# Feasibility Assessment:

## Aotearoa New Zealand Blue Carbon Resilience Credits

Environmental Finance Consulting Services

9 April 2022

# Feasibility Assessment:
## Aotearoa New Zealand Blue Carbon Resilience Credit Projects

Prepared by
Ekos Kāmahi Limited
PO Box 19
Christchurch 8140
Aotearoa New Zealand
t: +64 27 3563601
NZBN 9429048527453
www.ekos.co.nz

Cawthron Institute
98 Halifax St East
Nelson 7010
Aotearoa New Zealand
www.cawthron.org.nz

Authors:
Sean Weaver, Ekos.
Anna Berthelsen, Cawthron Institute
Jessica Schattschneider, Cawthron Institute
Tom Bennion, Bennion Law.

### Quality information
### Revision history

| Revision | Description | Date | Originators | Reviewers | Approver |
|---|---|---|---|---|---|
| 1.0 | Final | 9 April 2022 | Sean Weaver<br>Anna Berthelsen<br>Jessica Schattschneider<br>Tom Bennion | David Laing (Ekos)<br>Jim Sinner (Cawthron)<br>Ross Vennell (Cawthron)<br>Stefanie Simpson (TNC)<br>Erik van Eyndhoven (TNC)<br>Eric Wei (Nature Vest) | Sean Weaver |
| Suggested bibliographic reference:<br>Weaver, S.A., Berthelsen, A., Schattschneider, J., Bennion, T. 2022. Feasibility Assessment: Aotearoa New Zealand Blue Carbon Resilience Credit Projects. Report to The Nature Conservancy, January 2022. Ekos, Cawthron Institute, and Bennion Law. | | | | | |

# CONTENTS

# Executive Summary

According to the IPCC Sixth Assessment Report it "is unequivocal that human influence has warmed the atmosphere, ocean and land… changes … are irreversible for centuries to millennia… Global warming of $1.5^0$C and $2^0$C will be exceeded during the 21st century **unless deep reductions in carbon dioxide ($CO_2$) and other greenhouse gases occur in the coming decades.**" This clarion call leaves no doubt of the need for global efforts to reduce greenhouse gas emissions and adapt to climate change.

'Blue carbon' refers to carbon captured by the world's ocean and coastal ecosystems. For example, salt marsh ecosystems can remove carbon dioxide from the atmosphere at a rate ten times greater than tropical forests and store three to five times more carbon per hectare than tropical forests.

This report was commissioned by The Nature Conservancy to explore the feasibility of blue carbon and coastal resilience project development in Aotearoa New Zealand. The work was carried out by Ekos, the Cawthron Institute, and Bennion Law.

Our work examined the technical, financial, legal, and organizational feasibility of blue carbon and coastal resilience projects, through the scoping assessment of six potential project sites. This report is designed to inform potential blue carbon project development using the Verified Carbon Standard (VCS) standard and to clarify the requirements for the integration of technical and business elements of project design, development, and implementation.

A blue carbon project focuses on restoration or conservation interventions in coastal ecosystems that cause a reduction of greenhouse gas (GHG) emissions, and/or enhance the removal of these gases. This can be delivered through activities such as re-wetting and revegetating a tidal wetland or preventing an intact tidal wetland from being degraded. From a business perspective, the purpose of a blue carbon or coastal resilience project is to finance coastal conservation activities through the creation and sale of carbon credits and/or resilience credits. Gaining access to such market-based finance enables coastal conservation activities to be financially self-sustaining and to operate at scale.

Aotearoa New Zealand has an extensive coastline with many coastal ecosystems that are either at risk of degradation or exist in a degraded state and are potentially suitable for restoration. This includes coastal wetland (salt marsh, mangrove, and seagrass) habitats, many of which could be enhanced by rewetting or other measures. It also contains intact tidal wetland habitats, which could be protected from degradation. Six case study sites containing salt marsh or seagrass ecosystems (or both) were assessed for blue carbon project feasibility. Three sites are in the North Island (Te Repo Ki Pūkorokoro in the Firth of Thames, Wainui Repo Whenua in Tauranga Harbour, and Pukehina/Waihi also in the Bay of Plenty), and three in the South Island (Farewell Spit, Waimeha Inlet, and Wairau Lagoon).

This assessment found rewetting tidal salt marsh projects to be technically, financially, legally and organizationally feasible under certain project design conditions. Four of the six case study sites show significant potential; although some details (e.g., ecological data such as soil organic matter content and salinity) need to be confirmed. The seagrass conservation project examined faces several technical challenges and is considered in this assessment to not (currently) be technically feasible. Coastal resilience project options were potentially technically feasible but face methodological challenges that would need to be resolved before they can be tested for financial feasibility.

There is a real opportunity for tidal salt marsh restoration blue carbon projects in Aotearoa New Zealand. There are challenges associated with structuring financing and investment arrangements, but these are no different from any commercial venture.

We recommend that TNC undertakes a commercial pilot project that aggregates the four feasible salt marsh restoration sites examined in this study. This pilot project would generate technical and financial data that can inform the development of a nation-wide programme. We also recommend that a nation-wide inventory of degraded and intact tidal marsh ecosystems and have potential for blue carbon project development. Potential opportunities (and risks) for tidal marsh habitats due to future sea level rise should also be considered in this nation-wide assessment.

# Glossary

**Additionality:** A project activity is additional if it can be demonstrated that the activity results in emission reductions or removals that are more than what would be achieved under a "business as usual" scenario and that the activity would not have occurred in the absence of the incentive provided by the carbon markets. Additionality is an important characteristic of carbon projects because it indicates that they represent a net environmental benefit and a real reduction of GHG emissions and can thus be used to offset emissions.

**AFOLU:** Agriculture, Forestry and Other Land Use.

**Annual exceedance probability (AEP):** The chance that an event would reach or exceed a given magnitude in any year, expressed as a percentage or decimal (MFE 2017) and is sometimes expressed as an Annual Recurrence Interval (ARI, see next definition). Therefore, 1% AEP is equal to a 100 year ARI, a 2% AEP is a 50-year ARI, and a 10% AEP is a 10-year ARI.

**An annual recurrence interval (ARI):** The average number of years that it is predicted will pass before an event of a given magnitude occurs. For example, a 50-year ARI event would on average happen every 50 years. The ARI is sometimes also known as 'return period'.

**ARR:** afforestation, reforestation and revegetation

**AUWD:** avoiding unplanned wetland degradation

**Baseline Scenario:** The baseline scenario represents the activities and GHG emissions that would occur in the absence of the project activity. The baseline scenario shall be accurately determined so that an accurate comparison can be made between the GHG emissions that would have occurred under the baseline scenario and the GHG emission reductions and/or removals that were achieved by project activities. Baseline scenarios are not intended to be predictions of the future, but rather counterfactual constructions that can serve to highlight the level of emissions that would occur without the project.

**Buffer:** Non-tradable carbon credits for covering the risk of unforeseen losses in carbon stocks in the project. The buffer comprises a form of self-insurance for a carbon project and is typically a mandatory requirement of voluntary carbon standards such as the Verified Carbon Standard (VCS).

**Carbon credits:** A generic term for any tradable certificate representing one tonne of carbon dioxide or the equivalent amount of a different greenhouse gas ($tCO_2e$). In compliance carbon market instruments (e.g., the Aotearoa New Zealand Emissions Trading Scheme) carbon credits can be used by participants to comply with legal obligations. Carbon credits can be produced in carbon market allocation systems (e.g., allowances) or carbon projects that deliver carbon benefits to the atmosphere measured in tonnes of carbon dioxide (or carbon dioxide equivalent) that has either been avoided, reduced, or removed from the atmosphere (carbon sequestration).

**Carbon dioxide equivalent ($CO_2e$):** The amount of carbon dioxide ($CO_2$) emission that would cause the same integrated radiative forcing, over a given time horizon, as an emitted amount of a non-$CO_2$ greenhouse gas (GHG) or a mixture of GHGs. The $CO_2$-equivalent emission is calculated by multiplying the emission of a GHG by its Global Warming Potential (GWP) for the given time horizon. For a mix of GHGs the $CO_2e$ is obtained by summing the $CO_2$-equivalent emissions of each gas.

**Carbon offsets:** Carbon offsets are carbon credits representing either a) the right to emit one tonne of carbon dioxide equivalent ($tCO_2e$) (e.g., in a compliance carbon market), or b) voluntarily compensate for carbon dioxide equivalent emissions when there is already a legal right to emit those emissions (e.g., in a voluntary carbon market).

**Carbon pools:** A reservoir of carbon that has the potential to accumulate (or lose) carbon over time. In agriculture, forestry and other land uses (AFOLU) projects or programs, the carbon pools encompass aboveground biomass, belowground biomass, litter, dead wood, soil, and wood products.

**Carbon Stock**: The quantity of carbon held within a pool.

**$CO_2$:** Carbon dioxide, the main greenhouse gas responsible for human-induced climate change.

**$CO_2e$:** See Carbon dioxide equivalent.

**$CH_4$:** Methane, a powerful greenhouse gas responsible for human-induced climate change.

**CIW:** Conservation of intact wetlands.

**CUPP**: Conservation of Undrained or Partially drained Peatland.

**Clean Development Mechanism**: This is a United Nations-run carbon offset scheme allowing countries to fund greenhouse gas emissions-reducing projects in other countries and claim the saved emissions as part of their own efforts to meet international emissions targets. It has since progressed to a voluntary carbon market standard.

**Degraded Wetland:** A wetland which has been altered by human or natural impact through the impairment of physical, chemical and/or biological properties, and in which the alteration has resulted in a reduction of the diversity of wetland-associated species, soil carbon or the complexity of other ecosystem functions which previously existed in the wetland.

***Ex ante*:** Before the event and based on forecasts, projections and modelling.

***Ex post*:** After the event and based on empirical data.

**GHG:** Greenhouse gas. Restricted to the 'Kyoto greenhouse gases': carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride ($SF_6$).

**Grouped project:** A project to which additional instances of the project activity, which meet pre-established eligibility criteria, may be added after project validation.

**Ha:** hectare

**Impounded Water:** A pool of water formed by a dam or pit.

**IFM**: Improved Forest Management.

**Inundation:** Freshwater or seawater flooding of land or buildings. Coastal inundation specifically relates to flooding from seawater.

**IPCC:** Intergovernmental Panel on Climate Change.

**LiDAR:** Light Detection and Ranging, a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth. It is often used to obtain detailed elevation maps of an area.

**Leakage:** Net changes of anthropogenic emissions by GHG sources that occur outside the project or programme boundary but are attributable to/caused by the project or programme.

**Mangrove:** A subset of tidal wetlands in subtropical and tropical coastal ecosystems dominated by halophytic trees, shrubs, and other plants growing in brackish to saline tidal waters.

**Marsh:** A subset of wetlands characterized by emergent soft-stemmed vegetation adapted to saturated soil conditions. There are many kinds of marshes, ranging from the prairie potholes to the Everglades, coastal to inland, freshwater to saltwater, but the scope of the tidal restoration methodology is limited to tidal marshes. Salt marshes consist of salt-tolerant and dwarf brushwood vegetation overlying mineral or organic soils.

**Mean high water springs (MHWS):** The mean level of spring tides at standard atmospheric pressure. MHWS-6 is the $94^{th}$ percentile of spring tides (i.e., 6% of spring tides are higher than MHWS-6).

**Mean sea level (MSL):** An average level for the surface of the sea from which heights such as elevations may be measured.

**Methodology:** A specific set of criteria and procedures, which apply to specific project activities, for identifying the project boundary, determining the baseline scenario, demonstrating additionality, quantifying net GHG emission reductions and/or removals, and specifying the monitoring procedures.

**Mg:** Metric tonne.

**Mineral Soil:** Soil that is not organic (refer to definition of 'organic soil').

**Mudflat:** A subset of tidal wetlands consisting of soft substrate not supporting emergent vegetation.

**Aotearoa New Zealand Vertical Datum (NZVD2016):** Aotearoa New Zealand Vertical Datum 2016 as per standard LINZS25009.

**$N_2O$**: nitrous oxide.

**Open Water:** An area in which water levels do not fall to an elevation that exposes the underlying substrate.

**Organic soil**: Soil with a surface layer of material that has a sufficient depth and percentage of organic carbon to meet thresholds set by the IPCC (Wetlands supplement) for organic soil. For example, *soils that are never saturated with water for more than a few days must contain more than 20 percent organic carbon by weight i.e., about 35 percent organic matter* (IPCC 2014). Where used in this report, the term 'peat' is used to refer to organic soil.

**Peatland:** An area with a layer of naturally accumulated organic material (peat) that meets an internationally accepted threshold (e.g., host-country, FAO or IPCC) for the depth of the peat layer and the percentage of organic material composition. Peat originates because of water saturation. Peat soil is either saturated with water for long periods or is artificially drained. Common names for peatland include mire, bog, fen, moor, muskeg, pocosin and peat swamp (forest).

**Project activity**: The specific set of technologies, measures and/or outcomes, specified in a methodology applied to the project, that alter the conditions identified in the baseline scenario and which result in GHG emission reductions or removals.

**Project area:** Specific geographical area defined in hectares comprising the carbon accounting area to be used for implementing the project intervention/s and for project carbon accounting.

**Project contact**: Person with key knowledge of a project scenario or case study location.

**Project Crediting Period:** The project crediting period is the period for which GHG emission reductions or removals generated by the project are eligible for crediting. The project must have a robust operating plan covering this period.

**Project scenario**: The project scenario represents the activities and GHG emissions that would occur because of the project activity. The project scenario shall be accurately determined so that an accurate comparison can be made between the GHG emissions that would have occurred under the baseline scenario and the GHG emission reductions and/or removals that were achieved by project activities.

**Relative sea level rise (RSLR):** RSLR includes both the change of the level of the sea (such as from global warming) and movement of the land (such as from earthquake subsidence) for the relevant coastal area. Tidal gauges measure relative sea level rise.

**Representative Concentration Pathways (RCP):** Scenarios of future radiative forcing's from greenhouse gases.

**RDP**: Rewetting of Drained Peatland.

**RWE:** restoration of wetlands ecosystem.

**Salinity Average:** The average water salinity value of a wetland ecosystem used to represent variation in salinity during periods of peak $CH_4$ emissions (e.g., during the growing season in temperate ecosystems).

**Salinity Low Point:** The minimum water salinity value of a wetland ecosystem used to represent variation in salinity during periods of peak $CH_4$ emissions (e.g., during the growing season in temperate ecosystems).

**Seagrass Meadow:** An accumulation of seagrass plants over a mappable area. This definition includes both the biotic community and the geographic area where the biotic community occurs. Note that most seagrass meadows are sub-tidal, but a percentage are intertidal.

**Sea level rise (SLR):** The rise in the level of the sea. Also see Relative Sea Level Rise.

**SDG:** Sustainable Development Goals (SDGs).

**SD VISta:** Sustainable Development Verified Impact Standard.

**SD VISta Coastal Resilience Methodology:** Methodology for Coastal Resilience Benefits from Restoration and Protection of Tidal Wetlands – First SD VISta Methodology Addresses Coastal Resilience Benefits currently under review and validation.

**SMHZ:** Salt marsh habitat zone, which refers to the area within upper and lower elevation boundaries within which salt marsh habitat can survive in a given area.

**SOC:** Soil organic carbon.

**Tidal Marsh**: A subset of marshes consisting of salt tolerant and dwarf brushwood vegetation overlying mineral or organic soils.

**Tidal Wetland:** A subset of wetlands under the influence of the wetting and drying cycles of the tides (e.g., marshes, seagrass meadows, tidal forested wetlands, and mangroves). Sub-tidal seagrass meadows are not subject to drying cycles but are still included in this definition.

**Tidal Wetland Restoration:** Restoration of degraded tidal wetlands in which establishment of prior ecological conditions is not expected to occur in the absence of the project activity. For the purpose of the VM0033 methodology, this definition includes activities that create wetland ecological conditions on mudflats or within open or impounded water AND/OR Re-establishing or improving the hydrology, salinity, water quality, sediment supply and/or vegetation in degraded or converted tidal wetlands. This definition also includes activities that create wetland ecological conditions on uplands under the influence of sea level rise or activities that convert one wetland type to another or activities that convert open water to wetland.

**TRKP**: Te Repo Ki Pūkorokoro.

**TRKPM**: Te Repo Ki Pūkorokoro Miranda.

**VCS**: Verified Carbon Standard.

**VCS Program**: The GHG programme operated by Verra which establishes rules and requirements that operationalize the VCS to enable the validation of GHG projects and programs, and the verification of GHG emission reductions and removals.

**VM0007:** VCS Methodology REDD+ Methodology Framework (REDD+ MF).

**VM0033:** VCS Methodology for tidal wetland and seagrass restoration.

**WRC:** wetlands restoration and conservation.

# 1 Introduction

## 1.1 BLUE CARBON AND COASTAL RESILIENCE PROJECTS

This report examines the technical, financial, legal and organisational feasibility of blue carbon and/or coastal resilience projects in Aotearoa New Zealand, through the scoping assessment of six potential project sites.

This feasibility study is a component of a broader programme of The Nature Conservancy (TNC) exploring the potential of a blue carbon resilience credit as a conservation financing tool. This study estimates the blue carbon and coastal resilience project potential for these sites and provides recommendations and next steps for project development.

The specific consulting tasks in this study as stated in the Terms of Reference are:

1. Technical assessment for 6 project sites listed north to south as follows:
    a) Repo ki Pūkorokoro Reserve (approximately 20 ha) and nearby sites (salt marsh restoration via reintroduction of tidal flow).
    b) Wainui Repo Whenua.
    c) Pukehina, Bay of Plenty (existing farmland to be potentially rewetted to salt marsh).
    d) Farewell Spit (approximately 1,500 ha seagrass restoration and conservation).
    e) Waimeha[1] Inlet (approximately 3,440 ha salt marsh and seagrass conservation and restoration).
    f) Wairau Lagoon and estuary (approximately 1,980 ha salt marsh conservation).
2. Evaluate current and potential voluntary and regulatory market access; and programs that could provide funding support for project/market activities; identifying prospective offset and/or non-carbon payment for ecosystem services (PES) unit purchasers as relevant.
3. Assess the applicability of relevant methodologies for carbon credits (e.g., Verified Carbon Standard VM0033 and VM007 methodologies[2]) and resilience credits (Sustainable Development Verified Impact Standard (SD VISta) Coastal Resilience methodology[3] currently under review and validation) and if applicable consider potential impact of sea level rise.
4. Assess knowledge/data gaps to be filled for applying relevant methodologies above.
5. Carbon accounting estimates: project net Greenhouse Gas (GHG) benefits and offset potential based on baseline and with-project scenarios, considering Sea Leve Rise (SLR) and other relevant risks and based on best available scientific data, including site specific/locally relevant published values where available. In general, this will include:
    a) Determination of carbon pools relevant to the carbon accounting exercise.
    b) Establishment of a project baseline scenario; justify the baseline together with an additionality justification.
    c) *Ex ante* estimate of baseline emissions.
    d) *Ex ante* estimate project scenario emissions.
    e) *Ex ante* estimate of net carbon benefits (the difference between baseline and project scenarios to determine the gross carbon benefits delivered by the project).
    f) *Ex ante* estimate of project leakage.
    g) *Ex ante* estimate of buffer.
    h) *Ex ante* estimate of net carbon credits (net carbon benefits minus leakage, and buffer).

---

[1] Also referred to as Waimea Inlet.

[2] https://verra.org/methodologies/

[3] https://verra.org/project/sd-vista/methodologies/

i) Consideration of legal instruments of protection of project scenario.

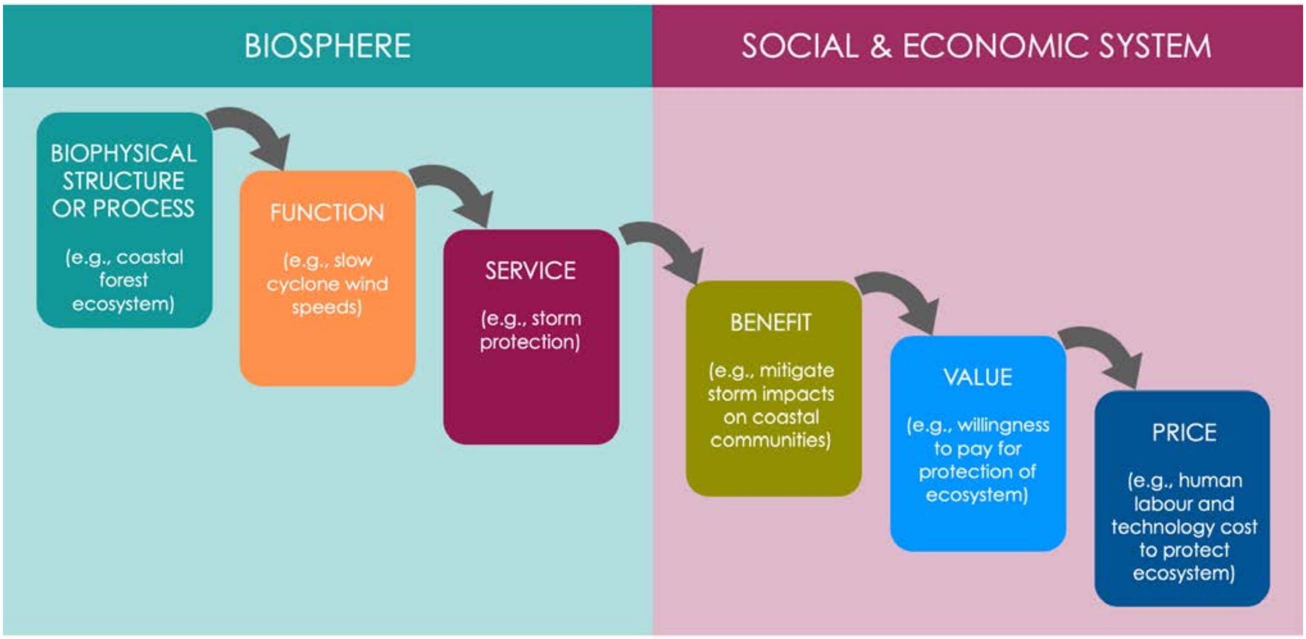
6. Identification of existing data and relevant models, and identification of data/modelling gaps to be filled for more precise estimates. Resilience benefits will be described by reviewing ongoing projects and studies, assuming they exist.
7. Financial feasibility – provide project cash flow based on estimates of project activity cost, carbon/resilience project development cost, carbon/resilience revenues, future monitoring/verification costs, and other future project cost needs (community/stakeholder management, etc). Also consider non-carbon ecosystem benefits that could provide ancillary revenue streams including the potential for non-carbon versions of payment for ecosystem services units and associated monetization. Include a range of price points.
8. Legal feasibility – assess relevant law/policies and regulations regarding credit trading, landowner authority to participate in market and transfer of carbon/resilience rights (including Public Conservation Lands, and if activity takes place on the foreshore or seabed – who has the rights, can they participate in a market), and recommendations for legal agreements for project development.
9. Organizational feasibility – identify partners and organisations to be involved in project development, and their prospective roles; consider context of a grouped (i.e., multiple) project approach.

## 1.2 FINANCING CONSERVATION

A blue carbon project, coastal resilience project, or biodiversity credit project is a means to finance conservation and/or resilience activities in coastal ecosystems that will deliver ecologically beneficial outcomes. These beneficial outcomes are delivered by ecosystems in the form of ecosystem services such as carbon sequestration and buffering of tidal flooding. Blue carbon, coastal resilience, and biodiversity credit projects are a form of 'payment for ecosystem services' structured through the creation of tradeable assets (e.g., carbon credits) that, when sold, create the revenue needed to fund the conservation activities.

The conceptual framework underlying the analysis in this report focuses on the way that ecological infrastructure (such as coastal ecosystems) delivers ecosystem services that provide benefits to society. These benefits can ultimately be priced in the social and economic system to pay for the human labour and technology to protect and enhance the ecosystems that generate the benefits (see Figure 1.2).

*Figure 1.2 Ecosystem service cascade (modified after Potschin and Haines-Young 2016).*



Conservation has traditionally been financed through grants and voluntary actions. The scale of the coastal ecosystem conservation challenge, however, is beyond the capacity of grant funding and without this funding for protection and restoration, these ecosystems have continued to decline. For this reason, the protection and restoration of coastal ecosystems will benefit from a sustainable financing approach that does not rely on grants and voluntary actions and can instead happen at scale.

A strategy for sustainable financing for coastal ecosystem protection can be developed. This would include both the cost of the problem (i.e., financial, and non-financial impact of degraded coastal ecosystems), and the cost of the solution. The solution cost can be funded through a blue carbon, coastal resilience or biodiversity credit project.

### 1.2.1 Cost of the Problem

The cost of the problem is the aggregated negative impacts of coastal ecosystem degradation. These costs can be financial and non-financial and in many cases are not experienced or counted by the person(s) who cause the problem. The entities which cause coastal degradation may not carry any formal responsibility, mainly because there is often no legal sanction against activities that cause these systems to degrade, and/or no financing mechanism to account for these costs. Planning laws and regulations are changing this situation, but despite this the threat to coastal ecosystems continues. This is also because conservation management costs money, and there is simply not enough grant funding and voluntary labour to solve the coastal conservation problem.

### 1.2.2 Cost of the Solution

The cost components of environmental protection solutions can be broken down into three key categories:

1. **Capital expenditure:** project development and (sometimes) creation of the conservation asset (e.g., revegetation, engineering to restore natural hydrological conditions).
2. **Operating expenditure:** operating and maintaining the project and conservation asset, and measurement reporting and verification (MRV) of conservation outcomes.
3. **Opportunity cost:** what people must give up to realise the conservation outcome, discussed further below.

#### 1.2.2.1 Opportunity Cost

Consider a landowner who is making a living from farming an area of coastal wetland that has been drained in the past and developed as improved pasture. This land development has come at a cost and is reflected in the new land value which is higher than the land value when it was a coastal wetland (and unproductive for farming). Then consider a wetland restoration proposal to re-establish this tidal wetland on the same land. For the proposal to succeed, the farmer will need to give up farming this land, give up the income they receive from that farming, and potentially give up a portion of land value on that land as it transitions from 'productive farmland' to 'non-productive land' in the eyes of the rural property market. This loss of revenue and land value is the opportunity cost of conservation in this example.

If this lost income could be replaced through some form of compensatory payment, the decision to voluntarily participate in conservation on such land can be much easier to make, particularly when farming the land is an integral component of the livelihood of that farmer and the value of their farm.

When that payment for ecosystem services can be delivered by a market-based mechanism, and when there is a ready market willing to pay this cost, then the conservation of coastal ecosystems can happen at scale. Programmes to generate blue carbon credits, sold through the carbon market, offer one such market-based mechanism.

### 1.2.3 Sustainable Financing & Market-Based Mechanisms

Sustainable financing is the ability of an activity to secure sufficient, stable, predictable, and long-term financial resources to cover the full costs of the effective delivery of the activity's intended outcomes. In other words, a sustainably financed activity is one that is financially self-sufficient and independently generates enough revenue to cover all its expenses.

Sustainable financing has three core components:

1. **Sustainable revenue streams** that deliver on-going cashflows to fund the operational expenditures of the activity or programme.
2. **Sustainable financing modalities** that deliver capital investment to fund the capital expenditure required to establish the activity.
3. **Sustainable business models** are plans for specific types of projects or initiatives that combine sustainable revenue streams with sustainable financing modalities to deliver a blue carbon outcome.

Market-based mechanisms in conservation financing are typically structured as payment-for-results or payment for ecosystem services. In a blue carbon project setting this can include carbon credit projects, resilience credit projects, and biodiversity credit projects.

### 1.2.4 Carbon Markets

The core supply-side purpose of the carbon market is to function as a sustainable revenue stream for projects that deliver carbon benefits, where those benefits would not otherwise happen if not for a) the project and b) the revenue from the sale of carbon credits (this proviso is the 'additionality' requirement of carbon market mechanisms).

Carbon markets involve the production and sale of carbon credits from projects that deliver carbon benefits to the atmosphere. The demand for carbon credits is driven either by regulatory obligations (the compliance carbon market) or voluntary offsetting by businesses, organisations, and products seeking to go net zero carbon (voluntary carbon offsets market).

Going 'net zero carbon' involves measuring a carbon footprint, developing and implementing a carbon emissions reduction plan, and compensating for carbon emissions that could not be reduced or avoided by purchasing (and cancelling/retiring)[4] carbon credits to match the volume of residual emissions.

Projects supplying carbon credits into the voluntary carbon offsets market can be fully funded for the project period without any need for grants, or where grant funding plays a co-financing project start-up role with the balance (perhaps the majority) of funding (including for on-going operations) delivered by the market mechanism. The key co-financing role that grants can play in a carbon market setting is to provide 'catalytic capital' to lift the financial performance of the sustainable business model sufficiently to attract capital from sustainable investment (e.g., private investment).

The carbon market has steadily increased in value since 2005 with current cumulative value standing at close to USD7 billion, with the majority of carbon credits produced in Asia (Ecosystem Marketplace 2021).

[4] The cancellation and/or retirement of carbon credits means the carbon credits can no longer be transacted. This is the act of consuming the carbon credits for their end-life purpose. This is a requirement for carbon offsetting programmes.

#### 1.2.4.1 Carbon Standards

An underlying feature of carbon projects is the quality assurance system behind carbon credit production, based on a 'carbon standard' that sets the conditions for demonstrating that a project activity generates legitimate carbon reduction. The carbon standards that are potentially applicable to blue carbon projects include:

| Standard | Weblink |
|---|---|
| Verified Carbon Standard (VCS) (operated by Verra): | https://verra.org/project/vcs-program/ |
| Sustainable Development Verified Impact (SD VISta) Standard (operated by Verra): | https://verra.org/project/sd-vista/ |
| Plan Vivo Standard | https://www.planvivo.org/ |
| Gold Standard for the Global Goals | https://www.goldstandard.org/articles/gold-standard-global-goals |

***Commodifying Nature or Not***

*Carbon market approaches to conservation are sometimes criticized for "commodifying nature". This is not always correct. Nature has long been commodified (wood, minerals, conversion of natural ecosystems to farmland, sale of rare species). Conservation efforts (whether market-based or grant-funded) are usually an attempt to disrupt this type of commodification. Furthermore, carbon projects need not put a price on nature. Nature has intrinsic value as well as value to human wellbeing. Carbon projects do, however, put a price on the human labour and technology cost to look after nature. The pricing of human labour and technology to look after nature is undertaken all the time in grant funding and is not controversial.*

#### 1.2.4.2 Carbon Project Cycle

The project cycle for a carbon project involves the following broad steps:

1. Feasibility assessment (this report).
2. Site-specific scoping (elements of this report).
3. Project development.
4. Project validation.
5. Project implementation.
6. Project monitoring, verification and credit issuance.
7. Credit monetization and revenue distribution.
8. Repeat step 5 and 6 through the project period.

### 1.2.5 Resilience Projects

Coastal ecosystems provide human communities, property and infrastructure with protection against the impacts of climate-related hazards and natural disasters by reducing erosion and flooding from storms and stabilizing and raising shorelines in the face of sea-level rise.

Restoring and protecting coastal ecosystems contributes to the United Nations' Sustainable Development Goal 13: Taking urgent action to combat climate change and its impacts, and Target 13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries.

The SD VISta Coastal Resilience methodology[5] provides an approach to quantifying the annual flood risk reduction (i.e., resilience) benefits of coastal ecosystems to people. SD VISta assets/units quantified using this methodology are not available to be used for offsetting negative impacts of activities which may increase the number of persons affected by coastal flooding events.

The project cycle for application of the SD VISta standard follows the same broad framework as that for carbon projects. The scope of coastal resilience projects falls under the UN Sustainable Development Goal 13: Climate Action.

### 1.2.6 Biodiversity Credit Projects

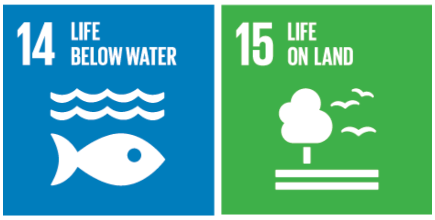
Biodiversity credits are like carbon credits but where the core ecosystem service delivered is a biodiversity benefit rather than a carbon benefit. While biodiversity credits are a market instrument, the biodiversity credit market is far less developed than the carbon market.

'Biodiversity offsets' compensate for (offset) biodiversity losses from one location by delivering biodiversity gains in another location. Between USD 2.6 billion and USD 7.3 billion in finance was delivered through biodiversity offsets in 2016 (see Bennett et al. 2017). In contrast, 'biodiversity credits' are not offsets but represent a unit of biodiversity conservation that has been measured, reported and verified and available for purchase by those who want to cause that biodiversity conservation outcome.

The standards available for use for the creation of biodiversity credits include:

| Standard | Weblink |
| --- | --- |
| Gold Standard for the Global Goals | https://www.goldstandard.org/articles/gold-standard-global-goals |
| Plan Vivo Standard[6] | https://www.planvivo.org/ |
| Sustainable Development Verified Impact (SD VISta) Standard (operated by Verra): | https://verra.org/project/sd-vista/ |

A broad range of activity types are possible under the SDG framework, focusing on those SDGs most relevant to biodiversity conservation[7]:




[5] Methodology for Coastal Resilience Benefits from Restoration and Protection of Tidal Wetlands, v 1.0, 28-July-2010 this version of the document issued.

[6] The biodiversity credit scope of the Plan Vivo standard is still in development and Ekos is involved in this process as an external technical advisor.

[7] https://www.un.org/sustainabledevelopment/sustainable-development-goals/

Biodiversity offset schemes are operated in some countries including:

- The biodiversity offset element of the US Water Act.
- The Biodiversity Offset Scheme (BOS) in Australia: https://www.environment.nsw.gov.au/topics/animals-and-plants/biodiversity-offsets-scheme/offset-obligations-and-credit-trading/biodiversity-offsets-scheme-public-registers
- The Natural England Biodiversity Offset Scheme in the UK: https://cieem.net/ne-biodiversity-credits-scheme/.

Information on biodiversity credit schemes (i.e., not offsets) is more limited. IHS Markit operates an international registry that includes the option for biodiversity credits, but limited information is publicly available for biodiversity credit projects on this registry.[8]

### 1.2.7 Market Access

Monetising carbon credits, resilience credits, or biodiversity credits (or stapled credits) will, like any commercial undertaking, require sales and marketing capability. In turn this will require assigning a sales and marketing role to appropriate entities in a commercial supply chain. Several intermediaries deliver ecosystem market services in different parts of the world. This includes CSR brokers and carbon and biodiversity market facilitators and resellers (and their networks).

Examples in Australia and Aotearoa New Zealand include:

- Australia: Green Collar (https://greencollar.com.au/), Tasman Environmental Markets (https://www.tasmanenvironmental.com.au/), Greenfleet (https://www.greenfleet.com.au/), Niche (https://niche-eh.com/).
- Aotearoa New Zealand: Ekos (https://ekos.co.nz/), Toitū Envirocare (https://www.toitu.co.nz/home), Carbon Click (https://www.carbonclick.com/).

Examples in Europe include:

- ZeroMission (https://zeromission.se/en/), MyClimate (https://www.myclimate.org/), South Pole (https://www.southpole.com/), Nature Based Ventures (https://www.nb.ventures/), Landlife (https://landlifecompany.com/), Forliance (https://forliance.com/).

Examples from North America include:

- Winrock International (https://winrock.org/), The Nature Conservancy (https://www.nature.org/en-us/), C-Quest Capital (https://cquestcapital.com/), ClimeCo (https://climeco.com/), Bluesource (https://www.bluesource.com/), TerraCarbon (http://www.terracarbon.com/index.html), Natural Capital Partners (https://www.naturalcapitalpartners.com/), Terra Global Capital (https://www.terraglobalcapital.com/).

Resilience credit and biodiversity credit monetisation strategies include:

a) Corporate Social Responsibility (CSR) buyers purchasing resilience or biodiversity credits. Buyer motivation: desire to contribute to financing coastal conservation and embed this into their value chain.
b) Voluntary carbon market buyers purchasing resilience or biodiversity credits in direct association with carbon credits. Buyer motivation: Desire for a localised (i.e., close to the buyer) nature-based solution

[8] https://ihsmarkit.com/products/environmental-registry.html

to voluntary carbon offsetting. This includes 'stapling' resilience or biodiversity credits to carbon credits.

The term 'stapling' here refers to combining (or stacking) different benefits/co-benefits together into a single (stapled) package. The purpose of stapling from a seller perspective is to enable a project outcome (e.g., a biodiversity conservation outcome) to gain access to market-based financing from a different market. For example, demand for nature-based solutions in the voluntary carbon offsets market is already well established and one of the key reasons why indigenous forest carbon credits are among the highest priced in the voluntary carbon market. In the Aotearoa New Zealand voluntary carbon market, indigenous forest carbon credits are rare, and demand is higher than supply. One way to service this market is to supply resilience or biodiversity credits stapled (1:1) to carbon credits.

## 1.3 FEASIBILITY TESTS

The overall feasibility of a blue carbon or coastal resilience project was tested by requiring a project to pass all the feasibility tests. Each feasibility assessment involved a feasibility test as follows:

The technical feasibility test required a project site to meet the following conditions:

- All necessary data sufficient to fulfil the technical methodological requirements of the VCS methodology applied.
- Technical data aligned with a potential tradable asset volume sufficient to warrant a financial feasibility assessment.

The financial feasibility test required project finances to demonstrate no negative cumulative cashflows across the 50-year project period. In other words, the project bank balance cannot fall below zero at any point in the project period thereby demonstrating that the project is financially sustainable without secondary investment.

The legal feasibility test required a project to have no legal barriers to implementation.

The organizational feasibility test required a project to have the potential for an organizational structure and organizational capability sufficient to deliver project development and project implementation.

## 1.4 DOCUMENT STRUCTURE

This document encompasses the following steps in the carbon project cycle: Step 1 (feasibility assessment) and with a limited contribution to Step 2 (site-specific scoping). This feasibility assessment is structured as follows:

- **Section 2 - Scientific Basis:** Provide background information on the science of the blue carbon and coastal resilience concepts.
- **Section 3 - Technical Feasibility:** Assess the alignment of proposed project activities to a validated ecosystem accounting methodology (i.e., certified to a standard).
- **Section 4 - Financial Feasibility:** Assess the costs and benefits of undertaking a project using the validated methodology.
- **Section 5 - Legal Feasibility:** Assess relevant law/policies/regulations regarding credit trading, landowner authority to participate in market and transfer of carbon/resilience rights, and recommendations for legal agreements to have in place for project development.
- **Section 6 - Organizational Feasibility:** Identify the organizational structure required to operate a blue carbon project or programme and identify potential participants and roles.
- **Conclusion:** Synthesis of all feasibility assessments.

Contributions:

Ekos led the overall project and reporting, led the introduction, financial and organizational feasibility, supported the technical feasibility, and reviewed/edited the full report.

Cawthron Institute led or contributed to (and reviewed) various sections, primarily Section 2 (scientific basis for blue carbon and the resilience methodology) and Section 3 subsections relating to methodology recommendations, project site descriptions and technical summary, carbon stocks, sequestration rates and emissions accounting values, other relevant environmental data, sea level rise and the resilience methodology. The above included the work in Appendices 1-6.

Bennion Law led the legal feasibility.

# 2 Scientific Basis

## 2.1 BLUE CARBON

Blue carbon is the carbon stored in coastal and in-shore marine ecosystems including tidal wetlands, seagrass meadows and mangrove systems. The carbon pools relevant to blue carbon are above ground live biomass, below ground live biomass, soil, and litter/deadwood.

Blue carbon ecosystems have been significantly impacted in the past and many continue to be threatened from coastal development and land-use change. Blue carbon management activities include the restoration and conservation of tidal wetlands, seagrass meadows, and mangrove systems. Conversion of tidal wetlands to pasture by draining and pasture development can lead to reduced carbon sequestration and storage at a coastal wetland site (Figure 2.1b). Greenhouse gas (GHG) emissions can also change with alteration in environmental conditions, including due to changes caused by humans.

*Figure 2.1a. Mechanisms by which carbon moves into and out of tidal wetlands. Source: Howard et al. 2014.*

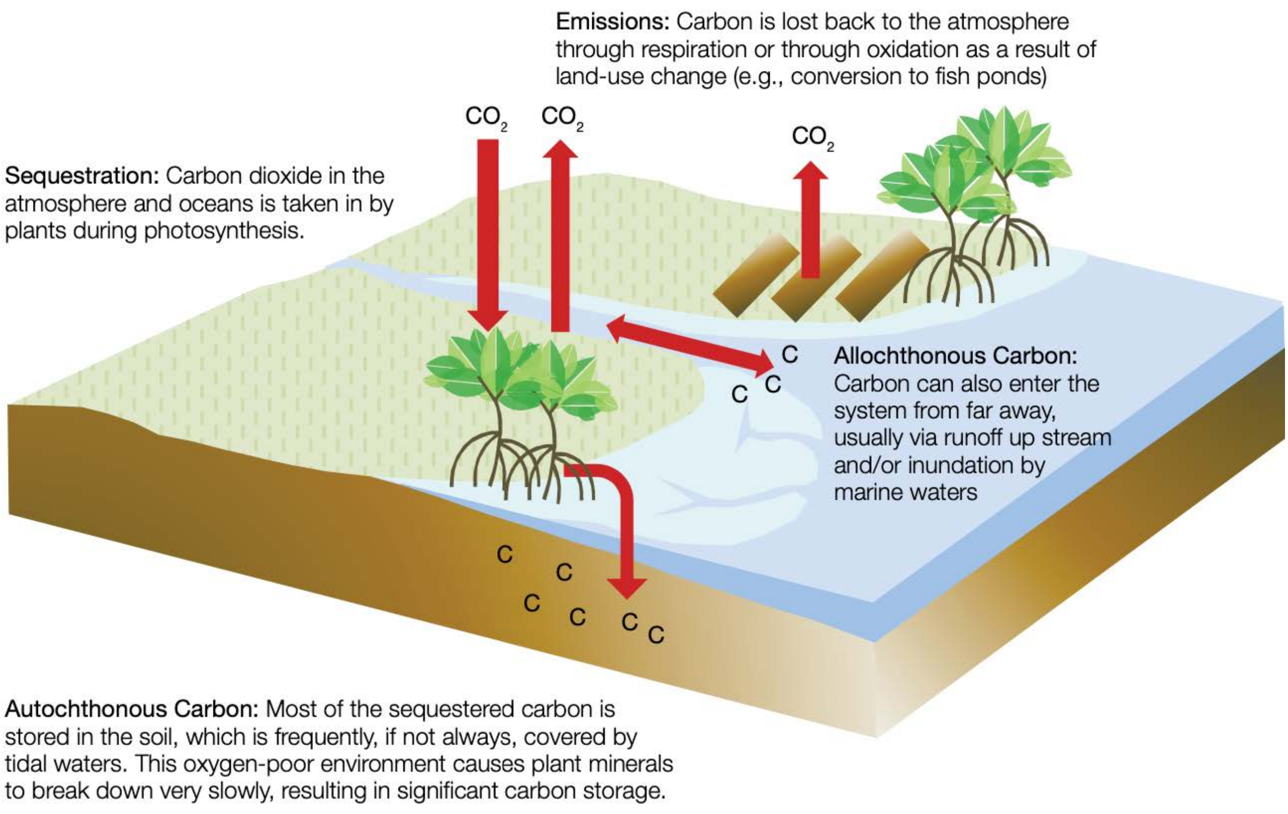
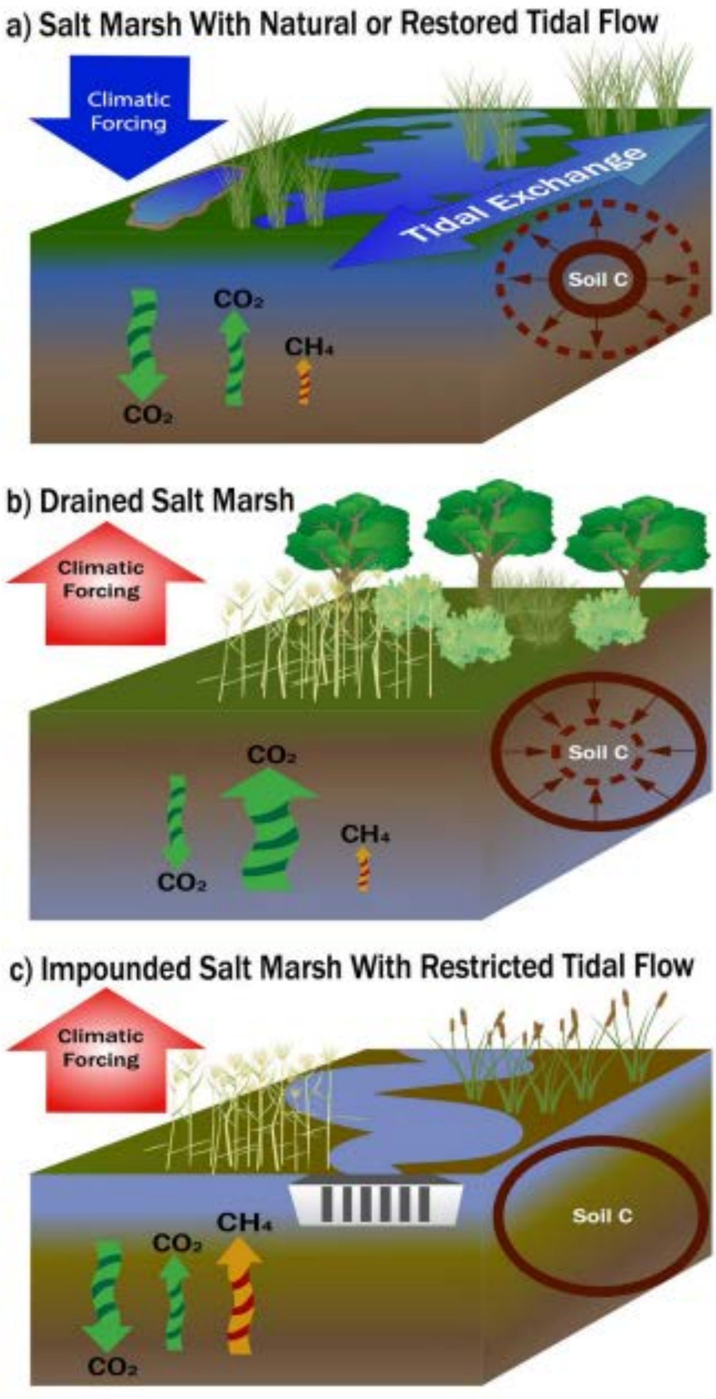


*Figure 2.1b. Conceptual model of carbon cycle processes and greenhouse gas flux in response to hydrological management in tidal wetlands.*




*(a) In unaltered or successfully restored salt marsh, sulphate ions inhibit methane emissions leading to high rates of net $CO_2$ uptake into non-gaseous carbon. This results in soil carbon sequestration and storage, and elevated soil carbon stocks.*

*(b) Salt marsh drainage increases exposure of soil carbon stocks to oxygen, and results in a rapid rate of aerobic respiration, resulting in $CO_2$* emissions.

*(c) Impoundment (caused by restricted water exchange with the sea) commonly leads to freshening and increased water levels, which cause an increase in methane emissions. Source: Kroeger et al. (2017).*

Tidal wetland restoration activities involving rewetting and revegetating of tidal wetland species (and associated weed and pest control) have been shown to help reverse this carbon loss of carbon sequestration (Kelleway et al. 2017, Macreadie et al. 2017, Dittmann et al. 2016).

Changes to plant species composition can alter primary production and carbon sequestration (Nie et al. 2017). As indicated above, restoration activities that change plant species composition in tidal wetlands (e.g., from pasture to salt marsh) can lead to increased carbon sequestration. However, in some cases, conservation-type activities that change plant species composition can decrease (rather than increase) carbon sequestration rates in tidal wetlands. For example, weed control of *Spartina anglica* in intact salt marsh habitats (where this species is not previously present) may lead to lower carbon sequestration, because sequestration rates for *Spartina* can be higher than some native species such as *Juncus kraussii* and *Salicornia quinqueflora* (e.g., Ellison & Beasy 2018[9]).

On the other hand, *Spartina* invasion can increase methane flux in salt marsh habitats (Yuan et al. 2014). It is also possible that other weeds that invade salt marshes in Aotearoa New Zealand (e.g., gorse and boxthorn) may not necessarily be detrimental for carbon sequestration/storage in these habitats. For example, gorse (*Ulex europaeus*) can improve soil fertility (Magesan et al. 2012), which in turn can improve carbon sequestration at least in terrestrial environments. Certain weed species may also be relatively woody in composition or potentially have faster growth rates, which could conceivably increase the above-ground biomass of the salt marsh habitat.

Soil disturbance in tidal wetland habitats can also lead to a reduction in carbon sequestration rates and loss of carbon stored in the soil (Macreadie et al. 2019, Kelleway et al. 2017, Persico et al. 2017). Hoofed animals (including livestock) can disturb tidal wetland soils and have been observed in some cases to cause extensive pugging of the substrates in mangrove and salt marsh habitats (Bellingham & Davis 2008) leading to degradation and GHG emissions.

Livestock grazing on salt marsh or mangroves and bird herbivory on seagrass meadows can also influence carbon storage and sequestration rates. Livestock grazing in salt marsh habitats has been found to diminish above-ground carbon storage (Muenzel & Martino 2018, Kingham 2013), and reduce salt marsh and mangrove vegetation cover (Bellingham & Davis 2008).

A preliminary study on seagrass meadows in Golden Bay, Aotearoa New Zealand found swan herbivory to have significantly impacted the seagrass habitat by reducing the biomass of shoots and rhizomes over short timeframes (Dixon 2009).

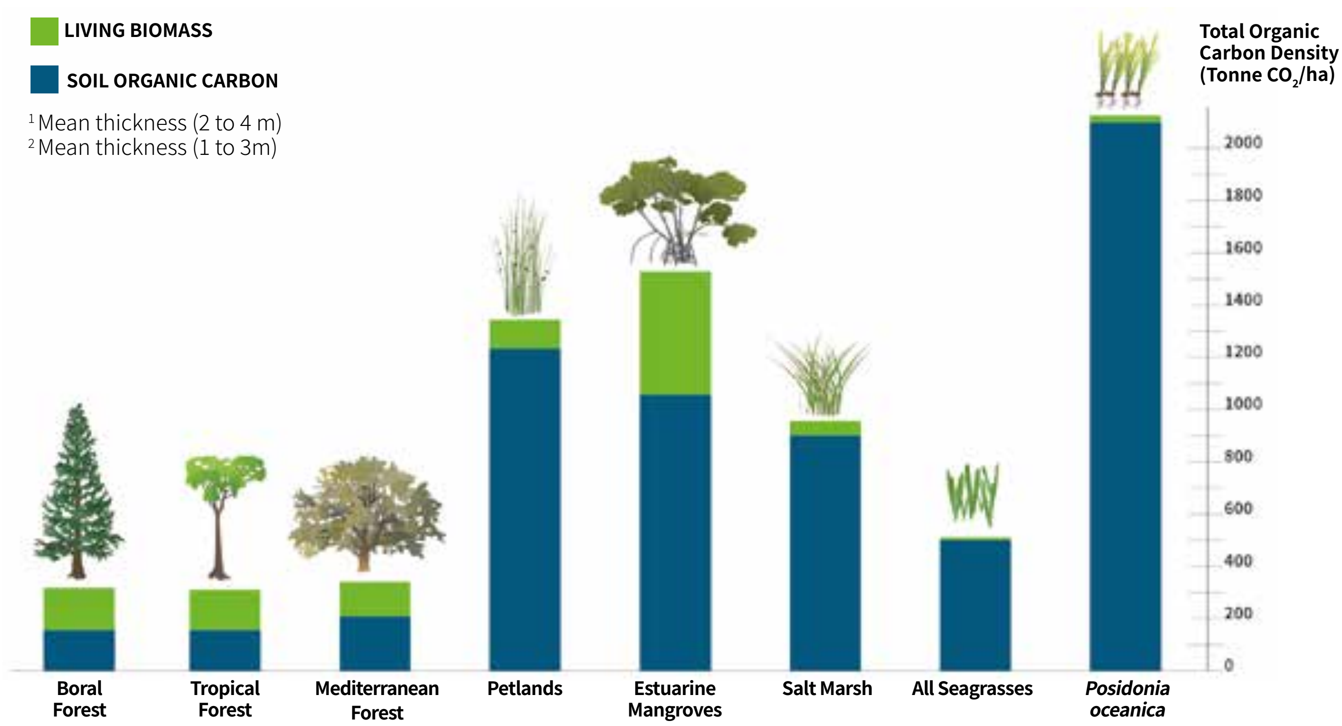
Relationships between carbon sequestration and grazing, however, can be complex and depend on a variety of factors such as stock density, grazer and salt marsh type and abiotic parameters. Livestock grazing can have variable effects on carbon storage and sequestration, reducing it in some cases (Morris & Jensen, 1998) or having little impact in others (Yu & Chmura, 2010, Elschot et al., 2015, Kingham et al. 2013). Ford et al. (2012) also found that greenhouse gas emissions from temperate salt marsh, measured as global warming potential over 100 years, did not differ significantly between cattle-grazed and un-grazed treatments.

Sedimentation can also influence carbon sequestration and storage in tidal wetland and seagrass habitats. This can be beneficial in some contexts (e.g., salt marsh and mangroves) and detrimental in others (e.g., smothering seagrass meadows and reducing photosynthesis rates (Turner & Schwarz 2006)).

The carbon stored in blue carbon biomes varies depending on the ecosystem (Figure 2.1c). It is worth noting, however, that it is the change on soil carbon stocks that is measured and relevant to blue carbon project development. That is, carbon credits are not produced from the carbon stocks in a blue carbon ecosystem, but from project activities and interventions that cause measurable beneficial change in carbon stocks in comparison with a baseline (business-as-usual) scenario.

[9] This is a Tasmanian study, but both *J. kraussii* and *S. quinqueflora* are also native to Aotearoa New Zealand.

*Figure 2.1c. Soil organic carbon storage in the top metre of the soil as a proportion of total ecosystem carbon density (i.e., storage) for major ecosystem types. Source: IUCN 2021.*




## 2.2 COASTAL RESILIENCE

Wetlands have an important role in protecting coastal communities (people and property) from the negative effects of storm surge and flooding. Coastal ecosystems such as marshes and forested wetlands can absorb and retain the energy of storm-driven waves and wind and, thus, mitigate the impacts of floods and waves on local communities (Boesch et al. 2006). Due to this mitigation capacity, wetland protection and enhancement can also result in financial benefits. According to the World Bank (2010), investments in preventive measures (including in maintaining and enhancing ecological infrastructure), are typically seven times less costly than the costs incurred due to natural hazards.

The frequency and the intensity of coastal flooding by tropical and ex-tropical cyclones are expected to increase globally in the coming decades because of accelerated SLR and climate change (Knutson et al. 2021). New models to estimate the ecosystem service value of storm protection can help to show the beneficial role of wetlands for coastal resilience and climate change adaption strategies. Process-based models (widely used in the engineering and insurance sectors to inform risk management and development decisions) have recently been used to quantify ecosystem benefits by comparing flood damage in scenarios with and without flood mitigation structures.

Beck et al. (2018) used a process-based approach to model the global ecosystem service value of coral reef ecosystems for different storm event scenarios. They estimate that for 100-year storm events, flood damage would increase by 91% (an increase of USD272 billion in costs) without these ecosystems. Menéndez et al. (2020) also used a process-based hydrodynamic approach and estimated that, globally, mangrove forests provide flood protection benefits exceeding USD65 billion per year. They concluded that if mangrove ecosystems were lost, 15 million more people would be flooded annually across the world.

While not as extensively studied as mangroves, the potential of salt marshes on attenuating storm surge and flooding has been investigated. Some of these studies concentrate in systematic field data with *in-situ* observations of level reduction in coastal wetlands (Stark et al, 2015; Van der Molen, 1997). A significant component of these studies, however, focuses on developing numerical modeling to measure the attenuation benefits of salt marsh habitats. Fagherazzi et al. (2012) compiled a review of several approaches to salt marsh resilience modeling and discussed how these models have been used to determine salt marsh survival under different scenarios of sea level rise. Recently Narayan (2017) showed how salt marsh protection performed in Ocean County (Barnegat Bay, USA) under a wide range of storm characteristics. Their findings show a reduction of annual flood risk by up to 70% across most elevations over the range of storm characteristics modelled, with the positive influence of marshes most evident at the highest risk locations (i.e., lowest elevation).

# 3 Technical Feasibility

The technical feasibility assessment will cover the following elements:

1. Overview of available methodologies.
2. Overview of project sites.
3. Carbon accounting for project sites.
4. Resilience accounting for project sites.
5. Technical summary of project sites (including technical feasibility assessment).

Sea level rise (SLR) is a cross-cutting issue for all project sites. While it is important to account for SLR in blue carbon projects it is beyond the scope of a feasibility assessment to specifically account for SLR in project carbon accounting. SLR will, however, need to be accounted for in full project development. An overview of SLR risk assessment for the project sites was conducted and is presented Appendix 6.

## 3.1 OVERVIEW OF AVAILABLE METHODOLOGIES

Every project that seeks to generate verifiable carbon credits must conform to a methodology from a recognised verification authority. The methodologies scoped for the potential projects described in this report are from the international carbon and sustainable development goal (SDG) certifier Verra, based in the USA[10]. The three specific methodologies assessed are:

Verified Carbon Standard (VCS):

- VM0033 Tidal Wetland and Seagrass Restoration.
- VM0007 REDD+ Methodology Framework.

SD VISta standard:

- Methodology for Coastal Resilience Benefits from Restoration and Protection of Tidal Wetlands.

Biodiversity credit project potential is not evaluated against an existing methodology as no biodiversity methodology had been validated to the SD VISta standard at the time of writing. Instead, biodiversity credit project potential is evaluated in generic terms based on local information available at each site and the principles of PES project types.

### 3.1.1 VM0033 Tidal Wetland and Seagrass Restoration

This methodology is categorized as a Restoring Wetland Ecosystems (RWE) and Afforestation, Reforestation and Revegetation (ARR) methodology.

#### 3.1.1.1 General Applicability

This methodology is applicable anywhere in the world and to activities that generate GHG emission reductions and/or removals through:

- Increased biomass.
- Increased autochthonous soil organic carbon.
- Reduced methane and/or nitrous oxide emissions due to increased salinity or changing land use.

[10] Verra is an international ecosystem accounting standard, formerly named the 'Verified Carbon Standard', but where now the Verified Carbon Standard (VCS) is a programme within the broader Verra framework.

- Reduced carbon dioxide emissions due to avoided soil carbon loss.

This methodology applies to the following strata:

- Strata with organic soil, with procedures for the estimation of emissions from peat depletion time (PDT).
- Strata with mineral soils and sediments with procedures for the estimation of emissions from soil organic carbon depletion time (SDT).

This methodology also includes an assessment of GHG emission reductions from the soil organic carbon (SOC) pool. This is calculated as either:

- The difference between the remaining SOC stock in the project and baseline scenarios after 100 years (total stock approach).
- The difference in cumulative carbon loss in both scenarios since the project start date (stock loss approach).

This methodology applies to:

- Carbon stocks and carbon stock change in trees and shrubs, using procedures from the Clean Development Mechanism tool: *AR-Tool14 Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities.*
- Carbon stock and carbon stock change in herbaceous vegetation, using procedures developed specifically for this methodology.

This methodology includes procedures for the consideration of sea level rise with respect to determining the geographic boundaries of the project area, and the determination of the baseline scenario and baseline emissions.

#### 3.1.1.2 Asset Description

The tradable units (assets) that would be created by projects using this methodology are called 'carbon credits'. Each carbon credit accounts for 1tCO2e of carbon benefits to the atmosphere and is calculated per ha per year. The tradeable units are permitted to be used as carbon offsets.

#### 3.1.1.3 Potential Relevance

This methodology has high potential relevance to the activities scoped in this feasibility assessment.

#### 3.1.1.4 Recommendations to Verra for Improving Methodology

General recommendations:

- The title of VM0033 implies that seagrass is considered separate to tidal wetland, whereas the definition of tidal wetland in the methodology includes seagrass. We suggest updating the title to better reflect the tidal wetland definition. For example: 'Methodology for Tidal Wetland (including Seagrass) Restoration".
- It is not necessarily easy to interpret what the term 'under the influence of the wetting and drying cycles of the tide' means in relation to the definition of 'tidal wetland' in VM0033 (and VM0007). This is especially so given the continuous pattern of natural vegetation succession that can occur inwards from the estuary boundary in Aotearoa New Zealand and the varying ways this definition could be interpreted in terms of timeframes and tidal influence. However, we recognise that it may make sense to leave this definition broad (as it is) to cater for different scenarios around the world.

More specific methodology recommendations are provided in relevant sections within this report (e.g., Section 3.3.3.1).

### 3.1.2 VM0007 REDD+ Methodology Framework

This methodology comprises a set of modules for different activity classes in the forest carbon activity sector.

#### 3.1.2.1 General Applicability

This methodology is applicable to:

- Project activities that reduce emissions from planned (APD) and unplanned (AUDD) deforestation and forest degradation.
- Activities that reduce emissions from forest degradation.
- Afforestation, reforestation and revegetation activities (ARR).
- Project activities that reduce emissions from planned (APWD) and unplanned (AUWD) wetland degradation.
- Wetland restoration activities (RWE).

#### 3.1.2.2 Asset Description

The tradable units (assets) created by projects using this methodology are called 'carbon credits'. Each carbon credit accounts for 1tCO2e of carbon benefits to the atmosphere and is calculated per ha per year. The tradeable units are permitted to be used as carbon offsets.

#### 3.1.2.3 Potential Relevance

This methodology has low potential relevance to the activities scoped in this feasibility assessment because the case study sites do not include forest activities. Mangrove projects at some of the project sites may be applicable under this methodology, but the case study activities did not initially include establishment or protection of mangroves.[11]

#### 3.1.2.4 Recommendations for Improving Methodology

Specific methodology recommendations are provided in relevant subsections within this report (e.g., in Appendix 2).

### 3.1.3 Resilience Methodology

The SD VISta 'Methodology for Coastal Resilience Benefits from Restoration and Protection of Tidal Wetlands' (also referred to as SD VISta Coastal Resilience Methodology in this report) is complementary to and incorporates elements from both VCS: VM0033 and VCS: VM0007. It focuses on coastal ecosystem management activities that provide protection against the impacts of climate-related hazards and natural disasters by reducing erosion and flooding from storms and stabilizing and raising shorelines in the face of sea-level rise.

The SD VISta Coastal Resilience Methodology provides a *'deemed estimate method'* and a *'scenario method'* to quantify the annual flood risk reduction (i.e., resilience) benefits of coastal ecosystems to people. Of the two, the *'deemed estimate method'* is the simpler method which can be used for mangrove protection projects. It is based on freely available datasets from a peer-reviewed, global study of mangrove resilience

[11] Mangroves would likely be relevant for some of the project sites over time (particularly norther sites) but were generally not considered in our scoping study (although they were mentioned in, but were not the focus of, the Sea Level Rise component.

benefits (Menendez et al., 2020). On the other hand, the *scenario method* uses a process-based approach, based on five steps for estimating flood protection benefits described by the World Bank (2016).

When using the scenario method, project boundaries include the *Project Area* and the *Project Impact Area*. The *Project Area* is defined as the whole area of tidal wetlands that will be maintained or restored due to project activities while the *Project Impact Area* refers to all areas that could be impacted in terms of flood risk reduction by restoration activities (this concept is further detailed in Section 3.4.2).

The scenario method aims to model the flood risk reduction benefits between two scenarios, the "with the wetland" scenario (defined as project scenario for restoration projects) and the "without the wetland" scenario (defined as baseline scenario for restoration projects), for four predefined flood storm conditions (10%, 4% 2% and 1% chance of occurrence). When using the scenario method, the methodology also requires the use of Manning's coefficients to account for the friction of land cover within the *Project Impact Area*. After assessing the flood extent and impact for both scenarios, the 'Net Coastal Resilience Project Impacts' can be calculated by assessing the coastal resilience benefits of the project in terms of reductions in the number of people impacted by flooding and/or reductions in the total property value damaged due to flooding within the area monitored by the project. Finally, the benefits from the coastal ecosystem will be estimated as the number of people and property protected per unit area of ecosystem which can then be converted a total benefits value for the project extent.

#### 3.1.3.1 General Applicability

This methodology applies to the restoration and protection of tidal marshes and mangroves only. It may be expanded to cover the restoration or protection of other coastal habitats such as coral reefs, seagrass meadows and oyster reefs.

#### 3.1.3.2 Asset Description

The tradable units (assets) that would be created by projects using this methodology are called 'Coastal Resilience Credits'. The unit (credit) accounts for the reduced number of people at risk of coastal flooding each year (in persons). The UN Sustainable Development Goal applicable to the tradeable units is SDG 13: Climate Change. The tradeable units are not permitted to be used as offsets of any kind.

#### 3.1.3.3 Potential Methodological Incompatibility

The definition of tradeable units in this methodology limits the potential to account for climate resilience benefits that are relevant to rural coastal settings in Aotearoa New Zealand. As a long and thin country, Aotearoa New Zealand has one of the largest coastlines per capita in the world. There is considerable rural property and infrastructure at risk of SLR and coastal flooding impacts. The human population is concentrated in cities and towns. However, few coastal tidal wetlands and other coastal ecological infrastructure are located in these urban and peri-urban settings, with much located rurally.

Thus, the opportunity to deliver resilience measures for coastal wetland conservation and coastal ecosystem restoration is low where the benefiting population is high, and high where the benefiting population is low. This incongruence significantly limits the applicability of this methodology to Aotearoa New Zealand climate change resilience opportunities. While this does not rule out the use of this methodology in Aotearoa New Zealand, the realistic opportunities for such projects to be financially viable are limited.

#### 3.1.3.4 Potential Relevance

This methodology has high potential relevance to the activities scoped in this feasibility assessment if there is a variation on the asset description as described below.

#### 3.1.3.5 Broaden Methodological Scope

This methodological incompatibility could be remedied through a variation in the asset description to include a definition that accounts for the property and infrastructure at risk from coastal climate change impacts measured (for example) in dollars per year as a contingent liability (i.e., future liability). Such a methodological scope would empower those promoting investments in coastal ecological infrastructure protection and enhancement (e.g., protecting tidal marsh, mangrove, and/or dune ecosystems) by providing a direct means of pricing:

a) The baseline cost of not adapting to climate change (e.g., allowing coastal ecosystems to degrade).
b) The project cost of climate change resilience measures (e.g., from the restoration and enhancement of coastal ecosystems).

This is particularly relevant to situations in which owners of, and lenders to, such property and/or infrastructure remain exposed to this risk. These entities need of self-insurance through investments in coastal ecosystem protection and enhancement as a resilience measure. This is also particularly relevant to the exit of the insurance industry from situations of high climate change risk (and increasing premiums when they do not exit), leaving self-insurance as an increasingly relevant option for coastal property/infrastructure owners[12].

Another option is to enable the interpretation of the asset measured in persons to include all persons beneficially impacted by infrastructure (e.g., the estimated number of persons that use a road or a bridge per year).

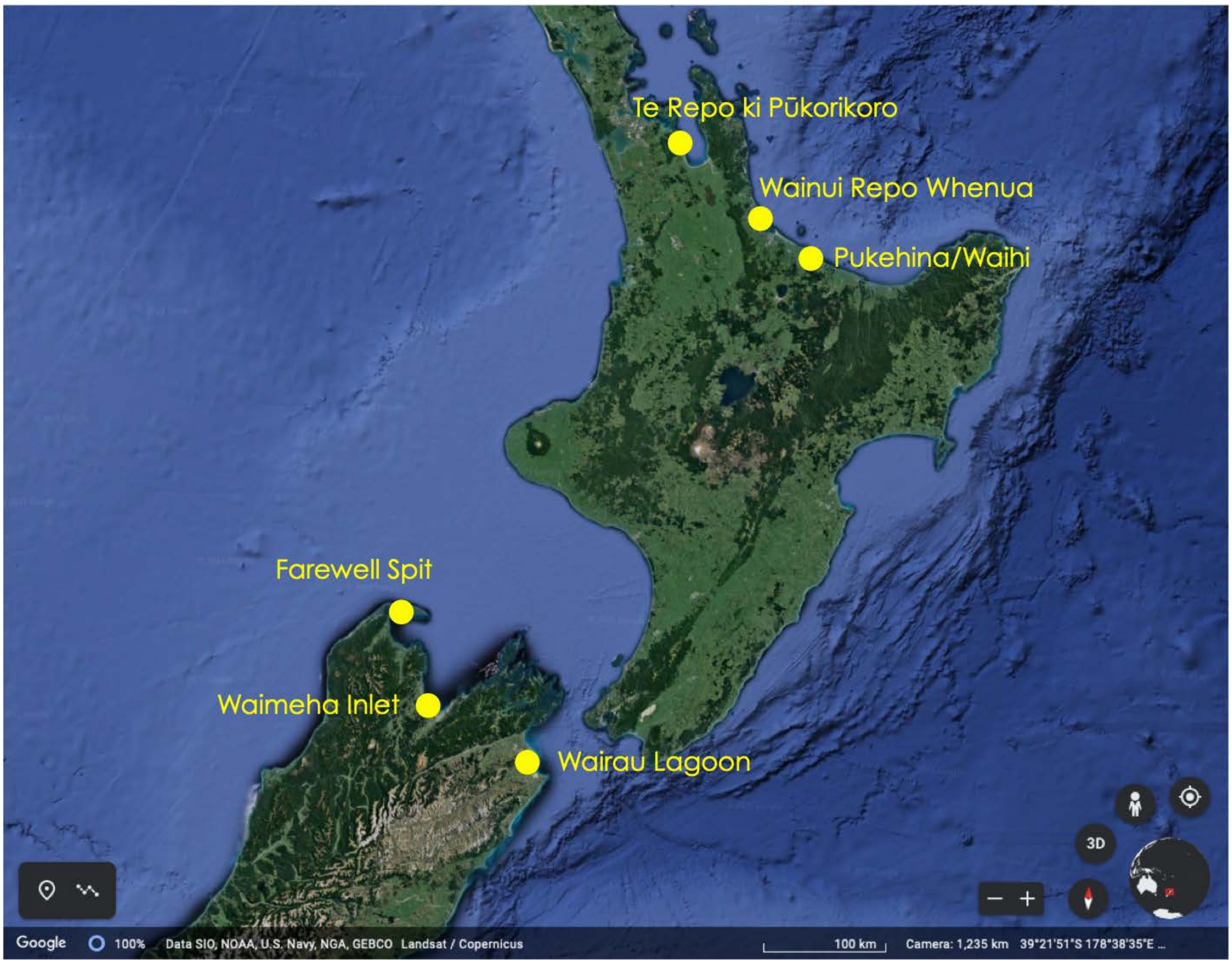
We recommend that the SD VISta 'Methodology for Coastal Resilience Benefits from Restoration and Protection of Tidal Wetlands' be broadened in scope to include an asset that was focused on property and infrastructure. This could still conceivably include the current 'persons' beneficially impacted by a resilience intervention (e.g., the number of persons that use bridges and roads).

[12] Note also that climate change risks are not restricted to coastal flooding and storm surges and include extreme weather events away from the coast. But the risk and resilience principle remain the same. In Aotearoa New Zealand, for example, there is an extensive rural roading network exposed to sediment trespass from erosion and flooding during high rainfall events (particularly the increasing number of ex-tropical cyclones). A resilience credit that functioned to reduce this risk would also have wide applicability in a Aotearoa New Zealand climate change resilience strategy.

## 3.2 OVERVIEW OF PROJECT SITES

Six case study locations were scoped in the current feasibility assessment (Figure 3.2).

*Figure 3.2: Location of case study sites.*




Each site was assessed for the following blue carbon project parameters:

- Potential blue carbon methodology alignment/applicability.
- Availability of relevant data to support blue carbon project development.
- Proposed baseline activity.
- Proposed project activity[13].
- Potential unit type.
- Preliminary quantification of potential blue carbon unit production.
- Financial feasibility.
- Legal feasibility.
- Organizational feasibility.

[13] Note that project activities outlined for most project scenarios assessed in our study were based on actual activities planned by local project proponents. However, some (namely those for the Farewell Spit and Pukehina project sites) are based on hypothetical situations as per the initial scope indicated and per follow-on information provided by project contacts.

A summary of the blue carbon methodologies assessed for each project is provided in Table 3.2a, and a summary of project sites and their potential baseline and project activities is provided in Table 3.2b.

*Table 3.2a. Summary of potential project activities evaluated. WRC = wetlands restoration and conservation, RWE = restoration of wetlands ecosystems, ARR = afforestation, reforestation and revegetation, CIW = conservation of intact wetlands, APWD = avoiding planned wetland degradation, AUWD = avoiding unplanned wetland degradation; RES = wetlands restoration and protection; ✓ = evaluated in this study and potentially applicable to the methodologies indicated.*

| Site | Region | Verra Methodology Assessed | | | | | |
|---|---|---|---|---|---|---|---|
| | | VM0033 (RWE) and VM0007 (CIW) | | | | | SD-VISta |
| | | WRC | | | | | |
| | | RWE | CIW | APWD | AUWD | ARR | RES |
| Te Repo ki Pūkorokoro | Waikato | ✓ | | | | ✓ | ✓ |
| Wainui Repo Whenua | Bay of Plenty | ✓ | | | | ✓ | ✓ |
| Pukehina/Waihī | Bay of Plenty | ✓ | | | | ✓ | ✓ |
| Farewell Spit | Tasman | ✓* | ✓* | | ✓* | | ✓ |
| Waimeha Inlet | Tasman | ✓ | ✓ | | ✓ | ✓ | ✓ |
| Wairau Lagoon | Marlborough | | ✓ | | ✓ | ✓ | ✓ |

* Activity type classification is pending further information from these sites.

*Table 3.2b. Site assessment summary for blue carbon project development.*

| Site | Area (ha) | Baseline Activity | Potential Project Activity | Potential unit Type |
|---|---|---|---|---|
| Te Repo ki Pūkorokoro | 19.5 | Degraded & drained wetland. | Rewetting and restoring wetland. | Carbon Credit<br>Resilience Credit<br>Biodiversity Credit |
| Wainui Repo Whenua | 20 | Degraded & drained wetland. | Rewetting and restored wetland. | Carbon Credit<br>Resilience Credit<br>Biodiversity Credit |
| Pukehina/Waihī * | 20.5 | Degraded & drained wetland. | Rewetting and restoring wetland. | Carbon Credit<br>Resilience Credit<br>Biodiversity Credit |
| Farewell Spit* | 55,830 | Degraded seagrass meadows from sedimentation and bird grazing. Alternatively, intact seagrass meadows at risk of degradation through these threats. | Reduced sedimentation & bird population control. | Carbon Credit<br>Resilience Credit<br>Biodiversity Credit |
| Waimeha Inlet | 4.5 | Degraded & drained wetland. | Rewetting and restoring wetland. | Carbon Credit<br>Biodiversity Credit<br>Resilience Credit |
| Wairau Lagoon | 647 | Intact salt marsh at risk of invasion from invasive weeds. | Weed control | Resilience Credit<br>Biodiversity Credit |
| | 243.4 | Intact salt marsh at risk of degradation from livestock. | Prevention of livestock access. | Carbon Credit<br>Resilience Credit |

* Project activities outlined for this project site are hypothetical i.e., there are no current plans to undertake the activities outlined.

## 3.3 CARBON ACCOUNTING FOR PROJECT SITES

Applicability conditions relating to each project scenario were assessed based on the VM0007 and VM0033 methodologies (see Appendix 2 for results). This information was provided by the project contacts and gathered through questionnaires. Assessing applicability conditions for the various Tools and Modules relevant to the VCS methodologies was beyond the scope of this study.

### 3.3.1 Applicable Carbon Pools

The carbon pools accounted for in this feasibility assessment are those specified in the VM0033 methodology and shown in Table 3.4.1.

*Table 3.4.1. Carbon pools accounted for and justification.*

| Carbon Pool | Included | Justification |
|---|---|---|
| Above ground tree biomass (AGTB) | Yes | Major carbon pool may significantly increase or decrease in both the baseline and project scenarios, in the case of establishment or presence of tree vegetation.<br>Above-ground tree biomass in the baseline scenario must be included.<br>Above-ground tree biomass in the project scenario may be included or conservatively omitted. |
| Above ground non-tree biomass (BGNTB) | Yes | Carbon stock in this pool may increase in the baseline scenario and may increase or decrease in the project scenario. |
| Below ground biomass (BGB) | Yes | Major carbon pool may significantly increase in the baseline, or decrease in the project, or both, in case of presence of tree vegetation.<br>Below ground biomass in the baseline scenario must be included.<br>Below ground biomass in the project scenario may be included or conservatively omitted. |
| Dead wood (DW) | No | This pool is optional for WRC methodologies. |
| Litter | No | This pool is optional for WRC methodologies. Litter is only included indirectly in association with the quantification of herbal biomass. |
| Soil | Yes | The soil organic carbon stock may increase due to the implementation of the project activity. |
| Wood products | Yes | Carbon stock in this pool may increase in the project scenario. |

### 3.3.2 Applicable GHG Sources

The below ground biomass and soil carbon emissions to be accounted for in this feasibility assessment are those specified in the VM0033 methodology and shown in Table 3.4.2.

*Table 3.4.2. Below ground GHG sources applicable to project sites.*

| Source | | Gas | Included? | Justification |
|---|---|---|---|---|
| Baseline | The production of methane by microbes | $CH_4$ | Yes | May be conservatively excluded in the baseline scenario, except where baseline is a saltmarsh area artificially impounded and flooded with freshwater and the project is aiming to re-instate tidal flushing. |
| | Denitrification/nitrification | $N_2O$ | Yes | May be conservatively excluded in the baseline scenario. |
| | Burning of biomass and organic soil | $CO_2$ | Yes | Implicitly included in the Fire Reduction Premium approach. |
| | | $CH_4$ | Yes | Implicitly included in the Fire Reduction Premium approach. |
| | | $N_2O$ | Yes | Implicitly included in the Fire Reduction Premium approach. |
| | Fossil fuel use | $CO_2$ | Yes | Conservatively excluded in the baseline scenario. |
| | | $CH_4$ | No | Conservatively excluded in the baseline scenario. |
| | | $N_2O$ | No | Conservatively excluded in the baseline scenario. |
| Project | The production of methane by microbes | $CH_4$ | Yes | Potential major source of emissions in the project in low salinity and freshwater areas. |
| | Denitrification/nitrification | $N_2O$ | Yes | May increase as a result of the project activity. |
| | Burning of biomass and organic soil | $CO_2$ | No | CO2 is addressed in carbon stock change procedures. |
| | | $CH_4$ | Yes | Potential major source of fire emissions. |
| | | $N_2O$ | Yes | Potential major source of fire emissions. |
| | Fossil fuel use | $CO_2$ | Yes | Potential source of emissions in the project scenario. |
| | | $CH_4$ | No | Not a significant source of emissions in project fuel use. |
| | | $N_2O$ | No | Not a significant source of emissions in project fuel use. |

### 3.3.3 Carbon Stocks, Sequestration Rates, and Emissions Applied

#### 3.3.3.1 Approach

Information was gathered from each site for both intact and degraded tidal wetland habitats relevant to greenhouse gas (GHG) accounting under VCS methodologies VM0033 and VM0007. The greenhouse gases considered were carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide ($N_2O$).

Default values (where available) were compiled from the relevant methodologies. Where possible, these default values were then compared with values from Aotearoa New Zealand and Australia or other countries where the same/or similar wetland species were present. In addition, key informants were consulted (e.g., staff from the Department of Conservation and other active researchers in this field) to complement information gathered from the literature.

At this scoping stage, the values provided for 'degraded' habitats represented one general level of degradation (i.e., drained wetland that is pasture), and therefore do not distinguish between varying degrees/types of stressor impacts.

When there was a selection of values from different sources the most local data available was used (i.e., from Aotearoa New Zealand rather than elsewhere). This approach aligns with the relevant VCS methodologies in relation to using published data (rather than default values) as well as following a conservative approach.

Carbon accounting values for salt marsh, mangroves and seagrass are provided in the tables in sections 3.3.3.2 and 3.3.3.3 below. Where possible above-ground biomass and below-ground biomass (i.e., soil carbon) was included for intact and degraded habitats.

Knowledge gaps were identified for all of the individual project sites assessed in our study for which there were no specific data. For example, we know of only one published carbon sequestration rate value for salt marsh in Aotearoa New Zealand. Furthermore, published carbon stock data for salt marsh are currently only available from one estuary in Aotearoa New Zealand. We consider these data to be inadequate for representation at the national scale, given the variation in salt marsh habitat types occurring around the country (Haacks & Thannheiser 2003, Thannheiser & Holland 1994), as well as the range in environmental parameters (e.g., geomorphic setting, elevation, hydrology, biological feedbacks [Abbott et al. 2019 and references within]) that have potential to influence carbon storage and/or sequestration. We also know of no published GHG emissions data for salt marsh habitats in Aotearoa New Zealand. Besides for intact salt marsh, there is also a knowledge gap for the above carbon and GHG-related values regarding degraded habitats and those in various stages of restoration. Only very limited data are currently also available for other tidal wetland habitats (mangrove and seagrass) in Aotearoa New Zealand. We understand that there are several individual studies in progress or planned to refine carbon-related values for tidal wetlands in Aotearoa New Zealand. This includes (but is not necessarily limited to) studies for Wairau Lagoon, Waimeha Inlet, Pounawea Estuary and Mokomoko Inlet in the South Island and Rangaunu Harbour, Pūkorokoro Miranda (Firth of Thames), Lake Ōnoke, Pāuatahanui and Whangarei Harbour in the North Island (Helen Kettles and Olya Albot pers. comms.).

Recommendations for future carbon accounting research for blue carbon projects in New Zealand include:

- Quantification of site-specific carbon accounting values and/or of representative default factors applicable to New Zealand. Much research needs to be conducted in this space, and this would ideally target specific project sites that show feasibility for carbon credits. Alternatively, research could focus on characterising key habitat types and environmental conditions in Aotearoa New Zealand generally, to determine representative (i.e., default) values that could be used across similar sites. The carbon accounting parameters, tidal wetland habitats and site locations to prioritise in Aotearoa New Zealand depend on which project types are considered the most feasible for carbon credits, noting that knowledge of **carbon sequestration rate** is key for restoration-type activities and that, based on the findings of our feasibility study, **salt marsh (degraded and restored)** is a key habitat. Data need to be collected and reported in a standardised manner, to allow comparison between different studies (to therefore help prioritise project sites or habitats when assessing feasibility for carbon credit projects). The data should also be collected and reported in a manner relevant to carbon offset methodologies (e.g., VM0033 and VM0007), to ensure relevant carbon accounting calculations can be carried out. Note that data gaps also need to be filled for other environmental values (i.e., relating to salinity and soil organic carbon) relevant for use during carbon accounting – refer Section 3.3.4 (Other Relevant Environmental Data).

- In relation to default values, Aotearoa New Zealand data currently available indicate that having separate carbon sequestration values for mangrove versus salt marsh would be more suitable and would reduce the potential for overestimation for salt marsh.

- The VM0033 methodology could consider factors such as the accumulation of calcium carbonates in tidal wetland habitats (Saderne et al. 2019) and the influence of nutrients on sequestration (Chmura et al. 2016, Irvine et al. 2012, Macreadie et al. 2017, Roughan et al. 2018). Note that VM0033 does not require nitrous oxide to be included in relation to seagrass carbon accounting, however, Oreska et al. (2020) suggest that it should.

#### 3.3.3.2 Carbon Stocks and Sequestration Rates for Saltmarsh

Carbon stock and carbon sequestration rates for saltmarsh ecosystems applied in this feasibility assessment are provided in Tables 3.3.3.2a & c.

*Table 3.3.3.2a Carbon sequestration for salt marsh (intact)* ***used*** *in carbon accounting for the project scenario for the financial feasibility assessment.*

| Component | VCS default value | Applicability conditions | NZ/Australia values | Remarks |
|---|---|---|---|---|
| **Soil carbon sequestration** | 1.46 tC ha$^{-1}$ y$^{-1}$ | Default value of 1.46 can only be used where vegetation crown cover > 50%. If crown cover is <15% then the default value can assumed to be zero (VM0033) | 0.24 ± 0.16 tC ha$^{-1}$ y$^{-1}$ | Total soil organic carbon accumulation rates in top 0.5 m of cores. Preserved salt marsh habitat pre 1944 in Whangamata Harbour, Aotearoa New Zealand. Based on wording in the paper, assume this relates to salt marsh comprised of *Juncus kraussii* and *Apodasmia* [*Leptocarpus*] *similis* (Perez et al. 2017). |
| | | | 1.5 tC ha$^{-1}$ y$^{-1}$ | Carbon accretion (mean ± SE) of *J. kraussii* in a Tasmanian estuary in top 0.3 m of cores (Ellison & Beasy 2018). |
| | | | 2.2 tC ha$^{-1}$ y$^{-1}$ | Carbon accretion (mean ± SE) of *S. quinqueflora* in Tasmanian estuary (Ellison & Beasy 2018). |
| | | | 0.39 ± 0.3 tC ha$^{-1}$ y$^{-1}$ | Australian tidal marsh soil sequestration rate (mean ± 1SD), n cores = 292 (Serrano et al. 2019). |
| | | | 0.91 tC ha$^{-1}$ y$^{-1}$ | IPCC 2017a |
| | | This is the soil carbon sequestration rate used in carbon credit calculations in this feasibility assessment. See Table 3.3.3.7. | 1.12 tC ha$^{-1}$ y$^{-1}$ | Average all values including VCS default value. This is the value applied in carbon accounting calculations in this feasibility assessment. |
| **Above & below ground sequestration** | | | | This element has been conservatively excluded from the carbon accounting for this feasibility assessment. |

*Table 3.3.3.2b Carbon stock and stock change for salt marsh (intact) collected for reference purposes for future project development but **not used** in carbon accounting for this feasibility assessment because salt marsh habitats in this feasibility assessment were not intact salt marsh systems.*

| Component | VCS default value | Applicability conditions | NZ/Australia values | Remarks |
|---|---|---|---|---|
| **Aboveground biomass stock** | 3 tC $ha^{-1}$ | May be applied for strata with 100 percent herbaceous cover. For areas with a vegetation cover <100 percent, a 1:1 relationship between vegetation cover and carbon stock must be applied (VM0033) | ~3 t $ha^{-1}$ | Organic carbon approximate mean value in top 1 m. *J. kraussii* was the dominant species. Tairua Harbour Coromandel Aotearoa New Zealand (Bulmer et al. 2020).<br>Captured here as a reference but not used in carbon stock change calculations in this feasibility assessment.<br>Not used because blue carbon project accounting focuses on stock change. |
| | 3.005 tC $ha^{-1}$ | May be applied for strata with 100 percent herbaceous cover. For areas with a vegetation cover <100 percent, a 1:1 relationship between vegetation cover and carbon stock must be applied (VMD0041 – for ARR project activities) | | Not used because blue carbon project accounting focuses on stock change. |
| **Soil carbon stock** | | | ~87 tC $ha^{-1}$ | Organic carbon approximate mean value in top 1 m, *J. kraussii* dominant species, in Tairua Harbour Coromandel Aotearoa New Zealand. Note that ~ 34% of this carbon is autochthonous (Bulmer et al. 2020).<br>Australian values also available for both *J. kraussii* and *S. quinqueflora* but are not provided here.<br>Not used because blue carbon project accounting focuses on stock change. |
| | | | 168 ± 127 tC $ha^{-1}$ | Australian tidal marsh soil stock in top 1 m (mean ± 1SD), n cores = 292 (Serrano et al. 2019).<br>Not used because blue carbon project accounting focuses on stock change. |
| **Methane ($CH_4$) emissions Salinity > 18 ppt** | 0.011 t $CH_4$ $ha^{-1}$ $yr^{-1}$ | | 0.018 ± 0.003 t $CH_4$ $ha^{-1}$ $y^{-1}$ | Relevant Australian estimate, Baldock et al. (2019) Table 5 and references within. Not used because local salinity data was not available at project sites. Relevant for full project development but will require local data gathering. |
| **Salinity > 20 ppt:** | 0.0056 t $CH_4$ $ha^{-1}$ $yr^{-1}$ | | 0.013 ± 0.008 t $CH_4$ $ha^{-1}$ $y^{-1}$ | Relevant Australian estimate, Baldock et al. (2019) Table 5 and references within. Not used because local salinity data was not available at project sites. Relevant for full project development but will require local data gathering. |
| **Nitrous oxide ($N_2O$) emissions** | 0.000157 t $N_2O$ $ha^{-1}$ $yr^{-1}$ to 0.000864 t $N_2O$ $ha^{-1}$ $yr^{-1}$ | Different values apply in different situations (VM0033 p 42) | | Not used because local applicability data was not available at project sites. Relevant for full project development but will require local data gathering. |

*Table 3.3.3.2c Carbon sequestration for salt marsh (degraded)* ***used*** *in carbon accounting for the financial feasibility assessment for the baseline scenario. In other words, baseline sequestration was conservatively set to zero in this feasibility assessment. Higher resolution assessment of sites during full project development may enable baseline emissions to be calculated other than conservatively setting to zero.*

| Component | VCS default value | Applicability conditions | NZ/Australia values | Remarks |
|---|---|---|---|---|
| **Soil carbon sequestration** | 0 t C $ha^{-1}$ $y^{-1}$ | <15% vegetation crown cover | | Soil carbon sequestration was modelled as zero in this feasibility assessment in the absence of more detailed local vegetation crown cover data. |
| | 1.46 t C $ha^{-1}$ $y^{-1}$ | <50% vegetation crown cover | | |

Th soil carbon sequestration rate used in carbon credit calculations in the financial feasibility assessment. See Table 3.3.3.7.

