Whanganui Port Wharf: Aquatic Assessment of Environmental Effects

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Prepared for Whanganui District Council

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EXECUTIVE SUMMARY

Te Pūwaha (a project collaboration between district and regional councils, industry, and in partnership with Whanganui iwi) was established to address the poor condition of the Whanganui Port and identify opportunities to enhance the lower Whanganui River and Estuary. The repair works proposed by Te Pūwaha are considered essential to improve the deteriorated state of the port and to create an economically and environmentally viable asset that can provide long-term benefit to the resident community. EOS Ecology was commissioned by Whanganui District Council to provide an assessment of the environmental effects of the proposed works on the intertidal and subtidal ecology of the Whanganui Estuary, with a particular focus in this report on the proposed construction around the wharves.

The proposed wharf works will include the removal of Wharves 2 & 3 and replacement with new structures built on the existing footprint. A boat hoist will be installed between the two new wharves, a replacement revetment wall will be installed between Wharf 3 and the adjacent public boat ramp, and abandoned marina piles will be removed from the port basin. The addition of a two-stage stormwater treatment system has also been proposed.

To assess the effect of these works on the aquatic ecology of the Whanganui Estuary, EOS Ecology undertook ecological surveys of subtidal and intertidal habitat within the estuary on 4–5 November 2021. The Whanganui Estuary is a relatively shallow and dynamic estuary system, characterised by freshwater river inflow and substantial tidal influence. Intertidal and subtidal habitats are present within the estuary and port basin, with an exclusively subtidal habitat under the wharves. The infauna communities at intertidal and subtidal sites were quantified within the main channel of the lower Whanganui River, in the port basin, and under the wharves via the collection of infauna cores.

The ecological surveys found a total of 28 macroinvertebrate infauna taxa across all sites, but the community structure was different between intertidal and subtidal areas. Due to the dominance of subtidal habitat around the wharves, further attention was given to the subtidal sampling sites. A total of 20 macroinvertebrate infauna taxa were identified in the subtidal sampling sites, with pipis (*Paphies australis*) being the most abundant at 60.7% of all individuals collected in the subtidal zone. The community composition was similar between subtidal sites under the wharves, in the port basin and in the main river channel, suggesting that the area under the wharves is not unique within the subtidal areas of the wider estuary. No threatened species were recorded in any of the subtidal or intertidal sampling sites.

Although the community structure was similar across all subtidal areas (including wharf, port, and river sites), the size of the pipis found did vary between areas. The largest pipis were found in the main channel of the river (outside of the port basin) and smallest were in the port basin. The pipis collected from the sites under the wharves were slightly smaller than those collected from the river, but larger than those found in the port basin away from the wharves.

A literature review identified fish species that are present in the Whanganui Estuary on a permanent or regular basis, including īnanga, smelt, shortfin eel, yellow-eye mullet, grey mullet, yellow-belly flounder, and black flounder. Several recreational fish commonly targeted at the river mouth may also be found in the port basin, including kahawai, snapper, john dory, and kingfish. All of these species are highly mobile, and likely move about freely within the estuary.

The potential effects of the proposed wharf construction and operation on the aquatic ecology of the Whanganui Estuary include the release of contaminants (fine sediment, machinery-related hydrocarbons, and wet cementious material) in the construction phase, the disturbance or alteration of the subtidal habitat under the wharves, and the discharge of contaminants (fine sediment, heavy metals, and hydrocarbons) through stormwater.

Sediment release is expected during the wharf works due to a combination of disturbance and removal of the current seabed under the wharves, the construction of the new rock revetment under the wharves, and the introduction of sediment from the land by machinery operating from the shore. Given the existing high sediment load of the Whanganui River and Estuary, the sediment released during wharf construction is not expected to be outside of typical

suspended sediment concentrations in the area. As periodic dredging activities are already occurring within the port basin to maintain a navigable water depth for vessels, it is likely that the biota living within the port already experience periods of sediment resuspension. Additionally, higher-than-normal sediment loads will likely flush out of the system quickly due to the strong river and tidal flows at the mouth of the Whanganui Estuary, further reducing the impact of construction-related sediment release on the system.

The proposed use of concrete in the wharf works comes with a risk of untreated cement-contaminated water entering the environment. Cementitious wastewater has a very high pH, and if released into the estuary could result in detrimental effects to local aquatic taxa. There is also a risk of petroleum-based products being released into the environment by machinery during the construction phase. Steps should be taken to minimise the risk of spills, and preparations made to be able to contain any accidental release of these chemicals.

Construction activities around the port basin will cause some disturbance and displacement of aquatic habitat, as wharf piles and sediment will need to be removed before new structures can be installed. This will result in the disturbance or loss of the communities that currently inhabit the subtidal and intertidal areas within the port, as the removal or covering of colonised material will be unavoidable. Pipis, the most common infauna invertebrate in the subtidal areas of the estuary, can cope with short-term disturbances (less than eight to ten days) and can move great distances away from areas that become unsuitable. The ability of pipis to respond to the proposed works can be increased by staging the works to keep disturbance to a minimal timeframe.

While the wharf works will result in the loss of subtidal soft sediment habitat, a new rocky area will be created by the rock revetment under the new wharf structures. Similar habitat exists nearby, and these pre-existing rocky shore areas can contribute to the colonisation of the new habitat. The sloped walls of the proposed rock revetment are preferable to a vertical wall, and using a softer or textured rock will create more micro-habitat space and allow greater opportunity for new recruitment. The new rocky shore area created by the rock revetment could also provide cover and a food source for resident fish populations.

The addition of a two-stage stormwater treatment system would provide a benefit to the aquatic environment where none currently exists. While no measurements are available regarding the current release of contaminants through stormwater discharge, the proposed system will allow for the removal of some suspended solids, heavy metals, and petroleum-based compounds. If these measures are implemented, the receiving environment should benefit from the improved quality of the stormwater discharge.

With the implementation of recommended mitigation measures, we expect that the overall level of potential adverse effects of the wharf works to the aquatic ecology of the Whanganui Estuary will be very low. The new opportunities for rocky habitats under the wharves can enhance the environment and increase the abundance of the estuary system, whilst the creation of a stormwater treatment system will reduce the current input of stormwater-derived contaminants to the estuary.

1 INTRODUCTION

The original wharf structures at the Whanganui Port date back to the 1880s, as the growing European settlement began to support increased import/export operations through the port. Over time the port has continued to grow and change as demands have changed, and today there are three wharf structures, a hardstand between Wharf 2 and Wharf 3, and a public boat ramp at the east (upstream) end of Wharf 3 (Figure 1). These existing structures have undergone varying degrees of maintenance and reconstruction, and a 2009 assessment of the port has identified conditions of "untidiness, neglect and decay" as well as several serious health and safety risks (Atkinson 2009a).

To address the concerns of the current condition of the port and its effect on the lower Whanganui River and Estuary, the Te Pūwaha Port Project was initiated. Te Pūwaha is a collaboration between Whanganui District Council (WDC), Horizons Regional Council (HRC), Q-West Boat Builders, Whanganui District Employment Training Trust, and Whanganui Iwi. The project aims to secure the marine industries in Whanganui, connect with the community and make the area more attractive for users, increase environmental responsibility of port operations, and honour the heritage of the land. The Whanganui River is recognised by law as a living and indivisible whole, Te Awa Tupua, and guidance from Te Mata Puau introduced the concept of an abundance model (He Ara Tuku Rau) to recognise Te Awa Tupua and Tupua te Kawa (the natural law and value system of Te Awa Tupua). Under this model, the project seeks to identify restoration and enhancement opportunities in addition to the measures needed to avoid, remedy, or mitigate the effects of the port works.

As part of the scope of the Te Pūwaha Port Project, a series of works will be done in the port basin to improve the Whanganui Port and create an economically and environmentally viable community asset for the next fifty years and beyond. Whanganui District Council commissioned EOS Ecology to undertake an aquatic ecology assessment to be included as part of the Assessment of Environmental Effects (AEE) in the resource consent application. The extent of this report is limited to an assessment of effects of the redevelopment of the wharf areas and associated riverbed disturbance on the subtidal benthic (infauna macroinvertebrates) ecology and fish ecology. An assessment of the potential effects of additional proposed work (including dredging activities and associated spoil disposal, reclamation of a designated intertidal area for a new public space, ongoing port operations, and existing and future use of the port area and neighbouring river) will be provided in a later report, and as such will not be covered in this current report.

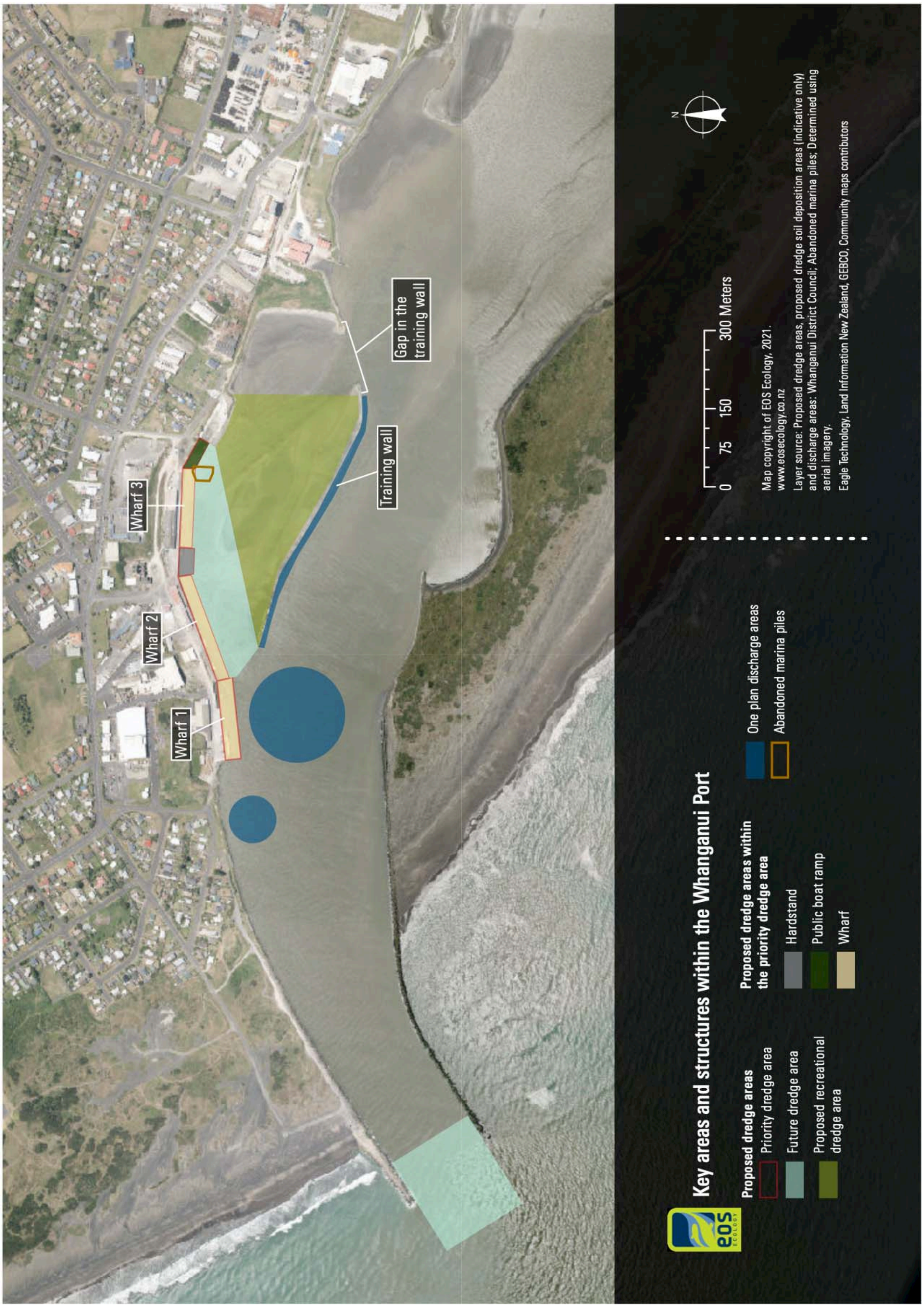


Figure 1 Map of the Whanganui Estuary and Port, highlighting the key areas and structures within the port basin.

