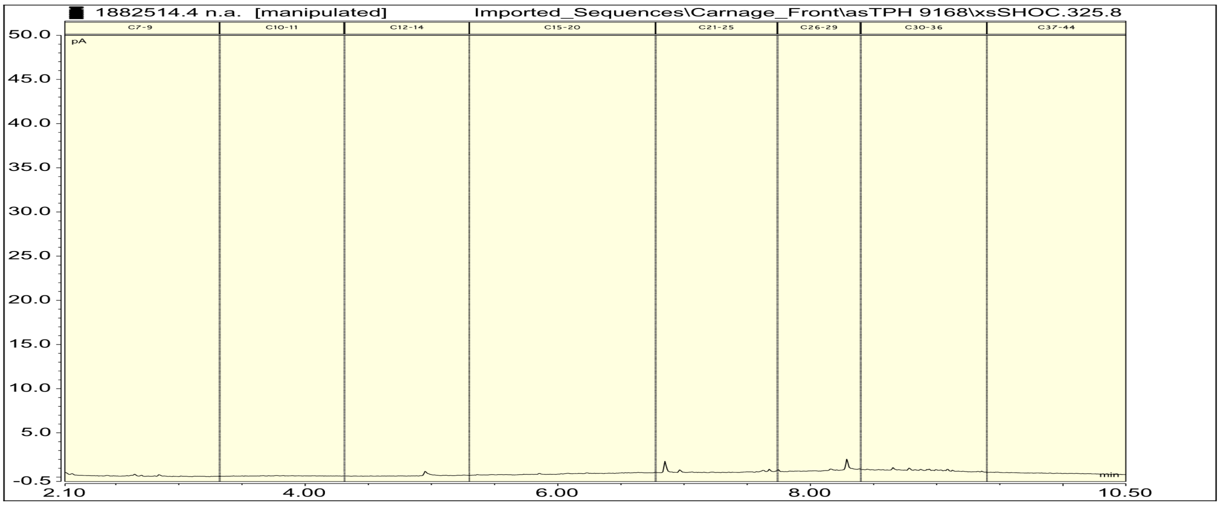
1882514.2
NWC2 23-Nov-2017
Client Chromatogram for TPH by FID



1882514.3
NWC3 23-Nov-2017
Client Chromatogram for TPH by FID



1882514.4
WWC1 23-Nov-2017
Client Chromatogram for TPH by FID



Analyst's Comments

Amended Report: This report replaces an earlier report issued on 04 Jan 2018 at 1:59 pm
Reason for amendment: Results for PAHt have been included for samples NWC3 [Elutriation extract], WWC1 [Elutriation extract] and WWC3 [Elutriation extract] at the request of 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 clean 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.

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Individual Tests			
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	15
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	15, 19-24
Total Arsenic*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0042 g/m^3	15, 19-24
Total Cadmium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.00021 g/m^3	15, 19-24
Total Chromium*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0011 g/m^3	15, 19-24
Total Copper*	Nitric acid digestion, ICP-MS, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0011 g/m^3	15, 19-24
Total Lead*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.0011 g/m^3	15, 19-24
Total Mercury*	Bromine Oxidation followed by Atomic Fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m^3	15, 19-24
Total Nickel*	Nitric acid digestion, ICP-MS with universal cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.007 g/m^3	15, 19-24
Total Zinc*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0042 g/m^3	15, 19-24
Total Ammoniacal-N	Saline sample. Phenol/hypochlorite colorimetry. Flow injection analyser. (NH4-N = NH4+-N + NH3-N). APHA 4500-NH3 H 22nd ed. 2012.	0.005 g/m^3	15, 19-24
Tributyl Tin Trace in Water samples by GCMS*	Solvent extraction, ethylation, SPE cleanup, GC-MS SIM analysis	0.00003 - 0.00005 g/m^3	15, 19-24

Sample Type: Sediment

Test	Method Description	Default Detection Limit	Sample No
Individual Tests			
Antifouling cobiocides suite in sediment by LCMSMS*	Ethyl acetate extraction, SPE cleanup, determination by LCMSMS.	-	1-6
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%.	-	1-6
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".	-	1-6
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	1-6
Dry Matter for Grainsize samples	Drying for 16 hours at 103°C, gravimetry (Free water removed before analysis).	0.10 g/100g as rcvd	1-6
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-6
Composite Environmental Solid Samples*	Individual sample fractions mixed together to form a composite fraction.	-	1-6
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	1-6
Antifouling cobiocides in sediment samples by LCMSMS*		0.010 mg/kg dry wt	1-6
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	7-8
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	1-6
3 Grain Sizes Profile*		0.1 g/100g dry wt	1-6

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
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 - 0.010 mg/kg dry wt	1-6
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	1-6
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	1-6
3 Grain Sizes Profile			
Fraction < 2 mm, >/= 63 µm*	Wet sieving using dispersant, 2.00 mm and 63 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-6
Fraction < 63 µm*	Wet sieving with dispersant, 63 µm sieve, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-6

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Individual Tests			
Non-Purgeable Organic Carbon (NPOC)*	Acidification, purging to remove inorganic C, super-critical persulphate oxidation at 375°C, IR detection. APHA 5310 C (modified) 22nd ed. 2012.	0.3 g/m^3	19-24
Polycyclic Aromatic Hydrocarbons Trace in Water, By Liq/Liq	Liquid / liquid extraction, SPE (if required), GC-MS SIM analysis [KBIs:4736,2695]	0.000005 g/m^3	21-22, 24

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

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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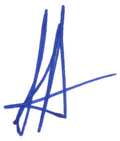

Ara Heron BSc (Tech)
Client Services Manager - Environmental

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ANALYSIS REPORT

Client:	Golder Associates (NZ) Limited	**Lab No:**	1883505 SPv6
Contact:	Emanuelle Desrochers	**Date Received:**	24-Nov-2017
	C/- Golder Associates (NZ) Limited	**Date Reported:**	28-Dec-2017
	PO Box 33849	**Quote No:**	88936
	Takapuna	**Order No:**	
	Auckland 0740	**Client Reference:**	Marine Sediment Samples
		Add. Client Ref:	1790454
		Submitted By:	Mr P Kennedy

Sample Type: Saline

Sample Name:		Sea Water for Elutriation				
Lab Number:		1883505.16				
Individual Tests						
Total Arsenic*	g/m³	< 0.0042	-	-	-	-
Total Cadmium*	g/m³	< 0.00021	-	-	-	-
Total Chromium*	g/m³	< 0.0011	-	-	-	-
Total Copper*	g/m³	< 0.0011	-	-	-	-
Total Lead*	g/m³	< 0.0011	-	-	-	-
Total Mercury*	g/m³	< 0.00008	-	-	-	-
Total Nickel*	g/m³	< 0.007	-	-	-	-
Total Zinc*	g/m³	< 0.0042	-	-	-	-
Total Ammoniacal-N	g/m³	0.010	-	-	-	-
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:		HWC4 23-Nov-2017	HWC5 23-Nov-2017	HWC6 23-Nov-2017	HWC7 23-Nov-2017	HWC8 23-Nov-2017
Lab Number:		1883505.4	1883505.5	1883505.6	1883505.7	1883505.8
Individual Tests						
Dry Matter	g/100g as rcvd	44	41	40	38	42
Dry Matter of Sieved Sample	g/100g as rcvd	45	43	40	43	43
Particle size analysis*		See attached report	See attached report	See attached report	See attached report	See attached report
Total Organic Carbon*	g/100g dry wt	1.22	1.17	1.25	1.18	1.20
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	8.3	7.1	6.8	8.4	7
Total Recoverable Cadmium	mg/kg dry wt	0.079	0.041	0.043	0.098	0.076
Total Recoverable Chromium	mg/kg dry wt	24	24	25	27	24
Total Recoverable Copper	mg/kg dry wt	19.9	18.0	22	22	24
Total Recoverable Lead	mg/kg dry wt	33	27	29	29	33
Total Recoverable Mercury	mg/kg dry wt	0.24	0.17	0.16	0.17	0.22
Total Recoverable Nickel	mg/kg dry wt	9.6	8.9	9.1	8.8	9
Total Recoverable Zinc	mg/kg dry wt	110	96	110	107	104

Sample Type: Sediment						
Sample Name:		HWC4 23-Nov-2017	HWC5 23-Nov-2017	HWC6 23-Nov-2017	HWC7 23-Nov-2017	HWC8 23-Nov-2017
Lab Number:		1883505.4	1883505.5	1883505.6	1883505.7	1883505.8
3 Grain Sizes Profile						
Fraction >/= 2 mm*	g/100g dry wt	< 0.1	< 0.1	< 0.1	< 0.1	0.1
Fraction < 2 mm, >/= 63 µm*	g/100g dry wt	34.9	33.3	30.8	33.0	33.2
Fraction < 63 µm*	g/100g dry wt	65.1	66.7	69.1	67.0	66.6
Polycyclic Aromatic Hydrocarbons Trace in Soil						
1-Methylnaphthalene	mg/kg dry wt	0.007	0.004	0.004	0.007	0.005
2-Methylnaphthalene	mg/kg dry wt	0.008	0.004	0.004	0.009	0.005
Acenaphthene	mg/kg dry wt	0.005	0.005	< 0.004	< 0.004	0.004
Acenaphthylene	mg/kg dry wt	0.011	0.005	0.005	0.008	0.008
Anthracene	mg/kg dry wt	0.035	0.013	0.012	0.014	0.017
Benzo[a]anthracene	mg/kg dry wt	0.140	0.076	0.068	0.091	0.101
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.187	0.107	0.094	0.134	0.143
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.20	0.120	0.105	0.146	0.157
Benzo[e]pyrene	mg/kg dry wt	0.099	0.057	0.051	0.071	0.076
Benzo[g,h,i]perylene	mg/kg dry wt	0.111	0.063	0.058	0.081	0.087
Benzo[k]fluoranthene	mg/kg dry wt	0.077	0.043	0.040	0.055	0.057
Chrysene	mg/kg dry wt	0.115	0.068	0.061	0.079	0.087
Dibenzo[a,h]anthracene	mg/kg dry wt	0.024	0.014	0.012	0.016	0.017
Fluoranthene	mg/kg dry wt	0.26	0.157	0.131	0.178	0.195
Fluorene	mg/kg dry wt	0.007	0.005	0.004	0.004	0.005
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.144	0.082	0.073	0.102	0.109
Naphthalene	mg/kg dry wt	0.017	< 0.017	< 0.017	< 0.018	< 0.016
Perylene	mg/kg dry wt	0.046	0.022	0.020	0.028	0.030
Phenanthrene	mg/kg dry wt	0.085	0.066	0.046	0.054	0.064
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES	mg/kg dry wt	0.27	0.155	0.137	0.192	0.20
Benzo[a]pyrene Toxic Equivalence (TEF)	mg/kg dry wt	0.27	0.155	0.137	0.191	0.20
Pyrene	mg/kg dry wt	0.26	0.152	0.119	0.171	0.183
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	-	-	-	0.003	< 0.004
Triphenyltin (as Sn)	mg/kg dry wt	-	-	-	< 0.003	< 0.003
Total Petroleum Hydrocarbons in Soil, GC						
C7 - C9	mg/kg dry wt	< 14	< 14	< 15	< 16	< 14
C10 - C11	mg/kg dry wt	< 14	< 14	< 15	< 16	< 14
C12 - C14	mg/kg dry wt	< 14	< 14	< 15	< 16	< 14
C15 - C20	mg/kg dry wt	< 14	< 14	< 15	< 16	< 14
C21 - C25	mg/kg dry wt	< 14	< 14	< 15	< 16	< 14
C26 - C29	mg/kg dry wt	< 14	< 14	< 15	< 16	< 14
C30 - C44	mg/kg dry wt	< 20	< 20	< 30	< 30	< 20
Total hydrocarbons (C7 - C44)	mg/kg dry wt	< 110	< 110	< 120	< 120	< 110

Sample Name:		HWC9 23-Nov-2017	HWC10 23-Nov-2017	HWC11 23-Nov-2017	HWC12 23-Nov-2017	Composite of HWC4, HWC5 & HWC6
Lab Number:		1883505.9	1883505.10	1883505.11	1883505.12	1883505.13
Individual Tests						
Dry Matter	g/100g as rcvd	41	38	38	39	29
Dry Matter of Sieved Sample	g/100g as rcvd	42	41	40	40	-
Particle size analysis*		See attached report	-	-	-	-
Total Organic Carbon*	g/100g dry wt	1.12	1.28	1.21	1.36	-
Antifouling cobiocides in sediment samples by LCMSMS						
Diuron*	mg/kg dry wt	-	-	-	-	< 0.010
Irgarol*	mg/kg dry wt	-	-	-	-	< 0.010

Sample Type: Sediment						
Sample Name:		HWC9 23-Nov-2017	HWC10 23-Nov-2017	HWC11 23-Nov-2017	HWC12 23-Nov-2017	Composite of HWC4, HWC5 & HWC6
Lab Number:		1883505.9	1883505.10	1883505.11	1883505.12	1883505.13
Antifouling cobiocides in sediment samples by LCMSMS						
Isoproturon*	mg/kg dry wt	-	-	-	-	< 0.010
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	6.8	7	7	6.9	-
Total Recoverable Cadmium	mg/kg dry wt	0.044	0.061	0.085	0.051	-
Total Recoverable Chromium	mg/kg dry wt	25	27	27	27	-
Total Recoverable Copper	mg/kg dry wt	21	29	25	28	-
Total Recoverable Lead	mg/kg dry wt	27	37	39	31	-
Total Recoverable Mercury	mg/kg dry wt	0.17	0.19	0.23	0.17	-
Total Recoverable Nickel	mg/kg dry wt	9.2	10	10	9.7	-
Total Recoverable Zinc	mg/kg dry wt	97	115	121	122	-
3 Grain Sizes Profile						
Fraction >/= 2 mm*	g/100g dry wt	< 0.1	0.3	< 0.1	< 0.1	-
Fraction < 2 mm, >/= 63 µm*	g/100g dry wt	31.3	26.6	25.7	26.8	-
Fraction < 63 µm*	g/100g dry wt	68.7	73.0	74.3	73.2	-
Organochlorine Pesticides Trace in Soil						
Aldrin	mg/kg dry wt	-	-	-	-	< 0.0010
alpha-BHC	mg/kg dry wt	-	-	-	-	< 0.0010
beta-BHC	mg/kg dry wt	-	-	-	-	< 0.0010
delta-BHC	mg/kg dry wt	-	-	-	-	< 0.0010
gamma-BHC (Lindane)	mg/kg dry wt	-	-	-	-	< 0.0010
cis-Chlordane	mg/kg dry wt	-	-	-	-	< 0.0010
trans-Chlordane	mg/kg dry wt	-	-	-	-	< 0.0010
2,4'-DDD	mg/kg dry wt	-	-	-	-	< 0.0010
4,4'-DDD	mg/kg dry wt	-	-	-	-	< 0.0010
2,4'-DDE	mg/kg dry wt	-	-	-	-	< 0.0010
4,4'-DDE	mg/kg dry wt	-	-	-	-	< 0.0010
2,4'-DDT	mg/kg dry wt	-	-	-	-	< 0.0010
4,4'-DDT	mg/kg dry wt	-	-	-	-	< 0.0010
Total DDT Isomers	mg/kg dry wt	-	-	-	-	< 0.006
Dieldrin	mg/kg dry wt	-	-	-	-	< 0.0010
Endosulfan I	mg/kg dry wt	-	-	-	-	< 0.0010
Endosulfan II	mg/kg dry wt	-	-	-	-	< 0.0010
Endosulfan sulphate	mg/kg dry wt	-	-	-	-	< 0.0010
Endrin	mg/kg dry wt	-	-	-	-	< 0.0010
Endrin aldehyde	mg/kg dry wt	-	-	-	-	< 0.0010
Endrin ketone	mg/kg dry wt	-	-	-	-	< 0.0010
Heptachlor	mg/kg dry wt	-	-	-	-	< 0.0010
Heptachlor epoxide	mg/kg dry wt	-	-	-	-	< 0.0010
Hexachlorobenzene	mg/kg dry wt	-	-	-	-	< 0.0010
Methoxychlor	mg/kg dry wt	-	-	-	-	< 0.0010
Total Chlordane [(cis+trans)* 100/42]	mg/kg dry wt	-	-	-	-	< 0.002
Polycyclic Aromatic Hydrocarbons Trace in Soil						
1-Methylnaphthalene	mg/kg dry wt	0.005	0.009	0.007	0.004	-
2-Methylnaphthalene	mg/kg dry wt	0.005	0.011	0.009	0.005	-
Acenaphthene	mg/kg dry wt	< 0.004	0.011	0.005	< 0.004	-
Acenaphthylene	mg/kg dry wt	0.006	0.011	0.009	0.007	-
Anthracene	mg/kg dry wt	0.011	0.023	0.018	0.013	-
Benzo[a]anthracene	mg/kg dry wt	0.087	0.132	0.103	0.091	-
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.132	0.187	0.158	0.130	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.161	0.21	0.182	0.149	-
Benzo[e]pyrene	mg/kg dry wt	0.079	0.103	0.086	0.073	-
Benzo[g,h,i]perylene	mg/kg dry wt	0.080	0.113	0.099	0.085	-

