ECOLOGICAL ASSESSMENT

Quality Assurance

Prepared by:

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Executive Summary

- The Ngā Ūranga to Pito-One section of Te Ara Tupua ("the Project") involves the construction of a 4.5 km-long, 5 m-wide, path from the Ngā Ūranga interchange (Ngā Ūranga) to just south of the Petone Railway Station (Pito-One).
- The Project is located along the coastal edge of Wellington Harbour and will be constructed on existing and new land and structures on the seaward side of the Hutt Valley Railway Line.
- A number of high ecological values and significant sites were identified along and adjacent to the Project footprint (Section 5.6). Ecological input into key design elements (Section 6.0) for the Project resulted in a number of potential ecological effects being avoided, minimised or mitigated.
- The overall level of effects of the Project on indigenous vegetation, herpetofauna, freshwater and coastal avifauna values were determined to be Low to Very Low based on the Project's adherence to the effects management hierarchy whereby measures to avoid, minimise, remedy and mitigate were implemented through design and management measures (Section 8.6 and Table 38).
- Based on these overall levels of effects of the Project, there are no residual adverse effects requiring offsetting for indigenous vegetation, herpetofauna, freshwater and coastal avifauna.
- Efforts were made to minimise the area of marine habitat lost to the Project and to avoid higher value area of marine habitat (e.g. rocky reefs and shingle beaches) (recognising Policies 10 and 11 of the NZCPS, significant marine habitat recognised in the PNRP and best ecological practice).
- Nevertheless, in the case of marine ecology, there will be residual adverse effects associated with the Project following the implementation of the effects management hierarchy (Table 38); these relate to permanent habitat loss (Very High at the Project footprint scale, and Very Low at the Wellington Harbour scale) (Table 32).
- In order to address these residual effects, options for offsetting were investigated in the first instance. The installation of living seawalls at strategic locations around Wellington Harbour are the only appropriate offsetting measure that can be implemented, and due to the scale of installation, are only a partial offset of the residual effects.
- Consequently, it was not possible to meet the biodiversity offsetting principles outlined in PNRP Schedule G2 (Greater Wellington Regional Council, 2019), including no net biodiversity loss. As a final measure, environmental compensation measures are also required to address the

residual effects of the Project. Given the PNRP does not include guidance on the development of environmental compensation, we sought guidance from the Local Government guidance document (Maseyk et al., 2018) and Appendix 4 of the draft (November 2019) National Policy Statement for Indigenous Biodiversity.

- Compensation measures to address these residual effects are recommended (Section 9.0) and include the treatment of stormwater run-off from SH2 between Pito-One and Ngā Ūranga and a dune revegetation programme on Pito-One foreshore.
- Waka Kotahi has agreed to adopt our recommendations, including in respect of measures to avoid, remedy / minimise, mitigate, and offset / compensate for effects on ecological values. Our recommended measures are reflected in the proposed conditions of consents, which we have reviewed.

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Appendices

Glossary of Abbreviations & Defined Terms

Ecology terms	Definition
Backshore	The zone of the shore or beach above the high-water line, acted upon only by severe storms or exceptionally high tides.
Biodiversity mitigation[1]	Mitigation is the abatement (lessening or repair) of the adverse effects of an activity, undertaken in direct response to, and at the same location as, that activity, designed and implemented in accordance with principles set out in Schedule G1 to the PNRP.
Biodiversity offset[1]	A measurable positive environmental outcome resulting from actions designed to redress the residual adverse effects on biodiversity arising from activities after appropriate avoidance, minimisation, and remediation measures have been applied. The goal of a biodiversity offset is to achieve no-net-loss and preferably a net-gain of indigenous biodiversity values. The principles to be applied when proposing and considering biodiversity offsets are provided in Schedule G2 (biodiversity offsetting) to the PNRP.
DGV	Default Guideline Value[2]
Effects management hierarchy[3]	A set of steps applied sequentially that seeks to, in order of prior application, avoid, remedy, and then mitigate for the impacts of development on biodiversity. Offsetting and compensation should only be considered after the effects management hierarchy has been applied to the best extent practicable. The critical aspect of the hierarchy is that offsetting or compensation is not considered until after the three prior steps have been taken.
Environmental compensation[3]	Positive actions (excluding biodiversity offsets) to compensate for residual adverse biodiversity effects arising from activities after all appropriate avoidance, remediation, mitigation and biodiversity offset measures have been applied.
EPT taxa	Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) taxa which are macroinvertebrates that are sensitive to water pollution. Because these species are generally found in streams with good water quality, their abundance provides an indication about how healthy a stream is.
Inshore	At sea but close (<0.5 km) to the shore.
Intertidal zone	The shore zone between the highest and lowest tide.
Mitigation[3]	Any action that alleviates or moderates the severity of an impact caused by something. Actions that mitigate impacts may also minimise those effects.
Offshore waters	Situated at sea, some distance (>0.5 km) from the shore.
Onshore waters	Situated on or near land, rather than at sea.
PAH	Polycyclic aromatic hydrocarbon
Residual adverse effects[1]	The negative effects on the environment remaining from an activity after avoidance, remediation, and mitigation measures have been taken.
Seral stage[4]	Development stages of an ecological succession not including climax community.

[1] Definition from GWRC (2019)

[2] As per Australian & New Zealand Guidelines for Fresh and Marine Water Quality (Australian and New Zealand Governments, 2018)

[3] Definition from Maseyk et al. (2018)

[4] Definition from Lincoln et al. (1998)

Ecology terms	Definition
Sessile[4]	Non-motile; permanently attached at the base.
Subtidal zone	Below the intertidal zone and is continuously covered by water.
Zone of influence (ZOI)[5]	The areas/resources that may be affected by the biophysical changes caused by the proposed Project and associated activities.

Term (Technical)	Abbreviation or Common Term	Definition / Description
Project Names		
Hutt Valley Railway Line	railway	The railway situated between the shared path and State Highway 2. This railway line is used for the Wairarapa, Melling, and Hutt Valley train services.
Ngā Ūranga		This is the Māori spelling for Ngauranga.
Ngā Ūranga ki Pito-One Shared Path	the Project	The section of Te Ara Tupua between Ngā Ūranga and Pito-One – the Project.
Pito-One to Melling	P2M	The section of Te Ara Tupua between Pito-One to Melling. P2M.
Pito-One		This is the Māori spelling for Petone.
Sector 1		The connection from the Ngā Ūranga Interchange and the shared bridge crossing the Hutt Valley Railway Line, to the coastal edge. Includes the Southern Construction Yard.
Sector 2		The shared path, rock revetment, ūranga, seawall structures and offshore habitats between Ngā Ūranga and Honiana Te Puni Reserve
Sector 3		Shared path connection to P2M adjacent to Honiana Te Puni Reserve, connections to Honiana Te Puni Reserve and Pito-One Esplanade, the Northern Construction Yard, Integrated Clubs Building, associated car parking, the temporary and permanent Tāwharau Pods and the Whare.
State Highway 2	SH2	
Te Ara Tupua		Te Ara Tupua is the name that has been gifted to the Waka Kotahi for use with the Wellington to Hutt Valley walking and cycling link projects. This was gifted by the Mana Whenua Steering Group on behalf of Taranaki Whānui.
Path and Features		
active modes of transport		Forms of active mobility including walking, running, cycling and micro mobility which may be utilised along the shared path.
ecological screens	screens	The purpose of the ecological screens is to provide a visual screen between shared path users and avifauna. This will result in the values of the ecological habitat not being compromised by the presence of path users. Primarily this will occur where there are shingle beaches that are being avoided by the Project. It is proposed that the screen will be provided through the use of a louvre style barrier (however this has not been confirmed. The objective of the barrier is that it will not be completely solid, but provide sufficient visual screening so that avifauna is not disturbed).

[5] Definition in Roper-Lindsay et al. (2018)

Term (Technical)	Abbreviation or Common Term	Definition / Description
		The height of this screen will vary (dependent on its location) from 1.2m – 1.8m. Over the length of the entire path only approximately 640m of the path will be screened (of which screening at Rocky Point will account for approximately 180m).
existing SH2 cycle path	existing cycle path	The narrow sealed area (of varying width) separated from SH2 by a wire rope barrier for pedestrians and cyclists. Runs from Ngā Ūranga to approximately 800 m south of Pito-One.
fencing	fencing	A transparent – tensioned chain link fence or similar is proposed at a height of 1.8m between the rail corridor and the shared path.
KiwiRail Traction Switching Station	Switching Station	The KiwiRail Traction Switching Station serves two purposes: to halve the overhead distances between substations to the north and south, and to improve the overall overhead voltage for trains. The Switching Station was built in the late 1950's to early 1960's.
lighting	lighting	Integrated lighting is proposed to be set within or alongside the fence structures or through bollards in planting areas. This is to achieve P3 lighting for safety and to avoid adverse lighting effects on wildlife.
shared path connections		Connection from the Project to existing paths and the southern and northern ends of the Project.
shared path	shared path	A 5m wide surface area. Includes shared path in sectors 1, 2 and 3.
Reclamation / Revetment / ūranga Terms		
bench	bench	A horizontal step in the rock revetment, provided to account for sea-level rise of 1 m or more. Its purpose is to enable future adaptation works to provide a shared path facility that is safe from coastal hazards as sea-level rises). Typically located at mean sea level (MSL) or, in one landing type, at mean high water springs (MHWS)".
coastal planting		Areas on the ūranga that will be planted with appropriate coastal species such as wharariki (flax), ngaio, pohuehue (muehlenbeckia) and taupata (coprosma) to provide habitat and amenity for path users.
crest	crest top of the revetment	The highest point of the revetment, approximately 450mm above the level of the path.
culvert extension		Culvert extensions are proposed to 23 existing culverts that intersect with the Project. Fish passage will be provided for in the four stream culvert extensions.
existing land		Land that is located above mean high water springs.
gathering spaces		Zones within particular ūranga that are intended as gathering spaces for people that are separate to the main 5m path. These may include paved areas, seating and other features such as artwork.
groyne		Small rock structures, constructed at select seawall locations to support the retention of shingle beach habitat.
high tide bench ūranga	high tide bench	A landing created by a variation to the standard revetment with a bench at MHWS / high tide level – alongside gathering spaces these benches may allow greater access the coastal edge for fishing and kayaks etc.
new surface area	new surface	New surface area from the top of the existing revetment/seawall/embankment to the crest of the proposed revetment. Comprised of existing land and new land.

Term (Technical)	Abbreviation or Common Term	Definition / Description
newly created land	new land	New permanent dry land created below existing MHWS that results in flat usable space. This does not include any part of the rock revetment below existing MHWS.
offshore habitat		An offshore habitat that will provide roosting habitat for various avifauna species. The offshore habitat will have a surface area above MHWS of approximately $10m^2$ and be constructed at a minimum of 40 metres from the path (which has been determined by the flight initiation distances of the various species along the length of the route). It is proposed that two of the offshore habitat will be constructed prior to the path construction works commencing to provide an alternative avifauna habitat during the construction period.
permanent project footprint within the CMA		Area of permanent Project works below existing MHWS extending out to: • the toe of any new revetment structure/s • the seaward edge of any new seawall/s • the toe of any new rip-rap rock protection installed at the base of any new seawall/s, and • includes the total area of seafloor that will be occupied by any new offshore habitat/s.
rock revetment	rock revetment	Rock armoured embankment that forms the seaward edge of proposed reclamation areas and provides protection from coastal processes. Covers all areas of rock revetment (not areas of seawall). The revetment's standard form. A sloping 1:2 rock seawall, with a bench at MSL to enable adaptation to sea level rise. Relates to 'typical path' sections only.
seawall	seawall	A section of path that is built on-top of a hard-engineered protection feature, in the form of a seawall with steel piles. The purpose of this variation in the path design is to avoid the significant shingle beach areas (as directed by Policy 11 of the New Zealand Coastal Policy Statement).
toe	toe	The bottom of the revetment – the point where the base of the revetment meets the existing sea bed.
total construction area in the CMA	area of disturbance	The total area of permanent and temporary seabed disturbance within the CMA related to the construction of the Project. Includes all area/s in the CMA that will be **permanently** occupied by: • offshore habitats, • path formation works, • rock revetment, • seawall structures, and • any permanent riprap rock protection feature/s (the Project footprint), <u>and</u> includes any area in the CMA that will be **temporarily** disturbed and/or occupied by the Project related to: any construction related activities, including temporary works and sediment control measures.
typical path		Shared path with rock revetment. This is to be used to describe the 5m surface width path and rock revetment sections in Sector 2.
typical ūranga		A landing created by extending the new surface area beyond the area required for the path, with a variation to the standard revetment profile.
ūranga (landings)	ūranga	Varied revetment profile and footprint. Areas where the design incorporates two landing types to provide for a varied and more naturalised shape to the rock

Term (Technical)	Abbreviation or Common Term	Definition / Description
		revetment; in long and cross section. The ūranga may feature coastal planting and gathering spaces with seating etc, for people.
varied coastal edge		The varied coastal edge is situated in Sector 2. It is to be used to describe the combination of the typical path, various ūranga and seawalls. These combined to provide a varied coastal edge.
Bridge and Construction Terms		
balustrade		The fall-from-height barrier along the bridge deck and ramps. Minimum 1.2m, height tbc
Bridge deck		The surface area of the bridge above the sloped ramps. 4m path width with 0.5m shoulders – which may be unmarked
edge girder		Strengthening structures at the edges of the bridge deck between the piers.
handrail		Integrated into the balustrade. To provide an accessible route over the bridge, as per D1 accessibility code.
Korokoro Stream Bridge	Korokoro Bridge	Upgrade to the bridge surface and balustrades.
lookout area		The flat, wider area of the bridge deck. Additional width is proposed to enable people to stop without obstructing passage of others and appreciate the views of the harbour and Matiu Somes Island.
pier		The vertical columns that support the superstructure of the bridge.
ramps		1:14 gradient ramps, with flat landings, as per the D1 accessibility code. 5m total width including shoulders – which may be unmarked
Southern Construction Yard Northern Construction Yard	construction yard	Construction yards: refer to the construction lay down areas that will be located within the KiwiRail Land at Ngā Ūranga in the south of the project, and Honiana Te Puni Reserve in the north. The construction yards will be used for storage of materials, equipment and site offices/facilities.
superstructure		The ramps and bridge deck (and everything on them) that are supported by the piers.
Shared path bridge		The bridge that will be constructed adjacent to the Ngā Ūranga interchange to convey path users from the land side, to the sea-side of the railway line.
throw screen		In addition to the balustrade, a barrier to prevent objects being thrown or dropped from the bridge onto the rail or trains.
Works at Honiana Te Puni Reserve		
Integrated Clubs Building		A new combined club building for both the Wellington Rowing Association and Wellington Water-ski Club. This building will be constructed in the eastern portion of Honiana Te Puni Reserve.
The new Whare	the Whare	A new building that will be constructed at Honiana Te Puni Reserve for the purpose of providing for cultural activities. This building will be constructed in the western portion of Honiana Te Puni Reserve.
new Honiana Te Puni Reserve sculpture	the new sculpture	A new sculpture overlooking Korokoro Stream and welcoming all as they cross the bridge. During construction the sculpture will be located beside the temporary nohoanga zone. Post construction it will be relocated to the vicinity of the Whare.

Term (Technical)	Abbreviation or Common Term	Definition / Description
new parking area	new parking area	A formed parking area will be provided at the eastern end of Honiana Te Puni Reserve, adjacent to the integrated clubs facility. A total of 54 formed car parks will be provided in this area. This includes; 30 Club car parks, 11 club car parks for cars and boats, and 13 public car parks.
Te Keo		A new sculpture positioned near the gateway to Te Ara Tupua and heralding the first access point to the reserve.
temporary and/permanent Tāwharau Pods	Tāwharau Pods	Three architectural pods that will provide for cultural expression and cultural and community uses. These will be temporarily situated on the eastern side of Honiana Te Puni Reserve during construction of the Project and then permanently relocated to the western side of Honiana Te Puni Reserve following Path construction.
waka launching area		The existing gravel boat ramp will remain unchanged in its current location. The grass access to the beach (the Waka ramp access) serviced by the ramp will be upgraded and reinforced with concrete inserts.
Stakeholder / Partner Terms		
consultation		Conversations with the public, stakeholders and partners where we are seeking feedback on a specific proposal as a part of the Project.
engagement		All conversations with the public, stakeholders and partners about the Project.
funding partner		Wellington City Council and Greater Wellington Regional Council are funding partners for the Project.
Honiana Te Puni Reserve	the Reserve	The reserve area at the western end of Pito-One foreshore. This is owned by Port Nicholson Block Settlement Trust and managed as a reserve by Hutt City Council.
mana whenua		Mana whenua are Māori with authority over the land.
Mana whenua Steering Group	MWSG	A group that has been established to guide the development of the project by providing mana whenua perspective covering a range of areas of work.
Ngāti Toa Rangatira and Te Rūnanga o Toa Rangatira	Ngāti Toa	Ngāti Toa are an iwi based in Porirua. They have statutory acknowledgement of their ties to Te Whanganui a Tara. They are represented by Te Rūnanga o Toa Rangatira.
partner		A number of organisations are partners in the Project. These include mana whenua, local government (3x councils) and funding partners, and KiwiRail due to the significant impact on rail corridor property.
Port Nicholson Block Settlement Trust	PNBST or the Trust	The Trust that received and managed Taranaki Whānui's Treaty of Waitangi settlement package and represents Taranaki Whānui.
stakeholder		All other organisations, community representatives and leaders with an interest in the project – that the project has engaged with.
Taranaki Whānui ki te Upoko o te Ika	Taranaki Whānui	Taranaki Whānui are a group of iwi in the Wellington and Hutt Valley region, descended from ancestors from Taranaki. Taranaki Whānui hold ahi kā in the Project area and have statutory acknowledgement of their ties to Te Whanganui a Tara (Wellington Harbour).
Taranaki Whānui Ltd		The commercial arm of Taranaki Whānui / Port Nicholson Block Settlement Trust.

Term (Technical)	Abbreviation or Common Term	Definition / Description
Wellington Rowing Association		The rowing association who utilise the rowing building at the northern end of the Project on Waka Kotahi NZ Transport Agency land adjacent to Honiana Te Puni Reserve.
Wellington Water Ski Club		The water ski club that utilise the clubrooms at the northern end of the Project within the western portion of Honiana Te Puni Reserve.

Abbreviation	Term
AEE	Assessment of Effects on the Environment
BCR	Benefit-cost ratio
BOL	Block of Line
BPO	Best Practicable Option
CAQMP	Construction Air Quality Management Plan
CBD	Central Business District
CEMP	Construction Environmental Management Plan
CESCP	Construction Erosion and Sediment Control Plan
CHI	Cultural Heritage Inventory
CIR	Cultural Impact Report
CLMP	Contaminated Land Management Plan
CMA	Coastal Marine Area
CNVMP	Construction Noise and Vibration Management Plan
CPA	Coastal Protection Areas
CPTED	Crime prevention through environmental design
CTMP	Construction Traffic Management Plan
dB	Decibel
DOC	Department of Conservation
EMP	Ecological Management Plan
GHW/GHW Trust	Great Harbour Way Trust
GPSLT	Government Policy Statement (on Land Transport)
GWRC	Greater Wellington Regional Council
Ha	hectares
HAIL	Ministry for the Environment's hazardous activities and industries list
HCC	Hutt City Council
HCDP	Hutt City District Plan
HMP	Heritage Management Plan
HNZPT	Heritage New Zealand Pouhere Taonga
HNZPTA	Heritage New Zealand Pouhere Taonga Act 2014
HSNO	Hazardous Substances and New Organisms Act 2001

Abbreviation	Term
LGWM	Let's Get Wellington Moving
LTMA	Land Transport Management Act 2013
m	metres
MACA Act	Marine and Coastal Area (Takutai Moana) Act 2011
MCA	Multi Criteria Analysis
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
MSL	Mean Sea Level
MWSG	Mana Whenua Steering Group
NES	National Environmental Standard
NESCS	National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health
NESAQ	Resource Management (National Environmental Standard for Air Quality) Regulations 2004
NLTF	National Land Transport Fund
NLTP	National Land Transport Programme
NoR	Notice of Requirement
NPS	National Policy Statement
NPSFM	National Policy Statement for Freshwater Management
NPSUDC	National Policy Statement for Urban Development Capacity
NZAA	New Zealand Archaeological Association
NZCPS	New Zealand Coastal Policy Statement 2010
ONF	Outstanding Natural Feature
ONL	Outstanding Natural Landscape
P2G	Pito-One to Grenada Link
P2M	Pito-One to Melling section of Wellington to Hutt Valley
PNRP	Proposed Natural Resources Plan
PWA	Public Works Act 1981
RCP	Operative Regional Coastal Plan for the Wellington Region
RDL	Regional Plan for Discharges to Land for the Wellington Region
RFP	Operative Regional Freshwater Plan for the Wellington Region
RLTP	Regional Land Transport Plan
RLTS	Regional Land Transport Strategy
RMA	Resource Management Act 1991
RPH	Regional Public Health
RPO	Rail Protection Officer
RPS	Regional Policy Statement
SH(x)	State Highway (number)
SLUR	Selected land use register
TMP	Traffic Management Plan

Abbreviation	Term
TSS	total suspended solids
CEDF	Cultural and Environmental Design Framework
WCC	Wellington City Council
WCDP	Wellington City District Plan

1.0 Introduction

The Ngā Ūranga ki Pito-One[6] section of Te Ara Tupua (Te Ara Tupua or the Project) involves the construction of a shared path from the Ngauranga interchange (Ngā Ūranga) to just south of the Petone Railway Station in the north (Pito-One) (refer to Map 1). For description and assessment purposes in this report, the Project has been divided into three sectors. These are:

- **Sector 1 - Ngā Ūranga Interchange and Bridge Crossing:**
  The southern construction yard and the connection from the Ngā Ūranga Interchange via the shared path bridge across the Hutt Valley Railway Line, to the coastal edge.
- **Sector 2 - Ngā Ūranga to Honiana Te Puni Reserve - Path and ūranga:**
  The typical shared path, rock revetment, ūranga, seawall structures and offshore habitats between Ngā Ūranga and Honiana Te Puni reserve; and
- **Sector 3 - Honiana Te Puni Reserve and Pito-One to Melling (P2M) Connection:**
  Shared path connection to P2M adjacent to Honiana Te Puni Reserve, connections to Honiana Te Puni Reserve and Pito-One Esplanade, the northern construction yard, integrated clubs building, associated car parking, the temporary and permanent Tāwharau Pods and the Whare.

The Project will cater for active transport modes including cycling and walking and will provide an alternative to the existing State Highway 2 (SH2) cycle path located between the Hutt Valley Railway Line and the southbound SH2 carriageway. Works at Honiana Te Puni Reserve provide for the removal and replacement of the existing Wellington Rowing Association and Wellington Water Ski Club facilities at, and adjacent to, Honiana Te Puni Reserve and the introduction of new cultural facilities into the Reserve.

The primary objective of the Project is to provide safe walking and cycling infrastructure between Wellington and the Hutt Valley which will act as a catalyst for increased use of active transport modes. The Project will also provide increased transport resilience, improve connections and integration with planned and existing walking and cycling infrastructure in Wellington City and Hutt City and reconnect people with this long-inaccessible part of the harbour's edge.

Boffa Miskell Ltd have been engaged to undertake an assessment of effects on the ecology associated with the proposed Ngā Ūranga ki Pito-One project. This report begins with a description of the Project (Section 3.0) and the methods used to collect ecological information and the undertake the ecological assessment (Section 4.0). Based on the information collected, the existing environment is described in terms of the indigenous vegetation, herpetofauna, freshwater, avifauna and marine ecology associated with, and adjacent to, the Project footprint (Section 5.0). We then outline the key design elements of the Project that were heavily reliant on ecological inputs (Section 6.0), based on the information that was gathered through the ecological investigations. Ecologically relevant construction activities, methods and materials are then outlined (7.0), followed by the assessment of effects on the indigenous vegetation, herpetofauna,

[6] This report uses the preferred Te Reo spelling of "Ngā Ūranga" and "Pito-One" even where the official name may instead use "Ngauranga" or "Petone".

freshwater, avifauna and marine ecology associated with, and adjacent to, the Project (Section 8.0). We then outline (Section 9.0) the proposed measures to address residual effects identified through the ecological assessment process, and finally how the effects management hierarchy has been adhered to for the Project (Section 10.0).

This report has been prepared in support of the notices of requirement and applications for resource consent for the Project made by Waka Kotahi under the COVID-19 Recovery (Fast-track Consenting) Act 2020 (COVID-19 Recovery Act). In particular, this report supports the assessment of the Project's effects on the environment as required by the COVID-19 Recovery Act. The requirements of the COVID-19 Recovery Act and an overall assessment of the effects of the Project on the environment are set out in the Assessment of Effects on the Environment

2.0 Qualifications / Experience & Code of Conduct

2.1 Dr Leigh Bull

- I am a primary author of this assessment and have the following qualifications, experience and expertise that are relevant to the Ngā Ūranga ki Pito-one Shared Path:
  - My qualifications include Bachelor of Science degree in Zoology (Victoria University of Wellington), Master of Science (Hons, 1st) in Ecology (Victoria University of Wellington), a Doctorate in Ecology and Biodiversity (Victoria University of Wellington).
  - I have 17 years' experience working as a practising ecologist. I currently hold the role of Senior Ecologist / Associate Partner at Boffa Miskell. My previous roles have included Species Protection Officer (Biodiversity Recovery Unit, Department of Conservation), Marine Technical Support Officer (Marine Conservation Unit, DOC) and post-doctorate research fellow at the Universite Paris Sud XI.
  - I am a Certified Environmental Practitioner Ecology Specialist with the Environment Institute of Australia and New Zealand and an Independent Hearings Commissioner.
  - I am very familiar with the Project area and the wider Wellington Harbour. Notably, my MSc thesis investigated little blue penguins on Matiu-Somes Island (Bullen, 1997).[7]
  - I have undertaken and prepared numerous avifauna monitoring programmes, habitat surveys, restoration plans and preparation and presentation of expert witness evidence.
  - I have significant experience in preparing assessments of ecological effects on terrestrial, freshwater, coastal and oceanic avifauna.
  - I have an in-depth understanding of potential construction and operational effects on avifauna values, having recently worked on a number of infrastructure projects such as the reinstatement of SH1 road and rail following the Kaikoura earthquake, various windfarms

[7] Authored using maiden name.

(e.g. West Wind, Te Uku, Waverly, Mt Munro, Central Wind), coastal Ports (e.g. NorthPort, Lyttelton Port Recovery, cruise berth and channel deepening), and Roads of National Significance (e.g. Transmission Gully, Mackays to Peka Peka, Puhoi to Warkworth, East-West Link, Warkworth to Wellsford).

  - I authored Chapter 5: Avifauna of the Ecological Impact Assessment (Boffa Miskell Ltd, 2016) for the East West Link Project, and participated in the development of the biodiversity offsetting and compensation package for that project (a 24 ha reclamation in the Mangere Inlet).
  - I have published numerous articles in scientific peer-reviewed journals pertaining to coastal and oceanic avifauna (Bull, 2000b, 2000a, 2006, 2007, 2009; Bull et al., 2002, 2004, 2005, 2013; Haywood & Bull, 2008; Jeffries et al., 2016; Pledger & Bullen, 1998), invasive species (Bull & Courchamp, 2009; Harris et al., 2012) and lizards (Hoare et al., 2007).
  - I was also a co-author of the Department of Conservations 2007 threat classification list (Hitchmough et al., 2007).
  - My experience with large reclamations projects includes the East-West Link, and the construction of a seawall around Ohau Point as part of reinstating SH1 following the 2016 Kaikoura earthquake.
- I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court Practice Note 2014. This assessment has been prepared in compliance with that Code. In particular, unless I state otherwise, this assessment is within my area of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

2.2 Dr Sharon De Luca

- I am a primary author of this assessment and have the following qualifications, experience and expertise that are relevant to the Ngā Ūranga ki Pito-one Shared Path:
  - My qualifications include a Bachelor of Science degree in Zoology (University of Auckland) and a Doctorate in Environmental and Marine Science (University of Auckland).
  - I have 19 years' experience in marine science and a strong background in ecotoxicology.
  - I am a Certified Environmental Practitioner Ecology Specialist with the Environment Institute of Australia and New Zealand and an Independent Hearings Commissioner.
  - Over recent years I have worked on a number of infrastructure projects including four Roads of National Significance with the Transport Agency where reclamation and/or discharges to the coastal environment were key issues.
  - I have an in-depth understanding of the effects of earthworks, stormwater, erosion and sediment control and construction on marine ecological values.
  - I have significant experience in assessment of effects on coastal/marine and freshwater ecological values, preparation of aquatic monitoring programmes, habitat surveys, contaminant analyses and restoration plans and preparation and presentation of expert witness evidence.

- I authored Chapter 4: Marine Ecology of the Ecological Impact Assessment (Boffa Miskell Ltd, 2016) for the East West Link Project, and participated in the development of the biodiversity offsetting and compensation package for that project (a 24 ha reclamation in the Mangere Inlet).

- I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court Practice Note 2014. This assessment has been prepared in compliance with that Code. In particular, unless I state otherwise, this assessment is within my area of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

3.0 Project Description

The Project will provide a 4.5 km-long shared path between Ngā Ūranga and Pito-One featuring the following key elements:

a) A rail overbridge (the shared path bridge) across the Hutt Valley Railway Line, connecting the shared path from Ngā Ūranga to the coastal edge;

b) A path with a 5 m surface width on existing and newly created land and coastal structures, on the seaward side of the Hutt Valley Railway Line;

c) A varied coastal edge which incorporates ūranga (landings), a rocky revetment and the intermittent use of strategically placed seawalls along the path edge. The coastal edge treatment provides resilence, reflects the natural landscape, avoids sensitive habitat areas, provides for cultural expression and enhances amenity;

d) Construction of new offshore habitat for coastal avifauna;

e) Connections to the Pito-One to Melling (P2M) path and the Pito-One Esplanade;

f) Construction of a new integrated clubs building at the eastern end of Honiana Te Puni Reserve (HTPR or the Reserve) and an associated car parking area; and

g) A two-stage development of new cultural facilities at HTPR, including:
   i. Construction of a temporary Tāwharau Pods, consisting of three small building pods designed to accommodate a range of cultural or community uses, at the eastern end of Honiana Te Puni Reserve; and
   ii. Post construction, the construction of the new Whare to the west of Korokoro Stream, and permanent relocation of the Tāwharau pods to a site adjacent to the Project at the western end of Honiana Te Puni reserve[8].

A full description of the Project including design, construction and operation is provided in *Chapter 3: Description of the Project* in the Assessment of Effects on the Environment.

[8] The construction of the Whare and Tāwharau Pods is at Taranaki Whānui's discretion

A description of the potential construction methodology that could be used to construct the Project is provided *in Chapter 4: Construction of the Project* of the Assessment of Effects on the Environment.

4.0 Methods

A combination of desktop (relevant databases, published and unpublished reports) and field investigations were undertaken to obtain information regarding the ecology associated with the Project and adjacent habitats. The extent of the field investigations included the Project footprint plus a zone of influence (ZOI) that covers the maximum likely extent of potential effects (i.e. 40m disturbance zone for avifauna).

In the following sections, for each area of ecology (vegetation, herpetofauna, freshwater, avifauna and marine) the existing information relied on is described first, followed by the methods used in field investigations. We then describe the methods used to assess the effects on ecological values and the effects hierarchy approach we have used.

4.1 Vegetation

Based on aerial photography, it was determined that the nature of the vegetation (being very limited in area) within the Project footprint did not warrant the use of set transects, or RECCE plots, or other quantitative plant abundance or diversity measures. Instead, the entire length of the Project footprint was initially walked on the 28 October 2014 and a botanical species lists was compiled of all vegetation species observed, whether, native, weed or part of amenity planting. No changes to the vegetation communities have been noted during subsequent visits to the Project footprint in the ensuing period since that initial site visit.

4.2 Herpetofauna

Both environmental and Health & Safety constraints associated with the proximity of the rail lines limited the ability to undertake herpetofauna field investigations along much of the Project footprint. As such, a desktop-based approach was undertaken whereby data from the DOC Bioweb database (accessed 13 August 2019) was used to assess local lizard communities within 2 km of the Project. Records more than 20 years old (pre-1999) were excluded. This species list served as the base species list of lizards recorded within the wider area and that could potentially occupy sites within the project area that have similar habitat types. Based on the known habitat preferences of herpetofauna found in the wider area, areas of herpetofauna habitat along the Project footprint were identified and mapped.

4.3 Freshwater

The NIWA Freshwater Fish Database (FFDB)[9] was interrogated on 2 August 2019. Data was downloaded for catchments through which the Project crosses.

Boffa Miskell have previously undertaken freshwater investigations in the Korokoro[10] and Horokiwi (Waihinahina) streams, as well as in the un-named stream which runs through Gilberd Bush Reserve in the catchment immediately south of the Horokiwi Stream (Boffa Miskell Ltd, 2013); the location of these streams is provided in Map 2. These report data are coupled with incidental stream and gully observations along the Ngā Ūranga – Pito-One coastal escarpment. The results of those investigations have been used to inform the description and values of the waterways intersecting with the Project.

4.4 Avifauna

An extensive literature search was undertaken to obtain previous avifauna data. Notably, Robertson (1992) reported on avifauna data collected from 17 sections around the Wellington Harbour over two 2-year periods (1975-77 and 1986-88). In that study each section of coastline was walked or cycled once a month during each 2-year period. All birds seaward of the high-tide line were recorded. The data from section (7) between Horokiwi and Ngā Ūranga was compiled for this current assessment.

New Zealand eBird database[11] was explored on 12 August 2019 and data extracted for the Wellington Harbour railway corridor up until that date.

Data from the Ornithological Society of New Zealand (OSNZ) atlas (C. J. R. Robertson et al., 2007) were collated from the 10 km x 10 km grid square (266, 599) which encompasses the section of coastline between Horokiwi and Ngā Ūranga, as well as the terrestrial and marine habitat either side of the coastline (refer to Map 3).

Targeted coastal bird surveys included:

- A search for nesting coastal birds along the Project footprint. The nesting bird survey (conducted on 14 January 2016) involved two suitably experienced ecologists walking and actively searching the coastal habitat along the Project footprint on the seaward side of the rail lines. All nesting birds or sign of nesting activity (e.g. nesting material) were recorded. The survey commenced at the Pito-One end of the Project two hours prior to low tide, and any signs of nesting birds were recorded. The objective of the survey was to identify nesting coastal bird species along the Project.
- During the nesting coastal bird survey, all observations of coastal birds (species, numbers, flight patterns and behaviours) were recorded. The objective of recording these observations was to obtain an understanding of the species present and how they were utilising this coastal edge.

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[9] https://niwa.co.nz/information-services/nz-freshwater-fish-database

[10] Freshwater investigations (fish, macro-invertebrates and physical habitat assessment) undertaken in two Korokoro Stream tributaries as part of the Petone to Grenada field investigations in 2016.

[11] https://ebird.org/explore

- Point count surveys were conducted at the Korokoro Stream mouth (refer to Map 3) in January and May 2016 during low and high tide events; refer to Table 1 for details of survey times and effort. An hour was spent on each occasion recording all avifauna species observed (and behaviours) utilising the foreshore and Korokoro Stream mouth. The objective of these surveys was to describe the range of species utilising the site at various stages of the tidal cycle.

In addition to the above-mentioned targeted surveys, all incidental avifauna observations were recorded during all ecology field investigations and Project site visits between 2016 and 2020. The objective was to record any significant observations that may have been made outside of the formally defined methods of data collection. They included observations of avifauna within or adjacent to the site, as well as unusually large numbers of a common or exotic species, or any unusual and noteworthy behaviour.

Table 1. Summary of coastal avifauna survey effort and weather conditions

SEASON	DATE	TIDE	OBS. PERIOD	WEATHER CONDITIONS
Summer	12/1/16	Low – 13:53	13:35 – 14:35	Warm (19°C) with a moderate northerly.
	15/1/16	High – 10:00	09:30 – 10:30	Warm (16°C) with a light breeze.
Autumn	20/5/16	Low – 09:43	09:15 – 10:15	Cool (11°C) with a strong northerly.
	20/5/16	High – 16:06	15:30 – 16:30	Cool (11°C) with a strong northerly with periods of rain.

4.5 Marine

4.5.1 Sector 2 (Path and ūranga)

Intertidal and shallow subtidal marine ecology data (both rocky shore and sand/gravel sediment habitats) informed the assessment of effects.

4.5.1.1 Intertidal

Existing data and information were compiled from previous stages of this project and work carried out for Horokiwi Quarry (Boffa Miskell Ltd, 2009, 2013, 2015). We also sought information/data from GWRC, but there was no data available close to the Project footprint. A gap analysis was undertaken based on the location and nature of existing data and information and the draft design (as it stood in April 2019, after an iterative process of design refinement with the objective of minimising adverse effects on ecological values); from which it was determined that additional rocky shore and soft sediment data was required as there was insufficient data along the Project. Sites were chosen at rocky/cobble and sand/gravel locations (refer to Map 4) along the Project to inform the assessment of the construction and operation of the design.

Intertidal sampling and data collection were carried out on 6 May 2019 by a Boffa Miskell ecologist, utilising a Wellington-based boat and skipper. Sampling was carried out two hours either side of low tide, which was at 1208 hrs. Six soft sediment (sand/gravel) sites[12] and six rocky/cobble sites[13] were selected based on aerial imagery along the Project footprint (Map 4).

[12] Chainages 2400, 2970, 3420, 3680, 3880, and 4140 (m).

[13] Chainages 1170, 1420, 2820, 3770, 3930, and 4210 (m).

At each of the six sand/gravel sites, (Map 4) three 15 cm diameter by 10 cm deep sediment cores were collected, sieved using a 0.5 mm mesh, and the retained material preserved in ethanol for later extraction, identification and enumeration of invertebrates by an independent laboratory (Biolive Invertebrate Services). In addition, at each site, a single composite sediment grain size sample was collected and held on ice until delivered to the University of Waikato for laser particle grain size analysis[14]. Benthic invertebrate assemblage data were analysed using multi-dimensional scaling (n-mMDS), permanova, descriptive statistics for abundance, richness, diversity and community composition.

At each of the rocky shore/cobble sites (Map 4), a 0.25m^2 quadrat was haphazardly placed at three locations along the mid region of the intertidal habitat and photographed. Within each quadrat the following data was collected:

- Macroalgae – species identification and percent cover.
- Mobile macroinvertebrates – species identification and abundance.
- Sedentary/encrusting macroinvertebrates – species identification and either abundance or percent cover.

Due to the paucity of organisms present within the intertidal rocky shore/cobble habitats, data was not plotted or analysed with descriptive statistics. Descriptions of the data are provided.

4.5.1.2 Subtidal

Existing data and information were compiled from previous stages of this project and assessments for other projects (Boffa Miskell Ltd, 2011, 2015). A gap analysis was undertaken based on the location of existing information and the draft Project design (as it stood in April 2019), from which it was determined that additional subtidal rocky shore and soft sediment data was required to inform the assessment of the construction and operation of the design at key points along the Project (see location descriptions below). Survey sites were chosen where the Project design (at that time) involved areas of reclamation or other works on rocky shore headlands and also a headland that was less affected by the Project design. We note that no sampling was undertaken between Chainages 0-1100 m as the Project footprint is constrained to an existing reclamation at that location, and as such there would be little effect on the marine environment at that location. Rather, sampling was focused on high value and high impact areas.

Subtidal sample/data collection (refer to Map 4) was carried out on 14 February 2019 by scientific divers from Toi Ohomai (previously Bay of Plenty Polytechnic), utilising a Wellington-based vessel and skipper. High tide on 14 February 2019 was at 1253 hrs, with samples being collected two hours either side of high tide.

The draft Project design aimed to minimise reclamation at the existing remnant headlands along the shoreline. As such, in order to characterise the existing environment, three survey sites were selected based on where the draft design indicated that it was likely that there would be a greater extent of reclamation/impact (Chainage 1500 m, 2200 m, and 3800 m). A fourth site was chosen at one of the most significant existing remnant headlands where the draft design indicated the least extent of reclamation/impact (Chainage 2900 m) (refer to Map 4). At each of the four subtidal survey sites (on Map 4 labelled "2019 Subtidal sand/gravel and rocky/cobble"), a transect was laid perpendicular to the shore, commencing at the low water mark and extending to 50 m (i.e. samples

[14] Samples were sieved to remove the >2mm prior to laser analysis. The proportion of >2mm fraction was added to the data set after laser analysis.

collected at 10 m, 20 m, 30 m, 40 m and 50 m). At every 10 m interval a single 0.25m^2 quadrat was placed on rocky/cobbly habitat and the following data collected:

- Macroalgae – species identification, percent cover and height.
- Mobile macroinvertebrates – species identification and abundance.
- Sedentary/encrusting macroinvertebrates – species identification and either abundance or percent cover.
- Fish – incidental species observed.

In addition, at every 10 m interval three replicate 15 cm diameter by 10 cm deep core samples were collected for benthic invertebrates. Sediment was sieved through a 0.5 mm mesh and the retained material preserved in ethanol for later extraction, identification and enumeration of invertebrates by an independent laboratory (Biolive Invertebrate Services).

Data were analysed using descriptive statistics for abundance, richness, diversity and community composition, multi-dimensional scaling (n-mMDS) plots and Permanova.

4.5.2 Sector 3 (Honiana Te Puni Reserve)

Intertidal sampling and data collection were carried out on 14 January 2016 on the foreshore to the east of Korokoro Stream. A 50m x 20m grid (subdivided into 10 10 m x 10 m smaller sub-grids) was established at the location identified as P1 on Map 4. The 10 sub-grids (P1-A to P1-J) were subdivided into four 5 m x 5 m grids. Sampling was undertaken at one of the randomly selected 5 m x 5 m small grids within each 10 m x 10 m sub-grids. Thus, a total of 10 samples per grid location were collected at this site. The sampling design is based on the Estuarine Environmental Assessment and Monitoring National Protocol (B. M. Robertson et al., 2002). Within each sub-grid the following was collected/surveyed:

- a 0.5 m x 0.5m quadrat was used to collect epifauna and macroalgae data the field. Macroinvertebrates were identified and counted (including an estimation of mud crab density through counting crab burrow holes), and percentage cover of macroalgae within the quadrat was estimated.
- a core sediment sample approximately 15 cm deep x 13 cm diameter for infaunal invertebrate analysis. The core of sediment was sieved through a 0.5 mm mesh and the retained material preserved using >60% ETOH. Macroinvertebrates were extracted from the retained material, identified and counted.

In addition, surface sediment (top 2 cm) was collected as part of three composite samples for contaminant analyses (copper, lead, zinc and PAHs). The results were compared with the sediment quality guidelines (Australian and New Zealand Governments, 2018).

4.6 Supporting information

In addition to the information collected through ecological field investigations and desktop investigation of relevant literature and databases, this assessment has been based on the information provided in the following supporting documents and plans:

- Nga Uranga ki Pito-one offshore habitat typical details (AECOM Drawing No. 60306339-SK-1034 Revision A, issue date 03.09.20).

- Nga Uranga ki Pito-one stormwater drainage construction plan layout plan (AECOM Drawing No. 60306339-SK-170 Rev F, issue date 03.09.20).
- Nga Uranga ki Pito-one stormwater drainage construction plan indicative sections (AECOM Drawing No. 60306339-SK-171 Rev D, issue date 28.08.20).
- Nga Uranga ki Pito-one stormwater drainage construction plan indicative sections – Sheet 2 (AECOM Drawing No. 60306339-SK-172 Rev A, issue date 03.09.20).
- Nga Uranga ki Pito-one stormwater drainage construction plan indicative sections – Sheet 3 (AECOM Drawing No. 60306339-SK-173 Rev A, issue date 03.09.20).
- Te Ara Tupua Nga Uranga ki Pito-one coastal occupation plans. AECOM plan set sheet number CI-1201 to CI-1212 Revision A, dated 03.09.2020.
- Te Ara Tupua (Nga Uranga ki Pito-one). Typical cross sections: Piki Wahine ūranga. AECOM Sheet No. CI-1090 Revision A dated 03.09.20.
- Te Ara Tupua (Nga Uranga ki Pito-one). Typical cross sections: Shared path & revetment. AECOM Sheet No. CI-1091 Revision A dated 03.09.20.
- Te Ara Tupua (Nga Uranga ki Pito-one). Typical cross sections: Tahataharoa ūranga. AECOM Sheet No. CI-1092 Revision A dated 03.09.20.
- Te Ara Tupua (Nga Uranga ki Pito-one). Typical cross sections: Paroro-rangi Point ūranga. AECOM Sheet No. CI-1093 Revision A dated 03.09.20.
- Te Ara Tupua (Nga Uranga ki Pito-one). Typical cross sections: Karanga Point ūranga. AECOM Sheet No. CI-1094 Revision A dated 03.09.20.
- Te Ara Tupua (Nga Uranga ki Pito-one). Typical cross sections: Seawall (1.8 m ecological screen). AECOM Sheet No. CI-1095 Revision A dated 03.09.20.
- Te Ara Tupua (Nga Uranga ki Pito-one). Typical cross sections: Seawall (3.9 m high). AECOM Sheet No. CI-1096 Revision A dated 03.09.20.
- Te Ara Tupua (Nga Uranga ki Pito-one). Typical cross sections: Seawall (1.2 m ecological screen). AECOM Sheet No. CI-1097 Revision A dated 03.09.20.
- Te Ara Tupua (Nga Uranga ki Pito-one). Typical cross sections: Seawall (3.5 m high). AECOM Sheet No. CI-1098 Revision A dated 03.09.20.
- Te Ara Tupua (Nga Uranga ki Pito-one). Typical cross sections: Horokiwi ūranga. AECOM Sheet No. CI-1099 Revision A dated 03.09.20.
- Coastal Process Assessment (NIWA).
- Erosion and Sediment Control Assessment (BECA).
- Noise & Vibration Assessment (AECOM).
- Historic Heritage Assessment (Heritage Solutions).
- AECOM (2019c). *Ngauranga to Petone cycleway - Sediment quality assessment.* Report prepared by AECOM for the Transport Agency, dated 7 May 2019.
- AECOM (2019b). *Ngauranga to Petone cycleway - Contaminant assessment.* Report prepared by AECOM for the Transport Agency, dated 15 November 2019.
- AECOM (2019a). N2P SH2 Stormwater Quality Design Memorandum (Version 3). Report prepared by AECOM for the Transport Agency, dated 20 December 2019.
- Isthmus plan titled '*Stage 1 - Construction and Enabling Works – Proposed use of reserve during construction*', dated 1 July 2020.
- Isthmus plan titled '*Stage 1 - Construction and Enabling Works – Construction spaces*', dated 1 July 2020.

- Isthmus plan titled '*Stage 1 - Construction and Enabling Works – Concept masterplan'*, dated 1 July 2020.
- Isthmus plan titled '*Stage 1 - Construction and Enabling Works – East side arrangement'*, dated 1 July 2020.
- Isthmus plan titled '*Stage 1 - Construction and Enabling Works – Tāwharau Pods-Temporary Location'*, dated 1 July 2020.
- Isthmus plan titled '*Construction and Enabling Works – Club building requirements'*, dated 1 July 2020.
- Isthmus plan titled '*Construction and Enabling Works – Club building proposed relocation'*, dated 1 July 2020.
- Isthmus plan titled '*Stage 2 – Restoration and Identity – Concept masterplan'*, dated 1 July 2020.
- Isthmus plan titled '*Stage 2 – Restoration and Identity – Landscape treatment'*, dated 1 July 2020.

4.7 Ecological assessment

The methods used to undertake this assessment are consistent with the EIANZ guidelines for undertaking ecological impact assessments (Roper-Lindsay et al., 2018), whereby ecological values are assigned (refer to Table 2 for species, Table 3 for terrestrial and aquatic habitats, and Table 4 for marine ecology) and the magnitude of effects identified (Table 5) in order to determine the overall level of effect of the proposal (Table 6).

In New Zealand, no regional or national guidelines or criteria for the assessment of marine ecological values have been developed to date. In the absence of such guidelines, we have adopted the EIANZ guidelines (Roper-Lindsay et al., 2018) approach to assess marine ecological value (including species richness and diversity).[15] This approach has been used and accepted in previous Board of Inquiry and Environment Court consenting processes for major roads.[16]

We have described marine ecological values in this report as ranging from Very Low to Very High; Table 4 lists the characteristics we have used to guide our assessment of the ecological values of parts of the marine environment within the Project area. Due to the lack of marine assessment criteria and guidelines in New Zealand, our assessment of low, moderate and high benthic invertebrate species richness and diversity is based on our expert judgement and experience. However, the principles and approach to assessing level of effect are directly applicable to marine environments.

According to Roper-Lindsay et al. (2018), the overall level of effect can then be used to guide the extent and nature of the ecological management response required (including the need for biodiversity offsetting):

- Very High adverse effects require a net biodiversity gain.[17]

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[15] Dr De Luca is currently leading a team of marine ecologists who are drafting revisions to the EIANZ guidelines to include marine ecology.

[16] See evidence of Dr De Luca in Board of Inquiry Hearings for NZTA Projects: Pūhoi to Warkworth, Waterview Connection, Transmission Gully, Mackays to Peka Peka, and East West Link.

[17] Though when ecological compensation is required because biodiversity offsetting is not possible, the principles of no-net-loss or net-gain do not apply (Maseyk et al., 2018).

- High and Moderate adverse effects require no net loss of biodiversity values.
- Low and Very Low effects should not normally be a concern. If effects are assessed taking impact management developed during project shaping into consideration, then it is essential that prescribed impact management is carried out to ensure Low or Very Low effects.

Table 2: Criteria for assigning ecological value to species (Roper-Lindsay et al., 2018).

ECOLOGICAL VALUE	SPECIES CLASSIFICATION
NEGLIBLE	Exotic species, including pests, species having recreational value.
LOW	Nationally and locally common indigenous species.
MODERATE	Species listed as any other category of *At Risk* (Recovering, Relict, Naturally Uncommon) found in the ZOI either permanently or seasonally; or Locally (ED) uncommon or distinctive species.
HIGH	Species listed as *At Risk – Declining* found in the ZOI either permanently or seasonally.
VERY HIGH	*Nationally Threatened* (Nationally Critical, Nationally Endangered, Nationally Vulnerable) species found in the ZOI either permanently or seasonally.

Table 3: Assigning overall value to areas (refer to Appendix 1 for the matters to be considered for terrestrial and freshwater communities) (Roper-Lindsay et al., 2018)

VALUE	DESCRIPTION
NEGLIBLE	Area rates Very Low for three matters and Moderate, Low or Very Low for remainder.
LOW	Area rates Low or Very Low for majority of assessment matters and Moderate for one. Limited ecological value other than as local habitat for tolerant native species.
MODERATE	Area rates High for one matter listed in Appendix 1, Moderate and Low for the remainder, or Area rates Moderate for two or more assessment matters Low or Very Low for the remainder Likely to be important at the level of the Ecological District.
HIGH	Area rates High for two of the assessment matters listed in Appendix 1, Moderate and Low for the remainder, or Area rates High for one of the assessment maters, Moderate for the remainder. Likely to be regionally important and recognised as such.
VERY HIGH	Area rates High for three or all of the four assessment matters listed in Appendix 1. Likely to be nationally important and recognised as such.

Table 4: Criteria for assigning ecological value to marine habitats.

ECOLOGICAL VALUE	CHARACTERISTICS
VERY LOW	• Benthic invertebrate community degraded with very low species richness, diversity and abundance. • Benthic invertebrate community dominated by tolerant organisms with no sensitive taxa present. • Marine sediments dominated by silt and clay grain sizes (>85%). • Surface sediment anoxic (lacking oxygen). • Elevated contaminant concentrations in surface sediment, above GV threshold concentrations (Australian and New Zealand Governments, 2018). • Invasive, opportunistic and disturbance tolerant species highly dominant. • Vegetation/macroalgae absent. • Habitat extremely modified.
LOW	• Benthic invertebrate community degraded with low species richness, diversity and abundance. • Benthic invertebrate community dominated by tolerant organisms with few/no sensitive taxa present. • Marine sediments dominated by silt and clay grain sizes (>75%). • Surface sediment predominantly anoxic (lacking oxygen). • Elevated contaminant concentrations in surface sediment, above GV threshold concentrations (Australian and New Zealand Governments, 2018). • Invasive, opportunistic and disturbance tolerant species dominant. • Vegetation/macroalgae provides minimal/limited habitat for native fauna. • Habitat highly modified.
MEDIUM	• Benthic invertebrate community typically has moderate species richness, diversity and abundance. • Benthic invertebrate community has both tolerant and sensitive taxa present. • Marine sediments typically comprise less than 75% silt and clay grain sizes. • Shallow depth of oxygenated surface sediment. • Contaminant concentrations in surface sediment generally below GV threshold concentrations (Australian and New Zealand Governments, 2018). • Few invasive opportunistic and disturbance tolerant species present. • Vegetation/macroalgae provides moderate habitat for native fauna. • Habitat modification limited.
HIGH	• Benthic invertebrate community typically has high diversity, species richness and abundance. • Benthic invertebrate community contains many taxa that are sensitive. • Marine sediments typically comprise <50% smaller grain sizes. • Surface sediment oxygenated. • Contaminant concentrations in surface sediment rarely exceed DGV threshold concentrations (Australian and New Zealand Governments, 2018). • Invasive opportunistic and disturbance tolerant species largely absent. • Vegetation/macroalgae provides significant habitat for native fauna. • Habitat largely unmodified.
VERY HIGH	• Benthic invertebrate community typically has very high diversity, species richness and abundance. • Benthic invertebrate community contains dominated taxa that are sensitive. • Marine sediments typically comprise <25% smaller grain sizes. • Surface sediment oxygenated with no anoxic sediment present. • Contaminant concentrations in surface sediment significantly below DGV threshold concentrations (Australian and New Zealand Governments, 2018).

ECOLOGICAL VALUE	CHARACTERISTICS
	• Invasive opportunistic and disturbance tolerant species absent. • Vegetation/macroalgae sequences intact and provides significant habitat for native fauna. • Habitat unmodified.

Table 5: Criteria for describing magnitude of effect (Roper-Lindsay et al., 2018)

MAGNITUDE	DESCRIPTION
VERY HIGH	Total loss of, or very major alteration, to key elements/ features of the baseline conditions such that the post development character/ composition/ attributes will be fundamentally changed and may be lost from the site altogether; AND/OR Loss of a very high proportion of the known population or range of the 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 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 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/patterns; AND/OR Having a minor effect on the known population or range of the element / feature.
NEGLIGIBLE	Very slight change from existing baseline condition. Change barely distinguishable, approximating to the "no change" situation; AND/OR Having a negligible effect on the known population or range of the element / feature.

Table 6: Criteria for describing the level of effect (Roper-Lindsay et al., 2018)

LEVEL OF EFFECT		ECOLOGICAL AND / OR CONSERVATION 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

4.8 Effects management hierarchy

The order of priority for ecological impact management we have applied to this assessment is outlined in Table 7 and Figure 1. This process has followed the effects management hierarchy as described in Roper-Lindsay et al. (2018) and Maseyk et al. (2018).

Table 7: Effects management hierarchy and terminology (Maseyk et al., 2018)

EFFECTS MANAGEMENT HIERARCHY	DEFINITION
1) Avoidance	To modify a project proposal to prevent any environmental damage or loss of an ecological or environmental feature or function.
2) Remediation	To reverse or stop any environmental damage.
3) Mitigation	To alleviate, or to abate, or to moderate the severity of something (environmental damage), and typically occurs at the point of impact.
4) Biodiversity offset	A measurable conservation outcome resulting from actions designed to compensate for residual, adverse biodiversity effects arising from activities after appropriate avoidance, remediation, and mitigation measures have been applied. The goal of a biodiversity offset is to achieve no-net-loss, and preferably a net-gain, of indigenous biodiversity values. Biodiversity offsetting includes: • **Like-for-like offset -** The residual effect is offset to a no-net-loss or net-gain level by exchanging the same type of biodiversity in accordance with all of the offset principles. • **Trading-up offset -** An out-of-kind exchange of biodiversity that demonstrably exchanges biodiversity of a lesser conservation value for biodiversity of greater conservation value. Meets key offset principles except equivalence of type but is considered to overall deliver an equivalent or improved outcome, because the biodiversity gained is considered to be of greater conservation importance to the biodiversity lost. No standard metrics are currently available to evaluate the exchange so trading up involves an element of subjectivity and societal preference.
5) Environmental compensation	Non-quantified biodiversity benefits are offered to compensate for biodiversity losses. The compensation actions may benefit different biodiversity to that lost (out-of-kind compensation), including biodiversity of lesser conservation concern than that lost. Compensation is not quantified or balanced with losses and may involve subjective decision-making subject to socio-political influences.

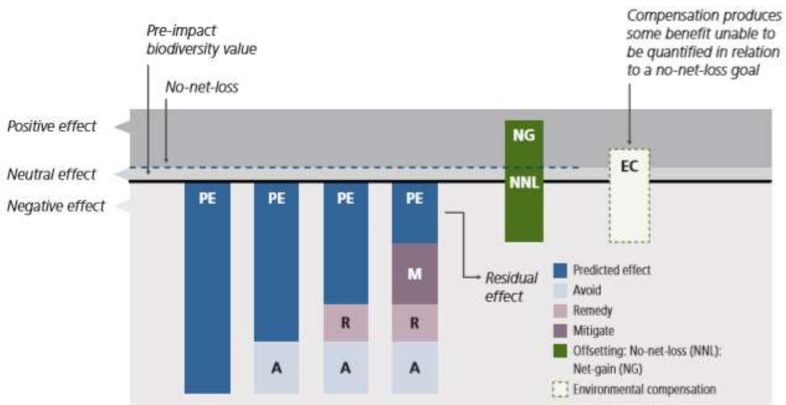

Figure 1: Conceptual illustration of effects management hierarchy progressing from avoidance to environmental compensation (Figure 2 from Maseyk et al. (2018))

5.0 Results - Existing Environment

5.1 Vegetation

A list of the plant species recorded along the Project is provided in Appendix 2; a total of 56 species were identified, comprising 35 exotic and 21 native species. Native vegetation was generally found within areas of amenity roadside plantings, wilding along the road edges and where small peninsulas provided sufficiently sized platforms between the sea and the railway. Exotic species were found throughout the area, particularly scattered through the gravel and the sealed paths along the Project.

The majority of the vegetation cover within the Reserve is grassed recreational fields, with scattered amenity trees (Photo 1). Where the stream flows through the Reserve, there are planted and maintained riparian strips consisting of oioi and wiwi backed by a mixture of toetoe, taupata, and flax. There are also several large areas of glasswort on the Reserve reclamation (Photo 2).

Photo 1: Recreational fields at the Reserve

Photo 2: Area of glasswort along the coastal frontage of the reserve.

Small areas of roadside amenity planting are located near the Ngā Ūranga overpass, opposite the Horokiwi Road intersection (outside of the Project footprint) and within the Honiana Te Puni Reserve. Nine native species in total have been planted consisting of coastal shrubs and secondary forest species such as tree daisy, karo, manuka and pohutukawa (refer to Appendix 2 for latin names); the latter two being the only native species recorded as having an *At Risk* (*Declining*) and *Threatened* (*Nationally Vulnerable*) classification respectively (de Lange et al., 2018). While both manuka and pohutukawa are widespread throughout New Zealand, their current threat classifications have been assigned due to the recent (2017) detection of myrtle rust[18] in New Zealand.

The amenity planting provides little in the way of habitat value due to their fragmented nature, limited size, area and intactness, and inclusion of species not "appropriate" in an ecological sense to the area (e.g. karo and pohutukawa).

[18] A fungal disease that severely attacks plants in the myrtle family including pōhutukawa, mānuka and rātā.

Outside of the amenity plantings, most of the sealed and gravelled area between the road and railway has been regularly sprayed with herbicide, preventing most invading perennial seedlings from establishing. However, a few taupata, flax and pohutukawa have become established in some places, particularly at the southern end of the shared path.

5.1.1 Ecological value

While both manuka and pohutukawa are classified as *At Risk* and *Threatened* respectively, they do not trigger the rarity criteria due to the context in which they are found along the Project. In the case of pohutukawa, Wellington is outside the natural geographic range for this species, which extends only as far south as the volcanic plateau (Greater Wellington Regional Council, 2010). The manuka has been planted and would not have occurred naturally along this coastal margin; as such, the rarity criteria are not triggered here.

Overall, the vegetation associated with the Project ranks low for all four criteria listed in Appendix 1 (representativeness, rarity / distinctiveness, diversity and pattern, ecological context), and as such is considered to be of Negligible ecological value (refer to Table 3).

5.2 Herpetofauna

Given the logistical difficulties in conducting herpetofauna surveys along the Project, it is not surprising that there are no DOC Bioweb database records within that area; however, three species have been recorded within 2 km of the Project since 1999 (Table 8). Based on their habitat preferences, the Project footprint provides potential habitat for northern grass skink and raukawa gecko, both of which are classified as *Not Threatened* (Hitchmough et al., 2016).

Table 8: Lizard fauna recorded within 2 km of the Project since 1999.

Specific name	Common name	Threat classification[19]	Habitat preference[20]
Oligosoma polychroma	Northern grass skink	*Not Threatened*	• Sand dunes, grasslands, herbfields, wetlands, rocky areas including rock piles and scree, and scrub.
Mokopirirakau sp. "Southern North Island"	Ngahere gecko (southern North Island forest gecko)	*At Risk - Declining*	• Forest and shrublands.
Woodworthia maculata	Raukawa gecko (common gecko)	*Not Threatened*	• Forest trees (retreat sites are beneath loose bark or in deep hollows, often on standing dead trees). • Creviced rock outcrops, bluffs and rock tumbles, including associated scrubby vegetation, in open or scrubby areas. • Coastlines among driftwood and boulders banks, including associated dense vegetation such as pohuehue, often down to high-tide line.