*Table 3.3.3.2d Carbon emissions for salt marsh (degraded)* ***used*** *in carbon accounting for this feasibility assessment for the baseline scenario. The project scenario for this feasibility assessment assumes the avoidance of these baseline emissions in the project scenario.*

| Component | VCS default value | Applicability conditions | NZ/Australia values | Remarks[14] |
|---|---|---|---|---|
| **Above ground biomass stock** | Data gap | | | Not used because blue carbon project accounting focuses on stock change. |
| **Soil carbon stock** | Data gap | | | Not used because blue carbon project accounting focuses on stock change. |
| **Methane emissions (salinity <18 ppt)** | 0 t C $ha^{-1}$ $y^{-1}$ | $CH_4$ emissions in the baseline scenario may be conservatively set to zero (VM0033). | 4.03 ± 0.37 t $CH_4$ $ha^{-1}$ $yr^{-1}$ | Relevant Australian estimate, drained wetland - flood phase (mean ± 1SE), Baldock et al. (2019) Table 5 and references within. Potential baseline circumstance - artificial drained coastal acid sulphate wetland (flooded phase), northern NSW (refer Gatland et al. 2014).<br>In absence of local data VCS default value of zero was applied. |
| | | | 0.023 ± 0.009 t $CH_4$ $ha^{-1}$ $yr^{-1}$ | Relevant Australian estimate, drained wetland -post-flood phase (mean ± 1SE), Baldock et al. (2019) Table 5 and references within. Potential baseline circumstance - artificial drained coastal acid sulphate wetland (post-flood phase), northern NSW (refer Gatland et al. 2014).<br>In absence of local data VCS default value of zero was applied. |
| **Nitrous oxide emissions** | | Where the project proponent demonstrates that $N_2O$ emissions do not increase in the project scenario compared to the baseline scenario, $N_2O$ emissions need not be accounted for. In all cases, $N_2O$ emissions may be conservatively excluded in the baseline scenario (VM0033). | | $N_2O$ emissions were excluded from this feasibility assessment due to lack of local data. Potential to include in full project development. |

This is the soil methane emissions rate used in carbon credit calculations for this feasibility assessment in the baseline scenario. See Table 3.3.3.7.

[14] Methane emissions values for intact and degraded salt marsh are provided (in this table and Table 3.3.3.2c.). Carbon accounting details for intermediate restoration states were not provided - only emissions factors for intact and degraded states were collected.

### 3.3.3.3 Carbon Emissions from Degraded Salt Marsh

Local data was not available for carbon emissions from degraded salt marsh ecosystems. To progress this feasibility assessment, proxy data were obtained from the literature and applied across all sites for the activity type: restoring degraded tidal salt marsh.

Greenhouse gas emissions from degraded tidal salt marsh ecosystems change rapidly through time with high emissions (>200 $tCO_2e$/ha/yr) in the first 5 years following disturbance, decaying to <50 $tCO_2e$/ha/yr between years 10-20, and dropping to ~5$tCO_2e$/ha/yr after 30 years (Figure 3.3.3.3a, Table 3.3.3.3a and Lovelock et al. 2017).[15]

*Figure 3.3.3.3a Modelled $CO_2e$ emission rates from disturbed seagrass (blue) and tidal marshes (orange) showing the rate of emissions at 30 years following disturbance (blue arrow). Source: modified after Lovelock et al 2017.*

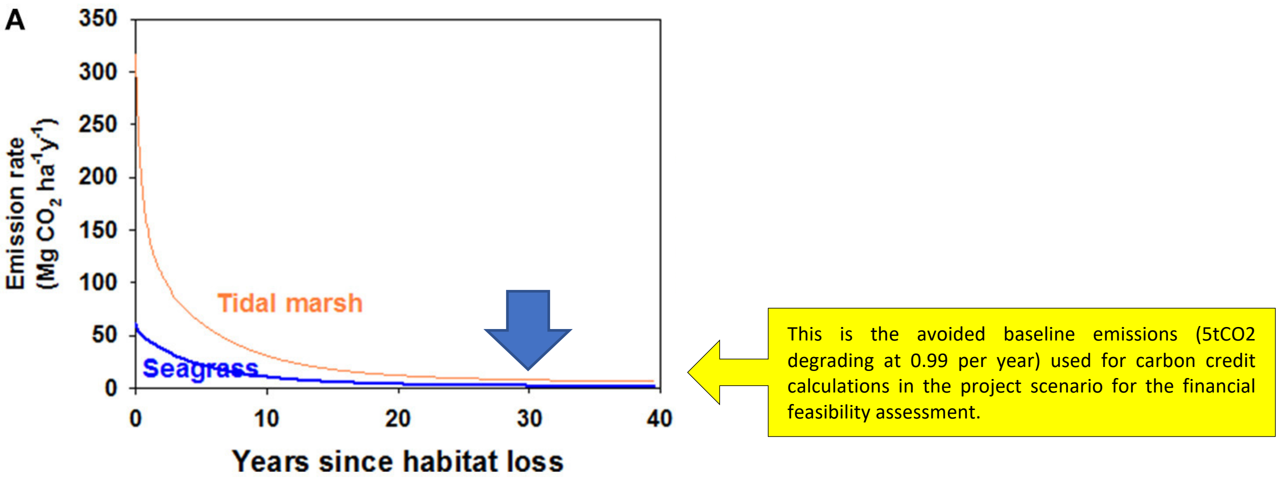



*Table 3.3.3.3a. Range of CO2 emissions from degraded coastal wetlands showing that the baseline emissions factor applied for this feasibility assessment (5tCO2 per year degrading by a factor of 0.99 per year) is plausible and conservative (i.e., slightly lower than the lowest factor of 6.4 shown below). Source: Lovelock 2017.*

| Disturbance | Method for estimating $CO_2$ emission | Time elapsed since disturbance (years) | $CO_2$ eq emission Mg ha-1 year-1 | k $year^{-1}$ $(d^{-1})$ |
|---|---|---|---|---|
| **TIDAL MARSH** | | | | |
| Reclamation | Change in stock of soil organic matter (top 1 m) | 9 | 0.73 | 0.022 (0.000059) |
| Dieback due to wrack accumulation | Change in stock of soil organic matter after 1 year | I | 4.4 | 0.093 (0.00026) |
| Bioturbation and erosion of banks | Loss of soil volume (horizontal) | 30 | 13–54 | NA |
| | Model $\alpha = 1.0$ | 30 | 13.9 | 0.184 (0.0005) |
| | Model $\alpha = 0.5$ | 30 | 10.1 | 0.043 (0.0001) |
| | Model $\alpha = 0.0$ | 30 | 6.4 | 0.021 (0.00006) |

[15] According to this study (Lovelock et al 2017) the fraction of the original carbon pool emitted in the first three years after disturbance was highly sensitive to the proportion of carbon deposited in an oxic environment.

Due the absence of detailed local data (as expected for a feasibility assessment/scoping study) the financial feasibility assessment in this study needed to use conservative assumptions to enable baseline carbon emissions to be estimated at a low-resolution *ex ante* for a 'rewetting tidal marsh' activity type.

The financial feasibility assessment in Section 4, therefore, conservatively assumes that the original conversion of the intact tidal marsh to degraded tidal marsh was >30 years prior to the project. Accordingly, the financial feasibility assessment applies a baseline emission factor of 5.0t$CO_2$e/ha/yr degrading by a factor of 0.99 per year for the project period (see Table 3.3.3.7).

Project development at a specific site will gather more detailed local habitat change data, and potentially more detailed baseline emissions data, and as a result deliver a baseline emissions profile at a higher resolution than what was possible in this scoping study.

#### 3.3.3.4 Carbon Stock and Sequestration Rates for Mangroves

Carbon stock and carbon sequestration rates for mangrove ecosystems are supplied here as a reference but not applied in this feasibility assessment due to no mangrove ecosystems being covered directly as potential project types. Carbon accounting data for mangrove ecosystems, however, is provided as a reference in Table 3.3.3.4.

*Table 3.3.3.4 Carbon stock and sequestration rates for mangrove (intact) not used in this feasibility assessment but provided here for reference purposes.*

| Component | VCS default value | Applicability conditions | NZ/Australia values | Remarks |
|---|---|---|---|---|
| **Soil carbon sequestration** | 0 t C $ha^{-1}$ $y^{-1}$ | <15% crown cover (VM0033) | | |
| | 1.46 t C $ha^{-1}$ $y^{-1}$ | >50% crown cover (VM0033) | 3.67 t C $ha^{-1}$ $yr^{-1}$ | Firth of Thames, Aotearoa New Zealand (Lovelock et al. 2010) |
| | | | 0.655 ± 0.163 t C $ha^{-1}$ $yr^{-1}$ | Total soil organic carbon accumulation rates in top 50cm. Preserved mangrove (*Avicennia marina*) habitat, post 1944. Whangamata Harbour Aotearoa New Zealand (Perez et al. 2017). |
| **Above ground biomass stock** | | | ~5 t C $ha^{-1}$ | Organic carbon approximate mean value in top 1 m. mangrove (*Avicennia marina*). Tairua Harbour Coromandel Aotearoa New Zealand (Bulmer et al. 2020). |
| **Soil carbon stock** | | | ~42 t $ha^{-1}$ | Organic carbon approximate mean value in top 1 m, mangrove (*Avicennia marina*), in Tairua Harbour Coromandel Aotearoa New Zealand. Note that ~ 44% of this carbon is autochthonous (Bulmer et al. 2020) |

### 3.3.3.5 Carbon Stocks and Sequestration Rates for Seagrass Ecosystems

Carbon stock and sequestration rates for seagrass ecosystems are supplied here as a reference but not applied in the financial feasibility assessment due to the seagrass activity type not passing the technical feasibility test in this study. Carbon stock and sequestration rates for seagrass ecosystems is provided in Table 3.3.3.5a & b.

*Table 3.3.3.5a Carbon stock and sequestration rates for seagrass (intact).*

| Component | VCS default value | Applicability conditions | NZ/Australia values | Remarks |
|---|---|---|---|---|
| **Soil carbon sequestration** | 0.43 t C $ha^{-1}$ $yr^{-1}$ | Oreska et a (2020) (based on *Posidonia oceanica*) established by the Intergovernmental Panel on Climate Change (IPCC) for national GHG inventories. | | |
| **Above ground biomass stock** | | | ~0.5 t $ha^{-1}$ | Organic carbon approximate mean value, *Zostera muelleri*, in Tairua Harbour Coromandel (Bulmer et al. 2020). |
| **Soil carbon stock** | | | ~26.5 t $ha^{-1}$ | Organic carbon approximate mean value, *Zostera muelleri*, in Tairua Harbour Coromandel<br>Note that ~ 24% of this carbon is autochthonous (Bulmer et al. 2020) |
| | | | 112 ± 88 Mg C $ha^{-1}$ | Australian seagrass soil stock in top 1m (mean ± 1SD), n cores = 549 (Serrano et al. 2019). |

*Table 3.3.3.5b Carbon stock and sequestration rates for seagrass (degraded).*

| Component | VCS default value | Applicability conditions | NZ/Australia values | Remarks |
|---|---|---|---|---|
| **Soil carbon sequestration** | | | 0. t C $ha^{-1}$ $yr^{-1}$ | Assume 'zero' if aboveground biomass is zero and only autochthonous carbon sources are included. |
| **Above ground biomass stock** | | | 0. t C $ha^{-1}$ | Organic carbon approximate mean value, unvegetated tidal flats, in Tairua Harbour Coromandel. (Bulmer et al. 2020). |
| **Soil carbon stock** | | | 26 t c $ha^{-1}$ | Organic carbon approximate mean value, unvegetated tidal flats, in Tairua Harbour Coromandel. Note that this carbon was derived from various sources. (Bulmer et al. 2020). |
| **Methane emissions** | | Salinity >18 ppt | 0.739 µmol $m^{-2}$ C $hr^{-1}$ | Bare ground methane flux, 9-month average, America (Oreska et al. 2020). |

### 3.3.3.6 Carbon Emissions for Degraded Seagrass Ecosystems

Carbon emissions rates for seagrass ecosystems are supplied here as a reference but not applied in the financial feasibility assessment due to the seagrass activity type not passing the technical feasibility test in this study. Emissions from degraded seagrass ecosystems change rapidly through time with high emissions (>50 $tCO_2$ $ha^{-1}yr^{-1}$) in the first 5 years following disturbance, decaying to ~10 $tCO_2$ $ha^{-1}yr^{-1}$ between years 10-20, and dropping to ~3 $tCO_2$ $ha^{-1}yr^{-1}$ after 30 years (Lovelock et al. 2017).

For restoration of seagrass meadow project types, this feasibility assessment conservatively assumes that the original conversion of the intact seagrass meadow to degraded seagrass meadow was >30 years prior to the project. This approach applies a baseline emission factor of 3.0 $tCO_2$ $ha^{-1}yr^{-1}$ degrading by a factor of 0.99 per year for the project period.

For avoided degradation of seagrass meadow project types, this feasibility assessment assumes that the proposed conversion of intact seagrass meadow in the baseline occurs 1 year after the project start date. The project start date is the date that the seagrass meadow is subjected to interventions that would prevent its degradation. For this project type this feasibility assessment applies emissions factors for seagrass meadow degradation following Lovelock 2017 (Table 3.3.3.6).

*Table 3.3.3.6. CO2 emissions from degraded seagrass meadows. Source: Lovelock 2017.*

| Disturbance | Method for estimating $CO_2$ emission | Time elapsed since disturbance (years) | $CO_2$ eq emission Mg ha-1 year-1 | k $year^{-1}$ ($d^{-1}$) |
|---|---|---|---|---|
| **SEAGRASS** | | | | |
| Loss due to declining water quality | Change in soil organic matter (top 15 cm) | 38 | 2.41 | 0.022 (0.00006) |
| Experimental clearing | Change in soil organic matter (top 5 cm) | 2 | 0 | 0 |
| Seismic testing | Change in soil organic matter (top 50 cm) | 50 | 1.9 | 0.026 (0.00007) |
| Loss due to erosion by boat moorings | Change in soil organic matter (top 30 cm) | 80 | 4.4–8.8 | 0.017 (0.00005) |
| | Model $\alpha = 1.0$ | 30 | 4.72 | 0.183 (0.0005) |
| | Model $\alpha = 0.5$ | 30 | 3.39 | 0.042 (0.0001) |
| | Model $\alpha = 0.0$ | 30 | 2.05 | 0.018 (0.00005) |

#### 3.3.3.7 Carbon Accounting Emissions Data Applied in Financial Feasibility Assessment

The carbon accounting data used in the Financial Feasibility Assessment indicated in yellow in this section is presented in Table 4.1.8 in Section 4.1.8.

### 3.3.4 Other Relevant Environmental Data

Key ecological information regarding salinity (average[16] and low point[17]) and soil organic content[18], relevant to carbon accounting, was compiled from project questionnaires where this information was provided by respondents and supporting literature for Aotearoa New Zealand was also identified[19] when not available locally.

[16] **Salinity Average** is the average water salinity value of a wetland ecosystem used to represent variation in salinity during periods of peak $CH_4$ emissions (eg, during the growing season in temperate ecosystems) (VM0033).

[17] **Salinity Low Point** is the minimum water salinity value of a wetland ecosystem used to represent variation in salinity during periods of peak $CH_4$ emissions (eg, during the growing season in temperate ecosystems) (VM0033).

[18] **Organic Soil** is soil with a surface layer of material that has a sufficient depth and percentage of organic carbon to meet thresholds set by the IPCC (Wetlands supplement) for organic soil. Where used in the VM0033 methodology (and this report), the term peat is used to refer to organic soil.

[19] A comprehensive literature review on this information was beyond the scope of this feasibility assessment.

Supporting information on salinity in relation to tidal wetlands and estuaries in Aotearoa New Zealand can be obtained from sources including Partridge & Wilson (1987), Bergin (1991), Robertson et al. (2002) and Tay et al. (2013). Supporting information on soil carbon content of salt marsh in Aotearoa New Zealand can be obtained from sources including Daniel King and Olya Albot (Victoria University, pers. comm.), Johnson & Gerbeaux (2004), Hewitt et al. (2010), National Soil Database (Manaaki Whenua – Landcare Research), Goff & Chagué-Goff (1999) and Thannheiser & Holland (1994). Based on these information sources, we understand that both mineral and 'peaty' soils can be present in salt marsh habitats in Aotearoa New Zealand, noting that various definitions are used in relation to the organic carbon content of 'peaty' or 'organic soil' (e.g., see Johnson & Gerbeaux [2004], Hewitt et al. [2010] and Kazemian [2018] for comparison), which may differ to that indicated by VM0033 (i.e., based on IPCC 2014). Supporting information on soil carbon content of seagrass habitat in Aotearoa New Zealand can be obtained from sources including Berthelsen et al. (2016) and Zabarte-Maeztu (2021). Where there is a knowledge gap for salinity and organic soil content for a project site, further investigation will be required during project development.

Refer to Appendix 4 and Appendix 5 for our results relating to salinity and organic soil content respectively for each project site.

### 3.3.5 Quantification of Baseline GHG Emission Reductions and Removals

The carbon accounting calculation used in the financial feasibility assessment for this study is provided in Table 3.3.5 showing the first 6 years. Baseline emissions are avoided in the project scenario and are therefore summed with project scenario carbon sequestration. Note that the carbon accounting applied in the financial feasibility assessment is purposefully conservative to avoid raising financial expectations without additional supporting evidence. Project development may prove this financial feasibility analysis to be too conservative (but this is typically better than the reverse).

*Table 3.3.5 Carbon accounting applied in financial feasibility assessment in this study.*

| | **Activity Type: Restoring Tidal Saltmarsh** | | **Project year:** | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| | | **Source** | **Calculation** | | | | | | |
| 1 | Baseline carbon emissions (tCO2/ha/yr) | Section 3.3.3.3 | Decaying at 0.99 per year | 5.000 | 4.950 | 4.901 | 4.851 | 4.803 | 4.755 |
| 2 | Baseline methane emissions (tCH4/ha/yr) | Table 3.3.3.2d | 0.023 - 0.009 = 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 |
| 3 | Baseline methane emissions (tCO2e/ha/yr) | IPCC AR6 | 0.014 x 27.2 | 0.381 | 0.381 | 0.381 | 0.381 | 0.381 | 0.381 |
| 4 | Baseline N2O emissions (tCO2e/ha/yr) | Table 3.3.3.2a | Conservatively excluded | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5 | Project Scenario: Carbon sequestration (tC/ha/yr) | Table 3.3.3.2a | Average NZ/Aus values | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 |
| 6 | Project Scenario: Carbon sequestration (tCO2/ha/yr) | Carbon factor | 1.12 x 3.66 | 4.10 | 4.10 | 4.10 | 4.10 | 4.10 | 4.10 |
| **7** | **Project Carbon Benefits** | | **Sum lines 1,3,4,6** | **9.480** | **9.430** | **9.381** | **9.331** | **9.283** | **9.235** |

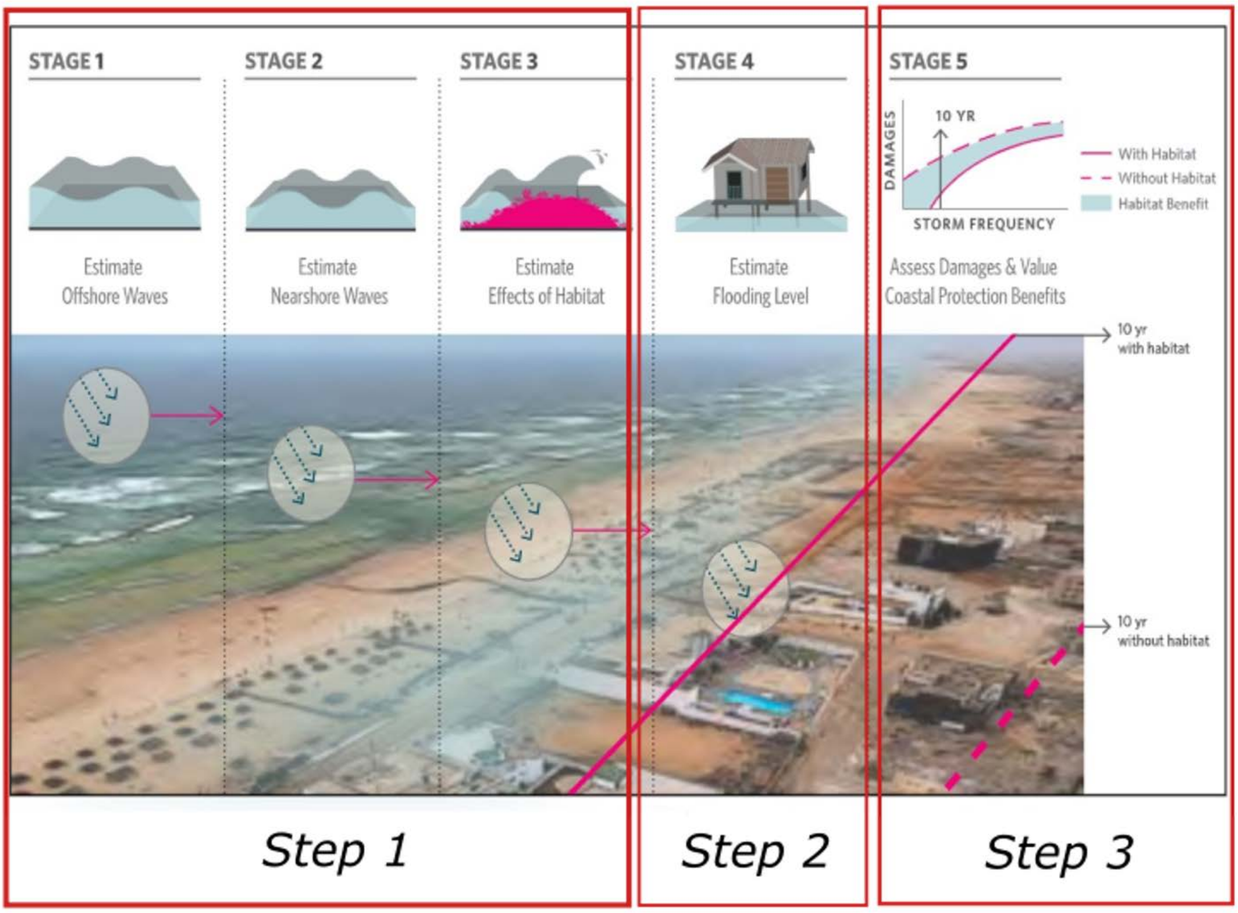
GHG emission reductions and removals methodology requirements of the VM0033 methodology are presented in Appendix 7.

# 3.4 RESILIENCE ACCOUNTING FOR PROJECT SITES

The purpose of this feasibility study is to assess the applicability of the SD VISta 'Methodology for Coastal Resilience Benefits from Restoration and Protection of Tidal Wetlands' and the availability of key datasets and inundation models relevant to the *scenario method* for each of the project sites.

The applicability conditions required by the SD VISta coastal resilience methodology is shown in Table A3.a. Figure 3.4 shows the three high-level steps associated with resilience assessments using the *scenario method*. Various models and key datasets may be used to perform each step, once they meet the requirements specified in the SD VISta Coastal Resilience methodology. In this feasibility study we only assessed the availability of existing inundation models and key datasets, as the creation of new models and datasets was beyond the scope of this study. Recommendations are given on how the available datasets and models could be improved for each project site.

*Figure 3.4. Three steps of the SD VISta Coastal Resilience methodology based on the conceptual of processes-based stages from World Bank (2016).*




When applicable, maps of flood extent were generated and used to estimate the number of people and property (assets) affected by flooding in the *Project Impact Area*.

Site specific applicability, data availability and data quality, and an estimation of affected people and property for each case study site is presented in Appendix 3.

### 3.4.1 Assessing Data Availability

Information of the availability of the six key datasets (see Table A3.b) and of inundation models (Table A3.c) specified in the SD VISta Coastal Resilience methodology was gathered through questionnaires answered by project contacts and from data publicly available in open portals. We then compared the compatibility of the data available with the requirements of the methodology.

The process of assessing the availability of coastal inundation models was primarily based on the following factors:

- Public availability.
- Spatial resolution.
- Existence of reports documenting the process used to develop the models.

Micro-scale numeric inundation models developed by council were preferentially selected.[20] When coastal inundation models and datasets were available, we evaluated their compatibility with what is required in the SD VISta Coastal Resilience methodology, as well as their overall quality. For this evaluation we used two predefined tables (*Requirements table* and *Quality check table*) aiming to reduce the subjectiveness of the data gathering and the evaluation process, and promoting a higher level of reproductivity to the methodology:

- **Requirements table** – requirements expected by the SD VISta methodology for each key dataset (Table A3.b) and inundation model (Table A3.c).

- **Quality check table** – criteria used to assess the quality of a specific key datasets (Table A3d) and inundation model (Table A3e), based on what is specified in the SD VISta Coastal Resilience methodology and in the literature. Each criterion can be classified into one of the three scores: high, moderate, low.

### 3.4.2 Estimating Affected Assets

For each potential project site for which this methodology was applicable, the number of assets (people and property) within the *Project Impact Area* was estimated (i.e., the area that can potentially be affected by flooding events and therefore it must be monitored by the project).

According to the SD VISta Coastal Resilience methodology, the *Project Impact Area* can be identified as follows:

> *"To identify the area to be assessed for flood reduction purposes, the project impact area is bounded up to the 10 m elevation contour and an alongshore width comprising the project area where additionally is considered at least 2x the alongshore width of the project area. This area can be delineated using topography data from digital or print elevation data or maps."*

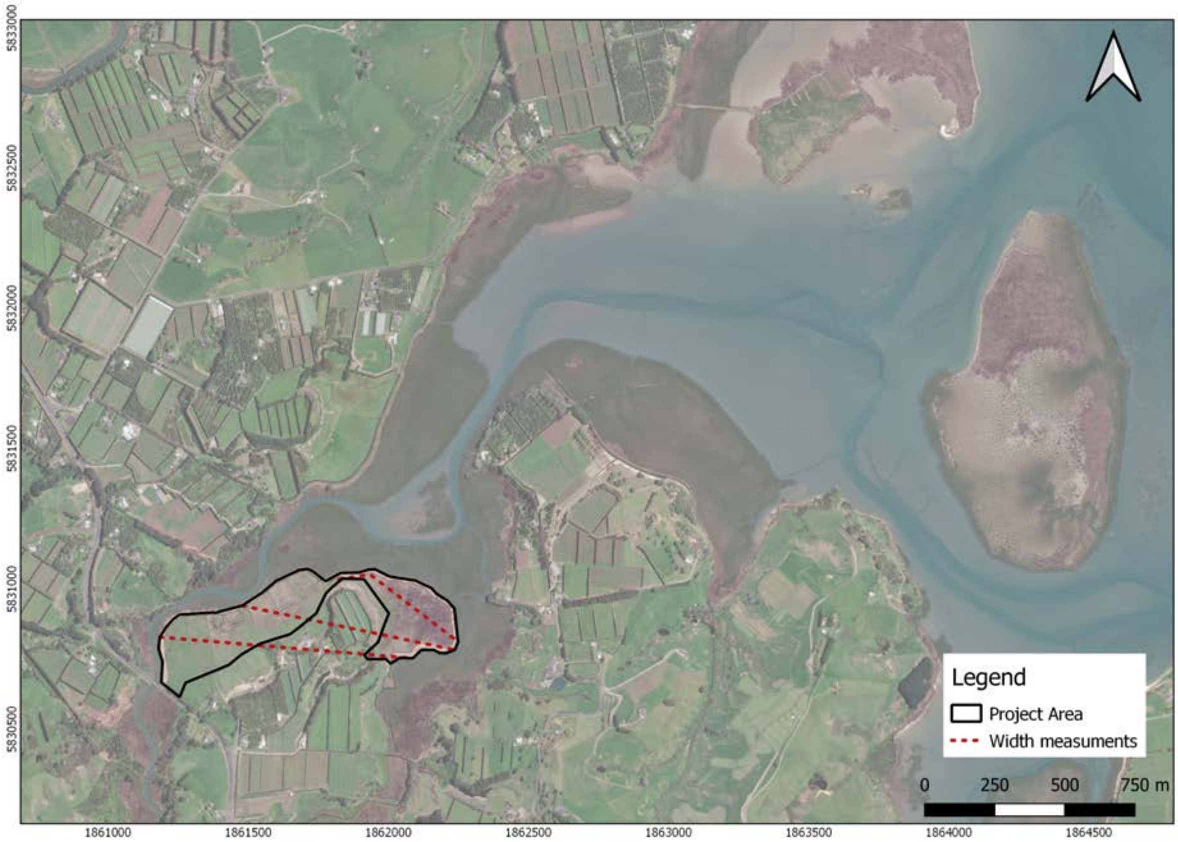
As the polygon defining the spatial boundaries of the projects (i.e., *Project Area*) were all irregular, we assumed that the alongshore width was the resulted average between three measurements of width between the shoreline and the inshore limit of the project area (Figure 3.4.2). This value was then multiplied by two to

[20] Manning's coefficient is used in numerical process-based inundation models to incorporate the effects of bottom friction due to different land cover and land uses. Spatial differences in the coefficient's value can be used with the inundation model to predict the effects of different land uses on the extent of inundation. In these non-linear shallow water models, the wave attenuation caused by land cover is also modelled using spatial differences in the Manning coefficient. The Manning coefficient can be calculated for each land cover class by the Gauckler–Manning's coefficient formula, which is dependent on many factors, and requires information on vegetation characteristics and field investigations (Kaiser et al 2011).

For Spartina-like canopy vegetation, with a stem diameter of 1.3 cm and a leaf area 8 times that of the frontal area Sheng et al. (2012) used Manning coefficient of 0.1–0.3. Sheng et al. (2021) classified six distinct wetland classes, for which the values ranged between 0.05-0.2. For subtropical marshes, Shih & Rahi (1981) found that the Manning's coefficient ranged from 0.16 to 0.55 in a subtropical marsh over the flow depth varying between 65 to 40 cm.

define the distance of the buffer to be used around the *Project Area*. The 10m contour was then identified to demarcate the onshore boundary.

*Figure 3.4.2. Method applied for measuring width of the Project Area for the Wainui Repo Whenua. The average length of the three red dashed were considered as the alongshore width for this project.*




The input data used for quantifying the assets were as follows:

- 2018 Census Individual (part 1) total Aotearoa New Zealand by Statistical Area 1.
- NZ Building Outlines.

'Affected Properties' assets were estimated by counting the number of existing buildings within the *Project Impact Area*. For estimating the number of 'affected person' assets, we first counted the number of residential buildings (i.e., buildings with an area between 50 $m^2$ and 600 $m^2$) in each Statistical Area surrounding the *Project Impact Area.* Then, we calculated the percentage of these residential buildings that were inside the *Project Impact Area* multiplying this number with the total number of 'usually resident population count' (from census data).

The number of people and property potentially affected by different scenarios (i.e.: with and without the project) was not estimated in this feasibility assessment. For future resilience projects using the SD VISta Coastal Resilience methodology this estimation will need to be concentrated on the difference between affected assets for the different scenarios. This feasibility assessment used a simplified approach that considered the assets within the *Project Impact Area* when applicable.

The Waimeha Inlet is the project site with the highest potential for delivering measurable outcomes as currently defined in the Coastal Resilience Methodology, although amendment to the methodology is also recommended (see Section 3.1.3.5 above).

### 3.4.3 Applicability to Project Sites

All project sites meet the applicability requirements of the SD VISta Coastal Resilience methodology (Table A3.a) except the Farewell Spit site, although we continued assessing the data availability for all six sites despite the applicability of the SD VISta Coastal Resilience methodology (Table 3.4.3a). Most sites have high quality datasets including land cover, topography, population and properties – each of which are suitable for the application of the methodology. The National Land Cover Database (LCDB) is suitable for all sites with some having additional local data. For example, Waimeha Inlet and Wairau Lagoon have local land cover layers produced from previous wetland mapping. Due to the importance of these dataset in understanding the role of wetlands on wave attenuation, an updated local wetland mapping study is recommended for all sites prior to the start of future resilience projects. This will account for possible habitat loss that is not captured in the layers considered in this data evaluation – although this is an issue for full project development and is beyond the scope of this feasibility assessment. Farewell Spit was the only site where the LCDB is not applicable as the LCDB does not include submerged habitats such as seagrass meadows. For this site the only information on the extent of the seagrass meadows is available for visualization at SeaSketch Portal[21] (although the shapefile is not publicly available for download). This data is a compilation of studies and as such, an updated mapping study of the seagrass extent is recommended for project development. Seagrass meadows, however, are not included in SD VISta Coastal Resilience methodology.

Pre-existent flooding models were also assessed for each of our project sites and evaluated on how well they meet the SD VISta Coastal Resilience methodology requirements (Tables 3.4.3). Flooding models were available for most of our project sites modelled at different levels of robustness, flood extent and water levels expected for different storm periods. Comparing the models available for all of our project sites, the model developed for the Tauranga Regional Council is the one that best fits the resilience methodology requirements. It uses a validated numerical modelling approach (Delft2D FM hydrodynamic model) considering land cover friction (from the Manning's coefficient). The wave set up included in the Tauranga model was calculated at over 100 points using empirical formula, although effects of runup (one of the resilience methodology's requirements), were not considered. Moreover, the number of return periods and the inland boundaries used by the model did not fully satisfy the methodology requirements either. This will need to be remedied during project development should a resilience project be undertaken. The outputs of this model can be used for the first assessment of the number of people and properties potentially affected by flooding caused by different storm events scenarios.

Tasman District Council has developed a flooding model applicable to the Farewell Spit and Waimeha Inlet sites. This model uses a passive approach commonly known as 'bathtub'. Passive flood modelling does not provide a comprehensive picture of hazards because it ignores dynamic processes such as seasonal waves, storm surge, and erosion, which have been shown to have a considerable impact on coastal communities (Anderson et al 2018). Accordingly, the development of a more robust model is recommended, that can include the effects from land friction. The same recommendation is applicable to the Pūkorokoro site.

For the Waihi site the flooding model selected uses a hydrodynamic approach but does not cover the full extent of the estimate *Project Impact Area*. The model also does not account for inland friction for present day nor 50-year and 100-year future scenarios and is, therefore, not applicable for resilience projects in the area.

The Wairau site does not have a flooding model available so a flooding model for this area would need to be developed based on the data available if project development proceeds.

[21] https://www.seasketch.org/#projecthomepage/5357cfa467a68a303e1bb87a

*Table 3.4.3a Summary of the resilience data availability assessment for the six project sites. The first column lists the key datasets available for each site that might be relevant to future projects following the SD VISta resilience methodology. In the second column are the existing coastal inundation models (when available) evaluated in our study and the result of this assessment. The third column summarizes the data gaps and recommendations for the key datasets. For more details about the key datasets for each site, refer to the site-specific assessment in Appendix 3.*

| Site | Key Datasets | Coastal inundation model | Data gaps and recommendations |
|---|---|---|---|
| **Te Repo ki Pūkorokoro** | - Project Area provided by DOC<br>- 8m National DEM<br>- LCDB v5.0<br>- 2018 NZ Census<br>- NZ Building Outlines | WRC Costal Inundation tool *– not suitable for projects following the SD VISta Coastal Resilience methodology.* | - Digital elevation of at least 10 m resolution within the *Project Area*<br>- Attributes in the spatial layer detailing land rights holders and user rights for all discrete areas of lands.<br>- Updated local wetland mapping study |
| **Wainui Repo Whenua** | - Project Area provided by BOPRC<br>- Tauranga and Coast LiDAR 1m DEM<br>- LCDB v5.0<br>- 2018 NZ Census<br>- NZ Building Outlines | Tauranga Harbour modelling (2019) – *suitable for the initial assessment of flood impacts to people and property.* | - Attributes in the spatial layer detailing land rights holders and user rights for all discrete areas of lands.<br>- Updated local wetland mapping study |
| **Pukehina/ Waihī** | - Project Area provided by TNC<br>- Bay of Plenty - Tauranga and Coast LiDAR 1m DEM<br>- 8m National DEM<br>- LCDB v5.0<br>- 2018 NZ Census<br>- NZ Building Outlines | Coastal Protection Areas Re-assessment (Tonkin & Taylor, 2015) – *the models and outputs from this study are not suitable for projects following the SD VISta Coastal Resilience methodology.* | - Attributes in the spatial layer detailing land rights holders and user rights for all discrete areas of lands.<br>- Updated local wetland mapping study |
| **Farewell Spit** | - Seagrass meadow extent available map on SeaSketch Portal<br>- Tasman - Golden Bay LiDAR 1m DEM<br>- 8m DEM<br>- 2018 NZ Census<br>- NZ Building Outlines | Tasman Bay and Golden Bay coastal inundation model – *this model is not suitable for projects following the SD VISta Coastal Resilience methodology.* | - Attributes in the spatial layer detailing land rights holders and user rights for all discrete areas of lands.<br>- Undertake an updated assessment of the seagrass around the Farewell Spit. |
| **Waimeha Inlet** | - Project Area provided by TDC<br>- Nelson and Tasman LiDAR 1m DEM<br>- Local salt marsh mapping (Stevens et al, 2020).<br>- 2018 NZ Census<br>- NZ Building Outlines | Tasman Bay and Golden Bay coastal inundation model – *this model is not suitable for projects following the SD VISta Coastal Resilience methodology.* | - Attributes in the spatial layer detailing land rights holders and user rights for all discrete areas of lands.<br>- Updated local wetland mapping study. |
| **Wairau Lagoon** | - Project Area based on habitat mapping provided by Cawthron (Berthelsen et al, 2015)<br>- Marlborough Blenheim LiDAR 1m DEM<br>- 8m National DEM<br>- Local habitat mapping (Berthelsen et al, 2015)<br>- 2018 NZ Census<br>- NZ Building Outlines | No coastal inundation model developed in the *Project Area* of this site was identified by our study. | - Attributes in the spatial layer detailing land rights holders and user rights for all discrete areas of lands.<br>- Updated local wetland mapping study. |

# 3.5 TECHNICAL SUMMARY OF PROJECT SITES

## 3.5.1 Te Repo ki Pūkorokoro

### 3.5.1.1 Project Location

Te Repo ki Pūkorokoro is located on the western coastline of the Firth of Thames in the Waikato District (Figures 3.5.1.1a-g inclusive). The site is situated in the coastal floodplain where the Pūkorokoro stream meets the sea to form a tidal wetland ecosystem. The tidal wetland system at Te Repo ki Pūkorokoro has been heavily modified with drainage of the wetland area and conversion to pasture. The project site is located on farmland to the west (inland) of the coast road (Figure 3.5.1.1c below).

*Figure 3.5.1.1a. Location of Te Repo ki Pūkorokoro in the Firth of Thames.*

*Figure 3.5.1.1b. Overview of Te Repo ki Pūkorokoro study area.*


*Figure 3.5.1.1c. Te Repo ki Pūkorokoro proposed project site (yellow shading).*

*Figure 3.5.1.1d. Oblique aerial view of Te Repo Ki Pōkorokoro project site.*

*Figure 3.5.1.1e. Project area (green outline at left) and adjacent management areas (green outline at middle, and Findlay reserve in orange outline. The two green polygons represent Te Repo ki Pūkorokoro reserve. Red hashed polygons are areas with extant mangrove ecosystems and green hashed polygons are areas with extant tidal wetland. (from LUCAS NZ Land Use Map 1990 2008 2012 2016). Source: Schattschneider (Cawthron Institute).*

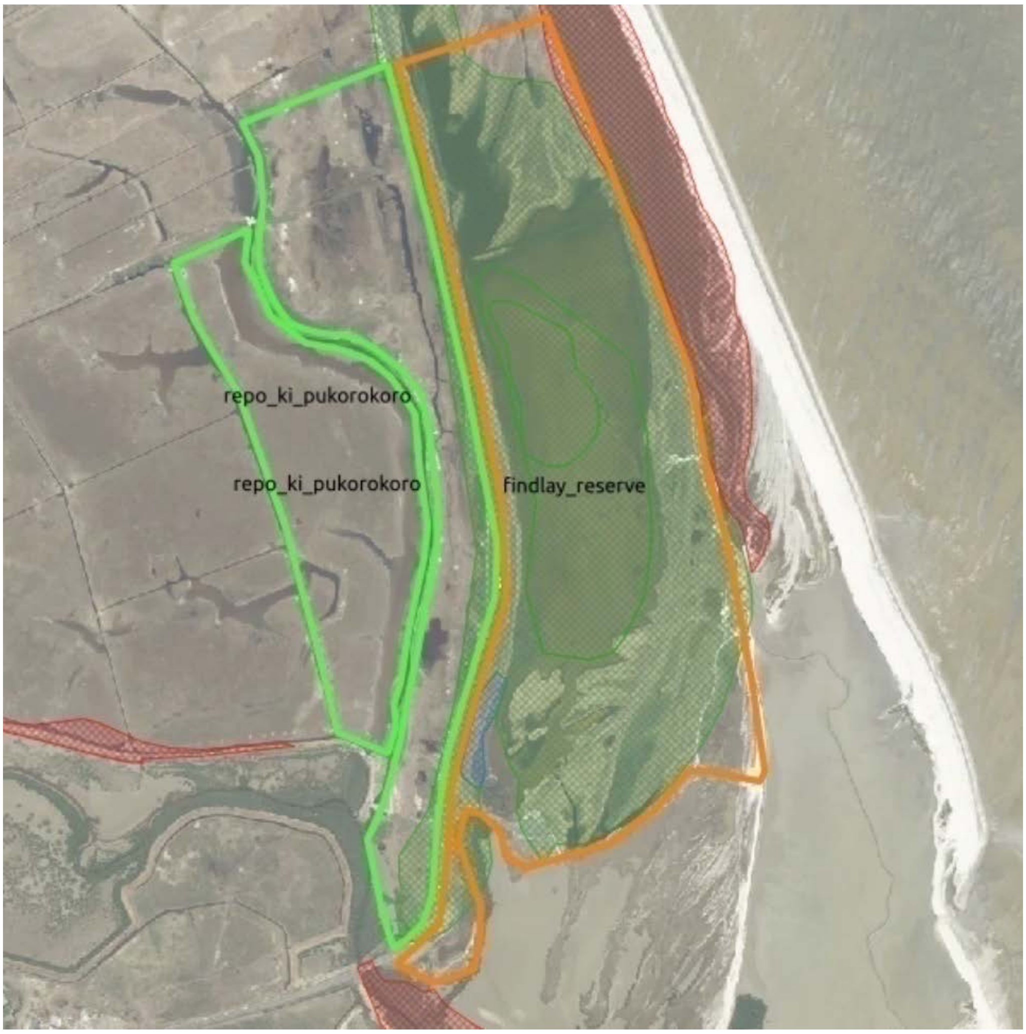


*Figure 3.5.1.1f. Proposed habitat types in the project area and surroundings. Source: David Lawrie (PMNT).*

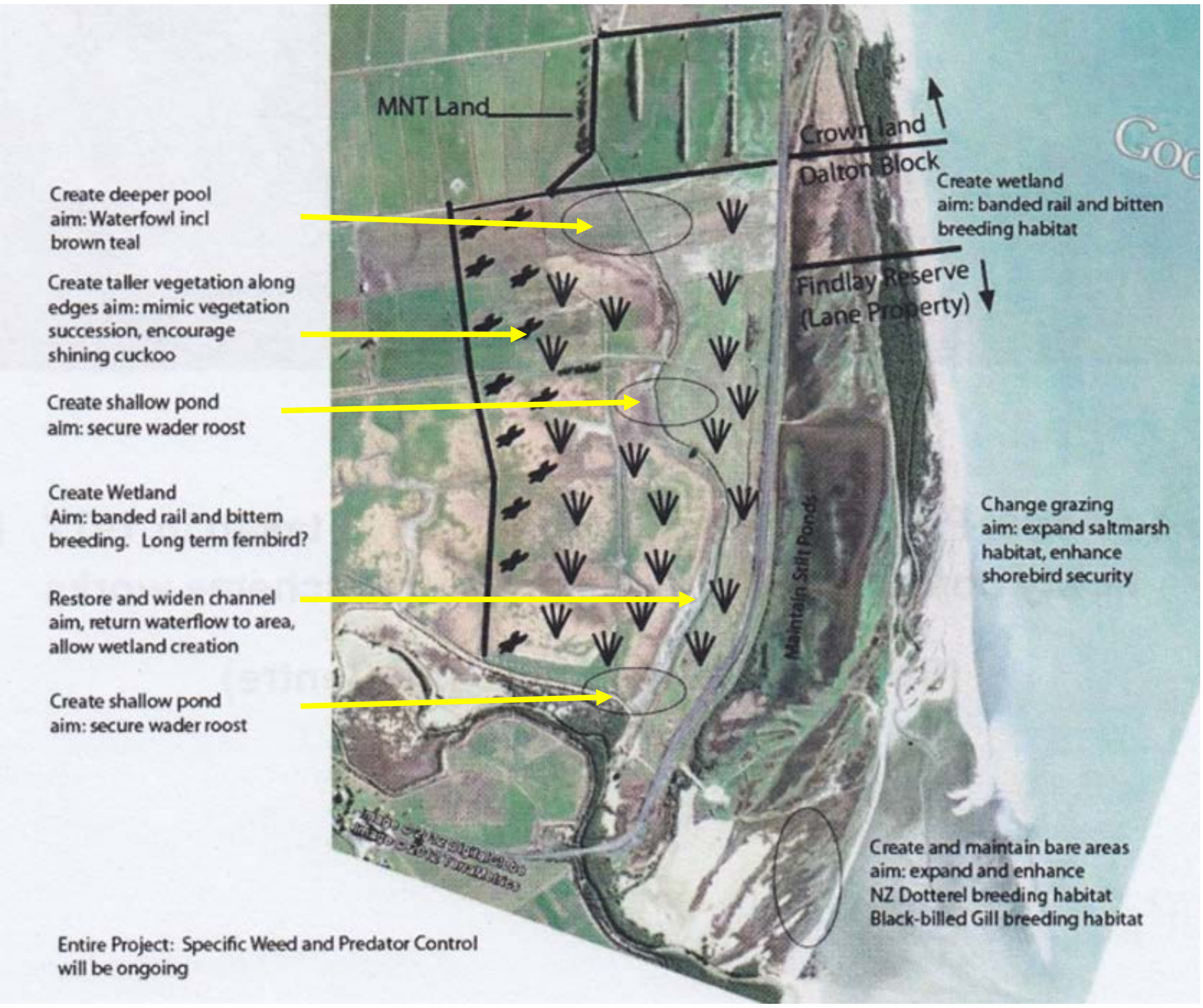
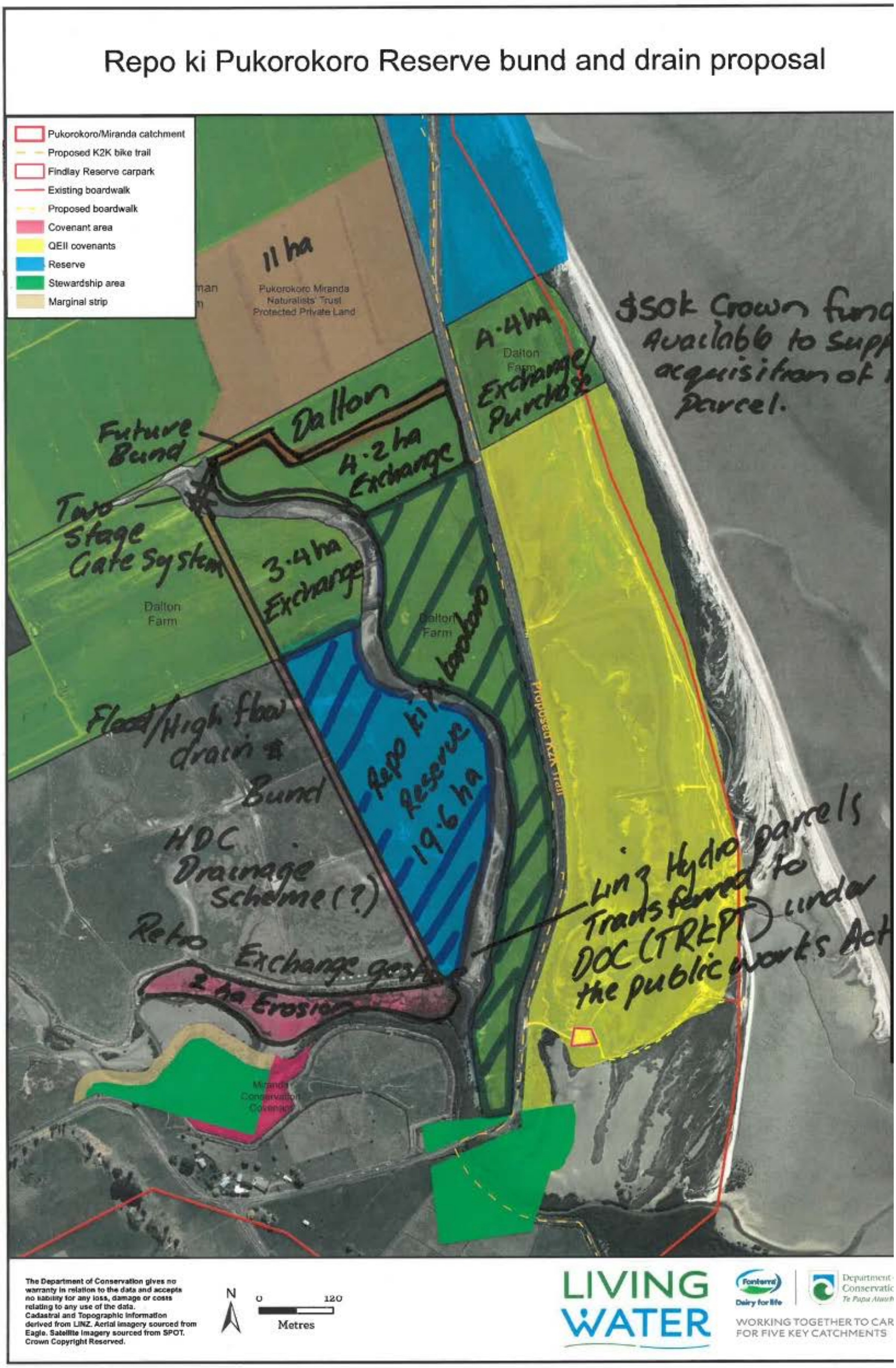


*Figure 3.5.1.1g. Proposed hydrological management interventions for the project area and surroundings.*



### 3.5.1.2 Key Project Attributes

Information for key project attributes was collected from a questionnaire (Appendix 1 (A1.1)), this is presented in Table 3.5.1.2.

*Table 3.5.1.2 Key project attributes.*

| Attribute | Description |
|---|---|
| Land Tenure | The land is owned by the Department of Conservation. |
| Key Stakeholders | This project is part of the Fonterra Living Water Collaboration[22].<br>The main stakeholders are:<br>• Te Repo Ki Pūkorokoro Trust.<br>• Department of Conservation<br>• Fonterra. |
| Governance Arrangements | Proposed future management structure is a Management and Control Agreement between the Te Repo Ki Pūkorokoro (TRKP) Trust and DOC. The TRKP Reserve is administered by DOC with the TRKP Trust (established in 2020 and representing iwi, community, farmers and other interested parties), providing advice and input into day-to-day site management. |
| Project Purpose | The proposed project purpose is to restore the wetland ecosystem and associated hydrology by rewetting and revegetation. Wetland rewetting is to be delivered from landward freshwater and tidal water sources. |
| Temporal Boundaries | The proposed project will have a project period of 30 years with a nominal start date of 1 January 2023 and an end date of 31 December 2052. Project development is estimated to require 1 year, starting 1 January 2023. |
| Geographic Boundaries | The physical boundary of the proposed project is shown in Figure 3.6.1.1e and amounts to 19.6ha. |
| **Baseline Scenario** | |
| Determination of Most Plausible Baseline Scenario | Continued degradation of tidal saltmarsh and associated emissions from aerobic respiration of drained and impounded saltmarsh. Justification: Business as usual without rewetting this wetland will lead to the continuation of baseline emissions. |
| Baseline activities | • The 1975 establishment of (non-consented) flapgates, bunds and subsequent dairy and dry-stock grazing resulted in an almost complete loss of tidal wetland and a degraded Pūkorokoro Stream ecosystem. The existing flapgates limit tidal inundation to the Pūkorokoro Stream that flows through the full extent of the Reserve. Note that, pre-1975, the area was tidally inundated.<br>• The hydrological state of the Pūkorokoro Stream and associated drain and streams has been monitored in recent years. Vegetation types and species lists (flora and fauna, including freshwater fish) have been mapped and reported in recent years.<br>• The land has been hydrologically modified since 1975 by unconsented drain and tide flapgates. Currently the Reserve is (over) grazed by cattle with no riparian management applied.<br>• Golder (2014) provide additional information on baseline conditions. |
| Reassessment of the Baseline Scenario | The baseline will be reassessed 10-yearly in accordance with VCS rules. |
| **Project Scenario** | |
| Project intervention activities aligned with VM0033 methodology. | • WRC + RWE. Rewetting tidal wetland and reducing sediment and nutrients in the catchment.<br>• Plus ARR for revegetation activities. |
| Primary outcomes of the project scenario. | • Proposed revegetation activities are shown in Figure 3.6.1.1f.<br>• Proposed hydrological management activities are shown in Figure 3.6.1.1g.<br>• Regular tidal inundation is planned for ponds and associated wetland that are to be excavated in the Reserve, adjoining the Pūkorokoro Stream. |

[22] https://www.livingwater.net.nz/catchment/Pūkorokoro-miranda/

| | |
|---|---|
| | • Limiting of high sediment and high nutrient input from the agricultural landscape through a new drain and bund and<br>• The reintroduction of appropriate coastal flora will all designed to enable establishment of a mosaic of dryland coastal shrubland/grassland, saltmarsh meadow, seagrass, limited mangrove forest and unvegetated tidal mudflats. |
| Restoration management activities. | • Pest control inside the project area provide important habitat for waders and other coastal/seabirds including bar-tailed godwit, red knot, wrybill and fernbird. We note that this activity will not significantly alter the carbon stocks between baseline and project scenario but is an important co-benefit of the project.<br>• Existing non-consented flapgates are to be removed and a weir installed on the Pūkorokoro Stream to provide both fish passage and tidal inundation. The weir will be of wooden construction and allow for ease of adjustment. A new drain will be installed, and weirs placed to redirect farm drain flow, located on the project area western boundary. These new drain structures will enable drainage into the Miranda Stream. Structures and works are designed to manage flow from the farmland catchment by bypassing the project area. The Pūkorokoro Stream (and proposed linked ponds) within the project area will receive regular if not daily tidal inundation.<br>• Marine silt in the project area is to be excavated to form a series of tidal ponds. The high sediment load from the farm drain will be directed through the new drain bypassing the project area.<br>• Salinity to the newly created tidal ponds will be delivered through daily tidal exchange.<br>• Water quality (sediment, nutrient *E. coli* and other contaminants) will be improved by construction of the new drain and its bund, bypassing the reserve.<br>• Reintroduction of priority threatened plant species and communities. Selected regionally threatened species on the Pūkorokoro Miranda coastline are being actively managed and it is envisaged re-seeding and transplanting would be undertaken in the project area including *Zostera muelleri* replanting and *Thyridia repens* transplanting. The project area currently contains nine vegetation types but important herbfield and sedgeland are both small and highly modified.<br>• The project area will be destocked of grazing farm animals (currently dairy and dry-stock cattle grazing). Some areas be grazed in the short term by sheep or light cattle for weed control (e.g., control of fennel).<br>• The new drain and bund will be covered by an easement between the Dalton Family Trust and DOC. The parties have yet to define boundaries and responsibilities for the management and maintenance of the new drain and bund easement. The Finlay reserve is owned jointly by PMNT and QEII National Trust. The new works will require consents from both Waikato regional Council and Hauraki District Council. Both councils have been involved in design discussions.<br>• Water management, particularly tide management, is critical to the establishment of tidal wetland. DOC, WRC, HDC, TRKP Trust and affected farmers acknowledge the need to consider the medium- to long term implications of climate change. The area was impacted by tidal surge events in 2014 and 2017 which resulted in emergency works to remedy flood damage to mainly farmland north of the project area.<br>• Sediment from farmland and dynamic coastal accretion along the Chenier plain on the coast are matters impacting on maintaining regular tidal exchange. The new drain will effectively bypass the Pūkorokoro Stream in the project area, but detailed engineering design is ongoing to be satisfied sediment accumulation between the Miranda Stream and both the new drain and the project area is understood. The Findlay Reserve is also being investigated on this matter.<br>• Sea level rise management is being considered with Council engineers and Living Water contracted hydrologists and engineers. The structures proposed are envisaged to provide for adaptive management with the understanding that transition management is needed to provide for environmental change. Weirs will for example be of wooden construction and able to be modified to accommodate emergency events or simply for the optimization of tidal exchange requirements to maintain ecological integrity in the |

| | |
|---|---|
| | ponded areas. Local farmers are acutely aware of future farming challenges on the former Chenier plain. |
| Applicability: Blue Carbon. | Presented in Appendix A2.1. |
| Applicability: Resilience. | Presented in Appendix A3.1. |
| Site-specific salinity conditions. | Presented in Appendix A4.1. |
| Site-specific soil carbon conditions. | Presented in Appendix A5.1. |
| Site-specific sea level rise conditions. | Presented in Appendix A6.2.1. |

#### 3.5.1.3 Blue Carbon Project

A blue carbon project undertaken using the VCS VM0033 methodology was considered by assessing available carbon accounting data and site-specific technical data (Appendices 1 to 6). The baseline activity is continued degradation of 19.6 ha of tidal saltmarsh and associated emissions from aerobic respiration of drained and impounded saltmarsh. This baseline arises from the establishment of (non-consented) flapgates and bunds in 1975 and subsequent dairy and dry-stock grazing. This resulted in an almost complete loss of tidal wetland and a degraded Pūkorokoro Stream ecosystem. The existing flapgates limit tidal inundation to the Pūkorokoro Stream that flows through the full extent of the project area. Note that, pre-1975, the area was tidally inundated. The main project activity is rewetting and restoration of 19.6 ha of tidal wetland.

Technical Feasibility Test

The technical feasibility for a blue carbon project is summarised in Table 3.5.1.3.

*Table 3.5.1.3. Technical feasibility test for a blue carbon project at Te Repo Ki Pūkorokoro.*

| Feasibility Criteria | Assessment |
|---|---|
| Does the project meet the necessary data requirements sufficient to fulfil the technical methodological requirements of the VCS methodology applied? | Yes |
| Is the project technical data aligned with a potential tradable asset volume sufficient to warrant a financial feasibility assessment? | Yes |

#### 3.5.1.4 Coastal Resilience Project

A coastal resilience project under the SD VISta standard was considered and technical information relating to a potential resilience project at this site is presented in Appendix A3.1. The main project intervention considered at this site is wetland restoration of a 20ha area.

Technical Feasibility Test

The technical feasibility for a coastal resilience project is summarised in Table 3.5.1.4.

*Table 3.5.1.4. Technical feasibility test for a coastal resilience project at Te Repo Ki Pūkorokoro.*

| Feasibility Criteria | Assessment |
|---|---|
| Does the project meet necessary data requirements sufficient to fulfil the technical methodological requirements of the SD VISta methodology applied? | Yes |
| Is the project technical data aligned with a potential tradable asset volume sufficient to warrant a financial feasibility assessment? | No |

#### 3.5.1.5 Biodiversity Credit Project

A biodiversity credit project was considered at the project site based on information gathered for a blue carbon project activity (i.e., information presented in this section above). The additional benefits arising from salt marsh restoration are likely to have a significant beneficial impact on biodiversity at this site. As such, a biodiversity credit project is potentially technically feasible at this site provided measurable project benefits meet the requirements of a biodiversity credit project. Because no methodology for biodiversity credits was available from the SD VISta standard, a formal assessment was unable to be undertaken.

If a biodiversity credit project methodology were developed that aligned with the biodiversity benefits delivered from the project interventions at this site, then a biodiversity credit project would likely be technically feasible.

#### 3.5.1.6 Conclusion

This technical feasibility assessment has reached the following conclusions for this site:

1. A salt marsh restoration blue carbon project at the Te Repo Ki Pūkorokoro site is technically feasible.
2. A coastal resilience project at the Te Repo Ki Pūkorokoro site is not technically feasible.
3. A biodiversity credit project at the Te Repo Ki Pūkorokoro site is technically feasible (in principle).

#### 3.5.1.7 Recommended Next Steps

Applicability Conditions

- Fill any knowledge gaps identified in our assessment of Applicability Conditions for VM0033 (refer to A2.1 for a site-specific assessment).
- Assess Applicability Conditions for the various relevant Tools and Modules required by VM0033 (as indicated in Appendix 2).

Carbon Measurement

- Fill knowledge gap relating to site-specific data (or representative default values) relating to salt marsh habitat for use in carbon accounting.
- Fill knowledge gap on site-specific values for soil organic content and salinity.
- For further information, refer Sections 3.3.3.1 (Approach) and 3.3.4 (Other Relevant Environmental Data).

Resilience Measurement

- Develop an updated assessment of the land cover at a local scale.
- Use a numerical approach considering land friction and wave contributions for all the four required storm event periods
- Use updated aerial images or land cover data to classify the project boundaries using the Manning coefficient.
- Use the 10m elevation contour as the inland boundary for the model.

Sea Level Rise

- Fill in knowledge gaps, for example increase accuracy of approaches to predict future SLR impacts on salt marsh at this site (refer Appendix 6 A6.1.3 Knowledge Gaps).
- Ensure engineering solutions for controlling tidal flow are suitable for mitigating SLR risk.
- Assess the feasibility of acquiring land suitable for enabling inland migration of tidal wetland (to help mitigate the risk of SLR at this site).

- Consider predicted changes to tidal wetland species composition in response to SLR within future project development.
- For further discussion on changing tidal wetland species composition in response to SLR and also on engineering solutions to mitigate SLR impacts refer to A6.2.1 for a site-specific assessment and to A6.1.2 (Risk of SLR and Management/Mitigation Options)

### 3.5.2 Wainui Repo Whenua

#### 3.5.2.1 Project Location

Wainui Repo Whenua is a 20 ha degraded tidal salt marsh ecosystem located to the north-west of Tauranga between Tauranga and Katikati and adjacent to the southern basin of the Tauranga Harbour (see Figures 3.5.2.1a-f).

*Figure 3.5.2.1a. Location of Wainui Repo Whenua project site near Tauranga.*

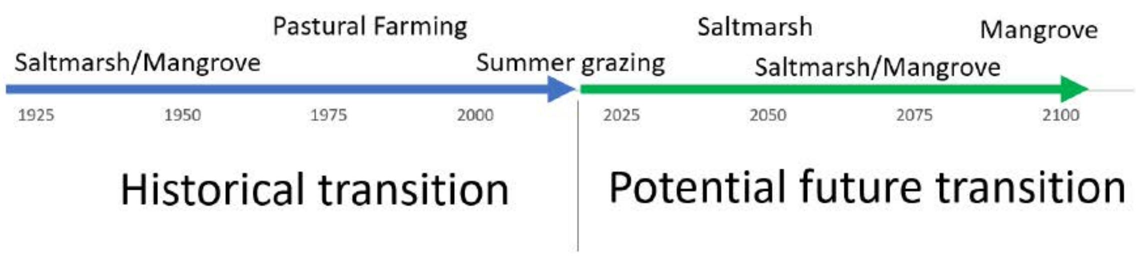

*Figure 3.5.2.1b. Overview of Wainui Repo Whenua study area.*

*Figure 3.5.2.1c. Wainui Repo Whenua proposed project site (yellow shading).*


*Figure 3.5.2.1d. Oblique view of eastern end of project site.*

*Figure 3.5.2.1e. Oblique view of western portion of project site.*


*Figure 3.5.2.1f. Temporal sequence of project transition from baseline to project outcomes.*




### 3.5.2.2 Key Project Attributes

Information for key project attributes was collected from a questionnaire (Appendix 1 (A1.1)) and is presented in Table 3.5.2.2.

*Table 3.5.2.2 Key project attributes.*

| Attribute | Description |
|---|---|
| Land Tenure | The land is owned by the Bay of Plenty Regional Council (BOPRC). |
| Key Stakeholders | Bay of Plenty Regional Council. |
| Governance Arrangements | Proposed project governance arrangements are yet to be determined. Currently governed and managed by Bay of Plenty Regional Council. |
| Project Purpose | The proposed project purpose is to restore the wetland ecosystem and associated hydrology by rewetting and revegetation. Wetland rewetting is to be delivered from landward freshwater and tidal water sources. |

| | |
|---|---|
| Temporal Boundaries | The proposed project will have a project period of 30 years with a nominal start date of 1 January 2023 and an end date of 31 December 2052. Project development is estimated to require 1 year, starting 1 January 2023. |
| Geographic Boundaries | The physical boundary of the proposed project is shown in Figure 3.6.2.1.c with a total area of 20ha. |
| **Baseline Scenario** | |
| Determination of Most Plausible Baseline Scenario | Continued degradation of tidal saltmarsh and associated emissions from aerobic respiration of drained and impounded saltmarsh. Justification: Business as usual without rewetting this wetland will lead to the continuation of baseline emissions. |
| Baseline activities | • Grazed open pasture on drained/reclaimed land.<br>• Drained and flap-gated before, but recently re-connected to the tide. |
| Reassessment of the Baseline Scenario | The baseline will be reassessed 10-yearly in accordance with VCS rules. |
| **Project Scenario** | |
| Project intervention activities aligned with VM0033 methodology. | • WRC + RWE. Rewetting tidal wetland and reducing sediment and nutrients in the catchment.<br>• Plus ARR for revegetation activities. |
| Primary outcomes of the project scenario. | • Improved hydraulic connectivity between Wainui Stream and the new salt marsh.<br>• Establish an appropriate hydraulic regime to support the reestablishment of salt marsh habitat.<br>• Maximize area for re-establishment of salt marsh vegetation. |
| Restoration management activities. | • Creating, restoring and/or managing hydrological conditions (e.g., removing tidal barriers, improving hydrological connectivity, restoring tidal flow to wetlands or lowering water levels on impounded wetlands).<br>• Changing salinity characteristics (e.g., restoring tidal flow to tidally restricted areas).<br>• (Re-)introducing native plant communities (e.g., reseeding or replanting).<br>• Improving management practice(s) (e.g., removing invasive species, reduced grazing).<br>• Protecting at-risk wetlands (e.g., establishing conservation easements, establishing community supported management agreements, establishing protective government regulations, and preventing disruption of water and/or sediment supply to wetland areas).<br>• Improving water management on drained wetlands.<br>• Creating accommodation space for wetlands migrating with sea-level rise.<br>• The same methods will be used across the site for hydrological and revegetation outcomes. There is limited elevation across the site and predominately saline hydrological regime restricting the species of which it can host.<br>• Desired target water levels met by commissioning an extra 4 x 600mm culverts in addition to the existing 2 culverts on site.<br>• Target revegetation approach. 25% of the 20 ha will be planted in 2021 with 20,000 saltmarsh plants species include: *Apodasmia similis, Plagianthus divaricatus* and *Juncus kraussii var. australiensis*. Predicted to transition from salt marsh to mangroves over time as the sea level rises. |
| Applicability: Blue Carbon. | Presented in Appendix A2.2. |
| Applicability: Resilience. | Presented in Appendix A3.2. |
| Site-specific salinity conditions. | Presented in Appendix A4.2. |
| Site-specific soil carbon conditions. | Presented in Appendix A5.2. |
| Site-specific sea level rise conditions. | Presented in Appendix A6.2.2. |

#### 3.5.2.3 Blue Carbon Project

A blue carbon project undertaken using the VCS VM0033 methodology was considered by assessing available carbon accounting data and site-specific technical data (Appendices 1 to 6).

The baseline activity is continued degradation of tidal saltmarsh and associated emissions from aerobic respiration of drained and impounded saltmarsh. The main project activity is rewetting tidal wetland. Rewetting began in 2020 with a planned regime of hydrological enhancement/restoration currently underway.

Technical Feasibility Test

The technical feasibility for a blue carbon project is summarised in Table 3.5.2.3.

*Table 3.5.2.3. Technical feasibility test for a blue carbon project at Wainui Repo Whenua.*

| Feasibility Criteria | Assessment |
|---|---|
| Does the project meet necessary data requirements sufficient to fulfil the technical methodological requirements of the VCS methodology applied? | Yes |
| Is the project technical data aligned with a potential tradable asset volume sufficient to warrant a financial feasibility assessment? | Yes |

#### 3.5.2.4 Coastal Resilience Project

A coastal resilience project under the SD VISta standard was considered and technical information relating to a potential resilience project at this site is presented in Appendix A3.2. The main project intervention considered at this site is wetland restoration of a 20ha area.

Technical Feasibility Test

The technical feasibility for a coastal resilience project is summarised in Table 3.5.2.4.

*Table 3.5.2.4. Technical feasibility test for a coastal resilience project at Wainui Repo Whenua.*

| Feasibility Criteria | Assessment |
|---|---|
| Does the project meet necessary data requirements sufficient to fulfil the technical methodological requirements of the SD VISta methodology applied? | Yes |
| Is the project technical data aligned with a potential tradable asset volume sufficient to warrant a financial feasibility assessment? | No |

#### 3.5.2.5 Biodiversity Credit Project

A biodiversity credit project was considered at the project site based on information gathered for a blue carbon project activity (i.e., information presented in this section above). The additional benefits arising from salt marsh restoration are likely to have a significant beneficial impact on biodiversity at this site. As such, a biodiversity credit project is potentially technically feasible at this site provided measurable project benefits meet the requirements of a biodiversity credit project. Because no methodology for biodiversity credits was available from the SD VISta standard, a formal assessment was unable to be undertaken. If a biodiversity credit project methodology were developed that aligned with the biodiversity benefits delivered from the project interventions at this site, then a biodiversity credit project would likely be technically feasible.

#### 3.5.2.6 Conclusion

This technical feasibility assessment has reached the following conclusions for this site:

1. A salt marsh restoration blue carbon project at the Wainui Repo Whenua site is technically feasible.
2. A coastal resilience project at the Wainui Repo Whenua site is not technically feasible for this site.

3. A biodiversity credit project at the Wainui Repo Whenua site is technically feasible (in principle).

#### 3.5.2.7 Recommended Next Steps

Applicability

- Fill any knowledge gaps identified in our assessment of Applicability Conditions for VM0033 (refer to Appendix 2 A2.2 for a site-specific assessment).
- Assess Applicability Conditions for the various relevant Tools and Modules required by VM0033 (refer Appendix 2).

Carbon Measurement

- Fill knowledge gap on site-specific data (or representative default values) relating to salt marsh habitat for use in carbon accounting. For example, carbon sequestration rates and GHG emissions.
- Fill knowledge gap on site-specific values for soil organic content and salinity.
- For further information, refer Sections 3.3.3.1 (Approach) and 3.3.4 (Other Relevant Environmental Data).

Resilience

- Update assessment of the land cover at a local scale.
- Use a numerical approach considering land friction and wave contributions for all the four required storm event periods.
- Replicate the methodology used by Tauranga Harbour inundation modelling (Reeve et al. 2019) for classifying the habitat using the Manning coefficient
- Source the bathymetry datasets used for constructing the Tauranga Harbour model grid.
- Use the 10m elevation contour as the inland boundary for the model.

Sea Level Rise

- Increase accuracy of approaches to predict future SLR impacts on salt marsh at this site (refer Appendix 6 A6.1.3 Knowledge Gaps.
- Ensure engineering solutions for controlling tidal flow are suitable for mitigating SLR risk.
- Assess the feasibility of acquiring land suitable for enabling inland migration of tidal wetland (to help mitigate the risk of SLR at this site).
- Consider predicted changes to tidal wetland species composition in response to SLR within future project development.
- For further discussion on changing tidal wetland species composition in response to SLR and also on engineering solutions to mitigate SLR impacts refer to Appendix 6 A6.2.2 for a site-specific assessment and A6.1.2 (Risk of SLR and Mitigation Options).

### 3.5.3 Pukehina/Waihī

#### 3.5.3.1 Project Location

The Pukehina/Waihī project site is a 20 ha degraded wetland located to the south-east of Tauranga, between Tauranga and Whakatane (see Figures 3.5.3.1a-c).

*Figure 3.5.3.1a. Location of Pukehina/Waihī project site near Tauranga.*

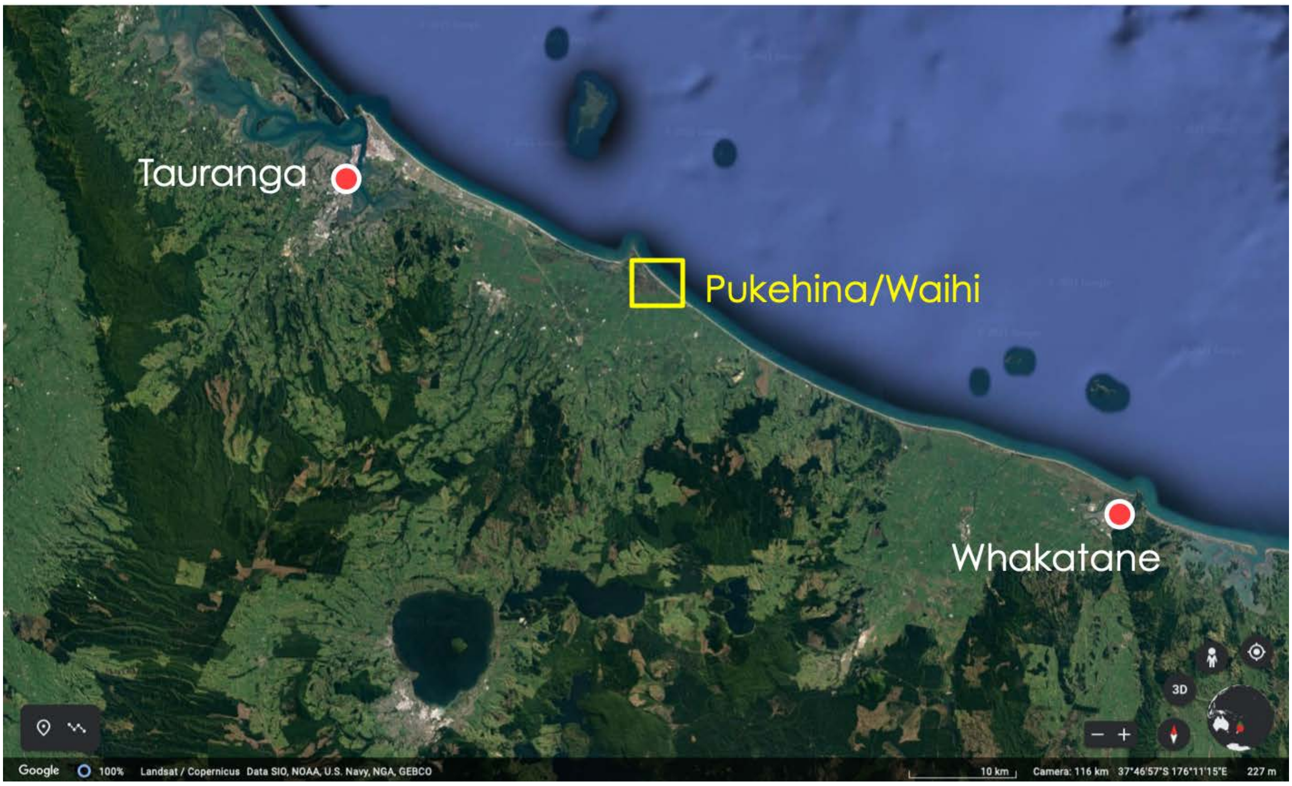



*Figure 3.5.3.1b. Overview of Pukehina/Waihī project area.*

*Figure 3.5.3.1c. Pukehina/Waihī proposed project site (yellow shading).*


### 3.5.3.2 Key Project Attributes

Information for key project attributes was collected from a questionnaire (Appendix 1 (A1.1)) and is presented in Table 3.5.3.2.

*Table 3.5.3.2 Key project attributes*

| Attribute | Description |
|---|---|
| Land Tenure | The land is privately owned (owner details are confidential as this is commercially sensitive). |
| Key Stakeholders | • Landowner (details kept confidential).<br>• Anna Dawson (BOPRC).<br>• Carl McGuinness (The Nature Conservancy). |
| Governance Arrangements | Proposed project governance arrangements are yet to be determined. The land is currently privately owned and governed and managed by the landowner. |
| Project Purpose | The proposed project purpose is to restore the wetland ecosystem and associated hydrology by rewetting and revegetation. Wetland rewetting is to be delivered from landward freshwater and tidal water sources. |
| Temporal Boundaries | The proposed project will have a project period of 30 years with a nominal start date of 1 January 2023 and an end date of 31 December 2052. Project development is estimated to require 1 year, starting 1 January 2023. |
| Geographic Boundaries | The physical boundary of the proposed project is shown in Figure 3.6.3.1.c and amounts to 20.5 ha in total. |

| Baseline Scenario | |
|---|---|
| Determination of Most Plausible Baseline Scenario | Continued degradation of tidal saltmarsh and associated emissions from aerobic respiration of drained and impounded saltmarsh. Justification: Business as usual without rewetting this wetland will lead to the continuation of baseline emissions. |
| Baseline Activities | Current land use is dairy grazing and associated pasture on drained wetland, fertilised but mainly with organic fertilisers (no inorganic nitrogen used). Property drainage is maintained via drainage canals. |
| Reassessment of the Baseline Scenario | The baseline will be reassessed 10-yearly in accordance with VCS rules. |
| **Project Scenario** | |
| Project intervention activities aligned with VM0033 methodology. | • WRC + RWE. Rewetting tidal wetland and reducing sediment and nutrients in the catchment.<br>• Plus ARR for revegetation activities. |
| Primary outcomes of the project scenario. | • Improved hydraulic connectivity between tidal flows and the new salt marsh and associated revegetation with wetland species. |
| Restoration management activities. | Rewetting and revegetation. |
| Applicability: Blue Carbon. | Presented in Appendix A2.3. |
| Applicability: Resilience. | Presented in Appendix A3.3. |
| Site-specific salinity conditions. | Presented in Appendix A4.3. |
| Site-specific soil carbon conditions. | Presented in Appendix A5.3. |
| Site-specific sea level rise conditions. | Presented in Appendix A6.2.3. |

#### 3.5.3.3 Blue Carbon Project

A blue carbon project undertaken using the VCS VM0033 methodology was considered by assessing available carbon accounting data and site-specific technical data (Appendices 1 to 6).

The baseline activity is continued degradation of tidal saltmarsh and associated emissions from aerobic respiration of drained and impounded saltmarsh. The current land use is dairy grazing and associated pasture on drained wetland, fertilised but mainly with organic fertilisers (no inorganic nitrogen used). Pasture drainage is maintained via drainage canals. The main project activity is rewetting tidal wetland.

Technical Feasibility Test

The technical feasibility for a blue carbon project is summarised in Table 3.5.3.3.

*Table 3.5.3.3. Technical feasibility test for a blue carbon project at Pukehina/Waihi.*

| Feasibility Criteria | Assessment |
|---|---|
| Does the project meet necessary data requirements sufficient to fulfil the technical methodological requirements of the VCS methodology applied? | Yes |
| Is the project technical data aligned with a potential tradable asset volume sufficient to warrant a financial feasibility assessment? | Yes |

#### 3.5.3.4 Coastal Resilience Project

A coastal resilience project under the SD VISta standard was considered and technical information relating to a potential resilience project at this site is presented in Appendix A3.3. The main project intervention considered at this site is wetland restoration of a 20ha area.

Technical Feasibility Test

The technical feasibility for a coastal resilience project is summarised in Table 3.5.3.4.

*Table 3.5.3.4. Technical feasibility test for a coastal resilience project at Pukehina/Waihi.*

| Feasibility Criteria | Assessment |
|---|---|
| Does the project meet necessary data requirements sufficient to fulfil the technical methodological requirements of the SD VISta methodology applied? | Yes |
| Is the project technical data aligned with a potential tradable asset volume sufficient to warrant a financial feasibility assessment? | No |

#### 3.5.3.5 Biodiversity Credit Project

A biodiversity credit project was considered at the project site based on information gathered for a blue carbon project activity (i.e., information presented in this section above). The additional benefits arising from salt marsh restoration are likely to have a significant beneficial impact on biodiversity at this site. As such, a biodiversity credit project is potentially technically feasible at this site provided measurable project benefits meet the requirements of a biodiversity credit project. Because no methodology for biodiversity credits was available from the SD VISta standard, a formal assessment was unable to be undertaken.

If a biodiversity credit project methodology were developed that aligned with the biodiversity benefits delivered from the project interventions at this site, then a biodiversity credit project would likely be technically feasible.

#### 3.5.3.6 Conclusion

This technical feasibility assessment has reached the following conclusions for this site:

1. A salt marsh restoration blue carbon project at the Pukehina/Waihī site is technically feasible.
2. A coastal resilience project at the Pukehina/Waihī site is not technically feasible.
3. A biodiversity credit project at the Pukehina/Waihī site is technically feasible (in principle).

#### 3.5.3.7 Recommended Next Steps

Applicability

- Fill any knowledge gaps identified in our assessment of Applicability Conditions for VM0033 (refer to Appendix 2 A2.3 for a site-specific assessment).
- Assess Applicability Conditions for the various relevant Tools and Modules required by VM0033 (refer Appendix 2).

Carbon Measurement

- Fill knowledge gap on site-specific data (or representative default values) relating to salt marsh habitat for use in carbon accounting. For example, carbon sequestration rates and GHG emissions.
- Fill knowledge gap on site-specific values for soil organic content and salinity.
- For further information, refer Sections 3.3.3.1 and 3.3.4.

Resilience

- Update assessment of the land cover at a local scale.
- Use a numerical approach considering land friction and wave contributions for all the four required storm event periods.
- Use updated aerial images or land cover data to classify the project boundaries using the Manning coefficient
- Use the 10m elevation contour as the inland boundary for the model.

Sea Level Rise

- Increase accuracy of approaches to predict future SLR impacts on salt marsh at this site (refer Appendix 6 A6.1.3 Knowledge Gaps.
- Ensure engineering solutions for controlling tidal flow are suitable for mitigating SLR risk.
- Assess the feasibility of acquiring land suitable for enabling inland migration of tidal wetland (to help mitigate the risk of SLR at this site).
- Consider predicted changes to tidal wetland species composition in response to SLR within future project development.
- For further discussion on changing tidal wetland species composition in response to SLR and also on engineering solutions to mitigate SLR impacts refer to Appendix 6 A6.2.3 for a site-specific assessment and A6.1.2 (Risk of SLR and Mitigation Options).

### 3.5.4 Farewell Spit

#### 3.5.4.1 Project Location

The Farewell Spit project site is a seagrass ecosystem located at the north-west end of Golden Bay, Tasman District (see Figures 3.5.4.1a-f). Project activities for this site are assessed as a hypothetical scenario. Key information underpinning the hypothetical scenario was collected from a questionnaire (Appendix 1 (A1.1)).