Sample Type: Sediment						
Sample Name:		HWC9 23-Nov-2017	HWC10 23-Nov-2017	HWC11 23-Nov-2017	HWC12 23-Nov-2017	Composite of HWC4, HWC5 & HWC6
Lab Number:		1883505.9	1883505.10	1883505.11	1883505.12	1883505.13
Polycyclic Aromatic Hydrocarbons Trace in Soil						
Benzo[k]fluoranthene	mg/kg dry wt	0.064	0.084	0.069	0.055	-
Chrysene	mg/kg dry wt	0.084	0.116	0.093	0.082	-
Dibenzo[a,h]anthracene	mg/kg dry wt	0.017	0.022	0.021	0.016	-
Fluoranthene	mg/kg dry wt	0.160	0.28	0.21	0.180	-
Fluorene	mg/kg dry wt	0.003	0.010	0.006	0.004	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.102	0.143	0.131	0.104	-
Naphthalene	mg/kg dry wt	< 0.017	0.018	0.018	< 0.018	-
Perylene	mg/kg dry wt	0.030	0.036	0.030	0.027	-
Phenanthrene	mg/kg dry wt	0.050	0.097	0.070	0.051	-
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES	mg/kg dry wt	0.192	0.27	0.23	0.188	-
Benzo[a]pyrene Toxic Equivalence (TEF)	mg/kg dry wt	0.192	0.27	0.23	0.188	-
Pyrene	mg/kg dry wt	0.155	0.25	0.196	0.175	-
Polychlorinated Biphenyls Trace in Soil						
PCB-18	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-28	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-31	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-44	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-49	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-52	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-60	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-77	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-81	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-86	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-101	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-105	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-110	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-114	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-118	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-121	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-123	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-126	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-128	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-138	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-141	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-149	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-151	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-153	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-156	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-157	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-159	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-167	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-169	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-170	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-180	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-189	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-194	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-206	mg/kg dry wt	-	-	-	-	< 0.0010
PCB-209	mg/kg dry wt	-	-	-	-	< 0.0010
Mono-Ortho PCB Toxic Equivalence (TEF)*	mg/kg dry wt	-	-	-	-	< 0.0010
Non-Ortho PCB Toxic Equivalence (TEF)*	mg/kg dry wt	-	-	-	-	< 0.0010
Total PCB (Sum of 35 congeners)	mg/kg dry wt	-	-	-	-	< 0.04

Sample Type: Sediment						
Sample Name:		HWC9 23-Nov-2017	HWC10 23-Nov-2017	HWC11 23-Nov-2017	HWC12 23-Nov-2017	Composite of HWC4, HWC5 & HWC6
Lab Number:		1883505.9	1883505.10	1883505.11	1883505.12	1883505.13
Tributyl Tin Trace in Soil samples by GCMS						
Dibutyltin (as Sn)	mg/kg dry wt	< 0.005	0.005	0.008	< 0.005	-
Monobutyltin (as Sn)	mg/kg dry wt	< 0.007	< 0.007	< 0.007	< 0.007	-
Tributyltin (as Sn)	mg/kg dry wt	< 0.004	< 0.004	0.007	< 0.004	-
Triphenyltin (as Sn)	mg/kg dry wt	< 0.003	< 0.003	< 0.003	< 0.003	-
Total Petroleum Hydrocarbons in Soil, GC						
C7 - C9	mg/kg dry wt	< 15	< 16	< 16	< 16	-
C10 - C11	mg/kg dry wt	< 15	< 16	< 16	< 16	-
C12 - C14	mg/kg dry wt	< 15	< 16	< 16	< 16	-
C15 - C20	mg/kg dry wt	< 15	< 16	< 16	< 16	-
C21 - C25	mg/kg dry wt	< 15	< 16	< 16	< 16	-
C26 - C29	mg/kg dry wt	< 15	< 16	< 16	< 16	-
C30 - C44	mg/kg dry wt	< 20	< 30	< 30	< 30	-
Total hydrocarbons (C7 - C44)	mg/kg dry wt	< 110	< 120	< 120	< 120	-

Sample Name:		Composite of HWC7, HWC8 & HWC9	Composite of HWC10, HWC11 & HWC12			
Lab Number:		1883505.14	1883505.15			
Individual Tests						
Dry Matter	g/100g as rcvd	41	41	-	-	-
Antifouling cobiocides in sediment samples by LCMSMS						
Diuron*	mg/kg dry wt	< 0.010	< 0.010	-	-	-
Irgarol*	mg/kg dry wt	< 0.010	< 0.010	-	-	-
Isoproturon*	mg/kg dry wt	< 0.010	< 0.010	-	-	-
Organochlorine Pesticides Trace in Soil						
Aldrin	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
alpha-BHC	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
beta-BHC	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
delta-BHC	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
gamma-BHC (Lindane)	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
cis-Chlordane	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
trans-Chlordane	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
2,4'-DDD	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
4,4'-DDD	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
2,4'-DDE	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
4,4'-DDE	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
2,4'-DDT	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
4,4'-DDT	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
Total DDT Isomers	mg/kg dry wt	< 0.006	< 0.006	-	-	-
Dieldrin	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
Endosulfan I	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
Endosulfan II	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
Endosulfan sulphate	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
Endrin	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
Endrin aldehyde	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
Endrin ketone	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
Heptachlor	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
Heptachlor epoxide	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
Hexachlorobenzene	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
Methoxychlor	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
Total Chlordane [(cis+trans)* 100/42]	mg/kg dry wt	< 0.002	< 0.002	-	-	-
Polychlorinated Biphenyls Trace in Soil						
PCB-18	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-28	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-

Sample Type: Sediment						
	Sample Name:	Composite of HWC7, HWC8 & HWC9	Composite of HWC10, HWC11 & HWC12			
	Lab Number:	1883505.14	1883505.15			
Polychlorinated Biphenyls Trace in Soil						
PCB-31	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-44	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-49	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-52	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-60	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-77	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-81	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-86	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-101	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-105	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-110	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-114	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-118	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-121	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-123	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-126	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-128	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-138	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-141	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-149	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-151	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-153	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-156	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-157	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-159	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-167	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-169	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-170	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-180	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-189	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-194	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-206	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
PCB-209	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
Mono-Ortho PCB Toxic Equivalence (TEF)*	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
Non-Ortho PCB Toxic Equivalence (TEF)*	mg/kg dry wt	< 0.0010	< 0.0010	-	-	-
Total PCB (Sum of 35 congeners)	mg/kg dry wt	< 0.04	< 0.04	-	-	-

Analyst's Comments

Appendix No.1 - Particle size Report 1883505

Appendix No.2 - Settling Velocity Results

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 clean 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.

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Individual Tests			
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	16
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	16
Total Arsenic*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0042 g/m^3	16

Sample Type: Saline			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Cadmium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.00021 g/m^3	16
Total Chromium*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0011 g/m^3	16
Total Copper*	Nitric acid digestion, ICP-MS, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0011 g/m^3	16
Total Lead*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.0011 g/m^3	16
Total Mercury*	Bromine Oxidation followed by Atomic Fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m^3	16
Total Nickel*	Nitric acid digestion, ICP-MS with universal cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.007 g/m^3	16
Total Zinc*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0042 g/m^3	16
Total Ammoniacal-N	Saline sample. Phenol/hypochlorite colorimetry. Flow injection analyser. (NH4-N = NH4+-N + NH3-N). APHA 4500-NH3 H 22nd ed. 2012.	0.005 g/m^3	16
Tributyl Tin Trace in Water samples by GCMS*	Solvent extraction, ethylation, SPE cleanup, GC-MS SIM analysis	0.00003 - 0.00005 g/m^3	16

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Individual Tests			
Antifouling cobiocides suite in sediment by LCMSMS*	Ethyl acetate extraction, SPE cleanup, determination by LCMSMS.	-	13-15
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%.	-	4-12
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	4-15
Dry Matter for Grainsize samples	Drying for 16 hours at 103°C, gravimetry (Free water removed before analysis).	0.10 g/100g as rcvd	4-12
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	4-12
Composite Environmental Solid Samples*	Individual sample fractions mixed together to form a composite fraction.	-	4-12
Particle size analysis*	Malvern Laser Sizer particle size analysis. Subcontracted to Earth Sciences Department, Waikato University, Hamilton.	-	4-9
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	4-12
Antifouling cobiocides in sediment samples by LCMSMS*		0.010 mg/kg dry wt	13-15
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	13-15
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	4-12
3 Grain Sizes Profile*		0.1 g/100g dry wt	4-12
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 - 0.010 mg/kg dry wt	4-12
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	7-12
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	4-12
3 Grain Sizes Profile			
Fraction < 2 mm, >/= 63 µm*	Wet sieving using dispersant, 2.00 mm and 63 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	4-12
Fraction < 63 µm*	Wet sieving with dispersant, 63 µm sieve, gravimetry (calculation by difference).	0.1 g/100g dry wt	4-12

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

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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

Analysis - Under

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Measurement Details

Sample Name 1883505/4
SOP File Name Marine Sediment.msop
Lab Number 2017260/1
Operator Name rodgers

Measurement Details

Analysis Date Time 15/12/2017 4:38:27 PM
Measurement Date Time 15/12/2017 4:38:27 PM
Result Source Measurement

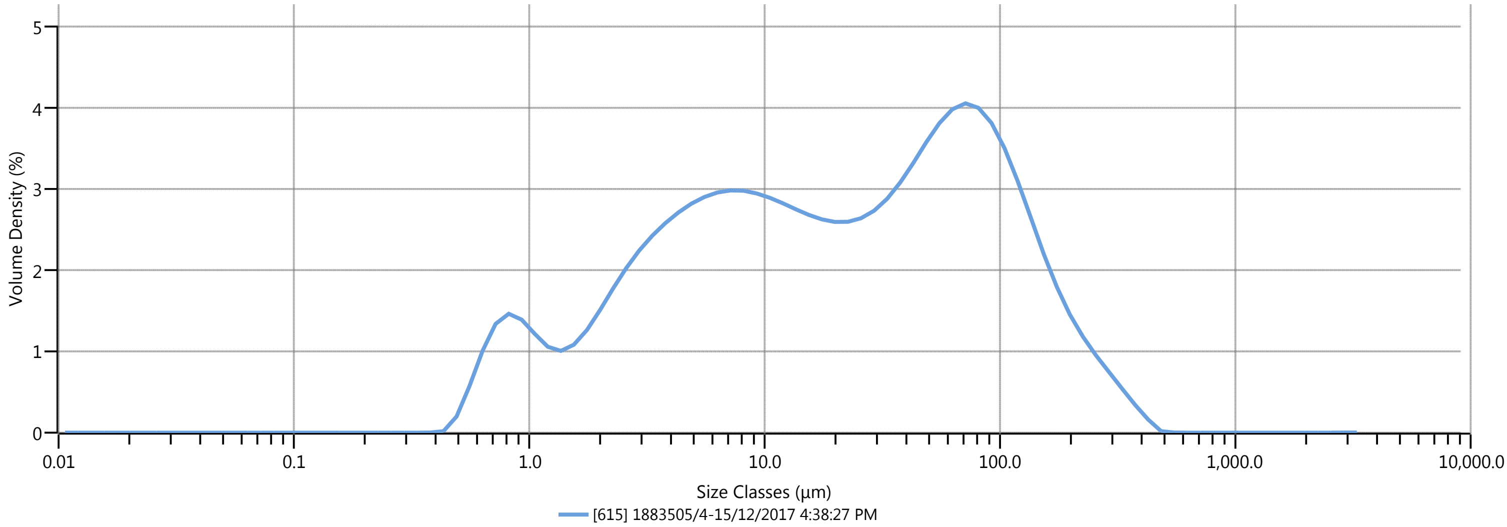
Analysis

Particle Name Marine Sediment
Particle Refractive Index 1.500
Particle Absorption Index 0.200
Dispersant Name Water
Dispersant Refractive Index 1.330
Scattering Model Mie
Analysis Model General Purpose
Weighted Residual 0.82 %
Laser Obscuration 12.92 %

Result

Concentration 0.0103 %
Span 6.136
Uniformity 2.010
Specific Surface Area 1119 m^2/kg
D [3,2] 5.36 µm
D [4,3] 47.6 µm
Dv (10) 1.94 µm
Dv (50) 20.3 µm
Dv (90) 127 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	32.54	88.0	81.76	350	99.56	1410	100.00
0.0600	0.00	15.6	45.46	105	86.04	420	99.92	1680	100.00
0.120	0.00	31.0	57.29	125	89.73	500	100.00	2000	100.00
0.240	0.00	37.0	60.67	149	92.70	590	100.00	2380	100.00
0.490	0.08	44.0	64.29	177	94.96	710	100.00	2830	100.00
0.980	4.91	53.0	68.61	210	96.68	840	100.00	3360	100.00
2.00	10.30	63.0	73.00	250	97.97	1000	100.00		
3.90	19.57	74.0	77.24	300	98.98	1190	100.00		

Analysis - Under

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Measurement Details

Sample Name 1883505/5
SOP File Name Marine Sediment.msop
Lab Number 2017260/2
Operator Name rodgers

Measurement Details

Analysis Date Time 15/12/2017 4:46:41 PM
Measurement Date Time 15/12/2017 4:46:41 PM
Result Source Measurement

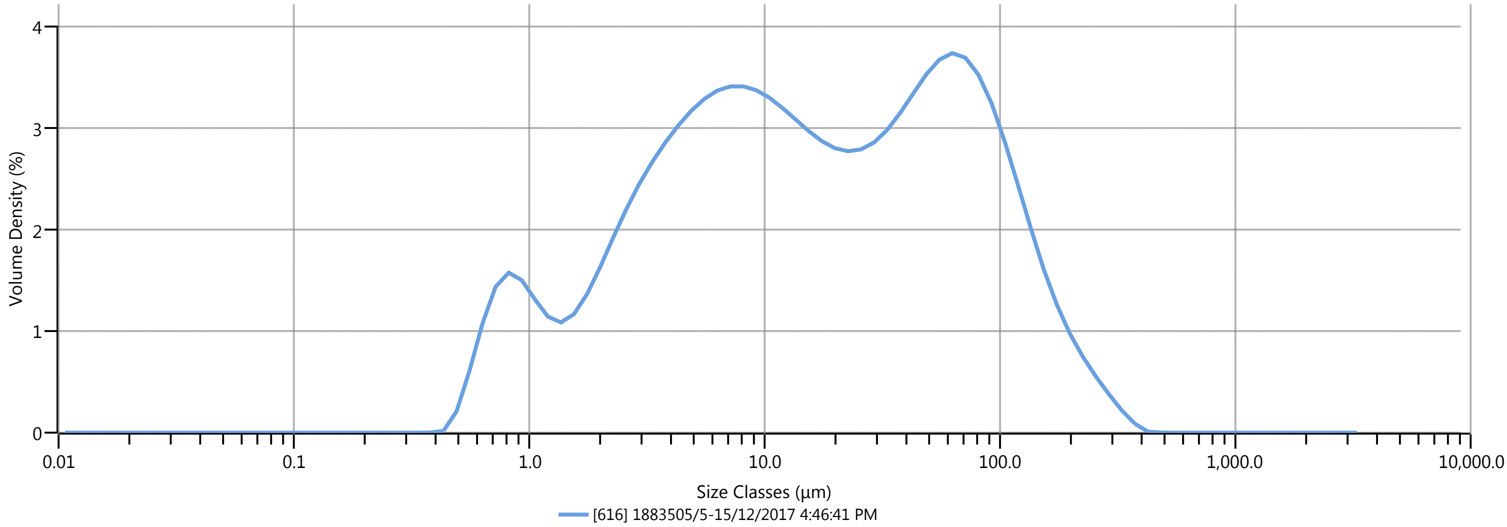
Analysis

Particle Name Marine Sediment
Particle Refractive Index 1.500
Particle Absorption Index 0.200
Dispersant Name Water
Dispersant Refractive Index 1.330
Scattering Model Mie
Analysis Model General Purpose
Weighted Residual 0.83 %
Laser Obscuration 13.33 %

Result

Concentration 0.0098 %
Span 6.684
Uniformity 2.129
Specific Surface Area 1213 m^2/kg
D [3,2] 4.95 µm
D [4,3] 37.9 µm
Dv (10) 1.79 µm
Dv (50) 15.2 µm
Dv (90) 103 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	35.89	88.0	86.73	350	99.92	1410	100.00
0.0600	0.00	15.6	50.53	105	90.32	420	100.00	1680	100.00
0.120	0.00	31.0	63.21	125	93.28	500	100.00	2000	100.00
0.240	0.00	37.0	66.70	149	95.53	590	100.00	2380	100.00
0.490	0.08	44.0	70.37	177	97.15	710	100.00	2830	100.00
0.980	5.27	53.0	74.64	210	98.33	840	100.00	3360	100.00
2.00	11.09	63.0	78.83	250	99.13	1000	100.00		
3.90	21.22	74.0	82.74	300	99.68	1190	100.00		

Analysis - Under

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Measurement Details

Sample Name	1883505/6
SOP File Name	Marine Sediment.msop
Lab Number	2017260/3
Operator Name	rodgers

Measurement Details

Analysis Date Time	15/12/2017 4:55:11 PM
Measurement Date Time	15/12/2017 4:55:11 PM
Result Source	Measurement

