APPENDIX 14

ECOLOGICAL EFFECTS ASSESSMENT

[4S]

4SIGHT CONSULTING

LAND. PEOPLE. WATER.

Doug’s Opua Boatyard

For Doug Schmuck

Ecology and Sediment and Water Quality Assessment

November 2019

REPORT INFORMATION AND QUALITY CONTROL

Prepared for:	Doug Schmuck Owner Doug's Opua Boatyard

Author:	Dr Pete Wilson Senior Coastal Scientist	
Reviewer:	Mark Poynter Principal Ecology Consultant	
Approved for Release:	Michael Lindgreen Director	

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1 INTRODUCTION

Doug's Opua Boatyard (DOBY) has been in operation under existing consent conditions for many years and is applying for resource consent to make improvements to the boatyard infrastructure. DOBY is in a small, relatively sheltered embayment known as Walls Bay about 300 m west of the Opua Wharf and Car Ferry Terminal (Figure 1). The slipway and jetty are located at the northern end of the beach adjacent to Richardson St, within the wider bay at Opua.

4Sight Consulting Ltd (4Sight) was engaged by DOBY to undertake an assessment of effects from proposed improvements on ecology and water and sediment quality. The proposed improvements include:

- reconstruction/remediation of the slipway;
- reconstruction of the wharf;
- using wharf facility berths as a marina; and
- undertaking capital and maintenance dredging.

Figure 1: Location of Doug's Opua Boatyard and nearby key features.

New capital and maintenance dredging are proposed to form five all-tide berths and an approach channel to the wharf and slipway. Installation of a subsurface erosion barrier is proposed by Total Marine Services to avoid any potential for erosion of the beach as a result of the dredging.

The proposed dredging footprint covers an area approximately 4560 m^2 comprising intertidal and subtidal sediment extending from the beach at the slipway to approximately 130 m in north-east toward the Veronica Channel. Dredging will be conducted by Total Marine Services using a barge-mounted long reach digger and hopper barge. It is estimated that 4352 m^3 of dredge spoil material will be removed and all dredged material will be barged to an approved dump site for disposal on land. A report by Total Marine Services describing the work in detail in included in Appendix I. Some disturbance to a small area of the beach and foreshore is expected shoreward of the proposed dredge footprint during construction of the new wharf and refurbishment of the slipway.

The majority of content in this report is reproduced from a previous 4Sight report by Brown (2018a).

2 WORK CARRIED OUT

The following work has been undertaken as part of this assessment of effects:

- Desktop review of published literature. This included relevant reports by 4Sight and others, State of the Environment reports and planning documents from Northland Regional Council, consent conditions for DOBY, and previous council hearing documents such as the s42A and addendum to the s42A reports for a previous application.
- A field survey was conducted by 4Sight on 31 May 2018. During this survey, sediment, water, infauna samples, and samples of edible shellfish were collected from intertidal and subtidal locations in Walls Bay and later analysed. The site was also inspected and photographed. A reference/control site was sampled in Te Haumi, approximately 2.2 km northwest of DOBY, that is known to support a large pipi bed and is away from the effects of DOBY and other boating activities nearby (e.g., ferry terminal and wharf).
- A site visit on 19 February 2019 to meet with Doug Schmuck and inspect the improvements that had been implemented at DOBY since the survey above.
- Four additional sediment samples were collected from Walls Bay by 4Sight on 16 May 2019 and analysed for copper lead and zinc.

3 EXISTING ENVIRONMENT

The beach in Walls Bay is approximately 60 m in length and there is a rocky point extending into the subtidal zone at either end of the embayment. The beach is moderately steep and coarse-grained. There is a small retaining wall at the landward side of the beach, the base of which is approximately at the high tide mark. The coastal marine area at this location is designated as Marine 4 (Mooring) Management Area under Northland Regional Council's (NRC) Coastal Plan and Proposed Regional Plan.

3.1 Foreshore vegetation

The following characteristics were identified following a site inspection by 4Sight on 31 May 2018. Landward of the beach and immediately adjacent to the boatyard is a grassed area forming part of the Walls Bay Esplanade Reserve, which is owned and administered by the Far North District Council. There is a large pohutukawa (*Metrosideros excelsa*) on the northern end of the beach (can be seen in Figure 2). A range of other vegetation including manuka (*Leptospermum scoparium*), various adventive species such as tobacco weed (*Solanum mauritianum*) and wattle (*Acacia lophantha*) and scattered individuals of mangrove (*Avicennia marina*) are present on the slope immediately above the intertidal zone.

Figure 2: View from the south of Walls Bay looking north over the beach to the existing slipway and wharf.

A similar collection of trees and shrubs including manuka, wattle, and tobacco weed occupy the headland at the south end of the beach and southernmost end of the reserve (Figure 3).

Figure 3: View from the north end of Walls Bay looking south over the slipway and beach at low tide.

3.2 Hydrodynamics and sediment transport

Three small floats were deployed from a vessel between 10:30 and 10:35 am on 31 May 2018 and recovered on the same day between 11:09 and 11:15 am. Float positions were determined and recorded using a handheld GPS device. During deployment, the tide was ebbing and there was a light breeze (~4 to 5 knots) from the southeast. Thus, the wind direction was reinforcing the predominant tidal set to the northwest. Two of the floats drifted 55 m and 80 m in a northwest direction before beaching on the headland at the northern end of the embayment. The third float travelled 150 m in a northwesterly direction at an average speed of 6.95 cm s^{-1}. Considering the southeast wind at the time of deployment, the float velocities were consistent with the relatively low current speed derived from the hydrodynamic and sediment transport model developed and reported by MetOcean Solutions (2013). Relevant plots from the report are shown in Appendix D.

Modelled tidal currents by MetOcean Solutions (2013) indicate that peak tidal flows in the vicinity of DOBY are generally <5 cm s^{-1} (Appendix D(a)), and modelling of sediment transport capacity (Appendix D(b)) predicts a low potential for sediment transport. The relatively low current speeds and limited sediment transport capacity shown in the modelling study together with the observed current movement indicate that there is only limited potential for dredge spoil material and fine sediment disturbed by the proposed dredging activity to disperse beyond the close vicinity of the operations.

The longest uninterrupted fetch to DOBY, as calculated by Total Marine Services, is 700 m to the northeast.[1] The nearby marina and wharf in Opua Basin are likely to attenuate much of the wave climate energy at DOBY and it is likely to be further attenuated with the recent installation of wave attenuators on the nearby Opua wharf.[2]

3.3 Water quality

Water quality monitoring at DOBY has been conducted by Northland Regional Council (NRC) since 2003 at varying frequency but no greater than annually. The monitoring in the coastal marine area (CMA) is focussed around a stormwater discharge pipe located in the upper intertidal area between the slipway and the wharf.

NRC also conducts state of the environment (SOE) water quality monitoring at a location in the Opua Basin approximately halfway between DOBY and the Opua Wharf every second month (Appendix A). The purpose of this monitoring is to assess the state of the environment, identify environmental issues, and to track changes in water quality over time. The most recent SOE report summarises water quality data collected from January 2010 to December 2014.[3]

The assessment in this 4Sight report is limited to describing the general water quality in Walls Bay, excluding the stormwater discharge. An assessment of effects of stormwater discharges from DOBY was conducted for the *Schmuck v. Northland Regional Council* (2019) Environment Court appeal and is not required in this report to support the proposed consent works[4]. Thus, only monitoring sites that are outside of the immediate influence of the stormwater discharge (i.e., greater than 10 m from the discharge point) and have repeated measurements are included in this assessment.

The only consent monitoring site from DOBY that meets these criteria is the location at the end of the wharf (Table 1). It is important to note that the purpose of the consent monitoring is to assess the effects of the discharge; therefore, a full suite of parameters that would typically be used to describe the ecological health of the environment (e.g., nutrients, chlorophyll-a) has not been measured. A more thorough suite of water quality parameters (excluding metals) has been measured at the nearby SOE monitoring site and these data provide a good indication of typical water quality conditions in the Opua Basin (Table 2).

[1] Total Marine Services, 2019. Design of Timber Jetty, Pontoon and Dredging at Doug's Boatyard, Opua. Total Marine Services Technical Report No. 460248.1. 13 p. (Appendix I)

[2] Schmuck, D. Personal Communication. 10/09/2019.

[3] Griffiths, R., 2015. Coastal Water Quality Monitoring: 2010–2014 Results. Northland Regional Council technical report. 59 p.

[4] *Schmuck v. Northland Regional Council*, ENV-2018-AKL-00351, 9 April 2019.

To place water quality results in context, water quality results are compared to ANZECC & ARMCANZ (2000) default guideline values for water quality in aquatic ecosystems, more specifically, for marine/estuarine waters at the 95% protection limit. These values incorporate a recent 2018 update and are hereafter referred to as Default Guideline Values (DGVs).[5]

Table 1: Water quality results from samples collected by NRC at the end of the DOBY wharf. Values 'exceeding' the ANZECC default guideline value (DGV) are highlighted.

Date	**Copper** (g/m^3)	**Lead** (g/m^3)	**Zinc** (g/m^3)	**DO*** (%)	**Salinity** (ppt)	**Temperature** (°C)	**TSS*** (g/m^3)	**pH**
7/11/2003	<0.0100	<0.0020	<0.0200	7.4	32.3	16.7		
28/01/2004	<0.0100	<0.0020	0.0300		36.3	22.2		8.9
30/01/2004	<0.0100	<0.0020	<0.0200	89.9	32.6	22.6		
2/02/2006	0.0100	<0.0010	0.0100	73.8		22.9	6	
4/03/2010	<0.0011	<0.0011	<0.0042	107.6		23.5	7	8.1
17/05/2010	<0.0110	<0.0030	<0.0300	93.7		17.9	12	8
31/08/2015	<0.0020	<0.0010	<0.0100				37	
5/04/2017	<0.0020	<0.0010	<0.0100				39	
DGV	0.0013	0.0044	0.0150	80–110				7–8.5

* DO – dissolved oxygen; TSS – total suspended sediment.

[5] ANZECC & ARMCANZ (2000) Australian and New Zealand guidelines for fresh and marine water quality. Volume 1, The guidelines. Updated values available from: http://www.waterquality.gov.au/anz-guidelines/guideline-values/default/water-quality-toxicants

Table 2: Summary of NRC state of the environment water quality results in the Opua Basin from January 2010 to December 2014. Values exceeding the ANZECC default guideline value (DGV) are highlighted.

Parameter	Count	Minimum	Maximum	Mean	S.E Mean*	Median	ANZECC DGV
Salinity (ppt)	28	18.3	36.9	30.9	0.7	31.7	
Temperature (°C)	30	13.3	23.7	17.7	0.5	17.2	
Secchi depth (m)	30	0.65	2.3	1.1	0.1	1	
Turbidity (NTU)	28	1.9	9.4	6	0.4	6	10
Enterococci (per 100 mL)	30	5	291	23	10.1	5	
Faecal coliform (per 100 mL)	30	1	44	8	2	2	
Dissolved oxygen (% saturation)	30	61.7	101.7	92	1.4	93.4	80–110
Chlorophyll-*a* (mg/L)	12	0.0006	0.025	0.00413	0.0019	0.0023	0.004
Ammonium (mg/L)	30	0.005	0.375	0.00215	0.0123	0.005	0.015
Nitrate-nitrite nitrogen (mg/L)	30	0.001	0.125	0.0196	0.0073	0.005	0.015
Total phosphorus (mg/L)	30	0.01	0.035	0.0208	0.0011	0.02	0.03
Dissolved reactive phosphorus (mg/L)	30	0.005	0.02	0.0094	0.0006	0.009	0.005

* S.E Mean – Standard error of the mean

3.3.1 Water quality results from DOBY consent monitoring

The analytical detection limit for many metal concentrations is higher than the DGV. For these results, it's not possible to determine whether the actual metal concentration is likely to be within or exceed the guideline value. Furthermore, total metal concentrations have been measured by NRC, whereas the ANZECC DGVs are expressed as dissolved (bioavailable) metal. Therefore, values that exceed the DGV cannot be clearly linked to potential adverse environmental effects.

Results collected up to (and including) 2006 show that copper and zinc, but not lead, concentrations may have exceeded the DGV. Dissolved oxygen concentrations during this period also were outside of the DGV range at times. Until 2008, the discharge point was located halfway along the wharf on the northern side.[6] This means that monitoring results collected at this location up to 2008 are not suitable to assess the general water quality in Walls Bay; instead, they may reflect local influences due to the discharge rather than background water quality in Walls Bay.

The analytical methods used by the laboratory improved from 2015, which resulted in lower detection limits. The detection limit for total copper is still higher (double) than the guideline value for dissolved copper but results indicate that the concentration of copper at the end of the wharf has likely decreased since the 2003–2010 period. Lead and zinc concentrations were below the guideline value from at least 2015 onwards.

Salinity, temperature, total suspended sediment (TSS), and pH results show some degree of variability at the site but are within ranges that are typical for estuarine waters.

[6] Schmuck D., personal communication, 23/09/2019.

3.3.2 Water quality results from SOE monitoring

In general, the results gathered over the four-year period indicated that the water quality in the Opua Basin is of good quality. On occasion, nutrient concentrations (nitrogen and phosphorus) exceeded the DGV. This is not unexpected given catchment influences. Consequently, increased primary production (phytoplankton biomass) was likely elevated at times as indicated by the occasionally elevated chlorophyll-*a* concentrations. Dissolved reactive phosphorus was the only median value to exceed a DGV; however, this doesn't appear to be at levels that persistently fuel the excessive growth of nuisance marine algae. Furthermore, nutrients are not a typical contaminant of concern associated with boatyard activities.

The recreational water quality guidelines[7] state that the water is 'suitable for swimming' if the sample has a concentration less than 140 enterococci/100 mL. The SOE monitoring report[8] states that 100% of samples at Opua Basin were less than this value, however, the maximum reported value is 291 enterococci/100 mL, which exceeds this level. Irrespective of this small exceedance of the guideline value, the results indicate that the water quality in the Opua Basin is typically suitable for swimming.

Suitability of the water for shellfish-gathering is assessed using the faecal coliform indicator. The recreational water quality guidelines[7] state that "*the median faecal coliform content of samples taken over a shellfish-gathering season shall not exceed a Most Probable Number (MPN) of 14/100 mL[9], and not more than 10% of samples should exceed an MPN of 43/100 mL (using a five-tube decimal dilution test).*" Results from Opua Basin indicate that the waters are likely to be suitable for shellfish-gathering. Note that this only indicates whether the water is suitable for shellfish-gathering purposes in respect to the microbiological risk (i.e., faecal contamination) and does not take into consideration contaminants that may be present in the shellfish-flesh such as metals or other toxins.

3.4 Sediment quality

The historic and current sediment quality in Walls Bay is described using four datasets:

1) Sampling by Mr Doug Schmuck (26/08/1998) – intertidal sediment collected along a transect between the slipway and the wharf and analysed for metal concentrations. Sample locations in Appendix B;
2) Sampling by 4Sight (31/05/2018) – intertidal and subtidal samples distributed around Walls Bay and analysed for a range of physical characteristics, metal concentrations, and infauna. Sample locations in Appendix A; and
3) Sampling by Haigh Workman (31/01/2019) – intertidal sediment collected from a 3 × 3 grid centred on the slipway and analysed for metal concentrations.[10] Sample locations in Appendix B.
4) Sampling by 4Sight (16/05/2019) – intertidal sediment collected south of the slipway. Sample locations in Appendix B.

3.4.1 Physical characteristics

The substratum in the upper 1–2 m of the shore comprises mostly sand and gravel with a high proportion of whole dead shell (mostly pipis [*Paphies australis*] and some Pacific oyster [*Crassostrea gigas*] shell). The substratum in the mid-intertidal zone comprises sand, gravel and shell gravel. The gravel component of the sediment increases in the mid and lower intertidal and the low intertidal comprises coarser gravel and sand overlaying muddy sand. In the very low intertidal zone, a layer of fine silty mud overlays the coarser gravel and sand and muddy sand.

Results of grain size analysis of subtidal sediment samples collected at sites S1, S3, and SC are presented in Appendix C and summarised in Table 3.

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[7] Ministry of Health and Ministry for the Environment, 2003. Microbiological water quality guidelines for marine and freshwater recreational areas.