*Figure 3.5.4.1a. Location of Farewell Spit project site.*


*Figure 3.5.4.1b. Overview Farewell Spit project area showing approximate extent of seagrass meadows (yellow shading).*

*Figure 3.5.4.1c. Proposed project area.*


*Figure 3.5.4.1d. Seagrass cover (%) in the proposed project area. Above is a shapefile compiled from a mixture of sources including Battley et al. (2005) and Robertson et al. (2012) and was the most recent data available in Seasketch.*[23]


[23] https://www.seasketch.org/#projecthomepage/5357cfa467a68a303e1bb87a

*Figure 3.5.4.1e. Zostera surface cover on the Farewell Spit tidal flats. Percentage surface cover is based on a visual assessment with reference to standard photographs. Source: Battley et al. 2005.*

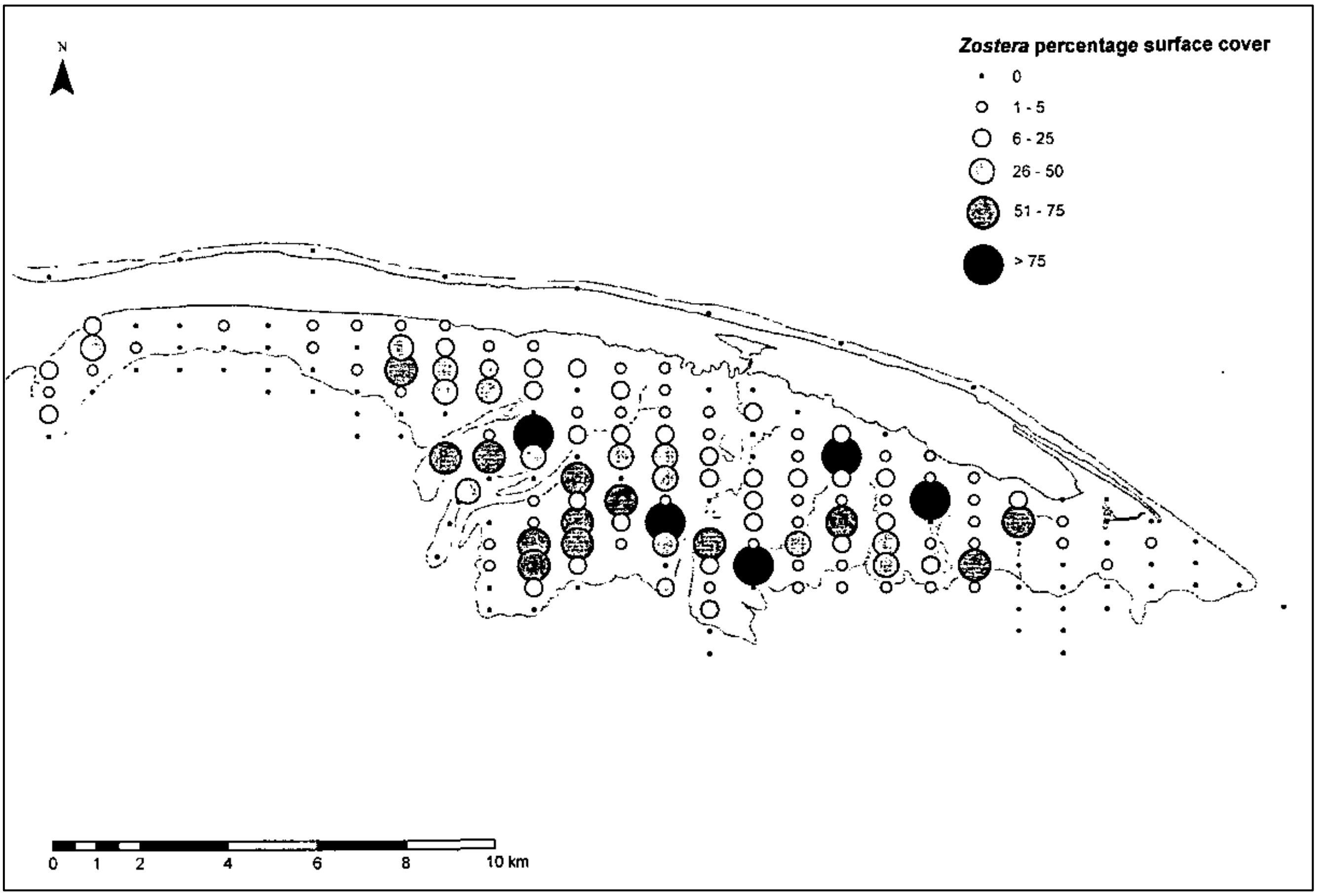
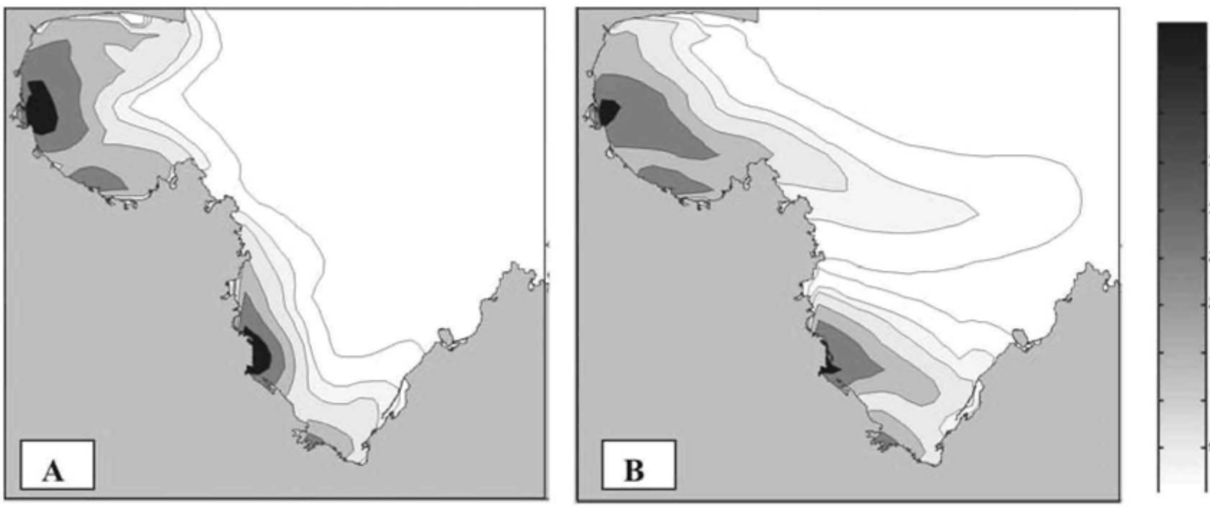



*Figure 3.5.4.1f. Surface water concentrations (mg litre$^{-1}$) of suspended sediments (2$\mu$m grain size) after 10 days flood river flow conditions forced with no wind (A) and a 10 knot northerly wind (B). Source: Tuckey et al. 2006.*



Sedimentation

Sedimentation has been identified (through a vulnerability assessment) of being a moderate to high risk to various s seagrass (*Zostera muelleri*) meadows in the proposed project area (Robertson et al. 2012). However, the risk of fine sediments to seagrass meadows located directly alongside Farewell Spit is unknown (and may be relatively low based on historical information e.g., Battley et al. 2005). Sedimentation rates at the project location will be influenced by factors such as sediment flows down major river systems in the area combined with tidal flows and tidal circulation (Figure 3.5.4.1f).

Bird Herbivory

Preliminary research by Dixon (2009) (Table 3.5.4.1) and anecdotal evidence suggests that grazing by swans may have a significant impact on the biomass of seagrass meadows at Farewell Spit. Monitoring by Fish & Game Aotearoa New Zealand shows that Farewell Spit has a relatively high swan population compared to sites in the Nelson-Marlborough subregion (Figure 3.5.4.1g).

*Figure 3.5.4.1g. Swan trend counts for Nelson-Marlborough subregion. Source: Fish and Game Aotearoa New Zealand.*

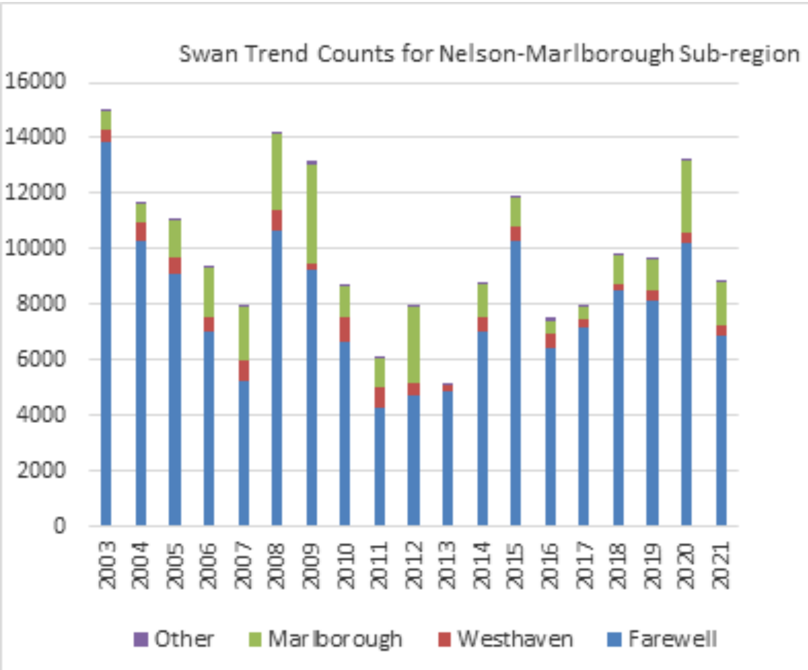



*Table 3.5.4.1. Mean values of shoot number per m², shoot biomass (g per m²) and rhizome biomass (g per m²) after 2 months at Puponga, 4 months at Te Rae, and 6 months at White Pine Creek. Source: Dixon 2009.*

| | | mean | | | |
|---|---|---|---|---|---|
| | | exclosure | control | *F* | *P* |
| Puponga | shoot number/m² | 11417 | 4923 | $F_{1,11}$=15.18 | 0.0030 |
| | shoot biomass g/m² | 86.2 | 27.4 | $F_{1,11}$=29.20 | 0.0003 |
| | rhizome biomass g/m² | 136.3 | 51.1 | $F_{1,11}$=19.90 | 0.0012 |
| Te Rae | shoot number/m² | 8722 | 212 | $F_{1,11}$=163.25 | <.0001 |
| | shoot biomass g/m² | 108.2 | 1.9 | $F_{1,11}$=100.92 | <.0001 |
| | rhizome biomass g/m² | 108.8 | 5.3 | $F_{1,11}$=70.75 | <.0001 |
| White Pine Creek | shoot number/m² | 8212 | 8085 | $F_{1,11}$=0.01 | 0.9235 |
| | shoot biomass g/m² | 102.8 | 98.2 | $F_{1,11}$=0.13 | 0.7246 |
| | rhizome biomass g/m² | 79.7 | 71.9 | $F_{1,11}$=0.52 | 0.4891 |

### 3.5.4.2 Key Project Attributes

Information was gathered for key project attributes using a questionnaire (Appendix 1 (A1.1)) and are presented in Table 3.5.4.2.

*Table 3.5.4.2 Key project attributes.*

| Attribute | Description |
|---|---|
| Land Tenure | The potential project area is comprised of inshore marine seabed and is subject to the Takutai Moana Act 2011. |
| Key Stakeholders | • Department of Conservation (DOC)<br>• Fish & Game<br>• Aotearoa New Zealand Landcare Trust)<br>• Project Mohua. |
| Governance Arrangements | Proposed project governance arrangements are yet to be determined. |
| Project Purpose | The proposed project purpose is to restore the seagrass ecosystem through sedimentation control and the control of bird herbivory. |
| Temporal Boundaries | The proposed project will have a project period of 30 years with a nominal start date of 1 January 2023 and an end date of 31 December 2052. Project development is estimated to require 1 year, starting 1 January 2023. |
| Geographic Boundaries | The physical boundary of the proposed project comprises the total area of existing intertidal seagrass present (including the full range of percentage covers), at 5,553ha and shown in Figure 3.6.4.1c. |
| **Baseline Scenario** | |
| Determination of Most Plausible Baseline Scenario | Continued degradation of seagrass meadows from sedimentation and bird herbivory. Justification: Business as usual without reduced sedimentation and bird herbivory will lead to the continuation of baseline emissions. |
| Baseline activities | • Intact and/or partially altered intertidal seagrass meadow present (including the full range of percent cover).<br>• Note, have assumed the seagrass meadows are 'partially altered' or 'intact' based on risk information in other reports and existing percent cover (unless TDC state otherwise e.g., intact or degraded).<br>• Note, Robertson et al. (2012) state that the Golden Bay estuaries are filling with mud, which is causing siltation problems. Seagrass risk rating to mud for the estuaries was often moderate (and sometimes high and sometimes low). Mud was noted as the major stressor affecting eelgrass habitat in the region general Tasman region.<br>• Note, have assumed only considering intertidal seagrass as there was no known data located on subtidal seagrass (Dixon 2009 says that there does not appear to be any subtidal seagrass).<br>• Sedimentation has been identified as one source of degradation of seagrass ecosystems in this area. Sedimentation rates at the project location will be influenced by sediment flows down major river systems in the area combined with tidal flows and tidal circulation.<br>• Most larger sediments settle in the estuary systems that link the rivers to the coastal waters. The particularly high flow rates of the Aorere River and to a lesser extent the Takaka River during flood events may also help to explain the shallower (largely <30 m) bathymetry of Golden Bay, as the residual currents for the area are small (<5 cm s–1) and a considerable amount of the sediment (10+ µm grain size) is likely to settle within the confines of the bay. Riverine influences extend to the 2 µm sediments, where depositional sediments can be seen to accumulate in the northwestern corner of Golden Bay, at the southwestern end of Farewell Spit.<br>• The predicted fate of fine sediments entering the Nelson Bays from both the Motueka and other major rivers is consistent with local general knowledge of their bathymetric and seabed characteristics. For example, the model predicts a build-up of sediment along the southern side of Farewell Spit and this result also agrees with local knowledge |

| | |
|---|---|
| | of the area (Battley et al. 2005). These very fine muddy sediments are known to make up large tidal mudflats in this corner of Golden Bay. It must be noted, however, that the modelling performed here did not include waves and wave-driven near-shore littoral drift that is likely to alter the near-shore distributions of sediments. |
| Reassessment of the Baseline Scenario | The baseline will be reassessed 10-yearly in accordance with VCS rules. |
| **Project Scenario** | |
| Project intervention activities aligned with VM0033 methodology. | • RWE |
| Primary outcomes of the project scenario. | • Reduced sedimentation through revegetation and changed land management practices in catchments delivering sediment to project area.<br>• Swan population control. |
| Restoration management activities. | • Riparian revegetation along the length of river catchments delivering sediment to the north-western Golden Bay inshore marine environment.<br>• Changes in land use practices on pasture that will reduce sedimentation delivery.<br>• Revegetation of erosion-prone non-forest lands in relevant catchments.<br>• Reducing the swan population through population control measures (e.g., culling). |
| Applicability: Blue Carbon. | Presented in Appendix A2.4. |
| Applicability: Resilience. | Presented in Appendix A3.4. |
| Site-specific salinity conditions. | Presented in Appendix A4.4. |
| Site-specific soil carbon conditions. | Presented in Appendix A5.4. |
| Site-specific sea level rise conditions. | Presented in Appendix A6.2.4. |

#### 3.5.4.3 Blue Carbon Project

There are two principal activity types potentially relevant to seagrass (*Zostera muelleri*) management at Farewell Spit. This includes activities that would reduce/avoid the degradation of intact seagrass (seagrass conservation), and activities that would enable the restoration of seagrass carbon stocks (seagrass restoration). The key methodological question, therefore, is whether the potential management interventions considered in this project area constitute conservation or restoration.

If the seagrass meadows in the Farewell Spit area were intact, and if there was a threat to the carbon stocks in this intact ecosystem through planned or unplanned degradation then a seagrass conservation project would be the appropriate classification and VCS VM0007 would apply. The information currently available on seagrass distribution indicates the presence of seagrass meadows in the proposed project area (refer Figures 3.5.4.1d and 3.5.4.1e). We know of no prior baseline information to indicate whether the overall size of seagrass meadows in this area have reduced over time. Therefore, existing meadows could be considered intact in this respect. However, existing seagrass beds could also potentially be considered as degraded (and therefore could undergo restoration). This is given that some of these are at risk of/vulnerable to sedimentation and have previously been damaged by bird herbivory, noting that we do not have information quantifying any seagrass loss or degradation caused by sedimentation or stating whether there is any existing damage from bird herbivory.

Project activities could therefore conceivably be considered as either conservation (under VM0007) or restoration (VM0033), pending further information. Either way, , the main potential project activities would be sedimentation reduction and bird control which, if implemented, may protect intact seagrass meadows or halt or slow the rate of degradation enabling the seagrass ecosystem to be restored, thereby either protecting existing carbon stocks or increasing their carbon stocks through a period of net carbon sequestration respectively.

In a restoration scenario, active restoration could also be considered. Active seagrass restoration could potentially be carried out in degraded seagrass habitats once threats causing the degradation in the first instance were removed. Active seagrass restoration in Aotearoa New Zealand has been successful trialled at small scales using material transplanted from nearby donor beds (Matheson et al. 2017). There is also potential for low impact restoration (see review by Clark & Berthelsen 2021). Recent research has shown promise for low impact restoration, for example, in relation to growing beach-cast plants in nurseries in preparation for transplantation to the wild (Hindmarsh & Hooks 2022 in draft). Low impact restoration using seagrass seeds may also potentially be viable in the future, given that seagrass flowering is more prevalent than previously thought (including for the Top of the South region - Zabarte-Maeztu et al. 2021; Hindmarsh & Hooks 2022 in draft), and that seed-based restoration methods have been established for *Zostera muelleri* overseas (Emma Jackson pers. comm.).

A seagrass restoration or conservation blue carbon project was considered for the Farewell Spit project area by assessing available carbon accounting data and site-specific technical data (Appendices 1 to 6). This did not include active revegetation but focused on enhancing seagrass habitat through reduction of sedimentation.

Based on the data gathered in this assessment a blue carbon project is not technically feasible at this site. This is due to technical challenges with both project activities. For sedimentation, there are the following technical challenges:

- A knowledge gap on whether seagrass habitats are currently degraded due to sedimentation (i.e., whether previous areas have been lost or existing beds are in poor health).
- A lack of baseline sedimentation deposition data for comparison with project data.
- A lack of baseline carbon stock and stock change data in the seagrass meadows.
- The source of sedimentation is widespread and non-point source.
- Most of the sediment delivered to the north-western Golden Bay inshore marine environment will likely be sourced from the length of the Aorere and Takaka rivers.
- It will be challenging to successfully attribute measurable change in carbon stocks to measurable change in sedimentation in the seagrass meadows.
- It will be challenging to successfully attribute measurable carbon stock change to specific catchment management interventions in these rivers until there is higher resolution data at both sediment source and sink and thus, the corresponding impacts on carbon stocks.

For swan population control there are the following technical challenges:

- A lack of baseline data on the relationship between swan population dynamics and their corresponding impact on seagrass biomass, and the geographical distribution of these dynamics. Preliminary studies have begun the process of providing initial data, but more data is required to meet the technical feasibility threshold for a carbon project.
- A lack of data on the impact of a reduced swan population on seagrass biomass and carbon stocks.
- Operational challenges on how to reduce the population of a protected species in a key habitat.

<u>Technical Feasibility Test</u>

The technical feasibility for a blue carbon project is summarised in Table 3.5.4.3.

*Table 3.5.4.3. Technical feasibility test for a blue carbon project at Farewell Spit.*

| Feasibility Criteria | Assessment |
|---|---|
| Does the project meet necessary data requirements sufficient to fulfil the technical methodological requirements of the VCS methodology applied? | No |
| Is the project technical data aligned with a potential tradable asset volume sufficient to warrant a financial feasibility assessment? | No |

#### 3.5.4.4 Coastal Resilience Project

A coastal resilience project under the SD VISta standard was considered and technical information relating to a potential resilience project at this site is presented in Appendix A3.4. The main project intervention considered at this site is the enhancement of seagrass habitat through reduced sedimentation and reduced swan herbivory.

The main technical challenge for a blue carbon project at this site was the lack of baseline data and the difficulties associated with transparently attributing project interventions to measurable change to the project area. The SD Vista methodology is not applicable for this site, as it is not currently applied to seagrass meadows habitats. The methodology may be expanded to cover other tidal wetland as seagrass in the future, although, the technical challenge for a blue carbon project might also apply to a future resilience project.

<u>Technical Feasibility Test</u>

The technical feasibility for a coastal resilience project is summarised in Table 3.5.4.4.

*Table 3.5.4.4. Technical feasibility test for a coastal resilience project at Farewell Spit.*

| Feasibility Criteria | Assessment |
|---|---|
| Does the project meet necessary data requirements sufficient to fulfil the technical methodological requirements of the SD VISta methodology applied? | No |
| Is the project technical data aligned with a potential tradable asset volume sufficient to warrant a financial feasibility assessment? | No |

#### 3.5.4.5 Biodiversity Credit Project

A biodiversity credit project was considered at the project site based on information gathered for a blue carbon project activity (i.e., information presented in this section above). The additional benefits arising from seagrass enhancement are likely to have a significant beneficial impact on biodiversity at this site. The main challenge for a biodiversity project at this site is the attribution of project interventions to measurable beneficial change to biodiversity.

Because no methodology for biodiversity credits was available from the SD VISta standard, a formal assessment was unable to be undertaken.

If a biodiversity credit project methodology were developed that aligned with the biodiversity benefits delivered from the project interventions at this site, then a biodiversity credit project may be technically feasible provided attribution of project interventions to measurable beneficial biodiversity enhancement impacts was able to be demonstrated.

#### 3.5.4.6 Conclusion

This technical feasibility assessment reached the following conclusions:

1. A blue carbon project for seagrass meadows at Farewell Spit is currently not technically feasible.
2. A coastal resilience project at Farewell Spit is not technically feasible.

3. A biodiversity credit project at Farewell Spit may be technically feasible (in principle) but faces considerable technical challenges.

#### 3.5.4.7 Recommended Next Steps

Applicability

- Fill any knowledge gaps identified in our assessment of Applicability Conditions for VM0033 (refer to Appendix 2 A2.4 for a site-specific assessment).
- Assess Applicability Conditions for the various relevant Tools and Modules required by VM0033 (refer Appendix 2).

Carbon Measurement

- Fill knowledge gap with additional site-specific data (or representative default values) relating to seagrass habitat for use in carbon accounting.
- Fill knowledge gap in site-specific values for soil organic content and salinity.
- For further information, refer Sections 3.3.3.1 (Approach) and 3.3.4 (Other Relevant Environmental Data).

Resilience

- Develop an updated assessment of the seagrass mapping around the Farewell Spit.
- Use a numerical approach considering land friction and wave contributions for all the four required storm event periods.
- Use updated aerial images or land cover data to classify the project boundaries using the Manning coefficient.
- Use the 10m elevation contour as the inland boundary for the model.

Sea Level Rise

- Fill in knowledge gaps identified to better predict future impacts of SLR on seagrass at this site (refer Appendix 6, A6.1.3 Knowledge Gaps).
- For further discussion on changing tidal wetland species composition in response to SLR refer to Appendix 6 A6.2.4 for a site-specific assessment and to A6.1.2 (Risk of SLR and Mitigation Options).

### 3.5.5 Waimeha Inlet

#### 3.5.5.1 Project Location

The Waimeha Inlet project site is a 4.6 ha degraded salt marsh ecosystem located to the west of Nelson City, between Nelson, Richmond and Motueka (see Figures 3.5.5.1a-f).

*Figure 3.5.5.1a. Location of Waimeha Inlet project site.*


*Figure 3.5.5.1b. Overview of Waimeha Inlet project area.*

*Figure 3.5.5.1c. Project area.*


*Figure 3.5.5.1d Grazed salt marsh cut off from the sea by large earth bund (right) and channelizing to drain the water. Source: Stevens 2021. Note that the project area shapefile provided to us for this study differs slightly in shape to that indicated in Stevens 2021 – See Appendix 6 (A6.2.5) of this report.*

*Figure 3.5.5.1e. Rushland and herb field currently within paddocks used for grazing stock. Source: Stevens 2021.*

*Figure 3.5.5.1f. Outline of proposed restoration footprint, Borck Creek to Sandeman Reserve. Source: Stevens 2021.*

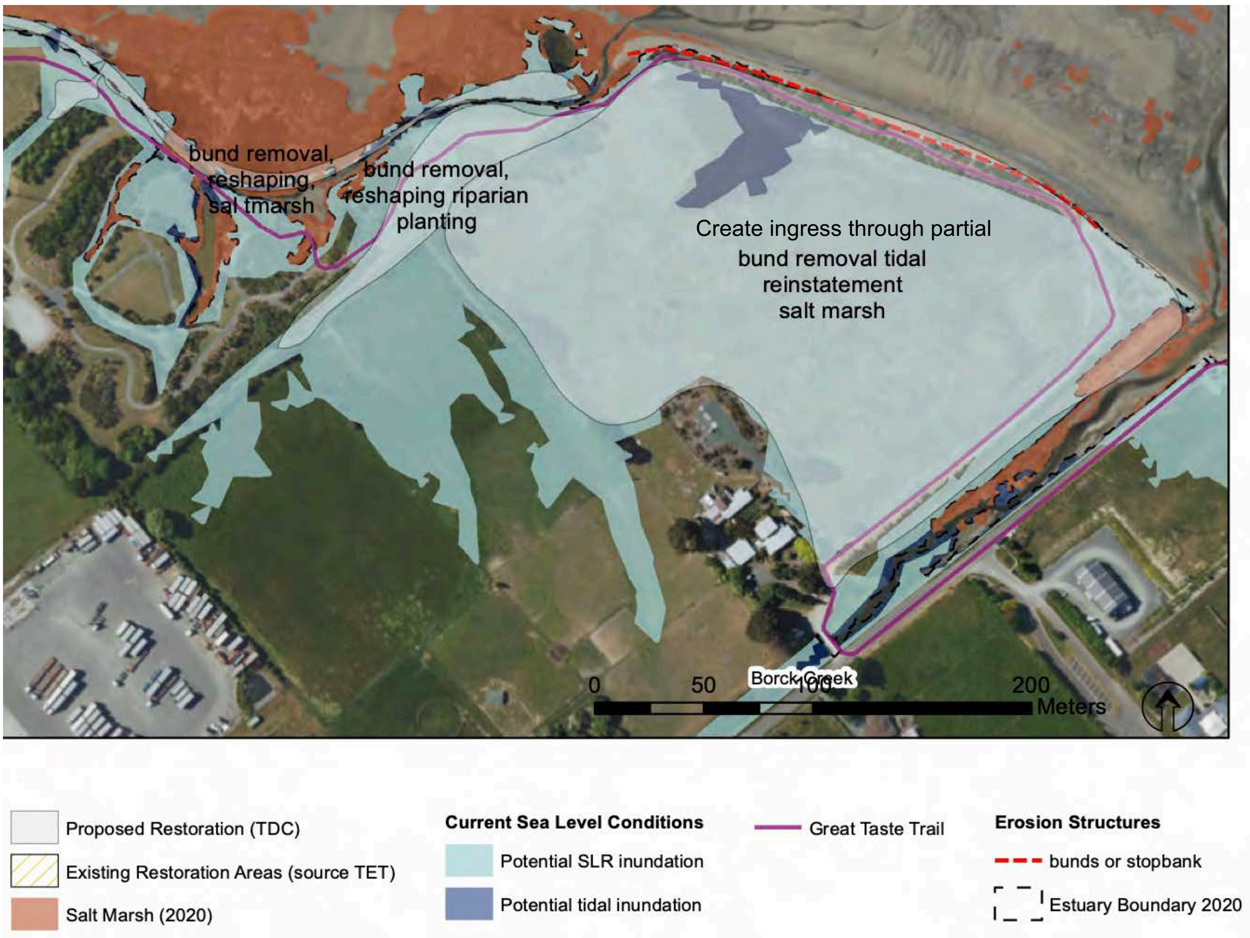


*Table 3.5.5.1. Summary of restoration scoring criteria, Borck Creek to Sandeman Reserve. Source: Stevens 2021.*

| Borck Creek to Sandeman<br>Proposed criteria for prioritising salt marsh restoration | | Low (1) | Moderate (3) | High (5) | |
|---|---|---|---|---|---|
| **PRELIMINARY HIGH LEVEL SCREENING** | | | | | |
| 1 | Land ownership | Private | Conservation ownership | **Council owned** | 5 |
| 2 | Tidal inundation | Terrestrial | Within current tidal range | **Within 100yr SLR range** | 5 |
| 3 | Extent of historic degradation | Largely intact | Modified | **Heavily degraded** | 5 |
| 4 | Biodiversity benefit | No change | Some benefits | **Large improvements** | 5 |
| 5 | Proximity to existing restoration initiative | Unconnected (>500m) | Nearby (within 500m) | **Adjoining** | 5 |
| 6 | Proximity to ecologically important vegetated area | Unconnected (>500m) | **Nearby (within 500m)** | Adjoining | 3 |
| 7 | Value of infrastructure assets potentially affected within restoration | **>$100k** | $10-$100k | <$10k | 1 |
| | | | | Screening Score | **29** |
| **HABITAT CRITERIA** | | | | | |
| 1 | Area available at site | <1ha | **1-5ha** | >5ha | 3 |
| 2 | Mean width of intertidal area | 0-50m | 50-500m | **>500m** | 5 |
| 3 | Protection from currents/waves | Unprotected | Partially protected | **Mostly protected** | 5 |
| 4 | Extent of shoreline armouring | **75-100%** | 25-75% | <25% | 1 |
| 5 | Width of riparian buffer | Absent | **0-10m** | >10m | 3 |
| 6 | Adjacent land suitable for coastal retreat in response to SLR | No | **Yes (with changes)** | Yes (without changes) | 3 |
| 7 | Degree of local habitat connectivity/diversity | Degraded | Significantly modified | **Largely intact** | 5 |
| 8 | Likely benefit to birds compared to current state | Small | Moderate | **Large** | 5 |
| 9 | Likely benefit to fish compared to current state | Small | **Moderate** | Large | 3 |
| | | | | Habitat Score | **33** |
| **IMPLEMENTATION CRITERIA** | | | | | |
| 1 | Proven restoration methodology | Unproven | Demonstrated | **Well established** | 5 |
| 2 | Likely risk of failure (e.g. erosion, plant desiccation) | High | Moderate | **Low** | 5 |
| 3 | Likely cost of initial restoration | High (>$50k/ha) | **Moderate ($10-50k/ha)** | Low (<10k/ha) | 3 |
| 4 | Likely cost of ongoing site maintenance | High (>$10k pa) | **Moderate ($5-10k pa)** | Low (<$5k pa) | 3 |
| 5 | Site accessibility | Difficult | Moderate | **Easy** | 5 |
| 6 | Extent of physical site preparation required | High | **Moderate** | Low | 3 |
| 7 | Is resource consent likely to be required? | Notified consent | Non-notified consent | **Permitted** | 5 |
| 8 | Potential adverse impact from restoration works | Significant | **Moderate** | Slight | 3 |
| 9 | Likely human amenity value | Low | Moderate | **High** | 5 |
| # | Time frame for establishing desired changes | Slow | Moderate | **Fast** | 5 |
| | | | | Implementation Score | **42** |
| | | | | Overall Site Score | **104** |

### 3.5.5.2 Key Project Attributes

Information was gathered for key project attributes using a questionnaire (Appendix 1 (A1.1)) and are presented in Table 3.5.5.2.

*Table 3.5.5.2. Key project attributes.*

| **Attribute** | **Description** |
|---|---|
| Land Tenure | The potential project area is comprised of farmland that will be converted to tidal salt marsh and is privately owned by the Tasman District Council. |
| Key Stakeholders | • Tasman Environment Trust<br>• Department of Conservation<br>• Tasman District Council |
| Governance Arrangements | Proposed project governance arrangements are yet to be determined. |
| Project Purpose | The proposed project purpose is to restore the wetland ecosystem and associated hydrology by rewetting and revegetation. Wetland rewetting is to be delivered from landward freshwater and tidal water sources. |

| | |
|---|---|
| Temporal Boundaries | The proposed project will have a project period of 30 years with a nominal start date of 1 January 2023 and an end date of 31 December 2052. Project development is estimated to require 1 year, starting 1 January 2023. |
| Geographic Boundaries | The physical boundary of the proposed project comprises the total area of 4.6ha and shown in Figure 3.6.5.1c. |
| **Baseline Scenario** | |
| Determination of Most Plausible Baseline Scenario | Continued degradation of tidal saltmarsh and associated emissions from aerobic respiration of drained and impounded saltmarsh. Justification: Business as usual without rewetting this wetland will lead to the continuation of baseline emissions. |
| Baseline activities | • Current land use is livestock grazing and associated pasture on drained wetland.<br>• Property drainage is maintained via prevention of tidal incursion through bunds, limited tidal ingress through flapgated pipes, and the removal of tidal water through drainage canals.<br>• The remaining salt marsh is in a compromised state due to limited inundation, historical modification and stock grazing. |
| Reassessment of the Baseline Scenario | The baseline will be reassessed 10-yearly in accordance with VCS rules. |
| **Project Scenario** | |
| Project intervention activities aligned with VM0033 methodology. | • WRC + RWE +ARR |
| Primary outcomes of the project scenario. | • Reconnect tidal flows to rewet the wetland.<br>• Exclude stock. |
| Restoration management activities. | • Removal of stock and fencing.<br>• Significantly increase culvert size or open bunds to reinstate tidal flows at both east and west ends of the site.<br>• Removing tidal barriers, improving hydrological connectivity, restoring tidal flow to wetlands or lowering water levels on impounded wetlands.<br>• Changing salinity characteristics (e.g., restoring tidal flow to tidally-restricted areas).<br>• Enhance salt marsh habitat through weed and pest control.<br>• Infill plant within the rushland to increase shoot densities and increase cover. This will help protect against desiccation.<br>• Revegetation of native plant communities (e.g., reseeding or replanting).<br>• Open the eastern side of the site to improve connection to Borck Creek particularly for flood flows to create a delta system with sediment retention.<br>• Creating accommodation space for wetlands migrating with sea-level rise. |
| Applicability: Blue Carbon. | Presented in Appendix A2.5. |
| Applicability: Resilience. | Presented in Appendix A3.5. |
| Site-specific salinity conditions. | Presented in Appendix A4.5. |
| Site-specific soil carbon conditions. | Presented in Appendix A5.5. |
| Site-specific sea level rise conditions. | Presented in Appendix A6.2.5. |

#### 3.5.5.3 Blue Carbon Project

A blue carbon project undertaken using the VCS VM0033 methodology was considered by assessing available carbon accounting data and site-specific technical data (Appendices 1 to 6).

The baseline activity is continued degradation of tidal saltmarsh and associated emissions from aerobic respiration of drained and impounded saltmarsh. The current land use is livestock grazing and associated pasture on drained wetland. The main project activity is rewetting tidal wetland.

Technical Feasibility Test

The technical feasibility for a blue carbon project is summarised in Table 3.5.5.3.

*Table 3.5.5.3. Technical feasibility test for a blue carbon project at Waimeha Inlet.*

| Feasibility Criteria | Assessment |
|---|---|
| Does the project meet necessary data requirements sufficient to fulfil the technical methodological requirements of the VCS methodology applied? | Yes |
| Is the project technical data aligned with a potential tradable asset volume sufficient to warrant a financial feasibility assessment? | Yes |

#### 3.5.5.4 Coastal Resilience Project

A coastal resilience project under the SD VISta standard was considered and technical information relating to a potential resilience project at this site is presented in Appendix A3.5. The main project intervention considered at this site is wetland restoration of a 4.6ha area.

Technical Feasibility Test

The technical feasibility for a coastal resilience project is summarised in Table 3.5.5.4.

*Table 3.5.3.4. Technical feasibility test for a coastal resilience project at Waimeha Inlet.*

| Feasibility Criteria | Assessment |
|---|---|
| Does the project meet necessary data requirements sufficient to fulfil the technical methodological requirements of the SD VISta methodology applied? | Yes |
| Is the project technical data aligned with a potential tradable asset volume sufficient to warrant a financial feasibility assessment? | No |

#### 3.5.5.5 Biodiversity Credit Project

A biodiversity credit project was considered at the project site based on information gathered for a blue carbon project activity (i.e., information presented in this section above). The additional benefits arising from salt marsh restoration are likely to have a significant beneficial impact on biodiversity at this site. As such, a biodiversity credit project is potentially technically feasible at this site provided measurable project benefits meet the requirements of a biodiversity credit project. Because no methodology for biodiversity credits was available from the SD VISta standard, a formal assessment was unable to be undertaken.

If a biodiversity credit project methodology were developed that aligned with the biodiversity benefits delivered from the project interventions at this site, then a biodiversity credit project would likely be technically feasible.

In the wider Waimeha Inlet there is an opportunity to continue to undertake a conservation project that controls (and may eventually eradicate) the invasive weed *Spartina* (*Spartina* spp.). While such a project would protect the biodiversity value of the areas where *Spartina* is controlled or eradicated, such a project would likely decrease[24] carbon stocks in the project area over time. For this reason, *Spartina* control/eradiation was

[24] *Spartina* habitat has potential to store more carbon than some native salt marsh habitats in Aotearoa New Zealand (Refer Section 2.1).

considered not technically feasible for a blue carbon project but could be technically feasible for a biodiversity credit project.

#### 3.5.5.6 Conclusion

This technical feasibility assessment has reached the following conclusions:

1. A salt marsh restoration blue carbon project at Waimeha Inlet is technically feasible (assessed in relation to the Borck Creek to Sandeman Reserve project site).
2. A coastal resilience project at Borck Creek to Sandeman Reserve, Waimeha Inlet is not technically feasible, considering the rewetting and restoring wetland project activities.
3. A biodiversity credit project at Borck Creek to Sandeman Reserve, Waimeha Inlet is technically feasible (in principle).

#### 3.5.5.7 Additional Potential Project Sites

Stevens & Southwick (2021) identified four additional salt marsh restoration projects in the Waimeha Inlet that they indicated are ready for project development: Waimeha River Delta, Sandeman Reserve, Bests Island Golf Course, Lower Queen Street. We did not receive this information through our project contacts and therefore did not assess these scenarios further in our project, although recognise here they may have potential for blue carbon project development.

The Tasman Environmental Trust (TET) have also identified 24 previous project sites around the Waimeha Inlet primarily adjacent to tidal wetland areas but including some areas with a tidal influence (e.g., adjacent to streams with tidal influence). However, only a minimal number of sites (which were all very small) were indicated to be planned for future restoration.

Project activities (including previous) include:

- Revegetation of tidal mudflats – very minimal area.
- Improving water quality and altering sediment supply through riparian revegetation (e.g., reducing nutrient loads leading to improved water clarity to expand seagrass meadows, recovering tidal and other hydrologic flushing and exchange or reducing nutrient residence time).
- Revegetation of native plant communities (e.g., reseeding or replanting) surrounding the estuary.
- Improving management practice(s) (e.g., removing invasive species, reduced grazing).
- Creating accommodation space for wetlands migrating with sea-level rise.
- Native revegetation of the 30m coastal margin, managed retreat set-back for pine forestry on Rough and Rabbit Island, using primarily salt tolerant species such as *Myoporum latum*, *Atriplex cinerea*, and *Plagianthus divaricatus*.

In relation to the restoration of vegetated habitats surrounding the estuary, note the challenges associated with identifying tidal wetland habitat using the VM0033 definition of this (see our comment on this in Section 3.1.1.4 - Recommendations to Verra for Improving Methodology).

#### 3.5.5.8 Recommended Next Steps

Applicability

- Fill any knowledge gaps identified in our assessment of Applicability Conditions for VM0033 (refer to Appendix 2 A2.5 for a site-specific assessment).
- Assess Applicability Conditions for the various relevant Tools and Modules required by VM0033 (refer Appendix 2).

Carbon Measurement

- Fill knowledge gap on site-specific data (or representative default values) relating to salt marsh habitat for use in carbon accounting. For example, carbon sequestration rates and GHG emissions.
- Fill knowledge gap on site-specific values for soil organic content and salinity.
- For further information, refer Sections 3.3.3.1 (Approach) and 3.3.4 (Other Relevant Environmental Data).

Resilience

- Developer an updated assessment of the land cover at a local scale.
- Use a numerical approach considering land friction and wave contributions for all the four required storm event periods.
- Use updated aerial images or land cover data to classify the project boundaries using the Manning coefficient.
- Use the 10m elevation contour as the inland boundary for the model.

Sea Level Rise

- Fill in knowledge gaps, for example increase accuracy of approaches to predict future SLR impacts on salt marsh at this site (refer Appendix 6 A6.1.3 Knowledge Gaps).
- Ensure any engineering solutions for controlling tidal flow are suitable for mitigating SLR risk.
- Assess the feasibility of acquiring land suitable for enabling inland migration of tidal wetland (to help mitigate the risk of SLR at this site).
- Consider predicted changes to tidal wetland species composition in response to SLR within future project development.
- For further discussion on changing tidal wetland species composition in response to SLR and also on engineering solutions to mitigate SLR impacts, refer to Appendix 6 A6.2.5 for a site-specific assessment and to A6.1.2 (Risk of SLR and Mitigation Options).

### 3.5.6 Wairau Lagoon

#### 3.5.6.1 Project Location

The Wairau Lagoon project site is an intact tidal marsh ecosystem located to the east of Blenheim (see Figures 3.5.6.1a-d). The proposed project activity involves tidal marsh conservation and enhancement.

*Figure 3.5.6.1a. Location of Wairau Lagoon project site.*


*Figure 3.5.6.1c. Proposed project (black hatching) area including areas designated for weed control. Source: Cawthron Institute.*

*Figure 3.5.6.1d. Proposed area designated to cattle exclusion (black hatching). Source: Cawthron Institute.*


### 3.5.6.2 Key Project Attributes

Information was gathered for key project attributes using a questionnaire (Appendix 1 (A1.1)) and are presented in Table 3.5.6.2.

*Table 3.5.6.2. Key project attributes.*

| Attribute | Description |
|---|---|
| Land Tenure | The potential project area is comprised of tidal salt marsh owned by the Department of Conservation. |
| Key Stakeholders | • Department of Conservation<br>• Marlborough District Council |
| Governance Arrangements | Proposed project governance arrangements are yet to be determined. |
| Project Purpose | The proposed project purpose is to avoid tidal wetland degradation through exclusion of grazing and weed control. |
| Temporal Boundaries | The proposed project will have a project period of 30 years with a nominal start date of 1 January 2023 and an end date of 31 December 2052. Project development is estimated to require 1 year, starting 1 January 2023. |
| Geographic Boundaries | The physical boundary of the proposed project comprises the total area of existing tidal salt marsh at 647ha (Figure 3.6.6.1c,d), of which 243.4ha remains accessible to cattle (see Figure 3.6.6.1d). |
| **Baseline Scenario** | |
| Determination of Most Plausible Baseline Scenario | Continued low level livestock incursion, and continued build-up of invasive weeds. Justification: Business as usual without livestock exclusion and weed control will lead to threats to soil carbon. Weed control is a biodiversity conservation intervention and is unlikely to contribute significantly to the delivery of measurable carbon benefits. |
| Baseline Activities | • Occasional (infrequent) cattle incursions into the project area from adjacent farmland. |

| | |
|---|---|
| | • Occasional sheep incursions into the project area from adjacent farmland.<br>• Continued spread of invasive weeds. |
| Reassessment of the Baseline Scenario | The baseline will be reassessed 10-yearly in accordance with VCS rules. |
| **Project Scenario** | |
| Project intervention activities aligned with VM0007 methodology. | • WRC + CIW + AUWD |
| Primary Outcomes of the Project Scenario. | • Avoided emissions from degradation caused by cattle intrusion.<br>• Enhanced removals through weed control. |
| Restoration management activities. | • Limiting livestock (cattle and sheep) damage to salt marsh habitats. DOC undertake informal surveillance (when they are regularly in the area for other purposes e.g., track maintenance) of livestock followed by reporting to farmers and in some cases take further action themselves e.g., shooting the cattle if the farmer doesn't take action. Note, cattle can damage the salt marsh largely by pugging but also some grazing (although they generally eat the surrounding pasture grasses). Note sheep incursions occur on the Boulder Bank area.<br>• Annual control of exotic weeds (e.g., boxthorn, gorse and few wilding pines) to a limited extent in existing saltmarsh in the lagoon/estuary. This is generally conducted by a contractor for approximately $9,000 or $10,000 (cost includes boulder bank which is not tidal wetland). Note, DOC have indicated that the area would benefit from more weed control efforts but there currently isn't enough funding.<br>Note: There has been only one cattle incursion since 2013. Sheep incursions on the boulder bank are more common perhaps once every year or two, perhaps more unreported incursions as that area has no public access and DOC access only with permission through the neighbouring farm. |
| Applicability: Blue Carbon. | Presented in Appendix A2.6. |
| Applicability: Resilience. | Presented in Appendix A3.6. |
| Site-specific salinity conditions. | Presented in Appendix A4.6. |
| Site-specific soil carbon conditions. | Presented in Appendix A5.6. |
| Site-specific sea level rise conditions. | Presented in Appendix A6.2.6. |

### 3.5.6.3 Blue Carbon Project

A blue carbon project undertaken using the VCS VM0007 methodology was considered by assessing available carbon accounting data and site-specific technical data (Appendices 1 to 6).

Technical Feasibility Test

The technical feasibility for a blue carbon project is summarised in Table 3.5.6.3.

*Table 3.5.3.3. Technical feasibility test for a blue carbon project at Wairau Lagoon.*

| Feasibility Criteria | Assessment |
|---|---|
| Does the project meet necessary data requirements sufficient to fulfil the technical methodological requirements of the VCS methodology applied? | Yes |
| Is the project technical data aligned with a potential tradable asset volume sufficient to warrant a financial feasibility assessment? | No |

Based on the data gathered in this assessment a blue carbon project is not technically feasible at this site. This stems from technical challenges for both project activities as follows:

- The very limited extent of livestock intrusion into the project area since 2013 means that the negative impact of livestock intrusion on carbon stocks in the baseline is very limited. This limited positive carbon benefit will be difficult to measure and difficult to attribute to the project intervention.
- The weed control activities are likely to reduce carbon stocks initially (emissions from weed removal – particularly woody weeds like gorse and wilding pines) but (as carbon stocks recover in the non-weedy vegetation) carbon sequestration will eventually replace carbon lost from weed removal. In addition, carbon sequestration rates in the baseline scenario may be higher than carbon sequestration rates in the project scenario due to the higher growth rates of exotic species (e.g., wilding pines) compared with indigenous vegetation. As such, the weed removal activity will likely deliver a measurable biodiversity benefit but not necessarily a significant measurable carbon benefit.

Note that a relatively large area of land (including farmland) surrounding the Wairau Lagoon may have potential for salt marsh restoration, especially when future sea level rise is considered (refer Section A6.2.6 for sea level rise site-specific assessment and Section A6.1.2 - Risk of SLR and Mitigation Options, and also note our general recommendation for land-scape scale feasibility assessment refer Executive Summary and Section 7.5 Overall Summary). However, no planned project activities in relation to restoration were indicated by project contacts and hypothetical scenarios for this site location were not assessed.

#### 3.5.6.4 Coastal Resilience Project

A coastal resilience project under the SD VISta standard was considered and technical information relating to a potential resilience project at this site is presented in Appendix A3.6. The two main project interventions considered at this site are increased control of livestock incursion to the project area and weed control.

<u>Technical Feasibility Test</u>

The technical feasibility for a coastal resilience project is summarised in Table 3.5.6.4.

*Table 3.5.6.4. Technical feasibility test for a coastal resilience project at Wairau Lagoon.*

| Feasibility Criteria | Assessment |
|---|---|
| Does the project meet necessary data requirements sufficient to fulfil the technical methodological requirements of the SD VISta methodology applied? | Yes |
| Is the project technical data aligned with a potential tradable asset volume sufficient to warrant a financial feasibility assessment? | No |

For a coastal resilience project under the current Coastal Resilience methodology the 'persons' at risk is very low compared with the area of tidal marsh involved. For this reason, while technically feasible in principle, the number of tradable assets would be very low and unlikely prove financially viable. The remedy here is to update the Coastal Resilience methodology (as recommended) and then undertake a coastal resilience project but assessing this was beyond the scope of this feasibility assessment.

As such, the limited <u>additional</u> beneficial impact from a project intervention at this site (increased livestock control and weed control) makes it very difficult to demonstrate additional coastal resilience impacts sufficient to deliver measurable additional benefits to form the basis of coastal resilience units.

#### 3.5.6.5 Biodiversity Credit Project

A biodiversity credit project was considered at the project site based on information gathered for a blue carbon project activity (i.e., information presented in this section above). The additional benefits arising from weed control are likely to have a significant beneficial impact on biodiversity at this site. As such, a biodiversity credit project is potentially technically feasible at this site provided measurable project benefits meet the requirements of a biodiversity credit project. Because no methodology for biodiversity credits was available from the SD VISta standard, a formal assessment was unable to be undertaken.

If a biodiversity credit project methodology were developed that aligned with the biodiversity benefits delivered from the project interventions at this site (weed control and consequent biodiversity enhancement) then a biodiversity credit project would likely be technically feasible.

#### 3.5.6.6 Conclusion

This technical feasibility assessment has reached the following conclusions:

1. A salt march conservation blue carbon project at Wairau Lagoon is not technically feasible.
2. A coastal resilience project at Wairau Lagoon is not technically feasible.
3. A biodiversity credit project at Wairau Lagoon is technically feasible (in principle).

#### 3.5.6.7 Recommended Next Steps

Applicability

- Fill any knowledge gaps identified in our assessment of Applicability Conditions for VM0033 (refer to Appendix 2 A2.6 for a site-specific assessment).
- Assess Applicability Conditions for the various relevant Tools and Modules required by VM0033 (refer Appendix 2).

Carbon Measurement

- Fill the knowledge gap on site-specific data (or representative default values) relating to salt marsh habitat for use in carbon accounting. For example, carbon sequestration rates and GHG emissions.
- Fill the knowledge gap on site-specific values for soil organic content and salinity.
- For further information, refer Sections 3.3.3.1 (Approach) and 3.3.4 (Other Relevant Environmental Data).

Resilience

- An updated assessment of the land cover at a local scale.
- Use a numerical approach considering land friction and wave contributions for all the four required storm event periods
- Use updated aerial images or land cover data to classify the project boundaries using the Manning coefficient
- Use the 10m elevation contour as the inland boundary for the model.
- Source the bathymetry datasets collected in the last Wairau Lagoon Subtidal Survey (Roberts et al 2021).

Sea Level Rise

- Fill in knowledge gaps, for example increase accuracy of approaches to predict future SLR impacts on salt marsh at this site (refer Appendix 6 A6.1.3).
- Consider feasibility of a plan for any engineering solutions to control tidal flow to mitigate SLR risk.
- Assess the feasibility of acquiring land suitable for enabling inland migration of tidal wetland (to help mitigate the risk of SLR at this site).
- Consider predicted changes to tidal wetland species composition in response to SLR within future project development.

- For further discussion on changing tidal wetland species composition in response to SLR and also on engineering solutions to mitigate SLR impacts, refer to Appendix 6 A6.2.6 for a site-specific assessment and to A6.1.2 (Risk of SLR and Mitigation Options).

## 3.6 CONCLUSION: TECHNICAL FEASIBILITY

The technical feasibility assessment found the following results for the project sites examined:

| Project Site | Project Type | Activity Type | Technically Feasible? |
|---|---|---|---|
| Te Repo Ki Pūkorokoro | Blue Carbon | Tidal salt marsh restoration | Yes |
| | Coastal Resilience | Tidal salt marsh restoration | No |
| Wainui Repo Whenua | Blue Carbon | Tidal salt marsh restoration | Yes |
| | Coastal Resilience | Tidal salt marsh restoration | No |
| Pukehina/Waihi | Blue Carbon | Tidal salt marsh restoration | Yes |
| | Coastal Resilience | Tidal salt marsh restoration | No |
| Farewell Spit | Blue Carbon | Seagrass restoration | No |
| | Coastal Resilience | Seagrass restoration | No |
| Waimeha Inlet | Blue Carbon | Tidal salt marsh restoration | Yes |
| | Coastal Resilience | Tidal salt marsh restoration | No |
| Wairau Lagoon | Blue Carbon | Tidal salt marsh conservation | No |
| | Coastal Resilience | Tidal salt marsh conservation | No |

Blue carbon projects focusing on the tidal salt marsh restoration activity type were found to be technically feasible and the most suitable for blue carbon project development. Note that the impact of sea level rise and its mitigation will need to be included in project design (refer to Appendix 6).

# 4 Financial Feasibility

The purpose of project-based carbon financing (creation and sale of carbon credits) is to enable human induced carbon benefits to the atmosphere to occur that could not otherwise occur. The project needs to demonstrate that the benefits to the atmosphere would not have happened without the project (project additionality) and in turn, that the project would not be feasible without the revenue from the sale of carbon credits (financial additionality). In this way, the buyer of carbon credits from a blue carbon project knows that they are causing the project benefits to occur through their carbon credit purchase action and spending.

At a minimum, a project is feasible for implementation when it is both technically feasible and financially feasible. The bottom line of a financial feasibility test is whether project revenues can cover all project costs. Project revenues can come from non-commercial (grants) and commercial sources (carbon credit sales). In this feasibility assessment, a project is considered commercially feasible when all revenues come from commercial sources. When grant funding is required, a project can be financially feasible but not commercially feasible.

Another financial feasibility consideration is whether a project is financially feasible as a stand-alone project or whether it is financially feasible at scale. 'At scale' here refers to the ability to undertake projects wherever they are needed, at the order of magnitude needed, and not be limited by fixed funding constraints (e.g., not limited by finite grant sources).

Globally, diminishing public funds has seen a growing gap in the finance available versus finance required to protect healthy terrestrial and marine ecosystems (estimated at approximately USD300 billion to USD400 billion every year) (GEF, 2021). In contrast, the institutional investment community (collectively holding around USD300 trillion in assets) are potentially available as investors in conservation activities (Illes, et at. 2017; Tideline 2019; RPA 2017). So, while there is a limited volume of grant funding available for salt marsh conservation projects, there is a very large volume of money potentially available from private investment sources. This money can enable blue carbon project activities to operate at scale.

Securing private investment funding for blue carbon projects requires such projects to be commercially feasible. This can include projects that are fully commercial (e.g., no grant funding required) or that involve blended finance (e.g., a combination of grant and commercial finance but where grant funding is available at the scale needed). Independence from grant funding creates considerable freedom for project developers and enables the deployment of project development activities at a pace that is not constrained by grant funding cycles.

For this reason, a component of the financial feasibility assessment tests the commercial feasibility of blue carbon projects in a fully commercial setting. Here carbon credit sales revenues cover all project development costs, project operational costs and opportunity costs. Because project development must occur before carbon credits are issued to a project, this activity must be funded prior to carbon credit sales revenue accumulation. As such, in a fully commercial context project development needs to be funded by a loan of some kind. In turn, carbon credit sales revenues need to cover project operational costs, opportunity costs and loan repayments with interest (i.e., a return on investment to the lender).

The commercial feasibility test in this section focuses on the ability of a project to cover operational costs, opportunity costs, and loan repayment costs at an interest rate of 5%, with loan repayments starting in year 1, and a loan maturity of 25 years (like a 25-year mortgage).

This feasibility assessment also scopes the potential for the use of 'blended finance' involving a combination of grant and investment funding, where a grant is used to catalyse the private investment (catalytic capital). This is a common approach to carbon project development in new activity types (such as blue carbon).

## 4.1 APPROACH & METHODS

The financial feasibility for blue carbon projects was assessed using information from the technical feasibility section of this report. The financial feasibility assessment focused on the activity type that passed the financial feasibility assessment and where there is a methodology available for project development. This was restricted to tidal marsh restoration as a blue carbon project. While a biodiversity credit project is technically feasible and may be financially feasible, there is currently no methodology available for project development, which is why a biodiversity credit project was excluded from this financial feasibility assessment.

Different project interventions with different cost implications were modelled to provide insights into the financial impact of different high-level project design approaches and to enable an economic lens to help guide project design.

### 4.1.1 20 Hectare Comparative Study

Three of the tidal marsh project sites had similar project areas of approximately 20ha. This included the Te Repo Ki Pūkorokoro, Wainui Repo Whenua, and Pukehina/Waihī sites. For this reason, a 20ha exemplar project size was modelled in the financial analysis. This was designed to enable the comparison of the financial impact of three different high-level project design attributes:

1. Different stem densities for revegetation activities.
2. Inclusion and exclusion of engineering costs.
3. Inclusion and exclusion of grant-support.

In the 20ha comparative study, the following high-level project design scenarios were financially modelled (scenarios numbered sequentially):

Fully Commercial (i.e., no grant support)

No engineering costs.

1. Revegetating at 8,000 stem/ha.
2. Revegetating at 1,000 stem/ha.
3. Revegetating at 0 stem/ha (i.e., natural revegetation/regeneration).

With engineering costs of NZD50k/USD34k.

4. Revegetating at 8,000 stem/ha.
5. Revegetating at 1,000 stem/ha.
6. Revegetating at 0 stem/ha (i.e., natural revegetation/regeneration).

Semi-Commercial (i.e., grant supported)

No engineering costs.

7. Revegetating at 8,000 stem/ha.
8. Revegetating at 1,000 stem/ha.
9. Revegetating at 0 stem/ha (i.e., natural revegetation/regeneration).

With engineering costs of NZD50k/USD34k.

10. Revegetating at 8,000 stem/ha.
11. Revegetating at 1,000 stem/ha.
12. Revegetating at 0 stem/ha (i.e., natural revegetation/regeneration).

### 4.1.2 Economies of Scale

The next comparative study involved an assessment for economies of scale. Here, one of the project types from the 20ha comparative study was used as the basis for an economy of scale analysis. This used the fully commercial natural revegetation project design (scenarios 3 and 6 above) and included the following scale scenarios:

No engineering costs.

13. 20ha project.
14. 30ha project.
15. 40ha project.
16. 50ha project.
17. 60ha project.

With engineering capital expenditure of NZD50k/USD34k.

18. 20ha project.
19. 30ha project.
20. 40ha project.
21. 50ha project.
22. 60ha project.

A total of 22 comparative scenarios were modelled in this analysis.

### 4.1.3 Detailed Example

A single exemplar project scenario was presented to provide a detailed example of project financial performance indicators contained in all 22 scenarios modelled but where detailed reporting for each was beyond the scope of this report. This used scenario 3 above (fully commercial, natural revegetation and no engineering costs).

### 4.1.4 Key Financial Assumptions

All financial modelling undertaken in this feasibility assessment used the following key assumptions:

- Cashflow period: 50 years.
- Project period: 50 years.
- Discount rate: 6.0%.
- Project start date: 2023.
- Starting carbon price: The starting carbon price was calculated for each project scenario as the break-even starting price for the project to pass the financial viability test (i.e., determined as a modelling output rather than an input). This includes grant funded project scenarios to enable the starting carbon price to be capped at NZD100.
- Carbon price change: Three scenarios for annual carbon price change were modelled (rising at NZD1.50 per annum (p.a.); rising at NZD4.75 p.a.; rising at NZD8.00 p.a.). The middle scenario (NZD4.75) was applied in the 22 comparative scenarios and all three applied in the detailed example.
- Financial viability test: No negative cumulative cashflows across the cashflow period. In other words, the project bank balance never falls below zero even though cashflows in any given year (free cashflows) can be negative, with the balance from previous years providing sufficient surplus to absorb those negative cashflow years.
- Percentage of carbon credits sold: 80%. This leaves 20% of annual carbon credit production to be placed into a buffer reserve (self-insurance required by international carbon standards).

- Project development costs for a 20 ha project:[25] variable depending on the project activity including project management plan, project business plan, all trading and legal arrangements, revegetation costs, third party validation and first verification costs (see preliminary budget below in Table 4.1.4).
- Estimated on-going project monitoring and verification costs included, with the verification component budgeted at NZD40,000 every 4 years.
- Investment introduced: Variable and dependent on the capital expenditure requirements.
- Investment period: 25 years. This was modelled as a loan from a lender (bank or other investor) where the principal is invested in year 0 to fund the project, the project makes annual payments to pay down the debt through time, with the terminal payment in year 25. Note that this loan modelling is for purposes of illustrating the profitability of the project where the structure of the investment may be debt financing (loan) or equity[26] financing.
- Interest rate charged on a loan: 5.0%
- Start date for debt repayments: Year 1.
- Average seedling prices for tidal marsh revegetation projects: NZD2.30 (i.e., accommodating different proportions of higher and lower cost seedlings).
- NZD-USD exchange rate uses 0.675379 (Source: XE, accessed January 2022).[27]
- The cost of sea level rise mitigation was excluded (i.e., variable and site specific) but will need to be included in project development.

This financial feasibility needed to use estimated 'placeholder' costs in lieu of detailed project cost data (such detail was beyond the scope of this multi-project feasibility assessment). These costs were captured in a preliminary budget that would need to be subject to detailed refinement in site-specific scoping and then project development. Figure 4.1.4a and b presents the preliminary budget used for a 20 ha exemplar project and differs only whereby Figure 4.1.4b involves no native plantings (i.e., leaving nature to undertake the revegetation).

*Figure 4.1.4a. Preliminary project budget for a 20 ha project involving planting 1,000 stems per ha of native vegetation.*

**Capital Expenditure**

| Project Year: | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| Project Description (management & business plan) | $50,000 | - | - | - | - |
| Legal, accounting, admin & contingency | $30,000 | | | | |
| Hydrology intervention | - | - | - | - | - |
| Native seedling cost | $46,000 | - | - | - | - |
| Native freight & packing costs | $3,000 | - | - | - | - |
| Native pre-planting spot spraying cost | $17,500 | - | - | - | - |
| Native pre-planting pest control cost | $1,000 | - | - | - | - |
| Native seedling treatment cost | - | - | - | - | - |
| Native planting cost | $27,000 | - | - | - | - |
| Native planting management cost | $2,000 | - | - | - | - |
| Native survival monitoring cost | - | $2,300 | - | - | - |
| Native blanking cost | - | - | - | - | - |
| Native fertilizer cost | - | - | - | - | - |
| Native releasing cost | - | - | - | - | - |
| Native pest control cost (carbon protection) | - | $1,100 | $1,100 | - | - |
| Project Validation | $40,000 | | | | |
| Project management capex elements | $26,475 | $510 | $165 | - | - |
| **TOTAL CAPEX** | $242,975 | $3,910 | $1,265 | - | - |

[25] Also, likely to be similar for moderately larger projects up to a point - due to fixed costs irrespective of project size.

[26] See Section 4.1.6.1 for a description of debt and equity financing.

[27] https://www.xe.com/

*Figure 4.1.4b. Preliminary project budget for a 20 ha project involving planting 0 stems per ha of native vegetation.*

**Capital Expenditure**

| Project Year: | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| Project Description (management & business plan) | $50,000 | - | - | - | - |
| Legal, accounting, admin & contingency | $30,000 | | | | |
| Hydrology intervention | - | - | - | - | - |
| Native seedling cost | - | - | - | - | - |
| Native freight & packing costs | - | - | - | - | - |
| Native pre-planting spot spraying cost | - | - | - | - | - |
| Native pre-planting pest control cost | - | - | - | - | - |
| Native seedling treatment cost | - | - | - | - | - |
| Native planting cost | - | - | - | - | - |
| Native planting management cost | - | - | - | - | - |
| Native survival monitoring cost | - | - | - | - | - |
| Native blanking cost | - | - | - | - | - |
| Native fertilizer cost | - | - | - | - | - |
| Native releasing cost | - | - | - | - | - |
| Native pest control cost (carbon protection) | - | - | - | - | - |
| Project Validation | $40,000 | | | | |
| Project management capex elements | $12,000 | - | - | - | - |
| **TOTAL CAPEX** | $132,000 | - | - | - | - |

### 4.1.5 Carbon Price Change

For each of the scenarios modelled a break-even starting carbon price was calculated. For the fully commercial scenarios this break-even starting carbon price varied depending on the cost profile of that scenario. Due to uncertainties associated with actual future carbon prices and price change, coupled with experience from working with carbon market investors and their price modelling preferences, three different average annual carbon price change scenarios were modelled in this analysis:

- CP1: Starting at the break-even carbon price (e.g., NZD100 for the grant supported scenarios) and increasing at NZD1.50 p.a.[28]
- CP2: Starting at the break-even carbon price and increasing at NZD4.75 p.a.
- CP3: Starting at the break-even carbon price increasing at NZD8.00 p.a.

Rationale for the three different carbon pricing scenarios:

- CP1 is a conservative carbon price change scenario assuming a low average annual carbon price increment that does not involve Aotearoa New Zealand aligning its domestic carbon price with OECD nations such as the EU and the UK (current carbon prices in those markets are approximately NZD132/USD89.[29]
- CP3 is a more aggressive (but plausible) carbon pricing scenario that models what the carbon price may do should the government manage the carbon price to align with Europe and the UK and takes on board the carbon pricing recommendations of the Productivity Commission and the Climate Change Commission. This scenario is aligned with the current NZ government price controls that have an annual carbon price rise of greater than NZ$8 p.a. We also note that Aotearoa New Zealand carbon prices can also fall because of government policy change (see below).

[28] The carbon price change scenarios were calculated in real terms (i.e., in addition to inflation).

[29] Ember daily carbon prices: https://ember-climate.org/data/carbon-price-viewer/

- CP2 is the average of CP1 and CP3, is considered plausible and conservative. While lower than the rate of carbon price change contained in current government price controls, history has shown government price controls for carbon credits to cause carbon prices to drop (see Figure 4.1.5 below).

*Figure 4.1.5a. EU carbon price March to November 2021. Source Ember daily carbon prices (footnote on previous page).*

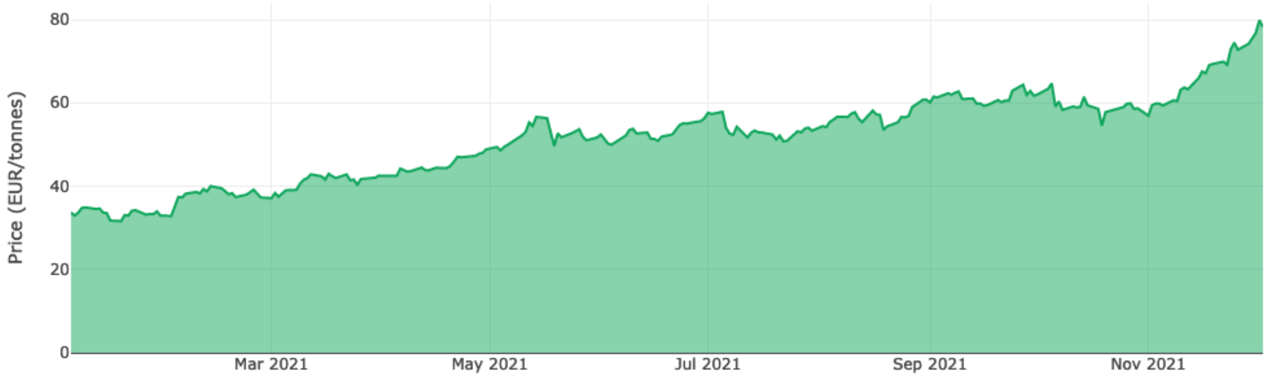
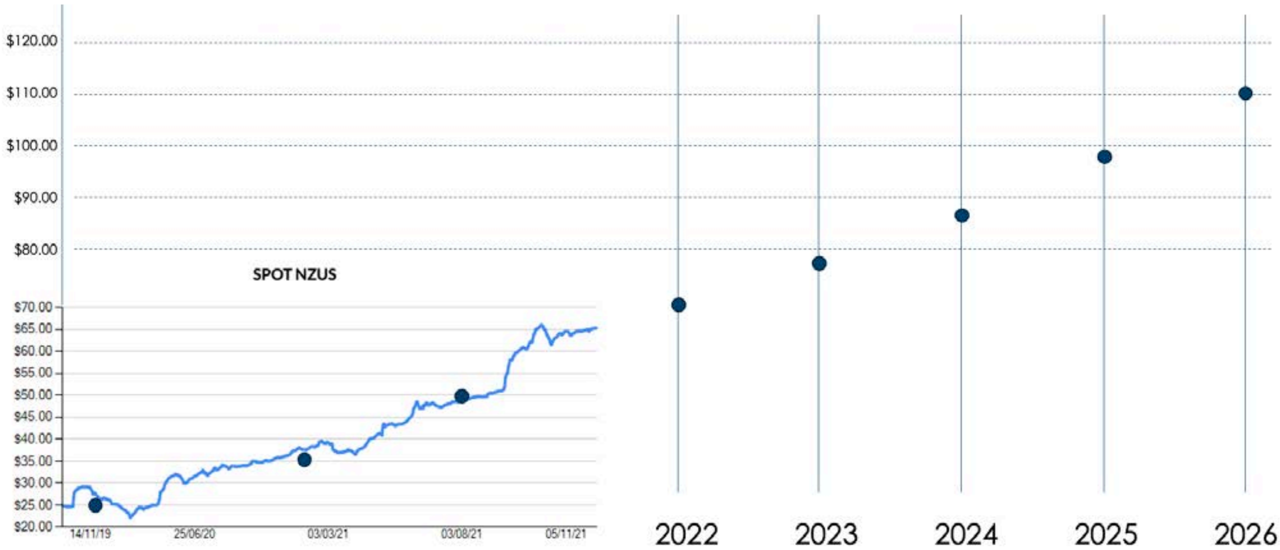



*Figure 4.1.5b. NZU spot price (NZD) – historical and projections based on NZ government price controls (blue dots). Source: CommTrade Carbon[30], and Ministry for the Environment government carbon market price controls[31].*

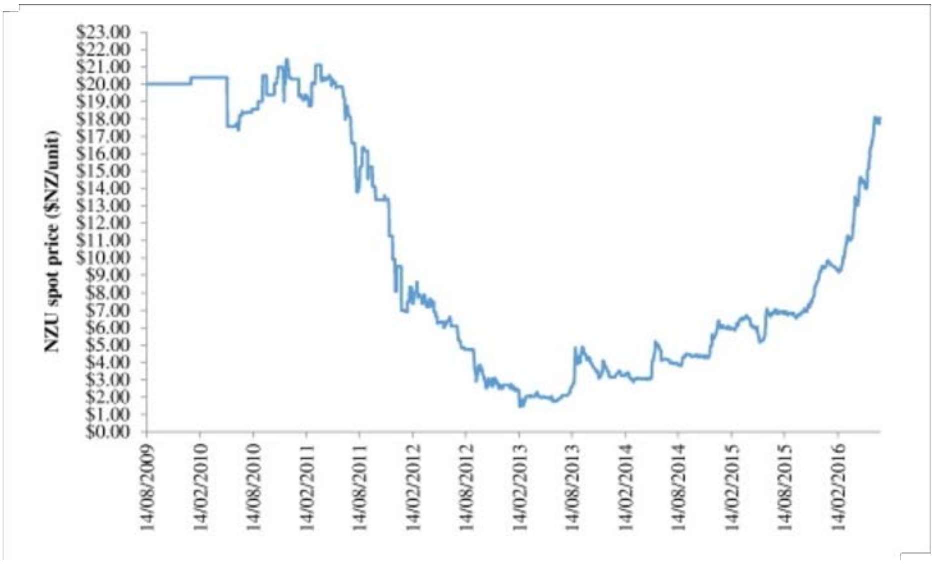



Note that carbon prices can go down as well as up and the history of the carbon price in Aotearoa New Zealand confirms this. Figure 4.1.5c shows the history of the NZU spot price between 2009 and 2016.

[30] https://www.commtrade.co.nz/

[31] https://environment.govt.nz/news/release-of-updates-to-nz-ets-regulations-and-sgg-levy/

*Figure 4.1.5c. NZU Spot Price History 2009-2016. Source: Evison 2017.*




Due to the reporting complexities associated with running three different carbon price change scenarios for a comparative analysis, the comparative analysis (scenarios 1-22 inclusive) used CP2 (average between CP1 and CP3). The detailed example reported on all three carbon price change scenarios.

### 4.1.6 Investment and Debt Servicing

Two broad commercial models were run in this analysis:

1. Fully commercial.
2. Catalytic capital.

#### 4.1.6.1 Fully Commercial

The fully commercial scenarios required the project to be financially self-sustaining in the absence of any grant funding. This was modelled on the assumption of debt financing (i.e., a commercial loan), but provides project profitability information to inform an equity financing option.

Debt financing involves a secured or unsecured loan to be paid back (usually with interest) in the future. When a lender wants to reduce the risk of never getting their money back, they will secure the loan against an asset of the borrower entity without taking any ownership of the borrower entity itself. A common example is a home mortgage where the loan is secured against the house. Here the bank lender does not take ownership of any portion of the house but has an agreement with the borrower to take possession of the house should there be a default on debt payments. The bank then sells the house to recover its debt.

Equity financing involves the lender securing the loan through taking ownership of percentage (i.e., shares) of the borrower entity. By taking a portion of ownership of the borrower entity the equity investor co-owns all profits delivered by the borrower entity. These profits are delivered as dividends to the equity investor (e.g., annually or quarterly) and may be higher than an interest rate on debt. Here the loan is repaid to the equity investor in the form of dividends plus revenue from the sale of shares when the equity investor seeks to exit the venture. If the borrower entity becomes profitable, the value of shares at the time of sale may be higher than the value of the shares when originally purchased by the equity investor. The downside of an equity arrangement for the equity investor is that the project or venture may not financially perform as well as originally projected (e.g., if carbon prices drop below expectations) or may fail outright. In these situations, the equity investor makes a loss. Equity investors, therefore, must take calculated risks with the hope that their ventures that succeed compensate for their ventures that fail.

In equity financing situations, the borrower entity is usually a limited liability company (i.e., not a charity because the latter cannot offer shares). The borrower entity in a blue carbon project venture could be a special purpose vehicle (company) established specifically to manage the financial flows of the project, including owning project assets (e.g., carbon rights), managing all revenues and cashflows.

The fully commercial scenarios calculated the minimum starting carbon price required for the project to break even. This was undertaken for the different revegetation scenarios with and without NZD50k of engineering intervention.

#### 4.1.6.2 Catalytic Capital

Catalytic capital is a class of funding that catalyses the participation of other investments. It does this by accepting higher risk and lower (or no) financial returns for its portion of an overall investment. The rest of the investment (i.e., that portion not covered by catalytic capital) can then operate on a lower risk and higher return basis. This lower risk and higher return can enable the participation of investors with lower risk and higher return requirements.

Examples:

- **Catalytic Grant:** Grant funding provided to lift the commercial performance of a venture by providing funds for capital expenditure for free. This has the effect of lowering the capital expenditure portion of an investment without lowering the returns to that investor. This raises the profitability of the investment sufficient to enable the participation of commercial investors.
- **Concessionary debt:** Debt instruments (i.e., loans) can be made 'concessional' by offering below-market interest rates, flexible repayment timelines or generous grace periods, relaxed collateral requirements, and/or less rigid underwriting guidelines (relative to traditional lenders).
- **Equity instruments:** Equity can take on a catalytic role when the investor accepts lower capital returns; takes the most junior equity position in the overall capital structure to absorb losses before other investments, and/or has a longer or undefined exit timing compared to traditional equity investments.
- **Hybrid instruments**: These are either debt instruments with equity characteristics or equity instruments with debt characteristics. Examples include convertible loans, royalty-based lending, redeemable equity, and preferred shares.
- **Guarantees and risk insurance:** These are common instruments used by catalytic capital investors to provide assurance of principal repayment to other investors in the case of default. This is a capital-efficient way for catalytic capital investors to enable investment by others, as capital is only drawn upon from the guarantor if a default event occurs.

The catalytic capital model used in this analysis is a catalytic grant. The grant amount was calculated as the minimum grant required to deliver a financially viable investment[32] where the starting carbon price is NZD100.00/USD67.50 and increasing in real terms[33] at an average annual rate of NZD4.75 (USD3.20).

### 4.1.7 Carbon Accounting Inclusions and Exclusions

This financial feasibility assessment applied the following assumptions:

- The degraded salt marsh (baseline) is a net carbon source
- The restored salt marsh (project) is a net carbon sink.

[32] No negative cumulative cashflows over the 50-year project period.

[33] Exclusive of inflation.

- Significant measurable carbon stock change is restricted to soil carbon.
- Above ground and below ground carbon stock change from revegetation of predominantly herbaceous vegetation is considered to not be significant and was conservatively excluded.

Experience from forest carbon activity types has shown that non-tree vegetation delivers a (usually) insignificant additional contribution to above ground and below ground live carbon stocks per ha. For example, the 50-year average above and below ground carbon sequestration rate of indigenous forest vegetation is 6.3 tCO2e/ha/yr[34] according to the national default (lookup) tables. Note that actual field measurement of native forest carbon sequestration by forest industry players is commonly significantly lower than the national default tables[35]. Average carbon sequestration rates for manuka shrublands are in the order of 2.0 tCO2e/ha/yr (Carswell et al 2009), and lower still for herbaceous vegetation. According to Dai et al (2020) modelling carbon sequestration in herbaceous wetlands remains challenging due to rapid carbon flux combined with complex hydroecological processes. Moreover, the majority of carbon stock change arising from rewetting a wetland are derived from hydrological interventions causing changes in soil carbon rather than above and below ground live biomass.

These factors led to the decision to conservatively exclude above and below ground live vegetation carbon pools from the carbon accounting in this feasibility assessment. There will be an opportunity to include tidal marsh revegetation carbon pools in full project development if this is considered significant for the project area in question and where data is available to demonstrate this. From a financial feasibility perspective, it is far more prudent to apply conservative carbon yield models at a scoping stage. Here, project development (with more time and resources to devote to site-specific carbon measurement), has the opportunity to over-deliver on expectations. The opposite delivers considerably more investment risk (i.e., where scoping studies over-estimate potential carbon credit yields and associated revenues).

### 4.1.8 Net Carbon Credit Calculation

This financial feasibility assessment modelled avoided baseline carbon emissions and enhanced carbon sequestration in the project scenario using data provided in Sections 3.3.3.2 and 3.3.3.3 above, and 4.1.8 below. It was beyond the scope of this feasibility assessment to undertake a carbon stock change analysis using all potentially relevant carbon pools and gases. This is because a scoping study lacks the resources for high-resolution due diligence on all potentially relevant carbon pools and gases capable of passing a significance threshold for a given site.

The calculation of net carbon credits follows the requirements of VM0033 and involves the calculation of the gross carbon credits minus a risk buffer. The buffer is calculated in project development using a project risk assessment which was beyond the scope of this feasibility assessment. This is why a 20% buffer was applied as a placeholder for this financial feasibility assessment.

The calculation of net carbon credits is presented for the first 6 years[36] in Table 4.1.8.

[34] Data from the Ministry for Primary Industries national default tables (Ministry for Primary Industries 2017).

[35] David Janett, Owner Forest Management Ltd pers. comm.

[36] This shows the first 6 years of a 50-year project period.

*Table 4.1.8. Calculation of net carbon credits for a 20 ha project exemplar.*

| | Activity Type: Restoring Tidal Saltmarsh | | Project year: | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| | Carbon Benefit | Source | Calculation | | | | | | |
| 1 | Baseline carbon emissions avoided (tCO2/ha/yr) | Section 3.3.3.3 | Decaying at 0.99 per year | 5.000 | 4.950 | 4.901 | 4.851 | 4.803 | 4.755 |
| 2 | Baseline methane emissions avoided (tCH4/ha/yr) | Table 3.3.3.2d | 0.023 - 0.009 = 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 |
| 3 | Baseline methane emissions avoided (tCO2e/ha/yr) | IPCC AR6 | 0.014 x 27.2 | 0.381 | 0.381 | 0.381 | 0.381 | 0.381 | 0.381 |
| 4 | Baseline N2O emissions avoided (tCO2e/ha/yr) | Table 3.3.3.2a | Conservatively excluded | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 5 | Project Scenario: Carbon sequestration (tC/ha/yr) | Table 3.3.3.2a | Average NZ/Aus values | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 |
| 6 | Project Scenario: Carbon sequestration (tCO2/ha/yr) | Carbon factor | 1.12 x 3.66 | 4.10 | 4.10 | 4.10 | 4.10 | 4.10 | 4.10 |
| 7 | Gross carbon credits (tCO2e/ha/yr) | | Sum lines 1,3,4,6 | 9.480 | 9.430 | 9.381 | 9.331 | 9.283 | 9.235 |
| 8 | Gross carbon credits (tCO2e/20ha project/yr) | | Line 7 x 20 (i.e., 20ha) | 190 | 189 | 188 | 187 | 186 | 185 |
| 9 | 20% Buffer (tCO2e/20ha project/yr) | | Line 8 x 0.2 | 38 | 38 | 38 | 37 | 37 | 37 |
| 10 | Net Carbon credits (tCO2e/20ha project/yr) | | Line 8 minus line 9 | 152 | 151 | 150 | 149 | 149 | 148 |

The financial feasibility assessment applied a 25-year cashflow for investment modelling and a 50-year cashflow for modelling a 50-year project period.

## 4.2 20 HECTARE COMPARATIVE STUDY

Project scenarios modelling a 20ha exemplar project were analysed with three high-level variables:

1. Revegetation at different stem densities.
2. With and without engineering interventions requiring NZD50k (USD34k) of capital expenditure.
3. With and without a catalytic capital grant.

A revegetation component is proposed as a project activity in four of the five tidal wetland case study sites. The above ground and below ground live carbon stocks were, however, conservatively excluded from the carbon accounting in this feasibility assessment due to the carbon impact of such activities considered to be insignificant when using non-forest vegetation. Blue carbon tidal salt marsh restoration projects will, however, continue to have the option to include revegetation activities for biodiversity co-benefit purposes. As such, it is instructive to examine the financial impact of revegetation at different stem densities to help illustrate how high-level project design can be informed by financial analysis.

Three revegetation planting stem densities were modelled:

1. 8,000 stems per ha (sph).
2. 1,000 sph.
3. 0 sph (i.e., natural revegetation through bird, water, and wind dispersal).

### 4.2.1 Capital Expenditure

Capital expenditure costs are modelled as those required for the establishment of the project. This includes project development (project business plan, management plan, legal requirements, validation audit, registry account establishment, plus contingencies) and any revegetation and/or engineering interventions at the establishment phase. This can be understood as establishing the conservation asset and the carbon credit production system.

#### 4.2.1.1 Revegetation and no Engineering Costs

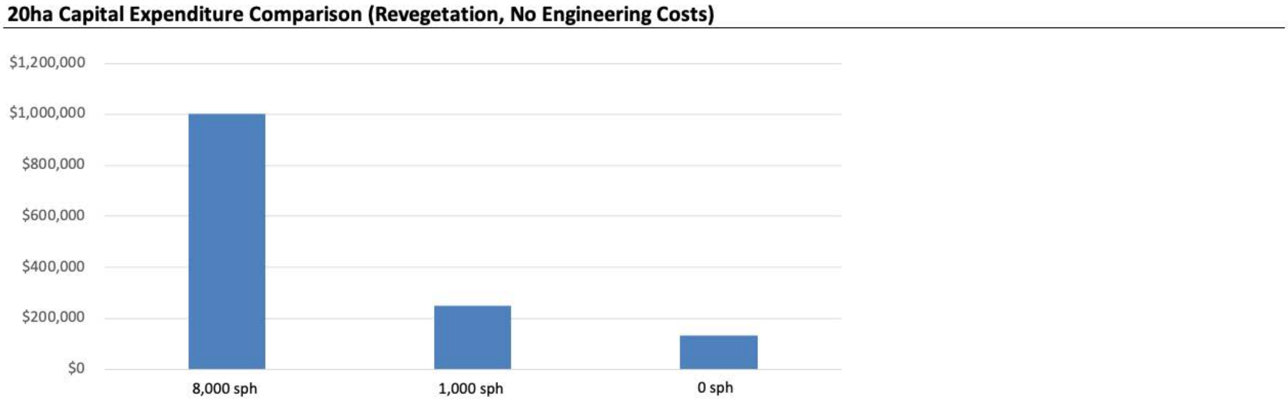
Capital expenditure required for a revegetation project varies considerably depending on the revegetation stem density. Ecological restoration projects involving revegetation commonly involve planting densities of 8,000 stems per ha (sph). Less common is a planting density of only 1,000 sph, although these are becoming common in the forest carbon project sector. The logic behind lower stem density plantings is to lower the capital expenditure costs of a carbon project whilst providing a seed source for natural revegetation. Ecosystems left to regenerate without human intervention are also common and involve zero planting costs.

For this reason, low stem density plantings that deliver biodiversity enhancement outcomes and no plantings (i.e., natural revegetation) are plausible project types for tidal marsh restoration projects that rely principally on hydrological interventions such as rewetting, and reintroduction of tidal flows.

When no engineering costs are included in the cost-benefit analysis this simply assumes that either no engineering interventions are required, or that engineering interventions are funded separately (e.g., as a grant or in-kind contribution by a project stakeholder).

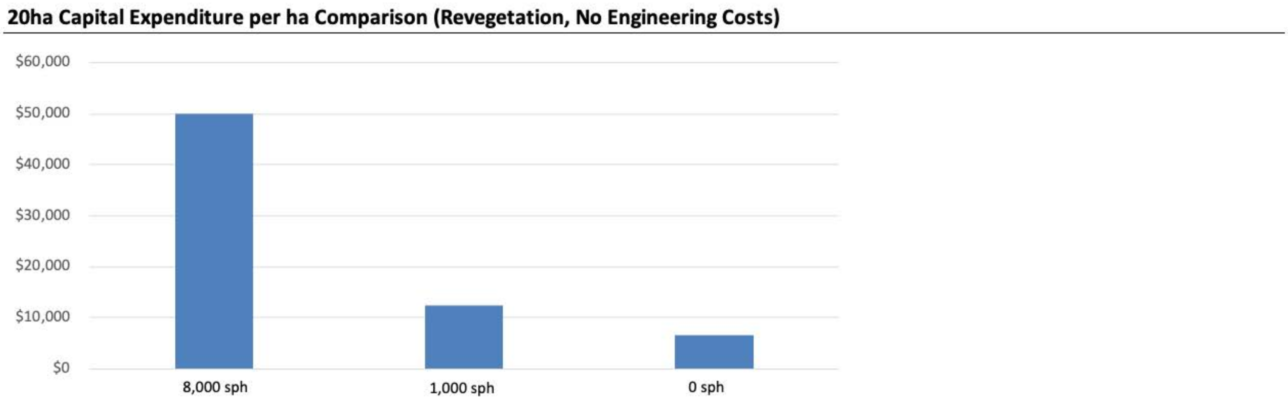
Results for capital expenditure requirements for the different stem density scenarios with no engineering costs is presented in Figures 4.2.1.1a (total capital expenditure) and 4.2.1.1b (capital expenditure per ha).

*Figure 4.2.1.1a Total capital expenditure for a 20ha project involving three revegetation treatments and no engineering costs.*




As can be seen in Figure 4.2.1.1a the total capital expenditure required for project establishment varies greatly depending on stem density with 8,000 sph requiring NZD1m (USD675k). This is an order of magnitude higher than the capital expenditure required for revegetation at 1,000 sph (NZD248k (USD167k)) and 0 sph (NZD132k (USD89k)).

*Figure 4.2.1.1b Capital expenditure per ha for a 20ha project involving three revegetation treatments and no engineering costs.*[37]




[37] While capital expenditure per ha is simply the total capital expenditure divided by 20ha, this graph has been included to visually portray the per ha costs for different project treatments. Costs per ha are a key feature of carbon project financing and often more instructive than total capital expenditure in comparative studies and feasibility assessments.

Capital expenditure per ha for the different treatments is:

- 8,000 sph: NZD50k (USD34k).
- 1,000 sph: NZD12.4k (8.4k).
- 0 sph: NZD6.6k (USD4.4k).

