TASMAN ENVIRONMENTAL TRUST

Core & Restore Project

Field Protocol

7 November 2023

Lauren Walker, Anna Berthelsen, Dan Chamberose, Vikki Ambrose, Jen Skilton, Sean Waters, Elaine Asquith, Sam Flewitt

Purpose

This document sets out the field protocols that were followed during the Core & Restore Blue Carbon Project pilot study fieldwork carried out at Waimeha Inlet (November 2021) and Onetahua (May 2022). It has been refined to some extent after the pilot study to reflect the knowledge we gained and safeguard the matauranga of the iwi who contributed to the field protocol.

Recommended citation

Walker, L., Berthelsen, A., Chamberose, D., Ambrose, A., Skilton, J., Waters, S., Asquith, E., & Flewitt, S. (2023). Core & Restore Project Pilot: Field Protocol. Nelson: Tasman Environmental Trust.

Limitations

This document is currently only intended for use by the Core & Restore Blue Carbon pilot study field team. Additional resources (costs and time) would be required to extend the application of this field protocol (e.g., for nation-wide use and/or to other types of blue carbon data collection).

Copyright ©

Acknowledgements

Tasman Environmental Trust (TET) gratefully acknowledges the significant contributions and commitment of its key partners and supporters in the Core & Restore Blue Carbon Project Pilot: Cawthron Institute (Cawthron), Beca, Ngāti Apa ki te Rā Tō, Nelson City Council (NCC), Manawhenua ki Mohua (MKM) and the Department of Conservation (DOC).

We especially thank the following individuals:

Gillian Bishop (QSM)	Project advocacy and governance (TET)
Lauren Walker	Project lead and key contributor (Lauren Walker Ltd)
Dr Anna Berthelsen	Technical lead and key contributor (Cawthron)
Dr Sean Waters	Technical advisor and key contributor (Cawthron)
Elaine Asquith	Technical advisor and key contributor (Cawthron)
Dan Chamberose	Technical advisor and key contributor (Beca)
Sam Flewitt	Technical advisor and key contributor (Independent, previously Beca)
Dr Jen Skilton	Technical advisor and key contributor (Ngāti Apa ki te Rā Tō)
Aaron Hemi	Cultural advisor (Ngāti Apa ki te Rā Tō)
Helen Kettles	Key advisor, project supporter and contributor (DOC)
Dr James Butler	Technical advisor and key contributor (Cawthron)

Vikki Ambrose	Tea Bag Experiment (NCC)
Dr Harry Allard	Tea Bag Experiment (NCC)
Shane Paratene	Cultural Monitor, NCC Tea Bag Experiment (Ngāti Kuia)
Ursula Passl	Manawhenua ki Mohua Liaison & Support
Makere Chapman	Project Kuia (MKM)
Syd Eru	Cultural Monitor and Field Assistant (MKM)
Raelene Mason	Cultural Monitor and Field Assistant (MKM)
Andrew Lamason	DOC Liaison & Support (Takaka)
Amanda Harvey	DOC Liaison and Practical Advisor (Onetahua Farewell Spit)
Dr Chris Wheatley	HealthPost Nature Trust Liaison & Support
Graham & Belinda Postles	Landowners (Manuka Island)
Frank & Shelley Creighton	Landowner (Neimann Creek)

We thank the following individuals for their technical advice / input:

Trevor James	Habitat health, extent & restoration options (TDC)
George Daly	Saltmarsh restoration options (TDC)
Leigh Stevens	Habitat health, extent & restoration options (Salt Ecology)
Mike Crump	Laboratory analysis protocols (NIWA)
Dr Richard Bulmer	Coring techniques, lab analysis, data comparison (Tidal Research)
Dr Stracey Trevathan-Tackett	Various technical aspects (Deakin University)
Olya Albot	Sampling & lab analysis methods; sharing preliminary results (PhD Researcher)

We acknowledge the cultural significance of Waimeha Inlet and Onetahua Farewell Spit and are grateful for the support and kind wishes of Te Tauihu iwi for our pilot study.

We especially thank the following iwi:

- **Ngāti Apa ki te Rā Tō** : For being a key project partner from the outset, helping us navigate tikanga and cultural safety, blessing our mahi at our launch celebration, being part of our team in both Waimeha Inlet and Onetahua Farewell Spit, and blessing our mahi at our Core & Restore Hui in March 2023.
- **Manawhenua ki Mohua**: For supporting our Onetahua Farewell Spit fieldwork, welcoming our project team to Mohua with a pōwhiri, blessing our mahi with a beautiful karakia at dawn, providing cultural monitoring and field assistance, allowing us to share the Onetahua Farewell Spit blue carbon data, and being part of our Core & Restore Hui in March 2023.
- **Te Ātiawa**: For providing guidance and information to help us engage with Te Tauihu iwi early on and help us ensure the cultural safety of our Waimeha Inlet fieldwork, and for being part of our Core & Restore Hui in March 2023.
- **Ngāti Kuia:** For providing cultural monitoring for the NCC Tea Bag Experiment and being part of our launch celebration and our Core & Restore Hui in March 2023.

We thank the following individuals for their advice and support with media and communications:

Niki Morrell	Lead media and communications advisor (Bold Communications)
Kirsten Fitzsimmons	Key partner communications (Cawthron)
Sandrine Marrasse	Key partner communications (NCC)

Andrew Hobbs	Key partner communications (Beca)
Sam Thorn	Key partner communications (Ngāti Apa ki te Rā Tō)

Thanks also to the TET team:

Sky Davies	Project governance and funding
Marios Gavalas	Administrative support & help with events
Abby Boffa	Funding and accountability reporting
Kathryn Brownlee	Project accounting & financial reporting; help with events; blue carbon restoration (Battle for the Banded Rail).

The input into project development provided by Dr Fiona Ede, Dr Ed Challies (University of Canterbury), Jo Martin (NCC) and the Kidson family (Sally Kidson, Liz Gavin, Matthew Kidson and Katrina Kidson) is very much appreciated.

The funding support provided by TET, NCC, Pic's Peanut Butter, HealthPost Nature Trust, Kidson Investments Ltd, Live Ocean, and Nelson Tasman Climate Forum is greatly appreciated, as are the in-kind contributions provided by the key partners, Lauren Walker Ltd, Andy McDonald (photographer and videographer @NZAndy) and Nikki Morrell (Bold Communications).

Author contributions

Lauren Walker (Lauren Walker Ltd) co-led the write up of this Field Protocol alongside **Anna Berthelsen** (Cawthron). She brought the various contributions together, led the write up of the risk management section and refined and simplified the Protocol following the pilot. Anna Berthelsen led the write up of Part 1 of this Field Protocol relating to the sediment core sampling and analysis, led the safety planning for the Cawthron team and contributed to the overall refinement of the Protocol following the pilot. **Dan Chamberose** (Beca), contributed to Part 1 of this Field Protocol, carried out the services checks, and led the safety planning for the Beca team. **Vikki Ambrose** (NCC) led the write up of Part 2 of this Field Protocol relating to the Tea Bag Experiment. **Jen Skilton** (Ngāti Apa ki te Rā Tō), contributed to the cultural safety protocols and together with **Sean Waters** (Cawthron), **Elaine Asquith** (Cawthron) and **Sam Flewitt** (Independent, previously Beca) provided input into the development of the Field Protocol. All of the authors participated in the pilot fieldwork.

Contents

Overview

Blue carbon is the carbon stored in coastal and marine ecosystems. Blue carbon wetland ecosystems (seagrasses, coastal marshes, and mangroves) can be incredibly efficient at storing and sequestering atmospheric carbon dioxide. Blue carbon ecosystems are extremely important from a cultural perspective and also help improve water quality, provide habitat for wildlife and commercially valuable fish, and help protect shorelines from storm damage.