[8] Griffiths, R., 2015. Coastal Water Quality Monitoring: 2010–2014 Results. Northland Regional Council technical report. 59 p.

[9] 14 MPN/100 mL is equivalent to 14 enterococci/100 mL.

[10] Collings, E., 2019. Geoenvironmental Appraisal: 1 Richard Street, Opua. Haigh Workman report prepared for Doug's Opua Boatyard.

Table 3: Summary of subtidal sediment grainsize data.

Site	% Gravel (>2 mm)	% Sand (2–0.063 mm)	% Mud (<0.063 mm)
S1	4	57	39
S3	6	71	23
SC	2	52	46

3.4.2 Metal concentrations in Walls Bay

The upper 2 cm of the sediment was sampled for metal analysis. This broadly represents the cumulative effects over approximately the past 10 years. The actual time period the depth of sediment integrates over is determined by mediating processes including bioturbation, tides and wave action, and other physical and chemical disturbances.

To put the sediment quality results in context, they are compared to the ANZECC & ARMCANZ (2000) Default Guideline Values (DGVs) for toxicants in sediment.[11] These values incorporate the most recent update in 2013. The DGV and DGV-high thresholds indicate 10% and 50% chance, respectively, of adverse effects on marine organisms. NRC compares results from their SOE sediment monitoring programme to both the ANZECC and Canadian Sediment Quality Guidelines Threshold Effect Level (CCME TEL[12]) and they recommend that the more conservative CCME TEL values be used as the standard set of guideline values (Bamford, 2016) for background sites.

A summary of measured sediment metal concentrations from all sampling occasions is presented and compared to the relevant guideline values in Table 4. Additionally, visual representations of the results are presented in Appendix E.

[11] http://www.waterquality.gov.au/anz-guidelines/guideline-values/default/sediment-quality-toxicants

[12] http://st-ts.ccme.ca/en/index.html

Table 4: Sediment toxicant guideline values and metal concentration results from four sampling occasions. Values are highlighted the colour of the highest guideline value that they exceed.

Metal concentration (mg kg^{-1} dry weight)	**Arsenic**	**Cadmium**	**Chromium**	**Copper**	**Lead**	**Mercury**	**Nickel**	**Zinc**
Guideline values								
CCME TEL	7.24	0.7	52.3	18.7	30.2	0.13	15.8	124
ANZECC DGV	20	1.5	80	65	50	0.15	21	200
ANZECC DGV-high	70	10	370	270	220	1	52	410
Doug Schmuck (1998)								
1				1860	1710	0.377		857
2				563	82.9	0.502		256
3				503	62.9	0.688		231
4				166	39.4	0.513		142
5				65.6	18.8	0.4		129
4Sight (2018)								
S1	21	0.028	14.1	10.7	10	0.27	7.2	82
S2	23	0.027	15.3	12.1	10.3	0.35	8.3	90
S3	32	0.03	17	35	15.7	0.41	8.6	120
SC	21	0.025	15.1	11.7	10.4	0.33	7.5	85
ISL	37	0.064	12.3	370	67	0.21	14.3	430
M	25	0.034	9.5	320	53	0.12	10.6	260
I3	30	0.025	13.1	230	68	0.21	10.1	210
I5	27	0.049	11.5	29	23	0.21	13.3	113
Haigh Workman (2019)								
ES231	29	< 0.10	11	370	92	0.16	8	310
ES233	34	< 0.10	15	1280	134	0.15	10	590
ES236	25	< 0.10	11	480	91	0.15	9	320
ES239	29	< 0.10	13	370	90	0.2	9	300
ES241	36	< 0.10	14	2000	140	0.13	11	770
ES244	26	< 0.10	13	450	69	0.25	9	290
ES246	27	< 0.10	15	320	66	0.19	9	290
ES248	26	< 0.10	14	530	84	0.17	10	420
ES251	24	< 0.10	13	184	40	0.16	9	210
4Sight (2019)								
A1				640	93			330
A2				350	85			300
A3				370	87			300
A4				290	74			290

*Maps showing the location of each sample are presented in Appendices A and B.

Cadmium, chromium, and nickel concentrations at all sites (where they were measured) were below CCME TEL and, therefore, also well below ANZECC DGV threshold values. Arsenic and mercury concentrations exceeded CCME TEL and ANZECC DGV threshold values at all but one site where they were measured; the concentrations were generally consistent across the sites and the elevated levels of these metals are likely to be related to catchment geology rather than a result of anthropogenic factors. Elevated levels of arsenic and mercury that are likely to be of natural origin have also been found in coastal sediments at other sites in the Bay of Islands (e.g., Brown 2018b). The rest of this section will only discuss the three metals most commonly found in sediments associated with boatyard and slipway activities, that is, copper, lead, and zinc.

Results from sediment sampling in 1998 show elevated levels of copper, lead, and zinc that are above the DGV-high north of the slipway and in the upper-intertidal (high shore) area (Appendix E; Figure E1). The concentration of all metals decreases with increasing distance from the shore. Copper concentrations exceed the DGV-high by the greatest amount of the four metals, however, they decrease below the DGV-high trigger level approximately 10 m from the shore. A similar pattern is also seen for zinc and lead. The high metal concentrations recorded in 1998 are likely a result of practices at and prior to that time and uncontrolled activities from the boatyard that occurred before consents were required and granted.

Sampling conducted during 2019 indicates a marked decrease in sediment metal concentrations north of the slipway since 1998 (Appendix E; Figures E2–E4). For example, the concentration of copper closest to the shore, north of the slipway, decreased from 1860 mg kg^{-1} in 1998 to 480 mg kg^{-1} in 2019; that is, at Site 1 in 1998 and Site ES236 in 2019 (Appendix B). The results also indicate that metal contamination is relatively localised to the slipway.

Metal concentrations are notably higher along the slipway but decrease by at least half at a distance 2m north and south of the slipway. The concentrations of copper, lead, and zinc appear to remain at similar levels up to 15m south of the slipway based on the 2019 sampling conducted by 4Sight (Appendix E). The four additional samples south of the slipway have very similar concentrations to those that were collected about 2m either side of the slipway. This may indicate that generally, the levels of copper, lead, and zinc are elevated throughout Walls Bay as a result of past practices.

All metal concentrations in subtidal sediments are below the DGV indicating that the metal contamination is localised and restricted to intertidal sediments.

3.4.3 Metal concentrations in the proposed excavated and dredged material and disposal options

3.4.3.1 Bulk metals concentrations

Earthworks are proposed to excavate and reconfigure the existing slipway (see Total Marine Services report in Appendix I). This also provides an opportunity to remediate the sediment that has elevated metal concentrations in this area as proposed by Haigh Workman.[13]

Sediment sampling has revealed that sediment metal concentrations vary across different locations in Walls Bay and the DOBY slipway. In order to estimate the mean concentration of copper, lead, and zinc in the dredged and excavated material, sediments were categorised into one of three groups determined by their location. The mean metal concentration for each bulk sediment from each category of material to be excavated was calculated by weighting the mean metal concentration of each group by the volume of sediment, in the following way:

Sediment volume for the category location divided by the total sediment volume times the metal concentration. By way of illustration for copper:

$(4352/4674\ m^3 \times 19\ mg/kg) + (102/4674\ m^3 \times 1270\ mg/kg) + (220/4674\ m^3 \times 362\ mg/kg) = 63\ mg/kg$

The sediment groups are described below, the subtidal sediment area is depicted in Appendix H and the slipway sediment areas in Figure 4:

- Subtidal sediment (4352 m^3)
  - All sediment below low tide mark
  - Low metal concentrations
  - Mean sediment metal concentrations from 4Sight samples S1, S2, and S3 (Locations in Appendix B)
- Slipway rails (102 m^3)
  - Sediment from the slipway plus 1 m either side of the slipway (total 4 m across)
  - Very high metal concentrations

[13] Collings, E., 2019. Geoenvironmental Appraisal: 1 Richard Street, Opua. Haigh Workman report prepared for Doug's Opua Boatyard.

– Mean sediment metal concentration from Haigh Workman samples 233, 241, and 248 (Locations in Appendix B)

- Remainder of slipway (220 m^3)
  – Sediment from the slipway, excluding the rails and 1 m either side of the rails
  – High metal concentrations
  – Mean sediment metal concentration from Haigh Workman samples 236, 244, 251, 231, 239, and 246 (Locations in Appendix B). These samples were collected approximately 2 m north and south of the slipway.

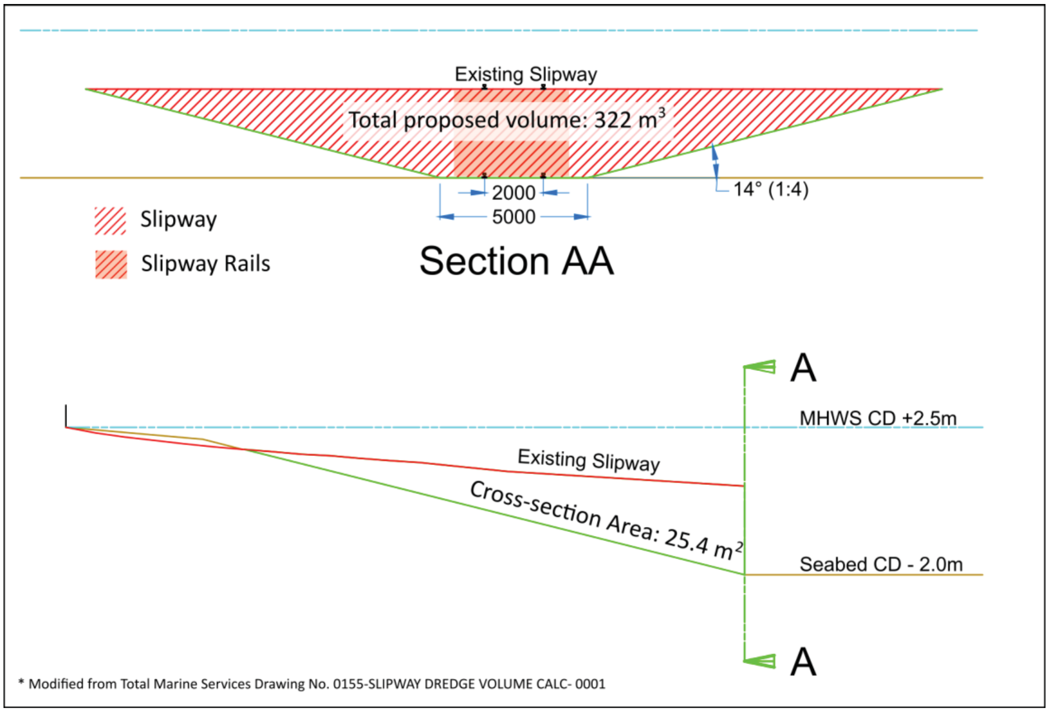

Figure 4: Diagram showing the sediments proposed to be excavated from the DOBY slipway and their groupings for assessing their metal content.

The estimated mean copper, lead, and zinc concentrations for each sediment-group and the overall volume-weighted mean is shown in Table 5.

Table 5: Estimate of sediment metal concentrations in the three groupings of sediment proposed to be dredged or excavated from Walls Bay and the estimated volume-weighted mean

	Sediment volume (m^3)	Mean metal concentration (mg/kg)		
		Copper	**Lead**	**Zinc**
Subtidal	4352	19	12	97
Slipway rails (4 m wide strip: slipway rails + 1 m either side)	102	1270	119	593
Slipway (remainder of excavated slipway)	220	362	75	287
Total volume	4674			
Volume-weighted mean		**63**	**17**	**117**
ANZECC DGV		65	50	200

The approach used to calculate the volume-weighted mean is very conservative because sediment metal concentrations were measured in the upper 2-cm of the sediment, which is most likely to contain the highest level of metals. It was then assumed that the surficial metal concentration extended the entire depth of the excavated or dredged material, when it's highly likely that sediment metal concentrations decrease with depth.

Even using a conservative approach, the volume-weighted mean concentration of all metals was estimated to be below the applicable ANZECC DGV (Table 5). This indicates that, if all the sediment was well-mixed, the concentration of copper, lead, and zinc would have a low risk to the environment.

The main reason that the volume-weighted mean concentrations are relatively low is that there is a much greater volume (1–2 orders of magnitude) of unpolluted subtidal sediment, which has low metal concentrations, than there is of the slipway, or slipway rail sediment that has elevated metal concentrations.

3.4.3.2 Disposal options

There are several disposal options which could be considered for this material. These include:

- Ensure the sediment horizons/locations are relatively well mixed. The total volume (4674 m^3) of material would be suitable for local land disposal.
- Remediate/stabilise the slipway material (e.g., by lime i.e., 'mudcreting': total volume 322 m^3). The material would be suitable for local land disposal;
- Dispose of the slipway material (total volume 322 m^3) as a discrete volume to an approved special waste facility.

3.5 Biota

3.5.1 Investigation method

Samples to describe infaunal communities (animals living within the sediments) within and near the area proposed to be dredged were collected on 31 May 18 at four subtidal sites (S1, S2, S3 and SC; Appendix A) using a box dredge (sample volume 5230 cm^3) and at four intertidal sites (ISL, M, I3 and I5; Appendix A) using a spade (sample area 14 cm × 14 cm, volume 1960 cm^3). Samples were preserved in 70% ethanol before being sent to Gary Stephenson of Coastal Marine Ecology Consultants for faunal identification to the lowest practicable taxonomic denomination.

Two dredge tows were conducted using a modified scallop dredge (epifauna dredge; mouth width 60 cm, mesh size 6 mm) to collect epifaunal samples (samples of larger-bodied animals living on the sediment surface) in the same area. Epifauna was identified at the site at the time of sampling.

To survey rocky intertidal habitat, a 15 m transect line was laid from a fixed location (Appendix A) and quadrats (0.5 x 0.5 m) were positioned at 0, 5, 10 and 15 m along the transect. The percentage cover of algal species and the identity and numbers of macrofaunal organisms was recorded within each quadrat.

A prior survey was conducted on 14 March 2018 to broadly determine the status of edible shellfish on the beach adjacent to the boatyard. Ten shellfish samples were collected from the intertidal zone on the beach in Walls Bay where the boatyard is located (Brown 2018a). The general zone where shellfish were known to be present was initially identified by the boatyard owner Mr Doug Schmuck and confirmed by the 4Sight ecology consultant prior to conducting the sampling. The area to be sampled was defined by GPS corner points (pipi bed survey in Appendix A) and 10 sample stations were successively and haphazardly placed within the defined area.

Each sample unit consisted of a 28 × 28 cm quadrat (area of 0.078 m^2) dug to a depth of ~15 cm. The contents were passed through a 2 mm aperture sieve. All individuals of the target species retained on the sieve were identified, counted, and measured across their widest axis to the nearest millimetre.

Approximately 30 individual edible shellfish of *Paphies australis* (pipis) were collected from each of three sites and analysed for metal concentrations in their flesh:

- Site **I1** – at the boatyard slipway;
- Site **I2** – representative of the middle of the edible shellfish population where pipis were dense and there was a high proportion of large individuals; and

- Site **TH** – a reference or control site in the intertidal zone of the beach at Te Haumi, a location approximately 2.2 km northwest of Doug's Boatyard that is known to support a large pipi bed.

These locations are shown in Appendix A (excluding Te Haumi).

3.5.2 Subtidal infauna

A total of 43 separate infaunal taxa were identified within samples collected from the subtidal zone (Appendix F). The mean number of taxa per sample (taxonomic richness) was 25.0 ± 4.5 (95% CI) and the mean number of individuals per sample (abundance) was 226 ± 116 (95% CI). Values for the taxonomic richness and abundance in each sample are shown in Table 6. This is similar to the diversity reported within the subtidal area of the Opua Marina expansion nearby which used the same sampling approach and recorded a total of 36 taxa (Poynter & Associates, 2014).

Table 6: Taxonomic richness and abundance in samples from each subtidal site.

Site	S1	S2	S3	SC
No. of taxa	28	24	29	19
No. of individuals	210	201	388	104

The dominant species in the subtidal infaunal community were the introduced bivalve mollusc known as the rice shell (*Theora lubrica*), and representatives from several families of polychaete worms (Ophelidae, Maldanidae, Capitellidae and Spionidae). All the taxa encountered were considered typical and widespread in soft sediment shallow subtidal habitat in Bay of Islands and around much of the New Zealand coast.