2 METHODS

2.1 Infauna Ecological Surveys

41 sites were sellected for ecological assessment, with 20 sites in subtidal habitats and 21 sites in intertidal habitats (Figure 2). Sites were chosen to ensure coverage of the proposed dredging and deposition areas, along with sites in unaffected areas to provide a local comparison to potential impact sites. Infauna cores were collected at each of the 41 sites on 4–5 November 2021.

Using the same methodology for all sites, subtidal samples were collected via use of a boat and divers and intertidal samples were collected by hand during low tide exposure. A 130 mm diameter core was pushed 150 mm into the sediment then dug out and inverted into a 500-micron mesh bag. This was then washed in seawater to remove sediment before emptying out and preserving in 70% isopropanol (isopropyl alcohol) prior to laboratory processing. Two replicate cores were taken at each to site to correspond with past studies in this location (Brennan *et al.*, 2019), and with other nationally recognised protocols for determining densities of pipis (*Paphies australis*)(Pawley *et al.*, 2013; Berkenbusch & Neubauer, 2018).

A free search was also carried out during the intertidal sampling to ascertain the extent and distribution of pipis and other shellfish. This involved a hand search over low tide exposed areas and shallow water areas around the lower intertidal/upper subtidal zone. Other observations on distribution of fauna were also made during this search.

In the laboratory, each infauna core sample was washed through a 500-micron sieve prior to processing. Processing involved the identification and counting of all invertebrates to the lowest practical level of classification using a full count procedure and stereo microscope.

2.2 Data Analysis

Density (presented as numbers per double core) and taxa richness were calculated for each site from the combination of the two infauna samples collected at each site. Distribution of the infauna (intertidal and subtidal) community was examined using non-metric multidimensional scaling (NMS). NMS is a non-metric statistical technique that condenses site data to a single point in low-dimensional ordination space using some measure of community dissimilarity (Bray-Curtis metric in this instance). Interpretation is straightforward such that points on an x-y plot that are close together represent sites that are more similar in community composition than those further apart (Clarke & Gorley, 2015). Differences in infauna community composition between the intertidal and subtidal zones, and between the different sampling areas (wharf/port/river) within the subtidal zone, were tested using the analysis of similarities (ANOSIM) procedure, which is a non-parametric procedure applied to the similarity matrix that underlies the NMS ordination. ANOSIM is an approximate analogue of the standard ANOVA (analysis of variance) and compares the similarity between groups using the R test statistic. R=0 where there is no difference in the infauna community between groups, while R=1 where the groups have completely different communities. Where ANOSIM results showed significant or near-significant differences in infauna community compositions, the similarity percentages (SIMPER) procedure was used to determine which taxa where responsible. NMS, ANOSIM, and SIMPER were all carried out in PRIMER v7.0.17 (Clarke & Gorley, 2015).

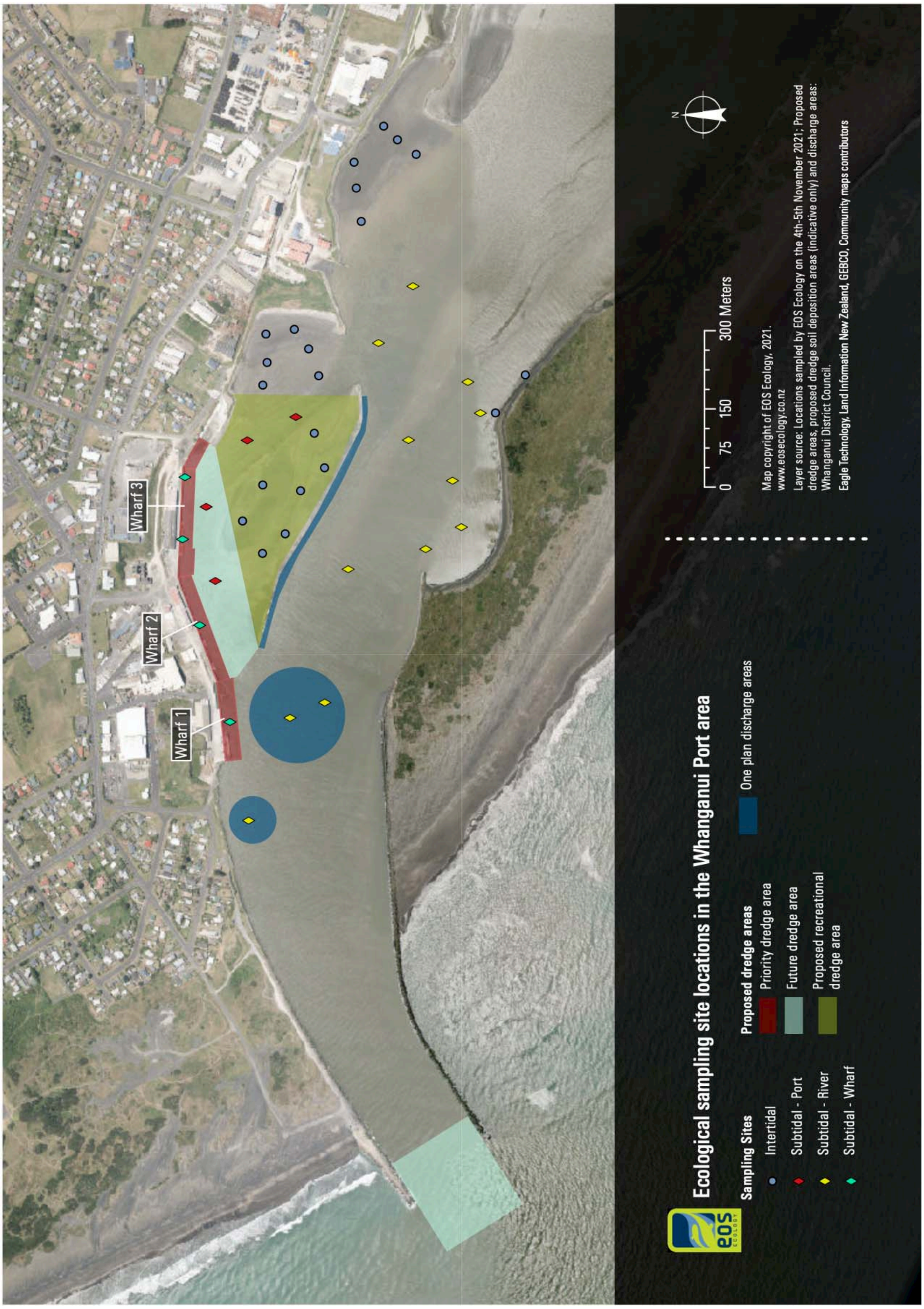


Figure 2 Sampling sites to assess the aquatic ecology of the Whanganui Estuary and Port. Sampling undertaken by EOS Ecology on 4–5 November 2021.

3 STATE OF THE EXISTING ENVIRONMENT

3.1 Whanganui Estuary Overview

The 7,169 km^2 Whanganui River catchment is dominated by native forest and pasture (56% and 35%, respectively) and has a highly modified estuary catchment (Stevens & Robertson, 2017). The Whanganui Estuary is a large (3.53 km^2) and shallow dynamic river estuary characterised by tidal flows, coastal surges, and freshwater flood events (Shand, 2016; Stevens & Robertson, 2017). Tides are semi-diurnal, with tidal ranges of 0.9 m during neap tides and 2.1 m during spring tides (Shand, 2016). Peak tidal flows at the river mouth are reported to be between 300 m^3/s (neap tide) and 1000 m^3/s (spring tide), with tidal influence reaching up to 11 km upstream (Shand, 2016). The lower Whanganui River has a mean annual freshwater flow of 210 m^3/s and a mean annual flood flow of 2684 m^3/s, with maximum flood flows recorded between 1063 m^3/s (1969) and 4755 m^3/s (2015) (Blackwood & Bell, 2016; Stevens & Robertson, 2017). The substantial tidal range and large freshwater inflow contribute to the flushing of the estuary system, and the Whanganui Estuary has been classified a Shallow, Short Residence Time Tidal River Estuary (SSRTRE) (Dudley *et al.* 2017).

Intertidal habitat makes up approximately 27% (0.96 km^2) of the 3.53 km^2 estuary area and consists predominately of firm muddy sand and soft mud (66% and 17%, respectively) (Stevens & Robertson, 2017). Subtidal habitat, the dominant estuary habitat, exists across the remaining 73% (2.527 km^2) of the estuary (Stevens & Robertson, 2017).

3.1.1 History of the Whanganui Port

The Whanganui River and the lands around the mouth of the river have been an area of human significance since the earliest arrivals from East Polynesia. Present day mana whenua can be traced back to the initial settlement of the area, perhaps as early as AD 1250–1300, and a Ngā Rauru settlement functioning as a fishing pā formally sat near the area currently occupied by the Whanganui Port (Dodd, 2021). European traders and missionaries began to arrive in the early 1800s, and a shore whale fishery was operating at the mouth of the river by mid-1841. The Crown "purchased" Whanganui in 1848, resulting in further European settlement to support the growing town and river port. Whanganui was declared a port of entry in 1855, and a pilot station and customs house soon followed (Dodd, 2021).

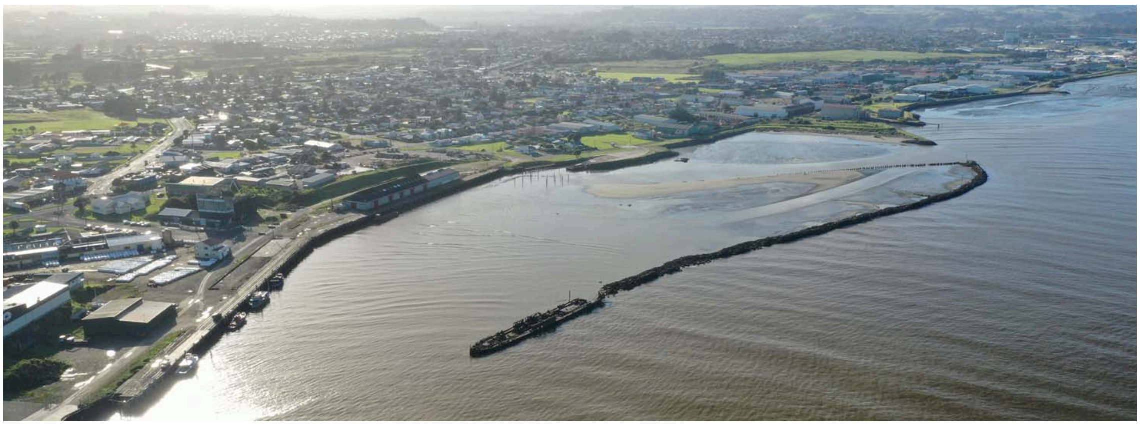
The original wharf facilities at Whanganui Port were built in the mid-1880s (Figure 3), including the construction of the 260 m North Mole, a rail link connecting the town and the port, and a small goods shed (Dodd, 2021). A freezing works was added in 1890 to support a local frozen meat export industry, and over time the port and associated buildings have continued to grow and change to reflect the use and industries of the day (Figure 3). In 1903 the wharf was described as 320 feet in length, and the western end was extended in 1908 to increase storage (Dodd, 2021). Wharf 3 was added around 1924 (Atkinson, 2009a).

Today the port is in a derelict condition, with Atkinson (2009b) reporting un-repaired structural damage and deterioration from decay and worm infestation in the timber structure of the wharves, and failure of cross braces and bottoms walings as a result of deferred maintenance. The structural elements below the water are reported to be in a heavily deteriorated condition, although the deeper structures were not inspected due to ongoing siltation infilling the dredged area under the wharves (Teear, 2021). The horizontal infrastructure of the port is also reported to be in poor condition, with a lack of formalised discharge of stormwater due to unmaintained and broken stormwater pipes (Phil Wardale, WDC, pers. comm. 29 November 2021). As a result, untreated stormwater runoff is currently soaking through the broken wharf structure and making its way into the port area.

Heads wharf being constructed in May 1884.
(Harding & Denton Collection, Wanganui District Library, NZC2.1.271 (Source: Dodd, 2021))

Heads wharf probably during the early 1900s.
(Reproduced from Sole 2008:84 (Source: Dodd, 2021))

Whites Aviation aerial photo of wharves in 1948 (Source: Dodd, 2021).