Tasman Environmental Trust (TET) led a pilot study to collect data to measure blue carbon storage in estuarine sediments[1] and decomposition rates in blue carbon habitats in Te Tauihu. The goal was to report reliable data for blue carbon habitats at Waimeha Inlet and Onetahua to help demonstrate the value of local estuaries for storing carbon and the importance of protecting and restoring them.

There were two parts to the pilot, which was carried out from November 2021 to May 2022:

1. **Core sampling** at Waimeha Inlet and Onetahua: this was carried out by TET, Cawthron, Beca, Ngāti Apa ki te Rā Tō, with technical leadership from Cawthron. Manawhenua ki Mohua assisted with the field work at Onetahua.
2. **Tea bag experiment** at Waimea Inlet and Nelson Haven: this citizen science experiment was carried out by Nelson City Council and volunteers.

This document is divided into two parts:

1. Part 1: sets out the protocols for sediment core sampling and analysis
2. Part 2: sets out the protocols for the tea bag experiment

Besides gathering information on carbon stocks in coastal wetland habitats, the pilot study aimed to inform the future development of TET's *Core & Restore Blue Carbon Project* by helping us understand:

- Whether two slightly different manual sediment core sampling methods deliver the same results
- The practicality, safety, and cost effectiveness of the soil sampling methods
- How many people are needed in a field crew & what their roles would be
- What might be involved in training community-based field crews
- What the costs might be for a full-scale project across Te Tauihu
- How the data from both 'hard science' and 'citizen science' methods can be used to (a) help communities understand the carbon storage value of coastal wetlands; and (b) inform the development of protection and restoration plans.

Pilot study results

Pilot study results and recommended next steps are presented in the following reports:

- A pilot study overview document (Walker 2023);
- A technical report for blue carbon stocks (Berthelsen et al. 2023); and
- A technical report for tea bag-related results (Zaiko and Pearman 2022).

[1] The terms 'sediment' and 'soil' can be used interchangeably. 'Sediment' is more commonly used in the marine context, so we have largely used this term in this field protocol.

PART ONE: SEDIMENT CORE SAMPLING & ANALYSIS

Aims

The aim of the core sampling was to collect sediment carbon data following methods in the Blue Carbon Initiative Manual ('BCI Manual') (Howard et al 2014) to ensure that the results were robust, internationally credible, and suitable for use by other parties (e.g., as baseline data for a blue carbon credit scheme). The focus was on measuring the below-ground carbon pool, relating to the sediment and below-ground plant biomass such as roots.

Given that this was a pilot study, a limited number of cores were collected at the field sites in Waimeha Inlet and Onetahua (Tasman Region, Aotearoa New Zealand).

Waimeha Inlet

The aims for Waimeha Inlet were to:

1. Collect sediment carbon values in two key saltmarsh habitats: rushland (8 cores); herbfield (8 cores)[2]. In Waimeha Inlet, the rushland habitat sampled was dominated by *Juncus kraussii* (wīwī, searush) or *Apodismia similis* (oioi, jointed wire rush)[3] and the herbfield habitat by *Salicornia*[4] *quinqueflora* (ureure, glasswort).
2. Collect some data on sediment carbon values on farmland adjacent to the saltmarsh habitats to estimate the potential for carbon storage if the farmland was restored to saltmarsh; and also collect data in a previously restored area to understand what carbon stocks there are in this type of habitat.
3. Compare data collection (practicality and effectiveness) for two slightly different manual sediment coring methods[5]. Coring device 1 had an internal diameter of 70 mm and a length of 125 cm, while coring device 2 had an internal diameter of 62 mm and length of 55 cm.
4. Collect some data on sediment carbon values in an unvegetated area on the tidal flat if time permits.

Onetahua

The aims for Onetahua were to:

---

[2] In Waimeha Inlet, salt marsh is dominated by herbfield (162 ha) followed by rushland (87 ha) (Stevens et al. 2020).

[3] Oioi is often found growing with sea rush. The easiest way to identify oioi is by the dark bands along the stem that give the stem a slight zigzag appearance. Sea rush is green whereas the colour of oioi varies from dull green to deep orange and even purplish.

[4] Synonym is *Sarcocornia*.

[5] BCI Manual (Howard et al. 2014): Because bulk density measurements may be altered by any coring technique (particularly hammering) if the soil is compressible, experimentation with different soil sampling equipment in representative sites is recommended to ensure the sampling of relatively undisturbed cores. The type of coring gear needed will vary according to the vegetation and soil type.

1. Collect data on sediment carbon values in the seagrass habitat (*Zostera muelleri),* focussing on three seagrass areas with different percent coverage[6]:
    - 75-100% cover (4 cores)
    - 50-75% cover (4 cores)
    - 25-50% cover (4 cores)

    The sites were all situated relatively high up the shoreline, with each one representing a different percentage cover (as per above). Seagrass is known to be temporally variable in its spatial distribution (Turner and Schwarz 2006). However, we decided to focus our seagrass sampling on different percent cover categories to align with our saltmarsh sampling which related to different vegetation types. There are many factors that could have been tested, e.g., tidal height and distance from river or estuary mouth. However, our capacity for this was limited given that this was a pilot study.

2. Collect data on sediment carbon values in an unvegetated area on the tidal flat if time permits.
3. Compare data collection methods (practicality, cost and effectiveness) for two slightly different manual sediment coring methods[7]. As for Waimeha Inlet, cores for Onetahua were collected using manual coring with two slightly different coring devices. Coring device 1 had an internal diameter of 70 mm and a length of 125 cm, while coring device 2 had an internal diameter of 62 mm and length of 55 cm.

Site selection, timing, and layout

Considerations for site selection included:

- Presence of key habitats (saltmarsh, seagrass) in areas large enough to sample.
- Iwi permission/considerations (relevant to site location and timing of sampling).
- Permits from other agencies (where required) e.g., Ministry for Primary Industries (MPI), Department of Conservation (DOC).
- Relative representativeness of the site within the estuary, especially in terms of nutrients/organic material. Consider organic pollution from point source or diffuse (e.g. rivers/land runoff) and depositional environment. Also recognising that, in terms of geomorphic setting, estuaries can be subject to both riverine and oceanic influence.
- Ease of access for fieldwork, consider substrate, tides and land access.
- Suitable vehicle parking.
- Timing in regard to laboratory opening hours.
- Filming considerations.
- Pros and cons of whether to be in area close to public (or relevant businesses).

Waimeha Inlet

The core sampling locations for Waimeha Inlet are shown in Figure 1.

[6] Using Battley et al (2005), Figure 3, page 12 as a reference guide.
[7] Refer footnote 5.