These figures are instructive because they are transferrable to projects of different scales and provide a useful benchmark for project costs.

#### 4.2.1.2 Revegetation With Engineering Costs

Revegetation capital expenditure with NZD50k additional engineering costs has only a minor impact on the total capital expenditure as shown in Figure 4.2.1.2a.

*Figure 4.2.1.2a. Total capital expenditure for a 20ha project involving three revegetation treatments and NZD50k engineering costs.*

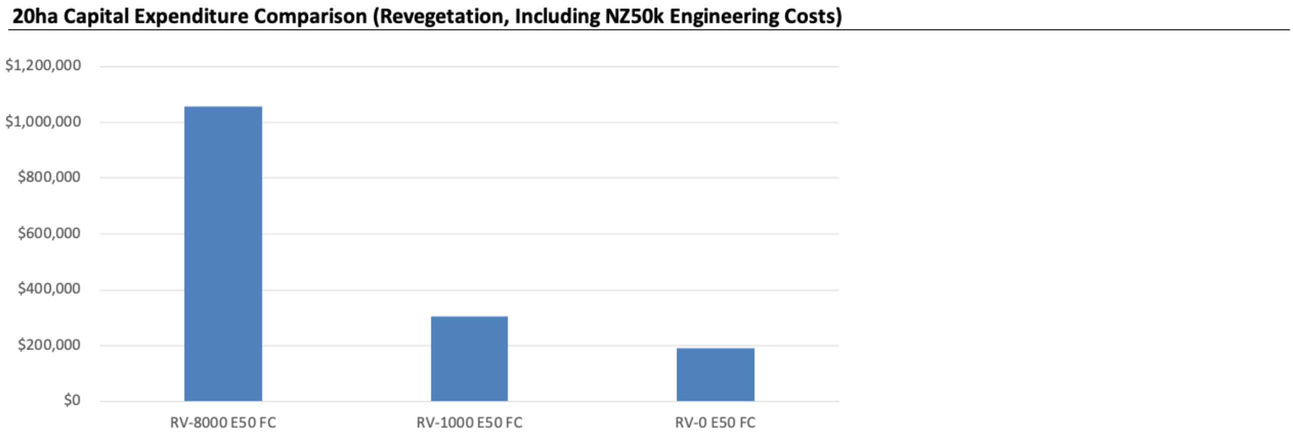
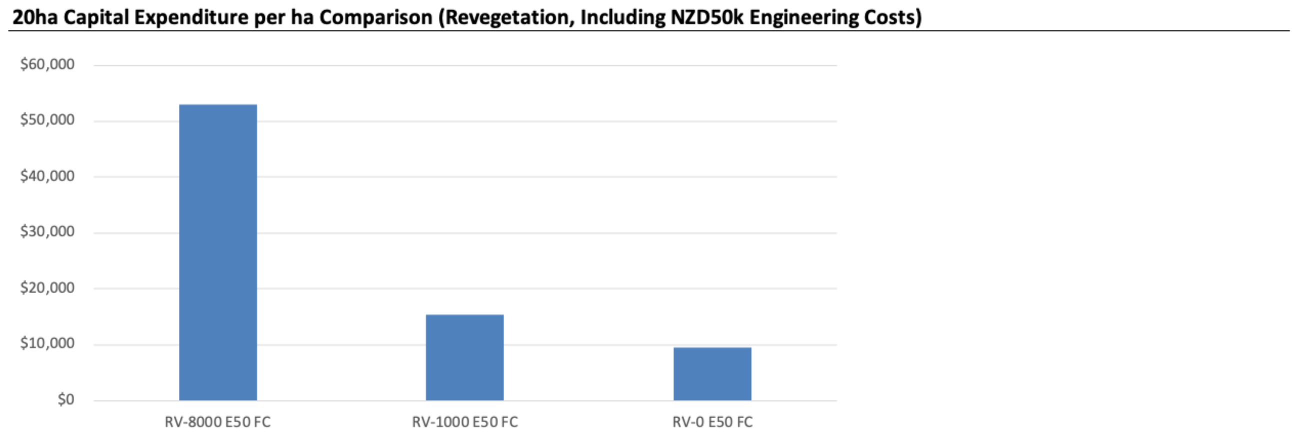



*Figure 4.2.1.2a. Capital expenditure per ha for a 20ha project involving three revegetation treatments and NZD50k engineering costs.*




#### 4.2.1.3 Conclusion: Capital Expenditure

Revegetation densities are a far more sensitive component of project finances than engineering intervention costs. For this reason, projects seeking to keep capital expenditure costs to a minimum will benefit from reducing revegetation stem densities more than from reducing engineering interventions.

### 4.2.2 Carbon Price Required to Break Even

Figure 4.2.2a shows the break-even starting carbon price required for the fully commercial and the grant-supported projects. The grant-supported scenarios serviced a NZD100 (USD68) starting carbon price with the aid of grant funding, with different grant amounts required for the different stem density and engineering interventions.

*Figure 4.2.2a. Break-even starting carbon price (per $tCO_2$) required (revegetation scenarios, and no engineering costs).*

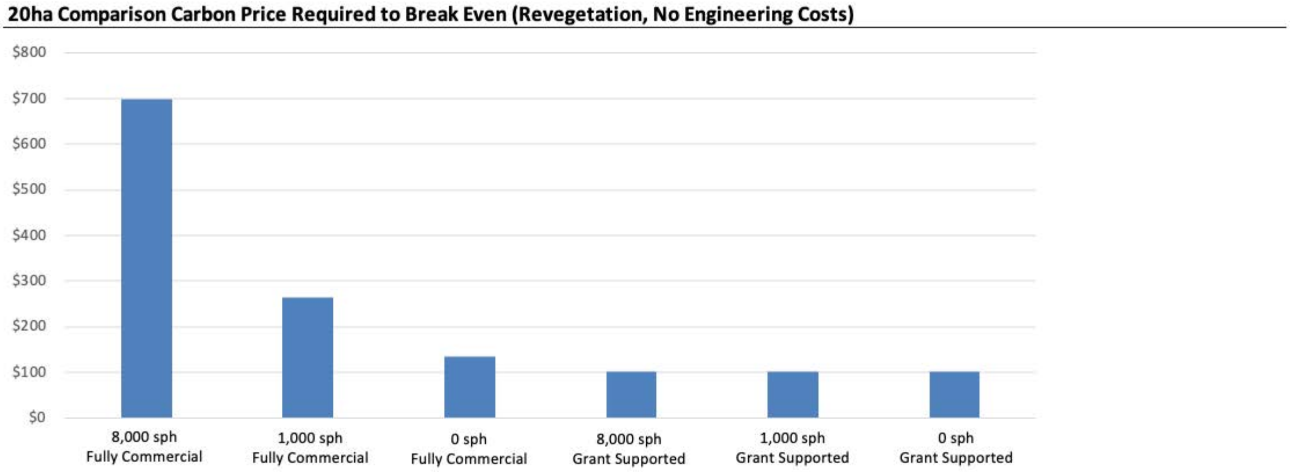
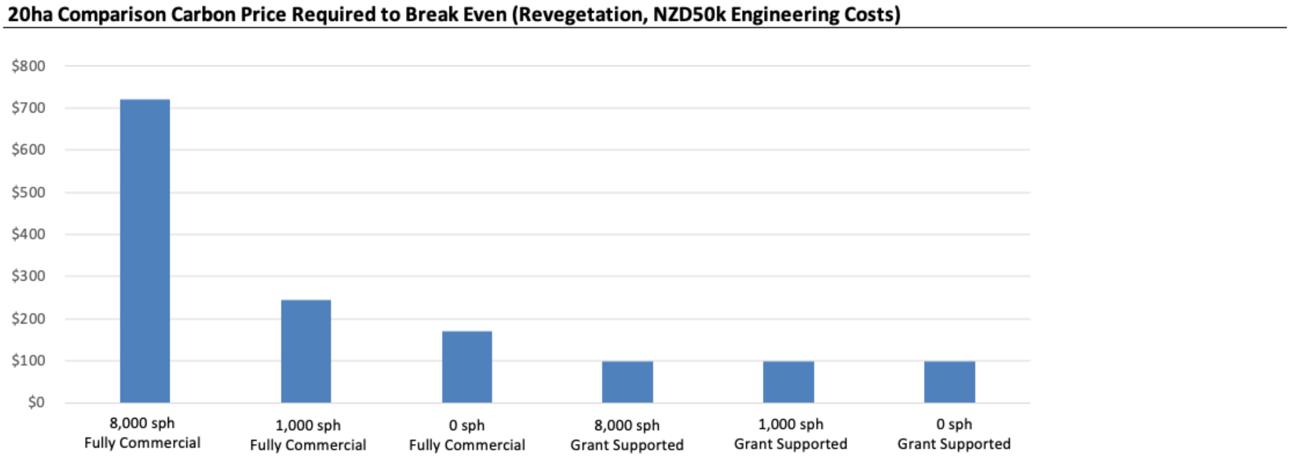



*Figure 4.2.2b. Break even starting carbon price (per $tCO_2$) required (revegetation scenarios, and NZD50k engineering costs).*




The fully commercial scenarios show what carbon price is required to sustain a carbon project at the three different revegetation treatments (8,000 sph, 1,000 sph, and 0 sph) with and without a NZD50k engineering intervention.

*Table 4.2.2. Break even carbon price (per $tCO_2$) required for fully commercial revegetation scenarios with and without NZD50k engineering costs.*

| | No Engineering Costs | | NZD50k Engineering Costs | |
|---|---|---|---|---|
| **Scenario** | NZD | USD | NZD | USD |
| **8,000 sph** | $698 | $471 | $720 | $486 |
| **1,000 sph** | $216 | $146 | $246 | $166 |
| **0 sph** | $134 | $90 | $170 | $115 |

As can be seen in Figures 4.2.2a, 4.2.2b and Table 4.2.2 additional engineering costs has a lower relative impact on the break-even carbon price compared with the impact of the revegetation planting density.

The lowest carbon prices modelled are fixed at NZD100 (USD68) in the grant supported scenarios. The grant required to sustain these projects is shown in Section 4.2.4 below.

#### 4.2.2.1 Conclusion: Carbon Pricing

Carbon pricing conclusions:

- As expected for the fully commercial scenarios, the highest starting carbon price of NZD720 (USD486) is required for the costliest scenario (revegetation at 8,000 sph with a NZD50k engineering intervention).
- Project types requiring higher carbon prices will not deliver significantly higher carbon benefits. This is because most of the carbon benefits are delivered from soil carbon, and result from hydrological changes between the baseline and project scenarios (Section 4.1.7 above). Above and below ground revegetation impacts were conservatively excluded from this financial feasibility assessment because it was assumed that they would not pass a significance test. Full project development may determine that revegetation impacts were significant and should be included.

The break-even carbon prices indicated above can be compared with international voluntary carbon market price trends shown in Tables 4.2.2.1a and 4.2.2.1b.

It is important to note that even without human intervention in actively planting native wetland vegetation (and funding this in the capital expenditure), such vegetation will naturally regenerate on tidal wetland sites through natural dispersal by birds and wind. As such, excluding native revegetation from the cost component of the business model does not exclude native revegetation from occurring. A middle path in this context is where a small planting is undertaken primarily to establish a desirable seed source for natural regeneration at the site.

*Table 4.2.2.1a. Transacted voluntary carbon offset volume and average price by standard. Source: Ecosystem Marketplace 2021.*

| | 2019 | | 2020 | | To August 2021 | |
|---|---|---|---|---|---|---|
| | Vol: MtCO2 | Price/tCO2 (USD) | Vol: MtCO2 | Price/tCO2 (USD) | Vol: MtCO2 | Price/tCO2 (USD) |
| **American Carbon Registry (ACR)** | 2.5 | $5.36 | 5.4 | $8.44 | 2.0 | $11.37 |
| **Clean Development Mechanism (CDM)** | 4.9 | $2.02 | 7.0 | $2.19 | 8.2 | $1.13 |
| **Climate Action Reserve (CAR)** | 4.0 | $2.34 | 2.1 | $4.44 | 4.9 | $2.12 |
| **Gold Standard** | 13.2 | $5.27 | 13.9 | $4.57 | 5.2 | $3.94 |
| **Plan Vivo Standard** | 0.9 | $8.99 | 1.2 | $8.49 | 0.7 | $11.58 |
| **Verified Carbon Standard (VCS)** | 44 | $1.74 | 66.1 | $3.76 | 125.6 | $4.17 |

*Table 4.2.2.1b. Voluntary carbon market size by product category 2019-August 2021. Source: Ecosystem Marketplace 2021.*

| | 2019 | | | 2020 | | | To August 2021 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Vol: MtCO2 | Price/tCO2 (USD) | Value (USDm) | Vol: MtCO2 | Price/tCO2 (USD) | Value (USDm) | Vol: MtCO2 | Price/tCO2 (USD) | Value (USDm) |
| **Forestry & Land Use** | 36.7 | $4.33 | $159.1 | 48.1 | $5.60 | $269.4 | 115.0 | $4.73 | $544 |
| **Renewable Energy** | 42.4 | $1.42 | $60.1 | 80.3 | $0.87 | $70.1 | 80.0 | $1.10 | $88.4 |
| **Energy efficiency/Fuel switching** | 3.1 | $3.87 | $11.9 | 31.4 | $1.03 | $32.3 | 16.1 | $1.57 | $24.2 |
| **Agriculture** | - | - | - | 0.3 | $9.23 | $2.8 | 3.4 | $1.36 | $4.6 |
| **Waste disposal** | 7.3 | $2.45 | $18.0 | 8.3 | $2.76 | $22.9 | 2.7 | $3.93 | $10.6 |
| **Transportation** | 0.4 | $1.70 | $0.7 | 1.1 | $0.64 | $0.7 | 2.1 | $1.00 | $2.1 |
| **Household devices** | 6.4 | $3.84 | $24.9 | 3.5 | $4.95 | $17.3 | 1.8 | $5.75 | $10.4 |
| **Chemical processes/ industrial manufacturing** | 4.1 | $1.90 | $7.7 | 1.3 | $1.90 | $2.5 | 1.1 | $3.22 | $3.5 |

As can be seen from Tables 4.2.2.1a and b, the results presented here (including a NZD100 carbon price for the grant-supported projects) are an order of magnitude higher than prices in the international carbon market. A strategy for monetizing carbon credits from salt marsh restoration projects at the prices modelled is presented in Section 4.4.4 below.

### 4.2.3 Investment Required

The investment required for each project scenario was linked to the capital expenditure requirement. This was then adjusted slightly up or downwards sufficient to cover project costs in the establishment and early implantation years. This also accounts for the projected annual carbon revenue flows during early implementation.

The investment required for the fully commercial and the grant-supported scenarios remained the same. For this reason, the results are presented for the three different revegetation interventions with and without NZD50k of engineering intervention.

*Figure 4.2.3 Investment required (revegetation, no engineering costs) (fully commercial & grant-supported).*

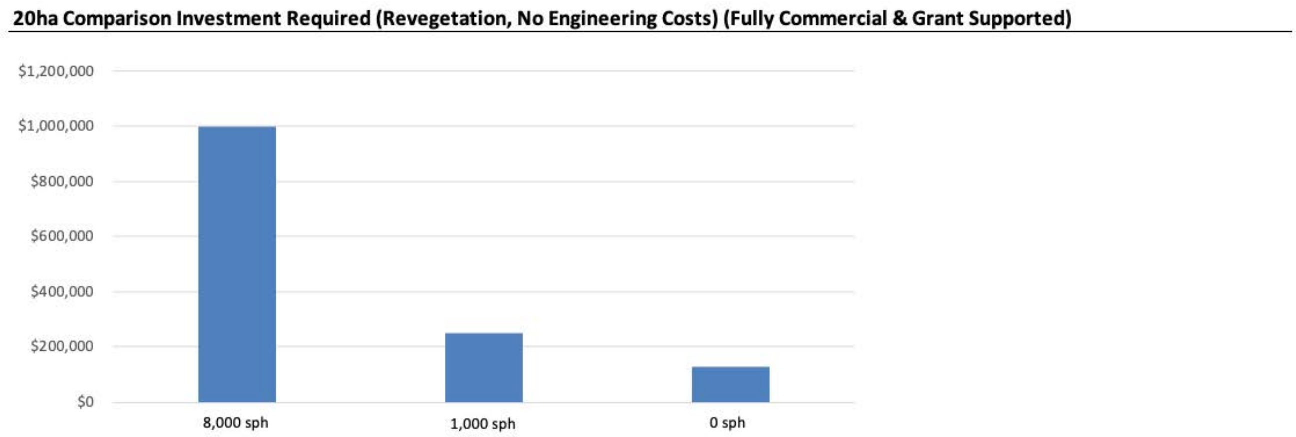



*Table 4.2.3. Investment required (revegetation, with and without NZD50k engineering costs), (fully commercial & grant-supported).*

| | **No Engineering Costs** | | **NZD50k Engineering Costs** | |
|---|---|---|---|---|
| **Scenario** | NZD | USD | NZD | USD |
| **8,000 sph** | $1,000,000 | $675,370 | $1,050,000 | $675,370 |
| **1,000 sph** | $250,000 | $145,205 | $300,000 | $202,611 |
| **0 sph** | $130,000 | $87,800 | $200,000 | $135,074 |

#### 4.2.3.1 Conclusion: Investment Required

Key conclusions:

- The highest investment required is for a project type with revegetation at 8,000 sph with or without a NZD50k engineering intervention.
- The lowest investment required is for a project type with natural revegetation and with or without a NZD50k engineering intervention.
- Note that the higher investment amounts will not deliver significantly higher carbon benefits.

### 4.2.4 Catalytic Capital Required

Grant support in the form of catalytic capital is not required for the fully commercial scenarios, but consequently, the fully commercial scenarios require higher starting carbon prices to enable the projects to break even. One way to lower the carbon price is to gain access to lower-cost capital (e.g., lower interest rates). The least cost capital is a grant (i.e., with zero pay-back and zero interest rate).

Catalytic capital in the form of different grant funding amounts was modelled to enable each project scenario to break even whilst capping the carbon price at NZD100 (USD68). The selection of NZD100 was arbitrary but plausible (i.e., within the range of plausible carbon prices that could be sustained in the Aotearoa New Zealand domestic voluntary carbon market).[38] This analysis provides an illustration of the inverse relationship between carbon price and catalytic grant funding required.

*Figure 4.2.4a. Grant required to cap the carbon price at NZD100 (USD68) (per $tCO_2$) for three revegetation interventions (with no engineering costs).*

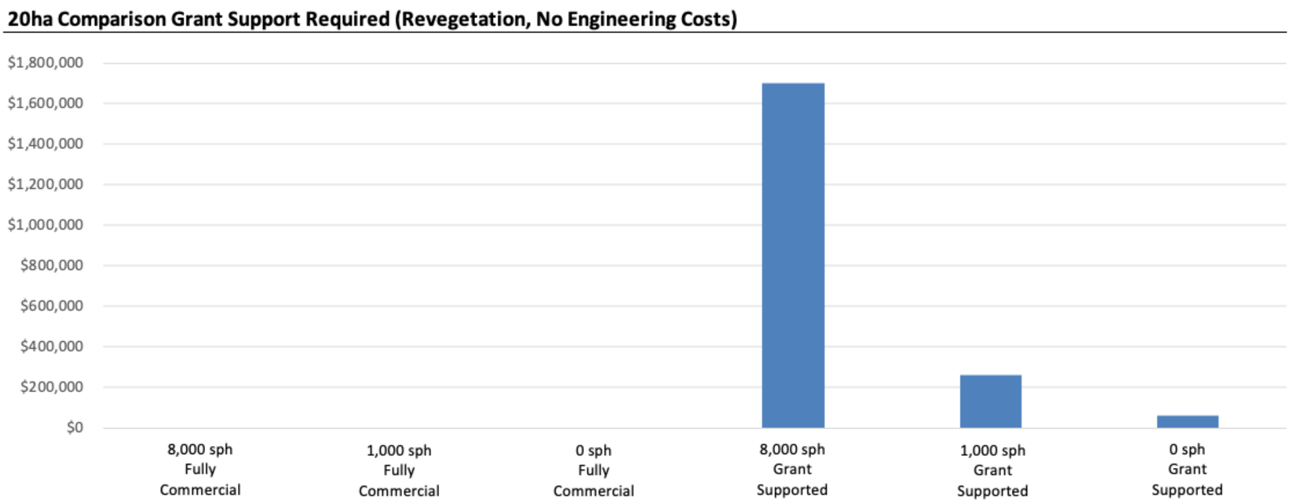



*Table 4.2.4. Grant required to cap the carbon price at NZD100 (USD68) (per $tCO_2$) (revegetation, with and without NZD50k engineering costs).*

| | No Engineering Costs | | NZD50k Engineering Costs | |
|---|---|---|---|---|
| **Scenario** | NZD | USD | NZD | USD |
| **8,000 sph** | $1,700,000 | $1,148,000 | $1,750,000 | $1,148,000 |
| **1,000 sph** | $260,000 | $175,500 | $350,000 | $236,400 |
| **0 sph** | $60,000 | $40,500 | $160,000 | $108,000 |

The highest amount of grant support is required for revegetation scenario with 8,000 sph, which is an order of magnitude higher than the grant support required for a project using natural revegetation.

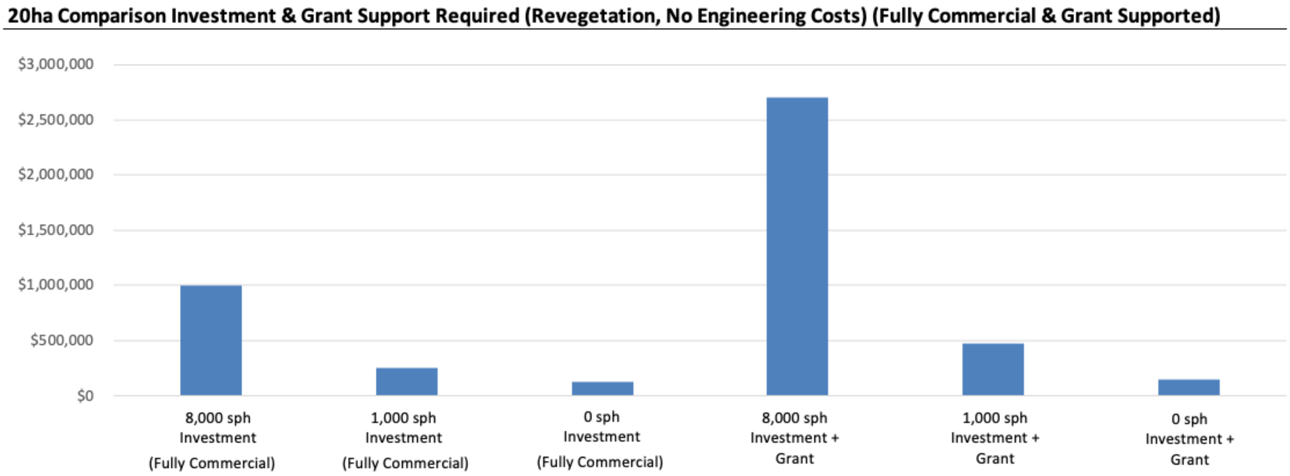
The amount of grant funding required to service a deeply uneconomic commercial project is very high because the project needs to service a large amount of debt as well as a portion of the capital expenditure. This is because the private investor is funding a portion of the capital expenditure. The larger the capital expenditure,

[38] Note that the domestic voluntary carbon market in Aotearoa New Zealand already includes Ekos buyers that (at the time of writing) were paying close to NZD100 per carbon credit from native reforestation carbon projects in the NZETS (February 2022). As such, the international average carbon price for voluntary carbon credits (i.e., produced in the international voluntary carbon market) is not an appropriate comparison with the domestic voluntary carbon situation in Aotearoa New Zealand.

the larger the amount of capital supplied by the private investor, the larger the debt, and the larger the burden of debt servicing. Because the carbon credit production rate remains relatively low, the project cannot afford to service this amount of debt from cashflows from carbon credit sales. Here additional grant funding is needed in reserve to enable the project to have enough cash to service the debt from the portion of capital expenditure funded by private investment. This is a very inefficient financing model.

It is also possible to make a comparison between the investment amount required for fully commercial projects, and the combined grant and investment required for grant-supported projects (see Figure 4.2.4b).

*Figure 4.2.4b. Investment required (fully commercial) and grant + investment required for grant supported project scenarios involving revegetation and no engineering costs.*




#### 4.2.4.1 Conclusion: Catalytic Capital

Reducing the starting carbon price to a price point comparable with the NZU spot price for a tidal salt marsh project will typically require grant support (or similar). The amount of the grant required will depend on the project development and establishment costs and this will depend on the planting density for revegetation as well as any engineering costs.

A project with no engineering costs that uses natural revegetation needs a grant of NZD60,000 plus an investment of NZD85,000 to break even when applying a starting carbon price of NZD100 and rising on average at NZD4.75 p.a.

### 4.2.5 Conclusion

Based on carbon credit production rates modelled in this feasibility assessment (Table 4.1.8) and revegetation scenarios presented above, the least cost approach to tidal wetland project development is natural revegetation with no engineering costs or engineering costs funded separately. Under a fully commercial approach, this scenario requires a break-even starting carbon price of NZD134 (USD90) and rising at NZD4.75 (USD3.20) p.a. When catalytic capital is available in the form of a grant, the break-even starting carbon price can be capped at NZD100 (USD68) and requires an investment of NZD85,000 (USD57,500) and a catalytic grant of NZD60,000 (USD40,500). Should a lower carbon price be required, then a larger catalytic capital grant will be required assuming the investment amount remains the same.

Assuming project development takes at least one year, and the project start date is 2023 and first issuance year is in 2024, the NZD100 starting carbon price is broadly comparable to the projected NZU carbon price controls for 2024 of NZD87.81. Note that the NZU spot price rose to >NZD86.00 in February 2022. The vast majority of carbon credits purchased at that price were from carbon projects that are predominantly industrial pine plantations (i.e., with few co-benefits). Voluntary carbon market buyers in the Aotearoa New Zealand domestic voluntary carbon market have consistently paid above the NZU spot price for native forest carbon credits. Ekos, for example, provides landowners with a premium wholesale price that is 20% above the NZU spot price for native forest carbon credits.

A blue carbon project could also conceivably command a price premium in the NZ voluntary carbon market as evidenced by Ekos experience in price sensitivity among voluntary carbon buyers for carbon credits from native forest carbon projects. In addition, there is always the ability to sell higher priced carbon credits in a mixed basket blended with lower priced carbon credits to enable the aggregate average price to sit within a price sensitivity threshold. This is a routine procedure in the domestic voluntary carbon market.

## 4.3 ECONOMY OF SCALE ANALYSIS

Project scenarios modelling five different fully commercial project sizes were analysed using the highest performing project scenario from Section 3.2 above (natural revegetation):

1. 20ha
2. 30ha
3. 40ha
4. 50ha
5. 60ha

This analysis was undertaken to examine the financial impact of economies of scale.

### 4.3.1 Capital Expenditure Required

It was assumed that the capital expenditure remained fixed for the different project sizes due to fixed project development costs that did not change as the project size increased from 20 to 60 ha (i.e., for a project with no native revegetation planting, so no absolute increase in plants and planting effort required). As project size increases the capital expenditure per ha decreases as shown in Figure 4.3.1a. Note that this analysis is designed to illustrate a trend rather than model exactly what will occur in any given project. For example, engineering costs may be much higher than NZD50,000, and vary from one project to another. But at the same time, engineering costs may be covered from outside the commercial carbon project investment boundary (e.g., funded by a separate grant). There are far too many variables possible in a blue carbon project to create a ‘one size fits all’ financial analysis, which is why the purpose of this section is to illustrate the principle of economies of scale and how this can impact on project financial feasibility.

*Figure 4.3.1a Capital expenditure per ha required at different project sizes (no engineering costs).*

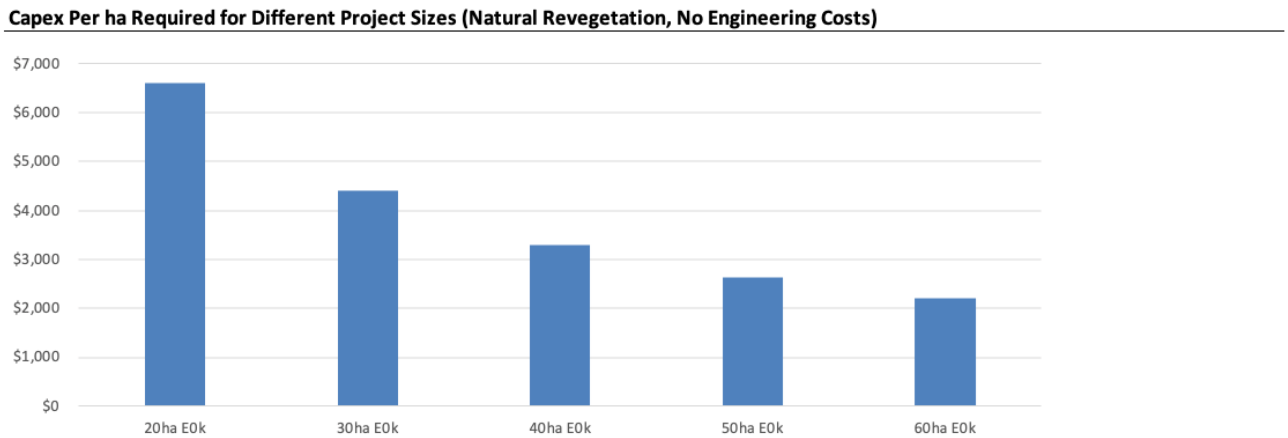
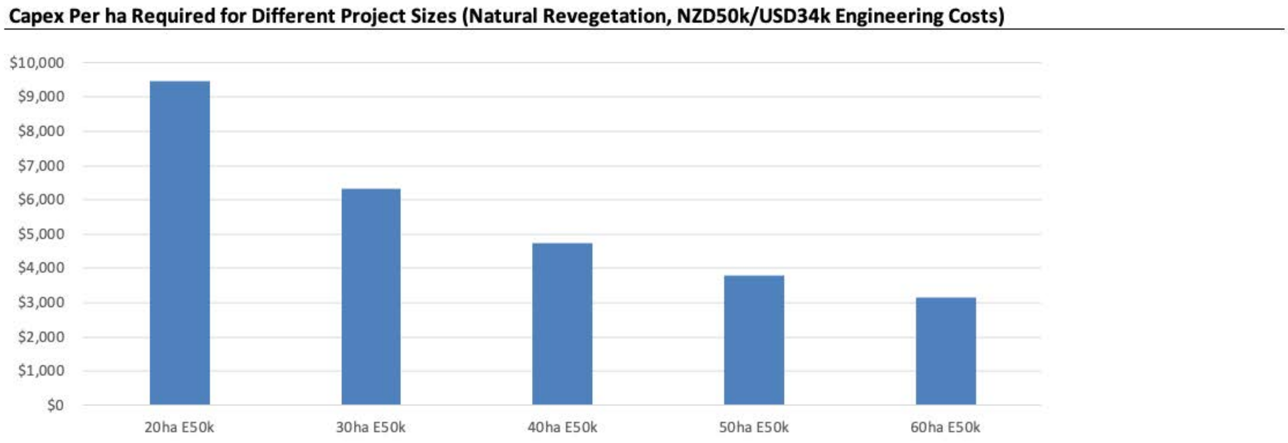


*Figure 4.3.1b Capital expenditure per ha required at different project sizes (with NZD50k engineering costs).*




As shown in Figures 4.3.1a and 4.3.1b capital expenditure per ha drops significantly as the project size increases from 20ha to 60ha.

### 4.3.2 Carbon Price Required to Break Even

As the capital expenditure per ha decreases the starting carbon price required to break even declines as shown in Figure 4.3.2a and b.

*Figure 4.3.2a Starting carbon price (per $tCO_2$) required to break even at different project sizes (no engineering costs).*

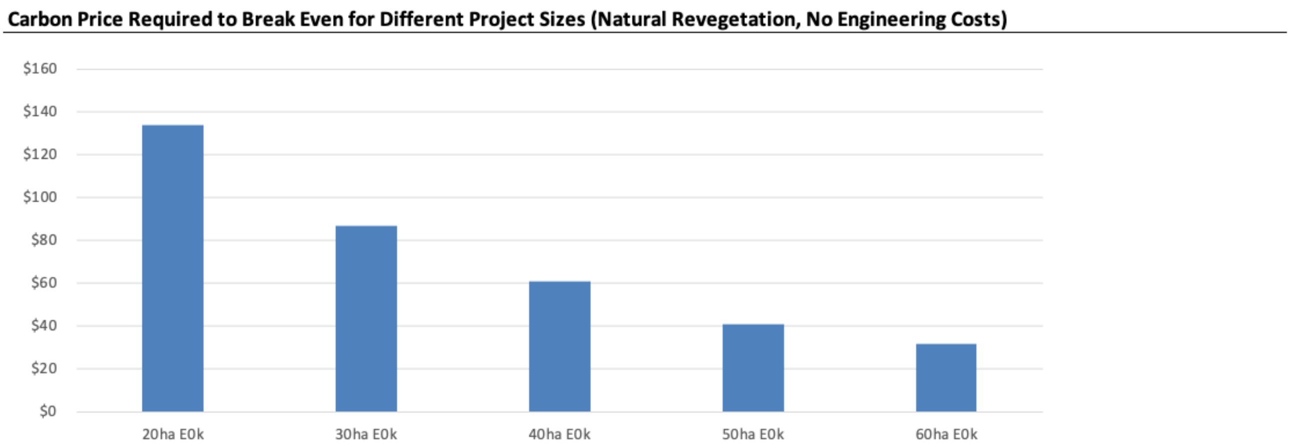


*Figure 4.3.2b Starting carbon price (per $tCO_2$) required to break even at different project sizes (with NZD50k engineering costs).*

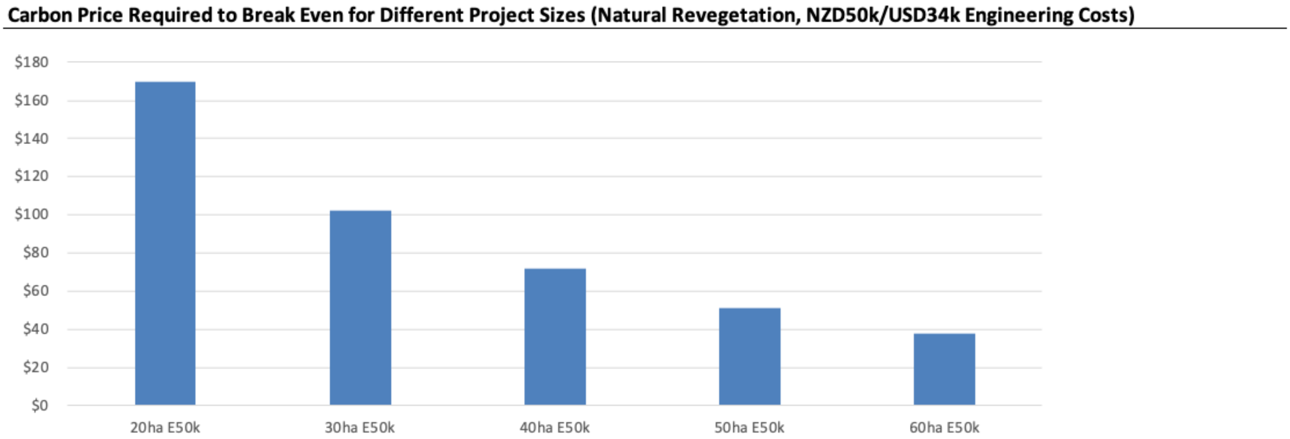



*Table 4.3.2. Break-even starting carbon prices (per $tCO_2$) for different project sizes. Grey shading indicating pricing at or lower than NZU spot price at time of writing.*

| | No Engineering Costs | | NZD50k Engineering Costs | |
|---|---|---|---|---|
| **Scenario** | NZD | USD | NZD | USD |
| **20ha** | $134 | $91 | $170 | $115 |
| **30ha** | $87 | $59 | $102 | $69 |
| **40ha** | $61 | $41 | $72 | $49 |
| **50ha** | $41 | $28 | $51 | $34 |
| **60ha** | $32 | $22 | $38 | $26 |

As can be seen in Figure 4.3.2a and b and Table 4.3.2 larger projects can deliver carbon prices at and lower than the NZU spot price at the time of writing of NZD72 (USD49)[39].

### 4.3.3 Conclusion: Economy of Scale Analysis

This economy of scale analysis shows that the commercial viability of tidal marsh blue carbon projects increases with relatively small increases in scale (all things being equal). As the project size increases its ability to sustain additional capital expenditure costs increases. Such additional capital expenditure can include additional engineering interventions and/or revegetation, sea level rise mitigation, as well as additional project development costs.

## 4.4 20HA DETAILED EXAMPLE

A detailed financial feasibility analysis was undertaken for a single project scenario as an exemplar to provide high resolution insights into project financial performance indicators. The project scenario used for this analysis has the following high-level design parameters: 20ha involving natural revegetation with no engineering costs, and on a fully commercial basis (i.e., without a grant and with a plausible interest rate on debt used to fund project establishment). The management intervention is to change the land use from pastoral grazing to tidal salt marsh where the change in hydrological conditions to enable reversion to tidal marsh are either negligible or are funded separately to the carbon project cashflows. Such a project type is

[39] NZU spot price on 14 March 2022. Source: Jarden Commtrade: https://www.commtrade.co.nz/

additional because without the project and associated carbon revenues the landowner could not justify the change in land use.

### 4.4.1 Assumptions

Table 4.4.1 shows the key assumptions for this exemplar project.

*Table 4.4.1. Key assumptions.*

**Client Information**

| | | | |
|---|---|---|---|
| **Client:** | TNC | **Area (ha):** | 20.0 |
| **Site:** | Te Repo ki Pūkorokoro | **Cashflow(yrs):** | 50 |
| **Region:** | Waikato | **Activity:** | WRC-RWE |

**Assumptions**

| **Seedlings** | **Unit price** | **Count** | **Cost** |
|---|---|---|---|
| Natives | $2.30 | 0 | $0 |
| Total | | 0 | $0 |

| **Planting Areas** | **ha** | **Remarks** |
|---|---|---|
| Natives | 20.0 | Natural revegetation |
| | | |

| | | | |
|---|---|---|---|
| First planting year | 2023 | Discount Rate Client | 6.00% |
| Starting Carbon Price | $134.00 | Discount Rate Landowner | 6.00% |
| CP1 price rise p.a. | $1.50 | Grant funding | $0 |
| CP2 price rise p.a. | $4.75 | Fencing costs | $0 |
| CP3 price rise p.a. | $8.00 | Total credit supply | 6,744 |
| Project development costs | $50,000 | Average annual credit supply | 134 |

Of note in the key assumptions is a project development (planning) cost of NZD50,000, the use of a 6% discount rate, no grant funding, no engineering or fencing costs, no revegetation costs, a minimum starting carbon price capable of financially sustaining this project of NZD134.00, and three different carbon price change scenarios (CP1, CP2, and CP3).

The NZD134.00 starting carbon price was calculated for this scenario as the lowest carbon price that could deliver a financially self-sustaining project funded by a loan. This carbon price is required to fund project development costs, project operational costs, and any opportunity costs. This carbon price does not create a revenue windfall for the landowner.

### 4.4.2 Project Financial Performance

Key financial performance indicators for this exemplar project are shown in Table 4.4.2 below.

*Table 4.4.2. Key financial performance indicators.*

**Project Performance**

| Cash Capex | Cash Capex/ha | IRR IRR CP1 25-yr | IRR IRR CP2 25-yr | IRR IRR CP3 25-yr | IRR CP1 50-yr | IRR CP2 50-yr | IRR CP3 50-yr | Investor Input |
|---|---|---|---|---|---|---|---|---|
| $132,000 | $6,600 | 2.4% | 6.6% | 9.5% | 5.1% | 8.7% | 11.1% | $130,000 |

| 25-yr Carbon NPV CP1 | 25-yr Carbon NPV CP2 | 25-yr Carbon NPV CP3 | 25-yr Rental NPV Op Cost | 50-yr Carbon NPV CP1 | 50-yr Carbon NPV CP2 | 50-yr Carbon NPV CP3 | 50-yr Rental NPV Op Cost | Top Interest rate CP2 |
|---|---|---|---|---|---|---|---|---|
| ($20,717) | $23,125 | $66,865 | $84,261 | $59 | $75,329 | $148,430 | $102,137 | 5.00% |

#### 4.4.2.1 Capital Expenditure

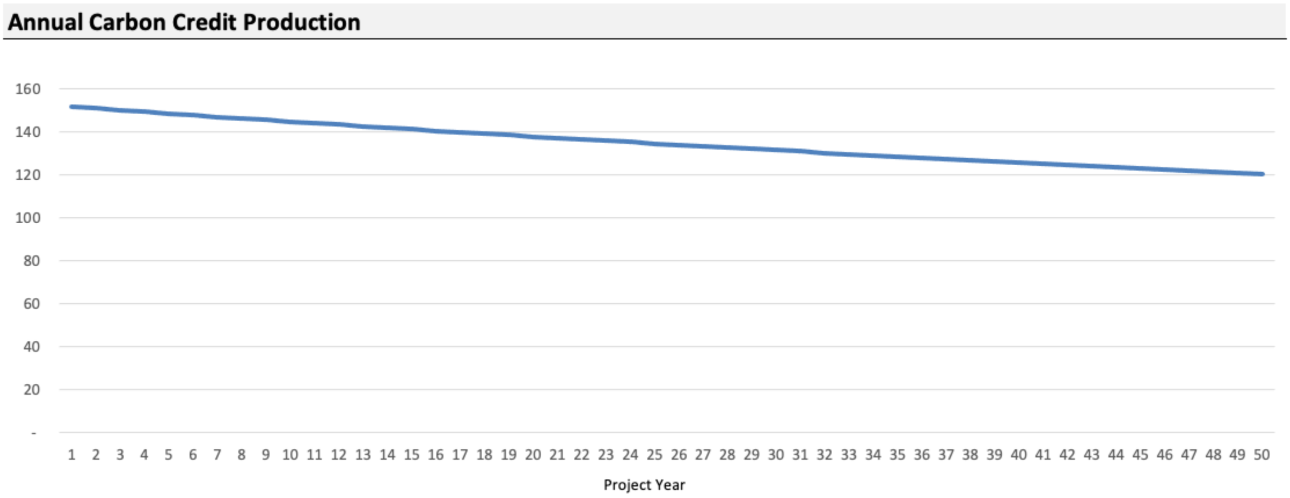
Cash capex indicates the capital expenditure required for this project, which is also shown on a per ha basis. This is the sum of costs required to establish the project and includes NZD50,000 of project development costs introduced as a placeholder estimate of project development costs. In practice, this low-resolution placeholder for project development and other capital expenditure costs would arise from high-resolution due diligence during project development.

The other key financial performance indicators are examined below.

### 4.4.3 Carbon Credit Yield

The carbon credit yield curve is shown in Figure 4.4.3 below and is derived from Table 4.1.8. This yield curve is from a combination of avoided baseline carbon and methane emissions combined with enhanced carbon sequestration in the project scenario.

*Figure 4.4.3. Carbon credit yield curve.*



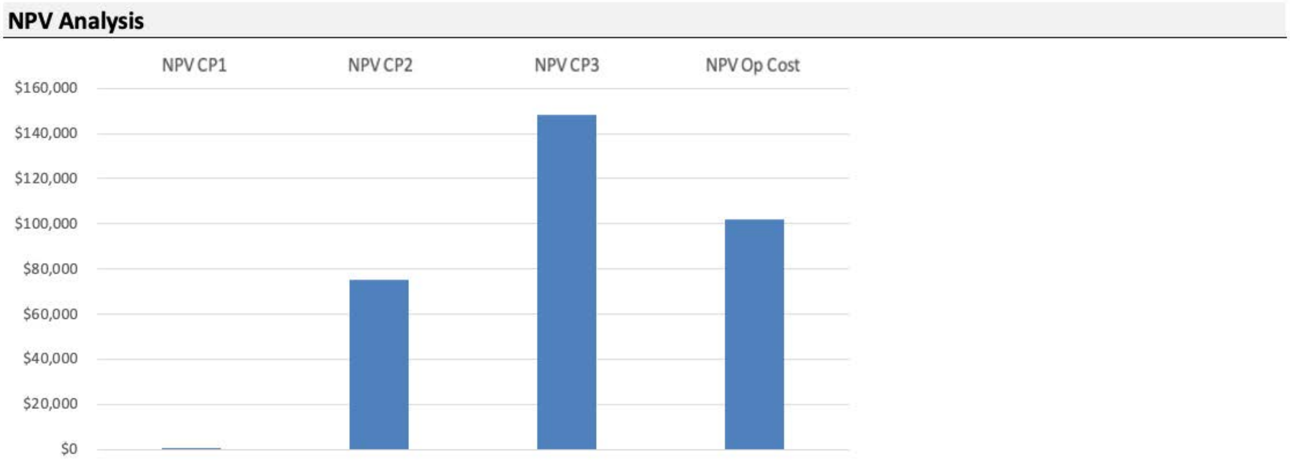

The decline in the carbon credit yield curve comes from the modelled decline in baseline emissions from the degraded saltmarsh in the baseline. This modelled decline arises from the decline in baseline emissions from degraded wetland ecosystems and is explained in Section 3.3.3.3.

### 4.4.4 Net Present Value

The net present value (NPV) is another measure of the financial sustainability of a project/investment. The NPV is the difference between the present value of inward and outward cashflows over a cashflow period. It can be used in comparison with alternative investments to help make investment decisions. One useful comparison is the NPV of a blue carbon project in comparison with the NPV of business-as-usual. The financial performance of business-as-usual for a salt marsh restoration blue carbon project might be the value to the farmer to continue grazing a drained tidal wetland. This is calculated in this exemplar as the NPV of land rental revenues if the same land were leased out for grazing at a land rental rate equivalent to 3% of an assumed land value of NZD15,000 per ha[40]. This is shown in Figure 4.4.4.

[40] The modelled land value of NZD15,000/ha for the exemplar project site assumed that land value is negatively impacted by being flood-prone land, with either lower productivity than land that is not flood prone, or has a higher management cost due to the need for drainage management.

*Figure 4.4.4. Net present value of the carbon project for the three different carbon price change scenarios (CP1, CP2, and CP3)[41] and compared with the NPV of the opportunity cost of leasing the land for grazing.*




As shows in Figure 4.4.4 the comparison of carbon credit NPV with leasing the same land for grazing indicates that carbon credit revenue at CP1 and CP2 produces lower net revenue (i.e., after all carbon project costs have been accounted for) than leasing the land for grazing. The NPV at CP1 and CP2 are low but not below zero. This means that they perform better than an alternative investment with a 6% IRR by the margin shown (i.e., the discount rate is 6%).

Note also that in many situations carbon credit profits will need to compete with farming profits for farmers to make the decision to retire grazing land for conservation. This will not be the case for all landowners but will be the case for many. In particular, the profitability of land retired for conservation will impact on overall land value/sale value of a farm. In many situations, a farmer will have purchased the farm whereby the affected paddocks were priced based on their productivity for farming, even though that productivity is dependent on legally sanctioned wetland drainage.

### 4.4.5 Internal Rate of Return (IRR)

The modelled internal rate of return (IRR) for this exemplar project is shown in Figure 4.4.5 for the three different carbon price change scenarios (CP1, CP2, and CP3).

The internal rate of return (IRR) is an indicator of financial sustainability for a project and is used by an investor to help make an investment decision. It is not the same as the interest rate that a project could deliver on a loan. The IRR was calculated for two cashflow periods: 25 years and 50 years. The 25-year cashflow period is equal to the blue carbon project investment period, whereas the 50-year cashflow period is equal to the blue carbon project period which extends beyond the investment period in this scenario. The IRR for each cashflow period was calculated using the three different carbon price change scenarios (CP1, CP2 and CP3).

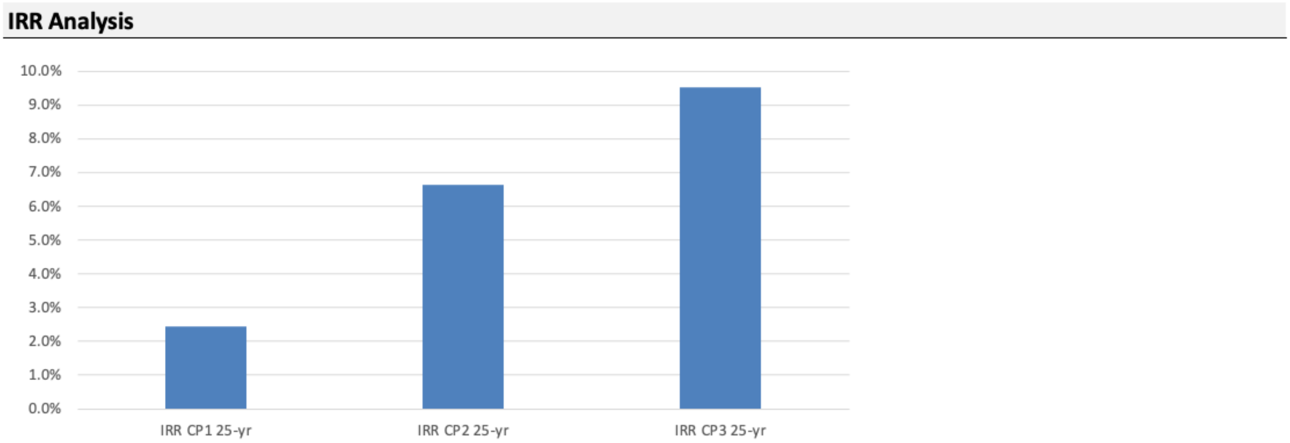
The IRR for the 25-year cashflow is the most useful for the investor and the IRR for both the 25-year cashflow and the 50-year cashflow is useful for the project proponent.

The investment success indicator in this analysis is a starting carbon price of NZD134 and rising at the middle carbon price change scenario CP2 (rising at NZD4.75 p.a.). As such, the IRR relevant to this success indicator is IRR CP1 25-yr of 6.6%.

[41] CP1 = carbon price rising at NZD150 per year; CP2 = carbon price rising at NZD475 per year; CP3 = carbon price rising at NZD8.00 per year. Each of these carbon price rise scenarios have the same starting carbon price of NZD134.00.

If actual carbon prices run higher than CP2 (they are currently tracking at CP3) then the project will be more profitable. This will enable it to spend more money on conservation management interventions or return a greater surplus to the project proponent.

*Table 4.4.5. Internal rate of return for the three different carbon price change scenarios (CP1, CP2, and CP3).*




### 4.4.6 Free Cashflows

Free cashflows are the net sum of all costs and revenues in any given year and are shown in Figure 4.4.6 for the three different carbon price change scenarios (CP1, CP2, and CP3).

*Figure 4.4.6. Free cashflows at three different carbon price change scenarios (CP1, CP2, and CP3).*

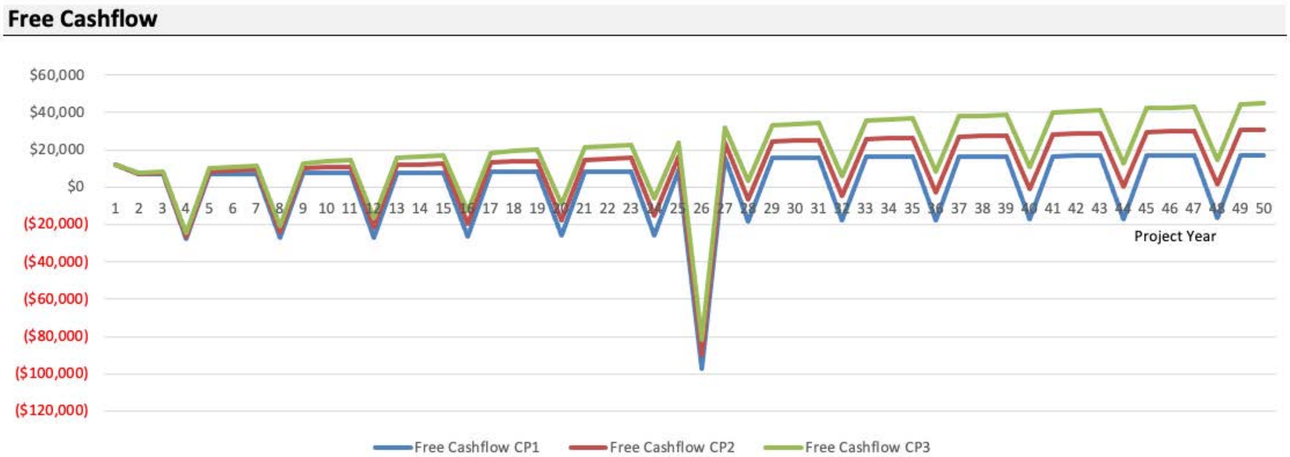
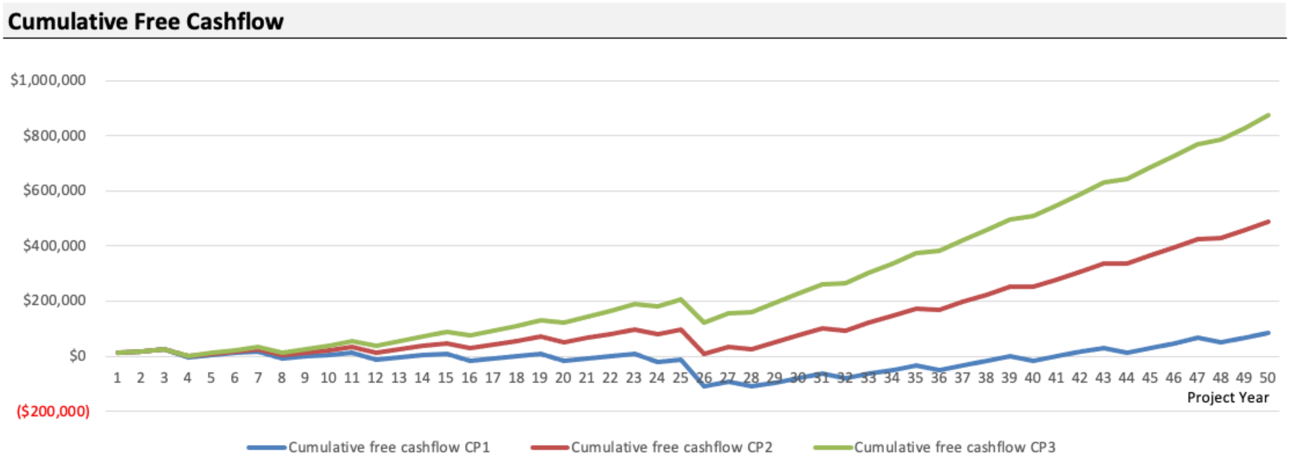



Figure 4.4.6 shows the impact of the different carbon price change scenarios (CP1, CP2, and CP3) with CP1 showing the highest and CP3 the lowest cashflow positions in any given year. The regular downward spikes are caused by the 5-yearly verification costs. The large downward spike in the middle of Figure 4.4.6 shows the terminal payment for debt repayments on the investment. Debt repayments begin in year 1 at a rate of NZD7,000 p.a. but then need to clear the residual debt at the investment maturity with the terminal payment.

### 4.4.7 Cumulative Free Cashflows

Cumulative free cashflows are the equivalent of the bank balance of the project in any given year and is shown in Figure 4.4.7.

*Figure 4.4.7. Cumulative free cashflows at three different carbon price change scenarios (CP1, CP2, and CP3).*




The investment success test used for all financial feasibility modelling in this analysis is for there to be no negative cumulative cashflows in the project at carbon price change scenario CP2 (annual carbon price rise of NZD4.75 (USD3.20)). This can be seen in the red line in Figure 4.4.7 above which never dips below zero, whereas the CP1 scenario does. This means that if the carbon price starts at the NZD134 (USD90) minimum price for this scenario and rises at NZD1.50 p.a. across the cashflow period the investment will fail, and the investor will not get their money back at the interest rate of 5%. If, on the other hand, the carbon price rises at NZD4.75 p.a. the investment will succeed. Note also that bringing the starting carbon price down to the NZU spot price can be delivered if the project was larger, as shown in Section 4.3.2 above, or if sufficient grant support is included.

Cumulative free cashflows for the 25-year investment period are shown in tabular form in Table 4.4.7. This shows the start and end date for the investment period (highlighted in yellow in Table 4.4.7). The balance of NZD11,732 in year 0 is the result of the investment of NZD130,000 introduced as revenue minus, plus the carbon credit revenue projected for that year, minus the capital and operational expenditure for that year.

Note that carbon credit revenues are modelled in this analysis as if they were delivered annually the year after the carbon credits were produced and monetised at the carbon price modelled for that year. In practice, carbon credits would be issued periodically (e.g., 3-yearly or 5-yearly) as a result of periodic verification audits and monetised in different ways depending on the monetisation strategy and commercial arrangements with buyers.

*Table 4.4.7. Cumulative free cashflows at the CP2 carbon price change scenario.*

**Cumulative Cashflow Detail CP2 with Investor Input and Output Years (yellow)**

| Project Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| Cumulative free cashflow | $11,723 | $18,885 | $26,482 | $101 | $8,552 | $17,424 | $26,712 | $2,656 | $12,764 | $23,276 |
| Project Year | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| Cumulative free cashflow | $34,187 | $12,363 | $24,061 | $36,147 | $48,617 | $28,936 | $42,163 | $55,762 | $69,730 | $52,111 |
| Project Year | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 |
| Cumulative free cashflow | $66,807 | $81,863 | $97,273 | $81,638 | $97,750 | $8,071 | $31,871 | $25,148 | $49,624 | $74,433 |
| Project Year | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 |
| Cumulative free cashflow | $99,573 | $94,695 | $120,487 | $146,602 | $173,036 | $169,940 | $197,005 | $224,381 | $252,066 | $250,693 |
| Project Year | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 |
| Cumulative free cashflow | $278,988 | $307,585 | $336,481 | $336,694 | $366,181 | $395,960 | $426,030 | $427,407 | $458,050 | $488,977 |

### 4.4.8 Investment Summary

Table 4.4.8 shows the investment summary for this exemplar project and modelled as if it were structured as a loan. The key metrics are the investment of NZD130,000, a 25-year investment maturity, a 5.00% interest rate, NZD7,000 loan repayments paid annually and a total debt repayment including principal and interest of NZD281,136.

*Table 4.4.8. Investment summary for this exemplar project.*

| Investment & Returns | |
|---|---|
| Investment Principal | $130,000 |
| Investment term (yrs) | 25 |
| Interest rate | 5.00% |
| Grant | $0 |
| Grant + Investment | $130,000 |
| Total interest | $151,136 |
| Total debt repayment (P+I) | $281,136 |
| Average interest p.a. | $6,045 |
| Annual loan repayments (P+I) | $7,000 |
| Loan re-payment start year | 1 |

### 4.4.9 Conclusion: 20ha Detailed Example

The fully commercial version of this 20ha exemplar project is financially feasible if the carbon credits can be monetized for a minimum break-even starting price of NZD134/tCO2e and rising at NZD4.75 p.a. The NZU spot price at the time of writing is NZD72.00/tCO2e. To get the same project to financially feasible with a starting carbon price equivalent to the current NZU spot price, the project would need to be larger (between 30 and 40ha) or would need a catalytic capital grant of NZD190,000[42] if it remained at 20ha.

## 4.5 CARBON CREDIT MONETIZATION STRATEGIES

When monetizing units (of anything) where there is a disconnect between the break-even unit price and buyer price sensitivity (upper limits to willingness-to-pay) there is sometimes an option to blend a small volume of

[42] The grant amount is higher than the capital provided by private investment because the grant would need to contribute to the servicing of debt from the investor whilst coping with lower carbon revenue because the starting carbon price (which contributes to revenue) is reduced from NZD100.00 to NZD68.30 (i.e., less revenue).

the target unit type with a large volume of a lower cost unit type to deliver an aggregate unit price that aligns with willingness-to-pay price thresholds. This opportunity exists in the voluntary carbon market where a wide range of unit prices exist in the market (see Table and 4.2.2.1b). The lower end of unit prices in Table 4.2.2.1b are for renewable energy credit types and are as low as USD1.10 (NZD1.63).

For example, a 20ha blue carbon project with a break-even starting carbon price of NZD134 could be financially sustained at a price point of NZD68.30 (the NZU spot price at the time of writing this calculation) if it were sold in a mixed basket of 50% blue carbon credits at NZD134.00 and 50% renewable energy credits at NZD1.63. The aggregate unit price of this mixed basket is NZD67.82 (USD45.80).

The mixed basket approach presents many different blend options depending on the price and availability of the lower cost portion of carbon credits. A mixed basket of carbon credits is a routine carbon credit monetisation procedure at Ekos and other carbon credit resellers. At Ekos we use this procedure to enable us to sustain premium prices for landowners with native forest carbon projects, by blending the mix with lower cost but high-quality carbon credits from our rainforest carbon projects in the Pacific Islands. Because voluntary carbon buyers can source carbon credits from across the entire spectrum of international voluntary carbon project supplies, there are many opportunities to create mixed basket blends (like blended whisky).

## 4.6 CONCLUSION

### 4.6.1 Fully Commercial

The financial feasibility assessment for a fully commercial approach (i.e., without catalytic capital in the form of grant funding) found the following for the blue carbon project types examined:

| Project Area (ha) | Revegetation | Engineering Costs NZD | Break-even starting Carbon Price NZD | Financially Feasible? |
|---|---|---|---|---|
| Revegetation stem density analysis | | | | |
| 20 | Revegetation @ 8,000 sph | 50,000 | 720 | No |
| 20 | Revegetation @ 1,000 sph | 50,000 | 246 | No |
| 20 | Revegetation @ 0 sph | 50,000 | 170 | Marginal |
| 20 | Revegetation @ 8,000 sph | 0 | 698 | No |
| 20 | Revegetation @ 1,000 sph | 0 | 216 | No |
| 20 | Revegetation @ 0 sph | 0 | 134 | Yes |
| Economy of scale analysis | | | | |
| 20 | Revegetation @ 0 sph | 50,000 | 170 | Marginal |
| 30 | Revegetation @ 0 sph | 50,000 | 102 | Marginal |
| 40 | Revegetation @ 0 sph | 50,000 | 72 | Yes |
| 50 | Revegetation @ 0 sph | 50,000 | 51 | Yes+ |
| 60 | Revegetation @ 0 sph | 50,000 | 38 | Yes+ |
| 20 | Revegetation @ 0 sph | 0 | 134 | Marginal |
| 30 | Revegetation @ 0 sph | 0 | 87 | Yes |
| 40 | Revegetation @ 0 sph | 0 | 61 | Yes |
| 50 | Revegetation @ 0 sph | 0 | 41 | Yes+ |
| 60 | Revegetation @ 0 sph | 0 | 32 | Yes+ |

Marginal = not financially feasible without innovation in carbon credit monetization (e.g., blending with lower cost credit types and selling as a mixed basket).
Yes + = financially feasible with opportunities to increase project budget for additional benefits (e.g., revegetation).

The most financially viable high-level project design for a 20ha tidal wetland restoration project involved natural revegetation (i.e., no active planting of vegetation) and no engineering costs needing to be covered by carbon credit sales revenues. This required an investment of NZD130,000 (USD87,800) and a break-even starting carbon price of NZD134 (USD90) and rising at NZD4.75 (USD3.20) p.a. When catalytic capital is available in the form of a grant, the break-even starting carbon price can be capped at NZD100 (USD68) and requires an investment of NZD85,000 (USD57,500) and a catalytic grant of NZD60,000 (USD40,500). Should a lower carbon price be required, then a larger catalytic capital grant will be required assuming the investment amount remains the same.

The economy of scale analysis showed that the commercial viability of a fully commercial project increased significantly with an increase in project size. For projects with natural revegetation and without any engineering costs to be covered by carbon credit cashflows a project size of 40ha and above delivered projects with break-even starting carbon prices below the NZU spot price at the time of writing. As the project size increased above 40ha, the break-even starting carbon price dropped to levels considerably lower than the NZU spot price. Projects of 50ha or 60ha in area can, therefore, accommodate increased capital expenditure costs including revegetation costs within a carbon price point up to the NZU spot price range.

Projects that require a break-even starting carbon price that is higher than the NZU spot price (e.g., NZD134 (USD90) required for a fully commercial 20 ha project) can sustain such prices in a commercial carbon market setting if these carbon credits are monetised using a mixed basket approach with a blend of blue carbon credits combined with lower-cost voluntary carbon credits from other project types. The mixed basket approach to carbon credit monetisation provides considerable flexibility to support projects that require higher starting carbon prices.

This feasibility assessment modelled the financial feasibility of project scenarios on the assumption that the average annual rate of carbon price rise was NZD4.75 in real terms. This is designed to accommodate future carbon price change fluctuations associated with government policy change. This approach, however, may prove to be conservative given that the NZ government price controls have benchmarked annual carbon price increments at above NZD8.00 until 2026 (or may prove to be aggressive if future governments change the price controls downwards). If these price controls are not negatively impacted by changes in government policy in the future (e.g., through a change of government) then a higher annual carbon price rise scenario can be plausibly applied. Under a higher annual carbon price change model (e.g., NZD8.00 p.a.) the break-even starting carbon price for all scenarios would drop, and the potential commercial feasibility of all scenarios would rise.

The carbon benefits delivered by project scenarios modelled in this feasibility assessment are restricted to soil carbon and arising from hydrological interventions (rewetting). This was due to the assumption that the net carbon benefits from mostly herbaceous revegetation would be very low per hectare and not significantly impact on total carbon benefits delivered by a project and were, therefore, conservatively excluded. If this assumption remains valid (e.g., from higher resolution due diligence during project development), then any additional effort and cost associated with revegetation would add short-term biodiversity benefits but not carbon benefits to the project. As such, significant additional cost associated with revegetation cannot be justified from a cost/benefit perspective. In addition, natural revegetation does occur in wetland environments with seed dispersal by wind, water, and birds. Here nature covers the capital expenditure costs of revegetation and creates a natural distribution and composition of consequent vegetation.

The ability to attract private investment to finance blue carbon projects will ultimately depend on the terms of that investment and this will vary from one investor to another (where the investor is a supplier of cash in exchange for that cash being paid back with interest).

Some investors seek project financial modelling that shows only the internal rate of return for the project (e.g., investors using an equity (co-ownership of project) arrangement for financial security). Other investors prefer modelling focused on interest paid on borrowing (e.g., investors using a debt-financing arrangement with other forms of security on the loan/debt). Accordingly, this financial analysis models both a 5% interest rate on borrowing shown in the detailed example (Section 4.4) and a corresponding internal rate of return (IRR) (in this case 6.6% at CP2 (carbon price rising at NZD4.75 p.a.)) and 9.5% at CP3 (carbon price rising at NZD8.00 p.a.)).

This level of return on investment[43] may be sufficient to attract an investor[44], or returns may need to be higher (depending on the investor preferences and terms). As a rule of thumb, the lower the investment security arrangements the higher the investment risk and the higher the returns required of the investor. In reverse, the higher the security arrangements (e.g., guaranteeing a particular return), the lower the investment risk and the lower the expected return by the investor.

If a higher return on investment is needed to attract investment funding, then project developers may need to secure catalytic capital (e.g., grant support) to lift the profitability of the project (i.e., increasing the IRR) sufficient to meet a return on investment (ROI) requirements of an investor. In the latter situation of blended finance, a grant funder can provide the catalytic support needed to enable private investment funding (investment and carbon credit sales revenues) to do most of the financial work in the project or programme.

Once the profitability of project design is sufficient to attract private investment, there is an opportunity to transition from collection of projects to a nation-wide programme of activities (e.g., a blue carbon trading scheme). Such a nation-wide programme can be facilitated/catalysed by catalytic capital of some form (e.g., grants to enable projects to leverage private capital investment. The financial indicators in this feasibility assessment suggest that a blue carbon trading scheme is possible in Aotearoa New Zealand.

### 4.6.2 Catalytic Capital

If catalytic capital (e.g., grant funding) is involved in project financing, the project financial viability changes significantly depending on how much catalytic capital is provided. For example, a 20 ha project with no engineering costs that uses natural revegetation needs a grant of NZD60,000 plus an investment (e.g., borrowing) of NZD85,000 to break even when applying a starting carbon price of NZD100 and rising on average at NZD4.75 p.a.

Because there are countless ways to structure the relationship between project design, grant funding support, carbon pricing, and project area, this analysis has restricted its focus to showing the impact of different configurations to help illustrate the financial realities involved.

[43] The return on investment here is a financial return for the use of money, but where the investor does not have any interest in acquiring or using the carbon credits. Someone who is using the carbon credits is a carbon buyer rather than a carbon project investor in this model. Sometimes the carbon buyer will also be an investor in a project – where the buyer provides the cash capital to build the project and also purchases some or all of the carbon credits. Under these arrangements sometimes the payment for the carbon credits is delivered in the form of the capital investment to get the project going. Under these arrangements the project does not generate cash returns from carbon credit sales because the carbon credits are delivered to the investor at no additional sales cost (i.e., because the buyer/investor has already paid for them through the investment).

[44] Impact investors with an 'impact first' approach (i.e., beneficial impact is more important that financial returns) may be willing to invest at this level of return.

# 5 Legal Feasibility

## 5.1 INTRODUCTION

Any project site for a blue carbon project will have its own legal particularities which require site specific due diligence. It is, however, possible to sketch out in reasonable detail the legal requirements affecting the sites by type, and generally assess legal feasibility, including any major legal impediments that might affect the implementation of a project.

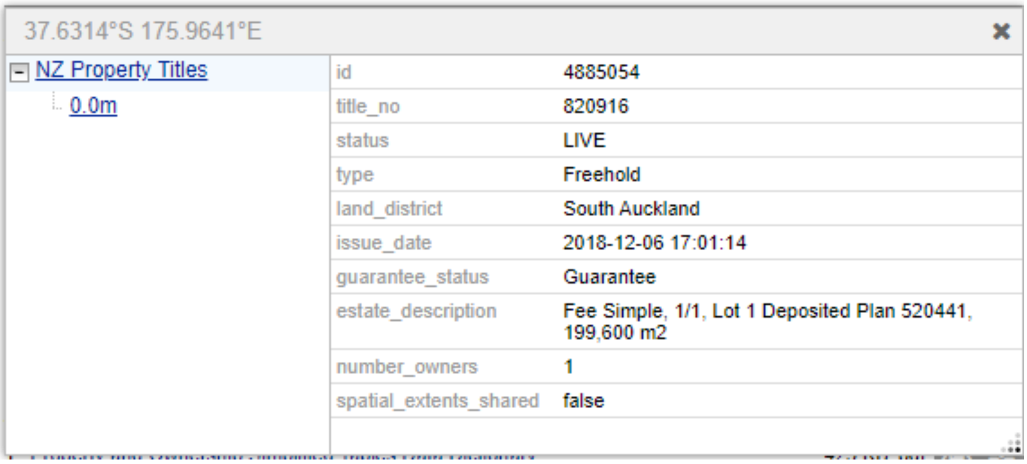
For each site, the main determinants of legal feasibility are:

- Property rights under the common law and statute law;
- The sustainable management regime under the Resource Management Act 1991 which governs uses that can be made of land and water, whether above or below the high tide mark, and
- The ability to establish carbon contracts based on sequestration below the high tide mark.

## 5.2 PROPERTY RIGHTS

Where project sites are on registered land titles with fixed boundaries, the property belongs those owners noted on the title. Property ownership does not change even if the land is currently underwater or might become so after tidal flows are diverted to drown it as part of wetland restoration.

For example, the Wainui Repo Whenua project is located on freehold land with one owner:



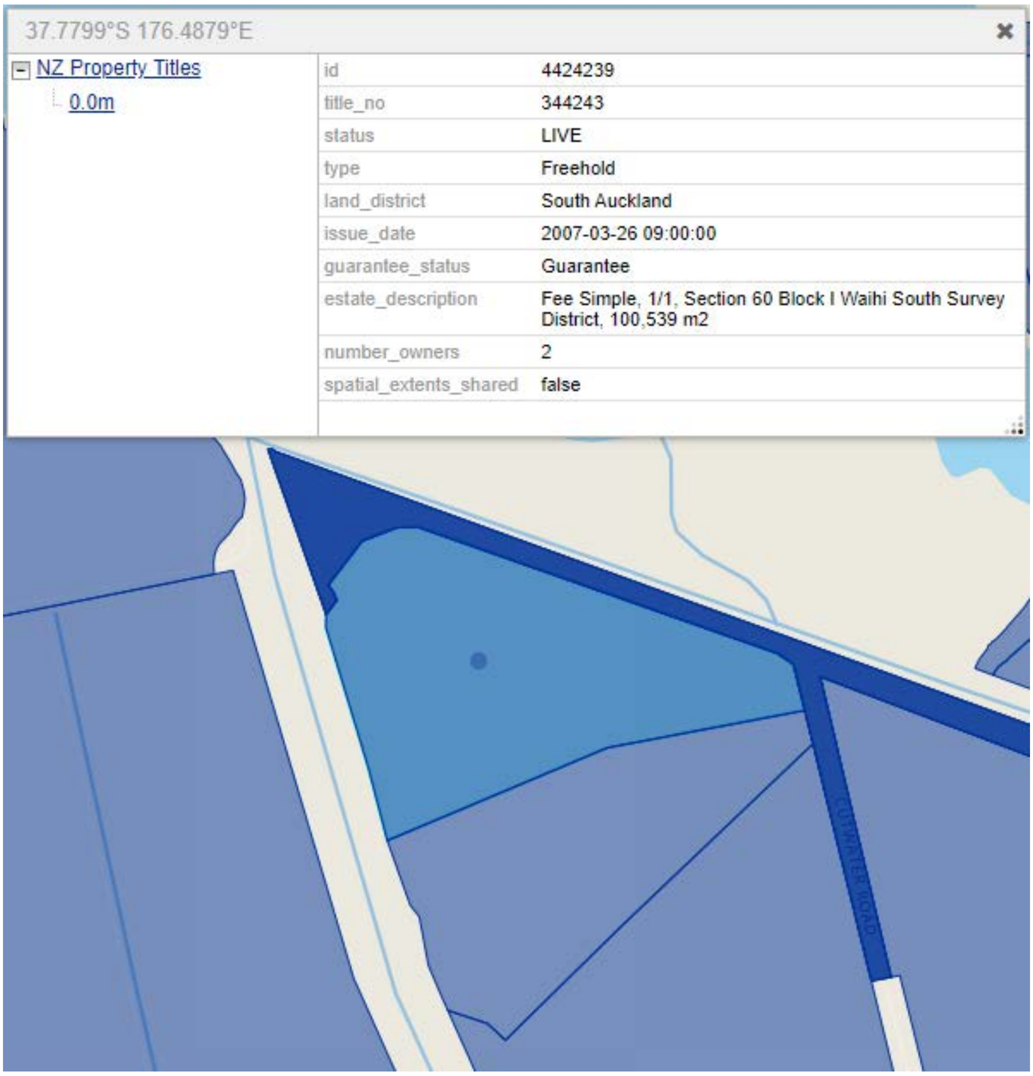
37.6314°S 175.9641°E

NZ Property Titles
0.0m

| | |
|---|---|
| id | 4885054 |
| title_no | 820916 |
| status | LIVE |
| type | Freehold |
| land_district | South Auckland |
| issue_date | 2018-12-06 17:01:14 |
| guarantee_status | Guarantee |
| estate_description | Fee Simple, 1/1, Lot 1 Deposited Plan 520441, 199,600 m2 |
| number_owners | 1 |
| spatial_extents_shared | false |

Source: LINZ online

The Pukehina/Waihi project site is registered with 2 owners:



37.7799°S 176.4879°E

NZ Property Titles
0.0m

| | |
|---|---|
| id | 4424239 |
| title_no | 344243 |
| status | LIVE |
| type | Freehold |
| land_district | South Auckland |
| issue_date | 2007-03-26 09:00:00 |
| guarantee_status | Guarantee |
| estate_description | Fee Simple, 1/1, Section 60 Block I Waihi South Survey District, 100,539 m2 |
| number_owners | 2 |
| spatial_extents_shared | false |

For projects on sites that lack a registered property title, almost invariably because they lie below high-water mark, or where the registered property title has a "water boundary" (i.e., the freehold title plan specifies the high-water mark as a boundary rather than a fixed line), the situation is more complex because of the effect of the Marine and Coastal Area (Takutai Moana) Act 2011.

For example, Farewell Spit:


## 5.3 TAKUTAI MOANA ACT 2011

The Marine and Coastal Area (Takutai Moana) Act 2011 (hereafter the Takutai Moana Act 2011) provides a scheme for recognition of Maori customary rights in the "common marine and coastal area" (CMCA). This covers all land below mean high water springs that is not already in private title or set aside as a Crown reserve.[45]

[45] Section 9 Takutai Moana Act 2011. Definition of "common marine and coastal area".

Section 11 of the Act is very significant in terms of and ownership because it provides:

> ***11 Special status of common marine and coastal area***
>
> *(1) The common marine and coastal area is accorded a special status by this section.*
>
> *(2) Neither the Crown nor any other person owns, or is capable of owning, the common marine and coastal area, as in existence from time to time after the commencement of this Act.*
>
> *(3) On the commencement of this Act, the Crown and every local authority are divested of every title as owner, whether under any enactment or otherwise, of any part of the common marine and coastal area.*
>
> *(4) Whenever, after the commencement of this Act, whether as a result of erosion or other natural occurrence, any land owned by the Crown or a local authority becomes part of the common marine and coastal area, the title of the Crown or the local authority as owner of that land is, by this section, divested.*

The CMCA excludes private freehold land titles which have fixed boundaries (as opposed to “water boundaries” noted above, where the freehold title plan uses the high-water mark as a boundary) and most Crown reserves. It includes all other Crown land and local authority land which is now, or may become subsequently through erosion, below the line of mean high-water springs (even of those Crown and local authority titles have fixed boundaries).

Accordingly, the discussion that follows about customary rights orders under the Takutai Moana Act 2011 refers to controls that generally extend to the mean high water springs mark, unless a coastal freehold title with fixed boundaries reduces part of the area to the lower “mean high water” level or a Crown reserve extends below high water and has a fixed boundary.

It is also important to note that, depending on the slope of the foreshore across a project area, “mean high water springs” may differ significantly from “mean high water”.

Mean high water springs are “the long-term average of the highest high tide (‘spring tide’) that occurs after every new and full moon.”[46] More technically, “[t]he average of the levels of each pair of successive high waters, … during that period of about 24 hours in each semi-lunation (approximately every 14 days), when the range of the tide is greatest (Spring Range).”[47]

Mean high water mark is the mean of the high-water mark over a long period, not just the mean at the spring high tide level. Many freehold land titles use this measure. This is because the Crown grants from which many private freehold titles are derived have their seaward boundary defined as “the line of high-water mark at ordinary tides”.[48]

While the Takutai Moana Act 2011 provides that the CMCA is owned by no-one, they are subject to any pre-existing customary interests. Recognition of those interests may only occur via a High Court order or through direct negotiation with the Crown. Both processes are provided for under the Takutai Moana Act 2011, which also sets out the legal effect of the recognition of customary rights. Public access across the entirety of the CMCA for navigation and recreation is provided under the Act, and customary interests may affect those rights in some very limited situation and over limited areas (wahi tapu areas - described below).

---

[46] https://niwa.co.nz/publications/cou/no13-2007/a-better-way-to-define-the-foreshore

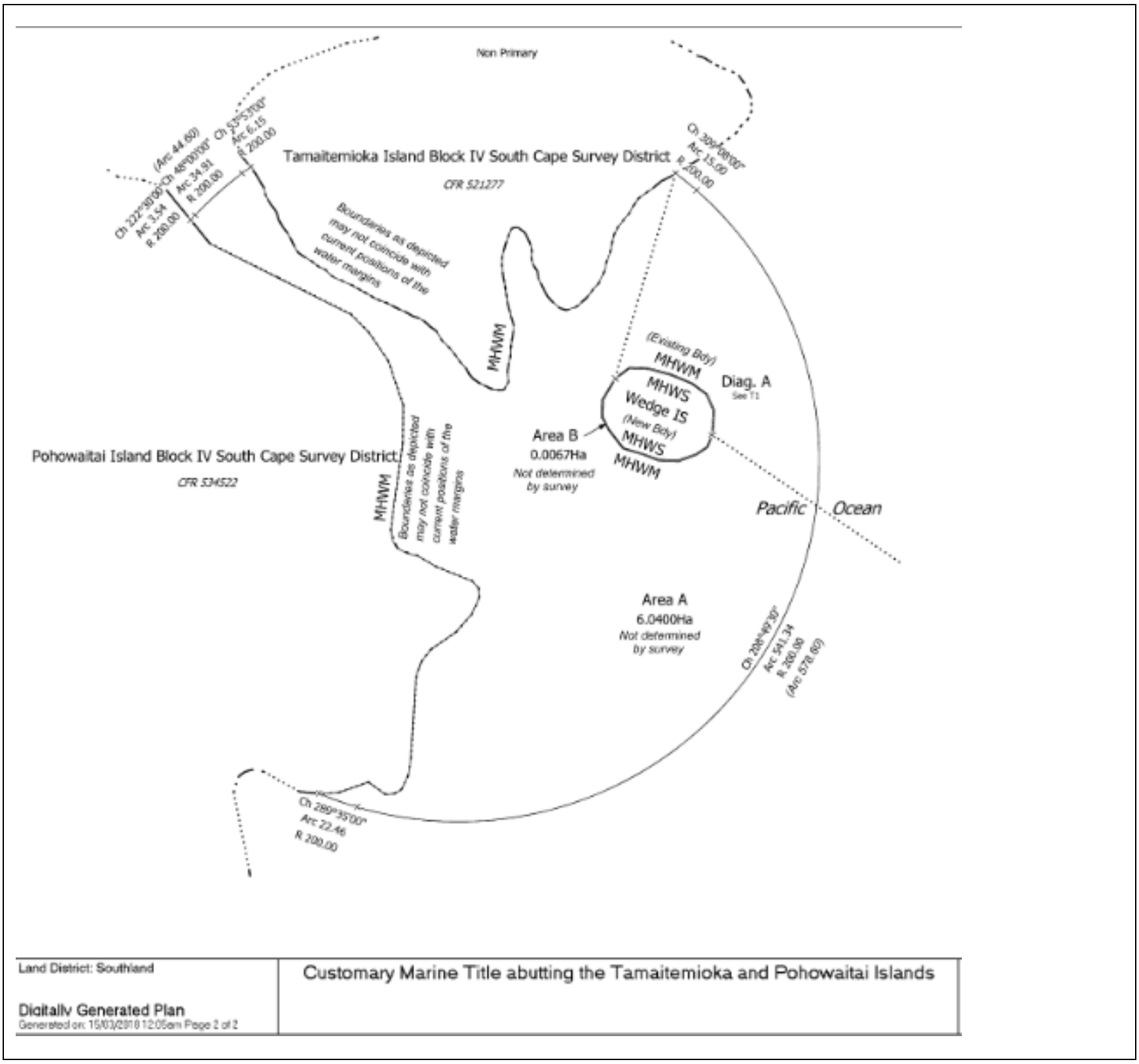
[47] https://www.linz.govt.nz/sea/tides/introduction-tides/definitions-tidal-terms

[48] For example, the Crown Grants Act 1908 s35 defined the seaward boundary of Crown grants in this way - https://qualityplanning.org.nz/node/739

Applications for orders to recognise customary interests have to be made by or on behalf of an iwi, hapū, or whanau and had to be filed by 1 April 2017. Over 350 applications have been filed, most overlapping, and they together cover the entire NZ coastline. The applications are listed on a High Court website.[49]

Only one order has to date been granted, for a tiny, remote area of just over 6 hectares off the South Island, adjoining a Maori land block.[50] Three further interim decisions have been made granting orders in the Bay of Plenty region (around Whakatane, Napier and Tauranga) and orders in the North Island, pending the resolution of appeals and the preparation of maps.[51]

The map accompanying the first (and so far, only recognition order) is shown below:




[49]https://www.courtsofnz.govt.nz/the-courts/high-court/high-court-lists/marine-and-coastal-area-takutai-moana-act-2011-applications-for-recognition-orders/

[50] *Re Tipene* [2016] NZHC 3199.

[51] *Re Edwards (Te Whakatōhea No 2)* [2021] NZHC 1025, *Re Reeder (Ngā Pōtiki Stage 1 – Te Tāhunga o Rangataua)* [2021] NZHC 2726, *Re Ngāti Pahauwera* [2021] NZHC 3599.

Recognition of customary interests comes in two forms:

- A Protected Customary Rights order (PCR).
- A Customary Marine Title Order (CMT).

The main effect of these orders is to alter the application of the Resource Management Act 1991 to the areas that they cover. Since that regime governs what activities can and cannot be undertaken in the area below mean high water springs, the effect of recognition orders is discussed as part of the consideration of the RMA regime below.

## 5.4 THE RESOURCE MANAGEMENT ACT 1991

The RMA 1991 is a comprehensive planning regime of sustainable management over all activities occurring on land and the foreshore and seabed from mean high water springs out to 12 nautical miles – the extent of the territorial sea.

District and councils manage most planning above mean high water springs, regional councils manage planning below that mark, including regulating the use of water and discharge of contaminants.

There are 16 regional coastal plans, and as many regional water plans and plan regulating the discharge of contaminants.

The default regime for activities that take place above mean high water springs is generally permissive ie activities may be undertaken unless a district or city plan regulates them in some manner.

In contrast, for activities involving:

- Use of water, whether above or below the high tide mark, including water diversion and damming;
- Contaminants in water (including sediment);
- Activities below the mean high water springs that interfere with the soil of the foreshore and seabed;

the default regime is restrictive. For most non-trivial activities involving water, contaminants and interference in the foreshore/seabed, a regional coastal plan and/or a regional water plan needs to permit that activity or a resource consent[52] is required.

This includes:

- Any taking, use, damming or diversion of any water – water permits:[53]
- Discharging any contaminant or water into water; or contaminant onto or into land in circumstances which may result in that contaminant entering water – discharge permits.[54]

Below mean high water springs (coastal permits):[55]

- Any reclamation or draining;
- Erecting, altering or demolishing any structure;
- Disturbing the foreshore and seabed "(including by excavating, drilling, or tunnelling) in a manner that has or is likely to have an adverse effect on the foreshore or seabed (other than for the purpose of lawfully harvesting any plant or animal)";

---

[52] Resource consents are acquired from local government entities with jurisdiction over the particular activities concerned.

[53] Section 14(2)-(3).

[54] Section 15(1)(a)(-(b).

[55] Section 12.

- Destroying, damaging or disturbing "any foreshore or seabed (other than for the purpose of lawfully harvesting any plant or animal) in a manner that has or is likely to have an adverse effect on plants or animals or their habitat";
- Introducing or plant any exotic or introduced plant;
- Occupying any part of the foreshore and seabed;
- Removing any sand, shingle, shell, or other natural material.