Drone photo taken 20 May 2021 at low tide. (Source: Horizons Regional Council)

Figure 3 **Historic and recent photos of the Whanganui Port wharves.**

3.2 Physico-chemical Factors

3.2.1 Port and Wharves

The Whanganui Port is on the northern side of the Whanganui River, approximately 1 km upstream from the river mouth. The port is contained by three wharf structures on the north (true right) bank of the river and a training wall to the south, in the centre of the river (Figure 1). The wharves are timber piled structures with reinforced concrete deck slab supported by timber capping beams and stringers. Wharf 1 sits at the western (downstream) end of the port, with Wharves 2 and 3 following upstream along the true right bank. A hardstand is located between Wharf 2 and Wharf 3, and a public boat ramp is at the east end of Wharf 3 (Figure 1). A series of abandoned marina piles extend into the port basin area between the boat ramp and the adjacent end of Wharf 3.

A gap between the east (upstream) end of the training wall and the east end port (Figure 1) was opened in 1994 to allow a portion of the river to flow through the port, contributing to a flushing of this habitat. Soft sediments dominate the port basin, with firm muddy sand common in the intertidal areas, changing to soft mud in the transitions to subtidal habitats and with some areas of firmer sand in the deeper channels (Stevens & Robertson, 2017).

3.2.2 Bathymetry

A bathymetric survey by Discovery Marine Ltd (DML) in August 2021 shows that the area adjacent to and under the existing wharves is deeper than much of the rest of the port basin (Figure 4). The upstream and downstream openings of the port basin are also deeper, with a moderately deep channel running from the upstream opening to the east end of Wharf 3 (Figure 4).

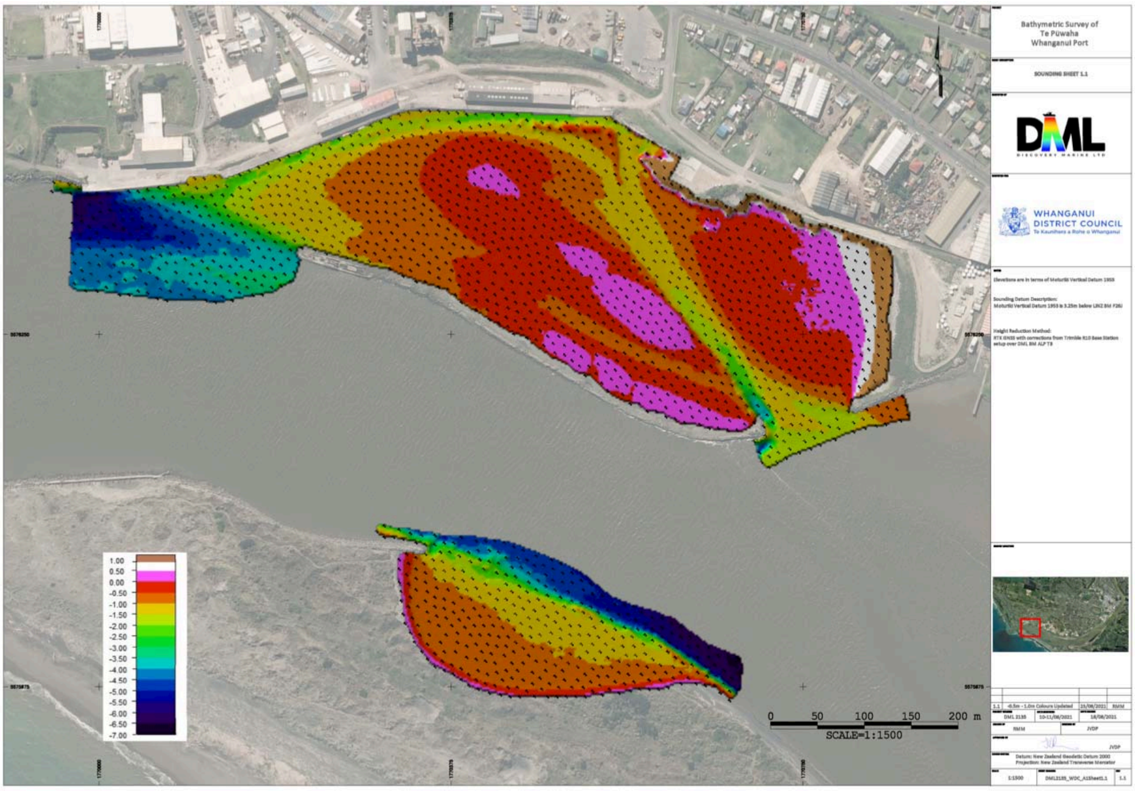


Figure 4 Bathymetric survey of the Wanganui Port, as undertaken by Discovery Marine Ltd (DML) in August 2021.

3.2.3 Hydrodynamics

Due to the partially open nature of the Whanganui Port, the movement of water through the port basin is somewhat dynamic. The gap in the training wall to the east of the port allows a portion of the lower Whanganui River to divert into and flow through the port basin, and the opening at the western end of the basin allows for tidal inflow on the incoming tide. A 2018 assessment by Shand & Knook reported depth-averaged velocity magnitudes between <0.5 m/s and >1.0 m/s through the port basin, with a change in direction of flow drawing water from the river mouth area into the port during flood tide and low river flow (Figure 5). Shand & Knook (2018) also noted that a widening of the channel just south of the public boat ramp decreases localised water velocity, and periodic dredging under the wharves has maintained an area of higher flow velocity adjacent to the wharves.

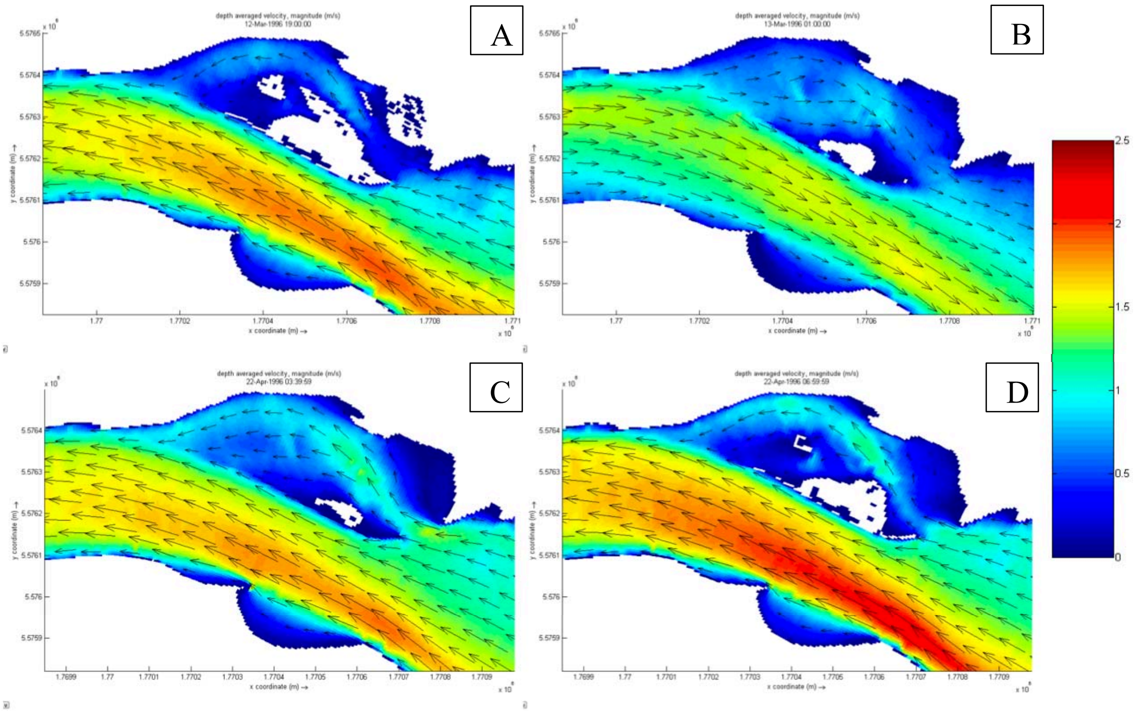


Figure 5 Depth-averaged velocity magnitude (m/s) of the lower Whanganui River and Port basin. A: low river flow, ebb tide; B: low river flow, flood tide; C: high river flow, ebb tide; D: high river flow, flood tide. (Source: Shand & Knook, 2018)

3.2.4 Water Quality

Horizons Regional Council undertakes water quality monitoring of the Whanganui River on an approximately monthly basis. The areas that are monitored include Te Rewa (approximately 49 km upstream of the project area) and Wharf Street Boat Ramp (approximately 6 km upstream of the project area) (Figure 6). The results between the two sites are broadly similar, indicating an average turbidity value between 40-50 NTU for the two sites (Table 1). These turbidity values are significantly more than the 4.2 NTU trigger value specified in the ANZECC guidelines (ANZECC, 2018) for warm dry lowland rivers (note that the ANZECC guidelines recommend that trigger values should be applied as the 80th percentile of the reference system, should a reference system exist).

The LAWA website[1] data collected over the past ten years from the Te Rewa site shows that water clarity measures (black disc and turbidity) are within the worst 25 % of 'like sites' in New Zealand. This site also shows that nitrogen measures (total nitrogen, total oxidised nitrogen and ammoniacal nitrogen) and dissolved reactive phosphorus are within the best 50 % of 'like sites' in New Zealand, whilst total phosphorus are within the worst 50 % of 'like sites' in New Zealand.

The geology of the Whanganui River catchment is such that the soils are erosive, which is reflected in the high suspended sediment and phosphorus levels. The erosive nature of the catchment's soils is further reflected in NIWA's suspended sediment yield estimator[2], which, based on an empirical model that relates sediment yield to mean annual rainfall and to an 'erosion terrain' classification that is then calibrated off river-gauging data, indicates that the mid Whanganui River catchment has a suspended sediment yield of 500–2000 tonnes per km^2 per year. Based on the estuary classification by Stevens & Robertson (2017), and associated CLUES modelled data, the Whanganui Estuary has an estimated suspended sediment load of 5898 kilo tonnes per year, which is more than five times the estimated natural state suspended sediment load. Suspended sediment is readily carried out to sea at the estuary as river flows typically dominate over tidal flows (Stevens & Robertson, 2017).

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[1] www.lawa.org.nz/explore-data/manawatu-wanganui-region/river-quality/whanganui/whanganui-at-te-rewa

[2] www.niwa.co.nz/freshwater/management-tools/sediment-tools/suspended-sediment-yield-estimator

Figure 6 Location of water quality monitoring sites in the lower Whanganui River. Sampling undertaken by Horizons Regional Council (HRC).

Table 1 Summary water quality data from two locations in the lower Whanganui River (refer to Figure 6 for locations). 'Value' is the average value for that time series. 'No.' refers to the number of records for that value. Data provided by Horizons Regional Council (HRC) from their monitoring programmes.

Location & time period	Turbidity (NTU)#		Turbidity (FNU)#		Black disc (m)		Suspended sediment conc (mg/l)		Total Suspended Sediment (g/m^3)	
	Value	No.	Value	No.	Value	No.	Value	No.	Value	No.
Te Rewa	**49.6**	**258**	**42.0**	**101**	**0.83**	**120**	**82.8**	**94**	**94.4**	**171**
Before 2015	42.7	211	37.7	54	0.83	91	53.4	47	86.4	124
2015–2017	79.1	35	26.3	35	0.87	23	75.2	35	84.1	35
2018–2019	84.8	12	106.3	12	0.70	6	216.8	12	208.0	12
Wharf Street Boat Ramp	**44.2**	**127**	**45.6**	**127**	**0.54**	**148**	**118.1**	**125**	**89.9**	**159**
Before 2015	40.2	149	41.3	48	0.54	148	93.3	46	89.9	159
2015–2017	*53.3	*36	53.1	36			144.2	36		
2018–2021	*43.6	*43	44.0	43			122.8	43		

The HRC record turbidity via two methods. The EPA 180.1 method (in NTU units) that uses a wider visible wavelength that is more sensitive to the effects of organic matter but better able to detect smaller particles; and the ISO 7027 standard (in FNU units) which uses near infrared wavelengths that are less susceptible to organic matter. Refer to Bright *et al*. (2018) for further information on the different between these two measures.