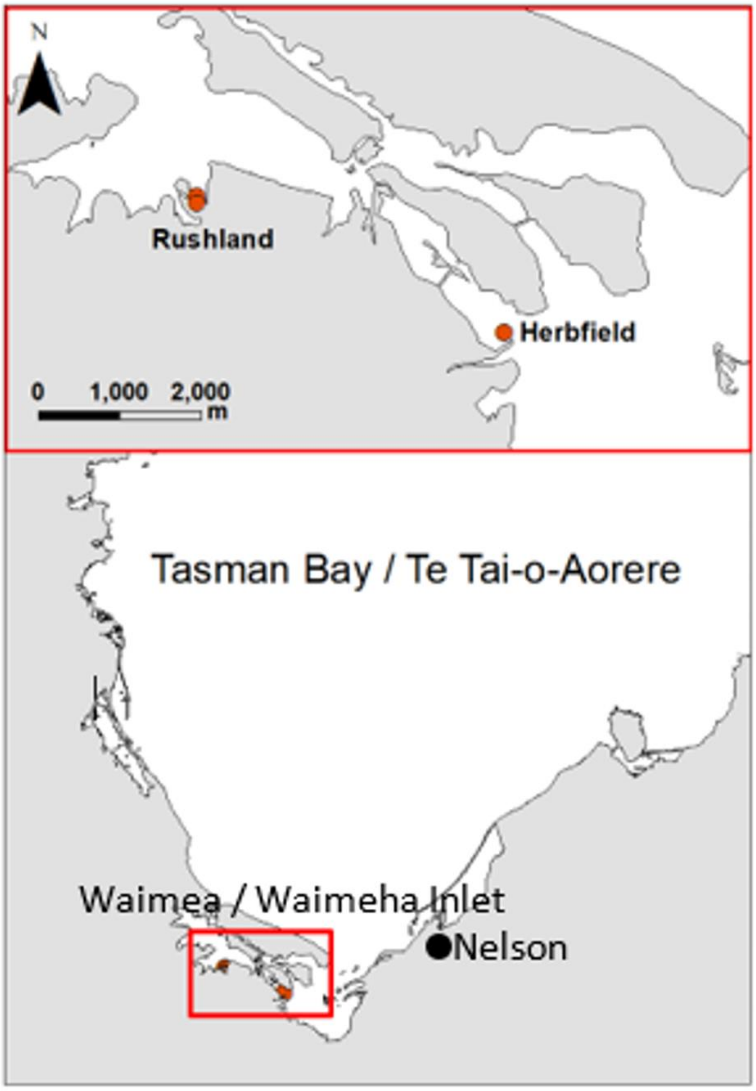


Figure 1: Waimeha / Waimea Inlet showing the saltmarsh (rushland and herbfield) pilot study sites in the red box. A third site (herbfield [recovering]) can be seen in close proximity directly south of the rushland site. (figure taken directly from Berthelsen et al. 2023).

At each intact rushland and herbfield project site, we planned two core collection areas separated by a distance of approximately six metres. Distance between cores may need to be a range due to restrictions relating to habitat area (especially for rushland). At each core collection area, four sediment cores are to be collected within a few metres of each other. Two of the cores are to be collected using a one type of manual corer and the other two using the other type of manual corer.

Two cores following the same sampling layout are also planned for adjacent farmland and at least one core in restored (i.e., recovering) saltmarsh habitat. We will plan to also take a sediment core in unvegetated substrate if time permits, plus potentially subsample for analysis. We will take a GPS reading to record the location of each core sample.

Onetahua

The core sampling locations for Onetahua were near Triangle Flat, inside the DOC Nature Reserve, as shown in Figure 2.

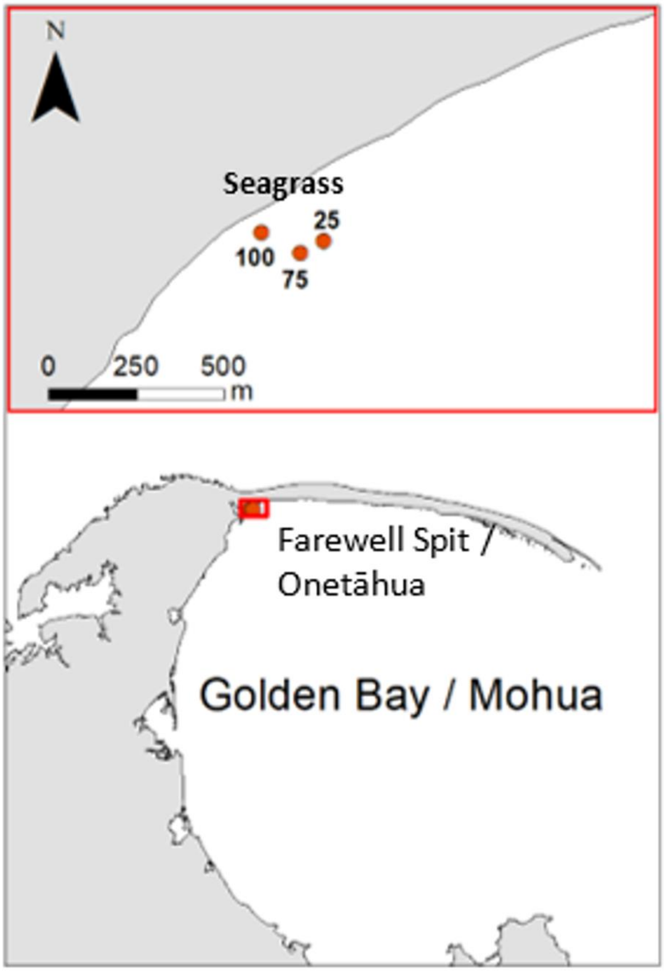


Figure 2: Onetahua / Farewell Spit pilot study sites in the red box, representing the three seagrass percent cover categories (25%, 75%, 100%). Map taken directly from Berthelsen et al. 2023.

Risk management

Permits

Appropriate permits and permissions were obtained prior to the sampling taking place:

- The sediment sample collection was done under Cawthron's MPI sample collections special permit at both Waimeha Inlet and Onetahua.
- DOC gave written permission for us to take sediment samples inside the Nature Reserve at Onetahua.
- Te Tahuihu iwi were informed of the proposed sampling locations at Waimeha Inlet and they offered support and kind wishes for the pilot study.
- Manawhenua ki Mohua and Ngāti Apa ki te Rā Tō gave their approval for us to carry out sediment sampling in the proposed locations at Onetahua.

Service location checks

Service location checks were carried out by Beca in order to confirm that there were no buried or overhead services located in the sampling locations.

This was done in accordance with the 'NZ Ground Investigation Specification – Permit to Dig Instructions', which sets out the requirements for assessing and managing the risk of sampling in proximity to buried services.

Service location checks can be carried out by:

- Lodging a 'beforeUdig' request for the sampling areas: https//www.beforeudig.co.nz/home
- Viewing local council services in the GIS system
- Contacting local service providers.

Where services are located in proximity to the sampling locations, service providers may be asked to mark out the location of the services prior to the sampling taking place.

Cultural safety

Waimeha Inlet

- Cultural monitoring was not required, however Te Ātiawa advised that the Waimeha Inlet is culturally significant for iwi and that a karakia would be needed before and after the field work.
- Cultural Advisor, Aaron Hemi offered a karakia to bless the mahi on behalf of Ngāti Apa ki te Rā Tō at our Launch Celebration, and our field team used a karakia provided by Te Ātiawa after we had completed the sampling.
- Te Ātiawa provided Accidental Discovery Procedures for us to follow if material of significance to Māori was accidentally discovered during the sampling.

Onetahua

- Manawhenua ki Mohua welcomed our team to Mohua with a powhiri and our Project Kuia, Makere Chapman, offered a karakia at dawn to bless our mahi.
- Two whanau members from Manawhenua ki Mohua joined our field team as cultural monitors and field assistants.
- Manawhenua ki Mohua and Ngāti Apa ki te Rā Tō provided Accidental Discovery Procedures for us to follow if material of significance to Māori was accidentally discovered during the sampling.

Health and Safety

A health and safety plan was created for each pilot field trip by the Project Lead, with input from TET, Cawthron and Beca (Appendix A). Cawthron and Beca each provided job safety analyses for their respective teams.

Methods

To accurately quantify the below-ground carbon pool, we needed to collect, subsample, and analyse soil cores and quantify the following three parameters:

1. Sediment depth (we only sampled to a certain depth so did not estimate the entire sediment carbon pool)
2. Dry bulk density

3. Sediment organic carbon content %Corg (given we focussed on the below-ground carbon pool, this is also to include carbon content of below-ground plant biomass such as roots).

We initially aimed to collect sediment cores to a depth of 1m, but the substrate made this impractical in both pilot sampling locations, so we aimed for at least 50cm soil core depth instead although this was not always achieved e.g., due to gravel and shell layers present in the sediment.

