NGĀI TAHU SEAFOOD

Environmental Monitoring and Management Plan: Hananui Aquaculture Project

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1. INTRODUCTION

Ngāi Tahu Seafood Resources Limited (NTS) was granted resource consent ([insert reference]) for the Hananui Aquaculture Project (HAP) to develop and operate salmon farms within an approximately 1,285 ha area off the northern coast of Rakiura/Stewart Island. The consent conditions relating to the management of seabed and water column effects require an Environmental (Water Column and Seabed) Monitoring and Management Plan (EMMP) to be prepared and implemented during the development and operation of the HAP.

The following consent conditions are relevant:

- Condition 74 - prior to the first introduction of fish to the marine farms, the consent holder must submit an EMMP prepared by a suitably qualified and experienced professional (SQEP) to the Manager Resource Management, Environment Southland (ES), for certification.
- Conditions 75 and 76 – these set out the objectives of the EMMP and the minimum information that needs to be contained within the EMMP.
- Conditions 77-79 – these set out requirements for the EMMP to be reviewed at least every 5 years and in other specific circumstances and for updates and amendments to be made.
- Condition 2 – sets out the process to follow for the Manager Resource Management, ES to certify the EMMP and for any amendments and updates to be made.
- Condition 3 – requires the consent holder to implement the certified EMMP during the development and operation of the HAP.

1.1 STATUS OF THE EMMP

[This document represents the final EMMP prepared by a SQEP for submission to ES. It incorporates feedback from the ES Manager Resource Management on the draft EMMP.]

The EMMP is subject to future review and updates in accordance with conditions 77-79 of the resource consent.

1.2 OBJECTIVES OF THE EMMP

This EMMP has the following objectives:

(a) Achieve compliance with condition 66 of the resource consent;

(b) Detail the adaptive management regime that will be implemented under the resource consent; and

(c) Detail the monitoring programme that will be implemented to assess the effects of the marine farming activity on the water column and seabed.

1.3 STAGES OF DEVELOPMENT

The HAP has been approved on the basis that it will be developed in two stages:

- Stage 1: Consists of one block of 10 pens at each of the four farm sites and a total discharge of 15,000 tonnes of feed per annum across all four farm sites for the purpose of growing finfish.

- Stage 2: As a maximum, a second block of 10 pens will be introduced at each of the four farm sites. The total feed discharge will rise to 25,000 tonnes of feed per annum. Progression to Stage 2 will be dependent on the monitoring results from Stage 1 and effects remaining within thresholds under the proposed adaptive management regime.

Condition 80 of the resource consent sets out how progression from Stage 1 can occur:

Progression from Stage 1, or any alternative stage, to Stage 2 shall only occur if:

(a) A minimum of two full production cycles has been completed at Stage 1 during which:

i. At least 12,500 tonnes of feed has been used across all four farms in two 12-month periods;

ii. The marine farm has been operated and monitored in accordance with the certified EMMP; or

(b) An alternative stage has been completed in accordance with recommendations in the relevant Stage Progression Report (SPR) and has been operated and monitored in accordance with the certified EMMP; and

(c) a SPR for the completed stage has been prepared by a SQEP, recommends that progression from Stage 1 or any alternative stage is appropriate, and has been certified by the Manager Resource Management, Environment Southland in accordance with condition 2.

This EMMP reflects the staged approach to development.

1.4 KEY DOCUMENTS REVIEWED

The following key documents have been reviewed and considered in developing this EMMP:

- Resource consent [insert reference] and associated conditions of consent
- Report titled '*Recommendations for seabed monitoring at the proposed Hananui salmon farming area*' by Cawthron, dated 20 November 2025.
- Water Column Assessment by SLR Consulting New Zealand Limited dated 6 November 2025.

1.5 STRUCTURE OF THE EMMP

This document is structured as follows:

- Section 2 - Seabed monitoring requirements.
- Section 3 - Water column monitoring requirements.
- Section 4 - The adaptive management framework.
- Section 5 - Modelling review and validation, and reporting requirements.