[19] Hitchmough et al. (2016)

[20] Atlas of the amphibians and reptiles of New Zealand https://www.doc.govt.nz/our-work/reptiles-and-frogs-distribution/atlas/

Along the coastal section of the Project, the majority of the Project footprint affects current intertidal areas, or areas of riprap embedded in concrete. The lizard habitat there is limited to areas of vegetation which provides cover and artificial and natural rock/debris piles above the high-water mark.

Within HTPR, the large areas of mown grass do not provide habitat for native herpetofauna. Potential lizard habitat within the Reserve includes areas of vegetation which provides cover (Photo 4), rock boulderfields and debris piles above the high-water mark. During a site visit to HTPR on 22 January 2020, a northern grass skink was observed in the rock boulderfield by the boardwalk on the eastern side of the Korokoro Stream (refer to Photo 3).

The potential lizard habitat within the Project footprint occurs in highly scattered, isolated patches (Map 5). Given the small size and isolated nature of these habitats, it is expected that lizards may be present in these areas but will be in low numbers.

Photo 3: Rock boulderfield on eastern bank of Korokoro Stream

Photo 4: Low-growing coastal vegetation in front of existing car park at eastern end of reserve.

5.2.1 Ecological value

Given that the two potentially present species within the Project footprint are classified *as Not Threatened* and the available habitat has only a low potential value due to its context and condition, the herpetofauna values are considered to be **Low** (refer to Table 2).

5.3 Freshwater

There are a number of culverts which pass under SH2 between Ngā Ūranga interchange and Pito-One and which exit into the coastal environment. The purpose of these culverts is to convey stormwater from the state highway and adjacent hills, and to convey streams (both perennial and intermittent) underneath both the state highway and rail corridor. The steep nature of the coastal escarpment and small catchment sizes mean that most of these systems do not have permanent flow and very limited potential fish habitat up stream of the state highway.

Detailed in the following sections are the ecological values associated with the three larger catchments that have some potential aquatic habitat up stream of SH2 and that drain under the Project and for which field data has been previously collected.

5.3.1 Korokoro Stream

The Korokoro Stream catchment is approximately 1,670 ha, discharging into Wellington Harbour (see Photo 5). The Korokoro Stream catchment is largely within indigenous forest (50%, Landcover Database version 4), while the remaining is in exotic forest (13%), gorse and broom scrub (11%), and agricultural land use (pastures) (17%). Just 5% of the catchment is roads and transport infrastructure (at the downstream end of the catchment). At the stream mouth, the tidally-influenced reaches of Korokoro stream are a heavily industrialised area (see Photo 5, Photo 6 and Photo 7).

Freshwater fish and koura records obtained from the NIWA FFDB for the Korokoro Stream catchment are provided in Table 9. Taylor & Kelly (2001) identified several areas suitable for inanga spawning habitat at the Korokoro Stream mouth; the best location was downstream of a weir, between the train track and the Esplanade turnoff, along both banks of the waterway for a distance of approximately 5 m.

The Korokoro Stream (and tributaries) is listed as a river with significant indigenous ecosystems in Schedule F1 of Greater Wellington Regional Council's proposed Natural Resources Plan (PNRP; GWRC (2019)) (see Map 6).

Photo 5:Lower Korokoro catchment with stream passing under an industrial area and existing transport infrastructure onto coast.

Photo 6:Korokoro Stream mouth

Photo 7:Pedestrian and cycle bridge across Korokoro Stream

*Table 9: NIWA FFDB records for the Korokoro Stream catchments (data accessed 2 August 2019). *indicates migratory species.*

Species	Common name	Threat classification[21]	Year recorded
Anguilla australis	Shortfin eel*	*Not Threatened*	1975, 1982, 2007, 2016
Anguilla dieffenbachii	Longfin eel*	*At Risk - Declining*	1952, 1974, 1975, 1982, 2007, 2009, 2016
Galaxiias argenteus	Giant kokopu*	*At Risk - Declining*	1982, 2009
Galaxiias brevipinnis	Koaro*	*At Risk - Declining*	2007
Galaxiias fasciatus	Banded kokopu*	*Not Threatened*	2009, 2016
Galaxiias maculatus	Inanga*	*At Risk - Declining*	1952, 2007, 2009, 2016
Gobiomorphus cotidianus	Common bully*	*Not Threatened*	1952, 1985, 2007, 2009
Gobiomorphus hubbsi	Bluegill bully*	*At Risk - Declining*	1975, 1982, 2007, 2016
Gobiomorphus huttoni	Redfin bully*	*Not Threatened*	1952, 1974, 1975, 1982, 1985, 2007, 2009, 2016
Paranephrops planifrons	Koura	*Not Threatened*	2016
Retropinna	Common smelt*	*Not Threatened*	2009
Salmo trutta	Brown trout	*Introduced & Naturalised*	1974, 1975, 1982, 1985, 2007, 2009, 2016

5.3.2 Waihinahina (Horokiwi) Stream

The Project intersects the stream mouth of the Waihinahina (Horokiwi) Stream (refer to Map 2). The Waihinahina Stream drains a small 55 ha catchment east towards the Wellington Harbour. The historic stream (prior to the Horokiwi Quarry) was comprised of three gully tributaries combining to form a rocky coastal perennial stream under a broadleaf coastal forest that fell in steps (with waterfalls) to the coast. Most of the smaller “drainage” gullies were (or are) ephemeral. Over the years of quarrying almost no part of the natural stream remains. The current waterway is largely in an open concrete culvert for some 600 m before it is piped and culverted underground. It emerges

[21] Dunn et al. (2018) for freshwater fish; Grainger et al. (2018) for freshwater invertebrate (koura).

from the culvert at the main quarry face where it cascades down the exposed quarrying face. The stream (after about 130 m) then passes under SH2 via concrete culverts (see Photo 8) to a tidal flat.

Much of the main stem has been lost to a piped system under the quarry, and the catchment largely filled with overburden. There is little of the remaining waterway in anything close to a reasonable habitat condition. No fish remain in the middle and upper catchment and there is no habitat currently (and for the foreseeable future) for native fish.

Fourteen aquatic macroinvertebrate taxa have been recorded in the headwaters of the Horokiwi Stream (Boffa Miskell Ltd, 2008). Although this is a low taxa richness, the community was predominantly of EPT taxa. These reasonable quality assemblages are in the gully headwaters disconnected from the coastal waterway.

The only "stream" habitat related to the coastal edge, and connected, is the small approximately 130 m reach above SH2 (see Photo 9). Many years of quarry-related activities, vegetation removal and the culverting of much of the lower stream system has modified and compromised the ecological values of the area.

The Waihinahina Stream is not listed as a river with significant indigenous ecosystems in Schedule F1 of Greater Wellington Regional Council's proposed Natural Resources Plan (PNRP; GWRC (2019)).

Photo 8: Waihinahina Stream exiting into the coastal environment through culverts under SH2

Photo 9: Waihinahina catchment and quarry (red dashed ellipse denotes approximate stream location above SH2)

5.3.3 Gilberd Bush Stream

BML (2013) describes a un-named stream located to the immediate south of the Waihinahina Stream catchment (see Photo 10), in the Gilberd Bush Reserve (refer to Map 2). The gully contains a short (1.5 km) bifurcated steep headwater coastal stream. Through a culvert under SH2 (see Photo 11), the stream rises very steeply up a short coastal face (some 120 m), through at least two water fall sections to enter into a long semi-buried concrete pipe (see Photo 12 and Photo 13). The stream emerges (after approximately 20 m) from this pipe into a completely concrete formed half pipe channel and travels up the steep slope to the gully floor a further 120 m (see Photo 14). The concrete half pipe channel continues along the gully for a further 200 m at a more level gradient to a crossing culvert (passing through a concrete box chamber settling bay on the way; see Photo 15). Upstream of the culvert is a dug out, rock, bitumen and concrete bric-a-brac lined basin. Above this basin the stream takes on a more natural substrate bed for a further 120 m prior to entering the forested canopy section of the upper gully (see Photo 16).

BML (2013) reported the basin, culvert and concrete channel and outlet pipe was completely dry at the time of that survey. An electric fishing machine was used to survey 100 m of the forested natural section (which still retained water), fishing the riffles as well as the pools below and above "weir" structures. No fish were sampled. Based on observations during the stream assessment, BML (2013) conclude that the combination of the SH2 culvert, historic disturbances during earlier quarry activities, array of water falls, and the historic piping and concrete channel, fish passage has been obstructed for many years. While the habitat in the upper section (above the point where the stream re-enters the coastal forest in the deeply incised gully system), which equates to around 500 m of the main stem, has no fish potential, it remains a habitat of some quality for macroinvertebrate communities.

The Gilberd Bush stream is not listed as a river with significant indigenous ecosystems in Schedule F1 of Greater Wellington Regional Council's proposed Natural Resources Plan (PNRP; GWRC (2019)).

Photo 10: Gully immediately south of Waihinahina (Horokiwi) catchment containing an un-named (Gilberd Bush) stream.

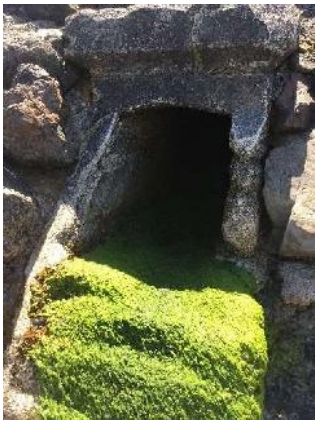

Photo 11: Culvert passing under SH2.

Photo 12: Rain flow discharging pipe.

Photo 13: A view down through the lower coastal systems steep slopes through which no surface water flows.

Photo 14: Concrete channel through main gully reach

Photo 15: Concrete box settling basin

Photo 16: Forested gully section

5.3.4 Un-named streams

There are three other small catchments intersecting with the Project which have not been inspected as part of this assessment but have been characterised based on our knowledge of adjacent waterways and consideration of the likely flow and habitat morphology.

The first un-named stream is located to the south of the Gilberd Bush stream (refer to Map 2); the catchment is approximately 20 ha and there is some 800 linear meters of stream habitat above SH2. This stream has six steep tributaries, likely ephemeral, under coastal broadleaf forest (largely mahoe) on steep rocky substrate. The main stem will likely have a similar macroinvertebrate fauna as both Gilberd Bush and Waihinahina (Horokiwi) streams; that is, EPT taxa and MCI indicating excellent water quality (120+) and be representative of a coastal rocky Wellington stream fauna. It is unlikely however, that there will be any native fish populations as the surface water resource in the main stem is likely to be small (creating only shallow flows riffles and pools) and the flow is also likely to be intermittent.

The second un-named stream is also located to the south of Gilberd Bush stream (refer to Map 2) and is likely to be at least intermittent (there are six ephemeral flow paths further south). This catchment is approximately 16 ha and above SH2 the main stem is approximately 450 m. This stream has not been inspected but its headwater systems are very steep and likely to be ephemeral, and the main stem an intermittent surface flow series of shallow runs, riffles and small pools. There is a possibility that there is an occasional banded kokopu or kōaro, but passage to the sea is significantly interrupted by the SH2 and rail culvert system.

The third un-named stream is located between the Korokoro and Waihinahina (Horokiwi) streams (refer to Map 2). The catchment is approximately 30 ha with a short main stemmed stream (300 m) serviced by four headwater tributaries. The catchment is largely seral coastal broadleaf vegetated with some modification in the base of the main stem, including a possible dam and ponding and a ford / crossing. The access to the coast for the stream is again through an existing culvert under the SH2 and rail. As with Waihinahina, the headwater ephemeral and intermittent sections are likely to have a representative macroinvertebrate fauna but no permanent fish habitat and between the intermittent nature and current fish passage issue it is unlikely that there are any native fish populations.

These three un-named streams are not listed as a river with significant indigenous ecosystems in Schedule F1 of Greater Wellington Regional Council's proposed Natural Resources Plan (PNRP; GWRC (2019)).

5.3.5 Ecological value

5.3.5.1 Korokoro Stream

The Korokoro Stream, given its catchment condition, remains largely in representative riparian condition with native forests and seral stage habitats, with good quality water, and a natural flow regime, channel path and morphology. The instream fauna is diverse and representative and contains a range of *At Risk* fish species. It is one of a very few catchment systems nearly fully vegetated with no other land use (there is some forestry in the catchment) that includes the entire stream system from hill lands to the coastal connection. In terms of context, pattern, representativeness, rarity and distinctiveness, the Korokoro rates highly. Following the EIANZ guidance (Roper-Lindsay et al., 2018) and acknowledging the stream (and catchment) rate high for over three criteria, the ecological value of the Korokoro stream is considered to be Very High.

5.3.5.2 Waihinahina (Horokiwi) Stream

The upper stream (above the open quarry and historic channel modifications and where the stream may be perennial), is relatively representative of a coastal stream habitat with a broadleaf-mahoe riparian condition and a macroinvertebrate fauna representative of such variable flow rocky, incised steep catchments with a MCI indicating good water quality.

The upper stream is however, largely isolated from the coast and not connected and has little habitat remaining in the middle and lower reaches. Context and pattern are disrupted and there are no recorded rare or distinctive features or species. There is no native fishery. The upper reaches rate High for representativeness, but Low for rarity, Moderate for diversity, Low for pattern, and Low for context; the overall value of the upper stream being Moderate.

The middle and lower reaches (including the 150 m between the quarry and SH2) are highly disturbed, not representative, and Low for all other criteria. As such, these sections of waterway are considered to be of Negligible freshwater value.

5.3.5.3 Gilberd Bush Stream

As with the Waihinahina (Horokiwi), the upper reach of the Gilberd Bush stream within the forested reserve (Gilberd Bush Reserve) has good condition aquatic habitat with a representative macroinvertebrate fauna and natural flow regime, a riparian broadleaf coastal forest with instream functions and structures that are normal and good quality. No native fish or species with rarity or any distinctive features are present. The criteria suggest a value of High.

Below the forest the channel is largely unnatural, modified and ephemeral with an absence in natural substrate, an absence of instream fauna, fish or riparian vegetation. For these reasons the lower stream (approximately half the entire stream length) has a Negligible freshwater value.

5.3.5.4 Un-named streams

The three larger systems which all likely have some perennial portions have strong riparian cover and relatively natural flow regimes and stream morphology. While unlikely to have fish populations, naturally these areas were of limited abundance and diversity. They have, we surmise, relatively simple but representative macroinvertebrate fauna. All have interrupted lower reaches due to the existing piped sections under SH2 and the rail. These streams are considered to have Moderate freshwater value based on moderate representativeness and diversity and pattern, and low rarity and context.

5.4 Avifauna

At a broadscale, the Wellington Harbour (Port Nicholson) – inland waters is identified in Schedule F2c of the PNRP (Greater Wellington Regional Council, 2019) as significant habitat for indigenous birds in the coastal marine area. The values associated with the inland waters include:

- Five *Threatened* or *At Risk* species are known to be resident or regular visitors to Wellington Harbour (Port Nicholson): little penguin, fluttering shearwater, red-billed gull, Caspian tern and white-fronted tern.
- Providing foraging habitat for the majority of the regional population of spotted shags.
- Large numbers (up to several thousand) of fluttering shearwaters enter the harbour during winter months to rest and feed.

- Providing foraging habitat and access for little penguins to several large, secure nesting colonies on Matiu/Somes, Mokopuna and Makaro/Ward Islands.

At a finer scale, Schedule F2c identifies the Wellington Harbour from Pito-One Beach rowing club to Ngā Ūranga railway station as providing habitat for indigenous birds in the coastal marine area (refer to Map 6); the PNRP reports six *Threatened* or *At Risk* indigenous bird species are known to be resident or regular visitors to this habitat (variable oystercatcher, red-billed gull, black shag, little black shag, pied shag and white-fronted tern).

When the site was assessed by McArthur et al. (2015) against the criteria in the Wellington Regional Policy Statement for Policy 23, it was recognised as significant based on diversity values (Category 2), but it did not meet the rarity (Category 3) or ecological context (Category 3) criteria (refer to Table 10 for criteria). As such, the Wellington Harbour foreshore between Pito-One Beach rowing club to Ngā Ūranga railway station can be described as providing habitat for:

- 4-6 *Threatened* or *At Risk* species known to be resident at or regularly using the site (Category 2 for Diversity);
- <5% of the regional population of a *Threatened* or *At Risk* species (Category 3 for Rarity); and
- Seasonal or core habitat for <33% of the regional population of a protected (but not *Threatened* or *At Risk*) species (Category 3 for Ecological District).

Avifauna species data obtained from Robertson (1992) (coastal section between Horokiwi and Ngā Ūranga), OSNZ atlas data (10 x 10 km grid square, refer to Map 3), eBird (Wellington Harbour rail corridor) and field investigations are in Appendix 3. Due to the focus of Robertson (1992) and eBird data being collected along and adjacent to the Project area, these sources, along with the targeted field investigations, provide the most representative list of the avifauna utilising the site and adjacent CMA. Details of observations recorded during the coastal bird surveys along the Project and at the Korokoro Estuary are provided in Appendix 4, with general patterns of species use summarised below.

Table 10: Criteria developed by McArthur et al. (2015) to translate RPS Policy 23 criteria to score significant indigenous coastal and freshwater bird habitat in the Wellington Region. Red text identifies the category scores for the Project site.

Policy 23 Criteria	RARITY	DIVERSITY	ECOLOGICAL CONTEXT
Category 1 site (meets the RPS Policy 23 criteria)	The site provides habitat for: ≥10% of the regional population of a nationally critical species; or ≥15% of the regional population of a nationally endangered species; or ≥20% of the regional population of a nationally vulnerable species; or ≥25% of the regional population of an at risk species	7 or more threatened or at risk species are known to be resident at or regularly using the site	The site provides seasonal or core habitat for ≥67% of the regional population of a protected (but not threatened or at risk) species
Category 2 site (meets RPS Policy 23 Criteria	The site provides habitat for 25% of the regional population of a threatened or at risk species	4-6 threatened or at risk species are known to be resident at or regularly using the site	The site provides seasonal or core habitat for 33-66% of the regional population of a protected (but not threatened or at risk) species

Policy 23 Criteria	RARITY	DIVERSITY	ECOLOGICAL CONTEXT
Category 3 site (does not meet RPS Policy 23 criteria)	The site provides habitat for <5% of the regional population of a threatened or at risk species	Less than 4 threatened or at risk species known to be resident at or regularly using the site	The site provides seasonal or core habitat for <33% of the regional population of a protected (but not threatened or at risk) species

As identified through the results of the botanical surveys (refer to Section 5.1), there is very limited terrestrial vegetative habitat available for avifauna. The coastal margin of the Project comprises a mix of habitat values for coastal avifauna, including:

- Relatively large areas of concrete embedded rip-rap (Photo 17) which provide no foraging or nesting opportunities, and only limited roosting habitat (Photo 18 and Appendix 4).
- Rocky headlands and outcrops (Photo 19) which are used primarily as high tide roosts by variable oystercatcher, shags, gulls and white-fronted tern (Photo 20 and Appendix 4).
- Intertidal habitats (gravel / shingle beaches and rocky pools) which are used as foraging habitat for a number of species such as gulls, white-faced heron, shags and variable oystercatcher (Photo 21 and Appendix 4). The areas of shingle beaches themselves are also classified as an endangered ecosystem type (Holdaway et al., 2012; Williams et al., 2007).
- Backshore nesting habitat occurs above MHWS on the beach adjacent to the KiwiRail signal station. Both variable oystercatcher and black-backed gull were confirmed breeding at this location, and an empty penguin burrow was found under vegetation (refer to Map 7 and Appendix 4).
- Crevices in the loose rip-rap above MWHS provide potential nesting habitat for little penguins, with one nest confirmed (refer to Map 7 and Photo 22 and Appendix 4).
- In addition, the near shore waters adjacent to the Project provide foraging habitat for inshore feeders such as shags, terns and gulls (Appendix 4).

Photo 17: Concrete-rock embedded seawall which provides no crevices for nesting little penguins.

Photo 18:Little shag basking on the crest of the existing revetment.

Photo 19: *Example of a high value rocky outcrop and headland roosting habitat.*

Photo 20:White-fronted tern and red-billed gull roosting on the rocky outcrops and existing revetment.

Photo 21: Example of a high value gravel intertidal foraging habitat.

Photo 22: Little penguin burrow located within the existing loose rip-rap along the coastal margin.

Table 11 provides a summary of the coastal and oceanic birds recorded on and adjacent to the Project, along with their threat classifications, habitat use and estimated national and regional populations. The three species recorded nesting along the Project are black-backed gull, variable oystercatcher and little penguin (refer to Map 7); the latter two species are classified as *At Risk* (H. A. Robertson et al., 2017). Details regarding breeding biology of these three species are provided in the following sections to provide relevant context for assessment of effects.

5.4.1 Breeding species

5.4.1.1 Black-backed gull

Black-backed gull is a very abundant, widespread and locally common native species which is classified *Not Threatened*. This species is one of only two native bird species not afforded any level of protection under the Wildlife Act (1953).

Table 11: Habitat utilisation by native coastal avifauna species associated with the Project site and Wellington Harbour (denotes nesting birds recorded along the Project).*

SPECIES	THREAT STATUS[22]	VALUE[23]	HABITAT USE	ESTIMATED NATIONAL POPULATION	ESTIMATED REGIONAL POPULATION
Reef heron	*Threatened - Nationally Endangered*	Very High	• Occasionally forages in intertidal rocky shore zone of the Project.	300-500 birds[24]	15 birds (McArthur et al., 2019)
Caspian tern	*Threatened – Nationally Vulnerable*	Very High	• Listed in the PNRP as known to be resident or regular visitor to the Wellington Harbour. • One bird observed traversing the Korokoro Estuary (refer to Appendix 4).	1300-1400 breeding pairs[25]	45 birds (McArthur et al., 2019)
Little penguin*	*At Risk - Declining*	High	• Two nests located above MWHS along the Project (one in rip rap and one under vegetation at Rocky Point). • Reported to utilise the culverts under SH2 to access coastal escarpment (Brent Tandy, DOC, pers. comm). • Forages in the Wellington Harbour.	5,000 – 10,000 breeding pairs of Northern little penguin (G. A. Taylor, 2000b)	420 breeding pairs (McArthur et al., 2019)
Red-billed gull	*At Risk - Declining*	High	• Roosts on coastal edge and forages on the shingle beaches. Maximum 7 birds recorded during a survey period (refer to Appendix 4). • Forages inshore and onshore. • Listed in the PNRP as known to be resident or regular visitors to this area.	Approximately 28,000 breeding pairs (Frost & Taylor, 2018)	2,478 breeding birds (McArthur et al., 2019)
White-fronted tern	*At Risk - Declining*	High	• Most recorded in harbour between the months of March and May (H. A. Robertson, 1992) • Observed roosting on coastal edge and foraging offshore. Maximum 30 birds recorded during a survey period (refer to Appendix 4). • Forages in the Wellington Harbour, inshore and offshore.	12,000 – 15,000 breeding pairs (G. A. Taylor, 2000a)	298 breeding birds (McArthur et al., 2019)

[22] Robertson et al. (2017)

[23] Refer to Table 2

[24] Adams, R. 2013. Reef heron. In Miskelly, C.M. (ed.) *New Zealand Birds Online* www.nzbirdsonline.org.nz

[25] Fitzgerald, N. 2013. Caspian tern. In Miskelly, C.M. (ed.) *New Zealand Birds Online* www.nzbirdsonline.org.nz

SPECIES	THREAT STATUS[22]	VALUE[23]	HABITAT USE	ESTIMATED NATIONAL POPULATION	ESTIMATED REGIONAL POPULATION
Pied shag	*At Risk - Recovering*	Moderate	• Low numbers roost on coastal edge, rock outcrops and headlands of the Project. Maximum 3 birds recorded during a survey period (refer to Appendix 4). • Forages in the Wellington Harbour, inshore and offshore. • Listed in the PNRP as known to be resident or regular visitors to this area.	~3,200 breeding pairs (Wildlife Management International Ltd, 2013)	474 birds (McArthur et al., 2019)
Variable oystercatcher*	*At Risk - Recovering*	Moderate	• Forages in intertidal zone and roosts on coastal edge, rock outcrops and headlands of the Project. • Birds recorded at each of the major shingle beaches along the Project. • One nest recorded in the backshore above MHWS at Rocky Point • Maximum 6 birds recorded during a survey period (refer to Appendix 4). • Listed in the PNRP as known to be resident or regular visitors to this area.	~4,000 birds (Southey, 2009)	728 breeding birds (McArthur et al., 2019)
Fluttering shearwater	*At Risk – Relict*	Moderate	• Forages offshore; recorded on the water and does not make landfall on the Project. • Listed in the PNRP as known to be resident or regular visitor to the Wellington Harbour; mostly April to October (H. A. Robertson, 1992).	>100,000 birds (G. A. Taylor, 2000b)	~50 breeding birds (McArthur et al., 2019)
Black shag	*At Risk - Naturally Uncommon*	Moderate	• One bird recorded roosting on the rock outcrops of the Project (refer to Appendix 4). • Forages in the Wellington Harbour, inshore and offshore • Listed in the PNRP as known to be resident or regular visitors to this area.	5,000 – 10,000 breeding pairs (G. A. Taylor, 2000b)	250 breeding birds (McArthur et al., 2019)
Little black shag	*At Risk - Naturally Uncommon*	Moderate	• Mainly visit Wellington Harbour from May to August, but a few present in all months (H. A. Robertson, 1992). • Forages inshore.	2,000 – 4,000 birds (G. A. Taylor, 2000b)	
Little shag	*Not Threatened*	Low	• Roosts on coastal edge, rock outcrops and headlands (single bird recorded; refer to Appendix 4). • Forages inshore.	10,000 birds (G. A. Taylor, 2000b)	

SPECIES	THREAT STATUS[22]	VALUE[23]	HABITAT USE	ESTIMATED NATIONAL POPULATION	ESTIMATED REGIONAL POPULATION
			• Mainly a winter visitor to Wellington Harbour (H. A. Robertson, 1992).		
Black-backed gull*	*Not Threatened*	Low	• Most frequently observed coastal bird recorded along the Project. Maximum 20 birds recorded during a survey period (refer to Appendix 4). • Roosts on coastal edge, rock outcrops and headlands of the project. • Nests on the gravel backshore above MHWS of the project. • Inshore and offshore forager.	>1,000,000 breeding pairs (G. A. Taylor, 2000b)	Very abundant
Spotted shag	*Not Threatened*	Low	• Roosts on coastal edge, rock outcrops and headlands of the Project. Maximum 2 birds recorded associated with the coastal edge during a survey period (refer to Appendix 4). • Harbour and coastal inshore forager. • Resident in Wellington Harbour from June to February, most nesting on Matiu/Somes Island (H. A. Robertson, 1992).	<30,000 breeding pairs (G. A. Taylor, 2000b)	~350 birds (Waugh et al., 2013)
White-faced heron	*Not Threatened*	Low	• Forages in intertidal zone of the Project (single bird recorded during a survey; refer to Appendix 4).	Abundant	Abundant

Birds breed both in colonies or solitary, and nests are a bulky collection of grass, small sticks or seaweed, or a simple scrape in sand or shingle.[26] The breeding season is generally September through March, with most eggs laid mid-October to late-November.

Black-backed gulls are opportunists, taking a variety of food, including offal, refuse, carrion, marine invertebrates and shellfish, fish, eggs, lizards, birds, mammals, fruit and plant material (Heather & Robertson, 2005).

5.4.1.2 Variable oystercatcher

Variable oystercatchers are almost exclusively a coastal wader, favouring sandy and rocky shorelines (Crossland, 2001). They are intertidal foragers, including on rock platforms. Most birds are sedentary, defending territories throughout the year. Robertson (1992) reported variable oystercatcher breeding at isolated spots around Wellington Harbour, with the largest breeding population (11 pairs) on Matiu-Somes Island. The nest is a shallow scrape, usually on a sandy beach just above spring-tide level, but also on shingle beaches and wave platforms (Heather & Robertson, 2005).

The breeding season is generally September through March, with most eggs (2-3) laid from mid-September to early February (Bell, 2010). Breeding success of variable oystercatchers is often low, with main causes of failure being predation of eggs or chicks by a range of mammalian and avian predators, flooding of nests by big tides, and disturbance resulting from human recreational use of the coast.[27]

5.4.1.3 Little penguin

The little penguin is an Australasian coastal species that breeds in loose colonies. This species nests around much of Wellington Harbour coastline, the largest colony being on Matiu-Somes Island, which has an estimated *c.* 300 pairs / 700+ adults (de Lisle 2014, Rumble 2018b, Taylor 2018 *in* Overmars (2019)). When ashore, little penguins are nocturnal, typically coming ashore after dusk and leaving before dawn. Adults are present at colonies throughout the year, though numbers are lowest between completion of moult (April) and start of breeding (August) (Marchant et al., 1990). Bullen (1997) reported very few birds on Matiu/Somes Island from March-June.

For most colonies in New Zealand the breeding season begins around August and continues until January when chicks fledge (Davis & Renner, 2010). The yearly cycle of little penguins on Matiu/Somes Island has three non-exclusive parts: (a) July to January - breeding; (b) December to March - moult; (c) March to August - occupation of nesting burrows and pair formation (Bullen, 1997; Kinsky, 1959, 1960). Egg laying (one or two eggs) occurs from late July through to mid-November, with a peak period from late August to late September ((Bull, 2000b; Kinsky, 1959, 1960).

Nests are generally situated close to the sea in burrows excavated by the birds or other species, or in caves, rock crevices (including rip-rap revetments), under logs or in or under a variety of man-made structures including nest boxes, pipes, stacks of wood or timber, and buildings. Little penguins exhibit high levels of fidelity, generally returning to the same landing site, nest and mate

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[26] Miskelly, C.M. 2013. Southern black-backed gull. In Miskelly, C.M. (ed.) *New Zealand Birds Online*. www.nzbirdsonline.org.nz

[27] Dowding, J.E. 2013 [updated 2017]. Variable oystercatcher. *In* Miskelly, C.M. (ed.) *New Zealand Birds Online.* www.nzbirdsonline.org.nz

each breeding season (Bull, 2000b; Pledger & Bullen, 1998). Pledger & Bullen (1998) calculated the probabilities of mate and nest fidelity and provided statistically valid evidence that little penguins on Matiu-Somes Island show a strong tendency to return to the their previous mate and nest. Bull (2000b) reported that the bond to the nest had a stronger influence on breeding success rather than the bond to the mate.

Little penguins are confined to land during the annual moult (mainly between January and March), during which all feathers are replaced simultaneously over the period of 2-3 weeks (Gales et al., 1988; Kinsky, 1960; Reilly & Cullen, 1983). Moulting birds fast for the entire moult period as they are unable to swim without getting water-logged (Heather & Robertson, 2005).

Thus, birds are vulnerable to disturbance and predation when on land during both the nesting and moulting periods.

During the breeding season, little penguin are generally near shore foragers. A study tracking the foraging of little penguin nesting in Wellington Harbour (Matiu-Somes Island, Days Bay and Balena Bay) recorded penguins foraging mostly within the harbour and within 12 km of their colony (Poupart et al., 2017). The birds showed consistent foraging patterns between years, and there were no differences in their range, distance travelled or trip duration between the different breeding stages (Poupart et al., 2017). Within Wellington Harbour, birds were recorded foraging mostly in its centre and eastern sides (Poupart et al., 2017; Zhang et al., 2015).

5.4.2 Ecological value

Following the EIANZ guidelines (Roper-Lindsay et al., 2018), we have assigned ecological value to coastal avifauna species based on their NZ Threat Classification (refer to Table 2). As listed in Table 11, the native coastal avifauna associated with the Project range from **Low** to **Very High** ecological value.

5.5 Marine

5.5.1 Relevant marine habitats identified in the PNRP

The following marine habitats are present within or adjacent to the Project and identified in the respective schedules of the PNRP (Greater Wellington Regional Council, 2019):

- Korokoro Estuary (Schedule F4: Sites of significant indigenous biodiversity values in the coastal marine area (refer to Map 6);
- Seal haulouts (Schedule F5: Habitats with significant indigenous biodiversity values in the coastal marine areas);
- Macroalgae (Schedule F5: Habitats with significant indigenous biodiversity values in the coastal marine areas); and
- Subtidal rocky reefs (Schedule F5: Habitats with significant indigenous biodiversity values in the coastal marine areas).

5.5.2 Overview of marine habitats relevant to the Project

The Project occurs along a shoreline that has been highly modified through reclamation in the past in order to construct both road and rail network. The least modified part of this shoreline occurs at the Pito-One end of the Project, where there is a sand/gravel beach present (shown below in Photo 23).

The intertidal and shallow subtidal areas within the Project's ZOI comprise a mosaic of benthic substrates (rocky reef, cobbles, boulders, gravel, shingle beaches, concrete and brick debris) (Map 8). It is difficult to delineate some substrate types when in fact substrates such as cobbles and gravels progressively grade into one another over relatively small spatial scales. The mosaic of shallow subtidal rocky reef / cobble / macroalgae habitat and shingle beaches adjacent to or within the Project footprint have been approximately mapped using the most recent aerial imagery, taken at low tide, that had good water clarity within the shallow subtidal habitat (Map 8). The habitat areas between the mapped rocky reef / cobble / macroalgae and shingle beaches comprise primarily sand/gravel (collectively referred to throughout this document as 'soft sediment'). Although the spatial extent of habitat types has been drawn, there will be some variability due to some habitats graduating into other habitats, the spatial variability over small areas and combination of habitat types present[28].

For assessing ecological values in the marine environment at and adjacent to the Project, due to the intertidal and shallow subtidal zones being a mosaic of substrate types, we have used the highest values present as being representative of the entire marine habitat.

Photo 23: Sand/gravel beach along the Pito-One foreshore, shown on the right-hand side of the photo.

[28] Fieldwork, beyond that which we undertook at survey sites, to attempt to validate the mapped boundaries is unlikely to result in greater accuracy, nor result in changes to the assessment of effects on marine ecological values.

5.5.3 Sector 2 (Ngā Ūranga to Pito-One) - Intertidal

The intertidal habitats along the Project comprise a mixture of rocky shore (both natural and constructed) with cobbles and soft sediment gravel/sand and shingle) beaches. Each of these habitat types (rocky shore and soft sediment) are described in the following sections.

5.5.3.1 Rocky shore

Existing Information

Existing data from a previous phase of the Project in 2014 detected, at approximately chainage 1400 m and 2900 m (Map 4), the presence of barnacles (*Chaemosipho columna*), little black mussel (*Limnoperla pulex*), limpets (*Cellana ornata* and *Patelloida corticata*), an unidentified whelk, sea lettuce (*Ulva lactuca*), *Carpophullum maschalocarpum*, and unidentified green turfing algae (Boffa Miskell Ltd, 2015).

2019 Surveys

Six predominately rocky shore areas were surveyed in 2019 (Photo 24 to Photo 29). Similar species were detected in the 2014 and the 2019 surveys.

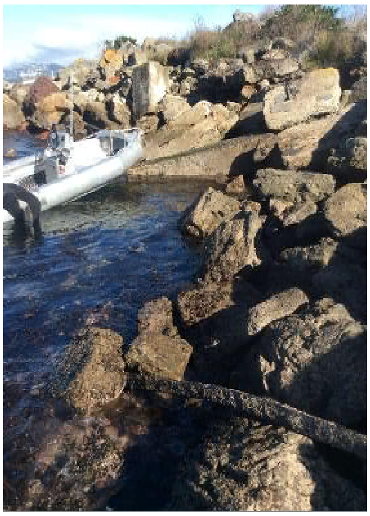

Photo 24: Survey site at chainage 1170m – showing concrete and rock boulders and gravel substrate.

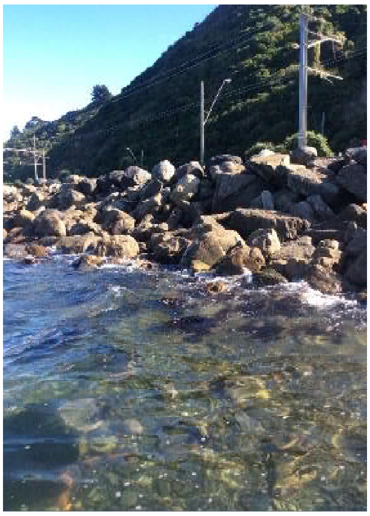

Photo 25: Survey site at chainage 1420m – showing concrete/rock boulder substrate.

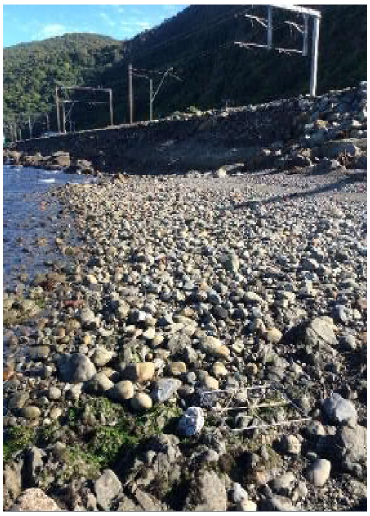

Photo 26: Survey site at chainage 2820m – showing cobble and gravel substrate.

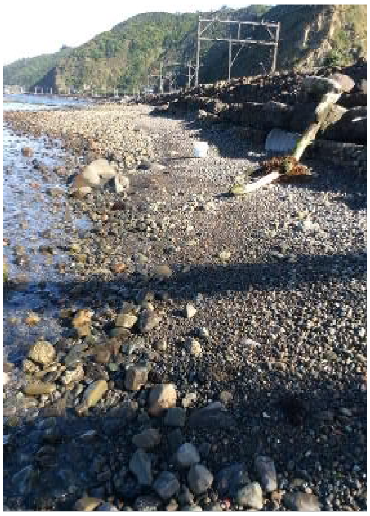

Photo 27: Survey site at chainage 3770m – showing cobble/gravel substrate.

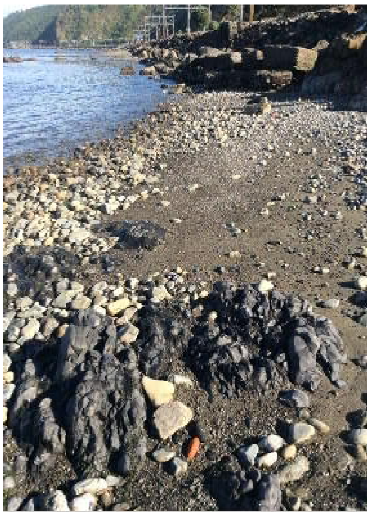

Photo 28: Survey site at chainage 3930m – showing cobble, boulder habitat.

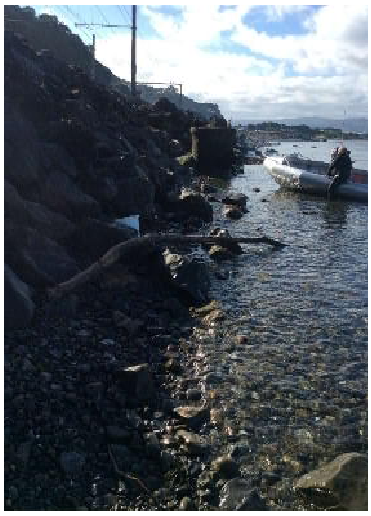

Photo 29: Survey site at chainage 4210m – showing cobble, boulder, gravel habitat.

The presence of macroalgae and invertebrates in replicate quadrats, at each site (refer to Map 4 rocky shore 2019 survey sites), is presented in Table 12 below. The greatest diversity of organisms was detected at chainage 1420 m and 3930 m where the substrate is concrete/rock boulders and cobbles and bedrock respectively. The lowest range of organisms was detected where there were greater proportions of gravel (Table 12). There was high variability in the percentage cover and number of mobile organisms both within and between sites. Overall, there was a low diversity and abundance of organisms present at intertidal rocky shore sites.

Table 12: Percentage cover (in blue) or number of mobile individuals (in yellow) of hard shore macroalgae and invertebrates recorded at the 2019 rocky shore survey sites (refer to Map 4)

Chainage (m)	Distance	Habitat*	*Ulva lactuca*	*Gigatina sp.*	Red encrusting algae	Pink coralline paint	Barnacles (*Chaemosipho columna*)	Tubeworms	Mussels (*Mytilus edulis*)	Limpets (*Cellana denticulata* and *Cellana radians*)	Oyster borer (*Lepsiella scobina*)	*Diloma aethiops*
1170	1	CoRG										
	2	CoRG										1
	3	CoRG								1		
1420	1	CoR					20			3		
	2	CoR	15				20			1		2
	3	CoR			2		5	1			15	
2820	1	CG										

Chainage (m)	Distance	Habitat*	*Ulva lactuca*	*Gigartina sp.*	Red encrusting algae	Pink coralline paint	Barnacles (*Chaemosipho columna*)	Tubeworms	Mussels (*Mytilus edulis*)	Limpets (*Cellana denticulata* and *Cellana radians*)	Oyster borer (*Lepsiella scobina*)	*Diloma aethiops*
	2	CG	5									
	3	CG	5	2							2	1
3770	1	CG										
	2	CG										
	3	CG										
3930	1	CR	2	2			1		5			
	2	CR	1	1			1		2			
	3	CR	2	5			1		2			
4210	1	BCG										
	2	BCG	1									
	3	BCG	1			1						

***We have broadly characterised the main substrate types within the quadrats surveyed as follows: CG = cobbles and gravel, CoR = concrete/rock boulders, CoRG = concrete/rock boulders and gravel, BCG = boulders, cobbles and gravel, CR = cobbles and reef/bedrock.**

Additional hard shore species that were not present within the quadrats but observed on the shoreline are included in Table 13. Organisms detected are common intertidal species, with a wide distribution throughout New Zealand,[29] with no *Threatened* or *At Risk* taxa observed (Freeman et al., 2014).

Table 13: Incidental observations of rocky shore species

Phyllum	Class	Species	Common Name
Cnidaria	Anthozoa	*Actinia tenebrosa*	Beadlet anemone
Crustacea	Decapoda	*Petrolithes elongatus*	NZ half crab
Echinodermata	Asteroidea	*Patiriella regularis*	Common cushion star
Mollusca	Bivalvia	*Xenostrobus neozelandicus*	Black mussels
Mollusca	Chitonida	*Sypharochiton pelliserpentis*	Snakeskin chiton
Mollusca	Gastropoda	*Austrolittorina antipodium*	Banded periwinkle
Mollusca	Gastropoda	*Haustrum haustorium*	Rock snail
Mollusca	Gastropoda	*Notoacmea sp.*	Limpet
Mollusca	Gastropoda	*Lunella smaragda*	Cat's eye snail

[29] Where data exists on distribution (Cook, 2010).

The proposed Eastern Bays shared path project located on the eastern side of Wellington Harbour will, if consents are granted and construction proceeds, also encroach into Wellington Harbour intertidal habitat at various points. The effect of that project on intertidal marine ecology was assessed by EOS Ecology (2019). Epifauna and incidentally observed epifauna species detected had a number of similarities to Project species list, although the number of taxa detected by EOS Ecology was higher than that for the Project because the EOS ecologists searched within the cobble/gravel substrate of each quadrat identifying cryptic species and infaunal taxa (not just epifauna). Fifteen species were common to both datasets, with a beta-diversity index[30] of 0.48,[31] which indicates a moderate level of similarity between the two locations within Wellington Harbour.

5.5.3.2 Soft sediment

Existing Information

Soft sediment intertidal surveys carried out in 2009 (Boffa Miskell Ltd, 2009) at approximately 1400 m and 2900 m chainages revealed the benthic invertebrate community was dominated by amphipods and polychaete worms, with gastropods, isopods and oligochaete worms present in lower abundance.

Sediment grain size at 1400 m and 2900 m was dominated by sand and gravel size classes.

Benthic invertebrate taxa groups and sediment grain size were similar between the 2009 survey and the 2019 survey.

2019 Surveys

The soft sediment habitats comprise a mosaic of boulders, cobbles, shingle beach, gravel and sand. At some sites, a mosaic of habitats is present, which made it difficult to determine if habitat was predominantly rocky shore or soft sediment beach. However, benthic cores and surface sediment samples were collected from the finest grained areas within each site. The soft sediment sites surveyed are represented in Photo 30 to Photo 34 below (except chainage 3880 m where the camera malfunctioned).

Intertidal soft sediment habitats along the Project are dominated by medium/coarse sand and gravel to varying degrees. The site at chainage 2400 m has the highest proportion of gravel, with the site at 2970 m having the lowest proportion of gravel (Figure 2). Silt and clay sized sediment was not detected at any site (Figure 2). Cobbles and boulders were also present at all sites but were not sampled as part of surficial soft sediment grain size analyses, which we have limited to gravel as the coarsest grain size.

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[30] Beta diversity measures the change in diversity of species from one environment to another.

[31] 15 common species, 18 taxa detected for the Project, 44 species detected for Eastern Bays (15*2/sum(18+44) = 0.48). We note that different taxonomists were used for each project, different survey methods were used, and habitats are not identical, which would result in some additional variation in the taxa detected.

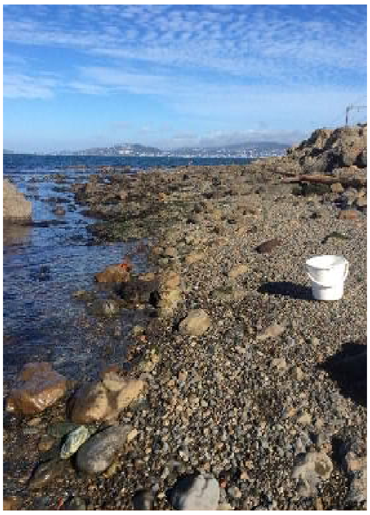

Photo 30: Survey site at chainage 2400m

Photo 31: Survey site at chainage 2970m

Photo 32: Survey site at chainage 3420m

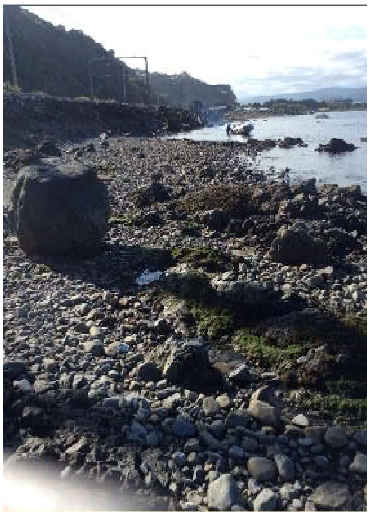

Photo 33: Survey site at chainage 4140m

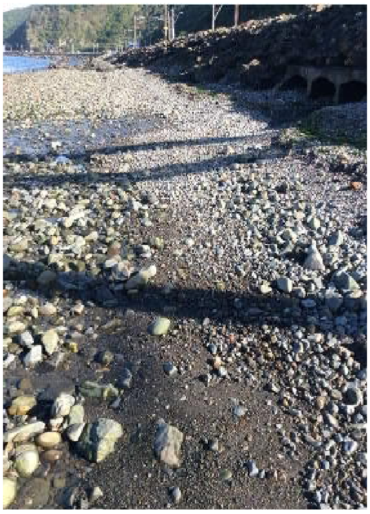

Photo 34: Survey site at chainage 3680m

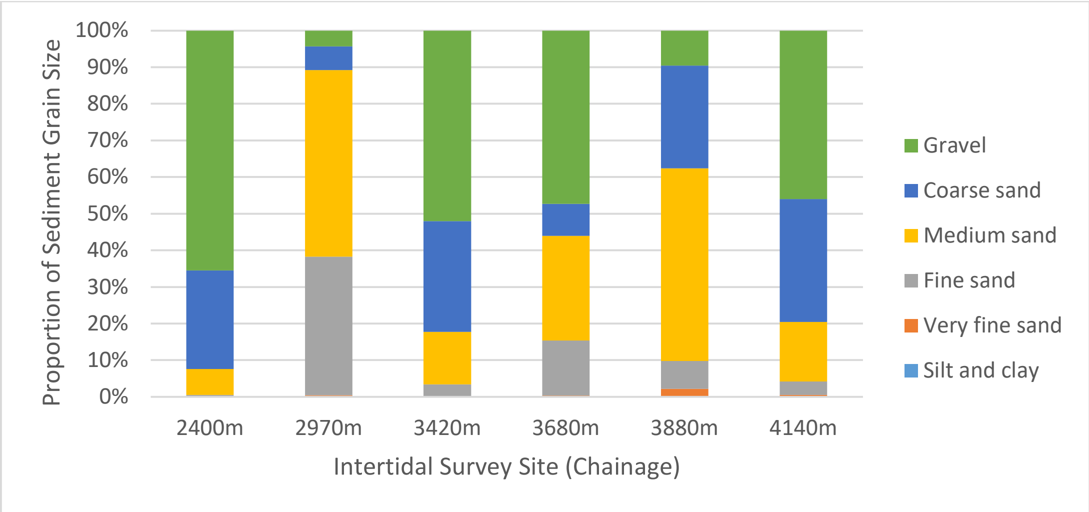

Figure 2: Proportion of intertidal benthic sediment grain size (refer to Map 4 for survey locations)

Intertidal soft sediment benthic invertebrate assemblages are dominated by amphipods, oligochaete and polychaete worms at all sites (Figure 3). Gastropods and amphipods are common at chainage 2400 m (Figure 3). Gastropods did not form a large part of the benthic invertebrate communities at sites other than 2400 m. Benthic invertebrate average abundance is highest at chainage 2970 m and 3420 m, primarily due to large numbers of oligochaete worms in the core samples (Figure 3). Site 2400 m has the next highest abundance and a more even spread of abundance across taxa. Sites 3680 m, 3880 m and 4140 m has the lowest abundance of around 10 organisms per core (Figure 3 and Figure 4).

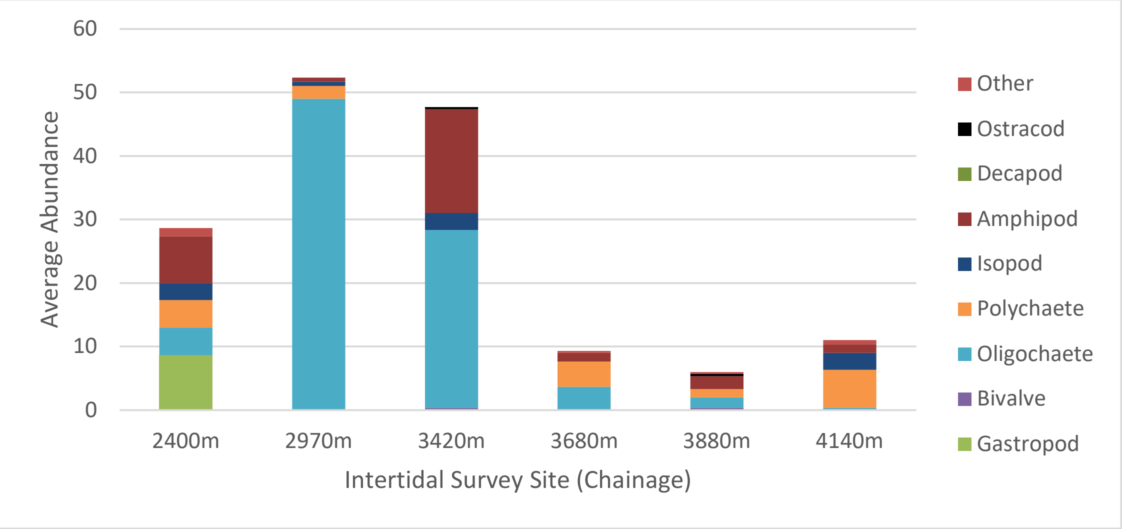

Figure 3: Average abundance and proportion of main benthic soft sediment taxa groups by survey site (refer to Map 4 for survey locations)

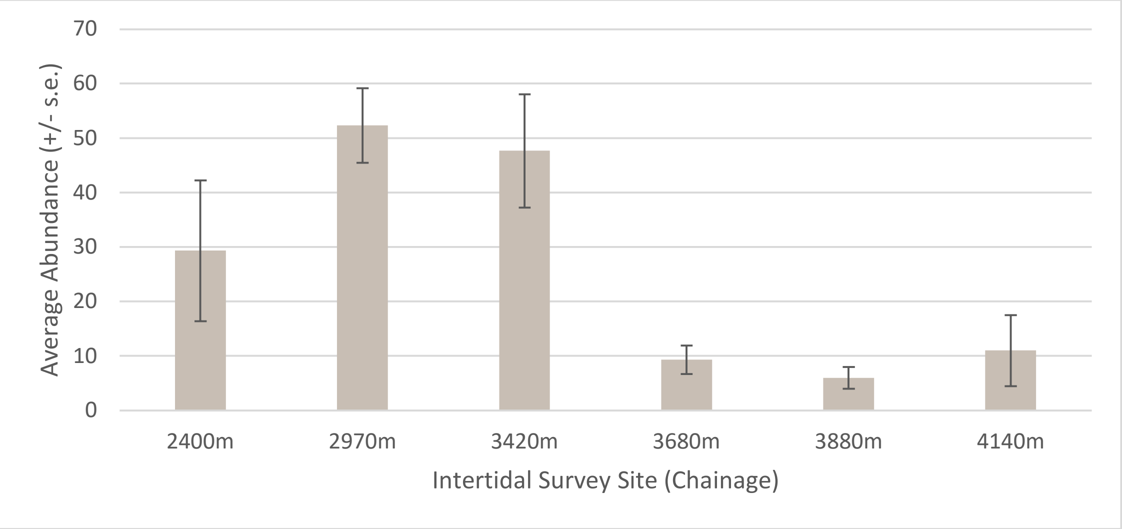

Figure 4: Average abundance of soft sediment benthic invertebrates by survey site (refer to Map 4 for survey locations)

Species richness is highest at sites 2400 m (approximately 9 taxa per core sample), and relatively low at all other sites (approximately 3-4 taxa per core sample) (Figure 5).

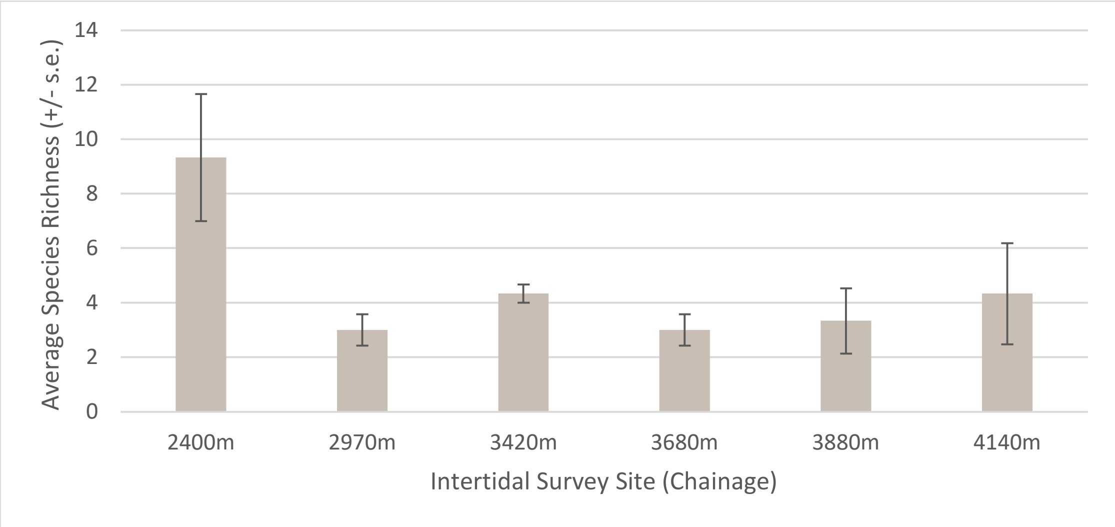

Figure 5: Average species richness of soft sediment benthic invertebrates by site (refer to Map 4 for survey locations)

Average Shannon-Wiener (SW) Diversity Index[32] was highest at site 2400 m (approximately 1.8, indicating moderate diversity), with site 2970 m the lowest Index (approximately 0.3, reflecting very low diversity) (Figure 6). Sites 3420 m and 3680 m had low SW diveristy, whereas sites 3880 m and 4140 m had moderate SW diveristy (Figure 6).

The variability in abundance, species richness and diversity of intertidal organisms among sites is expected, given the high spatial variability of habitat/substrate types within and among sites.

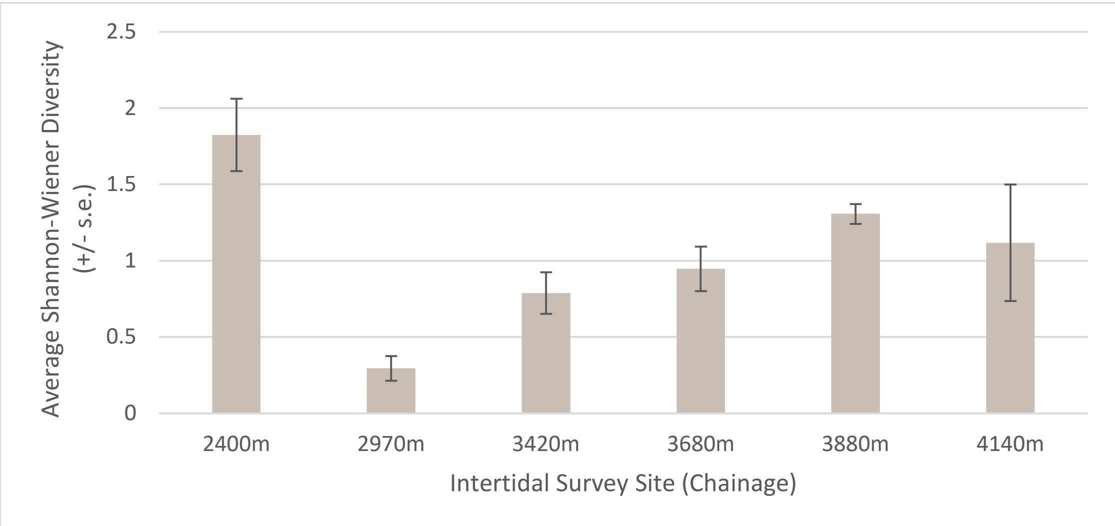

Figure 6: Average Shannon-Wiener Diversity Index for soft sediment benthic invertebrates (refer to Map 4 for survey locations)

[32] Shannon-Wiener Diversity Index takes into account both number of taxa and evenness (i.e. the spread of individuals across individual taxa). Communities with a large number of species that are evenly distributed are the most diverse and communities with few species that are dominated by one species are the least diverse. Based on Dr De Luca's expert opinion, an index <0.5 is considered very low, <1 is low, 1-2 is considered moderate, and >2 is considered high.

Intertidal soft sediment assemblages varied among the sites. The multi-dimensional scaling plot below shows that chainages 2970 m and 3680 m have similar assemblages (indicated by the symbols clustered together), whereas 2400 m and 3420 m have different assemblages to most other sites (Figure 7). The community composition at sites 3880 m and 4140 m is more variable among replicates (as shown by the large spacing between the symbols in Figure 7). A permanova analysis revealed significant differences in assemblages between sites (p=0.007), but pair-wise testing was not able to distinguish which sites were different from each other.

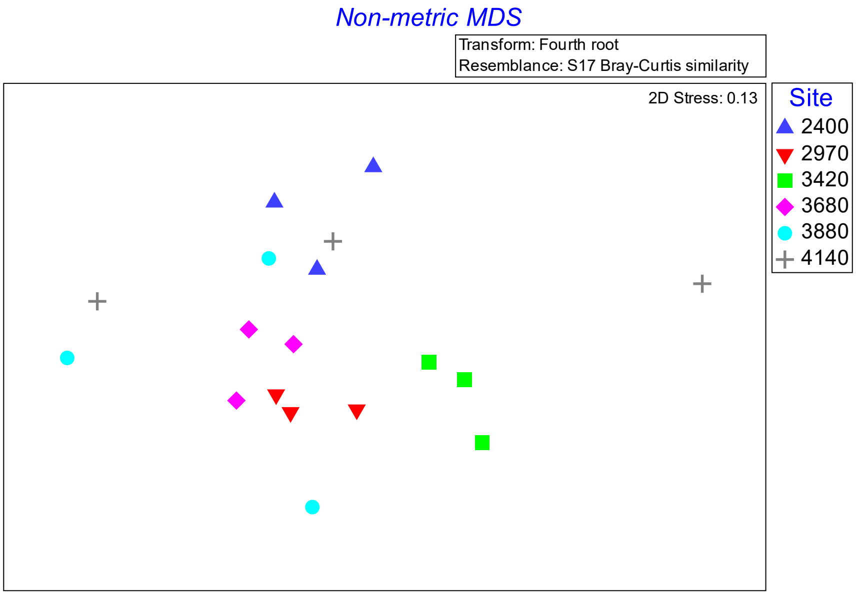

Figure 7: MDS plot of soft sediment benthic invertebrate assemblages at survey sites (by chainage; refer to Map 4)

5.5.4 Sector 2 (Ngā Ūranga to Pito-One) - Subtidal

5.5.4.1 Rocky reef

Existing Information

The 2010 subtidal survey data collected for Horokiwi Quarries Ltd (Boffa Miskell Ltd, 2011), involved three 100 m long transects at the Horokiwi Stream mouth, and two 100 m long reference transects (located 50 m north and 50m mouth of the stream).

The dive team noted that the benthic habitat at 0 m to 50 m along all transects comprised cobble and boulders with sand/silt, whereas the benthic habitat between 50 m and 100 m was primarily cobble and sand/silt.

Carpophyllum species were the dominant canopy macroalgae at all sites, with crustose coralline algae was the dominant turfing macroalgae species. Red filamentous and foliose algae were present at the sites located adjacent to Horokiwi Stream. Those algae taxa are known to be sensitive to sedimentation.

All transects generally had a moderate abundance of mobile and sessile epifauna. The control north transect (located approximately at 4400 m chainage of the current Project) had the highest abundance of mobile invertebrates, whereas the control south transect (located approximately at

2900 m chainage of the current Project) had the lowest abundance of mobile species. Sea stars and gastropods (snails and whelks) were present along the length of each transect, but sea urchins were present primarily at 40 m along the transects.

The communities present along all transects are similar to the 2019 data and are representative of semi-exposed rocky shore subtidal communities with catchments containing urban, rural and forested landuses.