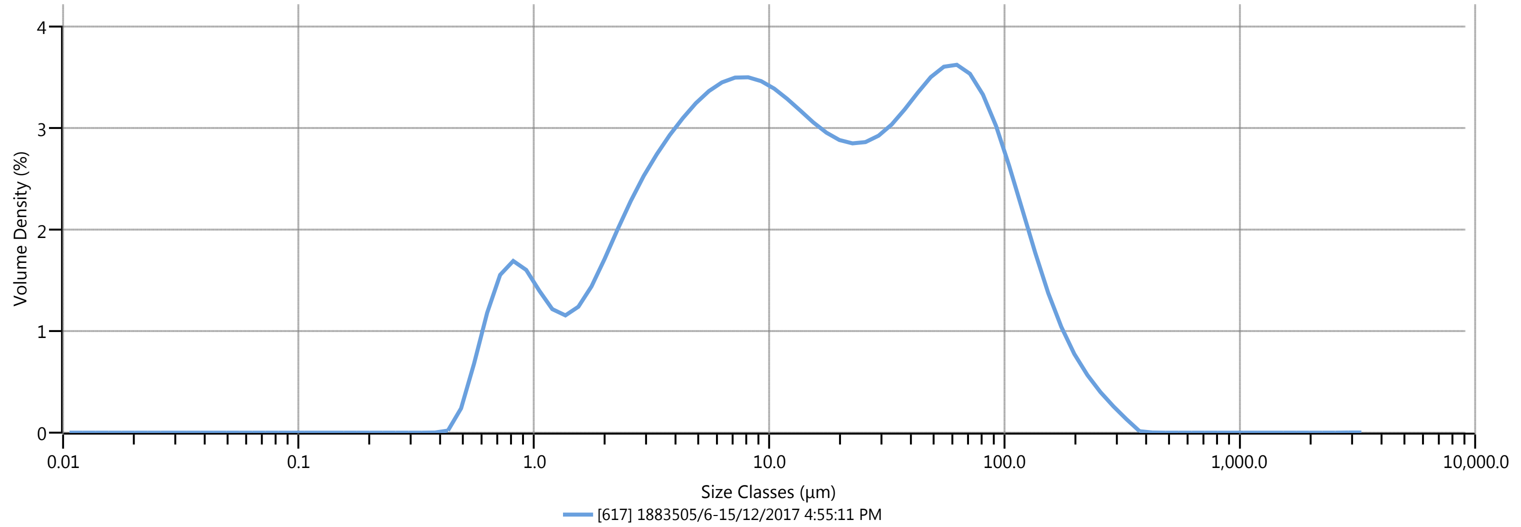
Analysis

Particle Name	Marine Sediment
Particle Refractive Index	1.500
Particle Absorption Index	0.200
Dispersant Name	Water
Dispersant Refractive Index	1.330
Scattering Model	Mie
Analysis Model	General Purpose
Weighted Residual	0.84 %
Laser Obscuration	15.95 %

Result

Concentration	0.0114 %
Span	6.722
Uniformity	2.116
Specific Surface Area	1279 m^2/kg
D [3,2]	4.69 µm
D [4,3]	34.5 µm
Dv (10)	1.66 µm
Dv (50)	13.8 µm
Dv (90)	94.6 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	37.38	88.0	88.57	350	99.99	1410	100.00
0.0600	0.00	15.6	52.44	105	91.88	420	100.00	1680	100.00
0.120	0.00	31.0	65.46	125	94.56	500	100.00	2000	100.00
0.240	0.00	37.0	69.00	149	96.54	590	100.00	2380	100.00
0.490	0.09	44.0	72.70	177	97.91	710	100.00	2830	100.00
0.980	5.71	53.0	76.94	210	98.85	840	100.00	3360	100.00
2.00	11.88	63.0	81.03	250	99.45	1000	100.00		
3.90	22.35	74.0	84.79	300	99.83	1190	100.00		

Analysis - Under

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Measurement Details

Sample Name 1883505/7
SOP File Name Marine Sediment.msop
Lab Number 2017260/4
Operator Name rodgers

Measurement Details

Analysis Date Time 18/12/2017 8:28:19 AM
Measurement Date Time 18/12/2017 8:28:19 AM
Result Source Measurement

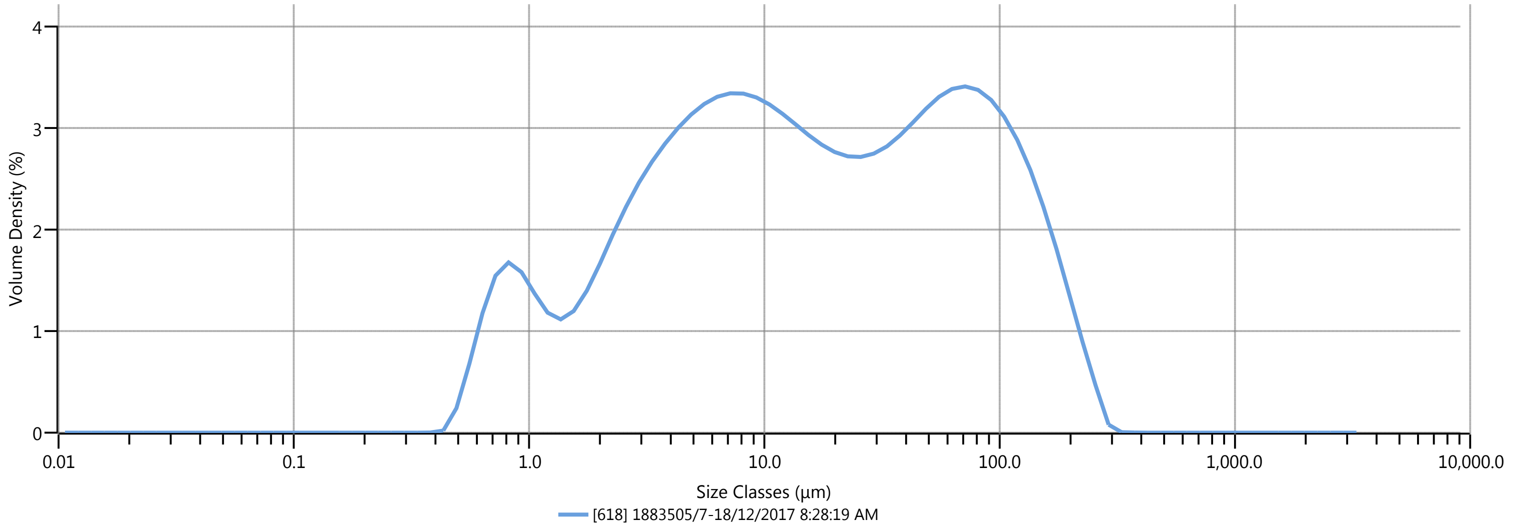
Analysis

Particle Name Marine Sediment
Particle Refractive Index 1.500
Particle Absorption Index 0.200
Dispersant Name Water
Dispersant Refractive Index 1.330
Scattering Model Mie
Analysis Model General Purpose
Weighted Residual 0.93 %
Laser Obscuration 15.24 %

Result

Concentration 0.0111 %
Span 7.398
Uniformity 2.219
Specific Surface Area 1252 m^2/kg
D [3,2] 4.79 µm
D [4,3] 38.9 µm
Dv (10) 1.69 µm
Dv (50) 15.0 µm
Dv (90) 113 µm

Frequency (compatible)



Result

Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	36.33	88.0	84.83	350	100.00	1410	100.00
0.0600	0.00	15.6	50.71	105	88.54	420	100.00	1680	100.00
0.120	0.00	31.0	63.12	125	91.92	500	100.00	2000	100.00
0.240	0.00	37.0	66.40	149	94.84	590	100.00	2380	100.00
0.490	0.09	44.0	69.79	177	97.13	710	100.00	2830	100.00
0.980	5.67	53.0	73.66	210	98.78	840	100.00	3360	100.00
2.00	11.67	63.0	77.43	250	99.70	1000	100.00		
3.90	21.87	74.0	81.01	300	99.99	1190	100.00		

Analysis - Under

Measurement Details

Sample Name	1883505/8
SOP File Name	Marine Sediment.msop
Lab Number	2017260/5
Operator Name	rodgers

Measurement Details

Analysis Date Time	18/12/2017 8:36:15 AM
Measurement Date Time	18/12/2017 8:36:15 AM
Result Source	Measurement

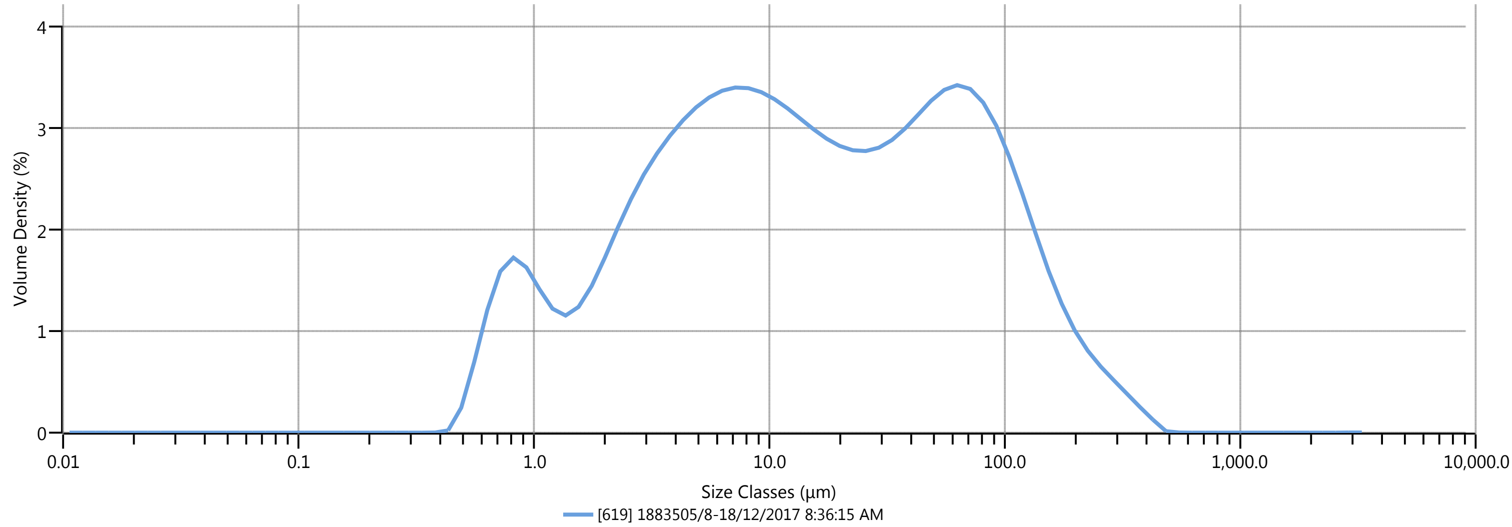
Analysis

Particle Name	Marine Sediment
Particle Refractive Index	1.500
Particle Absorption Index	0.200
Dispersant Name	Water
Dispersant Refractive Index	1.330
Scattering Model	Mie
Analysis Model	General Purpose
Weighted Residual	0.83 %
Laser Obscuration	13.31 %

Result

Concentration	0.0093 %
Span	7.372
Uniformity	2.365
Specific Surface Area	1285 m^2/kg
D [3,2]	4.67 μm
D [4,3]	38.7 μm
Dv (10)	1.63 μm
Dv (50)	14.1 μm
Dv (90)	106 μm

Frequency (compatible)



Result

Size (μm)	% Volume Under	Size (μm)	% Volume Under	Size (μm)	% Volume Under	Size (μm)	% Volume Under	Size (μm)	% Volume Under
0.0500	0.00	7.80	37.31	88.0	86.50	350	99.67	1410	100.00
0.0600	0.00	15.6	51.93	105	89.85	420	99.93	1680	100.00
0.120	0.00	31.0	64.61	125	92.67	500	100.00	2000	100.00
0.240	0.00	37.0	67.97	149	94.87	590	100.00	2380	100.00
0.490	0.09	44.0	71.43	177	96.49	710	100.00	2830	100.00
0.980	5.83	53.0	75.39	210	97.69	840	100.00	3360	100.00
2.00	12.02	63.0	79.23	250	98.57	1000	100.00		
3.90	22.55	74.0	82.81	300	99.26	1190	100.00		

Analysis - Under

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Measurement Details

Sample Name	1883505/9
SOP File Name	Marine Sediment.msop
Lab Number	2017260/6
Operator Name	rodgers

Measurement Details

Analysis Date Time	18/12/2017 8:44:03 AM
Measurement Date Time	18/12/2017 8:44:03 AM
Result Source	Measurement

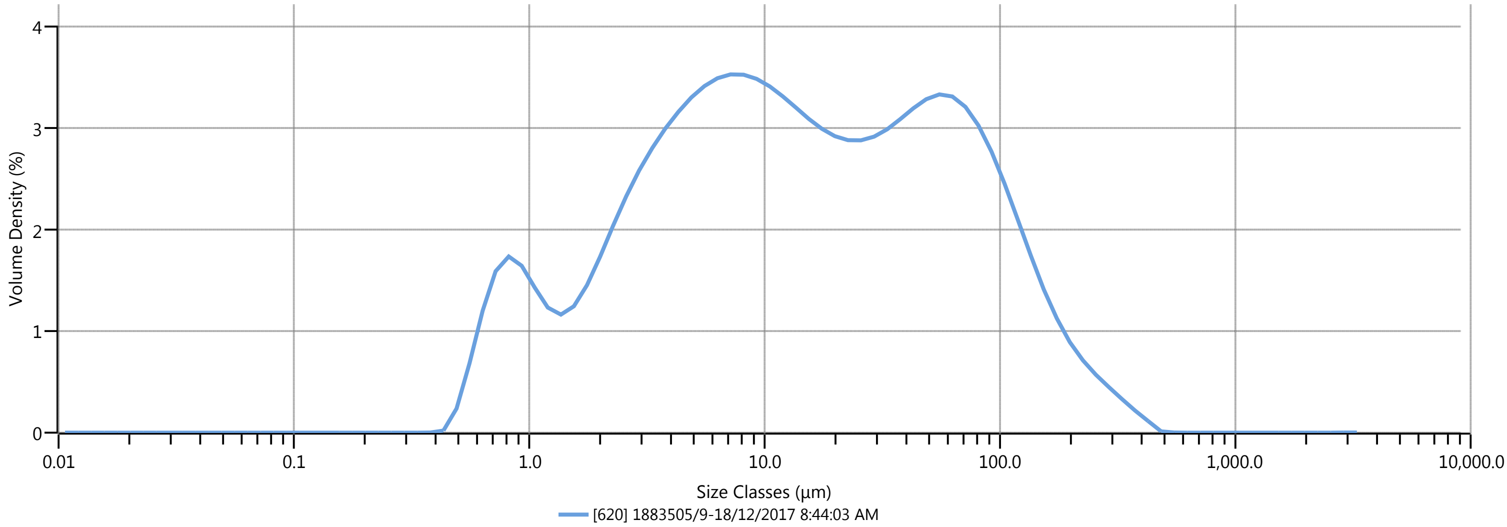
Analysis

Particle Name	Marine Sediment
Particle Refractive Index	1.500
Particle Absorption Index	0.200
Dispersant Name	Water
Dispersant Refractive Index	1.330
Scattering Model	Mie
Analysis Model	General Purpose
Weighted Residual	0.83 %
Laser Obscuration	11.56 %

Result

Concentration	0.0079 %
Span	7.261
Uniformity	2.334
Specific Surface Area	1298 m^2/kg
D [3,2]	4.62 µm
D [4,3]	36.3 µm
Dv (10)	1.62 µm
Dv (50)	13.4 µm
Dv (90)	98.7 µm

Frequency (compatible)



Result

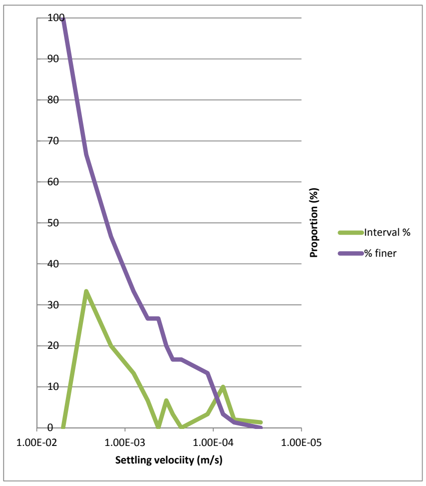
Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under	Size (µm)	% Volume Under
0.0500	0.00	7.80	38.00	88.0	87.94	350	99.71	1410	100.00
0.0600	0.00	15.6	53.18	105	91.00	420	99.94	1680	100.00
0.120	0.00	31.0	66.31	125	93.53	500	100.00	2000	100.00
0.240	0.00	37.0	69.79	149	95.48	590	100.00	2380	100.00
0.490	0.09	44.0	73.35	177	96.92	710	100.00	2830	100.00
0.980	5.83	53.0	77.33	210	97.98	840	100.00	3360	100.00
2.00	12.07	63.0	81.09	250	98.76	1000	100.00		
3.90	22.76	74.0	84.51	300	99.36	1190	100.00		

Sample 1883505.4

Mass (g)	25
Particle densiity (kg/m3)	2660
Temperature (°C)	20
Viscosity (Pa.s)	0.00100
Fluid density (kg/m3)	998.21
K [(mm/min)^(1/2)]	0.00428
Bulk density (t/m3)	2.660

Time		Hydrometer reading											
(min)	time (sec	Rh	R'h	x	y	HR	HR (m)	V (HR/t)	D (mm)	R'h+x	P	% finer	Interval %
0.5	30	1.0125	1.0120	-0.9980	43	151	0.151	5.03E-03	0.07443	0.0140	0.089735	100.00	0
1	60	1.01	1.0095	-0.9980	57	165	0.165	2.75E-03	0.05501	0.0115	0.073711	66.67	33.33
2	120	1.0085	1.0080	-0.9980	65	173	0.173	1.44E-03	0.03983	0.0100	0.064096	46.67	20.00
4	240	1.0075	1.0070	-0.9980	84	192	0.192	8.00E-04	0.02967	0.0090	0.057687	33.33	13.33
6	360	1.007	1.0065	-0.9980	91	199	0.199	5.53E-04	0.02466	0.0085	0.054482	26.67	6.67
8	480	1.007	1.0065	-0.9980	93	201	0.201	4.19E-04	0.02147	0.0085	0.054482	26.67	0.00
10	600	1.0065	1.0060	-0.9980	96	204	0.204	3.40E-04	0.01934	0.0080	0.051277	20.00	6.67
12	720	1.00625	1.0058	-0.9980	99	207	0.207	2.88E-04	0.01779	0.0078	0.049675	16.67	3.33
15	900	1.00625	1.0058	-0.9980	99	207	0.207	2.30E-04	0.01591	0.0078	0.049675	16.67	0.00
30	1800	1.006	1.0055	-0.9980	101	209	0.209	1.16E-04	0.01130	0.0075	0.048072	13.33	3.33
45	2700	1.00525	1.0048	-0.9980	101	209	0.209	7.74E-05	0.00923	0.0068	0.043265	3.33	10.00
60	3600	1.0051	1.0046	-0.9980	101	209	0.209	5.81E-05	0.00799	0.0066	0.042304	1.33	2.00
120	7200	1.005	1.0045	-0.9980	101	209	0.209	2.90E-05	0.00565	0.0065	0.041663	0.00	1.33