* Data presented is from the 'ISO-NTU' turbidity data provided by HRC due to no data being available for Turbidity (NTU). The ISO-NTU turbidity data is turbidity data collected via the ISO 7027 standard but converted to an NTU-equivalent value.

3.3 Infauna Macroinvertebrates

3.3.1 Community Composition

A total of 28 infauna taxa were identified from the 41 intertidal and subtidal sites within the Whanganui Estuary and Port. Of these 28 taxa, Corophiidae amphipod crustaceans (36 sites), pipi bivalves *Paphies australis* (30 sites), freshwater mud snails (*Potamopyrgus sp.*, 24 sites), and Flabellifera isopod crustaceans (17 sites) were the most widespread. All other taxa were found at 12 or fewer sites, with 16 taxa present at three or fewer sites. Taxa richness varied from 3–10 taxa per site, while densities ranged from 5–326 individuals per site.

NMS ordination of infauna community data partitioned by sampling site location showed little overlap between intertidal and subtidal sites (Figure 7). An ANOSIM comparing the infauna community at intertidal and subtidal sites showed an overall statistically significant (p=0.001) moderate (Global R=0.45) difference in community composition between the two tidal zones (Figure 7). SIMPER analysis indicated this difference was the result of the greater abundance of pipis (*Paphies australis*) in the subtidal zone, and the greater abundance of the amphipod *Paracorophium excavatum* and the mud snail *Potamopyrgus sp.* in the intertidal zone sites.

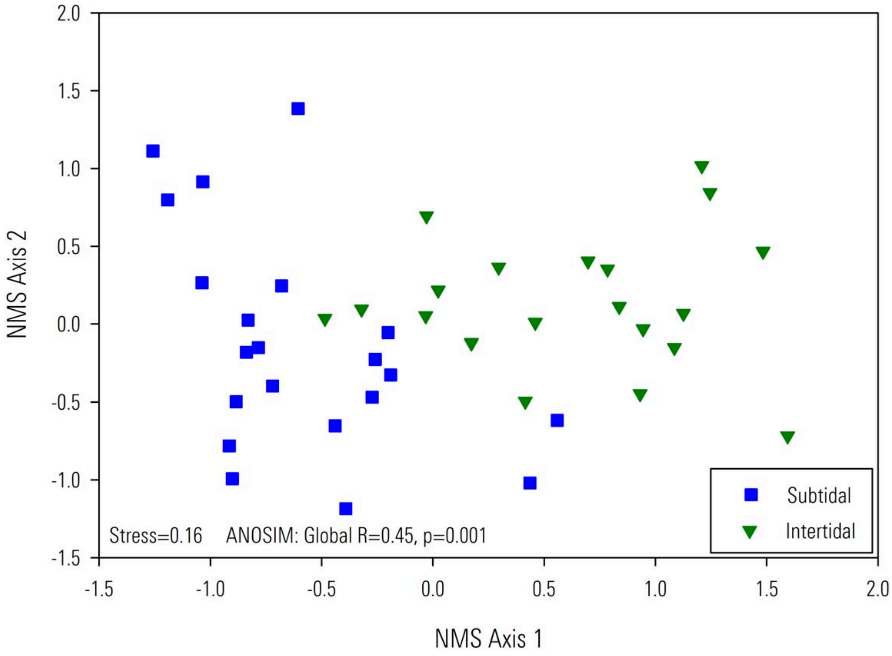

Figure 7 Non-metric multidimensional scaling (NMS) ordination of benthic infauna collected from 21 intertidal and 20 subtidal sites in the Whanganui Estuary and Port by EOS Ecology on 4–5 November 2021. Green triangles denote sites in the intertidal zone and blue squares denote sites in the subtidal zone.

Subtidal Community

Given the difference between the infauna community composition in the intertidal and subtidal zones, and the nature of the wharf works primarily impacting the subtidal habitats under the wharves, further analysis has focused on the 20 subtidal sites.

Of the 1959 infauna animals found in the subtidal sites, a total of 20 taxa were identified. Pipis were the most abundant and accounted for 60.7% of all individuals (Table 2). The next most abundant subtidal infauna taxa were Corophiidae amphipods and the ubiquitous snail *Potamopyrgus,* at 31.4% and 3.9% overall abundance, respectively (Table 2, Figure 8). The remaining 17 taxa found in the subtidal infauna sites occurred at less than 1% overall abundance, meaning that the subtidal community of the Whanganui Estuary is dominated by a few (three) taxa. A similar community composition was evident for the subset of four subtidal sites adjacent to the wharf area, where pipis were the most abundant taxa (65.4% across all four wharf sites), followed by Corophiidae amphipods (27.9%) and *Potamopyrgus* (2.8%) (Table 2). Taxa richness was relatively low across all sites but was especially low in the wharf sites, with a total of nine taxa (and an average of five taxa per site) recorded from the wharf area (Table 2). Concomitantly, the total number of individuals found in samples from the wharf sites were less than those found within the port basin and river areas (Table 2).

No invertebrate taxa of conservation concern (as listed in the threatened species list of Freeman *et al.* (2014)) were recorded from the project area. Whilst the community was not dominated by taxa that are indicative of significant nutrient enrichment, contaminated sediment, or excessive fine sediment input (O'Brien *et al.*, 2010; Podlesińska & Dąbrowska, 2019), the community structure was uneven with only three taxa representing 96% of all individuals.

Within the subtidal sites, there was significant overlap of the infauna community in the wharf, port, and river sites (Figure 9). An ANOSIM comparing the infauna community of subtidal sites from the three sampling areas (wharf/port/river) showed that there was not a statistically significant (Global R=0.016, p=0.42) overall difference in community composition between the three sampling areas for the subtidal samples (Figure 9).

Table 2 Summary of benthic invertebrate fauna identified in infauna core samples collected at 20 subtidal sites within the different areas of the Whanganui Estuary (Port = 4 sites, River = 12 sites, Wharf = 4 sites) by EOS Ecology on 4–5 November 2021. Values are presented as average numbers per double core, with overall percent abundance in parenthesis.

Faunal Group 1	Taxa	Port	River	Wharf	Total
Chelicerata	Acarina	0.25 (0.2%)			0.05 (0.1%)
Crustacea	Anthuridae	0.5 (0.3%)		0.25 (0.4%)	0.15 (0.2%)
	Austrominius modestus		1 (1.1%)		0.6 (0.6%)
	Flabellifera	0.75 (0.5%)	0.17 (0.2%)	0.25 (0.4%)	0.3 (0.3%)
	Halicarcinus		0.08 (0.1%)	0.25 (0.4%)	0.1 (0.1%)
	Mysidacea		0.25 (0.3%)		0.15 (0.2%)
	Paracalliope sp.	0.5 (0.3%)			0.1 (0.1%)
	Paracorophium excavatum	80.75 (55.6%)	17.75 (19.5%)	19.75 (27.9%)	30.75 (31.4%)
	Phreatogammarus sp.		0.08 (0.1%)		0.05 (0.1%)
	Valvifera		0.08 (0.1%)		0.05 (0.1%)
Insecta	Collembola		0.17 (0.2%)		0.1 (0.1%)
	Pycnocentria		0.08 (0.1%)		0.05 (0.1%)
Mollusca	*Arthritica* sp.		0.08 (0.1%)		0.05 (0.1%)
	Cyclomactra ovata	3.5 (2.4%)	0.17 (0.2%)	0.75 (1.1%)	0.95 (1.0%)
	Paphies australis	41.25 (28.4%)	70 (76.7%)	46.25 (65.4%)	59.5 (60.7%)
	Potamopyrgus sp.	15.25 (10.5%)	0.58 (0.6%)	2 (2.8%)	3.8 (3.9%)
Polychaeta	*Heteromastus filiformis*			0.25 (0.4%)	0.05 (0.1%)
	Nereidae	0.5 (0.3%)	0.33 (0.4%)		0.3 (0.3%)
	Perinereis brevicirris	1.75 (1.2%)	0.42 (0.5%)	1 (1.4%)	0.8 (0.8%)
	Scolelepis sp.	0.25 (0.2%)			0.05 (0.1%)
Total$^{\#}$ Number of Individuals		**581**	**1095**	**283**	**1959**
Taxa Richness (Site Average)		**6**	**3.75**	**5**	**4.45**
Taxa Richness (Total$^{\#}$)		**11**	**15**	**9**	**20**

\# Refers to the total as calculated from all samples within each area.

Pipi bivalves (*Paphies australis)* (60.7%)

Corophiidae amphipod (*Paracorophium excavatum*) (31.4%)

Freshwater mud snail (*Potamopyrgus sp.)* (3.9%)

Figure 8 Images of the most abundant and widespread benthic infauna collected from 20 subtidal sites in the lower Whanganui.

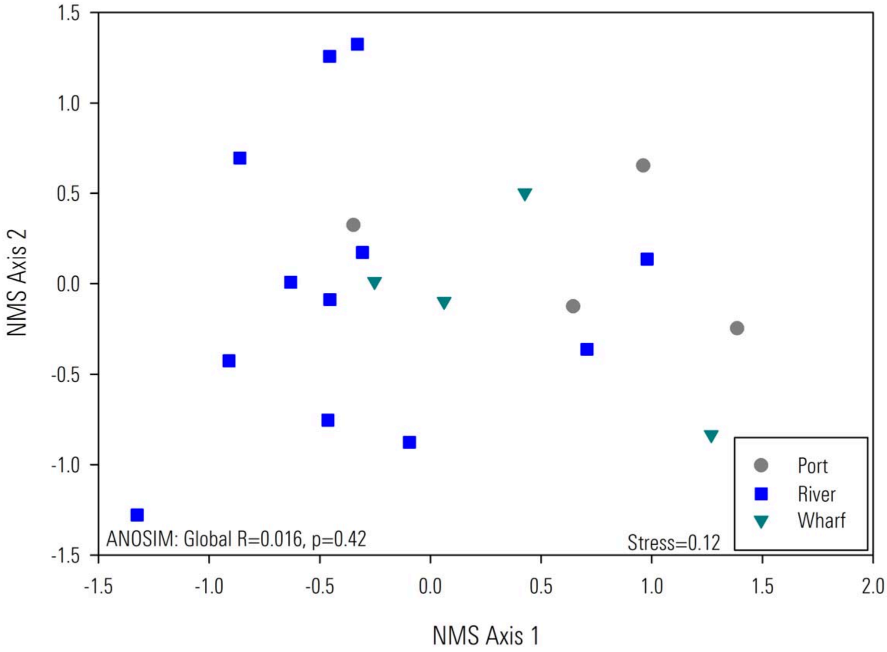

Figure 9 Non-metric multidimensional scaling (NMS) ordination of benthic infauna collected from 20 subtidal sites in the Whanganui Estuary and Port by EOS Ecology on 4–5 November 2021. Coloured symbols denote the area type where samples were collected (Port = 4 sites, River = 12 sites, Wharf = 4 sites).

3.3.2 Pipi Distribution

Pipis were much more abundant in the subtidal sites (mean of 59.5 pipis per site) than in the intertidal sites (mean of 3.7 pipe per site) (Figure 10). Given the difference in pipi density between the intertidal and subtidal areas, and the nature of the wharf works primarily impacting the subtidal habitats under the wharves, further analysis has focused on the 20 subtidal sites.

The density of pipis ranged from 1-313 individuals per double core collected in subtidal habitats, and pipis represented the highest proportion (50–99%) of total density in 14 of the 20 subtidal sites. Whilst there was a higher mean density of pipis in the river area (mean of 70 pipis per site) compared to the port and wharf areas (mean of 41.25 and 46.25 pipis per site, respectively), the high variability within sites (as shown by the large error bars) indicates that there is unlikely to be any statistically significant difference between the three surveyed areas (Figure 11). Within the wharf area, high densities of pipis were found at three of the four subtidal sites adjacent to the wharves (Figure 13), representing 87% of the total density in the site adjacent to Wharf 2, and 73% of the total density in one of the two sites adjacent to Wharf 3. The other site adjacent to Wharf 3, at the eastern extent of the wharf sites (Figure 13), had a much smaller density of pipis (3%) and was dominated by Corophiidae amphipods. This was also the wharf site furthest away from the main channel within the port basin and likely receives the slowest velocity of water flow (Figure 5; Shand & Knook, 2018), which is consistent with the preference of pipis to reside in estuarine areas with coarser sandy sediment and moving water above (Hayward *et al.*, 1994; Jones *et al.*, 2005).