3.5.3 Intertidal infauna

Eighteen separate taxa were identified in the samples from the intertidal zone (Appendix F). The mean number of taxa per sample (taxonomic richness) was 7.5 ± 2.3 (95% CI) and the number of individuals per sample (abundance) ranged widely from 9 at site M to 140 at site I5. The high abundance at that site was due to large numbers of the spionid polychaete *Aonides trifida* (Appendix F). Values for the taxonomic richness and abundance in each sample are shown in Table 7.

Table 7: Taxonomic richness and abundance in samples from each intertidal site.

Site	ISL	M	I3	I5
No. of taxa	11	6	7	6
No. of individuals	20	9	11	140

The most commonly sampled species in the intertidal infaunal community were the pipi (*Paphies australis*), and polychaete worms from the families Syllidae, Capitellidae and Spionidae. The spionid worm *Aonides trifida* was particularly abundant at site I5. All the taxa identified from the intertidal samples were common species in New Zealand intertidal habitats.

3.5.4 Rocky intertidal zone

Biota identified within transects on the rocky intertidal shoreline at either end of Walls Bay is shown in Table 8 and examples of the quadrats are shown in Figure 5. All the biota seen were species commonly found in the intertidal zone in Northland. The seaweed Neptunes necklace (*Hormosira banksii*) grew extensively on the rocky habitat and Pacific oysters (*Crassostrea gigas*) were abundant. The snail *Nerita melanotragus* was also commonly found within quadrats at both transect sites (Table 8).

Table 8: Biota seen at rocky intertidal transects TN and TS in quadrats at distances 0, 5, 10, and 15 m along each transect. Algal presence expressed as percent cover and fauna as number of individuals.

Common name	Species name	North Transect (TN) 35.31104 S, 174.11697 E				South Transect (TS) 35.31182 S, 174.11670 E			
		0m	5 m	10 m	15 m	0 m	5 m	10 m	15 m
Mudflat anemone	*Anthopleura aureoradiata*		1						
Pacific oyster	*Crassostrea gigas*	7		25	4	20	50	>100	50
Topshell	*Diloma zelandica*					1			
Red seaweed	*Gracilaria chilensis*								2%
Neptunes necklace	*Hormosira banksii*	95%	1%	80%	10%	80%	1%	10%	20%
Chiton	*Ischnochiton maorianus*			3					
Sea snail	*Nerita melanotragus*	2		1	2		3	4	3
Cushion star	*Patiriella regularis*	1							

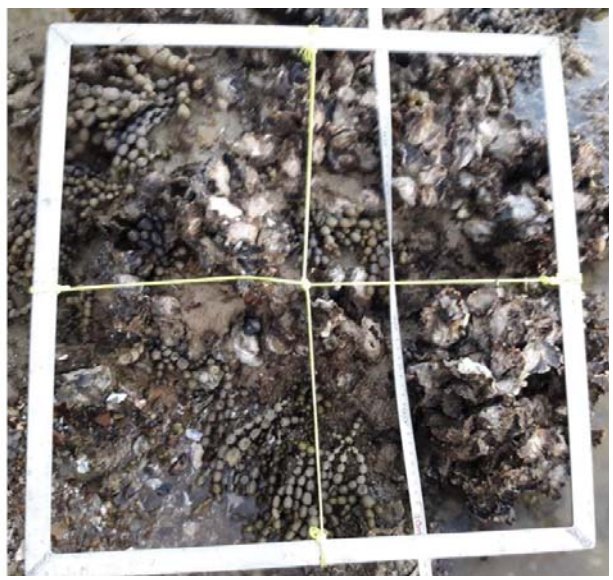

Figure 5: Representative quadrats from the northern (T1, left) and southern (T2, right) intertidal transects.

3.5.5 Subtidal epifauna

Biota was sparse in samples collected in epifauna dredge tows D1 and D2. In D1 there was a single cushion star (*Patiriella regularis*), four cockles (*Austrovenus stutchburyi*), and one whelk (*Cominella maculosa*). In D2, only two cockles (*A. stutchburyi*) were collected.

3.5.6 Edible shellfish

Two species of edible shellfish were identified in the survey: pipis (*Paphies australis*); and cockles (*Austrovenus stutchburyi*). There were a few Pacific oysters (*Crassostrea gigas*) growing on rocks at either end of the beach and on the boatyard wharf structures, but no measurements were made of the oyster population in this survey.

3.5.6.1 Pipis (*Paphies australis*)

The survey found pipis in all quadrats sampled on the mid and lower intertidal. The mean density of pipis was 288 m^{-2}. The population on the beach adjacent to the boatyard meets the definition of a bed of pipis (where shellfish density is greater than 10 m^{-2}, e.g., Pawley and Smith, 2014). Length frequency data and summary statistics are shown in Figure 6 and Table 9.

There is no legal minimum size for the harvest of pipis, but a generally accepted "rule of thumb" is that they are considered as harvestable at shell length greater than 50 mm (Pawley and Smith 2014). The mean density of harvestable pipis surveyed at the beach was 51 m^{-2}. The Ministry for Primary Industries has historically used a general guideline to define a harvestable shellfish population as 25 m^{-2} for pipis 50 mm and over (Pawley and Smith 2014), thus, the population surveyed was a harvestable pipi bed. Assuming a nominal area of between 250 to 300 m^2 of suitable beach habitat it can be estimated that the bed holds approximately 12,500 to 15,300 edible sized pipi.

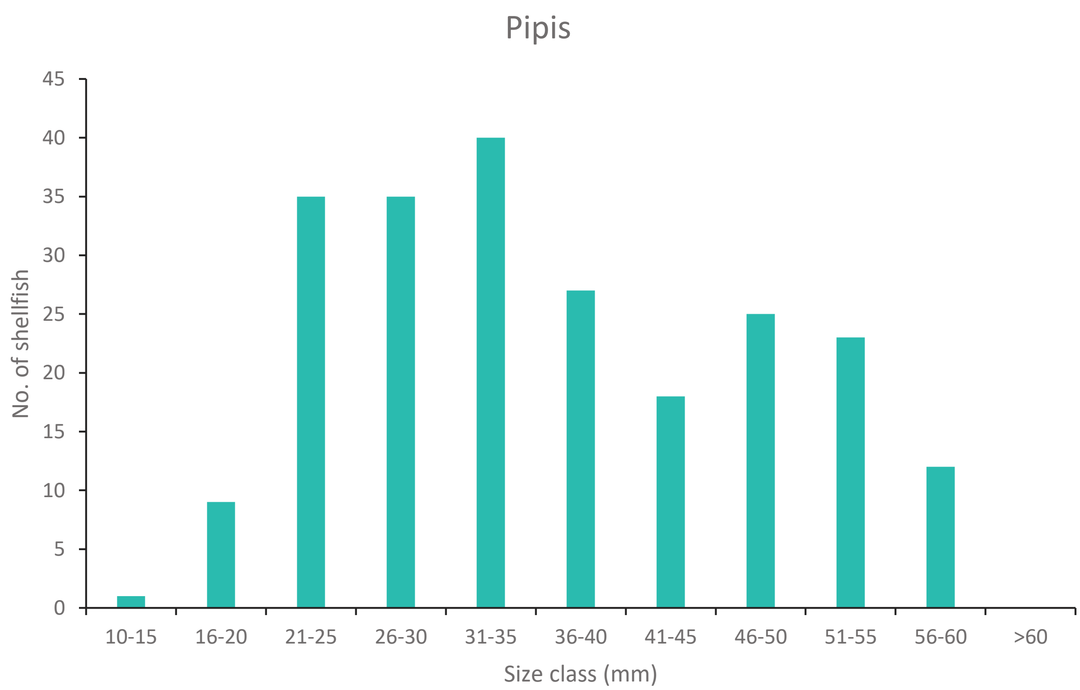

Figure 6: Size frequency of all surveyed pipis.

Table 9: Pipi length frequency distribution summary statistics (mm).

Mean	Median	Mode	Range
36.36	33	32	15–60

3.5.6.2 Cockles (*Austrovenus stutchburyi*)

Cockles were found in 7 of the 10 quadrats sampled, and they were most abundant in the lower intertidal zone. The mean density of cockles was 41 m^{-2} so the cockle population also meets the definition of a bed. Length frequency data and summary statistics are shown in Figure 7 and Table 10: Cockle length frequency summary statistics (mm).

There is no legal minimum size for the harvest of cockles, but a generally accepted "rule of thumb" is that they are considered as harvestable at shell length greater than 30 mm (Pawley and Smith 2014). The mean density of harvestable cockles surveyed at the beach was 11 m^{-2} which was below the accepted guideline used historically to define a harvestable shellfish population (Pawley and Smith 2014).

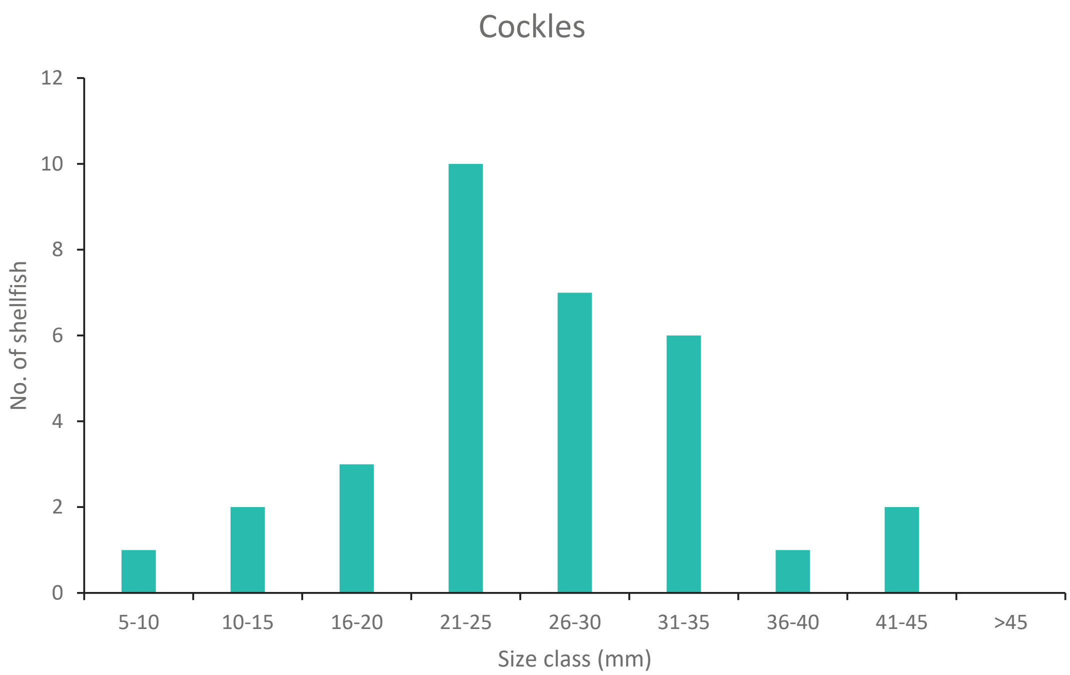

Figure 7: Size frequency of all surveyed cockles.

Table 10: Cockle length frequency summary statistics (mm).

Mean	Median	Mode	Range
25.9	25	21	8–42

3.5.6.3 Metal concentrations in shellfish flesh

Concentrations of metals and metalloids in pipis were similar in the samples collected from the slipway site (I1), the site in the middle of the shellfish bed (I2), and the distant reference site at Te Haumi (TH) (Table 11 and Appendix A).

Schedule 19 of the Australia New Zealand Food Standards Code (2016 version) stipulates the following guidelines for concentrations of trace metals in shellfish tissue:

- Arsenic (inorganic): 1 mg kg^{-1} wet weight;
- Cadmium: 2 mg kg^{-1} wet weight; and
- Lead: 2 mg kg^{-1} wet weight.

There are no published guidelines for acceptable concentrations of chromium, copper, nickel, or zinc in shellfish tissue; however, the previous food standards (New Zealand Food Regulations 1984, revoked in December 2002) prescribed a copper guideline of 30 mg kg^{-1} wet weight in any food except animal offal and tea. The metal concentrations in the pipis collected at all sites did not exceed levels stipulated in the New Zealand Food Standards and copper was well below that cited in the previous regulations.

Table 11: Metal concentrations in pipi flesh.

Metal (mg kg^{-1})	Sample site			Guideline value (mg kg^{-1})
	I1	I2	TH	
Arsenic (total)*	1.1	1.12	1.43	—
Estimated arsenic (inorganic)	0.110	0.112	0.143	1
Cadmium	0.034	0.047	0.049	2
Chromium	0.07	0.04	< 0.03	—
Copper	1.94	1.71	1.13	30$^{\Delta}$
Lead	0.062	0.077	0.017	2
Nickel	< 0.10	0.11	0.09	—
Zinc	8.6	8.9	9.7	—

* Inorganic arsenic is conservatively estimated to be about 10% of total arsenic (McMurtrie, 2012) so all levels of inorganic arsenic measured in the shellfish samples in this survey should be well below the Australia NZ Food Standard of 1 mg kg^{-1}.

$^{\Delta}$ No longer in force — see text.

4 ECOLOGICAL EFFECTS

Ecological and water quality effects could arise from the different elements of the proposal as identified in Section 1.0 of this report. Dredging represents the greatest disturbance to the present environment and dredging effects are discussed more fully below in Section 4.1. Effects arising from the other elements of the proposal are discussed in subsequent sections.

4.1 Dredging

4.1.1 Capital dredging effects on edible shellfish and other marine biota

The ecological features in the vicinity of the boatyard that are potentially influenced by the proposed dredging activities are all common and widespread in the Bay of Islands and Northland. It is expected that within the timeframe of months to approximately a year, the dredged substrate and biota are likely to return to the same or similar sandy mud/gravel substratum inhabited by the same or similar assemblage of biota. The effects to subtidal and intertidal biota from the proposed capital dredging works are therefore expected to be less than minor in the medium to long term.

In terms of ecological values, the harvestable pipi bed in the beach intertidal zone is the most important feature identified in the survey. Pipi populations are known to be potentially vulnerable to the effects of excessive sedimentation. In this case, the risk is assessed as low because of the small amount of material likely to be lost in the relatively small dredging project and inherently intermittent nature of the dredging operation. However, as a precautionary measure, it is proposed to deploy a silt curtain around the dredging plant for the duration of the dredging operation to avoid the potential risk of detrimental effects of sedimentation to the pipi bed.

Installation of a subsurface erosion barrier is designed to avoid potential erosion effects on the beach habitat and associated pipi bed over the longer term as a result of the dredging. 4Sight are aware of NRC's views regarding the subsurface barrier and its efficacy and/or suitability in this situation, which were expressed in an addendum to the s42A report[14]. The decision on the most appropriate approach is left to be determined by the engineers. Regardless of the final decision, the environmental effects are assessed here if such an approach was implemented. The ecological

[14] Northland Regional Council, 2018. Addendum to s42A report for resource consent application APP.039650.01.01.

effects associated with the installation of the erosion barrier are expected to influence only the northern end of the pipi bed. Furthermore, the purpose of the subsurface erosion barrier is to support the edge of the pipi bed and prevent movement of the pipi bed onto the slipway. For these reasons, we expect the overall effects to be less than minor.

Analysis of metals in shellfish flesh found no evidence of accumulation of metal contaminants in pipis collected from the pipi bed adjacent to the boatyard relative to concentrations observed in shellfish flesh further from the slipway including a background reference site several kilometres away.

4.1.2 Capital dredging effects on water and sediment and quality

There is likely to be some increased turbidity in the water column resulting from the suspension of fine silts and clays associated with the dredging operation. Available hydrodynamic modelling information and field observations indicate that there is only limited potential for fine sediment disturbed by the proposed dredging activity to disperse far beyond the close vicinity of the operations. The proposed silt curtain deployment will further mitigate against the possibility of adverse turbidity and sedimentation effects beyond the works footprint.

Intertidal sediments near the slipway contain elevated levels of copper, zinc, and lead. The dredging activity will potentially disturb a small area that could lead to resuspension of some sediment and contaminants in the water column. However, most of the contaminated sediment disturbed by the dredging process will be removed and transported to an approved disposal site on land, thus, removing this historical contamination from the marine ecosystem. On balance, effects from the proposed dredging activities in terms of contaminants are expected to be less than minor.