The following are appended:

- Appendix 1 – Water column monitoring maps

2. SEABED MONITORING

2.1 GENERAL APPROACH TO SEABED MONITORING

Farm locations within the proposal area have been selected to minimise interactions with ecologically sensitive biogenic habitats, with predicted primary organic deposition constrained to sandy seabed habitats[1]. While measurable change may occur in these sandy areas, effects are not expected to be significant. Due to resuspension, very low levels of farm-related material may be dispersed into biogenic habitats outside the proposal area; however, deposition in these areas is predicted to be minimal, and adverse effects are considered unlikely.

Seabed monitoring will be undertaken to establish pre-development (baseline) conditions prior to the commencement of farming activities, assess compliance with consent conditions within the Environmental Quality Zones (EQZ) once marine farming is underway, verify modelled depositional patterns and predicted environmental effects, and identify any departure from predicted conditions at an early stage so that adaptive management can be implemented where required (see Section 4). Seabed effects associated with the HAP will be managed under a zones approach comprising three EQZ that traverse the area of expected maximum effect to beyond the maximum predicted spatial extent of detectable farm-related effects.

EQZ for Stage 1 are defined using Stage 1 depositional modelling, as detailed in the seabed effects assessment (Bennett et al. 2025).

- Zone 1 (blue line in Figure 1; shown in a simplified elliptical form to support consistent placement of monitoring stations) encompasses the zone of maximum effect (ZME) corresponding to the 0.5 kg·m2·yr-1 solids flux contour[2], which represents the boundary for predicted effects with no resuspension processes considered.
- Zone 2 (orange line in Figure 1) encompasses the primary footprint (7 $g \cdot m^{-2}$ residual solids[3] contour) which may receive a moderate level of deposition per farm block at Stage 1. This footprint considers the influence of resuspension processes on solids dispersal dynamics and generally aligns with the proposal area boundary, although it extends beyond the boundary in places where the residual solids contour crosses the proposal area boundary.
- Beyond Zone 2 is a spatially defined area extending 3 km in the predominant current flow direction (northwest / southeast) and 2 km cross-current from the Zone 2 boundary. This area encompasses the 0.7 $g \cdot m^{-2}$ residual solids footprint (or outer limit of effects [OLE]; Bennett et al. 2025) and extends beyond it to capture the maximum spatial extent at which farm-related effects may be detectable.

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[1] Biogenic habitats comprise bushy-bryozoan thickets, bryozoan–sponge reefs, and patchy low-relief bryozoan–sponge habitats, while sandy habitats comprise sand, sandy shell hash and coarse gravel–shell–sand substrates (Bennett et al. 2025).

[2] Solids flux refers to the rate at which particulate matter is deposited onto the seabed surface from the overlying water column in the absence of resuspension (Bennett et al. 2025).

[3] Residual solids refer to the particulate waste material that remains on the seabed, accounting for secondary transport through resuspension (Bennett et al. 2025).

Outside the spatially defined Beyond Zone 2 area natural conditions are predicted, with no effect expected from farm activities.

The EQZ are defined such that monitoring effort is appropriately focused to demonstrate that the most affected areas do not exceed the maximum permitted level of enrichment, and that effects do not extend beyond the predicted effects area. Consistent with this, the monitoring programme is designed to determine the actual seabed footprint of the farms, identify whether organic deposition remains within the benthic environment's carrying capacity, and track changes over time to verify that observed effects align with predictions and natural variability.

Monitoring effort will be proportionate to the level of certainty regarding depositional effects and benthic response (Giles et al. 2021). During the initial years of operation, when uncertainty is greatest, sampling intensity will be elevated, particularly at farm blocks operating at peak production, to increase confidence in model predictions and improve understanding of benthic response to enrichment. As certainty increases and response patterns become better defined, monitoring intensity will be adjusted accordingly (and may be reduced). Monitoring station placement has been configured to maintain continuity with any future Stage 2 monitoring.