Max P	0.08973
Min P	0.04166

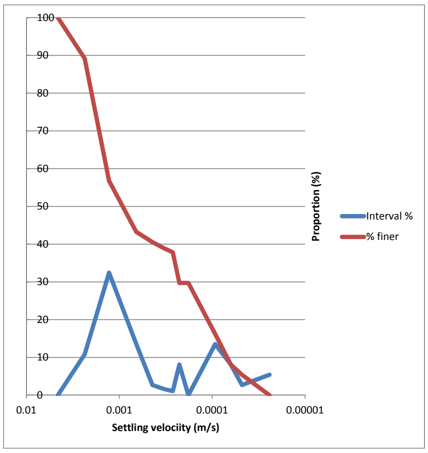


Sample 1883505.6

Mass (g)	25
Particle densiity (kg/m3)	2720
Temperature (°C)	20
Viscosity (Pa.s)	0.00100
Fluid density (kg/m3)	998.21
K [(mm/min)^(1/2)]	0.00421
Bulk density (t/m3)	2.720

Time		Hydrometer reading											
(min)	t (sec)	Rh	R'h	x	y	HR (mr	HR (m)	V (HR/t)	D (mm)	R'h+x	P	% finer	Interval %
0.5	30	1.01375	1.01325	-0.9980	35	137.5	0.1375	0.0045833	0.06977	0.0153	0.096465	100.00	0
1	60	1.01275	1.01225	-0.9980	39	141.5	0.1415	0.0023583	0.05005	0.0143	0.09014	89.19	10.81
2	120	1.00975	1.00925	-0.9980	52	154.5	0.1545	0.0012875	0.03698	0.0113	0.071163	56.76	32.43
4	240	1.0085	1.008	-0.9980	55	157.5	0.1575	0.0006563	0.02640	0.0100	0.063256	43.24	13.51
6	360	1.00825	1.00775	-0.9980	56	158.5	0.1585	0.0004403	0.02163	0.0098	0.061674	40.54	2.70
8	480	1.0081	1.0076	-0.9980	56	158.5	0.1585	0.0003302	0.01873	0.0096	0.060726	38.92	1.62
10	600	1.008	1.0075	-0.9980	57	159.5	0.1595	0.0002658	0.01680	0.0095	0.060093	37.84	1.08
12	720	1.00725	1.00675	-0.9980	60	162.5	0.1625	0.0002257	0.01548	0.0088	0.055349	29.73	8.11
15	900	1.00725	1.00675	-0.9980	60	162.5	0.1625	0.0001806	0.01385	0.0088	0.055349	29.73	0.00
30	1800	1.006	1.0055	-0.9980	65	167.5	0.1675	9.306E-05	0.00994	0.0075	0.047442	16.22	13.51
45	2700	1.00525	1.00475	-0.9980	68	170.5	0.1705	6.315E-05	0.00819	0.0068	0.042698	8.11	8.11
60	3600	1.005	1.0045	-0.9980	70	172.5	0.1725	4.792E-05	0.00713	0.0065	0.041116	5.41	2.70
120	7200	1.0045	1.004	-0.9980	72	174.5	0.1745	2.424E-05	0.00507	0.0060	0.037953	0.00	5.41

Max P	0.09647
Min P	0.03795

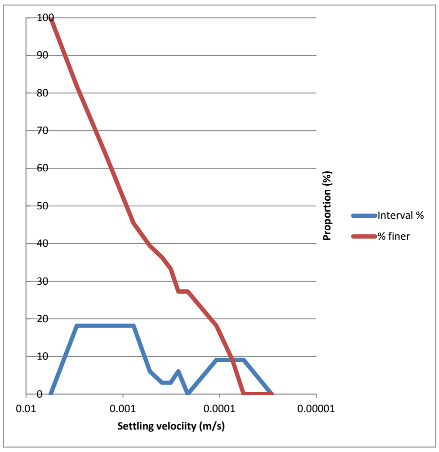


Sample 1883505.9

Mass (g)	25
Particle densiity (kg/m3)	2720
Temperature (°C)	20
Viscosity (Pa.s)	0.001002
Fluid density (kg/m3)	998.2063
K [(mm/min)^(1/2)]	0.0042075
Bulk density (t/m3)	2.72

Time		Hydrometer reading											
(min)	t (sec)	Rh	R'h	x	y	HR (mr	HR (m)	V (HR/t)	D (mm)	R'h+x	P	% finer	Interval %
0.5	30	1.013	1.0125	-0.998	65	167.5	0.1675	0.0055833	0.07701	0.0145	0.091721	100	0
1	60	1.0115	1.011	-0.998	77	179.5	0.1795	0.0029917	0.056371	0.013	0.082233	81.81818	18.18
2	120	1.01	1.0095	-0.998	78	180.5	0.1805	0.0015042	0.039971	0.0115	0.072744	63.63636	18.18
4	240	1.0085	1.008	-0.998	84	186.5	0.1865	0.0007771	0.02873	0.01	0.063256	45.45455	18.18
6	360	1.008	1.0075	-0.998	87	189.5	0.1895	0.0005264	0.023646	0.0095	0.060093	39.39394	6.06
8	480	1.00775	1.00725	-0.998	87	189.5	0.1895	0.0003948	0.020478	0.00925	0.058512	36.36364	3.03
10	600	1.0075	1.007	-0.998	90	192.5	0.1925	0.0003208	0.01846	0.009	0.05693	33.33333	3.03
12	720	1.007	1.0065	-0.998	90	192.5	0.1925	0.0002674	0.016852	0.0085	0.053767	27.27273	6.06
15	900	1.007	1.0065	-0.998	90	192.5	0.1925	0.0002139	0.015073	0.0085	0.053767	27.27273	0.00
30	1800	1.00625	1.00575	-0.998	92	194.5	0.1945	0.0001081	0.010713	0.00775	0.049023	18.18182	9.09
45	2700	1.0055	1.005	-0.998	97	199.5	0.1995	7.389E-05	0.008859	0.007	0.044279	9.090909	9.09
60	3600	1.00475	1.00425	-0.998	101	203.5	0.2035	5.653E-05	0.007749	0.00625	0.039535	0	9.09
120	7200	1.00475	1.00425	-0.998	106	208.5	0.2085	2.896E-05	0.005546	0.00625	0.039535	0	0.00

Max P	0.09172
Min P	0.03953



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ANALYSIS REPORT

Client:	Golder Associates (NZ) Limited - Auckland	**Lab No:**	1890995 SPv8
Contact:	Mr P Kennedy	**Date Received:**	06-Dec-2017
	C/- Golder Associates (NZ) Limited - Auckland	**Date Reported:**	11-Jan-2018
	PO Box 33849	**Quote No:**	89367
	Takapuna	**Order No:**	
	Auckland 0740	**Client Reference:**	
		Submitted By:	Mr P Kennedy

Sample Type: Sediment

Sample Name:		WH-C-01 06-Dec-2017	WH-C-02 06-Dec-2017	WH-C-03 06-Dec-2017	WH-C-04 06-Dec-2017	WH-C-05 06-Dec-2017
Lab Number:		1890995.1	1890995.2	1890995.3	1890995.4	1890995.5
Individual Tests						
Dry Matter	g/100g as rcvd	56	51	55	53	49
Dry Matter of Sieved Sample	g/100g as rcvd	53	54	53	54	47
Total Organic Carbon*	g/100g dry wt	0.78	0.60	0.96	1.07	1.14
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	7.6	7.7	8.0	9.9	7.6
Total Recoverable Cadmium	mg/kg dry wt	0.059	0.052	0.068	0.061	0.056
Total Recoverable Chromium	mg/kg dry wt	15.7	14.8	20	18.5	23
Total Recoverable Copper	mg/kg dry wt	13.3	9.0	32	116	52
Total Recoverable Lead	mg/kg dry wt	23	16.4	35	67	51
Total Recoverable Mercury	mg/kg dry wt	0.35	0.21	0.61	0.59	0.69
Total Recoverable Nickel	mg/kg dry wt	6.6	7.1	8.8	9.9	9.8
Total Recoverable Zinc	mg/kg dry wt	50	42	94	150	121
3 Grain Sizes Profile						
Fraction >/= 2 mm*	g/100g dry wt	< 0.1	< 0.1	0.5	0.7	< 0.1
Fraction < 2 mm, >/= 63 µm*	g/100g dry wt	41.0	47.4	55.6	65.7	44.7
Fraction < 63 µm*	g/100g dry wt	58.9	52.5	43.8	33.6	55.3
Polycyclic Aromatic Hydrocarbons Trace in Soil						
1-Methylnaphthalene	mg/kg dry wt	0.010	0.007	0.014	0.56	0.048
2-Methylnaphthalene	mg/kg dry wt	0.011	0.005	0.012	0.76	0.060
Acenaphthene	mg/kg dry wt	0.013	0.007	0.023	2.7	0.058
Acenaphthylene	mg/kg dry wt	0.020	0.013	0.040	0.079	0.021
Anthracene	mg/kg dry wt	0.046	0.026	0.068	0.25	0.072
Benzo[a]anthracene	mg/kg dry wt	0.28	0.156	0.39	2.5	0.54
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.38	0.24	0.56	2.4	0.58
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.45	0.27	0.28	3.9	0.71
Benzo[e]pyrene	mg/kg dry wt	0.24	0.127	0.29	1.99	0.34
Benzo[g,h,i]perylene	mg/kg dry wt	0.25	0.147	0.34	1.79	0.37
Benzo[k]fluoranthene	mg/kg dry wt	0.170	0.104	0.26	1.62	0.28
Chrysene	mg/kg dry wt	0.31	0.154	0.34	3.5	0.47
Dibenzo[a,h]anthracene	mg/kg dry wt	0.050	0.027	0.078	0.55	0.089
Fluoranthene	mg/kg dry wt	0.66	0.35	0.76	5.7	1.02
Fluorene	mg/kg dry wt	0.016	0.010	0.021	2.4	0.040
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.29	0.174	0.44	2.3	0.45
Naphthalene	mg/kg dry wt	0.020	< 0.015	0.021	1.13	0.050
Perylene	mg/kg dry wt	0.071	0.042	0.094	0.54	0.119
Phenanthrene	mg/kg dry wt	0.26	0.129	0.28	4.9	0.33

Sample Type: Sediment						
Sample Name:		WH-C-01 06-Dec-2017	WH-C-02 06-Dec-2017	WH-C-03 06-Dec-2017	WH-C-04 06-Dec-2017	WH-C-05 06-Dec-2017
Lab Number:		1890995.1	1890995.2	1890995.3	1890995.4	1890995.5
Polycyclic Aromatic Hydrocarbons Trace in Soil						
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES	mg/kg dry wt	0.56	0.34	0.79	4.0	0.89
Benzo[a]pyrene Toxic Equivalence (TEF)	mg/kg dry wt	0.56	0.34	0.79	4.0	0.89
Pyrene	mg/kg dry wt	0.64	0.36	0.68	4.8	0.81
Tributyl Tin Trace in Soil samples by GCMS						
Dibutyltin (as Sn)	mg/kg dry wt	0.008	< 0.005	0.022	0.22	0.110
Monobutyltin (as Sn)	mg/kg dry wt	< 0.007	< 0.007	< 0.007	0.035	0.019
Tributyltin (as Sn)	mg/kg dry wt	0.011	< 0.004	0.043	0.40	0.190
Triphenyltin (as Sn)	mg/kg dry wt	< 0.003	< 0.003	< 0.003	0.012	< 0.003
Total Petroleum Hydrocarbons in Soil, GC						
C7 - C9	mg/kg dry wt	< 11	< 12	< 11	< 11	< 12
C10 - C11	mg/kg dry wt	< 11	< 12	< 11	< 11	< 12
C12 - C14	mg/kg dry wt	< 11	< 12	< 11	< 11	< 12
C15 - C20	mg/kg dry wt	< 11	< 12	< 11	12	< 12
C21 - C25	mg/kg dry wt	< 11	< 12	< 11	28	< 12
C26 - C29	mg/kg dry wt	< 11	< 12	< 11	30	13
C30 - C44	mg/kg dry wt	< 20	< 20	< 20	70	21
Total hydrocarbons (C7 - C44)	mg/kg dry wt	< 90	< 90	< 90	140	< 100

Sample Name:		WH-C-06 06-Dec-2017	WH-C-07 06-Dec-2017	WH-C-08 06-Dec-2017	WH-C-09 06-Dec-2017	WH-C-10 06-Dec-2017
Lab Number:		1890995.6	1890995.7	1890995.8	1890995.9	1890995.10
Individual Tests						
Dry Matter	g/100g as rcvd	50	50	48	51	53
Dry Matter of Sieved Sample	g/100g as rcvd	48	49	45	48	50
Total Organic Carbon*	g/100g dry wt	1.05	1.02	1.19	1.03	1.09
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	8.4	8.0	7.9	8.1	9.3
Total Recoverable Cadmium	mg/kg dry wt	0.081	0.063	0.035	0.064	0.113
Total Recoverable Chromium	mg/kg dry wt	21	22	23	22	18.7
Total Recoverable Copper	mg/kg dry wt	27	34	33	26	13.2
Total Recoverable Lead	mg/kg dry wt	41	43	34	41	33
Total Recoverable Mercury	mg/kg dry wt	0.46	0.56	0.21	0.28	0.44
Total Recoverable Nickel	mg/kg dry wt	10.8	9.6	9.5	9.8	8.1
Total Recoverable Zinc	mg/kg dry wt	105	107	109	106	73
3 Grain Sizes Profile						
Fraction >/= 2 mm*	g/100g dry wt	< 0.1	< 0.1	0.2	< 0.1	< 0.1
Fraction < 2 mm, >/= 63 µm*	g/100g dry wt	50.0	49.7	41.4	47.7	50.2
Fraction < 63 µm*	g/100g dry wt	49.9	50.3	58.4	52.3	49.8
Polycyclic Aromatic Hydrocarbons Trace in Soil						
1-Methylnaphthalene	mg/kg dry wt	0.010	0.019	0.008	0.012	0.018
2-Methylnaphthalene	mg/kg dry wt	0.010	0.017	0.008	0.013	0.023
Acenaphthene	mg/kg dry wt	0.018	0.056	0.016	0.023	0.016
Acenaphthylene	mg/kg dry wt	0.015	0.013	0.013	0.016	0.034
Anthracene	mg/kg dry wt	0.050	0.050	0.031	0.033	0.065
Benzo[a]anthracene	mg/kg dry wt	0.29	0.33	0.164	0.194	0.41
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.36	0.37	0.22	0.28	0.59
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.40	0.45	0.28	0.34	0.66
Benzo[e]pyrene	mg/kg dry wt	0.193	0.21	0.131	0.157	0.32
Benzo[g,h,i]perylene	mg/kg dry wt	0.21	0.22	0.126	0.168	0.39
Benzo[k]fluoranthene	mg/kg dry wt	0.154	0.178	0.109	0.131	0.26
Chrysene	mg/kg dry wt	0.26	0.30	0.174	0.20	0.39
Dibenzo[a,h]anthracene	mg/kg dry wt	0.046	0.054	0.029	0.036	0.073
Fluoranthene	mg/kg dry wt	0.57	0.69	0.38	0.48	0.85

Sample Type: Sediment						
Sample Name:		WH-C-06 06-Dec-2017	WH-C-07 06-Dec-2017	WH-C-08 06-Dec-2017	WH-C-09 06-Dec-2017	WH-C-10 06-Dec-2017
Lab Number:		1890995.6	1890995.7	1890995.8	1890995.9	1890995.10
Polycyclic Aromatic Hydrocarbons Trace in Soil						
Fluorene	mg/kg dry wt	0.018	0.038	0.015	0.019	0.021
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.26	0.29	0.160	0.21	0.45
Naphthalene	mg/kg dry wt	0.021	0.015	< 0.016	0.022	0.036
Perylene	mg/kg dry wt	0.068	0.070	0.041	0.051	0.106
Phenanthrene	mg/kg dry wt	0.21	0.28	0.158	0.23	0.31
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES	mg/kg dry wt	0.52	0.56	0.32	0.41	0.86
Benzo[a]pyrene Toxic Equivalence (TEF)	mg/kg dry wt	0.52	0.56	0.32	0.41	0.85
Pyrene	mg/kg dry wt	0.52	0.55	0.33	0.40	0.80
Tributyl Tin Trace in Soil samples by GCMS						
Dibutyltin (as Sn)	mg/kg dry wt	0.025	0.053	0.028	0.025	< 0.005
Monobutyltin (as Sn)	mg/kg dry wt	< 0.007	0.011	< 0.007	< 0.007	< 0.007
Tributyltin (as Sn)	mg/kg dry wt	0.025	0.037	0.046	0.018	< 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	< 12	< 13	< 12	< 11
C10 - C11	mg/kg dry wt	< 12	< 12	< 13	< 12	21
C12 - C14	mg/kg dry wt	< 12	< 12	< 13	< 12	< 11
C15 - C20	mg/kg dry wt	< 12	< 12	< 13	< 12	< 11
C21 - C25	mg/kg dry wt	< 12	< 12	< 13	< 12	50
C26 - C29	mg/kg dry wt	< 12	< 12	< 13	< 12	44
C30 - C44	mg/kg dry wt	< 20	38	< 20	< 20	70
Total hydrocarbons (C7 - C44)	mg/kg dry wt	< 90	< 90	< 100	< 90	184