The average length of pipis within the 20 subtidal sites was 22.97 mm, with the smallest individual measuring 1.5 mm and the largest measuring 39 mm. Whilst there appeared to be little difference in pipi density between the three areas (wharf, port, river) within the subtidal sites, there was some difference in the mean pipi size (Figure 12). The average size of pipis collected within the four sites adjacent to the wharves was 22.32 mm (range: 6–34 mm), which represents a larger average size compared to pipis collected from other subtidal sites within the port basin (average: 12.02 mm; range: 1.5–33 mm) but a similar size as pipis collected from subtidal sites in the main river (average: 25.27mm; range: 4–39mm) (Figure 12).

Pipis, which dominated the subtidal infauna in both number and distribution, are more tolerant of lower salinity and finer sediment than other *Phaphies* species such as tuatua (which was recorded by Brennan *et al.* (2019) in an intertidal beach area on the true-left side of the Whanganui River), although they are still relatively intolerant of silted habitats. They can extend further into river mouth/estuaries, although their range will stop as soon as salinity drops too low or sediment becomes too fine (Jones *et al.*, 2005).

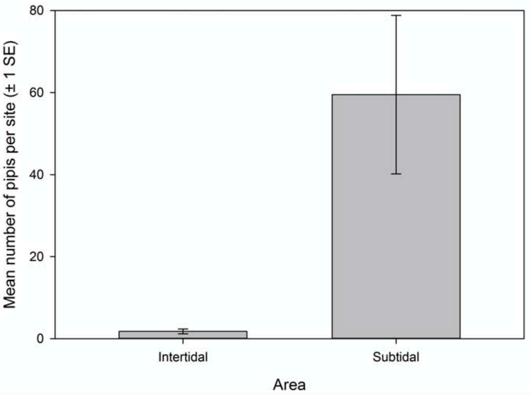

Figure 10 Mean number of pipis (*P. australis*) identified in infauna core samples collected at 21 intertidal and 20 subtidal sites in the Whanganui Estuary by EOS Ecology on 4–5 November 2021.

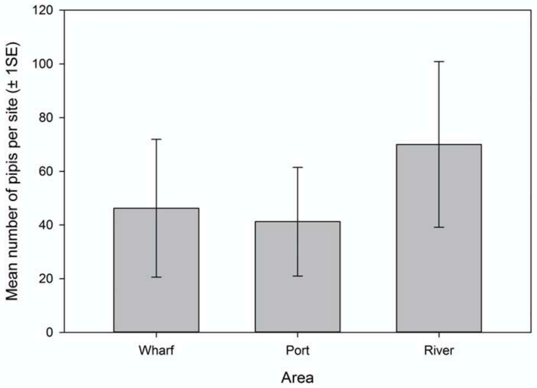

Figure 11 Mean number pipis (*P. australis*) identified in infauna core samples collected at 20 subtidal sites in the Whanganui Estuary by EOS Ecology on 4–5 November 2021. (Port = 4 sites, River = 12 sites, Wharf = 4 sites).

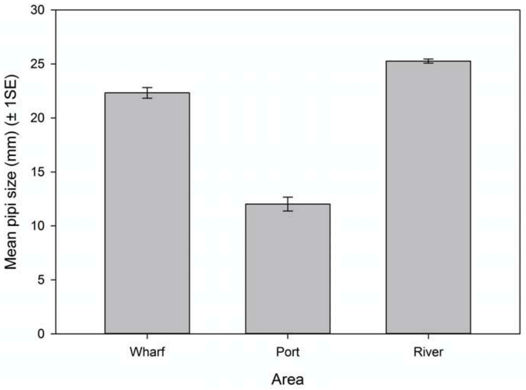

Figure 12 Size of pipis (*P. australis*) identified in infauna core samples collected at 20 subtidal sites in the Whanganui Estuary by EOS Ecology on 4–5 November 2021. (Port = 4 sites, River = 12 sites, Wharf = 4 sites).

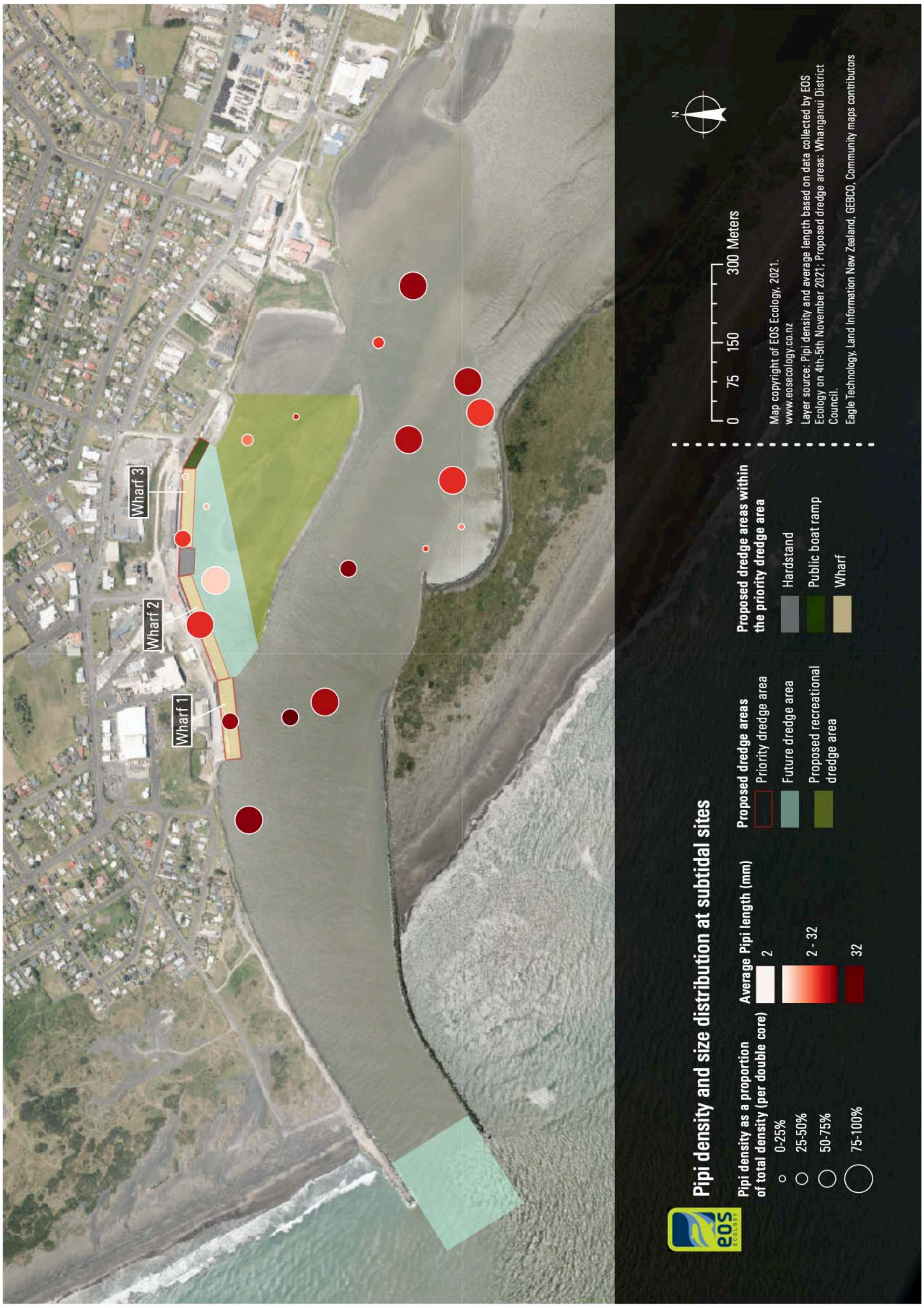

Figure 13 Map showing the density (as a proportion of total density per double core) and size distribution (average length) of pipis (*P. australis*) identified in infauna core samples collected at 20 subtidal sites in the Whanganui Estuary and Port by EOS Ecology on 4–5 November 2021.

3.4 Fish

The Whanganui River catchment has a relatively diverse freshwater fish assemblage (by New Zealand standards). The New Zealand Freshwater Fish Database (NZFFD; Crow, 2017) includes records for numerous native and endemic species including īnanga (*Galaxias maculatus*), shortfin eel (*Anguilla australis*), longfin eel (*A. dieffenbachii*), torrentfish (*Cheimarrichthys fosteri*), kōaro (*G. brevipinnis*), banded kōkopu (*G. fasciatus*), shortjaw kōkopu (*G. postvectis*), Cran's bully (*Gobiomorphus basilis*), upland bully (*G. breviceps*), common bully (*G. cotidianus*), and redfin bully (*G. huttoni*). It is also a renowned lamprey (*Geotria australis*) catchment, with Māori historically building extensive utu piharau (lamprey weirs) to capture them (Waitangi Tribunal, 1999). A number of estuarine and/or marine fish are present in the lower river including yellow-eye mullet (*Aldrichetta forsteri*), grey mullet (*Mugil cephalus*), smelt (*Retropinna retropinna*), yellow-belly flounder (*Rhombosolea leporine*) and black flounder (*Rhombosolea retiaria*) (Crow, 2017; Hicks & Bell, 2003). Some of these species penetrate significant distances upstream (i.e., tens of kilometers). Introduced fishes known to occur in the river include brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), and gambusia/mosquito fish (*Gambusia affinis*).

Recreational fishing is a popular activity at the river mouth, particularly from the easily accessed North Mole where kahawai (*Arripis trutta*) are a common target, although snapper (*Pagrus auratus)*, john dory (*Zeus faber*), and kingfish (*Seriola lalandi*) are also caught. Historically, many hapū travelled to the river mouth to fish for kahawai (Waitangi Tribunal, 1999).

Īnanga (the main species of the recreational whitebait catch) spawn in the lower reaches of rivers throughout New Zealand. Recent īnanga spawning surveys in the lower Whanganui River recorded spawning over a distance of 18.5 km, extending upstream from Kowhai Park north boat ramp (Rutledge, 2019). The downstream end of this spawning zone is some 10 km upstream of the river mouth (approximately 9 km upstream of the port basin).

3.5 Ecological Values Assessment

Roper-Lindsey *et al.* (2018) provides guidance for the evaluation of ecological value or importance in terms of four "matters": representativeness, rarity/distinctiveness, diversity and pattern, and ecological context. However, these "matters" are more suited for application to terrestrial habitats (e.g., forests, vegetation assemblages, and wetlands that have distinct boundaries) rather than freshwater or marine environments. Roper-Lindsey *et al.* (2018) actually states, "*Although a wide range of metrics and measures are used in the assessment of freshwaters there is no unifying set of attributes used to assign value or significance.*" We have therefore adapted a method that uses a suite of attributes to determine ecological value and from that, to assign a value to a site following the five-point scale of Roper-Lindsey *et al.* (2018) of Very High, High, Moderate, Low, Negligible. These assessment categories and criteria are outlined in Section 8.2, whilst the final characterisation of the surveyed area to the Roper-Lindsey *et al.* (2018) five point scale is provided in Table 3.

Table 3 Aquatic ecological values site assessment summary for the Whanganui Estuary adjacent to the wharf area. The five point 'values' scale (Very High, High, Moderate, Low, Negligible) of Roper-Lindsay *et al.* (2018) is based off the scoring of a number of characteristics. Further detail regarding the characteristics is provided in Appendix 8.2.

Site Score	Site Score Description	Reasoning for Site Score
Low	A system that is very modified and few aspects of its natural state remain, but with a few aspects that are still in moderate condition.	» No regionally or locally rare benthic infauna taxa were encountered; no taxa of conservation concern (as listed in the threatened species list of Freeman *et al.* (2014); low species richness and diversity with sites dominated by 1–3 taxa. High densities of pipis were found at some sites, but these are also present in the wider subtidal area. » Marine sediments near the wharf were dominated by silts (Reuben Hansen, Tonkin & Taylor, pers. comm. 9 December 2021). » Very high suspended sediment levels, ranked within the worst 25% of like sites in New Zealand. » Habitat generally homogenous, limiting the ability to support a diverse invertebrate and macroalgae community. » Intertidal zone limited through modified structures. » Limited or modified coastal vegetation zone. » Habitat very modified.