2.1.1 Initial habitat mapping

A multibeam echosounder survey (MBES) will be undertaken within selected parts of the survey area prior to pre-development monitoring, targeting areas necessary to update the 2022 multibeam dataset and assess any changes in biogenic habitat extent since that time. Some mapping beyond the immediate survey footprint will be required for identifying suitable reference locations that are demonstrably outside the influence of farm-related deposition.

2.1.2 Pre-development monitoring

Pre-development surveys are designed to capture the environmental state prior to the commencement of farming activities and establish reference conditions against which potential farming effects at both Stage 1 and Stage 2 can be distinguished. The purpose of this work is to refine the baseline to a level that enables clear attribution of future changes to farming activities, rather than to natural background variability and episodic disturbance events (storms or extreme weather events). To achieve this, pre-development surveys will characterise both spatial and temporal variability within the HAP site, including areas not previously sampled, to ensure comprehensive baseline coverage. Historical data will be incorporated into the baseline monitoring design where appropriate (e.g. Bennett et al. 2025).

Pre-development surveys will occur before the site is stocked but may occur after farm structures have been installed. Sampling will be undertaken across multiple seasons over a minimum 2-year period for biogenic habitat and 1 year for sandy habitat[4], capturing natural interannual[5] and seasonal environmental and ecological variability. In addition, where feasible, targeted re-surveys of selected reference sites may be triggered following significant storm or wave events to improve understanding of storm-driven influence on biogenic habitats and clarify the natural movement and redistribution of sandy substrates.

[4] However, this period may be extended where high spatial or temporal variability is observed, as determined through expert judgement.
[5] It is acknowledged that a single year of data will not capture interannual variability in the case of sandy habitats.

For sandy habitats, pre-development sampling aims to capture the range of sediment types and associated macrofaunal communities across the site, enabling meaningful spatial and temporal comparisons between habitat types[6]. For biogenic habitats, the aim is to confirm the spatial extent of areas of biogenic habitat (i.e. to map changes since the previous multibeam survey in 2022; Bennett et al. 2025), to further characterise community assemblages and their condition, and to understand how these vary naturally over time in the absence of farming.

Pre-development surveys will verify the placement of long-term monitoring stations to ensure they are representative of habitat types and aligned with the final farm configuration. This approach is consistent with best-practice environmental management (e.g. Giles et al. 2021). Pre-development surveys will also support refinement of methodological approaches and provide opportunities to calibrate and validate emerging monitoring tools, including environmental DNA (eDNA) methods, by validating them with infaunal data collected across sites and seasons before farming begins.

The pre-development monitoring design outlined in this EMMP is conceptually aligned with the routine monitoring framework, with the same core sampling locations, indicators, and replication approach to enable direct comparison between pre- and post-development conditions. Indicative monitoring locations are provided in Figure 1, however, initial habitat mapping and pre-development surveys will confirm the final selection and positioning of suitable reference sites. Pre-development sampling locations will be retained for Stage 1 monitoring to maintain spatial consistency and support meaningful temporal analysis. The pre-development monitoring programme will also inform the refinement of the ongoing monitoring design, including adjustments to replication levels and, where appropriate, methodological approaches, to ensure that the monitoring programme achieves adequate statistical power and sensitivity for detecting farm-driven effects and supporting robust before–after comparisons.

2.1.3 Routine (operational) monitoring

Routine (operational) monitoring will be undertaken while any farms are stocked. Initial sampling locations are based on depositional modelling outputs and the available habitat map for the site (Bennett et al. 2025). Locations may be refined following completion of pre-development surveys and any subsequent depositional footprint mapping.