2019 Survey

The dive team noted the following general habitat description in their 2019 survey:

> *The subtidal marine habitat, similar to the intertidal habitat, is a mosaic of rocky reef, cobbles, gravel and sand. From north to south along the alignment, the shore profile becomes steeper with a more compressed band of reef at the southern end, less fine sediment and greater water clarity. In general, the shallows have large, square-sided boulders used in the historic reclamation, which transition into a band of gravel/rounded boulders (often on bedrock) with short tufting algae (primarily Ulva spp.). With greater depth, larger rounded boulders with encrusting species and a Carpophyllum spp canopy (often at 100% cover, with epiphytic growth and laden with fine silt) are common. Along the transects, in deeper water and a variable distance from the shore, the Carpophyllum forest gives way to a flatter profile of fine sediment and smaller cobbles that support low numbers of sea urchins and sea cucumbers. Between the shallow boulder habitats are gravel/cobble habitats.*

Mobile benthic invertebrates

Gastropods (snails and whelks; primarily cat's eye, *Turbo smaragdus*) and echinoderms (sea stars and urchins; primarily cushion star, *Patirella regularis*) were present at all sites, whereas a small number of decapods (crabs; primarily *Petrolithes elongatus*) were also present at chainage 2900 m (Figure 8). Abundance of mobile invertebrates is low at all sites, but lowest at 1500 m (approximately four organisms per quadrat) and highest at 2200 m (approximately eight per quadrat) (Figure 8). All marine organisms detected are common throughout semi-exposed shores in New Zealand and no *Threatened* or *At Risk* marine invertebrate taxa were detected in these surveys (Cook, 2010; Freeman et al., 2014).

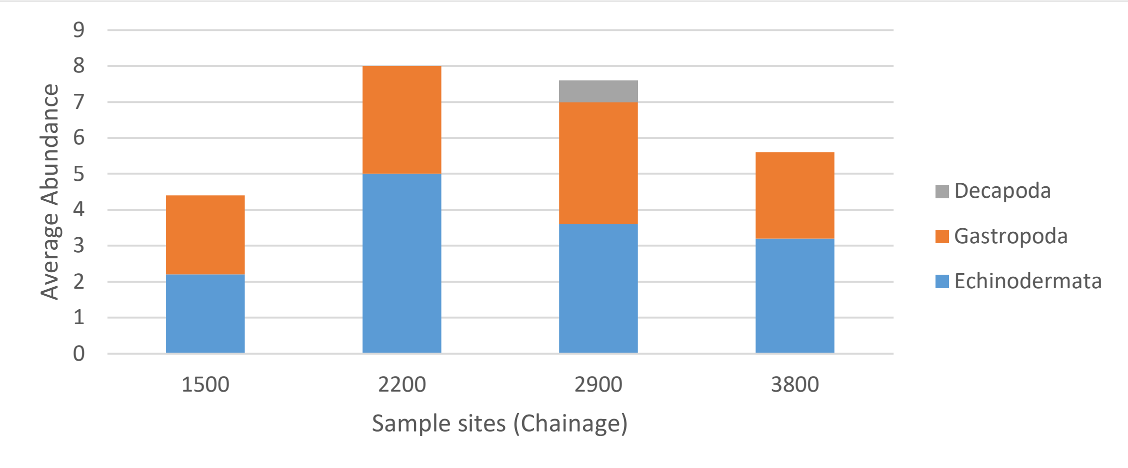

Figure 8: Average abundance of main mobile invertebrate taxa groupings within each transect across all distances (10-50 m) (refer to Map 4 for survey locations).

Analysis of mobile invertebrate taxa by distance from shore showed a reduction in abundance from 10 m to 30 m as well as a decrease in abundance of echinoderms with distance (Figure 9).

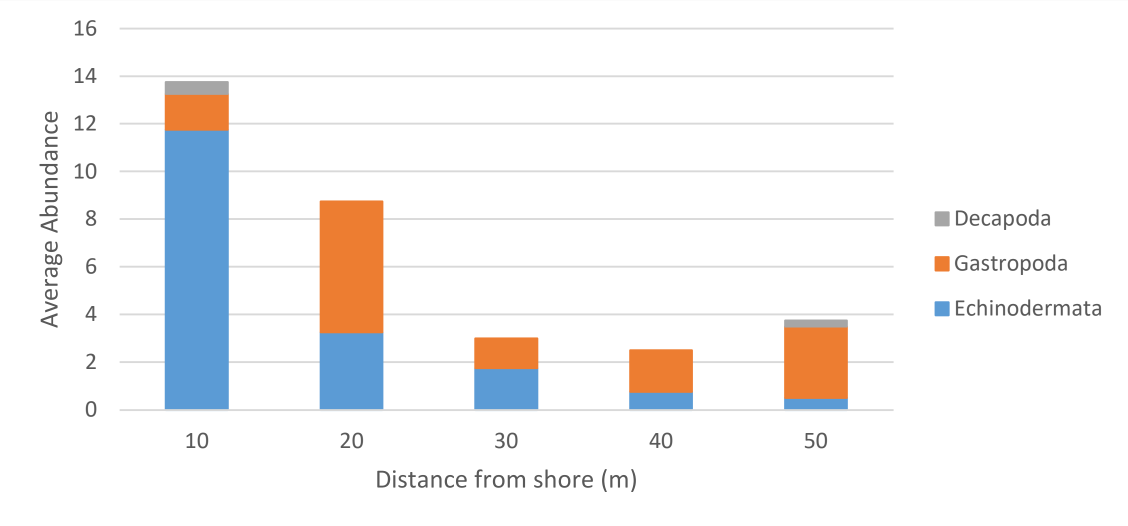

Figure 9: Average abundance of main mobile invertebrate habitat taxa groupings at each distance from shore (m) across all transects.

Benthic invertebrate species richness (i.e. number of taxa) is low across all sites, ranging between approximately 1 and 2.5 per quadrat (Figure 10).

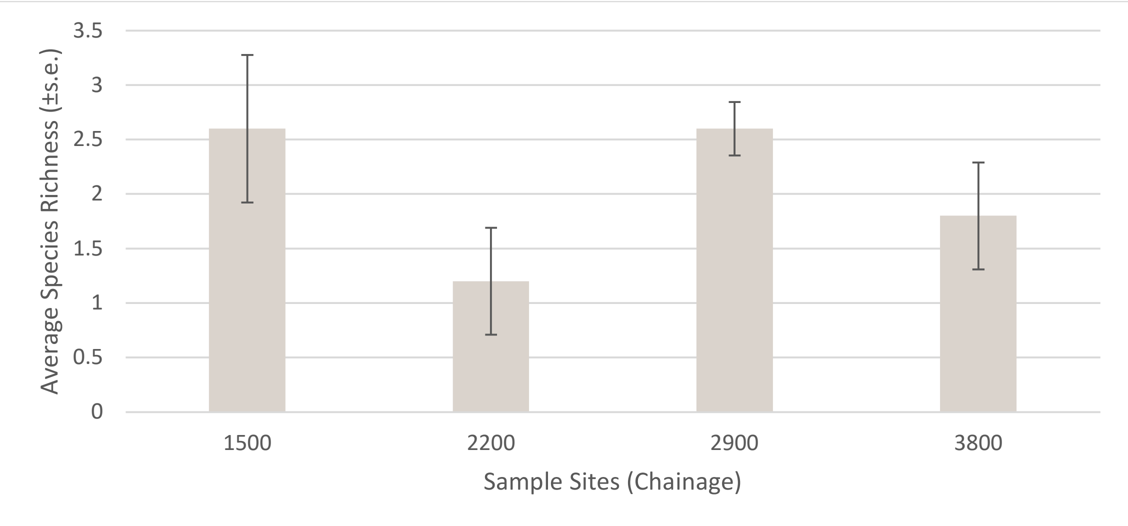

Figure 10: Average species richness (± s.e.) for mobile invertebrates within each transect across all distances (10-50 m) (refer to Map 4 for survey locations).

Similar to Figure 10, Figure 11 shows low species richness across all distances from the shore surveyed (1.25-3 individuals per quadrat).

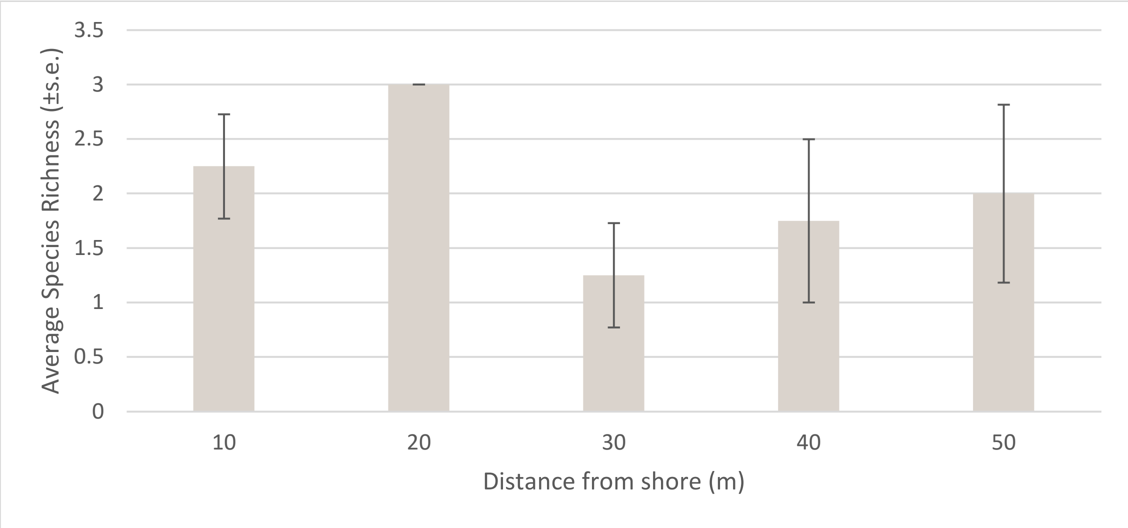

Figure 11: Average species (± s.e.) richness for mobile invertebrates at each distance from shore (m) across all transects.

Average Shannon Wiener Diversity Index was low at all sites, except 2200 m which had very low diversity (<0.2) (Figure 12).

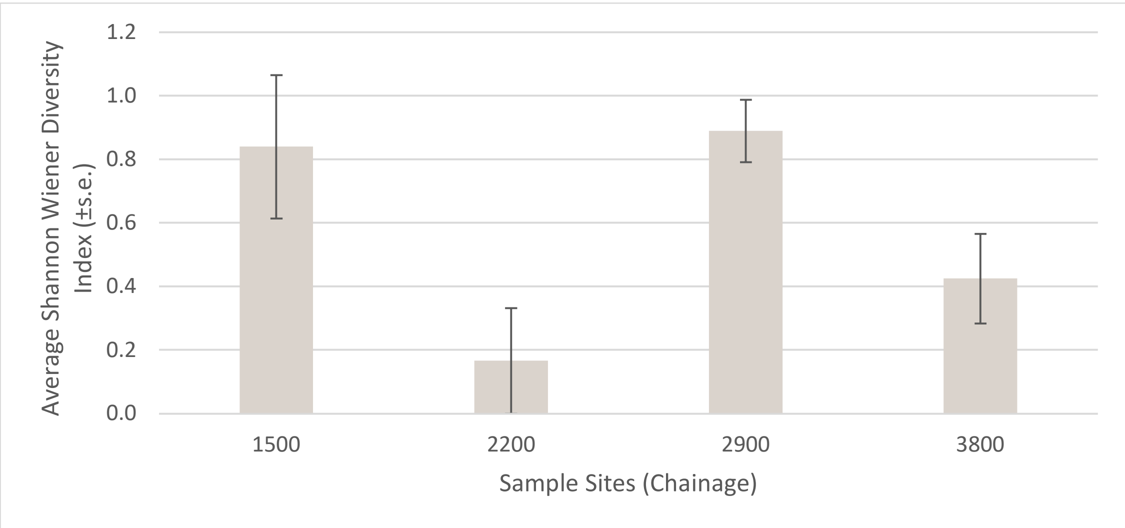

Figure 12: Average Shannon Wiener Diversity Index (± s.e.) for mobile invertebrates within each transect across all distances (10-50 m) (refer to Map 4 for survey locations).

Average Shannon-Wiener Diversity was also low when analysed by distance from shore, with diversity very low at 30 m and low at all other distances from the shore (Figure 13). We note that there is high variability within most of the distances, indicating high across site variability.

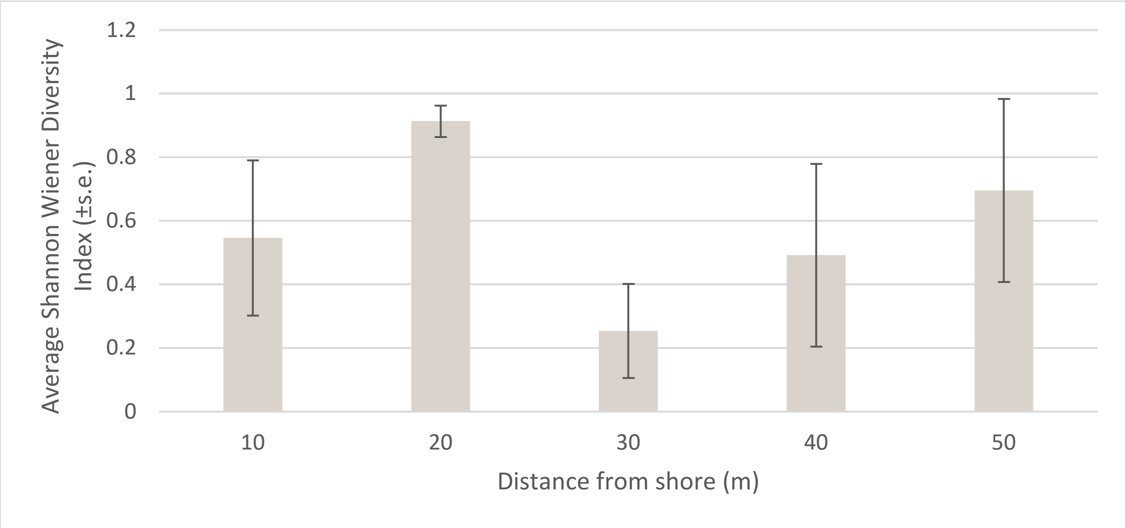

Figure 13: Average Shannon Wiener Diversity Index (± s.e.) for mobile invertebrates at each distance from shore (m) across all transects.

Sessile benthic invertebrates

Table 14 below indicates presence of the main taxa groups across sites and distance from shore for sessile and encrusting species. Sessile or encrusting invertebrates included barnacles, anemone, mussels, sponges, sea squirts and tube worms. All taxa are present in low abundance (five organisms in a quadrat was the highest detected across all sites and distances from shore, being orange sea squirt (*Cnemidocarpa* sp at chainage 1500 m at 50 m distance)) or in low percentage cover (35% of green lipped mussel (*Perna canaliculus*) and blue mussels (*Mytilus edulis*) was the highest at site chainage 3380 m at 10 m distance), without strong patterns relating to distance from shore or chainage (Table 14). All taxa are also common throughout New Zealand, with no *Threatened* or *At Risk* species detected (Cook, 2010; Freeman et al., 2014).[33]

Table 14: Percentage cover (in blue) or number of individuals (in yellow) for sessile/encrusting marine invertebrates recorded at the 2019 subtidal survey sites (refer to Map 4).

Chainage (m)	Transect Distance (m)	Ascidian (*Cnemidocarpa* sp.)	Colonial Ascidian (*Aplidium benhami*)	Sponge (yellow and orange encrusting)	Limpet (*Sigapatella novaezelandiae*)	Tubeworm (*Protula* sp.)	Oyster (*Ostrea chilensis*)	Anemone (*Oulactis magna*)	Annemone (*Anthothoe albocincta*)	Fan Worm (*Branchiomma* sp.)	Mussel (*Perna canaliculus* and *Mytilus edulis*)
1500	10										
	20	3	5	5							
	30									3	
	40	2			3	2	1				
	50	5									
2200	10										

[33] Where data available.

Chainage (m)	Transect Distance (m)	Ascidian (*Cnemidocarpa* sp.)	Colonial Ascidian (*Aplidium benhami*)	Sponge (yellow and orange encrusting)	Limpet (*Sigapatella novaezelandiae*)	Tubeworm (*Protula* sp.)	Oyster (*Ostrea chilensis*)	Anemone (*Oulactis magna*)	Annemone (*Anthothoe albocincta*)	Fan Worm (*Branchiomma* sp.)	Mussel (*Perna canaliculus* and *Mytilus edulis*)
	20	4		10				1			
	30					1					
	40									3	
	50										
2900	10								10		
	20			20				1	10		15
	30	1							20		
	40	1									
	50	4									
3800	10					3					35
	20					1					
	30										
	40	4		10		1					
	50	1									

The MDS plot below does not show any clear grouping of sites of distances along transects (Figure 14). This reinforces that there are no clear patterns in sessile benthic invertebrate community composition between sites or along transect distances across the sites.

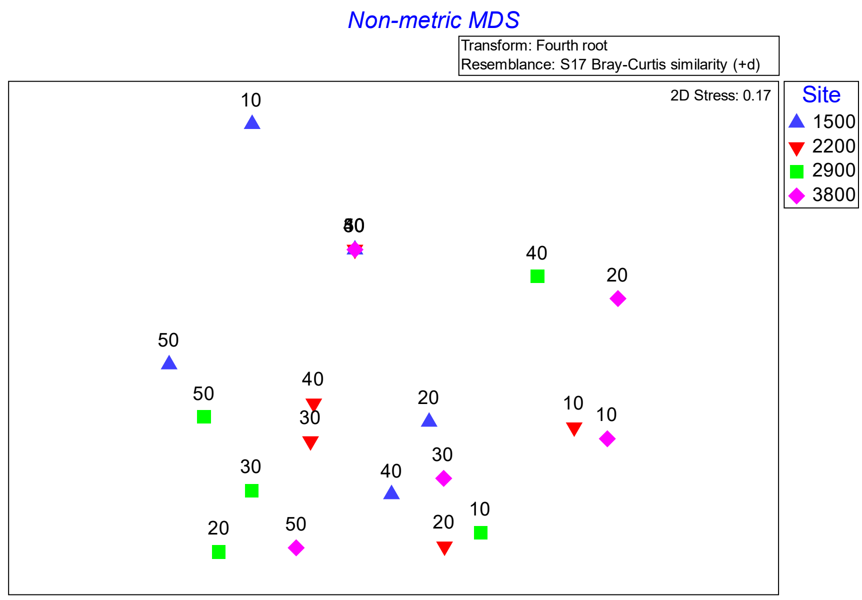

Figure 14: nMDS plot showing mobile invertebrate species assemblage at each sample site (by chainage; refer to Map 4), with distance from shore (m).

Fish and ray surveys were not undertaken. However, fish and rays incidentally observed during the benthic surveys included common triplefin (*Forsterygion lapillum*), variable triplefin (*Forsterygion varium*), banded wrasse (*Notolabrus facicola*), blue cod (*Parapercis colias*), green wrasse (*Notolabrus inscriptus*) and eagle ray (*Myliobatis tenuicaudatus*). The fish and rays observed during the dive surveys are also common throughout New Zealand.

Macroalgae

Figure 15 shows the breakdown of the average percentage cover of macroalgal species across the four sample sites. Where percent cover is greater than 100%, that is due to pink corallina paint being present on the substrate with taller canopy algal species above. Average percentage cover is lowest at chainage 1500 m and highest at 2900 m (Figure 15).

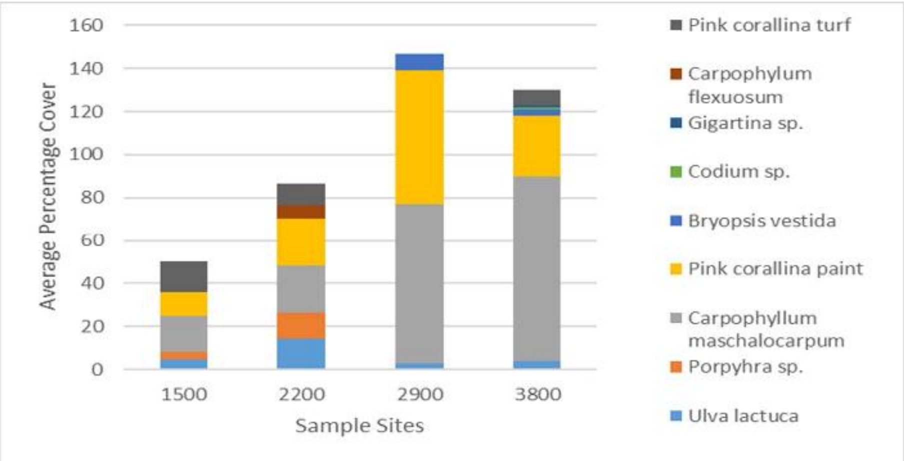

Figure 15: Average percentage cover of marine plants at each sample chainage (refer to Map 4 for 2019 subtidal survey locations).

The macroalgae species present are markedly different between 10 m and the other distances from the shore, with the community at 10 m comprising more *Ulva lactuca*, *Bryopsis vestida* and *Carpophylum flexuosum* (Figure 16). The communities at 20-50 m were mainly dominated by *Carpophyllum maschalocarpum* and pink corallina paint (Figure 16). Observations by the scientific observers was that *C. maschalocarpum* was the tallest macroalgae present, achieving heights of up to 1.5m at some locations.

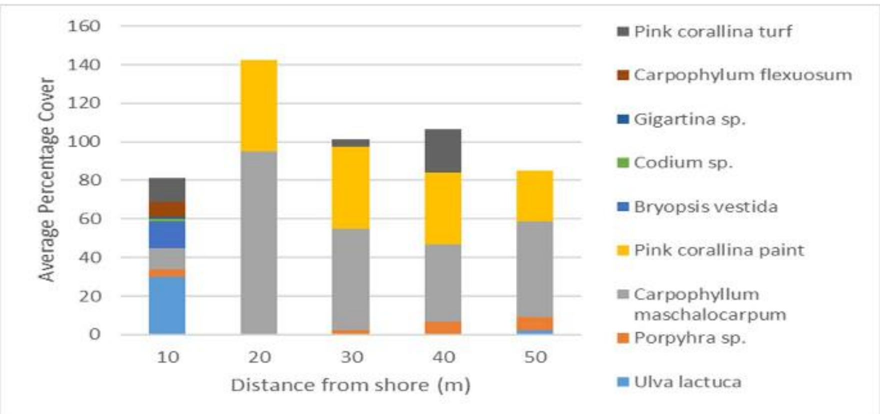

Figure 16: Average percentage cover of marine plants at each distance from shore (m).

Marine macroalgae composition differs among sites and with distance from the shore, which is shown in the nMDS plot below (Figure 17), with no clear groupings by site or distance from shore.

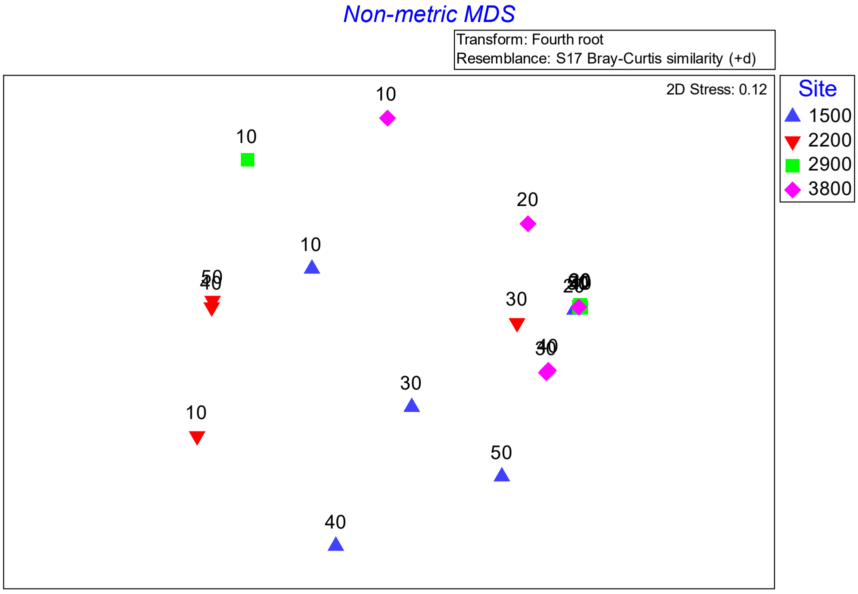

Figure 17: nMDS plot showing marine plant species assemblage at each sample site (by chainage; refer to Map 4), with distance from shore (m).

5.5.4.2 Soft sediment

Existing Information

At chainage 0 m, 1400 m and 2900 m, soft sediment core samples indicated all sites at both 15 m from the shore and 30 m from the shore were dominated by polychaete worms, a small number of other taxa groups including amphipods, gastropods (snails and whelks), bivalves (shellfish), decapods (crabs), ostracods and horseshoe worms (Boffa Miskell Ltd, 2015). The taxa detected in 2014 have similarities to the 2019 survey data.

2019 Survey

Figure 18 and Figure 19 show the abundance and main subtidal benthic invertebrate taxa composition by chainage (sample site) and by distance from shore. Chainage 2200 m has the lowest average benthic invertebrate abundance at around 115 per core, whereas chainage 1500 m and 3800 m have the highest abundance at approximately 275-280 per core (Figure 18). The soft sediment assemblage at all sites comprise a high proportion of polychaete worms, oligochaete worms (excluding 2200 m), amphipods, and gastropods (Figure 18). All taxa detected in the survey are common and generally found throughout New Zealand (Cook, 2010)[34] and no *Threatened* or *At Risk* or taxa were detected (Freeman et al., 2014).

[34] Where distribution data exists.

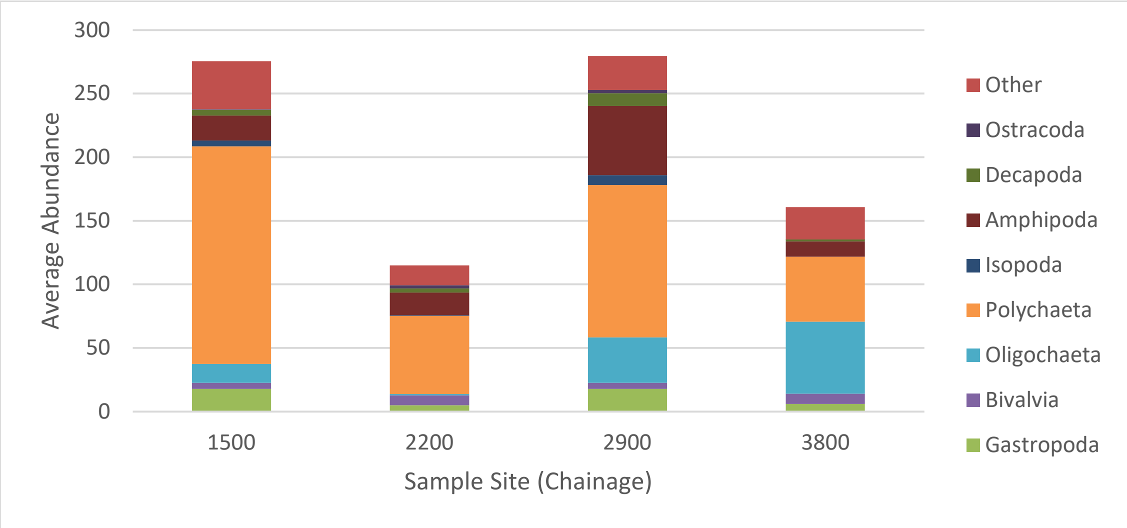

Figure 18: Average abundance of main soft sediment invertebrate taxa groupings at each sample site (refer to Map 4 for 2019 subtidal survey locations).

There does not appear to be a clear trend in abundance or the proportion of main taxa with distance from the shore (Figure 19), with 10 m and 40 m having the lowest abundance of soft sediment invertebrates (approximately 150 per core) and 20 m having the highest abundance (approximately 290 individuals per core).

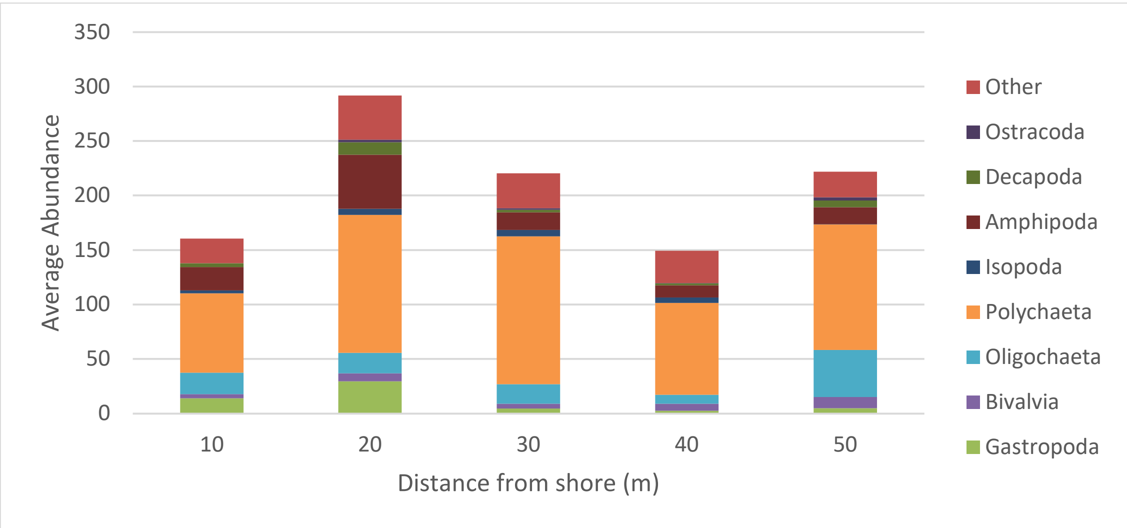

Figure 19: Average abundance of main soft sediment invertebrate taxa groupings at each distance from shore (m).

Soft sediment benthic invertebrate species richness was relatively similar among survey sites, with the highest number of taxa at 1500 m (approximately 35 taxa per core) and lowest at 3800 m (approximately 25 taxa per core) (Figure 20).

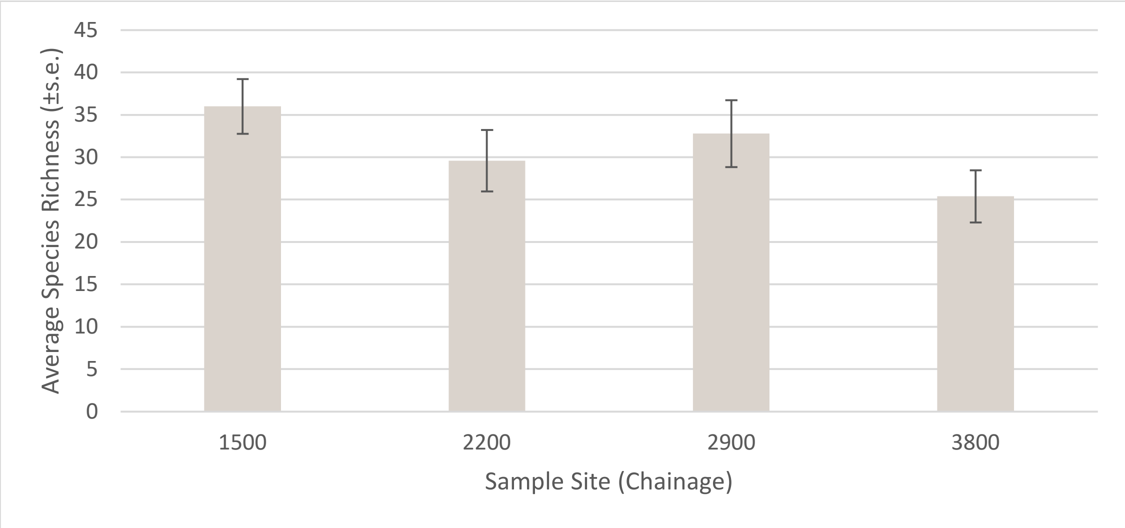

Figure 20: Average species richness (± s.e.) for soft sediment invertebrates at each sample site (refer to Map 4 for 2019 subtidal survey locations).

Species richness is relatively similar when analysed by distance from the shore, with highest number of taxa at 50 and 20m (approximately 35 taxa per core) and lowest at 30 m and 40 m (approximately 25 taxa per core) (Figure 21).

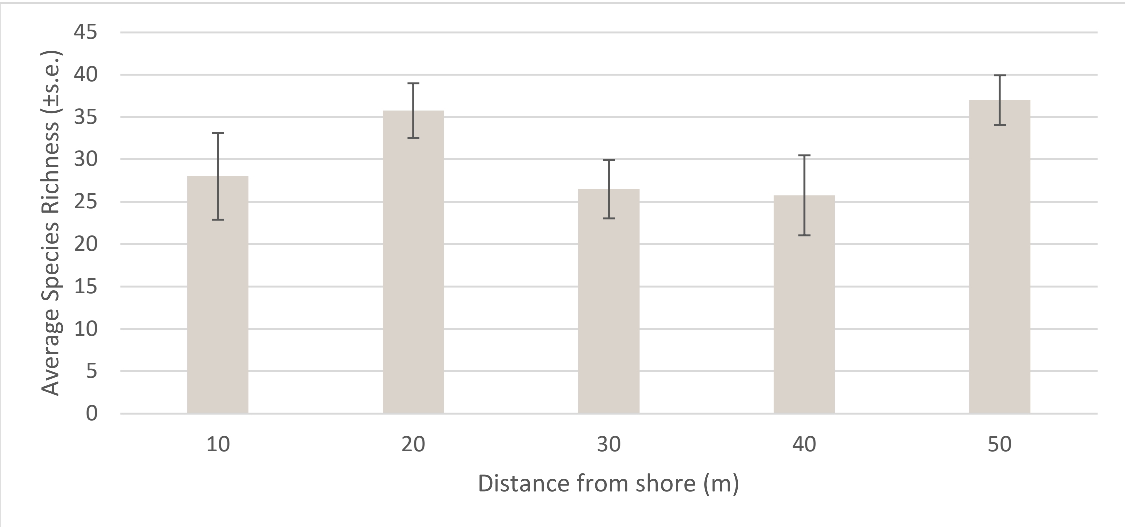

Figure 21: Average species (± s.e.) richness for soft sediment invertebrates at each distance from shore (m).

Average Shannon Wiener Diversity Index is quite consistent across sites and distance from shore, with all data points at approximately 2.5, indicating relatively high diversity (Figure 22 and Figure 23).

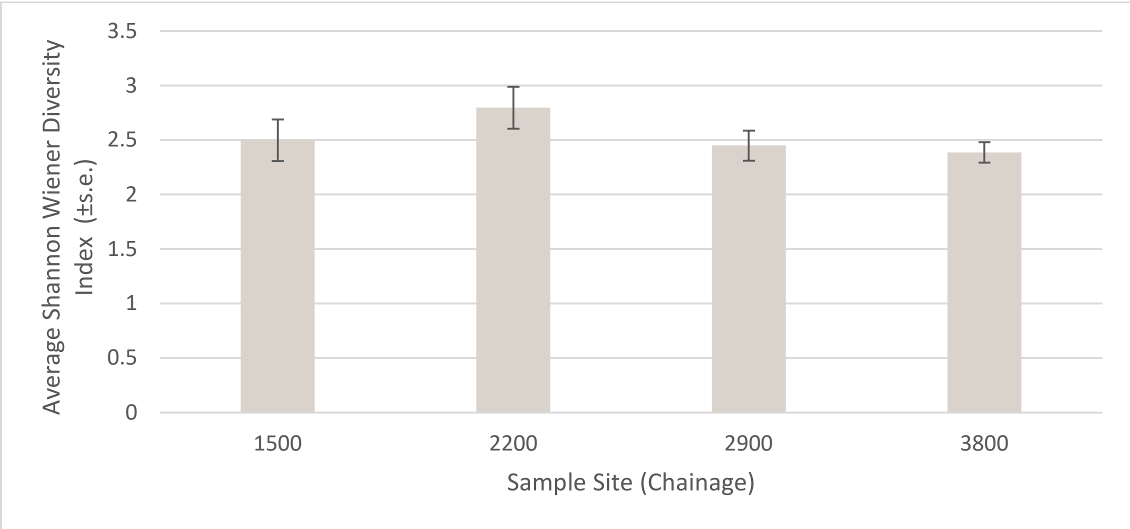

Figure 22: Average Shannon Wiener Diversity Index (± s.e.) for soft sediment invertebrates at each sample site (refer to Map 4 for 2019 subtidal survey locations).

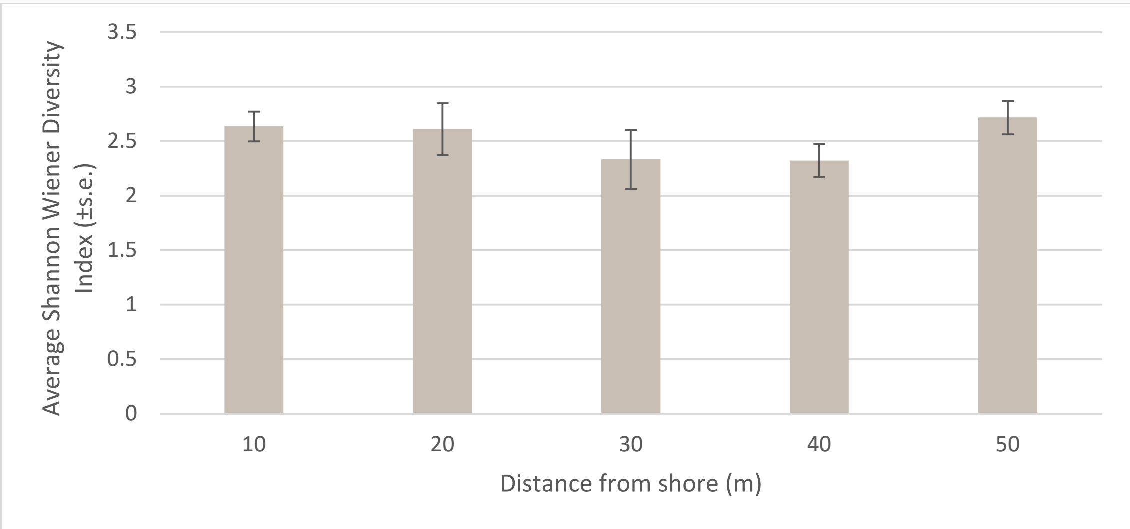

Figure 23: Average Shannon Wiener Diversity Index (± s.e.) for soft sediment invertebrates at each distance from shore (m).

The nMDS plot below (Figure 24) shows that the soft sediment community composition at most sites are clustered together with few clear patterns. Site 3800 m chainage separates somewhat from the assemblages at the other three sites. In addition, 10 m from shore at 2900 m appear to have a different invertebrate soft sediment community composition compared to the other soft sediment sites (Figure 24).

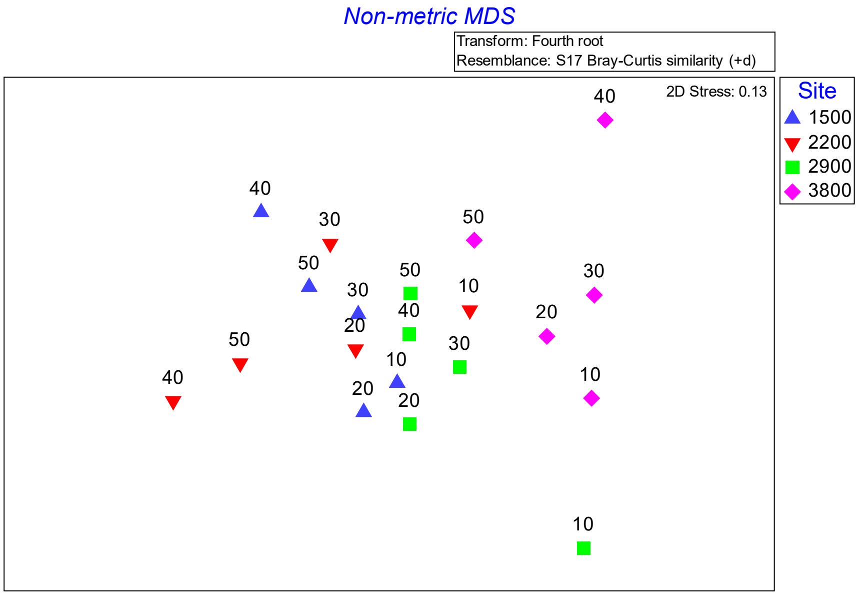

Figure 24 nMDS plot showing soft sediment invertebrate species assemblage at each sample site (by chainage; refer to Map 4), with distance from shore (m).

A permutational analysis of variance (Permanova) of the subtidal soft sediment assemblages indicated that there were significant differences in assemblages among sites (p=0.007).

A survey undertaken in 2016 by NIWA (Hewitt, 2019) on behalf of GWRC revealed subtidal assemblages at one site (WH10) located 0.5 km SSE of the Ngā Ūranga Stream mouth had an average of just less than 10 taxa per core and an average of approximately 25 total abundance per core, which was similar to a large of other sites surveyed throughout the harbour by NIWA. We detected approximately 25-35 taxa per core and 100-290 total abundance per core (Figure 18 to Figure 21), which is higher than that detected by NIWA.[35] NIWA concluded that the assemblages at WH10 were in the High Health Group, but also detected a statistically significant decrease in average number of taxa, average total abundance and total number of taxa compared over time (compared to 2006 and 2011 data).

5.5.4.3 Sediment Quality and Grain Size

AECOM (2019c) outline the approach taken to the selection of nine sediment quality sampling sites (Map 4) at approximately 400 m intervals along the Project alignment, along with the methods and a briefly summary of the results received from Hill Laboratories. AECOM (2019c) considered GWRC's Selected Landuse Register (SLUR and WCC's stormwater discharge points to determine their preferred survey sites (see Figure 1 in AECOM (2019c)). AECOM (2019c) note that the dive team had to modify[36] some of the survey locations as there was insufficient soft sediment present for collection. AECOM (2019c) selected contaminant and/or grain size tests for each survey site, based on the information collected from the SLUR and proximity of stormwater discharge points (see Table 2 in AECOM (2019c)).

[35] NIWA used a larger core – 200 mm diameter x 250 mm deep, whereas we used a 130 mm diameter x 150 mm deep core.

[36] Some of the survey sites were located perpendicular to the shore at greater distance from the shore in order to find suitable sediment for collection (as shown in Figure 1, AECOM (2019c)).

We have converted AECOM's (2019c) survey site identifiers to chainages for ease of interpretation and integration with the ecology data (Table 15).

Table 15: AECOM's sediment quality survey site identifier and corresponding chainage and distance seaward from proposed survey site that the actual sample was collected.

AECOM's sediment quality survey site identifier	Corresponding chainage / distance from proposed site
N2P_SS_01	1190 m (7.5 m)
N2P_SS_02	1510 m (30 m)
N2P_SS_03	1930 m (30 m)
N2P_SS_04	2320 m (15 m)
N2P_SS_05	2650 m (5 m)
N2P_SS_06	3060 m (20 m)
N2P_SS_07	3410 m (60 m)
N2P_SS_08	3670 m (60 m)
N2P_SS_09	4010 m (0 m)

Sediment from all nine site (Figure 1 in AECOM (2019c)) were surveyed for a selection of heavy metals (arsenic, cadmium, copper, chromium, lead, nickel and zinc). All sites recorded concentrations of heavy metals significantly below Australian and New Zealand Government's Default Guideline Value (DGV) of 21 mg/kg (Figure 25 to Figure 31), except for nickel at chainages 1510 m (30 mg/kg), 2320 m (28 mg/kg) and 2650 m (32 mg/kg).

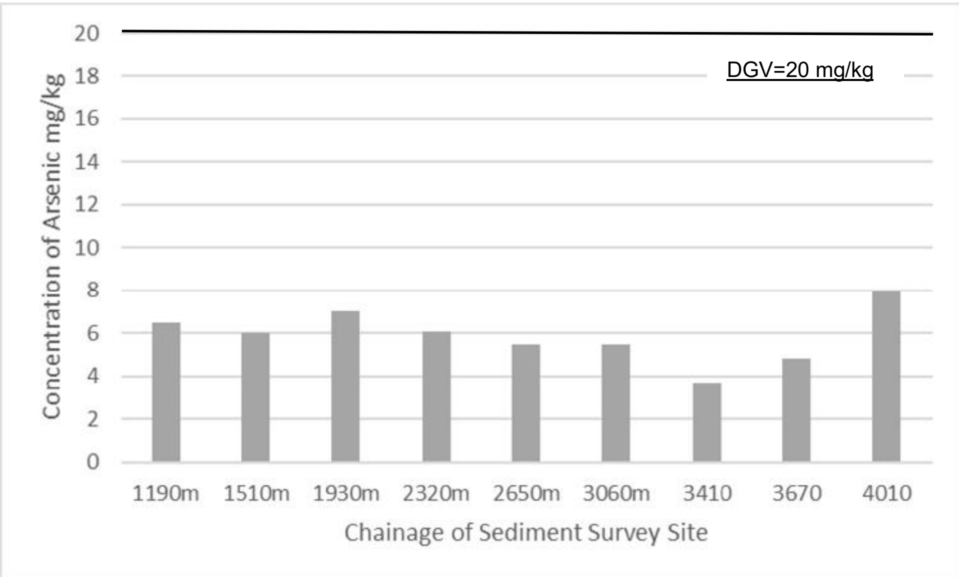

Figure 25: Concentration of arsenic in marine sediment along the Project.

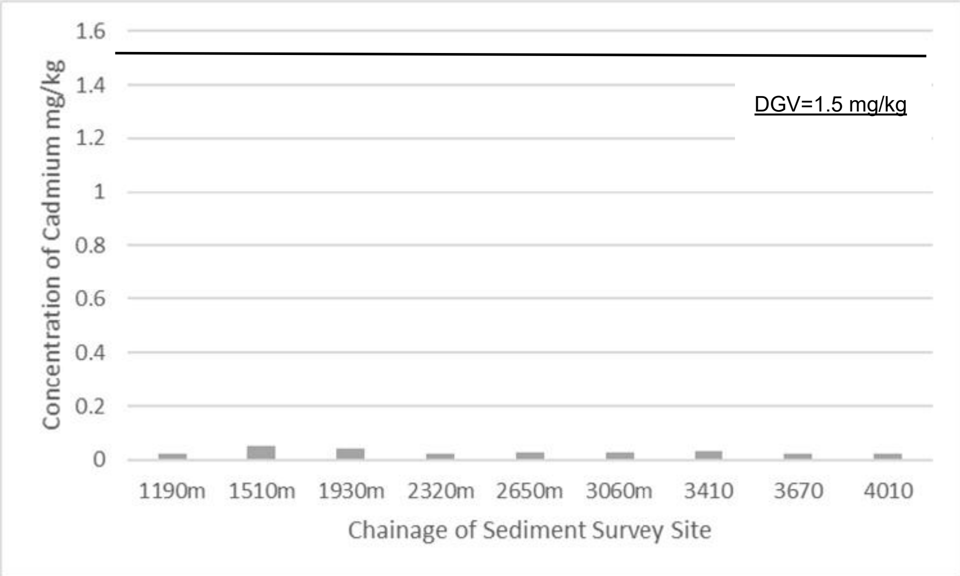

Figure 26: Concentration of cadmium in marine sediment along the Project.

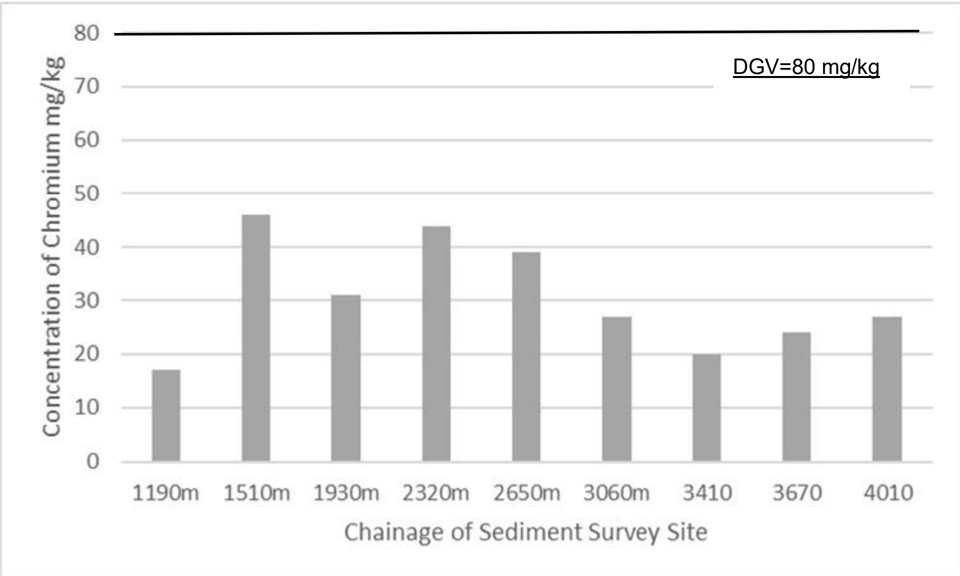

Figure 27: Concentration of chromium in marine sediment along the Project.

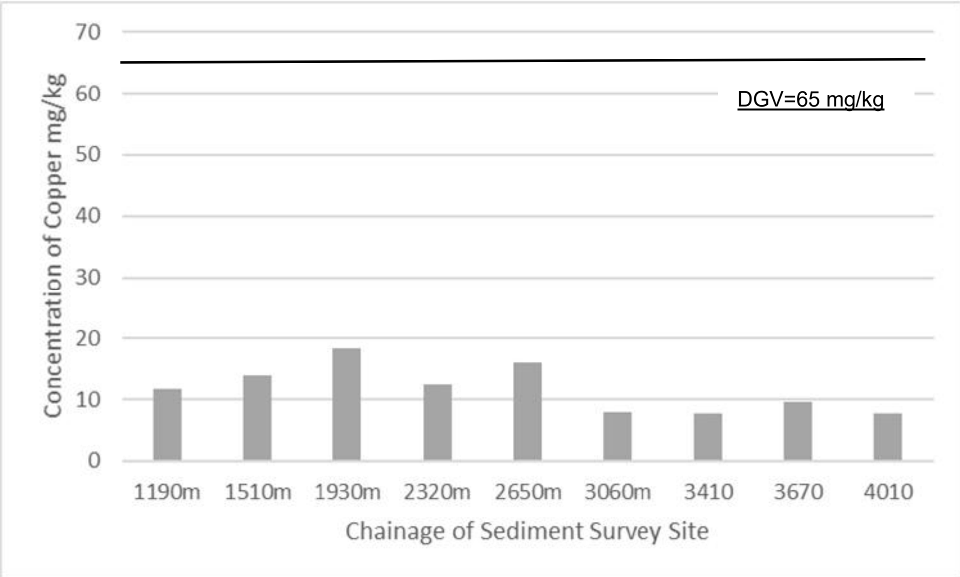

Figure 28: Concentration of copper in marine sediment along the Project.

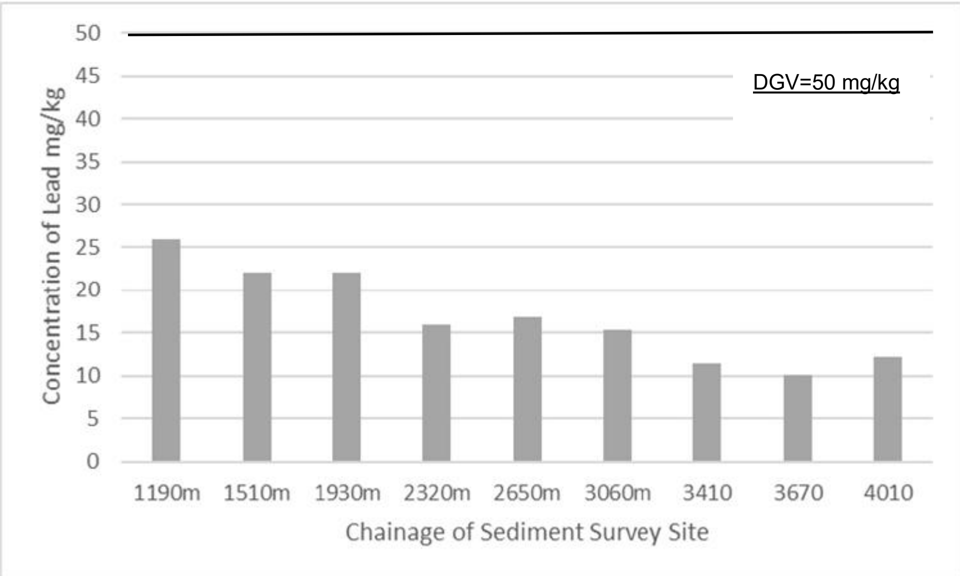

Figure 29: Concentration of lead in marine sediment along the Project.

Sources of nickel in marine sediment could be both anthropogenic and/or natural. Anthropogenic sources potentially include fill material associated with the rail corridor (and associated sediment runoff), discharges of stormwater in the area of the Wellington/Port Nicholson Harbour, potentially hazardous activities and industries in the catchment that may discharge to the wider harbour. Nickel occurring naturally in greywacke basement rock within the catchment may also contribute to the concentration of nickel in marine sediment (Natalie Rowe (AECOM) *pers. comm.* 6/3/20). Monitoring of marine sediment quality is undertaken periodically by Greater Wellington Regional Council at established survey locations. The closest survey sites to the Project area are adjacent to the Ngā Ūranga Stream mouth in the subtidal habitat. The highest concentration of nickel reported in the 2011 GWRC survey at those two closest was 18.2 mg/kg, slightly lower than the DGV of 21 mg/kg and lower than that detected at chainage 1510 m, 2320 m and 2650 m in the surveys carried out for the Project (Oliver, 2014) (Figure 30).

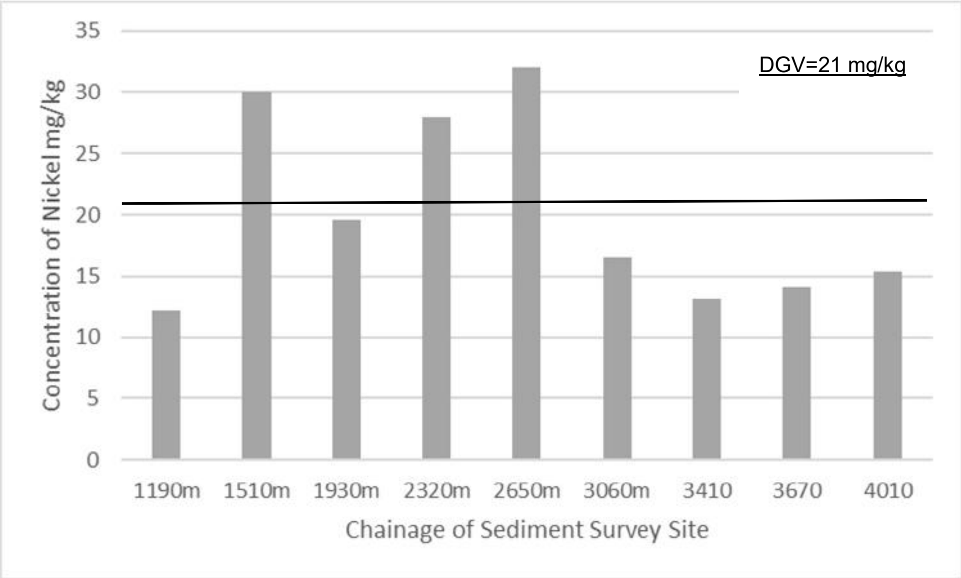

Figure 30: Concentration of nickel in marine sediment along the Project.

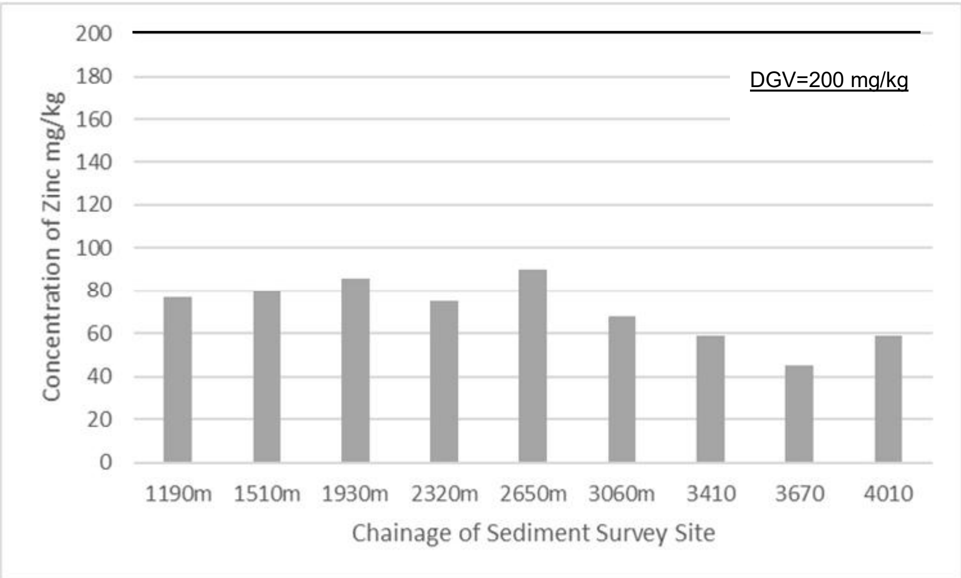

Figure 31: Concentration of zinc in marine sediment along the Project.

Hydrocarbons were also analysed in sediment collected at all sites, with only one site recording concentrations above the laboratory detection limits (TPHs in the range C_{15}-C_{36} at 71 mg/kg at site at 2650 m chainage). The concentration detected (71 mg/kg) is significantly below the DGV of 280 mg/kg (see AECOM (2019c)).

Polycyclic aromatic hydrocarbons (PAHs) were tested on a subset of the sites (2320 m, 2650 m, 3410 m, 3670 m, 4010 m). Of those sites, no PAHs were detected above laboratory detection limits at 3670 m and 4010 m. At 2650 m, most individual PAHs tested revealed a low concentration, with total PAHs also being low at 0.4 mg/kg.[37] Site 3410 m recorded fluoranthene and pyrene above laboratory detection limits but at low concentrations (0.22 mg/kg and 0.21 mg/kg respectively) (see AECOM (2019c)).

Organochlorine pesticides and semi volatile organic compounds were also tested for at a subset of the sites, with concentrations of all contaminants being below the laboratory detection method (see AECOM (2019c)).

Individual sediment grain size analyses were undertaken on sediment collected at sites 1190 m, 1930 m, 2650 m, 3410 m, 3670 m and 4010 m. Figure 32 below shows that there is high variability in grain size distribution between the sites surveyed, whilst noting that the distance from shore at each site where samples were collected varied due to availability or lack of soft sediment for collection (see Figure 1, AECOM (2019c)). Gravel dominated site 1190 m (95%), 1930 m (55%) and 3670 m (63%), whereas a more even spread of grain sizes were present at sites 2650 m, 3410 m and 4010 m (Figure 32). The differences in the proportion of grain sizes across sites does not appear to be reflected in the contaminant data. Often where silt and clay particles are present in higher proportion, contaminants are usually detected in higher concentration due to the contaminants binding to fine organic particles within the silt and clay, however this relationship is not evident at the sites surveyed, given the very low proportion of silt and clay detected.

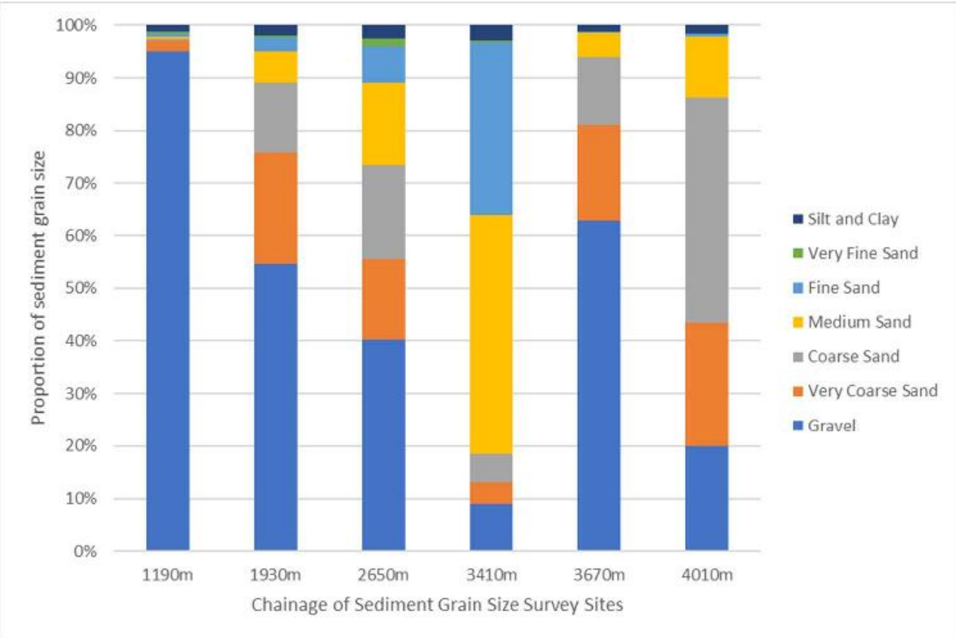

Figure 32: Subtidal sediment grain size composition at selected sites along the Project.

NIWA undertook a survey of sediment quality at a number of sites throughout Wellington Harbour in 2016 on behalf of GWRC (Hewitt, 2019). One survey site was located 0.5km SSE of the Ngā Ūranga Stream mouth (WH10) in 20 m water depth, which is significantly beyond the Project footprint and disturbance area. Mercury was detected above the DGV of 0.15 mg/kg at most sites

[37] The concentration of total PAHs cannot be compared to the DGV as sediment was not tested for Total Organic Carbon (TOC) content and therefore the PAH concentration cannot be normalised to 1% TOC as recommended by the ANZG (2018). However, the concentration of PAHs without normalisation to 1% TOC is low and likely to be below effects threshold concentrations.

in Wellington Harbour, including WH10 where the concentration was 0.32 mg/kg. In addition, DDT was detected above the DGV of 1.2 mg/kg at most sites in Wellington Harbour including WH10 at 2.1 mg/kg. Mercury and DDT were not analysed in the 2019 samples collected for this Project. Mercury and DDT are historical legacy contaminants accumulated in sediment following widespread historic use (Williamson (2014) cited in Hewitt (2019)).