Most of the blue carbon activities which have been proposed are "rewetting tidal wetland" (Te Repo ki Pūkorokoro, Wainui Repo Whenua, Pukehina/Waihi, Waimeha Inlet).

The Tasman Environment Trust (TET) have usefully detailed what this activity can typically involve:

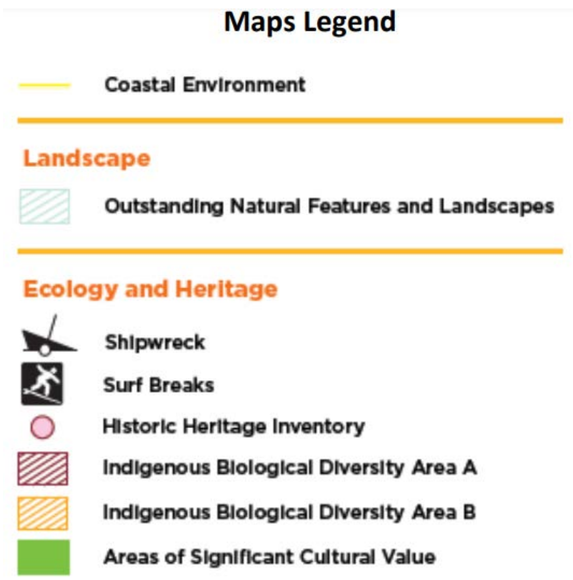
- *Revegetation of tidal mudflats.*
- *Improving water quality and altering sediment supply through riparian revegetation (e.g., reducing nutrient loads leading to improved water clarity to expand seagrass meadows, recovering tidal and other hydrologic flushing and exchange or reducing nutrient residence time).*
- *Revegetation of native plant communities (e.g., reseeding or replanting).*
- *Improving management practice(s) (e.g., removing invasive species, reduced grazing).*
- *Creating accommodation space for wetlands migrating with sea-level rise.*
- *Native revegetation of the 30m coastal margin*

From the above, it can be seen that very passive management, such as simply allowing regeneration of native species, might fall outside the default settings in the Act, and not require any rule in a regional plan to expressly permit it, or need to get a resource consent.

However, any form of active management would inevitably involve alteration of water flows and the soil of the foreshore or seabed and therefore be subject to regional plans. So, if rewetting involves removing working tidal flood gates, or otherwise channelling seawater onto the land, then a rule in a regional plan would have to permit that activity, or a consent would be required. Similarly, replanting would involve soil disturbance. Even removing invasive species such as mangroves would be subject to plan rules.

As an example, the Wainui Repo Whenua project is included in the Bay of Plenty Regional Coastal Plan and is shown on three maps in that plan as follows:[56]


[56] Maps 07a-c Aongatete/Pahoia. at https://www.boprc.govt.nz/your-council/plans-and-policies/plans/regional-plans/regional-coastal-environment-plan

| | |
|---|---|
|  |  |

These show that the site is simultaneously part of "Indigenous Biological Diversity Area A" (purple shading), an area of "Outstanding Natural Features and Landscapes" (blue shading) and an area of "Significant Cultural Value" (green colouring).

The rules in the plan generally provide that activities must not have adverse effects on certain biological diversity and landscape characteristics of the site.

Wetland enhancement is specifically provided for, for example:

**Rule DD 5** **Permitted – Planting indigenous plant species**

The disturbance of the foreshore and seabed associated with the planting of indigenous plant species is a permitted activity, subject to the following conditions:

(a) The disturbance of the foreshore or seabed shall be limited to the extent necessary to carry out the activity; and

**Rule DD 6** **Permitted – Wetland enhancement in the Coastal Marine Area**

The modification of a wetland in the coastal marine area for the purposes of wetland maintenance or enhancement, where:

1 The activity is undertaken in accordance with either:

(a) A Coastal Wetland Management Agreement or Biodiversity Management Plan with the Regional Council; or

(b) A Reserve Management Plan prepared by a district or city council, the Department of Conservation, or the Regional Council; or a Conservation Management Strategy prepared by the Department of Conservation.

The Plan also includes specific rules for mangrove management, including:

| | | |
|---|---|---|
| 2.3.2 | **Rules for mangrove management** | |
| | **Rule DD 19** | **Permitted – Removal of mangrove seedlings**<br><br>The removal of mangrove seedlings is a permitted activity where:<br><br>1 It is within an area that has been subject to a seedling removal resource consent and there are no established mangroves in the area; or<br><br>2 Seedling removal does not occur within 5 metres of established mangroves; and<br><br>3 There is no disturbance of, or removal of seedlings from within, areas of established mangroves. |
| | **Rule DD 21** | **Controlled – small-scale removal of mangroves as part of a wider ecological enhancement or restoration project**<br><br>Removal of mangroves is a controlled activity where:<br><br>1 The activity is not in an Indigenous Biological Diversity Area A; and<br><br>2 A report from a suitably qualified and experienced ecologist has assessed that the adverse effects on threatened indigenous species will be no more than minor and whether the mangroves to be removed provide significant habitat for threatened or at risk indigenous species; and<br><br>3 The activity is undertaken in accordance with an approved Harbour Margins Restoration Plan, Wetland Management Agreement, Biodiversity Management Plan or an approved catchment plan. |

Note that small-scale removal could not occur under Rule DD 21 because that rule does not apply to sites that are "Indigenous Biological Diversity Area A". A more restrictive regime would apply and is set out later in the plan.

Separately, the Bay of Plenty Regional Natural Resources Plan includes rules governing water flows and quality in wetlands and matters related to that, such as restoration activities. For example:

| | |
|---|---|
| **WL R1 (Rule 78)** | **Permitted – Introduction of Indigenous Plants into a Wetland**<br><br>The introduction of indigenous plant species into a wetland for the purposes of wetland enhancement is a permitted activity subject to the following conditions;<br><br>(a) Only indigenous plant species that naturally occur (or would have likely to have naturally occurred in the past) at that locality shall be introduced into the wetland.<br>(b) The disturbance of the wetland, including damage to indigenous vegetation, shall be no more than minor. |

| | |
|---|---|
| **WL R2 (Rule 79)** | **Permitted – Wetland Maintenance and Enhancement Under a Registered Management Document** |

Any modification of a wetland for the purposes of wetland maintenance or enhancement where:

1 The activity is undertaken in accordance with:
   (a) A Regional Council Environmental Programme that specifically includes the wetland works, or
   (b) A Wetland Management Agreement with the Regional Council, or
   (c) A reserves management plan prepared by a district or city council, the Department of Conservation, the Regional Council, or Fish and Game NZ; or a Conservation Management Strategy prepared by the Department of Conservation.

And

2 The activity is consistent with WL P3; and

3 The activity is restricted to the activities in (a) to (i) inclusive:
   (a) Where the activity is the removal of exotic plant species and rubbish using machinery, and the activity is not otherwise permitted by WL R6, the activity shall comply with (i) and (ii):
      (i) The machinery shall be kept out of the bed of the wetland where practicable; and
      (ii) The disturbance of the wetland shall be limited to the extent necessary to carry out the activity.
   (b) Where the activity is the construction and use of structures, the structures shall be for the purpose of improving amenity values, or providing access to a wetland. This includes, but is not limited to, boardwalks within a wetland. **Note:** Mai mai are addressed by BW R26.
   (c) Where the activity is the diversion of water within a wetland, the activity shall not cause flooding or ponding on any land or property owned or occupied by another person.
   (d) Where the activity is the damming of water within a wetland, the activity shall comply with (i) to (xiii) inclusive:
      (i) The wetland is not located in a stream or river.

As this example demonstrates, the rules that will apply to any project site under the regional plans that apply to the coast and water (and the district land if works above high-water mark are included) are varied and complex. The project sites fall under different regions and different plans apply in each place.

However, in general, as this example also illustrates, activities that enhance indigenous biodiversity and restore wetlands are likely to be permitted or otherwise relatively lightly controlled and encouraged under regional coastal plans and regional water plans.

As noted above, the Takutai Moana Act 2011 modifies this regime.

Under a Protected Customary Rights order (PCR), the holders of the order may, below mean high water springs, undertake customary activities regardless of rules in any plans under the RMA 1991 governing water, the foreshore and seabed and contaminants. These are activities involve the collection of traditional resources such as sand, shells, driftwood and the like. Regional councils are forbidden from issuing resource consents under regional plans which have more than minor effects on the activity, unless the holders of the order agree. There is nothing to prevent holders privately charging a rental for giving permission.

Under a Customary Marine Title Order (CMT), the holders of the order have a right of veto over the issue of any resource consent falling within the area of the order. There is no requirement to give reasons. Once again, there is nothing to prevent holders privately charging a rental for giving permission, although once given, permission cannot be withdrawn.

Within a CMT, rights holding groups may also apply to have areas set aside as wahi tapu, and restrict public access to them. Consequently, if any project area should in the future become subject to orders of this nature, they have the potential to complicate the ability to obtain resource consents for the activity.

By way of example, the Wainui Repo Whenua site is subject to three applications for customary orders from Nga Hapu o Ngai Te Rangi, Nga Hapu o Ngati Ranginui, and Ngati Pukenga.[57] Two of those groups have recently been successful in obtaining CMT orders held on a joint basis for an area in the eastern extremity of the Tauranga harbour about 15km from the project site. A hearing, and possible final orders for this area for CMT or PCR are some years off.

A separate regime applies under the Ngā Rohe Moana o Ngā Hapū o Ngāti Porou Act 2019, but none of the projects lies within the area covered by that Act.

## 5.5 CARBON SEQUESTRATION – WHO HOLDS THE RIGHTS?

Projects need a carbon rights holder, being the landowner or an entity to which the carbon rights have been legally assigned by the landowner.

If the land on which the project is established is in a private freehold title with fixed boundaries, including parts currently or intended to be below mean high-water springs, what we might call a “land-based blue carbon project”, the situation is relatively straightforward. The definition of land includes all things attached to the land, whether underwater or not, and would include the store of carbon associated with the plants in a regenerating wetland.

The fact that a project requires resource consents does not affect the underlying ownership, just as the need to obtain such consents would not affect ownership of a forest development on private land.

If the land is underwater and part of a Crown reserve (and therefore not part of the common marine and coastal area), rights would accrue to the Crown as landowner.

If the land falls within the CMCA, either through parts of private freehold titles having water boundaries or being former Crown or local authority land now underwater (whether boundaries are fixed or not), section 11 of the Takutai Moana Act 2011 provides that no one owns or can own those areas. We might call these “marine-based blue carbon projects”.

Since any blue carbon development in the CMCA requires resource consents, the next question is whether the consenting regime under the RMA 1991 provides anything approximating a property interest.

While section 122(1) provides that "[a] resource consent is neither real nor personal property" it nevertheless provides that on the death of the holder of the consent, it passes to their personal representative, and, on bankruptcy, passes to the Official Assignee[58] in both cases "as if the consent were personal property".

The holder of a resource consent may also grant a charge over the consent as if it were personal property, "but the consent may only be transferred to the chargee, or by or on behalf of the chargee, to the same extent as it could be so transferred by the holder."[59]

Section 122 also provides:

---

[57] Te Kete Kōrero a Te Takutai Moana Information Hub:

https://maca-nds.maps.arcgis.com/apps/MapSeries/index.html?appid=1ed9665a8d2c4d38b4f9ddcb2d186f1b

[58] Section 122(2)(a)

[59] Section 122(3).

*(6) Except to the extent—*

*(a) that the consent expressly provides otherwise; and*

*(b) that is reasonably necessary to achieve the purpose of the consent,—*

*no coastal permit shall be regarded as an authority for the holder to remove sand, shingle, shell, or other natural material as if it were a licence or profit à prendre.*

Sections 135 to 137 provide for transfers of coastal permits, water permits and discharge permits, in each case subject to whatever rules may apply to limit such transfers in plans and/or conditions that may be applied by consent authorities.

One possible further issue is that coastal permits, water permits, and discharge permits cannot be granted for longer than 35 years[60] and must be renewed when they expire. The existing consents continues to operate while the new one is sought.[61]

However, some security around renewal is provided by the requirement that, in assessing the renewed application, if there are competing applications for the same resource, the consent authority must give priority to processing the application by the existing consent holder.[62]

The consent authority must also assess:[63]

- The efficiency of the existing holders use of the resource,
- The "use of industry good practice by the person",
- Whether there have been any recent enforcement actions taken against the consent holder.

Taken together, these provisions amount to a pseudo-property rights regime for resource consents, within the constraints set out in the Act.

Under this regime, marine farm consents are commonly traded as arguably the most valuable component of the farm. Consents for sand mining have also been traded, and one case has even held that jointly held consents are subject to the common law rule of survivorship on the death of one of the holders.[64]

In terms of the five key incidents of ownership:[65]

1. The right to exclude: coastal permits are required to preserve public access as far as they reasonably can, Section 6(d) RMA 1991. but the consent would prevent interference in or taking of any of the regenerating biomass. In the same manner that marine farm consents allow recreational use around structures, but no interference with them or the biomass growing on them. Related to this, in 2005 the High Court held that a regional council could not issue further water permits which undermined or affected extremely valuable water permits it had previously issued to a hydroelectric generator – applying to resource consents a principle from property law known as 'non-derogation from grant'.[66]

[60] Section 123(c)-(d).

[61] Section 124.

[62] Section s124B(3).

[63] Section 124B(4).

[64] *Armstrong v Public Trust* [2007] NZLR 859 per Fogarty J (HC).

[65] Taken from Johnson 2007.

[66] *Aoraki Water Trust v Meridian Energy Limited*, [2005] 2 NZLR 268.

2. The right to possess: possession is limited by the public right of access, but the rights which are held are protected by 'non-derogation from grant'.
3. The right to use: coastal, water and discharge permits provide rights to use.
4. The right to alienate (or transfer or dispose of); there is a limited regime under the RMA 1991 in the coastal which is currently operational in relation to marine farms, sand mining, white bait stands and the like.
5. The right to receive income: marine farms, sand mining, and white bait stands all provide the ability to derive income from a time limited and partial occupation of sea space.

The discussion above means that it would be important to understand whether the plan rules which apply to any project area manage transfers in any way, and for consent conditions to be carefully crafted to allow for, or at least not to impede, transfers.

Finally, if the foreshore or seabed is in the CMCA and is subject to CMT or even PCR orders, the customary rights holders may seek a private rental or seek to become partners in any projects.

## 5.6 CONCLUSION

The legal feasibility for a blue carbon project is determined by a combination of:

- Property rights under the common law and statute law,
- The sustainable management regime under the Resource Management Act 1991 which governs uses that can be made of land and water, whether above or below the high tide mark, and
- The ability to establish carbon contracts based on sequestration below the high tide mark.

It is useful to divide projects into land-based blue carbon projects and marine based blue carbon projects.

Land-based blue carbon projects are projects situated on land above mean high water mark, or, for any land below mean high water mark, there is a registered property title with a fixed survey line. Projects with those underlying property conditions are legally equivalent to a private forest when considering property and associated carbon contract rights. While resource consents may be required for some of the activities, such as diverting water to flood the land, that is the legal equivalent to obtaining consents for establishing and manage trees in a private forest.

Marine based blue carbon projects are projects falling outside of the above conditions, ie situated on land below high water mark either without any registered title, or with a registered title that denotes "high water mark" as a boundary in words instead of a fixed line (known as a "water boundary"). The situation for projects having these underlying property conditions is more complex. No property ownership of those areas is possible, whether by the state or private persons. The only interest potentially available, and potentially tradeable, is the sole right under a resource consent (called a 'coastal permit') to manage the flora in that area of foreshore and seabed for a period of up to 35 years (the term being specified in the consent, and consents are renewable for further terms). In addition, if that area of foreshore and seabed is subject to a customary marine title order, permission must be sought from the Māori holders of the order before rights under the consent can begin to be exercised. In terms of resource consents that might be required under the RMA 1991 for each type of project, for land-based blue carbon projects, for passive management activities such as natural regeneration of indigenous vegetation that does not involve alteration to water flows or soil of the foreshore, resource consents are unlikely to be required by any plan under the RMA 1991. However, for any form of active management such as the alteration of water flows (e.g., through removing tidal flood gates or channelling of seawater, re replanting in any areas of foreshore or seabed within fixed boundaries in a registered title), RMA plans are likely to require resource consents to be obtained.

For marine based blue carbon projects, similarly, passive regeneration of foreshore and seabed is likely to be a permitted activity under the regional coastal plan, and active management activities such as clearing existing vegetation and replanting, are likely to require resource consents. This means that, for passive regeneration projects in the foreshore and seabed, since no-one owns those areas, there is no interest generated via the need for consents under the RMA that could be used in a carbon sequestration scheme.

Are land-based blue carbon projects legally feasible? In principle yes. In practice, it will depend on each situation.

Are marine based blue carbon projects legally feasible? In principle, possibly, but there are significant challenges to be addressed and would likely need to be tested in practice.

The legal feasibility assessment found the following results for the project sites examined:

| **Project Land Type** | **Intervention** | **Ability to establish property rights** | **Require regional plan permission or consent** | **Ability to establish carbon rights** |
|---|---|---|---|---|
| **Land-based project** | Without alteration of water flows | Yes | No | Yes |
| | With alteration of water flows | Yes | Yes | Yes |
| **Marine-based project** | Passive regeneration | No | No | No |
| | Active regeneration (clearing, replanting) | No | Yes | Yes |

# 6 Organizational Feasibility

*Task: Identify partners and organisations to be involved in project development, and their prospective roles; consider context of a grouped (i.e., multiple) project approach.*

The project development cycle for a blue carbon project involves the synthesis of technical and business elements of project function. Organizations involved in project development, therefore, need to deliver both technical and business outputs (Table 6.1).

*Table 6.1. Blue carbon project development cycle.*

| Step | Output | Description | Outcome |
|---|---|---|---|
| 1 | Feasibility Assessment (this report) | High-level scoping study. | Enables decision on whether to proceed to project development at any of the case study sites. |
| 2 | Project Business Case | Preliminary management plan and business plan (sometimes called a Project Idea Note). | Investment ready for full project development. |
| 3 | Project Description | Comprehensive management plan and business plan. | Validation ready.<br>Investment ready for project implementation. |
| 4 | Project Validation Report | Result of validation audit by a VCS accredited validation/verification body. | Project is valid and can be implemented and fully registered in the VCS system. |
| 5 | Project Management Reports | On-going activities reported in annual and sub-annual reporting. Verification of output delivery subject to project controls defined in Project Description. | Tidal marsh restoration activities are delivered, verified and reported. |
| 6 | Project Monitoring Reports | Carbon accounting from actual data from project delivery milestones according to the project verification cycle. There is a maximum timeframe in the VCS (5-yearly) for project verifications. | Project is being implemented according to the Project Description and is verification ready. |
| 7 | Project Verification Reports | Result of verification audit by a VCS accredited validation/verification body. | Carbon benefits for reporting period verified and carbon credits issued in carbon registry. |
| 8 | Carbon credit monetization | Carbon revenue allocated according to project business plan component of Project Description. | Carbon revenue received. |
| 9 | Carbon revenue investment | Annual financial management of project to enable the project to be financially sustainable. | Project operational costs, opportunity costs, and debt servicing costs have been met. |
| 10 | Repeat steps 5-9 over project period | | The project is financially sustainable and causing target outcomes. |

## 6.1 TECHNICAL AND BUSINESS ELEMENTS

The management plan and business plan for the delivery of all project elements is contained in the Project Description comprising a series of documents, spreadsheets, shapefiles and other data that in their aggregate form the implementation plan for the project.

The technical components of the Project Description are guided at a high resolution by the VCS Standard and methodology and focus on carbon accounting and resource management components of the proposed project. For example, the VM0033 Methodology has detailed requirements for the following project elements:

- Applicability conditions.
- Project boundaries.
- Baseline scenario.
- Additionality.
- Quantification of baseline and project emissions.
- Monitoring.

The business components (governance, financial, and project management elements) of a project are guided at a low resolution by the VCS standard and methodologies (which are weighted towards technical elements). For example, the VM0033 requires projects to provide details of land rights and user rights for the project area and requires the application of the VCS AFOLU[67] Non-Permanence Risk Tool for the calculation of buffer credits for project self-insurance. This VCS AFOLU Non-Permanence Risk Tool identifies three main classes (and associated sub-classes) of project risk requiring assessment:

- Internal risk.
    - Project management risk.
    - Financial viability risk.
    - Opportunity cost risk.
    - Project longevity risk.
- External risk.
    - Land and resource tenure risk.
    - Community engagement risk.
    - Political risk.
- Natural risk.
    - Fire
    - Pest and diseases.
    - Extreme weather.
    - Geological events.
    - Other natural risk.

The AFOLU Non-Permanence Risk Tool provides requirements for each of these risk elements, but the method of delivery of risk mitigation for each is up to project developers to determine and will form important components of the business plan elements of the Project Description.

There are also additional project risk elements of the business plan component of the Project Description. These include project internal risks such as project governance risk, investment risk, and project permanence beyond the project period.

The Climate Community and Biodiversity Standard (CCB)[68] offered by Verra/VCS provides guidance for the provision of community and biodiversity co-benefits with community safeguards that would reduce some aspects of project governance risk. These are guided by the following safeguard requirements:

- Identify all stakeholders and ensure their full and effective participation.
- Recognize and respect customary and statutory rights.
- Obtain free, prior and informed consent.

[67] Agriculture, Forestry and Other Land Uses (AFOLU).

[68] The CCB is a programme of Verra, which operates the Verified Carbon Standard and the SD VISta standard.

- Assess and monitor direct and indirect costs, benefits and risks.
- Identify and maintain high conservation values.
- Demonstrate net positive climate, community and biodiversity benefits.

For VCS projects, these risk mitigation components are optional (i.e., application of the CCB standard is not a requirement for blue carbon (or any) projects).[69]

### 6.1.1 Investment Risk

Two key investment decisions need to be made for a carbon project to proceed and upon which the entire project depends. These decisions are made by the two primary stakeholders in the project:

1. A decision by the landowner to undertake the project and provide the land capital investment.
2. A decision by the funder/investor to undertake the project and provide the financial capital investment.

Ideally, these decisions will be informed by high resolution due diligence on all project costs and benefits that result from full project development. Full project development though, typically costs tens of thousands of dollars (i.e., a significant part of the capital investment required for the project). This creates a chicken-and-egg situation whereby an investment in project development is required prior to the availability of a high-resolution analysis of project costs and benefits, the latter of which will inform the two key investment decisions described above.

This necessitates the commitment of the two key investors to an investment decision with imperfect information (a high-risk option). This risk is reduced when the Project Business Case (requiring a much smaller investment in project scoping) contains a conservatively modelled cost benefit analysis based on plausible preliminary carbon accounting projections. Such projections are easier to deliver when the organization/s involved in project development have a prior history of blue carbon project development and can draw upon proxy data from other projects. In a pioneering situation where prior project information is not available, full project development would ideally be funded by grant as a pilot project.

One of the purposes of a pilot project is to create data that can be used as proxy data in subsequent project development in a commercial financing setting. This will help reduce investment risk for those future projects, whereby each subsequent project incrementally reduces investment risk for those that follow.

Investment risk can be further reduced by ensuring that project development is adequately resourced (in terms of financial and human capability resources) in a manner that attends to a series of key investment risk elements, the mitigation of which is ideally included in the Project Description. In this way, the Project Description can function as the project management plan, project business plan and project operating manual.

The Project Description can then be validated to the VCS Standard (focusing on the technical aspects and a 'must-have' element) and to an investment standard (focusing on business aspects and a 'nice-to-have' element). At present there are no specific investment standards for carbon projects, but the equivalent of an investment validation exercise can be undertaken in the form of detailed due diligence by the primary stakeholders (landowner and investor). Alternatively, the business elements of the Project Description could be validated to a generic investment standard such as the Global Investment Performance Standards (GIPS)[70].

---

[69] In the Plan Vivo Standard community and biodiversity components are mandatory.

[70] The GIPS comprise a set of voluntary standards used to ensure the full disclosure and fair representation of investment models and investment performance (CFA Institute 2020). Available here: https://www.cfainstitute.org/-/media/documents/code/gips/2020-gips-standards-firms.ashx

Small projects would not likely justify costly investment validation, but larger scale investments will certainly benefit from such validation or similar in the form of due diligence scrutiny.

The VCS validation audit would need to be conducted by a VCS-accredited Validation and Verification Body (VVB),[71] and the investment validation could be conducted by an accounting firm or investment advisor.

Table 6.1.1 outlines key investment risk elements, the consequence of those risk remaining unmitigated and a means of mitigating them.

*Table 6.1.1 Project development investment risk elements and mitigation options.*

| **Investment Risk** | **Consequence** | **Mitigation** |
|---|---|---|
| Under-investment in governance elements | Disorganisation of project setup phase and project development proceeding prior to appropriate oversight. | • Budget[72] for and establish a project governance group/board as the first step in project development.<br>• Governance group/board should comprise key stakeholder representatives and clear governance rules. Key stakeholders will likely include project investors (landowner and capital investor), project leader, project technical coordinator. |
| | Poor strategic decisions by project leader that cause project delays or project failure. | • Budget for and undertake regular (e.g., quarterly) project governance meetings to provide transparent mandates to project leader and receive regular reporting on the delivery of these mandated outputs. |
| | Disputes that lead to parties exiting the project or causing delays. | • Budget for consultative and co-design processes among key project stakeholders during project development and implementation.<br>• Develop a dispute resolution protocol suitable to the parties involved. |
| Under-investment in business management elements | Failure to deliver project accountability to project governors and investors. | • Budget for and recruit a project leader who is accountable for all project outputs.<br>• Engage project leader with demonstrated capability to lead project across and provide necessary accountability.<br>• Clearly define project leader role description in relation to accountability to project governors and investors.<br>• Clearly define all internal roles and responsibilities to provide accountability to the project leader. |
| | Failure to coordinate project activities leading to non-delivery of key project dependencies. | • Budget for recruitment of project manager (could be part of the role of the project leader or a dedicated role).<br>• Engage project manager with demonstrated capability to manage a project with equivalent complexity.<br>• Budget for and acquire project management tools fit for purpose (e.g., project management software).<br>• Budget for a project management setup phase to establish all project controls prior to project development work being undertaken.<br>• Clearly define all internal roles, responsibilities, and lines of reporting in relation to project controls.<br>• Establish a project management committee to meet regularly (e.g., monthly) to provide project management oversight. |

[71] Accredited VCS VVBs can be found here: https://verra.org/project/vcs-program/validation-verification/

[72] It is common to under-price the provision of human resources and activities in carbon project development and this can lead to significant inefficiencies, time delays, and escalating costs. It is, therefore, important that budgets are accurate and arise from suitable due diligence including appropriate compensation rates for the skill sets required, all overhead costs, and contingencies. Many activities will take longer than originally expected, particularly in pioneering projects where previous project budget information is not available.

| Investment Risk | Consequence | Mitigation |
|---|---|---|
| | Failure to monetize carbon credits at projected carbon prices leading to investment failure. | • Budget for carbon credit sales and marketing activities.<br>• Engage carbon credit sales and marketing service provider or project team member with demonstrated capability.<br>• Engage carbon credit buyers/resellers with supply agreements sufficient to de-risk project investment resellers prior to project implementation.<br>• (Ideally) engage carbon credit buyers in supply agreements prior to project development. |
| | Failure to manage project carbon credit issuance, monetisation and project finances transparently. | • Budget for and engage project administrator with demonstrated capability.<br>• Establish and operate project administration systems for carbon credit and financial management. |
| | Failure to financially resource all project activities | • Accurately budget for all business and technical elements.<br>• Ensure that project revenues are sufficient to cover all project costs, including contingencies.<br>• Establish and manage project financial controls to ensure that financial resources allocated to activities are delivered to those activities. |
| Under-investment in technical elements | Failure to create carbon credits and loss of carbon credit sales revenues to fund the project. | • Budget for and recruit a technical coordinator with demonstrated capability to lead technical elements of project development.<br>• Budget for the comprehensive delivery of all technical elements through detained budget planning for each technical requirement of the methodology.<br>• Ensure that the technical components to be delivered are restricted in type and scope to what is necessary and material to the carbon project. This helps avoid the proliferation of 'nice-to-have' project components that may be interesting but are ultimately immaterial and can escalate project costs.<br>• Engage technical service providers/technical staff with demonstrated capability to deliver technical elements, and budget for the likely higher rates of pay that this will tend to require. This will reduce the risk of costly delays that can arise when less competent participants are involved.<br>• Provide technical training for the project development team specific to carbon projects, and resource this with training providers with experience in carbon project development.<br>• Ensure technical elements are delivered efficiently (guided by a project manager with demonstrated capability). |
| Under-investment in community relations | Disputes with community stakeholders that damages project reputation and causes project delays. | • Develop a community consultation plan.<br>• Budget for and engage with community consultation activities in the community consultation plan. This should include consultation at an early stage in project development to enable community inputs into project design. For example, a local tangata whenua, and/or a local community conservation group may have important local ecological knowledge that would benefit project design and implementation and reduce the risk of conflict with such local groups. |
| | Negative publicity about the project leading to conflict and delays. | • Develop and implement a project communications plan.<br>• Ensure project communications plan has appropriate controls such as specific communication roles and responsibilities. |

## 6.2 ORGANIZATIONAL STRUCTURE

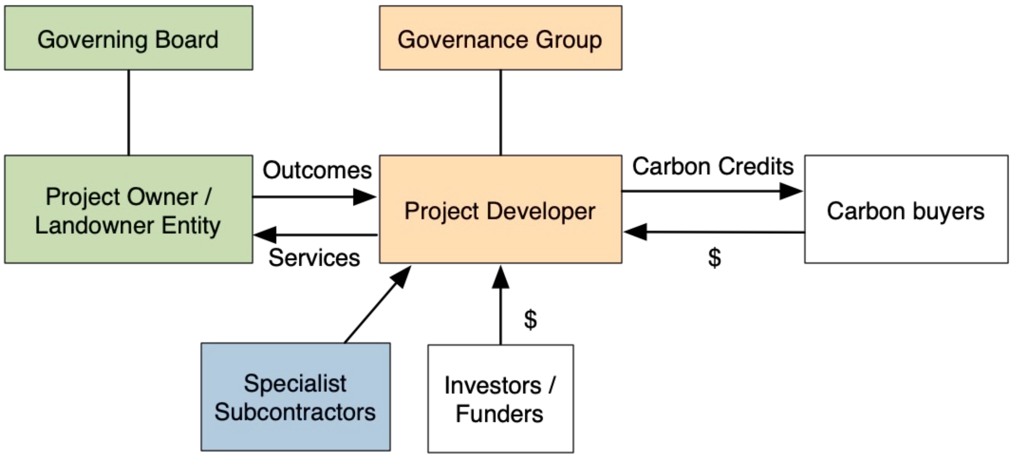
Project development and implementation requires an organizational structure with the following elements as shown in Table 6.2.

*Table 6.2. Organization elements for a blue carbon project.*

| Stakeholder | Description |
|---|---|
| Carbon rights holder | The carbon rights holder can be the landowner or an entity to which the carbon rights have been legally assigned by the landowner. The carbon rights holder is the project owner and needs to exist as a single legal entity |
| Governing Board | Provides a transparent mandate for all strategic decisions relating to project development. |
| Project developer | The project developer is the entity that takes responsibility for project development and implementation. |
| Specialist subcontractors | The project developer may require the services of specialist subcontractors for specific tasks that are either beyond the capability of the project developer or are more efficiently undertaken by a subcontractor. |
| Programme Operator | When a programme of activities is undertaken with several projects developed and operated concurrently and when a project is to be scaled up it is necessary to have an entity to coordinate activities across all projects. A programme operator functions as a project development coordinator and can provide some elements of project development that are most efficiently undertaken across several projects. This can include:<br>• Programme design & maintenance.<br>• Programme promotion and project recruitment.<br>• Investment analysis and investment portfolio packaging for each investment cycle.<br>• Raising capital.<br>• Carbon credit marketing and sales.<br>• Project design and investment modelling.<br>• Recruitment and project management of project development entities.<br>• Operation of programme quality system including quality controlling:<br>    o Project financing & investment.<br>    o Project recruitment.<br>    o Project design.<br>    o Project development.<br>    o Project implementation.<br>    o Carbon credit monetization.<br>    o Revenue disbursement & benefit sharing.<br>• Government relations, policy and advocacy.<br>• Coordinating programme resourcing where necessary.<br>• Fundraising for co-financing grants from local and central government. |
| Carbon standard | The VCS Standard has been identified as the standard for blue carbon project development. |
| Validation and Verification Body (VVB) | Validation of the Project Description and verification of project monitoring reports is undertaken by a validation and verification body (VVB) that is accredited to the VCS Standard. A list of accredited VVBs is provided on the VCS website: https://verra.org/project/vcs-program/validation-verification/ |
| Carbon registry | The VCS has its own carbon registry that issues and tracks carbon credits for projects. |
| Carbon credit reseller/s | A carbon credit reseller is an entity that brokers carbon credit sales by functioning as an intermediary between carbon buyers and sellers. Examples of carbon credit resellers in Aotearoa New Zealand include Ekos, Toitū Envirocare, and Carbon Click. |
| Carbon credit buyer/s | Carbon credit buyers include:<br>• End users of carbon credits (i.e., using the carbon credits to offset residual emissions as part of a net zero carbon exercise).<br>• Traders who buy carbon credits for purposes of arbitrage (buying and then on-selling at a higher price) |
| Investor/s | This includes Grant providers and/or investors. |

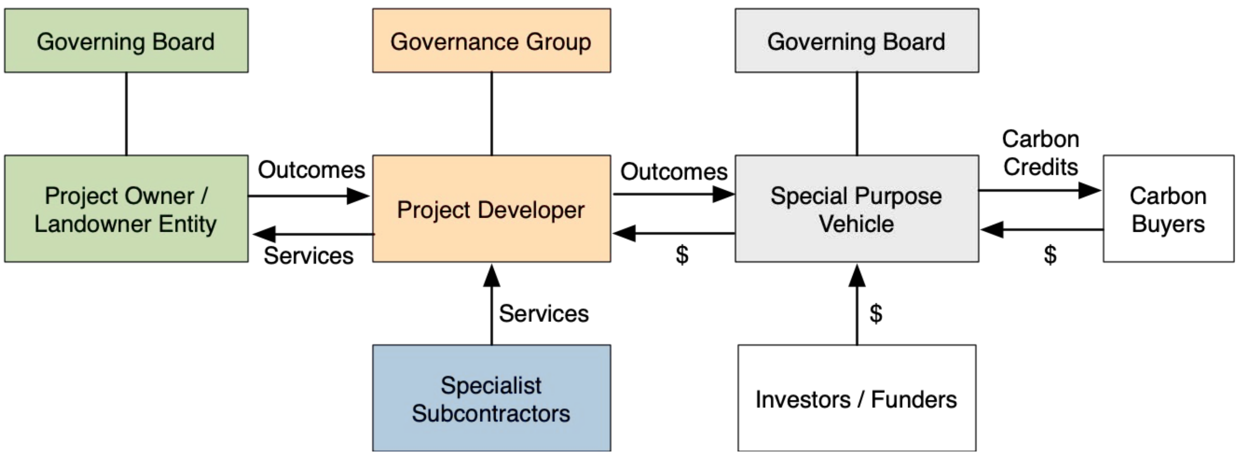
Small projects that do not involve a private investor (e.g., where project development is funded by a grant) can have a simple organizational structure as shown in Figure 6.2a.

*Figure 6.2a. Possible organizational structure for a blue carbon project funded by grant.*



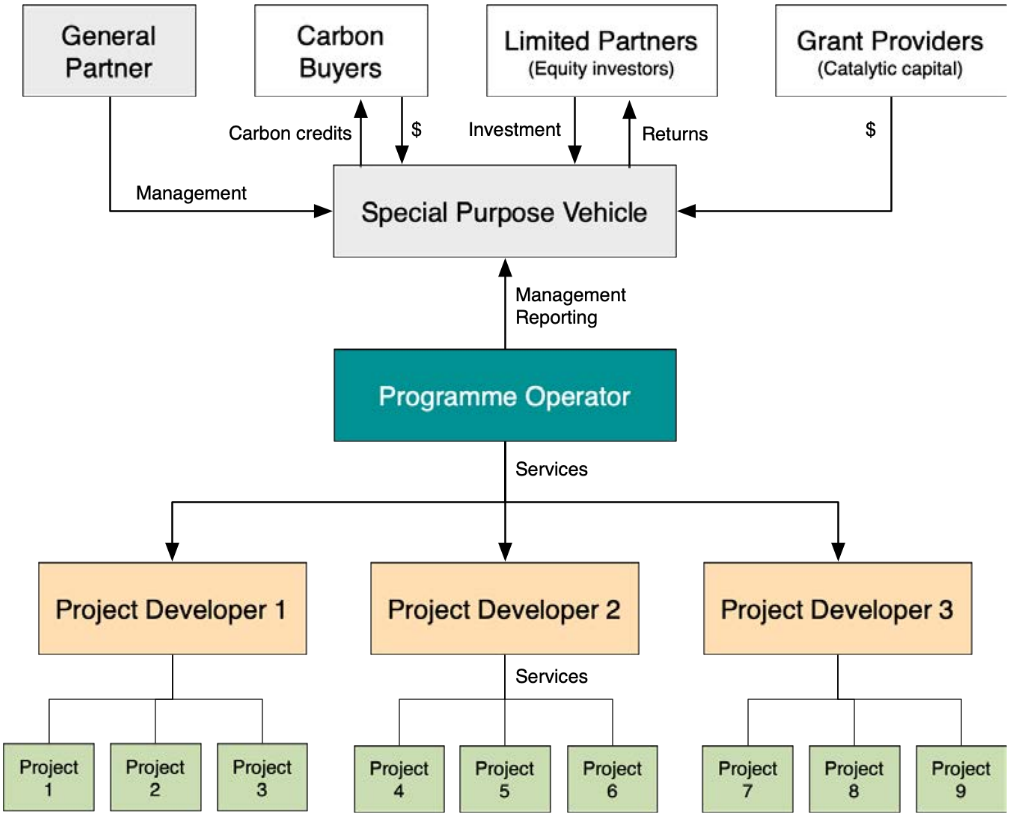

When a project is seeking private investment to fund project development there is an option to establish a special purpose vehicle (SPV) (dedicated company) to manage the investment. This enables the investor to take a percentage of ownership of the SPV (i.e., acquire shares) to secure the investment. An example of this organizational structure is provided in Figure 6.2b.

*Figure 6.2b. Possible organizational structure for a blue carbon project funded by investment and using special purpose vehicle (SPV).*




Scaling up blue carbon activities will necessitate an organizational structure that is investment ready for the scale of investment required (e.g., millions of dollars and above). A possible structure for this scale of activity is shown in Figure 6.2c.

*Figure 6.2c. Possible organizational structure for larger investments at a programmatic scale.*




## 6.3 ORGANIZATIONAL CAPABILITY

This feasibility assessment did not undertake an empirical assessment of organizational capability to deliver on the organizational requirements from each potential project site, but instead focused on the organizational requirements for blue carbon projects. The organizational capability needed to deliver a blue carbon project or programme requirements described above is available in Aotearoa New Zealand. This includes:

- Landowners that can provide land for recruitment into blue carbon projects.
- Local stakeholders in each of the project sites capable of providing local ecological knowledge for project design and implementation. Examples include Te Repo Ki Pūkorokoro Trust, local councils, Department of Conservation, Aotearoa New Zealand Landcare Trust, Fish & Game Aotearoa New Zealand, Tasman Environment Trust.
- Carbon project developers experienced in developing projects in the Aotearoa New Zealand Emissions Trading Scheme, and the international voluntary carbon market. Examples include Aotearoa New Zealand Permanent Forests Ltd, Aotearoa New Zealand Carbon Farming Ltd, Banks Peninsula Conservation Trust, Ekos[73].
- Some carbon project developers will have experience as carbon Programme Operators in the forest carbon sector (e.g., Ekos) or have experience sufficient to transition into operating as a Programme Operator (e.g., The Nature Conservancy, WWF, Royal Forest and Bird Protection Society, Aotearoa New Zealand Landcare Trust, Project Crimson).

[73] Ekos declares an interest and recognises the need to manage any conflicts of interest transparently with TNC.

- Technical service providers capable of providing scientific and technical inputs. Examples include the Cawthron Institute[74], Salt Ecology, Terramoana, Boffa Miskell, WSP, Wildlands, Tonkin and Taylor, Envirostrat, Landcare Research.
- Investment advisors capable of structuring (and potentially brokering) investments for blue carbon projects. Examples include Deloitte, KMPG, Impact Ventures Ltd.

## 6.4 CONCLUSION

There is no barrier to organizational structure or capability to develop and implement blue carbon projects in Aotearoa New Zealand. The key in any commercial conservation activity is to ensure that the project developer and project development team has a structure and capability sufficient to attract investment (i.e., is investment ready) in a manner that will reduce investment risk to the two primary investors: landowners and capital investors. This investment readiness will require a combination of project controls and project management, transparent mandates for all project decisions, an effective project governance structure, suitable skills, realistic budgeting and realistic planning around project timeframes.

[74] The Cawthron Institute declares an interest and recognises the need to manage any conflicts of interest transparently with TNC.

# 7 Conclusion

This work examined the technical, financial, legal, and organizational feasibility of blue carbon and coastal resilience projects, through the scoping assessment of six potential project sites. This report is designed to inform potential blue carbon project development using the VCS standard and the SD VISta standard and to clarify the requirements for the integration of technical and business elements of project design, development, and implementation.

## 7.1 TECHNICAL FEASIBILITY

The technical feasibility assessment found the following results for the project sites examined:

| Project Site | Project Type | Activity Type | Technically Feasible? |
|---|---|---|---|
| Te Repo Ki Pūkorokoro | Blue Carbon | Tidal salt marsh restoration | Yes |
| | Coastal Resilience | Tidal salt marsh restoration | No |
| Wainui Repo Whenua | Blue Carbon | Tidal salt marsh restoration | Yes |
| | Coastal Resilience | Tidal salt marsh restoration | No |
| Pukehina/Waihi | Blue Carbon | Tidal salt marsh restoration | Yes |
| | Coastal Resilience | Tidal salt marsh restoration | No |
| Farewell Spit | Blue Carbon | Seagrass restoration | No |
| | Coastal Resilience | Seagrass restoration | No |
| Waimeha Inlet | Blue Carbon | Tidal salt marsh restoration | Yes |
| | Coastal Resilience | Tidal salt marsh restoration | No |
| Wairau Lagoon | Blue Carbon | Tidal salt marsh conservation | No |
| | Coastal Resilience | Tidal salt marsh conservation | No |

Blue carbon projects focusing on the tidal salt marsh restoration activity type were found to be technically feasible and the most suitable for blue carbon project development.

In summary the following technical feasibility assessment conclusions were drawn from this study:

- Tidal salt marsh restoration blue carbon project activity types were found to be technically feasible and the most suitable for blue carbon project development in Aotearoa New Zealand currently.
- Seagrass conservation blue carbon projects are not currently technically feasible, until further data is available on:
  - Swan browsing impacts on seagrass biomass and soil carbon.
  - Swan ecological benefits to seagrass ecosystems.
  - Sedimentation impacts on seagrass biomass and soil carbon.
  - Attribution of swan population control and seagrass biomass and soil carbon.
  - Attribution of reduced sediment delivery from streams on seagrass biomass and soil carbon.
- Coastal resilience projects are not technically feasible in rural situations due to the low number of tradeable assets produced (derived from people beneficially impacted) compared with the scale of intervention required.

## 7.2 FINANCIAL FEASIBILITY

The financial feasibility assessment found the following for the blue carbon project types examined:

| **Project Area (ha)** | **Revegetation** | **Engineering Costs NZD** | **Break-even starting Carbon Price NZD** | **Financially Feasible?** |
|---|---|---|---|---|
| Revegetation stem density analysis | | | | |
| 20 | Revegetation @ 8,000 sph | 50,000 | 720 | No |
| 20 | Revegetation @ 1,000 sph | 50,000 | 246 | No |
| 20 | Revegetation @ 0 sph | 50,000 | 170 | Marginal |
| 20 | Revegetation @ 8,000 sph | 0 | 698 | No |
| 20 | Revegetation @ 1,000 sph | 0 | 216 | No |
| 20 | Revegetation @ 0 sph | 0 | 134 | yes |
| Economy of scale analysis | | | | |
| 20 | Revegetation @ 0 sph | 50,000 | 170 | Marginal |
| 30 | Revegetation @ 0 sph | 50,000 | 102 | Marginal |
| 40 | Revegetation @ 0 sph | 50,000 | 72 | Yes |
| 50 | Revegetation @ 0 sph | 50,000 | 51 | Yes+ |
| 60 | Revegetation @ 0 sph | 50,000 | 38 | Yes+ |
| 20 | Revegetation @ 0 sph | 0 | 134 | Marginal |
| 30 | Revegetation @ 0 sph | 0 | 87 | Yes |
| 40 | Revegetation @ 0 sph | 0 | 61 | Yes |
| 50 | Revegetation @ 0 sph | 0 | 41 | Yes+ |
| 60 | Revegetation @ 0 sph | 0 | 32 | Yes+ |

Marginal = not financially feasible without innovation in carbon credit monetization (e.g., blending with lower cost credit types and selling as a mixed basket).
Yes + = financially feasible with opportunities to increase project budget for additional benefits (e.g., revegetation, sea level rise mitigation).

The most financially viable project design for a 20ha tidal wetland restoration project involved natural revegetation (i.e., no active planting of vegetation) and no engineering costs needing to be covered by carbon credit sales revenues. The economy of scale analysis showed that the commercial viability of a fully commercial project increased significantly with an increase in project size. For projects with natural revegetation and without any engineering costs to be covered by carbon credit cashflows, a project size of 40ha and above delivered projects with break-even starting carbon prices below the NZU spot price at the time of writing. As the project size increased above 40ha the break-even starting carbon price dropped to levels considerably lower than the NZU spot price. Projects of 50ha or 60ha in area can, therefore, accommodate increased capital expenditure costs including revegetation costs within a carbon price point up to the NZU spot price range.

Projects that require a break-even starting carbon price that is higher than the NZU spot price (e.g., NZD134 (USD90) required for a fully commercial 20 ha project) can sustain such prices in a commercial carbon market setting if these carbon credits are monetised using a mixed basket approach with a blend of blue carbon credits combined with lower-cost voluntary carbon credits from other project types. The mixed basket approach to carbon credit monetisation provides considerable flexibility to support projects that require higher starting carbon prices.

The ability to attract private investment to finance blue carbon projects will ultimately depend on the terms of that investment and this will vary from one investor to another, and a capital raising strategy is likely to be more successful if it pursues impact investors (i.e., investors seeking to maximise beneficial impact delivery and modest financial returns. Gaining access to impact investment will present the opportunity to develop a nation-wide blue carbon programme.

## 7.3 LEGAL FEASIBILITY

The most legally straight-forward project types are those that do not involve riverbeds, lake-beds or the seabed in project land tenure. Tidal salt marsh restoration and conservation activity types, therefore, will have the least number of legal complexities and/or legal barriers to implementation.

The legal feasibility assessment found the following results for the project sites examined:

| Project Land Type | Intervention | Ability to establish property rights | Require regional plan permission or consent | Ability to establish carbon rights |
|---|---|---|---|---|
| **Land-based project** | Without alteration of water flows | Yes | No | Yes |
| | With alteration of water flows | Yes | Yes | Yes |
| **Marine-based project** | Passive regeneration | No | No | No |
| | Active regeneration (clearing, replanting) | No | Yes | Yes |

## 7.4 ORGANIZATIONAL FEASIBILITY

There is no barrier to organizational structure or capability to develop and implement blue carbon projects in Aotearoa New Zealand. The key in any commercial conservation activity is to ensure that the project developer and project development team has a structure and capability sufficient to attract investment (i.e., is investment ready) in a manner that will reduce investment risk to the two primary investors: landowners and capital investors. This investment readiness will require a combination of project controls and project management, transparent mandates for all project decisions, an effective project governance structure, suitable skills, realistic budgeting and realistic planning around project timeframes.

## 7.5 OVERALL SUMMARY

There is a real opportunity for tidal salt marsh restoration blue carbon projects in Aotearoa New Zealand. There are also challenges associated with structuring financing and investment arrangements, but these are no different from any commercial venture.

We recommend that TNC commits to providing funding for and undertaking a commercial pilot project that aggregates the four salt marsh restoration sites examined in this study. This pilot project will generate technical and financial data that can inform the development of a nation-wide programme. We also recommend that TNC undertakes a nation-wide inventory of tidal marsh ecosystems including those that have been drained in the past and have potential for rewetting. Potential opportunities (and risks) for tidal marsh habitats due to future sea level rise should also be considered in this nation-wide assessment.

## 7.6 RECOMMENDED NEXT STEPS

This feasibility assessment has identified four sites where a blue carbon project is feasible in principle:

- Te Repo Ki Pūkorokoro.
- Wainui Repo Whenua.
- Pukehina/Waihi.
- Waimeha Inlet.

Each of these sites have the potential for a tidal salt marsh restoration project involving rewetting the tidal marsh. The recommended next steps for each of these sites is as follows:

1. Confirm the site-specific legal feasibility through:
    a. Assessment of detailed land tenure status.
    b. Confirmation of management interventions planned for each site.
    c. Review rules in local government plans with respect to proposed management interventions.
    d. Seek Resource Consent in situations where this is required.
    e. Identify carbon property rights owner for purposes of carbon contracts.
2. If pursuing a programmatic approach:
    a. Establish a Programme Governance Group to oversee programmatic activities.
    b. Appoint a Programme Operator to coordinate and support projects across the programme.
3. For each individual project site:
    a. Identify the carbon rights owner and confirm that the latter is a single legal entity.
    b. Establish a Project Governance Group (includes the carbon rights owner) and an annual timetable for Project Governance Group meetings.
    c. Project Governance Group appoints a Project Developer that reports to the Project Governance Group.
    d. Secure a project development agreement between the Project Developer and the carbon rights owner (ensuring that the carbon rights owner is a single legal entity).
    e. Project Governance group secures funding for project development. If funding involves private investment, then establish an appropriate organizational structure capable of administering the investment (e.g., special purpose vehicle).
    f. Project Governance Group agrees all roles and responsibilities and approve subcontractors for recruitment into Project Consortium.
    g. Project Developer recruits and manages subcontractors in the Project Consortium.
    h. Project Developer appoints a Project Management Committee to oversee project development operations.
    i. Project Developer oversees the development of a Project Business Case. The Project Business Case encompasses:
        i. A draft Project Description pursuant to the carbon standard and methodology applied.
        ii. A gap analysis for data or methodology requirements necessary for completion of Project Description.
        iii. A budget for completing the Project Description (including any data gathering requirements to fill data and methodology gaps).
    j. Decision: Project Governance Group reviews Business Case and decides to proceed to full project development or decides to exit the project.
    k. Proceed to development of full Project Description.

We also recommend that next steps include a feasibility assessment for a mangrove activity type (restoration and/or conservation).

# References

Anderson TR, Fletcher CH, Barbee MM, Romine BM, Lemmo S, Delevaux JM 2018. Modeling multiple sea level rise stresses reveals up to twice the land at risk compared to strictly passive flooding methods. Scientific reports, 8(1), 1-14.

Aoki LR, McGlathery KJ, Wiberg PL, Oreska MP, Berger AC, Berg P, & Orth RJ 2021. Seagrass recovery following marine heat wave influences sediment carbon stocks. Frontiers in Marine Science, 7: 1170.

Babcock RC, Bustamante RH, Fulton EA, Fulton DJ, Haywood MDE, Hobday AJ, Kenyon R, Matear RJ, Plagányi EE, Richardson AJ and Vanderklift MA 2019. Severe Continental-Scale Impacts of Climate Change Are Happening Now: Extreme Climate Events Impact Marine Habitat Forming Communities Along 45% of Australia's Coast. Front. Mar. Sci. 6:411. doi: 10.3389/fmars.2019.00411

Bahramifar A, Shirkhani R, Mohammadi M 2013. An anfis-based approach for predicting the manning roughness coefficient in alluvial channels at the bank-full stage.

Baldock J, Cannard T, Kelleway J, Lovelock CE, Steven A and Vanderklift M 2019. Technical assessment of the Verified Carbon Standard – "VM0033 Methodology for Tidal Wetland and Seagrass Restoration." CSIRO Final report prepared for the Department of Environment and Energy, Canberra, Australia. 25 October 2019, 65 pp.

Battley PF, Melville DS, Schuckard R, Balance P 2005. Quantitative survey of the intertidal benthos of Farewell Spit, Golden Bay. Marine Biodiversity Biosecurity Report. No.7.

Beck MW, Losada IJ, Menéndez P et al. 2018. The global flood protection savings provided by coral reefs. Nat Commun 9:2186. https://doi.org/10.1038/s41467-018-04568-z

Bellingham M, Davis A 2008. Livestock Grazing Impacts on Estuarine Vegetation in the Southern Kaipara Harbour, Aotearoa New Zealand. Report prepared for Auckland Regional Council by Aristos Consultants Ltd.

Bergin DO 1991. Experimental Restoration of Indigenous Salt Marsh Maketu Estuary. Forest Research Institute Contract Report: FEW 91/31.

Berthelsen A, Clement D, Gillespie P 2016. Shakespeare Bay Estuary Monitoring 2016. Prepared for Marlborough District Council. Cawthron Report No. 2833. 40 p. plus appendices.

Berthelsen A, Gillespie P, Clement D, Peacock L 2015. State of the environment monitoring of Wairau Estuary. Prepared for Marlborough District Council. Cawthron Report No. 2741. 62 p. plus appendices.

Best ÜSN, van der Wegen M, Dijkstra J, Willemsen PWJM, Borsje BW, Roelvink D 2018. Do salt marshes survive sea level rise? Modelling wave action, morphodynamics and vegetation dynamics, Environmental Modelling and Software doi: 10.1016/j.envsoft.2018.08.004.

Boesch DF, Shabman L, Antle LG, et al. 2006. A new framework for planning the future of coastal Louisiana after the hurricanes of 2005. Cambridge, MD: University of Maryland Center for Environmental Science.

Bulmer RH, Stephenson F, Jones HF, Townsend M, Hillman JR, Schwendenmann L & Lundquist CJ 2020. Blue carbon stocks and cross-habitat subsidies. Frontiers in Marine Science, 7: 380.

Carswell, F.E., Burrows, L.E., and Mason, N.W.H. 2009. Above-ground carbon sequestration by early-successional woody vegetation. Science for Conservation 297. Department of Conservation, Wellington.

CFA Institute 2020. Global investment performance standards (GIPS) for firms.

Chmura G L, Kellman L, Van Ardenne L, & Guntenspergen GR 2016. Greenhouse gas fluxes from salt marshes exposed to chronic nutrient enrichment. PloS one, 11(2), e0149937.

Clarkson B 2018. Wetland Delineation Protocols. Prepared for Tasman District Council by Manaaki Whenua Landcare Research.

Costa MDP, Lovelock CE, Waltham NJ, Moritsch MM, Butler D, Power T, Thomas E, Macreadie PI, 2022. Modelling blue carbon farming opportunities at different spatial scales, Journal of Environmental Management, 301:113813, ISSN 0301-4797, https://doi.org/10.1016/j.jenvman.2021.113813.

Dai, X., Yang, G., Liu, D., and Wan, R. 2020. Vegetation carbon sequestration mapping in herbaceous wetlands by using a MODIS EVI time-series data set: A case in Poyang Lake Wetland, China. Remote Sensing **2020**, *12*(18), 3000; https://doi.org/10.3390/rs12183000

Day JW Jr, Scarton F, Rismondo A, Are D. 1998. Rapid deterioration of a salt marsh in Venice Lagoon, Italy. J. Coastal Res. 14:583–90.

Dittmann S, Bestland E, Davies R & Stirling E 2016. Carbon burial and sediment accumulation rates in coastal saltmarsh sediments on Adelaide's northern shores. Report for the Adelaide and Mount Lofty Ranges NRM Board. Flinders University, Adelaide.

Dittmann S, Mosley L, Clanahan M, Quinn J, Crooks S, Emmer I, Min Thomson S, Seaman R 2019. Proof of concept for tidal re-connection as a blue carbon offset project. Goyder Institute for Water Research Technical Report Series No. 19/29.

Dixon H 2009. Effect of black swan foraging on seagrass and benthic invertebrates in western Golden Bay. Master of Science in Ecology, Massey University, Palmerston North, Aotearoa New Zealand.

Ellison JC, Beasy KM 2018. Sediment carbon accumulation in southern latitude saltmarsh communities of Tasmania, Australia. Biology, 7(2): 27.

Elschot K, Elschot K, Bakker JP, Temmerman S, Koppel J Van De 2015. Ecosystem engineering by large grazers enhances carbon stocks in a tidal salt marsh. Mar. Ecol. Prog. Ser. 537: 9–21. https://doi.org/10.3354/meps11447.

Evison, D. 2017. The Aotearoa New Zealand forestry sector's experience in providing carbon sequestration services under the Aotearoa New Zealand Emissions Trading Scheme, 2008 to 2012. Forest Policy and Economics, vol 75: 89-94.

Fagherazzi S et al. 2012. Numerical models of salt marsh evolution: Ecological, geomorphic, and climatic factors. Rev. Geophys. 50: 1–28.

Ford H, Garbutt A, Jones L, Jones D L 2012. Methane, carbon dioxide and nitrous oxide fluxes from a temperate salt marsh: Grazing management does not alter Global Warming Potential. Estuarine, Coastal and Shelf Science, 113: 182-191.

Gatland JR, Santos IR, Maher DT, Duncan TM, Erler DV 2014. Carbon dioxide and methane emissions from an artificially drained coastal wetland during a flood: Implications for wetland global warming potential. Journal of Geophysical Research: Biogeosciences, 119: 1698-1716.

Gedan KB, Silliman BR & Bertness MD 2009. Centuries of human-driven change in salt marsh ecosystems. Annual review of marine science, 1: 117-141.

Gillespie P, Asher R 1999. Impact of the Nelson (Bell Island) regional sewerage discharge on Waimea Inlet: Bacteriological water quality. Cawthron Report No. 460. Prepared for the Nelson Regional Sewerage Business Unit and Tasman District Council. 11 p

Global Environment Fund (GEF) 2021. Blended Finance. Available online: https://www.thegef.org/topics/blended-finance

Golder Associates 2014. Miranda High Tide Roosting Areas Initial Hydrological Assessment. Submitted to John Gumbley. Report Number. 1378610548-003.

Graeme M, Dahm J 2006. The potential effect of sea level rise on coastal vegetation, Pilot study – Coromandel Harbour. Prepared for Environment Waikato by Natural Solutions and Eco Nomos Ltd. Environment Waikato Technical Report 2007/05.

Hewitt AE 2010. Aotearoa New Zealand soil classification. 3rd edition, Lincoln, N.Z: Manaaki Whenua Press. (Landcare Research science series, ISSN 1172-269X; no.1) ISBN 978-0-478-34710-4.

Horstman EM, Lundquist CJ, Bryan KR, Bulmer RH, Mullarney JC, Stokes DJ 2018. The Dynamics of Expanding Mangroves in Aotearoa New Zealand. In Makowski C, Finkl CW (eds.), Threats to Mangrove Forests, Coastal Research Library 25, https://doi.org/10.1007/978-3-319-73016-5_2

Howard J, Hoyt S, Isensee K, Telszewski M, Pidgeon E (eds) 2014. Coastal Blue Carbon: Methods for assessing carbon stocks and emissions factors in mangroves, tidal salt marshes, and seagrasses. Conservation International, Intergovernmental Oceanographic Commission of UNESCO, International Union for Conservation of Nature. Arlington, Virginia, USA.

Howe AJ, Rodriguez JF & Saco PM 2009. Surface evolution and carbon sequestration in disturbed and undisturbed wetland soils of the Hunter estuary, southeast Australia. Estuarine, Coastal and Shelf Science, 84: 75-83.

Hume T 2020. Wharekawa Coast 2120 Coastal Processes and Hazards. Draft report prepared for Waikato Regional Council by Hume Consulting Ltd. https://wharekawacoast2120.hauraki-dc.govt.nz/wp-content/uploads/2020/08/Wharekawa-Coast2120-Coastal-Processes-Hazards.pdf

Illes, A, Russi, D, Kettunen, M and Robertson M 2017. Innovative mechanisms for financing biodiversity conservation: experiences from Europe, final report in the context of the project “Innovative financing mechanisms for biodiversity in Mexico. Brussels, Belgium. Available online: https://ieep.eu/uploads/articles/attachments/dcc74b53-6750-4ccd-99b9-dc9e9d659dd4/IFMs_for_biodiversity_EUROPE_Illes_et_al_2017.pdf?v=63664510044

IPCC 2017. Emission factor detail (ID:522933). Annual emission factor associated with rewetting (EFRE) of tidal marsh on aggregated organic and mineral soils at initiation of vegetation reestablishment. Available here: https://www.ipcc-nggip.iges.or.jp/EFDB/ef_detail.php

IPCC 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press.

IPCC 5th Assessment Report

IPCC 6th Assessment Report

Irvine IC, Vivanco L, Bentley PN, & Martiny JB 2012. The effect of nitrogen enrichment on C1-cycling microorganisms and methane flux in salt marsh sediments. Frontiers in microbiology, 3: 90.

IUCN 2021. Manual for the creation of blue carbon projects in Europe and the Mediterranean. Otero, M., (Ed.).

Johnson, D., 2007. Reflections on the Bundle of Rights” 32 Vermont Law Review 247 noted in "Public Property and Private Use Rights: Exclusive occupation of the coastal marine area in Aotearoa New Zealand" Robert A Makgill 2011. https://www.waitangitribunal.govt.nz/assets/Documents/Publications/ENVC-Hearing-6Oct14-s274-evidence-chief-Appendix-3-Makgill.pdf

Johnson P, Gerbeaux P 2004. Wetland types in Aotearoa New Zealand. Department of Conservation.

Kaiser G, Scheele L, Kortenhaus A, Løvholt F, Römer H, Leschka S 2011. The influence of land cover roughness on the results of high resolution tsunami inundation modeling. Natural Hazards and Earth System Sciences, 11(9), 2521-2540.

Kelleway J, Serrano O, Baldock J, Cannard T, Lavery P, Lovelock CE, Macreadie P, Masqué P, Saintilan N, Steven ADL 2017. Technical review of opportunities for including blue carbon in the Australian Government’s Emissions Reduction Fund. CSIRO, Australia.

Kingham R 2013. The Broad-scale Impacts of Livestock Grazing on Saltmarsh Carbon Stocks. Bangor University. PhD thesis Prifysgol Bangor University Available at: http://e.bangor.ac.uk/4923/.

Kirwan ML, Temmerman S, Skeehan EE, Guntenspergen GR, Fagherazzi S 2016. Overestimation of marsh vulnerability to sea level rise. Nature Climate Change, 6(3), 253-260.

Kirwan, Matthew L.; Temmerman, Stijn; Skeehan, Emily E.; Guntenspergen, Glenn R.; Fagherazzi, Sergio (2016). Overestimation of marsh vulnerability to sea level rise. Nature Climate Change, 6(3), 253–260. doi:10.1038/nclimate2909

Knutson TR, Chung MV, Vecchi G, Sun J, Hsieh T-L, Smith AJP 2021: ScienceBrief Review: Climate change is probably increasing the intensity of tropical cyclones. In: Critical Issues in Climate Change Science, edited by: Corinne Le Quéré, Peter Liss & Piers Forster.

Kopp RE, Horton RM, Little CM, Mitrovica JX, Oppenheimer M, Rasmussen DJ, … & Tebaldi C 2014. Probabilistic 21st and 22nd century sea-level projections at a global network of tide-gauge sites. Earth's future, 2(8), 383-406.

Lambin EF, Turner BL, Geist HJ, Agbola SB, Angelsen A, Bruce JW, Coomes OT, Dirzo R, Fischer G, Folke C, et al. 2001. The causes of land-use and land-cover change: moving beyond the myths. Global Environmental Change, 11, 261-269

Louis A. Schipper, Paul L. Mudge, Miko U. F. Kirschbaum, Carolyn B. Hedley, Nancy E. Golubiewski, Simeon J. Smaill & Francis M. Kelliher (2017) A review of soil carbon change in Aotearoa New Zealand's grazed grasslands, Aotearoa New Zealand Journal of Agricultural Research, 60:2, 93-118, DOI: 10.1080/00288233.2017.1284134

Lovelock CE 2020. Blue carbon from the past forecasts the future. Science, 368(6495), 1050–1052. doi:10.1126/science.abc3735.

Lovelock CE, Cahoon DR, Friess DA, Guntenspergen GR, Krauss KW, Reef R., ... & Triet T 2015. The vulnerability of Indo-Pacific mangrove forests to sea-level rise. Nature, 526(7574), 559-563.

Lovelock CE, Fourqurean JW and Morris JT 2017. Modeled CO2 Emissions from Coastal Wetland Transitions to Other Land Uses: Tidal Marshes, Mangrove Forests, and Seagrass Beds. Front. Mar. Sci. 4:143. doi: 10.3389/fmars.2017.00143

Lovelock CE, Sorrell BK, Hancock N, Hua Q, Swales A 2010. Mangrove forest and soil development on a rapidly accreting shore in Aotearoa New Zealand. Ecosystems, 13(3), 437-451.

Macreadie PI, Anton A, Raven JA, Beaumont N, Connolly RM, Friess DA, ... & Duarte CM 2019. The future of Blue Carbon science. Nature communications, 10(1), 1-13.

Macreadie PI, Nielsen DA, Kelleway JJ, Atwood TB, Seymour JR, Petrou K, ... & Ralph PJ 2017. Can we manage coastal ecosystems to sequester more blue carbon?. Frontiers in Ecology and the Environment, 15(4), 206-213.

Magesan GN, Wang H, Clinton PW 2012. Nitrogen cycling in gorse-dominated ecosystems in Aotearoa New Zealand. Aotearoa New Zealand Journal of Ecology, 21-28.

Menéndez P, Losada IJ, Torres-Ortega S et al. 2020. The Global Flood Protection Benefits of Mangroves. Sci Rep 10, 4404. https://doi.org/10.1038/s41598-020-61136-6

MfE 2017. Coastal hazards and climate change: Guidance for local government. Ministry for the Environment Publication ME1341. Wellington, Ministry for the Environment. 279 p. + Appendices http://www.mfe.govt.nz/publications/climate-change/coastal-hazards-and-climate-change-guidance-local-government. Wellington, Ministry for the Environment.

Ming Nie, Lei Shang, Chengzhang Liao, Bo Li 2017. Changes in Primary Production and Carbon Sequestration after Plant Invasions. Chapter in Vilà, M., & Hulme, P. E. (Eds.). (2017). Impact of biological invasions on ecosystem services (Vol. 12). Cham: Springer International Publishing.

Ministry for Primary Industries 2017. A guide to carbon look-up tables for forestry in the Emissions Trading Scheme. MPI, Wellington.

Morris JT, Jensen A 1998. The carbon balance of grazed and non-grazed Spartina anglica saltmarshes at Skallingen, Denmark. J. Ecol. 86, 229–242.

Muenzel D, Martino S 2018. Assessing the feasibility of carbon payments and Payments for Ecosystem Services to reduce livestock grazing pressure on saltmarshes. Journal of Environmental Management, 225:46–61. doi:10.1016/j.jenvman.2018.07.060 .

Narayan S, Beck MW, Wilson P, Thomas CJ, Guerrero A, Shepard CC., ... & Trespalacios D 2017. The value of coastal wetlands for flood damage reduction in the northeastern USA. Scientific reports, 7(1), 1-12.

Negandhi K, Edwards G, Kelleway JJ, Howard D, Safari D & Saintilan N 2019. Blue carbon potential of coastal wetland restoration varies with inundation and rainfall. Sci Rep, 9, 4368.

Nie M, Shang L, Liao C, Li B 2017. Changes in primary production and carbon sequestration after plant invasions. In Impact of biological invasions on ecosystem services (pp. 17-31). Springer, Cham.

Orchard S, Hughey KF, Schiel DR 2020. Coastal tectonics and habitat squeeze: response of a tidal lagoon to co-seismic sea-level change. Natural Hazards, 103(3): 3609-3631.

Oreska MPJ, McGlathery KJ, Aoki LR, Berger AC, Berg P & Mullins L 2020. The greenhouse gas offset potential from seagrass restoration. Scientific Reports 10:7325.

Partridge TR, Wilson JB 1987. Salt tolerance of salt marsh plants of Otago, Aotearoa New Zealand. Aotearoa New Zealand Journal of Botany, 25(4):559-566.

Partridge TR, Wilson JB 1988. The use of transplants in determining environmental tolerance in salt marshes of Otago, Aotearoa New Zealand. Aotearoa New Zealand Journal of Botany, 26(2):183-192.

Pendleton L, Donato DC, Murray BC, Crooks S, Jenkins WA, et al. 2012. Estimating Global ''Blue Carbon'' Emissions from Conversion and Degradation of Vegetated Coastal Ecosystems. PLoS ONE 7(9): e43542. doi:10.1371/journal.pone.0043542

Pérez A, Machado W, Gutierrez D, Stokes D, Sanders L, Smoak JM, Santos I, Sanders CJ 2017. Changes in soil organic carbon accumulation driven by mangrove expansion and deforestation in a Aotearoa New Zealand estuary, Estuarine, Coastal and Shelf Science. doi: 10.1016/j.ecss.2017.05.009.

Persico EP, Sharp SJ, Angelini C 2017. Feral hog disturbance alters carbon dynamics in southeastern US salt marshes. Marine Ecology Progress Series, 580, 57-68.

Raw JL, Adams JB, Bornman TG, Riddin T, Vanderklift MA 2021. Vulnerability to sea-level rise and the potential for restoration to enhance blue carbon storage in salt marshes of an urban estuary. Estuarine, Coastal and Shelf Science, 260, 107495. doi:10.1016/j.ecss.2021.107495

Reeve G, Stephens S, Wadhwa S 2019. Tauranga Harbour inundation modelling. Prepared for Bay of Plenty Regional Council. NIWA CLIENT REPORT No: 2018269HN.

Rezaie AM, Loerzel J, Ferreira CM 2020. Valuing natural habitats for enhancing coastal resilience: Wetlands reduce property damage from storm surge and sea level rise. PloS one, 15(1), e0226275.

Riahi K, Rao S, Krey V, Cho C, Chirkov V, Fischer G, ... & Rafaj P 2011. RCP 8.5—A scenario of comparatively high greenhouse gas emissions. Climatic change, 109(1), 33-57.

Roberts KL, Stevens LM, Southwick M, Forrest, BM 2021. Wairau Lagoon Subtidal Survey 2021. Salt Ecology Report 068, prepared for Marlborough District Council, June 2021. 67p.

Robertson B, Stevens, LM 2012. Tasman Coast: Waimea Inlet to Kahurangi Point habitat mapping, ecological risk assessment and monitoring recommendations. Prepared for Tasman District Council by Wriggle Coastal Management Limited. 125p plus appendices.

Robertson BM, Gillespie PA, Asher RA, Frisk S, Keeley NB, Hopkins GA, Thompson SJ, Tuckey BJ 2002. Estuarine Environmental Assessment and Monitoring: A National Protocol. Part A. Development, Part B. Appendices, and Part C. Application. Prepared for supporting Councils and the Ministry for the Environment, Sustainable Management Fund Contract No. 5096. Part A. 93p. Part B. 159p. Part C. 40p plus field sheets.

Rockefeller Philanthropy Advisors (RPA). 2017. Impact investing an introduction. Available Online: https://www.rockpa.org/wp-content/uploads/2017/10/RPA_PRM_Impact_Investing_Intro_WEB.pdf

Rogers K, Kelleway JJ, Saintilan N, Megonigal JP, Adams JB, Holmquist JR, ... & Woodroffe CD 2019. Wetland carbon storage controlled by millennial-scale variation in relative sea-level rise. Nature, 567(7746): 91-95.

Roughan BL, Kellman L, Smith E, Chmura GL 2018. Nitrous oxide emissions could reduce the blue carbon value of marshes on eutrophic estuaries. Environmental Research Letters, 13(4), 044034.

Saderne V, Geraldi NR, Macreadie PI, Maher DT, Middelburg JJ, Serrano O, ... & Duarte CM 2019. Role of carbonate burial in Blue Carbon budgets. Nature communications, 10(1), 1-9.

Schipper LA, Mudge PL, Kirschbaum MUF, Hedley CB, Golubiewski NE, Smaill SJ, Kelliher FM 2017. A review of soil carbon change in Aotearoa New Zealand's grazed grasslands, Aotearoa New Zealand Journal of Agricultural Research, 60:2, 93-118, DOI: 10.1080/00288233.2017.1284134

Serrano O, Lovelock CE, Atwood TB, Macreadie PI, Canto R, Phinn S, ... & Duarte CM 2019. Australian vegetated coastal ecosystems as global hotspots for climate change mitigation. Nature communications, 10(1), 1-10.

Sheng YP, Lapetina A, Ma G 2012. The reduction of storm surge by vegetation canopies: Three-dimensional simulations. Geophysical research letters, 39(20).

Sheng YP, Rivera-Nieves AA, Zou R, Paramygin VA 2021. Role of wetlands in reducing structural loss is highly dependent on characteristics of storms and local wetland and structure conditions. Scientific reports, 11(1): 1-14.

Shih SF, Rahi GS 1982. Seasonal variations of Manning's roughness coefficient in a subtropical marsh. Transactions of the ASAE, 25(1), 116-0119.

Smale D, Wernberg T, Oliver ECJ, Thomsen M, Harvey BP, Straub SC, Burrows MT, Alexander LV, Benthuysen JA, Donat MG, Feng M, Hobday AJ, Holbrook NJ, Perkins-Kirkpatrick SE, Scannell HA, Sen GA, Payne Ben L, Moore PJ 2019. Marine heatwaves threaten global biodiversity and the provision of ecosystem services. Nature Climate Change, –. doi:10.1038/s41558-019-0412-1.

Smale DA, Wernberg T, Oliver EC, Thomsen M, Harvey BP, Straub SC, ... & Moore PJ 2019. Marine heatwaves threaten global biodiversity and the provision of ecosystem services. Nature Climate Change, 9(4): 306-312.

Stark J et al. 2015. Observations of tidal and storm surge attenuation in a large tidal marsh." Limnology and Oceanography 60.4: 1371-1381.

Stephens SA 2017. Tauranga Harbour extreme sea level analysis. NIWA Client Report to Bay of Plenty Regional Council, March 2017, 2017035HN, 47p.

Stevens LM, Scott-Simmonds T, Forrest BM 2020. Broad Scale Intertidal Monitoring of Waimea Inlet. Salt Ecology Report 052, prepared for Tasman District and Nelson City Councils, November 2020. 50p.

Stevens LM, Southwick M. 2021. A preliminary assessment of salt marsh rehabilitation options for Waimea Inlet. Salt Ecology Report 058 prepared for Tasman District Council. March 2021. 56p.

Tasman District Council 2019. Coastal Hazards Assessment in Tasman Bay/Te Tai o Aorere and Golden Bay/Mohua.

Tasman District Council 2020. Coastal Management Project Coastal Risk Assessment for Tasman Bay/Te Tai o Aorere and Golden Bay/Mohua.

Thannheiser D, Holland P 1994. The Plant Communities of Aotearoa New Zealand Salt Meadows. Global Ecology and Biogeography Letters, 4(4), 107–115. doi:10.2307/2997436.

Tideline. 2019. Catalytic Capital: Unlocking more investment and impact. Available online: https://tideline.com/wp-content/uploads/2020/11/Tideline_Catalytic-Capital_Unlocking-More-Investment-and-Impact_March-2019.pdf

Tonkin & Taylor 2015 Coastal Protection Areas Re-assessment - Stage Two. Technical report prepared for Western Bay of Plenty District Council.

Tuckey, BJ, Gibbs, MT, Knight, BR, and Gillespie, PA 2006. Tidal circulation in Tasman and Golden Bays: Implications for river plume behaviour. Aotearoa New Zealand Journal of Marine and Freshwater Research. Vol 40: 305-324.

Turner SJ, Schwarz A-M 2006. Management and conservation of seagrass in Aotearoa New Zealand: an introduction. Department of Conservation Science for Conservation 264.

Van der Molen J 1997. Tidal distortion and spatial differences in surface flooding characteristics in a salt marsh: implications for sea-level reconstruction. Estuarine, Coastal and Shelf Science 45.2: 221-233.

VCS 2019. AFOLU Non-Permanence Risk Tool, V4.0. Verra.

VM0007 REDD+ Methodology Framework (REDD+ MF). Version 1.6, 8 September 2020.

VM0033 Methodology for Tidal Wetland and Seagrass Restoration. Version 1.0, 20 November 2015.

World Bank, and United Nations 2010. Natural hazards, unnatural disasters: the economics of effective prevention. The World Bank, 2010.

World Bank. 2016. Managing Coasts with Natural Solutions: Guidelines for Measuring and Valuing the Coastal Protection Services of Mangroves and Coral Reefs. M. W. Beck and G-M.Lange, editors. Wealth Accounting and the Valuation of Ecosystem Services Partnership (WAVES), World Bank, Washington, DC.

Yu OT, Chmura GL 2010. Soil carbon may be maintained under grazing in a St Lawrence Estuary tidal marsh. Environ. Conserv. 36: 312–320. https://doi.org/10. 1017/S0376892910000184.

Yuan J, Ding W, Liu D et al. (2014) Exotic Spartina alterniflora invasion alters ecosystem–atmosphere exchange of CH4 and N2O and carbon sequestration in a coastal salt marsh in China. Glob Change Biol 21(4):1567–1580.

Zabarte-Maeztu I 2021. Sediment-effects on seagrass Zostera muelleri in Aotearoa New Zealand. Unpublished thesis, University of Waikato, Biological Sciences.

# Appendices

## APPENDIX 1. PROJECT SITE QUESTIONNAIRE & RESULTS

### A1.1 Questionnaire

| | Information Request Question |
|---|---|
| 1 | Please describe the project activities relating to all types of tidal wetland.<br>Relevant timeframes for this are between up to 5 years earlier than the present and at least 20 (up to 100) years into the future. |
| 2 | Is there any data defining the spatial boundaries of the project area? If so, please elaborate on this.<br>Note that, ideally this data would separate out any different wetland restoration or conservation activity types within each project area. |
| 3 | Please indicate which (if any) of the following activities apply to the project:<br>a) Creating, restoring and/or managing hydrological conditions (e.g., removing tidal barriers, improving hydrological connectivity, restoring tidal flow to wetlands or lowering water levels on impounded wetlands).<br>b) Altering sediment supply (e.g., beneficial use of dredge material or diverting river sediments to sediment-starved areas).<br>c) Changing salinity characteristics (e.g., restoring tidal flow to tidally-restricted areas).<br>d) Improving water quality (e.g., reducing nutrient loads leading to improved water clarity to expand seagrass meadows, recovering tidal and other hydrologic flushing and exchange or reducing nutrient residence time).<br>e) (Re-)introducing native plant communities (e.g., reseeding or replanting).<br>f) Improving management practice(s) (e.g., removing invasive species, reduced grazing).<br>g) Protecting at-risk wetlands (e.g., establishing conservation easements, establishing community supported management agreements, establishing protective government regulations, and preventing disruption of water and/ or sediment supply to wetland areas).<br>h) Improving water management on drained wetlands.<br>i) Recharging sediment to avoid drowning of coastal wetlands.<br>j) Creating accommodation space for wetlands migrating with sea-level rise. |
| 4 | Do the project activities include fire management? |
| 5 | Do the project activities include the burning of organic soil or prescribed burning of herbaceous and shrub aboveground biomass (cover burns)? |
| 6 | Will the project activity apply nitrogen fertilizer(s), such as chemical fertilizer or manure, to the project area during the project crediting period? |
| 7 | Is any of the land used by your project activity registered under the Clean Development Mechanism or under any other greenhouse gas (GHG) program (both voluntary and compliance-oriented)? |
| 8 | Please describe baseline for the project site prior to the start of project activities. |
| 9 | Please detail whether the land is/was drained, partially drained or undrained at the start of the project activities. |
| 10 | Please indicate which (if any) of the following situations apply to the project:<br>Baseline agents of wetland degradation<br>a) Cause an alteration in the hydrology of the project area (involving drainage, interrupted sediment supply, or both) and/or a loss of soil organic carbon;<br>b) Have no documented and uncontested legal right to degrade the wetland;<br>c) and are either residents in the reference region for wetland degradation or immigrants. |
| 11 | In relation to tidal wetland restoration activities, please indicate which (if any) of the following relate to the project area prior to the project start date:<br>a) The area is free of any land use that could be displaced outside the project area, as demonstrated by at least one of the following, where relevant:<br>i) The project area has been abandoned for two or more years prior to the project start date; or |

| | |
|---|---|
| | ii) Use of the project area for commercial purposes (i.e., trade) is not profitable as a result of salinity intrusion, market forces or other factors. In addition, timber harvesting in the baseline scenario within the project area does not occur; or<br>iii) Degradation of additional wetlands for new agricultural/aquacultural sites within the area will not occur or is prohibited by enforced law.<br>OR<br>b) Is under a land use that will continue at a similar level of service or production during the project crediting period (e.g., reed or hay harvesting, collection of fuelwood, subsistence harvesting, commercial fishing). |
| 12 | Please comment on whether you able to demonstrate (a) or (b) in the question above (11) based on verifiable information such as laws and bylaws, management plans, annual reports, annual accounts, market studies, government studies or land use planning reports and documents. |
| 13 | Do you have any reason to believe that project activities may lead to a significant increase in the GHG emissions outside the project area due to changes in hydrological connectivity of the project area with adjacent areas e.g., flooding of upstream vegetated areas leading to increased methane release.<br>Please elaborate on this. |
| 14 | Do you have any reason to believe that any changes in hydrology would not result in the accumulation or maintenance of soil organic carbon stock (SOC), noting that:<br>a) This pertains to projects that intend to sequester carbon through sedimentation and/or vegetation development. AND<br>b) This does not pertain to projects that increase salinity to reduce methane ($CH_4$) emissions. Projects that aim to decrease $CH_4$ emissions through increased salinity must account for any changes in SOC stocks. |
| 15 | Are you able to demonstrate that sea level rise impacts on the project are irrelevant or expected to be insignificant within the next 10 years, or that there is a plan in place for effectively mitigating such impacts?<br>If so, please elaborate on this. |
| 16 | Have you accounted for how projected sea level rise may impact the project activities (ideally over a 100-year timeframe)? If so, please elaborate and provide any information that you have (and that is additional to any information already requested in this questionnaire). |
| 17 | Are you able to demonstrate that hydrologically connected areas adjacent to the project boundary shall not have a significant negative impact on the project area?<br>If so, please elaborate on this. |
| 18 | Please provide information on the organic content (e.g., % organic carbon by weight) of the soil (to at least 20cm soil depth if possible) related to the project activities. |
| 19 | Please provide tidal range and water salinity information (for example, in relation to the salinity average and the salinity low point) for your project site. |
| 20 | Please provide any information you have on sediment loading values for your project site. This is in context of the potential for tidal wetland to rise vertically with sea level rise due to suspended sediment loads in the system. |
| 21 | Is the data in a geospatial format (e.g.: line or polygon data in a shapefile format)? |
| 22 | Is the spatial and temporal scale defined in the metadata? If not, is this information available in other data sources (e.g., reports, project documentation)? |
| 23 | Is there any ground elevation data from aerial or measurements from field surveys or aerial/satellite imagery of at least 10 m resolution within project area? |
| 24 | Is there any flooding model being used by the project (or model's outputs, as flooding maps and projections)? |
| 25 | Is the flooding model used by the project publicly available? If yes, please provide the access link to it. If the answer is no, please provide the contact details of the person responsible by the flooding model development and any documentation or summary of how the model was developed. |
| 26 | Does the model consider the local nearshore topography? |
| 27 | Is there any hydrodynamic model being used by the project (or model's outputs, as maps and projections)? |
| 28 | Is the hydrodynamic model used by the project publicly available? If yes, please provide the access link to it. If the answer is no, please provide the contact details of the person responsible by the hydrodynamic model development and any documentation or summary of how the model was developed. |
| 29 | Is it downscaled to a local scale? |
| 30 | Does it consider the contribution of waves (from runup and setup)? |
| 31 | Does it consider Mean Sea Level? |
| 32 | Does it consider multiple storm return periods? |
| 33 | Is there any LiDAR bathymetric data collected for the project area? |
| 34 | Is there any LiDAR topographic data collected for the project area? |

# APPENDIX 2. SITE-SPECIFIC APPLICABILITY: BLUE CARBON

Methods Used to Assess Applicability Conditions

Applicability conditions for each project scenario were assessed based on the VM0007 and VM0033 methodologies. The information used for assessment was provided by the project contacts and gathered through questionnaires. Where the requested information was not provided, we have indicated that the relevant information relating to the Applicability Conditions is to be confirmed. The assessments for the project sites are in Tables A2.1 to A2.6 below (direct quotes from the questionnaire responses are italicized).

Summary of Applicability Condition Results and Recommendations

The key Applicability Conditions were largely met for the project scenarios, although some scenarios were hypothetical and therefore specific details were not necessarily confirmed or clearly defined (i.e., for the Pukehina/Waihī Estuary and Farewell Spit sites). The Waimeha Inlet restoration site did not meet the Applicability Condition relating to the potential use of fertilizer when replanting vegetation. Some of the conditions were not able to be assessed pending information that needs to be confirmed during further project development. An example of one such knowledge gap is whether the soil at the project sites is organic (i.e., peatland); further information on this is provided in Section 3.3.4 and Appendix 5.

We recommend filling any knowledge gaps highlighted in our assessment of these Applicability Conditions. The next step in project development is to assess the Applicability Conditions for the various Tools and Modules relevant to the VM0007/VM0033 methodologies for each project scenario. Our recommendations for improving the methodologies in respect to the Applicability Conditions are:

- The question relating to 'Baseline agents' would ideally be translated for common use (i.e., it is difficult for the layperson to understand).
- It would be useful to clarify in the VM0007 methodology whether project sites that don't contain peatland soils are eligible for CIW Activity Types.
- We suggest updating the following sentence (in italics) as the word 'country' could be considered irrelevant given there could be state/local laws prohibiting this. *Degradation of additional wetlands for new agricultural/aquacultural sites within the country will not occur or is prohibited by enforced law.*
- Note that there is slightly different wording for leakage in VM0007 vs VM0033. Ideally, definitions would be aligned unless there was a specific reason not to do this.
- It is not easy to interpret what the term 'influence of drying cycles of the tide' means in relation to the definition to tidal wetland, especially given the continuous pattern of natural vegetation succession that can occur inwards from the estuary boundary in Aotearoa New Zealand. However, we recognize that it may make sense to leave this definition broad (as it is) to cater for different scenarios around the world.