Sample Name:		WH-C-11 06-Dec-2017	WH-C-12 06-Dec-2017	Composite of WH-C-01, WH-C-02 and WH-C-03	Composite of WH-C-04, WH-C-05 and WH-C-06	Composite of WH-C-07, WH-C-08 and WH-C-09
Lab Number:		1890995.11	1890995.12	1890995.13	1890995.14	1890995.15
Individual Tests						
Dry Matter	g/100g as rcvd	51	55	54	50	47
Dry Matter of Sieved Sample	g/100g as rcvd	49	51	-	-	-
Total Organic Carbon*	g/100g dry wt	0.96	0.85	-	-	-
Antifouling cobiocides in sediment samples by LCMSMS						
Diuron*	mg/kg dry wt	-	-	< 0.010	< 0.010	< 0.010
Irgarol*	mg/kg dry wt	-	-	< 0.010	< 0.010	< 0.010
Isoproturon*	mg/kg dry wt	-	-	< 0.010	< 0.010	< 0.010
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	7.1	7.1	-	-	-
Total Recoverable Cadmium	mg/kg dry wt	0.050	0.052	-	-	-
Total Recoverable Chromium	mg/kg dry wt	20	18.5	-	-	-
Total Recoverable Copper	mg/kg dry wt	27	17.9	-	-	-
Total Recoverable Lead	mg/kg dry wt	40	31	-	-	-
Total Recoverable Mercury	mg/kg dry wt	0.24	0.21	-	-	-
Total Recoverable Nickel	mg/kg dry wt	9.0	8.4	-	-	-
Total Recoverable Zinc	mg/kg dry wt	101	90	-	-	-
3 Grain Sizes Profile						
Fraction >/= 2 mm*	g/100g dry wt	< 0.1	< 0.1	-	-	-
Fraction < 2 mm, >/= 63 µm*	g/100g dry wt	55.7	51.9	-	-	-
Fraction < 63 µm*	g/100g dry wt	44.3	48.0	-	-	-
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

Sample Type: Sediment						
Sample Name:		WH-C-11 06-Dec-2017	WH-C-12 06-Dec-2017	Composite of WH-C-01, WH-C-02 and WH-C-03	Composite of WH-C-04, WH-C-05 and WH-C-06	Composite of WH-C-07, WH-C-08 and WH-C-09
Lab Number:		1890995.11	1890995.12	1890995.13	1890995.14	1890995.15
Organochlorine Pesticides Trace in Soil						
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	-	-	0.0028	0.0067	0.0025
2,4'-DDE	mg/kg dry wt	-	-	< 0.0010	< 0.0010	< 0.0010
4,4'-DDE	mg/kg dry wt	-	-	0.0014	0.0072	0.0023
2,4'-DDT	mg/kg dry wt	-	-	< 0.0010	< 0.0010	< 0.0010
4,4'-DDT	mg/kg dry wt	-	-	0.0036	0.0022	0.0029
Total DDT Isomers	mg/kg dry wt	-	-	0.008	0.016	0.008
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						
1-Methylnaphthalene	mg/kg dry wt	0.008	0.010	-	-	-
2-Methylnaphthalene	mg/kg dry wt	0.007	0.011	-	-	-
Acenaphthene	mg/kg dry wt	0.019	0.013	-	-	-
Acenaphthylene	mg/kg dry wt	0.007	0.010	-	-	-
Anthracene	mg/kg dry wt	0.029	0.034	-	-	-
Benzo[a]anthracene	mg/kg dry wt	0.153	0.159	-	-	-
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.179	0.183	-	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.23	0.21	-	-	-
Benzo[e]pyrene	mg/kg dry wt	0.105	0.101	-	-	-
Benzo[g,h,i]perylene	mg/kg dry wt	0.101	0.114	-	-	-
Benzo[k]fluoranthene	mg/kg dry wt	0.087	0.081	-	-	-
Chrysene	mg/kg dry wt	0.144	0.143	-	-	-
Dibenzo[a,h]anthracene	mg/kg dry wt	0.021	0.022	-	-	-
Fluoranthene	mg/kg dry wt	0.32	0.40	-	-	-
Fluorene	mg/kg dry wt	0.013	0.013	-	-	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.125	0.136	-	-	-
Naphthalene	mg/kg dry wt	< 0.015	0.018	-	-	-
Perylene	mg/kg dry wt	0.036	0.035	-	-	-
Phenanthrene	mg/kg dry wt	0.137	0.170	-	-	-
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES	mg/kg dry wt	0.26	0.27	-	-	-
Benzo[a]pyrene Toxic Equivalence (TEF)	mg/kg dry wt	0.26	0.27	-	-	-
Pyrene	mg/kg dry wt	0.29	0.34	-	-	-
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	0.0022	< 0.0010

Sample Type: Sediment						
Sample Name:		WH-C-11 06-Dec-2017	WH-C-12 06-Dec-2017	Composite of WH-C-01, WH-C-02 and WH-C-03	Composite of WH-C-04, WH-C-05 and WH-C-06	Composite of WH-C-07, WH-C-08 and WH-C-09
Lab Number:		1890995.11	1890995.12	1890995.13	1890995.14	1890995.15
Polychlorinated Biphenyls Trace in Soil						
PCB-49	mg/kg dry wt	-	-	< 0.0010	0.0018	< 0.0010
PCB-52	mg/kg dry wt	-	-	< 0.0010	0.0038	< 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	0.0111	0.0029
PCB-105	mg/kg dry wt	-	-	< 0.0010	0.0026	< 0.0010
PCB-110	mg/kg dry wt	-	-	< 0.0010	0.0088	0.0020
PCB-114	mg/kg dry wt	-	-	< 0.0010	< 0.0010	< 0.0010
PCB-118	mg/kg dry wt	-	-	< 0.0010	0.0076	0.0020
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	0.0022	< 0.0010
PCB-138	mg/kg dry wt	-	-	< 0.0010	0.0124	0.0033
PCB-141	mg/kg dry wt	-	-	< 0.0010	0.0022	< 0.0010
PCB-149	mg/kg dry wt	-	-	< 0.0010	0.0078	0.0022
PCB-151	mg/kg dry wt	-	-	< 0.0010	0.0022	< 0.0010
PCB-153	mg/kg dry wt	-	-	< 0.0010	0.0093	0.0028
PCB-156	mg/kg dry wt	-	-	< 0.0010	0.0015	< 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	0.0034	0.0011
PCB-180	mg/kg dry wt	-	-	< 0.0010	0.0049	0.0014
PCB-189	mg/kg dry wt	-	-	< 0.0010	< 0.0010	< 0.0010
PCB-194	mg/kg dry wt	-	-	< 0.0010	0.0011	< 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	0.09	< 0.04
Tributyl Tin Trace in Soil samples by GCMS						
Dibutyltin (as Sn)	mg/kg dry wt	0.031	0.016	-	-	-
Monobutyltin (as Sn)	mg/kg dry wt	< 0.007	< 0.007	-	-	-
Tributyltin (as Sn)	mg/kg dry wt	0.032	0.032	-	-	-
Triphenyltin (as Sn)	mg/kg dry wt	< 0.003	< 0.003	-	-	-
Total Petroleum Hydrocarbons in Soil, GC						
C7 - C9	mg/kg dry wt	< 12	< 11	-	-	-
C10 - C11	mg/kg dry wt	< 12	< 11	-	-	-
C12 - C14	mg/kg dry wt	< 12	< 11	-	-	-
C15 - C20	mg/kg dry wt	< 12	< 11	-	-	-
C21 - C25	mg/kg dry wt	< 12	< 11	-	-	-
C26 - C29	mg/kg dry wt	< 12	< 11	-	-	-
C30 - C44	mg/kg dry wt	< 20	< 20	-	-	-
Total hydrocarbons (C7 - C44)	mg/kg dry wt	< 90	< 90	-	-	-

Sample Type: Sediment						
	Sample Name:	Composite of WH-C-10, WH-C-11 and WH-C-12				
	Lab Number:	1890995.16				
Individual Tests						
Dry Matter	g/100g as rcvd	52	-	-	-	-
Antifouling cobiocides in sediment samples by LCMSMS						
Diuron*	mg/kg dry wt	< 0.010	-	-	-	-
Irgarol*	mg/kg dry wt	< 0.010	-	-	-	-
Isoproturon*	mg/kg dry wt	< 0.010	-	-	-	-
Organochlorine Pesticides Trace in Soil						
Aldrin	mg/kg dry wt	< 0.0010	-	-	-	-
alpha-BHC	mg/kg dry wt	< 0.0010	-	-	-	-
beta-BHC	mg/kg dry wt	< 0.0010	-	-	-	-
delta-BHC	mg/kg dry wt	< 0.0010	-	-	-	-
gamma-BHC (Lindane)	mg/kg dry wt	< 0.0010	-	-	-	-
cis-Chlordane	mg/kg dry wt	< 0.0010	-	-	-	-
trans-Chlordane	mg/kg dry wt	< 0.0010	-	-	-	-
2,4'-DDD	mg/kg dry wt	< 0.0010	-	-	-	-
4,4'-DDD	mg/kg dry wt	< 0.0010	-	-	-	-
2,4'-DDE	mg/kg dry wt	< 0.0010	-	-	-	-
4,4'-DDE	mg/kg dry wt	0.0014	-	-	-	-
2,4'-DDT	mg/kg dry wt	< 0.0010	-	-	-	-
4,4'-DDT	mg/kg dry wt	0.0014	-	-	-	-
Total DDT Isomers	mg/kg dry wt	< 0.006	-	-	-	-
Dieldrin	mg/kg dry wt	< 0.0010	-	-	-	-
Endosulfan I	mg/kg dry wt	< 0.0010	-	-	-	-
Endosulfan II	mg/kg dry wt	< 0.0010	-	-	-	-
Endosulfan sulphate	mg/kg dry wt	< 0.0010	-	-	-	-
Endrin	mg/kg dry wt	< 0.0010	-	-	-	-
Endrin aldehyde	mg/kg dry wt	< 0.0010	-	-	-	-
Endrin ketone	mg/kg dry wt	< 0.0010	-	-	-	-
Heptachlor	mg/kg dry wt	< 0.0010	-	-	-	-
Heptachlor epoxide	mg/kg dry wt	< 0.0010	-	-	-	-
Hexachlorobenzene	mg/kg dry wt	< 0.0010	-	-	-	-
Methoxychlor	mg/kg dry wt	< 0.0010	-	-	-	-
Total Chlordane [(cis+trans)* 100/42]	mg/kg dry wt	< 0.002	-	-	-	-
Polychlorinated Biphenyls Trace in Soil						
PCB-18	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-28	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-31	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-44	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-49	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-52	mg/kg dry wt	0.0017	-	-	-	-
PCB-60	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-77	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-81	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-86	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-101	mg/kg dry wt	0.0037	-	-	-	-
PCB-105	mg/kg dry wt	0.0012	-	-	-	-
PCB-110	mg/kg dry wt	0.0030	-	-	-	-
PCB-114	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-118	mg/kg dry wt	0.0028	-	-	-	-
PCB-121	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-123	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-126	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-128	mg/kg dry wt	< 0.0010	-	-	-	-

Sample Type: Sediment

Sample Name:		Composite of WH-C-10, WH-C-11 and WH-C-12				
Lab Number:		1890995.16				
Polychlorinated Biphenyls Trace in Soil						
PCB-138	mg/kg dry wt	0.0028	-	-	-	-
PCB-141	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-149	mg/kg dry wt	0.0016	-	-	-	-
PCB-151	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-153	mg/kg dry wt	0.0020	-	-	-	-
PCB-156	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-157	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-159	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-167	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-169	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-170	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-180	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-189	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-194	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-206	mg/kg dry wt	< 0.0010	-	-	-	-
PCB-209	mg/kg dry wt	< 0.0010	-	-	-	-
Mono-Ortho PCB Toxic Equivalence (TEF)*	mg/kg dry wt	< 0.0010	-	-	-	-
Non-Ortho PCB Toxic Equivalence (TEF)*	mg/kg dry wt	< 0.0010	-	-	-	-
Total PCB (Sum of 35 congeners)	mg/kg dry wt	< 0.04	-	-	-	-

Sample Type: Aqueous

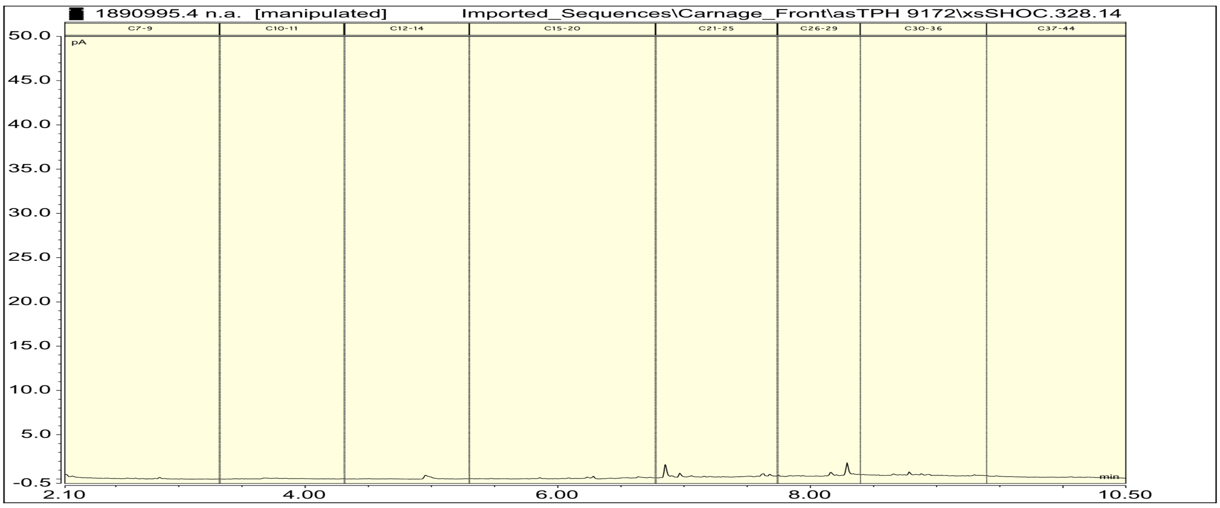
Sample Name:		WH-C-01 [Elutriation extract]	WH-C-02 [Elutriation extract]	WH-C-03 [Elutriation extract]	WH-C-07 [Elutriation extract]	WH-C-08 [Elutriation extract]
Lab Number:		1890995.17	1890995.18	1890995.19	1890995.20	1890995.21
Individual Tests						
Total Arsenic*	g/m^3	0.0130	0.0194	0.0069	0.0115	0.0065
Total Cadmium*	g/m^3	< 0.00021	< 0.00021	< 0.00021	< 0.00021	< 0.00021
Total Chromium*	g/m^3	< 0.0011	< 0.0011	< 0.0011	< 0.0011	< 0.0011
Total Copper*	g/m^3	< 0.0011	< 0.0011	< 0.0011	< 0.0011	< 0.0011
Total Lead*	g/m^3	< 0.0011	< 0.0011	< 0.0011	< 0.0011	< 0.0011
Total Mercury	g/m^3	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008
Total Nickel*	g/m^3	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
Total Zinc*	g/m^3	< 0.0042	< 0.0042	< 0.0042	< 0.0042	< 0.0042
Total Ammoniacal-N	g/m^3	4.4	5.1	2.3	2.7	3.1
Non-Purgeable Organic Carbon (NPOC)*	g/m^3	4.2	3.6	3.4	3.7	3.9
Tributyl Tin Trace in Water samples by GCMS						
Dibutyltin (as Sn)	g/m^3	< 0.00006	< 0.00006	< 0.00006	< 0.00006	< 0.00006
Tributyltin (as Sn)	g/m^3	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Triphenyltin (as Sn)	g/m^3	< 0.00004	< 0.00004	< 0.00004	< 0.00004	< 0.00004

Sample Name:		WH-C-09 [Elutriation extract]	WH-C-04 [Elutriation extract]			
Lab Number:		1890995.22	1890995.23			
Individual Tests						
Total Arsenic*	g/m^3	0.0198	< 0.0042	-	-	-
Total Cadmium*	g/m^3	< 0.00021	< 0.00021	-	-	-
Total Chromium*	g/m^3	< 0.0011	< 0.0011	-	-	-
Total Copper*	g/m^3	< 0.0011	< 0.0011	-	-	-
Total Lead*	g/m^3	< 0.0011	< 0.0011	-	-	-
Total Mercury	g/m^3	< 0.00008	< 0.00008	-	-	-
Total Nickel*	g/m^3	< 0.007	< 0.007	-	-	-
Total Zinc*	g/m^3	< 0.0042	< 0.0042	-	-	-