2.2 SANDY SEABED MONITORING

Sample type/parameters

A range of parameters, listed in Table 1, will be measured to characterise seabed enrichment levels across the site, including confirmation of background conditions at reference sites. Triplicate[7] sediment grab samples will be collected from each sampling station to capture small-scale variability at each site. This approach will be applied

[6] For instance, the northeastern portion of the proposal area appears to comprise consolidated coarse gravel and shell, rather than unconsolidated sand; pre-development sampling will be designed to capture these habitat differences (Bennett et al. 2025).
[7] Three replicates are proposed initially; however, additional replication may be required if higher variability is detected during pre-development surveys.

during both pre-development surveys and routine (ongoing) monitoring[8]. Sampling stations and replicates for each station are provided in Table 2.

Where statistical testing is applied within the initial adaptive management triggers (AMT) framework (see Section 2.2.4), power analysis using baseline data (collected during pre-development surveys) will be undertaken to confirm that replication and station numbers are sufficient to robustly assess farm-related effects with AMT. A follow-up power analysis once the farm is operational may also be appropriate once variability at impacted sampling stations has been established.

Three main sample types will be used:

- Sediments[9]: collected with a grab sampler, from which a range of parameters will be measured either with sensors employed in situ, or with subsequent laboratory processing.
- Water: in situ measurement of water column dissolved oxygen (DO).
- Visual: seabed imagery collected using a remote operated vehicle (ROV) mounted camera, drop-camera, video sled or other equivalent seabed-imagery collection method. At least five seabed images should be captured from video / still images at each station for assessment of epifaunal indicators, bacterial cover and any other relevant observations.

[8] Once sufficient data have been processed to assess variability and / or demonstrate that observed farm effects remain within predicted ranges, the need to continue processing all replicates should be reviewed in consultation with experts, and sampling effort may be reduced accordingly for the remainder of Stage 1 monitoring.
[9] At some stations, infaunal communities may be too depauperate to support complex community metrics, limiting outputs to abundance and diversity (see Bennett et al. 2025). Larger or composite samples may enable calculation of additional metrics.

Table 1. Parameters to be measured and their role in monitoring of sandy seabed environments at and around the HAP site. AMT = adaptive management triggers, against which acceptability of farming impacts can be assessed. Adaptive management triggers are provided in Table 3.

Parameter	Sample type	Proposed measurement method	Approximate time frame for results	Purpose / use
Total free sulphides	Benthic grab	Laboratory processing*	Immediate (method-dependent)	AMT
Organic content		% ash-free dry weight (AFDW)	4 weeks +	Context for interpretation of other parameters, pre-development surveys
Redox / pH		Electronic probe *in situ*	immediate	AMT
Infaunal community metrics		Laboratory processing – calculation of metrics (e.g. abundance, diversity)	6–8 weeks +**	AMT
Bacterial DNA (Bacterial Metabarcoding Biotic Index [b-MBI])			4 weeks +	AMT Model validation***
Grain size		Laboratory processing	4 weeks +	Context for interpretation of other parameters, pre-development surveys
Contaminant levels, incl. zinc, copper			4 weeks +	AMT****
Farm waste tracers			4 weeks +	Model validation and weight of evidence for causality
Near-bottom water column dissolved oxygen (DO)	Oxygen sensor	Electronic sensor attached to benthic grab	Immediate	AMT
Bacterial mat / outgassing	Seabed imagery Drop-cam, ROV or similar	Visual assessment of areal coverage of bacterial mat, presence / absence of outgassing	Immediate	AMT
Epifaunal community composition		Assessment of epifauna and other conspicuous indicators (manual or with image analysis software)	Review immediate, quantification 4 weeks +	Context for interpretation of other parameters

* At least two laboratory methods are available. Ideally, ultraviolet (UV) spectrophotometry of sediment pore water would be used, but this method requires further development of method-specific thresholds; this work is ongoing. Total free sulphides have traditionally (e.g. Fletcher et al. 2022) been measured with the ion-selective electrode method.
** Processing time will increase significantly if larger infaunal samples are required.
*** For example, as a means for progressing between stages.

**** Sediment metal concentrations should be assessed against the widely accepted default guideline (DGV) of ANZG (2018) and will not be considered further in this document.