### A2.1 Te Repo Ki Pūkorokoro

<table>
<tr><th>Applicability Conditions</th><th>Conditions Met<br>TBC= to be confirmed</th><th>Remarks</th></tr>
<tr><td>All land areas registered under the CDM or under any other GHG program (both voluntary and compliance-oriented) must be transparently reported and excluded from the project area. The exclusion of land in the project area from any other GHG program must be monitored over time and reported in the monitoring reports.</td><td>Yes</td><td></td></tr>
<tr><th>Applicability for ARR</th><th>Conditions Met</th><th>Remarks</th></tr>
<tr><td>ARR activities are applicable under the following conditions:<br>• The project area is non-forest land or land with degraded forest[1].<br>• In strata with drained[2] organic soil, ARR activities must be combined with rewetting.</td><td>Yes</td><td></td></tr>
<tr><td>ARR activities are not eligible under the following conditions:<br>• The project scenario involves the application of nitrogen fertilizers.<br>• If ARR activities enhance peat oxidation. Therefore, on peatland, the project must include at least some degree of rewetting. In a tidal system where the tidal regime is restored or continues to be in place, ARR activities are considered not to enhance peat oxidation.</td><td>Yes</td><td></td></tr>
<tr><th>Applicability for WRC</th><th>Conditions Met</th><th>Remarks</th></tr>
<tr><td>WRC activities are not eligible under the following conditions:</td><td></td><td></td></tr>
<tr><td>a) Project activities lower the water table, unless the project converts open water to tidal wetlands, or improves the hydrological connection to impounded waters.</td><td>Yes</td><td>Given that regular tidal inundation is planned. However, “marine silt in the project area is to be excavated to form a series of tidal ponds. The silt transported to form the new drain bund. The high sediment load from the farm drain will be directed through the new drain, bypassing the Reserve wetland”. It would need to be confirmed that this would not lower the water table.</td></tr>
<tr><td>b) Changes in hydrology do not result in the accumulation or maintenance of SOC stock, noting that:<br>• This pertains to projects that intend to sequester carbon through sedimentation and/or vegetation development and<br>• This does not pertain to projects that increase salinity to reduce $CH_4$ emissions. Projects that aim to decrease $CH_4$ emissions through increased salinity must account for any changes in SOC stocks.</td><td>TBC</td><td>This will be confirmed during project development.</td></tr>
<tr><td>c) Hydrological connectivity of the project area with adjacent areas leads to a significant increase in GHG emissions outside the project area.</td><td>Yes</td><td></td></tr>
</table>

| | | |
|---|---|---|
| d) Project activities include the burning of organic soil. | Yes | No burning activities are planned. |
| e) Nitrogen fertilizer(s), such as chemical fertilizer or manure, are applied in the project area during the project crediting period. | Yes | |
| **Applicability for RWE (including relevance to VM0033)** | **Conditions Met** | **Remarks** |
| For RWE project activities, prior to the project start date, the project area must meet the following conditions[3]:<br>a) The area is free of any land use that could be displaced outside the project area, as demonstrated by at least one of the following, where relevant:<br>i. The project area has been abandoned for two or more years prior to the project start date; or<br>ii. Use of the project area for commercial purposes (i.e., trade) is not profitable as a result of salinity intrusion, market forces, or other factors. In addition, timber harvesting in the baseline scenario within the project area does not occur; or<br>iii. Degradation of additional wetlands for new agricultural/aquacultural sites within the country will not occur or is prohibited by enforced law.<br>OR<br>b) The area is under a land use that could be displaced outside the project area, although in such case, baseline emissions from this land use must not be accounted for, and where degradation of additional wetlands for new agricultural/aquacultural sites within the country will not occur or is prohibited by enforced law.<br>OR<br>c) The area is under a land use that will continue at a similar or greater level of service or production during the project crediting period (e.g., reed or hay harvesting, collection of fuelwood, subsistence harvesting, commercial fishing). | Yes a(ii) | *The Reserve* (i.e., project area) *forms part of a farm block that was sold in 2019 to an adjoining landowner (Dalton Family Trust) for which a pre-purchase agreement with DOC enabled the Crown to purchase the project area for establishment of the proposed tidal wetland. The project area is currently grazed by the Dalton family until the project is readied for restoration.*<br><br>*The Reserve* (i.e., project area) *is administered by DOC for the purpose of conservation management. Prior to DOC purchase of the project area, the use of the land for grazing was economically sub-optimal. Recent inundation by a tidal surge of local farms is continuing to have significant impacts of farm viability with elevated soil salinity levels persisting three years after the most recent surge event.*<br><br>*Saltwater intrusion from the reserve into adjoining farmland is not anticipated.* |
| The project proponent must demonstrate (a), (b) or (c) above, based on verifiable information such as laws and bylaws, management plans, annual reports, annual accounts, market studies, government studies or land use planning reports and documents. | Yes | Refer to DOC pre-purchase agreement and management plan (access to and the exact content of these documents needs to be confirmed).<br><br>*The amicable DOC-Dalton land purchase demonstrated a willingness to forgo commercial use of the Reserve land.* |
| **Tidal Wetland Restoration**: Project activities restoring tidal wetlands may include any of the following, or combinations of the following:<br>a. Creating, restoring and/or managing hydrological conditions (e.g., removing tidal barriers, improving hydrological connectivity, restoring tidal flow to wetlands or lowering water levels on impounded wetlands).<br>b. Altering sediment supply (e.g., beneficial use of dredge material or diverting river sediments to sediment-starved areas). | Yes (a, c, e, f, g) | Project activities will involve rewetting, as well as revegetation of native plant communities (including weeding). |

| | | |
|---|---|---|
| c. Changing salinity characteristics (e.g., restoring tidal flow to tidally-restricted areas).<br>d. Improving water quality (e.g., reducing nutrient loads leading to improved water clarity to expand seagrass meadows, recovering tidal and other hydrologic flushing and exchange or reducing nutrient residence time).<br>e. (Re-)introducing native plant communities (e.g., reseeding or replanting).<br>f. Improving management practice(s) (e.g., removing invasive species, reduced grazing).<br>g. In RWE-ARR project activities, the prescribed burning of herbaceous and shrub aboveground biomass (cover burns) may occur | | |
| **Peatland Rewetting**: This methodology is applicable to rewetting drained peatland (RDP) activities on project areas that meet the VCS definition for peatland (see VCS Program Definitions)[4]. | TBC | The organic content of the soil at the project site needs to be confirmed. |
| **Additional (to conditions for RWE above) applicability for VM0033** | **Conditions Met** | **Remarks** |
| This methodology is applicable under the following conditions:<br>a. Live tree vegetation may be present in the project area and may be subject to carbon stock changes (e.g., due to harvesting) in both the baseline and project scenarios.<br>b. The prescribed burning of herbaceous and shrub aboveground biomass (cover burns) as a project activity may occur.<br>c. Where the project proponent intends to claim emission reductions from reduced frequency of peat fires, project activities must include a combination of rewetting and fire management.<br>d. Where the project proponent intends to claim emission reductions from reduced frequency of peat fires, it must be demonstrated that a threat of frequent on-site fires exists, and the overwhelming cause of ignition of the organic soil is anthropogenic (e.g., drainage of the peat, arson).<br>**e.** In strata with organic soil, afforestation, reforestation, and revegetation (ARR) activities must be combined with rewetting. | Yes (a, b)<br>TBC (c, d, e) | No plans for prescribed burning.<br>The organic content of the soil needs to be confirmed. |
| This methodology is not applicable under the following conditions:<br>a. Project activities qualify as IFM or REDD.<br>b. Baseline activities include commercial forestry.<br>Note: criteria were removed from here if they were identical to any of those above. | Yes (a, b) | |

Footnotes:

[1] Restoring carbon stocks in degraded and managed forest (e.g., enrichment planting) is not an eligible activity as it falls in the category of Improved Forest Management (IFM). Restoring carbon stocks in a degraded but unmanaged forest is an afforestation, reforestation and revegetation (ARR) activity.

[2] This requirement supports mangrove reforestation in the natural habitat. ARR activities located in tidal systems where the tidal regime is restored or continues to be in place are eligible.

[3] These conditions are included to avoid leakage.

[4] Rewetting of Drained Peatland (RDP) and Conservation of Undrained or Partially drained Peatland (CUPP) project activities are both subcategories of Restoration of Wetland Ecosystems (RWE) and Conservation of Intact Wetlands (CIW) of the Wetlands Restoration and Conservation (WRC) project category.

## A2.2 Wainui Repo Whenua

| **Applicability Conditions** | **Conditions met TBC = to be confirmed** | **Remarks** |
|---|---|---|
| All land areas registered under the CDM or under any other GHG program (both voluntary and compliance-oriented) must be transparently reported and excluded from the project area. The exclusion of land in the project area from any other GHG program must be monitored over time and reported in the monitoring reports. | Yes | |
| **Applicability for ARR** | **Conditions met** | **Remarks** |
| ARR activities are applicable under the following conditions:<br>a. The project area is non-forest land or land with degraded forest[1].<br>b. In strata with drained[2] organic soil, ARR activities must be combined with rewetting. | Yes | Baseline is grazed open pasture on drained/ reclaimed land that will be rewetted. |
| ARR activities are not eligible under the following conditions:<br>a. The project scenario involves the application of nitrogen fertilizers.<br>b. If ARR activities enhance peat oxidation. Therefore, on peatland, the project must include at least some degree of rewetting. In a tidal system where the tidal regime is restored or continues to be in place, ARR activities are considered not to enhance peat oxidation. | Yes (a)<br><br>TBC (b) | The organic content of the soil needs to be confirmed to determine whether it is peatland. |
| **Applicability for WRC** | **Conditions met** | **Remarks** |
| WRC activities are ***not*** eligible under the following conditions: | | |
| a. Project activities lower the water table, unless the project converts open water to tidal wetlands, or improves the hydrological connection to impounded waters. | Yes | Given that tidal flow is to be reconnected. |
| b. Changes in hydrology do not result in the accumulation or maintenance of SOC stock, noting that:<br>• this pertains to projects that intend to sequester carbon through sedimentation and/or vegetation development and<br>• b) this does not pertain to projects that increase salinity to reduce $CH_4$ emissions. Projects that aim to decrease $CH_4$ emissions through increased salinity must account for any changes in SOC stocks. | TBC | This will need to be confirmed during project development. |
| c. Hydrological connectivity of the project area with adjacent areas leads to a significant increase in GHG emissions outside the project area. | Yes | |
| d. Project activities include the burning of organic soil. | Yes | No burning activities are planned. |
| e. Nitrogen fertilizer(s), such as chemical fertilizer or manure, are applied in the project area during the project crediting period. | Yes | |

| Applicability for RWE (including relevance to VM0033) | Conditions met | Remarks |
|---|---|---|
| For RWE project activities, prior to the project start date, the project area must meet the following conditions[3]:<br>a) The area is free of any land use that could be displaced outside the project area, as demonstrated by at least one of the following, where relevant:<br>i. The project area has been abandoned for two or more years prior to the project start date; or<br>ii. Use of the project area for commercial purposes (i.e., trade) is not profitable as a result of salinity intrusion, market forces, or other factors. In addition, timber harvesting in the baseline scenario within the project area does not occur; or<br>iii. Degradation of additional wetlands for new agricultural/aquacultural sites within the country will not occur or is prohibited by enforced law.<br>OR<br>b) The area is under a land use that could be displaced outside the project area, although in such case, baseline emissions from this land use must not be accounted for, and where degradation of additional wetlands for new agricultural/aquacultural sites within the country will not occur or is prohibited by enforced law.<br>OR<br>c) The area is under a land use that will continue at a similar or greater level of service or production during the project crediting period (e.g., reed or hay harvesting, collection of fuelwood, subsistence harvesting, commercial fishing). | Yes (a ii) | |
| The project proponent must demonstrate (a), (b) or (c) above, based on verifiable information such as laws and bylaws, management plans, annual reports, annual accounts, market studies, government studies or land use planning reports and documents. | Yes | *Restoration justification is primarily for biodiversity purposes, and secondarily for cultural and climate change purposes, on land that is marginally profitable under long term grazing. There is no regulatory imperative driving the land use change, but as Council owns the land it considers its highest and best value use is as tidal wetland with benefits rather than low-value grazing with adverse environmental effects.*<br><br>*Project outcomes will align with specific objectives from the Bay of Plenty Regional Coastal Environment Plan that aims to restore and promote the sustainable management of the natural and physical resources of the Bay of Plenty Coastal environment.*<br><br>*High quality estuarine and palustrine wetland habitat is listed as a threatened or rare* |

| | | |
|---|---|---|
| | | *ecosystem in the Regional Coastal Environment Plan as per the definition in the Aotearoa New Zealand Coastal Policy Statement.*<br><br>*Land is surrounded by Bay of Plenty Regional Council Priority Biodiversity Level 2 sites. Saltmarsh vegetation is currently present on the estuary side of the stop banks, as well as immediately upstream of the site. These areas of vegetation are identified as Significant Ecological Features (U14/124) under the Western Bay of Plenty District Plan, while the Wainui Estuary has been identified as a regionally significant Indigenous Biological Diversity Area (IBDA A18).* |
| **Tidal Wetland Restoration**: Project activities restoring tidal wetlands may include any of the following, or combinations of the following:<br>a. Creating, restoring and/or managing hydrological conditions (e.g., removing tidal barriers, improving hydrological connectivity, restoring tidal flow to wetlands or lowering water levels on impounded wetlands).<br>b. Altering sediment supply (e.g., beneficial use of dredge material or diverting river sediments to sediment-starved areas).<br>c. Changing salinity characteristics (e.g., restoring tidal flow to tidally-restricted areas).<br>d. Improving water quality (e.g., reducing nutrient loads leading to improved water clarity to expand seagrass meadows, recovering tidal and other hydrologic flushing and exchange or reducing nutrient residence time).<br>e. (Re-)introducing native plant communities (e.g., reseeding or replanting).<br>f. Improving management practice(s) (e.g., removing invasive species, reduced grazing).<br>g. In RWE-ARR project activities, the prescribed burning of herbaceous and shrub aboveground biomass (cover burns) may occur. | Yes (a, c, e, f, g) | |
| **Peatland Rewetting**: This methodology is applicable to rewetting drained peatland (RDP) activities on project areas that meet the VCS definition for peatland (see VCS Program Definitions)[4]. | TBC | The soil organic content at the project site needs to be confirmed. |
| **Additional (to conditions for RWE above) applicability for VM0033** | **Conditions met** | **Remarks** |
| This methodology is applicable under the following conditions:<br>a. Live tree vegetation may be present in the project area, and may be subject to carbon stock changes (e.g., | Yes (a,b)<br><br>TBC (c,d,e) | |

| | | |
|---|---|---|
| due to harvesting) in both the baseline and project scenarios.<br>b. The prescribed burning of herbaceous and shrub aboveground biomass (cover burns) as a project activity may occur.<br>c. Where the project proponent intends to claim emission reductions from reduced frequency of peat fires, project activities must include a combination of rewetting and fire management.<br>d. Where the project proponent intends to claim emission reductions from reduced frequency of peat fires, it must be demonstrated that a threat of frequent on-site fires exists, and the overwhelming cause of ignition of the organic soil is anthropogenic (e.g., drainage of the peat, arson).<br>**e.** In strata with organic soil, afforestation, reforestation, and revegetation (ARR) activities must be combined with rewetting. | | The soil organic content at the project site needs to be confirmed |
| This methodology is not applicable under the following conditions:<br>a. Project activities qualify as IFM or REDD.<br>b. Baseline activities include commercial forestry.<br>Note: criteria were removed from here if they were identical to any of those above. | Yes (a, b) | |

Footnotes:

[1] Note that restoring carbon stocks in degraded and managed forest (e.g., enrichment planting) is not an eligible activity as it falls in the category of Improved Forest Management (IFM). Restoring carbon stocks in a degraded but unmanaged forest is an afforestation, reforestation and revegetation (ARR) activity.

[2] This requirement supports mangrove reforestation in the natural habitat. ARR activities located in tidal systems where the tidal regime is restored or continues to be in place are eligible.

[3] These conditions are included to avoid leakage.

[4] Rewetting of Drained Peatland (RDP) and Conservation of Undrained or Partially drained Peatland (CUPP) project activities are both subcategories of Restoration of Wetland Ecosystems (RWE) and Conservation of Intact Wetlands (CIW) of the Wetlands Restoration and Conservation (WRC) project category.

## A2.3 Pukehina/Waihī

| Applicability Conditions | Conditions met<br>TBC= to be confirmed | Remarks |
|---|---|---|
| All land areas registered under the CDM or under any other GHG program (both voluntary and compliance-oriented) must be transparently reported and excluded from the project area. The exclusion of land in the project area from any other GHG program must be monitored over time and reported in the monitoring reports. | Yes | |
| **Applicability for ARR** | **Conditions met** | **Remarks** |
| ARR activities are applicable under the following conditions:<br>a. The project area is non-forest land or land with degraded forest[1].<br>b. In strata with drained[2] organic soil, ARR activities must be combined with rewetting. | Yes (a) | |
| ARR activities are not eligible under the following conditions:<br>a. The project scenario involves the application of nitrogen fertilizers.<br>b. If ARR activities enhance peat oxidation. Therefore, on peatland, the project must include at least some degree of rewetting. In a tidal system where the tidal regime is restored or continues to be in place, ARR activities are considered not to enhance peat oxidation. | Yes | |
| **Applicability for WRC** | **Conditions met** | **Remarks** |
| WRC activities are ***not*** eligible under the following conditions: | | |
| a. Project activities lower the water table, unless the project converts open water to tidal wetlands, or improves the hydrological connection to impounded waters. | Yes | Given that tidal reconnection could occur |
| b. Changes in hydrology do not result in the accumulation or maintenance of SOC stock, noting that<br>• this pertains to projects that intend to sequester carbon through sedimentation and/or vegetation development and<br>• b) this does not pertain to projects that increase salinity to reduce $CH_4$ emissions. Projects that aim to decrease $CH_4$ emissions through increased salinity must account for any changes in SOC stocks. | TBC | This will need to be confirmed during project development. |
| c. Hydrological connectivity of the project area with adjacent areas leads to a significant increase in GHG emissions outside the project area. | Yes | |
| d. Project activities include the burning of organic soil. | Yes | No burning activities are planned. |
| e. Nitrogen fertilizer(s), such as chemical fertilizer or manure, are applied in the project area during the project crediting period. | Yes | |
| **Applicability for RWE (including relevance to VM0033)** | **Conditions met** | **Remarks** |
| For RWE project activities, prior to the project start date, the project area must meet the following conditions[3]: | TBC | Knowledge Gap – information not provided and it is not easy to assume given the scenario is hypothetical at this stage. The |

| | | |
|---|---|---|
| a. The area is free of any land use that could be displaced outside the project area, as demonstrated by at least one of the following, where relevant:<br>i. The project area has been abandoned for two or more years prior to the project start date; or<br>ii. Use of the project area for commercial purposes (i.e., trade) is not profitable as a result of salinity intrusion, market forces, or other factors. In addition, timber harvesting in the baseline scenario within the project area does not occur; or<br>iii. Degradation of additional wetlands for new agricultural/aquacultural sites within the country will not occur or is prohibited by enforced law.<br>OR<br>b. The area is under a land use that could be displaced outside the project area, although in such case, baseline emissions from this land use must not be accounted for, and where degradation of additional wetlands for new agricultural/aquacultural sites within the country will not occur or is prohibited by enforced law.<br>OR<br>c. The area is under a land use that will continue at a similar or greater level of service or production during the project crediting period (e.g., reed or hay harvesting, collection of fuelwood, subsistence harvesting, commercial fishing). | | most likely scenario could be a) ii. |
| The project proponent must demonstrate (a), (b) or (c) above, based on verifiable information such as laws and bylaws, management plans, annual reports, annual accounts, market studies, government studies or land use planning reports and documents. | TBC | Knowledge Gap - See above |
| **Tidal Wetland Restoration**: Project activities restoring tidal wetlands may include any of the following, or combinations of the following:<br>a. Creating, restoring and/or managing hydrological conditions (e.g., removing tidal barriers, improving hydrological connectivity, restoring tidal flow to wetlands or lowering water levels on impounded wetlands).<br>b. Altering sediment supply (e.g., beneficial use of dredge material or diverting river sediments to sediment-starved areas).<br>c. Changing salinity characteristics (e.g., restoring tidal flow to tidally-restricted areas).<br>d. Improving water quality (e.g., reducing nutrient loads leading to improved water clarity to expand seagrass meadows, recovering tidal and other hydrologic flushing and exchange or reducing nutrient residence time).<br>e. (Re-)introducing native plant communities (e.g., reseeding or replanting).<br>f. Improving management practice(s) (e.g., removing invasive species, reduced grazing).<br>g. In RWE-ARR project activities, the prescribed burning of herbaceous and shrub aboveground biomass (cover burns) may occur | Yes (a, c, e, f, g) | |

| | | |
|---|---|---|
| **Peatland Rewetting**: This methodology is applicable to rewetting drained peatland (RDP) activities on project areas that meet the VCS definition for peatland (see VCS Program Definitions)[4]. | TBC | The organic content of the soil needs to be confirmed. |
| **Additional (to conditions for RWE above) applicability for VM0033** | **Conditions met** | **Remarks** |
| This methodology is applicable under the following conditions:<br>a. Live tree vegetation may be present in the project area, and may be subject to carbon stock changes (e.g., due to harvesting) in both the baseline and project scenarios.<br>b. The prescribed burning of herbaceous and shrub aboveground biomass (cover burns) as a project activity may occur.<br>c. Where the project proponent intends to claim emission reductions from reduced frequency of peat fires, project activities must include a combination of rewetting and fire management.<br>d. Where the project proponent intends to claim emission reductions from reduced frequency of peat fires, it must be demonstrated that a threat of frequent on-site fires exists, and the overwhelming cause of ignition of the organic soil is anthropogenic (eg, drainage of the peat, arson).<br>**e.** In strata with organic soil, afforestation, reforestation, and revegetation (ARR) activities must be combined with rewetting. | Yes (a)<br>Yes (b)<br><br>TBC (c, d, e) | Assume this is not a requirement given 'may' is mentioned twice.<br>There are no plans for prescribed burning indicated.<br>The organic content of the soil needs to be confirmed. |
| This methodology is not applicable under the following conditions:<br>a. Project activities qualify as IFM or REDD.<br>b. Baseline activities include commercial forestry.<br><br>Note: criteria were removed from here if they were identical to any of those above. | Yes (a, b) | |

## A2.4 Farewell Spit

| **Applicability Conditions** | **Conditions met TBC = to be confirmed** | **Remarks** |
|---|---|---|
| All land areas registered under the CDM or under any other GHG program (both voluntary and compliance-oriented) must be transparently reported and excluded from the project area. The exclusion of land in the project area from any other GHG program must be monitored over time and reported in the monitoring reports. | Yes | |
| **Applicability for WRC** | **Conditions met** | **Remarks** |
| WRC activities are *not* eligible under the following conditions: | | |
| 1. Project activities lower the water table, unless the project converts open water to tidal wetlands, or improves the hydrological connection to impounded waters. | Yes | |
| 2. Changes in hydrology do not result in the accumulation or maintenance of SOC stock, noting that | TBC | This will need to be confirmed during project development. |

| | | |
|---|---|---|
| • this pertains to projects that intend to sequester carbon through sedimentation and/or vegetation development and<br>• b) this does not pertain to projects that increase salinity to reduce $CH_4$ emissions. Projects that aim to decrease $CH_4$ emissions through increased salinity must account for any changes in SOC stocks. | | |
| 3. Hydrological connectivity of the project area with adjacent areas leads to a significant increase in GHG emissions outside the project area. | TBC | |
| 4. Project activities include the burning of organic soil. | Yes | No burning activities are planned. |
| 5. Nitrogen fertilizer(s), such as chemical fertilizer or manure, are applied in the project area during the project crediting period. | Yes | |
| **Applicability for CIW** | **Conditions met** | **Remarks** |
| This methodology is applicable to conservation of undrained and partially drained peatland (CUPP) activities on project areas that meet the VCS definition for peatland (see VCS Program Definitions). | TBC | The organic content of the soil in the project site needs to be confirmed. |
| Project activities conserving tidal wetlands may include:<br>a. Protecting at-risk wetlands (e.g., establishing conservation easements, establishing community supported management agreements, establishing protective government regulations, and preventing disruption of water and/ or sediment supply to wetland areas)<br>b. Improving water management on drained wetlands<br>c. Maintaining or improving water quality for seagrass meadows<br>d. Recharging sediment to avoid drowning of coastal wetlands<br>e. Creating accommodation space for wetlands migrating with sea-level rise | Yes (a or c) | Helping to protect intact seagrass from swan/geese herbivory/damage and also from sediment impacts. |
| **Avoiding Unplanned Wetland Degradation (AUWD)**<br>Avoiding unplanned wetland degradation activities[5] are eligible under the following condition:<br>• Baseline agents of wetland degradation<br>(i) cause an alteration in the hydrology of the project area (involving drainage, interrupted sediment supply, or both) and/or a loss of soil organic carbon;<br>(ii) have no documented and uncontested legal right to degrade the wetland; and<br>(iii) are either residents in the reference region for wetland degradation or immigrants.<br>Under any other condition, this methodology must not be used. | Yes (i) | |

### A2.5 Waimeha Inlet

| Applicability Conditions | Conditions met TBC= to be confirmed | Remarks |
|---|---|---|
| All land areas registered under the CDM or under any other GHG program (both voluntary and compliance-oriented) must be transparently reported and excluded from the project area. The | Yes | |

| | | |
|---|---|---|
| exclusion of land in the project area from any other GHG program must be monitored over time and reported in the monitoring reports. | | |
| **Applicability for ARR** | **Conditions met** | **Remarks** |
| ARR activities are applicable under the following conditions:<br>a. The project area is non-forest land or land with degraded forest[1].<br>b. In strata with drained[2] organic soil, ARR activities must be combined with rewetting. | Yes (a)<br>TBC (b) | |
| ARR activities are not eligible under the following conditions:<br>a. The project scenario involves the application of nitrogen fertilizers.<br>b. If ARR activities enhance peat oxidation. Therefore, on peatland, the project must include at least some degree of rewetting. In a tidal system where the tidal regime is restored or continues to be in place, ARR activities are considered not to enhance peat oxidation. | Potentially No (a)<br><br>TBC (b) | *Possibly use slow release NPK fertilizer pellets on plantings*<br><br>The organic content of the soil in the project site needs to be confirmed. |
| **Applicability for WRC** | **Conditions met** | **Remarks** |
| WRC activities are ***not*** eligible under the following conditions: | | |
| a. Project activities lower the water table, unless the project converts open water to tidal wetlands, or improves the hydrological connection to impounded waters. | Yes | Given that there are plans for tidal reconnection. |
| b. Changes in hydrology do not result in the accumulation or maintenance of SOC stock, noting that<br>• this pertains to projects that intend to sequester carbon through sedimentation and/or vegetation development and<br>• b) this does not pertain to projects that increase salinity to reduce $CH_4$ emissions. Projects that aim to decrease $CH_4$ emissions through increased salinity must account for any changes in SOC stocks. | TBC | Will need to be confirmed during project development. |
| c. Hydrological connectivity of the project area with adjacent areas leads to a significant increase in GHG emissions outside the project area. | Yes | |
| d. Project activities include the burning of organic soil. | Yes | No burning activities are planned. |
| e. Nitrogen fertilizer(s), such as chemical fertilizer or manure, are applied in the project area during the project crediting period. | Yes | |
| **Applicability for RWE (including relevance to VM0033)** | **Conditions met** | **Remarks** |
| For RWE project activities, prior to the project start date, the project area must meet the following Conditions[3]:<br>a. The area is free of any land use that could be displaced outside the project area, as demonstrated by at least one of the following, where relevant:<br>i. The project area has been abandoned for two or more years prior to the project start date; or<br>ii. Use of the project area for commercial purposes (i.e., trade) is not profitable as a result of salinity intrusion, market forces, or other factors. In addition, timber harvesting in the baseline scenario within the project area does not occur; or | TBC | |

| | | |
|---|---|---|
| iii. Degradation of additional wetlands for new agricultural/aquacultural sites within the country will not occur or is prohibited by enforced law.<br>OR<br>b. The area is under a land use that could be displaced outside the project area, although in such case, baseline emissions from this land use must not be accounted for, and where degradation of additional wetlands for new agricultural/aquacultural sites within the country will not occur or is prohibited by enforced law.<br>OR<br>c. The area is under a land use that will continue at a similar or greater level of service or production during the project crediting period (e.g., reed or hay harvesting, collection of fuelwood, subsistence harvesting, commercial fishing). | | |
| The project proponent must demonstrate (a), (b) or (c) above, based on verifiable information such as laws and bylaws, management plans, annual reports, annual accounts, market studies, government studies or land use planning reports and documents. | TBC | |
| **Tidal Wetland Restoration**: Project activities restoring tidal wetlands may include any of the following, or combinations of the following:<br>a. Creating, restoring and/or managing hydrological conditions (e.g., removing tidal barriers, improving hydrological connectivity, restoring tidal flow to wetlands or lowering water levels on impounded wetlands).<br>b. Altering sediment supply (e.g., beneficial use of dredge material or diverting river sediments to sediment-starved areas).<br>c. Changing salinity characteristics (e.g., restoring tidal flow to tidally-restricted areas).<br>d. Improving water quality (e.g., reducing nutrient loads leading to improved water clarity to expand seagrass meadows, recovering tidal and other hydrologic flushing and exchange or reducing nutrient residence time).<br>e. (Re-)introducing native plant communities (e.g., reseeding or replanting).<br>f. Improving management practice(s) (e.g., removing invasive species, reduced grazing).<br>g. In RWE-ARR project activities, the prescribed burning of herbaceous and shrub aboveground biomass (cover burns) may occur | Yes (a, c, e, f, g) | |
| **Peatland Rewetting**: This methodology is applicable to rewetting drained peatland (RDP) activities on project areas that meet the VCS definition for peatland (see VCS Program Definitions)[4]. | TBC | The organic content of the soil in the project site needs to be confirmed. |
| **Additional (to conditions for RWE above) applicability for VM0033** | **Conditions met** | **Remarks** |
| This methodology is applicable under the following conditions:<br>a. Live tree vegetation may be present in the project area, and may be subject to carbon stock changes (e.g., due to harvesting) in both the baseline and project scenarios. | Yes (a)<br>Yes (b)<br>TBC (c, d, e). | The organic content of the soil in the project site needs to be confirmed. |

| | | |
|---|---|---|
| b. The prescribed burning of herbaceous and shrub aboveground biomass (cover burns) as a project activity may occur.<br>c. Where the project proponent intends to claim emission reductions from reduced frequency of peat fires, project activities must include a combination of rewetting and fire management.<br>d. Where the project proponent intends to claim emission reductions from reduced frequency of peat fires, it must be demonstrated that a threat of frequent on-site fires exists, and the overwhelming cause of ignition of the organic soil is anthropogenic (eg, drainage of the peat, arson).<br>**e.** In strata with organic soil, afforestation, reforestation, and revegetation (ARR) activities must be combined with rewetting. | | |
| This methodology is not applicable under the following conditions:<br>a. Project activities qualify as IFM or REDD.<br>b. Baseline activities include commercial forestry.<br>Note: criteria were removed from here if they were identical to any of those above. | Yes (a, b) | |

Footnotes:

[1] Note that restoring carbon stocks in degraded and managed forest (e.g., enrichment planting) is not an eligible activity as it falls in the category of Improved Forest Management (IFM). Restoring carbon stocks in a degraded but unmanaged forest is an afforestation, reforestation and revegetation (ARR) activity.

[2] This requirement supports mangrove reforestation in the natural habitat. ARR activities located in tidal systems where the tidal regime is restored or continues to be in place are eligible.

[3] These conditions are included to avoid leakage.

[4] Rewetting of Drained Peatland (RDP) and Conservation of Undrained or Partially drained Peatland (CUPP) project activities are both subcategories of Restoration of Wetland Ecosystems (RWE) and Conservation of Intact Wetlands (CIW) of the Wetlands Restoration and Conservation (WRC) project category.

## A2.6 Wairau Lagoon

| Applicability Conditions | Conditions Met TBC=to be confirmed | Remarks |
|---|---|---|
| All land areas registered under the CDM or under any other GHG program (both voluntary and compliance-oriented) must be transparently reported and excluded from the project area. The exclusion of land in the project area from any other GHG program must be monitored over time and reported in the monitoring reports. | Yes | |
| **Applicability for WRC** | **Conditions met** | **Remarks** |
| WRC activities are *not* eligible under the following conditions: | | |
| 1. Project activities lower the water table, unless the project converts open water to tidal wetlands, or improves the hydrological connection to impounded waters. | Yes | |
| 2. Changes in hydrology do not result in the accumulation or maintenance of SOC stock, noting that<br>• this pertains to projects that intend to sequester carbon through sedimentation and/or vegetation development and | Yes | Project activities are not expected to change hydrology. |

| | | |
|---|---|---|
| • b) this does not pertain to projects that increase salinity to reduce $CH_4$ emissions. Projects that aim to decrease $CH_4$ emissions through increased salinity must account for any changes in SOC stocks. | | |
| 3. Hydrological connectivity of the project area with adjacent areas leads to a significant increase in GHG emissions outside the project area. | Yes | No planned changes to hydrological connectivity. |
| 4. Project activities include the burning of organic soil. | Yes | No burning activities are planned. |
| 5. Nitrogen fertilizer(s), such as chemical fertilizer or manure, are applied in the project area during the project crediting period. | Yes | |
| **Applicability for CIW** | **Conditions met** | **Remarks** |
| This methodology is applicable to conservation of undrained and partially drained peatland (CUPP) activities on project areas that meet the VCS definition for peatland (see VCS Program Definitions). | TBC | The organic content of the soil in the project site needs to be confirmed. |
| Project activities conserving tidal wetlands may include:<br>a. Protecting at-risk wetlands (e.g., establishing conservation easements, establishing community supported management agreements, establishing protective government regulations, and preventing disruption of water and/ or sediment supply to wetland areas)<br>b. Improving water management on drained wetlands<br>c. Maintaining or improving water quality for seagrass meadows<br>d. Recharging sediment to avoid drowning of coastal wetlands<br>e. Creating accommodation space for wetlands migrating with sea-level rise | Yes (a) | Project would help to protect intact salt marsh from cattle damage. |
| **Avoiding Unplanned Wetland Degradation (AUWD)**<br>Avoiding unplanned wetland degradation activities[5] are eligible under the following condition:<br>• Baseline agents of wetland degradation<br>(i) cause an alteration in the hydrology of the project area (involving drainage, interrupted sediment supply, or both) and/or a loss of soil organic carbon;<br>(ii) have no documented and uncontested legal right to degrade the wetland; and<br>(iii) are either residents in the reference region for wetland degradation or immigrants.<br>Under any other condition, this methodology must not be used. | Yes (i) – | It is expected that unplanned livestock presence in salt marsh habitat causes soil disturbance and presumably subsequent loss of carbon from the soil (see main body of the report for further information on this). |

# APPENDIX 3. SITE-SPECIFIC APPLICABILITY: RESILIENCE

The applicability conditions for each project scenario (refer to Key project attributes tables in Appendix A1 for information on individual project scenarios) were assessed based on the SD VISta Coastal Resilience methodology (Table A3.a). The availability and compatibility of existing inundation models (Table A3.c) and datasets (Table A3.b) with what is required in the SD VISta Coastal Resilience Methodology was also assessed. The relevant information about the project scenario and data availability was provided by project contacts and gathered through questionnaires, using the method described in Appendix 2.

All project scenarios met the requirements for the applicability of the SD VISta Coastal Resilience methodology, except the scenario for the Farewell Spit site, as seagrass meadows are the not eligible in the current version of the methodology. In terms of data availability, the high-resolution DEM required by the methodology for the *Project Area* was identified as a data gap for the Te Repo Pūkorokoro site. The National Land Cover Database (LCDB v5.0) fits the methodology requirements for land cover data but, due to its spatial resolution and classification process, it is only suitable for use in national and regional environment monitoring. Therefore, for the Wairau Lagoon and Waimeha site we recommend using the available GIS layers from local habitat mapping. Farewell Spit is the only site for which the LCDB does not cover the *Project Area*. The available land cover data for this site is a compilation of the seagrass meadows mapped by Robertson et al. (2012) and Batley et al. (2005). This data is only available for visualization at the Sea Sketch[75] portal. For future projects developed at this site, we recommend an updated mapping study of the seagrass extent.

Pre-existent flooding models were also assessed for each site and evaluated for how well they meet the SD VISta Coastal Resilience methodology requirements. Flooding models were available for most study sites modelled at different levels of robustness, flood extent and water levels expected for different storm periods. Comparing the models available for all sites, the model developed for the Tauranga Regional Council is the one that best fits the resilience methodology requirements. It uses a validated numerical modelling approach (Delft2D FM hydrodynamic model) considering land cover friction (from the Manning's coefficient).

Inundation maps using outputs from existing models and the estimation of the number of assets (people and property) within the area potentially impacted in terms of flood risk reduction by the project interventions (i.e., *Project Impact Area*) were also assessed for projects with applicable interventions. The potential interventions for Farewell Spit and Wairau Lagoon were not applicable, due to difficulties associated with transparently attributing the interventions to measurable change to the *Project Area* (refer to Section 3.5.4.3 for further information), and the low additional impact on interventions to coastal resilience (refer to Section 3.5.6.3 for further information), respectively. Thus, the number of affected assets within the *Project Impact Area* was not assessed for these two sites.

In terms of data availability, we concluded that the Wainui Repo Whenua is the site most prepared to develop a project following the SD VISta Coastal Resilience methodology. However, in terms of the number of assets within the area that may be affected by the project activity (i.e., estimated *Project Impact Area*), Waimeha is the project site that has the highest potential for delivering measurable outcomes as currently defined in the Coastal Resilience Methodology in comparison to the other sites assessed by this feasibility study.

Our recommendations for improving the SD VISta Coastal Resilience methodology are:

- The refinement of the wording around the assessment of the *Project Impact Area*, especially on how to measure the alongshore width for an irregular *Project Area*.
- We suggest reviewing the consistency of the wording used to classify projects that maintain the area of habitats described in the SD VISta Coastal Resilience methodology (defined as protection projects) and in VCS methodologies (defined as conservation projects).

[75] https://www.seasketch.org/#projecthomepage/5357cfa467a68a303e1bb87a

- We suggest removing the word "including" in the first phrase of the *Applicability Conditions* section (in Page 7 of the current version of the methodology) and rephrase it, clarifying that the methodology is currently only applicable for salt marsh and mangroves.

*Table A3.a. Applicability conditions for the SD VISta Coastal Resilience methodology and the corresponding project classification.*

| Project Type | Activities |
|---|---|
| Restoration projects | Creating, restoring and/or managing hydrological conditions These activities can include the use of structures such as temporary coastal structures. |
| | Altering sediment supply (e.g., beneficial use of dredge material or diverting river sediments to sediment-starved areas) |
| | Changing salinity characteristics (e.g., restoring tidal flow to tidally restricted areas) |
| | Improving water quality (e.g., recovering tidal and other hydrologic flushing and exchange or reducing nutrient residence time) |
| | Re-introducing native plant communities (e.g., reseeding or replanting) |
| | Improving management practice(s) (e.g., removing invasive species, reduced grazing) |
| | The prescribed burning of herbaceous and shrub aboveground biomass (cover burns) as a project activity may occur. |
| Protection Projects | Protecting at-risk wetlands (e.g., establishing conservation easements, establishing community supported management agreements, establishing protective government regulations, and preventing disruption of water and/ or sediment supply to wetland areas) |
| | Recharging sediment to avoid drowning of coastal wetlands |
| | Creating accommodation space for wetlands migrating with sea-level rise |
| | Avoiding degradation from alterations in the hydrology of the project area (involving drainage, interrupted sediment supply, or both) |

*Table A3.b. List of key datasets and respective requirements.*

| Dataset | Requirements |
|---|---|
| Spatial layer defining the boundaries of the Project area | Attributes for each discrete area of land that will be maintained or restored due to project activities:<br>• Name of the project area (including compartment numbers, local name (if any).<br>• Unique identifier for each discrete parcel of land.<br>• Map(s) of the area (preferably in digital format).<br>• The project area must be geo-referenced for location and extent and provided in digital.<br>• format in accordance with SD VISta rules.<br>• Total area.<br>• And details of land rights holder and user rights. |
| Digital Elevation Model for the Project Area | Measurements from field surveys or aerial/satellite imagery of at least 10 m resolution within project area. |
| Digital Elevation Model for the Project Impact Area | Global or regional datasets with at least 90m resolution for project impact area. |
| Land cover | Regional land cover data. |
| Population | Data from peer reviewed literature or global or regional datasets of at least 10 km resolution. |
| Building outlines | Data from peer reviewed literature or global or regional datasets of at least 10 km resolution. |

*Table A3.c. List of inundation model requirements and additional description.*

| Requirement | Description |
|---|---|
| Models selected shall estimate the total water level ($\eta$) in meters. | |
| Models shall estimate ($\eta$) due to offshore storm conditions. | Adding the contributions from:<br>1. Mean sea-level (MSL).<br>2. Astronomical tide (AT).<br>3. Storm surge (SS).<br>4. Wave driven flooding (contribution of waves from runup and setup). |
| The models must assess the probability of storm events occurrence probabilities for four return periods. | 1 in 10 year (10%), 1 in 25 year (4%), 1 in 50 year (2%) and 1 in 100 year (1% chance of occurrence in a given year). |
| Manning's friction coefficients must be used to determine the friction of land cover. | |
| Models must have the following SD VISta model characteristics. | 1. Models shall be publicly available, though not necessarily free of charge, from a reputable and recognized source (e.g., the model developer's website).<br>2. Model parameters shall be determined based upon studies by appropriately qualified experts that identify the parameters as important drivers of the model output variable(s).<br>3. Models shall have been appropriately reviewed, tested and validated (e.g., ground-truth and using empirical data or results compared against results of similar models) by a recognized, competent organization, or an appropriate peer review group.<br>4. All plausible sources of model uncertainty, such as structural uncertainty or parameter uncertainty, shall be assessed using recognized statistical approaches.<br>5. Models shall have comprehensive and appropriate criteria for estimating uncertainty, and the model shall be calibrated by parameters to be appropriate for the given location.<br>6. Models shall apply conservative factors to discount for model uncertainty (in accordance with the most current criteria set out in the SD VISta Standard, v1.0), and shall use conservative assumptions and parameters that are likely to underestimate, rather than overestimate, the SD VISta assets. |

*Table A3.d. List of criteria used to evaluate the quality of the key datasets.*

| **Data** | **Criteria** | **Data quality** | | |
|---|---|---|---|---|
| | | **High** | **Moderate** | **Low** |
| Spatial layer defining the boundaries of the *Project area* | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | File format | Geospatial data (e.g: .geojson, shp) | Table (e.g: .csv) | Static image (e.g.: .png, .jpg, .pdf) |
| Digital Elevation Model for the *Project Area* | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Spatial scale | Fine (10m resolution or higher) | | Coarse (< 10m resolution) |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| Digital Elevation Model for the *Project Impact Area* | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| | Spatial scale | Fine (90m resolution or higher) | | Coarse (90m resolution or less) |
| Land cover | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| | Spatial scale | Fine (Regional dataset) | Intermediat e (National dataset) | Coarse (Global dataset) |
| | Creation date | 2 years ago, or less | 2 – 5 years ago | More than 5 years ago |
| Population | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| | Spatial scale | Fine (regional or national dataset) | | Coarse (global dataset) |
| | Creation date | Less than 5 years | 5 – 10 years ago | More than 10 years ago |
| Building outlines | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| | Spatial scale | Fine (regional or national dataset) | | Coarse (global dataset) |
| | Creation date | Less than five years | 5 – 10 years ago | More than 10 years ago |

*Table A3.e. List of criteria used to evaluate the quality of available inundation models.*

| Criteria | Data quality | | |
|---|---|---|---|
| | **High** | **Moderate** | **Low** |
| **1** Does the data available fill the requirements specified in the SD VISta methodology*? | Yes | Partially | No |
| **2** Type of approach | Numerical modelling | | Analytical or semi-empirical approximations |
| **3** Output file format | Structured data (.netcdf , geospatial data) | Proprietary formats | Static image (e.g.: .png, .jpg, .pdf) |
| **4** Is the data publicly available? | Yes | Partially | No |
| **5** Is the data available free of charge? | Yes | Partially | No |

## A3.1 Te Repo Ki Pūkorokoro

### Assessing the applicability of the methodology for the project scenario

The project scenario for Te Repo Ki Pūkorokoro site meets the requirements for the applicability of the SD VISta Coastal Resilience Methodology for restoration projects. For further information on the project scenario activities for this site refer to Appendix 1 (A1.2.1), and for information on the SD VISta Coastal Resilience Methodology applicability requirements refer to Table A3.a.

### Assessing key datasets and inundation model availability

Most of the key datasets required by SD VISta Coastal Resilience methodology were available for the Repo Ki Pukorokoro Miranda Reserve site. To evaluate the compatibility of existing inundation models with what is required in the SD VISta Coastal Resilience Methodology, as well as their overall quality available, we used the Coastal Inundation Tool [76] developed by Bay of Plenty Regional Council and Environment Canterbury.

### Evaluating key datasets and Inundation models

The only key dataset that is not available for this site is the Digital Elevation Model (DEM) for the *Project Area* (Table A3.1a). LiDAR data from the Waikato west coast and Hauraki Plains has been captured in a scale that is in accordance with the resilience methodology, although, the LiDAR survey did not cover the whole *Project Area*.

For the *Project Impact Area* the use of the national 8m DEM is recommended. This dataset covers the entire *Project Impact Area*, meets the requirements in the methodology and is publicly available by the LINZ Data Service (LDS [77]) portal.

The *Project Area* is defined by the shapefile provided by DOC, but it does not include all the required attributes, particularly the ones related to land rights holder and user rights.

Land cover, population and building outlines datasets are also available in a national scale. For the development of more accurate resilience models, a local and updated assessment of the land cover is recommended.

[76] https://www.waikatoregion.govt.nz/assets/Coastal-Inundation-Tool-V2-User-Guide.pdf

[77] https://data.linz.govt.nz/

The data quality assessment (Table A3.1b) shows that all key datasets that met the requirements of the SD VISta Coastal Resilience Methodology are of high quality, apart from the spatial layer defining the boundaries of the *Project Area* and land cover layer.

*Table A3.1a. Data availability for Te Repo Ki Pūkorokoro.*

| **Data** | **Source** | **Does the data meet the requirements of the SD VISta Coastal Resilience methodology?** |
|---|---|---|
| Spatial layer defining the boundaries of the *Project Area* | Shapefile provided by DOC | Partially |
| Digital Elevation Model for the *Project Area* | Waikato West Coast and Hauraki-Plains LiDAR 1m DEM 2015[2] | No |
| Digital Elevation Model for the *Project Impact Area* | 8m Digital Elevation Model (2012)[3] | Yes |
| Land cover | LCDB v5.0 – Land Cover Database version 5.0, Mainland New Zealand[4] | Yes |
| Population | 2018 Census Individual (part 1) total New Zealand by Statistical Area 1 – Census usually resident population count[5] | Yes |
| Building outlines | NZ Building Outlines[6] | Yes |

[1] See Table 3.4.3b for the key dataset requirements
[2] https://data.linz.govt.nz/layer/53622-waikato-west-coast-and-hauraki-plains-lidar-1m-dem-2015/
[3] https://data.linz.govt.nz/layer/51768-nz-8m-digital-elevation-model-2012/
[4] https://lris.scinfo.org.nz/layer/104400-lcdb-v50-land-cover-database-version-50-mainland-new-zealand/
[5] https://datafinder.stats.govt.nz/layer/104612-2018-census-individual-part-1-total-new-zealand-by-statistical-area-1/
[6] https://data.linz.govt.nz/layer/101290-nz-building-outlines/

*Table A3.1b: Quality of the selected key datasets for the Te Repo Ki Pūkorokoro project site (evaluation in green).*

| **Data** | **Criteria** | **Data quality** | | |
|---|---|---|---|---|
| | | **High** | **Moderate** | **Low** |
| Spatial layer defining the boundaries of the *Project area* | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | File format | Geospatial data (e.g: .geojson, shp) | Table (e.g: .csv) | Static image (e.g.: .png, .jpg, .pdf) |
| Digital Elevation Model for the *Project Area* | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Spatial scale | Fine (10m resolution or higher) | | Coarse (< 10m resolution) |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| Digital Elevation Model for the *Project Impact Area* | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| | Spatial scale | Fine (90m resolution or higher) | | Coarse (90m resolution or less) |
| Land cover | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |

| | | | | |
|---|---|---|---|---|
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| | Spatial scale | Fine (Regional dataset) | Intermediate (National dataset) | Coarse (Global dataset) |
| | Creation date | 2 years ago, or less | 2 – 5 years ago | More than 5 years ago |
| Population | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| | Spatial scale | Fine (regional or national dataset) | | Coarse (global dataset) |
| | Creation date | Less than 5 years | 5 – 10 years ago | More than 10 years ago |
| Building outlines | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| | Spatial scale | Fine (regional or national dataset) | | Coarse (global dataset) |
| | Creation date | Less than five years | 5 – 10 years ago | More than 10 years ago |

The WRC Costal Inundation tool uses a passive approach known as 'bathtub' that does not include the effects of currents, friction, waves or other hydraulic processes that affect water movement or inundation. The outputs of the model are presented in two different categories:

- Connected inundation areas: areas where water could directly (or via waterways) flow to the sea for a chosen water level, and
- Disconnected inundation: areas that are at or below a chosen water level but may have no direct flow path to the sea.

The aim of this tool is to map areas that may be subject to inundation, in different sea level scenarios relative to Moturiki Vertical Datum 1953 (MVD-53). It is important to note that this tool is not designed to define actual coastal inundation hazards and it should only be used to identify areas where further work should be undertaken.

The tool allows the user to select sea level scenarios for specific areas around the Waikato region and visualize both types of area that are likely to be inundated. The sea level scenarios are based on tide levels, storm tides and projected sea level rise. Direct advice was received from the Waikato Regional Council to select the best sea level scenarios relevant to the SD VISta Coastal Resilience Methodology. The GIS layers corresponding to the selected sea level conditions were also provided by the Waikato Regional Council. The GIS layers show the RL level for the Pūkorokoro area for different scenarios. They have been determined using the Tararu tide gauge converted in Moturiki Vertical datum 1953.

Table A3.1c shows that the model does not meet most of the requirements of the SD VISta Coastal Resilience Methodology. Future hydrodynamic models should be developed accounting for land friction, wave contributions (wave runup and set up) and model flood extends from the storm events for all the four return periods required by the methodology.

*Table A3.1c: Evaluation of the available coastal inundation model for Te Repo Ki Pūkorokoro Miranda Reserve based on the requirements for the SD VISta Coastal Resilience Methodology.*

| **Criteria** | **Does the data meet the requirements of the SD VISta Coastal Resilience methodology?** |
|---|---|
| 1- Models selected shall estimate the total water level ($\eta$) in meters | **Yes.** |
| 2- Models shall estimate ($\eta$) due to offshore storm conditions<br><br>***i-****mean sea-level (MSL),*<br>***ii-*** *astronomical tide (AT),*<br>***iii-****storm surge (SS) ,*<br>***iv-*** *waves from runup and setup)* | **Partially***:*<br>***i-mean sea-level (MSL):***<br>**Yes,** Mean sea-level offset relative to MVD-53 (m). MSL Averaging Period 2008–2014 (0.18m).<br><br>***ii-astronomical tide (AT):***<br>**Yes,** From the following tide gauges: Whitianga, Tararu and Kawhia tide gauges<br><br>***iii-storm surge (SS):***<br>***Yes,***<br>For each tide gauge, storm surge levels were calculated from the difference between the tide value and storm tide value. The lower storm surge value is the difference between the<br>MHWS10 tide value and the 39% AEP storm tide value (which represents a "biannual" event. The upper storm surge value is the difference between the maximum high tide value and the maximum storm tide value<br><br>***iv- waves from runup and setup:***<br>**No,** no information on wave set up and run up provided in the Coastal Inundation Tool |
| 3- The models must assess the probability of storm events occurrence probabilities for four return periods (10%, 4%, 2% and 1%) | ***Partially***, the return periods used by the model are the following:<br>1% |
| 4- Manning's friction coefficients must be used to determine the friction of land cover | **No.** |
| 5- Models must have the following SD VISta model characteristics<br>***i-****Models shall be publicly available, though not necessarily free of charge*<br><br>***ii-*** *Model parameters shall be determined based upon studies by appropriately qualified experts that identify the parameters as important drivers of the model output variable(s).*<br><br>***iii-*** *Models shall have been appropriately reviewed, tested and validated (e.g., ground-truth and using empirical data or results compared against results of similar models) by a recognized, competent organization, or an appropriate peer review group.*<br><br>***iv-*** *All plausible sources of model uncertainty, such as structural uncertainty or parameter uncertainty, shall be assessed using recognized statistical approaches.* | **i – Yes**<br><br>**ii- Yes**, Coastal Inundation Tool was developed in collaboration with Bay of Plenty Regional Council and Environment Canterbury<br><br>**iii- No**<br><br>**iv- No**<br><br>**v- No**<br><br>**vi-** ***No*** |

| | |
|---|---|
| ***v-*** *Models shall have comprehensive and appropriate* ***criteria*** *for estimating uncertainty, and the model shall be calibrated by parameters to be appropriate for the given location.*<br><br>***vi-*** *Models shall apply conservative factors to discount for model uncertainty (in accordance with the most current criteria set out in the SD VISta Standard, v1.0), and shall use conservative assumptions and parameters that are likely to underestimate, rather than overestimate, the SD VISta assets* | |

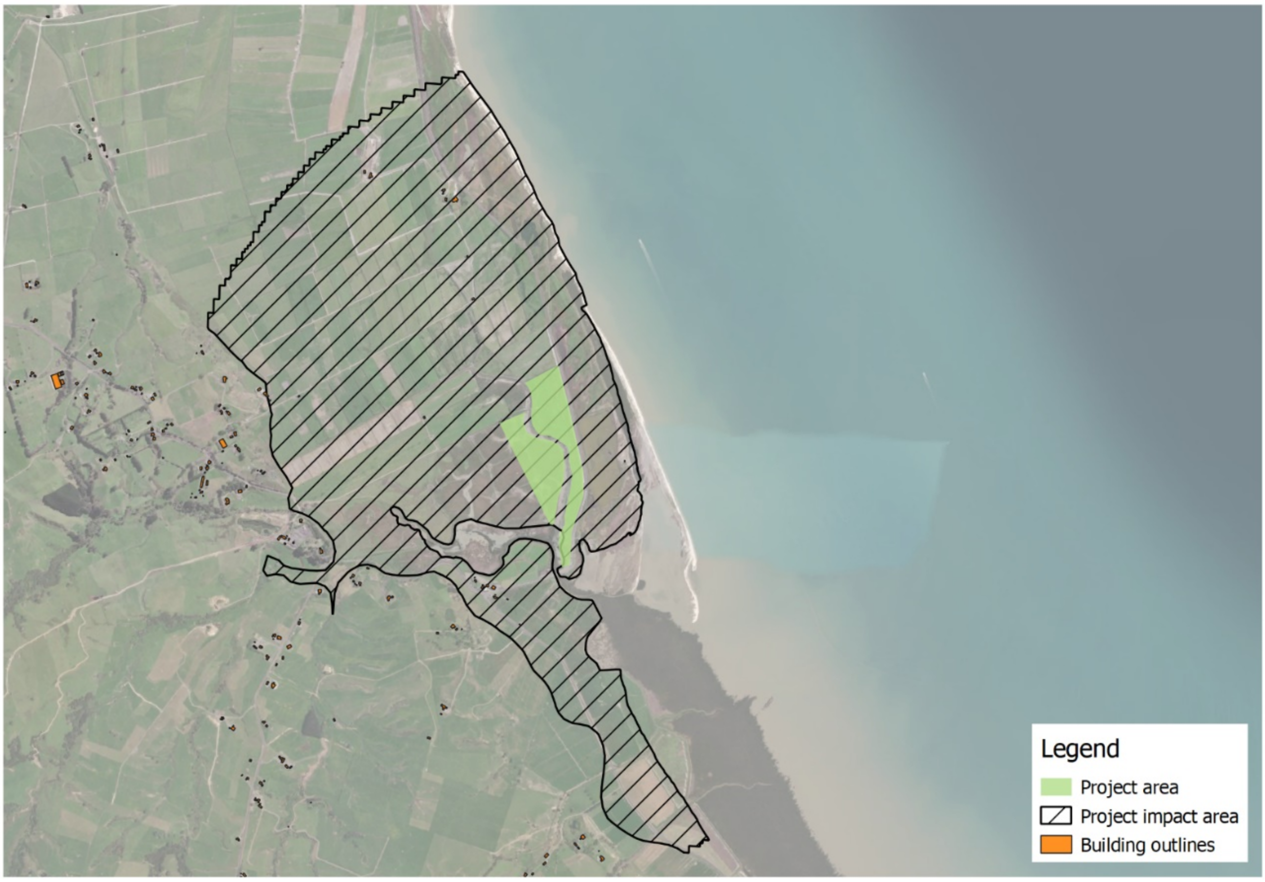
*Table A3.1d: Quality of the selected coastal inundation model for Te Repo Ki Pūkorokoro project site (evaluation in green).*

| **Criteria** | **Data quality** | | |
|---|---|---|---|
| | High | Moderate | Low |
| **1** Does the data available fill the requirements specified in the SD VISta methodology*? | Yes | Partially | No |
| **2** Type of approach | Numerical modelling | | Analytical or semi-empirical approximations |
| **3** Output file format | Structured data (.netcdf , geospatial data) | Proprietary formats | Static image (e.g.: .png, .jpg, .pdf) |
| **4** Is the data publicly available? | Yes | Partially | No |
| **5** Is the data available free of charge? | Yes | Partially | No |

### Estimating Affected Assets

The method described in Section 3.4.2 was used to estimate the *Project Impact Area*, using the 8m national DEM for extracting the 10m elevation contour that limits the inland boundary. Figure A3.1a shows the boundaries of the *Project Area* and the *Project Impact Area*. It was estimated that the total *Project Impact Area* is 458ha and that 19 people and 28 buildings are within this area. Even though the model selected did not meet most of the requirements expected by the SD VISta Coastal Resilience Methodology, flood damages maps were generated comparing the effects of the different storm event scenarios available to exemplify how inundation model outputs could be used for this project.

*Figure A3.1a. Estimated Project Impact Area for Te Repo Ki Pūkorokoro Project Area.*




A comparison was made between the inundated areas at the present day MHWS10 tide level and the 1% AEP, that correspond to the present day tide level of RL1.8m and RL2.62m, respectively (Moturiki Vertical Datum 1953) (see Figures A3.1b,c). Other scenarios were modelled and output values were presented in tables, but this assessment only selected the ones where the outputs were available in existing GIS raster layers. The maps indicate that the whole *Project Impact Area* would be inundated under a 1% AEP.

*Fig A3.1b. Present day – MHWS10 scenario: estimated flooded extend for the Repo Ki Pūkorokoro Project Impact Area.*

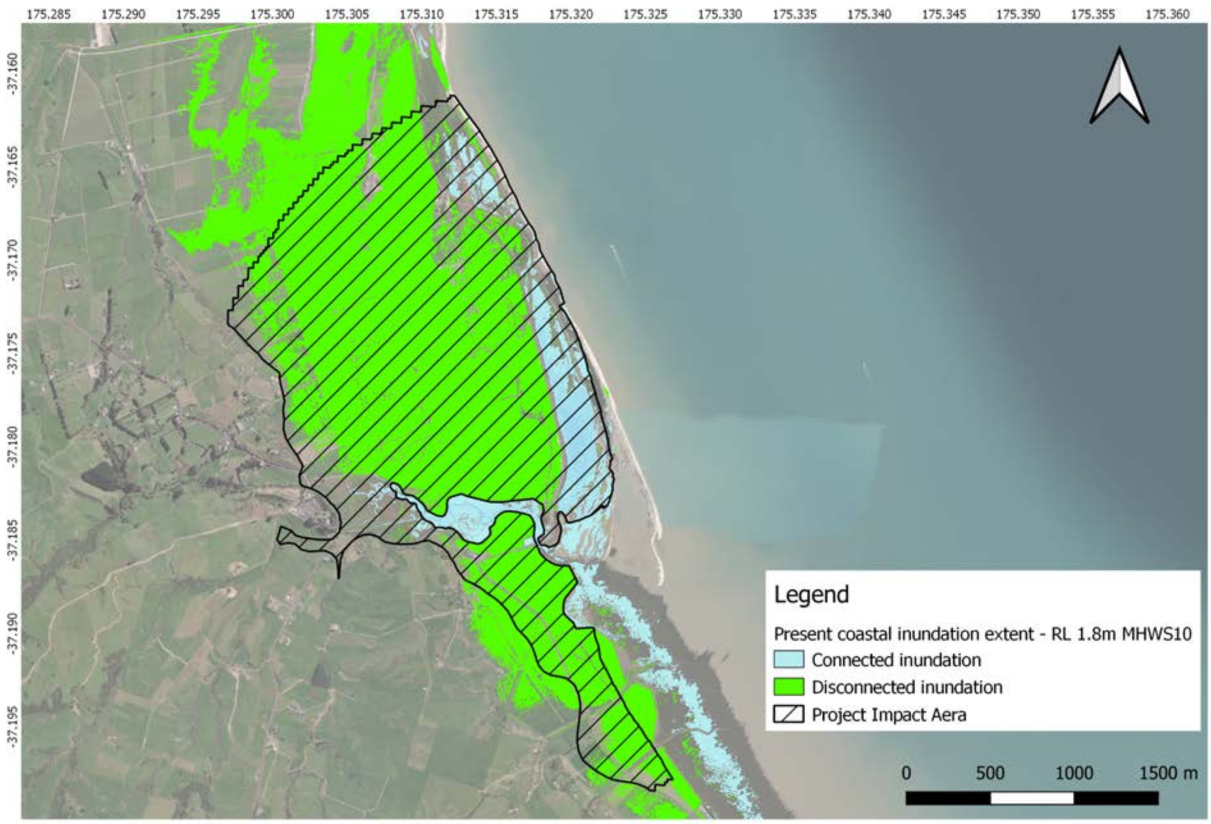
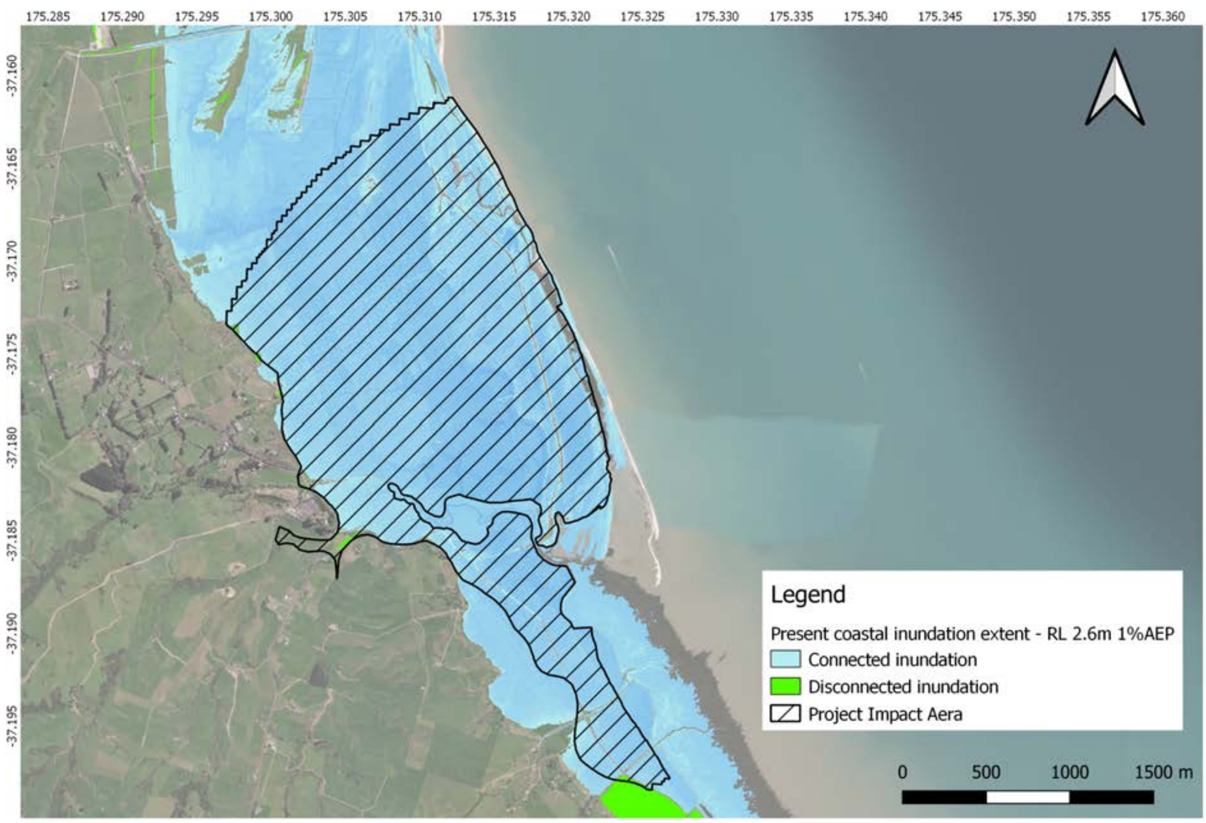



*Fig A3.1c. Present day – 1% AEP scenario: estimated flooded extend for the Repo Ki Pūkorokoro project impact area.*



### Recommendations

Recommendations for applying the SD VISta Coastal resilience methodology for the Repo Ki Pūkorokoro site in relation to the data available and the selected model available, include the following:

- The WRC Coastal inundation tool model covered the whole *Project Impact Area* but uses a simplified (passive) approach that did not meet most of the requirements of the methodology. Therefore, the use of the model outputs for assessing the number of assets affected by flooding in the baseline scenario is not recommended.
- An updated wetland mapping study at local scale should be undertaken.
- Address the data gap of Digital Elevation Model for the *Project Area* of at least 10m resolution
- Future models should:
    - Use a numerical approach considering land friction and wave contributions (wave runup and wave setup) for all the four required storm event periods
    - Replicate the methodology used by Tauranga Harbour inundation modelling (Reeve et al. 2019) for classifying the habitat using the Manning coefficient using updated aerial images (see A3.2)
    - Use the 10m elevation contour as the inland boundary for the model.

## A3.2 Wainui Repo Whenua

### Assessing the applicability of the methodology for the project scenario

The project scenario for Wainui Repo Whenua site meets the requirements expected for the applicability of the SD Vista Coastal Resilience Methodology for restoration projects. For further information on the project scenario activities for this site refer to Appendix 1 (A1.2.2), and for information on the SD Vista Coastal Resilience Methodology applicability requirements refer to Table A3.a.

### Assessing key datasets and inundation model availability

All key datasets (Table A3.2) required by SD VISta Coastal Resilience methodology were available for the site. To evaluate the compatibility of existing inundation models with what is required in the SD VISta Coastal Resilience Methodology, as well as their overall quality available, we used the coastal inundation model developed by NIWA for the Tauranga Harbour (Reeve et al. 2019).

### Evaluating key datasets and inundation models

To comply with all requirements of the SD VISta Coastal Resilience methodology, this assessment recommends refining the available spatial layer by defining the boundaries of the *Project area* to include all the required attributes specified in the methodology. If land ownership and user rights are not uniform for the entire *Project Area,* we also recommend compartmentalizing the spatial layer into different discrete areas of land.

Digital Elevation Model (DEM) for the *Project Area* and for the *Project Impact Area* are available from different sources of datasets. Even though the resilience methodology doesn't require a high-resolution DEM for the *Project Impact Area*, there are several topographic LiDAR surveys conducted in the Bay of Plenty region that cover the whole extension of the *Project Impact Area*. The latest one was conducted between 2020 and 2021 and the Digital Elevation Model (DEM) extracted from the LiDAR points can be accessed from LINZ public portal. It is referenced to NZVD2016 vertical datum, but alternatively, an option is to use the LiDAR data collected during 2011 and 2013 of which uses the Moturiki Vertical Datum 1953.

Land cover data is publicly available through the national Land Cover Database (LCDB). This dataset meets the requirements of the methodology for land cover data, but due to its spatial resolution and classification process, this dataset is only suitable for use in national and regional environment monitoring[78] . Since accurate and timely land cover data is recognized as having a critical role on improving modelling results (Lambin et al 2001) recent local land cover data from local observations could improve the development of new models following the SD VISta Coastal Resilience methodology. Broadscale habitat mapping was not conducted in the Bay of Plenty estuaries, however mangroves, sea lettuce cover, and seagrass habitat are mapped at intermittent periods using aerial imagery. Estuarine land use and vegetation uses was also conducted by NIWA as part of the development of Tauranga Harbour modelling (2019). A sequence of classification algorithms used aerial photos and elevation data from LiDAR to differentiate land use types in areas around the Tauranga Harbour. The resulting land use layer was then converted to Manning coefficient values (Figure A3.2a). These layers are an intermediate result generated for the development of the flooding model, but they could potentially be used for the development of new model following the SD VISta Coastal Resilience Methodology.

All key datasets are of high quality, apart from the spatial layer defining the boundaries of the *Project Area* and land cover layer (A3.2b). As noted above, future models might benefit from land cover data generated from local efforts. However, this assessment did not have access to any of these layers by the end of our data availability process, and as such we cannot confirm their availability quality.

[78] https://lris.scinfo.org.nz/layer/104400-lcdb-v50-land-cover-database-version-50-mainland-new-zealand/

*Figure A3.2a. Land cover classification using Manning coefficient for different land uses (source: Reeve et al. 2019).*

| Vegetation land use classification | Manning's n | Reference/source |
|---|---|---|
| Muds | 0.015 | (Chow 1959) |
| Sands | 0.026–0.035 (used range relative to depth) | (Chow 1959; Arcement & Schneider 1989) |
| Mangroves | 0.01–0.22 (0.1 used) | (Musleh & Cruise 2006) |
| Wetlands | 0.04–0.1 (0.04 used) | (Narayan et al. 2017) |
| Kiwifruit Orchards | 0.025–0.12 (used 0.05) estimated low vegetation density | (Arcement & Schneider 1989) |
| Exotic forest | 0.085–0.120 (0.11 used) | (Arcement & Schneider 1989) |
| Grass | 0.01–0.08 (0.02 used) | (Henderson 1966; Engman Edwin 1986; Arcement & Schneider 1989) |
| Buildings | 1 | - |
| Roads | 0.012–0.016 (0.013 used) | (Ali 2001) |
| Lakes/water bodies | 0.02 | (Narayan et al. 2017) |

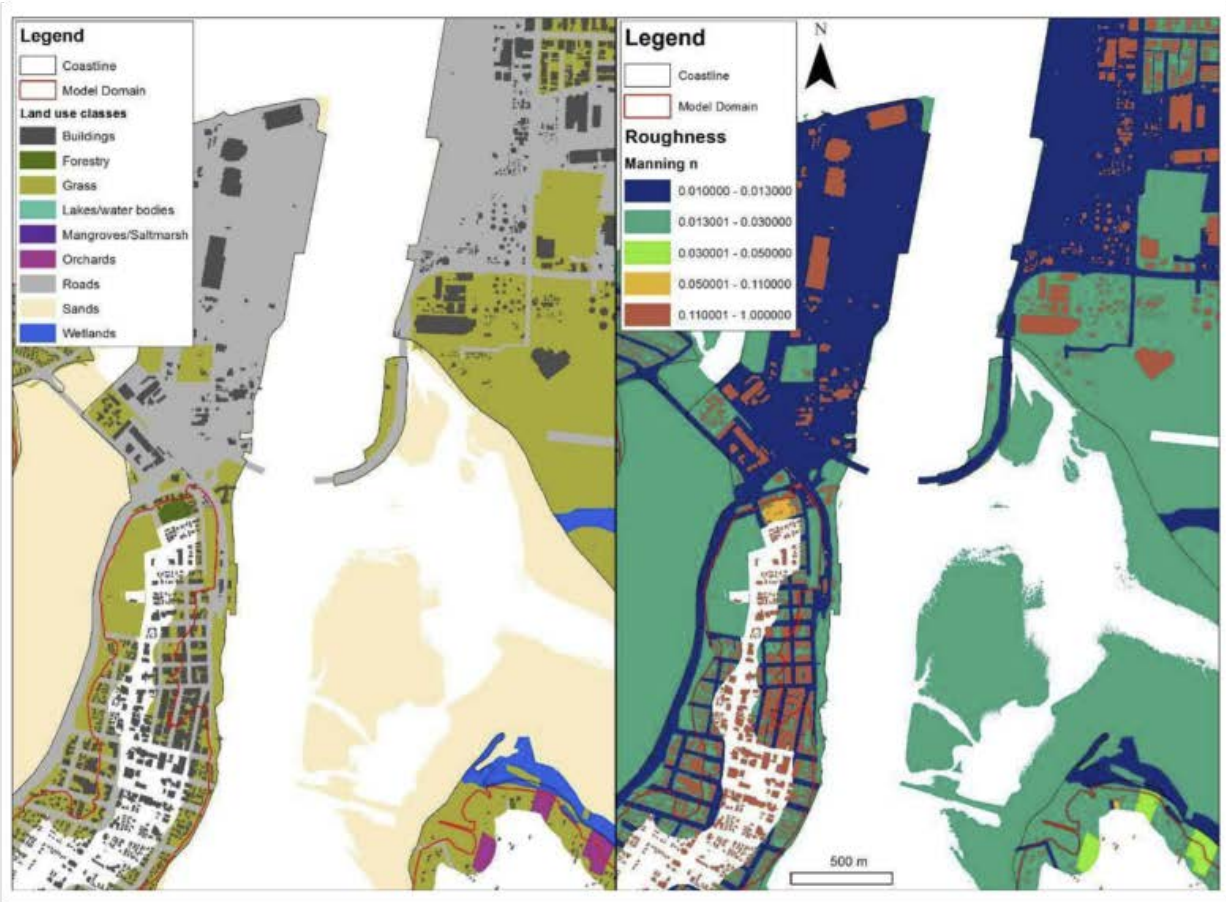


*Table A3.2a. Data availability for Wainui Repo Whenua.*

| **Data** | **Source** | **Does the data meet the requirements of the SD VISta Coastal Resilience methodology?** |
|---|---|---|
| Spatial layer defining the boundaries of the *Project Area* | Shapefile provided by BOPRC | Partially |
| Digital Elevation Model for the *Project Area* | Bay of Plenty – Tauranga and Coast LiDAR 1m DEM (2015)[2] | Yes |
| Digital Elevation Model for the *Project Impact Area* | Bay of Plenty – Tauranga and Coast LiDAR 1m DEM (2015)[2] | Yes |
| Land cover | LCDB v5.0 – Land Cover Database version 5.0, Mainland New Zealand[3] | Yes |
| Population | 2018 Census Individual (part 1) total New Zealand by Statistical Area 1 – Census usually resident population count[4] | Yes |
| Building outlines | NZ Building Outlines[5] | Yes |

[1] See Table 3.4.3b for the key dataset requirements.
[2] https://data.linz.govt.nz/layer/53556-bay-of-plenty-tauranga-and-coast-lidar-1m-dem-2015/
[3] https://lris.scinfo.org.nz/layer/104400-lcdb-v50-land-cover-database-version-50-mainland-new-zealand/
[4] https://datafinder.stats.govt.nz/layer/104612-2018-census-individual-part-1-total-new-zealand-by-statistical-area-1/
[5] https://data.linz.govt.nz/layer/101290-nz-building-outlines/

*Table A3.2b: Quality of the selected key datasets for the Wainui Repo Whenua project site (evaluation in green).*

| **Data** | **Criteria** | **Data quality** | | |
|---|---|---|---|---|
| | | High | Moderate | Low |
| Spatial layer defining the boundaries of the *Project Area* | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | File format | Geospatial data (e.g: .geojson, shp) | Table (e.g: .csv) | Static image (e.g.: .png, .jpg, .pdf) |
| Digital Elevation Model for the *Project Area* | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Spatial scale | Fine (10m resolution or higher) | | Coarse (< 10m resolution) |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charge? | Yes | Partially | No |
| Digital Elevation Model for the *Project Impact Area* | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charge? | Yes | Partially | No |
| | Spatial scale | Fine (90m resolution or higher) | | Coarse (90m resolution or less) |

| | | | | |
|---|---|---|---|---|
| Land cover | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charge? | Yes | Partially | No |
| | Spatial scale | Fine (Regional dataset) | Intermediate (National dataset) | Coarse (Global dataset) |
| | Creation date | 2 years ago, or less | 2 – 5 years ago | More than 5 years ago |
| Population | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charge? | Yes | Partially | No |
| | Spatial scale | Fine (regional or national dataset) | | Coarse (global dataset) |
| | Creation date | Less than 5 years | 5 – 10 years ago | More than 10 years ago |
| Building outlines | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charge? | Yes | Partially | No |
| | Spatial scale | Fine (regional or national dataset) | | Coarse (global dataset) |
| | Creation date | Less than five years | 5 – 10 years ago | More than 10 years ago |

The inundation model selected in this feasibility study was constructed by NIWA for the Bay of Plenty Regional Council (BOPRC), Tauranga City Council (TCC) and Western Bay of Plenty District Council (WBOPDC). It is a hydrodynamic model set up in 2-dimensional mode (Delft2D FM) to predicted depth-averaged flows, and it was constructed from hydrographic charts, bathymetry survey data and LiDAR data. The model mesh was explicitly designed to incorporate the seabed and all land elevations up to the +5 m contour above Moturiki vertical datum 1953 (MVD–53). The model was forced with tides, annual average river flows, wind, and air pressure. It can predict the extent of overland inundation by incorporating representative land use and vegetation roughness values for intertidal areas >−0.5 m MVD–53. The MSL was set to 0.13 m MVD–53 as projected for the year 2020 (Stephens, 2017).

The model setup is satisfactory based on the SD VISta Coastal resilience methodology requirements. The model's ability to simulate overland inundation was validated and calibrated against post-inundation surveys, complying with the validation and calibration criteria expected by the SD VISta Coastal Resilience Methodology.

Instead of simulating wave effects, an empirical formula was used to estimate wave setup, based on wind fetch and depth. To fully fit the requirements of the SD VISta Coastal Resilience Methodology it should also account for wave runup effects as well. Present day inundation scenarios were modelled for three different return periods, two of which (2% and 1% AEP) matched the storm events expected by the methodology.

Even though the selected inundation model did not entirely meet the SD VISta Coastal resilience methodology requirements (Table A3.2c), its quality was considered high based on the criteria established in the data quality assessment (Table A3.2d).

*Table A3.2c. Evaluation of the available coastal inundation model for Wainui Repo Whenua based on the requirements for the SD VISta Coastal Resilience Methodology.*

| **Criteria** | **Does the data meet the requirements of the SD VISta Coastal Resilience methodology?** |
|---|---|
| 1- Models selected shall estimate the total water level ($\eta$) in meters | **Yes.** |
| 2- Models shall estimate ($\eta$) due to offshore storm conditions<br><br>***i-****mean sea-level (MSL),*<br>***ii-*** *astronomical tide (AT),*<br>***iii-****storm surge (SS),*<br>***iv-*** *waves from runup and setup* | **Partially***:*<br>***i-mean sea-level (MSL):***<br>**Yes**, 0.13 m MVD–53<br><br>***ii-astronomical tide (AT):***<br>**Yes**, NIWA's tidal model<br><br>***iii-storm surge (SS):***<br>**Yes**, "storm surge validation is addressed in Section 4, where the model is compared to the 5 January 2018 storm-tide event, using sensitivity testing, and through validation against the 5 January 2018 storm-tide. Nevertheless, if the model can predict the propagation of the tide well, due to accurate bathymetry, and bed roughness and eddy viscosity parameters, for example, then it should also model the propagation of storm surge well."<br><br>***iv- waves from runup and setup:***<br>***Partially***<br>- *No runup*.<br>- Empirical formulas were used to estimate wave setup |
| 3- The models must assess the probability of storm events occurrence probabilities for four return periods (10%, 4%, 2% and 1%) | ***Partially***, the return periods used by the model are following:<br>2%, 1% and 0.2%. |
| 4- Manning's friction coefficients must be used to determine the friction of land cover | **Yes.** |
| 5- Models must have the following SD VISta model characteristics<br>***i-****Models shall be publicly available, though not necessarily free of charge*<br><br>***ii-*** *Model parameters shall be determined based upon studies by appropriately qualified experts that identify the parameters as important drivers of the model output variable(s).*<br><br>***iii-*** *Models shall have been appropriately reviewed, tested and validated (e.g., ground-truth and using empirical data or results compared against results of similar models) by a recognized, competent organization, or an appropriate peer review group.*<br><br>***iv-*** *All plausible sources of model uncertainty, such as structural uncertainty or parameter uncertainty, shall be assessed using recognized statistical approaches.* | **I – Yes**, resulting inundation map outputs are available as digital GIS layers. These inundation hazard map outputs can be used for RMA planning and climate change adaptation planning.<br><br>**ii- Yes**, the model was prepared by NIWA for Bay of Plenty Regional Council<br><br>**iii- Yes**, the wave set up component was calculated at over 100 sites using empirical formula and the results validated well with observed elevations in exposed locations modelling storm-tide around the entire harbour and calculating the wave setup component. The model's ability to simulate overland inundation was validated against post-inundation surveys from the 5 January 2018 storm event with good results.<br><br>**iv- Yes**, The following parameters were adjusted in the hydrodynamic model to achieve a best fit between modelled and observed values:<br>*Smagorinsky eddy coefficient and Sea-bed roughness* |

| | |
|---|---|
| ***v-*** *Models shall have comprehensive and appropriate* ***criteria*** *for estimating uncertainty, and the model shall be calibrated by parameters to be appropriate for the given location.*<br><br>***vi-*** *Models shall apply conservative factors to discount for model uncertainty (in accordance with the most current criteria set out in the SD VISta Standard, v1.0), and shall use conservative assumptions and parameters that are likely to underestimate, rather than overestimate, the SD VISta assets* | The measure of the 'goodness of fit' between observed and predicted was estimated using the following four statistical skill measures:<br>*Skill, Root mean square error, Cross-correlation function and Bias*<br><br>**v- Yes**, The Section "*Model Calibration and Verification*" details how the model estimated was calibrated and estimated uncertainty.<br><br>**vi- *Yes.*** The model does not include waves, so cannot simulate the effects of wave setup and runup. Therefore, it is expected to *under predict* total inundation at wave-exposed locations. |

*Table A3.2d. Quality of the selected coastal inundation model for Wainui Repo Whenua project site (evaluation in green).*

| **Criteria** | **Data quality** | | |
|---|---|---|---|
| | High | Moderate | Low |
| **1** Does the data available fill the requirements specified in the SD VISta methodology*? | Yes | Partially | No |
| **2** Type of approach | Numerical modelling | | Analytical or semi-empirical approximations |
| **3** Output file format | Structured data (.netcdf , geospatial data) | Proprietary formats | Static image (e.g.: .png, .jpg, .pdf) |
| **4** Is the data publicly available? | Yes | Partially | No |
| **5** Is the data available free of charge? | Yes | Partially | No |

## Estimating Affected Assets

The method described in Section 3.4.2 was used to estimate the *Project Impact Area* using the available LiDAR 1m DEM (2015) for extracting the 10m elevation contour to limit the inland boundary. For practical reasons, we selected the DEM from the 2015 LiDAR survey as it also covers the *Project Area*. For future efforts, we recommend using the most recent LiDAR dataset available at LDS (LiDAR 1m DEM - 2020-2021). It was estimated that the total *Project Impact Area* is 165ha and that 19 people and 15 buildings are within this area. Flood damages maps were also generated to compare the effects of the different storm event scenarios available. The most extreme scenario (0.2% AEP) has an additional ~90ha of inundated area compared to the mild scenario (MHWS7). However, there is only a small difference in the number of affected properties, with only 1 additional building being affected by inundation in the 0.2% AEP scenario compared to MHWS7.