5.5.5 Sector 3 (Honiana Te Puni Reserve) – Intertidal

The intertidal beach substrate at Korokoro Stream mouth comprises sand and gravel banks (Photo 35 and Photo 36). Amphipods were the dominant taxa collected from the intertidal habitat of the Korokoro Estuary; polychaetes, as well as bivalves, isopods and gastropods were present in low proportions at this site (Figure 33). Abundance, diversity and richness of infauna[38] was low (Table 16) and very few epifauna[39] were observed along the soft sediment foreshore. Results of the contaminant analyses show that concentrations of lead, copper, zinc and PAHs within the intertidal sample were below ANZG (2018) default guideline value (DGV) (Table 17).

To the east of the Korokoro Estuary, the coastal margin of the Reserve reclamation is bound by an approximately 200 m long seawall (Photo 37) which does not provide any habitat opportunities for colonisation of sessile marine invertebrates (Photo 38).

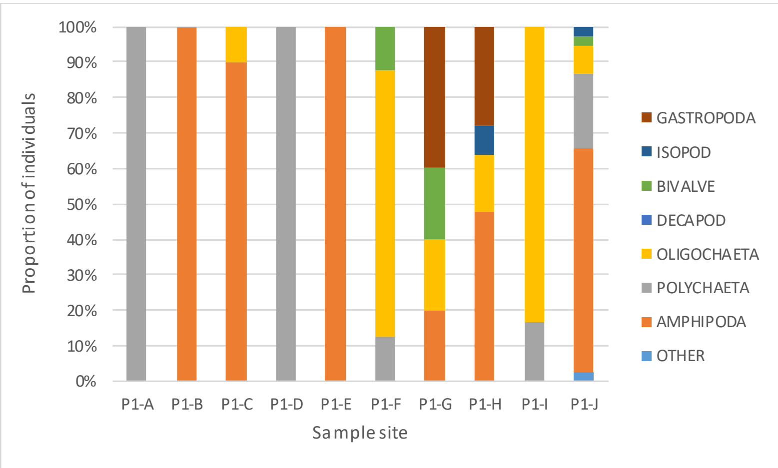

Figure 33: Intertidal infauna composition recorded at the Korokoro Estuary sample site (Pito-One foreshore)

Table 16: Infauna results from the intertidal samples collected at the Korokoro Estuary, Pito-One foreshore

SAMPLE	No. INDIVIDUALS	SPECIES RICHNESS	SHANNON WEINER DIVERSITY
P1-A	2	2	0.6931
P1-B	459	2	0.0155
P1-C	10	2	0.3251
P1-D	1	1	-
P1-E	1	1	-

[38] Animals living in the sediments of the ocean floor or river or lake beds.

[39] Animals living on the surface of the seabed or a riverbed or attached to submerged objects or aquatic animals or plants.

SAMPLE	No. INDIVIDUALS	SPECIES RICHNESS	SHANNON WEINER DIVERSITY
P1-F	8	3	0.7356
P1-G	5	4	1.3322
P1-H	25	5	1.2595
P1-I	7	3	0.7963
P1-J	38	6	1.1059
Ave P1 (s.e.)	**55.6 (44.98)**	**2.9 (0.53)**	**0.78 (0.14)**

Table 17: Contaminant concentrations recorded at the at the Korokoro Estuary, Pito-One foreshore

CONTAMINANT	SAMPLE CONCENTRATIONS mg/kg (± s.e.)	DGV (mg/kg)
Copper	10.7 (± 7.6)	65
Lead	17.7 (± 12.5)	50
Zinc	67 (± 46.7)	200
Total PAHs	0.4 (± 0.2)	10


Photo 35: Korokoro Estuary and foreshore


Photo 36: Example of typical substrate recorded in the quadrat


Photo 37: Existing seawall along the eastern coastal margin of the Reserve


Photo 38: Seawall face with no marine invertebrate colonisation.

5.5.6 Marine ecological value

5.5.6.1 Sector 2 (Ngā Ūranga to Pito-One)

The marine habitat along the Project is characterised by coarse sediments (sand, cobbles, and boulders – both natural and man-made) and rocky reefs, generally sparse (yet variable) fauna in intertidal habitats but more diverse flora and fauna in subtidal habitats. No clear patterns or trends were present in subtidal habitats with respect to sites along the Project or distance from the shore. There is variability within and between habitat types, but because the habitats are primarily mosaics and not particularly easy to separate, we have assessed marine values as an overall single feature, taking the highest value from intertidal soft sediment, intertidal rocky reef, subtidal soft sediment and subtidal rocky reef habitats.

As such, we have assessed the marine ecological values as High, because all the high ecological value criteria (Table 4) are generally met in at least one of the habitat types apart from habitat modification (e.g. existing reclamation and associated seawalls / revetment), which is considered moderately modified and there is a lack of dominance of opportunistic and disturbance tolerant species.

The high ecological value characteristics (Table 4) detected are:

- Benthic invertebrate community typically has high diversity, species richness and abundance (soft sediment subtidal in particular).
- Benthic invertebrate community contains many taxa that are sensitive e.g. bivalves, gastropods, ostracods. For example, 14 of the 118 taxa[40] (12%) detected in subtidal soft sediment cores have known sensitivity to either organic enrichment, sediment or contaminants.
- Marine sediments typically comprise <50% smaller grain sizes (i.e. fine sand, very fine sand, silt and clay).
- Surface sediment oxygenated (no anoxic sediment was observed during sample collection).
- Contaminant concentrations in surface sediment rarely exceed DGV threshold. concentrations (Australian and New Zealand Governments, 2018).
- Vegetation/macroalgae provides significant habitat for native fauna (primarily the significant macroalgae present in subtidal habitats).

The medium ecological value characteristics (Table 4) detected are:

- Few invasive opportunistic and disturbance tolerant species present (e.g. of the 118 taxa detected in subtidal soft sediment, 14 taxa (12%) are known to be sensitive to either organic enrichment, sediment or contaminants, and 14 taxa (12%) are known to be tolerant to organic enrichment, sediment or contaminants).
- Habitat modification limited (to the existing reclamation and riprap).

5.5.6.2 Sector 3 (Honiana Te Puni Reserve)

The surveys carried out within the mobile sand/gravel intertidal Korokoro Estuary area are likely to be largely representative of the mobile sand/gravel intertidal beaches along the Pito-One foreshore, with relatively (and naturally) low benthic invertebrate species richness and diversity, benthic invertebrate community composition dominated by tolerant taxa, sediments dominated by

[40] Most marine organisms have not been studied for sensitivity to organic enrichment, sediment or contaminants.

sand and gravels, low sediment contaminant concentrations, no macroalgae habitat, high degree of modification in parts, and sediments appeared oxygenated (Table 4). The rock wall does not provide marine habitat value. On balance, the ecological value of the Korokoro Estuary and intertidal Pito-One foreshore is assessed as **Low**.

5.6 Summary of Ecological Values & Significance

Table 18 provides a summary of the ecological values and PNRP significant sites that have been identified in Sections 5.1 to 5.5 in association with the Project.

Table 18: Summary of ecological values and significance (PNRP) associated with the Project

ECOLOGICAL COMPONENT		VALUE	SCHEDULED SIGNIFICANT (PNRP)
INDIGENOUS VEGETATION		Negligible	No
HERPETOFAUNA		Low	No
FRESHWATER	Korokoro Stream	Very High	Yes
	Waihinahina (Horokiwi) Stream	Negligible	No
	Gilberd Bush Stream	Negligible	No
	Un-named streams (x3)	Moderate	No
AVIFAUNA	**Habitat**		
	Wellington Harbour from Pito-One Beach rowing club to Ngā Ūranga railway	-	Yes
	Wellington Harbour (Port Nicholson) – inland waters	-	Yes
	Species		
	Reef heron	Very High	-
	Caspian tern	Very High	-
	Little penguin	High	-
	Red-billed gull	High	-
	White-fronted tern	High	-
	Pied shag	Moderate	-
	Variable oystercatcher	Moderate	-
	Fluttering shearwater	Moderate	-
	Black shag	Moderate	-
	Little black shag	Moderate	-
	Little shag	Low	-
	Black-backed gull	Low	-
	Spotted shag	Low	-
	White-faced heron	Low	-

ECOLOGICAL COMPONENT		VALUE	SCHEDULED SIGNIFICANT (PNRP)
MARINE	Sector 2 - Subtidal rocky reef / cobble / macro-algae[41]	High	Yes
	Sector 2 - Subtidal soft sediment[35]	High	-
	Sector 2 - Intertidal hard shore[35]	High	-
	Sector 2 - Intertidal soft sediment[35]	High	-
	Sector 3 – Intertidal	Low	Yes (Korokoro Estuary)

6.0 Ecological Input into Key Design Elements

Following the identification of the species of high ecological value and their habitat utilisation as outlined above, the Project Ecologists were instrumental in advising on the design of the Project to either avoid or minimise effects on those values. The ecological criteria for the key design features to achieve this outcome are outlined in the following sections.

6.1 Minimising permanent marine habitat loss

Loss of marine habitat for construction of the Project is a result of the decision to build the shared path seaward of the existing reclamation that provides for the existing road and rail infrastructure. Subsequently, a collaborative and iterative design process occurred which included (amongst others) objectives to minimise the area of marine habitat lost to the Project and to avoid higher value area of marine habitat (e.g. rocky reefs and shingle beaches) (recognising Policies 10 and 11 of the NZCPS, significant marine habitat recognised in the PNRP and best ecological practice).[42]

6.2 Relocation of KiwiRail signal station

The avifauna investigations identified the following habitat usage at Rocky Point:

- Three species breeding above MHWS, including two *At Risk* species (refer to Table 11 and Map 7);
- Foraging in the intertidal zone; and
- Roosting on the existing rock outcrops.

Due to the location of the existing KiwiRail signal station at Rocky Point, an earlier Project design was aligned to avoid that building, but which would therefore have eliminated or encroached into these avifauna habitats. Due to the high level of avifauna effects that alignment would have resulted in, Waka Kotahi worked with KiwiRail to provide for the relocation the signal station and thereby enable the shared path to remain on existing land.

[41] All marine habitats are assessed collectively as having High ecological value due to the mosaic of habitats present. This is a conservative approach.

[42] Refer to Effects Management Hierarchy

6.3 Offshore habitats for roosting avifauna

The very nature and purpose of the Project is to encourage the use of the coastal margin between Pito-One and Ngā Ūranga, an area which is currently inaccessible to people and which is used by a number of *Threatened* and *At Risk* avifauna species as roosting habitat. As such, the Project Ecologists sought to identify an alternative undisturbed area for coastal avifauna to roost during both the construction and operation of the Project through the creation of offshore roosting habitats.

The Project Ecologists provided the following criteria for the proposed offshore habitats:

- Located a minimum of 40 m from the low tide mark on the toe of the revetment (refer to Section 8.4.2);
- Not be located in areas identified as having high value subtidal marine habitat (refer to Map 8);
- Have a surface area of approximately 10 m^2 at least 1.5 m above mean high water[43] to ensure usable area outside of the splash zone;
- To be designed to allow for sea level rise so that they provide undisturbed roosting habitat throughout the life of the Project;
- At least one offshore habitat to be located adjacent to Rocky Point which has been identified as a nesting site for variable oystercatcher, a species vulnerable to disturbance;
- Be located in areas where there are no natural rock outcrops of headlands;
- Situated away from the rowing course; and
- Be designed so as not to encourage people to view them as platforms to swim out to (and thereby disturb roosting birds).

The proposed locations of the offshore habitats are shown on Map 8 (marine values). We recommend that as part of determining the final location of the offshore habitats, that subtidal divers confirm that there are no high marine values at those sites. If the divers report the presence of high marine values at a proposed location, then other sites should be investigated (considering all the above criteria).

6.4 Seawall sections & screening

An earlier version of the Project design had a revetment treatment along the entire coastal length of the Project. However, following the identification of shingle beaches as an endangered ecosystem type as well as providing foraging and breeding habitat for *At Risk* avifauna species, a design refinement process was undertaken to seek changes to avoid adverse effects on these areas and the species utilising those habitats. From that, six key locations were re-designed to minimise the footprint and retain the shingle beaches at those locations through the use of a seawall design.

This design change not only largely avoids the direct loss of those shingle beaches, but it was identified through coastal processes investigations that the inclusion of strategically placed groynes and the placement of rip-rap at the base of seawall (to attenuate and dissipate wave energy) would encourage beach replenishment and therefore have the additional benefit of protecting those

[43] Designed to be 2.5 m above mean high water which comprises the 1.5 m and an additional 1.0 m to allow for sea level rise over the life of the Project (refer to AECOM Drawing No. 60306339-SK-1034 Revision A, issue date 03.09.20).

beaches from effects of sea level rise over the next 100 years; thereby increasing the viability and long term survival of shingle beaches for the coastal birds that currently use them. An additional design feature to the seawall sections was the inclusion of screening to reduce visual disturbance to coastal avifauna by path users. The Project Ecologists provided the following criteria for the proposed screening:

- Given the number of avifauna species breeding at Rocky Point, the height of the screen at that location should be sufficiently high that people cannot see directly over it;
- If the screen is to be slatted, it should incorporate a louvered aspect so that people cannot view birds directly; and
- Screening should be attached on the landward side of the capping beam, not the seaward side (as people could use the capping beam as a step).

7.0 Construction

7.1 Construction materials

The material that will be used for the rocky revetment, seawall and path formation works includes:

- Rock armouring for the main revetment structure (primary and secondary to approximately 1.5 m layer thickness);
- Geotextile membrane;
- Clean gravels and other filter type material (self-compacting fill below water level);
- General fill (may include geogrid);
- Precast concrete piles forming post set into bedrock;
- In-situ concrete as foundation to RC piles;
- Precast concrete panels as infill sitting between the posts; and
- Cast in-situ reinforced concrete capping beam.

Given there is no local source of suitable rock armouring, the material will be sourced from outside of the Wellington region and transported to site. The clean gravel fill material will be sourced from local Wellington quarries or the Hutt River gravel quarrying operation. General fill material will be obtained from local Wellington borrow pits, riverbeds or quarry overburden.

Fill and gravel/rock stockpiles and construction material laydown areas will be located in the north and south construction yards.

7.2 Construction methods & sequencing

A detailed description of the indicative construction methodology for the Project is contained within Section 5 of the AEE; a brief summary is provided below. General construction aspects across the whole Project include:

- Enabling works;

- Night-time works;
- General construction works;
- Rock revetment and path formation works;
- Construction of the other CMA structures;
- Temporary occupation of the CMA for construction;
- Culvert works;
- Construction of the rail overbridge; and
- Erosion and sediment control measures.

7.2.1 Enabling works

Enabling works and site establishment activities will be required to access and prepare the Project area for construction. These works will include:

- A range of site investigations including surveys, utilities investigations, geotechnical and contaminated land investigations to inform detailed design and construction planning;
- Deconstruction of the existing Wellington Rowing Association building at Honiana Te Puni Reserve;
- Construction of a new integrated clubs' building, car park, and associated path works at the eastern side of Honiana Te Puni Reserve;
- Creation of site access points, construction yards, erection of fencing and hoardings, and pre-construction ecological avoidance and mitigation works; and
- Identification, protection and/or relocation of existing network utilities situated within, or in close proximity to, the construction area.

7.2.2 Rock revetment and path formation works

The existing rock revetment that supports the Hutt Valley Railway Line will remain in place for the duration of the works and will not be modified. Additional material will be placed on top of this existing revetment.

For construction of the Project from land the following methodology is anticipated:

- The rock revetment will be constructed first, in staged sections, longitudinally into the water. The revetment will form a permeable coffer dam which will provide wave protection/attenuation during the works. The toe of the rock revetment will be undercut to form a strengthened rock toe;
- The formed permeable coffer dam will then be lined with a geotextile cloth. This will be used to line the inside face to mitigate the potential loss/discharge of sediment during the placement of fill behind the revetment;
- General fill will be placed within the lined coffer dam area using trucks and/or articulated dumpers and a digger to assist with moving material. Machinery will access the construction face of each section across previously constructed sections or installed seawalls. A digger operating on a construction platform will then place the fill material;
- Compaction of material will only occur above the water level (determined by tides). Gravel self-compacts so compaction will not be required below water level; and

- Fill will be placed and compacted between the permeable coffer dam and the existing revetment to reach the final level and the shared path will sit on top of this newly created land. The portion of land created above mean highwater springs, behind the revetment will become reclaimed land

Alternative access for the delivery of fill to the construction area may also be possible via rail utilising side-tipping wagons. Where the rail line is used, the following general methodology is anticipated:

- The rock revetment will be constructed first, in staged sections, longitudinally into the water. The toe of the rock revetment will be undercut to form a strengthened rock toe. The revetment will form a permeable coffer dam which will provide wave protection/attenuation;
- Material including general fill, gravel, and rock riprap will be brought to site at night-time using KiwiRail's side-tipping wagons;
- Material will be tipped from the side-tipping wagons on the seaward side of the railway line, over the existing railway edge into the contained construction footprint; and
- The final placement of material will be via a digger operating from a construction platform on the seaward edge of the railway line. This will follow the same methodology as the land-based construction set out above.

Construction in the CMA will be susceptible to adverse weather conditions. Weather forecasts will be actively monitored to enable closure of the permeable coffer dam in advance of adverse weather, thereby protecting general fill contained within the coffer dam from wave action and any unintended discharge of sediment into the harbour.

7.2.3 Construction of other CMA structures

7.2.3.1 Rock revetment

For the construction of the typical ūranga, and at narrow areas, the following general methodology is anticipated:

- Place gravel up to MHWS with a digger and line with rock riprap;
- Place geotextile layer over the gravels (as required);
- Place fill onto the geotextile layer to raise the formation above MHWS and compact this material;
- Place geotextile over the created slope; and
- Line the slope with rock riprap; and
- Place fill behind the rip rap using a digger or dump truck to the formation level and compact the material.

For the construction of the wider (e.g. high tide bench) ūranga the following general methodology is anticipated:

- Place gravel and rock riprap with a digger progressively to form a bund up to MHWS and compact the material;
- Place a geotextile layer to the backslope of the embankment;
- Place sand/gravel fill behind the bund up to MHWS and compact;

- Raise the new bund above MHWS with general fill and compact;
- Line the new bund with a geotextile layer;
- Cover the bund with rock riprap; and
- Place general fill behind the bund using a digger and dump truck to the formation level and compact the material.

7.2.3.2 Offshore habitat

At least two of the four offshore bird habitat structures will be created prior to start of any works in the CMA that may impact coastal birds, and the remaining habitats will be completed prior to the completion of construction. This will provide avifauna with alternative roosting locations once disturbance to their habitat along the Project occurs. Typical design details are shown in AECOM Drawing No. 60306339-SK-1034 (Revision A, issue date 03.09.20).

Bathymetric survey will confirm the seabed profile and the exact position of the structure. A single proof bore (1 sq.m) will be drilled to approximately 3m below rock level (rock level is expected at between 6-7 m below the existing seabed) at each of the offshore habitat locations. The purpose of this is to inform how the seabed will perform under loading. It is anticipated that a jack-up or floating barge will be used to perform this activity. If a jack-up barge is used, an additional area of 4sq.m of seabed will be disturbed at each offshore habitat site associated with the placement of the jack-up barge legs.

In order to minimise the potential discharge of sediment during the drilling operation, casing may be installed in the marine deposits and used to circulate the drilling fluid. Any sediment which is loosened and entrained during drilling will be brought to the surface/barge platform and captured within the circulation tank. Environmentally friendly drilling mud may also be used to help bind the soil/rock together. Bunding such as silt socks and other controls may also be installed around the perimeter of the barge.

For construction of the offshore habitat the following methodology is anticipated:

- Deliver riprap and other material required for habitat construction to the location by a barge, positioned with GPS;
- Deploy a floating silt curtain around the work zone;
- With a long reach digger positioned on the barge (or on a separate jack up barge) unload the riprap from the delivery barge to form the outer ring of the habitat area;
- Fill the central core with gravel;
- Repeat with rock riprap and gravel until the habitat is above MHWS; and
- Above MHWS, fill and level off top of rocks with GAP 100 material or similar.

7.2.3.3 Seawalls

For the construction of the seawalls the following construction methodology is anticipated:

- Where the toe of the seawall will be situated above MHWS, a digger either operating on existing land or previously constructed coastal works can be used for construction of the seawall;
- A cut will be required to establish a level work platform. This will be designed so as not to destabilise the adjacent KiwiRail revetment;
- An auger drill will be used to create post holes into which pre-cast posts will be placed. Dewatering of the post holes may be required and temporary steel casings will be inserted

to prevent the post holes from collapsing during concreting. The temporary steel casings will be inserted using a vibrohammer attachment to refusal;

- The digger will be used to place post and panel reinforced concrete elements. The panels will be placed and grouted; and
- Backfill will then be used to fill the void between the existing KiwiRail revetment and the pre-cast panels. This material will be compacted. The finished shared path will sit on top of this newly created surface.
- Where the toe of the seawall is situated at or below MHWS, a crane will be positioned on previously completed areas or structures. The swing zone of the crane will necessitate that works occur during either the night-time or a BOL;
- Construction using the crane will be similar for works above MHWS; however, where panels and posts are required, steeling casings will be used. A vibrohammer will be used to get the steel casings into, and out of, position; and
- Some rock rip-rap will be placed at the base of the seawalls structure for wave dissipating purposes.

7.2.3.4 Groynes

Groynes will be constructed at specified locations. These will be comprised of rock and will support beach nourishment at the adjacent shingle beaches. The rocks used for the groynes will not be cemented in place. For construction of the groynes, the following general methodology is anticipated:

- Construction will occur at the same time as the adjacent seawall;
- Deliver the rock to the groyne location via a dump truck; and
- Place the rocks for the groyne with a long reach digger from the formed path.

7.2.4 Beach nourishment

As outlined in the Coastal Process Assessment, beach nourishment along sections of the seawall will occur during the construction phase using salvaged shingle / gravel material. Small quantities of salvaged material will be placed by hand at the back of the beach by the boulders at the toe of the sea wall.

This process may need to be periodically repeated (using the same technique and similar appropriate material) throughout the life of the Project.

7.2.5 Culverts

Twenty three culverts will need to be extended for the Project and will extend into the CMA (refer Table 19 below taken from AECOM Drawing No. 60306339-SK-170 Rev F, issue date 03.09.20). The culvert extension works will occur prior to the construction of the rock revetment, ūranga and seawalls so that flows can be maintained during the works.

For the stormwater culverts (20 in total , as shown in Table 19 below) the following general methodology is anticipated:

- Work will be planned for periods of fine weather when there are low flows in the culverts;

- Construction of a compacted pipe bed for the extended culvert may be required depending on geotechnical conditions. Where this is required an excavator will be used to undercut the seabed and then place clean gravel;
- Place the prefabricated culvert section with a crane or excavator in the compacted pipe bed; and
- Secure the culvert in place with rapid hardening cement at low tide to prevent potential alkaline contamination of the seawater surrounds when the tide rises.

For the intermittent and perennial stream culvert extensions (four in total, as shown in Table 19 below) the following general methodology is anticipated:

- Works will be planned for summer so that works may occur in the dry;
- If stream flow persists, a dam and divert methodology will be utilised for the period of construction. This will involve the use of a temporary dam at the headwall of the culvert and a pump to convey water around the work zone (further information relating to this can be found in the Erosion and Sediment Control Assessment;
- Construction of a compacted pipe bed for the extended culvert may be required depending on geotechnical conditions. Where this is required, an excavator will be used to undercut the seabed and then place clean gravel;
- Place the prefabricated culvert section with a crane or excavator in the compacted pipe bed; and
- Secure the culvert in place with rapid hardening cement at low tide to prevent potential alkaline contamination of the seawater surrounds when the tide rises.

Where the works will occur below MHWS they will occur at low tide. It is anticipated that each culvert extension will take between 1-10 days to complete depending on the length.

Table 19: Project culvert schedule (from AECOM Drawing No. 60306339-SK-170 Rev F, issue date 03.09.20)

REF No.	CHAINAGE	APPROX. LENGTH OF PIPE EXTENSION (m)	GOING THROUGH	NOTES
1	980	-	Revetment	Stormwater
2	1151	22	Revetment	Stormwater
3	1344	22	Revetment	Stormwater
4	1508	24	Revetment	Stormwater
5	1635	15	Revetment	Stormwater
6	1790	23	Revetment	Intermittent un-named stream #2
7	1922	12	Revetment	Stormwater
8	2070	10	Revetment	Stormwater
9	2216	7	Revetment	Stormwater
10	2339	5	Wall	Intermittent un-named stream #1
11	2423	1	Revetment	Stormwater
12	2543	*Culvert to be confirmed (stormwater)*		
13	2647	9	Revetment	Stormwater
14	2786	11	Revetment	Stormwater

REF No.	CHAINAGE	APPROX. LENGTH OF PIPE EXTENSION (m)	GOING THROUGH	NOTES
15	3042	2	Revetment	Stormwater
16	3120	13	Revetment	Stormwater
17	3266	12	Revetment	Stormwater
18	3411	2	Wall	Intermittent Gilberd Bush Stream
19	3677	5	Wall	Perennial Waihinahina Stream
20	3787	13	Revetment	Stormwater
21	3988	13	Revetment	Stormwater
22	4013	12	Revetment	Stormwater
23	4219	9	Revetment	Stormwater
24	4304	6	Revetment	Stormwater
25	4486	-	-	Intermittent un-named stream #3

7.2.6 The Shared Path Bridge

The construction of the Shared Path Bridge (the Hutt Valley Railway Line overbridge at Ngā Ūranga) will involve:

- Geotechnical investigations at the location of the heavy lift crane and pile rig to confirm if any ground strengthening is required and determining where the crane and rig can be safely placed during construction;
- Construction of a temporary access bridge across the railway line so that construction personnel can safely access both sides of the railway line during the bridge works;
- Concrete piles will be installed using a boring methodology. Where deemed suitable, uncontaminated spoil may be used for construction of shared path areas.
- The temporary casings that will be used to help install the concrete piles will then be removed by a combination of crane and vibrohammer so it may be used for the next pile;
- Bridge piers will have formwork and reinforcing steel placed with a crane, and then cast in-situ with concrete;
- The precast bridge beams and cast-in-situ deck will then be placed with a crane during a KiwiRail BOL to avoid disruptions to the rail network; and
- The bridge deck will be reinforced and concreted in place utilising standard construction techniques.

Works to construct the bridge utilising large machinery will be required to occur at night-time and during KiwiRail BOL.

7.3 Honiana Te Puni Reserve

The Project includes the demolition and development of a number of activities and new facilities at Honiana Te Puni Reserve, including:

- The temporary use of the western half of the Reserve as a construction yard for the Project;

- Removal of the Wellington Rowing Association building;
- Removal of the Wellington Water Ski Clubrooms following completion of the construction of the Project;
- The new integrated clubs building and carparking/access;
- The temporary, then permanent, Tāwharau Pods (three pod buildings);
- The new multi-functional Whare;
- Upgrades to the Waka ramp access which will involve a reinforced grass route leading from the formed accessway. No works are proposed to upgrade or modify the existing gravel beach ramp which this reinforced route will service;
- Additional path and road areas within HTPR;
- Two new sculptures; and
- Upgrade to the Korokoro Stream bridge surface and balustrades. There are no upgrade works proposed to the width and supporting structures of the bridge. This means that there are no works required within the bed of the stream or on the adjoining banks.

Not all of these activities are certain to be delivered, but we have assumed (on a conservative basis) that they will be in carrying out our assessment of effects.

7.4 Erosion & sediment control

The following proposed erosion and sediment control measures have been taken from the Erosion & Sediment Control Technical Assessment for the Project.

7.4.1 Land-based

Stabilised entranceways will be constructed at the entry of both the northern and southern laydown areas. Given the current asphalt or gravel hardfill surfaces and long length of both of these entrance points, it is unlikely sediment will be tracked on to public roads.

A silt fence will be positioned around the lower extent of the northern laydown area to treat potential dirty runoff. This silt fence will also represent a barrier to avoid machinery or stockpiling on unstabilised land within the reserve. Similarly, the new carpark and building developments throughout Honiana Te Puni Reserve will require a silt fence around their construction perimeters to treat potential sediment runoff and isolate works from other grassed areas of the Reserve.

Localised silt fences may also be implemented in the vicinity of Korokoro Stream to protect from potential runoff from the accessway. Any runoff from the Korokoro bridge will be diverted via the use of asphalt bunds.

7.4.2 CMA works

All materials used in the revetment wall construction process will be clean hardfill, free of fines, to minimise any erosion and sediment loss risk. However, the revetment wall is required to be embedded into the sea floor to provide a stable base for filling and minimise potential settlement or lateral movement. This embedment is required to be 0.5 m deep and will involve seafloor sediments being excavated and removed from site. Excavated sediments will either be reused as backfill (if suitable) or removed from site to a licenced fill.

This excavation will produce sediment suspension within the marine environment that will be contained with the implementation of a silt curtain (turbidity curtain). A silt curtain will be required to be set up in a sequenced process to allow the containment and settlement of disturbed sediments near the excavations, while taking place. This silt curtain will be a minimum 5 m from the excavations, promoting settlement to a confined working zone as much as practical. Additional silt curtains may be deployed at any stage of the Project for isolated works, or in the event that sediment is observed to discharge from the broader construction activities. Any silt curtain established will have the appropriate specification for a marine environment and be of a suitable depth.

The CMA works zone will be a moving work zone to allow the controlled containment of potential sediment loss from backfilling activities. This process involves the longitudinal advancement of the new pervious revetment wall and placement of geofabric on its internal side to act as a filter for potential sediment loss from the imported fill. Perpendicular hardfill 'dams' will then be advanced from the existing shoreline to the new revetment intermittently to create contained areas for backfilling. This method creates contained 'silos' with the new revetment and 'dam' acting as coffer dams with lined geofabric filters. A silt curtain may be incorporated into this process in the place of any perpendicular coffer dam.

Silt curtains control the migration of suspended sediment and facilitate localised settling. Erosion control and management of the clean aggregate importation and placement within the works area is therefore a priority, as opposed to the contained settling of sediment within the silt curtain area.

In the event of an adverse weather or marine forecast the contractor shall assess all works within the coastal environment. The following actions will be undertaken if the forecast is anticipated to generate a wave or tidal risk to the Project works area:

- Remove all machinery and equipment from the potential risk zone.
- Ensure all loose materials are stockpiled and/or covered in a low risk zone, away from potential sea inundation.
- Close off the current works area by constructing a new hardfill 'dam' (as specified above) at the current point of revetment extension.
- Remove any silt curtain installed in the event of a severe wave forecast.
- Following a severe weather event, the works zone will be assessed for damage and sediment loss areas.

7.4.3 Culvert extensions

The following methodology will be implemented for each intermittent and perennial stream culvert extension should there be flow within the culvert at the time of construction:

- Install a temporary dam at the headwall of the culvert with the use of sandbags or a driven sheet pile.
- Establish a pump that conveys water around the works zone:
    - This pump will have a minimum capacity to pump twice the stream's baseflow at the time of construction.
    - This pump will require a pumping eye or fish screen installed at its intake to prevent drawing in biota or sediment.

- The discharge point of any pumped water will be to a stable area with adequate erosion protection in place.
- Upon completion of works, the temporary dam and pump can be removed to allow the conveyance of water through the new extension.

The following procedures will take place prior to any adverse rainfall forecast likely to result in discharge through the culvert extension work areas:

- Remove all material and equipment out of the stormwater flow path.
- Pin geofabric or polythene to the base of the flow path should material be erodible (i.e. not hardfill) to convey any stormwater flow over exposed soils.
- Contingency measure - a temporary dam and divert methodology with the use of a dam and novacoil to bypass stormwater through the site can be implemented.

7.5 Contaminants

AECOM (2019b) have identified the existing reclamation (KiwiRail land) at the southern (Ngā Ūranga) end of the Project as a HAIL[44] site. Contaminated material will be removed from site and disposed at tip sites approved for the purpose.

Refuelling of trucks and dumpers will occur within the construction yards at the south and north ends in suitably protected/bunded areas. Tracked excavators and cranes will be refuelled from mobile fuel trucks on site but away from the water's edge within temporarily created bunded areas (pulled up by the excavator itself) to prevent potential spillages from entering the water. Spill kits will be carried on the fuel trucks and will be available at the construction yards at all times.

7.6 Noise & vibration

Construction may occur during both daylight and night-time hours. The following work may be carried out at night:

- Some southern bridge construction work immediately adjacent to or over the rail lines;
- Offloading and stockpiling of rock (and maybe general fill); and
- Delivery and placement of rock from side-tipping rail wagons at certain sections of the path.

The Noise & Vibration Assessment reports that the delivery, movement and tipping of rock for the revetment are likely to result in high levels of noise. The vibration intensive works planned for the project include the use of earthmoving machinery, vibratory rolling and piling. However, the vibration levels generated by earthmoving machinery and truck movements are not considered significant when compared with the levels expected during the piling and vibratory rolling activity.

With respect to underwater noise, the Noise & Vibration Assessment considers the method for the construction of the offshore habitats (i.e. placement of rocks using an excavator from a barge) will not be any significant noise source that would have any measurable effect on marine fauna from this activity. Propagation of airborne noise sources into the water will not result in significant underwater noise levels, and any engine noise from the barge or tugs will be at a low level

[44] Ministry for the Environment Hazardous Activities and Industries List

comparable to normal marine vessel movements. There is the potential for work to take place under water during construction of the sea walls, where these are located below MHWS level. However, if this work takes place underwater at all it will be in very shallow water and there will be limited propagation into deeper water. Vibratory or impact pilling will not be used to construct the sea walls. As such, the Noise and Vibration assessment considered that there would be a negligible impact on marine fauna from activities associated with the construction of the sea walls.

8.0 Assessment of Effects

In addition to the ecological investigations, this assessment of ecological effects has been based on the information provided in the supporting documentation and plans listed in Section 4.6 above. Also, we note that the level of potential effects we identify in the following sections are also based on the implementation of all the recommendations provided throughout the assessment. We understand that Waka Kotahi has agreed to implement all recommendations (as reflected in the proposed conditions). If any of our recommendations were not to be implemented, the level of potential effect and therefore any mitigation / offset / compensation requirements would need to be revisited.

8.1 Indigenous vegetation

The following potential construction and operational phase effects (both direct and indirect) on indigenous vegetation were considered for this assessment:

- Clearance of indigenous vegetation;
- Loss of *Threatened* or *At Risk* species;
- Increases in the extent of edge effects;
- Fragmentation of habitats.

As noted in Section 5.1 and shown on Map 9, the indigenous vegetation associated with the Project comprises scattered areas of roadside amenity planting and areas of revegetation within the Honiana Te Puni Reserve. Pohutukawa and manuka were the only *Threatened* or *At Risk* species recorded along the Project; however, both were only present in low numbers as part of the amenity planting mixes, rather than as a large stand of ecological significance.

Albeit it being a very small amount, the construction of the Project will result in the loss of the majority of the existing vegetation within the Project footprint. Due to the scattered nature of the existing vegetation, the loss of this will not result in any increased edge effects or fragmentation of habitats. A total area of 4,335 m^2 of indigenous vegetation occurs under the Project footprint (which includes both the design, laydown and integrated clubs building footprints; refer to Map 9).

8.1.1 Level of effects & measures to avoid, remedy & mitigate

While the ecological value of the vegetation lost does not warrant mitigation, the following measures will occur:

- The revetment designs will include approximately 9,700 m^2 of native revegetation,[45] an area which is much greater than will be lost.
- Options for including threatened plant species into planting mixes will also be explored.

Based on the **Negligible** ecological value (Section 0) of the existing native vegetation and the **Positive** magnitude of effect, the overall level of effect of the Project on indigenous vegetation will be a **Net Gain** (refer to Table 6).

In summary, there will be a positive ecological outcome for indigenous vegetation associated with the Project and as such there will be no residual effects requiring offsetting.

8.2 Herpetofauna

The following potential construction and operational phase effects (both direct and indirect) on native herpetofauna were considered for this assessment:

- Direct loss of lizard habitat within the Project area;
- Displacement to unsuitable surrounding habitat;
- Lizard mortality during vegetation clearance and site works; and
- Ongoing disturbance.

8.2.1 Loss of habitat

Project works will result in direct habitat loss for lizards within the Project footprint, including the proposed laydown site at the Honiana Te Puni Reserve and the integrated clubs building (refer to Map 5). The areas of potentially suitable habitat within the Project footprint are small and isolated (refer to Map 5) – further habitat loss may render some areas too small to sustain a population.

8.2.2 Displacement into unsuitable habitat

As mentioned above, the lizard habitats within the site are isolated (refer to Map 5); this means that any lizards that are displaced through construction would be dispersing into less suitable or entirely unsuitable habitat, or into habitat that may already be occupied to capacity. Displacement may expose lizards to increased competition for refuge habitats and increased exposure to predators.

8.2.3 Lizard mortality or injury

Lizard fauna are mobile over short distances but may not be able to escape during site preparation and construction, particularly if carried out during colder months when lizards are less active. Activities that may impact lizards include vegetation clearance and earthworks. Lizard mortality and injury are recommended to be avoided as much as practicable by salvaging lizards immediately prior to vegetation/habitat clearance.

[45] Calculations provided by Project Design team

8.2.4 Ongoing disturbance

A potential operational effect is disturbance to resident populations caused by the use of the shared path. However, given the proximity to the railway and SH2, it is expected any additional disturbance would be relatively minor.

8.2.5 Level of effects & measures to avoid, remedy & mitigate

The potential lizard habitats within the footprint are of generally low quality and are expected to house low numbers of lizards. While only *Not Threatened* species are expected to be present within the site, all native lizards are protected under the Wildlife Act (1953). As such, where practicable, clearance of areas of lizard habitat (as identified in Map 5) should be avoided. Avoidance will likely only be possible for areas of vegetation within the proposed laydown area at the Honiana Te Puni Reserve, as the footprint of the shared itself path is constrained by the railroad on one side and the ocean on the other.

Where the removal of lizard habitat cannot be avoided, measures are recommended to avoid and minimise the potential effects on resident lizard populations. This recommendation includes the preparation of a Lizard Management Plan (LMP), which will include:

- Descriptions of the lizard habitats present within the footprint;
- Lizard species that are expected to be present;
- Legal and permitting requirements;
- Salvage and relocation methods;[46]
- Measures to mitigate adverse effects during and post-construction; and
- Procedures for incidental discovery of lizards during works.

In order to mitigate any effects, revegetation both on the Project and within Honiana Te Puni Reserve should incorporate a species mix which would provide habitat and food resources for native herpetofauna (e.g. *Muehlenbeckia complexa*). Wooden debris should also be included which would provide suitable refugia for lizards (as well as invertebrates).

In summary, only robust and common species would be present within these areas, and using the EIANZ guidelines (Table 2), they are assigned **Low** ecological value (Section 5.2.1). Therefore, based on a Low ecological value and with an appropriate salvage plan and habitat enhancement, a **Negligible** magnitude of effect (Table 5) on the wider populations, the overall level of effect on herpetofauna associated with the Project is considered to be **Very Low** (Table 6).

As such, the potential effects on indigenous herpetofauna associated with the Project can be appropriately mitigated and as such there will be no residual effects requiring offsetting.

8.3 Freshwater systems

Construction works do not interact with freshwater systems, which are all upstream of SH2. Furthermore, in the case of the Korokoro Stream bridge, there are no upgrade works proposed to

[46] We note that undertaking of any lizard salvage operation would be consistent with the key principles outlined in DOC's guidelines on this topic (Department of Conservation, 2019).

the width and supporting structures of the bridge and therefore no works required within the bed of the stream or on the adjoining banks. As such, there will be no direct impacts on freshwater systems associated with the construction of the Project.

Culverts that exit under the Project through the revetment and seawall structures will need to be extended; this includes one culvert that conveys a perennial stream (the Waihinahina (seawall)), and three that convey intermittent streams (Gilberd Bush (seawall), and un-named 1 (seawall) and 2 (revetment) streams).

Currently, other than for the Korokoro Stream, there are no recorded or likely populations of native fish in any of the smaller escarpment streams including the largest (Waihinahina / Horokiwi) stream (as shown on Map 2). Fish passage above the SH2 culvert in some streams is already challenged by other modification, structures, and flow issues. In the smaller un-named streams, we consider it highly unlikely that there is sufficient flow and habitat even if currently passage is afforded by the existing culverts to support a population of native fish.

The extension of culverts will not in any material way alter or make more difficult access to and passage through those culverts.

There will be no works on the banks of or in the bed of the Korokoro Stream. Therefore, neither the inanga spawning areas on the banks, nor existing fish passage will be adversely affected. There is also understood to be no potential for sediment discharge to the Korokoro Stream. On this basis, potential adverse effects on the Korokoro Stream related to the Project will not arise.

8.3.1 Level of effects & measures to avoid, remedy & mitigate

As a form of mitigation, it is recommended that culvert extension associated with the intermittent and perennial streams (refer to Table 19) will be designed and installed to ensure fish passage.[47]

Given there will be no loss of freshwater habitat, the general absence of fish populations in the streams that intersect with the Project, and the allowance for fish passage in all four stream culvert extensions, we consider the magnitude of the effects will be **Negligible**. As such, we have determined the potential effects of the Project on the freshwater environments as follows:

STREAM	ECOLOGICAL VALUE[48]	MAGNITUDE OF EFFECT[49]	LEVEL OF EFFECT[50]
Korokoro Stream	Very High	Negligible	Low
Un-named stream 3	Moderate	Negligible	Very Low
Waihinahina Stream	Negligible	Negligible	Very Low
Gilberd Bush stream	Negligible	Negligible	Very Low
Un-named stream 2	Moderate	Negligible	Very Low
Un-named stream 1	Moderate	Negligible	Very Low

[47] Fish passage is not necessary in the stormwater culvert extensions.

[48] Refer to Table 3

[49] Refer to Table 5

[50] Refer to Table 6

In summary, the potential effects on the freshwater environments associated with the Project can be appropriately mitigated and as such there will be no residual effects requiring offsetting.

8.4 Avifauna

The following potential construction and operational phase effects (both direct and indirect) on native avifauna were considered for this assessment:

- Direct / permanent loss of habitat;
- Disturbance and effective habitat loss;
- Cumulative effects;
- Mortalities;
- Food supply and foraging ability;
- Lighting; and
- Pollution and litter.

The assessment of effects on coastal avifauna has been undertaken at a regional scale based on information obtained regarding species use of the Project footprint and in the context of their estimated regional populations.

8.4.1 Direct / permanent loss of habitat

Areas of foraging, roosting and breeding avifauna habitat have been identified (refer to Map 7) and the Project design has sought to avoid these areas as much as possible, particularly the intertidal shingle beaches.

Nevertheless, the construction works associated with the formation of the shared path and coastal protection structures will result in the direct loss of foraging and roosting habitat for a number of *Threatened* and *At Risk* species, as well as the loss of the nesting sites for little penguin and black-backed gull during the construction phase. However, this effect will be temporary (during the construction phase) due to the finished revetment design incorporating appropriate nesting habitat (refer to Section 8.4.1.1 below).

A break-down of the areas of the different types of avifauna habitats lost under the 6.84 ha coastal construction footprint is provided in Table 20 and Map 7. In terms of habitat that will be available following the construction of the Project:

- While approximately 1.20 ha of existing coastal avifauna roosting habitat will be lost under the Project footprint, approximately 1.8 ha[51] of riprap will be available for birds to roost on the constructed revetment above MHWS.
- Furthermore, the proposed offshore habitats will provide an additional 288 m^2 of roosting habitat.[52]

[51] Slope area (not plan) calculated above MHWS to the crest of the revetment.

[52] Slope area (not plan) of sides of structure above high tide calculated to be 62 m^2 for each offshore habitat structure, plus 10 m^2 for the top of the structure.

- Approximately 0.87 ha[53] of habitat will remain between the toe of the footprint and MLWS (i.e. shingle beaches and adjacent habitat above MHWS).

Table 20: Areas of avifauna habitat types under the coastal construction footprint (refer to Map 7)

HABITAT TYPE	AREA UNDER COASTAL CONSTRUCTION FOOTPRINT
Backshore nesting	0.15 ha
Concrete embedded rip-rap	0.87 ha
Intertidal and nearshore foraging	4.22 ha
Large rip-rap (penguin habitat)	0.03 ha
No habitat	0.07 ha
Rock outcrop	0.01 ha
Roosting rip-rap	1.16 ha
Shingle beach	0.33 ha[54]
TOTAL COASTAL CONSTRUCTION FOOTPRINT	**6.84 ha**

8.4.1.1 Level of effects & measures to avoid, remedy & mitigate

There is little terrestrial avifauna habitat associated with the Project, and no *Threatened* or *At Risk* terrestrial avifauna species. As such, the revegetation areas will more than replace (mitigate) any terrestrial avifauna habitat loss.

The Project footprint currently provides foraging, roosting and breeding habitat for a number of *Threatened* and *At Risk* coastal avifauna, albeit only very small proportions of their regional populations (refer to Table 11 and Appendix 4). The Project has sought to avoid, remedy, minimise and mitigate potential effects on coastal avifauna through habitat loss as follows:

- The path formation alignment **avoiding** areas of avifauna habitat as much as possible. This includes, at six locations along the path, a variation to the standard revetment design (in the form of a vertical seawall) which avoids significant ecological areas (shingle beaches) through a reduced footprint.
- The relocation of the KiwiRail signal station at Rocky Point to enable a redesign of the path alignment to avoid the direct / permanent loss of nesting and foraging habitat at that location.
- In association with the construction of vertical sea walls, at some locations, construction of groynes that will support the long-term survival of shingle beaches (as referred to in Coastal Processes Assessment).
- The creation of offshore habitats to minimise effects of disturbance on roosting birds. These habitats will be constructed prior to the construction of the pathway to provide roosting avifauna with an area of undisturbed habitat (during and after construction). The offshore habitat locations have been strategically placed outside areas of high marine value (refer to Map 8).

[53] Comprising 0.2 ha above MHWS, and 0.67 between MHWS and MLWS.
[54] Comprising 0.06 ha above MHWS and 0.27 ha below MHWS.

- The use of natural boulders for the revetment material will provide more opportunities[55] for nesting penguins than is currently present. In addition, it is recommended nesting boxes be incorporated within the planted area[56] on the Piki Wahine Point ūranga (chainage 700-900 m). Wooden nesting boxes should be designed as per the DOC guidelines[57] and installed at approximately 5 m spacings.[58] A minimum of 20 boxes will be incorporated into the Project, and the most appropriate placement of the nest boxes will be determined during the detailed design phase in consultation with DOC and Places for Penguins.
- It is recommended that tall structures such as wooden poles be incorporated into the ūranga designs to provide further safe roosting habitat for species such as shags and gulls.
- In addition, a predator control programme is recommended for the life of the Project with the primary objective being to protect nesting birds, eggs and chicks from predation by introduced mammals. The detail of the predator control programme will be included in a Predator Control Management Plan which will be prepared with stakeholder input.

Taking the above measures and recommendations into consideration, and in the regional scale context, we have determined the potential effects of the direct/permanent habitat loss on the local coastal avifauna populations as outlined in Table 21. We consider it very likely that the level of effects determined below will occur due to the direct and quantifiable nature of the activity.

Table 21: Assessment of potential effects of the direct/permanent habitat loss on the local coastal avifauna populations

SPECIES	ECOLOGICAL VALUE[59]	MAGNITUDE OF EFFECT[60]	LEVEL OF EFFECT[61]
Reef heron	Very High	Negligible	Low
Caspian tern	Very High	Negligible	Low
Little penguin	High	Positive	Net gain
Red-billed gull	High	Negligible	Very Low
White-fronted tern	High	Negligible	Very Low
Variable oystercatcher	Moderate	Low	Low
Fluttering shearwater	Moderate	n/a	n/a
Pied shag	Moderate	Negligible	Very Low
Black shag	Moderate	Negligible	Very Low
Little black shag	Moderate	Negligible	Very Low
Little shag	Low	Negligible	Very Low
Black-backed gull	Low	Negligible	Very Low
Spotted shag	Low	Negligible	Very Low
White-faced heron	Low	Low	Very Low

[55] Approximately 1.8 ha of riprap will be available along the constructed revetment above MHWS

[56] Approximately 2,182 m^2

[57] https://www.doc.govt.nz/globalassets/documents/conservation/native-animals/birds/nest-box-design.pdf

[58] Recommendations taken from meeting notes with Department of Conservation and Places for Penguins representatives on 5 November 2019.

[59] Refer to Table 2

[60] Refer to Table 5

[61] Refer to Table 6

8.4.2 Disturbance & effective habitat loss

Disturbance activities can occur during both the construction (e.g. noise, vibration and plant movement) and operational (presence of humans and dogs) phases of the Project. Disturbance to avifauna may result in short- or long-term displacement, decreased feeding rates, and unattended nests (leading to incubation failure and increased opportunities for predators), energy and time costs (Borgmann, 2010; Bowles, 1995; Kaldor, 2019; Lord et al., 2001; Price, 2008; Walls, 1999, p. 199). Disturbance can result in an effective loss of habitat (Hockin et al., 1992).

Giling *et al.*'s (2008) study of a little penguin population nesting on the breakwater at St Kilda (Melbourne) reported that although the penguins show a clear preference to nest in the restricted region of the breakwater, their continued presence in the publicly accessible region when nest sites are not limiting indicates that human disturbance is not incompatible with some nesting activity.

Numerous studies have reported various distances at which various bird species are disturbed by human activities (including walking, running and dogs) (Glover et al., 2011; Goss-Custard et al., 2006, p.; Haase, 1995; Rodgers & Schwikert, 2002; Rodgers & Smith, 1995; Thomas et al., 2003; Weston et al., 2012). The distance at which a bird flees from perceived danger is referred to as the flight initiation distance (FID). FIDs differ between species and are also significantly influenced by a number of factors including the starting distance of the human approach, flock size, previous exposure to humans and stimulus type (walker, jogger, walker with dog) (Glover et al., 2011).

Weston et al.'s (2012) review of FIDs included nine species recorded along the Project, thus providing the most relevant measures for this Project on which to base potential disturbance distances (Table 22). Caspian tern was recorded as having the highest mean FID distance (35 m), followed closely by the shags and herons. Red-billed gull were reported as having the lowest FID of 16.8 m. While no FID is available for variable oystercatcher, Walls (1999) noted that breeding success of variable oystercatcher is impaired by disturbance from people and dogs.

Based on the FIDs of species known to utilise the Project footprint, we have calculated the area of effective habitat loss based on a 40 m buffer zone from the revetment at low tide (this being the most seaward point that people would be able to access (refer to Map 7). Based on a 40 m buffer zone, disturbance could also occur within an additional 14.1 ha of coastal habitat (refer to Map 7) due to disturbance associated with the operation of the path.

The Project ZOI for coastal avifauna therefore includes the Project footprint and 40 m coastal buffer zone.

Table 22: Mean flight initiation distances (FID; as reported in Weston et al. (2012)) for species recorded along the Project

SPECIES		THREAT CLASSIFICATION	MEAN FID (m)
Caspian tern	*Hydroprogne caspia*	*Threatened*	35.0
Black shag	*Phalacrocorax carbo*	*At Risk*	32.3
Pied shag	*Phalacrocorax varius*	*At Risk*	31.3
White-faced heron	*Egretta novaehollandiae*	Not Threatened	31.2
Reef heron	*Egretta sacra*	*Threatened*	31.1
Little black shag	*Phalacrocorax sulcirostris*	*At Risk*	24.0
Black-backed gull	*Larus dominicanus*	Not Threatened	24.4

SPECIES		THREAT CLASSIFICATION	MEAN FID (m)
Little shag	*Phalacrocorax melanoleucos*	Not Threatened	19.8
Red-billed gull	*Larus novaehollandiae*	*At Risk*	16.8

8.4.2.1 Level of effects & measures to avoid, remedy & mitigate

The close proximity of the Project area to the railway lines and SH2 means that the avifauna currently utilising the site are used to experiencing a relatively high level of noise disturbance; coastal birds are often seen foraging and roosting within 40 m of the rail and road corridor. Project construction and operation will add to the current level of human disturbance experienced by these birds. The mobile nature of birds means that those species foraging or roosting in the area will be able to disperse away from the construction works to other such habitat around the Wellington Harbour. However, the parental duties of nesting birds (e.g. incubating eggs, guarding and feeding chicks) makes them less mobile and more susceptible to disturbance effects. Such species along the Project are little penguin, variable oystercatcher and black-backed gull.

As such, potential effects relating to construction and operational disturbance are as follows:

- Disturbance will primarily relate to effects on feeding and roosting activities.
- Species that use harbour waters largely beyond 40 m of the Project area are not expected to be affected (fluttering shearwater, Caspian tern).
- Species utilising habitats closest to the source of disturbance will be most impacted, particularly those confined to the intertidal zone (variable oystercatcher, reef heron, white-faced heron). The other susceptible *At Risk* species are black shag, pied shag, little black shag and red-billed gull.
- Effects will be greater on species that are more sensitive to noise and disturbance (reef heron, shag species).
- Little penguin, variable oystercatcher and black-backed gull have been confirmed breeding along the Project. Effects of noise and disturbance are potentially greater during the breeding season, especially when eggs and young chicks are present.

While construction effects will be temporary, the operational phase will result in ongoing disturbance through human activities. The Project has sought to avoid, minimise and mitigate potential effects on coastal avifauna through disturbance and effective habitat loss as follows:

- The revetment alignment **avoiding** areas of avifauna habitat as much as possible; this includes at six locations along the shared path a variation to the standard shared path formation design, involving the use of a smaller footprint sea wall structure, to avoid foraging and breeding habitat. The visual screening along these areas has been designed to interrupt the line of sight between path users and avifauna utilising the beaches, thereby minimising the effects of visual disturbance on birds at these locations.
- The creation of offshore habitats to minimise effects of disturbance on roosting birds. These habitats will be constructed prior to the construction of the path to provide roosting avifauna with an area of undisturbed habitat. The offshore habitat locations have been strategically placed a minimum distance of 40 m from the low tide mark on the revetment to ensure that they are beyond the FID of the most sensitive species (refer to Table 22).

They have also been located adjacent to several beaches which are utilised by avifauna, thereby reducing the distance over which birds have to fly to access an undisturbed site (refer to Map 7).

- Best endeavours[62] to ensure that dogs are restrained on leads and confined to the 5 m formed pathway and on the flat gathering areas of the ūranga (i.e. not on the rip-rap revetment or shingle beaches).

It is also recommended that:

- Nesting boxes for little penguin be incorporated within the planted area[63] on the Piki Wahine Point ūranga (chainage 700-900 m). Wooden nesting boxes should be designed as per the DOC guidelines[64] and installed at approximately 5 m spacings.[65] A minimum of 20 boxes will be incorporated into the Project, and the most appropriate placement of the nest boxes will be determined during the detailed design phase in consultation with DOC and Places for Penguins.
- Tall structures such as wooden poles will incorporated into the ūranga designs to provide further safe roosting habitat for species such as shags and gulls.
- Educational signage is provided along the shared path regarding the coastal bird values that are present, and the need to respect their space.

Taking the above measures and recommendations into consideration, and in the regional scale context (refer to Table 11), we have determined the potential effects of disturbance and effective habitat loss on local populations of coastal avifauna species as outlined in Table 23. We consider it likely that the level of effects determined below will occur due to the known behaviour of the species involved, and the proportion of their local populations recorded along the Project.

Table 23: Assessment of potential effects of disturbance and effective habitat loss on the local coastal avifauna populations

SPECIES	ECOLOGICAL VALUE[66]	MAGNITUDE OF EFFECT[67]	LEVEL OF EFFECT[68]
Reef heron	Very High	Negligible	Low
Caspian tern	Very High	Negligible	Low
Little penguin	High	Low	Low
Red-billed gull	High	Negligible	Very Low
White-fronted tern	High	Negligible	Very Low
Variable oystercatcher	Moderate	Low	Low
Fluttering shearwater	Moderate	Negligible	Very Low
Pied shag	Moderate	Negligible	Very Low

[62] We understand that initial discussions between Waka Kotahi and WCC and HCC have been positive, in terms of providing for bylaws requiring dogs to be on a lead on the shared path.

[63] Approximately 2,182 m^2

[64] https://www.doc.govt.nz/globalassets/documents/conservation/native-animals/birds/nest-box-design.pdf

[65] Recommendations taken from meeting notes with Department of Conservation and Places for Penguins representatives on 5 November 2020.

[66] Refer to Table 2

[67] Refer to Table 5

[68] Refer to Table 6

SPECIES	ECOLOGICAL VALUE[66]	MAGNITUDE OF EFFECT[67]	LEVEL OF EFFECT[68]
Black shag	Moderate	Negligible	Very Low
Little black shag	Moderate	Negligible	Very Low
Little shag	Low	Negligible	Very Low
Black-backed gull	Low	Low	Very Low
Spotted shag	Low	Negligible	Very Low
White-faced heron	Low	Negligible	Very Low

8.4.3 Cumulative effects on coastal birds

The assessment of cumulative effects requires the consideration of appropriate temporal and spatial boundaries for the assessment, and consideration of the interactions of the ecological effects of the Project along with past and future activities. One type of cumulative effect is incremental habitat loss (permanent or effective) or degradation which can be difficult to assess on a project-by-project basis.

For the Project, in the context of cumulative effects on coastal birds, we have considered the appropriate temporal scale is prior to the original reclamation along the Project to enable the construction of the rail line in 1874 (refer to the Historic Heritage Assessment for the Project). We have determined that the appropriate spatial scale for consideration of cumulative effects is the Wellington Harbour. With respect to potential future effects, we are aware of the proposed Eastern Bays shared pathway project which also involves a coastal reclamation (Overmars, 2019) and potential disturbance to coastal avifauna.

8.4.3.1 Level of effects & measures to avoid, remedy & mitigate

More than half of Wellington Harbour edges have been modified through armouring or reclamation (52%[69]). Whilst the Project occurs along an already modified harbour edge, it involves additional reclamation and permanent occupation of areas which provide foraging, roosting and nesting habitat for a number of *Threatened* and *At Risk* coastal birds. Furthermore, it will result in the loss of one of the very few areas of coastal habitat that remains inaccessible to humans, thereby affording protection to coastal avifauna from disturbance. Of the approximately 59.95 km of coastal edge habitat around the Wellington Harbour between Palmer and Pencarrow heads (refer to Map 10), currently approximately 53.45 km (89%) is accessible to people on foot, with the remaining 6.5 km (11%) not accessible to people on foot. The Project will result in approximately 3.5 km of that 6.5 km to become accessible to people on foot, leaving 3 km (5%) of undisturbed coastal edge available around Wellington Harbour. The cumulative effect will be most felt by species that are reliant on the specific habitat types (e.g. breeding and foraging) along the Project, and that are most vulnerable to disturbance. That said, we note that the creation of offshore habitats will minimise effects of disturbance on roosting birds.

Based on the above, we have determined the potential cumulative effects of the Project on regional populations of coastal avifauna species as outlined below in Table 24.

[69] Data provided by Dr Megan Oliver, Greater Wellington Regional Council and Stevens (2018).

Table 24: Assessment of potential cumulative effects on the regional coastal avifauna populations

SPECIES	ECOLOGICAL VALUE[70]	MAGNITUDE OF EFFECT[71]	LEVEL OF EFFECT[72]
Reef heron	Very High	Low	Moderate
Caspian tern	Very High	Negligible	Low
Little penguin	High	Low	Low
Red-billed gull	High	Negligible	Very Low
White-fronted tern	High	Negligible	Very Low
Variable oystercatcher	Moderate	Moderate	Moderate
Fluttering shearwater	Moderate	Negligible	Very Low
Pied shag	Moderate	Negligible	Very Low
Black shag	Moderate	Negligible	Very Low
Little black shag	Moderate	Negligible	Very Low
Little shag	Low	Negligible	Very Low
Black-backed gull	Low	Negligible	Very Low
Spotted shag	Low	Negligible	Very Low
White-faced heron	Low	Negligible	Very Low

8.4.4 Mortalities

The mobile nature of most avifauna species means that the potential for direct mortalities associated with construction activities are likely to be confined to birds that may be breeding within the Project footprint. The following nesting habitats have been identified as present along the Project footprint which will require measures to minimise effects on nesting birds:

- Potential and confirmed little penguin nesting habitat is present within the crevices of boulder rip-rap along the Project footprint.
- The backshore above MHWS on the beach adjacent to the KiwiRail signal station provides nesting habitat for little penguin, black-backed gull and variable oystercatcher (refer to Map 7).

In addition, little penguins are confined to land each year during the 2-3 week annual moult phase (generally February – March).

During the operational phase of the Project, mortalities could occur if dogs are off-lead along the Project. Little penguins are particularly vulnerable to dogs when on land because unlike other birds, they are unable to fly away from danger. Thus, little penguins are vulnerable to construction mortalities and predation when on land during both the nesting and moulting periods.

Adult variable oystercatcher are less likely to be impacted by mortalities as they are mobile and able to fly away from danger (such as construction machinery or dogs). However, chicks do not fly until they are 6-7 weeks old and as such are vulnerable to mortalities during that period.