The low current speeds and limited capacity for sediment transport predicted in the vicinity of the proposed dredging area indicate that there will only be potential for localised dispersal of suspended sediment and any associated contaminants; as noted, this will be further limited using a silt curtain. Shellfish beds and other ecological features beyond the site are highly unlikely to be put at risk or adversely affected or exposed to significant sediment, sediment-associated contaminants, or dissolved contaminants generated during the dredging process.

4.1.3 Maintenance dredging effects

Maintenance dredging has not been conducted at DOBY within the past 10 years. This may, in part, be due to the relatively stable beach and the low sediment transport capacity of the Opua Basin. 4Sight is advised by Mr Doug Schmuck that maintenance dredging is likely to be infrequent and confined to parts of the capital dredged area where localised sediment may preferentially accumulate. Although estimates of specific dredging intervals and volumes have not been provided, it is likely the area affected and volume for any maintenance dredging episode will be small and less than that originally dredged.

The main environmental effects that may arise from maintenance dredging are the same as those from capital dredging. In terms of water quality, there would be resuspension of sediment, but elevated turbidity in the adjacent water column is likely to be localised, short term, and of minor significance. As for the capital dredging, sediment losses and redistribution of any associated contaminants can be largely confined to the works area using a silt curtain.

In terms of benthic habitats and associated macrobenthos, maintenance dredging effectively temporarily removes the community in the dredged area. As noted, this activity is likely to be confined to 'hot spots' of sedimentation. Overall, effects on benthic community and local biodiversity values are unlikely to be significant given that surveys to date have indicated the local benthos is comprised of common species which are widely distributed.

Due to the ability to mitigate potential water quality related effects, and the small scale and expected infrequency of maintenance dredging, the environmental effects from this activity are expected to be less than minor.

4.1.4 Previous NRC recommendations in respect of dredging

4Sight accept recommendations provided by NRC in the addendum to the s42A report regarding temporal restrictions on dredging activities. Expert advice from R. Griffiths, NRC Marine Research Specialist stated:[15]

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[15] Northland Regional Council, 2018. Addendum to s42A report for resource consent application APP.039650.01.01. Appendix 2.

> *"I recommend that a temporal restriction be placed on dredging activity. This was a key recommendation of a report by Cawthron Institute 'Review of Northland Regional Council's consent conditions for dredging' (Morrisey and Barter 2015). This report recommends a closed season for cockle and pipi spawning and settlement of October – January inclusive."*

Furthermore, Mr Griffiths highlighted that "*The area in question has high recreational values during the summer period, and users will have higher expectations of water clarity during the summer period."* The recreational water quality guidelines[16] note that the precise bathing period likely varies according to location, but it can generally be defined as the period between 1 November and 31 March.

The recommended temporal restriction on dredging activities, incorporating the above two scenarios, is from October to March (inclusive) each year. This means that capital and/or maintenance dredging could be conducted from April to September (inclusive).

4.2 Reconstruction/remediation of the slipway

Earthworks are proposed to excavate and reconfigure the existing slipway (see Figure 4 and Total Marine Services report in Appendix I). This also provides an opportunity to remediate the sediment that has elevated metal concentrations in this area as proposed by Haigh Workman.[17]

There is evidence of localised contamination by some metals close to the slipway and extending along the beach proper for some distance. It is likely that historical vessel maintenance and slipway and boatyard activities at the site since the 1960s have been the major contributors to the existing contaminant levels. Improvements to the system for handling washdown water and stormwater from the boatyard hardstand implemented since 2002 represent improved environmental management and reduced potential for contaminants to enter the coastal marine area.

If earthworks are carried out as proposed by Haigh Workman, appropriate erosion and sediment control measures will be in place. This will limit sediment dispersal and the resuspension of potentially contaminated sediments to the wider Walls Bay and Opua Basin.

Excavation of sediments that have elevated metal concentrations along the slipway will have the effect of reducing the overall level of metal contamination in the sediments of Walls Bay and will provide some degree of remediation of the area.

The 4Sight survey has confirmed that biota in the more or less immediate footprint area of the slipway is very limited. Potential loss of this biota is not significant ecologically. Relatively rapid recolonization of the location with the same or similar species is expected. The anticipated environmental effects from this activity will less than minor and, due to the nature of removing contaminated sediments, have an overall positive effect.

4.3 Reconstruction of the wharf

A wharf and pontoon are proposed to be constructed in Walls Bay to replace the existing structure in the CMA adjacent to DOBY. The pontoon will be capable of berthing a 50-foot launch in all reasonable weather conditions. The details of the wharf and construction have been described in a report by Total Marine Services.[18]

The existing wharf is proposed to be dismantled and the replacement wharf to be constructed on the northern side of the previous wharf using marine grade H6 timer and piles. It is estimated that the total area that will be affected by the wharf construction is 4 m^2 and about 7.5 m^3 of sediment will be removed for the piles.

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[16] Ministry of Health and Ministry for the Environment, 2003. Microbiological water quality guidelines for marine and freshwater recreational areas.

[17] Collings, E., 2019. Geoenvironmental Appraisal: 1 Richard Street, Opua. Haigh Workman report prepared for Doug's Opua Boatyard.

[18] Total Marine Services, 2019. Design of Timber Jetty, Pontoon and Dredging at Doug's Boatyard, Opua. Total Marine Services Technical Report No. 460248.1. 13 p. (Appendix I)

Capital dredging, discussed above in Sections 4.1.1 and 4.1.2, is required to accommodate all-tide access and to allow boats to remain floating at low tide.

The wharf construction will likely be carried out at a similar time to the capital dredging. Notwithstanding, any potential for sediment disturbance and dispersal as a result of the old wharf deconstruction and new wharf construction is small and probably negligible. The effects should be captured by the controls in place for the dredging or could, if necessary, otherwise be dealt with in a similar matter to the capital dredging.

Irrespective, effects from this component of the works are expected to be less than minor and probably negligible.

4.4 Using wharf facility berths as a marina

The wharf facilities at the end of the reconstructed wharf have been proposed for use as a marina. This would provide berthing for two boats.

The following is understood:

- No contaminant generating maintenance work will be allowed at these berths;
- As per current requirements at other marinas, for example Opua, boats will be required to have waste holding tanks and these are to be carefully managed during occupation of the berth. Specifically, the holding tanks will have to be verifiably secured in a locked position when the vessel berths and shoreside facilities will have to be used; and
- Oil collecting bilge pads will be required to be in place and no bilge water discharges, beyond that required for normal vessel operations and security, will be allowed.

On the basis of the above controls, there should be no risk to the water quality or the high recreation values that NRC has identified for Walls Bay.

Given the large number of vessels which use, frequent, and transit through the Walls Bay/Opua area daily, no additional monitoring is required to assess the presence of a few extra vessels. In all likelihood, were these vessels not to be present at the proposed DOBY marina, most of them would be present somewhere else nearby.

Overall, the small number of boats that are able to be berthed in the proposed marina are unlikely to pose any significant adverse ecological or water quality effects to the surrounding environment; therefore, it is anticipated the effects from this activity to be less than minor.

5 SUMMARY AND CONCLUSIONS

Capital dredging effects on edible shellfish and other marine biota

- The ecological features in Walls Bay are common and widespread in the Bay of Islands and Northland. It is anticipated that the sediments and biota are likely to return to the same or similar state within months or up to a year following the dredging activities.
- The ecological effects associated with the installation of a subsurface erosion barrier are expected to influence only the northern end of the pipi bed and to be less than minor.
- The deployment of a silt curtain around the dredged area for the duration of the dredging operation is recommended to avoid the potential risk of detrimental effects of sedimentation to the nearby pipi bed.
- The effects to subtidal and intertidal biota from the proposed capital dredging works are therefore expected to be less than minor in the medium to long term.

Capital dredging effects on water and sediment and quality

- There is likely to be some elevated turbidity levels during dredging operations from the resuspension of fine sediments. Results from the hydrodynamic model indicates that there is only limited potential for these resuspended sediments to disperse far beyond the close vicinity of the operations
- Intertidal sediments near the slipway contain elevated levels of copper, zinc, and lead that may be resuspended during dredging activities. The use of a silt curtain will restrict resuspended sediment to the dredging area.

- On balance, effects from the proposed dredging activities in terms of contaminant losses or exposure of biota to contaminants, are expected to be less than minor.

Maintenance dredging effects

- Maintenance dredging has not been conducted within the past 10 years by DOBY. It is anticipated that small scale localised maintenance dredging may be required in the future.
- The environmental effects from this activity are expected to be less than those from capital dredging, that is, less than minor.

Previous NRC recommendations in respect of dredging

- 4Sight agree with an NRC staff recommendation to the effect that to protect the nearby shellfish during spawning and settlement and to ensure high-quality water for swimming, a temporal restriction is proposed so that dredging activities would only be conducted between April and September (inclusive) each year.

Reconstruction/remediation of the slipway

- There is evidence of localised contamination by some metals in intertidal sediments close to the slipway. The proposed earthworks to decrease the grade of the slipway from 8% to 4% would provide an opportunity to excavate the contaminated sediments and dispose of them in an appropriate landfill. This will remove historical contamination permanently from the marine ecosystem and is a positive effect.
- The area to be excavated is small and any affected biota and habitats are anticipated to recover to the same or similar condition within months or up to a year from the excavation activities.
- The anticipated environmental effects will be less than minor.

Reconstruction of the wharf

- The effects of the wharf reconstruction and the associated capital dredging are anticipated to be less than minor.

Using wharf facility berths as a marina

- The proposed use of wharf berths for a marina would provide berthing for two boats. Given the controls proposed and the small number of boats, it is unlikely there will be any adverse water quality or related ecological effects.

Overall, it is concluded that the proposed upgrade to structures and deepening around the facility can be carried out with only short term and less than minor ecological or water quality effects that are confined largely to the immediate works area.

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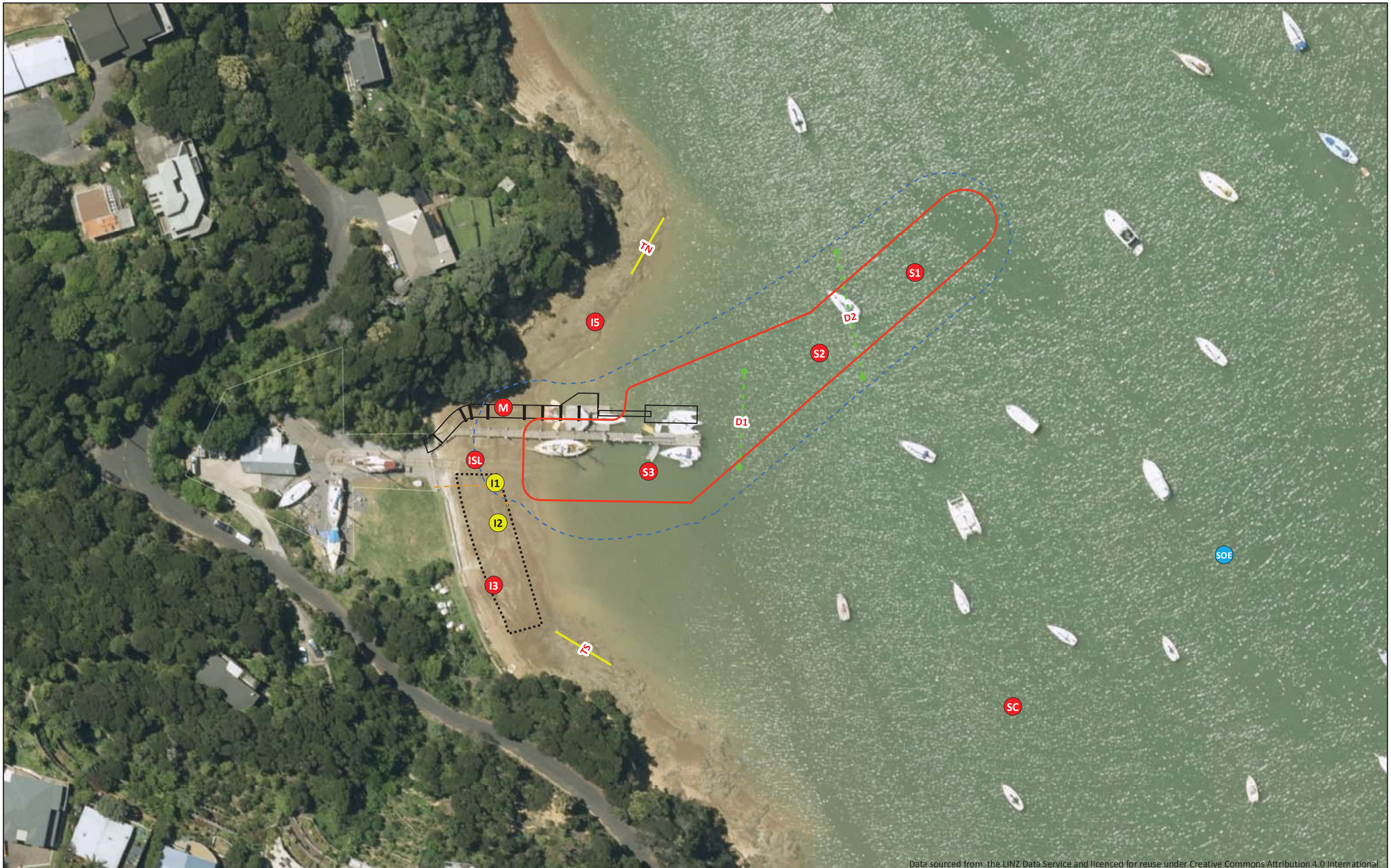
4SIGHT CONSULTING

Appendix A:

Map: Sampling Locations



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0 20 40 m

AA3213 - DOUG'S OPUA BOATYARD

Doug's Opua Boatyard

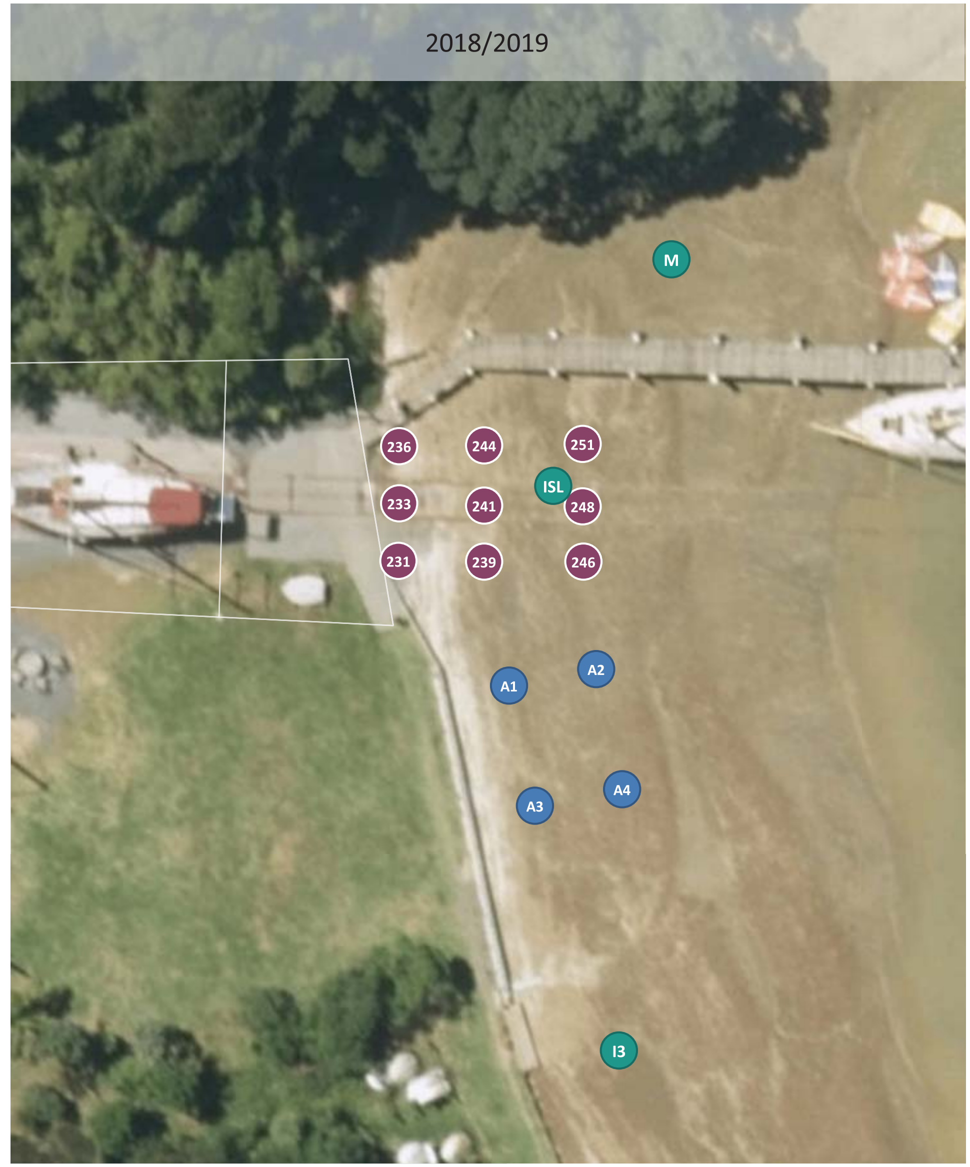
- Sediment Contaminants and Infauna
- Shellfish Contaminants
- NRC SOE Monitoring
- Epifauna Dredge
- Rocky Intertidal Transect
- Subsurface Erosion Barrier
- Dredge Footprint
- Batter Boundary
- Pipi Bed Survey

Date Created: 11/04/2019
Status: FINAL
Drawn: PW
Checked: MP
Approved: ML

4SIGHT CONSULTING

Appendix B:

Map: Sediment Sampling Locations



1 : 250 @A3

0 5 10 m

AA3213 - Doug's Opua Boatyard

DOBY Intertidal Sediment Sampling Locations

Prepared for Doug's Opua Boatyard by 4Sight Consulting

Doug Schmuck (1998)
Haigh Workman (2019)
4Sight (2018)
4Sight (2019)

Date: 13/08/2019
Version: 1.0
Author: PW
Checked: MP
Approved: ML

4SIGHT CONSULTING

Appendix C:

Sediment Grainsize Analysis Reports

166 Bank Street
Whangarei
P: 09 438 4417
E: info@geocivil.co.nz
M: 027 6565 226

TEST REPORT

Lab Job No:	8174-007
Your ref.:	AA3213
Date of Issue:	19-06-2018
Date of Re-Issue:	-
Page:	1 of 4

Test Report.