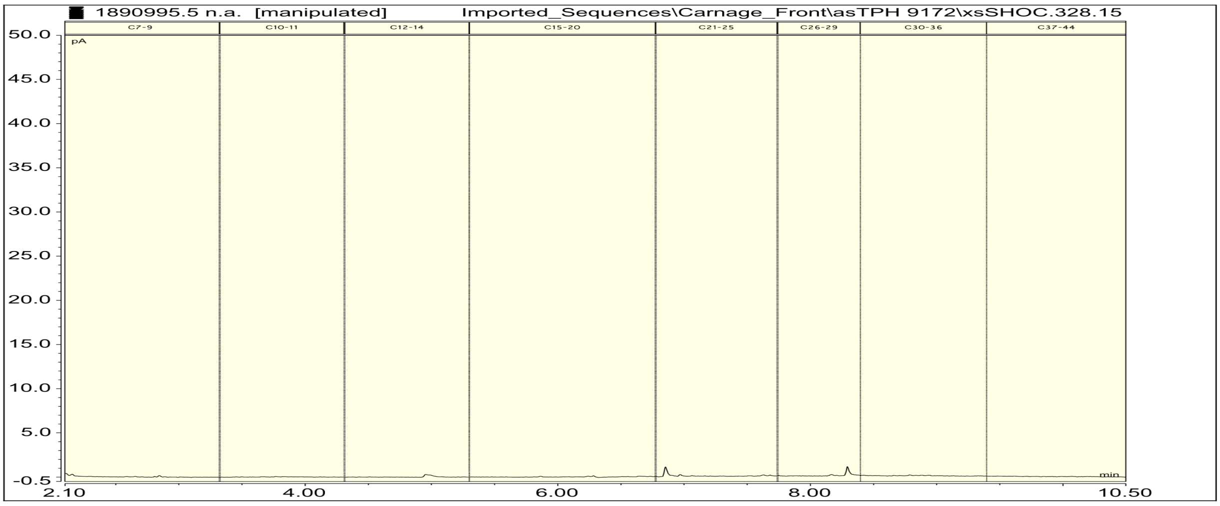
Sample Type: Aqueous

Sample Name:		WH-C-09 [Elutriation extract]	WH-C-04 [Elutriation extract]			
Lab Number:		1890995.22	1890995.23			
Individual Tests						
Total Ammoniacal-N	g/m³	4.7	1.2	-	-	-
Non-Purgeable Organic Carbon (NPOC)*	g/m³	4.9	3.0	-	-	-
Polycyclic Aromatic Hydrocarbons Trace in Water, By Liq/Liq						
Acenaphthene	g/m³	-	< 0.000008	-	-	-
Acenaphthylene	g/m³	-	< 0.000008	-	-	-
Anthracene	g/m³	-	< 0.000008	-	-	-
Benzo[a]anthracene	g/m³	-	< 0.000008	-	-	-
Benzo[a]pyrene (BAP)	g/m³	-	< 0.000008	-	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	g/m³	-	< 0.000008	-	-	-
Benzo[g,h,i]perylene	g/m³	-	< 0.000008	-	-	-
Benzo[k]fluoranthene	g/m³	-	< 0.000008	-	-	-
Chrysene	g/m³	-	< 0.000008	-	-	-
Dibenzo[a,h]anthracene	g/m³	-	< 0.000008	-	-	-
Fluoranthene	g/m³	-	< 0.000008	-	-	-
Fluorene	g/m³	-	< 0.000008	-	-	-
Indeno(1,2,3-c,d)pyrene	g/m³	-	< 0.000008	-	-	-
Naphthalene	g/m³	-	< 0.00004	-	-	-
Phenanthrene	g/m³	-	< 0.000008	-	-	-
Pyrene	g/m³	-	0.000009	-	-	-
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	-	-	-

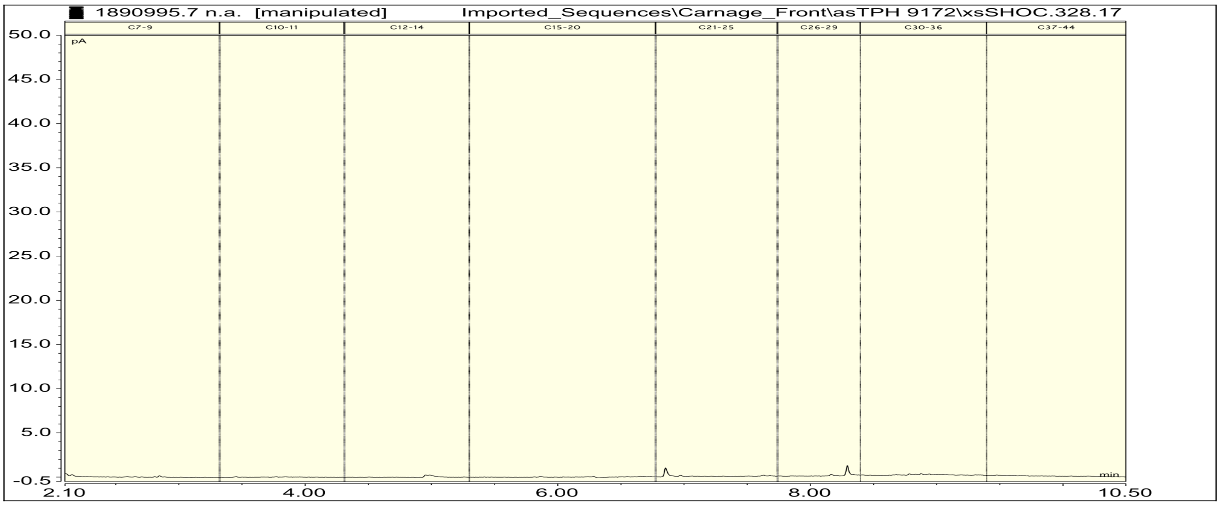
1890995.4
WH-C-04 06-Dec-2017
Client Chromatogram for TPH by FID



1890995.5
WH-C-05 06-Dec-2017
Client Chromatogram for TPH by FID



1890995.7
WH-C-07 06-Dec-2017
Client Chromatogram for TPH by FID



1890995.10
WH-C-10 06-Dec-2017
Client Chromatogram for TPH by FID

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 clean 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.

Sample Type: Sediment

Test	Method Description	Default Detection Limit	Sample No
Individual Tests			
Antifouling cobiocides suite in sediment by LCMSMS*	Ethyl acetate extraction, SPE cleanup, determination by LCMSMS.	-	13-16
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%.	-	1-12
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".	-	1-4, 7-9
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	1-16
Dry Matter for Grainsize samples	Drying for 16 hours at 103°C, gravimetry (Free water removed before analysis).	0.10 g/100g as rcvd	1-12
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-12
Composite Environmental Solid Samples*	Individual sample fractions mixed together to form a composite fraction.	-	1-12
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	1-12
Antifouling cobiocides in sediment samples by LCMSMS*		0.010 mg/kg dry wt	13-16
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	13-16
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	1-12
3 Grain Sizes Profile*		0.1 g/100g dry wt	1-12
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 - 0.010 mg/kg dry wt	1-12
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	1-12
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	1-12
3 Grain Sizes Profile			
Fraction < 2 mm, >/= 63 µm*	Wet sieving using dispersant, 2.00 mm and 63 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-12
Fraction < 63 µm*	Wet sieving with dispersant, 63 µm sieve, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-12

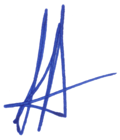
Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Individual Tests			
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	17-23
Total Arsenic*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0042 g/m³	17-23
Total Cadmium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.00021 g/m³	17-23
Total Chromium*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0011 g/m³	17-23
Total Copper*	Nitric acid digestion, ICP-MS, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0011 g/m³	17-23
Total Lead*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.0011 g/m³	17-23
Total Mercury	Bromine Oxidation followed by Atomic Fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m³	17-23
Total Nickel*	Nitric acid digestion, ICP-MS with universal cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.007 g/m³	17-23
Total Zinc*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0042 g/m³	17-23

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Ammoniacal-N	Saline sample. Phenol/hypochlorite colorimetry. Flow injection analyser. (NH4-N = NH4+-N + NH3-N). APHA 4500-NH3 H 22nd ed. 2012.	0.005 g/m^3	17-23
Non-Purgeable Organic Carbon (NPOC)*	Acidification, purging to remove inorganic C, super-critical persulphate oxidation at 375°C, IR detection. APHA 5310 C (modified) 22nd ed. 2012.	0.3 g/m^3	17-23
Polycyclic Aromatic Hydrocarbons Trace in Water, By Liq/Liq	Liquid / liquid extraction, SPE (if required), GC-MS SIM analysis [KBIs:4736,2695]	0.000005 g/m^3	23
Tributyl Tin Trace in Water samples by GCMS*	Solvent extraction, ethylation, SPE cleanup, GC-MS SIM analysis	0.00003 - 0.00005 g/m^3	17-23

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

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.



Ara Heron BSc (Tech)
Client Services Manager - Environmental

APPENDIX D

Sediment Cores

Table A1: Western Reclamation sediment core information.

ID	WH-C-01	WH-C-02	WH-C-03	WH-C-04	WH-C-05	WH-C-06	WH-C-07	WH-C-08	WH-C-09	WH-C-10	WH-C-11	WH-C-12
Site	7	8	1	4	3	2	12	6	5	11	10	9
Core 1 (cm)	89	76	52	41	68	55	76	48	75	67	74	75
Core 2 (cm)	64	96	64	52	70	60	74	69	74	57	60	72
Core 3 (cm)	84	54	*	40	65	62	78	63	80	67	81	78
depth	79	75	58	44	68	59	76	60	76	64	72	75
Colour	-	-	7.5 GY 4/1	C1 & C2: 5G 4/1 C3: 10 BG 2/1	-	5G 4/1	-	-	-	-	-	-
Notes	-	-	-	All three cores hit solid ground	-	-	-	Core 1 hit solid ground	-	All three cores hit solid ground	-	-

Table A2: Viaduct Harbour sediment core information.

ID	WWC-1	WWC-2	WWC-3	NWC-1	NWC-2	NWC-3	HWC-4	HWC-5	HWC-6	HWC-7	HWC-8	HWC-9	HWC-10	HWC-11	HWC-12
Site	6	2	1	5	4	3	15	14	13	10	11	12	9	8	7
Core 1 (cm)	50	36	80	60	75	55	42	43	40	30	55	48	50	60	60
Core 2 (cm)	70	68	60	53	50	90	64	70	65	36	53	57	35	55	26
Core 3 (cm)	75	62	75	80	60	40	61	55	75	32	46	50	90	40	50
Average depth	65	55	72	64	62	62	56	56	60	33	51	52	58	52	45
Notes	Possible anoxic smell?		-	Possible anoxic smell?	-	-	-	Possible anoxic smell?	Possible anoxic smell?	-	-	-	-	-	-

HWC-4

HWC-5

HWC-6

HWC-7

HWC-8

HWC-9

HWC-10

HWC-11

HWC-12

NWC-1 NWC-2 NWC-3

WWC-1

WWC-2

WWC-3

WH-C-01

WH-C-02

WH-C-03

WH-C-04

WH-C-05

WH-C-06

WH-C-07

WH-C-08

WH-C-09

WH-C-10

WH-C-11

WH-C-12

APPENDIX E

Laboratory Reports – Water Quality

Hill Laboratories
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ANALYSIS REPORT

SPv2

Client:	Golder Associates (NZ) Limited	**Lab No:**	1880781
Contact:	Emanuelle Desrochers	**Date Received:**	21-Nov-2017
	C/- Golder Associates (NZ) Limited	**Date Reported:**	12-Dec-2017
	PO Box 33849	**Quote No:**	88938
	Takapuna	**Order No:**	
	Auckland 0740	**Client Reference:**	Water Quality Samples
		Add. Client Ref:	1790454
		Submitted By:	Carmen Venter

Sample Type: Saline

Sample Name:		IV1-1 21-Nov-2017	IV2-1 21-Nov-2017	HB-1 21-Nov-2017	OV-1 21-Nov-2017	
Lab Number:		1880781.1	1880781.2	1880781.3	1880781.4	
Turbidity*	NTU	1.64	1.54	4.1	5.0	-
pH*	pH Units	7.9	7.9	8.0	8.0	-
Salinity*		35	35	35	35	-
Total Suspended Solids*	g/m³	< 3	< 3	6	8	-
Dissolved Copper*	g/m³	0.0030	0.0038	0.0012	< 0.0010	-
Dissolved Lead*	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-
Dissolved Zinc*	g/m³	0.008	0.008	0.005	< 0.004	-
Total Nitrogen	g/m³	0.22	0.43	0.22	0.23	-
Total Ammoniacal-N	g/m³	0.015	0.038	0.013	0.016	-
Nitrite-N	g/m³	0.0015	0.0013	< 0.0010	< 0.0010	-
Nitrate-N	g/m³	0.0160	0.0186	0.0084	0.0073	-
Nitrate-N + Nitrite-N	g/m³	0.0175	0.0199	0.0089	0.0080	-
Dissolved Reactive Phosphorus	g/m³	0.0160	0.0056	0.0144	0.0143	-
Non-Purgeable Organic Carbon (NPOC)*	g/m³	1.8	2.4	2.0	2.0	-
Chlorophyll a*	g/m³	0.00161	0.00152	0.0013	0.0023	-

Analyst's Comments

Supplement to test report 1880781v1, issued 29-Nov-2017. The Enterococci results have been removed at the request of 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 clean 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.

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Total Nitrogen Digestion	Caustic persulphate digestion. APHA 4500-N C 22nd ed. 2012.	-	1-4
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	1-4
Turbidity*	Saline sample. Analysis using a Hach 2100N, Turbidity meter. APHA 2130 B 22nd ed. 2012.	0.05 NTU	1-4
pH*	Saline water, pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	1-4
Salinity*	Conductivity Meter (WTW Cond 340i with nonlinear temperature compensation according to EN 27 888). APHA 2520 B 22nd ed. 2012.	0.2	1-4
Total Suspended Solids*	Saline sample. Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D 22nd ed. 2012.	3 g/m³	1-4

Sample Type: Saline			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	1-4
Dissolved Copper*	Filtered sample, ICP-MS, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	1-4
Dissolved Lead*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	1-4
Dissolved Zinc*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.004 g/m^3	1-4
Total Nitrogen	Alkaline persulphate digestion, automated Cd reduction/sulphanilamide colorimetry. APHA 4500-N C & 4500-NO_3^- I 22nd ed. 2012 (modified).	0.010 g/m^3	1-4
Total Ammoniacal-N	Saline sample. Phenol/hypochlorite colorimetry. Flow injection analyser. (NH4-N = NH4+-N + NH3-N). APHA 4500-NH3 H 22nd ed. 2012.	0.005 g/m^3	1-4
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO3- I 22nd ed. 2012 (modified).	0.0010 g/m^3	1-4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-4
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO3- I 22nd ed. 2012 (modified).	0.0010 g/m^3	1-4
Dissolved Reactive Phosphorus	Saline sample. Molybdenum blue colorimetry. Flow injection analyser. APHA 4500-P G 22nd ed. 2012.	0.0010 g/m^3	1-4
Non-Purgeable Organic Carbon (NPOC)*	Acidification, purging to remove inorganic C, super-critical persulphate oxidation at 375°C, IR detection. APHA 5310 C (modified) 22nd ed. 2012.	0.3 g/m^3	1-4
Chlorophyll a*	Acetone extraction. Fluorometer. Trace level. APHA 10200 H (modified) 22nd ed. 2012.	0.00002 g/m^3	1-4

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

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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

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W www.hill-laboratories.com

ANALYSIS REPORT

Client:	Golder Associates (NZ) Limited	**Lab No:**	1884481 SPv2
Contact:	Mr P Kennedy	**Date Received:**	27-Nov-2017
	C/- Golder Associates (NZ) Limited	**Date Reported:**	12-Dec-2017
	PO Box 33849	**Quote No:**	88938
	Takapuna	**Order No:**	
	Auckland 0740	**Client Reference:**	Water Quality Samples
		Add. Client Ref:	1790454
		Submitted By:	Emanuelle Desrochers

Sample Type: Saline

Sample Name:		IV1-R2 27-Nov-2017	IV2-R2 27-Nov-2017	HB-R2 27-Nov-2017 5:20 pm	OV-R2 27-Nov-2017	
Lab Number:		1884481.1	1884481.2	1884481.3	1884481.4	
Turbidity*	NTU	1.69	3.2	4.2	6.0	-
pH*	pH Units	8.0	8.0	8.0	8.0	-
Salinity*		35	35	35	35	-
Total Suspended Solids*	g/m³	4	6	7	10	-
Dissolved Copper*	g/m³	0.0045	0.0026	0.020	< 0.0010	-
Dissolved Lead*	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-
Dissolved Zinc*	g/m³	0.004	< 0.004	< 0.004	0.011	-
Total Nitrogen	g/m³	0.21	0.171	0.186	0.156	-
Total Ammoniacal-N	g/m³	0.016	0.013	0.019	0.014	-
Nitrite-N	g/m³	0.0012	< 0.0010	< 0.0010	< 0.0010	-
Nitrate-N	g/m³	0.0068	0.0043	0.0029	0.0016	-
Nitrate-N + Nitrite-N	g/m³	0.0080	0.0053	0.0038	0.0019	-
Dissolved Reactive Phosphorus	g/m³	0.0115	0.0122	0.0124	0.0124	-
Non-Purgeable Organic Carbon (NPOC)*	g/m³	1.8	1.8	2.3	1.9	-
Chlorophyll a*	g/m³	0.0019	0.0028	0.0023	0.0018	-

Analyst's Comments

Supplement to test report 1884481v1, issued 6-Dec-2017. The Enterococci results have been removed at the request of 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 clean 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.