[70] Refer to Table 2
[71] Refer to Table 5
[72] Refer to Table 6

8.4.4.1 Level of effects & measures to avoid, remedy & mitigate

Potential mortalities of nesting birds (and moulting penguins) during the construction phase will be avoided through the following measures:

- For little penguin:
  - As part of the enabling works, little penguin habitat is recommended to be modified outside of the nesting and moulting season to make it uninhabitable the following season. Immediately prior to any penguin habitat modification works, a penguin detector dog should confirm the absence of any birds.
  - Immediately prior to any construction works, a penguin detector dog should be used to confirm the absence of any birds in the areas to be impacted.
  - If an active nest is detected, a 20 m exclusion zone (as recommended by DOC for protection of penguins and oystercatchers) should be established around the nest to ensure machinery and personnel do not come within 20 m of the nesting bird.
  - If a moulting penguin is detected, the ability to move any such birds to an appropriate location will be dependent on the necessary DOC permitting requirements.
- For variable oystercatcher:
  - If construction works are to occur within 40 m of an area identified as potential variable oystercatcher nesting habitat during the breeding season, a suitably qualified and experienced ornithologist should check for the presence of active nests.
  - If an active nest is detected, a 20 m exclusion zone (as recommended by DOC for protection of penguins and oystercatchers) should established around the nest to ensure machinery and personnel do not come within 20 m of the nesting bird.

Potential measures to minimise mortalities of nesting and moulting birds during the operational phase of the Project should include:

- Dogs restrained on leads and confined to the 5 m formed pathway and on the flat gathering areas of the ūranga (i.e. not on the rip-rap revetment or shingle beaches).
- Educational signage about avoiding areas of nesting habitat during the breeding and moulting seasons.

Based on the above measures and recommendations, and in the regional scale context, we have determined the potential effects of mortalities on local coastal avifauna species as outlined below in Table 25. We note that in the case of mortalities of birds associated with the Project, the likelihood of such events occurring has been taken into consideration as part of this assessment. For instance, with the above measures for little penguin, the likelihood of mortalities occurring during the construction phase has been significantly reduced and such an event is very unlikely. Similarly, it is highly unlikely that a mortality of a foraging reef heron caused by an off-lead dog would occur due to their infrequent used of the site, their mobile nature, and the requirement for dogs to be on-lead. While the likelihood of such an event is highly unlikely, were it to occur the magnitude of effect from a single reef heron mortality would be greater than Negligible, and more likely Moderate.

Table 25: Assessment of potential effects of mortalities on the local coastal avifauna populations

SPECIES	ECOLOGICAL VALUE[73]	MAGNITUDE OF EFFECT[74]	LEVEL OF EFFECT[75]
Reef heron	Very High	Negligible	Low
Caspian tern	Very High	Negligible	Low
Little penguin	High	Low	Low
Red-billed gull	High	Negligible	Very Low
White-fronted tern	High	Negligible	Very Low
Variable oystercatcher	Moderate	Low	Low
Fluttering shearwater	Moderate	Negligible	Very Low
Pied shag	Moderate	Negligible	Very Low
Black shag	Moderate	Negligible	Very Low
Little black shag	Moderate	Negligible	Very Low
Little shag	Low	Negligible	Very Low
Black-backed gull	Low	Negligible	Very Low
Spotted shag	Low	Negligible	Very Low
White-faced heron	Low	Negligible	Very Low

8.4.5 Food supply & foraging ability

The potential effects of the Project on effective loss of foraging habitat are discussed above in Section 8.4.2.

Impacts on food supply or the ability of visual foragers can have flow-on effects to avifauna through reduced foraging resources.

If, during construction, runoff from the site is untreated prior to discharge to the receiving environment, there is the potential for adverse effects on marine water quality through increased suspended sediment and on marine invertebrates from the clogging of fine structures (such as gills) and smothering of benthic organisms (prey species) from deposited sediment. Impacts on benthic and fish communities can affect food supply for coastal and oceanic avifauna. In addition, increased water turbidity associated with construction activities can impact on the foraging ability of visual foragers to located prey items.

8.4.5.1 Level of effects & measures to avoid, remedy & mitigate

The assessment of effects on marine ecology below notes that with the proposed robust erosion and sediment control measures in place and with best practice site management, adverse effects on marine ecological values beyond the work area is assessed as Very Low and of a temporary nature (refer to Section 8.5.1.3).

Based on the Very Low level of effect on marine ecology, and the ability for avifauna species to forage over the wider area, and in the regional scale context, we have determined the potential

[73] Refer to Table 2

[74] Refer to Table 5

[75] Refer to Table 6

effects on food supply and foraging ability on local populations of coastal avifauna species will be of a temporary (construction phase) nature and as outlined below in Table 26.

Table 26: Assessment of potential effects on food supply and foraging ability on local populations of coastal avifauna

SPECIES	ECOLOGICAL VALUE[76]	MAGNITUDE OF EFFECT[77]	LEVEL OF EFFECT[78]
Reef heron	Very High	Negligible	Low
Caspian tern	Very High	Negligible	Low
Little penguin	High	Negligible	Very Low
Red-billed gull	High	Negligible	Very Low
White-fronted tern	High	Negligible	Very Low
Variable oystercatcher	Moderate	Low	Low
Fluttering shearwater	Moderate	Negligible	Very Low
Pied shag	Moderate	Negligible	Very Low
Black shag	Moderate	Negligible	Very Low
Little black shag	Moderate	Negligible	Very Low
Little shag	Low	Negligible	Very Low
Black-backed gull	Low	Negligible	Very Low
Spotted shag	Low	Negligible	Very Low
White-faced heron	Low	Negligible	Very Low

8.4.6 Lighting

Light-induced mortalities have been recorded for a number of seabirds, particularly petrels, whereby they are attracted to artificial light sources and either collide with structures or are vulnerable to predation when on land (Black, 2005; Deppe et al., 2017; Le Corre et al., 2002, 2003; Montevecchi et al., 2006; Reed et al., 1985; A. Rodríguez et al., 2012; A. Rodríguez & Rodríguez, 2009). Another potential effect of attraction to artificial lights is that birds are temporarily diverted towards the light(s) and away from other areas (e.g. breeding colonies). The potential for either of these effects has been considered for this assessment.

Incidences of attraction to artificial lights and strike have been attributed to low levels of moonlight and inclement weather resulting in poor visibility (Deppe et al., 2017; Poot et al., 2008; Reed et al., 1985; A. Rodríguez & Rodríguez, 2009).

While shags have been recorded foraging at night, we found no records of species being attracted to artificial lights.

8.4.6.1 Level of effects & measures to avoid, remedy & mitigate

Artificial lighting will be used along the Project during the construction phase when works are being undertaken at night. In order to minimise any effects of attracting birds to construction lighting, it

[76] Refer to Table 2

[77] Refer to Table 5

[78] Refer to Table 6

should be kept to the minimum required for safe operation and wherever practicable, be directed downwards and shielded to reduce light emanating horizontally or vertically.

The lighting design for the operational phase of the Project will be developed during detailed design, but will need to achieve P3 standards (New Zealand Transport Agency, 2014). As such, it is recommended that the final lighting design also include lights that are directed and shielded to reduce light emanating horizontally or vertically. Lights must not be pointed upwards or outwards towards the coastal waters.

Based on the recommendations outlined above, we have determined the potential effects of attraction to artificial lighting causing fatalities on local populations of coastal avifauna species as outlined in Table 27. We consider it likely that the level of effects determined below will occur due to the extensive lighting already present in the existing environment associated with SH2, and nature of the proposed lighting for the Project will not increase the risk of light-attraction to birds.

Table 27: Assessment of potential effects of attraction to artificial lighting causing fatalities on local populations of coastal avifauna

SPECIES	ECOLOGICAL VALUE[79]	MAGNITUDE OF EFFECT[80]	LEVEL OF EFFECT[81]
Reef heron	Very High	Negligible	Low
Caspian tern	Very High	Negligible	Low
Little penguin	High	Negligible	Very Low
Red-billed gull	High	Negligible	Very Low
White-fronted tern	High	Negligible	Very Low
Variable oystercatcher	Moderate	Negligible	Very Low
Fluttering shearwater	Moderate	Negligible	Very Low
Pied shag	Moderate	Negligible	Very Low
Black shag	Moderate	Negligible	Very Low
Little black shag	Moderate	Negligible	Very Low
Little shag	Low	Negligible	Very Low
Black-backed gull	Low	Negligible	Very Low
Spotted shag	Low	Negligible	Very Low
White-faced heron	Low	Negligible	Very Low

8.4.7 Pollution & litter

Marine pollutants include hydrocarbons, heavy metals, hydrophobic persistent organic pollutants and small plastic debris. The location of seabirds at or near the top of the marine food web makes them particularly sensitive to these pollutants (Burger & Gochfeld, 2002; Furness & Camphuysen, 1997). Some toxins can have a range of effects on seabirds, including affecting development, physiology and behaviour, reproductive performance and survival rates (Burger et al., 1992; Burger

[79] Refer to Table 2

[80] Refer to Table 5

[81] Refer to Table 6

& Gochfeld, 1993, p. 199; Finkelstein et al., 2006; Fry, 1995; Howarth et al., 1982). Pollutants can also affect seabirds indirectly by altering their habitat structure and prey availability.

Ingestion and entanglement of marine litter (including discarded fishing line and hooks; see Photo 39), particularly plastics, is common among seabirds and can cause death by dehydration, blockage of the digestive tract, or toxins released in the intestines (Brandão et al., 2011; Colabuono et al., 2009; Furness, 1985; Hutton et al., 2008; Pierce et al., 2004; Verlis et al., 2013). Ingestion of plastics may not be restricted to the individual seabird that consumed them because adults that regurgitate food to their chicks could pass them onto their offspring (Auman et al., 1997; Fry et al., 1987; van Franeker & Bell, 1988). Among seabirds, the ingestion of plastics is directly related to foraging behaviour and diet (Ryan, 1987). For example, species that feed on surface or near-surface dwelling invertebrates are more likely to confuse pieces of plastic with their prey than are piscivores, therefore, the former have a higher incidence of ingested plastics (Azzarello & Van Vleet, 1987); although piscivores have been recorded to consume plastic bags and food-handling gloves (Sagar, 2013). In addition, seabirds have been reported as entangled in plastic debris, including discarded fishing gear (B. Rodríguez et al., 2013; Schrey & Vauk, 1987; Votier et al., 2011).

The presence of human litter can attract rodents, which in turn can prey on native fauna such as lizards and birds.

Photo 39: Australasian gannet with fishing hook in bill and fishing line wrapped around legs.

8.4.7.1 Level of effects & measures to avoid, remedy & mitigate

As outlined in Section 7.5, the following measures will minimise the risk of contaminant pollution include:

- There being very limited excavation work associated with the Project;
- If there is contaminated material within the rail corridor it is likely to remain undisturbed;

- Pile shaft borings at the bridge site will be tested for contamination. If any is detected, the material will be removed from site and disposed of in the appropriate manner;
- Refuelling of trucks and dumpers will occur within the construction yards at the south and north ends in suitably protected/bunded areas.
- Tracked excavators will be refuelled from mobile fuel trucks on site away from the water's edge within temporarily created bunded areas (pulled up by the excavator itself) to prevent potential spillages from entering the water.
- Spill kits will be held on site should remediation be required.

Based on the above measures, we have determined the potential effects of contaminant pollution on coastal avifauna species to be **Negligible**.

However, it is likely that there will be an increase in litter in the coastal area due to the increased human activity/presence during both construction and operational phases of the Project. Litter should be managed through the construction phase by maintaining a tidy construction site, which will be the responsibility of the contractor.

During the operational phase, the main risk to coastal avifauna from litter will be in the regard to discarded fishing line and tackle that may be left behind by recreational fishers; inshore and intertidal species will be the most vulnerable due to their foraging locations, as well as opportunistic feeders such as gulls. Recommended measures to avoid and mitigate the impacts of litter (including discarded fishing gear) include:

- Placement of rubbish bins on each ūranga that provides the function of a gathering space for people.
- A predator control programme (as outlined in Section 8.4.1.1).
- Signage along the path indicating appropriate locations to fish from, as well as identifying areas where fishing should not occur due to the coastal avifauna values that are present.
- Educational signage around the impact plastics and fishing gear on Wellington Harbour coastal avifauna.
- Six-monthly coastal clean-up along the pathway (including rip-rap) and within the shallow coastal edge as part of scheduled path maintenance will minimise the accumulation or rubbish and debris and minimise potential adverse effects on coastal avifauna.

Based on the above measures and recommendations, we have determined the potential effects of ingestion and/or entanglement of litter (primarily discarded fishing gear) on local populations of coastal avifauna species as outlined below in Table 28.

Table 28: Assessment of potential effects of ingestion and/or entanglement of litter on local populations of coastal avifauna

SPECIES	ECOLOGICAL VALUE[82]	MAGNITUDE OF EFFECT[83]	LEVEL OF EFFECT[84]
Reef heron	Very High	Negligible	Low
Caspian tern	Very High	Negligible	Low
Little penguin	High	Negligible	Very Low

[82] Refer to Table 2

[83] Refer to Table 5

[84] Refer to Table 6

SPECIES	ECOLOGICAL VALUE[82]	MAGNITUDE OF EFFECT[83]	LEVEL OF EFFECT[84]
Red-billed gull	High	Negligible	Very Low
White-fronted tern	High	Negligible	Very Low
Variable oystercatcher	Moderate	Negligible	Very Low
Fluttering shearwater	Moderate	Negligible	Very Low
Pied shag	Moderate	Negligible	Very Low
Black shag	Moderate	Negligible	Very Low
Little black shag	Moderate	Negligible	Very Low
Little shag	Low	Negligible	Very Low
Black-backed gull	Low	Negligible	Very Low
Spotted shag	Low	Negligible	Very Low
White-faced heron	Low	Negligible	Very Low

8.4.8 Avifauna effects summary

A summary of each level of potential effect for each coastal avifauna is provided in Table 29, along with the overall level of effect on each species resulting from the Project as a whole.

Table 29: Summary of potential positive and negative effects associated with the Project for each local population of coastal bird species based on the measures and recommendations outlined in the preceding sections. (LT= long term, ST = short term)

SPECIES	POTENTIAL EFFECT							OVERALL LEVEL OF EFFECT
	Direct / permanent habitat loss (LT)	Disturbance / effective habitat loss (LT)	Cumulative effects (LT)	Mortalities (LT)	Food supply & foraging ability (ST)	Lighting (LT)	Pollution & litter (LT)	
Reef heron	Low	Low	Moderate	Low	Low	Low	Low	**Low**
Caspian tern	Low	Low	Low	Low	Low	Low	Low	**Low**
Little penguin	Net gain	Low	Low	Low	Very Low	Very Low	Very Low	**Low**
Red-billed gull	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	**Very Low**
White-fronted tern	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	**Very Low**
Variable oystercatcher	Low	Low	Moderate	Low	Low	Very Low	Very Low	**Low**
Fluttering shearwater	n/a	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	**Very Low**
Pied shag	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	**Very Low**
Black shag	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	**Very Low**
Little black shag	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	**Very Low**
Little shag	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	**Very Low**
Black-backed gull	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	**Very Low**
Spotted shag	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	**Very Low**
White-faced heron	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	**Very Low**

8.5 Marine

The following potential construction and operational phase effects (both direct and indirect) on the marine ecology were considered for this assessment:

- Permanent habitat loss (through creation of new land and permanent occupation by coastal structures);
- Mortality of marine assemblages;
- Disturbance beyond the works footprint, including:
    - Physical disturbance;
    - Suspended sediment;
    - Resuspension of sediment contaminants;
    - Deposited sediment;
    - Noise and vibration;
    - Construction of stormwater outlets;
    - Erosion and sediment control measures;
- Cumulative effects; and
- Increased usage of the marine environment.

8.5.1 Potential construction effects

8.5.1.1 Permanent loss of marine habitat (creation of new land and permanent occupation by coastal structures)

The primary direct impact of construction of the Project is the permanent loss of benthic (and pelagic) marine habitat through the creation of new land (current CMA that will be modified to be usable area above MHWS) and permanent occupation (structures and material deposited below MHWS within the CMA and associated works to protect the new land and coastal edge) (Map 4). Whilst reclamation and permanent occupation have different definitions, the ecological effect is the same i.e. permanent loss of marine habitat.

Benthic habitat mapping of the intertidal and shallow subtidal areas within and adjacent to the Project's footprint provides the ability to estimate the area of the two main habitat types (gravel/sand and shingle beaches (soft sediment) and the mosaic habitat of rocky reef/cobbles/macroalgae (Table 30).

Assessment of the magnitude of effect arising from permanent loss of marine habitat must be considered at a range of spatial and temporal scales e.g. at the spatial scale of the Project footprint and the scale of the harbour, and at both short-term and long-term time periods.

Table 30: Estimate of area[85] of habitat types affected permanent habitat loss from the construction of the Project.

EFFECTS	MARINE HABITAT TYPE		TOTAL AREA
Intertidal Habitat Effects	**Gravel/sand & shingle beach/shingle beaches (soft sediment)**	**Rocky reef / cobble / macroalgae**	
Loss of benthic marine habitat under Project footprint	0.14 ha	0.98 ha	1.12 ha
Mortality of marine organisms	0.14 ha	0.98 ha	1.12 ha
Disturbance beyond the works footprint			0.44 ha
Subtidal Habitat Effects	**Gravel/sand & shingle beach (soft sediment)**	**Rocky reef / cobble / macroalgae**	**TOTAL AREA**
Loss of benthic marine habitat under Project footprint	1.38 ha	2.30 ha	3.68 ha
Mortality of marine organisms	1.38 ha	2.30 ha	3.68 ha
Disturbance beyond the works footprint			2.79 ha

Spatial context

At the scale of the Project footprint, the permanent loss of 4.8 ha of marine habitat is a **High** magnitude of effect (Table 5),[86] as there is major loss of key marine elements and features resulting in fundamental changes to the habitat affected. In combination with overall **High** ecological values (Table 18), the level of effect is **Very High** (Table 6).

Within the CMA, the Project footprint is constrained to depths of 5 m or less below MHWS. In order to determine the magnitude of effect of permanent habitat loss at the scale of the Wellington Harbour, we have used bathymetry data to determine the extent of Wellington Harbour which occurs 5 m or less below MHWS, and therefore the proportion of that habitat type lost under the Project footprint. Based on the contour data, 1070.8 ha of Wellington Harbour occurs 5 m below MHWS; thus the 4.8 ha of permanent habitat loss associated with the Project represents 0.45% of that area.

In the context of harbour edge modification, it is noted that more than half of the harbour edge is already modified, including the harbour edge adjacent to the Project. The loss of modified intertidal/harbour edge habitat (at the Harbour scale) adds to the cumulative effect of harbour edge loss which is discussed below. However, the marine ecological values of the intertidal soft sediment (naturally depauperate) and the intertidal rocky shore (largely unnatural rock and debris with moderate species diversity) are generally lower than the subtidal habitats of rocky reef/cobble/macroalgae habitat exists and high diversity soft sediment habitats. However, in order to be conservative, and because many of the habitat types overlap and blend together, we have

85 Data provided by the Project engineering design team.

86 The area subject to temporary construction disturbance effects is addressed separately below.

assumed that all marine habitat (intertidal and subtidal) is of **High** marine ecological value (Table 18).

At the scale of the Wellington Harbour for habitat occurring at a depth of up to 5 m below MHWS, the loss of habitat on overall harbour marine ecological values is assessed as a **Low** magnitude of effect (Table 5), with the key marine elements and features of the Harbour unaffected. In combination with **High** ecological values (Table 18), the level of effect of resulting from the permanent loss of marine habitat (less than 5 m depth) is **Low** (Table 6).

Temporal context

The area of benthic habitat (hard shore and soft shore) that will be permanently lost through the creation of new land and permanent occupation is a permanent effect. However, it is important to consider that the faces of the new structures (revetment, seawalls, offshore rocky habitats and groynes) below MHWS are expected to be colonised by the same suite of common hard shore benthic invertebrates that are currently present. Colonisation by marine organisms assists, to a small degree, to mitigate some of the loss of hard shore habitat. However, successional processes of colonisation will take some time to fully mature to a community similar to that removed, with biofilms and algae likely to develop first, followed by opportunistic and smaller organisms that tend to have more rapid life cycles. In the longer term (e.g. >5 years) it is likely that the communities present on the structures will be similar to those removed.

Based on the spatial and temporal levels of effect on marine ecology, offsetting or compensation is required for the permanent loss of marine habitat, but only at the spatial scale of the Project footprint.

8.5.1.2 Mortality of marine assemblages

Sessile or slow-moving organisms within the area of new land and permanent occupation footprint are likely to suffer mortality, whereas mobile organisms (such as fish) will be able to leave, or avoid, the construction area. Macroalgae and benthic invertebrates are the primary taxa groups that will be smothered by deposition of material (riprap on the seaward edge, fill behind riprap etc) to construct the shared path. Surveys did not reveal any *At Risk* or *Threatened* marine organisms in the Project area, with all organisms being common and widely distributed. Mortality of organisms within the Project area is assessed as a **Low** magnitude of effect (Table 5), due to the organisms being common, ubiquitous and able to recolonise the new structures (revetment, seawalls, offshore rocky habitats and groynes) and the loss of some taxa within the works footprint will not affect the ecosystem functioning. In combination with **High** ecological value (Table 18), the level of effect is assessed as **Low** (Table 6)**.**

Based on this level of effect on the marine ecology, mitigation, offsetting or compensation is not required for macroalgae and benthic invertebrate mortalities.

8.5.1.3 Disturbance beyond the works footprint

Disturbance beyond the works footprint could occur to the excavation of the toe of the revetment, deposition of the revetment material, deployment of silt curtains, construction of stormwater outlets, noise and vibration, spill of material beyond the work footprint (and associated effects on organisms due to elevated suspended sediment and smothering), and resuspension of benthic sediment and associated contaminants. Based on a potential 10 m disturbance zone, an area of 3.23 ha (comprising 0.44 ha and 2.79 ha of intertidal and subtidal habitat respectively) beyond the works footprint may be disturbed during construction (refer to Table 30). Each of the potential disturbance activities are assessed in the following sections.

Physical disturbance

Physical disturbance of marine habitat beyond the permanent footprint of the Project is estimated to occur an additional 10 m from the construction footprint boundary during excavating the toe of the revetment and potentially when the outer revetment material is placed on the seabed. There is likely to be mortality of sessile and slow-moving organisms within that 10 m physical disturbance footprint.

Suspended sediment

If, during construction, runoff from the site is untreated or not adequately managed prior to discharge to the receiving environment, or if construction material deposited in the marine environment is not free of fine sediment, there is the potential for adverse effects on marine water quality through increased suspended sediment. Marine organisms can be adversely affected by suspended sediment through clogging of fine structures (such as gills and feeding apparatus), inability for predators to detect prey, and smothering of benthic organisms when suspended sediment drops out of suspension.

Effects of suspended sediment are a factor of concentration and duration of exposure. Many marine organisms can withstand periods of elevated suspended sediment through ceasing feeding, closing valves (bivalve shellfish), or through avoiding affected areas if the organism is mobile. For example, in a laboratory test, pipi (*Paphies australis*) were able to withstand up to 75 mg/L suspended sediment for a period of 13 days before sublethal adverse effects were detected (Hewitt et al., 2001), whereas the condition of horse mussel (*Atrina zealandica*) was found to be lower after three days exposure to 80 mg/L suspended sediment (Ellis et al., 2002).

Resuspension of sediment contaminants

The concentration of nickel in sediment at chainage 1510 m (approximately 30 m from MHWS), 2320 m (approximately 15 m from MHWS) and 2650 m (approximately 5 m from MHWS) was detected above the DGV threshold of 21 mg/kg.[87] Resuspension of sediment at these sites could result in nickel becoming temporarily bioavailable and potentially could cause adverse effects on benthic and pelagic organisms present. In marine organisms, dissolved nickel can impair the regulation of ions, inhibit respiration, and cause oxidative stress (Blewett & Leonard, 2017). In acute studies in tropical and subtropical waters, anemone and sea urchins were found to be the most sensitive to dissolved nickel (at 65 and 120 µg Ni L^{-1}). The Project design at these three locations is minimised with respect to the extent the works extend into the CMA (refer to Map 8). Standard revetment is proposed at 1510 m and 2650 m, and a seawall is proposed at 2320 m. At chainage 2650 m, the sediment survey site is within the revetment footprint and it will be important that temporary sediment resuspension is minimised at this site in particular.

For context, organisms are currently exposed to contaminants in sediment (mostly in concentrations below effects thresholds) and during storm events when sediment is resuspended organisms are exposed to potentially resuspended and bioavailable contaminants. The subtidal marine communities along the Project remain diverse and abundant, and therefore it is unlikely that nickel is having a significant adverse effect on marine ecological values currently. If during

[87] Noting that elevated nickel in sediment could be more widespread than that detected at the sites surveyed.

construction, nickel becomes bioavailable the effect on marine organisms will be temporary (only during construction activities) and will be minimised through the use of best practice erosion and sediment control mechanisms.

Deposited sediment

Deposited sediment (especially if the sediment is silt and clay grain size) at depths greater than approximately 3 mm sediment can have adverse effects[88] on the most sensitive benthic organisms (Lohrer et al., 2006). Sensitive soft sediment and hard shore organisms could perish if sediment is deposited on benthic habitat within the disturbance area at >3mm depth.

Noise & vibration

An additional disturbance during construction is through noise and vibration. Noise and vibration can have adverse effects on marine organisms, with the level of effect depending on degree and duration of the disturbance. Vibration from offloading material, use of vibratory compaction rollers and piling of foundations is likely to occur for short and limited periods. Marine organisms affected by noise and vibration may temporarily cease normal behaviour and could cease feeding, retract into shell, stop moving or hide.

As noted in Section 7.6 above, Noise & Vibration Assessment for the Project considered that there would be a negligible impact on marine fauna from activities associated with the construction of the sea walls.

Construction of stormwater outlets

Construction of stormwater outlets that protrude through the existing revetment will be extended through the new revetment and seawalls (refer to Table 19). Work will be carried out at low tide with rapid hardening cement to prevent potential alkaline contamination of seawater.

Erosion & sediment control measures

The indicative construction methodology provides for erosion and sediment control measures to minimise the discharge of sediment and suspended sediment to the marine environment beyond the work area (refer to Section 7.3). These measures include silt fences around stockpiled material, silt curtains placed in the marine environment 5-10 m from the work area, using only clean gravels and riprap (i.e. minimal fine material) on the seaward edge of the new embankment and below MHWS, use of geotextile fabric to separate clean material from general fill and carrying out concrete works at low tide. On that basis, the spread of generated suspended sediment and the discharge and deposition of sediment, and effects on water quality beyond the work areas will be minimised.

Slow-moving or sessile organisms within the 10 m disturbance area beyond the footprint of the Project (in both soft sediment and rocky shore/cobble/macroalgae habitat) are likely to perish, whereas fish and other mobile organisms will be able to move away. Subtidal and intertidal organisms detected in our surveys are common throughout New Zealand,[89] with no *Threatened* or *At Risk* marine invertebrates detected.

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[88] Refer to Appendix 6 for a summary of known marine organism tolerance to sediment / mud.

[89] Where distribution literature exists (Cook, 2010).

Upon completion of construction, the disturbed area will be recolonised by organisms from adjacent benthic habitat and in the longer term (>5 years) is likely to comprise an assemblage of organisms similar to the existing assemblage.

With these robust erosion and sediment control measures in place and with best practice site management (refer to the Erosion & Sediment Control Assessment for the Project), adverse effects from the activities discussed above on marine ecological values at the scale of the 10 m wide disturbance footprint small is assessed as potentially having a **Low-Negligible** magnitude of effect in the short term (0-5 years), but a **Negligible** magnitude of effect in the longer term (>5 years). In combination with **High** ecological values, the level of effect is assessed as **Low** in the short-term, but **Very Low** in the long-term.

Based on these levels of effects on marine ecological values, the small area involved, the temporary nature of construction, and the recovery of the area anticipated in the long term, mitigation offsetting or compensation is not required for disturbance within the estimated area beyond the final footprint of the structures.

Based on this level of effect on the marine ecology, mitigation, offsetting or compensation is not required for physical disturbance beyond the disturbance footprint.

8.5.1.4 Cumulative effects on marine ecology

More than half of Wellington Harbour edges have been modified through armouring or reclamation (38.3 km[90] or 52%; refer to Table 31). Stevens (2018) notes the almost unbroken stretch of modification extending from Seatoun to Eastbourne; the Project is located within that stretch of shoreline and has previously been modified (reclaimed with the seaward edge comprising riprap boulders and concrete debris) to enable construction of rail in 1874 (refer to the Historic Heritage Assessment for the Project). Whilst the Project occurs along an already modified harbour edge, it involves an additional 4.8 ha of land creation and permanent occupation of benthic and pelagic habitat within the harbour, which adds to the cumulative effect of marine habitat loss and modification. As noted above in Section 8.5.1.1, the area of habitat loss (4.8 ha) comprises 0.45% of the Wellington Harbour habitat 5 m below MHWS, which, while a small percentage of the harbour edge, adds to the cumulative loss of marine habitat. The Eastern Bays Shared Path, across the harbour on the north-eastern side, is predicted to involve 0.3 ha of marine habitat loss (EOS Ecology, 2019) and there may be other projects planned around and within Wellington Harbour that we are not aware of that could result in further habitat loss. The magnitude of effect of cumulative loss of modified marine habitat edge is assessed as **Low** at the scale of the Wellington Harbour edge. In combination with **High** ecological values, the level of effect of cumulative loss of marine habitat is **Low**.

Based on this level of cumulative effects on marine ecological values, mitigation, offsetting or compensation for the additional modification and contribution to the cumulative loss of coastal marine habitat in the Wellington Harbour is not required.

[90] Data provided by Dr Megan Oliver (Greater Wellington Regional Council) for the Wellington Harbour Whaitua. Note that the data includes coastal and estuarine shorelines, the latter of which extends landward to various extents.

Table 31: Wellington Harbour shore types[90]

SHORE TYPE	LENGTH OF SHORELINE (Km)	PROPRTION OF WELLINGTON HARBOUR SHORELINE
Bedrock (platform or sloping)	21	28%
Sediment beach (mixed sand gravel shell or pebble-cobble or sand)	15	20%
Man-made (permeable or solid vertical)	38.3	52%

8.5.2 Potential operational effects

Operation of the shared path is likely to facilitate higher numbers of people accessing the marine environment. As such, there could be more harvesting of marine species for consumption, trampling of sessile organisms through people rock hopping along/down the proposed revetment and additional deposition of litter/debris. Over-harvesting can be managed through signage about recreational harvest limits and surveillance by Fisheries Officers. Additional signage about the ecology and value of the marine organisms present could also help to limit physical damage (through trampling) and collection of organisms. Six-monthly coastal clean-ups along the pathway (including rip-rap) and within the shallow coastal edge as part of scheduled path maintenance will minimise the accumulation or rubbish and debris and minimise potential adverse effects on marine ecological values.

Conversely, enabling access of people to the marine environment may also involve a greater appreciation and protection of marine ecological values.

Operational effects on marine organisms are assessed as a **Low** magnitude of effect. In combination with **High** ecological values, the level of effect is assessed as **Low**.

Based on this level of effect on the marine ecology, mitigation, offsetting or compensation is not required for the operation of the Project.

8.5.3 Marine ecology effects summary

A summary of each level of potential effect on the marine ecology resulting from the Project is provided in Table 32. It is important to recall that we have valued all marine **High**, as the habitats are a mosaic and it is difficult to tease them apart. Therefore, a value of **High** was conservatively applied to all marine habitats.

Table 32: Summary of ecological value, magnitude and level of effect on marine ecological values, with mitigation measures in place. (LT= long term, ST = short term)

IDENTIFIED ACTUAL AND POTENTIAL EFFECTS	ECOLOGICAL VALUE	DOMINANT SUBSTRATE TYPE	INTERTIDAL OR SUBTIDAL HABITAT	MAGNITUDE OF EFFECT	LEVEL OF EFFECT
Permanent habitat loss at the scale of the Project footprint	High	A mosaic of gravel/sand/cobble and rocky reef / hard shore / macroalgal	Intertidal and subtidal	High	Very High

IDENTIFIED ACTUAL AND POTENTIAL EFFECTS	ECOLOGICAL VALUE	DOMINANT SUBSTRATE TYPE	INTERTIDAL OR SUBTIDAL HABITAT	MAGNITUDE OF EFFECT	LEVEL OF EFFECT
Permanent habitat loss at the scale of <5m depth habitat within the Wellington Harbour	High	A mosaic of gravel/sand/cobble and rocky reef / hard shore / macroalgal	Intertidal and subtidal	Low	Low
Mortality of marine invertebrate assemblages	High	A mosaic of gravel/sand/cobble and rocky reef / hard shore / macroalgal	Intertidal and subtidal	Low	Low
Disturbance beyond the works footprint	High	A mosaic of gravel/sand/cobble and rocky reef / hard shore / macroalgal	Intertidal and subtidal	Negligible-Low (ST) Negligible (LT)	Low (ST) Very Low (LT)
Cumulative effects of loss of marine habitat and harbour edge habitat	High	A mosaic of gravel/sand/cobble and rocky reef / hard shore / macroalgal	Intertidal and subtidal	Low	Low
Operational effects	High	A mosaic of gravel/sand/cobble and rocky reef / hard shore / macroalgal	Intertidal and subtidal	Low	Low

8.6 Overall summary of ecological effects

A summary of the overall levels of ecological effects associated with the Project is provided in Table 33. Note that the overall levels of effects are based on the Project's adherence to the effects management hierarchy whereby measures to avoid, minimise, remedy and mitigate have been explored and implemented through design and management measures. This is discussed in more detail in Section 10.0 below.

Table 33: Summary of potential ecological effects based on the implementation of the effects management hierarchy (measures to avoid and mitigate) and recommendations outlined in the preceding sections of this assessment.

ECOLOGY	VALUE	MAGNITUDE OF EFFECT	OVERALL LEVEL OF EFFECT
INDIGENOUS VEGETATION			
Indigenous vegetation	Negligible	Positive	Net gain
HERPETOFAUNA			
Herpetofauna	Low	Negligible	Very Low
FRESHWATER			
Korokoro Stream	Very High	Negligible	Low
Un-named stream 3	Moderate	Negligible	Very Low
Waihinahina Stream	Negligible	Negligible	Very Low

ECOLOGY	VALUE	MAGNITUDE OF EFFECT	OVERALL LEVEL OF EFFECT
Gilberd Bush stream	Negligible	Negligible	Very Low
Un-named stream 2	Moderate	Negligible	Very Low
Un-named stream 1	Moderate	Negligible	Very Low
COASTAL AVIFAUNA			
Reef heron	Very High	Neg - Low	Low
Caspian tern	Very High	Negligible	Low
Little penguin	High	Positive – Low	Low
Red-billed gull	High	Negligible	Very Low
White-fronted tern	High	Negligible	Very Low
Variable oystercatcher	Moderate	Low - Moderate	Low
Fluttering shearwater	Moderate	Low	Very Low
Pied shag	Moderate	Negligible	Very Low
Black shag	Moderate	Negligible	Very Low
Little black shag	Moderate	Negligible	Very Low
Little shag	Low	Negligible	Very Low
Black-backed gull	Low	Neg - Low	Very Low
Spotted shag	Low	Negligible	Very Low
White-faced heron	Low	Neg - Low	Very Low
MARINE			
Permanent habitat loss at the scale of the Project footprint	High	High	Very High
Permanent habitat loss at the scale of <5m depth habitat available within the Wellington Harbour	High	Low	Low
Mortality of marine invertebrate assemblages	High	Low	Low
Disturbance beyond the works footprint	High	Negligible-Low (ST) Negligible (LT)	Low (ST) Very Low (LT)
Cumulative effects of loss of marine habitat and harbour edge habitat	High	Low	Low
Operational effects	High	Low	Low

As noted in Section 4.7, the overall level of effect can be used to guide the extent and nature of the ecological management response required, including the need for biodiversity offsetting or environmental compensation. According to Roper-Lindsay et al. (2018):

- Very High adverse effects require a net biodiversity gain.[91]
- High and Moderate adverse effects require no net loss of biodiversity values.
- Low and Very Low effects should not normally be a concern. If effects are assessed taking impact management developed during project shaping into consideration, then it is essential that prescribed impact management is carried out to ensure Low or Very Low effects.

On this basis, the **Low** to **Very Low** overall level of effects of the Project on indigenous vegetation, herpetofauna, freshwater and coastal avifauna (Table 38) means that there are no residual adverse effects requiring offsetting or compensation.[92]

However, in the case of marine ecology, there will be residual adverse[93] affects associated with the Project following the implementation of the effects management hierarchy (refer to Table 38); these relate to permanent habitat loss (**Very High**). Measures to address these residual effects are discussed below in Section 9.0.

9.0 Measures to Address Residual Effects using the Effects Management Hierarchy

Having stepped the ecological effects of the Project through the effects management hierarchy in relation to first avoiding, remedying and mitigating as much as possible, the current assessment identified one category of residual effect (permanent marine habitat loss at the scale of the Project footprint) that, because of its absolute (loss of habitat) and permanent nature, cannot be adequately addressed through mitigation (as described in Section8.5.1.1). As such, this residual effect must be addressed through the application of the subsequent steps in the effects management hierarchy (refer to Figure 1): offsetting or compensation.[92]

Other recent examples of New Zealand projects directly impacting the marine environment, also requiring offsetting and / or compensating, include East-West Link (Boffa Miskell Ltd, 2016), SH20 – Onehunga (Tonkin & Taylor Ltd, 2011), SH88 shared path (Ryder Consulting, 2015) and Whangarei Harbour deepening (Coffey, 2017; Ryder Consulting, 2017). At the advice of Dr Jamie Steer (Senior Biodiversity Advisor, GWRC), we have used these examples to obtain learnings that could be applied to the Project in regard to offsetting and compensation measures for addressing the effects of permanent habitat loss in the marine environment. The proposed offset and compensation for each of these recent projects are summarised in Table 34 below. We note that with the exception of the 0.55 ha declamation for the East West Link project, no other projects were able to achieve a

[91] Though when ecological compensation is required because biodiversity offsetting is not possible, the principles of no-net-loss or net-gain do not apply (Maseyk et al., 2018).

[92] The level of potential effects identified are based on the design plans listed in 4.6, the construction methodology outlined in Section 7.0, and the implementation of all the measures and recommendations identified to avoid, minimise and mitigate potential effects. If the design or construction methodology were to change, or any of the measures and recommendations not implemented, the level of potential effect and therefore any mitigation / offset / compensation requirements would need to be revisited.

[93] Defined in GWRC (2019) as "*The negative effects on the environment remaining from an activity after avoidance, remediation, and mitigation measures have been taken*".

like-for-like offset (and in that case, the declamation amounted to a partial rather than complete offset). Rather, they provided a form of compensation to address the residual effects.

Table 34: Recent New Zealand examples of offset and compensation measures for projects directly effecting the marine environment.

PROJECT	MARINE IMPACT	OFFSET / COMPENSATION
East West Link	Permanent loss of habitat (24.2 ha) within the CMA	• Post-graduate research scholarship to investigate potential to facilitate enhancement of the benthic invertebrate assemblage e.g. potentially transplanting large invertebrates that are uncommon in the northern part of the Inlet, such as bivalves. • 0.55 ha declamation[94] at Otahuhu Creek and estuarine fringe revegetation. • The benefits of treating catchment stormwater and leachate prior to discharge into the CMA counter-balance some of the effect.
SH20 – Onehunga	Permanent loss of habitat (9.1 ha) within the CMA	• Development of an ecological mitigation plan to enhance biodiversity values in the terrestrial and coastal foreshore environments, and to monitor the effects of these efforts.
SH 88 shared path	Permanent loss of habitat within the CMA	• No biodiversity offset or compensation known to be proposed.
Whangarei Harbour deepening (dredge and disposal within the CMA)	Capital dredging – displacement / reduction of benthic productivity within a 4.37 km^2 (437 ha) area of seabed.	• Contributing funding of $150,000 one month prior to the commencement – to enable the assessment and monitoring of effect of the project on the harbour; • Contributing ten annual payments of $50,000 as an ongoing kaitiaki fund – to enable the assessment and monitoring of the effects to continue for maintenance dredging. • Contributing $150,000 for the design and implementation of a 12 month water quality monitoring programme for Rauiri/Blacksmiths Creek; or contributing $150,000 towards ecological restoration projects in the harbour, including understanding pipi biology, re-seeding Mair Bank and Marsden Point, restoring and/or reseeding seagrass beds, studying bird habitats, maintenance or enhancement of habitat of the variable oystercatchers and other shorebirds, mahinga kai/kaimoana restoration, and works to improve coastal water quality.

These New Zealand examples serve to illustrate the difficulties in addressing the effects of permanent habitat loss in the marine environment. Biodiversity offsetting literature and policy has largely been developed for terrestrial or freshwater application. However, there are real differences between marine and terrestrial or freshwater environments in relation to ecology, connectivity, data availability, management options, and impact perception, and marine offsets are therefore often regarded as challenging (Dickie et al., 2013; Jacob et al., 2020; Niner et al., 2017a, 2017b; Shumway et al., 2018). For instance, in the case of connectivity, terrestrial systems are highly connected to marine systems through runoff and river flows, delivering materials such as nutrients, sediments, and toxins to marine ecosystems (Shumway et al., 2018).

[94] The small area of declamation relating to removal of existing bridge abutments was required in order to upgrade the existing bridge across the Otahuhu Creek as part of the East-West project.

The approach taken for the Project to identify appropriate offsetting and compensation measures included a strong focus on seeking input and advice from numerous stakeholders. Initial concepts for offset and / or compensation were presented to DOC, mana whenua and GWRC at a workshop on 2 October 2019. In general, the attendees at the workshop provided a clear steer that any required offset or compensation measures should be as physically close to the Project as possible (ideally within Wellington Harbour), and that any such measures should provide a benefit to the marine environment (i.e. improving the ecological health of the harbour) given that the measures required were a result of the permanent loss of 4.8 ha of marine habitat associated with the Project works. We also supported this approach.

Following the 2 October 2019 workshop, a series of meetings were held with individual agencies/groups to identify projects that could be considered as potential offset or compensation measures. At least 44 potential projects were identified by various stakeholders, details of which are provided in Appendix 5 (along with the relevant meeting dates). As set out in Appendix 5, all identified possible projects have been carefully considered in terms of what benefits they would bring and how they might be implemented.

We note that in the first instance, we considered only those projects that could provide a benefit to the marine environment and associated ecological sequences; this approach is consistent with offsetting principles (seeking to address an effect as close to the impact as possible) and was supported by stakeholders at the October meeting. Following this and in discussion with the Project's Cultural Advisor, the ecological merits of each of the marine-related projects were considered by the Project Ecologists in the context of the ecological effects (permanent loss of marine habitat) of the Project requiring offset and / or compensation.

9.1 Offsetting

In reference to offsetting in the marine environment, Dickie et al. (2013) note that it is not essential to develop complex numerical models. Rather, it is more important that key ecological attributes or processes should be present to support a sustainable offset and to ensure that the ecosystems and/or key components of them are sustained with the impact and offset in place. In the following sections we discuss several forms of biodiversity offsetting including like-for-like, trading-up and enhancement offsetting.

9.1.1 Like-for-like

Based on the nature of the residual effect (permanent loss of marine habitat), the options for a like-for-like offset relate to the creation of additional marine habitat. In the marine environment that would be though the process of declamation; that being the return of reclaimed land to foreshore and seabed.

Reclamations, which started in the 1850's, have added more than 155 ha to Wellington.[95] The major reclamations have centred around increasing the amount of useable flat land for Wellington city, as well as for Port and rail activities. Due to the infrastructure that these reclamations currently support, declamation of these areas is not possible. There are smaller areas of

[95] WCC's Old Shoreline Heritage Trail Brochure

reclamation around the Wellington Harbour which are owned by some of the stakeholders which were involved in the series of meetings to discuss potential offset and / or compensation measures; however, the only instance in which the possibility of declaiming land was raised as an option to investigate related to Honiana Te Puni Reserve.

As shown in the aerial imagery time series in Figure 34 below, Honiana Te Puni Reserve land has been reclaimed. Hard-filling of this area occurred throughout the late 1960s to 1980s, however the composition of the fill material used to form this reclamation is unknown. In its current form, the existing seawall at the east of Honiana Te Puni Reserve (refer to Photo 37 on page 71) acts as a control on the shoreline in this area, and has effectively allowed the shoreline west of the seawall to build out which has also been supplemented by filling/dumping, and part of this infilled area has been occupied by the Korokoro Stream estuary.[96]

Preliminary investigations by the Project Coastal Process expert noted that the removal of the entire seawall would see the shoreline retreat by 30 m in the vicinity of the wall itself as control on shoreline position would revert to the existing groyne (150 m east) and the revetment at the Water Ski Club (500 m west). Adjacent shorelines would also be affected as a new equilibrium beach position developed. Some retreat (0-30 m) would occur to the west of the existing seawall, including retreat of the gravel barrier which currently impounds the Korokoro Estuary (reducing the size of this estuary/lagoon feature), and the retreat would taper to zero at the Water Ski Club. Some minor and temporary advance of the beach would occur between the existing seawall and the existing groyne 150 m east.

Thus, it was found that declamation at Honiana Te Puni Reserve through the removal of the existing seawall had the potential to impact on the ecological values at the Korokoro Estuary (an area identified as significant in Schedule F4 of the PNRP). As such, this was not considered as a viable option as a possible offset for the effects of the Project.

9.1.2 Trading-up

Trading-up is an out-of-kind exchange of biodiversity, and usually involves exchanging the loss of biodiversity of lesser conservation concern for biodiversity of greater conservation concern (e.g. exchanging non-threatened species for a gain in a nationally *Threatened* species) (Maseyk et al., 2018).

In the case of the Project, given the residual effect relates to the marine environment, any form of trading-up would also be required to provide benefits within the marine environment. The marine investigations for the Project detected only common and widespread intertidal and subtidal benthic invertebrate species, with no *Threatened* or *At Risk* taxa being observed (refer to Sections 5.5.3 and 5.5.4). As such trading-up in this instance would involve measures that would increase abundance and / or distribution of *Threatened* or *At Risk* marine species within the Wellington Harbour. We did not detect any *Threatened* or *At Risk* marine invertebrates in our surveys and we are not aware of any *Threatened* or *At Risk* resident populations of fish or marine mammals resident within the Wellington Harbour[97] that we may have considered for trading up.

[96] Dr Michael Allis (Project Coastal Processes expert), pers. comm. July 2020.

[97] The Wellington region is a natural corridor for the movement of fish, invertebrates and marine mammals between the North and South Islands and from east to west coasts (MacDiarmid et al., 2012).

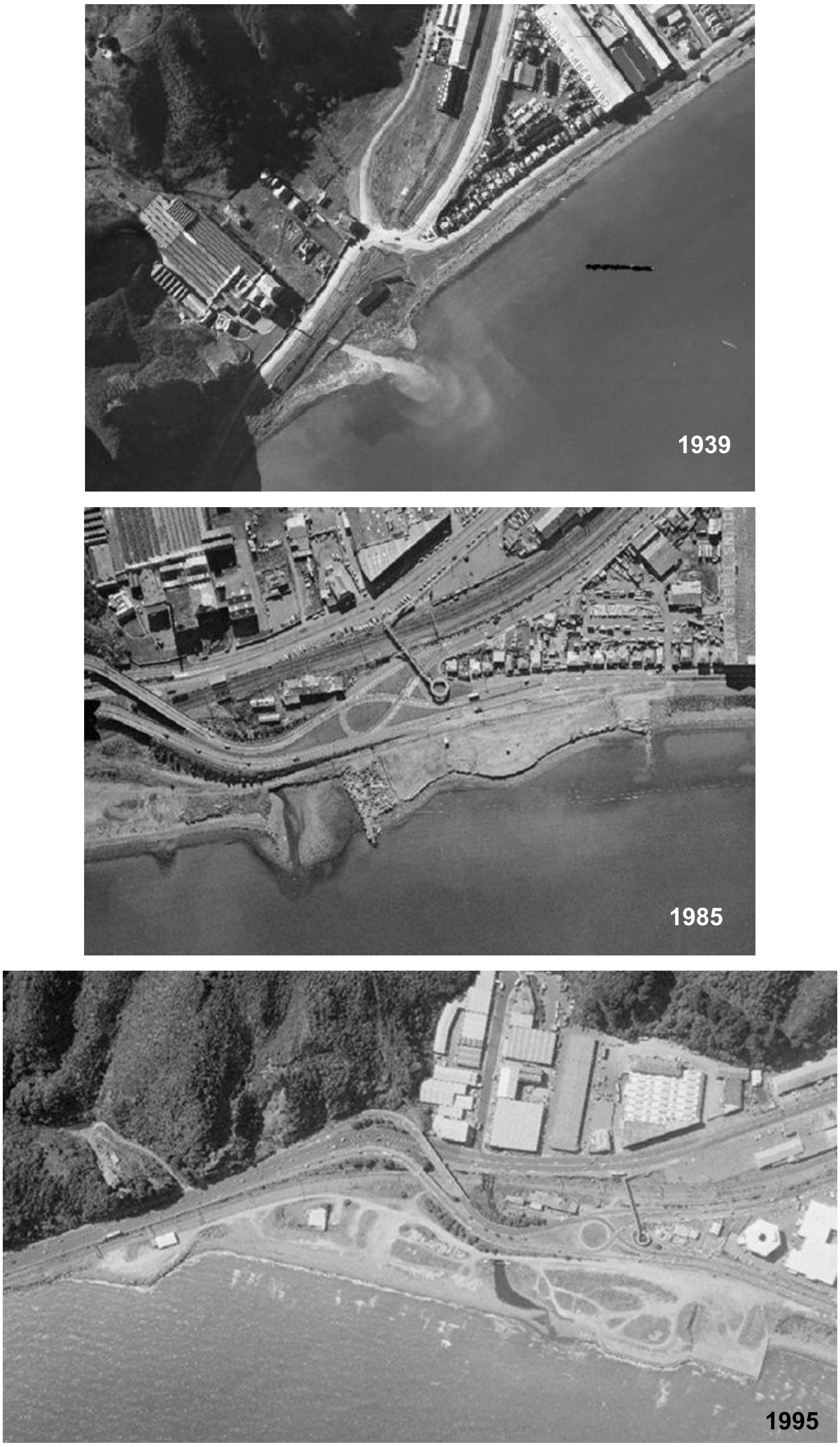

Figure 34: Aerial imagery showing the reclamation of Honiana Te Puni Reserve over time (image sources from Retrolens.nz)

9.1.3 Enhancement

Enhancement offsetting involves enhancing the quality of degraded natural habitats through ecological management. The possibility of using enhancement offsetting options to address the residual effects of the Project are discussed in the following sections.

9.1.3.1 Living seawalls

One recommended measure to contribute in part to offsetting the Project's residual effects of marine habitat loss relates to the use of Living Seawalls[98] on appropriate artificial coastal structures around Wellington Harbour (within intertidal range), where permission can be obtained from the land- or asset-owner. Living Seawalls can be attached to artificial structures in the marine environment to add complexity to these structures and provide habitat for marine life (see Figure 35).

Figure 35: Examples of retrofitted living seawalls.

The ecological benefit associated with the creation of Living Seawalls is to increase habitat complexity for intertidal marine sessile community succession. For example, usually barnacles, small seaweeds, oysters, marine snails and limpets are the first to colonise these tiles. Many of these organisms are present on the existing modified intertidal hard shore within the Project footprint. Over time, successional processes are likely to further develop the complexity of the habitats and provide for increased biodiversity. Living seawalls have been developed by the Sydney Institute of Marine Science (SIMS) and Reef Design Lab and they structures have been very successful in Sydney Harbour,[99] with biofilms giving way to barnacles, oysters and other sessile organisms.

Given the high level of modification to the edges of Wellington Harbour, there is the potential to retrofit existing seawalls and structures within the concrete tile marine environments. Initial site investigations around the harbour and discussions with landowners (primarily Wellington City Council) identified a number of potential locations including Honiana Te Puni Reserve, Frank Kitt's Park lagoon, Point Jerningham, Little Karaka Bay, Balena Bay, Weka Bay Greta Point and Aberdeen Quay. However, a number of these sites were deemed unsuitable based on additional ecological, engineering and heritage investigations.

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[98] Sydney Institute of Marine Science and Reef Design Lab.

[99] https://www.sims.org.au/page/130/living-seawalls-landing

As such, two locations (Frank Kitt's Park Lagoon and Greta Point; refer Table 35) were identified as being acceptable from an ecological, engineering and heritage perspective, and for which permissions have been secured from WCC to use as sites to deploy Living Seawalls. As such, a minimum of 60 m^2 of Living Seawalls will be retrofitted onto the existing seawalls at Frank Kitt's Park Lagoon and Greta Point to in part offset a small proportion of the 4.8 ha of marine habitat lost under the Project footprint.

Dr Jacqui Bell (a senior marine ecologist at Boffa Miskell) has previously liaised with SIMS, investigating the option of deploying Living Seawalls in New Zealand. While Living Seawalls have shown to be successful in Sydney Harbour, we are not aware of any Living Seawall installations in New Zealand to date. However, based on their success in Sydney, we consider the risk of failure to create additional habitat for encrusting and sessile marine organisms is low.

We recommend that the entire 8.4 m^2 of Living Seawalls be deployed at Frank Kitt's Park lagoon, due to this site being highly visible and providing a significant opportunity for educational purposes. However, at Greta Point we recommend an approach whereby as an initial trial a minimum of three Living Seawall panels be deployed and these be monitored for recolonisation over a two year period. The results of that trial (i.e. the rate of colonisation by marine sessile organisms) will then inform where the remainder of the Living Seawall panels should be deployed, with the requirement being to install a minimum of 60 m^2 of permanent Living Seawall panels. The intention would be for the Greta Point site to then be utilised to its full extent (meeting the 60 m^2 total requirement) unless observations from the trial period strongly indicate an alternative site should be sought.

Living seawalls should be monitored annually in order to document the colonisation by marine organisms.

Table 35: Proposed locations to deploy Living Seawalls around Wellington Harbour

SITE DETAILS	SITE PHOTO
Location: Frank Kitts Park lagoon **Area available within intertidal zone:** 8.4 sq.m	
Location: Greta Point **Area available within intertidal zone:** 53 sq.m	

9.1.3.2 Marine pest control

Norton & Warburton (2015) reported that biodiversity offsetting has the potential to enhance biodiversity values through funding of invasive species control. To date, management strategies have been developed mainly for the control of terrestrial invasive species. However, unlike the terrestrial environment, managing invasive species is particularly challenging in the ocean mainly because marine ecosystems are highly connected across broad spatial scales.

In a recent scientific publication on this matter, Giakoumi et al. (2019) reported that eradication of marine invasive species has only been achieved when species were detected early, and management responded rapidly. Thus, for established invasive populations eradication is unlikely and the aim of management is generally to reduce their populations below densities that cause significant environmental harm (Usseglio et al., 2017).

The detection of marine invasive species is highly specialised and currently undertaken by the Ministry for Primary Industries (MPI) through their national Marine High Risk Site Surveillance programme, which includes Wellington Harbour (Woods et al., 2019). Given MPI and Biosecurity New Zealand have an established process for dealing with invasive marine organisms, there would be little benefit in seeking to control marine invasive species as part of the offset package for the Project.

Thus, while the control of marine invasive species will not be included as part of the offsetting package, all machinery and equipment that will enter the CMA during the construction should be cleaned and checked to ensure that no new marine invasive species will be introduced in the Wellington Harbour as a result of the Project.

9.1.4 Assessment of offsetting against PNRP Schedule G2 principles

Schedule G2 of the PNRP (Greater Wellington Regional Council, 2019) outlines the principles to be applied when proposing and considering a biodiversity offset. Table 36 outlines how each of these principles have been applied with regard to offsetting the residual effects associated with the permanent loss of marine habitat for the Project. As discussed in Sections 9.1.1 and 9.1.3, the only identified potential measure that could be classified as an offset for the residual effects of the permanent loss of marine habitat is the living seawalls.

While the use of living seawalls as an offset meets a number of the G2 principles (refer to Table 36), it does not of itself meet Principle 6, being no net biodiversity loss. As discussed below, compensation measures have therefore been considered and proposed.

Table 36: Implementation of G2 principles for biodiversity offsetting on the Project

PRINCIPLE		IMPLEMENTATION
1) Adherence to the mitigation hierarchy	The proposed biodiversity offset will be assessed in accordance with the mitigation hierarchy set out in Policies P32 and P41. Any proposal for a biodiversity offset will demonstrate how it addresses the residual adverse effects of the activity.	• In terms of the effects management hierarchy, the Project has first sought to avoid and minimise effects through the project footprint. • A residual effect associated with the permanent loss of 4.8 ha of marine habitat has been identified (see Sections 8.5 and 8.6 above) • Options for offsetting this effect have been investigated (see Sections 9.1.1 and 9.1.2), and the identified viable offset (living seawalls) is proposed to be implemented.

PRINCIPLE		IMPLEMENTATION
2) Limits to what can be offset	Consideration of biodiversity offsetting is inappropriate where: (a) there is no appropriate site, knowledge, proven methods, expertise or mechanism available to design and implement an adequate biodiversity offset, or	• The offset measures (living seawalls) will be undertaken at an appropriate site, that being within the Wellington Harbour and on existing seawall structures which provide no habitat complexity for intertidal marine sessile community succession. • Living Seawalls is a Sydney Institute of Marine Sciences initiative that builds on years of marine green engineering research that shows retrofitting existing seawalls with habitat enhancing units can improve the ecological performance of artificial structures.[100]
	(b) when an activity is anticipated to cause residual adverse effects on an area after an offset has been implemented where: i. the ecosystem or species are "threatened" (as defined by the New Zealand Threat Classification System categories: Nationally Critical, Nationally Endangered, and Nationally Vulnerable, or ii. the ecosystem is naturally uncommon.	• The marine habitat that will be permanently lost as part of the Project footprint and for which offsets are proposed do not include any Threatened or At Risk species, and as such the proposed measures are within the limits of biodiversity offsets / compensation.
3) Additional conservation outcomes	Any proposal for a biodiversity offset will demonstrate that the actions taken to achieve positive effects on biodiversity are additional to what would have occurred without the proposed biodiversity offset, including any activities required by any associated resource consent/s.	• The creation of living seawalls around Wellington Harbour is not already required, nor are they already being undertaken or are planned as part of existing management programmes
4) Landscape context	Any proposals for biodiversity offsetting will: (a) demonstrate that positive effects are achieved preferentially, first at the site, then the relevant catchment, then within the ecological district, except where there is an appropriate ecological rationale for doing otherwise, and	• The proposed locations of the Living seawalls (refer to Section 9.1.3.1) are within the same harbour in which the effect of the Project (permanent marine habitat loss) will occur. The sites chosen are appropriate as they are existing structures which have no habitat complexity. Furthermore, they will be constructed in areas that are visible to many Wellingtonians and may serve as a form of environmental educational tool.
	(b) complement and contribute to the protection of significant indigenous vegetation, or the habitats of threatened fauna at the local, regional or national level, and	• The living seawalls may provide habitat for intertidal marine sessile organisms within the Wellington harbour.
	(c) take into account available information on the full range of biological, social and cultural values of biodiversity and support an ecosystem-scale approach, and	• As noted above, the living seawalls may serve as an environmental educational tool.
	(d) take into consideration other likely future developments, such as competing land use pressures, within the landscape.	• We are not aware of any proposed activities that may impact the existing seawalls on which the living seawalls will be constructed.
5) Long-term outcomes	The proposed biodiversity offset will: (a) demonstrate that management arrangements, legal arrangements (e.g. covenants) and financial arrangements (e.g. bonds) are in place that allow the positive effects to endure as long as the residual	• Waka Kotahi has received agreement in principle from the asset owner (WCC) for the deployment of Living seawalls on the existing seawalls listed in Table 35.

[100] https://www.sims.org.au/page/130/living-seawalls-landing

PRINCIPLE		IMPLEMENTATION
	adverse effects of the activity, and preferably in perpetuity, and	
	(b) be able to be implemented and enforced in line with any resource consent conditions associated with the activity. These conditions should include: i. specific, measurable and time-bound targets, and ii. mechanisms for adaptive management using the results of periodic milestones to determine whether the biodiversity offset is on track and how to rectify if necessary, and	• The construction and implementation of the living seawalls will be included as a consent condition for the Project.
	(c) establish roles and responsibilities for managing, governing, monitoring and enforcing the biodiversity offset, and	• Within the agreement that Waka Kotahi is developing, the roles and responsibilities for managing the living seawalls will be established. • The requirement for the monitoring ecological success (i.e. colonisation) will be included in the consent conditions for the Project. The monitoring period should be for a minimum of two years.
	(d) undertake methods by which analysis will identify when milestones of the biodiversity offset are not achieved, and the causes of non-achievement, and how to revise the offset-management plan to avoid similar occurrences.	• Consent conditions will specify the quantum of living seawall to be constructed.
6) No net biodiversity loss	Any proposals for biodiversity offsets will provide measurable positive effects on biodiversity preferentially, first at the site, then the relevant catchment, then within the ecological district, which can reasonably be expected to result in no net loss and preferably a net gain of biodiversity. No net loss means no reasonably measurable overall reduction in: (a) the diversity of indigenous species or recognised taxonomic units; and	• The provision of a minimum of 60 m^2 of created habitat through the construction of the living seawalls only offsets a small portion of the 4.8 ha of marine habitat that will be permanently lost under the footprint of the project. Additional measures to compensate for those effects are proposed, as discussed below.
	(b) indigenous species' population sizes (taking into account natural fluctuations) and long term viability; and	• Currently no marine organisms are inhabiting the existing seawalls where the construction of the living seawalls is proposed. As such, this offset measure will not result in a measurable reduction in the population size and long term viability of any affected indigenous species at either a regional or a national level.
	(c) the natural range inhabited by indigenous species; and	• Currently no marine organisms are inhabiting the existing seawalls where the construction of the living seawalls is proposed. As such, this offset measure will not result in a measurable reduction in the natural range of any indigenous species.
	(d) the range and ecological health and functioning of assemblages of indigenous species, community types and ecosystems; and	Currently no marine organisms are inhabiting the existing seawalls where the construction of the living seawalls is proposed. As such, this offset measure will not result in measurable reduction in: • the existing range of any indigenous species, community type or ecosystem; or • the ecological health of any indigenous species, community type or ecosystem; or • the natural functioning of any indigenous community type or ecosystem.