No. W18-332

PROJECT:	**Grading Analysis**
CLIENT:	4Sight Consulting Office 3, Shop 10 Oceans Resort Hotel, Marina Road PO Box 402 053, Tutukaka 0153
ATTENTION:	Stephen Brown
INSTRUCTIONS:	Determination of the particle size distribution (wet sieving method)
TEST METHOD:	NZS 4402:1986 2.8.1
SAMPLING METHOD:	N/A
TEST RESULTS:	As Per Laboratory Sheets attached

G. Breckon

Laboratory Technician

D.Krissansen

Approved Signatory

IANZ ACCREDITED LABORATORY

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

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166 Bank Street
Whangarei
P: 09 438 4417
E: info@geocivil.co.nz

DETERMINATION OF THE PARTICLE SIZE DISTRIBUTION

NZS 4402:1986 Test 2.8.1

Client:	4 Sight Consulting	**Sample No.**	18-236	**Lab Job No:**	8174-007
Client Sample No:	S1	**Tested by:**	L.C	**Client Ref no:**	AA3213
Date Collected:	31/05/2018	**Date:**	18/06/2018	**Report no:**	W18-332
Test Details:	Wet sieving method	**Checked by:**	Csrecko	**Page:**	2 of 4
History:	Natural	**Date:**	21/6/18		

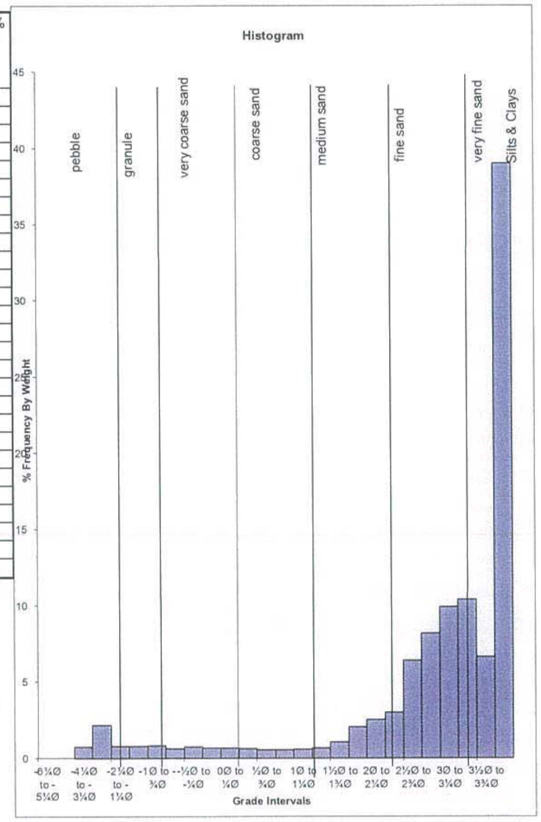
Weight of dry Sample(grams): 406.63

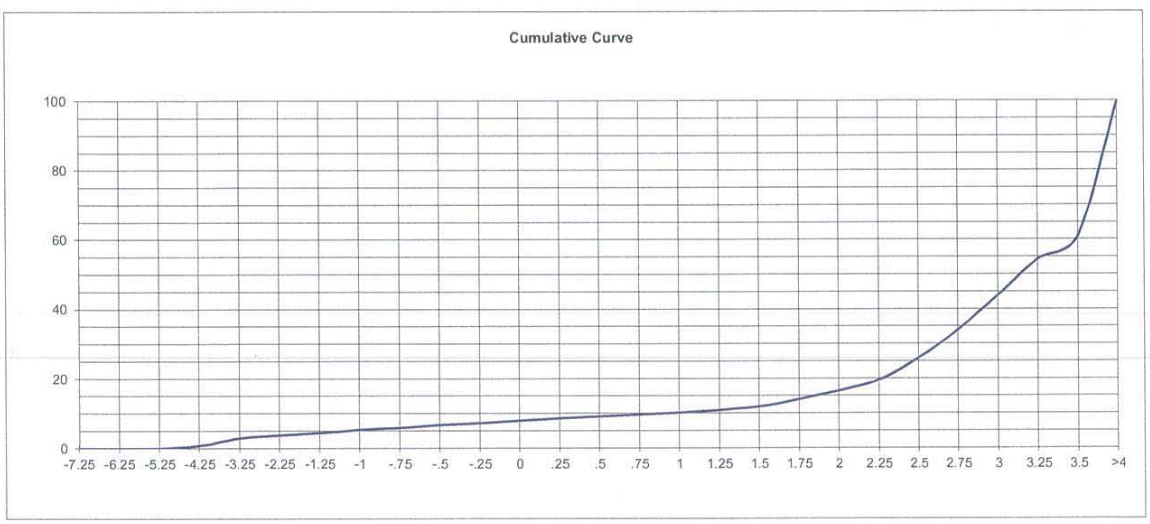
GRADE INTERVALS	BS TEST SIEVE (mm)	WEIGHT RETAINED ON SIEVE (g)	% FREQUENCY (WEIGHT)	CUMULATIVE % FREQUENCY
-6¼Ø to -5¼Ø	37.5	0	0	0
-5¼Ø to -4¼Ø	19	0	0	0
-4¼Ø to -3¼Ø	9.5	0	0	0
-3¼Ø to -2¼Ø	4.75	3.02	1	1
-2¼Ø to -1¼Ø	2.36	8.82	2	3
-1¼Ø to -1Ø	2	3.16	1	4
-1Ø to -¾Ø	1.70	3.21	1	4
-¾Ø to -½Ø	1.40	3.32	1	5
-½Ø to -¼Ø	1.18	2.59	1	6
-¼Ø to 0Ø	1.00	2.97	1	7
0Ø to ¼Ø	0.850	2.64	1	7
¼Ø to ½Ø	0.710	2.65	1	8
½Ø to ¾Ø	0.600	2.55	1	9
¾Ø to 1Ø	0.500	2.17	1	9
1Ø to 1¼Ø	0.425	2.18	1	10
1¼Ø to 1½Ø	0.355	2.40	1	10
1½Ø to 1¾Ø	0.300	2.64	1	11
1¾Ø to 2Ø	0.250	4.23	1	12
2Ø to 2¼Ø	0.212	8.31	2	14
2¼Ø to 2½Ø	0.180	10.29	3	17
2½Ø to 2¾Ø	0.150	12.24	3	20
2¾Ø to 3Ø	0.125	25.94	6	26
3Ø to 3¼Ø	0.106	33.21	8	34
3¼Ø to 3½Ø	0.090	40.29	10	44
3½Ø to 3¾Ø	0.075	42.32	10	54
3¾Ø to 4Ø	0.063	26.97	7	61
smaller than 4Ø		158.51	39	100

sum 406.63
error/losses %

Mean Size		-	Ø
Standard Deviation		-	Ø
Skewness		-	Ø

Note:





D. Krissansen
Approved Signatory

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166 Bank Street
Whangarei
P: 09 438 4417
E: info@geocivil.co.nz

DETERMINATION OF THE PARTICLE SIZE DISTRIBUTION

NZS 4402:1986 Test 2.8.1

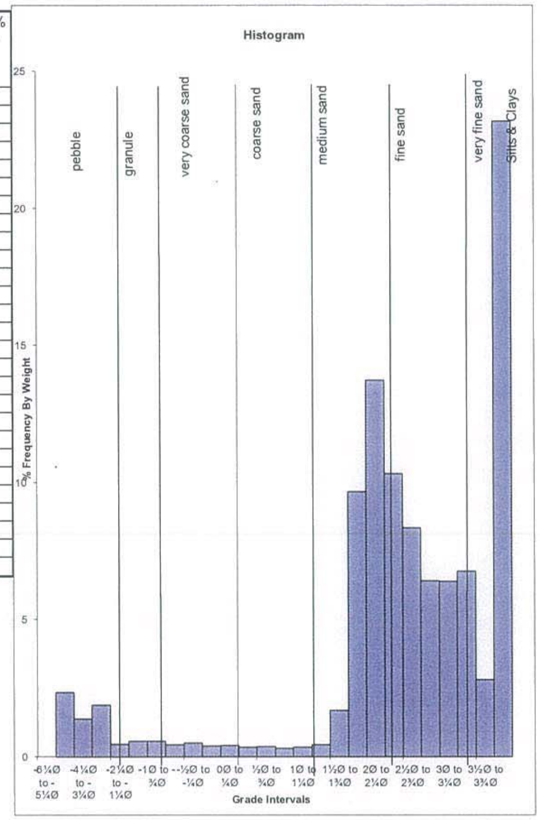
Client:	4 Sight Consulting	**Sample No.**	18-237	**Lab Job No:**	8174-007
Client Sample No:	S3	**Tested by:**	N.K	**Client Ref no:**	AA3213
Date Collected:	31/05/2018	**Date:**	13/06/2018	**Report no:**	W18-332
Test Details:	Wet sieving method	**Checked by:**	Grecko	**Page:**	3 of 4
History:	Natural	**Date:**	21/6/18		

Weight of dry Sample(grams): 522.68

GRADE INTERVALS	BS TEST SIEVE (mm)	WEIGHT RETAINED ON SIEVE (g)	% FREQUENCY (WEIGHT)	CUMULATIVE % FREQUENCY
-6¼Ø to -5¼Ø	37.5	0	0	0
-5¼Ø to -4¼Ø	19	0	0	0
-4¼Ø to -3¼Ø	9.5	12.29	2	2
-3¼Ø to -2¼Ø	4.75	7.21	1	4
-2¼Ø to -1¼Ø	2.36	9.79	2	6
-1¼Ø to -1Ø	2	2.39	0	6
-1Ø to -¾Ø	1.70	2.92	1	7
-¾Ø to -½Ø	1.40	2.97	1	7
-½Ø to -¼Ø	1.18	2.25	0	8
-¼Ø to 0Ø	1.00	2.63	1	8
0Ø to ¼Ø	0.850	1.98	0	9
¼Ø to ½Ø	0.710	2.14	0	9
½Ø to ¾Ø	0.600	1.82	0	9
¾Ø to 1Ø	0.500	1.94	0	10
1Ø to 1¼Ø	0.425	1.62	0	10
1¼Ø to 1½Ø	0.355	1.76	0	10
1½Ø to 1¾Ø	0.300	2.22	0	11
1¾Ø to 2Ø	0.250	8.87	2	12
2Ø to 2¼Ø	0.212	50.49	10	22
2¼Ø to 2½Ø	0.180	71.75	14	36
2½Ø to 2¾Ø	0.150	53.98	10	46
2¾Ø to 3Ø	0.125	43.66	8	54
3Ø to 3¼Ø	0.106	33.52	6	61
3¼Ø to 3½Ø	0.090	33.34	6	67
3½Ø to 3¾Ø	0.075	35.37	7	74
3¾Ø to 4Ø	0.063	14.63	3	77
smaller than 4Ø		121.14	23	100

sum	522.68	
error/losses		%

Mean Size		-	Ø
Standard Deviation		-	Ø
Skewness		-	Ø



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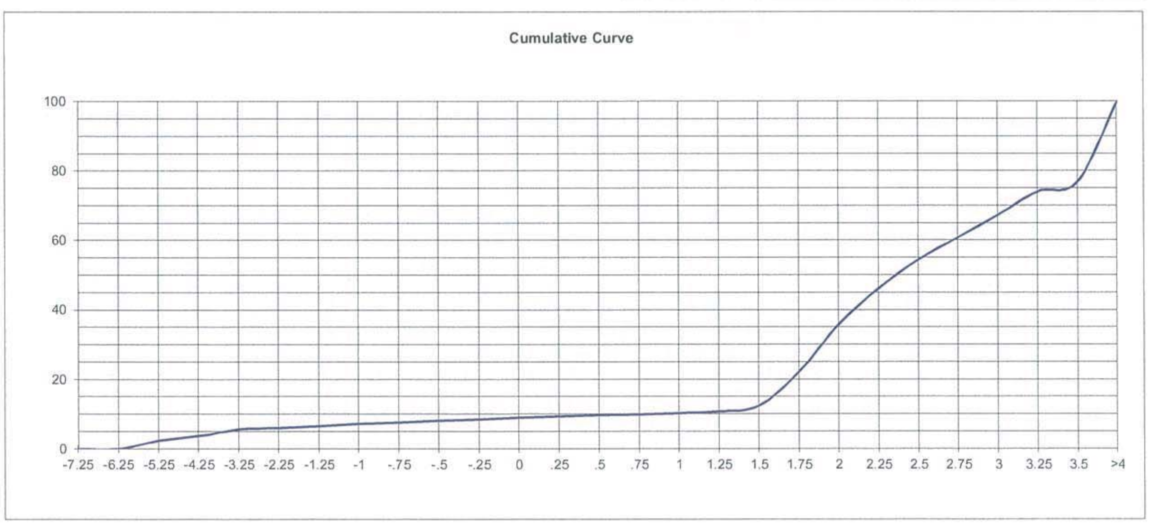

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166 Bank Street
Whangarei
P: 09 438 4417
E: info@geocivil.co.nz

DETERMINATION OF THE PARTICLE SIZE DISTRIBUTION

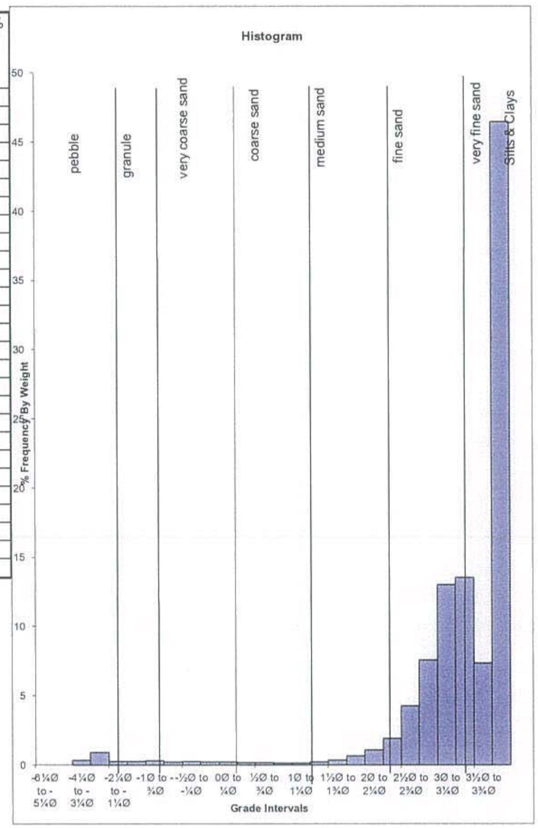
NZS 4402:1986 Test 2.8.1

Client:	4 Sight Consulting	**Sample No.**	18-238	**Lab Job No:**	8174-007
Client Sample No:	SC	**Tested by:**	L.C	**Client Ref no:**	AA3213
Date Collected:	-	**Date:**	18/06/2018	**Report no:**	W18-332
Test Details:	Wet sieving method	**Checked by:**	Becker	**Page:**	4 of 4
History:	Natural	**Date:**	21/6/18		
Weight of dry Sample(grams):	461.48				