*Figure A3.2b. Estimated Project Impact Area for the Wainui Repo Whenua project area.*

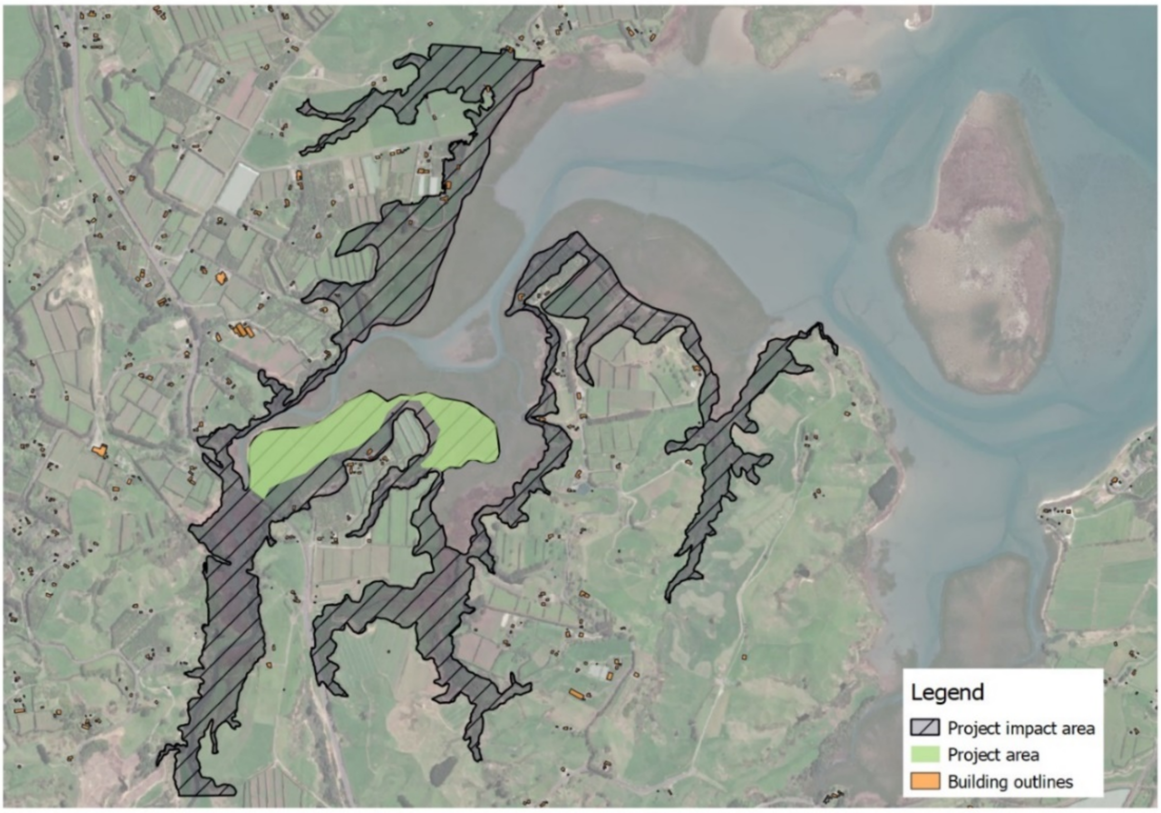



*Figure A3.2c. Present day – MHWS7 scenario: 3.47 ha of the Project Impact Area are estimated to be flooded under this scenario. No buildings are expected to be affected in the Project Impact Area for this scenario.*

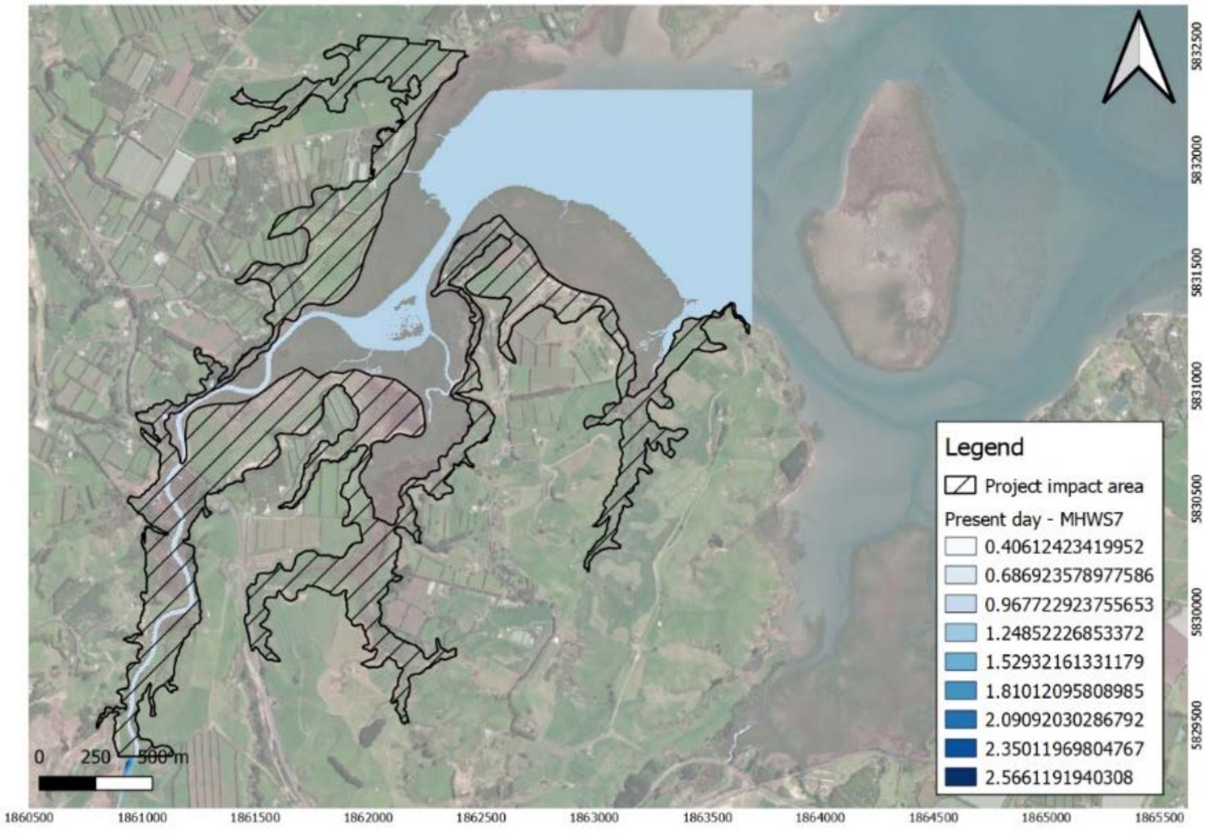


*Figure A3.2d. Present day – 2% AEP scenario: 79.06 ha of the Project Impact Area are estimated to be flooded under this scenario. No buildings are expected to be affected in the Project Impact Area for this scenario.*

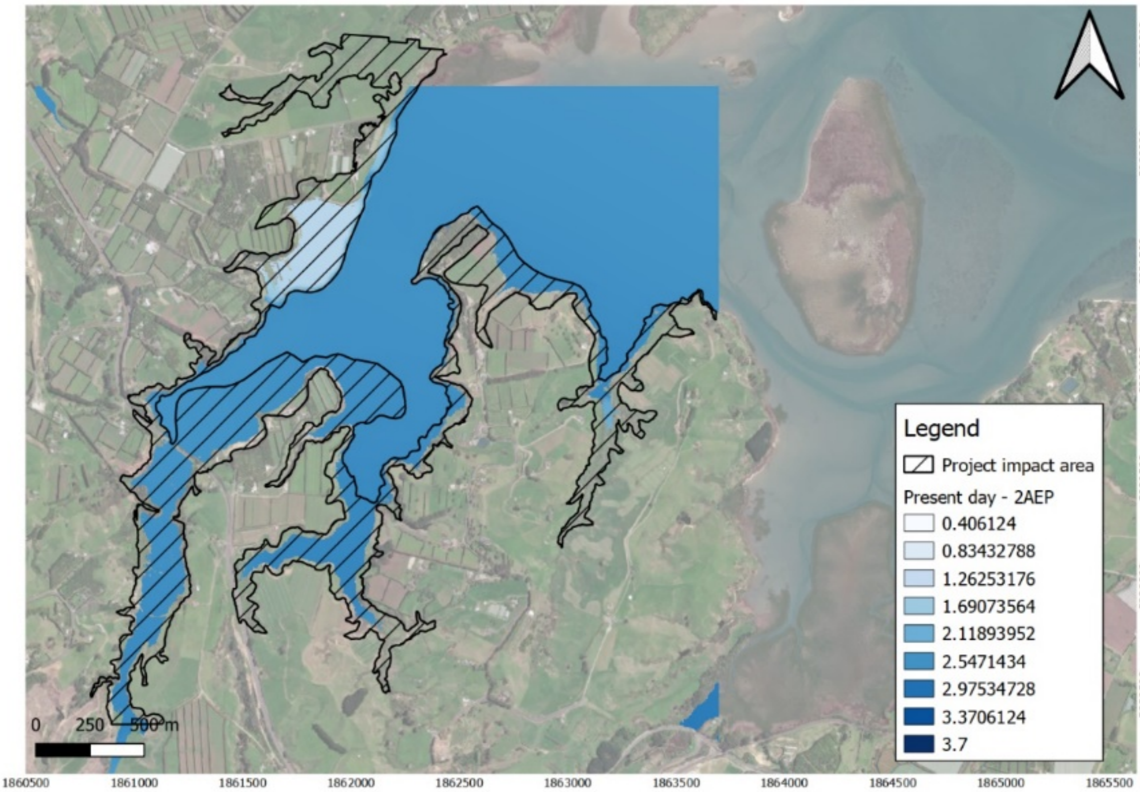



*Figure A3.2e. Present day – 1% AEP scenario: 86.05 ha of the Project Impact Area are estimated to be flooded under this scenario. One building is expected to be affected in the Project Impact Area for this scenario.*

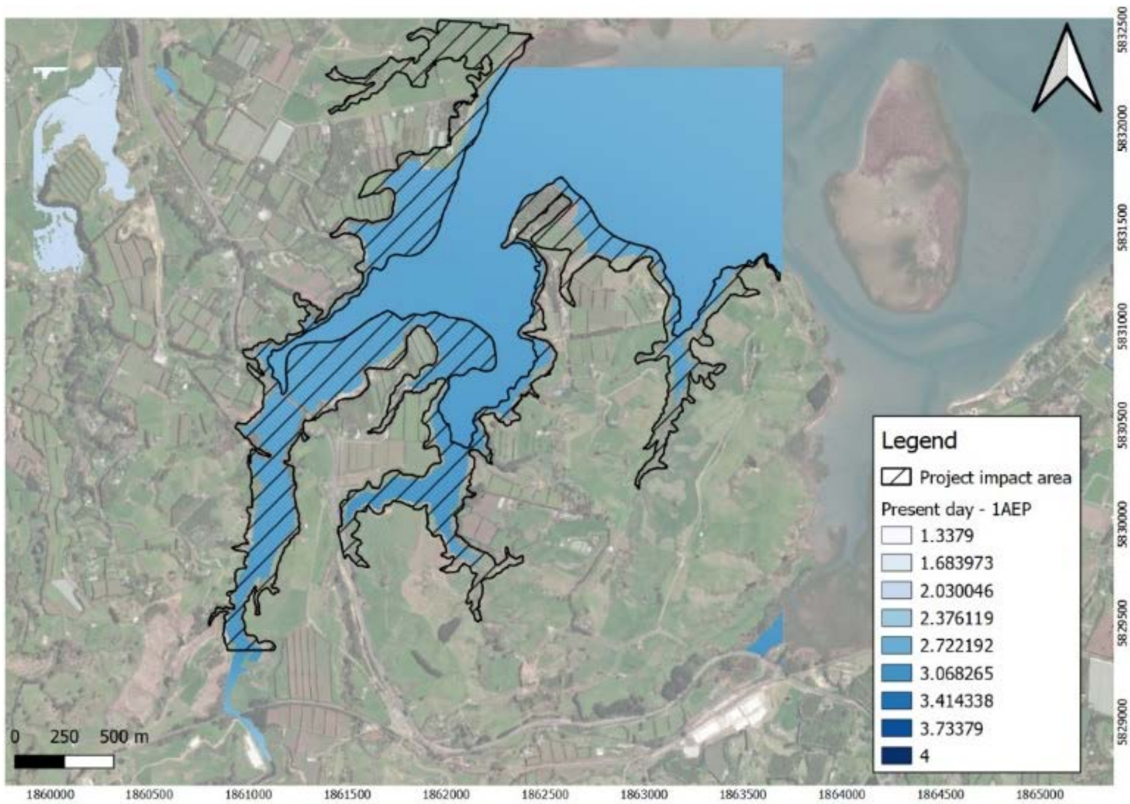
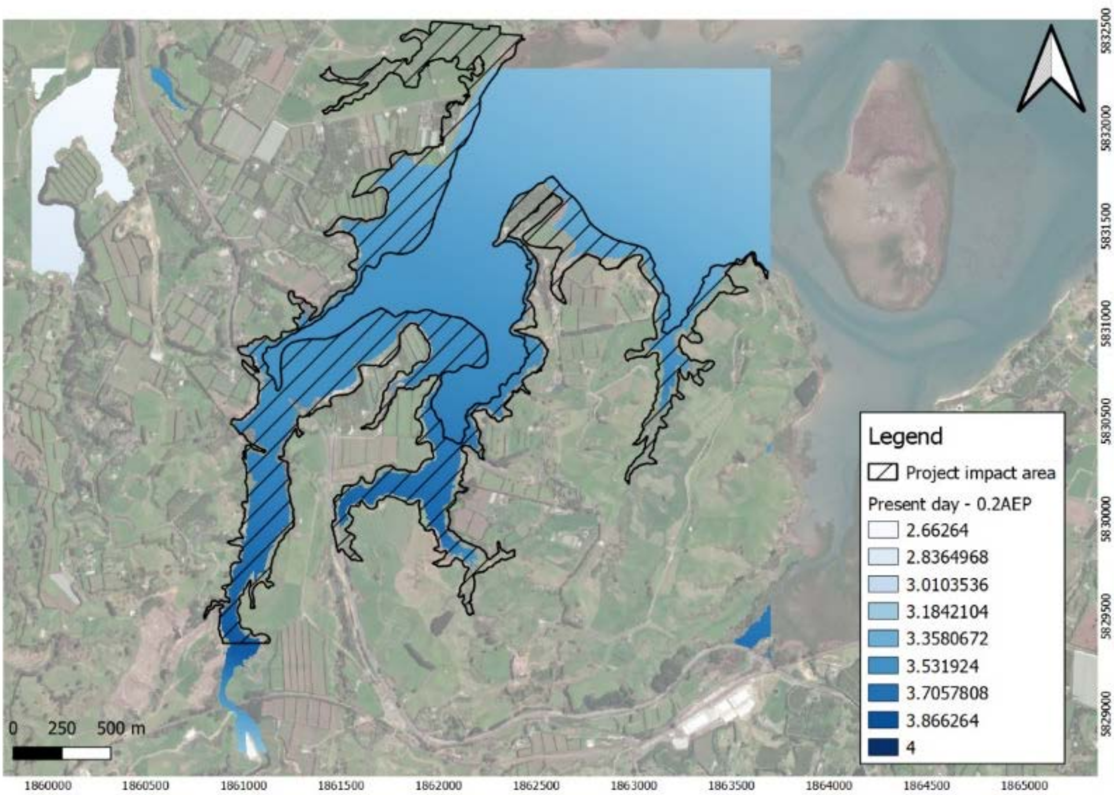


*Figure A3.2f. Present day – 0.2% AEP scenario: 94.46 ha of the Project Impact Area are estimated to be flooded under this scenario. One building is expected to be affected in the Project Impact Area for this scenario.*




## Recommendations

Recommendations for applying the SD VISta Coastal Resilience methodology for the Wainui Repo Whenua site in relation to the data available and the selected inundation model available, include the following:

- The spatial layer with the *Project Area* boundary should be improved to include relevant attributes required by the methodology like land rights holders
- The selected model did not meet all the requirements of the methodology (wave run up contributions were not considered, two required storm events scenarios were missing, and the inland boundary did not cover the whole *Project Impact Area*), although, it uses a numerical approach and accounts for land cover friction. Therefore, outputs of this model can be used for the first assessment of the number of people and properties potentially affected by flooding caused by different storm events scenarios, as demonstrated in the Estimating affected Assets Section above.
- An updated wetland mapping study at local scale should be undertaken.Future models should:
    - replicate the methodology used by Tauranga Harbour inundation modelling (Reeve et al. 2019) for classifying the habitat using the Manning coefficient using updated aerial images
    - use a numerical approach considering land friction as the one used on the Tauranga Harbour modelling (Reeve et al. 2019),
    - consider wave runup contribution
    - use the 10m elevation contour as the inland boundary for the model
    - estimate flooding levels for all four AEPs required by the SD VISta Coastal Resilience Methodology
    - source the bathymetry datasets used for constructing the Tauranga Harbour model grid.

### A3.3 Pukehina/Waihī

#### Assessing the applicability of the methodology for the project scenario

The project scenario for Pukehina/Waihi site meet the requirements expected for the applicability of the SD VISta Coastal Resilience Methodology for restoration projects. For further information on the project scenario activities for this site refer to Appendix 1 (A1.2.3), and for information on the SD Vista Coastal Resilience methodology applicability requirements refer to Table A3.a.

#### Assessing key datasets and inundation model availability

All key datasets required by SD VISta Coastal Resilience Methodology were available for the Pukehina/Waihi site. To evaluate the compatibility of existing inundation models with what is required in the SD VISta Coastal Resilience methodology, as well as their overall quality available, we used the coastal inundation model developed by Tonkin and Taylor to the Western Bay of Plenty District Council (Tonkin & Taylor 2015).

#### Evaluating key datasets and inundation models

All key datasets for the Pukehina/Waihi site met the requirements of the SD VISta Coastal Resilience Methodology (Table A3.3a). However, as with all the other projects assessed by this feasibility study, land rights should be incorporated in the spatial layer defining the spatial boundaries and local land cover data could improve the accuracy of new models following the SD VISta Coastal Resilience methodology.

*Table A3.3a. Key datasets available for Pukehina/Waihī site.*

| **Data** | **Source** | **Does the data meet the requirements of the SD VISta Coastal Resilience methodology?** |
|---|---|---|
| Spatial layer defining the boundaries of the *Project Area* | Shapefile provided by TNC | Partially |
| Digital Elevation Model for the *Project Area* | Bay of Plenty - Tauranga and Coast LiDAR 1m DEM (2015)[2] | Yes |
| Digital Elevation Model for the *Project Impact Area* | 8m Digital Elevation Model (2012)[3] | Yes |
| Land cover | LCDB v5.0 - Land Cover Database version 5.0, Mainland New Zealand [4] | Yes |
| Population | 2018 Census Individual (part 1) total New Zealand by Statistical Area 1 - Census usually resident population count[5] | Yes |
| Building outlines | NZ Building Outlines[6] | Yes |

[1] See Table 3.4.3b for the key dataset requirements.
[2] https://data.linz.govt.nz/layer/53556-bay-of-plenty-tauranga-and-coast-lidar-1m-dem-2015/
[3] https://data.linz.govt.nz/layer/51768-nz-8m-digital-elevation-model-2012/
[4] https://lris.scinfo.org.nz/layer/104400-lcdb-v50-land-cover-database-version-50-mainland-new-zealand/
[5] https://datafinder.stats.govt.nz/layer/104612-2018-census-individual-part-1-total-new-zealand-by-statistical-area-1/
[6] https://data.linz.govt.nz/layer/101290-nz-building-outlines/

*Table A3.3b. Quality of the selected key datasets for Waihī/ Pukehina site (evaluation in green).*

| Data | Criteria | Data quality | | |
|---|---|---|---|---|
| | | High | Moderate | Low |
| Spatial layer defining the boundaries of the *Project area* | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | File format | Geospatial data (e.g: .geojson, shp) | Table (e.g: .csv) | Static image (e.g.: .png, .jpg, .pdf) |
| Digital Elevation Model for the *Project Area* | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Spatial scale | Fine (10m resolution or higher) | | Coarse (< 10m resolution) |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| Digital Elevation Model for the *Project Impact Area* | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| | Spatial scale | Fine (90m resolution or higher) | | Coarse (90m resolution or less) |
| Land cover | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| | Spatial scale | Fine (Regional dataset) | Intermediate (National dataset) | Coarse (Global dataset) |
| | Creation date | 2 years ago, or less | 2 – 5 years ago | More than 5 years ago |
| Population | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| | Spatial scale | Fine (regional or national dataset) | | Coarse (global dataset) |
| | Creation date | Less than 5 years | 5 – 10 years ago | More than 10 years ago |
| Building outlines | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| | Spatial scale | Fine (regional or national dataset) | | Coarse (global dataset) |
| | Creation date | Less than five years | 5 – 10 years ago | More than 10 years ago |

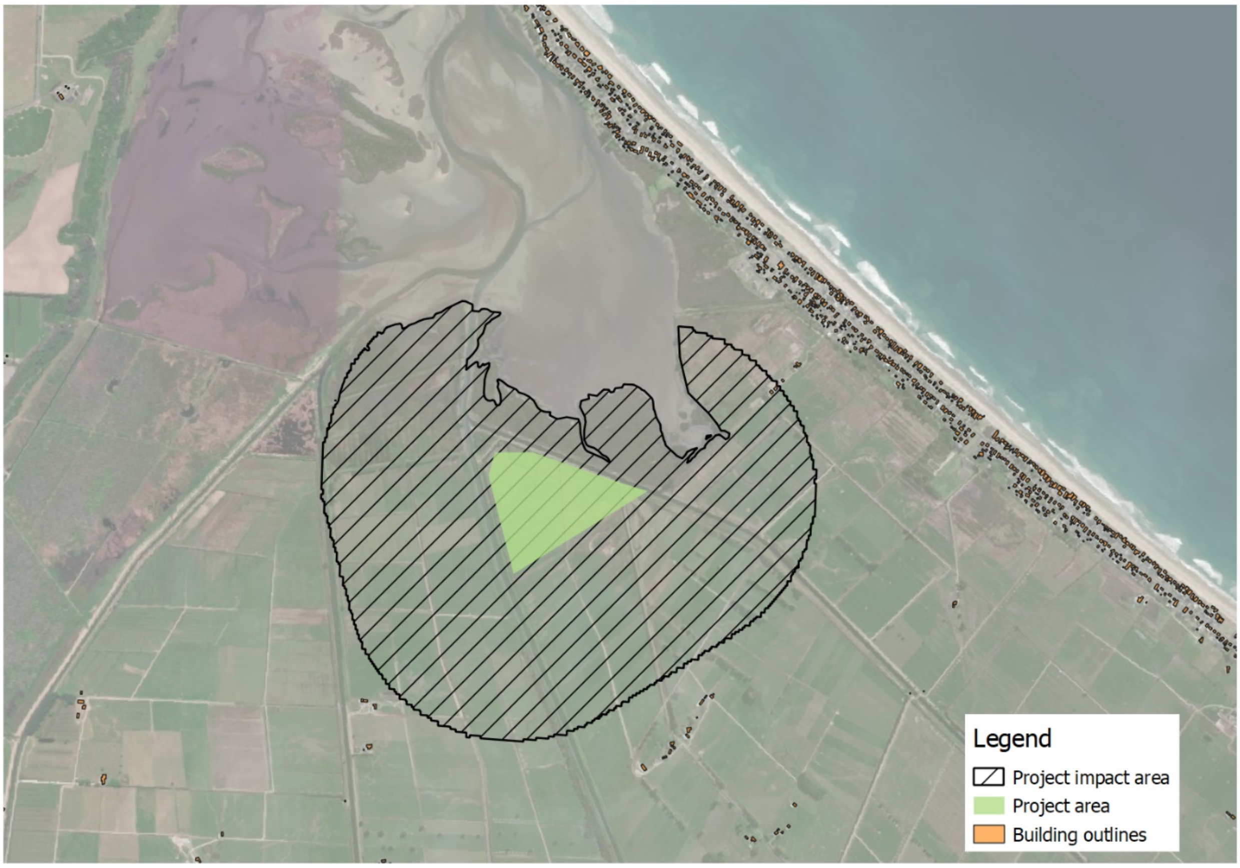
The only existing inundation model we identified for the Pukehina/Waihi region was the model developed by Tonkin and Taylor to for the Western Bay of Plenty District Council (Tonkin & Taylor, 2015). Based on what is described in the report and on the analysis of the GIS layers (Figure A2.3b) we do not recommend the use of this model for assessing flood extends of the Pukehina/Waihi projects following the SD VISta Coastal Resilience methodology. The reason is that the existing inundation model is focused on future scenarios (50 and 100 years), instead of present-day scenarios, and it does not cover the extend of the *Project Impact Area* as Figure A3.3a shows. Therefore, we did not evaluate this model according to the requirements of the SD VISta Coastal Resilience methodology, nor was the quality of the model assessed.

### Estimating Affected Assets

The method described in Section 3.4.2 was used to estimate the *Project Impact Area* (Figure A3.3a). It was estimated that the total *Project Impact Area* is 223ha and that two people and two buildings are within this area.

*Figure A3.3a. Proposed Coastal Inundation Zone* (CHZ) *for the year of 2115 (Tonkin & Taylor, 2015)*.

*Figure A3.3b. Estimated Project Impact Area for the Waihi/Pukehina Project Area.*




## Recommendations

Recommendations for applying the SD VISta Coastal Resilience methodology for the Pukehina/Waihi site in relation to the data available and the selected inundation model available, include the following:

- The spatial layer with the *Project Area* boundary should be improved by including relevant attributes required by the methodology like land rights holders
- The existing coastal inundation model for Pukehina/Waihi region does not account for present day scenarios and does not cover the whole *Project Impact Area*. Therefore,
  the use of the model outputs for assessing the number of assets affected by flooding is not recommended.
- An updated wetland mapping study at local scale should be undertaken.
- Future models should:
  - Use a numerical approach considering land friction and wave contributions (wave runup and wave setup) for all the four required storm event periods
  - Replicate the methodology used by Tauranga Harbour inundation modelling (Reeve et al. 2019) for classifying the habitat using the Manning coefficient using updated aerial images
  - Use the 10m elevation contour as the inland boundary for the model.

### A3.4 Farewell Spit

#### Assessing the applicability of the methodology for the project scenario

The project scenario for the Farewell Spit site does not meet the requirements expected for the applicability of the SD VISta Coastal Resilience Methodology since seagrass meadows are not eligible habitats in the current version of the methodology. For further information on the project scenario activities for this site refer to Appendix 1 (A1.2.4), and for information on the SD Vista Coastal Resilience Methodology applicability requirements refer to Table A3.a.

#### Assessing key datasets and inundation model availability

All key datasets (Table A3.4a) required by SD VISta Coastal Resilience Methodology were available for the Farewell Spit site. To evaluate the compatibility of existing inundation models with what is required in the SD VISta Coastal Resilience Methodology, as well as their overall quality available, we used the Tasman Bay and Golden Bay coastal inundation model developed by the Tasman District Council (Tasman District Council, 2019).

#### Evaluating key datasets and inundation model

All key datasets for the Farewell Spit site met the requirements of the SD VISta Coastal Resilience Methodology (Table 3.4a). It is important to note that we used the data requirements of the current version of the SD VISta methodology which is not currently applicable for the habitat present in this site. If in future version the methodology is expanded to include seagrass, the requirements for key dataset and models might differ from the ones used in our study.

Unlike the other project sites, the LCDB layer did not cover the *Project Area* of the Farewell Spit site. For this site the land cover and the spatial layer defining the boundaries of the *Project Area* were sourced from the SeaSketch Portal[79]. Polygons defining the seagrass meadows mapped by Robertson et al. (2012) and Batley et al. (2005) are available in the portal, although it does not allow the download of spatial layers. Because of this limitation, this assessment created the spatial layer defining the boundaries of the project area by georeferencing a screenshot of the SeaSketch mapping the desired habitats and vectoring a polygon on top of it in QGIS. The layer would still need to be implemented including the attributes required by the SD VISta Coastal Resilience Methodology.

In the Tasman Bay and Golden Bay coastal inundation model the extent of land potentially subject to coastal inundation is mapped using a passive approach (i.e., bathtub model), which involves identifying all land lying below a calculated water level. GIS layers with the modelled levels of the present day MHWS-6 and 1% AEP storm-tide/wave setup event are publicly available via an ArcGIS Rest API. The “Conditions and Limitations of Use” of these layers state that they should not be relied upon for making site specific decisions related to potential hazard exposure of coastal areas.

The model includes wave effects for open coast sandy beaches derived from the NIWA coastal calculator tool. The coastal calculator uses a wave setup and wave runup formula developed for sandy beaches assuming a constant beach slope. In the coastal calculator, the beach slope is assessed below the line of MHWS-6 (1.7-1.8m NZVD2016). The offshore wave conditions assessed in the NIWA coastal calculator are not applicable in a sheltered estuarine environment. So, for these environments the approached for assessing significant wave height (Hs) and wave setup used in the Tasman Bay and Golden Bay coastal inundation model followed the approached used by coastal practitioners Tonkin and Taylor Ltd on behalf of Nelson City Council (Tasman District Council 2019).

[79] https://www.seasketch.org/#projecthomepage/5357cfa467a68a303e1bb87a

*Table A3.4a. Key datasets available for the Farewell Spit site.*

| **Data** | **Source** | **Does the data meet the requirements of the SD VISta Coastal Resilience methodology?** |
|---|---|---|
| Spatial layer defining the boundaries of the *Project area* | Shapefile with the seagrass meadow extent based on the available map on SeaSketch Portal | Partially |
| Digital Elevation Model for the *Project Area* | Tasman - Golden Bay LiDAR 1m DEM (2017)[2] | Yes |
| Digital Elevation Model for the *Project Impact Area* | 8m Digital Elevation Model (2012)[3] | Yes |
| Land cover | Map of the seagrass extent available on the SeaSketch Portal | Yes |
| Population | 2018 Census Individual (part 1) total New Zealand by Statistical Area 1 - Census usually resident population count[4] | Yes |
| Building outlines | NZ Building Outlines | Yes |

[1] See Table 3.4.3b for the key dataset requirements.

[2] https://data.linz.govt.nz/layer/95503-tasman-golden-bay-lidar-1m-dem-2017/

[3] https://data.linz.govt.nz/layer/51768-nz-8m-digital-elevation-model-2012/

[4] https://datafinder.stats.govt.nz/layer/104612-2018-census-individual-part-1-total-new-zealand-by-statistical-area-1/

[5] https://data.linz.govt.nz/layer/101290-nz-building-outlines/

*Table A3.4b. Quality of the selected key datasets for Farewell Spit site (evaluation in green).*

| **Data** | **Criteria** | **Data quality** | | |
|---|---|---|---|---|
| | | High | Moderate | Low |
| Spatial layer defining the boundaries of the *Project area* | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | File format | Geospatial data (e.g: .geojson, shp) | Table (e.g: .csv) | Static image (e.g.: .png, .jpg, .pdf) |
| Digital Elevation Model for the *Project Area* | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Spatial scale | Fine (10m resolution or higher) | | Coarse (< 10m resolution) |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| Digital Elevation Model for the *Project Impact Area* | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| | Spatial scale | Fine (90m resolution or higher) | | Coarse (90m resolution or less) |
| Land cover | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |

| | | | | |
|---|---|---|---|---|
| | Spatial scale | Fine (Regional dataset) | Intermediate (National dataset) | Coarse (Global dataset) |
| | Creation date | 2 years ago, or less | 2 – 5 years ago | More than 5 years ago |
| Population | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| | Spatial scale | Fine (regional or national dataset) | | Coarse (global dataset) |
| | Creation date | Less than 5 years | 5 – 10 years ago | More than 10 years ago |
| Building outlines | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| | Spatial scale | Fine (regional or national dataset) | | Coarse (global dataset) |
| | Creation date | Less than five years | 5 – 10 years ago | More than 10 years ago |

*Table A3.4c. Evaluation of the available coastal inundation model for Farewell Spit based on the requirements for the SD VISta Coastal Resilience Methodology.*

| **Criteria** | **Does the data meet the requirements of the SD VISta Coastal Resilience methodology?** |
|---|---|
| 1. Models selected shall estimate the total water level ($\eta$) in meters | **Yes.** |
| 2. Models shall estimate ($\eta$) due to offshore storm conditions<br><br>***i-****mean sea-level (MSL),*<br>***ii-*** *astronomical tide (AT),*<br>***iii-****storm surge (SS) ,*<br>***iv-*** *waves from runup and setup)* | **Partially*:*<br>*i-mean sea-level (MSL):*<br>Yes,** 3.195m below Reference Mark N1 (AC4T) as defined by the NZVD2016 Datum.<br><br>***ii-astronomical tide (AT):*<br>Yes,** Astronomical Tide Levels at Port Nelson<br><br>***iii-storm surge (SS):*<br>Yes.**<br><br>***iv- waves from runup and setup:***<br>- No <u>*runup:*</u> The NIWA coastal calculator is used to assess wave runup only at the open coast sandy beach sites.<br><br>- <u>*setup:*</u> The NIWA coastal calculator is used to assess wave setup only at the open coast sandy beach sites. |
| 3. The models must assess the probability of storm events occurrence probabilities for four return periods (10%, 4%, 2% and 1%) | ***Partially***, the return periods used by the model are following:<br>1%. |

| | |
|---|---|
| 4. Manning's friction coefficients must be used to determine the friction of land cover | **No.** The method used is simplistically referred to as a 'bathtub' model. This is where the water level calculated at the coast is translated as a level surface across the landscape, without any regard as to whether water can physically reach a particular area or achieve the calculated level. |
| 5. Models must have the following SD VISta model characteristics<br>***i-****Models shall be publicly available, though not necessarily free of charge*<br><br>***ii-*** *Model parameters shall be determined based upon studies by appropriately qualified experts that identify the parameters as important drivers of the model output variable(s).*<br><br>***iii-*** *Models shall have been appropriately reviewed, tested and validated (e.g., ground-truth and using empirical data or results compared against results of similar models) by a recognized, competent organization, or an appropriate peer review group.*<br><br>***iv-*** *All plausible sources of model uncertainty, such as structural uncertainty or parameter uncertainty, shall be assessed using recognized statistical approaches.*<br><br>***v-*** *Models shall have comprehensive and appropriate* ***criteria*** *for estimating uncertainty, and the model shall be calibrated by parameters to be appropriate for the given location.*<br><br>***vi-*** *Models shall apply conservative factors to discount for model uncertainty (in accordance with the most current criteria set out in the SD VISta Standard, v1.0), and shall use conservative assumptions and parameters that are likely to underestimate, rather than overestimate, the SD VISta assets* | **i – Yes**, the model outputs can be accessed through an ArcGIS Rest API.<br><br>**ii- Yes**, the model was prepared by the Tasman District Council<br><br>**iii- No**.<br><br>**iv- No.**<br><br>**v- No**<br><br>**vi-** ***Yes.*** As it does not accurately represent the dynamic effects and variable processes over time. |

*Table A3.4d. Quality of the selected coastal inundation model for the Farewell Spit site (evaluation in green).*

| **Criteria** | **Data quality** | | |
|---|---|---|---|
| | High | Moderate | Low |
| **1** Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| **2** Type of approach | Numerical modelling | | Analytical or semi-empirical approximations |
| **3** Output file format | Structured data (.netcdf , geospatial data) | Proprietary formats | Static image (e.g.: .png, .jpg, .pdf) |
| **4** Is the data publicly available? | Yes | Partially | No |
| **5** Is the data available free of charges? | Yes | Partially | No |

## Estimating Affected Assets

Affected assets were not estimated to this site due to the difficulties associated with transparently attributing potential project interventions (enhancement of seagrass habitat through reduced sedimentation and reduced swan herbivory) to measurable change to the *Project Area* (for further information refer to Appendix 1 (A1.2.4)).

#### Recommendations

Recommendations for applying the SD VISta Coastal resilience methodology for the Farewell Spit site in relation to the key datasets available and the selected inundation model available, include the following:

- The spatial layer with the *Project Area* boundary should be improved including relevant attributes required by the methodology like land rights holders
- An updated assessment of the seagrass around the Farewell Spit at local scale should be undertaken..
- The model developed by the Tasman District evaluated in this feasibility study uses a simplified (passive) approach that did not meet most of the requirements of the methodology. Therefore, the use of the model outputs for assessing the number of assets affected by flooding is not recommended.
- Future inundation should:
    - use a numerical approach considering land friction, wave contributions (wave runup and wave setup) and all four AEPs required by the SD VISta Coastal Resilience Methodology
    - replicate the methodology used by Tauranga Harbour inundation modelling (Reeve et al. 2019) for classifying the habitat using the Manning coefficient using updated aerial images
    - use of a 10m elevation contour as the inland boundary for the model.

### A3.5 Waimeha Inlet

#### Assessing the applicability of the methodology for the project scenario

The project scenario for the Waimeha Inlet site meets the requirements expected for the applicability of the SD VISta Coastal Resilience Methodology for restoration projects. For further information on the Project Scenario activities for this site refer to Appendix 1 (A1.2.5), and for information on the SD Vista Coastal Resilience Methodology applicability requirements refer to Table A3.a.

#### Assessing key datasets and inundation model availability

All key datasets required by SD VISta Coastal Resilience Methodology were available for the Waimeha Inlet site. To evaluate the compatibility of existing inundation models with what is required in the SD VISta Coastal Resilience Methodology, as well as their overall quality available, we used the Tasman Bay and Golden Bay coastal inundation model developed by the Tasman District Council (Tasman District Council, 2019).

#### Evaluating key datasets and inundation model

As with as the other sites, the spatial layer defining the boundaries of the *Project area* was available, but it should be implemented to incorporate the attributes require in the methodology.

DEM derived from LiDAR surveys are publicly available for the *Project Area*. This dataset also covers the *Project Impact Area* of the restoration project, therefore high-resolution DEM can be also used for this area of the project.

Like the other project sites, population and building outlines data can be extracted from national datasets. The publicly available national LCDB layer could also be used by projects developed in the Waimeha Inlet following the SD VISta Coastal Resilience Methodology, but as discussed previously (see A2.2) local datasets are preferable. Therefore, for future efforts, this assessment recommends the use of the recent local habitat mapping data (Stevens et al, 2020).

*Table A3.5a. Data availability for Waimeha Inlet.*

| **Data** | **Source** | **Does the data meet the requirements of the SD VISta Coastal Resilience methodology?** |
|---|---|---|
| Spatial layer defining the boundaries of the *Project Area* | Shapefile provided by TDC (restoration) | Partially |
| Digital Elevation Model for the *Project Area* | Nelson and Tasman LiDAR 1m DEM 2008-2015[2] | Yes |
| Digital Elevation Model for the *Project Impact Area* | Nelson and Tasman LiDAR 1m DEM 2008-2015[3] | Yes |
| Land cover | Salt marsh layers (Stevens et al, 2020). | Yes |
| Population | 2018 Census Individual (part 1) total New Zealand by Statistical Area 1 - Census usually resident population count[4] | Yes |
| Building outlines | NZ Building Outlines[5] | Yes |

[1] See Table 3.4.3b for the key dataset requirements.
[2] https://data.linz.govt.nz/layer/95817-nelson-and-tasman-lidar-1m-dem-2008-2015/
[3] https://data.linz.govt.nz/layer/95817-nelson-and-tasman-lidar-1m-dem-2008-2015/
[4] https://datafinder.stats.govt.nz/layer/104612-2018-census-individual-part-1-total-new-zealand-by-statistical-area-1/
[5] https://data.linz.govt.nz/layer/101290-nz-building-outlines/

*Table A3.5b. Quality of the selected key datasets for the Waimeha Inlet project site (evaluation in green).*

| **Data** | **Criteria** | **Data quality** | | |
|---|---|---|---|---|
| | | High | Moderate | Low |
| Spatial layer defining the boundaries of the *Project area* | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | File format | Geospatial data (e.g: .geojson, shp) | Table (e.g: .csv) | Static image (e.g.: .png, .jpg, .pdf) |
| Digital Elevation Model for the *Project Area* | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Spatial scale | Fine (10m resolution or higher) | | Coarse (< 10m resolution) |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| Digital Elevation Model for the *Project Impact Area* | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| | Spatial scale | Fine (90m resolution or higher) | | Coarse (90m resolution or less) |

| | | | | |
|---|---|---|---|---|
| Land cover | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| | Spatial scale | Fine (Regional dataset) | Intermediate (National dataset) | Coarse (Global dataset) |
| | Creation date | 2 years ago, or less | 2 – 5 years ago | More than 5 years ago |
| Population | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| | Spatial scale | Fine (regional or national dataset) | | Coarse (global dataset) |
| | Creation date | Less than 5 years | 5 – 10 years ago | More than 10 years ago |
| Building outlines | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| | Spatial scale | Fine (regional or national dataset) | | Coarse (global dataset) |
| | Creation date | Less than 5 years | 5 – 10 years ago | More than 10 years ago |

The selected inundation model for this project site is the same as the one selected for Farewell Spit site. Refer to A3.4 for the evaluation of this model.

Nelson City Council is also developing a hydrodynamic coastal inundation model to capture the specific geographic situation for selected Nelson sites. The Council has indicated that the model will be completed in the near future but is unsure when it will become publicly available.

Estimating Affected Assets

The method described in Section 3.4.2 was used to estimate the *Project Impact Area* (Figure A3.5a). It was estimated that the total *Project Impact Area* is 72ha and that 65 people and 124 buildings are within this area. There is a considerable difference in the flooded area of the *Project Impact Area* expected between the MHWS6 (Figure A3.5a) and the 1% AEP (Figure A3.5b) scenario.

*Figure A3.5a. Estimated Project Impact Area for the Waimeha Inlet.*

*Figures A3.5b. Present day – MHWS6 scenario: estimated flooded extend for the Waimeha Inlet Project Impact Area.*

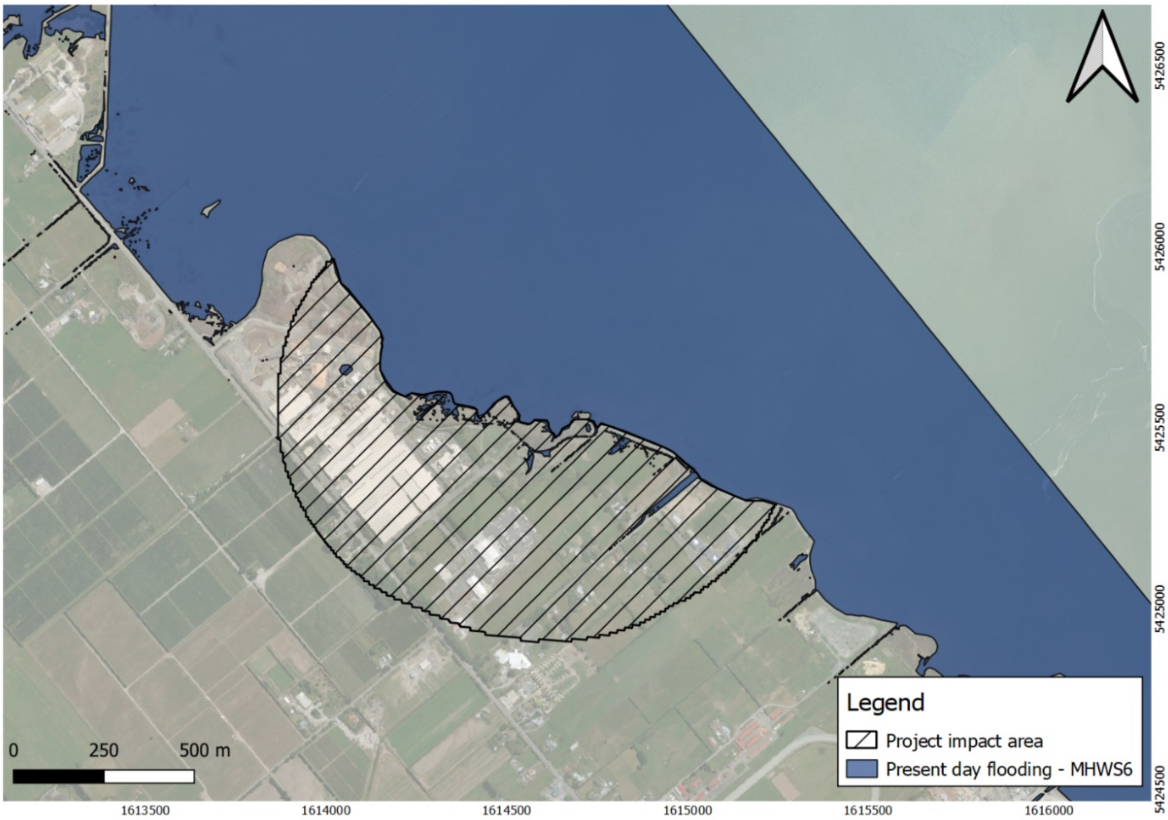
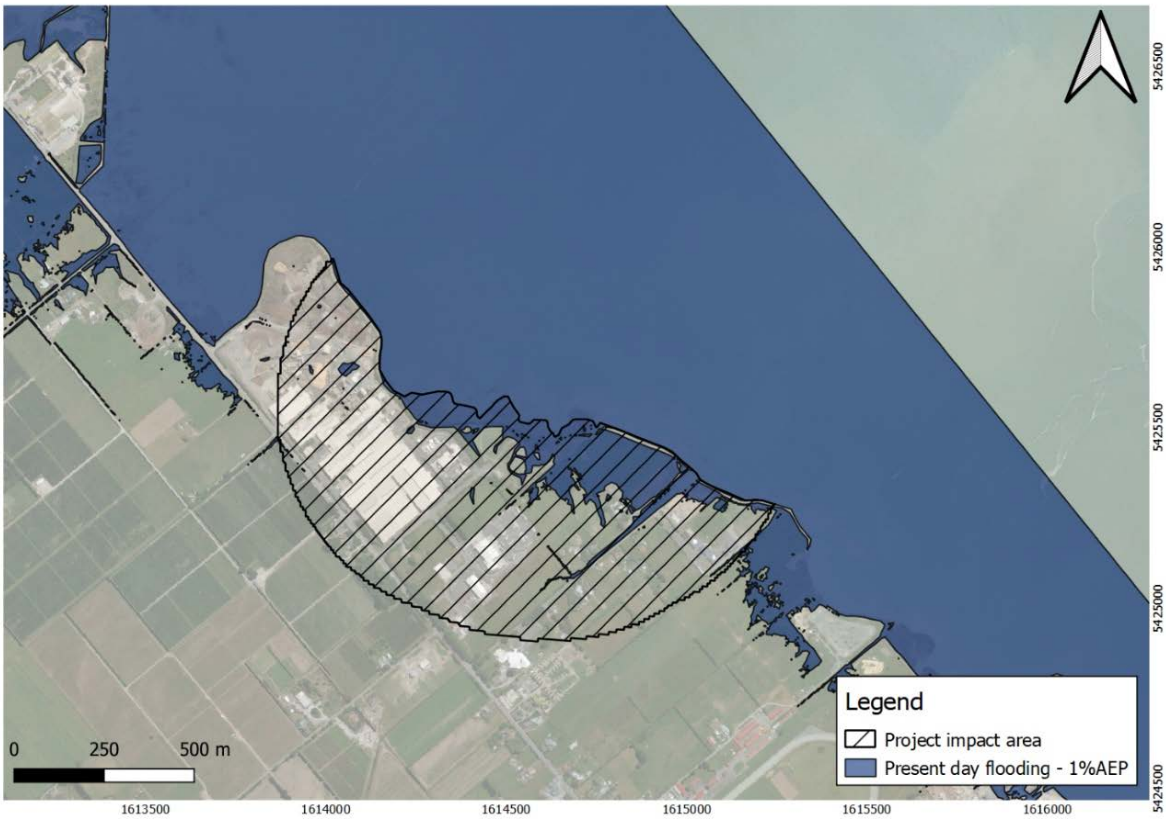



*Figure A3.5c. Present day – 1% scenario: estimated flooded extend for the Waimeha Inlet Project Impact Area.*



### Recommendations

Recommendations for applying the SD VISta Coastal Resilience methodology for the Waimeha Inlet site in relation to the data available and the selected model available, include the following:

- The spatial layer with the *Project Area* boundary should be improved including relevant attributes required by the methodology like land rights holders
- The model developed by the Tasman District evaluated in this feasibility study uses a simplified (passive) approach that did not meet most of the requirements of the methodology. Therefore, the use of the model outputs for assessing the number of assets affected by flooding is not recommended.
- An updated assessment of the land cover is recommended at a local scale, or the use of the available layers developed from recent habitat mapping efforts (Stevens et al, 2020).
- Future inundation models should:
    - use a numerical approach considering land friction, wave contributions (wave runup and wave setup) and all four AEPs required by the SD VISta Coastal Resilience Methodology
    - replicate the methodology used by Tauranga Harbour inundation modelling (Reeve et al. 2019) for classifying the habitat using the Manning coefficient using updated aerial images
    - use the 10m elevation contour as the inland boundary for the model.

## A3.6 Wairau Lagoon

### Assessing the applicability of the methodology for the project scenario

The project scenario for the Wairau Lagoon site meets the requirements expected for the applicability of the SD Vista Coastal Resilience Methodology for protection projects. For further information on the Project Scenario activities for this site refer to Appendix 1 (A1.2.6), and for information on the SD VISta Coastal Resilience Methodology applicability requirements refer to Table A3.a.

### Assessing key datasets and inundation model availability

All the available and selected key datasets met the criteria specified in the methodology. However, no coastal inundation model developed for the Wairau Lagoon region was identified during the data gathering process of this feasibility study.

### Evaluating key datasets and inundation model

The *Project Area* (Figure A3.6a) was sourced based on the information from project contacts regarding increased control of livestock intrusion and weed control around the Wairau Lagoon and on the spatial layers from the local habitat mapping conducted in 2015 (Berthelsen et al 2015). As well as the other sites, this spatial layer should be implemented to incorporate the attributes require in the methodology.

The publicly available national LCDB layer could also be used by projects developed in the Wairau Lagoon Inlet following the SD VISta Coastal Resilience Methodology, but as discussed previously (see A2.2) local datasets are preferable. Therefore, for future efforts, this assessment recommends the use of the recent local habitat mapping data (Berthelsen et al 2015).

The full assessment of the data availability and data quality are in Table A3.6a and Table A3.6b, respectively.

*Table A3.6a. Data availability for the Wairau site*

| **Data** | **Source** | **Does the data meet the requirements of the SD VISta Coastal Resilience methodology?** |
|---|---|---|
| Spatial layer defining the boundaries of the *Project Area* | Shapefile based on habitat mapping provided by Cawthron (Berthelsen et al, 2015) | Partially |
| Digital Elevation Model for the *Project Area* | Marlborough Blenheim lidar 1m dem 2014[2] | Yes |
| Digital Elevation Model for the *Project Impact Area* | 8m Digital Elevation Model (2012) [3] | Yes |
| Land cover | Local habitat mapping (Berthelsen et al, 2015) | Yes |
| Population | 2018 Census Individual (part 1) total New Zealand by Statistical Area 1 - Census usually resident population count [4] | Yes |
| Building outlines | NZ Building Outlines [5] | Yes |

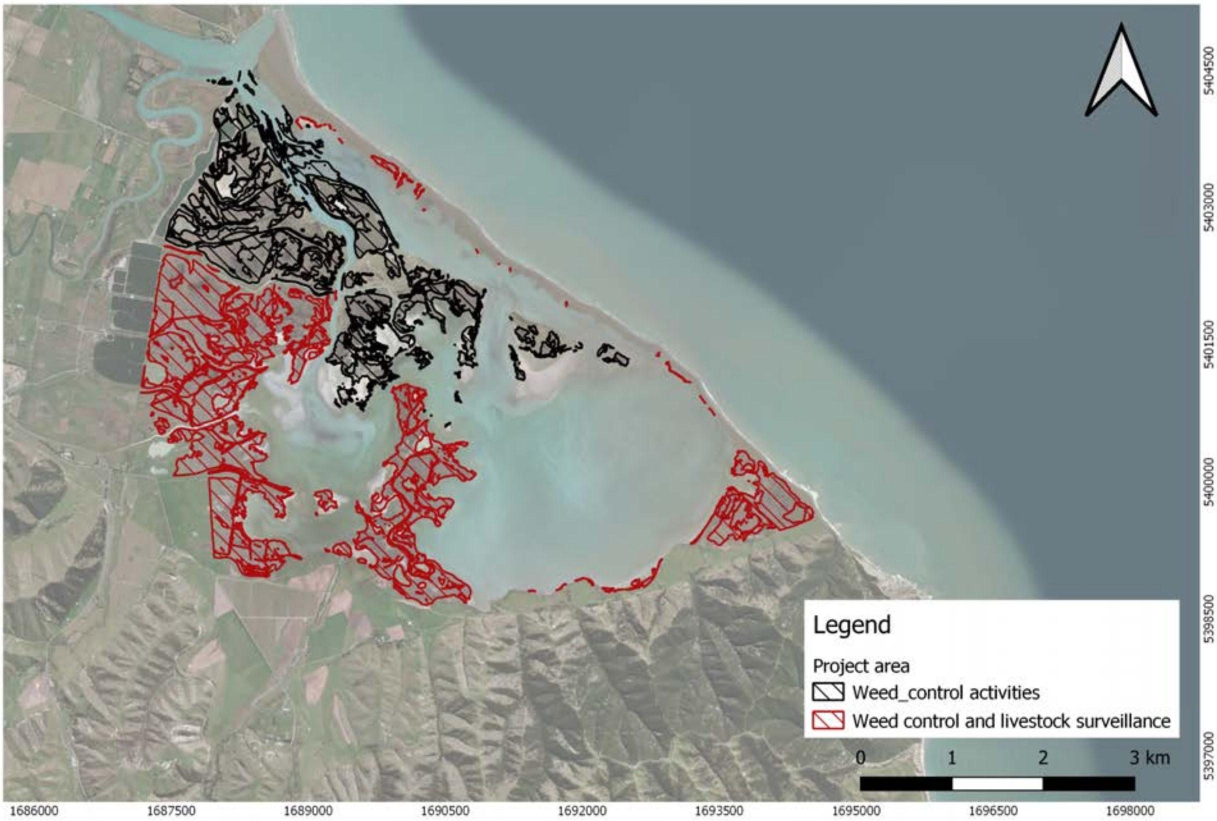
[1] See Table 3.4.3b for the key dataset requirements.
[2] https://data.linz.govt.nz/layer/95483-marlborough-blenheim-lidar-1m-dem-2014/
[3] https://data.linz.govt.nz/layer/51768-nz-8m-digital-elevation-model-2012/
[4] https://datafinder.stats.govt.nz/layer/104612-2018-census-individual-part-1-total-new-zealand-by-statistical-area-1/
[5] https://data.linz.govt.nz/layer/101290-nz-building-outlines/

*Table A3.6b. Quality of the selected key datasets for Wairau Lagoon site (evaluation in green).*

| **Data** | **Criteria** | **Data quality** | | |
|---|---|---|---|---|
| | | High | Moderate | Low |
| Spatial layer defining the boundaries of the *Project Area* | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | File format | Geospatial data (e.g: .geojson, shp) | Table (e.g: .csv) | Static image (e.g.: .png, .jpg, .pdf) |
| Digital Elevation Model for the *Project Area* | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Spatial scale | Fine (10m resolution or higher) | | Coarse (< 10m resolution) |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| Digital Elevation Model for the *Project Impact Area* | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| | Spatial scale | Fine (90m resolution or higher) | | Coarse (90m resolution or less) |
| Land cover | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |

| | | | | |
|---|---|---|---|---|
| | Is the data available free of charges? | Yes | Partially | No |
| | Spatial scale | Fine (Regional dataset) | Intermediate (National dataset) | Coarse (Global dataset) |
| | Creation date | 2 years ago, or less | 2 – 5 years ago | More than 5 years ago |
| Population | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| | Spatial scale | Fine (regional or national dataset) | | Coarse (global dataset) |
| | Creation date | Less than 5 years | 5 – 10 years ago | More than 10 years ago |
| Building outlines | Does the data available fill the requirements specified in the SD VISta methodology? | Yes | Partially | No |
| | Is the data publicly available? | Yes | Partially | No |
| | Is the data available free of charges? | Yes | Partially | No |
| | Spatial scale | Fine (regional or national dataset) | | Coarse (global dataset) |
| | Creation date | Less than five years | 5 – 10 years ago | More than 10 years ago |

*Figures A3.6a. Wairau Lagoon Project Impact Area and location of different project activities.*




## Estimating Affected Assets

The potential project interventions outlined for the Wairau Lagoon (increased control of livestock intrusion and weed control) do not have a high enough additional impact on coastal resilience to warrant a Coastal Resilience project (for further information refer to A1.2.6). Due to this fact, affected assets were not estimated for this site.

## Recommendations

Our recommendations for applying the SD VISta Coastal resilience methodology for the Wairau Lagoon site in relation to the data available and the selected model available, include the following:

- The spatial layer with the *Project Area* boundary should be improved including relevant attributes required by the methodology like land rights holders
- An updated assessment of the land cover is recommended at a local scale, or the use of the available layers developed from recent habitat mapping efforts (Berthelsen et al 2015).
- Future inundation models should:
    - use a numerical approach considering land friction, wave contributions (wave runup and wave setup) and all four AEPs required by the SD VISta Coastal Resilience Methodology
    - replicate the methodology used by Tauranga Harbour inundation modelling (Reeve et al. 2019) for classifying the habitat using the Manning coefficient using updated aerial images
    - use the 10m elevation contour as the inland boundary for the model.
    - source the bathymetry datasets collected in the last Wairau Lagoon Subtidal Survey (Roberts et al 2021).

# APPENDIX 4. SITE-SPECIFIC SALINITY ASSESSMENTS

Information relating to salinity (average[80] and low point[81]) was compiled for project sites where possible through our questionnaire (See Appendix 1, A1.1) and any follow-up responses and from preliminary literature review[82] when not available locally at this time. General supporting information on salinity in relation to tidal wetlands and estuaries in Aotearoa New Zealand can be obtained from various sources (See references in Section 3.3.4 – Other Relevant Environmental Data). Where there was a knowledge gap for a project site, further investigation will be required during project development.

### A4.1 Te Repo Ki Pūkorokoro

| **Salinity information provided by local stakeholders[1]** |
|---|
| • Hydrological monitoring of the existing flapgates indicate seawater to brackish water salinity levels depending on when the flapgates are deployed. The saltwater wedge in the Pūkorokoro Stream-farm drain is defined as being upstream of the Reserve (northern) boundary.<br>• Existing non-consented flapgates are to be removed and a weir installed on the Pūkorokoro Stream to provide both fish passage and tidal inundation. The weir will be of wooden construction and allow for ease of adjustment. A new drain will be installed, and weirs placed to redirect farm drain flow, located on the Reserve's western boundary. These (new) drain structures will enable drainage into the Miranda Stream. Structures and works are designed to manage flow from the farmland catchment by bypassing the Reserve. The Reserve's Pūkorokoro Stream (and proposed linked ponds) will receive regular if not daily tidal inundation.<br>• Salinity to the newly created "ponds" will be seawater, with the daily tidal exchange.<br>• Marine silt in the Reserve is to be excavated to form a series of tidal ponds. The silt transported to form the new drain bund.<br>• The reintroduction of appropriate coastal flora will all designed to enable establishment of a mosaic of dryland coastal shrubland/grassland, saltmarsh meadow, seagrass, limited mangrove forest and unvegetated tidal mudflats.<br>• Reintroduction of priority threatened plant species and communities has been described. Selected regionally threatened species on the Pūkorokoro Miranda coastline are being actively managed and it is envisaged re-seeding and transplanting would be undertaken in the project area including *Zostera muelleri* replanting and *Thyridia repens* transplanting. The project area currently contains nine vegetation types but important herbfield and sedgeland are both small and highly modified<br>• Refer to Golder Associates hydrological assessments and monitoring reports and Living matters freshwater fish assessment. |
| **Conclusion** |
| This remains a knowledge gap as information on salinity average and low point was not available. |

[1] Direct quotes from questionnaire responses and/or other types (or formats) of information received.

---

[80] **Salinity Average** is the average water salinity value of a wetland ecosystem used to represent variation in salinity during periods of peak $CH_4$ emissions (eg, during the growing season in temperate ecosystems) (VM0033).

[81] **Salinity Low Point** is the minimum water salinity value of a wetland ecosystem used to represent variation in salinity during periods of peak $CH_4$ emissions (eg, during the growing season in temperate ecosystems) (VM0033).

[82] A comprehensive literature review on this information was beyond the scope of this feasibility assessment.

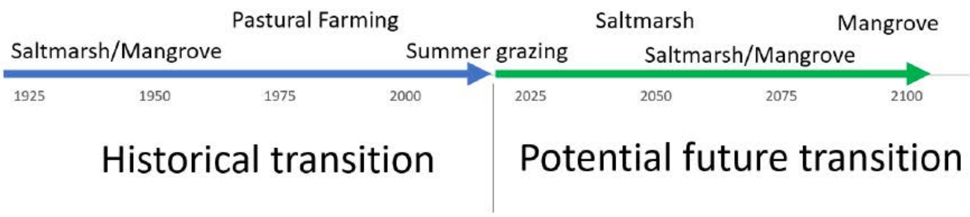
## A4.2 Wainui Repo Whenua

**Salinity information provided by local stakeholders[1]**

- All raw WQ data (salinity, water level, conductivity, dissolved $O_2$ and temp) is provided from a hobo river logger placed just at the top (western end) of the land parcel over a few months. Snip photo attached within email of location.
- The salinity would be much higher at the site. The Wainui at Old Railway Bridge was predominately used as a water level recording location. As you can see from the map – the property is completely surrounded by estuary – so is being fed water through a series of culverts directly from the estuary bar the most western culvert that would be more river influenced.
- One thing to note is that using Ōmokoroa Wharf Levels as an indicator for Wainui at SH2(ish) won't be viable after periods of rain in the Wainui river catchment, as the river levels will likely be doing something different to the tide levels.

Below is the property boundary of the Wainui Repo Whenua (Sargent Drive) and placement of the hobo logger ca. 20m upstream (blue dot).


- Highest and lowest salinity value for the WQ data provided was 15.3 ppt and 0.000 ppt respectively. The name of the file was 'Wainui at Old Railway Bridge'*. The date of this data was 22/05/2020 to 20/07/2020 (so 2 months-worth). Note: re-wetting occurred since 2019.
- The project site is completely surrounded by estuary – so is being fed water through a series of culverts directly from the estuary bar the most western culvert that would be more river influenced.
- No differences in management across the site, same hydrological methods used for target water levels and control as well as the planting plan. This is due to the limited elevation across the site and predominately-saline hydrological regime restricting the species of which it can host.
- Target revegetation approach. 25% of the 20 ha will be planted this winter (2021) with 20,000 saltmarsh plants species include: *Apodasmia similis*, *Plagianthus divaricatus* & *Juncus kraussii* var. *australiensis*
- Baseline is grazed open pasture on drained/reclaimed land.
- Drained and flap-gated before, but recently re-connected to the tide



| PRIMARY OUTCOMES | |
|---|---|
| **Restored saltmarsh hydrology** | • Improve hydraulic connectivity between the Wainui stream and the new saltmarsh area through appropriate methods<br>• Establish an appropriate hydraulic regime to support the reestablishment of saltmarsh habitat |
| **Restore an ecological corridor along the Wainui River** | • Maximise area for re-establishment of saltmarsh vegetation |

| **Conclusion** |
|---|
| This is a knowledge gap as the required salinity values were not available. |

1 Direct quotes from questionnaire responses and/or other types (or formats) of information received.

*Note that it has been indicated to us that the Wainui at Old Railway Bridge is upstream of the project site, and that *salinity at the actual project site would be much higher than this.*

### A4.3 Pukehina/Waihī

| **Salinity information provided by local stakeholders[1]** |
|---|
| • Current land use is as a dairy farm, vegetation therefore is pasture, fertilized but mainly with organic fertilizers (no inorganic nitrogen used). There is some fescue in the paddocks, but I believe he is trying to get rid of this.<br>• Property drainage is maintained via drainage canals. |
| **Conclusion** |
| This is a knowledge gap as the required salinity values were not available. |

1 Direct quotes from questionnaire responses and/or other types (or formats) of information received.

### A4.4 Farewell Spit

| **Salinity information provided by local stakeholders[1]** |
|---|
| No information was available. |
| **Conclusion** |
| This is a knowledge gap as the required salinity values were not available. |

1 Direct quotes from questionnaire responses and/or other types (or formats) of information received.

### A4.5 Waimeha Inlet (Borck Road to Sandeman Reserve – restoration scenario)

| **Salinity information provided by local stakeholders[1]** |
|---|
| • The area is largely cut off from the estuary by bunds constructed along the foreshore. The remaining salt marsh is in a compromised state due to limited inundation, historical modification and stock grazing.<br>• Grazed saltmarsh cut off from the estuary by bunding. Limited tidal ingress through flapgated pipes.<br>• Tidal flows reach the site through small pipes under the earth bund, while flow paths within the salt marsh have been channelised in an attempt to drain the area.<br>• Proposed project would reconnect tidal flows and exclude stock from ~4ha low-lying area of salt marsh between Borck to Sandeman Creeks. |
| **Conclusion** |
| This is a knowledge gap as the required salinity values were not available.<br>Supporting information includes: |

| |
|---|
| Freshwater contributions are minor in comparison to the size of the tidal compartment, resulting in a salinity range of 30-35 ppt throughout most of the Waimea Estuary (Gillespie & Asher 1999). However, reduced salinities have been reported for some localized areas in the vicinity of freshwater discharge channels (Gillespie & Asher 1999). The main freshwater inflow to the estuary is via the Waimea River and its tributaries, including the Roding, Lee, Wairoa and Waiiti rivers that drain the southern and eastern catchments. The resulting freshwater discharge (annual mean flow 20.8 m3/s), separates into a primary and a secondary channel at Rabbit Island to coincide with the two tidal openings. The primary channel, taking the majority of the flow, is presently on the eastern side of the Island. A number of smaller streams (total mean annual flow, 0.55-0.65 m3/s) also contribute to the total freshwater inflow. |

[1] Direct quotes from questionnaire responses and/or other types (or formats) of information received.

### A4.6 Wairau Lagoon (conservation scenario based on livestock control)

| **Salinity information provided by local stakeholders[1]** |
|---|
| No information was available.<br>The report by Roberts et al. (2021) contained some salinity information. |
| **Conclusion** |
| This is a knowledge gap as the required salinity values were not available.Supporting information for this site can be found in Roberts et al. (2021). |

[1] Direct quotes from questionnaire responses and/or other types (or formats) of information received.

# APPENDIX 5. SITE-SPECIFIC SOIL CARBON ASSESSMENTS

Information relating to whether the soil was organic[83] at the project sites was compiled for project sites where possible through our questionnaire (See Appendix 1, A1.1) responses and from preliminary literature review[84] when not available locally at this time. General supporting information on soil organic content in salt marsh habitats in Aotearoa New Zealand can be obtained from various sources (See references in Section 3.3.4 – Other Relevant Environmental Data). Where there was a knowledge gap for a project site, further investigation will be required during project development.

## A5.1 Te Repo Ki Pūkorokoro

| **Information provided by local stakeholders[1]** |
|---|
| • Soil carbon not measured. Limited one metre depth coring indicates: 100mm of organic silts and pasture topsoil; 700mm of firm grey marine clayey silt; 200-300mm of soft grey marine silt, at water table; then, minimum 100mm thick impervious shell layer.<br>• Scraped new ponds will not be greater than the depth of the shell layer and, for some areas, will be much shallower depending on the ease of excavating material for the new bund over successive dry summer months. |
| **Conclusion** |
| This remains a knowledge gap[2]. |

[1] Direct quote from the questionnaire responses and/or other types (or formats) of information received.

[2] After the completion of our study, another study has since confirmed the following in relation to soils at Pukorokoro Miranda Reserve: *The soils in the high marsh were very thin layers of sandy mud (3-5 cm thick), as the high marsh was mostly located on shell banks, and was consistently very dry, likely due to efficient drainage through the shell ridges. Soils in the mid marsh were very peaty, approximately 10 cm thick, underlain by sandy silts and some clays. It was particularly peaty in areas of Bolboschoenus medianus and Selliera radicans. Low marsh soils were 5-10 cm thick organic-rich muds underlain by sandy silts and clays* (Olya Albot pers. com.)

## A5.2 Wainui Repo Whenua

| **Information provided by local stakeholders[1]** |
|---|
| • No information provided. |
| **Conclusion** |
| This is a knowledge gap. |

[1] Direct quote from the questionnaire responses and/or other types (or formats) of information received.

## A5.3 Pukehina/Waihī

| **Information provided by local stakeholders[1]** |
|---|
| • No information provided. |
| **Conclusion** |
| This is a knowledge gap. |

[1] Direct quote from the questionnaire responses and/or other types (or formats) of information received.

[83] **Organic Soil** is soil with a surface layer of material that has a sufficient depth and percentage of organic carbon to meet thresholds set by the IPCC (Wetlands supplement) for organic soil. Where used in this methodology, the term peat is used to refer to organic soil (VM0033).

[84] A comprehensive literature review on this information was beyond the scope of this feasibility assessment.

### A5.4 Farewell Spit

| Information provided by local stakeholders[1] |
|---|
| • No information provided. |
| **Conclusion** |
| This is a knowledge gap. |

[1] Sourced from the questionnaire/s and/or other types (or formats) of information received. Question: *Please provide information on the organic content of the project area (e.g., % organic carbon by weight) of the soil (to at least 20cm soil depth if possible).*

### A5.5 Waimeha Inlet

| Information provided by local stakeholders[1] |
|---|
| • No information provided. |
| **Conclusion** |
| This is a knowledge gap. |

[1] Sourced from the questionnaire/s and/or other types (or formats) of information received. Question: *Please provide information on the organic content of the project area (e.g., % organic carbon by weight) of the soil (to at least 20cm soil depth if possible).*

### A5.6 Wairau Lagoon

| Information provided by local stakeholders[1] |
|---|
| • No information provided. |
| **Conclusion** |
| This is a knowledge gap. |

[1] Sourced from the questionnaire/s and/or other types (or formats) of information received. Question: *Please provide information on the organic content of the project area (e.g., % organic carbon by weight) of the soil (to at least 20cm soil depth if possible).*

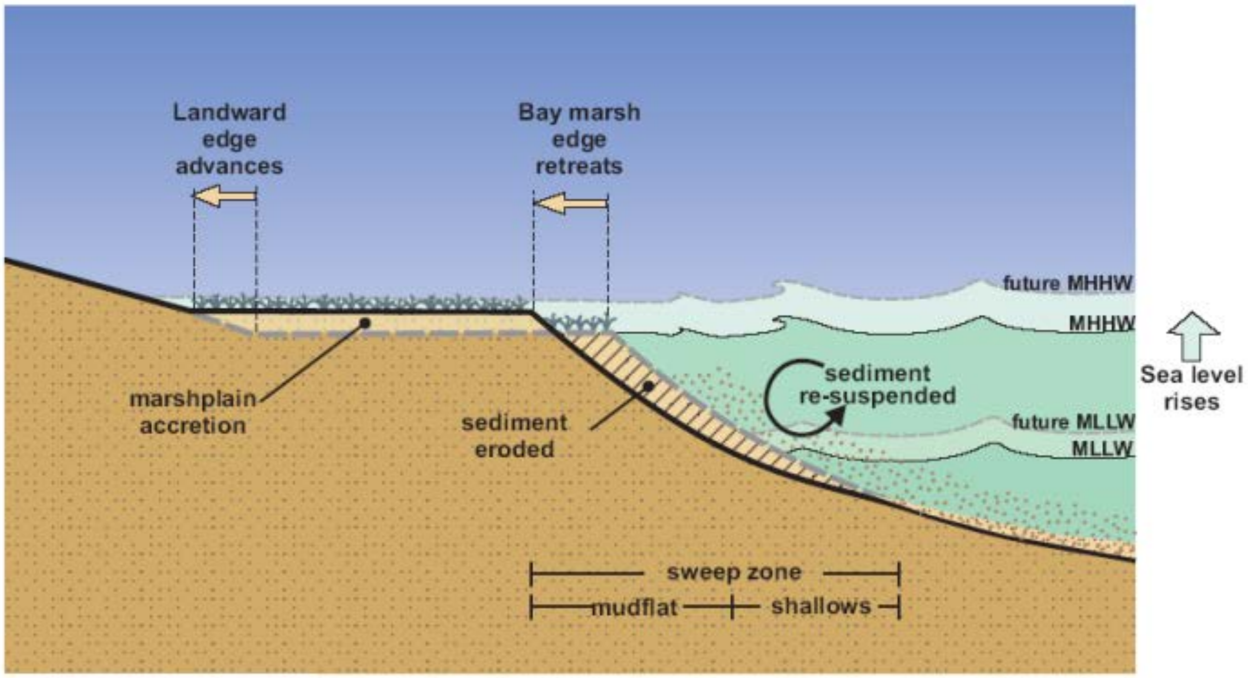
# APPENDIX 6. SEA LEVEL RISE ASSESSMENT

## A6.1 General Assessment

Sea level rise (SLR) poses both an opportunity and a risk to tidal wetland carbon offset projects, depending on the situation. Historically, SLR has been important for delivering sediment to facilitate vertical accretion of tidal wetlands such as salt marsh (Gedan et al. 2009). Future SLR can also increase the area available for tidal wetland restoration (Costa et al. 2022) and may increase tidal wetland carbon storage (Rogers et al. 2019, Kirwan et al. 2016). However, SLR also poses a risk to tidal wetlands because, if inundation outpaces the rate of vertical sediment accretion (Raw et al. 2021), existing areas of tidal wetland species can drown when water depth exceeds their physical tolerance (Gedan et al. 2009, Lovelock 2020). Vertical accretion rates for tidal wetlands are influenced by various factors including sediment supply, wetland type and shore height (Liu et al. 2021). Existing tidal wetland habitats may also migrate landward (Best et al. 2018), allowing soil carbon stocks (and biomass) to remain intact (Dittman et al. 2019). See Figure A6.1. However, often there are barriers (human-made or natural) impeding this and resulting in 'coastal squeeze' (Orchard et al. 2020). Coastal inundation, along with other climate impacts such as increased storm frequency and intensity, can also facilitate erosion of tidal wetland soil (Gedan et al. 2009, Day et al. 1998).

It is therefore important to determine (and plan to mitigate where possible) these risks during assessment of a carbon offset project. The relevant VCS methodologies for tidal wetlands recognize these risks and require that they are considered. Climate change presents other risks to tidal wetlands, for example marine heatwaves (e.g., Babcock et al. 2019, Smale et al. 2019, Aoki et al. 2021), but these are not assessed in our study.

*Figure A6.1 Potential impacts of sea level rise on tidal wetlands. Image taken from a Power Point presentation on Blue Carbon Methodologies by Amy Schmid 2020.[85] MHHW = mean higher high water , MLLW = mean lower low water.*




[85] https://www.chesapeakebay.net/channel_files/40438/crwg_presentation_19oct2020_schmid.pdf

### A6.1.1 Methods

Having considered the relevant methodologies and risk tools (such as VM0033 and VCS ALOFU Non-Permanence Risk Tool v4 19 September 2019), we assessed SLR risks for the project sites using two general approaches. One approach uses inundation model outputs to predict how inundation would change over time. The other approach uses tidal wetland elevation boundaries to predict the location[86] of the salt marsh habitat zone (SMHZ) over time. We focused on salt marsh habitat, given that this was the most relevant tidal wetland type (for the current project scenario) for all project sites except Farewell Spit.

We first determined the relevant timeframes and greenhouse gas trajectory (Representative Concentration Pathway, RCP) on which to base our SLR assessments[87]. Inundation data (i.e., model outputs) relating to the relevant timeframes and RCP were then sought for each project site where available. Where no outputs were available from a local model (e.g., regional or national), we used a global inundation model. Elevation (LiDAR) data, as well as information relating to salt marsh elevation boundaries, was also obtained where possible. Further information about implications of SLR and sediment loads was sought from each project site (Questions 6, 11, 12 and 16 of questionnaire – see Appendix 1 A1.1).

Inundation and elevation (including salt marsh boundaries) mapping over the project sites and nearby surrounding areas was then undertaken. This allowed the prediction of inundation and salt marsh habitat over time at the project sites. Each project site was also assessed for potential management interventions capable of mitigating SLR risk, possible approaches to account for reversals (carbon emissions) arising from such risks, and possible approaches to account for carbon emission reversals.

<u>Tidal Wetland Boundaries Relative to Tidal Height and Elevation</u>

Saltmarsh shoreline location and elevation are influenced by salt marsh species and local environmental conditions such as wave exposure (e.g., Graham & Dahl 2006) as well as by tidal range. We therefore obtained local information on salt marsh elevation boundaries either from project contacts or by estimating these ourselves based on present-day salt marsh distributions[88] in relation to elevation data (if both salt marsh habitat mapping and elevation data were available).

<u>Sea Level Rise Scenarios</u>

The timeframes on which we aimed to base our project site SLR assessments were:

1. 'Present day' (i.e., for the baseline scenario) and
2. 100 years into the future as required by VM0033[89].

Note that the actual year relevant to the '100-year' scenario would depend on the project timeline (i.e., start date). A ten-year period is also relevant for assessing SLR risk to the project site using the ALOFU Non-Permanence Risk Tool, but we did not assess this as it was beyond the scope of this study. The greenhouse gas

[86] This is a simplified approach, with various influencing factors not accounted for. For example, the approach does not account for all potential barriers or connections to tidal inundation present (only those that can be determined by elevation data), nor does it account for salt marsh vertical movement through sediment accretion.

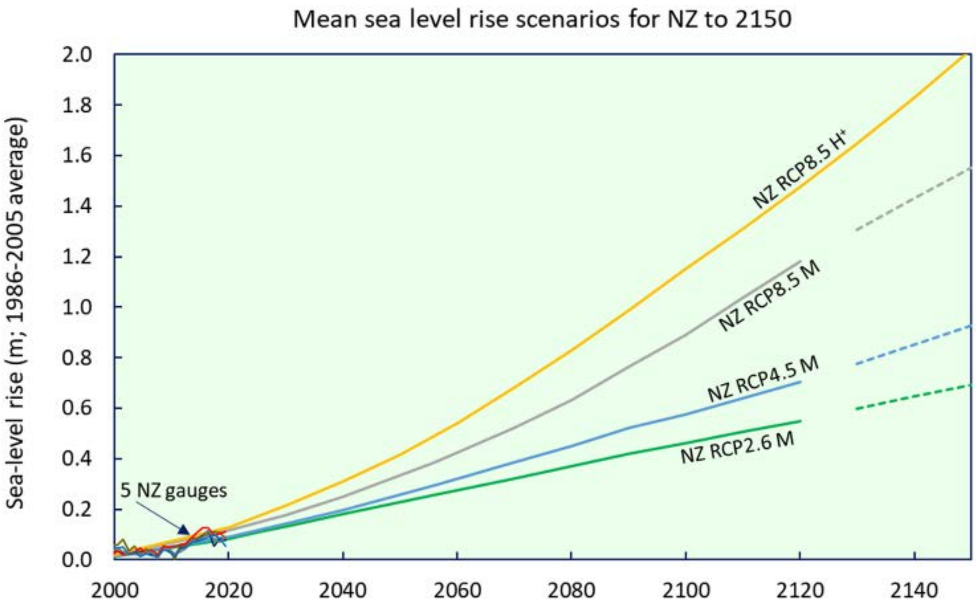
[87] In the end we sometimes used values that differed slightly from our determined timeframes and RCP, for example depending on data availability (such as inundation model outputs) for each project site.

[88] Note that estuarine areas are often heavily modified by humans and therefore mapped 'present-day' salt marsh boundaries may not be indicative of the natural salt marsh vegetation sequence that would have existed without any human modification.

[89] The projection of wetland boundaries within the project area must be presented in maps delineating these boundaries from the project start date until the end of the project crediting period, at intervals appropriate to the rate of change due to sea level rise, and at **t = 100** (VM0033).

concentration trajectory that we aimed to assess was RCP 8.5[90] *M* (median), based on a scenario for Aotearoa New Zealand which represents a SLR of 1.06[91] m to the year 20120 from the 1986–2005 baseline (Figure A6.1.1, MFE 2017[92]). However, in our assessments we often used values that differed slightly from the above SLR trajectory for the individual project sites, for example depending on data availability (such as inundation model outputs) for each site (Refer A6.2). When mapping the SMHZ, we used a 1 m increase in SLR from the 'present day' to represent the '100-year' scenario. One of the higher risk scenarios was selected for use in our study because this aligned with the general approach of the methodologies to be conservative in relation to uncertainty and risk.

*Figure A6.1.1: Four scenarios of New Zealand-wide sea-level rise projections recommended in the Ministry for the Environment's 2017 coastal guidance (MFE 2017). The three medium scenarios are based on the IPCC 5th Assessment Report; the highest scenario, and extensions to 2150 for the three medium scenarios, are based on KOPP et al. (2014). Measurements up to 2019 are from: Auckland, Moturiki, Wellington, Lyttelton, and Dunedin. Sea level height is relative to the average mean sea level over the recent period 1986-2005, which the IPCC uses as a zero baseline for projections. Plot taken from https://niwa.co.nz/natural-hazards/hazards/sea-levels-and-sea-level-rise accessed November 2021.*




The general aim of the local inundation models from which we used outputs in our study was to assess the risk of SLR to infrastructure and coastal areas (e.g., Reeve et al. 2019, Tasman District Council 2019). Therefore, only higher tidal/flooding heights (as described in the following sentence) most relevant to assessing flood risks were available for use as model outputs. Inundation outputs provided by the models related to mean high water springs (MHWS e.g., 6, 7[93], 10) and Annual Exceedance Probability (AEP, e.g., 1%, 2%). While the inundation models (based on MHWS) were useful for predicting inundation at the project sites, they were not

[90] RCP8.5 is described as – continuing high emission baseline scenario (Riahi et al, 2011), with no effective global emissions reduction. Comprises a rising radiative forcing pathway, with emissions stabilised soon after 2100 RCP8.5 provides a baseline pathway to compare the effectiveness of different levels of emission-reduction policies. An 'RCP8.5 world' would exhibit slow rates of economic development, slow uptake of technology. World population estimated to reach around 13 billion (MFE 2017).

[91] Between the years 2020 to 2120 this represents a 0.97 m increase in sea level rise (calculated from Table 10 in MFE 2017). Based on this, we calculate that the average SLR increase during this 100-year period is 9.7 mm per year, refer to Table 10 to see SLR predictions broken down into decadal increments.

[92] Refer to Section 5.7.1 of MFE 2017 for further information on how the SLR projections for Aotearoa New Zealand are calculated.

[93] For example, MHWS–7 refers to the height of the tide exceeded only by the highest 7% of all high tides, which is about the highest tide every fortnight (Reeve et al. 2019).

necessarily informative for indicating the distribution of salt marsh. This was because salt marsh can exist above and/or below MHWS and can survive infrequent flood events (Thannheiser & Holland 1994). This is why, besides modelling inundation, we also predicted salt marsh distribution based on elevation.

### A6.1.2 Risk of SLR and Mitigation Options

Based on our SLR risk assessment results for each project site (refer A6.2), we consider SLR to likely pose a substantial risk to carbon storage and sequestration at all project sites for our '100-year scenario' if mitigation action to reduce this risk is not taken (noting the limitations of our study). The risk to carbon credits could be mitigated to some extent by considering any predicted changes to tidal wetland species composition caused by SLR within future project development. Engineering solutions to control tidal level (already planned for some project sites) and/or the acquisition of land suitable for enabling inland migration of tidal wetland could be used to mitigate the risk of SLR at the project sites. On the other hand, there may be opportunity around some project sites to increase the area being considered for a carbon project.

Summary of SLR Risk Assessment

All project sites were predicted to be inundated (at MHWS tidal height) in our '100-year' SLR scenario. However, note that these results were based on relatively simple inundation models that did not consider factors such as sediment accretion (see below and A6.1.3 on Knowledge Gaps). In response to SLR, salt marsh habitat was predicted to migrate inland, fully or partially outside the current project's geographical boundaries of all project sites where we used our simple mapping approach[94] to assess this. To cater for landward migration, additional land outside the current project site boundaries would need to be acquired to sustain the carbon benefits delivered by tidal saltmarsh. This additional land would need to be connected to tidal flow, be free from coastal squeeze issues and meet all the relevant eligibility criteria for a blue carbon project.

Note that our SLR assessment did not consider sediment accretion rates of tidal wetland (salt marsh) habitats at the project sites. Given sediment accretion rates are influenced by various factors (Liu et al. 2021), we expect them to be relatively site specific. We do not know of any accretion values currently available for our project study sites. However, to provide examples for Aotearoa New Zealand, sediment accumulation rates at two salt marsh sites in Ahuriri Estuary (Hawkes Bay) were found to be 3.8 and 4.3 mm/yr (Chagué-Goff et al. 2000). Accretion rates from salt marsh Abel Tasman estuaries ranged from 2.33 – 3.0 mm/yr, based on the most recent value recorded for each sediment core (Goff & Chague-Goff 1999). In Auckland, salt marsh accretion was recorded as being less than 1 mm/yr between 1948-1949 (Chapman & Ronaldson 1958 in Swales et al. 2020). The accretion rates in the above studies do not appear to be high enough to counter the predicted SLR over a '100-year' timeframe under RCP 8.5*M* as outlined in MFE 2017, which we calculated to be 9.7 mm/year on average between 2020-2120 (refer A6.1.1 Methods). Note that information on sediment accretion for mangroves in Aotearoa New Zealand is also available (e.g., Swales et al. 2020, Young & Harvey 1996).

The VM0033 methodology (and references within) indicates that a sediment load of >300 mg per liter, in relation to marshes with a tidal range greater than 1 meter, could be enough to balance high-end IPCC scenarios for sea level rise. It also indicates that the most vulnerable tidal wetlands are those in areas with a small tidal range, those with elevations low in the tidal frame and those in locations with low suspended sediment loads. For the project sites assessed in our study, these factors would need to be considered during further project development. Note that sediment loading was a knowledge gap in our assessment that would need to be addressed.

[94] Various influencing factors were not accounted for in our simplified approach to assessing salt marsh location. For example, our approach does not account for all potential barriers/connections to tidal inundation present (only those that can be determined by elevation data), nor does it account for salt marsh vertical movement through sediment accretion.

Further discussion on implications of SLR in relation to changing tidal wetland species composition and mitigation options for reducing the risk of SLR is provided in the paragraph below. Note that SLR could also present an opportunity for a larger carbon credit project than currently proposed at some project sites (for example, Wairau Lagoon and Pukehina/Waihī). This could be the case if the relatively large area of land surrounding the project sites was considered and met the criteria for this purpose. We recommend a landscape-scale feasibility study to identify such opportunities at these (and other) areas in Aotearoa New Zealand. Sea level rise should be considered in any such study.

General implications for changing tidal wetland species composition at project sites

As the sea level rises, it can be expected that wetland species composition (or habitat type in general) at project sites will change (if vertical accretion rates of existing species are not high enough to keep pace) and this should be considered within future project assessments. Salt marshes in Aotearoa New Zealand contain vegetation sequences, with some plant species restricted to 'zones' (e.g., low-, mid-, hind-marsh) based on tidal level. Future plant species composition will also depend on the species already present (in intact wetlands) or those actively restored by project activities.

Over time, salt marsh habitats at some North Island[95] sites may be replaced by mangroves (*Avicennia marina*). Mangroves can survive from below the MHWS mark down to at least mean sea level (MSL) (Figure 3.5.3). Passive restoration (i.e., without human intervention) could potentially occur for revegetation of mangroves on project sites, given that mangroves are likely to colonize naturally if they are present nearby and environmental conditions are conducive (e.g., a certain level of % mud in the substrate is likely to be required). It is also possible that inundation levels could be high enough to drown mangroves within the 100-year timeframe, although this was not assessed in our study (note that Lovelock et al. (2015) discusses this topic). A way to help deal with the risk of subsidence and biomass loss is to use long-term storage in wood products from harvested trees as per the methodology VM0033[96]. This could be considered for NZ mangroves if it could be demonstrated that they met the relevant criteria.

In theory, seagrass (which exists at lower tidal levels than mangroves) could also follow behind salt marsh and mangroves in succession when these habitats migrate up the shore as sea level rises. However, the timeframe for recolonization by seagrass of substrates previously occupied by tidal wetlands (or any other substrate not originally unvegetated estuarine sand/sediment) is unknown for Aotearoa New Zealand and may be longer than timeframes relevant to the project scenarios.

Ultimately, if one type of tidal wetland is drowned by SLR and another type does not replace it, then eventually a change from a vegetated tidal wetland habitat to unvegetated habitat would occur, likely leading to reduced sequestration and the potential loss of stored carbon.

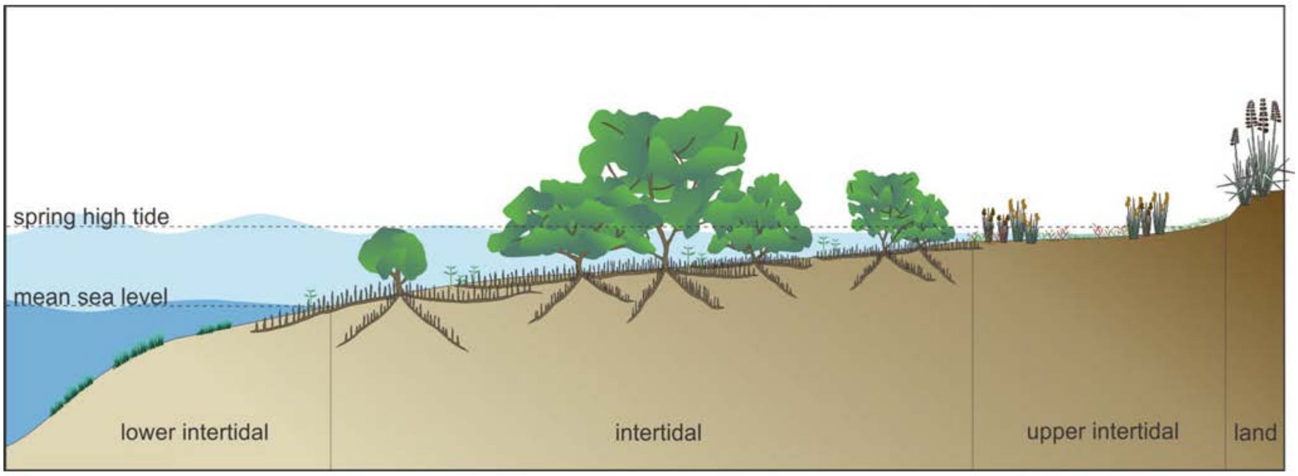
General discussion on engineering solutions for mitigation of SLR impacts at project sites

An option to mitigate the impacts of SLR on tidal wetland habitats, already considered for some of our project scenarios, is to control water levels using structures such as flapgates, weirs, culverts, bunds or drains. Consideration should also be given to any barriers that may cause water from freshwater sources to pool at project sites, as this could lead to decreased salinity (and increased water levels) which has implications for GHG emissions in tidal wetlands (e.g., Kroeger et al. 2017).