PRINCIPLE		IMPLEMENTATION
	(e) the cultural use values of indigenous habitats or species.	• The proposed offset does not result in a measurable reduction in the cultural use values of the affected indigenous habitats or species.
	Any proposals for biodiversity offset will demonstrate: that an explicit calculation of loss and gain has been undertaken as the basis for the biodiversity offset design, and should demonstrate the manner in which no net loss, and preferably net gain of biodiversity, can be achieved by the biodiversity offset, and	• The provision of a minimum of 60 m^2 of created habitat through the construction of the living seawalls will offset a small portion of the 4.8 ha of marine habitat that will be permanently lost under the footprint of the project. No explicit loss v gain calculation has been carried out (or is realistically possible in respect of the marine effects in question).
	(f) that the biodiversity offset design and implementation should include provisions for addressing sources of uncertainty and risk of failure in delivering the biodiversity offset, and	• As outlined in Section 9.1.3.1, intertidal areas have been identified around Wellington Harbour where Living Seawall should be deployed. We recommend that the entire 8.4 m^2 of Living Seawalls be deployed at Frank Kitt's Park lagoon. However, at Greta Point we recommend an approach whereby as an initial trial a minimum of three Living Seawall panels be deployed and these be monitored for recolonisation over a two year period. The results of that trial (i.e. the rate of colonisation by marine sessile organisms) will then inform where the remainder of the Living Seawall panels should be deployed, with the requirement being to install a minimum of 60 m^2 of permanent Living Seawall panels. • If no colonisation occurs, advise should be sought from a qualified marine ecologist to determine the reasons for the lack of colonisation, and recommendations made regarding the construction and location of the remaining area of living seawall.
	(g) that the offset is applied so that the ecological values being achieved through the offset are the same or similar to those being lost, and	• Areas of intertidal habitat lost under the Project include surfaces which encrusting organisms inhabit. As such, the living seawalls will provide similar habitat. It is anticipated that there will be a 6-month time lag from when the living seawalls are constructed, and colonisation processes are likely to begin to occur.
	(h) the intention to include and use a biodiversity offset management plan that: (i) sets out baseline information on the indigenous biodiversity that is potentially impacted by the proposed activity at both donor and recipient sites, and (ii) demonstrates how the requirements set out in this schedule will be carried out, and (iii) identifies the monitoring approach that will be used to demonstrate how the matters set out in this schedule have been addressed over an appropriate timeframe.	• A Biodiversity Offset Management Plan (BOMP) will be prepared which will include the necessary content as outlined in this principle.

9.2 Compensation

As outlined in Section 9.1 above, it is not possible to offset all the residual effects of the Project. Thus, in accordance with the effects management hierarchy (refer to Figure 1), environmental compensation must be provided to address the marine biodiversity loss at the Project site. As identified in Table 34 above, a number of recent New Zealand projects for which a permanent loss of the marine habitat has been proposed, have also proposed compensation measures to address those effects.

Noting the difficulties with addressing residual effects in the marine environment, contact was made with Dr Scott Whiting (Australian marine offsetting expert) at the recommendation of Dr Jamie Steer (GWRC Senior Biodiversity Advisor). During our discussion with Dr Whiting, he noted that it is rarely possible to offset the permanent loss of marine habitat due to the lack of options for declaiming, and that quantification of compensation is a matter of expert opinion (Dr Whiting, *pers. com*. with Dr De Luca). This is consistent with our experience and approach that has been taken on this current and other Projects which have included permanent loss of marine habitat (e.g. East West Link).

Environmental compensation produces a benefit but is not designed to demonstrate a no-net-loss outcome (Maseyk et al., 2018). It is typically a more subjective process than biodiversity offsetting and it is not required to adhere to any of the principles of biodiversity offsetting, especially no-net-loss or net-gain objectives (Maseyk et al., 2018). Maseyk et al. (2018) describe environmental compensation as non-quantified biodiversity benefits to compensate for biodiversity losses. The compensation actions may benefit different biodiversity to that lost (out-of-kind compensation), including biodiversity of lesser conservation concern than that lost.

Jacob et al. (2020) note that as on land, appropriate measures to address marine effects can include site-based actions aimed at averting future threats or remediating past ones. In fact, Dickie et al. (2013) report that the most effective way of addressing the residual impacts on the marine environment associated with anthropogenic activities is to remove or reduce pressures elsewhere in the system. Such measures can include:

- Voluntary closed areas or establishment of a new protected area for habitats or species which are declining due to over-harvesting or exploitation;
- Habitat rehabilitation;
- Eradication of invasive alien species;
- Retirement of property rights for marine exploitation (e.g. aggregates extraction licenses);
- Improved treatment plants to reduce pollutant inputs;
- Upgrading ships to reduce emissions and fuel use;
- The installation of litter bins and recycling stations in coastal recreational areas; and
- Litter/pollution control measures in-ports (e.g. for waste oil or sewage offload).

In the following paragraphs we discuss the two measures we have identified as compensation for the Project and which align with this concept for addressing effects through averting risk / loss or reversing pressures:

- Providing for treatment of stormwater runoff from an area of State Highway corridor that discharges into the Wellington Harbour, being a measure that will bring significant benefits in terms of reducing pollutant inputs; and
- Habitat rehabilitation, in the form of dune vegetation restoration and management along the Pito-One foreshore.

9.2.1 SH2 stormwater runoff treatment

In the case of the Project, the discharge of untreated stormwater (and associated contaminants) from SH2 into the Wellington Harbour was seen as an ongoing pressure that could be averted. The concept of treating the currently untreated stormwater runoff from SH2 adjacent to the Project was supported by numerous stakeholders, and in our opinion is an appropriate measure that will directly benefit the marine environment and is located adjacent to the Project footprint. The concept of stormwater treatment as a compensation measure for the Project has been strongly supported by both the Mana Whenua Steering Group and the wider iwi. During a Te Ara Tupua Project – Iwi engagement session at Te Tatau o Te Po Marae, it was recorded in the notes[101] that "*There was also specific support for the environmental protections that are evident throughout the design of the Project – specifically the creation of wildlife habitats and treatment of water run-off from State Highway 2*."

Currently stormwater run-off from SH2 between Pito-One and Ngā Ūranga is transported via overland flow paths to pipe culverts via road-side drains and catch-pits before discharging directly into Wellington Harbour without treatment. As a compensation measure for the Project effects on marine ecological values, it is proposed to treat stormwater run-off (i.e. capture contaminants) to reduce the Total Suspended Solids (TSS) and associated contaminants, by up to an annual average of 75% from the SH2 road surfaces adjacent to the Project (Map 11).[102]

AECOM (2019a)[103] have determined that proprietary filtration devices (PFDs) are the most feasible solution for this due to high TSS removal and feasible maintenance requirements. For example, a treatment option is the use of a suite of Storm360 Stormfilter devices, which would result in an estimated load reduction of 80% TSS, 47% zinc, 70% copper and 79% total petroleum hydrocarbons.[104] Ongoing maintenance of stormwater devices is required to ensure the long-term effectiveness of sediment and contaminant removal/reduction.

AECOM (2019a) report that using proven PFDs, and with regular maintenance of the devices, the risk of failure of the devices to treat stormwater to the standards above is considered to be low. As such, the proposed treatment of stormwater along SH2 has been deemed a feasible option as a compensation measure for the Project.

Benefits of this compensation measure include:

- Improved water and sediment quality and lower sediment load discharged to near shore intertidal and subtidal habitats;

[101] Summary report of the Te Ara Tupua Project – Iwi engagement session at Te Tatau o Te Po Marae on 13 July 2020 (5.30-7.30pm).

[102] Or from an equivalent area of state highway that currently drains untreated into the Harbour.

[103] Refer to Appendix 7 of this document for a copy of the AECOM (2019a) report.

[104] Table 3 in AECOM (2019a).

- Reduced contribution to cumulative effects on water and sediment quality within the Wellington Harbour (although not likely to be measurable given the myriad other contaminant inputs to the harbour that also require treatment);
- Reduced exposure of contaminants to organisms, and potentially reduced body burden of contaminants in organisms (which can reduce bioaccumulation up the food chain i.e. fish and birds);
- Reduced contaminants in harvested species (e.g. kaimoana species such as kina and paua), with potential benefits for human health; and
- Contributing towards meeting the Whaitua Te Whanganui-a-Tara objectives relating to water quality.

9.2.2 Pito-One foreshore dune vegetation restoration

Habitat rehabilitation has also been identified as a potential measure for averting risk/loss or reversing pressure (Dickie et al., 2013; Jacob et al., 2020). As such, appropriate opportunities relevant to the Project were explored, including from the list of potential projects identified by stakeholders (refer to Appendix 5). As noted earlier in Table 20, an area of 0.33 ha of shingle beaches, an endangered ecosystem type (Holdaway et al., 2012; Williams et al., 2007), will be lost under the Project footprint. As such, one of the recommended compensation measures relates to the rehabilitation of another endangered ecosystem type; that being coastal dunes.

The Pito-One foreshore is one of the few locations around the Wellington Harbour with a somewhat intact coastal dune which supports native sand-binding species such as spinifex (*Spinifex sericeus*) and the *At Risk – Declining*[105] pingao (*Ficinia spiralis*). Various community groups have previously undertaken revegetation programmes along the Pito-One foreshore. Through our discussions with HCC, it was identified that an approximately 0.8 ha area between the Settlers Museum and Hikoikoi Reserve (refer to Map 11) would benefit from additional coastal dune revegetation and vegetation management. The ecological benefit (and objective) associated with this revegetation programme would be enhanced resilience and integrity of a natural ecosystem type which is classified as endangered (Holdaway et al., 2012; Williams et al., 2007) and which is part of a natural coastal habitat sequence. A key to the success of this programme will also include the demarcation of the planted area to deter people from trampling across the dunes and thereby inhibiting the survival of the dune revegetation.

A programme should be developed as part of the Ecological Management Plan to guide the preparation and revegetation. Following the initial revegetation, a 5-year maintenance period should follow during which exotic weeds are controlled and dead plants are replaced, after which maintenance of the revegetated area would pass back to HCC. With robust and regular maintenance in place, and the demarcation of the dune planting with permanent demarcation, the risk of failure of the revegetation is considered to be low.

9.2.3 Assessment of compensation against draft NPSIB principles

In Table 37 we have assessed our biodiversity compensation measures against the 13 principles for biodiversity compensation in Appendix 4 of the Draft National Policy Statement for Indigenous

[105] de Lange et al. (2018)

Biodiversity (Ministry for the Environment, 2019) (Draft NPSIB). According to the Draft NPSIB, Principles 1–11 must be complied with for an action to qualify as biodiversity compensation, and Principles 12–13 should be met for an action to qualify as biodiversity compensation.

The Draft NPSIB is not in force, and as such it is not strictly required that the compensation proposal for the Project accords with the 13 principles. However, consideration against those principles is a useful and structured way of assessing the appropriateness of the proposed compensation measures. As outlined in Table 37, we are able to demonstrate that the compensation measures outlined above meet all biodiversity compensation principles.

Table 37: Assessment of the Project's adherence to the biodiversity compensation principles for residual effects as outlined in Appendix 4 of the Draft National Policy Statement for Indigenous Biodiversity (Ministry for the Environment, 2019)

PRINCIPLE FOR BIODIVERSTIY COMPENSATION	PROJECT COMPLIANCE WITH PRINCIPLE
1) Adherence to the mitigation hierarchy	Details have been provided throughout this assessment with regard to how the Project has sought to avoid and mitigate effects in the first instance (e.g. use of rip-rap material for the revetment, project redesign to minimise footprint to avoid shingle beaches, relocation of KiwiRail signal station at Rocky Point to avoid breeding habitat of At Risk bird species, creation of offshore habitats, inclusion of penguin nesting boxes). Once all options to avoid and mitigate were exhausted, potential measures to offsetting residual effects (permanent loss of 4.8 ha of marine habitat) were explored, included through detailed discussions with a range of key stakeholders. The use of living seawalls was identified as a possible offset measure (Section 9.1), however, the minimum of 60 m^2 of habitat created for marine sessile organisms will only be a minor partial offset for the 4.8 ha of marine habitat lost under the Project footprint. Of particular note, we explored options for declamation of land as a direct offset measure, but were unable to identify any suitable opportunities (Section 9.1.1). As such, compensation measures were then explored to address the remaining residual effects. The two measures proposed are the treatment of stormwater from SH2 adjacent to the Project (Section 9.2.1), and the rehabilitation of 0.8 ha of coastal dunes (an endangered ecosystem type) (Section 9.2.2). Internationally, both habitat rehabilitation and reducing contaminants into the marine environment have been identified as appropriate measures to address impacts in the marine environment (Section 9.2)
2) Limits to biodiversity compensation	The marine habitat that will be permanently lost as part of the Project footprint, and for which residual effects need to be compensated, does not include any Threatened or At Risk species, and as such the proposed measures are within the limits of biodiversity compensation.
3) Scale of biodiversity compensation	Internationally, both habitat rehabilitation and reducing contaminants into the marine environment have been identified as appropriate measures to address direct impacts on the marine environment. Whilst not directly quantifiable, it is our expert opinion that the scale of the proposed compensation is commensurate to the residual effect of permanent loss of marine habitat in that: • The stormwater treatment will be undertaken along the length of SH2 directly adjacent to the length of the Project (or that drains into the Harbour).

PRINCIPLE FOR BIODIVERSTIY COMPENSATION	PROJECT COMPLIANCE WITH PRINCIPLE
	• The loss of habitat is permanent, and the proposed stormwater treatment will be in perpetuity. • The stormwater treatment will lower the future contaminant load within the Wellington Harbour. • The proposed dune revegetation includes the restoration of an area of threatened ecosystem greater than that lost (i.e. 0.8 ha dune restored vs 0.33 ha of shingle beach loss).
4) Additionality	The compensation measures proposed are additional to the gains/benefits to the marine environment that would have occurred otherwise. Both of the proposed compensation measures are not currently being undertaken; nor are they planned as part of existing management programmes by Waka Kotahi (stormwater treatment) or HCC (dune rehabilitation). In particular, we understand that Waka Kotahi does not have plans in the coming >10 years to retrofit stormwater treatment to their existing networks. The additional gains in reduced discharge of sediment and associated contaminants that can be made in the interim are beneficial.
5) Landscape context	The compensation measures proposed occur close to the Project footprint and take into account the interactions between species, habitats, ecosystems, spatial connections and ecosystem function.
6) Long-term outcomes	All of the proposed compensation measures are intended to occur and endure over the long term. The proposed treatment of stormwater from SH2 (in perpetuity; or as long as the SH2 corridor remains in use) will have the long term benefits of reducing the contribution of contaminants into the harbour, and thereby reducing the cumulative effects on marine biota, water and sediment quality within the Wellington Harbour. In terms of the proposed dune rehabilitation, coastal vegetation sequences can be damaged during high intensity storm events. However, coastal species such as spinifex and pingao perform a dune-binding function and are adapted for such natural events. In addition, lost plants can be replaced so that the long-term outcome of the rehabilitation can be achieved under these circumstances.
7) Time lags	Implementation of compensation measures will occur prior to the path commencing operation. Furthermore, because there is currently no treatment of SH2 stormwater, the ecological benefits will commence as soon as the devices are installed; there is no time lag associated with this measure once in place.
8) Trading up	As outlined in Section 9.1.2, in light of the marine ecology values present in Wellington Harbour, no options for Trading up were found for this Project and as such this principle does not apply to the Project.
9) Financial contribution	Financial contributions do not form part of the compensation package and as such this principle does not apply to the Project (financial contributions are generally considered to be a 'last resort' form of compensation).
10) Biodiversity compensation in advance	Implementation of compensation measures will be prior to the path commencing operation. Furthermore, while deemed an offset rather than compensation, the installation of the living seawalls (refer to Section 9.1.1) could also be undertaken in advance of Project construction.

PRINCIPLE FOR BIODIVERSTIY COMPENSATION	PROJECT COMPLIANCE WITH PRINCIPLE
11) Science and matauranga Māori	Mana whenua have been closely involved in the development of the compensation measures and are supportive, particularly of the treatment of stormwater runoff from SH2 adjacent to the Project footprint.[101]
12) Stakeholder participation	There has been early, ongoing and effective participation of a large range of stakeholders to develop options for mitigation, offset and compensation measures (refer to Appendix 5).
13) Transparency	There has been a high level of transparency with stakeholders on this Project, both in relation to the design aspects and measures to mitigate, offset and compensate resulting ecological effects. The proposed compensation measures arose from the potential projects suggested by stakeholders, and the selection of these specific measures relating to permanent loss of marine habitat have been formally communicated to the stakeholders and subsequent workshops held to discuss their appropriateness.

10.0 Adherence to the Effects Management Hierarchy

As part of this ecological assessment, a package of design and management measures has been proposed for the impacts of the Project on the ecological values. There is a specific terminology that makes up the effects management hierarchy (Table 7), which describes the sequence of avoidance, remediation and mitigation of effects, and the offset or compensation for more than minor residual effects that cannot be adequately addressed by the preceding measures.

Both in terms of ecological best practice, and to satisfy the policy requirement of the PNRP, there is a need to understand which components of the effects management hierarchy are achieved by the overall package of measures we have proposed to address the effects of the Project. As such, the respective components of the hierarchy as applied to the Project are provided in Table 38. We have set out which components of the recommended ecological features of the Project are avoided, remedied or minimised, mitigated, offset or compensated for.

Table 38: Summary of the implementation of the effects management hierarchy for the recommended ecological features for the Project

ECOLOGY	AVOID	REMEDY / MINIMISE	MITIGATE	OFFSET	ENVIRONMENTAL COMPENSATION
Indigenous vegetation			• Revetment designs will include areas of native revegetation, much greater than will be lost. • Increasing and enhancing areas of revegetation in Honiana Te Puni Reserve. • Options for including threatened plant species into planting mixes will also be explored.		
Herpetofauna		• Salvage and relocation of lizards as necessary (to be undertaken in areas identified in Map 5). • Revegetation both on the Project and within Honiana Te Puni Reserve will incorporate a species mix which will provide habitat and food resources for native herpetofauna (e.g. *Muehlenbeckia complexa*). Wooden debris will also be included which will provide suitable refugia for lizards (as well as invertebrates).			
Freshwater systems		• Culvert extensions at Waihinahina (Horokiwi), Gilberd Bush and unnamed (1 and 2) streams to be designed and installed to ensure fish passage. • Freshwater Ecologist to advise on measures to ensure fish passage during culvert construction and operation.			
Coastal avifauna	• Revetment alignment avoids areas identified as having high value as much as possible. This includes, at six locations along the path, a variation to the standard revetment design which avoids significant ecological areas through a reduced footprint. • Creation of offshore habitats to avoid / minimise effects of disturbance on roosting birds. These habitats will be constructed prior to the construction of the shared path to provide roosting avifauna with an area of undisturbed habitat (during and after construction).	• Revetment design includes visual screening at six locations to minimise the effects of disturbance on birds at these locations. Use of natural boulders for the revetment material providing more opportunities for nesting penguins than is currently present. • Inclusion of educational signage along the shared path regarding: ○ the coastal bird values and threats to them; and ○ avoiding areas of nesting habitat during the breeding and moulting seasons. • Construction lighting kept to the minimum required for safe operation and wherever practicable, be directed downwards and shielded to reduce light emanating horizontally or vertically. • Operational light must be orientated downwards and shielded to reduce light emanating vertically. Lighting must not be orientated out towards coastal waters. • Requirement for an Ecological Management Plan to include a Coastal Avifauna Plan which specifies how construction effects on nesting coastal avifauna will be minimised. • Dogs are restrained on leads and confined to the 5 m formed pathway and on the flat gathering areas of the ūranga (i.e. not on the rip-rap revetment or shingle beaches). Waka Kotahi to use best endeavours to secure this outcome, in co-ordination with HCC and WCC.	• Small footprint vertical seawalls to support path at key locations, with associated groynes, that allow for long term survival of shingle beaches. • Incorporation of penguin nesting boxes into the larger planted area on the Piki Wahine ūranga (chainage 700-900 m). • Tall structures such as wooden poles may be incorporated into the ūranga designs to provide further safe roosting habitat for species such as shags and gulls. • A predator control programme (as outlined in Section 8.4.1.1). • Six-monthly coastal clean-up along the pathway (including rip-rap) and within the shallow coastal edge as part of scheduled path maintenance.		
Marine ecology	• Revetment alignment avoids areas identified as having the highest marine ecological value as much as possible. This includes, at six locations along the path, a variation to the standard revetment design which avoids significant ecological areas through a reduced footprint.		• Small footprint vertical seawalls to support path at key locations, with associated groynes, that allow for long term survival shingle beach habitat. • Revetment and offshore habitat structures, in the longer-term, will provide additional offshore habitat primarily for sessile organisms. • Educational signage about marine ecological values. • Six-monthly coastal clean-up along the pathway (including rip-rap) and within the shallow coastal edge as part of scheduled path maintenance.	• Installation of living seawalls to increase habitat diversity of existing seawalls around Wellington Harbour.	• Treatment of stormwater runoff from SH2 adjacent to the Project to reduce TSS and associated contaminants (by up to an annual average of 75%) entering the marine environment. • Approximately 0.8 ha coastal dune revegetation programme along Pito-One foreshore between Settlers Museum and Hikoikoi Reserve.

11.0 Conclusions

The design of the Project has been an iterative process, with many measures implemented to avoid, remedy, minimise or mitigate effects on high value ecological areas and habitats used by *Threatened* and *At Risk* avifauna. Through this iterative process, the design was altered to minimise the footprint, avoid and where not possible minimise effects on shingle beaches and macroalgae / cobble / reef habitat, provide new undisturbed offshore habitat for avifauna roosting, and to provide visual screening to decrease disturbance to avifauna using the shingle beach areas to forage and nest.

The final design results in the residual effects unable to be avoided being limited to permanent marine habitat loss.[106] The values lost through those effects will be addressed by generating positive effects on biodiversity within Wellington Harbour and near the Project area through biodiversity offsetting and compensation.

Input was sought from stakeholders and Project partners on a number of occasions throughout the Project development, including in regard to potential ecological offset and compensation measures for the permanent habitat loss in the marine environment. Applying the mitigation hierarchy, opportunities for offset measures were explored, resulting in the proposal for Living Seawalls to be installed as a partial offset, having the benefit of increasing marine habit diversity.

With no other available offset measures, compensation was required. Many stakeholders, including mana whenua, considered that treatment of SH2 runoff would be an excellent compensation measure; the Project team took this recommendation onboard and on the basis of its ecological merits, this was included as the main ecological compensation measure for the permanent loss of 4.8 ha of marine habitat. Furthermore, a coastal dune revegetation programme is recommended as additional compensation, having ecological merit due to the benefits of increasing an underrepresented habitat in the Wellington Harbour.

It is our opinion that the treatment of stormwater from SH2, a coastal dunes revegetation programme and the use of Living Seawalls around Wellington Harbour will appropriately offset and compensate for the permanent loss of marine habitat associated with the Project. More generally, in our opinion the potential and actual effects of the Project on ecological values have been appropriately addressed, through the range of measures outlined in this assessment.

Waka Kotahi has agreed to adopt our recommendations, including in respect of measures to avoid, remedy / minimise, mitigate, and offset / compensate for effects on ecological values. Our recommended measures are reflected in the proposed conditions of consents, which we have reviewed.

[106] The level of potential effects identified are based on the design plans listed in 4.6, the construction methodology outlined in Section 7.0, and the implementation of all the measures and recommendations identified to avoid, minimise and mitigate potential effects. If the design or construction methodology were to change, or any of the measures and recommendations not implemented, the level of potential effect and therefore any mitigation / offset / compensation requirements would need to be revisited.

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Appendix 1: EIANZ criteria for assigning ecological value to terrestrial and freshwater communities

FRESHWATER SYSTEMS:

MATTER	ATTRIBUTES TO BE ASSESSED
Representativeness	• Extent to which site/catchment is typical or characteristic • Stream order • Permanent, intermittent or ephemeral waterway • Catchment size • Standing water characteristics
Rarity / distinctiveness	• Supporting nationally or locally (i.e. ecological district) Threatened, At Risk or uncommon species • National distribution limits • Endemism • Distinctive ecological features • Type of lake/pond/wetland/spring
Diversity & pattern	• Level of natural diversity • Diversity metrics • Complexity of community • Biogeographical considerations - pattern, complexity, size, shape
Ecological context	• Stream order • Instream habitat • Riparian habitat • Local environmental conditions and influences, site history and development • Intactness, health and resilience of populations and communities • Contribution to ecological networks, linkages, pathways • Role in ecosystem functioning - high level, proxies

TERRESTRIAL:

MATTER	ATTRIBUTES TO BE CONSIDERED
Representativeness	Criteria for representative vegetation and aquatic habitats: • Typical structure and composition • Indigenous species dominate • Expected species and tiers are present • Thresholds may need to be lowered where all examples of a type are strongly modified Criteria for representative species and species assemblages: • Species assemblages that are typical of the habitat • Indigenous species that occur in most of the guilds expected for the habitat type
Rarity / distinctiveness	Criteria for rare/distinctive vegetation and habitats: • Naturally uncommon, or induced scarcity • Amount of habitat or vegetation remaining • Distinctive ecological features • National priority for protection Criteria for rare/distinctive species or species assemblages: • Habitat supporting nationally Threatened or At Risk species, or locally[107] uncommon species • Regional or national distribution limits of species or communities • Unusual species or assemblages • Endemism
Diversity & pattern	• Level of natural diversity, abundance and distribution • Biodiversity reflecting underlying diversity • Biogeographical considerations - pattern, complexity • Temporal considerations, considerations of lifecycles, daily or seasonal cycles of habitat availability and utilisation
Ecological context	• Site history, and local environmental conditions which have influenced the development of habitats and communities • The essential characteristics that determine an ecosystem's integrity, form, functioning, and resilience (from "intrinsic value" as defined in the RMA) • Size, shape and buffering • Condition and sensitivity to change • Contribution of the site to ecological networks, linkages, pathways and the protection and exchange of genetic material • Species role in ecosystem functioning - high level, key species identification, habitat as proxy

[107] Locally - defined as within Ecological District

Appendix 2: Plant species list

Scientific name	Common name	Conservation status (de Lange et al., 2018)	Between rail & coast	Between road & rail	Amenity planting
Asplenium oblonifolium	Shining spleenwort	Native - Not Threatened	✓	✓	
Calystegia soldanella	Shore convolvulus	Native - Not Threatened	✓	✓	
Clematis forsteri	Forster's clematis	Native - Not Threatened		✓	
Coprosma repens	Tauputa	Native - Not Threatened	✓	✓	✓
Cordyline australis	Ti kouka	Native - Not Threatened			✓
Hebe stricta	Koromiko	Native - Not Threatened		✓	
Leptospermum scoparium var. *scorparium*	Manuka	Native - At Risk (Declining)			✓
Metrosideous excelsa	Pohutukawa	Native – Threatened (Nationally Vulnerable)			✓
Microsorum pustulatum	Hounds tongue fern	Native - Not Threatened		✓	
Mulenbeckia complexa	Scrub pohuehue	Native - Not Threatened	✓	✓	✓
Olearia tenuafolium	Tree daisy	Native - Not Threatened			✓
Ozothamnus leptophyllus	Tauhinu	Native - Not Threatened		✓	
Phormium cookianum	Mountain flax	Native - Not Threatened	✓	✓	✓
Pittosporum crassifolium	Karo	Native - Not Threatened			✓
Poa cita	Silver tussock	Native - Not Threatened		✓	
Polystichum vestitum	Prickly shield fern	Native - Not Threatened		✓	
Pseudognaphalium luteoalbum	-	Native - Not Threatened	✓		
Pseudopanex arboreous	Five finger	Native - Not Threatened			✓
Pyrrosia eleagnifolia	leather leaf fern	Native - Not Threatened		✓	
Rytidosperma unarede	bristle grass	Native - Not Threatened		✓	
Tetragoinia implexicoma	Native spinach	Native - Not Threatened	✓		
Agapanthus praecox subsp. orientalis	Agapanthus	Exotic		✓	
Allium triquetrum	Onion weed	Exotic		✓	

Scientific name	Common name	Conservation status (de Lange et al., 2018)	Between rail & coast	Between road & rail	Amenity planting
Anagallis arvensis	Pimpernel	Exotic	✓	✓	
Aphanes inexspectata	Piert parsley	Exotic	✓	✓	
Arctotheca calendula	Cape weed	Exotic	✓	✓	
Atriplex prostrata	Orache	Exotic	✓	✓	
Brassica rapa	Wild turnip	Exotic	✓	✓	
Briza maxima	Large quaking grass	Exotic		✓	
Circium vulgare	Scotch thistle	Exotic	✓	✓	
Clematis vitalba	Old man's beard	Exotic		✓	
Conyza sumatrensis	Broad-leaved fleabane	Exotic	✓	✓	
Cortaderia selloana	Pampas	Exotic		✓	
Crepis capillaris	Hawksbeard	Exotic	✓	✓	
Cymbalaria muralis	Ivy-leaved toadflax	Exotic	✓	✓	
Cyperus eragrostis	Umbrella sedge	Exotic	✓	✓	
Cytisus scoparius	Broom	Exotic	✓	✓	✓
Dactylis glomerata	Cocksfoot	Exotic	✓	✓	
Ehrharta erecta	Veldt grass	Exotic	✓	✓	
Euphorbia peplus	Milkweed	Exotic	✓	✓	
Galium propinquum	Cleavers	Exotic	✓	✓	
Gamochaeta purpurea	Cudweed	Exotic	✓		
Geranium molle	Doves foot cranesbill	Exotic	✓	✓	
Holcus lanatus	Yorkshire fog	Exotic	✓	✓	
Juniperus spp	Conifer	Exotic		✓	
Lupinus arboreus	Tree lupin	Exotic	✓	✓	

Scientific name	Common name	Conservation status (de Lange et al., 2018)	Between rail & coast	Between road & rail	Amenity planting
Malva dendromorpha	Tree mallow	Exotic	✓	✓	
Plantago coronopus	Buck's horn plantain	Exotic	✓	✓	
Plantago lanceolata	Narrow leaved plantain	Exotic	✓	✓	
Rumex obtusifolius	Broad-leaved dock	Exotic	✓	✓	
Senecio skirrhodon	Gravel groundsel	Exotic	✓	✓	
Solanum nigrum	Black nightshade	Exotic	✓	✓	
Sonchus asper	Prickly sow thistle	Exotic	✓	✓	
Trifolium dubium	Suckling clover	Exotic		✓	
Trifolium repens	White clover	Exotic	✓	✓	
Ulex europaeus	Gorse	Exotic	✓	✓	

Appendix 3: Avifauna species list

Information regarding primary (dark green) and secondary (light green) habitats presented in the following table was obtained for each species from Heather & Robertson (2005). For the purpose of this report, primary habitat refers to the habitat in which the species spends most of its time. Secondary habitats are other habitat types which the species may also utilise.

SPECIES		CONSERVATION STATUS[108]		HABITAT								SOURCE					
				Native forest	Exotic Forest	Scrub / shrubland	Farmland / open country	Freshwater / wetlands	Coastal / Estuary	Oceanic	Urban/Residential	OSNZ (266, 599)	Robertson (1992)	eBird	Oct 2014 Project site visit	Jan 2016 Project site visit	2016 Korokoro survey
Bellbird	*Anthornis m. melanura*	Not Threatened	Not Threatened									x					
Bush falcon	*Falco novaeseelandiae* "bush"	At Risk	Recovering [DP]									x					
Kereru	*Hemiphaga novaeseelandiae*	Not Threatened	Not Threatened[CD Inc]									x					
Long-tailed cuckoo	*Eudynamys taitensis*	At Risk	Naturally Uncommon[De DP]									x					
Morepork	*Ninox n. novaeseelandiae*	Not Threatened	Not Threatened									x					
North Island fantail	*Rhipidura fuliginosa placabilis*	Not Threatened	Not Threatened[EF]									x		x			
North Island rifleman	*Acanthisitta chloris*	At Risk	Declining[DP]									x					
Red-crowned parakeet	*Cyanoramphus n. novaezelandiae*	At Risk	Relict									x					
Shining cuckoo	*Chrysococcyx l. lucidus*	Not Threatened	Not Threatened[DP]									x					
Tui	*Prosthemadera n. novaeseelandiae*	Not Threatened	Not Threatened[Inc]									x					
Blackbird	*Turdus merula*	Introduced	Introduced & Naturalised[SO]									x		x			
California quail	*Callipepla californica*	Introduced	Introduced & Naturalised[SO]									x					
Eastern rosella	*Platycercus eximius*	Introduced	Introduced & Naturalised[SO]									x					
Grey warbler	*Gerygone igata*	Not Threatened	Not Threatened									x					
Silvereye	*Zosterops lateralis lateralis*	Not Threatened	Not Threatened[SO]									x					
Canada goose	*Branta canadensis*	Introduced	Introduced & Naturalised[SO]									x					
Chaffinch	*Fringilla coelebs*	Introduced	Introduced & Naturalised[SO]									x					
Dunnock	*Prunella modularis*	Introduced	Introduced & Naturalised[SO]									x		x			
Goldfinch	*Carduelis carduelis*	Introduced	Introduced & Naturalised[SO]									x					
Greenfinch	*Carduelis chloris*	Introduced	Introduced & Naturalised[SO]									x					

108 Robertson et al. (2017) classifications with qualifiers: Conservation Dependent (CD), Data Poor (DP), Designated (De), Extreme Fluctuations (EF), Increasing (Inc), Island Endemic (IE), One Location (OL), Partial Decline (PD), Range Restricted (RR), Recruitment Failure (RF), Secure Overseas (SO), Sparse (Sp), Stable (St) and Threatened Overseas (TO).

SPECIES		CONSERVATION STATUS[108]		HABITAT								SOURCE					
				Native forest	Exotic Forest	Scrub / shrubland	Farmland / open country	Freshwater / wetlands	Coastal / Estuary	Oceanic	Urban/Residential	OSNZ (266, 599)	Robertson (1992)	eBird	Oct 2014 Project site visit	Jan 2016 Project site visit	2016 Korokoro survey
House sparrow	*Passer domesticus*	Introduced	Introduced & Naturalised[SO]									x		x			
Magpie	*Gymnorhina tibicen*	Introduced	Introduced & Naturalised[SO]									x					
NZ pipit	*Anthus n. novaeseelandiae*	At Risk	Declining									x					
Redpoll	*Carduelis flammea*	Introduced	Introduced & Naturalised[SO]									x					
Skylark	*Alauda arvensis*	Introduced	Introduced & Naturalised[SO]									x					
Song thrush	*Turdus philomelos*	Introduced	Introduced & Naturalised[SO]									x					
Spur-winged plover	*Vanellus miles novaehollandiae*	Not Threatened	Not Threatened[SO]									x	x	x			
Starling	*Sturnus vulgaris*	Introduced	Introduced & Naturalised[SO]									x		x			
Swamp harrier	*Circus approximans*	Not Threatened	Not Threatened[SO]									x					
Welcome swallow	*Hirundo n. neoxena*	Not Threatened	Not Threatened[Inc SO]									x		x			
Yellowhammer	*Emberiza citrinella*	Introduced	Introduced & Naturalised[SO]									x					
Black shag	*Phalacrocorax carbo novaehollandiae*	At Risk	Naturally Uncommon[SO Sp]									x	x	x		x	
Black swan	*Cygnus atratus*	Not Threatened	Not Threatened[SO]									x		x			
Black-billed gull	*Larus bulleri*	Threatened	Nationally Critical[RF]									x		x			
Feral goose	*Anser anser*	Introduced	Introduced & Naturalised[SO]									x					
Grey duck	*Anas s. superciliosa*	Threatened	Nationally Critical[SO]									x					
Grey teal	*Anas gracilis*	Not Threatened	Not Threatened[Inc SO]									x					
Kingfisher	*Todiramphus sanctus vagans*	Not Threatened	Not Threatened									x					
Little black shag	*Phalacrocorax sulcirostris*	At Risk	Naturally Uncommon[RR]									x	x	x			
Little shag	*Phalacrocorax melanoleucos brevirostris*	Not Threatened	Not Threatened[Inc]									x	x	x	x	x	
Mallard	*Anas platyrhynchos*	Introduced	Introduced & Naturalised[SO]									x	x	x			
NZ pied oystercatcher	*Haematopus finschi*	At Risk	Declining									x		x			
NZ shoveler	*Anas rhynchotis variegata*	Not Threatened	Not Threatened									x					

SPECIES		CONSERVATION STATUS[108]		HABITAT								SOURCE					
				Native forest	Exotic Forest	Scrub / shrubland	Farmland / open country	Freshwater / wetlands	Coastal / Estuary	Oceanic	Urban/Residential	OSNZ (266, 599)	Robertson (1992)	eBird	Oct 2014 Project site visit	Jan 2016 Project site visit	2016 Korokoro survey
Paradise shelduck	*Tadorna variegata*	Not Threatened	Not Threatened									x		x			
Pied shag	*Phalacrocorax varius varius*	At Risk	Recovering									x	x	x	x	x	
Pied stilt	*Himantopus h. leucocephalus*	Not Threatened	Not Threatened[SO]									x					
Pukeko	*Porphyrio m. melanotus*	Not Threatened	Not Threatened[Inc SO]									x					
Black-backed gull	*Larus d. dominicanus*	Not Threatened	Not Threatened[SO]									x	x	x	x	x	x
Caspian tern	*Hydroprogne caspia*	Threatened	Nationally Vulnerable[SO Sp]									x		x			x
Eastern bar-tailed godwit	*Limosa lapponica baueri*	At Risk	Declining[TO]									x					
Red-billed gull	*Larus novaehollandiae scopulinus*	At Risk	Declining									x	x	x		x	x
Reef heron	*Egretta sacra sacra*	Threatened	Nationally Endangered[DP SO Sp]									x	x	x			
Royal spoonbill	*Platalea regia*	At Risk	Naturally Uncommon[Inc RR SO Sp]									x					
Spotted shag	*Stictocarbo p. punctatus*	Not Threatened	Not Threatened									x	x	x		x	
Variable oystercatcher	*Haematopus unicolor*	At Risk	Recovering[Inc]									x	x	x	x	x	x
White-faced heron	*Egretta novaehollandiae*	Not Threatened	Not Threatened[SO]									x				x	
White-fronted tern	*Sterna s. striata*	At Risk	Declining[DP]									x	x	x		x	x
Antarctic fulmar	*Fulmarus glacialoides*	Migrant	Migrant[SO]										x				
Arctic skua	*Stercorarius parasiticus*	Migrant	Migrant[SO]											x			
Australasian gannet	*Morus serrator*	Not Threatened	Not Threatened[De Inc SO]									x	x	x		x	x
Common diving petrel	*Pelecanoides urinatrix urinatrix*	At Risk	Relict[RR Inc SO]									x					
Fluttering shearwater	*Puffinus gavia*	At Risk	Relict[RR]									x	x	x			
(Northern) little penguin	*Eudyptula minor iredalei*	At Risk	Declining[DP EF]									x		x	x	x	
Sooty shearwater	*Puffinus griseus*	At Risk	Declining[SO]									x	x				
Rock pigeon	*Columba livia*	Introduced	Introduced & Naturalised[SO]									x					

Appendix 4: Coastal avifauna surveys

RECORDED ALONG THE PROJECT			
Date	**Species**	**Number**	**Notes**
28/10/2014	Little penguin	1	Nest in rip-rap at approx Ch 3900
28/10/2014	Variable oystercatcher	2	On top of revetment by rail ballast at approx Ch 3900
28/10/2014	Black-backed gull	2	Roosting on shingle beach at approx Ch 3400
28/10/2014	Variable oystercatcher	1	Foraging on shingle beach approx Ch 3400
28/10/2014	Pied shag	1	Took flight from outcrop approx Ch 2990 towards Matiu/Somes Is
28/10/2014	Variable oystercatcher	1	Nest above MHWS approx Ch 2990
28/10/2014	Black-backed gull	2	Roosting on outcrop approx Ch 3020
28/10/2014	Variable oystercatcher	1	Foraging on outcrop approx Ch 2900
28/10/2014	Black-backed gull	2	Traversing offshore approx Ch 2900
28/10/2014	Black-backed gull	1	Nest above MHWS approx Ch 2850
28/10/2014	Black-backed gull	1	Nest on existing reclamation at approx Ch 0980
28/10/2014	Little shag	1	Basking on top of revetment approx Ch 4250
14/01/2016	Black-back gull	8	Traversing east along northern coast (Wgtn Rowing Assoc.)
14/01/2016	Black-back gull	1	Roosting on outcrop in front of Rowing Assoication
14/01/2016	Black-back gull	1	Roosting on outcrop approx Ch 4300
14/01/2016	Australasian gannet	1	Foraging offshore approx Ch 4250
14/01/2016	Variable oystercatcher	1	Foraging on rock outcrop approx Ch 3410
14/01/2016	Variable oystercatcher	1	Foraging on shingle beach approx Ch 3400
14/01/2016	Red-billed gull	2	Foraging on shingle beach approx Ch 3400
14/01/2016	Black-back gull	1	Resting on water offshore approx Ch 3380
14/01/2016	Black-back gull	5	Traversing north offshore along coast approx Ch 3200
14/01/2016	Black-back gull	1	Roosting on outcrop approx Ch 2990
14/01/2016	Pied shag	1	Roosting on outcrop approx Ch 2990
14/01/2016	Black-back gull	1	Roosting on roof of signal box approx Ch 2950
14/01/2016	Pied shag	2	Roosting on outcrop approx Ch 3020
14/01/2016	White-faced heron	1	Foraging on water edge approx Ch 2940
14/01/2016	Red-billed gull	1	Foraging on shingle beach approx Ch 2910
14/01/2016	Black shag	1	Roosting on outcrop approx Ch 2910
14/01/2016	Black-back gull	1	Roosting on outcrop approx Ch 2910
14/01/2016	Little penguin		Empty nest under flax at approx Ch 2900
14/01/2016	Black-back gull	2	Roosting on outcrop approx Ch 2850
14/01/2016	Variable oystercatcher	2	Foraging on outcrop approx Ch 2880
14/01/2016	Black-back gull	2	Resting on shingle beach approx Ch 2870
14/01/2016	Black-back gull	1	Nest above MHWS approx Ch 2850
14/01/2016	Black-back gull	1	Resting on shingle beach approx Ch 2860
14/01/2016	Black-back gull	1	Roosting on blocks approx Ch 2840
14/01/2016	Black-back gull	6	Traversing along coast approx Ch 2860

RECORDED ALONG THE PROJECT			
Date	**Species**	**Number**	**Notes**
14/01/2016	Black-back gull	1	Roost on outcrop approx Ch 2805
14/01/2016	Black-back gull	1	Roost on outcrop approx Ch 2800
14/01/2016	Black-back gull	1	Traversing along coast approx Ch 2440
14/01/2016	Black-back gull	1	Roosting on outcrop approx Ch 2350
14/01/2016	Variable oystercatcher	2	Foraging on rock platform approx Ch 2340
14/01/2016	Little shag	1	Roosting on outcrop approx Ch 2950
14/01/2016	White-fronted tern	30	Roosting on revetment in front of Wgtn Rowing Association.
14/01/2016	Spotted shag	2	Roosting on outcrop approx Ch 2850

RECORDED AT KOROKORO ESTUARY				
Date	**Tide**	**Species**	**Number**	**Notes**
12/01/2016	Low	Black-backed gull	2	Roosting on beach
12/01/2016	Low	Black-backed gull	3	Traversing coast
12/01/2016	Low	Red-billed gull	6	Foraging around stream mouth
12/01/2016	Low	Red-billed gull	1	Traversing coast
12/01/2016	Low	Variable oystercatcher	2	Foraging around stream mouth
12/01/2016	Low	White-fronted tern	3	Foraging offshore
12/01/2016	Low	White-fronted tern	2	Traversing coast
15/01/2016	High	Black-backed gull	4	Roosting on beach
15/01/2016	High	Black-backed gull	2	Traversing coast
15/01/2016	High	Red-billed gull	3	Roosting on beach
15/01/2016	High	Variable oystercatcher	1	Roosting on beach
20/05/2016	Low	Black-backed gull	1	Traversing coast
20/05/2016	Low	Black-backed gull	3	Roosting on beach
20/05/2016	Low	Caspian tern	2	Traversing coast
20/05/2016	Low	Red-billed gull	5	Foraging around stream mouth
20/05/2016	Low	White-fronted tern	2	Foraging offshore
20/05/2016	Low	Variable oystercatcher	2	Foraging around stream mouth
20/05/2016	Low	White-fronted tern	3	Traversing coast
20/05/2016	Low	Australasian gannet	1	Foraging offshore
20/05/2016	High	Black-backed gull	8	Roosting on beach
20/05/2016	High	Black-backed gull	2	Traversing coast
20/05/2016	High	Variable oystercatcher	1	Roosting on beach
20/05/2016	High	White-fronted tern	3	Roosting on beach

Appendix 5: Stakeholder consultation for measures to address residual ecological effects

	IDEA / SUGGESTION	SOURCE	BENEFIT							NOTES
			Marine	**Avifauna**	**Lizards**	**Vegetation**	**Terr. inverts**	**Freshwater habitat / biota**	**Water quality**	
1A	Opportunity to improve quality of soft sediment habitat through capturing contaminants (from SH2) and mud before entering the CMA.	DOC, GWRC, mana whenua meeting 20/6/19	Yes	Yes					Yes	**UPDATE:** Some sediment may be removed as part of the proposed SH2 stormwater treatment.
1B	Measures to reduce or minimise sediment discharges from the Hutt River (harbour modelling shown the water from the River hugs the shore and runs through the project areas prior to leaving the harbour)	DOC, GWRC, mana whenua, Royal Forest and Bird Protection Society of NZ (F&B) meeting 4/3/20	Yes					Yes	Yes	**UPDATE:** Sedimentation into the Hutt River from land-use activities a long way up the catchment. Debate between parties about ability to influence these land use changes and the ecological benefit.
2	Incorporating stormwater treatment / swales / rain gardens into design.	DOC, GWRC, mana whenua meeting 20/6/19 F&B meeting 5/7/19	Yes						Yes	F&B also asked if the existing cycleway could be turned into stormwater treatment areas when it is "decommissioned". **UPDATE:** This space may be required for proposed SH2 stormwater treatment devices, or for part of road safety upgrades.
3	Korokoro Stream / Estuary - Habitat creation (including wetland) and remediation of modified hard engineered areas.	GWRC meeting 2 April 2019 DOC, GWRC, mana whenua meeting 20/6/19 WCC offset/mitigation ideas meeting 22/10/19	Yes	Yes		Yes		Yes	Yes	**UPDATE:** Technically unfeasible due to the current infrastructure that the area supports. In addition, there is limited space for the retention of stormwater to allow effective treatment. Potential impact on estuary mouth if treatment wetland located there.
4	Kaiwharawhara Estuary - remediation of hard engineered edges.	GWRC meeting 2 April 2019 DOC, GWRC, mana whenua meeting 20/6/19	Yes					Yes		**UPDATE:** Land not available.
5	Provision of coastal platforms for seal haulouts within the revetment design. Need calm water (e.g. pools) for young seas. Avoid black warm surfaces on pathway to discourage seals laying on it.	Growing Places Charitable Trust meeting 21/6/19	Yes (seals)							**UPDATE:** Architectural rocks in the Project revetment design will be ideal for seal haulouts.
6	Minimise reclamation footprint	F&B meeting 5/7/19	Yes	Yes						**UPDATE:** Achieved through design refinement, carried out since the July 2019 meeting, whereby effects on shingle beaches were avoided through minimising the reclamation footprint by inclusion of vertical seawalls at six locations (refer to Section 6.0.
7	Enhance the texture of the rock amour and use of possible 'hanging gardens', living seawalls.	DOC, GWRC, mana whenua meeting 20/6/19 WCC offset/mitigation ideas meeting 22/10/19	Yes							Assist recolonisation of marine organisms **UPDATE:** Proposed as offset for the Project (refer to Section 9.1)
8	Stormwater treatment of SH2 road runoff adjacent to Te Ara Tupua	F&B meeting 5/7/19 F&B meeting 16/10/19	Yes							**UPDATE:** Proposed as compensation for the Project (refer to Section 9.2)
9	Te Mome Stream - Cap ground contamination, remove contaminated soil along stream and reveg riparian margins.	HCC offset/mitigation ideas meeting 29/10/19	Yes					Yes	Yes	Contaminated land either HCC or GWRC owned. Potential that solving contamination issue may assist with estuary restoration. **UPDATE:** Site investigation report provided by HCC and subsequent information indicate that Te Mome Stream contaminant levels have improved in recent years, therefore not progressed.
10	Mahanga Bay - opportunities, if degraded (potentially from previous mussel farming).	WCC offset/mitigation ideas meeting 22/10/19	Yes?							**UPDATE:** No data to indicate that the Bay is degraded.
11	Kaiwharawhara Stream - Repair leaking wastewater pipes	Wellington Water offset/mitigation ideas meeting 4/11/19	Yes						Yes	**UPDATE:** Issues relating to E. coli are human-related rather than ecological.

	IDEA / SUGGESTION	SOURCE	BENEFIT							NOTES
			Marine	Avifauna	Lizards	Vegetation	Terr. inverts	Freshwater habitat / biota	Water quality	
12	Hikoikoi Reserve - create a wetland treatment system?	Wellington Water offset/mitigation ideas meeting 4/11/19	Yes						Yes	**UPDATE:** Land not currently available and gradient of this area would make it very difficult to design an effective treatment system.
13	Create a stormwater retention device at Korokoro Stream	Growing Places Charitable Trust meeting 21/6/19	Yes						Yes	**UPDATE:** Limited space to achieve this.
14	Horokiwi Stream - potential planting upstream of SH2 to create inanga spawning habitat.	DOC, GWRC, mana whenua meeting 20/6/19 Growing Places Charitable Trust meeting 21/6/19						Yes	Yes	*Carex* ideal inanga spawning habitat. **UPDATE:** No benefit to the marine environment; not required to address freshwater ecology effects.
15	Predator control programme on the coastal escarpments	ERAT (Educating Residents About Trapping) - Petone open day.		Yes	Yes		Yes			**UPDATE:** No benefit to the marine environment; not required to address terrestrial ecology effects.
16	General need for a pest control programme associated with the alignment.	Growing Places Charitable Trust meeting 21/6/19		Yes	Yes	Yes	Yes			**UPDATE:** Predator control programme has been recommended as part of the Project (refer to Section 8.4.7)
17	Plant vines on structures	Growing Places Charitable Trust meeting 21/6/19				Yes	Yes			E.g. white rata (unlikely to be susceptible to myrtle rust and good habitat for stick insects), *Tecomanthe, Muehlenbeckia australis, Muehlenbeckia complexa*. **UPDATE:** *Muehlenbeckia* species included in the proposed uranga planting.
18	Inclusion of plant species into the revegetation which may be threatened or provide habitat for fauna	Growing Places Charitable Trust meeting 21/6/19			Yes	Yes	Yes			E.g. Cooks scurvy grass (*Lepidium oleraceum*), *Atriplex, Crassula kirkii* (saline freshwater ephemeral wetland*)*, *Melicytus crassifolius* (good for lizards), *Muehlenbeckia australis* (copper butterflies), stinging nettle (admiral butterflies) **UPDATE:** *Muehlenbeckia* species included in the proposed uranga planting.
19	Inclusion of logs into the revegetation areas to provide habitat	Growing Places Charitable Trust meeting 21/6/19			Yes	Yes	Yes			Logs on / in vegetation would provide habitat for katipo, beach cockroach, centipedes, large black beetle, peripetus. Note that these species would not be present in newly created areas. **UPDATE:** Wooden debris has been included in the proposed uranga planting areas.
20	Improve fish passage to all culvert outlets along the alignment	DOC, GWRC, mana whenua meeting 20/6/19						Yes		**UPDATE:** Culvert extensions at the outlet of perennial streams along the alignment have been designed to allow fish passage.
21	Re-vegetation of dotterel nesting sites – near Eastbourne (on deep gravel beaches).	HCC offset/mitigation ideas meeting 29/10/19				Yes				**UPDATE:** No benefit to the marine environment; not required to address avifauna effects.
22	Re-vegetate rocky shore lines around southern beaches.	HCC offset/mitigation ideas meeting 29/10/19				Yes				HCC have been undertaking re-vegetation around stormwater outlets at Eastbourne (general re-vegetation) following clearance of the outlets by GWRC on annual basis. **UPDATE:** No benefit to the marine environment.
23	Pito-One beach dune revegetation	HCC offset/mitigation ideas meeting 29/10/19				Yes				HCC had success in areas where high community use, however the section from Settlers museum to Hikoikoi Park could use some additional plants. **UPDATE:** No benefit to the marine environment, however included as a compensation measure as it allows for the

	IDEA / SUGGESTION	SOURCE	BENEFIT							NOTES
			Marine	Avifauna	Lizards	Vegetation	Terr. inverts	Freshwater habitat / biota	Water quality	
										enhancement of a naturally rare ecosystem close to the Project.
24	Annual weed control in Hutt River	HCC offset/mitigation ideas meeting 29/10/19				Yes				Boneseed, blackberry, fennel / weed control in Hutt River which can act as a seed source for the wider harbour. **UPDATE:** No benefit to the marine environment; not required to address vegetation effects.
25	Propogartion of regionally uncommon and endangered native plants	HCC offset/mitigation ideas meeting 29/10/19				Yes				Contribute to a propagation scheme (e.g. Percy's reserve) where regionally uncommon and endangered plants are planted in restoration projects. **UPDATE:** No benefit to the marine environment; not required to address vegetation effects.
26	Canadian goose control along the Hutt River	HCC offset/mitigation ideas meeting 29/10/19		Yes						Removing pest species may be beneficial for native waterbirds using the river corridor. **UPDATE:** No benefit to the marine environment; not required to address avifauna effects.
27	Wainuiomata catchment - removal of pest plants along waterways.	HCC offset/mitigation ideas meeting 29/10/19						Yes		**UPDATE:** No benefit to the marine environment; not required to address freshwater effects.
28	Wainuiomata catchment - remedy fish passage issues	HCC offset/mitigation ideas meeting 29/10/19						Yes		**UPDATE:** No benefit to the marine environment; not required to address freshwater effects.
29	Wainuiomata catchment - riparian planting of channelised waterways with low growing species (e.g. carex)	HCC offset/mitigation ideas meeting 29/10/19						Yes		**UPDATE:** No benefit to the marine environment; not required to address freshwater effects.
30	Remedy Waitangi Park wetlands to improve functionality	WCC offset/mitigation ideas meeting 22/10/19 Wellington Water offset/mitigation ideas meeting 4/11/19							Yes	**UPDATE:** No benefit to the marine environment; not required to address freshwater effects.
31	Stream daylighting - Kent and Cambridge	WCC offset/mitigation ideas meeting 22/10/19 Wellington Water offset/mitigation ideas meeting 4/11/19						Yes		**UPDATE:** No benefit to the marine environment; not required to address freshwater effects.
32	SH2 coastal escarpment - Harbour walkway concept	WCC offset/mitigation ideas meeting 22/10/19								Currently mixed ownership, including Council and private. Opportunities to purchase land along the escarpment and facilitate a coastal escarpment – Harbour walkway for recreational purposes? Would need to be a benefit not able to be achieved by other means. This might be difficult and primarily recreational rather than ecological benefits. **UPDATE:** No benefit to the marine environment.
33	SH2 coastal escarpment - Weed control	WCC offset/mitigation ideas meeting 22/10/19				Yes				Old man's beard infestations, including on Waka Kotahi / transit land. Potential to control. **UPDATE:** No benefit to the marine environment; not required to address vegetation effects.

#	IDEA / SUGGESTION	SOURCE	BENEFIT							NOTES
			Marine	Avifauna	Lizards	Vegetation	Terr. inverts	Freshwater habitat / biota	Water quality	
34	Mirimar Peninsula - opportunities for ecological restoration projects	WCC offset/mitigation ideas meeting 22/10/19		Yes	Yes	Yes				Northern end currently in LINZ ownership, but the land is to be transferred to DOC and managed by WCC as a Heritage Park. Not sure what that will entail at this stage, but likely opportunities for a number of ecological restoration / benefit projects. Several regionally threatened plant species present, as well as penguins. Options for native reveg, weed and pest control. Areas 4 and 5 are to be sold for housing, but potential for Waka Kotahi to purchase. **UPDATE:** No benefit to the marine environment; not required to address terrestrial effects.
35	Mirimar Peninsula - small stream at norther end - opportunities to improve?	WCC offset/mitigation ideas meeting 22/10/19						Yes?		**UPDATE:** No benefit to the marine environment; not required to address freshwater effects.
36	Identify and remedy fish barriers within WCC	WCC offset/mitigation ideas meeting 22/10/19						Yes		**UPDATE:** No benefit to the marine environment; not required to address freshwater effects.
37	Unnamed Stream (to the north of Horokiwi but south of Korokoro) - opportunities for pest management and general improvements?	WCC offset/mitigation ideas meeting 22/10/19		Yes?	Yes?	Yes?		Yes		**UPDATE:** No benefit to the marine environment; not required to address terrestrial effects.
38	Improvements to fish passage to and from Lake Kohangapiripiri	DOC, GWRC, mana whenua meeting 2/10/19 Email from GWRC 18/11/19 following meeting on 24/10/19						Yes		GWRC note this is within the Parangarahu Lakes Area KNE. **UPDATE**: No benefit to the marine environment; not required to address freshwater effects.
39	Improvements to fish passage through the Kaiwharawhara Stream	Email from GWRC 18/11/19 following meeting on 24/10/19						Yes		GWRC note this is within the Western Wellington Forests KNE. **UPDATE**: No benefit to the marine environment; not required to address freshwater effects.
40	Improvements to fish passage through the Korokoro Stream	Email from GWRC 18/11/19 following meeting on 24/10/19						Yes		GWRC note this is within the Belmont-Korokoro KNE. **UPDATE:** No benefit to the marine environment; not required to address freshwater effects.
41	Improvements at Baring Head/Ōrua-pouanui KNE	Email from GWRC 18/11/19 following meeting on 24/10/19		Yes	Yes					A KNE site with the most likely opportunities to implement offset/compensation measures relevant to the proposed shared path. **UPDATE:** No benefit to the marine environment; not required to address terrestrial effects.
42	Improvements at Parangarahu Lakes KNE	Email from GWRC 18/11/19 following meeting on 24/10/19		Yes	Yes					A KNE site with the most likely opportunities to implement offset/compensation measures relevant to the proposed shared path. **UPDATE:** No benefit to the marine environment; not required to address terrestrial effects.
43	Improvements at Wellington South Coast KNE	Email from GWRC 18/11/19 following meeting on 24/10/19		Yes	Yes					A KNE site with the most likely opportunities to implement offset/compensation measures relevant to the proposed cycleway/walkway. **UPDATE:** No benefit to the marine environment; not required to address terrestrial effects.

Appendix 6: Summary of known marine organism tolerance to sediment/mud

Sources: Gibbs & Hewitt (2004), Robertson & Stephens (2009) and Nicholls et al. (2009)

General Group	Taxa	Common Name	Tolerant / sensitive to mud	Reference
Amphipoda	*Amphipoda Unid.*	Amphipod	tolerant	Robertson and Stevens (2015) Porirua estuary Fine Scale Monitoring 2014/15, prepared by Wriggles for Greater Wellington regional Council.
Amphipoda	*Aora sp.*	amphipod	sensitive	Rod Asher (Biolive) Personal Communication (2017)
Amphipoda	*Caprellidae*	Caprillid amphipod	sensitive	expert opinion
Amphipoda	*Haustoridae*	Amphipod (family)	tolerant	Rod Asher (Biolive) Personal Communication (2017)
Amphipoda	*Lysianassidae*	Amphipod (family)	tolerant	Hurley & R. Cooper (1974) Preliminary description of a new species of *Paraw aldeckia (Crustacea Amphipoda: Lysianassidae*) from New Zealand (note), New Zealand Journal of Marine and Freshwater Research, 8:3, 563-567
Amphipoda	*Methalimedon sp.*	amphipod	tolerant	Hailes, S.F.; Hewitt, J.E. (2012). Manukau Harbour Ecological Programme: Report on data collected up until February 2011. Prepared by The National Institute of Water and Atmospheric Research for Auckland Council. Auckland Council Technical Report 2012/004.
Amphipoda	*Oedicerotidae sp*	amphipod	sensitive	Graham D. Fenwick (1983) Two new sand-dwelling amphipods from Kaikoura, New Zealand (Oedicerotidae and Lysianassidae), New Zealand Journal of Zoology, 10:2, 133-145.
Amphipoda	*Paradexamine pacifica*	amphipod	tolerant	Rod Asher (Biolive) Personal Communication (2017)
Amphipoda	*Phoxocephalidae*	Amphipod (family)	tolerant	Rod Asher (Biolive) Personal Communication (2017)
Amphipoda	*Pontophilus australis*	shrimp	tolerant	Hewitt & Funnell (2005) Benthic marine habitats and communities of the southern Kaipara. Auckland Regional Council, Technical Publication No. 275
Amphipoda	*Torridoharpinia sp*	phoxocephalidae amphipod	sensitive	Vonda J. Cummings, Rick D. Pridmore, Simon F. Thrush & Judi E. Hewitt (1995) Post-settlement movement by intertidal benthic macroinvertebrates: Do common New Zealand species drift in the water column?, New Zealand Journal of Marine and Freshwater Research, 29:1, 59-67
Amphipoda	*Liljeborgia sp*		sensitive	Rod Asher (Biolive) Personal Communication (2017)
Amphipoda	*Ampelisca sp.*	Amphipod (large)	tolerant	MA-25 and MA-28, Wareham, Plymouth and Bourne: Environmental Impact Statement, Volume 2
Ascidiacea	*Pyura lutea*	Sea Tulip	sensitive	Morton, J. E., & Miller, M. (1973). The New Zealand Sea Shore. Collins.
Ascidiacea	*Pyura sp.*	Sea squirt	sensitive	Morton, J. E., & Miller, M. (1973). *The New Zealand Sea Shore*. Collins.