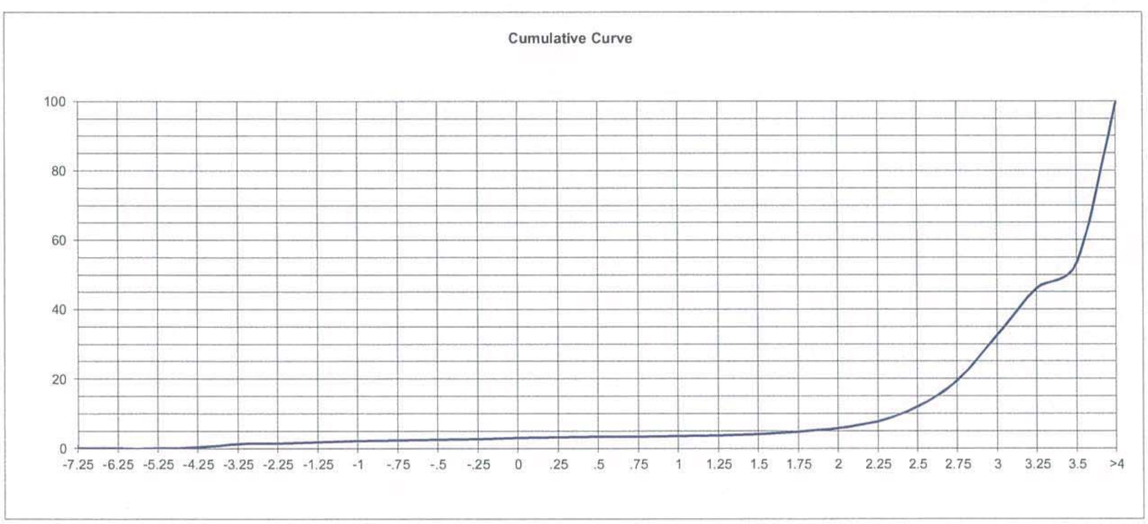
GRADE INTERVALS	BS TEST SIEVE (mm)	WEIGHT RETAINED ON SIEVE (g)	% FREQUENCY (WEIGHT)	CUMULATIVE % FREQUENCY
-6¼Ø to -5¼Ø	37.5	0	0	0
-5¼Ø to -4¼Ø	19	0	0	0
-4¼Ø to -3¼Ø	9.5	0	0	0
-3¼Ø to -2¼Ø	4.75*	1.65	0	0
-2¼Ø to -1¼Ø	2.36*	4.2	1	1
-1¼Ø to -1Ø	2*	1.26	0	2
-1Ø to -¾Ø	1.70*	1.21	0	2
-¾Ø to -½Ø	1.40*	1.28	0	2
-½Ø to -¼Ø	1.18*	1.07	0	2
-¼Ø to 0Ø	1.00*	1.09	0	3
0Ø to ¼Ø	0.850*	0.9	0	3
¼Ø to ½Ø	0.710*	0.92	0	3
½Ø to ¾Ø	0.600*	0.82	0	3
¾Ø to 1Ø	0.500	0.85	0	3
1Ø to 1¼Ø	0.425	0.53	0	3
1¼Ø to 1½Ø	0.355	0.66	0	4
1½Ø to 1¾Ø	0.300	0.88	0	4
1¾Ø to 2Ø	0.250	1.58	0	4
2Ø to 2¼Ø	0.212	3.07	1	5
2¼Ø to 2½Ø	0.180	5.07	1	6
2½Ø to 2¾Ø	0.150	8.87	2	8
2¾Ø to 3Ø	0.125	19.63	4	12
3Ø to 3¼Ø	0.106	34.96	8	20
3¼Ø to 3½Ø	0.090	60.17	13	33
3½Ø to 3¾Ø	0.075	62.49	14	46
3¾Ø to 4Ø	0.063	33.92	7	54
smaller than 4Ø		214.40	46	100

sum		247.08	
error/losses			%

Mean Size		-	Ø
Standard Deviation		-	Ø
Skewness		-	Ø



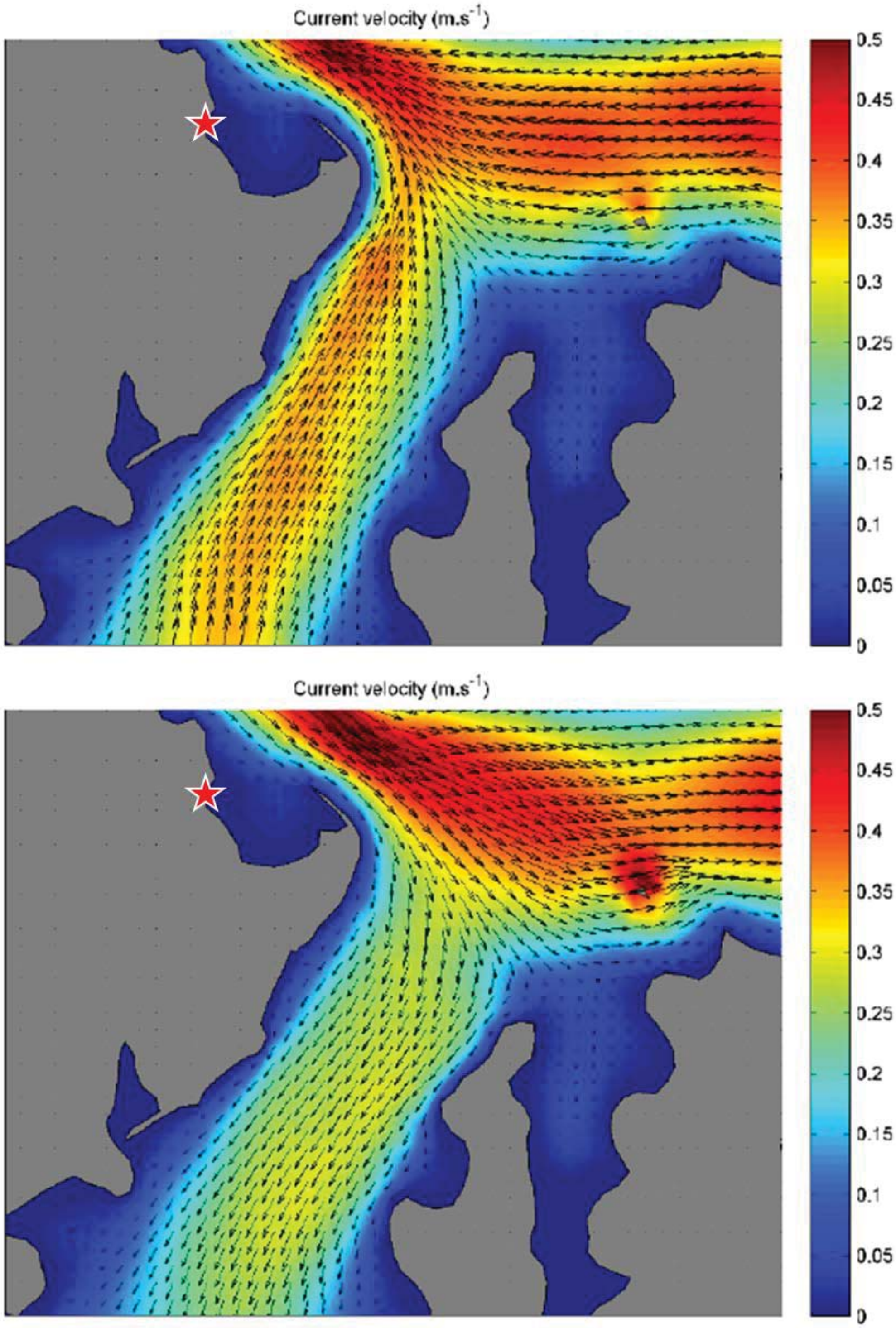
Note: *Predominantly shells and organics



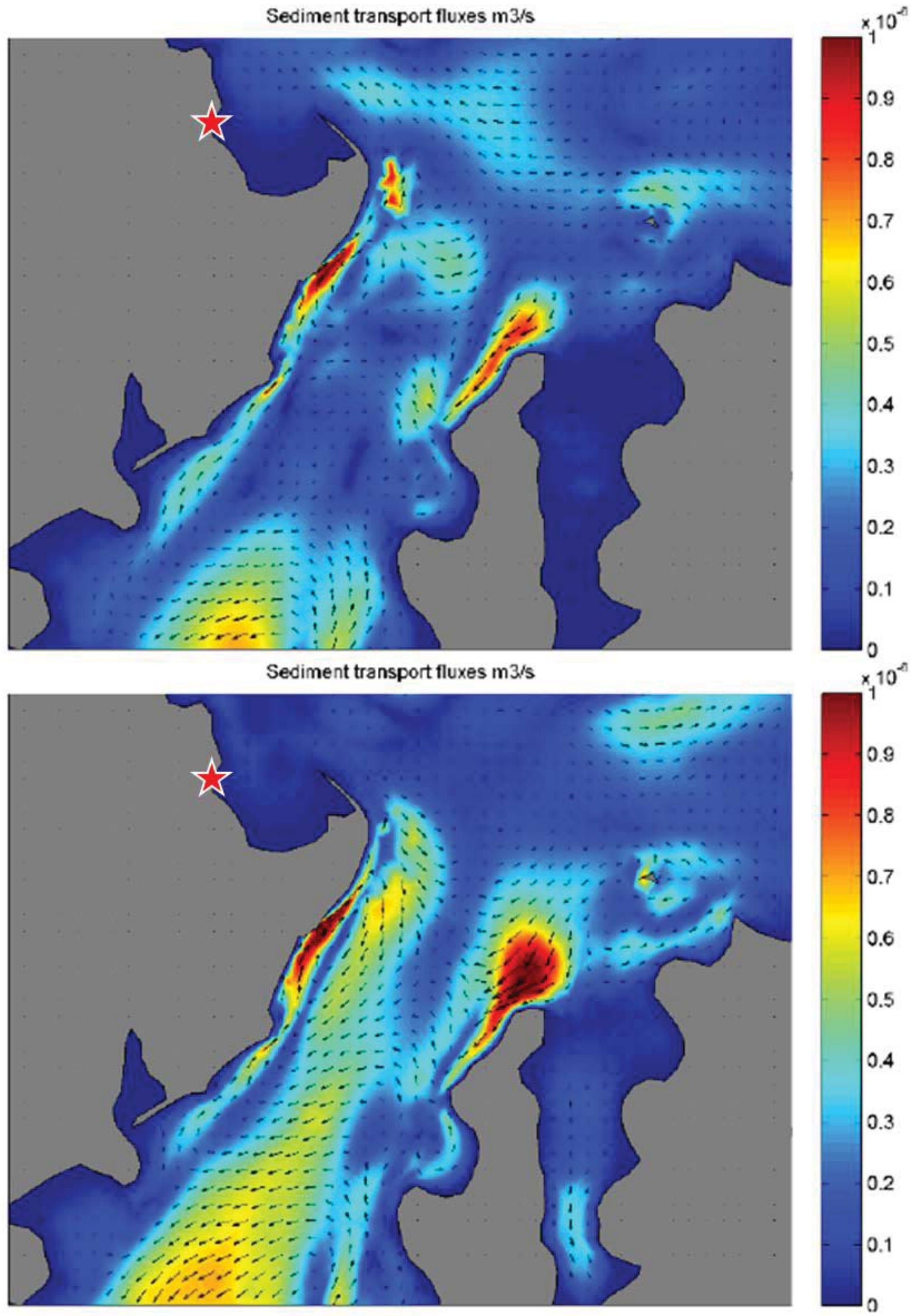
D. Krissansen
Approved Signatory

Appendix D:

Modelled Currents and Sediment Transport in The Bay of Islands



a) Depth-averaged peak spring ebb (top panel) and spring flood (bottom panel) tidal currents in the vicinity of Opua. Red star denotes the location of Doug's Opua Boatyard (Reproduced from MetOcean Solutions 2013)



b) Predicted sediment transport capacity over a neap tidal cycle (top panel) and spring tidal cycle (bottom panel) in the vicinity of Opua. Red star denotes the location of Doug's Opua Boatyard. (Reproduced from MetOcean Solutions 2013)

Appendix E:

Summary of Sediment Metal Concentration Results

1 : 300 @A3

0 6 12 m

AA3213 — Doug's Opua Boatyard

Sediment metal concentrations in Walls Bay

Prepared for Doug's Opua Boatyard by 4Sight Consulting

Default Guideline Value (DGV)

- Concentration < DGV
- DGV < Concentration < DGV-high
- Concentration > DGV-high

Concentrations in mg/kg dry weight

Date: 23/05/2019
Version: 1.1
Author: PW
Checked: MP
Approved: ML

4SIGHT CONSULTING

1 : 1200 @A3

0 20 40 m

AA3213 — Doug's Opua Boatyard

Subtidate sediment metal concentrations in Walls Bay

Prepared for Doug's Opua Boatyard by 4Sight Consulting

Default Guideline Value (DGV)

- Concentration < DGV
- DGV < Concentration < DGV-high
- Concentration > DGV-high

Concentrations in mg/kg dry weight

Date: 13/08/2019
Version: 1.1
Author: PW
Checked: MP
Approved: ML

4SIGHT CONSULTING

Appendix F:

Infauna Results

Species	Intertidal Sites				Subtidal Sites			
	ISL	M	I3	I5	S1	S2	S3	SC
ANTHOZOA							1	
NEMERTEA			1	2	3	4	1	1
NEMATODA	1							
POLYCHAETA								
Aonides trifida	4			120				
Armandia maculata					5	7	16	2
Asychis cf. *amphiglyptus*					14	18	8	4
Boccardia (Paraboccardia) syrtis	2		1		6	4	1	5
Capitella sp.		2		14				
Cirratulidae						3	5	
Cossura consimilis					2	9	9	5
Dorvilleidae					1		4	
Glycera lamelliformis		1				1	2	
Glyceridae (unidentified juveniles)					7	1	20	
Goniadidae						1	2	2
Hesionidae			1					
Heteromastus filiformis					30	44	140	10
Lumbrineridae					4	1		1
Macroclymenella stewartensis					8	7		5
Magelona sp.								1
Nereididae (unidentified juveniles)	2	2					26	
Paradoneis sp.					6	17	10	
Pectinaria australis					7	2	1	2
Phylo novazealandiae					4	7		10
Polydora sp.					1	9	2	
Polynoidae					1	1		
Prionospio aucklandica						1	2	
Prionospio yuriel					1		1	
Scoloplos cylindrifer				1				
Sigalionidae							2	
Syllidae	1		2	2	7	8	1	1
Terebellidae					1			
OLIGOCHAETA	1							
GASTROPODA								
Cominella glandiformis								1
Philine sp.					2	1		1
BIVALVIA								
Arcuatula senhousia	3	1						
Arthritica sp.					2			
Austrovenus stutchburyi							1	
Bivalvia sp. A							1	1
Bivalvia sp. B					1			1
Bivalvia sp. C							2	
Macomona liliana							2	
Nucula sp.					2			
Paphies australis	1	2	4	1				
Theora lubrica					70	50	122	50
CRUSTACEA								
Alpheus richardsoni					2	1		
Amphipoda except Phoxocephalidae	2		1					
Amphipoda Phoxocephalidae	1						1	
Eurylana sp.			1					
Isopoda Sphaeromatidae	2	1						
Nebalia sp.					1			
Ostracoda sp. A					5	2	1	1
Ostracoda sp. B					1			
Ostracoda sp. C					16	2	1	
HOLOTHUROIDEA							3	

Appendix G:

Laboratory Results: Metals in Shellfish Flesh

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28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

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

Certificate of Analysis

Client:	4SIGHT Consulting Limited	**Lab No:**	1995962 SUPv1
Contact:	Stephen Brown	**Date Received:**	07-Jun-2018
	C/- 4SIGHT Consulting Limited	**Date Reported:**	19-Jun-2018
	PO Box 402053	**Quote No:**	92483
	Tutukaka 0153	**Order No:**	AA3213 AEE
		Client Reference:	AA3213 AEE
		Add. Client Ref:	Marine Shelfish (Pipis)
		Submitted By:	Stephen Brown

Sample Type: Shellfish

	Sample Name:	I1 31-May-2018	I2 31-May-2018	TH 31-May-2018	
	Lab Number:	1995962.1	1995962.2	1995962.3	
Arsenic	mg/kg as rcvd	1.10 ± 0.16	1.12 ± 0.16	1.43 ± 0.21	-
Cadmium	mg/kg as rcvd	0.0339 ± 0.0048	0.0471 ± 0.0067	0.0488 ± 0.0069	-
Chromium	mg/kg as rcvd	0.069 ± 0.011	0.0407 ± 0.0070	< 0.03 ± 0.0056	-
Copper	mg/kg as rcvd	1.94 ± 0.28	1.71 ± 0.24	1.13 ± 0.16	-
Lead	mg/kg as rcvd	0.0624 ± 0.0089	0.077 ± 0.011	0.0165 ± 0.0027	-
Nickel	mg/kg as rcvd	< 0.10 ± 0.019	0.105 ± 0.020	0.093 ± 0.019	-
Zinc	mg/kg as rcvd	8.6 ± 1.3	8.9 ± 1.3	9.7 ± 1.4	-

The reported uncertainty is an expanded uncertainty with a level of confidence of approximately 95 percent (i.e. two standard deviations, calculated using a coverage factor of 2). Reported uncertainties are calculated from the performance of typical matrices, and do not include variation due to sampling.