Sample collection and analysis

At each sampling station, sediment samples will be collected using a van Veen grab, with each successful (full) grab constituting a replicate. Replication will be undertaken in accordance with the monitoring design to support statistical analysis.

Samples will be analysed to characterise sediment condition, geochemical properties and benthic biological response. This will include:

- Sediment characteristics: qualitative assessment (e.g. colour, odour, texture) and quantitative analysis of organic content and tracers, contaminant levels (e.g. zinc and copper) and sediment grain size (where relevant).
- Geochemical indicators: redox potential, pH (redox/pH index) and total free sulphide measurements.
- Near-bottom water column DO: measurements collected from an electronic sensor attached to benthic grab.
- Visual assessment: drop-camera video footage to assess seabed condition, including bacterial mat coverage and evidence of sediment outgassing.
- Biological indicators: assessment of benthic community structure using including macrofaunal sampling and bacterial environmental DNA (eDNA) analysis, as appropriate. Macrofaunal data will be used to derive standard community and biotic indices, while eDNA data will be used to derive bacterial-based indices of enrichment (bacterial Metabarcoding Biotic Index [b-MBI]).[10]

2.2.1 Pre-development (baseline) monitoring

Pre-development (baseline) monitoring will be conducted seasonally over approximately one year, with a target of three sampling events during this period. Sampling will be timed to capture natural spatial and temporal variability, particularly in relation to sediment characteristics and benthic community structure. Monitoring will also characterise the range of naturally occurring conditions (including low-fauna or naturally depauperate states) for comparison with any future changes associated with organic enrichment. Parameters to be sampled / analysed during pre-development monitoring include:

- Sediment characteristics:
    - a qualitative assessment of the sediment (e.g. colour, odour, texture) and
    - organic content
    - sediment grain size

[10] An index that uses bacterial environmental DNA (eDNA) for quantifying benthic organic enrichment (Fletcher et al. 2022). A baseline eDNA survey of the HAP site was undertaken in October 2021 and suggests that the b-MBI approach is a promising tool for monitoring of the site. Application of this index at the HAP site will require validation against macrofaunal data collected over a minimum of two years of farm operation. Following successful validation, the index may be used as a standalone indicator, potentially replacing the need for macrofaunal sampling.

- contaminant levels (e.g. zinc and copper)

- Geochemical indicators:
  - redox potential and pH (to calculate redox/pH index)
  - total free sulphides
- Near-bottom water column DO:
  - DO measured using an electronic sensor attached to benthic grab.
- Visual assessment:
  - drop-camera video footage to assess seabed condition and epifaunal communities
- Biological indicators:
  - bacterial environmental DNA (eDNA; used to derive bacterial-based indices of enrichment, bacterial Metabarcoding Biotic Index [b-MBI]).
  - macrofauna (macrofaunal data will be used to derive standard community and biotic indices)

Pre-development monitoring stations are shown in Figure 1 and correspond to the stations proposed for routine (ongoing) monitoring below (Section 2.2.3), which cover the predicted effect gradients and indicative reference locations. Results from pre-development monitoring will be used to refine the routine (operational) monitoring programme, including optimisation of station locations where required.

A dedicated pre-development monitoring report will be prepared at the completion of this phase. This report will confirm the final locations of all sampling stations and reference sites and will identify any required adjustments to the routine monitoring design. Where appropriate, the findings may be used to update or refine the ongoing monitoring programme presented in this plan.