4 ASSESSMENT OF ENVIRONMENTAL EFFECTS

4.1 Overview of Proposed Scheme/Project Details

At the time of writing this report, there was little detail available regarding construction methodology and the planned timing of construction to be completed in the Whanganui Port basin. The scope of all proposed works was provided by the Te Pūwaha Port Project (Figure 14), general information on construction options for the wharves was provided by Offshore & Coastal Engineering Ltd (Teear, 2021), and information on proposed stormwater treatment provided by Industrial Waters Solutions Ltd. (IWS, 2021). This report considers the potential ecological effects of the following works:

- Wharves 2 and 3 will be completely removed and replaced with new structures in the existing footprint. A number of construction methodologies are being considered and will be confirmed at a later date, but EOS Ecology has been advised that all options will result in the removal of the subtidal habitat under the wharves (Phil Whardale, WDC, pers. comm. 29 November 2021). The construction materials that are being considered include timber, concrete that will be poured *in situ*, a steel sheet pile retaining wall, and a rock revetment wall. Figure 15 shows the preliminary concept for the profile of the replacement wharves.
- A boat hoist will be installed in the elbow between Wharf 2 and Wharf 3 and is expected to be constructed with a methodology closely aligned to that chosen for the wharves.
- The addition of a two-stage stormwater treatment is proposed, such that stormwater falling on Wharf 2 and Wharf 3 (a combined catchment of 3000 m^2) will be pumped to a treatment and storage facility for removal of suspended solids, heavy metals, and petroleum-based compounds (IWS, 2021). The location of the discharge will be either into the port basin or into the main river channel.
- A series of abandoned marine piles will be removed from the area adjacent to the east end of Wharf 3. This is expected to be accomplished through vibration or a combination of cutting and dredging (Phil Whardale, WDC, pers. comm. 29 November 2021).
- A replacement revetment wall will be installed between the east end of Wharf 3 and the public boat ramp.

Figure 14 **A summary of proposed work to the Whanganui Port.** (Source: OCEL (Teear, 2021))

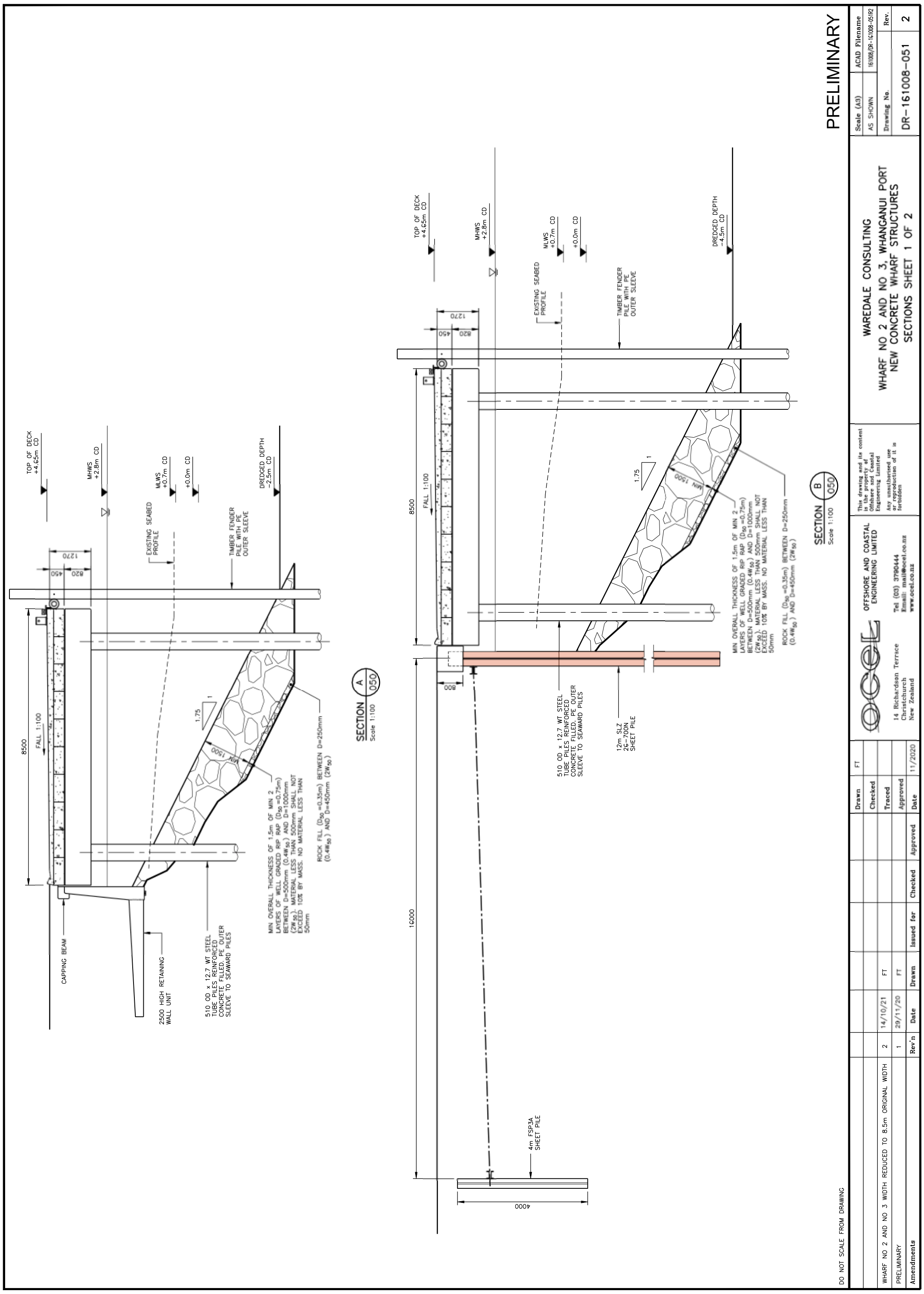

Figure 15 **Preliminary concept for the profile of replacement Wharf 2 and Wharf 3.** (Source: OCEL (Teear, 2021))

4.2 Potential Effects

The potential effects of the proposed works on aquatic ecology can be split into construction and operational effects. Construction effects relate primarily to the wharf repair works. Potential construction effects include the discharge of contaminants (especially fine sediment, machinery-related hydrocarbons, and wet cementitious material) and habitat disturbance (e.g., to the bed of the port area along the wharf during construction). Operational effects relate to the ongoing effects of the proposed structures once they are constructed and operating. Potential operational effects include a change in habitat under the replacement wharves, and the discharge of stormwater contaminants off the wharf area (e.g., fine sediment, heavy metals, and hydrocarbons).

4.2.1 Contaminants

Sediment

The wharf construction activities could generate sediment and disturb settled sediment underneath the wharves when moving or placing material, and sediment may also be introduced from the land via machinery operating from the shore or from the new rocks (and 'run of pit') being placed during construction of the revetment walls. Although sedimentation is a natural process within estuaries, increased inputs of land-derived (terrigenous) sediment to river and estuary environments can result in increased turbidity and suspended sediment concentrations and, with excess sediment, result in increased deposition. The impact of inputs of terrigenous fine sediment has been documented in a number of New Zealand studies on estuary and marine environments (Lohrer *et al.*, 2003; Thrush *et al.,* 2003a; Thrush *et al.,* 2003b; Cummings & Thrush, 2004; Gibbs & Hewitt, 2004; Taylor & Keeley, 2009). Terrigenous sediment can be detrimental to the survival of intertidal and subtidal invertebrate biota as it reduces light penetration into the water column, impacting primary production of pelagic phytoplankton and benthic macrophytes (algae that live in or on the sediments) and thus reducing a key food component to suspension feeders, herbivorous benthic grazers and deposit feeders (Gibbs & Hewitt, 2004). Suspended sediments can also interrupt feeding and respiration by clogging gill structures of filter feeders and can cause reduced oxygen levels as oxygen in the water column is consumed by microbes that break down the organic content in the sediment. Optical effects of suspended sediment are particularly prevalent when particles have a fine grain size. Increased turbidity can affect early life stages of benthic organisms and larval settlement (Schiel, 2004). Once settled from the water column, sedimentation can negatively impact benthic environments. Shoaling, embeddedness and other physical modification of habitat can result from sudden changes in sediment supply. Response to inputs of terrigenous sediment over 1 cm in estuaries by bivalves (*Paphies australis* and *Macomona liliana*) typically show a slow recovery of species, especially the response by juveniles (Cummings & Thrush, 2004).

The level of impact from sediment is, in part, determined by the ambient environmental conditions experienced. The Whanganui Estuary is broadly classified as a Shallow, Short Residence Time Tidal River Estuary (SSRTRE), indicating that it has a large flushing potential. A general description of the estuaries in the region by Davis-Colley *et al.* (2015) and for the Whanganui River specifically by Blackwood & Bell (2016) are that it is a well-flushed, turbid estuary that effectively discharges water to the sea without retention in the estuary. The suspended sediment load of the estuary is more than five times what it would naturally be expected to be, but due to the strong river and tidal flows at the entrance, little sediment has been found to settle and is easily flushed (Stevens & Robertson, 2017). Water quality monitoring upstream of the estuary also indicates a frequently high suspended sediment concentration; monthly monitoring indicates an average turbidity value between 40-50 NTU for the two sites, which is significantly more than the 4.2 NTU trigger value for warm dry lowland rivers (ANZECC, 2018). In addition, the port area does undergo periodic sediment dredging to maintain a navigable water depth in the port area for vessels, meaning that the biota of the port area are currently experiencing periods of sediment resuspension and sediment removal works.

Given the existing high suspended sediment load of the Whanganui River and the current port dredging activities, sediment discharge that is anticipated from the wharf works is expected to be well within the typical range of sediment concentrations experienced in the area. As such, the fauna currently living in this area have adapted to tolerate these conditions. In addition, pipis have been found to be able to move great distances away from unsuitable habitat and are able to cope with short-term disturbances (less than eight to ten days) (Cummings & Thrush, 2004; Gibbs & Hewitt, 2004; Taylor & Keeley, 2009). The levels of metals, pesticides, PAH, and TBT measured in the estuary sediment were found to be below the ANZECC (2018) Default Guideline Values (DGV) (Hansen, 2021), therefore the resuspension of such material should not pose an environmental risk in terms of redistribution of contaminated material.

Cementitious Products and Other Chemicals

There is the potential for the release of cementitious material during the *in situ* pouring of concrete. Concrete or cementitious (mortar, grout, plaster, stucco, cement, slurry) washout wastewater is caustic and considered to be corrosive with a pH over 12(3). Despite the strong buffering capacity of seawater, increases in pH can occur via natural (photosysnthesis) or anthroprogenic means, with subsequent effects on marine biota. The pH of the open ocean usually ranges from 7.5–8.5, with pH in inshore areas (including tidepools, bays, and estuaries) sometimes decreasing to 7.0 (Calabrese & Davis, 1966), thus the acceptable pH range is considered to be 7.0–8.7 pH units (Locke, 2008). pH levels higher than this can have detrimental effects on aquatic biota, from mortality of biota through to alterations in growth, photosynthesis, feeding and immune response (Locke, 2008 (review); Calabrese & Davis, 1966; Ringwood & Keppler, 2002 (bivalves); Chen & Durbin, 1994 (marine phytoplankton)). Changes in pH can also increase the bioavailability of heavy metals and can reduce recruitment rates for particular benthic species (ANZECC, 2018; Calabrese & Davis, 1966; Loyless & Malone, 1997; Ringwood & Keppler, 2002; Shaw, 1981). pH is a logarithmic measure of acidity, meaning that small changes in pH values can have large impacts.

The release of untreated cement-contaminated water into the Whanganui Estuary could alter pH and cause detrimental effects on the local ecosystem, particularly if it is concentrated in protected areas (i.e., areas of pooled water, etc.) or during low tide. Given the high impact of elevated pH on aquatic systems should there be an accidental spill, there will need to be strict control measures to ensure the site is contained to minimise the risk of spills.

There is also a risk that other contaminants associated with the machinery used during construction (i.e., petroleum-based products), particularly those working near or over the water, could enter the aquatic environment during machinery breakdowns. This risk should be small given that all machinery will be working out of the water and all machinery would be stored and refuelled away from the water.