For further information on uncertainty of measurement at Hill Laboratories, refer to the technical note on our website: www.hill-laboratories.com/files/Intro_To_UOM.pdf, or contact the laboratory.

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: Shellfish

Test	Method Description	Default Detection Limit	Sample No
Shucking of Shellfish*	Removal of tissue from shell.	-	1-3
Homogenise*	Mincing, chopping, or blending of sample to form homogenous sample fraction.	-	1-3
Biological Materials Digestion	Nitric and hydrochloric acid micro digestion, filtration.	-	1-3
Arsenic	Biological materials digestion. Analysis by ICP-MS.	0.02 mg/kg as rcvd	1-3
Cadmium	Biological materials digestion. Analysis by ICP-MS.	0.0008 mg/kg as rcvd	1-3
Chromium	Biological materials digestion. Analysis by ICP-MS.	0.006 mg/kg as rcvd	1-3
Copper	Biological materials digestion. Analysis by ICP-MS.	0.010 mg/kg as rcvd	1-3
Lead	Biological materials digestion. Analysis by ICP-MS.	0.002 mg/kg as rcvd	1-3
Nickel	Biological materials digestion. Analysis by ICP-MS.	0.02 mg/kg as rcvd	1-3
Zinc	Biological materials digestion. Analysis by ICP-MS.	0.2 mg/kg as rcvd	1-3

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

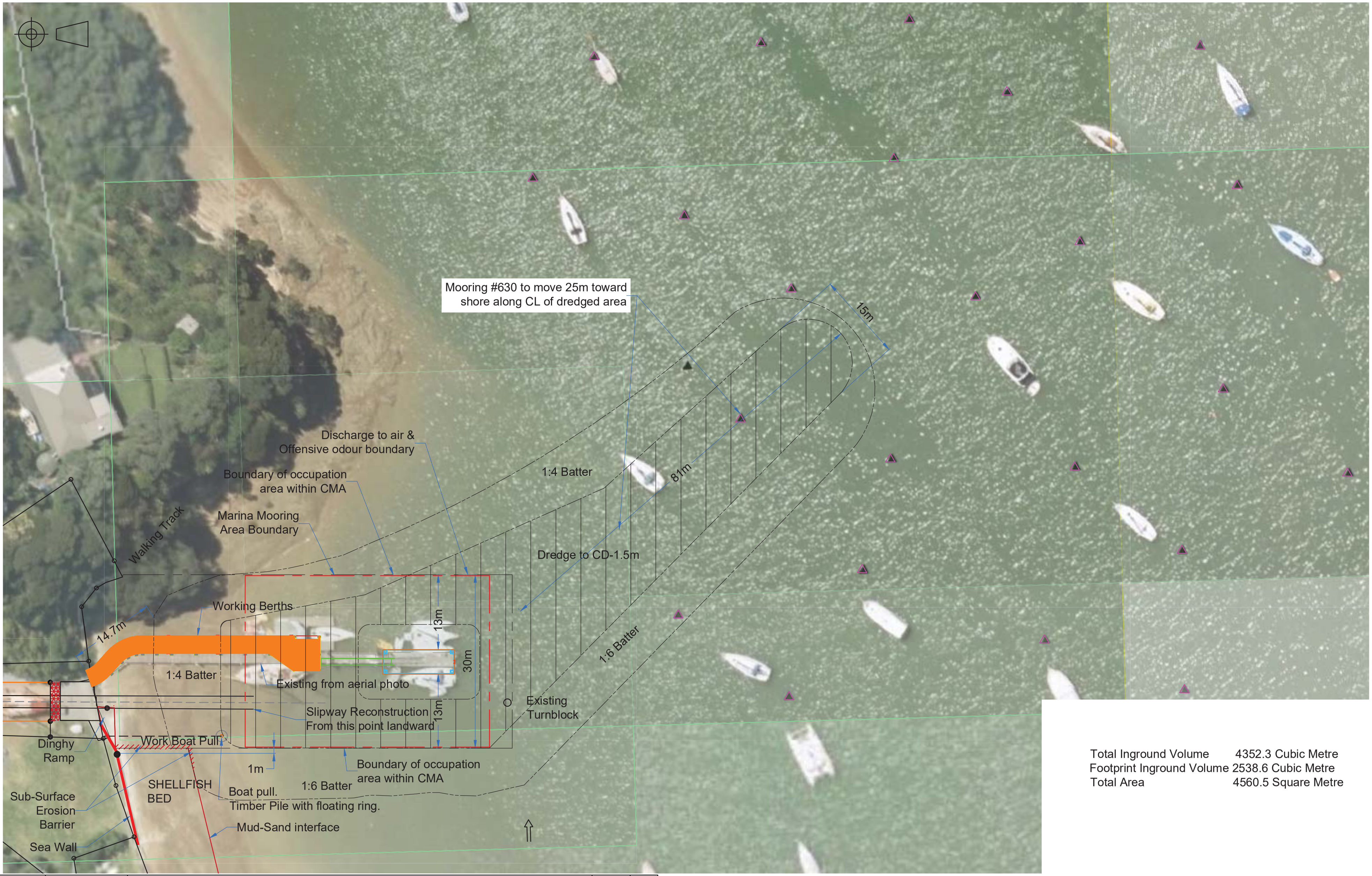
Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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

Malar Sritharan BSc
Laboratory Technician - Food and Bioanalytical

Appendix H:

Dredging and Excavation Plan



Total Inground Volume	4352.3 Cubic Metre	
Footprint Inground Volume	2538.6 Cubic Metre	
Total Area	4560.5 Square Metre	

Rev	Date	Description	Check	App
9	16/01/2019	MOVE LADDERS & STORM DRAIN, REMOVE DINGHY PULL & EXTEND DREDGING	WNM	AJ
10	17/01/2019	MOVE DRAIN, PONTOON BERTH, SECURITY GATE & MOORING AREA	WNM	AJ
11	17/01/2019	REMOVED CONCRETE SLIPWAY CAPPING	WNM	AJ
12	27/05/2019	REVISED DREDGING BOUNDARY	CC	AJ

Drawing No:	0155-0504-0004	Scale:	1:600
		Client:	Doug's Opua Boatyard
Date:	27/05/2019	Drawn by:	Craig Cave

TOTAL MARINE SERVICES LTD

APP-039650-01-01 Sheet 0004

Dredging Plan With NRC aerial overlay

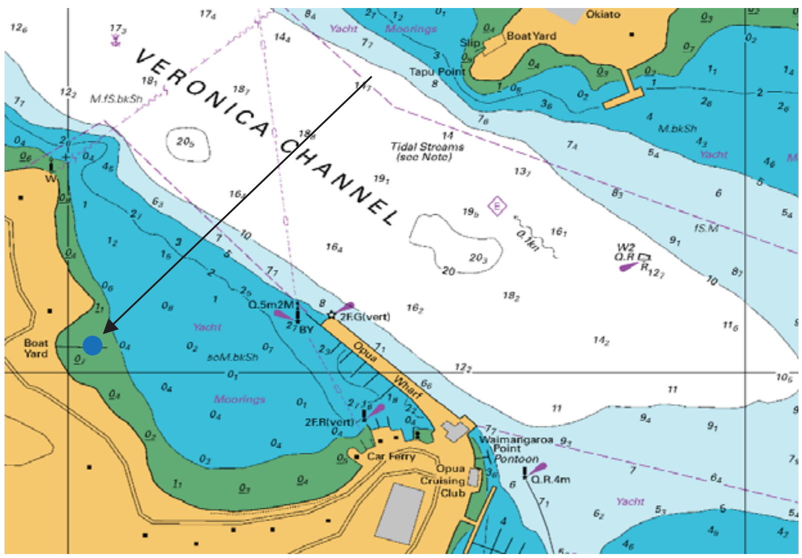
Appendix I:

Total Marine Services Technical Report

Technical Report: Design of Timber Jetty, Pontoon and Dredging at Doug's Boatyard Opua.

Summary:

This report presents the design for the replacement of the timber wharf with adjoining concrete pontoon, as the design life of the existing structure has expired and is no longer suitable to meet the modern higher environmental or safe standards of the expanded operation of the boat yard. Which is proposed in a small bay in the north-west corner of Opua Town Basin in the Bay of Islands, (indicated by the blue mark and arrow). A 43m long, 3m wide pile supported timber jetty, with an adjoining 12m aluminium gangway which provides access to a 12m x 4m polystyrene filled concrete pontoon is proposed. Additionally, dredging will be required to allow a vessel to navigate to and berth alongside the pontoon. The design chosen, has been chosen to minimise the environmental effects and impact on the natural aesthetics of the existing bay while still meeting the operational requirements of the boatyard.



TOTAL MARINE SERVICES LTD
TOTAL FLOATING SYSTEMS LTD

Table of Contents

1.0 Introduction

The replacement jetty and pontoon is proposed to be constructed in Walls Bay to replace the existing structure directly off Doug's Boatyard located at 1 Richardson St Opua. The pontoon should be capable of berthing a 50ft launch in all reasonable weather conditions.

An approximately 43m long 3m wide pile supported timber jetty will be constructed starting from the grassy berm at the north side of the beach. It will arch north-west following approximately the same arch as the natural bulkhead line of the northern end of the foreshore, while still being positioned over the foot print of the existing structure. The head of the jetty is a 4m x 6m timber turning area, which forms the abutment for the 12m long and 1.2m wide aluminium gangway. The aluminium gangway provides access to a 12m long, 4m wide polystyrene filled floating concrete pontoon which will be anchored in place using plastic sleeved driven steel piles. The area will then be dredged to allow a vessel to approach and berth alongside the pontoon.

This report analyses the sites locality and design considerations as well as the construction methodology.

2.0 Site Locality

Opua is part of a large confluence where the Kawakawa River/Inlet and Waikare River/Inlet meet. The site of the wharf is in a small bay in the northwest corner of the Opua Town Basin. The bay is comprised of a mud/sand gravel pocket beach separated by hard exposed rocky cusps on the boarders of the bay.

Currently the Opua Town Basin foreshore has many dwellings used as both permanent residences and holiday batches. There are several access routes via Franklin St, Beechy St and Richardson St. There are significant other marine developments (large concrete wharf, ferry landing and extensive timber boardwalks) in the bay itself and the immediate surrounding area, as well as other commercial marine operations (car ferry, bay of islands marina hardstand, marine service industry, ect.)

The design and location proposed for the structure (Figure 1) is intended to have negligible or minor impact on the unique natural aesthetics, environment, current residents and stakeholders in the area. The exact site proposed is shown in detail in the accompanied drawing 0155-0504

Figure 1: Opua Town Basin

2.1 Beach Morphodynamics

Because the site is a juxtaposition of harder igneous rock at soft sedimentary bays the coastal effects of erosion and sediment transportation are still altering the coast line. Consideration was given to the location of the site, so that the new structure and construction activities have negligible or minor impact on the natural beach morphodynamics.

The morphodynamics acting in the proposed bay are a function of two primary morphodynamic principles- swash and alongshore swash motion

Swash is simply the layer of turbulent water that travels up a beach, this moves material up and down a beach, which results in cross-shore sediment exchange. However, over the length of beach, breaking waves create a circulation system where the water-driven shoreward water across the surface zone, travels along the shore and returns to the offshore at the weakest point in the wave front at the centre of the bay via a backwash mini-rip (as shown in Figure 2). Swash causes erosion of the material away from the cusp horns (leaving only the hard, coarse material) and depositing it in the bay, from which point it is then transported out by the backwash.

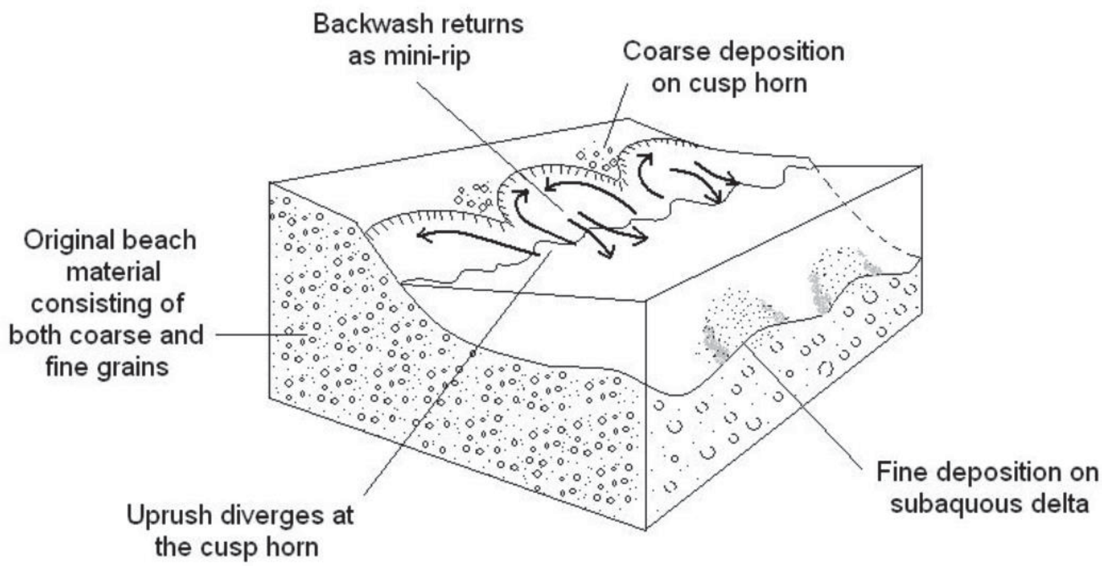


Figure 2: Beach cusp morphology (Masselink & Hughes 2003)

When beach cusp swash combines with alongshore swash motion it results in a slightly unsymmetrical beach cusp shape, which is exactly what is seen from an aerial shot of the proposed bay.

This alongshore swash motion is believed to cause a current moving N-NW, the presence of which was confirmed by Brown (2018) in his current drogue observations. MetOcean Solutions (2013) also indicate this current is due to tidal flows on the site, with their analysis work also indicating a N-NW direction.

It is likely this NW current is enhanced by an alongshore motion called longshore drift. This is when the incoming wave approaches the beach at an oblique angle, as they do at the proposed site as the only long fetch is from the E - SE, and thus, this creates an alongshore swash motion called a longshore drift which is illustrated by Figure 3.