Sediment coring

Much of the following information is taken directly (and/or modified) from the BCI Manual (Howard et al. 2014). Refer to Berthelsen et al. (2023) for more specific technical details on the sampling and subsampling carried out for the pilot study.

Obtaining sediment samples for bulk density measurements and carbon content analysis requires sediment sampling equipment that allows for extraction of a relatively undisturbed sediment sample that has undergone minimal compaction.

Taking a sediment core in tidal saltmarsh

Steps for taking a sediment core in tidal salt marsh and seagrass are as follows:

1. At the sampling location, the organic litter and living leaves, if present, should be removed from the surface before inserting the corer. We aimed to also remove seagrass above-ground biomass but found this to be impractical, hence our seagrass carbon data included above-ground carbon pool as well.
2. Steadily insert the coring device vertically into the sediment until the top of the corer is level with the sediment surface. The descent rate of the core has to be kept low (e.g., gentle hammering) to minimize core compaction. If the coring device will not penetrate to full depth, do not force it, there may be a large root or gravel fragment in the way; instead try another location.
3. Once at depth, twist the coring device to cut through any remaining fine roots, and seal the top end (the vacuum will prevent the loss of the sample). Gently pull the coring device out of the sediment while continuing to twist as it is being extracted. This twisting assists in retrieving a complete sediment sample.

Core Compression

Compression of sediment layers (also known as core compaction or core shortening) comes from three sources:

1. Weight from the sediments layers as they build over time;
2. Decomposition of organic matter with aging; and
3. Shifting of sediments during the coring process.

Sediment layers settle one on top of another with the top layers creating pressure on the lower layers. As a result, sediment layers are tightly pressed together, and the top organic-rich and low-density layers may become denser with aging.

These forms of compaction occur naturally and are difficult to determine, and therefore, are not considered. However, driving the coring tube into sediments will often compress the sediment, causing depth-variable changes in the bulk density of the sample (this is particularly true for seagrass sediments) and this may skew the estimate of carbon stocks (see Figure 3 below – from BCI Manual).

Cores that are much shorter than the depth to which the core tube was inserted in the sediment may also result from the above-described "nail effect," in which the core tube becomes plugged and consequently penetrates the sediment as a solid rod or nail.

Ideally, compressed samples would not be used in the sediment carbon analysis, but it is sometimes unavoidable. Efforts should be made to limit compression as much as possible and record each sample where it occurs to allow corrections.

If significant compaction has occurred, take another core nearby. Repeat until there is minimal compaction.

However, even the most efficient practices for minimizing core compression (e.g., specially designed augers, coring at a low descent rate, and use of rotation and cutting head), can result in core shortening of up to 30%. In these cases, a compression correction factor should be used to compensate for the "artificial" compression in the core sample recovered.

The compaction correction factor is calculated by dividing the length of sample recovery by the length of core penetration. During sample processing the corrected sample length is determined by multiplying the desired depth interval by the compaction correction factor. For example:

- A sample is recovered that is 150 cm long
- But the depth reached by the corer was 175 cm
- This will give you sediment compaction of 25 cm, a compaction correction factor can be found by dividing the length of the sample by the corer depth (150 cm / 175 cm = 0.86).
- If we then wanted to obtain a sample that represents the top 10 cm of the sediment we would need to multiply the depth interval (10 cm) by the compaction correction factor (10 x 0.86) giving a new sample recovery measurement of 8.57 cm.

For simplicity, a uniform compaction correction factor may be used for the entire length of the core. However, this technique assumes that all parts of the core are compacted equally, which may not be the case since bulk density and compatibility are likely to vary over the depth of the core. Thus, a more complex, but more accurate, method is to determine the degree of compression several times at different intervals during the coring process.

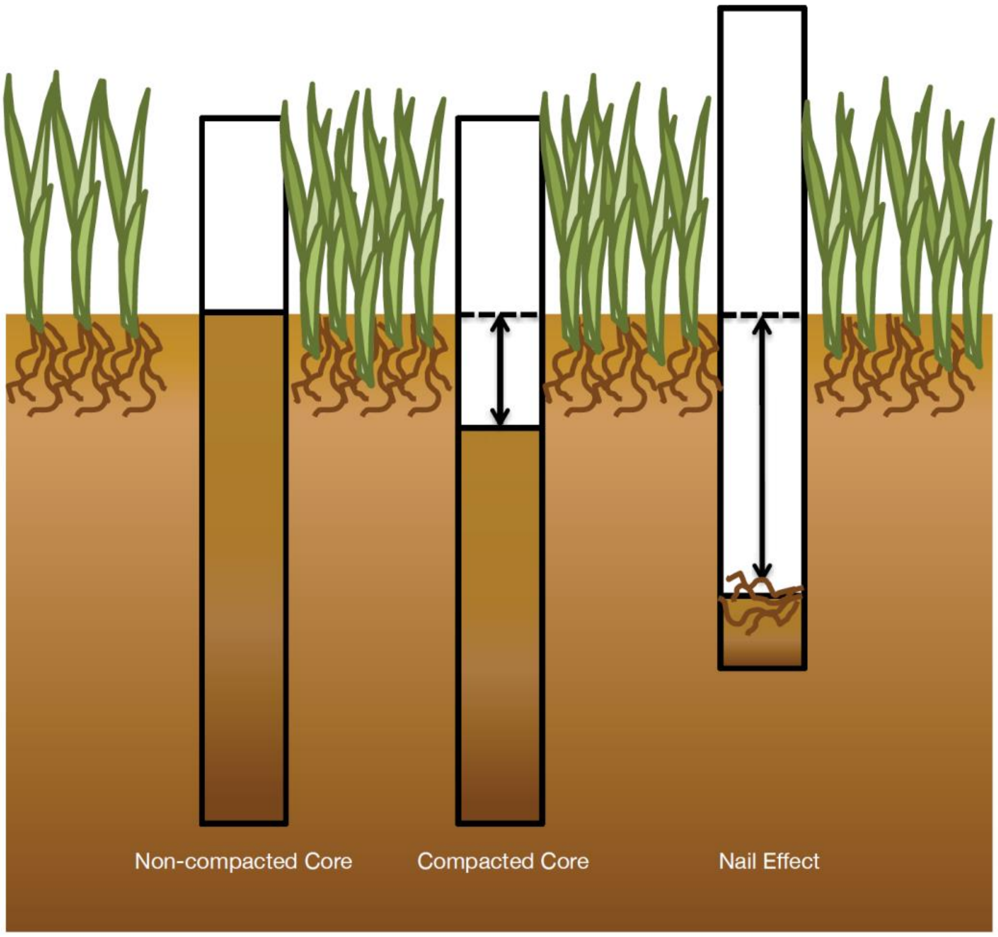


Figure 3. Diagram of soil core compaction that can occur while sampling. The top of a non-compacted core will be level with the surrounding ground (left). Cores can be compacted due to the force applied to the corer as it is driving into the soil (middle). The nail effect occurs when something (roots, rocks, shells, etc.) gets caught in the corer and compacts the soil underneath it (right). Figure and figure caption taken directly from Howard et al. (2014).

Extruding from the corer

- Refer to the 'Manual Coring Procedures' section further below.
- Refer to the BCI Manual (Howard et al 2014) if sediments are loose.

Archiving the core prior to sampling

Much of the following information is taken directly (and/or is modified) from the BCI Manual (Howard et al. 2014).

A photographic archive of the appearance of the sediment core is useful for keeping a record of the core. To archive the core:

1. Take a GPS recording of your coring site and assign the site a unique label; then
2. Photograph the entire core from top to bottom and record changes that occur with depth. Photos can be taken in the field once the core has been recovered and one of the splits has been cleaned.