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Total Nitrogen Digestion	Caustic persulphate digestion. APHA 4500-N C 22nd ed. 2012.	-	1-4
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	1-4
Turbidity*	Saline sample. Analysis using a Hach 2100N, Turbidity meter. APHA 2130 B 22nd ed. 2012.	0.05 NTU	1-4
pH*	Saline water, pH meter. APHA 4500-H⁺ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	1-4
Salinity*	Conductivity Meter (WTW Cond 340i with nonlinear temperature compensation according to EN 27 888). APHA 2520 B 22nd ed. 2012.	0.2	1-4
Total Suspended Solids*	Saline sample. Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D 22nd ed. 2012.	3 g/m³	1-4

Sample Type: Saline			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	1-4
Dissolved Copper*	Filtered sample, ICP-MS, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	1-4
Dissolved Lead*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	1-4
Dissolved Zinc*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.004 g/m^3	1-4
Total Nitrogen	Alkaline persulphate digestion, automated Cd reduction/sulphanilamide colorimetry. APHA 4500-N C & 4500-NO3$^-$ I 22nd ed. 2012 (modified).	0.010 g/m^3	1-4
Total Ammoniacal-N	Saline sample. Phenol/hypochlorite colorimetry. Flow injection analyser. (NH4-N = NH4+-N + NH3-N). APHA 4500-NH3 H 22nd ed. 2012.	0.005 g/m^3	1-4
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO3- I 22nd ed. 2012 (modified).	0.0010 g/m^3	1-4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-4
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO3- I 22nd ed. 2012 (modified).	0.0010 g/m^3	1-4
Dissolved Reactive Phosphorus	Saline sample. Molybdenum blue colorimetry. Flow injection analyser. APHA 4500-P G 22nd ed. 2012.	0.0010 g/m^3	1-4
Non-Purgeable Organic Carbon (NPOC)*	Acidification, purging to remove inorganic C, super-critical persulphate oxidation at 375°C, IR detection. APHA 5310 C (modified) 22nd ed. 2012.	0.3 g/m^3	1-4
Chlorophyll a*	Acetone extraction. Fluorometer. Trace level. APHA 10200 H (modified) 22nd ed. 2012.	0.00002 g/m^3	1-4

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

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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Client Services Manager - Environmental

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ANALYSIS REPORT

Client:	Golder Associates (NZ) Limited	**Lab No:**	1888870 SPv2
Contact:	Emanuelle Desrochers	**Date Received:**	04-Dec-2017
	C/- Golder Associates (NZ) Limited	**Date Reported:**	12-Dec-2017
	PO Box 33849	**Quote No:**	88938
	Takapuna	**Order No:**	
	Auckland 0740	**Client Reference:**	Water Quality Samples
		Add. Client Ref:	1790454
		Submitted By:	Mr P Kennedy

Sample Type: Saline

Sample Name:		IV1-R3 04-Dec-2017 10:30 am	IV2-R3 04-Dec-2017 10:30 am	HB-R3 04-Dec-2017 10:30 am	OV-R3 04-Dec-2017 10:30 am	
Lab Number:		1888870.1	1888870.2	1888870.3	1888870.4	
Turbidity*	NTU	3.0	2.6	5.4	5.3	-
pH*	pH Units	7.9	7.8	7.9	7.9	-
Salinity*		35	36	36	36	-
Total Suspended Solids*	g/m³	5	4	9	10	-
Dissolved Copper*	g/m³	0.0034	0.0030	0.0012	0.0019	-
Dissolved Lead*	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-
Dissolved Zinc*	g/m³	< 0.004	< 0.004	< 0.004	< 0.004	-
Total Nitrogen	g/m³	0.152	0.167	0.161	0.158	-
Total Ammoniacal-N	g/m³	0.019	0.019	0.021	0.018	-
Nitrite-N	g/m³	0.0013	0.0012	< 0.0010	< 0.0010	-
Nitrate-N	g/m³	0.0064	0.0075	0.0035	0.0020	-
Nitrate-N + Nitrite-N	g/m³	0.0076	0.0087	0.0043	0.0026	-
Dissolved Reactive Phosphorus	g/m³	0.0167	0.0162	0.0154	0.0143	-
Non-Purgeable Organic Carbon (NPOC)*	g/m³	1.6	1.6	1.6	1.4	-
Enterococci	MPN / 100mL	-	-	< 10	-	-
Chlorophyll a*	g/m³	0.0016	0.00057	0.0017	0.00068	-

Analyst's Comments

Supplement to test report 1888870v1, issued 11-Dec-2017. The Enterococci results have been removed at the request of 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 clean 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.

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Total Nitrogen Digestion	Caustic persulphate digestion. APHA 4500-N C 22nd ed. 2012.	-	1-4
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	1-4
Turbidity*	Saline sample. Analysis using a Hach 2100N, Turbidity meter. APHA 2130 B 22nd ed. 2012.	0.05 NTU	1-4
pH*	Saline water, pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	1-4
Salinity*	Conductivity Meter (WTW Cond 340i with nonlinear temperature compensation according to EN 27 888). APHA 2520 B 22nd ed. 2012.	0.2	1-4
Total Suspended Solids*	Saline sample. Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D 22nd ed. 2012.	3 g/m³	1-4

Sample Type: Saline			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22^{nd} ed. 2012.	-	1-4
Dissolved Copper*	Filtered sample, ICP-MS, ultratrace. APHA 3125 B 22^{nd} ed. 2012.	0.0010 g/m^3	1-4
Dissolved Lead*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22^{nd} ed. 2012.	0.0010 g/m^3	1-4
Dissolved Zinc*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22^{nd} ed. 2012.	0.004 g/m^3	1-4
Total Nitrogen	Alkaline persulphate digestion, automated Cd reduction/sulphanilamide colorimetry. APHA 4500-N C & 4500-NO3$^-$ I 22^{nd} ed. 2012 (modified).	0.010 g/m^3	1-4
Total Ammoniacal-N	Saline sample. Phenol/hypochlorite colorimetry. Flow injection analyser. (NH4-N = NH4+-N + NH3-N). APHA 4500-NH3 H 22nd ed. 2012.	0.005 g/m^3	1-4
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO3- I 22nd ed. 2012 (modified).	0.0010 g/m^3	1-4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-4
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO3- I 22nd ed. 2012 (modified).	0.0010 g/m^3	1-4
Dissolved Reactive Phosphorus	Saline sample. Molybdenum blue colorimetry. Flow injection analyser. APHA 4500-P G 22nd ed. 2012.	0.0010 g/m^3	1-4
Non-Purgeable Organic Carbon (NPOC)*	Acidification, purging to remove inorganic C, super-critical persulphate oxidation at 375°C, IR detection. APHA 5310 C (modified) 22^{nd} ed. 2012.	0.3 g/m^3	1-4
Chlorophyll a*	Acetone extraction. Fluorometer. Trace level. APHA 10200 H (modified) 22nd ed. 2012.	0.00002 g/m^3	1-4

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

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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ANALYSIS REPORT

Client:	Golder Associates (NZ) Limited	**Lab No:**	1893846 SPv2
Contact:	Emanuelle Desrochers	**Date Received:**	11-Dec-2017
	C/- Golder Associates (NZ) Limited	**Date Reported:**	22-Dec-2017
	PO Box 33849	**Quote No:**	88938
	Takapuna	**Order No:**	
	Auckland 0740	**Client Reference:**	Water Quality Samples
		Add. Client Ref:	1790454
		Submitted By:	Mr P Kennedy

Sample Type: Saline

Sample Name:		IV1-R4 11-Dec-2017 3:30 pm	IV2-R4 11-Dec-2017 3:30 pm	HB-R4 11-Dec-2017 3:30 pm	OVB-R4 11-Dec-2017 3:30 pm	
Lab Number:		1893846.1	1893846.2	1893846.3	1893846.4	
Turbidity*	NTU	2.0	1.86	4.0	3.6	-
pH*	pH Units	7.9	8.0	8.0	8.0	-
Salinity*		35	35	36	35	-
Total Suspended Solids*	g/m³	4	4	6	8	-
Dissolved Copper*	g/m³	0.0036	0.0052	0.0014	0.0015	-
Dissolved Lead*	g/m³	< 0.0010	0.0012	< 0.0010	< 0.0010	-
Dissolved Zinc*	g/m³	< 0.004	0.006	< 0.004	< 0.004	-
Total Nitrogen	g/m³	0.24	0.24	0.21	0.21	-
Total Ammoniacal-N	g/m³	0.012	0.009	0.011	0.010	-
Nitrite-N	g/m³	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-
Nitrate-N	g/m³	0.0050	0.0063	< 0.0010	< 0.0010	-
Nitrate-N + Nitrite-N	g/m³	0.0059	0.0071	0.0010	< 0.0010	-
Dissolved Reactive Phosphorus	g/m³	0.0141	0.0136	0.0131	0.0128	-
Non-Purgeable Organic Carbon (NPOC)*	g/m³	1.8	1.6	1.6	1.6	-
Chlorophyll a*	g/m³	0.0030	0.0029	0.0030	0.0033	-

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 clean 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.

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Total Nitrogen Digestion	Caustic persulphate digestion. APHA 4500-N C 22nd ed. 2012.	-	1-4
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	1-4
Turbidity*	Saline sample. Analysis using a Hach 2100N, Turbidity meter. APHA 2130 B 22nd ed. 2012.	0.05 NTU	1-4
pH*	Saline water, pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	1-4
Salinity*	Conductivity Meter (WTW Cond 340i with nonlinear temperature compensation according to EN 27 888). APHA 2520 B 22nd ed. 2012.	0.2	1-4
Total Suspended Solids*	Saline sample. Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D 22nd ed. 2012.	3 g/m³	1-4
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	1-4
Dissolved Copper*	Filtered sample, ICP-MS, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m³	1-4
Dissolved Lead*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.0010 g/m³	1-4

Sample Type: Saline			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Dissolved Zinc*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.004 g/m^3	1-4
Total Nitrogen	Alkaline persulphate digestion, automated Cd reduction/sulphanilamide colorimetry. APHA 4500-N C & 4500-$NO3^-$ I 22nd ed. 2012 (modified).	0.010 g/m^3	1-4
Total Ammoniacal-N	Saline sample. Phenol/hypochlorite colorimetry. Flow injection analyser. (NH4-N = NH4+-N + NH3-N). APHA 4500-NH3 H 22nd ed. 2012.	0.005 g/m^3	1-4
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO3- I 22nd ed. 2012 (modified).	0.0010 g/m^3	1-4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-4
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO3- I 22nd ed. 2012 (modified).	0.0010 g/m^3	1-4
Dissolved Reactive Phosphorus	Saline sample. Molybdenum blue colorimetry. Flow injection analyser. APHA 4500-P G 22nd ed. 2012.	0.0010 g/m^3	1-4
Non-Purgeable Organic Carbon (NPOC)*	Acidification, purging to remove inorganic C, super-critical persulphate oxidation at 375°C, IR detection. APHA 5310 C (modified) 22nd ed. 2012.	0.3 g/m^3	1-4
Chlorophyll a*	Acetone extraction. Fluorometer. Trace level. APHA 10200 H (modified) 22nd ed. 2012.	0.00002 g/m^3	1-4

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

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Ara Heron BSc (Tech)
Client Services Manager - Environmental

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ANALYSIS REPORT

Client:	Golder Associates (NZ) Limited - Auckland	**Lab No:**	1896794 SPv2
Contact:	Mr P Kennedy	**Date Received:**	15-Dec-2017
	C/- Golder Associates (NZ) Limited - Auckland	**Date Reported:**	05-Jan-2018
	PO Box 33849	**Quote No:**	88938
	Takapuna	**Order No:**	1790454
	Auckland 0740	**Client Reference:**	Water Quality Samples
		Add. Client Ref:	Sampled on: 15/121/7
		Submitted By:	Emanuelle Desrochers

Sample Type: Saline

Sample Name:		R5 - IV1 15-Dec-2017	R5 - IV2 15-Dec-2017	R5 - HB1 15-Dec-2017	R5 - OVB 15-Dec-2017	
Lab Number:		1896794.1	1896794.2	1896794.3	1896794.4	
Turbidity*	NTU	1.80	2.8	3.6	3.5	-
pH*	pH Units	8.0	7.9	8.0	8.0	-
Salinity*		36	36	36	36	-
Total Suspended Solids*	g/m^3	36	36	34	36	-
Dissolved Copper*	g/m^3	0.0029	0.0022	< 0.0010	< 0.0010	-
Dissolved Lead*	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-
Dissolved Zinc*	g/m^3	< 0.004	< 0.004	< 0.004	< 0.004	-
Total Nitrogen	g/m^3	0.176	0.169	0.180	0.188	-
Total Ammoniacal-N	g/m^3	0.018	0.017	0.034	0.016	-
Nitrite-N	g/m^3	0.0010	< 0.0010	< 0.0010	< 0.0010	-
Nitrate-N	g/m^3	0.0069	0.0049	0.0027	0.0014	-
Nitrate-N + Nitrite-N	g/m^3	0.0079	0.0059	0.0036	0.0016	-
Dissolved Reactive Phosphorus	g/m^3	0.0168	0.0162	0.0181	0.0126	-
Non-Purgeable Organic Carbon (NPOC)*	g/m^3	1.7	1.6	3.0	2.7	-
Chlorophyll a*	g/m^3	0.0021	0.0020	0.0014	0.0017	-

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 clean 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.

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Total Nitrogen Digestion	Caustic persulphate digestion. APHA 4500-N C 22nd ed. 2012.	-	1-4
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	1-4
Turbidity*	Saline sample. Analysis using a Hach 2100N, Turbidity meter. APHA 2130 B 22nd ed. 2012.	0.05 NTU	1-4
pH*	Saline water, pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	1-4
Salinity*	Conductivity Meter (WTW Cond 340i with nonlinear temperature compensation according to EN 27 888). APHA 2520 B 22nd ed. 2012.	0.2	1-4
Total Suspended Solids*	Saline sample. Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D 22nd ed. 2012.	3 g/m^3	1-4
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	1-4
Dissolved Copper*	Filtered sample, ICP-MS, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	1-4
Dissolved Lead*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	1-4

Sample Type: Saline			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Dissolved Zinc*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22^{nd} ed. 2012.	0.004 g/m^3	1-4
Total Nitrogen	Alkaline persulphate digestion, automated Cd reduction/sulphanilamide colorimetry. APHA 4500-N C & 4500-$NO3^-$ I 22^{nd} ed. 2012 (modified).	0.010 g/m^3	1-4
Total Ammoniacal-N	Saline sample. Phenol/hypochlorite colorimetry. Flow injection analyser. (NH4-N = NH4+-N + NH3-N). APHA 4500-NH3 H 22nd ed. 2012.	0.005 g/m^3	1-4
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO3- I 22nd ed. 2012 (modified).	0.0010 g/m^3	1-4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1-4
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO3- I 22nd ed. 2012 (modified).	0.0010 g/m^3	1-4
Dissolved Reactive Phosphorus	Saline sample. Molybdenum blue colorimetry. Flow injection analyser. APHA 4500-P G 22nd ed. 2012.	0.0010 g/m^3	1-4
Non-Purgeable Organic Carbon (NPOC)*	Acidification, purging to remove inorganic C, super-critical persulphate oxidation at 375°C, IR detection. APHA 5310 C (modified) 22^{nd} ed. 2012.	0.3 g/m^3	1-4
Chlorophyll a*	Acetone extraction. Fluorometer. Trace level. APHA 10200 H (modified) 22nd ed. 2012.	0.00002 g/m^3	1-4

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

APPENDIX F

Summary of Suspended Solids and Turbidity Data

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Golder Associates (NZ) Ltd
PO Box 33849
Auckland 0740
New Zealand

21 December 2017

Attention: Paul Kennedy

Dear Paul,

Waitemata Harbour Historic Water Quality Data

Please find attached our archive of historic marine water quality data pertaining to the vicinity of Central Auckland. All the results are for samples collected and analysed by Beca Ltd for various projects and consist mainly of Total Suspended Solids (TSS) analyses.

A brief explanation the information for each source provided in the attached tables is follows:

- **Various POAL Monitoring:**

This dataset consists of samples collected during dredging monitoring operations. The values provided are for the ***control samples only*** collected a minimum of 500 metres up-stream/current from the dredging activity and therefore unaffected by dredging activities. As a general rule these were all taken from the main channel to the north of POAL's wharves at-least 500 metres upstream or downstream from the location described in the table depending on the tidal movement, also given in the table.

- **Rangitoto Channel:**

Again control samples only taken as per the "Various POAL Monitoring" table (i.e. control samples collected 500 metres up-current of the dredging activity). However this set of data are from dredging of the main channel and therefore extend from near the port all the way around to Rangitoto Island. This dataset may provide additional context but these sample are not necessarily collected "within the vicinity of Central Auckland".

- **Westhaven Marina:**

Samples collected in the middle of each entrance into Westhaven Marina as described in the table ***while dredging activity was underway***, with the addition of Control samples unaffected by dredging activity in 2006 taken 500-metres to the seaward of the entrance.

- **Off-Wharf Sampling:**

Samples in this dataset were collected off the side of the wharves (described in the table) as part of the Britomart construction programme. The sampling programme was intended to detect possible impacts from dewatering Britomart but from memory no impact was seen in the data and this represents possibly the best indication of inner wharf water quality.

Should you have any questions please do not hesitate to call me.