General Group	Taxa	Common Name	Tolerant / sensitive to mud	Reference
Bivalvia	*Cyclomactra ovata*	bivalve	tolerant	A.G. Beu and J.I. Raine (2009). Revised descriptions of New Zealand Cenozoic Mollusca from Beu and Maxwell (1990). GNS Science miscellaneous series No. 27
Bivalvia	*Pleuromeris zealandica*	bivalve	sensitive	Rod Asher (Biolive) Personal Communication (2017)
Bivalvia	*Nucula hartvigiana*		sensitive	Hurley & R. Cooper (1974) Preliminary description of a new species of *Paraw aldeckia (Crustacea Amphipoda: Lysianassidae*) from New Zealand (note), New Zealand Journal of Marine and Freshwater Research, 8:3, 563-567
Bivalvia	*Arthritica bifurca*	Small bivalve	tolerant	Waikato Regional Council: Regional Estuary Monitoring Programme Website
Bivalvia	*Atrina zelandica*	Horse mussel	sensitive	
Bivalvia	*Diplodonta globus*	Small bivalve	sensitive	Rod Asher (Biolive) Personal Communication (2017)
Bivalvia	*Dosinia subrosea*	Fine biscuit shell	sensitive	Morley (2004) A photographic guide to seashells of New Zealand. New Holland.
Bivalvia	*Leptomya retiaria retiaria*	Small bivalve	sensitive	Morley (2004) A photographic guide to seashells of New Zealand. New Holland.
Bivalvia	*Modiolarca impacta (juveniles)*	Nesting Mussel	sensitive	No reference
Bivalvia	*Musculista senhousia*	Asian mussel	tolerant	Creese, Robert, Simon Hooker, Sharon De Luca, and Yvette Wharton. "Ecology and environmental impact of *Musculista senhousia* (Mollusca: Bivalvia: Mytilidae) in Tamaki Estuary, Auckland, New Zealand." New Zealand Journal of Marine and Freshwater Research. 31.2 (1997): 225-236.
Bivalvia	*Myllitella vivens vivens*	Small bivalve	sensitive	Rod Asher (Biolive) Personal Communication (2017)
Bivalvia	*Nucula nitidula*	Nut shell	sensitive	Brook, F. J., Grace, R. V., & Hayward, B. W. (1981). Soft-bottom benthic faunal associations of Tutukaka Harbour, Northland, New Zealand. *Tane*, *27*, 69-92.
Bivalvia	*Ostrea chilensis*	Flat oyster - Dredge Oyster	sensitive	Rod Asher (Biolive) Personal Communication (2017)
Bivalvia	*Paphies australis*	Pipi	sensitive	Hurley & R. Cooper (1974) Preliminary description of a new species of *Paraw aldeckia (Crustacea Amphipoda: Lysianassidae*) from New Zealand (note), New Zealand Journal of Marine and Freshwater Research, 8:3, 563-567.
Bivalvia	*Pecten novaezelandiae*	Scallop (Tipa)	tolerant	Cook, S. D. C. (2010). New Zealand coastal marine invertebrates. Canterbury University Press.

General Group	Taxa	Common Name	Tolerant / sensitive to mud	Reference
Bivalvia	*Theora lubrica*	Window shell	tolerant	Waikato Regional Council: Regional Estuary Monitoring Programme Website
Bivalvia	*Varinucula gallinacea*	Nut shell	sensitive	No reference
Bivalvia	*Zenatia acinaces*	Scimitar shell	sensitive	Cook, S. D. C. (2010). New Zealand coastal marine invertebrates. Canterbury University Press.
Bivalvia	*Gari stangeri*	Sunset shell	sensitive	Morley (2004) A photographic guide to seashells of New Zealand. New Holland.
Bivalvia	*Ruditapes largillierti*	Thick lipped buscuit shell	sensitive	Morley (2004) A photographic guide to seashells of New Zealand. New Holland.
Bryozoa	*Bryozoa (encrusting)*	Bryozoa	sensitive	Taylor, Paul D. "Secular Changes in Colony-Forms and Bryozoan Carbonate Sediments Through Geological History". Academic Search Premier. Sedimentology. Retrieved 23 October 2014.
Cirripedia	*Aaptolasma noleoria*	Barnacle	sensitive	No reference
Cirripedia	*Balanus sp.*	Barnacle	sensitive	Isaac, M.J. & J. Moyse, 1990. Crustacea I: Entomostraca. In: The Marine Fauna of the British Isles and North-West Europe (eds. Hayward and Ryland, 1990). Clarendon Press, Oxford.
Crustacea	*Nebalia sp.*	Small crustacean	tolerant	Song, J.-H.; Min, G.-S. (2016). A new species of *Nebalia (Malacostraca: Phyllocarida: Leptostraca)* from South Korea, with a key to the species of Nebalia Leach, 1814. Journal of the Marine Biological Association of the United Kingdom. 1-10.
Cumacea	*Cumacea*	Cumaceans	tolerant	Vargas, J. A. (1989). Seasonal abundance of *Coricuma nicoyensis* Watling and Breedy, 1988 (Crustacea: Cumacea) on a tropical mud flat. *Rev. Biol. Trop*, *31*, 207-211.
Cumacea	*Colurostylis lemurum*		tolerant	Sanchez, P., Demestre, M., Ramon, M., & Kaiser, M. J. (2000). The impact of otter trawling on mud communities in the northwestern Mediterranean. ICES Journal of Marine Science, 57(5), 1352-1358.
Cumacea	*Cyclapsis sp*		tolerant	Sanchez, P., Demestre, M., Ramon, M., & Kaiser, M. J. (2000). The impact of otter trawling on mud communities in the northwestern Mediterranean. ICES Journal of Marine Science, 57(5), 1352-1358.
Cumacea	*Diastylopsis elongata*		tolerant	Sanchez, P., Demestre, M., Ramon, M., & Kaiser, M. J. (2000). The impact of otter trawling on mud communities in the northwestern Mediterranean. ICES Journal of Marine Science, 57(5), 1352-1358.
Decapoda	*Decapoda (larvae Unid.)*	Unidentified Crab Larvae	sensitive	Rod Asher (Biolive) Personal Communication (2017)

General Group	Taxa	Common Name	Tolerant / sensitive to mud	Reference
Decapoda	*Halicarcinus sp.*		tolerant	Jones, M. B., Marsden, I, D., 2005, Life in the Estuary. Canterbury University Press. Raupō Pocket dictionary of modern Maori
Decapoda	*Hemiplax hirtipes*	Stalk-eyed Mud Crab	tolerant	Simons, M. J., & Jones, M. B. (1981). Population and reproductive biology of the mud crab, *Macrophthalmus hirtipes* (Jacquinot, 1853) (Ocypodidae), from marine and estuarine habitats. *Journal of Natural History*, *15*(6), 981-994.
Decapoda	*Macrophthalmus hirtipes*	crab	tolerant	Simons, M. J., & Jones, M. B. (1981). Population and reproductive biology of the mud crab, *Macrophthalmus hirtipes* (Jacquinot, 1853) (Ocypodidae), from marine and estuarine habitats. *Journal of Natural History*, *15*(6), 981-994.
Decapoda	*Notomithrax peronii*	Crab	tolerant	Griffin, D. J. G. (1966) The marine fauna of New Zealand: spider crabs, family Majidae (Crustacea, Brachyura). New Zealand Oceanographic Institute Memoir, 35: 1–111.
Decapoda	*Pagurus sp.*	Hermit Crab	sensitive	Burton, M., R. Burton. 2002. The International Wildlife Encyclopedia, Volume 1. New York: Marshall Cavendish Corporation.
Decapoda	*Palaemon affinis*	Estuarine Prawn	tolerant	A Guide to the Plants and Animals of the New Zealand Marine Studies Centre: McKinnon
Decapoda	*Philocheras sp.*	Shrimp	sensitive	Rod Asher (Biolive) Personal Communication (2017)
Decapoda	*Pinnotheres sp*	crab	sensitive	Rod Asher (Biolive) Personal Communication (2017)
Decapoda	*Pyromaia tuberculata*	Crab	sensitive	Rod Asher (Biolive) Personal Communication (2017)
Decapoda	*Notomitrax minor*		sensitive	Rod Asher (Biolive) Personal Communication (2017)
Decapoda	*Paguristes setosus*		sensitive	Burton, M., R. Burton. 2002. The International Wildlife Encyclopedia, Volume 1. New York: Marshall Cavendish Corporation.
Decapoda	*Unidentified hermit crab*		sensitive	Burton, M., R. Burton. 2002. The International Wildlife Encyclopedia, Volume 1. New York: Marshall Cavendish Corporation.
Decapoda	*Halicarcinus cookii*	Pill-box Crab	sensitive	Melrose, M. J. (1975) The marine fauna of New Zealand: Family Hymenosomatidae (Crustacea, Decapoda, Brachyura). New Zealand Oceanographic Institute Memoir 34: 1–123.
Decapoda	*Halicarcinus whitei*	Pill-box Crab	sensitive	Melrose, M. J. (1975) The marine fauna of New Zealand: Family Hymenosomatidae (Crustacea, Decapoda, Brachyura). New Zealand Oceanographic Institute Memoir 34: 1–123.

General Group	Taxa	Common Name	Tolerant / sensitive to mud	Reference
Echinodermata	*Patiriella regularis*	Cushion Star	sensitive	O'Loughlin, P.M., Waters, J.M., Roy, M.S. (2002) Description of a new species of *Patiriella* from New Zealand, and review of *Patiriella regularis (Echinodermata, Asteroidea*) based on morphological and molecular data. Journal of the Royal Society of New Zealand 32(4): 697–711.
Echinodermata	*Coscinasterias muricata*	11 arm sea star	sensitive	McKnight, D.G. (2006) The Marine Fauna of New Zealand: Asteroidea (sea-stars). 3. Orders Velatida, Spinulosida, Forcipulatida, Brisingida with addenda to Paxillosida, Valvatida. NIWA Biodiversity Memoir 120: 1–187.
Echinodermata	*Echinocardium sp.*		sensitive	Fell, H.B. (1952) Echinoderms from Southern New Zealand. Zoology Publications of Victoria University 18: 1–37.
Echinodermata	*Fellaster zelandiae*	sand dollar	sensitive	McKnight, D.G. (1979) An outline distribution of the New Zealand shelf fauna. Benthos survey, station list, and distribution of the Echinoidea. New Zealand Oceanographic Institute Memoir 47: 1–91.
Echinodermata	*Ophiuroidea*	Brittle stars	tolerant	Mills, V.S., O'Hara, T.D. (2013) Ophiuroids (Echinodermata: Ophiuroidea) of biogenic habitats on the continental shelf of New Zealand. Zootaxa 3613(5): 401–444.
Echinoidea	*Echinocardium cordatum*	Heart Urchin	sensitive	Degraer S., J. Wittoeck, W. Appeltans, K. Cooreman, T. Deprez, H. Hillewaert, K. Hostens, J. Mees, E. Vanden Berghe & M. Vincx (2006). The macrobenthos atlas of the Belgian part of the North Sea. Belgian Science Policy.
Echinoidea	*Echinocardium spat*	Heart Urchin	sensitive	Degraer S., J. Wittoeck, W. Appeltans, K. Cooreman, T. Deprez, H. Hillewaert, K. Hostens, J. Mees, E. Vanden Berghe & M. Vincx (2006). The macrobenthos atlas of the Belgian part of the North Sea. Belgian Science Policy.
Gastropoda	*Amalda sp*		tolerant	Morley (2004) A photographic guide to seashells of New Zealand. New Holland.
Gastropoda	*Cominella adspersa*	Speckled whelk	tolerant	Waikato Regional Council: Regional Estuary Monitoring Programme Website
Gastropoda	*Cominella glandiformis*	Estuarine whelk	sensitive	Hurley & R. Cooper (1974) Preliminary description of a new species of *Paraw aldeckia (Crustacea Amphipoda: Lysianassida*e) from New Zealand (note), New Zealand Journal of Marine and Freshwater Research, 8:3, 563-567
Gastropoda	*Duplicaria*	gastropod	tolerant	Cook, S. D. C. (2010). New Zealand coastal marine invertebrates. Canterbury University Press.
Gastropoda	*Epitonium tenellum*	Wentletrap shell	sensitive	Cook, S. D. C. (2010). New Zealand coastal marine invertebrates. Canterbury University Press.

General Group	Taxa	Common Name	Tolerant / sensitive to mud	Reference
Gastropoda	*Gastropoda Unid. Juv.*	Unidentified juvenile gastropod	sensitive	Rod Asher (Biolive) Personal Communication (2017)
Gastropoda	*Mauricolpus roseus*	gastropod	tolerant	http://seashellsofnsw.org.au/Turritellidae/Pages/Maoricolpus_roseus.htm accessed 13/02/14 Coastal Marine Inverts Vol 1
Gastropoda	*Nassarius burchardi*	Dog whelk	sensitive	Cook, S. D. C. (2010). New Zealand coastal marine invertebrates. Canterbury University Press.
Gastropoda	*Neoguraleus sp.*	Spiraled shell	sensitive	Cook, S. D. C. (2010). New Zealand coastal marine invertebrates. Canterbury University Press.
Gastropoda	*Pervicacia tristis*	Spiraled shell	sensitive	Rod Asher (Biolive) Personal Communication (2017)
Gastropoda	*Sigapatella sp.*	Slipper limpet	sensitive	Cook, S. D. C. (2010). New Zealand coastal marine invertebrates. Canterbury University Press.
Gastropoda	*Sigapatella tenuis*	Small circular slipper shell	sensitive	Cook, S. D. C. (2010). New Zealand coastal marine invertebrates. Canterbury University Press.
Gastropoda	*Splendrillia sp.*	Drill shell	sensitive	Rod Asher (Biolive) Personal Communication (2017)
Gastropoda	*Struthiolaria vermis vermis*	gastropod	tolerant	Cook, S. D. C. (2010). New Zealand coastal marine invertebrates. Canterbury University Press.
Gastropoda	*Xymene*	gastropod	tolerant	Morley (2004) A photographic guide to seashells of New Zealand. New Holland.
Gastropoda	*Zeacumantus sp.*	gastropod	tolerant	Rod Asher (Biolive) Personal Communication (2017)
Gastropoda	*Amalda novazelandiae*		tolerant	Morley (2004) A photographic guide to seashells of New Zealand. New Holland.
Gastropoda	*Cominella sp*		sensitive	Hurley & R. Cooper (1974) Preliminary description of a new species of *Paraw aldeckia (Crustacea Amphipoda: Lysianassidae*) from New Zealand (note), New Zealand Journal of Marine and Freshwater Research, 8:3, 563-567
Gastropoda	*Duplicaria tristis*		sensitive	Rod Asher (Biolive) Personal Communication (2017)
Gastropoda	*Struthiolaria papulosa*		sensitive	Rod Asher (Biolive) Personal Communication (2017)
Gastropoda	*Heterobranchia Unid.*	Slugs Marine	sensitive	Rod Asher (Biolive) Personal Communication (2017)
Gastropoda	*Philine auriformis*	White Slug	sensitive	Rod Asher (Biolive) Personal Communication (2017)
Gastropoda	*Philine sp*	White Slug	sensitive	Rod Asher (Biolive) Personal Communication (2017)
Gastropoda	*Amalda (gracilispira) northlandica*	Olive shell	tolerant	Morley (2004) A photographic guide to seashells of New Zealand. New Holland.

General Group	Taxa	Common Name	Tolerant / sensitive to mud	Reference
Gastropoda	*Amalda australis*	Olive shell	tolerant	Morley (2004) A photographic guide to seashells of New Zealand. New Holland.
Gastropoda	*Amalda depressa*	Olive shell	tolerant	Morley (2004) A photographic guide to seashells of New Zealand. New Holland.
Isopoda	*Isocladus*	Isopod group	sensitive	Rod Asher (Biolive) Personal Communication (2017)
Isopoda	*Valvifera*	Isopod group	sensitive	Rod Asher (Biolive) Personal Communication (2017)
Isopoda	*Unidentified isopod*		sensitive	Rod Asher (Biolive) Personal Communication (2017)
	Mysidacea	Mysid shrimp	tolerant	http://www.landcareresearch.co.nz/resources/identification/animals/freshwater-invertebrates/guide/jointed-legs/crustaceans/shrimps/mysid-shrimps
Nemertea	*Nemertea*	Proboscis worms	tolerant	
Osteichthyes	*Osteichthyes Unid.*	Fish Unid.	unknown	
Ostracoda	*Copytus novaezealandiae*	Ostracod	tolerant	Machado, C.P., Coimbra, J.C., Carrenõ, A.L., 2005. The ecological and zoogeographical significance of the subRecent Ostracoda of Cabo Frio, Rio de Janeiro State, Brazil. Marine Micropaleontology, 55, 235-253.
Ostracoda	*Diasterope grisea*	Ostracod	tolerant	Machado, C.P., Coimbra, J.C., Carrenõ, A.L., 2005. The ecological and zoogeographical significance of the subRecent Ostracoda of Cabo Frio, Rio de Janeiro State, Brazil. Marine Micropaleontology, 55, 235-253.
Ostracoda	*Neonesidea*	Ostracod	tolerant	Machado, C.P., Coimbra, J.C., Carrenõ, A.L., 2005. The ecological and zoogeographical significance of the subRecent Ostracoda of Cabo Frio, Rio de Janeiro State, Brazil. Marine Micropaleontology, 55, 235-253.
Ostracoda	*Parasterope quadrata*	Ostracod	tolerant	Machado, C.P., Coimbra, J.C., Carrenõ, A.L., 2005. The ecological and zoogeographical significance of the subRecent Ostracoda of Cabo Frio, Rio de Janeiro State, Brazil. Marine Micropaleontology, 55, 235-253.
Ostracoda	*Phylctenophora zealandica*	Ostracod	tolerant	Clark, D., Taylor, D., Keeley, N., Dunmore, R., Forrest, R., & Goodwin, E. (2011). *Assessment of effects of farming salmon at Ngamahau, Queen Charlotte Sound: deposition and benthic effects. Prepared for the New Zealand King Salmon Company Limited* (No. 1993, p. 52). Cawthron Report.

General Group	Taxa	Common Name	Tolerant / sensitive to mud	Reference
Ostracoda	*Scleroconcha arcuata*	Ostracod	tolerant	Clark, D., Taylor, D., Keeley, N., Dunmore, R., Forrest, R., & Goodwin, E. (2011). *Assessment of effects of farming salmon at Ngamahau, Queen Charlotte Sound: deposition and benthic effects. Prepared for the New Zealand King Salmon Company Limited* (No. 1993, p. 52). Cawthron Report.
Ostracoda	*Trachyleberis lytteltonsis*	Ostracod	tolerant	Clark, D., Taylor, D., Keeley, N., Dunmore, R., Forrest, R., & Goodwin, E. (2011). *Assessment of effects of farming salmon at Ngamahau, Queen Charlotte Sound: deposition and benthic effects. Prepared for the New Zealand King Salmon Company Limited* (No. 1993, p. 52). Cawthron Report.
Phoronida	*Phoronus sp.*	Horseshoe worms	sensitive	Rod Asher (Biolive) Personal Communication (2017)
Platyhelminthe	*Platyhelminthe*	worm	tolerant	Rod Asher (Biolive) Personal Communication (2017)
Polychaeta	*Neanthes sp*		tolerant	Kaplan et al. (1975) note that N. succinea and other large, mobile species are among the macrobenthos that are quickest to re-colonize sediments that had been disturbed by dredging.
Polychaeta	*Unidentified Nereid*		tolerant	Waikato Regional Council: Regional Estuary Monitoring Programme Website
Polychaeta: Ampharetidae	*Ampharetidae*	Polychaete worm	tolerant	
Polychaeta: Cossuridae	*Cossura consimilis*	Polychaete worm	tolerant	Waikato Regional Council: Regional Estuary Monitoring Programme Website
Polychaeta: Glyceridae	*Glyceridae*	Polychaete worm	tolerant	
Polychaeta: Hesionidae	*Hesionidae*	Polychaete Worm	sensitive	Robertson and Stevens (2015) Porirua estuary Fine Scale Monitoring 2014/15, prepared by Wriggles for Greater Wellington regional Council.
Polychaeta: Lumbrineridae	*Lumbrineridae*	Polychaete worm	tolerant	
Polychaeta: Magelonidae	*Magelona dakini*	Polychaete worm	sensitive	Rod Asher (Biolive) Personal Communication (2017)
Polychaeta: Maldanidae	*Maldanidae*	Bamboo Worms	tolerant	

General Group	Taxa	Common Name	Tolerant / sensitive to mud	Reference
Polychaeta: Nephtyidae	*Aglaophamus sp.*	Polychaete worm	sensitive	Waikato Regional Council: Regional Estuary Monitoring Programme Website
Polychaeta: Onuphidae	*Diopatra akarana*	Polychaete worm	sensitive	Rod Asher (Biolive) Personal Communication (2017)
Polychaeta: Onuphidae	*Onuphis aucklandensis*	Polychaete worm	tolerant	
Polychaeta: Oweniidae	*Myriochele sp.*	Polychaete worm	sensitive	Rod Asher (Biolive) Personal Communication (2017)
Polychaeta: Paraonidae	*Aricidea sp.*	Polychaete worm	tolerant	
Polychaeta: Pectinariidae	*Pectinaria australis*	Polychaete worm	tolerant	
Polychaeta: Phyllodocidae	*Phyllodocidae*	Paddle worms	tolerant	
Polychaeta: Sabellariidae	*Sabellaria kaiparaensis*	Polychaete worm	tolerant	Rod Asher (Biolive) Personal Communication (2017)
Polychaeta: Sabellidae	*Euchone pallida*	Fan worm	tolerant	Rod Asher (Biolive) Personal Communication (2017)
Polychaeta: Sabellidae	*Sabella sp.*	Umbrella worm	invasive	
Polychaeta: Serpulidae	*Hydroides elegans*	Fan worm	sensitive	
Polychaeta: Sigalionidae	*Sigalionidae*	Polychaete worm	sensitive	
Polychaeta: Spionidae	*Paraprionospio pinnata*	Polychaete worm	tolerant	
Polychaeta: Spionidae	*Polydora sp.*	Polychaete worm	tolerant	
Polychaeta: Spionidae	*Prionospio yuriel*	Polychaete worm	sensitive	Hurley & R. Cooper (1974) Preliminary description of a new species of *Paraw aldeckia (Crustacea Amphipoda: Lysianassidae*) from New Zealand (note), New Zealand Journal of Marine and Freshwater Research, 8:3, 563-567

General Group	Taxa	Common Name	Tolerant / sensitive to mud	Reference
Polychaeta: Spionidae	*Scolecolepides benhami*	Polychaete worm	tolerant	Robertson & Stevens (2015) Porirua estuary Fine Scale Monitoring 2014/15, prepared by Wriggles for Greater Wellington regional Council.
Polychaeta: Spionidae	*Spionidae (unid)*	Polychaete worm	tolerant	Kerckhof, F., & Faasse, M. A. (2014*). Boccardia proboscidea* and *Boccardiella hamata* (Polychaeta: Spionidae: Polydorinae), introduced mud worms new for the North Sea and Europe, respectively. *Marine Biodiversity Records*, *7*.
Polychaeta: Magelonidae	*Magelona dakini*	Polychaete worm	unknown	Waikato Regional Council: Regional Estuary Monitoring Programme Website
Polychaete: Orbiniidae	*Orbinia papillosa*	Polychaete worm	sensitive	Waikato Regional Council: Regional Estuary Monitoring Programme Website
Polychaeta: Terebellidae	*Terebellidae*	Polychaete worm	tolerant	Hutchings, P.A.;Smith, R.I. 1997 : Descriptions of new species and comments on previously described species of terebellid polychaetes from New Zealand and Australia Bulletin of Marine Science 60: 324-349.
Polychaeta: Spionidae	*Boccardia sp.*	Polychaete worm	tolerant	Lleonart, M., Handlinger, J., & Powell, M. (2003). Treatment of spionid mud worm (*Boccardia knoxi* Rainer) infestation of cultured abalone. *Aquaculture*, *217*(1), 1-10.
Polychaeta: Spionidae	*Prionospio multicristata*	Polychaete worm	tolerant	Clark, D., Taylor, D., Keeley, N., Dunmore, R., Forrest, R., & Goodwin, E. (2011). *Assessment of effects of farming salmon at Ngamahau, Queen Charlotte Sound: deposition and benthic effects. Prepared for the New Zealand King Salmon Company Limited* (No. 1993, p. 52). Cawthron Report.
Polychaeta: Polynoidae	*Polynoidae*	Scale worms	tolerant	Clark, D., Taylor, D., Keeley, N., Dunmore, R., Forrest, R., & Goodwin, E. (2011). *Assessment of effects of farming salmon at Ngamahau, Queen Charlotte Sound: deposition and benthic effects. Prepared for the New Zealand King Salmon Company Limited* (No. 1993, p. 52). Cawthron Report.
Polychaeta: Syllidae	*Sphaerosyllis sp.*	Polychaete worm	tolerant	Clark, D., Taylor, D., Keeley, N., Dunmore, R., Forrest, R., & Goodwin, E. (2011). *Assessment of effects of farming salmon at Ngamahau, Queen Charlotte Sound: deposition and benthic effects. Prepared for the New Zealand King Salmon Company Limited* (No. 1993, p. 52). Cawthron Report.
Polychaeta: Goniadidae	*Goniada sp.*	Polychaete worm	tolerant	Clark, D., Taylor, D., Keeley, N., Dunmore, R., Forrest, R., & Goodwin, E. (2011). *Assessment of effects of farming salmon at Ngamahau, Queen Charlotte Sound: deposition and benthic effects. Prepared for the New Zealand King Salmon Company Limited* (No. 1993, p. 52). Cawthron Report.

General Group	Taxa	Common Name	Tolerant / sensitive to mud	Reference
Polychaeta: Cirratulidae	*Cirratulidae*	Polychaete worm	tolerant	Clark, D., Taylor, D., Keeley, N., Dunmore, R., Forrest, R., & Goodwin, E. (2011). *Assessment of effects of farming salmon at Ngamahau, Queen Charlotte Sound: deposition and benthic effects. Prepared for the New Zealand King Salmon Company Limited* (No. 1993, p. 52). Cawthron Report.
Porifera	*Axinella sp.*	Yellow finger sponge	tolerant	Robertson and Stevens (2015) Porirua estuary Fine Scale Monitoring 2014/15, prepared by Wriggles for Greater Wellington regional Council.
Porifera	*Sponge (bread)*	Sponge Unid.	tolerant	Robertson and Stevens (2015) Porirua estuary Fine Scale Monitoring 2014/15, prepared by Wriggles for Greater Wellington regional Council.
Priapula	*Priapula*	Priapularins	tolerant	Robertson and Stevens (2015) Porirua estuary Fine Scale Monitoring 2014/15, prepared by Wriggles for Greater Wellington regional Council.
Tanaidacea	*Tanaid sp.*	Tanaid Shrimp	tolerant	
Anthozoa	*Edwardsia*		tolerant	Robertson and Stevens (2015) Porirua estuary Fine Scale Monitoring 2014/15, prepared by Wriggles for Greater Wellington regional Council.
Hemichordata	*Hemichordata*	Acorn worm	tolerant	Deland C, Cameron CB, Rao KP, Ritter WE, Bullock TH (2010) A taxonomic revision of the family Harrimaniidae (Hemichordata: Enteropneusta) with descriptions of seven species from the Eastern Pacific. Zootaxa 2408: 1-30

Appendix 7: Copy of Aecom (2019a) report

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22 December 2019

David Gedney
Associate Director
AECOM, Wellington

Dear David

N2P SH2 Stormwater Quality Design Memorandum -Version 2

1.0 Introduction

AECOM is currently engaged by NZTA to undertake consenting design of Ngauranga to Petone (N2P) along with other technical specialists. The project provides a 5m wide path between the Ngauranga interchange and Petone foreshore and will be constructed primarily on reclaimed land along the seaward side of the Wairapa rail line, protected from coastal erosion by a revetment structure. The path runs parallel to the Kiwirail corridor and State Highway 2 (SH2).

One of the options under consideration to compensate for effects of the project on marine ecology values is to improve the quality of stormwater run-off entering the harbour from SH2. AECOM has been instructed by NZTA to provide a high-level concept design and advice memorandum on the feasibility of treating stormwater runoff from the approximately 5km stretch of State Highway (SH2) between Ngauranga and Petone, ignoring other contributors to the systems such as KiwiRail and the hillside catchment to the north west of the project area (Figure 1).

AECOM submitted a high level concept and design memorandum on 22/11/2019 that recommends the practicality of water treatment devices to treat stormwater run-off to reduce the Total Suspended Solids (TSS) by up to 75% from the road surfaces.

NZTA has requested AECOM to undertake further analysis on the contaminant load generated from the existing road surfaces and the reduction of contaminant after the devices have been installed. Section 7.0 has been added that addresses the contaminant load generated from N2P SH2 and the reduction of load after the management options are in place.

Figure 1: Ngauranga to Petone (N2P) Cycleway/Walkway (Source: NZTA)

2.0 Objectives

The objective of the work is to undertake a review of the existing SH2 stormwater management system and determine the suitability and of stormwater quality devices to treat stormwater run-off to reduce the Total Suspended Solids (TSS) by up to 75% from the road surface. This memorandum will further advise on the associated high-level costs for the installation and maintenance of water quality treatment devices. It is to be noted that the work relies on the level of detail in the data made available from NZTA and collected from other sources as inputs to the work, and hence the scope is limited to concept only for consent purposes.

3.0 Data review

The following information was received from NZTA (Refer Appendix A)

1. Catchpits and road culverts along SH2 – The road culverts belong to Wellington City Council (WCC) and Hutt City Council (HCC). The culverts essentially pass flow from the hilly catchment to the north west of SH2 to the coastal marine area (CMA). Figure 2 below shows that the north bound and south bound lane drains to those culverts via roadside spoon drains and catchpit systems.

Figure 2: Catchpits and road culverts (Source NZTA)

2. Overland flow paths – The overland flow data from NZTA shows that both the north bound and southbound lanes drain to either side of the road and towards the central barrier. A small number of catchpits and grated drains have been identified along the central barrier of SH2.

Catchment areas have been identified with the help of aerial imagery and culvert locations as shown in Figure 2 above.

4.0 Catchment Area

From the data review, it is understood that the stormwater runoff from SH2 currently drain to several pipe culverts via road side drains and catchpits. Therefore, the point of concentration of each catchment has been assumed to be the catchpits in the proximity of the existing road culverts. The catchment area has been identified and mapped based on the assumption that flows from SH2 between two culverts distribute evenly. There are an approximate total of 48 catchments (24 in the northbound lane and 24 in the southbound lane totalling 11.5ha). The catchment boundaries can be further refined if/when the detailed road geometry/contours are available. Catchment areas are shown in Appendix B.

5.0 Run-off calculation

NZTA “Stormwater Treatment Standard for State Highway Infrastructure” recommends a 2-year, 1hour storm duration be used for water quality design. The 2-year, 1hour rainfall intensity for the water quality flow rate in the project area is 17.9mm/hr (Wellington Regional Council Standards).

A climate change factor has been allowed in accordance with Table 5.2 of Climate Change Effects and Impact Assessment: A Guidance Manual for Local Government in New Zealand (Ministry for the Environment, 2008), using a temperature increase of 2.1 degrees by 2090.

The rationale formula has been used to estimate water quality peak flows for each catchment (refer to Regional Standard for Water Services – WCC, HCC, UHCC and PCC). A Runoff Coefficient of 0.95 has been used considering SH2 is fully paved.

The calculation has been presented in Appendix C.

6.0 Stormwater quality

Construction of the proposed cycleway/walkway will require work in the CMA, including reclamation to create new land. The New Zealand Coastal Policy Statement (NZCPS) states that reclamation should be avoided unless there is a clear need for it, there are no practicable alternatives, and it will provide significant regional or national benefit.

Considering the cycle path project will bring significant benefits to the community in terms of better connectivity and resilience to coastal erosion risks, Policy 11 of the NZCPS require that the project mitigate (off-set) the impacts on the CMA. Currently no stormwater quality treatment is in place in SH2 between Ngauranga to Petone. Therefore, improvements to the quality of stormwater run-off from SH2 will help to compensate some of the impacts on coastal marine environment.

6.1 Water quality devices

Auckland Council GD01 has guidelines on stormwater management devices to provide attenuation and treatment. SH2 discharges directly to the sea outfalls and no stormwater attenuation is required, therefore the treatment devices selected are for water quality flows only. The following options have been assessed to provide water quality treatment devices.

6.1.1 Swale

Swales are shallow open drains (grassed or vegetated) that provide water quality treatment, primarily via interception by vegetation, as runoff flows along the surface of the swale. Swales are generally constructed using in situ topsoil, rather than engineered media. Any underdrain serves to de-water the swale between events, so that soils can dry out completely.

A swale requires a significant width alongside SH2. The Kiwirail corridor runs along parallel to the southbound lane and although there is a narrow path which could be available space following completion of the N2P project this is considered insufficient in width. The northbound lane is bordered with a steep hill spreading to the north west of SH2.

Therefore a swale cannot be constructed along the road corridor due to space constraints and has been discounted.

6.1.2 Bioretention devices

Bioretention is a stormwater management practice where runoff is filtered through a vegetated filter bed made of natural soil or engineered media. It performs a water quality function by removing both particulate and dissolved contaminants and reducing runoff temperature.

Typical bioretention devices are rain gardens and tree pits. Stormwater from the road/footpath are designed to flow to the rain garden/tree pits to provide soil moisture necessary to grow plants and trees. A perforated pipe collects the excess detention volume and discharge through an outlet pipe to the storm water system.

Bioretention devices require open space to grow plants and trees. Once again there is insufficient space available for this type of device, so they have been discounted.

6.1.3 Gross Pollutant Traps (GPTs)

Gross Pollutant Traps (GPTs) are devices that screen coarse contaminants such as plastic, litter, leaves or oils, to pre-treatment of sediments prior to filtration devices, ponds or wetlands. They are not effective to treat finer sediment and dissolved nutrient. Some of the GPTs available in the market are Vortcapture, Vortech, Enviorpod, Littatrap etc. GPTs can be installed in the existing road catchpits, but they require frequent maintenance which is not practical on SH2. GPTs alone are not effective to treat 75% TSS. GPTs combined with filtration devices can treat up to 75% TSS and reduce the overall treatment cost.

GPTs may be considered suitable if combined with PFDs (explained below).

6.1.4 Proprietary Filtration Devices (PFDs)

The proprietary filtration devices (PFDs) have been developed to remove an array of contaminants, including sediment, heavy metals and nutrients, and to meet the most stringent regulatory authority requirements. PFDs can be installed underground and in-line with existing stormwater system and can remove up to 75% TSS. Some of the PFDs available in the market are Stormfilter, UpFlo filter, First defence etc. PFDs can be used in the project to treat heavy metals, grease and other ‘contaminant of concern’ in road highways. PFDs are the suitable devices for SH2.

6.1.5 Ponds/Wetlands

Ponds and wetlands provide both water quality treatment and stormwater attenuation. Since attenuation is not a requirement in the project area, and the fact that ponds/wetlands require significant open space, provision of such devices has been discounted.

6.2 Summary of device options and cost (Supplied by SW360)

From the discussion above, proprietary filtration devices (PFDs) are the most feasible treatment solution due to lower maintenance requirements and high TSS removal. They can be installed underground, and in line with the existing stormwater system. PFDs can be designed to bypass high flows.

Stromwater360 (SW360) and Hynds (suppliers of PFDs) have been contacted for suitable product options and sizing. We have only received a recommendation from SW360 at the concept design stage. They advise that cost of treatment of 48 isolated catchment would be very high and not practical from an operation and maintenance stand-point. The catchments should be combined for a cost-effective solution. Since a precise network design and road geometry/contours are not available, it is difficult to assess if the catchment areas are connected or practically connectable. Therefore, Stormwater360 could not provide individual catchment area treatment devices, but rather provided a generic design based on a catchment area of 10,000m^2 per device.

6.2.1 NZTA informed design (calculation attached)

SW360 provided information on design factors affecting the standard device based on experience in treatment quality and O&M considerations of use in a highway setting.

To summarise these learnings:

- An increase in the sediment loading from a standard design is taken into account. Standard design uses 300kg/ha/year sediment loading, which is increased to 600kg/ha/year due to the traffic volumes on the highway;

- The specific type of contaminants from high volume highways differs from typical urban stormwater pollution in that there is an expected increase in dissolved heavy metals. SW360 standard treatment device use perlite filtration media, but with NZTA informed design, SW360 has developed a blend called ZPG which contains a mixture of zeolite, perlite and GAC (granulated activated carbon) which together provides enhanced filtration of particulate and dissolved heavy metals. Additionally, SW360 designs the filtration cartridges to increase the contact time the stormwater has with the filtration media (by restricting treatment flow) to further enhance the chemical filtration effects of the dissolved components.

- SW360 takes maintenance frequency into consideration for the design. Typically, NZTA projects are designed to have no less than 12 months designed maintenance frequencies due to the cost and time involved with closing lanes for maintenance.

6.2.2 Recommended device and unit cost

Although NZTA "Stormwater Treatment Standard for State Highway Infrastructure" recommends 2-year, 1 hour storm duration be used for water quality design, SW360 use Auckland Council's (GD01) statistical analysis that suggests that 10mm/hr constant rainfall intensity should be used. This will treat run-off from approximately 90% of the annual rainfall (and is equivalent to 25mm of water quality volume). Therefore 10mm/hr rainfall intensity has been used by SW360 to design their devices according to this information.

SW360 recommends following device to be suitable for treating stormwater from SH2 (refer to Appendix D for calculation). Per hectare (10,000m^2) treated:

- StormFilters: 25 filter cartridges per device x 69cm ZPG media with increased contact time for enhanced dissolved metals filtration.
- Vault details: 5.5m(L) x 2.4m(W) x 1.8m(H) with an internal forebay, considered pre-treatment of gross pollutants
- Catchment area treated: 10,000m^2/device (1Ha)
- Designed sediment loading: 600kg/ha/year
- Calculated using Rational Method with i=10mm/hr and C=0.95
- Driving Head requirement for this device = 930mm
- Estimated maintenance frequency: 12 months
- Rough costing: $95,500.00 plus GST & freight

In NZTA preferred standards, a gross pollutant trap can be installed for sediment pre-treatment (as opposed to the forebay) which will downsize the sediment loading calculation for the stormfilter. This is an economical design when considering larger stormfilters.

Total catchment area is 11.5ha, therefore 12 devices are required. Using the unit cost of each device and dividing total catchment area into 12 number 1ha catchments, the total cost of Stormfilter would be in the range of $1.16M (excluding GST, freight, installation, TMP, Confined Space Entry, Cartridge exchange).

6.2.3 Maintenance

Maintenance of Stormfilter devices varies per site and per product, depending on the specific contaminant and sediment loading coming of the contributing catchment. Maintenance frequency for stormfilters is typically recommended to be between 12 to 24 months. Annual inspection of the devices for each site will inform the requirement of full maintenance/replacement of the filter cartridges.

7.0 Contaminant Load Assessment

The contaminant load generated from the existing road surfaces and the reduction of contaminants after the devices have been installed have been assessed in this section. The Auckland Regional Council's (ARC) Contaminant Load Model (CLM) methodology has been used for the assessment. The Contaminant Load Model (CLM) was first developed in 2006, and is now used within the Auckland region and nationally.

7.1 Suitability of CLM in N2P SH2 project area

The primary purpose of the CLM methodology is to assess contaminant loads generated in a large catchment area of mixed urban land use. In general, the larger and more heterogeneous the urban area, the more reliable the model load estimates will be. The model estimates the annual loads of total suspended solids (TSS), total zinc (TZn), total copper (TCu) and total petroleum hydrocarbons (TPH).

Auckland Council's Technical Report 004 (Development of the CLM) discusses the application of CLM elsewhere in NZ. The source yields for TSS are dependent on rainfall patterns and soil types of the catchment, and therefore TSS load estimation could be significantly different from those in Auckland. Thereover TSS yield should be replaced with local data from either monitored sources or model application of similar projects in the nearby area. The model can predict contaminants (Zn, Cu and TPH) generated from the road surfaces reasonably well for most urban areas in New Zealand.

It should be noted that Technical Report 25 of NZTA has a case study of contaminant load assessment in the Mackay to Peka Peka Expressway (M2PP) in Wellington. However, the model was not validated or assessed in terms of its applicability to the Wellington region.

The suitability of the model to the Wellington region was assessed as part of the environmental effects assessment undertaken by NZTA on the Transmission Gully project (Transmission Gully Project Assessment of Water Quality Effects, Technical Report 15, 2011). From this assessment, it was concluded that it was appropriate to use the ARC CLM to model the estimated contaminant loads for the Transmission Gully Project.

N2P SH2 project area lies to the south of the Transmission Gully project. The model is therefore likely to be appropriate for N2P SH2 catchment area.

Iqbal Idris, Principal Network Engineer of NZTA has advised that there is no actual contaminant sampling data available with NZTA for the N2P SH2 project area.

Stromwater360 advised that their devises are designed for maximum 600kg/ha/year TSS load removal. This is a conservative approach for State Highway project.

7.2 Contaminants of Concern

N2P SH2 catchment is a impervious road catchment. Within the road catchment, vehicle tyres are the dominant sources of zinc (Zn) and vehicle brake pads are dominant sources of copper (Cu). The oil and grease (Total Petroleum Hydrocarbon, TPH) generated on the road surfaces also mix with stormwater run-off and discharge to the marine coastal area.

Total Suspended Solids (TSS) is produced from the pervious catchment, such as residential and commercial areas, parks and gardens, sports grounds, open grasslands etc. TSS load reduces as the impervious surface areas increase. Considering N2P SH2 is a impervious catchment, thereover, TSS is not a major 'contaminant of concern' in N2P SH2.

7.3 Traffic Loading

In CLM, the contaminant load generated from roads requires input of the length of all roads within the catchment and average vehicle per day (vpd). The total length of the road from Ngauranga to Petone is 5 km. State Highway traffic volumes 1975–2018 data has been used to estimate vehicle loading.

For N2P SH2, the vpd for the southbound and northbound lanes is 34,580 and 34,755 respectively. Therefore total vehicles per day for N2P SH2 is 69,335 vpd (or 70,000vpd)

7.4 Contaminant yields

The contaminant yields (refer to Table 1) for Zn, Cu and TPH have been used from Appendix B of Auckland Council's Technical Report 003 (Contaminant Load User Manual)

The CLM was developed for urban catchments in Auckland region which typically have 10% to 30% paved area. Therefore the TSS yields used in the CLM needs readjustment given that N2P SH2 catchment is 100% impervious. The objective of the work is to estimate the reduction of contaminant load after water quality devices have been installed. In the absence of actual field data, design criteria of StormFilter have been used for TSS yield. StormFilter has been designed for 600 kg/ha/year. SW360 confirm that this is a conservative estimate for NZTA's State Highway projects so as to have a minimum maintenance frequency of 1 year. Therefore a TSS yields of 60 g/m^2/year has been used for N2P SH2.

Table 1: Contaminant yields (g/m^2/year) used in the CLM

Road Classification Vehicles/day	TSS yield	Zinc Yield	Copper yield	Hydrocarbon yield
<1000		0.004	0.001	0.034
1000-5000		0.027	0.009	0.201
5000-20000		0.111	0.037	0.839
20000-50000		0.257	0.086	1.947
50000-100000	60	0.471	0.157	3.565
>100000		0.729	0.243	5.519

7.5 Management Options

As discussed in Section 4, the stormwater runoff from SH2 currently drain to several pipe culverts via road side drains and catchpits. Stormwater from catchpits will feed in to the Stormfilters and then to the culverts underneath SH2. Each management option in the CLM uses a Load Reduction Factor (LRF) for different contaminants. The following LRF for catchpits and StormFilters have been used in N2P SH2 as shown in Table 2.

Table 2: LRF used in N2P SH2

Treatment Option	TSS	Zn	Cu	TPH
Catchpits	0.2	0.11	0.15	0.15
Storm-filter	0.75	0.4	0.65	0.75

7.6 Contaminant Load calculation

The CLM calculates the annual load for each contaminant source using the following equation:

Source Load = Source Area X Source Yields X Load Reduction Factor X Area Fraction Managed

The following parameters have been used to calculate annual contaminant load.

- Vehicle per day – 50,000vpd - 100,000vpd
- Total length of catchment – 5000m
- Management train – catchpit and stormfilters

Table 3 presents initial and reduced loads for contaminants (kg/year)..The initial annual load estimates for TSS, Zn, Cu and TPH are 7200kg/year, 56.53kg/year, 18.8kg/year and 427.7kg/year respectively.

This will be reduced by 80%, 47%, 70% and 79% respectively after installation of Stormfilters. The detailed calculations are enclosed in Appendix F.

Table 3: Initial load and reduced load (kg/year)

Contaminants	Initial Load (kg/year)	Reduced load (kg/year)	% reduction
TSS	7200	1440	80%
Zinc	56.5	30.2	47%
Copper	18.8	5.6	70%
TPH	427.8	90.9	79%

8.0 Conclusion

Based on the analysis by AECOM, and the recommendations of SW360, 25 No Stormfilter cartridges will be required to treat each 1ha catchment area, hence a minimum of 1 large vault unit per hectare of road surface. The number of filter cartridges required to treat the overall 11.5ha catchment is approximately 288 with a purchase price of $1.16M for the road area in consideration. The cost of installation depends upon the approach taken, and we have provided some high-level costings in the attachment to this letter.

Option 1 - Retro-fit onto existing SW System

The existing system has been assessed as 48 separate catchments given the existing stormwater infrastructure in place. To treat each catchment would require the installation at the outfall from each system. The total cost of this is estimated as $3.9M, including a 25% contingency.

Approximate maintenance cost per annum $0.5M

Option 2 - 12 units on optimised catchments (NZTA SW system improvements not included)

In order to make the systems more efficient, SW360 recommends that the number of catchments be reduced to 12, each approx. 1 ha. This will provide a more cost-effective solution in terms of operation and maintenance but will increase the cost and disruption associated with the installation of the system.

The total cost of this is estimated as $2.5M, including a 25% contingency, but **excluding the cost of modifications to the existing network** to consolidate the catchments. Note: significant works would be necessary to connect/combine the catchment areas, i.e. investigations, design and construction. This is not a project cost and will need to be funded separately by NZTA.

Approximate maintenance cost per annum $0.5M

SW360 confirms that the Stormfilter meets >75% TSS removal and has been used in the NZTA projects successfully for water quality improvements.

9.0 Recommendation

Of the two options considered above AECOM recommends Option 1.

AECOM Imagine it. Delivered.

Yours faithfully

Prag Goswami
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APPENDICES

Appendix A: NZTA drainage map

Appendix B: Catchment areas

Appendix C: Water quality flow calculation (NZTA “Stormwater Treatment Standard for State Highway Infrastructure”)

Appendix D: Calculation for device selection (SW360 NZTA informed design)

Appendix E: Rough order costs

Appendix F: Contaminant Load Model spreadsheet

APPENDIX A

NZTA Drainage map


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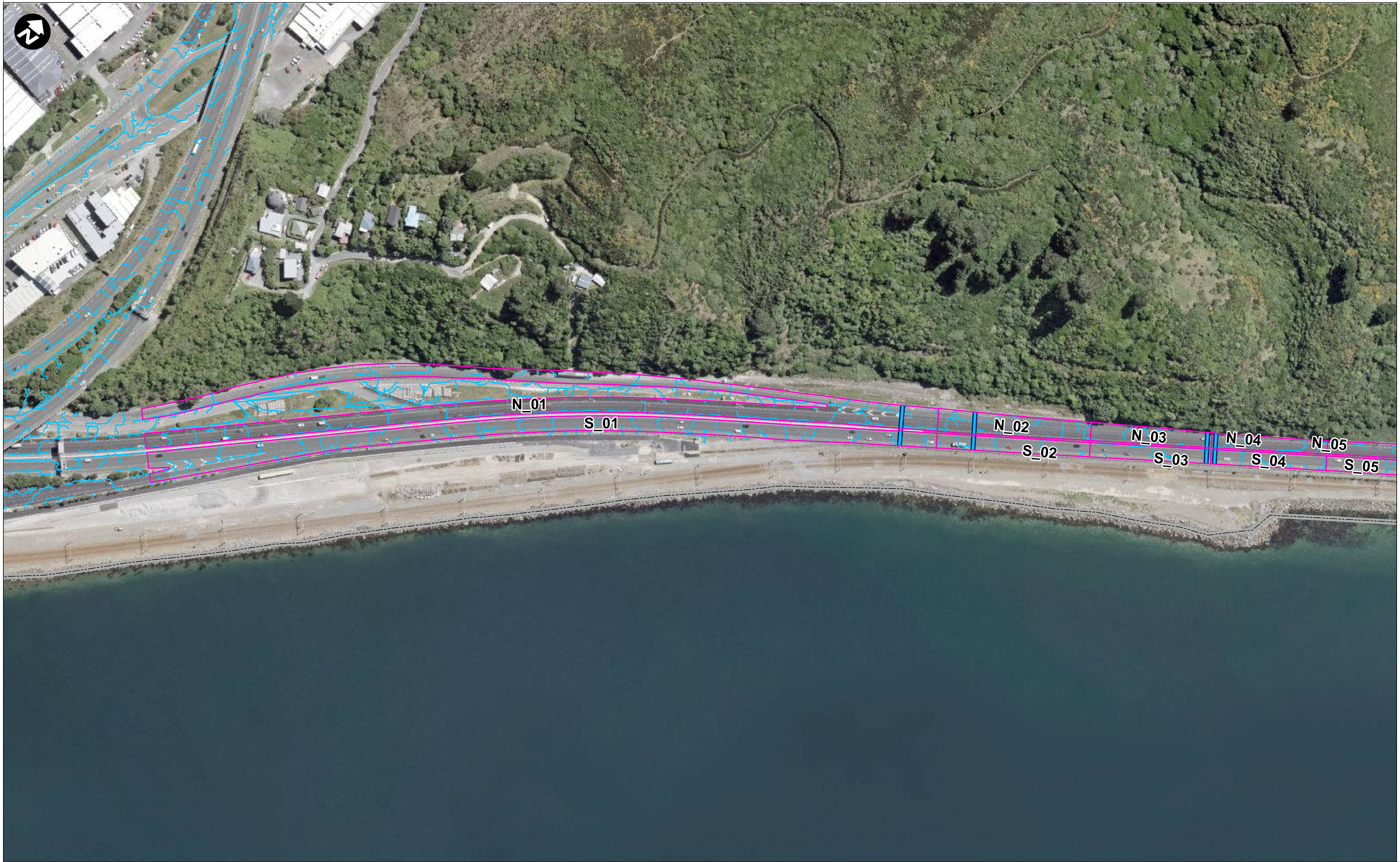
APPENDIX B

Catchment areas

ISO A3 297mm x 420mm



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KEY PLAN

Land Information New

SPATIAL REFERENCE

Scale: 1:2,500 (A3 size)

20 10 0 20 40 Meters

Map features depicted in terms of NZTM 2000 projection.

Data Sources:
Cadastral Boundaries – LINZ NZ Cadastral Dataset 2016

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Approved		Date	
Checked	P. Goswami	Date	
Designed	M. Bryant	Date	
Drawn	M. Bryant	Date	12/11/2019

ISSUE/REVISION

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PROJECT NUMBER

60306339

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MAP NUMBER

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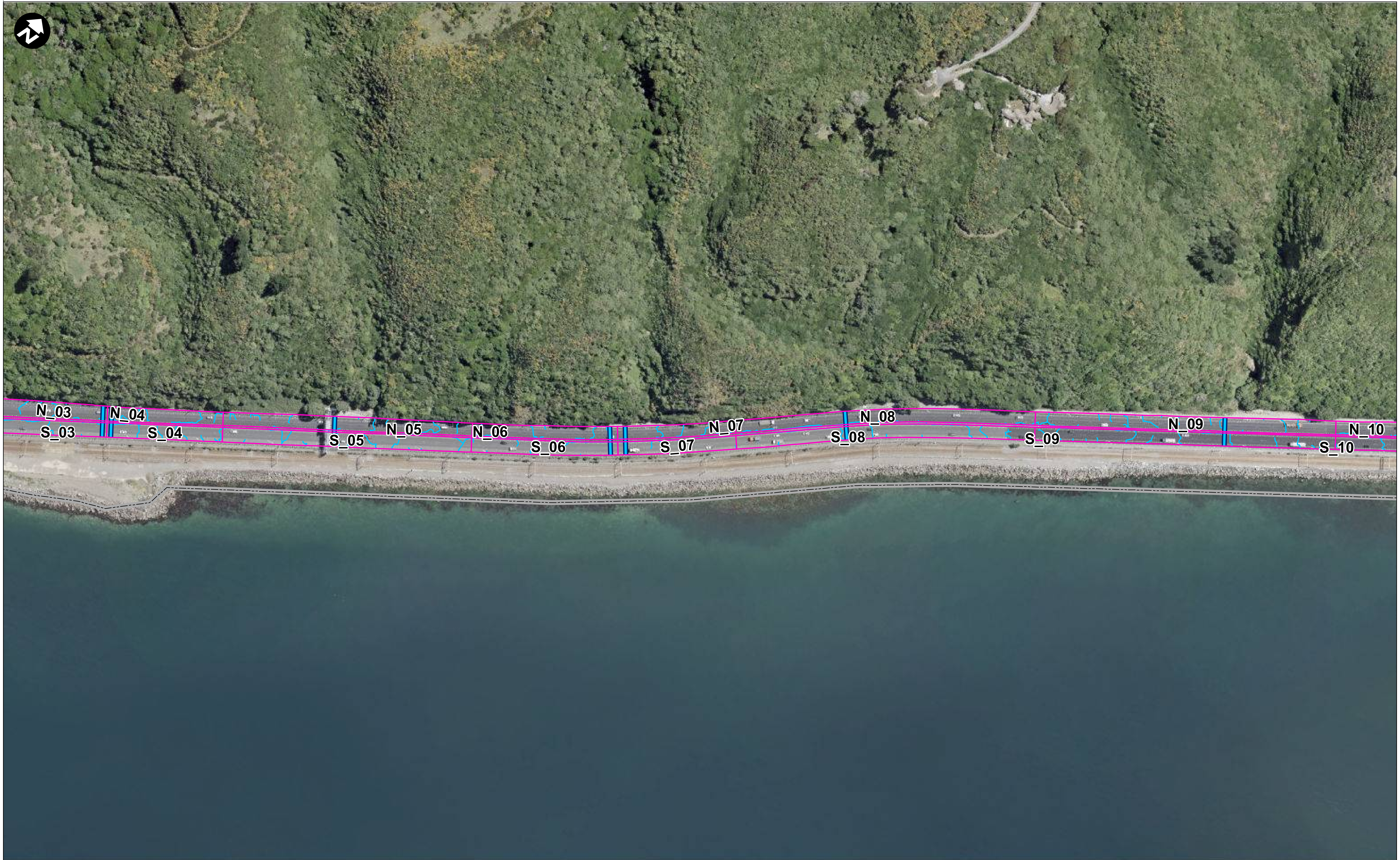

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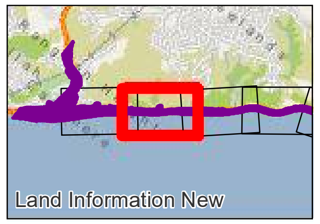

SPATIAL REFERENCE

Scale: 1:2,500 (A3 size)

20 10 0 20 40 Meters

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A	99.99.99	Xxxxx Xxxxx Xxxxx

PROJECT NUMBER

60306339

SHEET TITLE

MAP NUMBER

60306339_00_001_02

ISO A3 297mm x 420mm

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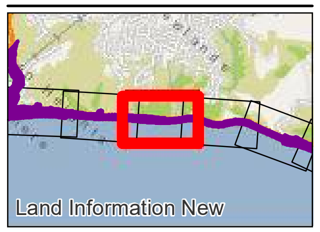

SPATIAL REFERENCE

Scale: 1:2,500 (A3 size)

20 10 0 20 40 Meters

Map features depicted in terms of NZTM 2000 projection.

Data Sources:
Cadastral Boundaries – LINZ NZ Cadastral Dataset 2016

PROJECT MANAGEMENT

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Checked	P. Goswami	Date	
Designed	M. Bryant	Date	
Drawn	M. Bryant	Date	12/11/2019

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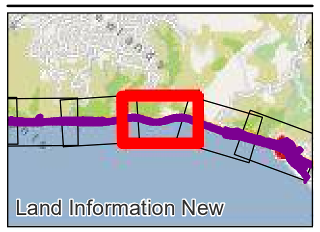

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PROJECT MANAGEMENT

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Drawn	M. Bryant	Date	12/11/2019

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A	99.99.99	Xxxxx Xxxxx Xxxxx

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60306339

SHEET TITLE

MAP NUMBER

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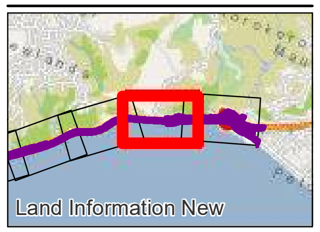

SPATIAL REFERENCE

Scale: 1:2,500 (A3 size)

20 10 0 20 40 Meters

Map features depicted in terms of NZTM 2000 projection.

Data Sources:
Cadastral Boundaries – LINZ NZ Cadastral Dataset 2016

PROJECT MANAGEMENT

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Drawn	M. Bryant	Date	12/11/2019

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PROJECT NUMBER

60306339

SHEET TITLE

MAP NUMBER

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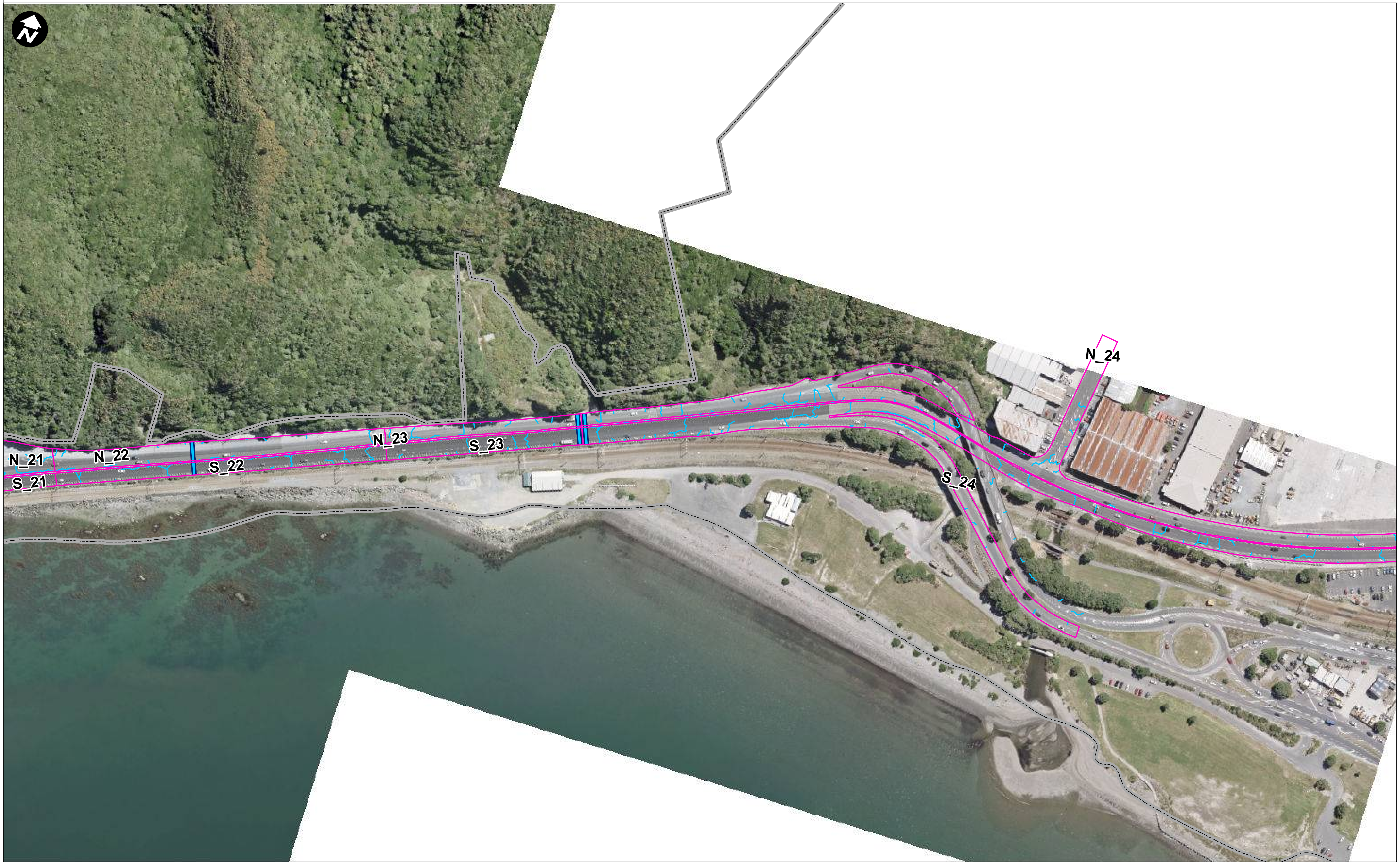

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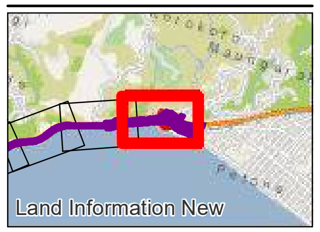

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Scale: 1:2,500 (A3 size)

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Map features depicted in terms of NZTM 2000 projection.