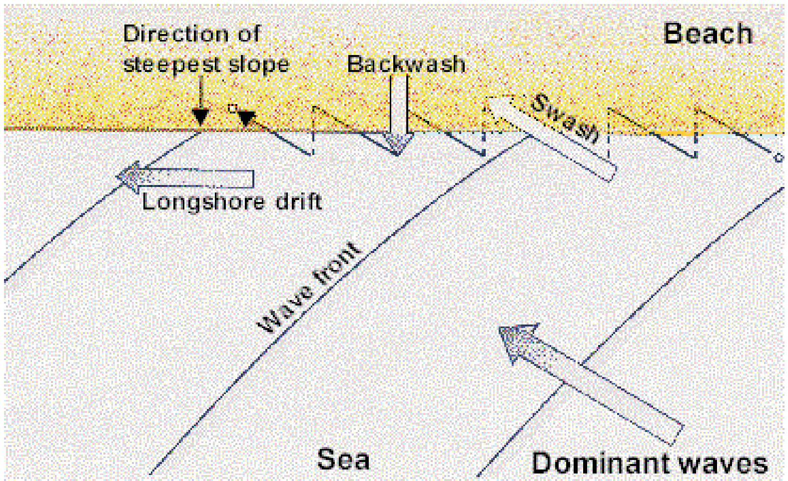


Figure 3: Longshore drift (Brunn, 2005)

This understanding of the natural morphodynamics occurring on the beach has been used to influence the design and positioning of the dredge cut, fixed structure and subsea erosion barrier.

2.2 Aesthetics

It is important that the design does not visually inhibit the view of the residents of Opua. Despite the existing structure already being there for years, for those residents that could see the structure it is important that it does not compromise the natural flow of the coast line and spoil the view.

Several different steps were taken to achieve this:

1. The positioning of the jetty as close as possible to the northern side of the existing wharf with in the historical structural footprint, while still keeping the structure over the footprint of the existing structure, adjacent to the steep vertical bank, restricts it from the view of most residents to the north.
2. For those residents that will be able to see the structure (to the south, east and by water) the jetty does not protrude perpendicular to the beach, it arcs following the natural radius of the beach and this meets with the rocky cusp and hugs that bulkhead line as close as feasibly possible so as not to impose on the beach front view.
3. For residents and public using the beach or the jetty, the jetty is designed with the lowest possible freeboard so it does not look invasive at low tide when the gap between the deck and the water is largest while still meeting the minimum engineering requirements for freeboard.
4. Lastly, the piles will be sleeved with PE sleeves, and the Joist and headstocks will be stained recessive colours so the structure "blends" in with the natural backdrop.

3.0 Construction

All of the companies within the Total Marine Group will be involved in this construction.

- Total Marine Services Ltd. will conduct all engineering design and project management, as well as conducting all the construction work on site.
- Total Floating Systems Ltd. will conduct the design and construction of the polystyrene core concrete floating pontoon.
- Total Engineering Services Ltd. will fabricate all the bracketry and pile guides used on the pontoon and jetty.
- Total Dredging Ltd will dredge the site to the required depth and batter angles, and then dispose of the dredged tailings.

Total Marine will also work with Manson Marine and Engineering Ltd to design and build the aluminium gangway.

3.1 Design

Please refer to drawing series 0155-0504

The design of the Jetty, Pontoon and Gangway is in accordance with relevant international and national standards.

- AS-NZS 3962 Guidelines for Design of Marinas
- AS-NZS 3600 Concrete Structures
- AS-NZS 1720 Timber Structures
- AS-NZS 1170 Structural Design Actions
- AS-NZS 1664 Aluminium Structures
- AS-NZS 1665 Welding of Aluminium Structures
- DNV-RP-C205 Environmental Conditions and Environmental Loads

The design of the structure is based on the longest fetch which is from the E-SE(6,500m), however there is currently a marina structure positioned on the western side of the main wharf, which does provide some attenuation to the site. The longer fetch was used for design purposes as the inner marina structure only has limited consent life and may not be positioned in that location in the future. However, given that marina structure is in that location, this creates a sheltered embayment effect on the site and the Opua Marina Basin. In which case, the longest fetch for the site is considered to be NE(700m) as shown in Figure 4, which has a significantly reduced wave climate than the design wave climate.

Preliminary analysis suggests the sea state will be as shown in Table 1 for the two different fetches considered, for design conditions in accordance with AS-NZS 1170 for a 50year design life, derived from the JONSWAP wave spectrum analysis shown in Figure 5.

Figure 4: Design Fetch SE-E (Red), Common Wind Storm Wave NE (Blue)

Table 1: Sea State Parameters for different fetches, wind speed 35.49 ms^{-1}

Sea state parameter	Sym	Value Fetch = 6.5km	Value Fetch = 700m
Significant wave height	H_s	1.46 m	0.46 m
Zero crossing period	T_z	3.04 sec	1.54 sec
Mean period	T_m	3.21 sec	1.59 sec
Wave length	L	16.09 m	3.95 m

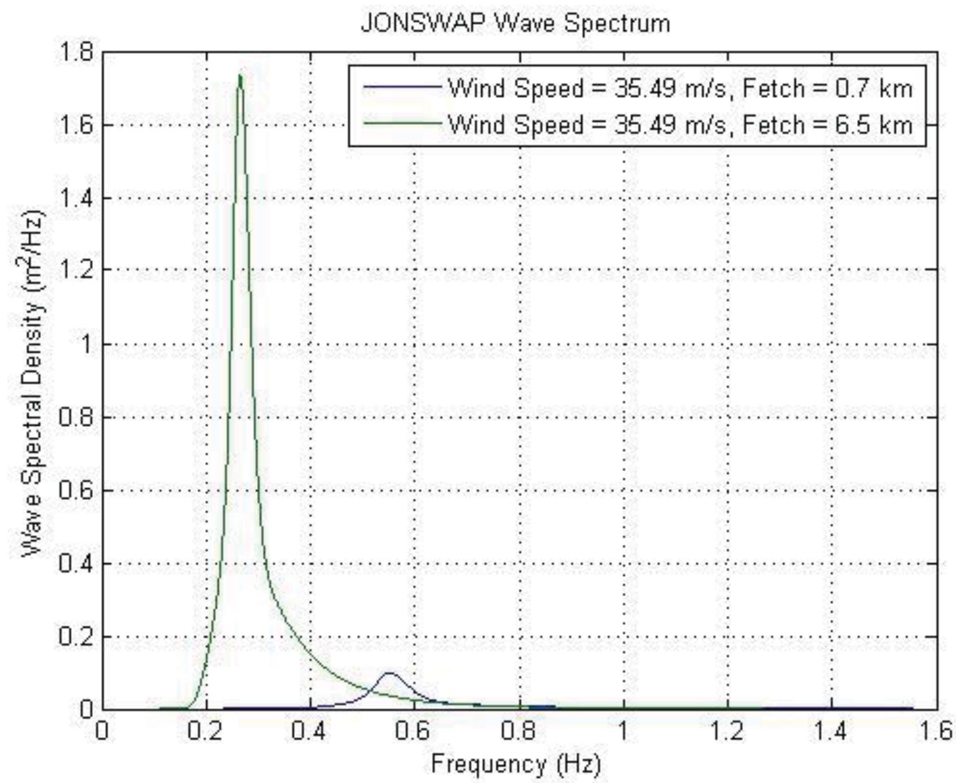


Figure 5: JONSWAP Analysis; Design Fetch 6.5km to the SE(Red), Common Wind Strom wave NE(Blue)

3.2 Dredging

Please refer to drawing 0155-0504-0004

The area will be dredged to allow all required vessels to access the wharf and berth alongside the pontoon. It is proposed to dredge the channel and berth to a depth of CD – 1.5m. It is estimated that the inground volume is 4352.3m^3, based on a hydrographic survey that was conducted by Total Marine.

Figure 6: Total Dredging Ltd.'s Longreach excavator and hopper barge

The primary method for dredging will be using a long reach excavator on a dredge barge, with a ripping tooth and rock bucket. All work associated with the dredging will be undertaken from a barge on the water and material removed from the sea bed will be transported to a land-based disposal site. The dredge barge will not be tidally restricted. However, due to the travel time between the disposal site and dredge site it is most likely that the barge will only be onsite dredging for 4-5 hours per day. It is proposed to use a silt curtain which will fully enclose the dredge barge to prevent sediment depositing outside the dredge area and reduce the plume.

A iterative drafting and current modelling study was conducted on the design of the dredge cut to determine the most suitable batter angles of the dredge profile, based on the predicted current and sediment volumes established by MetOcean(2013). A convergence study was done of all the batter angles in the dredge profile to maintain as high as possible average velocity, while also maintaining the lowest possible deviation in the velocity profile. Based on some more extensive previous dredge model studies we have conducted, this has proved to be a reliable method of determining an optimum dredge profile without doing extensive sedimentation modelling. The established optimum profile is shown on the attached 0155-0504-0004 drawing.

MetOcean(2013) Figure 2.3, identifies that there has been only minor sediment deposition occurring in the Opua marina area(to the SE of Opua Town Basin), this is also supported by the fact there has only been very small amounts of maintenance dredging that has occurred in the marina in the last 10-15 years. MetOcean(2013) sediment transportation modelling for stg 1 and stg 2 of the Opua marina Figure 6.19 & Figure 6.30 respectively, show comparatively no sediment transportation in the area of the Opua Town Basin compared to the Opua marina. Given the observation of little to no maintenance dredging and small amounts of material deposited in the Opua marina, and the modelling conducted by MetOceans that identified there is comparatively no sediment transportation in the area of DOBY compared to the Opua Marina, suggest minimal amount of maintenance dredging will be required on this site.

3.3 Sub-Surface Erosion Barrier

Please refer to drawing 0155-0504-0006

It has been identified Brown (2018) for 4 Sight Consulting that there is a small shellfish bed on the southern end of the beach (to the right-hand side of the slipway). A small section of the dredge batter is located on the edge of this shellfish bed.

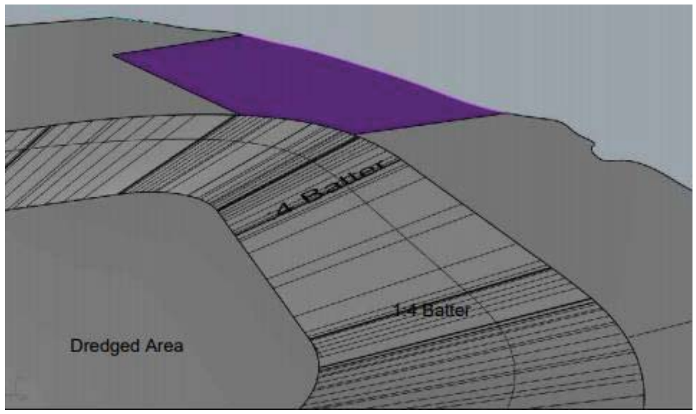


Figure 7: Dredge batter & Shellfish bed (blue) showing clash

Due to the ecological and cultural significance of the shellfish bed it was proposed that it was not acceptable to potentially remove or disturbed the section of shellfish bed that could be affected by the dredge batter.

Given the operational requirements of the boatyard and the directly adjacent slipway it was determined that it was not possible to reduce the dredge depth (and thus the project angle of the dredge batter). Additionally, it was assessed that it was not possible due to the geotechnical long-term stability of the site to increase steepness of the batter.

Given the requirements to preserve the shellfish bed and dredge depth, and the geotechnical limitations of the dredge batter, a retaining structure is required to support the edge of the shellfish bed. Two basic designs have been considered: a solid vertical wall (palisade or solider pile wall), or stabilised revetment structure.

The main consideration in the design of this structure is to have as minimal ecological or environment impact as possible while still achieving the required retaining over the available profile. It is apparent that the most practical and efficient method of achieving this is with a rock revetment structure due to its simple installation & construction and easy removal (if necessary) compared with comparable alternatives – pile and panel wall, concrete mattress or cement stabilised face.

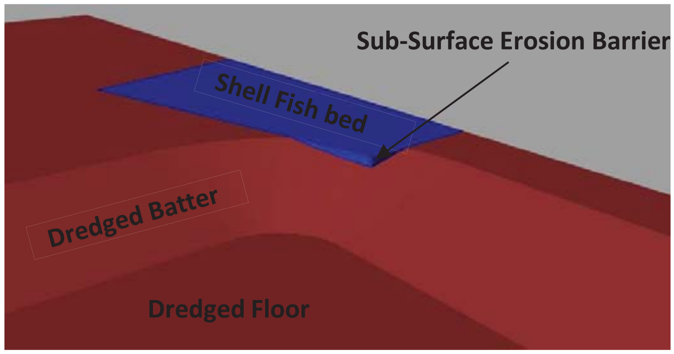


Figure 8:Concept depicting how the sub surface erosion barrier will retain edge of shellfish bed while still allowing required dredging.

Due to the alongshore longshore drift motion & current on the site discussed above, it is apparent that there may be a migration of the shellfish bed north and onto the existing slipway.

To stabilise the shellfish bed and prevent material building up on the slipway it is intended that the sub-surface erosion barrier as a solid fixed structure positioned perpendicular to the foreshore will act as a groyne like structure. This barrier will still have the same effect as a traditional groyne, that being to interrupt the alongshore drift motion and in turn limit the movement of the sediment. As shown in Figure 9, the structure will maintain the shellfish bed by allowing material to be deposited, but will keep the slipway clear by scouring out the material sitting on the slipway. Because the slipway is a hard structure this scouring will not cause any damage to the slipway structure.

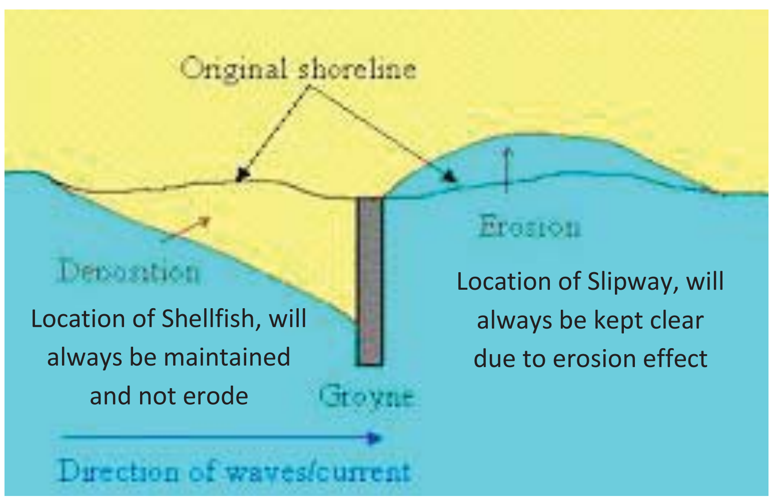


Figure 9: Illustration of how a groyne works

3.4 Timber Jetty

Please refer to drawing series 0155-0504-0002

The timber jetty will be constructed using marine grade H6 timber and piles, as per the drawings.

The piles will be pile driven, drilled and piled or drilled and grouted depending on the strata encountered. Preliminary geotechnical data suggests the latter option is most likely. In total there are 30 PE spine piles and 4 PE sleeved steel piles. This work will be conducted from Total Marine's piling barge. Considering tolerances and over drilling it is assessed that the total area affected for all the piles will be approximately 4m2 and an average of about 0.25 m3 of seabed removed per pile.

Figure 10: 50t Piling barge 'Northland Piler'

3.5 Pontoon

A pontoon will be constructed to support the maximum bending moment and shearing forces that will be incurred in the pontoon. As well, it will be capable of resisting the berthing impact loads and environmental forces of a 50' launch.

The pontoon is primarily comprised of a polystyrene core which gives it the required buoyancy, and will include strategically placed steel rebar for strength. Then an approximately 50mm of concrete cover will be used to bind it all together. Timber walers run down the sides of the pontoon and are held in place with galvanized steel through rods to support the bending moment. The stainless-steel pile guides and fenders are then attached.

Figure 11: Concrete pontoon casting process.

4.0 Conclusion

The proposed design, structure and methodology is consistent with other structures built by Total Marine historically. The design and materials proposed will result in a structure that will be fit for strength and purpose with minimal maintenance for 35 years.

5.0 References

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Brown/Dr Wilson 2018/2019 --- July 2018/Aug 2019

Andrew Johnson *BEng (Ocean)(HONS)*

Design & Project Engineer – Total Marine Group.

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www.4sight.consulting