[95] Mangroves are not known to occur in the South Island of Aotearoa New Zealand, although they are predicted to extend their southward boundary as temperature rises. However, there is very recent anecdotal evidence to suggest that some young mangrove plants are growing in estuarine habitat near Māpua in the Top of the South Island (Donald Morrisey Pers. Obs. 2022).

[96] Since biomass may be lost due to subsidence following sea level rise, restoration projects involving afforestation or reforestation may account for long-term carbon storage in wood products where trees are harvested before dieback (VM0033).

*Figure A6.1.2. A typical cross-shore profile of an intertidal area with mangroves in an estuary in northern Aotearoa New Zealand. The lower intertidal is dominated by seagrass (Zostera muelleri), mangroves thrive in the regularly flooded area above mean sea level, the upper intertidal is home to salt meadows comprising succulents and herbs such as saltwort (Salicornia quinqueflora) and remuremu (Selliera radicans), and salt marshes, covering rushes such as sea rush (Juncus kraussii) and oioi (Leptocarpus similis). At the landward end, coastal scrub such as flax (Phormium tenax) is prevalent. Figure and caption modified from Horstman et al. (2018).*




### A6.1.3 Knowledge Gaps

For all except two of our project sites (for which a global model was used), the inundation model outputs obtained were regionally and/or locally specific. Most of these models were relatively simple (e.g., following a 'bathtub' approach). The exception to this was the model for the Wainui Repo Whenua project site, which used a Delft2D FM hydrodynamic model. Ideally the accuracy of models would be improved over time, for example by following a 3D hydrodynamic approach and considering factors such as salt marsh accretion (e.g., Best et al. 2018). This should be considered in further project development. Given the importance of sediment supply for determining salt marsh accretion rates (Liu et al. 2021, VM0033), sediment loading (or other relevant parameters) would ideally be determined (and potentially predicted into the future) for sites for which further project development is planned.

Some of the models used did not consider factors such as barriers to tidal flow and aspects of relative sea level rise (e.g., subsidence, uplift, erosion and accretion). Catering for these factors within the models would improve the accuracy of their outputs. The regional and local inundation models also did not account for the most recent IPCC projections for SLR (i.e., from IPCC 2021), although the global model did. The impact of other factors relating to SLR, such as storm intensity and frequency and erosion impacts on tidal wetland habitats, would also need to be considered in a blue carbon project, either as an element of project development or a forward action (e.g., at second or third verification).

Alternative approaches for predicting the location of tidal wetland habitat, besides simply using habitat boundaries based only on elevation, could be used in the future. For example, tidal heights that are known to delineate upper and lower boundaries of tidal wetland in any given area could be an output of an inundation model.

Shorter temporal intervals (within a 100-year period) could also be assessed to further understand how salt marsh (and other tidal wetland) responds to SLR over time at the project site. This could include modelling change to wetland habitat distribution on a decadal basis to align with baseline revision requirements during the project period.

## A6.2 Site Specific Assessments

A Sea Level Rise (SLR) risk assessment is provided below for each project site.

### A6.2.1 Te Repo Ki Pūkorokoro

Detailed Methods for This Site

A local inundation model was used (Coastal Inundation Tool V2 User Guide[97]) to estimate the effects of future sea level rise on inundation of the Te Repo Ki Pūkorokoro project site. The 'present day' scenario used in our study was relative sea level rise (RSLR) of 1.8m and mean high water springs (MHWS-10). The '100-year' scenario used was RSLR of 2.8m and MHWS-10. These scenarios relate to the Pūkorokoro Miranda area, as they have been determined using the Tararu tide gauge converted to MVD-53. Note that specific Representative Concentration Pathways (RCP) climate change scenarios were not yet publicly available for the Firth of Thames. The questionnaire response indicated that elevation data were available for the project site but were not of a sufficiently accurate scale for the project. Therefore, salt marsh boundaries were not mapped. For further information on general methods refer Appendix 6 (A6.1) above.

Impact of Coastal Inundation on Tidal Wetland Distribution

In the '100-year' scenario, the Te Repo Ki Pūkorokoro project site was inundated at the tidal height of MHWS-10 (Figure A6.2.1). This was in relation to 'connected' inundation, where water can directly (or via waterways) flow to the sea[98]. In comparison, nearly all of the project site was covered by disconnected [99] inundation in the 'present-day' scenario (Figure A6.2.1), noting that project activities plan to improve tidal reconnection (e.g., flapgate removal, weir installation and new drainage) at the project site. We did not map the salt marsh habitat zone (SMHZ), however, SLR is likely to affect species make-up in the wetland, with mangroves potentially replacing salt marsh over time. In this respect, we note that the project plan is to enable establishment of limited mangrove forest in the first instance. Inundation could also be high enough to drown mangroves within the '100-year' scenario, although this was not assessed in our study.

The risk of SLR to the project area was recognised by the project contacts, with questionnaire responses including: "*highly relevant sea level rise impacts can be expected*" and "*The area has been modelled for sea level rise impacts with the flood plain, within which the Reserve is included, is expected to be tide inundated by the end of this Century -to the limit of high water mark according to plans drawn in 1869. Recent tidal surge events show the Reserve is somewhat protected by such events with inundation mainly sourced from north of the reserve and the elevated East coast Road limiting surge flooding effects. The East Coast Road is affected by flooding and long term may cease to be viable to maintain. Accordingly transition adaptive management engineering principles are being considered".* Further information on SLR implications in the Miranda area can be found in Hume (2020).

In relation to sediment loading, it was noted in the questionnaire responses that *Turbidity and drain flow into the Reserve Pūkorokoro Stream hydro parcel has been measured by Golder Associates at the northern end of the reserve and at the Miranda Stream.* Further information can be found in Golder Associates (2014).

[97] https://www.waikatoregion.govt.nz/assets/Coastal-Inundation-Tool-V2-User-Guide.pdf

[98] As described in the Coastal Inundation Tool V2 User Guide.

[99] The Coastal Inundation Tool V2 User Guide states that: *The disconnected inundation areas may or may not be 'real' and could actually be connected inundation areas. The disconnected inundation areas should still be regarded as areas that could be affected by coastal inundation. Flood protection assets such as stop banks or flood walls are provided as a layer in the tool. Therefore, disconnected areas behind identified stop banks/flood walls are assumed to be protected from coastal inundation up to the design crest level. Connected inundation areas behind identified stop banks/flood walls show that the flood protection has been overtopped.*

Based on the above results for the Te Repo Ki Pūkorokoro project site, we consider SLR to pose a substantial risk to carbon storage and sequestration at this site based on our '100-year' scenario if no mitigation action is taken to reduce this risk (noting the limitations of our study, refer A6.1.3 Knowledge Gaps). However, engineering solutions to control tidal level are planned for the project (see following section). The acquisition of land suitable for enabling inland migration of tidal wetland could also be used to mitigate the risk of SLR at this site. The SLR risk could also be mitigated to some extent by considering predicted changes to tidal wetland species composition within future project development. Please also refer to A6.1.2 (Risk of SLR and Mitigation Options) for general discussion on changing tidal wetland species composition in response to SLR and engineering solutions to mitigate SLR impacts.

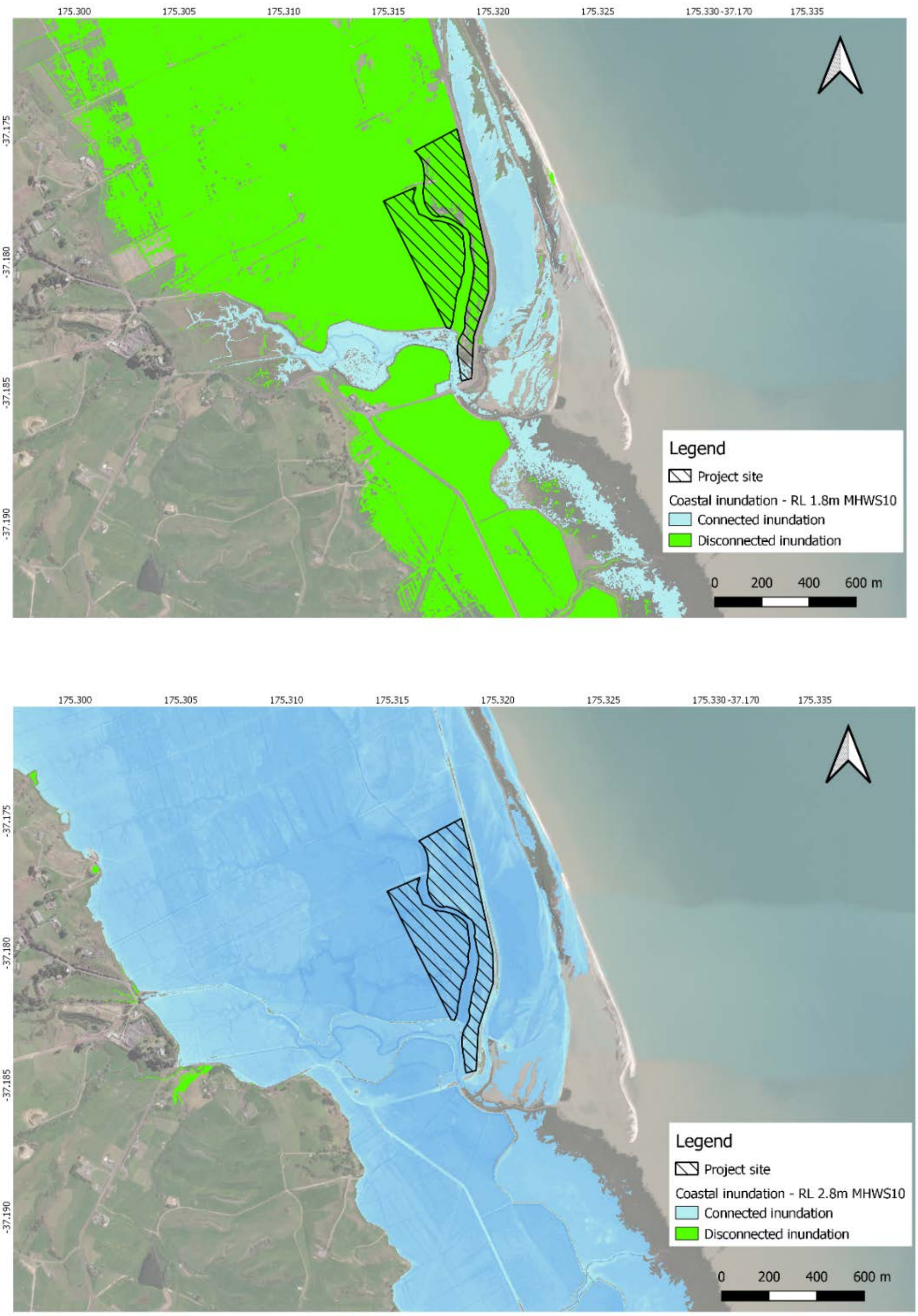
Potential Mitigation and Accounting for Reversals

Management options to mitigate the impacts of SLR on the project site include the following:

- Management of the Reserve and surrounding land (e.g., to allow inland migration) will require medium- to long-term strategic consideration to integrated catchment management and transition restoration management as the effects of climate change impact on the local environment, including an increase in storm events, tidal surges and sea level rise.
- Sea level rise (including the increased likelihood of storm events and tidal surges -two in recent years) is being considered by Council engineers and Living Water contracted hydrologists and engineers. The proposed structures could be designed to facilitate adaptive management. For example, weirs could be of wooden construction and able to be modified to accommodate emergency events or simply for the optimization of tidal exchange requirements to maintain ecological integrity in the ponded areas.

Other pieces of land nearby the project site are being considered for restoration (e.g., Findlay Reserve). However, these were not included in this study and therefore such areas were not assessed on whether they allow for inland tidal wetland migration.

*Figure A6.2.1. Inundation model output for the Te Repo Ki Pūkorokoro Miranda Reserve project site in relation to the 'present-day' (top map) and '100-year' (bottom map) scenarios. Tidal height for both scenarios is mean high water springs (MHWS-10). Connected inundation (blue shaded areas) represents areas where water could directly (or via waterways) flow to the sea for a chosen water level. Disconnected inundation (green areas) represents areas that are at or below a chosen water level but may have no direct flow path to the sea. Disconnected areas may still be affected by coastal inundation in some way, e.g., via groundwater.*



### A6.2.2 Wainui Repo Whenua

Detailed Methods for This Site

A regional inundation model was used (details in Reeve et al 2019, refer Section resilience) to estimate the effects of future sea level rise on inundation of the Wainui Repo Whenua project site. The 'present-day' and '100-year' (for the year 2130 based on RCP 8.5*M*, Reeves et al. 2019) scenarios used for the Wainui Repo Whenua project site in our study were those provided in the model for the tidal height of mean high water springs (MHWS-7). Modelled water depth was also available. Interim salt marsh lower and upper elevation boundaries used were 0.6 m and 1.2 m (MVD-53) respectively. This information was provided by the Bay of Plenty Regional Council (Josie Crawshaw pers. comm.) based on observations of present-day salt marsh habitat in Tauranga Harbour. The LiDAR data used were based on NZDV2016, so we converted all elevation boundary values from MVD-53 to NZVD2016 by subtracting 0.2 m. Therefore, the lower and upper elevation boundaries used for our 'present-day' scenario were 0.4 m and 1.0 m (NZVD2016) respectively and those used for the '100-year' scenario (i.e., plus 1 m SLR) were 1.4 m and 2.0 m (NZVD2016). For further information on general methods refer Appendix 6 (A6.1) above.

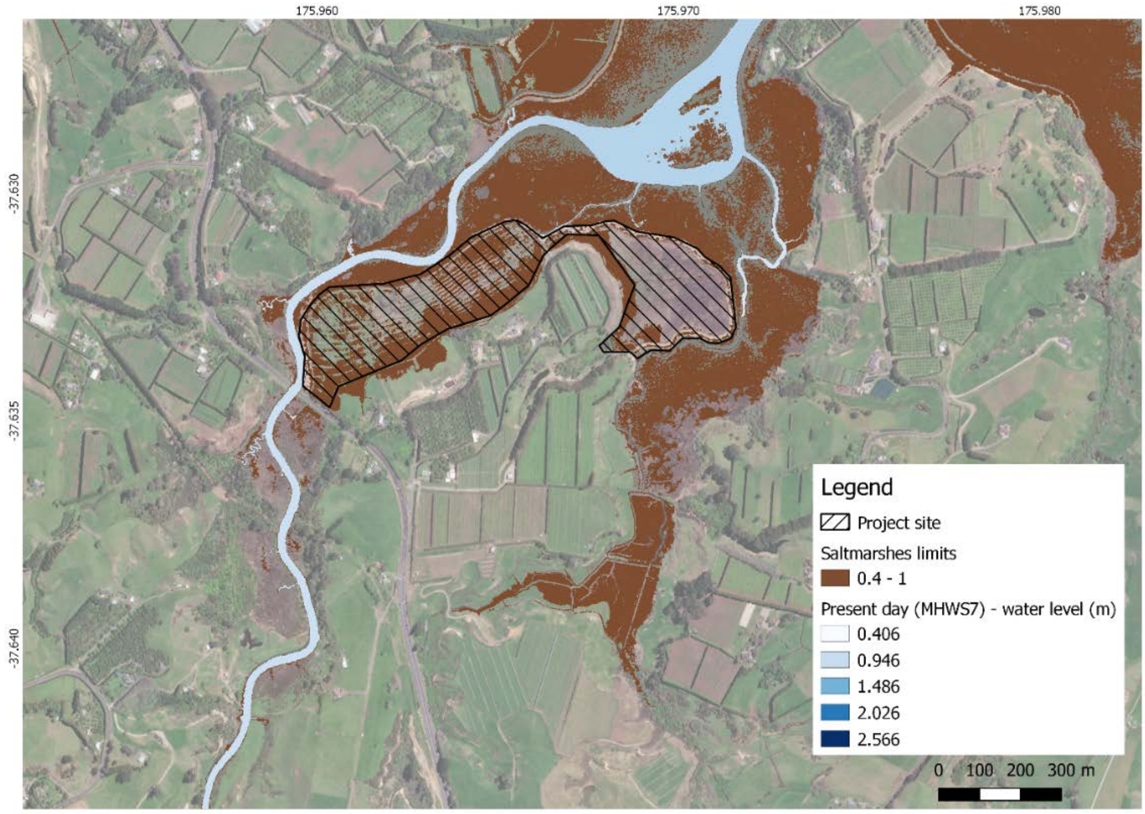
Impact of Coastal Inundation on Tidal Wetland Distribution

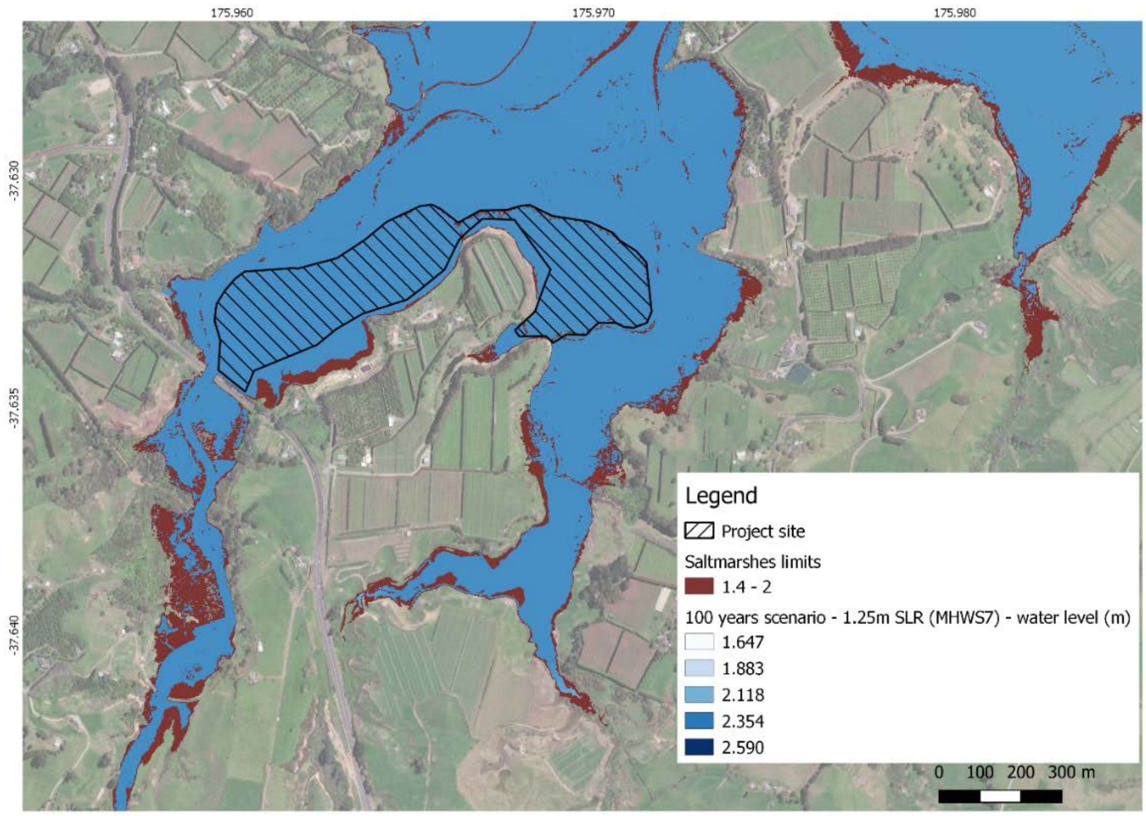
In the '100-year' scenario, the Wainui Repo Whenua project site was predicted to be fully covered by water (approximately 2.4m depth) at the tidal height of MHWS-7 (Figure A6.2.2). This level of inundation represents a marked increase compared to present-day water levels, given that the project site is currently located above MHWS-7 (Figure A6.2.2). The answers provided in the questionnaire for this project site recognised future inundation implications, stating that *It can be seen from the maps* [coastal inundation, referred to in the questionnaire] *that some storm events will start overtopping the bund and eventually the MHWS-7 (with SLR) will overtop the bund and there will be weir-spill in the wetland along the entire length on the bund.* It was also noted that *SLR would slowly increase a base water level in the wetland* and that *This may affect species make-up in the wetland over time (less saltmarsh)*.

The SMHZ mapped using our simple approach also predicted changes to salt marsh location caused by SLR, showing that, within our 'one-hundred year' scenario, salt marsh habitat was predicted to have migrated almost completely out of the project site. It is possible that mangroves may follow in succession behind the salt marsh as it migrates landwards. Mangroves currently surround the project site and could therefore provide a supply of propagules for colonisation. The inundation level may possibly be high enough to drown mangroves within the '100-year' scenario, although this was not assessed in our study. Due to the topography of the land, the area of salt marsh in the project site and immediate surrounding area was predicted to decrease in our '100-year' scenario (compared to the present-day area). The elevation data also indicated that much of the project site is below the SMHZ in the 'present-day' scenario, indicating that reconnected tidal flow needs to be controlled (which we understand it currently is, e.g., using culverts/weir) to ensure that the salt marsh is not drowned.

For the Wainui Repo Whenua project site, we therefore consider SLR to pose a substantial risk to carbon storage and sequestration at this site based on the '100-year' scenario if no mitigation action to reduce this risk is taken (noting limitations of our study - refer A6.1.3 Knowledge Gaps). Engineering solutions to control tidal level are already in operation to mitigate this to some extent. The acquisition of land suitable for enabling inland migration of tidal wetland could also be used to mitigate the risk of SLR at this site. The SLR risk to any carbon credits could also be mitigated to some extent by considering predicted changes to tidal wetland species composition within future project development. Please also refer to A6.1.2 (Risk of SLR and Mitigation Options) for general discussion on changing tidal wetland species composition in response to SLR and also engineering solutions to mitigate SLR impacts.

*Figure A6.2.2: Inundation model output for the Wainui Repo Whenua project site in relation to the 'present-day' (top plot) and '100-year' (bottom plot) scenarios used in our study. The tidal level for both scenarios is mean high-water springs (MHWS-7). Modelled water depth is also displayed. The salt marsh habitat zone mapped using a simple approach and delineated by upper and lower elevation contours (reddish brown area on map) is also displayed.*



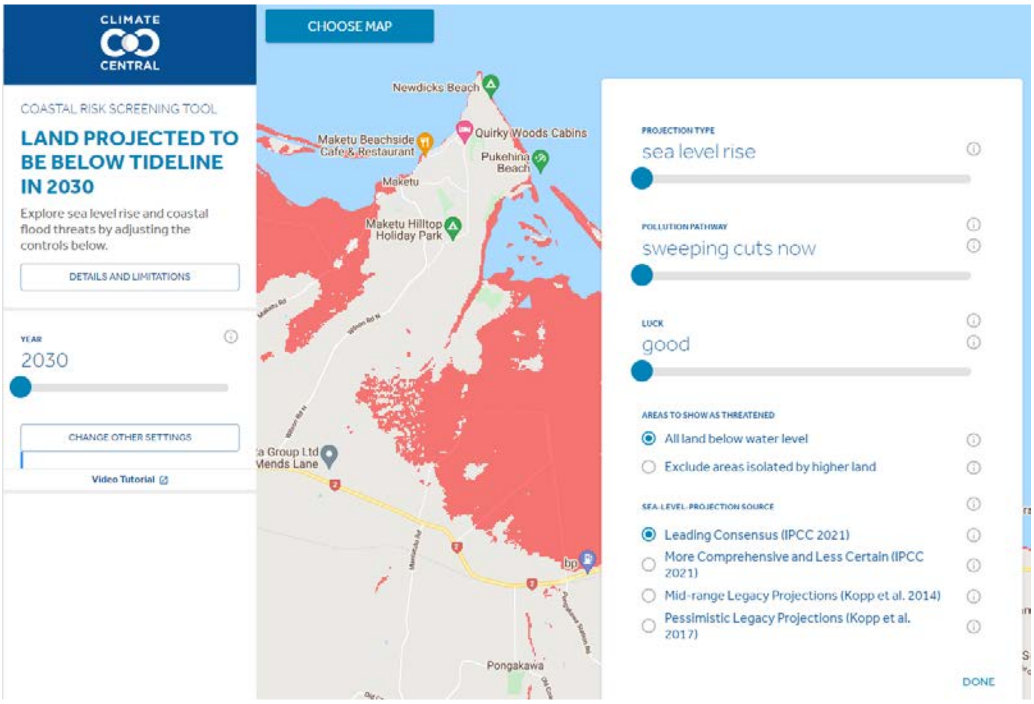



### A6.2.3 Pukehina/Waihī

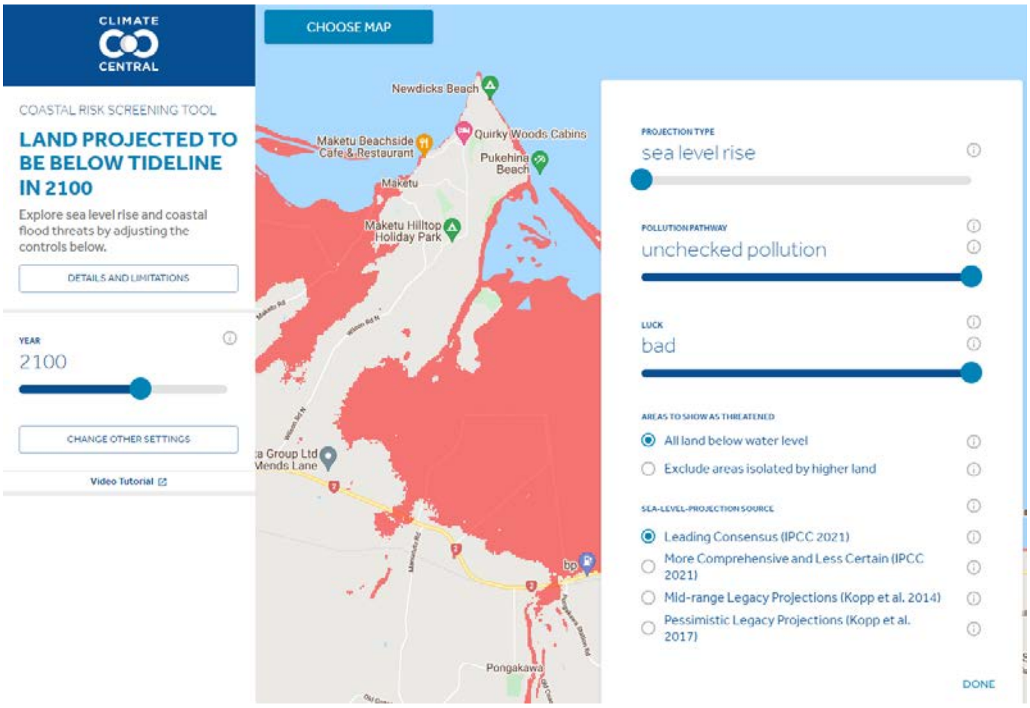
Detailed Methods for This Site

A global inundation model (Coastal Risk Screening Tool) was used to estimate the effects of future sea level rise on inundation of the Pukehina/Waihī Estuary project site, as a more local model was not available. A 'present-day' scenario was not available in the model, so we used the 'scenario closest to present-day' instead which was for the year 2030 and involved the lowest risk ratings for 'pollution' and 'luck'[100] (Figure A6.2.3a). For the '100-year' scenario, we used the year 2120 and the highest risk options for 'pollution' and 'luck' provided by the model (Figure A6.2.3a). For both timeframes, the SLR option without flooding was used. Interim salt marsh elevation boundaries were the same as those used for the Wainui Repo Whenua project site (Refer A6.2.2). These boundaries were based on observations from Tauranga Harbour; however, they appeared to be generally suitable for the Pukehina/Waihī Estuary based on visualization of estuarine habitat in aerial imagery overlaid with these boundaries (data not shown). For further information on general methods refer Appendix 6 (A6.1) above.

*Figure A6.2.3a: Inundation model inputs for the Pukehina/ Waihī Estuary project site in relation to the 'closest to present-day' (top plot) and '100-year' (bottom plot) scenarios used in our study. Link to model [https://coastal.climatecentral.org/map/](https://coastal.climatecentral.org/map/) (accessed December 2021).*




[100] 'Luck' in the model relates to different possible sensitivities given by the projections, and their likelihoods.




Impact of Coastal Inundation on Tidal Wetland Distribution

The model predicts that the Pukehina/Waihī project site will be inundated in both the 'closest to present-day' and '100-year' scenarios (Figure A6.2.3b). In the '100-year' scenario, much of the area surrounding the project site was predicted to be below the SMHZ (Figure A6.2.3c), indicating that a large area of land outside the project site would need to be acquired to allow salt marsh to migrate in response to SLR (based on our simple approach for assessing this). Sea level rise is likely to affect plant species make-up in the wetland, with mangroves potentially replacing salt marsh over time. It is possible that the level of inundation would be high enough to drown mangroves based on the '100-year' scenario, although this was not assessed in our study. In the 'present day', the project site was also largely predicted to be below the SMHZ (Figure A6.3c). If this is the case, then full tidal reconnection could potentially result in the salt marsh drowning (indicating that care therefore needs to be taken in respect to any activities involving rewetting).

For the Pukehina/Waihī project site, we therefore consider SLR to pose a substantial risk to carbon storage and sequestration at this site based on our '100-year' scenario if no mitigation action was taken to reduce this risk (noting limitations of our study - refer A6.1.3 Knowledge Gaps). Engineering solutions to control tidal level and/or the acquisition of land suitable for enabling inland migration of tidal wetland could be used to mitigate the risk of SLR at this site. This risk to any carbon credits could also be mitigated to some extent by considering predicted changes to tidal wetland species composition within future project development. Please also refer to A6.1.2 (Risk of SLR and Mitigation Options) for general discussion on changing tidal wetland species composition in response to SLR and also engineering solutions to mitigate SLR impacts. Note that SLR could also present an opportunity to increase the project area size (than that currently proposed) for a carbon credit project at this site. This would be the case if the relatively large area of land surrounding the site that is predicted to be suitable for salt marsh in the future was considered and met the criteria for this purpose.

*Figure A6.2.3b: Inundation model output for the Pukehina/ Waihī Estuary project site in relation to the 'closest to present-day' (top plot) and the '100-year' (bottom plot) scenarios used in our study. Note that an outline of the project sites was not added to the model output, please refer to Figure A5.3c below to see the location of the project site in relation to the estuary.*

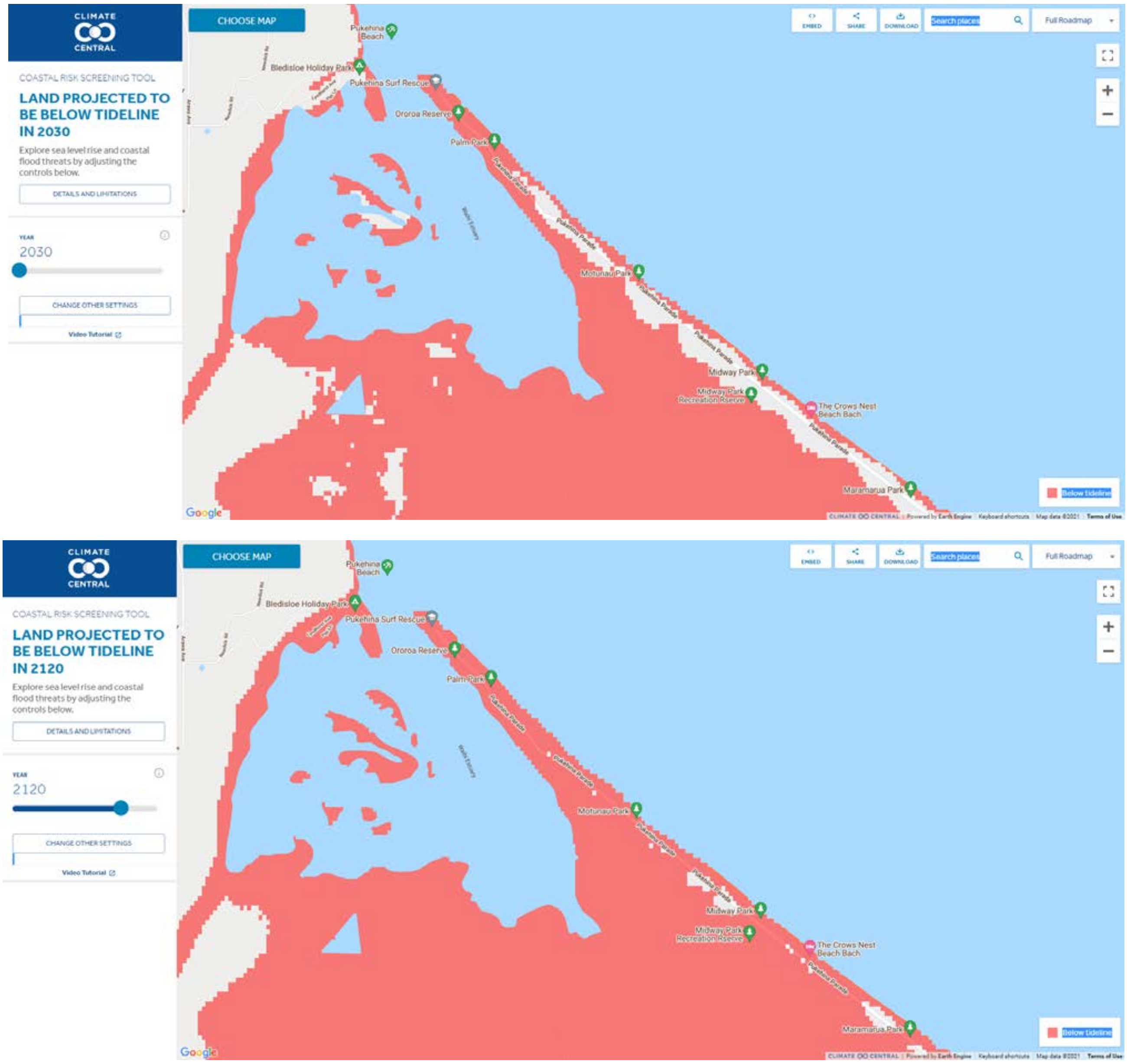
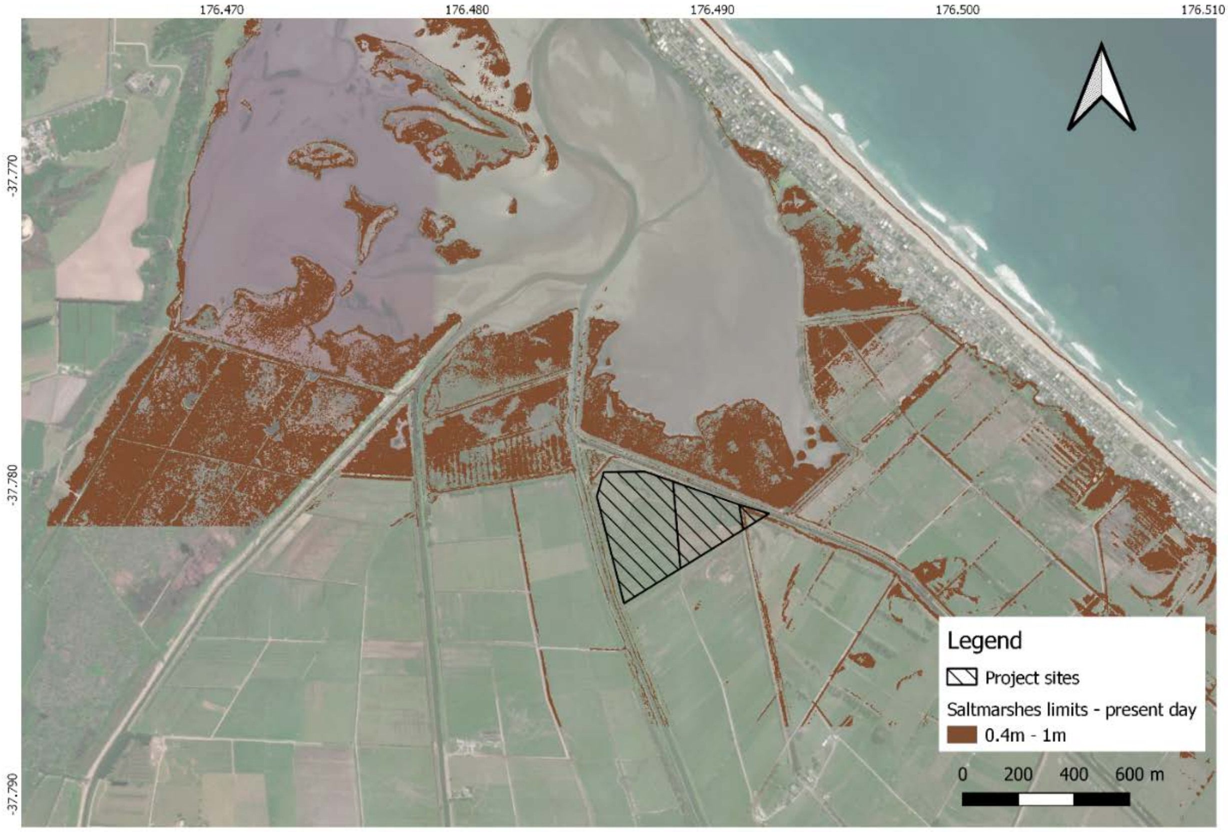
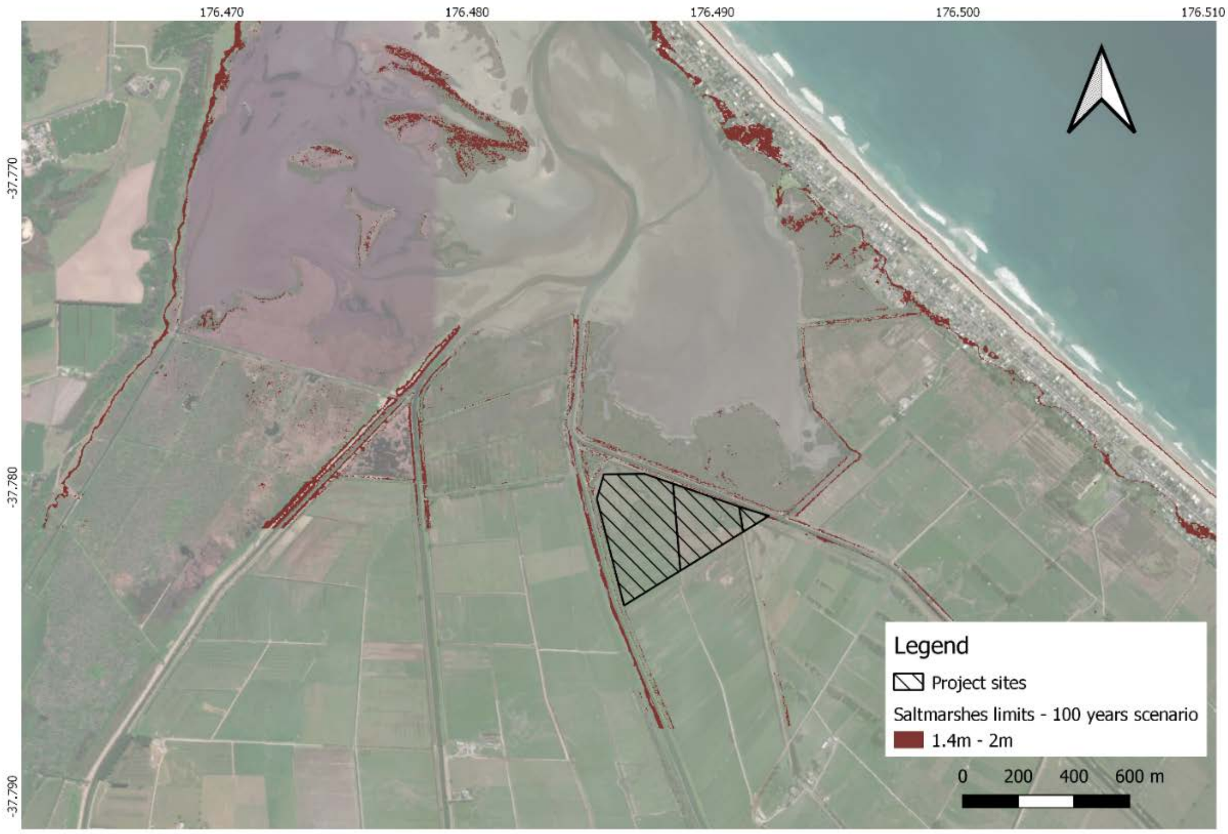


*Figure A6.2.3c: The salt marsh habitat zone (SMHZ, reddish brown areas in between salt marsh limits) in relation to the Pukehina/ Waihī Estuary project site. The SMHZ is mapped using a simple approach based on elevation data for the present-day (top plot) and '100-year' (bottom plot) scenarios used in our study.*



### A6.2.4 Farewell Spit

Detailed Methods for This Site

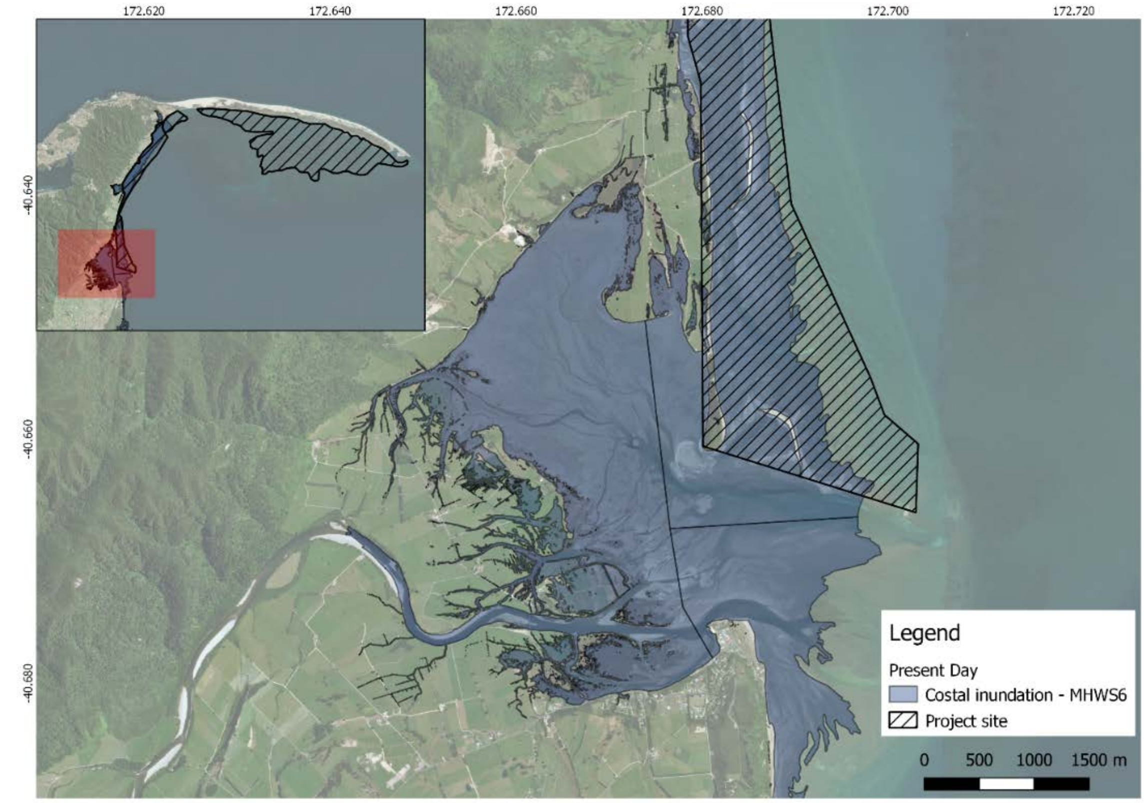
The inundation model (and model scenarios used in our study) were the same as described for the Waimeha Inlet project site. Inundation model outputs were not available for the area directly adjacent to Farewell Spit. We did not consider mapping seagrass elevation boundaries, with one reason being that seagrass can exist in the subtidal environment. For further information on general methods refer Appendix 6 (A6.1) above.

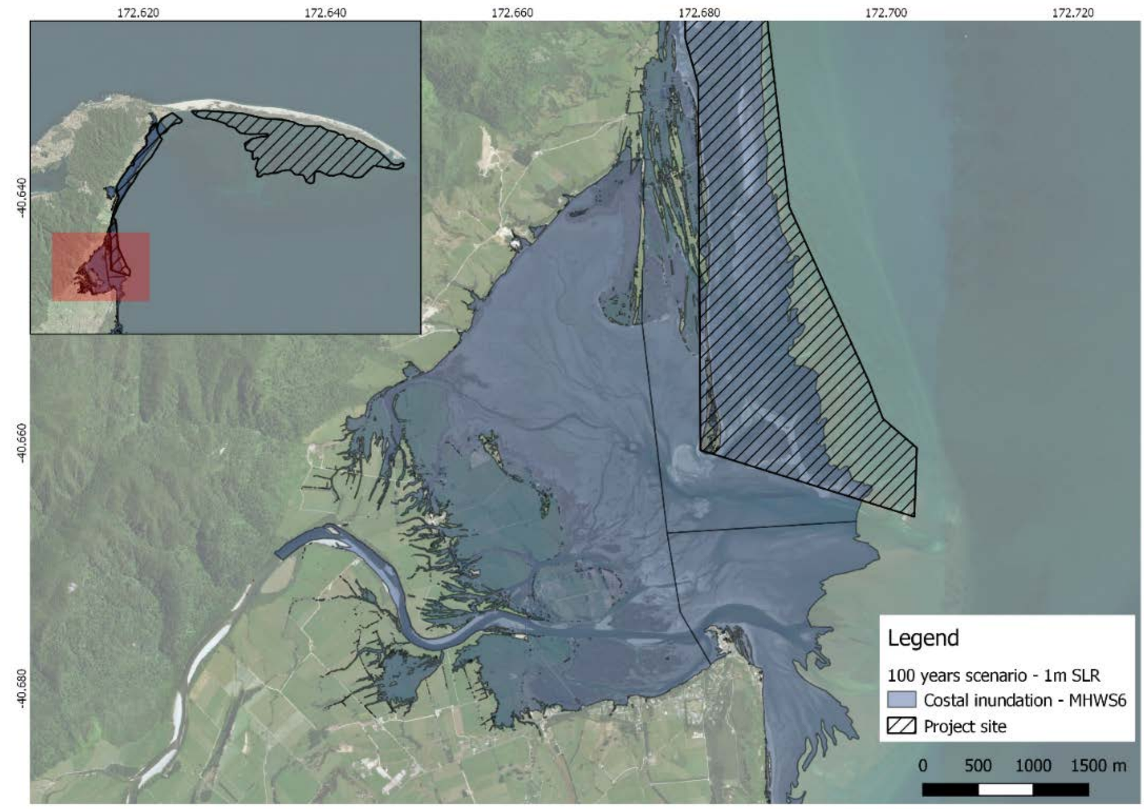
Impact of Coastal Inundation on Tidal Wetland Distribution

Over time, the model predicted that the seagrass beds in the Farewell Spit project site would become more inundated compared to ‘present-day’ water levels (Figure A6.2.4). At the lower intertidal levels initially, seagrass meadows will shift to becoming subtidal. *Zostera muelleri* can live both intertidally and sub-tidally, although water clarity plays an important role in determining the depth at which seagrass can grow (Turner & Schwarz 2006). However, we do not know of any subtidal seagrass currently existing in the Farewell Spit area. As the sea level rises, seagrass may also potentially colonise any currently unvegetated substrates further up the shore (as long as environmental conditions allow). Without modelled information on future water depth and tidal levels (e.g., low tides) as well as water clarity, it is difficult at this stage to comment further on how future coastal inundation may influence distribution of seagrass at this project site. The project site was not considered to be immediately near an area of medium or high historical coastal erosion (or accretion) based on the methodology used to assess this in Tasman District Council (2019).

For the Farewell Spit project site, we therefore consider SLR to likely pose a risk to carbon storage and sequestration at this site based on the ‘100-year’ scenario. The risk would be lower if the seagrass was able to successfully transition from an intertidal to a subtidal environment, although this seems unlikely. Extending the project site towards the coast may also potentially allow for landward migration of seagrass under certain circumstances. Please also refer to A6.1.2 (Risk of SLR and Mitigation Options) for general discussion on changing tidal wetland species composition (relating to seagrass only in this case) in response to SLR.

*Figure A6.2.4: Inundation model output for the Farewell Spit project site in relation to the 'present-day' (top plot) and '100-year' (bottom plot) scenarios used in our study. Inundation is based on mean high water springs (MHWS-6). The smaller box in each plot gives the overview of the entire project site, while the main map shows an area in higher resolution provided as an example.*



### A6.2.5 Waimeha Inlet (Borck Road to Sandeman Reserve project site)

Detailed Methods for This Site

A regional inundation model was used (Coastal Hazards Map Viewer, Tasman District Council 2019) to estimate the effects of future sea level rise on inundation of the Waimeha Inlet project site. Both the ‘present-day’ and ‘100-year’ (1m SLR) scenarios in the model were based on the tidal height of MHWS-6. The model also displayed areas of historical coastal erosion (high and medium), which were viewed online but were not mapped. Interim salt marsh elevation boundaries were determined by visualising habitat mapping data (from the year 2020 (Stevens et al. 2020[101])), in conjunction with LiDAR data, at and around the project site. Salt marsh habitat was observed to be generally located at elevations from 0.6 m to 2.0 m[102] in the ‘present day’, and 1 m was added to each of these boundaries to determine an approximate 100-year scenario**.** For further information on general methods refer to Appendix 6 (A6.1) above.

Impact of Coastal Inundation on Tidal Wetland Distribution

In the ‘100-year’ scenario, the Waimeha Inlet restoration project site and surrounding area was predicted to be fully inundated at the tidal height of MHWS-6 (Figure A6.2.5a). In comparison, most (but not all) of the project site was inundated at the same tidal height in the ‘present day’ scenario (Figure A6.2.5a). We understand that planned restoration interventions relating to tidal reconnection may influence this. The project site was not considered to be an area of medium or high historical coastal erosion (or accretion) based on the methodology used to assess this in Tasman District Council (2019). Mapped using our simple approach, the salt marsh habitat was predicted to migrate landwards and out of most of the project site based on the ‘100 year’ scenario, compared to the ‘present-day’ scenario where the site was fully located within salt marsh habitat (Figure A6.2.5b). From our maps, it appears that human-made infrastructure could prohibit salt marsh migration to some extent and lead to coastal squeeze on this habitat. SLR is likely to affect the composition of salt marsh species at the project site over time, noting that there will likely be no tidal wetland succession after these species reach their inundation tolerance. The response to question 15[103] in the questionnaire was “*No, although the site has been selected as it is able to potentially offset saltmarsh losses elsewhere in the estuary in response to SLR”.*

For the Waimeha Inlet project site, we therefore consider SLR to pose a substantial risk to carbon storage and sequestration at this site based on our ‘100-year’ scenario if no mitigation action is taken to reduce this risk (noting limitations of our study - refer A6.1.3 Knowledge Gaps). Engineering solutions to control tidal level and/or the acquisition of land suitable for enabling inland migration of tidal wetland could be used to mitigate the risk of SLR at this site although coastal squeeze could be a barrier to this. Please also refer to A6.1.2 (Risk of SLR and Mitigation Options) for general discussion on changing tidal wetland species composition in response to SLR and also engineering solutions to mitigate SLR impacts.

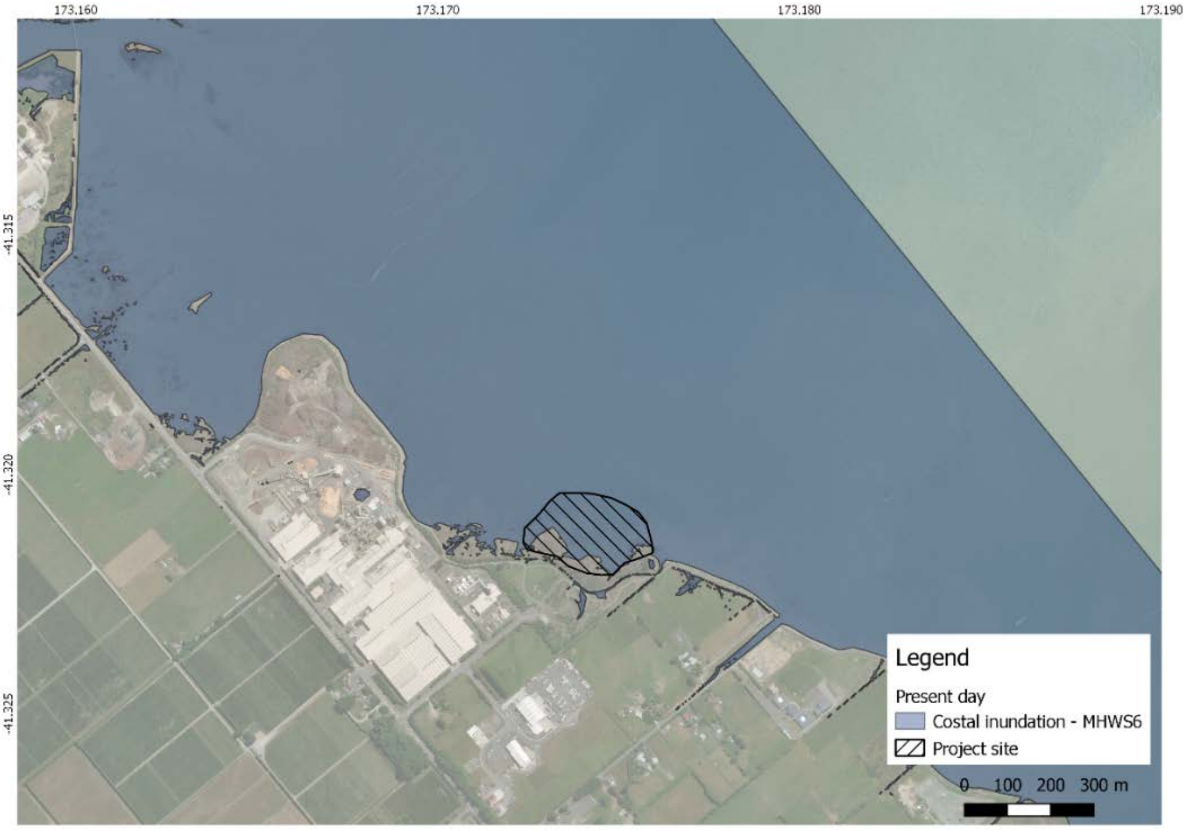
---

[101] Note that wetlands in Waimeha Inlet can be delineated through other methods, than those used by Stevens et al. 2020, such as those outlined in Clarkson (2018).

[102] Note that this does not necessarily hold true for salt marsh distribution at other sites in Waimeha Inlet.

[103] The question was: *Are you able to demonstrate that sea level rise impacts on the project are irrelevant or expected to be insignificant within the next 10 years, or that there is a plan in place for effectively mitigating such impacts? If so, please elaborate on this.*

*Figure A6.2.5a: Inundation model output for the Waimeha Inlet restoration project site in relation to the 'present-day' (top map) and '100-year' (bottom map) scenarios used in our study. The tidal height for both scenarios is mean high-water springs (MHWS-6).*



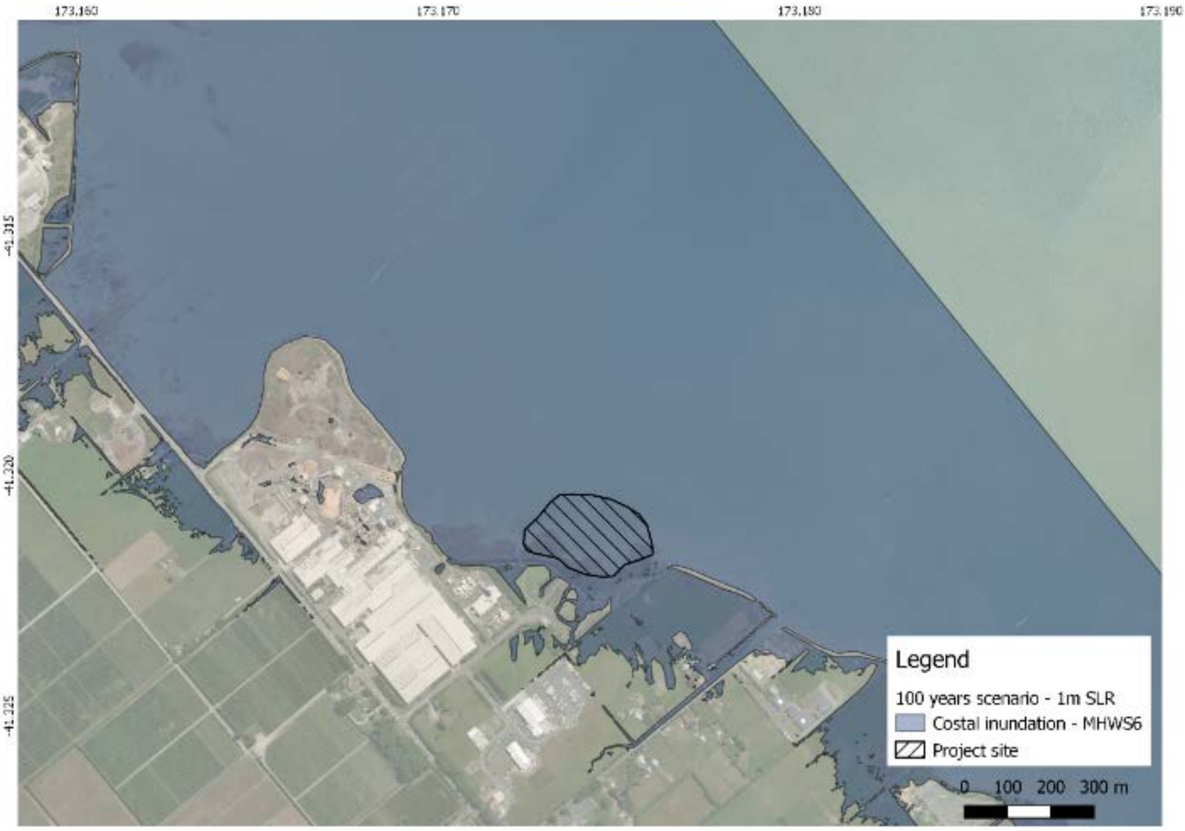



*Figure A6.2.5b. The salt marsh habitat zone (SMHZ, red/brown areas in between salt marsh elevation limits) in relation to the Waimeha Inlet restoration project site. The SMHZ is mapped using a simple approach based on elevation data for the 'present-day' (top plot) and '100-year' scenario (bottom plot).*


### A6.2.6 Wairau Lagoon

Detailed Methods for This Site

The model and model scenarios used for the Wairau Lagoon project area were the same as those described for the Pukehina/Waihī Estuary site (Refer Section A6.2.3). Interim salt marsh elevation boundaries within the project sites were visualised using habitat mapping data (Berthelsen et al. 2015) in conjunction with LiDAR elevation data. We observed present-day salt marsh habitat within the project sites to be generally located at elevations from 0.2 m to 0.8 m (with a few exceptions at >0.8 m), and we added 1 m to each of these boundaries to determine the interim '100-year' scenario. For further information on general methods refer to Appendix 6 (A6.1) above.

Impact of Coastal Inundation on Tidal Wetland Distribution

In the '100-year' scenario, the project site was predicted to be fully inundated (Figure A6.2.6a). In comparison, only some parts of the project site were predicted to be inundated in the 'closest to present-day' scenario. Salt marsh habitat, mapped using a simple approach, was predicted to migrate entirely out of the project site within the '100 year' scenario (Figure A6.2.6b). Native macrophytes such as *Ruppia sp.* (Roberts et al. 2021) could potentially replace salt marsh vegetation within the project area if future environmental conditions were conducive to this.

For the Wairau Lagoon project site, we therefore consider SLR to pose a substantial risk to carbon storage and sequestration at this site based on the '100-year' scenario if no mitigation action was taken to reduce this risk (noting limitations of our study - refer A6.1.3 Knowledge Gaps). Engineering solutions to control tidal level and/or the acquisition of land suitable for enabling inland migration of tidal wetland could potentially be used to mitigate the risk of SLR at this site. This risk to any carbon credits could also potentially be mitigated to some extent by considering predicted changes to tidal wetland species composition within future project development. Please also refer to A6.1.2 (Risk of SLR and Mitigation Options) for general discussion on changing tidal wetland species composition in response to SLR and also engineering solutions to mitigate SLR impacts. Note that SLR could also present an opportunity for increasing the project area (to be larger than that currently proposed) for a carbon credit project at this site. This could be the case if the relatively large area of land surrounding the site predicted to be suitable for salt marsh in the future (based on our simple approach used to assess this) was considered and met the criteria for this purpose.

*Figure A6.2.6a: Inundation model output for the Wairau Lagoon project sites in relation to the ‘closest to present-day’ (top plot) and ‘100-year’ (bottom plot) scenarios used in our study. Note that an outline of the project sites could not be added to the model output; please refer to Figure A5.6c below for the location of the project site in relation to the Wairau lagoon.*

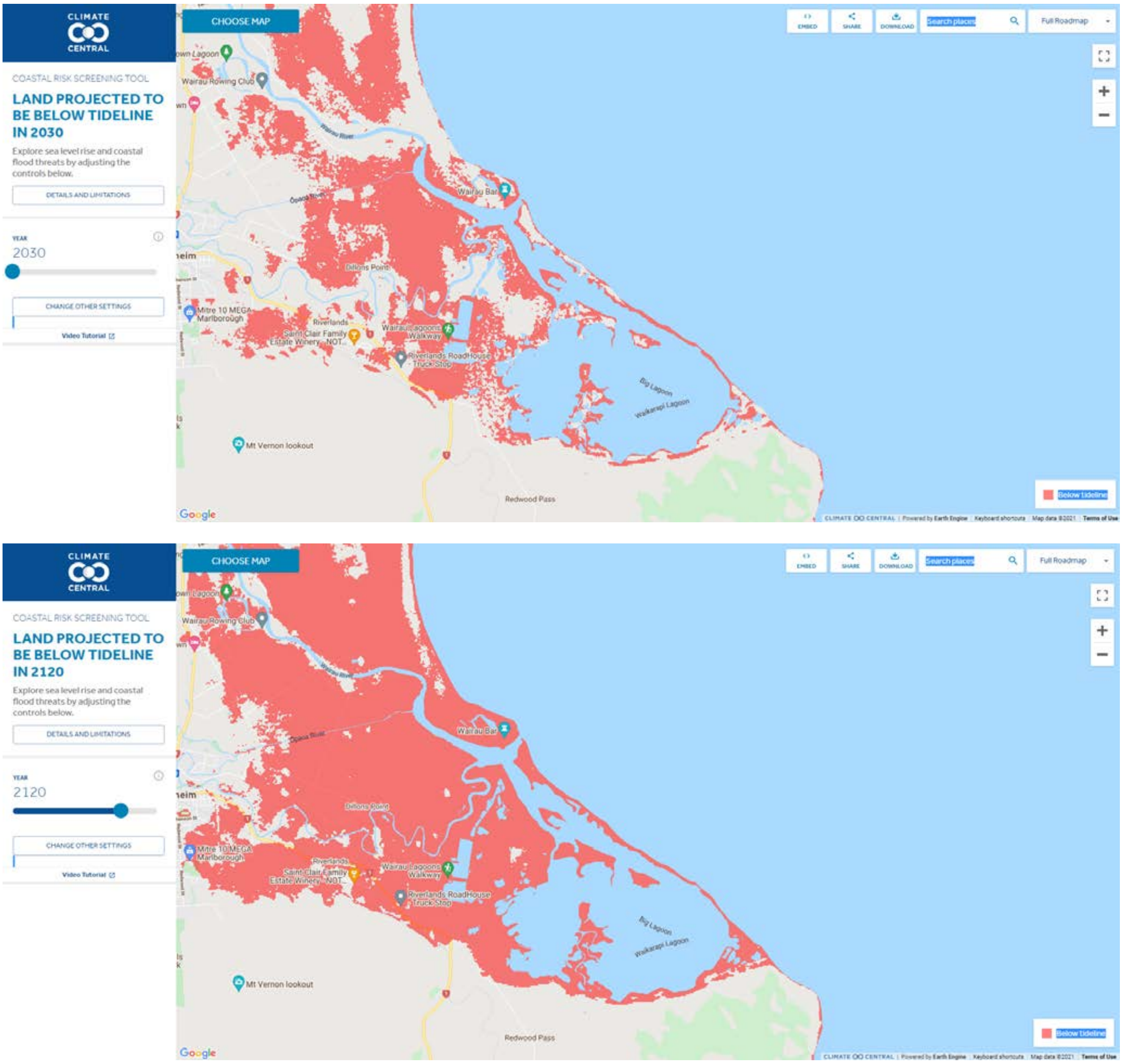
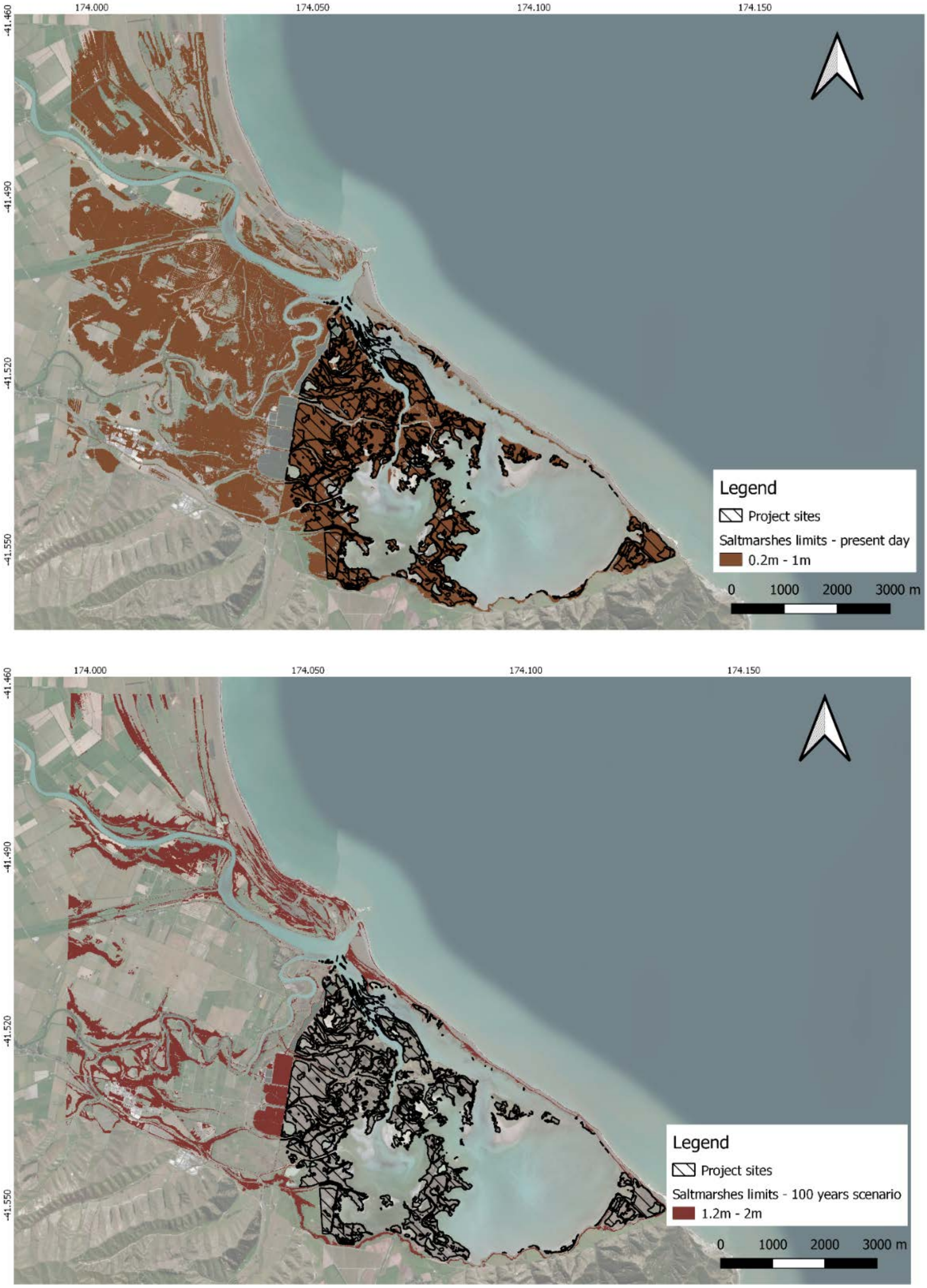


*Figure A6.2.6b: The salt marsh habitat zone (SMHZ, reddish brown areas in between salt marsh limits) in relation to the Wairau Lagoon project sites. Note that the sites presented are for both the livestock surveillance and weed control project scenarios combined. The SMHZ is mapped using a simple approach based on elevation data for the 'present-day' (top plot) and '100-year' (bottom plot) scenarios used in this study.*



# APPENDIX 7. GHG ACCOUNTING

GHG accounting requirements for the VM0033 methodology.

## A7.1 General Approach

Overall carbon accounting has applied the following equations:

$$GHG_{BSL} = GHG_{BSL\text{-}biomass} + GHG_{BSL\text{-}soil} + GHG_{BSL\text{-}fuel} \quad \textbf{(17)}$$

$$GHG_{BSL-biomass} = -\sum_{t=1}^{t^*} \sum_{i=1}^{M_{BSL}} \left( \frac{44}{12} \times \Delta C_{BSL-biomass,i,t} \right) \quad \textbf{(18)}$$

$$GHG_{BSL-soil} = \sum_{t=1}^{t^*} \sum_{i=1}^{M_{BSL}} GHG_{BSL-soil,i,t} \quad \textbf{(19)}$$

$$GHG_{BSL-fuel} = \sum_{t=1}^{t^*} \sum_{i=1}^{M_{BSL}} GHG_{BSL-fuel,i,t} \quad \textbf{(20)}$$

Where:

| | |
|---|---|
| $GHG_{BSL}$ | Net $CO_2$e emissions in the baseline scenario up to year $t^*$; t $CO_2$e |
| $GHG_{BSL\text{-}biomass}$ | Net $CO_2$e emissions from biomass carbon pools in the baseline scenario up to year $t^*$; t $CO_2$e |
| $GHG_{BSL\text{-}soil}$ | Net $CO_2$e emissions from the SOC pool in the baseline scenario up to year $t^*$; t $CO_2$e |
| $GHG_{BSL\text{-}fuel}$ | Net $CO_2$e emissions from fossil fuel use in the baseline scenario up to year $t^*$; t $CO_2$e |
| $\Delta C_{BSL\text{-}biomass,i,t}$ | Net carbon stock changes in biomass carbon pools in the baseline scenario in stratum $i$ in year $t$; t C $yr^{-1}$ |
| $GHG_{BSL\text{-}soil,i,t}$ | GHG emissions from the SOC pool in the baseline scenario in stratum $i$ in year $t$; t $CO_2$e $yr^{-1}$ |
| $GHG_{BSL\text{-}fuel,i,t}$ | GHG emissions from fossil fuel use the baseline scenario in stratum $i$ in year $t$; t $CO_2$e $yr^{-1}$ |
| $i$ | 1, 2, 3 …$M_{BSL}$ strata in the baseline scenario |
| $t$ | 1, 2, 3, … $t^*$ years elapsed since the project start date |

Estimation of GHG emissions and removals from the SOC pool is based on proxies and the use of literature-based data sources for SOC. Higher resolution data may be possible to gather during project development.

## A7.2 Accounting For Sea Level Rise

The methodology for accounting for sea level rise (SLR) follows the VM0033 methodology and focuses on:

Carbon stock change from above ground biomass due to oxidation is assumed to be immediately and entirely returned to the atmosphere and calculated using the following equation:

$$\Delta C_{BSL\text{-}biomass,i,t} = 12/44 \times (C_{BSL\text{-}biomass,i,t} - C_{BSL\text{-}biomass,i,(t\text{-}T)}) / T \qquad \textbf{(21)}$$

For the year of submergence:

$C_{BSL\text{-}biomass,i,t} = 0$

Where:

| | |
|---|---|
| $\Delta C_{BSL\text{-}biomass,i,t}$ | Net carbon stock change in biomass carbon pools in the baseline scenario in stratum *i* in year *t*; t C $yr^{-1}$ |
| $C_{BSL\text{-}biomass,i,t}$ | Carbon stock in biomass in the baseline scenario in stratum *i* in year *t* (from $C_{TREE\_BSL,t}$ in *AR-Tool14*); t $CO_2$e |
| *i* | 1, 2, 3 …$M_{WPS}$ strata in the baseline scenario |
| *t* | 1, 2, 3, … *t** years elapsed since the project start date |
| *T* | Time elapsed between two successive estimations ($T = t_2 - t_1$) |

Soil carbon stocks that are either held intact or eroded and transported beyond the project area. If project development analysis concludes that this is probable, then models will be developed to assess the time and rate of submergence of the project area.

The impacts of SLR have not been quantified on a site-by-site basis in this feasibility assessment but have been assessed in general and presented in Appendix 6.

### A7.3 Net Carbon Stock Change in Biomass Carbon Pools in the Baseline Scenario

Net carbon stock change in biomass carbon pools in the baseline scenario is estimated as:

$$\Delta C_{BSL\text{-}biomass,i,t} = \Delta C_{BSL\text{-}tree/shrub,i,t} + \Delta C_{BSL\text{-}herb,i,t} \qquad \textbf{(22)}$$

Where:

| | |
|---|---|
| $\Delta C_{BSL\text{-}biomass,i,t}$ | Net carbon stock change in biomass carbon pools in the baseline scenario in stratum *i* in year *t*; t C $yr^{-1}$ |
| $\Delta C_{BSL\text{-}tree/shrub,i,t}$ | Net carbon stock change in tree and shrub carbon pools in the baseline scenario in stratum *i* in year *t*; t C $yr^{-1}$ |
| $\Delta C_{BSL\text{-}herb,i,t}$ | Net carbon stock change in herb carbon pools in the baseline scenario in stratum *i* in year *t*; t C $yr^{-1}$ |
| *i* | 1, 2, 3 …$M_{BSL}$ strata in the baseline scenario |
| *t* | 1, 2, 3, … *t** years elapsed since the project start date |

Net GHG Emissions in from Soil in the Baseline Scenario

General

Net carbon stock change in the soil carbon pool in the baseline scenario is estimated as:

$$GHG_{BSL\text{-}soil,i,t} = A_{i,t} \times (GHG_{BSL\text{-}soil\text{-}CO2,i,t} - Deduction_{alloch} + GHG_{BSL\text{-}soil\text{-}CH4,i,t} + GHG_{BSL\text{-}soil\text{-}N2O,i,t}) \quad \textbf{(25)}$$

For organic soils where $t > t_{PDT\text{-}BSL,i}$:

$$GHG_{BSL\text{-}soil,i,t} = 0$$

For mineral soils where $t > t_{SDT\text{-}BSL,i}$:

$$GHG_{BSL\text{-}soil,i,t} = 0$$

Where:

| | |
|---|---|
| $GHG_{BSL\text{-}soil,i,t}$ | GHG emissions from the SOC pool in the baseline scenario in stratum *i* in year *t*; t $CO_2e$ $yr^{-1}$ |
| $GHG_{BSL\text{-}soil\text{-}CO2,i,t}$ | $CO_2$ emissions from the SOC pool in the baseline scenario in stratum *i* in year *t*; t $CO_2e$ $ha^{-1}$ $yr^{-1}$ |
| $Deduction_{alloch}$ | Deduction from $CO_2$ emissions from the SOC pool to account for the percentage of the carbon stock that is derived from allochthonous soil organic carbon; t $CO_2e$ $ha^{-1}$ $yr^{-1}$ |
| $GHG_{BSL\text{-}soil\text{-}CH4,i,t}$ | $CH_4$ emissions from the SOC pool in the baseline scenario in stratum *i* in year *t*; t $CO_2e$ $ha^{-1}$ $yr^{-1}$ |
| $GHG_{BSL\text{-}soil\text{-}N2O,i,t}$ | $N_2O$ emissions from the SOC pool in the baseline scenario in stratum *i* in year *t*; t $CO_2e$ $ha^{-1}$ $yr^{-1}$ |
| $A_{i,t}$ | Area of stratum *i* in year *t*; ha |
| $t_{PDT\text{-}BSL,i}$ | Peat depletion time in the baseline scenario in stratum *i* in years elapsed since the project start date; yr |
| $t_{SDT\text{-}BSL,i}$ | Soil organic carbon depletion time in the baseline scenario in stratum *i* in years elapsed since the project start date; yr |
| *i* | 1, 2, 3 …$M_{BSL}$ strata in the baseline scenario |
| *t* | 1, 2, 3, … *t** years elapsed since the project start date |

This feasibility assessment will use default factors provided in Section 3.3.3.

$CO_2$ Emissions from Soil

Net $CO_2$ emissions from the soil carbon pool used the default factors provided in Section 3.3.3 above.

Deduction for Allochthonous Carbon

The VM0033 methodology requires a reduction from the estimate of $CO_2$ emissions from the SOC pool to account for the percentage of sequestration resulting from allochthonous soil organic carbon accumulation (unless otherwise accounted for). There is an option to conservatively set this deduction to zero in the baseline scenario.

This feasibility assessment has elected to conservatively set this deduction to zero.

Methane Emissions from Soil

Methane emissions from soil is estimated using emission factors provided in Section 3.3.3.

Nitrous Oxide Emissions from Soil

Nitrous oxide emissions from soil has been conservatively excluded from the baseline in each project in this feasibility assessment.

Emissions from Fossil Fuel use in the Baseline

Emissions from fossil fuel use in the baseline has been conservatively excluded in this feasibility assessment.

## A7.4 Quantification of Project GHG Emission Reductions and Removals

### Accounting for Sea Level Rise

Sea level rise is accounted for in the same manner as the baseline quantification.

### Net GHG Emissions in Biomass Carbon Pools in the Project Scenario

Net carbon stock change in biomass carbon pools in the project scenario is estimated as

$$\Delta C_{WPS\text{-}biomass,i,t} = \Delta C_{WPS\text{-}tree/shrub,i,t} + \Delta C_{WPS\text{-}herb,i,t} \qquad \textbf{(56)}$$

Where:

| | |
|---|---|
| $\Delta C_{WPS\text{-}biomass,i,t}$ | Net carbon stock change in biomass carbon pools in the project scenario in stratum *i* in year *t*; t C $yr^{-1}$ |
| $\Delta C_{WPS\text{-}tree/shrub,i,t}$ | Net carbon stock change in tree and shrub carbon pools in the project scenario in stratum *i* in year *t*; t C $yr^{-1}$ |
| $\Delta C_{WPS\text{-}herb,i,t}$ | Net carbon stock change in herb carbon pools in the project scenario in stratum *i* in year *t*; t C $yr^{-1}$ |
| *i* | 1, 2, 3 …$M_{WPS}$ strata in the project scenario |
| *t* | 1, 2, 3, … *t** years elapsed since the project start date |

### Net GHG Emissions and Removals from Soil in the Project Scenario

General

Net GHG emissions from soils in the project scenario are estimated as follows:

$$GHG_{WPS\text{-}soil,i,t} = A_{i,t} \times (GHG_{WPS\text{-}soil\text{-}CO2,i,t} - Deduction_{alloch} + GHG_{WPS\text{-}soil\text{-}CH4,i,t} + GHG_{WPS\text{-}soil\text{-}N2O,i,t})^{(20)} \quad \textbf{(61)}$$

Where:

| | |
|---|---|
| $GHG_{WPS\text{-}soil,i,t}$ | GHG emissions from the SOC pool in the project scenario in stratum *i* in year *t*; t $CO_2e$ $yr^{-1}$ |
| $GHG_{WPS\text{-}soil\text{-}CO2,i,t}$ | $CO_2$ emissions from the SOC pool in the project scenario in stratum *i* in year *t*; t $CO_2e$ $ha^{-1}$ $yr^{-1}$ |
| $Deduction_{alloch}$ | Deduction from $CO_2$ emissions from the SOC pool to account for the percentage of the carbon stock that is derived from allochthonous soil organic carbon; t $CO_2e$ $ha^{-1}$ $yr^{-1}$ |
| $GHG_{WPS\text{-}soil\text{-}CH4,i,t}$ | $CH_4$ emissions from the SOC pool in the project scenario in stratum *i* in year *t*; t $CO_2e$ $ha^{-1}$ $yr^{-1}$ |
| $GHG_{WPS\text{-}soil\text{-}N2O,i,t}$ | $N_2O$ emissions from the SOC pool in the project scenario in stratum *i* in year *t*; t $CO_2e$ $ha^{-1}$ $yr^{-1}$ |
| $A_{i,t}$ | Area of stratum *i* in year *t*; ha |
| *i* | 1, 2, 3 …$M_{WPS}$ strata in the project scenario |
| *t* | 1, 2, 3, … *t** years elapsed since the project start date |

<u>$CO_2$ Emissions from Soil</u>

$CO_2$ emissions from soil are estimated using default factors as presented in Section 3.3.3.

<u>Deduction for Allochthonous Carbon</u>

The VM0033 methodology requires a reduction from the estimate of CO2 emissions from the SOC pool to account for the percentage of sequestration resulting from allochthonous soil organic carbon accumulation (unless otherwise accounted for). There is an option to conservatively set this deduction to zero in the baseline scenario.

This feasibility assessment has elected to conservatively set this deduction to zero.

<u>Methane Emissions from Soil</u>

Methane emissions from soil has been estimated using emission factors presented in Section 3.3.3.

<u>Nitrous Oxide Emissions from Soil</u>

Nitrous oxide emissions from soil has conservatively excluded from the baseline in this feasibility assessment.

<u>Net Non-CO2 Emissions from Burning in the Project Scenario</u>

Not applicable.

<u>Emissions from Fossil Fuel use in the Project Scenario</u>

Emissions from fossil fuel use in the project scenario are assumed to be below *de minimis* in this feasibility assessment and have been excluded.

### A7.5 Emission Reductions Due to Rewetting and Fire Management

The project proponent must apply the latest version of VCS module *VMD0046 Methods for monitoring soil carbon stock changes and GHG emission in WRC project activities* to estimate the Fire Reduction Premium (FRP).

This was not calculated in this feasibility assessment.

### A7.6 Leakage

#### Activity-Shifting Leakage

To be assessed on a site-by-site basis during project development (beyond the scope of this feasibility assessment).

#### Ecological Leakage

To be assessed on a site-by-site basis during project development (beyond the scope of this feasibility assessment).

### A7.7 Net GHG Emission Reductions and Removals

#### Calculation of Net GHG Emission Reductions

Calculated for a 20-ha exemplar project and provided in Sections 4.1.8 and 4.2.

#### Estimation of Uncertainty

Not covered in this feasibility assessment but will need to be addressed in project development.

#### Calculation of Verified Carbon Units

This was calculated for a 20-ha exemplar project and provided in Sections 4.1.8 and 4.2.

### A7.8 Additionality

Each project will use the latest version of the CDM Combined tool to identify the baseline scenario and demonstrate additionality for A/R CDM project activities for the demonstration of additionality, taking into account the additional guidance as required by the VM0033 methodology.

### A7.9 Monitoring

A monitoring plan has not been included in this feasibility assessment but will need to be addressed in project development and follow the applicable VCS methodology.

### A7.10 Reporting and Verification

Reporting will include the following:

| Report | Outcome | Remarks |
|---|---|---|
| Feasibility Assessment (this report) | Enables decision on whether to proceed to project development at any of the case study sites. | High-level scoping study. |

| | | |
|---|---|---|
| Preliminary Project Description | Investment ready for full project development. | Formerly named a Project Idea Note and designed as a project scoping document. |
| Project Description | Validation ready. | Comprehensive project accounting and management plan. Can also include project business plan (recommended). |
| Project Validation Report | Project is valid and can be implemented and fully registered in the VCS system. | Result of validation audit by a VCS accredited validation/verification body. |
| Project Monitoring Reports | Verification ready. | Carbon accounting from actual data from project delivery milestones.<br>There is a maximum timeframe in the VCS (5-yearly), but projects will typically also need to undertake sub-annual and annual reporting for project management purposes. |
| Project Verification Reports | Carbon credits issued. | Result of verification audit by a VCS accredited validation/verification body. |

# APPENDIX 8. ACKNOWLEDGEMENTS

The authors acknowledge and express thanks to the following people who helped make this report possible:

The Nature Conservancy: Carl McGuinness, Erik van Eyndhoven and Stefanie Simpson.

All project contacts:

- Wainui Repo Whenua Sargent Drive: Anna Dawson and Josie Crawshaw (Bay of Plenty Regional Council).
- Te Repo Ki Pūkororo: Trudy Lane, Dion Patterson (Department of Conservation), Mike Townsend and Whitney Mills (Waikato Regional Council).
- Pukehina/Waihī Estuary: Derek Spratt.
- Waimeha Inlet: Guinevere Coleman (Tasman District Council), Leigh Stevens (Salt Ecology), Skye Davies and Gillian Bishop and Julie Newell (Tasman Environmental Trust), Dan Chisholm (Department of Conservation).
- Wairau Lagoon/Estuary: Oliver Wade (Marlborough District Council), Phil Bradshaw and Rowan Hindmarsh-Walls and Simon Litchwark (Department of Conservation).
- Golden Bay/Farewell Spit: Helen Kettles and Hans Stoffregen (Department of Conservation), Lawson Davey (Fish & Game), Chris Wheatley (HealthPost Nature Trust), Annette Litherland (Manaaki Whenua – Landcare Research), Guinevere Coleman and Trevor James (Tasman District Council), Leigh Stevens (Salt Ecology).

Additional contribution from: Helen Kettles (Department of Conservation), Andrew La Croix (University of Waikato), Olya Albot and Daniel King (Victoria University), Paul Mudge (Manaaki Whenua – Landcare Research), Lisa Floerl and Gretchen Rasch (Cawthron Institute).