3. Extend a tape measure along the core starting at the top end and document the split from top to bottom (surface to depth) using detailed photographs of core sections in overlapping frames so that the images can be lined up for a complete core image. Be sure to include the tape measure in these images of the core.
4. Place a label with the core ID so that is appears in all photographs and identifies which direction is the top and bottom of the core and use a polarizing filter to limit the light reflected off the wet surface of the core.
5. It is also useful to record a written description of the core including observations of the sediment type (e.g., colour and texture) and any layers present.

Subsampling a sediment core

Much of the following information is taken directly (and/or is modified) from the BCI Manual (Howard et al. 2014).

Aim to subsample in the field.

The depths at which samples are taken from a sediment core are an important decision:

- For tidal salt marshes (and seagrass meadows), variations in carbon content are often most significant in the upper 20 to 50 cm of sediment; therefore, we recommend taking more detailed depth profiles.

  For example, 5 cm-thick samples can be collected continuously throughout the sediment (or upper 50 cm). As organic content of these sediment cores changes more slowly with depth below 50 cm, it may be practical to take fewer subsamples separated by larger intervals.

- It is imperative that the samples be collected in such a way that its original volume can be determined.

  For example, if whole core sections are removed, the volume can be calculated using the depth interval of the section and the diameter of the core barrel.

  Examples of subsampling strategies are provided in Figure 4. For the Core & Restore pilot study, to subsample, each core was divided into 10 cm sections using a knife, and then a 2 cm sample was cut from the middle of each section. Surface (i.e., top 2 cm) samples were also collected from the uppermost section (i.e., the 0–10 cm section).

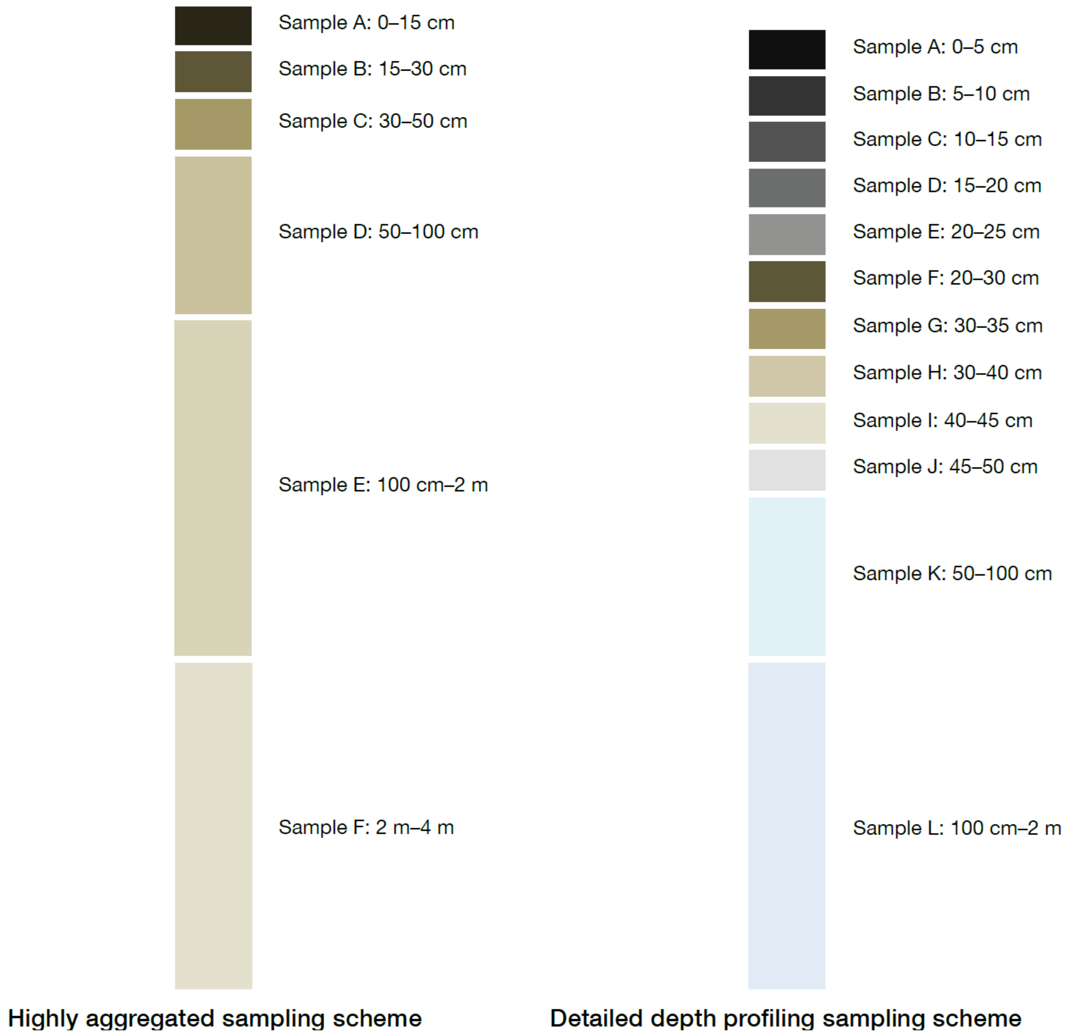


Figure 4. Core sampling strategies. Figure and caption from Howard et al. (2014).

The most accurate, and sometimes most practical, technique for subsampling is to determine the bulk density for each depth interval and then homogenize the subsample and determine the organic carbon content.

Alternatively, subsamples can be taken directly from each depth interval. To do this use a ruler or tape measure to determine the depths from which the subsamples will be collected. Subsample sizes are usually about 5 cm deep and will contain between 5 and 50 g of sample, depending on core barrel size and sediment composition.

If not sampling the entire core, samples should be collected at the approximate mid-point of each desired depth range. For example, if sampling the 0–15 cm depth interval, the sample would ideally come from the 5–10 cm depth; for the 50–75 cm depth the sample would be collected at the 60–65 cm depth, and so on.

For dense sediments, a knife can be used to remove subsamples. The blade of the knife should be cleaned between each subsample. Upon collection, samples are each placed in individual, numbered plastic containers/bags with the site, plot number, core identification, sediment depth, date, coring device used, diameter of core barrel for calculating volume, and any other relevant information.

Manual Coring Procedures

Carry out a services location check, as outlined earlier in the risk management section of this document.

Use a hand auger or hand probe to confirm the depth of the soft sediments to be sampled for blue carbon and help to ensure no dense layers are present that may impact sampling depth.

Once suitable depth of sediment is confirmed, commence sampling as follows:

Coring device 1:

- Hammer metal core into the ground
- Take core compaction measurements
- Pull core tube (with core) out of the ground
- Extrude core and take image and measurement
- Subsample core and place sample in pottle (store chilled).

Coring device 2:

- Clear away grass/vegetation/uneven ground at test location.
- Place thin-walled aluminium tube on ground surface and place piece of wood (2x4)/protective item on top of tube.
- Hammer in tube to desired depth using mallet to strike piece of wood/protective item (ensuring it does not damage the top of the tube).
- Take measurements to determine core compression/penetration into sediment.
- Wait for 2-3mins, then extract the tube using a chain with a chain and hook or pole.
- Gently extract sample from tube using pole with stopper or hand auger pipe with rags pushed into end of tube.
- Place in split and take photographs and measurements for core compression.
- Determine sample locations based on core compression calculation and sample as required.
- Photograph each sample and record all details of sample on sheet.

If coring device 2 (i.e., 0.5m long) is being used and deeper samples are required:

- Connect auger head and handle to 1m rod.
- Begin augering with the 100mm diameter (or greater) hand auger down the thin-walled tube hole already created to over drill it and allow room for tube to be placed back down hole. Once auger hole reaches bottom depth of previous tube sample, ensure base of hole is clean and free of loose sediment.
- Insert an empty thin-walled tube down the same hole, place piece of wood (likely length to allow it to stick out of hole by at least 0.5m)/protective item on top of tube and hammer to target depth using a mallet and piece of wood/rod.
- Repeat measurements (prior to extraction), extraction (using chain and hook (or similar), measurement (post extraction) and sampling/photographs as noted above.