4.2.2 Habitat Disturbance and Change

The wharf construction activities will result in local disturbances and changes to habitat that could impact intertidal and subtidal biota in the short or long-term, and may disturb fish in the area during construction. These works include the removal of wharf piles and *in situ* sediment, the construction of new wharves, the addition of a sheet pile retaining wall and/or rock revetment under the wharf area, and a replacement rock revetment between Wharf 3 and the public boat ramp. The proposed replacement wharf footprint will align with the current wharf structure footprint, and we understand that currently the only area that is seen as encroaching into the Coastal Management Area (CMA) beyond the existing structure is for the creation of the new boat hoist support structure. The portion of the support structure within the CMA will be a 55 m long wall on the outside of the lift bay (Figure 14).

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[3] www.concretewashout.com/index.php/industry_problems/concrete_washwater

The loss of biota as a result of colonised material being removed and some *in situ* material being covered with new material will be unavoidable. However, the new wharf support structures (i.e. sheet pile retaining wall or rock revetment wall) could create other habitat opportunities. Whilst both of these options represent a change in habitat from a subtidal soft sediment area to a hard structure habitat, the Whanganui Estuary has had rock revetment habitat since the 1880s and the new habitat could be similar to what is already available in the area.

The use of a sheet pile wall to retain the soil above the new wharf structures will further prevent the introduction of terrigenous sediment into the estuary system, which could benefit to the biota of the port area as discussed above. Once installed, the smaller footprint of these retaining walls represents an opportunity for some of the existing soft sediment habitat to re-establish over time. However, the vertical aligment and steel material of this wall option will not provide valuable habitat opportunities. As such, the rock revetment option will likely provide a greater opportunity for biota to become established.

In contrast to the vertical structure of the existing wharf and proposed sheet pile retaining wall, the sloped walls of the proposed rock revetment will provide an improved habitat. Sloped walls increase the habitat area available to intertidal species and provide more space between tidal zones, thereby decreasing competition and predation pressures between and within species (Chapman & Underwood, 2011). The type of rock chosen for the revetment will also influence the ability of biota to use the habitat, with harder rock types generally less favourable and softer or textured rocks generally more preferable (Chapman & Underwood, 2011). Recruitment of invertebrates in estuary and marine environments is generally by planktonic larval dispersal and settlement rather than adult migration, and the life history traits of each species (such as reproduction strategy and dispersal capabilities) determines their colonisation (Menn *et al.,* 2003; Kjeilen-Eilertsen *et al.,* 2004; Gardner & Wear, 2006; Speybroeck *et al.*, 2006; Leewis *et al*., 2012). If habitat is available, recruitment of species will be dependent on the larval influx from adjacent areas and from pelagic influences. Given the planktonic recolonisation mechanisms and the close proximity of existing rock revetment along the North Mole area, there should be a strong source for recolonisation of the new material being added. Based on a recent survey of the North and South Moles of the Whanganui Estuary, this rock revetment wall provides habitat for at least 23 taxa (Brennan *et al.*, 2019). It is probable that at least some of these taxa will colonise the new revetment wall, with the final species composition determined by the hydrodynamics within the port area (i.e., salinity level, tidal exposure, and flow). It is also likely that pipis will recolonise the subtidal area near the toe of the new revetment, as larger pipis were similarly observed in the subtidal sampling areas within a few meters of the toe of the training wall (pers. obs.).

The fish of the Whanganui River can be broadly split into two groups: those that migrate through the lower river/estuary at some point in their lifecycle but do not reside there, and those that permanently inhabit the lower river/estuary where the works are taking place. Given the project area is near to the river mouth and the conditions are estuarine, only a subset of the fish (Section 3.4) are likely to inhabit the area either permanently or on a regular basis (e.g., īnanga, smelt, shortfin eel, yellow-eye mullet, grey mullet, yellow-belly flounder, black flounder, kahawai, snapper, john dory, kingfish). The river width ranges from approximately 175 m wide at the mouth to about 300 m wide near the site of the old Tanae Groyne. Given the proposed works are all within the area of the working port, there will be a vast expanse of river width for migratory fish to pass upstream and downstream. Hence it is unlikely the works will have an adverse effect on fish passage. These are also highly mobile species that will move away from any disturbance, meaning it is unlikely the proposed construction works will cause any significant or measurable adverse effects on resident fish fauna. The works will have no adverse impact on īnanga spawning in the Whanganui River as downstream end of the spawning habitat is located approximately 9 km upstream of the project area.

Following completion of the works, the new wharf will create cover for fish similar to the existing wharf. Any new rock revetment will also provide some additional habitat for smaller fish species as well as an additional food source from the additional invertebrate taxa that will colonise the revetment.

4.2.3 Stormwater Discharge

Current contaminant loads from stormwater runoff have not been directly measured for Wharves 2 and 3, but as the new wharves will be built on the existing footprint and the catchment should be a similar size, the contaminant load is likely to be relatively unchanged following the competition of construction.

Contaminants from surface runoff in construction and urban areas, including petrochemicals (oil, fuel, and grease) and heavy metals (including copper from vehicle brake pads and zinc from tyre wear), can bind to sediment and cause sediment contamination in marine environments (Stoffers *et al.*, 1986; Dickinson *et al.*, 1996; Kennedy, 2003a; Kennedy 2003b; Moores *et al.*, 2010). Whilst heavy metals are found naturally in our environment, human activities are responsible for increasing levels above those that occur naturally. Heavy metals bind to sediment and wash into waterways, which can result in high contaminant concentrations as the heavy metal loads can accumulate over time. High levels of heavy metal loads can be toxic to marine organisms, with the relative toxicity of metals to marine biota thought to be in the order of (from most to least toxic) copper>cadmium>zinc>chromium>nickel>lead and arsenic (McClusky *et al.*, 1986 as cited in Bolton-Ritchie, 2003). When there is a mix of contaminants, they can either work synergistically (increasing the relative toxicity of one or more constituents) or antagonistically (reducing the relative toxicity of one or more constituents) (Ahsanullah *et al.*, 1981; Bolton-Ritchie, 2003; Thrush *et al.*, 2008).

The proposed addition of a two-stage stormwater treatment system will create a new level of protection to the environment where none currently exists, as the stormwater falling on the wharves currently soaks through the broken infrastructure and discharges untreated into the port basin. IWS has estimated this new treatment system would halve the contaminant load of the current untreated stormwater (IWS, 2021). Provided that the stormwater management devices are appropriate for the size of catchment and maintenance is done to ensure working order of the devices used, implementing the proposed stormwater treatment measures should benefit the receiving environment by improving the quality of the discharge. Based on the conclusion by IWS (2021) that the proposed stormwater treatment system will reduce the current contaminant loading by half and that any remaining contaminant levels will be diluted with mixing to levels below the AQWG 95% trigger levels or to 'background levels', then we would expect that the stormwater discharge (after mixing) will not be toxic to the receiving marine environment.

4.3 Determining the Magnitude of Effects

The magnitude of effects was determined using Table 9 of Roper-Lindsay *et al.* (2018), which is reproduced below (Table 4). An evaluation of the level of effects was undertaken utilising the matrix approach described in Roper-Lindsay *et al.* (2018) whereby the ecological value of the site to be disturbed is compared against the magnitude of effect (Table 5).

The level of effect derived from Table 5 was then adapted into planning terminology/RMA context using the continuum below, obtained from the Quality Planning website (www.qualityplanning.org.nz), with the addition of a positive effects category.

- **Positive effects** – The overall effects will be positive.
- **Nil effects** – No effects at all.
- **Less than minor adverse effects** – Adverse effects that are discernible day-to-day effects, but too small to adversely affect other persons.
- **Minor adverse effects** – Adverse effects that are noticeable but will not cause any significant adverse impacts.
- **More than minor adverse effects** – Adverse effects that are noticeable that may cause an adverse impact but could be potentially mitigated or remedied.

- **Significant adverse effects that could be remedied or mitigated** – An effect that is noticeable and will have a serious adverse impact on the environment but could potentially be mitigated or remedied.
- **Unacceptable adverse effects** – Extensive adverse effects that cannot be avoided, remedied or mitigated.

Table 4 Criteria for describing magnitude of effect (taken from Table 9 of Roper-Lindsay *et al.* (2018)).

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

Table 5 Matrix for determining the level of effects based on ecological value of site to be disturbed and magnitude of the effects of the proposed activity. Adapted from Table 10 of Roper-Lindsay *et al.* (2018).

		Ecological Value				
		Very High	High	Moderate	Low	Negligible
Magnitude	Very high	Very high	Very high	High	Moderate	Low
	High	Very high	Very high	Moderate	Low	Very low
	Moderate	High	High	Moderate	Low	Very low
	Low	Moderate	Low	Low	Very low	Very low
	Negligible	Low	Very low	Very low	Very low	Very low
	Positive	Net gain	Net gain	Net gain	Net gain	Net gain

4.4 Effects Management Requirements

We recommend that the following effects management measures are implemented to help to reduce the ecological impacts of the proposed project.

Reducing contaminants:

- Undertake strict erosion and sediment control measures to limit the input of terrigenous sediment to the Whanganui River.
- Use rock material for the rock revetment wall that is clean of fine sediment (i.e., silts).

- Implement measures to isolate, contain, and treat water potentially contaminated by wet cementitious products.
- If water that has been in contact with wet cementitious products is to be discharged to the receiving environment, then the pH of the water should be at a suitable level prior to discharge to the receiving environment.

Reducing habitat disturbance:

- Select construction options and materials with highest potential for biota recruitment to increase the value of available habitat to local taxa. The preference for sloped rock revetment walls over vertical steel sheet pile retaining walls will provide habitat that could increase taxa richness and density in the port basin.
- To improve the habitat values of the rock revetment, look to incorporate softer rock that will weather over time to provide micro-habitats suitable for colonisation by various intertidal biota. Create voids within the rock revetment to provide cover for larger species, including for fish. Also look for other design opportunities to add additional habitat/abundance values to the rock revetment, provided that they do not compromise structural integrity.
- Stage the works to keep the localised disturbance to a minimal timeframe and increase the ability of pipis to cope with the disturbance.
- If sediment is to be removed from under the wharf area where pipi densities are relatively high, then the redistribution of this sediment to a wider area within the Whanganui River could provide an opportunity for the pipis to re-establish rather than be lost from the system. If this sediment redistribution was to be undertaken, sediment from under Wharf 2 and the downstream end of Wharf 3 would be the most beneficial to redistribute, as these areas had high measured pipi densities. However, further discussion with the Te Pūwaha Port Project partners would be needed to establish is this is a viable option and if so, to then determine the specific area for sediment redistribution. As recent testing of sediment near the wharf area has shown contaminant levels that are below the ANZECC (2018) Default Guideline Values (Hansen, 2021), we feel that there is little risk that this would cause any wider contaminant issues.

Stormwater discharges:

- The creation of a two-stage stormwater treatment system will mean that stormwater discharging into the Whanganui Estuary will be of a better quality than the current stormwater discharges, which are not treated at all. However, regular maintenance of these systems should be undertaken to ensure they continue to perform in the long term.
- Discharge of treated stormwater into the port basin will dilute any contaminants that may remain after treatment, and the flushing of the port basin will move contaminants out of the local habitat. While discharge into the main channel of the river may increase the dilution factor, it may be preferable to discharge into the port basin as the river area supports a greater density and size of pipis and serves as a channel for migratory fish passage. However, location of the treated stormwater discharge point should also take into account future changes to the port area that could alter the current hydrodynamics of the port area such as the potential future closing of the training wall; under this scenario locating the discharge point near the downstream opening of the wharf area may be the best location to provide some level of tidal mixing.

4.5 Summary of Effects Following Additional Effects Management

In the absence of any effects management, the likely level of impact (as defined in Table 5) of the proposed wharf works is anticipated to range between Moderate and Negligible for the different components of the construction and operational phases (Table 6). However, Section 4.4 has covered a number of factors that can be considered and implemented to manage the effects of the Whanganui Port wharf works on the aquatic environment, which should reduce the magnitude of effect to range between Low to Positive (Table 6).