Data Sources:
Cadastral Boundaries – LINZ NZ Cadastral Dataset 2016

PROJECT MANAGEMENT

Approved		Date	
Checked	P. Goswami	Date	
Designed	M. Bryant	Date	
Drawn	M. Bryant	Date	12/11/2019

ISSUE/REVISION

Rev	Date	Description
A	99.99.99	Xxxxx Xxxxx Xxxxx

PROJECT NUMBER

60306339

SHEET TITLE

MAP NUMBER

60306339_00_001_06

APPENDIX C

Calculation based on NZTA "Stormwater Treatment Standard for State Highway Infrastructure" with an allowance for Climate Change

AECOM

Job Name: N2P SH2 Stormwater Quality
Job No: 60306339
Date: 15/11/2019

Calculations By: Prag Goswami

Checked by: Prag Goswami

Verified by: Mike Summerhays

N2P SH2 Lane Side	Catchment ID	Councils[1] (WCC/HCC)	Area (m2)	Area (ha)	Runoff Coefficient (C)	Climate Change [2] factor	Rainfall Intensity [3] for WQF 2 year 1 hr duration (mm/hr)	Water Quality Flow (WQF, m3/s)	WQF (L/s)
North Bound	1	WCC	10411.83	1.04	0.95	14.07%	17.9	0.056	56.1
North Bound	2	WCC	1601.73	0.16	0.95	14.07%	17.9	0.009	8.6
North Bound	3	WCC	1023.82	0.10	0.95	14.07%	17.9	0.006	5.5
North Bound	4	WCC	805.93	0.08	0.95	14.07%	17.9	0.004	4.3
North Bound	5	WCC	1702.74	0.17	0.95	14.07%	17.9	0.009	9.2
North Bound	6	WCC	943.39	0.09	0.95	14.07%	17.9	0.005	5.1
North Bound	7	WCC	756.14	0.08	0.95	14.07%	17.9	0.004	4.1
North Bound	8	WCC	2012.91	0.20	0.95	14.07%	17.9	0.011	10.8
North Bound	9	WCC	2106.14	0.21	0.95	14.07%	17.9	0.011	11.3
North Bound	10	WCC	1448.51	0.14	0.95	14.07%	17.9	0.008	7.8
North Bound	11	WCC	2073.86	0.21	0.95	14.07%	17.9	0.011	11.2
North Bound	12	WCC	1439.64	0.14	0.95	14.07%	17.9	0.008	7.8
North Bound	13	WCC	954.29	0.10	0.95	14.07%	17.9	0.005	5.1
North Bound	14	WCC	2353.87	0.24	0.95	14.07%	17.9	0.013	12.7
North Bound	15	WCC	642.59	0.06	0.95	14.07%	17.9	0.003	3.5
North Bound	15	WCC	1973.94	0.20	0.95	14.07%	17.9	0.011	10.6
North Bound	16	WCC	4985.28	0.50	0.95	14.07%	17.9	0.027	26.9
North Bound	17	WCC	5229.87	0.52	0.95	14.07%	17.9	0.028	28.2
North Bound	18	WCC	1388.91	0.14	0.95	14.07%	17.9	0.007	7.5
North Bound	19	WCC	867.86	0.09	0.95	14.07%	17.9	0.005	4.7
North Bound	20	WCC	1680.88	0.17	0.95	14.07%	17.9	0.009	9.1
North Bound	21	HCC	3918.31	0.39	0.95	14.07%	17.9	0.021	21.1
North Bound	22	HCC	2989.90	0.30	0.95	14.07%	17.9	0.016	16.1
North Bound	23	HCC	1271.00	0.13	0.95	14.07%	17.9	0.007	6.8
North Bound	24	HCC	8668.08	0.87	0.95	14.07%	17.9	0.047	46.7
South Bound	1	WCC	6727.11	0.67	0.95	14.07%	17.9	0.036	36.2
South Bound	2	WCC	1121.70	0.11	0.95	14.07%	17.9	0.006	6.0
South Bound	3	WCC	880.40	0.09	0.95	14.07%	17.9	0.005	4.7
South Bound	4	WCC	846.01	0.08	0.95	14.07%	17.9	0.005	4.6
South Bound	5	WCC	1834.64	0.18	0.95	14.07%	17.9	0.010	9.9
South Bound	6	WCC	1029.99	0.10	0.95	14.07%	17.9	0.006	5.5
South Bound	7	WCC	791.28	0.08	0.95	14.07%	17.9	0.004	4.3
South Bound	8	WCC	2020.37	0.20	0.95	14.07%	17.9	0.011	10.9
South Bound	9	WCC	1983.73	0.20	0.95	14.07%	17.9	0.011	10.7
South Bound	10	WCC	1294.36	0.13	0.95	14.07%	17.9	0.007	7.0
South Bound	11	WCC	1981.59	0.20	0.95	14.07%	17.9	0.011	10.7
South Bound	12	WCC	1337.76	0.13	0.95	14.07%	17.9	0.007	7.2
South Bound	13	WCC	996.38	0.10	0.95	14.07%	17.9	0.005	5.4
South Bound	14	WCC	1424.07	0.14	0.95	14.07%	17.9	0.008	7.7
South Bound	15	WCC	633.00	0.06	0.95	14.07%	17.9	0.003	3.4
South Bound	16	WCC	3675.00	0.37	0.95	14.07%	17.9	0.020	19.8
South Bound	17	WCC	4733.57	0.47	0.95	14.07%	17.9	0.026	25.5
South Bound	18	WCC	1387.93	0.14	0.95	14.07%	17.9	0.007	7.5
South Bound	19	WCC	881.70	0.09	0.95	14.07%	17.9	0.005	4.8
South Bound	20	WCC	1723.05	0.17	0.95	14.07%	17.9	0.009	9.3
South Bound	21	HCC	1671.94	0.17	0.95	14.07%	17.9	0.009	9.0
South Bound	22	HCC	2217.89	0.22	0.95	14.07%	17.9	0.012	12.0
South Bound	23	HCC	1611.35	0.16	0.95	14.07%	17.9	0.009	8.7
South Bound	24	HCC	8974.01	0.90	0.95	14.07%	17.9	0.048	48.4
TOTAL			**115030.3**	**11.50**					**619.8**

1 Catchment ID North Bound 21,22,23,24 and South Bound 21,22,23,24 belong to Hutt City Council (HCC).

1 Rest of the catchments belong to Wellington City Council (WCC)

2 Table 5.2 of Climate Change Effects and Impact Assessment (Ministry for the Environment, 2008)

3 NZTA “Stormwater Treatment Standard for State Highway Infrastructure” recommends 2 year 1 hr storm for water quality treatment

APPENDIX D

Calculation for device selection (SW360 NZTA Informed Design)

CSF 0054; StormFilter Flow-Based Sizing - Other

Project Name	NZTA Wellington High Level Design			**Location**	Wellington		
Job #	5759	**Device #**	Standard design	**Option #**	10,000m2	**Revision #**	RA
Author	Darren Tiddy			**Date**	15 November 2019		

CALCULATIONS - Please Read Instructions First

1.0 Water Quality Design Storm Peak Runoff Flowrate (RATIONAL METHOD)

1.1 Runoff Co-efficients		
Coefficient of Impervious Roof (**Croof**)	1.00	
Coefficient of Impervious Road (**Croad**)	0.95	
Coefficient of Pervious Area (**Cper**)	0.25	
1.2 Catchment Areas		
Area Impervious Roof (**Aroof**)	0	m^2
Area Impervious Road (**Aroad**)	10000	m^2
Area Pervious Area (**Aper**)	0	m^2
Area Total Catchment (**Acatch**)	10000	m^2
Product of Area & Coefficients (**CA**)	9500	m^2
1.3 Rainfall Intensity		
Water Quality Rainfall Intensity (**iWQ**)	10	mm/hr
1.4 Water Quality Design Storm Peak Runoff Flowrate		
Design Water Quality Treatment Flowrate (**Qwq**)	26.389	L/s

2.0 StormFilter Peak Treatment Flowrate

2.1 Preliminary		
Cartridge Media (**Media**)	ZPG	
Cartridge Height (**Hcart**)	69	cm
Diameter Disc Orifice (**d**)	24.0	mm
Internal bypass weir height (**Hweir**)	0.79	m
Priming depth (**Hprime**)	0.66	m
Area of a Cartridge (**Acart**)	0.181	m^2
2.2 StormFilter Cartridge Peak Treatment Flowrate		
StormFilter cartridge stage-discharge equation	$=0.111d^{2.06}\Delta h^{0.5}$	L/min
Peak treatment flowrate at internal bypass per cartridge (**Qcart**)	1.070	L/s/cart
Number (actual) of StormFilter cartridges required	24.663	cart(s)
Number (rounded) of StormFilter cartridges required	25	cart(s)
Design StormFilter Treatment Flowrate (**QSF**)	26.750	L/s

3.0 Estimate Sediment Mass Loading

3.1 StormFilter Manhole/Vault Dimensions		
Length Cartridge Bay (**Lbay**)	4.500	m
Width Cartridge Bay (**Wbay**)	2.100	m
Area Cartridge Bay (**Abay**)	9.450	m^2
Total area of Cartridges (**Acarts**)	4.524	m^2
Area Lower Volume (**Alow**)	4.926	m^2
Volume Lower Volume (**Vlow**)	3399	L
Area Upper Volume (**Aupp**)	9.450	m^2
Volume Upper Volume (**Vupp**)	945	L
Live storage volume at internal bypass (**Vstor**)	4344	L
3.2 Catchment Sediment Loading		
Estimated TSS Concentration Impervious Roof (**TSSroof**)	100	kg/ha/year
Estimated TSS Concentration Impervious Road (**TSSroad**)	600	kg/ha/year
Estimated TSS Concentration Pervious Area (**TSSper**)	200	kg/ha/year
Estimated Total TSS Load (**TSSload**)	600	kg/year
3.3 Treatment Efficiencies		
Pre-treatment Efficiency (**EFFpre**)	15	%
System Efficiency (**EFFsys**)	75	%
3.4 Maintenance Requirements		
Estimated number of cleans per annum (**nCleans**)	0.97	
Estimated Maintenance Frequency (**Mfreq**)	12.371	months

4.0 Design Summary

Design Water Quality Treatment Flowrate (**Qwq**)	26.389	L/s
StormFilter Design WQ Treatment flowrate (**QSF**)	26.750	L/s
StormFilter Design flowrate at internal bypass (**Qbypass**)	28.652	L/s
Number of StormFilter Cartridges required (**nTOTAL**)	25ea x 69cm ZPG cart(s)	
Treatment Flux per cartridge (**FLUX**)	1.0	L/s/m²
Restrictor Disc Size (**d**)	24.000	mm
Maximum Hydraulic Effect (**hmax**)	0.930	m
Estimated Maintenance Frequency (**Mfreq**)	12	months

INSTRUCTIONS

1.0. Use the rational method to compute the water quality design storm peak runoff flow rate. Values with blue text require user input. Values in red text are automatically calculated. Values with black text remain constant.

1.1 Input the appropriate runoff co-efficient for each sub-catchment.

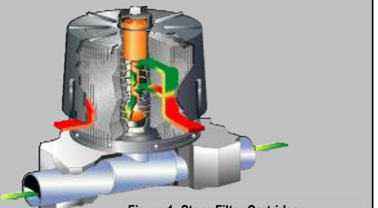


Figure 1: StormFilter Cartridge

1.2 Input the appropriate catchment area for each sub-catchment.

Enter impervious roof surface catchment area

Enter impervious paved surfaces catchment area

Enter pervious grassed/landscaped surfaces catchment area

Total catchment area *i.e. Acatch = Aroof + Aroad + Aper*

Product of catchment areas & runoff co-efficients *i.e. CA = (Croof x Aroof) + (Croad x Aroad) + (Cper x Aper)*

1.3 Input rainfall intensity

The 90th percentile rainfall intensity is recommended to be used for calculating the water quality flow. Where no statistical analysis of historical storm events has been undertaken, we recommned Iwq=10mm/hr is used. Alternative values can be checked against HiRDs or intensity tables in the local council Code of Practice

1.4 Compute the water quality design storm peak runoff flow rate via Rational Method

i.e. Q = f.C.i.A

$$Q = 0.111 d^{2.06} \Delta h^{0.5}$$

[Q]=l.min⁻¹; [d]=mm; [h]=m

Figure 2: StormFilter Stage Discharge Equation [1]

2.0. Use the stormfilter stage-discharge equation to calculate the StormFilter peak treatment flowrate.

Enter cartridge filtration media *i.e. Perlite or ZPG*

Enter cartridge height *i.e. 69cm / 46cm / 30cm*

Enter restrictor disc size, refer table below for max disc diameter

Cart Height (cm)	Actual Height (m)	Priming Depth (m)	Max Disc Diam. (mm)	Max. Design Q (L/s)	Filter Bed Area (m^2)	Flow Rate (L/s/m^2)	Bed Depth (mm)	Media Volume (m^3)	Flow Rate (L/s/m^3)
30	0.305	0.27	22.70	0.63	0.460	1.37	175	0.052	12.0
46	0.457	0.43	25.00	0.95	0.689	1.38	175	0.078	12.1
69	0.686	0.66	27.60	1.42	1.034	1.37	175	0.118	12.1

Table 1. StormFilter Cartridge Specifics [2]

Compute the Stormfilter peak treatment flowrate at internal bypass per cartridge via the StormFilter stage-discharge equation

Compute the number of actual StormFilter cartridges required i.e. CEILING(B35,1) = QWQ / QCART

Compute the number (rounded up to whole number) of StormFilter cartridges required

Compute the Stormfilter peak treatment flowrate at internal bypass via the StormFilter stage-discharge equation

3.0 Estimate sediment mass loading (Refer sheet '2. Mass Load Calcs' for more details)

3.1 Use tables 2 & 3 below to fill in StormFilter Dimensions based on number of cartridges as calculated in cl 2.2 above

3.2 Use table 3 below to fill in estimated TSS concentration. For roads with ≥25,000vpd, use minimum 600kg/ha/yr

3.3 Use 0% pretreatment for vaults/manholes with no forebay. Use 10-15% pretreatmnet for vaults/manholes with forebays. Use 50% pretreatment for upstream GPT ie EnviroPod. Use 75%-90% system efficiency

Std Manhole Dimensions	Without forebay				With forebay			
	Cart Bay Length (m)	Cart Bay Width (m)	Cart Bay Area (m^2)	Max Number Carts	Cart Bay Length (m)	Cart Bay Width (m)	Cart Bay Area (m^2)	Max Number Carts
1050	1.00	0.77	0.77	1	1.00	N/A	N/A	N/A
1200	1.00	1.03	1.03	3	1.00	0.76	0.76	2
1500	1.00	1.67	1.67	4	1.00	1.39	1.39	3
1800	1.00	2.44	2.44	7	1.00	1.83	1.83	5
2050	1.00	3.20	3.20	9	1.00	2.80	2.80	7

Table 2: Standard Stormwater360 Manhole Dimensions

Std Vault Dimensions	Without forebay				With forebay			
	Cart Bay Length (m)	Cart Bay Width (m)	Cart Bay Area (m^2)	Max Number Carts	Cart Bay Length (m)	Cart Bay Width (m)	Cart Bay Area (m^2)	Max Number Carts
3.4 L x 1.5 W x 1.8 D	2.85	1.50	4.28	11	2.30	1.80	4.14	8
4.5 L x 1.5 W x 1.8 D	3.95	1.50	5.93	17	3.40	1.50	5.10	14
4.2 L x 2.0 W x 1.8 D	3.95	1.95	7.70	23	3.40	2.10	7.14	18
5.6 L x 2.0 W x 1.8 D	5.05	1.95	9.85	31	4.50	2.10	9.45	26
5.6 L x 2.4 W x 1.8 D	5.05	2.40	12.12	39	4.50	2.10	9.45	27
6.2 L x 2.4 W x 1.8 D	5.60	2.40	13.44	44	4.50	2.40	10.80	33

Table 3: Standard Stormwater360 Vault Dimensions

Land Use	TSS (kg/ha/yr)
Road	281 - 723
Commercial	242 - 1369
Residential (low)	60 - 340
Residential (high)	97 - 547
Terraced	133 - 755
Bush	26 - 146
Grass	80 - 588
Roof	50-110 *(1)*
Pasture	103 - 583

Table 4: Suggested TSS loads [3]

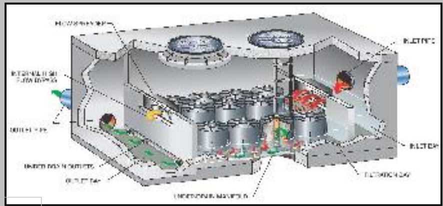


Figure 3: StormFilter Vault Cutaway

References

1. Derived from Stormwater Management Inc., Technical Publication PD-04-002.0
2. Contech Stormwater Solutions, StormFilter Product Design Manual.
3. Table 4-4, Technical Publication 10, 2nd Edition, May 2003, Auckland Regional Council

APPENDIX F
Contaminant Load Model Spreadsheet

Job Name: N2P SH2 Contaminant Load Assessment
Job No: 60306339
Date: 20/12/2019

Calculations By: Prag Goswami

Checked by: Nadine Wolfaardt

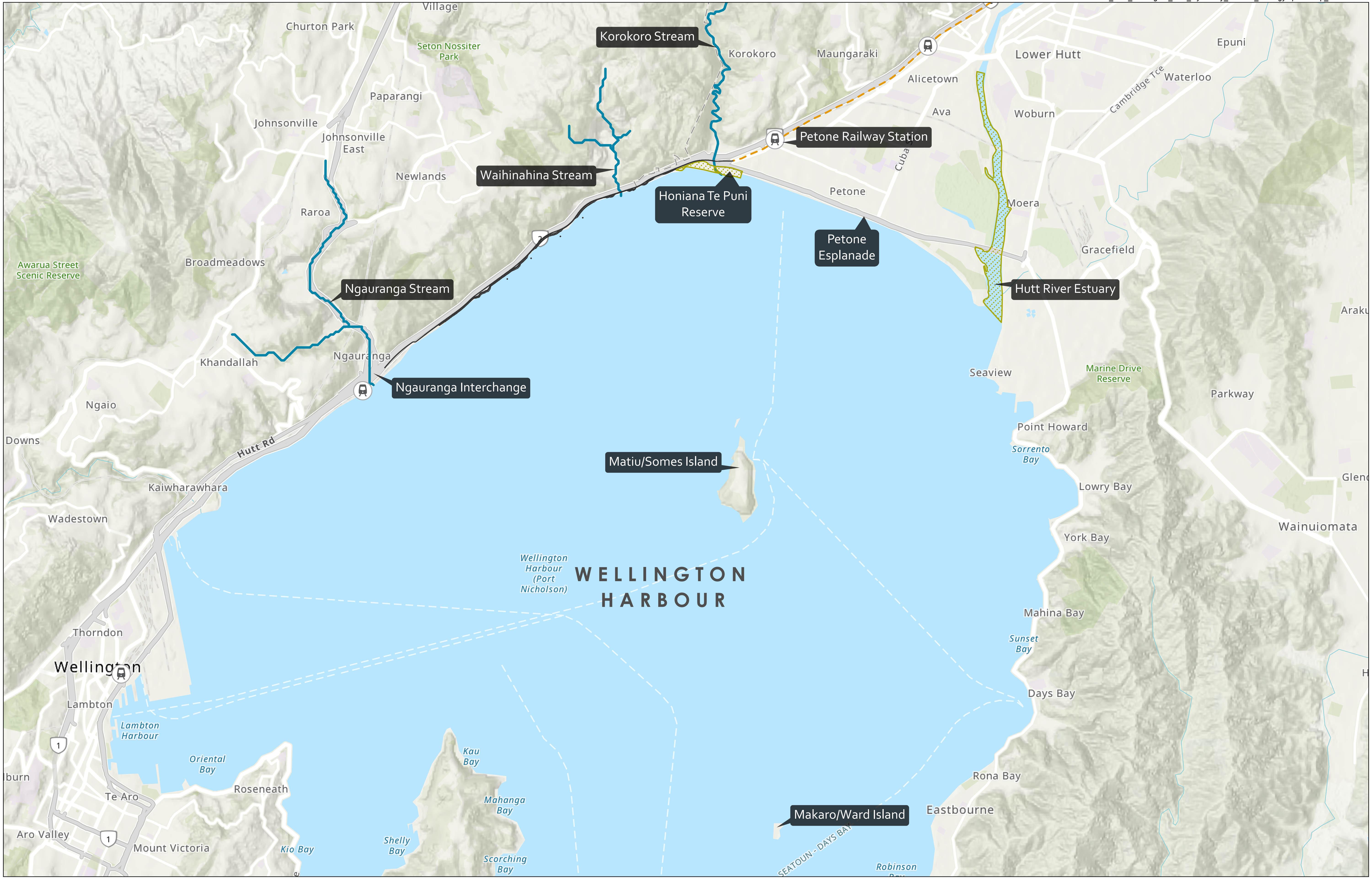
Contaminant Load Model based on Auckland Council's Techincal Report 003
Catchment Name N2P SH2

Catchment Area (m^2)				Source contaminant management train				Contaminant yields, loads, and load reduction factors							
								Total Suspended Solids (TSS)							
Source	Source type		Source Area (m^2)	1st Management Option (M1)	2nd Management Option (M2)	3rd Management Option (M3)	Fraction of area draining to train	Yield ($g\ m^{-2}\ a^{-1}$)	Initial Load ($g\ a^{-1}$)	Load Reduction Factor for M1	Load Reduction Factor for M2	Load Reduction Factor for M3	Combined LRF	Manual Load Reduction Factor	Reduced load ($g\ a^{-1}$)
	Vehicles/day	Length (m)													
	<1000														
	1000-5000														
Roads	5000-20000														
	20000-50000														
	50000-100000	5000	120000	Catchpits	Storm-filter		1	60.0	7200000.0	0.20	0.75		0.80		1440000.0
	>100000														

Catchment Area (m^2)				Source contaminant management train				Contaminant yields, loads, and load reduction factors							
								Zinc suspended particulate and dissolved (TZn)							
Source	Source type		Source Area (m^2)	1st Management Option (M1)	2nd Management Option (M2)	3rd Management Option (M3)	Fraction of area draining to train	Yield ($g\ m^{-2}\ a^{-1}$)	Initial Load ($g\ a^{-1}$)	Load Reduction Factor for M1	Load Reduction Factor for M2	Load Reduction Factor for M3	Combined LRF	Manual Load Reduction Factor	Reduced load ($g\ a^{-1}$)
	Vehicles/day	Length (m)													
	<1000														
	1000-5000														
Roads	5000-20000														
	20000-50000														
	50000-100000	5000	120000	Catchpits	Storm-filter		1	0.471	56532.0	0.11	0.40		0.47		30188.1
	>100000														

Catchment Area (m^2)				Source contaminant management train				Contaminant yields, loads, and load reduction factors							
								Copper suspended particulate and dissolved (TCu)							
Source	Source type		Source Area (m^2)	1st Management Option (M1)	2nd Management Option (M2)	3rd Management Option (M3)	Fraction of area draining to train	Yield ($g\ m^{-2}\ a^{-1}$)	Initial Load ($g\ a^{-1}$)	Load Reduction Factor for M1	Load Reduction Factor for M2	Load Reduction Factor for M3	Combined LRF	Manual Load Reduction Factor	Reduced load ($g\ a^{-1}$)
	Vehicles/day	Length (m)													
	<1000														
	1000-5000														
Roads	5000-20000														
	20000-50000														
	50000-100000	5000	120000	Catchpits	Storm-filter		1	0.157	18843.6	0.15	0.65		0.70		5606.0
	>100000														

Catchment Area (m^2)				Source contaminant management train				Contaminant yields, loads, and load reduction factors							
								TPH suspended particulate and dissolved (TTPH)							
Source	Source type		Source Area (m^2)	1st Management Option (M1)	2nd Management Option (M2)	3rd Management Option (M3)	Fraction of area draining to train	Yield ($g\ m^{-2}\ a^{-1}$)	Initial Load ($g\ a^{-1}$)	Load Reduction Factor for M1	Load Reduction Factor for M2	Load Reduction Factor for M3	Combined LRF	Manual Load Reduction Factor	Reduced load ($g\ a^{-1}$)
	Vehicles/day	Length (m)													
	<1000														
	1000-5000														
Roads	5000-20000														
	20000-50000														
	50000-100000	5000	120000	Catchpits	Storm-filter		1	3.565	427752.0	0.15	0.75		0.79		90897.3
	>100000														



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Projection: NZGD 2000 New Zealand Transverse Mercator

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1:40,000 @ A3

Data Sources: AECOM, Boffa Miskell, Basemap - Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors., Airbus,USGS,NGA,NASA,CGIAR,NCEAS,NLS,OS,NMA,Geodatastyr and the GIS User Community

LEGEND

- Ngauranga to Petone Cycleway
- Petone to Melling Cycleway

WELLINGTON HUTT CYCLEWAY - COASTAL ECOLOGY

Site Context

Date: 03 August 2020 | Revision: 1

Plan prepared for the NZ Transport Agency by Boffa Miskell Limited

Project Manager: Leigh.Bull@boffamiskell.co.nz | Drawn: HHu | Checked: LBu

Map 1

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0 300 m

1:12,500 @ A3

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LEGEND

— Ngauranga to Petone Cycleway

WELLINGTON HUTT CYCLEWAY - COASTAL ECOLOGY

Freshwater Streams

Date: 03 August 2020 | Revision: 1

Plan prepared for the NZ Transport Agency by Boffa Miskell Limited

Project Manager: Leigh.Bull@boffamiskell.co.nz | Drawn: HHu | Checked: LBu

Map 2

File Ref: W16035_LBU_Wellington_Hutt_Cycleway_Coastal_Ecology.aprx / Map_AvifaunaInvestigations

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Projection: NZGD 2000 New Zealand Transverse Mercator

0 800 m

1:45,000 @ A3

Data Sources: AECOM, OSNZ, Boffa Miskell, Basemap - Sourced from the LINZ Data Service and licensed for re-use under the Creative Commons Attribution 4.0 New Zealand licence

LEGEND

- Ngauranga to Petone Cycleway
- OSNZ Grid - DH143 (266, 599)
- Korokoro Stream Mouth

WELLINGTON HUTT CYCLEWAY - COASTAL ECOLOGY

Avifauna Investigations

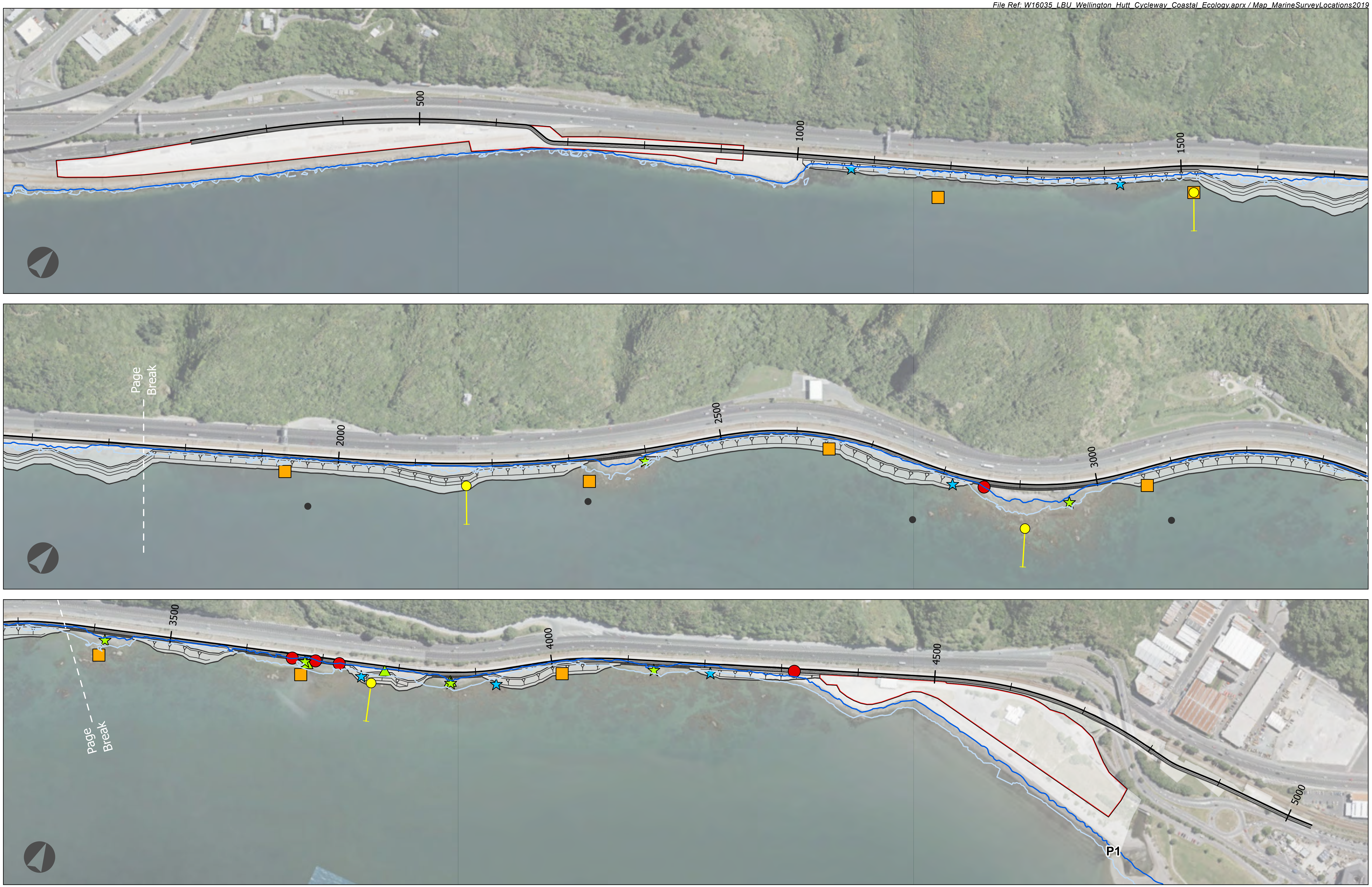
Date: 03 August 2020 | Revision: 1

Plan prepared for the NZ Transport Agency by Boffa Miskell Limited

Project Manager: Leigh.Bull@boffamiskell.co.nz | Drawn: HHu | Checked: LBu

Map 3

File Ref: W16035_LBU_Wellington_Hutt_Cycleway_Coastal_Ecology.aprx / Map_MarineSurveyLocations2019



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Projection: NZGD 2000 New Zealand Transverse Mercator

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1:4,500 @ A3

Data Sources: AECOM, Boffa Miskell, Basemap - Sourced from the LINZ Data Service and licensed for re-use under the Creative Commons Attribution 4.0 New Zealand licence

LEGEND

- Laydown Footprint
- Design Footprint
- MHWS
- MLWS
- Offshore Habitats

Survey Locations

- 2019 Intertidal Soft Sediment
- 2019 Rocky Shore
- 2019 Sediment Quality
- 2019 Subtidal Ecology
- 2010 Subtidal Ecology
- 2009 Intertidal Soft Sediment
- Subtidal Ecology Transect

WELLINGTON HUTT CYCLEWAY - COASTAL ECOLOGY

Marine Survey Locations 2019

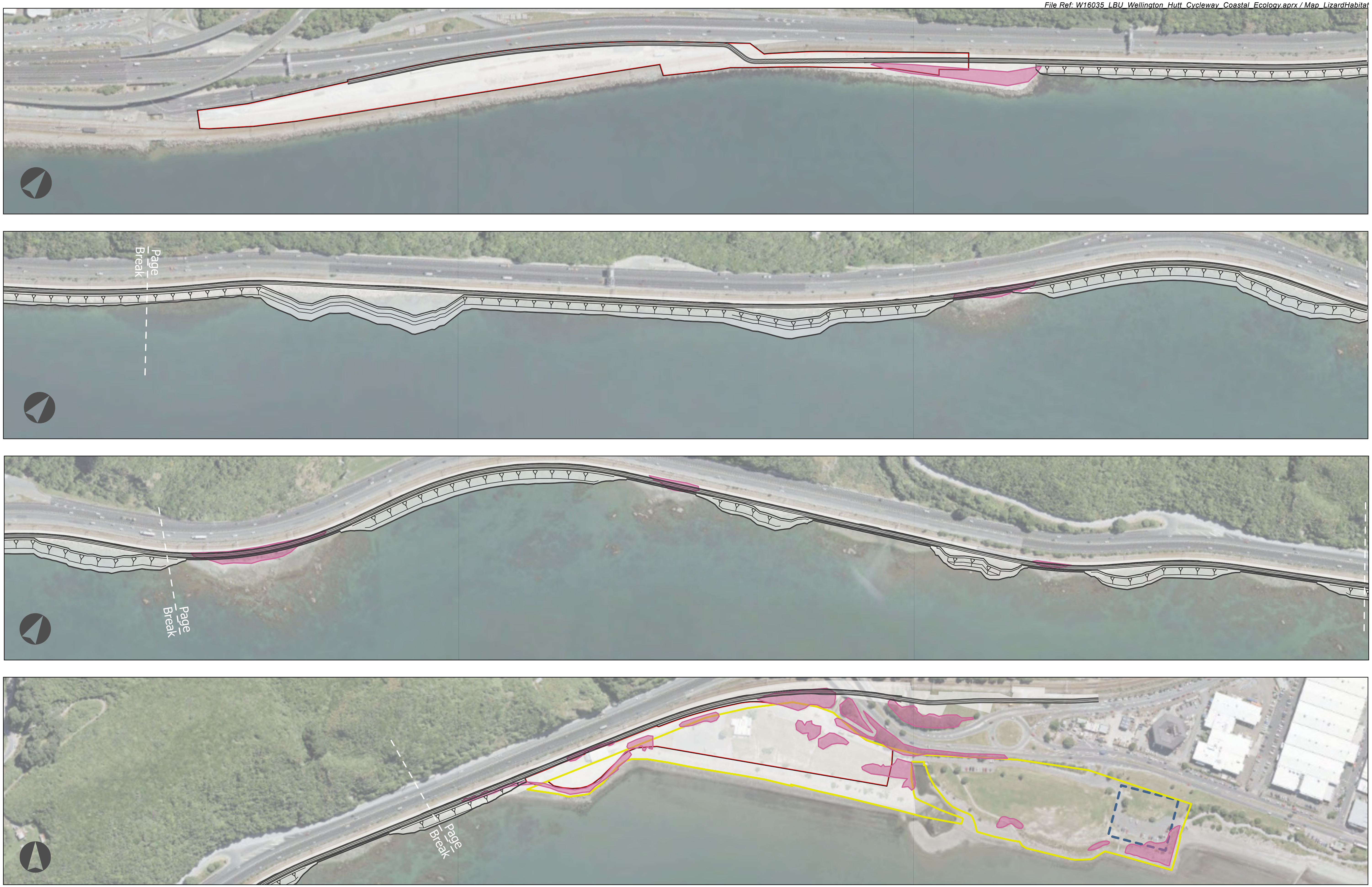
Date: 03 August 2020 | Revision: 5

Plan prepared for the NZ Transport Agency by Boffa Miskell Limited

Project Manager: Leigh.Bull@boffamiskell.co.nz | Drawn: HHu | Checked: LBu

Map 4

File Ref: W16035_LBU_Wellington_Hutt_Cycleway_Coastal_Ecology.aprx / Map_LizardHabitat



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Projection: NZGD 2000 New Zealand Transverse Mercator

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1:4,000 @ A3

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LEGEND

- Ngauranga to Petone Cycleway
- Laydown Footprint
- Design Footprint
- Watersports Footprint (indicative)
- Honiana Te Puni Reserve
- Potential Lizard Habitat

WELLINGTON HUTT CYCLEWAY - COASTAL ECOLOGY

Lizard Habitat

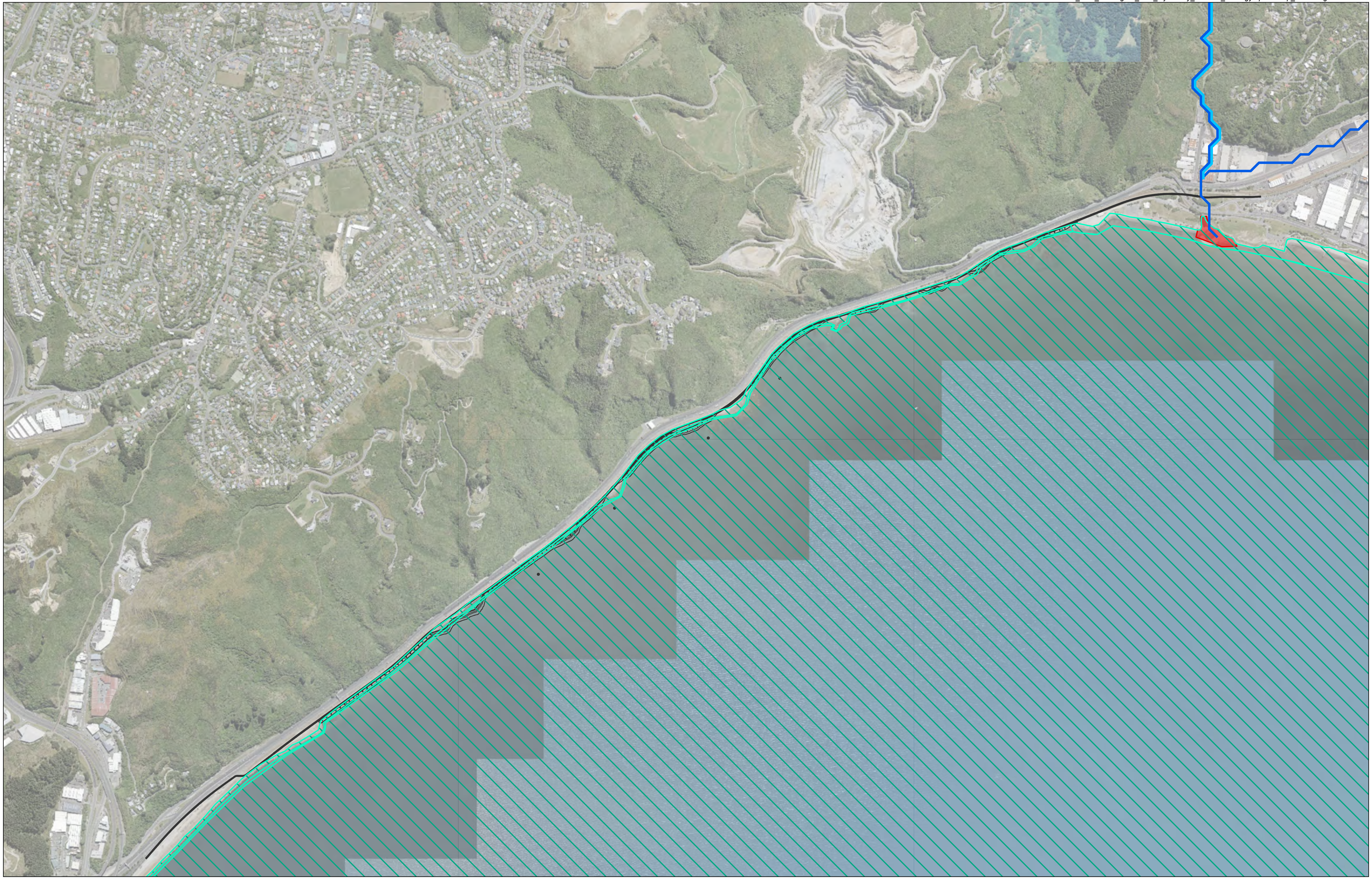
Date: 03 August 2020 | Revision: 3

Plan prepared for the NZ Transport Agency by Boffa Miskell Limited

Project Manager: Leigh.Bull@boffamiskell.co.nz | Drawn: HHu | Checked: LBu

Map 5

File Ref: W16035_LBU_Wellington_Hutt_Cycleway_Coastal_Ecology.aprx / Map_PNRPSignificantSites



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Projection: NZGD 2000 New Zealand Transverse Mercator

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1:12,500 @ A3

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LEGEND

- Ngauranga to Petone Cycleway
- Schedule F1: Threatened or At Risk Fish Habitat - Korokoro River
- Schedule F1: Migratory Fish Habitat - Korokoro River
- Schedule F2c: Habitats for indigenous birds in the coastal marine area
- Schedule F4 - Indigenous Biodiversity Coastal - Korokoro Estuary

WELLINGTON HUTT CYCLEWAY - COASTAL ECOLOGY

PNRP Significant Sites

Date: 03 August 2020 | Revision: 1

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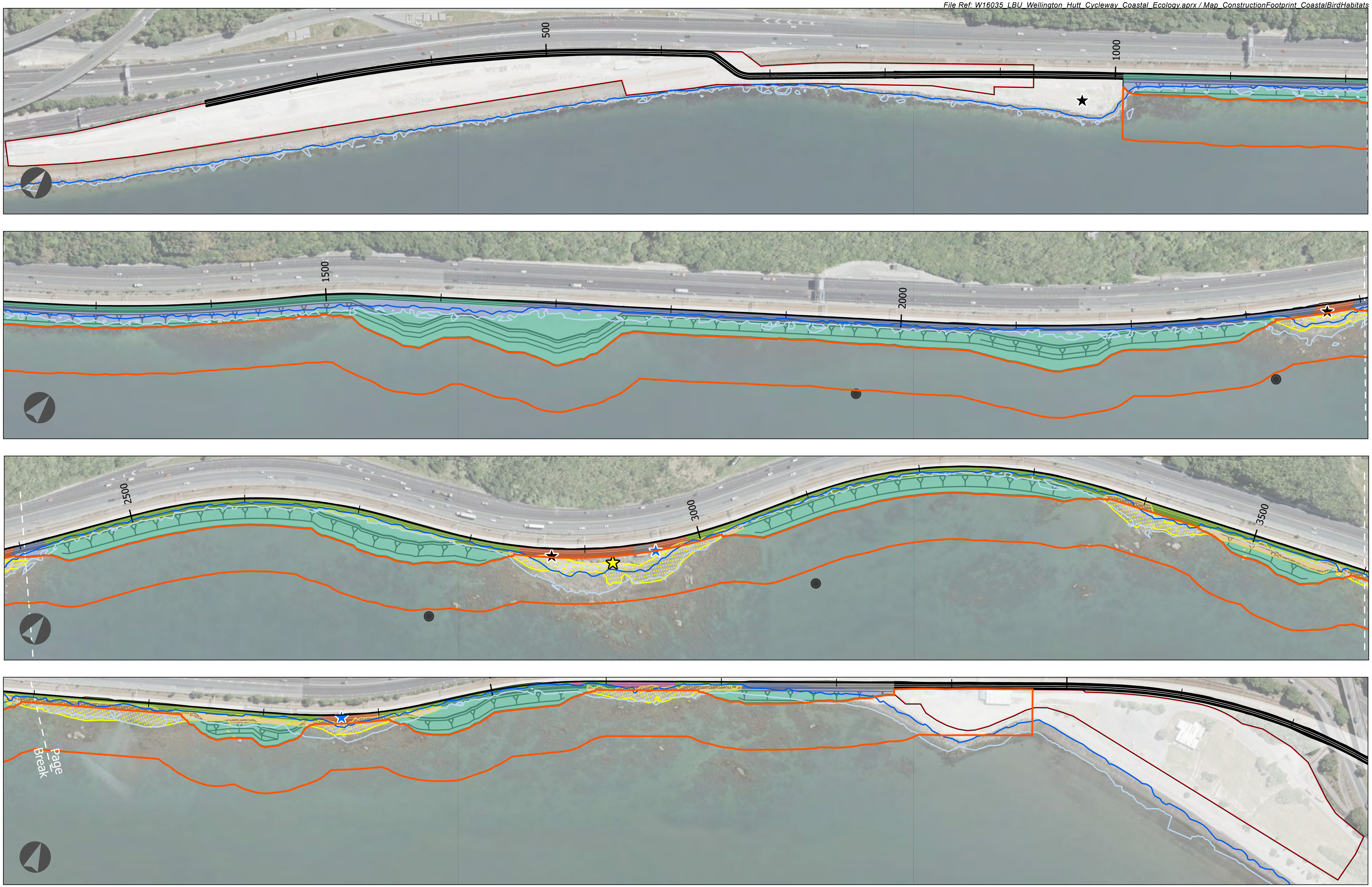
Project Manager: Leigh.Bull@boffamiskell.co.nz | Drawn: HHu | Checked: LBu

Map 6

File Ref: W16035_LBU_Wellington_Hutt_Cycleway_Coastal_Ecology.aprx / Map_ConstructionFootprint_CoastalBirdHabitats



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0 100 m

1:3,000 @ A3

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LEGEND

- Laydown Footprint
- Design Footprint
- Coastal Disturbance Zone (40m)
- MHWS
- MLWS
- Offshore Habitats

Avifauna Nesting

- Black-backed gull
- Little blue penguin
- Variable oystercatcher

Habitat Types

- Intertidal and nearshore foraging
- Backshore nesting
- Concrete embedded rip-rap
- Roosting rip-rap
- Large rip-rap
- Rock outcrops
- Shingle beaches
- No Habitat
- Shingle Beaches

WELLINGTON HUTT CYCLEWAY - COASTAL ECOLOGY

Construction Footprint - Coastal Bird Habitats

Date: 03 August 2020 | Revision: 5

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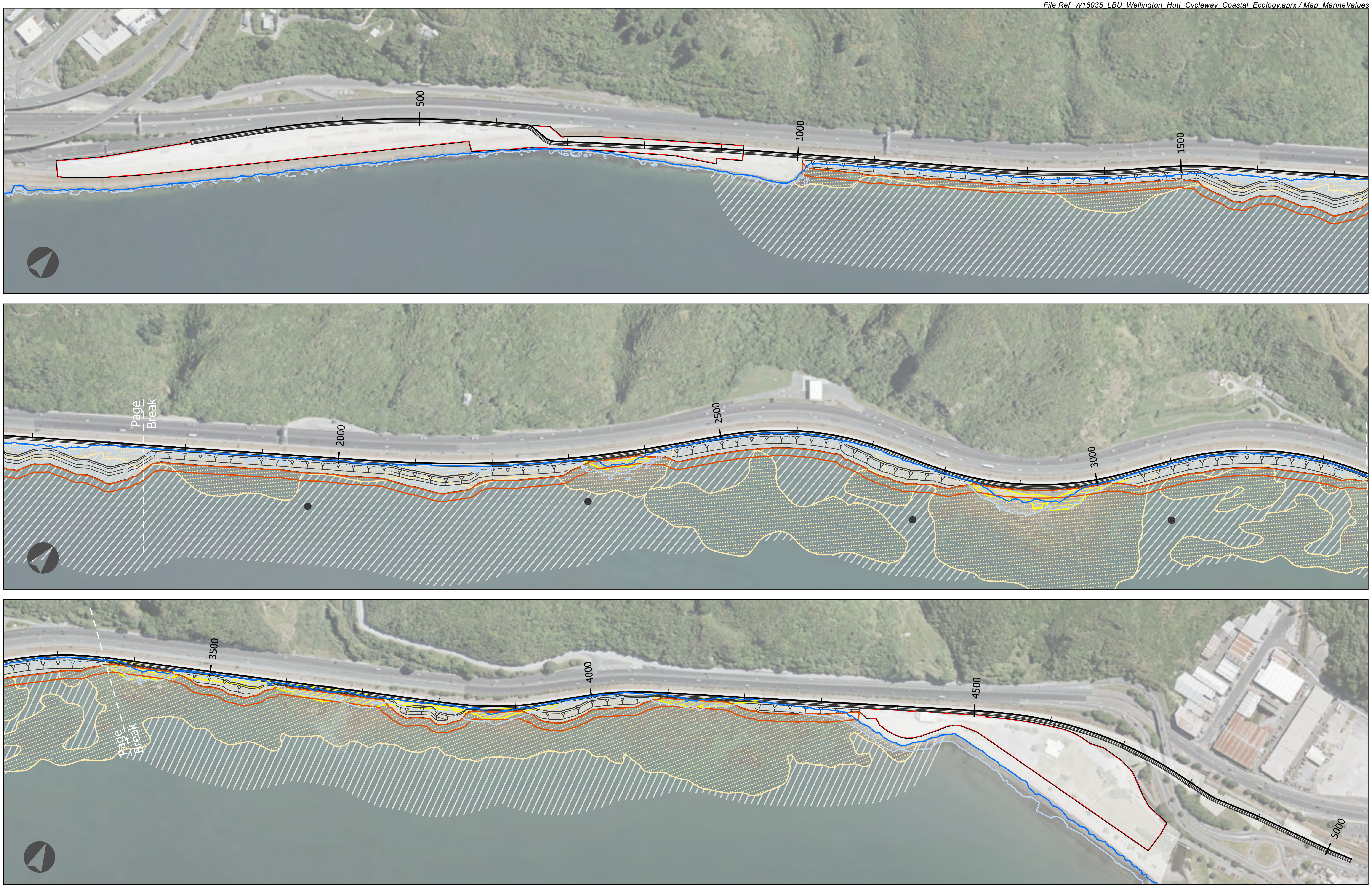
Project Manager: Leigh.Bull@boffamiskell.co.nz | Drawn: HHu | Checked: LBu

Map 7



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Projection: NZGD 2000 New Zealand Transverse Mercator

0 300 m

1:4,500 @ A3

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LEGEND

- Laydown Footprint
- Design Footprint
- Coastal Disturbance Zone (10m)
- MHWS
- MLWS
- Offshore Habitats

Marine Habitat

- Rocky Reef / Cobble / Macroalgae Habitat
- Sand / Gravel Habitat (Indicative)
- Shingle Beaches

WELLINGTON HUTT CYCLEWAY - COASTAL ECOLOGY

Marine Values

Date: 03 August 2020 | Revision: 5

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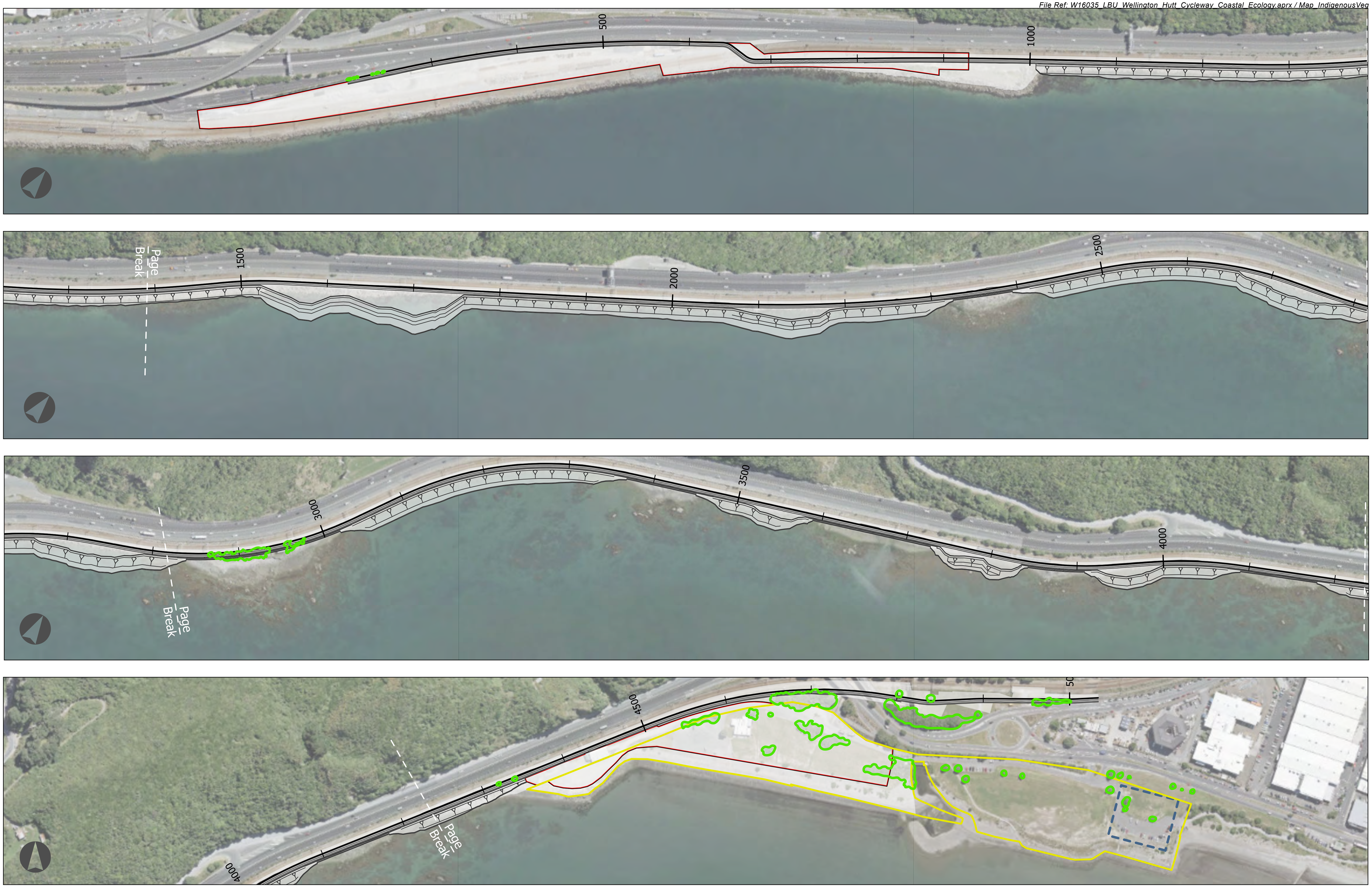
Map 8

File Ref: W16035_LBU_Wellington_Hutt_Cycleway_Coastal_Ecology.aprx / Map_IndigenousVeg



WELLINGTON HUTT CYCLEWAY - COASTAL ECOLOGY

Indigenous Vegetation

Date: 03 August 2020 | Revision: 4

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Map 9

LEGEND

- Ngauranga to Petone Cycleway
- Laydown Footprint
- Design Footprint
- Watersports Footprint (indicative)
- Honiana Te Puni Reserve
- Indigenous Vegetation

0 100 m

1:4,000 @ A3

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Projection: NZGD 2000 New Zealand Transverse Mercator

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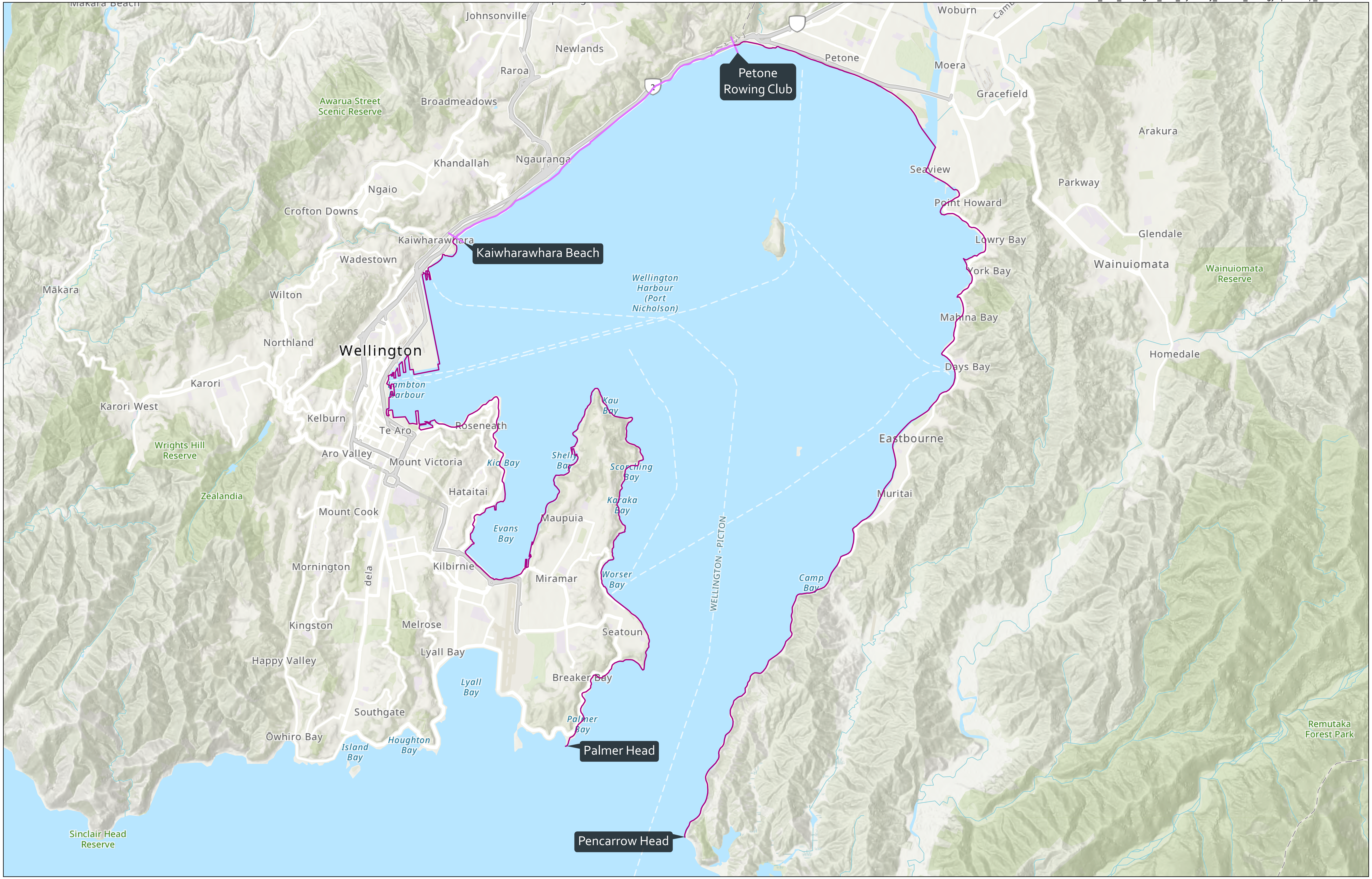

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Projection: NZGD 2000 New Zealand Transverse Mercator

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LEGEND

- Ngauranga to Petone Cycleway
- Foot access to coast
- No foot access to coast

WELLINGTON HUTT CYCLEWAY - COASTAL ECOLOGY

Coastal Access

Date: 03 August 2020 | Revision: 1

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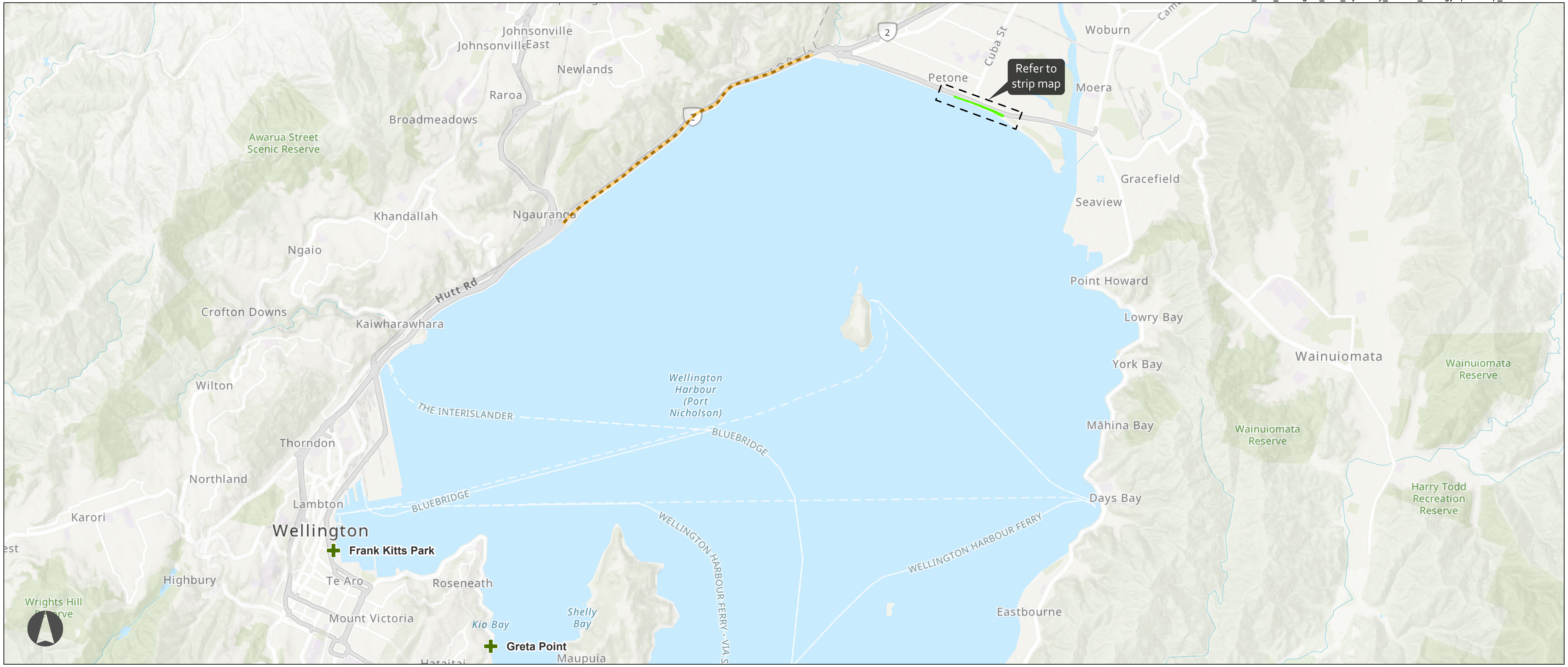
Project Manager: Leigh.Bull@boffamiskell.co.nz | Drawn: HHu | Checked: LBu

Map 10



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LEGEND
- Living Seawall (proposed location)
- SH2 Stormwater Treatment
- Foreshore Revegetation

WELLINGTON HUTT CYCLEWAY - COASTAL ECOLOGY

Proposed Measures to Address Residual Effects

Date: 01 October 2020 | Revision: 1

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Project Manager: Leigh.Bull@boffamiskell.co.nz | Drawn: HHu | Checked: LBu

Map 11

About Boffa Miskell

Boffa Miskell is a leading New Zealand professional services consultancy with offices in Auckland, Hamilton, Tauranga, Wellington, Christchurch, Dunedin and Queenstown. We work with a wide range of local and international private and public sector clients in the areas of planning, urban design, landscape architecture, landscape planning, ecology, biosecurity, cultural heritage, graphics and mapping. Over the past four decades we have built a reputation for professionalism, innovation and excellence. During this time we have been associated with a significant number of projects that have shaped New Zealand's environment.

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