To reinstate, backfill with augured material (left over from tube samples). Remember to clean sediment coring and subsampling equipment between sampling sites - to avoid cross-contamination.

Repeat above at other sampling locations.

Field equipment list

Equipment required for sediment coring fieldwork includes:

- Coring device(s). For the Core & Restore pilot study we used:
  - Coring device1 and associated equipment including hard hats x 2, core extruder, half pipe for core extrusion.
  - Coring device 2. At least 2 x Min. 60mm diameter, 0.5m to 1.0m long, thin-walled aluminium tubes, hand auger with 50mm and 100mm diameter auger heads, thin-walled aluminium tubes with extractor chain and rod to fit through thin-walled tube top holes. Multiple lengths of 2x4 pieces of wood. Rags or stopper to extract sample. Spit to capture extracted core.
- Spade
- Gloves (for contamination and abrasion/cut risks)
- Hand sanitiser for contamination risk
- Earplugs/muffs
- Bucket for washing equipment (including subsampling knife)
- Calculator for determining core compaction correction factor
- GPS
- Measuring tape and ruler
- Camera
- Sharp knife (or syringe to subsample if sediment is loose)
- Zip lock sample bags/sample pottles
- Sample labels (stickers/pens) – follow a consistent labelling protocol
- Field record sheet (on waterproof paper), pencils, clipboard
- A sled may also be useful for holding/transporting gear (depending on the field scenario).
- Chilly bin(s) with ice packs to store samples.
- Vehicle/s (each individual organisation)
- Personal clothing, personal protection equipment (PPE) and food/drink.
- MPI sample collection permit
- H&S documents and any other H&S requirements (e.g., first aid kit and tracker device) (each individual organisation)
- Laboratory sample submission/chain of custody form
- Courier considerations (tape, address, closing time – or cold storage overnight).
- Tide/tables and weather forecast
- BCI Manual (Howard et al. 2014) and Steven et al (SOE 2020) mapping report (for additional background information)
- Identification guide for salt marsh species e.g.(King 2022) https://www.researchgate.net/publication/354268056_The_Simple_Handbook_of_New_Zealand_Salt_Marsh_Plants. Various plant identification apps are also available online
- Everyone's cell phone numbers and next of kin and/or emergency contacts.

Note – some of the items above will be needed per core team and in some cases per person.

Sample storage and transportation to the lab

Cores will be processed at the sample location and subsamples placed into sample containers, labelled, and then stored in a chilly bin. Samples to be kept chilled until we are able to courier them to NIWA in Hamilton.

Laboratory and data analyses

Howard et al. (2014) outlined laboratory analysis option and data analysis steps. Refer to the technical report, Berthelsen et al. (2023), for details on the laboratory protocols and procedures and also how the data was analysed for the Core & Restore pilot study.

PART TWO: TEA BAG EXPERIMENT

Scope

Nelson City Council (NCC) carried out a small trial of the 'tea bag experiment' as part of this TET blue carbon pilot (29th November 2021) and then carried out the full experiment detailed below soon after (30th November and 1st December 2021).

NCC was responsible for all aspects of the tea bag experiment for both the pilot and the full experiment, including cultural safety, health and safety and environmental management.

The tea bag experiment is a citizen science experiment used for estuary/blue carbon education and understanding decomposition/carbon sequestration and the health of estuaries. Community volunteers and local businesspeople took part.

Using two types of tea bag/litter, over four site types, a total of 960 tea bags were planted in two estuaries (Waimeha Inlet and Nelson Haven). Incubation was for three months (90 days) after which the tea bags were recovered. This information was intended to assist NCC in selecting planting locations for future seagrass and saltmarsh restoration projects to enhance blue carbon sequestration.

Background

TeaComposition H_2O, the global aquatic decomposition initiative, was launched by the Blue Carbon Lab called the Tea Bag Index (TBI). The TBI ('tea bag experiment') is a standardised and cheap method to quantify microbial-driven decomposition by measuring the mass loss of tea within tea bags. The initiative's goal is to use Lipton green and red tea bags as a tool to give insight into long-term carbon sequestration in coastal and inland wetlands worldwide. The green and red teas simulate different litter properties found in these wetland habitats naturally.

For the TBI experiment decomposition indicates release of carbon into the atmosphere, areas no decomposition indicates sequestration of carbon in the seabed.

Aims

The aim was to collect data following methods from the Blue Carbon Laboratory Australia, developed from the original terrestrial Tea Bag Index protocol. The aim was for the results to be robust and internationally credible, and suitable for use by other parties.

The aim was to bury 960 teabags between two Nelson estuaries (16 quadrats per estuary) into four habitat types (salt marsh, seagrass meadow, patchy seagrass, and no growth/mud).

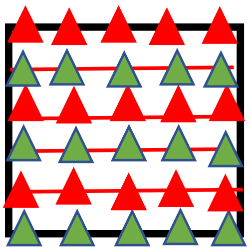
Site selection, timing, and layout

Considerations for site selection included:

- Presence of key habitat types in areas large enough to sample (need approximately a minimum area of $1m^2$ x 2 in each habitat).
- Iwi considerations.
- Site inputs e.g., rivers/land runoff/stormwater/industrial.
- Ease of access for fieldwork, consider substrate, tides and land access.
- Suitable vehicle parking.
- Filming considerations.

Methods

There were to be 15 replicates per quadrat and two replicate quadrats per site, with two site replicates. This would provide statistically robust data with site type vs placement in estuary comparisons possible.



1 x quadrat
3 rows green tea bags and
3 rows of rooibos teabags
Teabags planted 8cm deep and 15 cm apart

- Tea bags to be planted 8cm deep (mark on trowel)
- Tea bags to be planted 15cm apart (length of shovel part of trowel)
- 15 x teabags of each type per quadrat (total 30 teabags/quadrat)
- Each site to have duplicate quadrat
- Each sediment type to have duplicate site at different location in the estuary
- Tea bags are left in situ for 3 months
- March/April 22 tea bags to be retrieved
- Tea bags to be dried for 48 hours at 70˚C
- Tea bags to be reweighed
- Decomposition calculation made
- Results to be written up by 22 July 2022 and shared.

Field Equipment List

- Quadrats
- Stakes
- Pins
- Tea bags
- GPS
- Tide table/weather report
- Trowels
- Gloves

- H&S requirements (first aid kit)

Health & safety potential issues

- Incoming tide
- Sunburn
- Temperature
- Stuck in mud
- Plant poking eye as bend over saltmarsh

Volunteers advised to bring

- Appropriate footwear (list of types)
- Hat
- Sunglasses
- Sunscreen
- Water
- Snacks
- Warm top

Planting plan

The teabag planting plan is outlined below (Figure 4).