The Whanganui Estuary and Port is a heavily modified system where human use has been impacting the aquatic environment for centuries. The macroinvertebrate and fish populations that reside in this area have adapted to live in a system where an active port operates and which has a high suspended sediment load, and the long-term changes due to the proposed wharf works should not decrease the ability of the local taxa to continue to reside here. Some of the proposed works may improve the area for some biota, including the improvement of stormwater discharge into the port due to the addition of a stormwater treatment system. The new rock revetment will cause the loss of soft sediment habitat under the wharves, however the impact of this loss will be small on the scale of the wider estuary; there are other soft sediment areas within the port basin and river that currently support communities similar to what will be lost, and there is potential for some biota to relocate to similar habitats nearby. The addition of rocky shore habitat on the new rock revetment may also result in a net positive effect for the port through the creation of new habitat. This habitat may be colonised by other nearby rock shore areas, which may potentially increase the taxa richness within the port basin and could provide benefits to some of the resident species such as increasing cover for local fish fauna.

The effects management recommendations include the following:

- During the construction phase include the use of strict erosion measures and ensure rock material for the revetment wall is clean of fine sediment to reduce the introduction of sediment into the aquatic system.
- Wastewater that is potentially contaminated by wet cementitious products needs to be contained and treated to bring pH to a level similar to the surrounding environment before discharge.
- Sediment that is removed from under the wharf area could be redistributed in the wider area to allow pipis currently found in the sediment under the wharves a chance to re-establish rather than be lost altogether. Note that this requires further discussion with Te Pūwaha Port Project partners before confirming whether it is a viable option or not.
- The establishment of new communities after wharf construction can be assisted further by maximising the habitat values of the rock revetment wall, including such things as the inclusion of softer rocks (which will weather over time and create more habitat space for macroinvertebrates), and creating voids in the rock revetment.
- During the operation phase of the new wharf structures, the addition of a new stormwater system will decrease the contaminants being released into the aquatic environment. This discharge of the treated seawater into the port basin will further dilute any contaminants that may remain after treatment, and the flushing of this system by river and tidal flows will move these contaminants out of the Whanganui Estuary environment with less impact to the macroinvertebrate and fish communities in the lower Whanganui River.

It will be important to regularly audit/check the appropriate implementation of the effects management measures during construction, and provide regular maintenance to the new stormwater treatment system during wharf operation. Based on the matrix provided in Table 5 from Roper-Lindsey *et al.* (2018), taking into account the existing ecological value (of 'low') and the magnitude of effect after effects management, the level of potential adverse effect ranges from 'very low' to a 'net gain' (Table 6). This would relate a 'less than minor' or 'positive effect' in the planning terminology/RMA context.

Table 6 Summary of the level of effect of the proposed wharf repair/replacement operations on the receiving environment.

Effects stage	Existing Ecological Value	Magnitude of Effect		Overall Level of Potential Adverse Effect	
		BEFORE Effects Management	AFTER Effects Management	BEFORE Effects Management	AFTER Effects Management
Sediment (generate sediment and disturb settled sediment)	Low	Low	Negligible	Very Low	Very Low
Cementitious products and other chemicals (contaminant release)	Low	Moderate	Negligible	Low	Very Low
Habitat disturbance (soft sediment removal)	Low	Moderate	Low	Low	Very Low
Habitat change (rock revetment)	Low	Low	Negligible/Positive	Very Low	Very Low/Net Gain
Stormwater discharge	Low	Negligible	Positive	Very Low	Net Gain
OVERALL	**Low**			**Very Low**	**Very Low/Net Gain**

5 PROPOSED MONITORING AND ENHANCEMENT OPPORTUNITIES

In addition to the overall very low level of effect of the proposed wharf works after the effects management measures, there also are opportunities for enhancement of the Whanganui Estuary that can increase the abundance of the system. Whilst the loss of soft sediment under the wharves is unavoidable, the taxa richness within the port basin may increase with the change of the area under the wharf to include rocky habitat. The use of softer rocks to construct sloped-walled rock revetments under the wharves and between Wharf 3 and the public boat ramp will create an area with potentially high value to rocky shore taxa, and the proximity of the wharves to several rocky areas around the estuary (e.g. the basin training wall, the North and South Moles at the estuary mouth) suggests good probability that at least some of the resident rocky shore taxa within the estuary will colonise the new revetment wall habitat. Conducting periodic surveys along the rock revetment wall after construction could indicate how the new habitat is being used.

Overall, the addition of a new stormwater treatment system is expected to provide a benefit to the port area. Monitoring of influent and effluent discharges from the new stormwater treatment system could be undertaken to gain a better understanding of the level of contaminants in the site's stormwater runoff and allow the benefits of the system to be quantified. Ongoing monitoring can also be a useful tool to track the performance of the stormwater treatment system and provide an early indication for when maintenance and repairs become necessary.

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8 APPENDICES

8.1 Macroinvertebrate Data

Table 7 Summary of all benthic macroinvertebrates identified in infauna core samples collected in the Whanganui Estuary by EOS Ecology on 4–5 November 2021. Values are presented as numbers per double core totalled across all sites, with overall percent abundance in parenthesis. Frequency of occurrence is the number of sites where the taxon was found.

Faunal Group 1	Taxa	Intertidal Sites		Subtidal Sites		All Sites	
		Number	Frequency of Occurrence (n=21)	Number	Frequency of Occurrence (n=20)	Number	Frequency of Occurrence (n=41)
Chelicerata	Acarina			1 (0.05%)	1	1 (0.03%)	1
Crustacea	Anthuridae			3 (0.15%)	3	3 (0.08%)	3
	Austrohelice crassa	3 (0.15%)	2			3 (0.08%)	2
	Austrominius modestus			12 (0.61%)	3	12 (0.30%)	3
	Flabellifera	107 (5.31%)	13	6 (0.31%)	4	113 (2.84%)	17
	Halicarcinus	2 (0.10%)	2	2 (0.10%)	2	4 (0.10%)	4
	Mysidacea			3 (0.15%)	3	3 (0.08%)	3
	Paracalliope sp.			2 (0.10%)	1	2 (0.05%)	1
	Paracorophium excavatum	996 (49.45%)	20	615 (31.39%)	16	1611 (40.55%)	36
	Josephosella awa	3 (0.15%)	1	1 (0.05%)	1	4 (0.10%)	2
	Valvifera			1 (0.05%)	1	1 (0.03%)	1
Insecta	Collembola			2 (0.10%)	1	2 (0.05%)	1
	Pycnocentria			1 (0.05%)	1	1 (0.03%)	1
Mollusca	*Amphibola crenata*	5 (0.25%)	1			5 (0.13%)	1
	Arthritica sp.	138 (6.85%)	7	1 (0.05%)	1	139 (3.50%)	8
	Austrovenus stutchburyi	1 (0.05%)	1			1 (0.03%)	1
	Cyclomactra ovata	20 (0.99%)	5	19 (0.97%)	7	39 (0.98%)	12
	Paphies australis	37 (1.84%)	10	1190 (60.75%)	20	1227 (30.88%)	30
	Potamopyrgus sp.	580 (28.80%)	15	76 (3.88%)	9	656 (16.51%)	24
Nemertea	Nemertea	5 (0.25%)	4			5 (0.13%)	4
Polychaeta	*Aglaophamus macroura*	1 (0.05%)	1			1 (0.03%)	1
	Capitella spp.	7 (0.35%)	3			7 (0.18%)	3
	Heteromastus filiformis			1 (0.05%)	1	1 (0.03%)	1
	Nereidae	18 (0.89%)	6	6 (0.31%)	3	24 (0.60%)	9
	Nicon aestuariensis	32 (1.59%)	9			32 (0.81%)	9
	Perinereis brevicirris	2 (0.10%)	2	16 (0.82%)	10	18 (0.45%)	12
	Scolecolepides benhami	10 (0.50%)	3			10 (0.25%)	3
	Scolelepis sp.	47 (2.33%)	9	6 (0.31%)	1	48 (1.21%)	10
Grand Total		**2014**		**1959**		**3973**	
Taxa Richness		**19**		**20**		**28**	

8.2 Assessment Categories for Determining Ecological Value

Table 8 **Assessment categories and criteria for determining the ecological value for an Assessment of Environmental Effects.**

Value	Description	Characteristics
Very high	A pristine system that would be representative of conditions close to its pre-human condition (i.e., a reference condition). No anthropogenic contaminant inputs. Flora and fauna effectively unchanged from pre-human condition.	» Benthic invertebrate community: – High abundance of taxa that are sensitive to enrichment and settled sediments, and no pollution-tolerant species in high abundance. – High species richness, diversity, and abundance. – No invasive or pest species. » Marine sediments typically comprise less than 25% silt and clay grain sizes (Robertson *et al.*, 2016). » Surface sediment oxygenated. » No contaminant concentrations in surface sediment – all well below the ANZECC (2018) Default Guideline Values (DGV). » Habitat heterogenous, with the ability to support a diverse invertebrate and macroalgae community. » Vegetation/macroalgae sequences intact, providing significant habitat for native fauna. » Intertidal zone not limited through modified structures. » Habitat unmodified. » Presence of species with a threat classification of “Threatened – nationally critical” or equivalent regional threat classification may elevate an otherwise low, moderate, or high value site to be very high.
High	A system that has been modified through loss of natural intertidal/coastal vegetation and catchment land use change, to the extent it is no longer pristine or could considered to be in reference condition. However, many natural, pre-human qualities are retained.	» Benthic invertebrate community: – The presence of taxa that are sensitive to enrichment and settled sediments, and none of the more pollution-tolerant species in high abundance. – High species richness, diversity, and abundance. – No invasive or pest species, or only present in low numbers/abundance. » Marine sediments typically comprise less than 35% silt and clay grain sizes. » Sediment generally oxygenated near the surface. » Low contaminant concentrations in surface sediment – rarely exceed the ANZECC (2018) Default Guideline Values (DGV). » Habitat generally heterogenous, with the ability to support a diverse invertebrate and macroalgae community. » Vegetation/macroalgae provides significant habitat for native fauna. » Intertidal zone not limited through modified structures. » Habitat largely unmodified. » Presence of species with a threat classification of “Threatened – nationally endangered” or “Threatened – nationally vulnerable”or equivalent regional threat classification may elevate an otherwise moderate or low value site to be high.
Moderate	A system that retains components of its natural state, but has been modified in some areas (such as through a loss of intertidal/coastal habitat).	» Benthic invertebrate community: – The presence of taxa that are sensitive to enrichment and settled sediments, as well as some that are more tolerant. – Moderate species richness, diversity, and abundance. – Few invasive or pest species. » Marine sediments typically comprise less than 50% silt and clay grain sizes. » Sediment generally oxygenated near the surface. » Low contaminant concentrations in surface sediment – generally below the ANZECC (2018) Default Guideline Values (DGV) although some may be close to or just over the DGV. » Habitat generally homogenous, limiting the ability to support a diverse invertebrate and macroalgae community.

		» Intertidal zone only partially limited through modified structures. » Habitat only partly modified. » Presence of species with a threat classification of "At Risk" or equivalent regional threat classification may elevate an otherwise low value site to be moderate.
Low	A system that is very modified and few aspects of its natural state remain, but with a few aspects that are still in moderate condition.	» Benthic invertebrate community: – High abundance of taxa or individuals that are not sensitive to organic enrichment and settled sediments. – Low species richness, diversity, and abundance. – May have some invasive or pest species. » Marine sediments dominated by silt and clay grain sizes (>50%). » Surface sediment generally anoxic. » Elevated contaminant concentrations in surface sediment – some above the ANZECC (2018) Default Guideline Values (DGV). » Habitat generally homogenous, limiting the ability to support a diverse invertebrate and macroalgae community. » Intertidal zone limited through modified structures. » Limited or modified coastal vegetation zone. » Habitat very modified.
Very Low	A system that is highly modified and very few aspects of its natural state remain.	» Benthic invertebrate community: – Dominated by taxa that are not sensitive to organic enrichment and settled sediments. – Very low species richness, diversity, and abundance. – May have invasive or pest species, often in high abundance. » Marine sediments dominated by silt and clay grain sizes (>60%). » Surface sediment anoxic. » Elevated contaminant concentrations in surface sediment - most above the ANZECC (2018) Default Guideline Values (DGV). » Habitat homogenous, limiting the ability to support a diverse invertebrate and macroalgae community. » Intertidal zone severely limited through modified structures. » Limited or highly modified coastal vegetation zone. » Habitat extremely modified.

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