Yours sincerely

Brian Mills
Senior Environmental Scientist

on behalf of

Beca Limited

Direct Dial: +64 9 308 0869
Email: brian.mills@beca.com

Copy

Jennifer Hart, Beca

Various POAL monitoring

Sample Ref	Date	Location		Tide	Total Suspended Solids (g/m3)
		Control GPS coordinates (WGS 084)	Control Samples for (Location Name)		
17:141	17/07/2017	36°50.383S 174°47.369E	Fergusson dredging	Flood	5
17:083	8/05/2017	36°50.514S 174°46.590E	Fergusson dredging	Flood	5
17:070	12/04/2017	36°50.354S 174°46.915E	Fergusson dredging	Ebb	43
17:060	31/03/2017	36°50.503S 174°47.565E	Fergusson dredging	Flood	16
17:047	20/03/2017	36°50.483S 174°47.575E	Fergusson dredging	Flood	5
17:028	24/02/2017	36°50.351S 174°46.878E	Fergusson dredging	Ebb	37
17:010	2/02/2017	36°50.370S 174°46.888E	Fergusson dredging	Ebb	11
17:003	18/01/2017	36°50.356S 174°46.881E	Fergusson dredging	Ebb	8
16:177	20/12/2016	36°50.520S 174°47.536E	Fergusson dredging	Flood	14
16:166	9/12/2016	36°50.556S 174°46.528E	Fergusson dredging	Flood	6
16:146	11/11/2016	36°50.369S 174°46.036E	Fergusson dredging	Flood	6
16:132	14/10/2016	36°50.367S 174°46.855E	Fergusson dredging	Ebb	6
16:128	29/09/2016	36°50.392S 174°46.788E	Fergusson dredging	Ebb	7
16:120	16/09/2016	36°50.399S 174°46.807E	Fergusson dredging	Ebb	5
16:110	24/08/2016	36°50.339S 174°46.900E	Fergusson dredging	Ebb	38
16:103	11/08/2016	36°50.461S 174°47.537E	Fergusson dredging	Flood	5
16:096	29/07/2016	36°50.394S 174°47.599E	Fergusson dredging	Flood	6
16:082	12/07/2016	36°50.389S 174°47.832E	Fergusson dredging	Ebb	<3
16:077	13/06/2016	36°50.230S 174°47.050E	Fergusson dredging	Ebb	7
16:070	15/06/2016	36°50.262S 174°47.180E	Fergusson dredging	Flood	6
16:062	24/05/2017	36°50.214S 174°46.468E	Fergusson dredging	Ebb	20
16:052	10/05/2017	36°50.214S 174°46.468E	Fergusson dredging	Ebb	10
16:044	28/04/2016	36°50.325S 174°46.889E	Fergusson dredging	Ebb	3
16:036	14/04/2016	36°50.317S 174°46.875E	Fergusson dredging	Ebb	3
16:020	12/02/2016	36°50.270S 174°46.869E	Fergusson dredging	Ebb	11
15:174	18/12/2015	36°50.347S 174°47.488E	Fergusson dredging	Flood	7
15:156	27/11/2015	36°50.283S 174°46.578E	Fergusson dredging	Ebb	15
15:151	13/11/2015	36°50.305S 174°46.855E	Fergusson dredging	Ebb	29
15:105	28/08/2015	36°50.381S 174°47.409E	Fergusson dredging	Flood	4
11:162	9/12/2011		Port Approach - Western side of Fergusson Wharf	Flood	3.9
11:161	2/12/2011		Fergusson Wharf (West)	Flood	9.0
11:159	1/12/2011		Port Approach - Western side of Fergusson Wharf	Flood	7.1
11:147	18/11/2011		Port Approach - Western side of Fergusson Wharf	Flood	<3
11:113	9/09/2011		Adjacent Wynyard Quarter & Westhaven Marina	Ebb	<3
10:201	2/12/2010		Adjacent Orams Marine slipway & Westhaven Marina	Ebb	7.5
08:166	24/10/2008		Port Approach - NW of Bledisloe Wharf	Flood	10.9
08:067	6/05/2008		Port Approach - East of Freyberg Wharf	Flood	7.9
08:067	6/05/2008		Port Approach - East of Freyberg Wharf	Flood	7.9
08:067	6/05/2008		Port Approach - East of Freyberg Wharf	Ebb	8.5
08:067	6/05/2008		Port Approach - East of Freyberg Wharf	Ebb	8.5
08:061	22/04/2008		Port Approach - East of Bledisloe Wharf	Flood	8.4
08:061	22/04/2008		Port Approach - East of Bledisloe Wharf	Flood	8.4
08:061	22/04/2008		Port Approach - East of Bledisloe Wharf	Ebb	9.2
08:061	22/04/2008		Port Approach - East of Bledisloe Wharf	Ebb	9.2
07:105	30/07/2007		Viaduct Harbour	Ebb	6.0
07:092	21/06/2007		Port Approach - Jellicoe Wharf	Ebb	4.5
07:069	8/05/2007		Port Approach - Fergusson Wharf	Ebb	3.0
07:052	23/03/2007		Port Approach - Jellicoe Wharf	Ebb	9.6

Various POAL monitoring

Sample Ref	Date	Location		Tide	Total Suspended Solids (g/m3)
		Control GPS coordinates (WGS 084)	Control Samples for (Location Name)		
05:218	11/11/2005		Port Approach - NE of Jellicoe Wharf	Flood	5.2
05:207	26/10/2005		Port Approach - N of Fergusson Wharf	Flood	3.5
05:172	16/08/2005		Port Approach - N of Jellicoe Wharf	Flood	<3
05:158	3/08/2005		Port Approach - N of Jellicoe Wharf	Flood	4.0
05:156	28/07/2005		POAL Berth - Western side of Fergusson Wharf	Flood	6.0
05:144	13/07/2005		Port Approach - Between Jellicoe & Fergusson Wharf	Ebb	7.9
05:048	24/02/2005		Port Approach - Western side of Fergusson Wharf	Flood	6.2
02:327	18/09/2002		POAL Berth - Jellicoe Wharf (East)	Flood	3.6
02:316	4/09/2002		POAL Berth - Jellicoe Wharf (East)	Flood	7.6
02:299	22/08/2002		POAL Berth - Freyberg Wharf	Ebb	<3
02:242	18/07/2002		POAL Berth - Fergusson Wharf Deepening	Flood	8.1
01:077	26/03/2001		POAL Berth - Bledisloe Wharf (Kings Low Landing)	Ebb	15.8
01:066	13/03/2001		POAL Berth - Bledisloe Wharf	Ebb	26.1
01:038	16/02/2001		POAL Berth - Wynyard Wharf	Flood	4.6
01:029	9/02/2001		Port Approach - N of Jellicoe Wharf	Ebb	19.1
01:008	18/01/2001		POAL Berth - Queens Wharf (West)	Flood	8.5
00:303	4/12/2000		POAL Berth - Freyberg Wharf	Flood	3.7
----	6/11/2000		POAL Berth - Queens Wharf	Flood	5.3
----	23/05/2000		Port Approach - N of Jellicoe Wharf	Ebb	11.5
----	29/01/1999		POAL Berth - Freyberg Wharf	Ebb	8.6
----	13/01/1999		POAL Berth - Jellicoe Wharf	Flood	10.0
----	10/12/1998		POAL Berth - Freyberg Wharf	Flood	11.4
----	20/11/1998		POAL Berth - Freyberg Wharf	Ebb	8.7
----	6/11/1998		POAL Berth - Bledisloe Wharf	Ebb	2.5
----	5/11/1998		POAL Berth - Freyberg Wharf	Ebb	16.3
----	4/09/1998		POAL Berth - Fergusson Wharf	Flood	4.4
----	7/07/1997		POAL Berth - Jellicoe Wharf	Ebb	3.4

Rangitoto Channel

Sample Ref	Date	Control Samples for (Location Name)	Tide	Total Suspended Solids (g/m3)
16:178	20/12/2016	Rangitoto Channel	Flood	6
16:110	24/08/2016	Rangitoto Channel	Ebb	35
08:096	30/06/2008	Rangitoto Channel	Flood	<3
08:096	30/06/2008	Rangitoto Channel	Flood	<3
07:020	1/02/2007	Rangitoto Channel, SP6	Ebb	<3
06:237	15/12/2006	Rangitoto Channel, SP6	Flood	<3
06:219	22/11/2006	Rangitoto Channel, SP6	Ebb	5.4
06:193	25/10/2006	Rangitoto Channel	Ebb	6.6
06:180	27/09/2006	Rangitoto Channel adjacent to A buoy	Flood	<3
06:156	6/09/2006	Rangitoto Channel, SP9/SP10	Flood	1.4
06:116	19/07/2006	Rangitoto Channel	Flood	<3
06:091	14/06/2006	Rangitoto Channel	Ebb	<3
06:062	10/05/2006	Rangitoto Channel	Flood	<3
06:051	12/04/2006	Rangitoto Channel	Ebb	<3
06:037	16/03/2006	Rangitoto Channel	Ebb	<3
06:031	24/02/2006	Rangitoto Channel	Flood	<3
06:022	10/02/2006	Rangitoto Channel	Ebb	<3
06:012	26/01/2006	Rangitoto Channel	Flood	7.5
05:252	20/12/2005	Rangitoto Channel, SP9	Ebb	7.2
05:100	5/05/2005	Rangitoto Channel adjacent to Buoy 1	Flood	3.9
05:092	21/04/2005	Rangitoto Channel	Flood	<3
05:077	4/04/2005	Rangitoto Channel	Flood	<3
05:073	23/03/2005	Rangitoto Channel	Flood	<3
05:061	11/03/2005	Rangitoto Channel	Ebb	5.1
05:038	15/02/2005	Rangitoto Channel, SP5	Flood	8.0
05:016	26/01/2005	Rangitoto Channel, SP5	Ebb	4.2
05:002	11/01/2005	Rangitoto Channel, SP5	Ebb	17.8
04:212	21/12/2004	Rangitoto Channel, SP5	Flood	6.2
04:208	15/12/2004	Rangitoto Channel	Ebb	10.9
04:174	16/11/2004	Rangitoto Channel, SP5	Ebb	18.6
04:022	11/02/2004	Rangitoto Channel adj. Buoy 3 - Parnell Grit Area	Ebb	5.0
04:012	29/01/2004	Rangitoto Channel adj. Buoy 3 - Parnell Grit Area	Ebb	13.9
04:004	13/01/2004	Rangitoto Channel adj. Buoy 3 - Parnell Grit Area	Ebb	4.6
03:308	10/12/2003	Rangitoto Channel adj. Buoy 3 - Parnell Grit Area	Ebb	3.8
03:275	5/11/2003	Rangitoto Channel adj. Buoy 3 - Parnell Grit Area	Ebb	<3
03:270	23/10/2003	Rangitoto Channel adj. Buoy 3 - Parnell Grit Area	Ebb	3.5

Westhaven Marina during dredging activity

Sample Ref	Date	Location	Tide	Total Suspended Solids (g/m3)		
				Control	West Marina Entrance	East Marina Entrance
06:117	19/07/2006	Westhaven Marina	Ebb	<3	6.6	12.8
06:103	27/06/2006	Westhaven Marina	Ebb	7.2	6.2	4.3
03:010	9/01/2003	Westhaven Marina	Flood	----	19.9	17.5
02:457	9/12/2002	Westhaven Marina	Flood	----	15.6	16.4
----	13/08/1998	Westhaven Marina	Flood	----	13.9	7.8
----	31/07/1998	Westhaven Marina	Flood	----	8.3	10.7
----	7/07/1998	Westhaven Marina	Flood	----	5.7	11.4

Off-Wharf Sampling - Britomart Central Train Station Construction

Sample Ref	Rain (mm)	Tide (F/E)	Sampled (date)	Tide (height)	Wind	A (g/m3)	A (NTU)	B (g/m3)	B (NTU)	C (g/m3)	C (NTU)	D (g/m3)	D (NTU)	R1 (g/m3)	R1 (NTU)	R2 (g/m3)	R2 (NTU)
01:133	20.4	F	18/05/2001	2.7	M	4.6	2.6	9.1	2.3	6.2	2.5	3.4	2.5	2.7	2.3	2.7	2.4
01:142	9.8	E	24/05/2001	3.1	M	7	4.2	6.4	4.3	9.5	4.3	9.9	3.5	18.1	7.6	16.1	6.4
01:146	0.6	F	1/06/2001	3.1	L	3.3	3.1	6.4	4.1	10.5	3.6	9.4	3.2	13.1	7.8	11.1	3.2
01:152	1.0	E	7/06/2001	3.1	L	5.2	4.6	5.7	4.7	5.3	3.8	6.7	4.3	7.8	4.3	11.6	5.1
01:164	0.0	F	14/06/2001	2.8	L	3.7	2.6	2.9	2.4	9.5	2.5	2.2	1.6	8.8	2.2	9.9	2.2
01:169	0.4	E	21/06/2001	3.0	M	6.1	3.8	8.2	3.5	6.4	3.9	5.4	3.4	9.3	3.6	6.7	4.0
01:175	0.0	E	27/06/2001	3.2	L	2.9	2.6	4.1	2.7	4.1	3.3	4.2	2.8	4.7	3.3	7.9	4.5
01:186	0.0	F	5/07/2001	3.0	M	9.8	4.7	14.7	7.7	20.7	9	7.8	2.9	17.6	9.1	8.1	2.5
01:193	0.0	E	11/07/2001	2.8	L	8.9	2.6	11.7	3.2	8.4	2.6	9.5	2.8	8.3	2.4	9.9	2.3
01:196	9.8	F	16/07/2001	2.8	M	6.7	1.7	3.4	1.5	18.1	7.7	9.2	2.5	2.7	1.5	10.6	1.9
01:204	0.2	E	26/07/2001	3.4	L	3.9	3	4.4	2.8	7.2	4.2	4.5	3.3	12.1	3.2	5.2	3.9
01:209	3.4	E	2/08/2001	2.9	L	2.0	1.8	3.1	1.9	1.9	1.8	2.8	2.0	2.7	1.8	2.3	1.9
01:221	13.6	E	9/08/2001	2.9	M	9.1	4.3	6.6	4.7	3.1	2.2	4.3	2.2	4.1	2.3	3.1	2.2
01:224	0.1	F	16/08/2001	2.8	M	6	3.8	19.1	6.5	8.5	4.4	8.3	4.4	4.5	2	4.9	3
01:229	3.6	E	24/08/2001	3.4	M	5.7	3.6	9.1	2.7	9.1	5	12.1	4.3	16	4.3	13.9	4.4

Rain for preceding 24 hrs from N.Z. Herald
Tide F = Flood, E = Ebb
Wind L = Light, M = Moderate

Sample point	**A**	**B & C**		**D**	**R1**	**R2**
Sample position	Queens wharf; mid-eastern side	Captain Cook wharf; mid-western side &	mid-eastern side	Marsden wharf; mid-western side	Queens wharf; northeast corner	Bledisloe terminal northwest corner

APPENDIX G

Dredging Requirements

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No.	Revision	By	Chk	Appd	Date
A	DRAFT FOR COMMENT	LR	WJAI	JH	

Drawing Originator: Beca

Original Scale (A1) 1:1500
Reduced Scale (A3)

Design		
Drawn	LR	22/12/17
Dsg Verifier		
Dwg Check		

* Refer to Revision 1 for Original Signature

Approved For Construction*
Date

Client: Panuku Development Auckland — An Auckland Council Organisation

Project: AMERICAS CUP 36

Title: WYNYARD BASIN DREDGE PLAN

Discipline: CIVIL

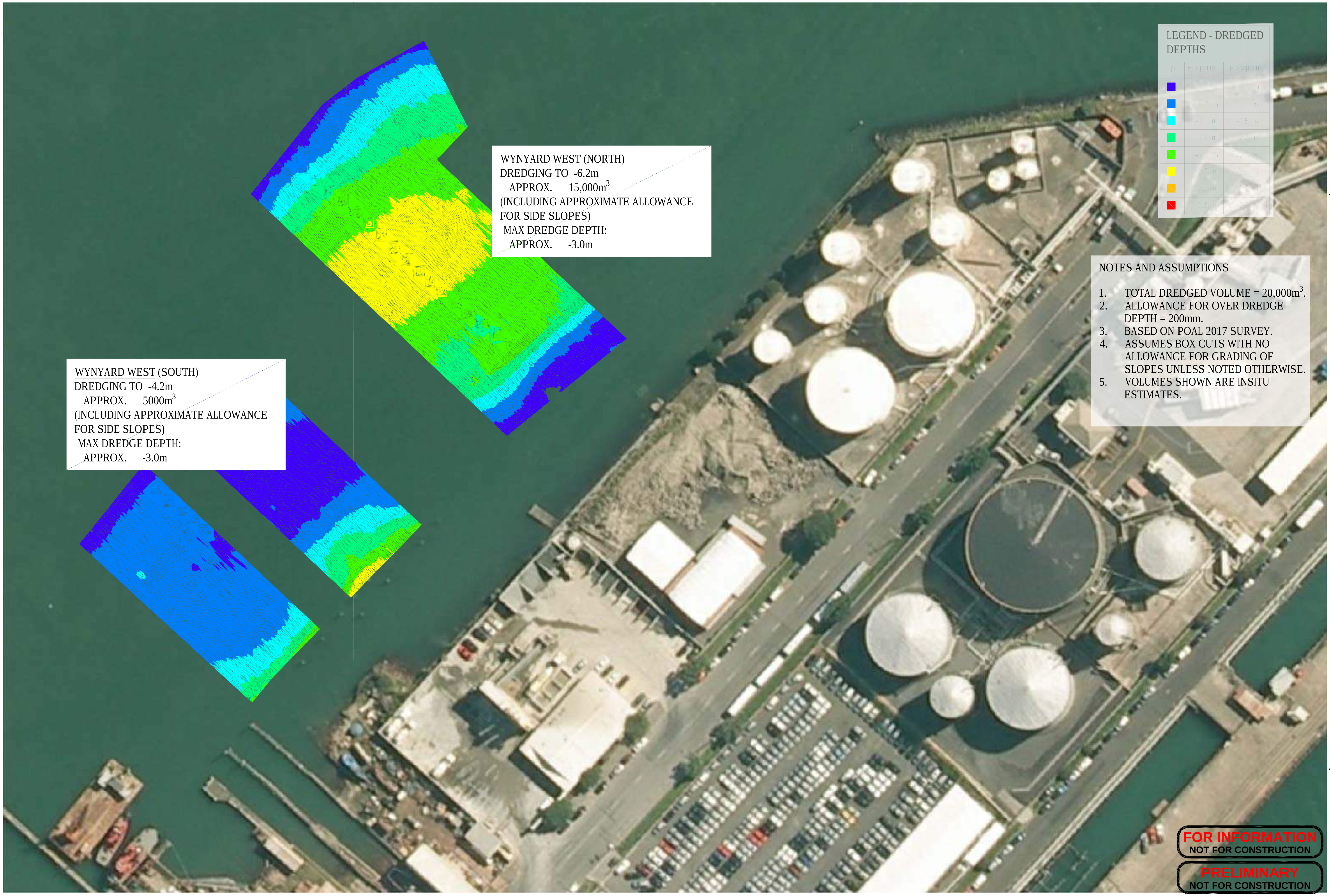
Drawing No. 3233847-CA-010 Rev. A

Document No. 3233847-CA-0010.DWG

DO NOT SCALE

IF IN DOUBT ASK.

Drawing Plotted: 11 Jan 2018 2:42 p.m.



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No.	Revision	By	Chk	Appd	Date
D	FINAL FINAL ISSUE FOR CONSENT APPLICATION	LR	JPG	JH	11/01/18
C	FINAL ISSUE FOR CONSENT APPLICATION	LR	JPG	JH	05/01/18
B	FINAL DRAFT ISSUE FOR COMMENT	LR	WJAI	JH	22/12/17

Drawing Originator: Beca

Original Scale (A1) 1:500
Reduced Scale (A3) 1:1000

Design		
Drawn	LR	22/12/17
Dsg Verifier		
Dwg Check		

* Refer to Revision 1 for Original Signature

Approved For Construction*

Date

Client: Panuku Development Auckland

Project: AMERICAS CUP 36

Title: CIVIL DRAWING 14
FFIRF DREDGE PLAN

Discipline: CIVIL

Drawing No.: 3233847-CA-014

Rev.: D

Document No. 3233847-CA-0014.DWG

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