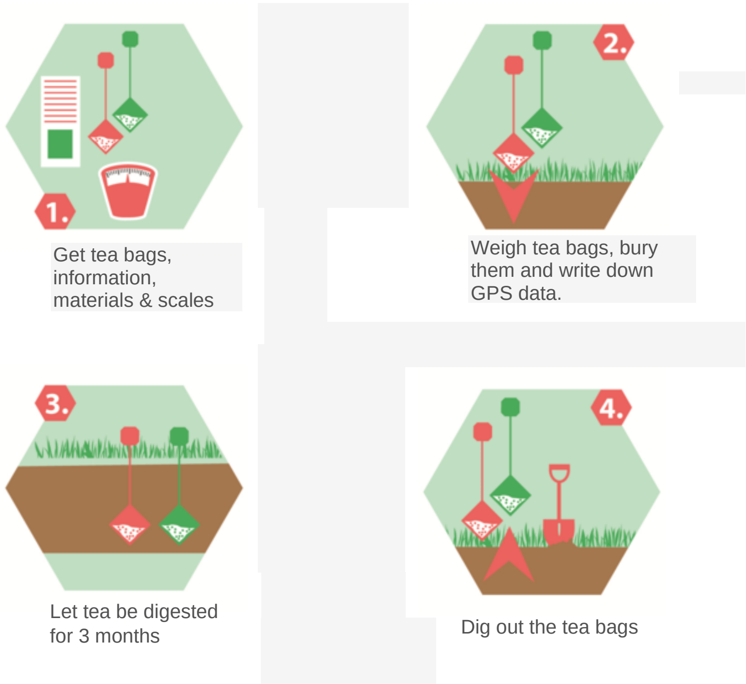


Figure 4. Diagrams showing the teabag planting plan.

Information links

http://www.teatime4science.org/about/the-project/

http://www.teatime4science.org/publications/

https://www.bluecarbonlab.org/teacomposition-h2o/

https://www.bluecarbonlab.org/publications/

References

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. 119 p.

Berthelsen A, Walker L, Skilton J, Chamberose D, Flewitt S, Waters S, Asquith E, Butler J, Kettles H. 2023. Sediment organic carbon stocks in coastal blue carbon habitats: pilot study for Te Tauihu. Nelson: Cawthron Institute. Cawthron Report 3867. Prepared for Tasman Environmental Trust.

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.

Howard J, Hoyt S, Isensee K, Pidgeon E, Telszewski M 2014. Field sampling of soil carbon pools in coastal ecosystems. In: Coastal Blue Carbon: methods for assessing carbon stocks and emissions factors in mangroves, tidal salt marshes and seagrass meadows. Arlington, Virginia: Conservation International. Updated version.

Stevens LM, Scott-Simmonds T, Forrest BM 2020. Broad scale intertidal monitoring of Waimea Inlet. Salt Ecology Report 052 prepared for Tasman District Council and Nelson City Council, November 2020. 50 p.

Walker, L, 2023. Core and Restore Project Pilot: Overview, Results and Next Steps. Prepared for Tasman Environmental Trust, November 2023.

Zaiko A, Pearman J 2022. Bacterial assemblages associated with carbon sequestration potential in marine wetland sediments. Prepared for Nelson City Council. Cawthron Report No. 3845. 13 p. plus appendices.

APPENDIX A: Health & Safety Plan

The Health and Safety Plan for the sediment sampling fieldwork was developed by the Project Lead, in accordance with the Tasman Environmental Trust Health and Safety Management System, and with input from Cawthron and Beca.

The Project Lead was the Designated Safety Officer for both the Waimeha Inlet and Onetahua Fieldwork. The responsibilities of the Designated Safety Officer are set out below:

Designated Safety officer responsibilities

1. To have read and understood the Tasman Environmental Trust Health and Safety management plan and associate forms and registers.
2. To have read and updated, as required, the hazard risk register.
3. Maintaining the required safety signage on site
4. Carry out a pre-start safety meeting to go over the induction checklist (below)
5. Verifying that all hazards are controlled by either elimination or minimisation methods, as per the current Hazard Risk Register (1)
6. Ensuring that everyone on site has the appropriate skills and experience to carry out the assigned tasks, or is properly supervised by a skilled and experienced person
7. Ensuring everyone on site is using all personal protective equipment (PPE) appropriate for the task
8. Responding appropriately to health and safety issued raised by personnel on site
9. Conducting regular toolbox meetings
10. Ensuring accidents and incidents are promptly recorded, using the Hazard Risk Reporting Form and an investigation is undertaken as soon as practicable
11. Monitor the health and safety performance of staff and contractors to ensure the specific safety rules are observed
12. Acting as a warden in case of an emergency
13. First Aid – know who is trained and who has 1st Aid Kits
14. By signing below, I confirm I understand and accept the responsibilities required of me as a Safety Officer for the Tasman Environmental Trust.

Name/Signature: ______________________________ Date: ___ /___ /_____

Induction checklist

What does the inductee need to know?

1. What are the existing hazards/risks and how are they controlled?
2. Your business/site specific safety rules
3. Who is the designated first aider and where do I find them?
4. The location of the first aid kits
5. Emergency/Evacuation procedures
6. ALL incidents/accidents/injuries have to be reported

What do you need to know?

1. What hazards/risks does the inductee introduce into your workplace and how are they controlled?
2. Is the inductee equipped with all PPE required to do his/her job safely?
3. Is the inductee fully trained/qualified to carry out his/her job?
4. Does the inductee have any allergies or other health issues you need to know about?
5. Did the inductee fully understand what you explained?

Waimeha Inlet: Sediment Sampling Fieldwork Safety Plan

This safety plan was discussed with the field team on the 25th November 2021.

Field team structure for Covid-19

The sediment sampling field crew operated in two bubbles to reduce Covid-19 risks; (a) Cawthron bubble; (b) Beca bubble. Each bubble appointed a leader and operated under their respective safe operating procedures (JSAs). Any assistants were required to follow the instructions of the bubble leader.

The two bubbles worked alongside each other, around 1m apart, as close communication was needed between the teams to ensure consistency in the application of the field protocol. This effectively meant that the two bubbles formed one 'field crew bubble'.

Hazard identification and management

Hazard register

- Generic hazards associated with working in the estuarine environment and the controls for managing them were identified and included in the Hazard Register in this Appendix.
- Any new hazards identified during the day were to be recorded by the Designated Safety Officer on the New Hazard Form included in this Appendix.

Job Safety Analysis

- Specific hazards associated with carrying out the sediment sampling in the pilot locations were identified by Cawthron and Beca and documented in their respective risk management systems, along with the relevant controls and safe work procedures.
- Specific hazards associated with carrying out the tea bag experiment and the controls for managing them were documented by NCC.
- Due to their size, the job safety analyses were created as separate documents to be read in conjunction with this Field Protocol.

COVID-19 Protection

All field crew members confirmed that they were vaccinated against COVID-19.

If any of the field crew or someone in their home bubble:

a) Was unwell or had any symptoms, or
b) Had been in contact with some that had travelled internationally, or
c) Had been in contact with someone who was a confirmed or probable Covid-19 case.

They were required to stay home.

The field crew was required to scan in using the COVID Tracer App on arrival at the picnic area at Waimeha Inlet.

- Workers were separated into work "bubbles". Limited contact outside of bubble. Physical distancing between individuals where possible. If one individual in bubble presents with symptoms, all are considered infected. Physical movements between locations are tracked and contact with third parties is recorded to enable tracking possible infection vectors if required. Work bubble will only operate with assigned vehicles and resources. Technical Team will control decontamination if required
- Workers are not required to wear personal protective equipment (PPE), however the following can be used if necessary: Gloves, N95 Masks, eye protection, antibacterial soaps and hand wash's. Ministry of Health guidelines recommend handwashing, good cough etiquette and cleaning of surfaces as a first priority.

Pre-start meeting

Prior to starting the field work, the Safety Officer carried out a pre-start meeting with the team to check that everyone was clear on the plan for carrying out the work safely.

The following items were discussed:

1. COVID protection measures are understood and agreed
2. PPE required (steel capped gumboots / work boots; hard hats if needed; hearing protection; hi-vis vests; sunscreen, water)
3. Emergency procedures
4. First Aid – both teams take; plus one from TET
5. Visitor control / public.
6. Procedure for reporting incidents/accidents is clear
7. Any site-specific hazards are identified, and controls discussed and agreed and documented
8. Spotter for unvegetated sampling

Onetahua: Sediment Sampling Fieldwork Safety Plan

This safety plan was discussed with the field team on the 11th of May 2022.

Field team structure

The sediment sampling field crew will operate in two teams (a) Cawthron Team; (b) Beca Team,, with each team appointing a leader and operating under their respective safe operating procedures (JSAs).

Any assistants were required to follow the instructions of the relevant team leader.

The two teams worked alongside each other, around 1m apart, as close communication was needed between the teams to ensure consistency in the application of the field protocol.

Hazard identification and management

Hazard register

Generic hazards associated with working in the estuarine environment and the controls for managing them were included in the Hazard Register later in this Appendix.

Any new hazards identified during the day were to be recorded by the Safety Officer on the New Hazard Form included later in this Appendix.

Job Safety Analysis

Specific hazards associated with carrying out the sediment sampling were identified by Cawthron and Beca and documented in their respective risk management systems, along with the relevant controls and safe work procedures.

Due to their size, these job safety analyses were included as a separate document to be read in conjunction with this Field Protocol.

COVID-19 Protection

The Onetahua Fieldwork was carried out under the Orange Traffic Light Setting:

- No limits for gatherings.
- No requirement to use My Vaccine Pass.
- No requirement to wear a face mask outdoors.
- Face masks required in most indoor settings including vehicles.
- No requirement to scan in or for a business to display a QR code poster or have mandatory record keeping.

Pre-start meeting

Prior to starting the field work, the Safety Officer carried out a pre-start meeting with the team to check that everyone was clear on how we were going to carry out the work safely.

The following items were discussed:

1. Tides – plan for ensuring work is undertaken safely on the incoming tide
2. PPE required (steel capped gumboots / work boots; hard hats if needed; hearing protection; hi-vis vests; sunscreen, water)
3. Emergency procedures
4. Earthquake and tsunami escape route
5. First Aid – both teams take; plus one from TET
6. Visitor control / public.
7. Procedure for reporting incidents/accidents is clear
8. Any site-specific hazards are identified, and controls discussed and agreed and documented
9. Safety plans for observers, MKM assistants, videographer and photographer

Generic hazards

Vehicle collision due to working on or near road.
Earthquake or tsunami and related events (e.g. rockfalls, etc.)
Loss of control of vehicle, collision. Driving into water at speed, brake failure.
Loss of traction due to water, mud, oil, ice or snow on roads.
Loss of control of the vehicle due to fatigue.
Collision, rolling, etc. due to poor visibility (fog, heavy rain, sun strike)
Loss of control/crash caused by wandering stock.
Insect stings (wasp, bee, etc.), contact with plants or venomous marine animals.
Stinging, biting, spiney and venomous marine organisms
Bank collapse, rock fall or other material falling while working on or near steep or unstable ground.
Drowning, hypothermia due to working near or in water.
Getting stuck in mud or quicksand.
COVID-19
Absorption/inhalation/ingestion of biological material including pathogens.
Contact with toxic bloom.
Lifting objects by hand that are too heavy, or not applying the correct lifting technique. Dropping object while lifting.
Slips, trips & falls linked to uneven ground/wet or icy surface/clutter.

Hazard	Potential Consequences	Raw Risk	Controls	Control level	Residual Risk	Person responsible	Review date
Contractors	Exposure to introduced hazards	High	- Ensure effective selection and approval - Site induction for Contractors before commencing work - Regular reviews and assessments regarding their H&S performance - Ensure their participation in safety meetings	2/5	Low	Management & Contractors	August 2022
Environmental Hazards (Sun, Wind, temperature	Sunburn, cancer, dehydration, wind burn, hyperthermia, hypothermia	High	- Ensure adequate supply and use of sun-block - Supply sufficient drinking water - Work in the shade where possible - Wear sun hats and protective clothing - Only work if weather permits - Minimize work between 11am and 4pm during the summer months - Self monitor body effects - Wear enough layers in cold conditions	4/5/6	Moderate	Management & Staff	August 2022
Estuarine mud eg B4BR monitoring survey	Getting stuck in mud, tides	High	Project leader to make team aware of tide charts for the day and determine times suitable for access to and from the worksite. Test mud porosity with a prob stick to assess depth and density. . Work within 2 hours of low tide. If sinking in mud , lie flat on surface and spread body weight evenly. Use hands and feet to push along surface to stable ground, or roll	5	Low	Management & Operator	August 2022
Hand tools	Personal injury	Moderate	- Use the correct tool for the job and keep tools maintained. - Only use tools you are competent in the use of. - Check the condition of the tool – do not use if faulty or defective. - Use all appropriate personal, protective equipment.	5/6	Low	Staff	August 2022

Manual handling	Sprains, strains, MSDs	High	- Avoid rapid movements when lifting/carrying - Don't lift a load that causes strain. Use two people for heavy lifts. - Use equipment for heavy lifting/carrying, not people, where possible (eg wheelbarrows) - Bend knees, keep good back posture (slightly curved towards tummy, butt out) - Lift/carry heavy objects close to your body front, and avoid twisting – turn with your whole body - Take breaks, don't work to exhaustion - Keep wrists straight - Ensure secure grip on the load	5	Moderate	Management & Staff	August 2022
Noise	Damage to hearing, Noise induced hearing loss	High	- Wear ear-protection if noise level makes it difficult to hear a talking voice. - Check earmuffs regularly and replace pads if worn - Measure noise levels if in doubt HOW? - Caution regarding in-ear music devices - Keep machinery/tools well maintained and fit silencers where applicable	6/5/4	Low	Management & Staff	August 2022
Wasps, bees	Stings, allergic reactions	Extreme	- Ensure team leaders are aware of team members with allergies. If life threatening allergy to stings, team member to stand down. Know what treatment/medications team members need/have if allergic reaction. Have comms in place for emergency services contact.. - site manager to alert all workers to risk of stings, that fly spray's available and process for spraying nests/ stinging insects.. - keep a safe distance from hives - Check inside plant guards for nests before work in guards.. Pull up guard and work from underneath, don't reach into top. - have fly spray on site to spray nests. Treated nests should be approached with caution and only after spray has had time to kill wasps	5/4/3	Low	Management & Staff	August 2022
Working with the public	Aggressive people	Moderate	- Avoid confrontation - Carry a form of communication eg cell phone		Low	Management & Staff	August 2022

Job specific hazards

Each team prepared their own Job Safety Analysis for each pilot study location. These were included as separate documents, due to their large size.

New hazard reporting form

Name :	
Date :	
Location of the identified Hazard/Risk?	
Describe the identified Hazard/Risk	
What could be the potential consequences?	
What are your suggestions to control the Hazard/Risk?	

For Office use only:

Raw risk assessment	**Extreme**	**High**	**Moderate**	**Low**
Required action/controls to mitigate the Hazard/Risk?				
Completed by:				
Date of completion:				
Residual risk assessment	**Extreme**	**High**	**Moderate**	**Low**
Entered into Hazard/Risk Register?			**Yes**	**No**

Accident report form

Accident/Incident particulars			
Date & Time			
Location			
Date reported			
Person making report			
Person injured			
Name			
Age			
Address			
Employer			
Type of injury			
Injured body part(s)			
Description (Describe what happened)			
Analysis (What were the causes?)			
How bad could it have been	Very serious	Serious	Minor
Chance of reoccurring	High	Occasional	Rare
Prevention (What action has or will be taken to prevent recurrence, when and by whom?)			
Treatment			
Type of treatment given			
Doctor/Hospital			
Investigation particulars			
Investigated by			
Investigation date			
Was it a notifiable Incident?	Yes	No	
WorkSafe NZ informed?	Yes	No	

APPENDIX B: Environmental Management

Aim to:

1. Minimise trampling of saltmarsh and seagrass vegetation, sedimentation of water (e.g., through washing equipment) and disturbance of any wildlife.
2. Do our best to reinstate the site.