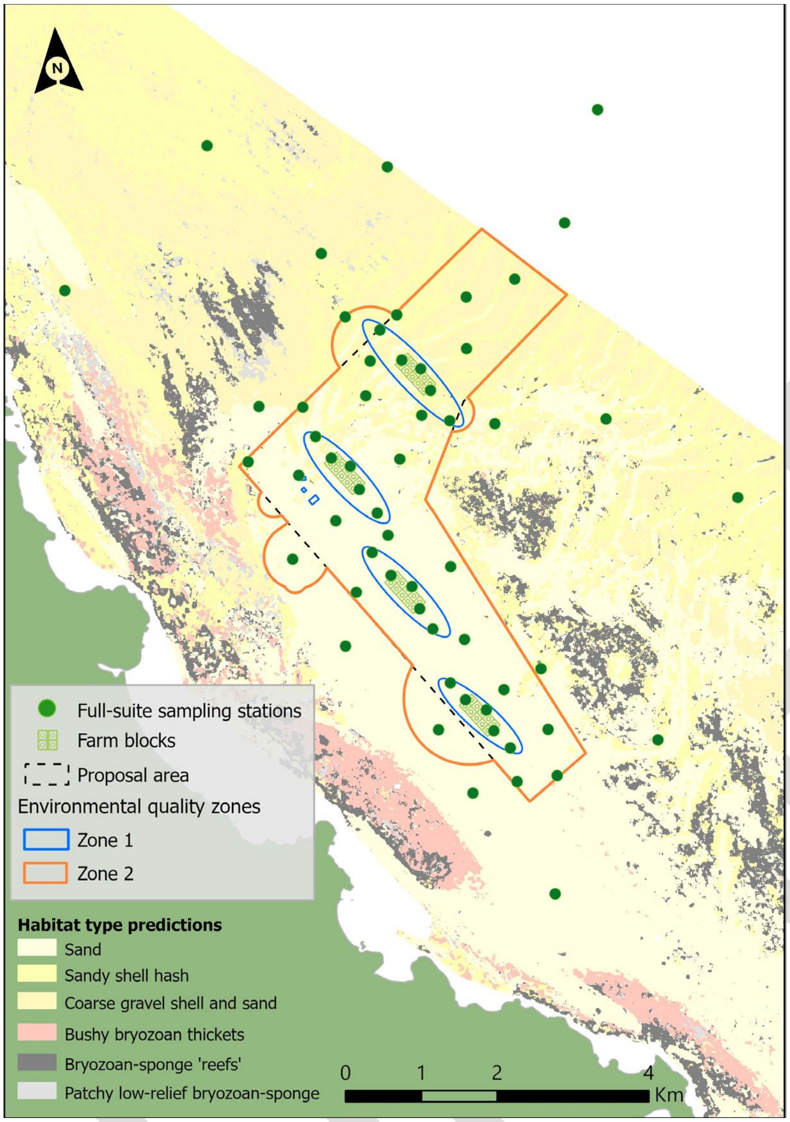

Figure 1. Indicative pre-development monitoring stations; locations are provisional and will be refined through pre-development surveys. Zone boundaries are based on Stage 1 depositional modelling (see Bennett et al. 2025) and are shown in simplified elliptical form to support consistent station placement.

2.2.2 Early phase monitoring

A single early-phase monitoring event will be undertaken approximately 10 months after feed is first discharged at the HAP site, and prior to the first farm reaching peak production, to characterise benthic responses to lower levels of organic enrichment in sandy habitats. Early phase monitoring will be undertaken at the same sampling stations as the pre-development surveys (Figure 1), except for farm stations where feed has not yet been discharged. The following parameters will be collected and analysed.

- Sediment characteristics:
    - A qualitative assessment of the sediment (e.g. colour, odour, texture)
    - organic content

  - contaminant levels (e.g. zinc and copper; Zone 1 stations only)
- Geochemical indicators:
  - redox potential and pH (to calculate redox/pH index)
  - total free sulphides
- Near-bottom water column DO:
  - DO measured using an electronic sensor attached to benthic grab.
- Visual assessment:
  - drop-camera video footage to assess seabed condition, including presence of bacterial mats and / or outgassing, as well as epifaunal community composition,
- Biological indicators:
  - eDNA (b-MBI)
  - Macrofauna (and associated indicators)

This approach allows early evaluation of indicator performance under initial operational conditions, with results interpreted using expert judgement to assess the trajectory of effects relative to AMT thresholds, provide an early basis for refining trigger levels if needed, and confirm indicator suitability before peak feed inputs and maximum effects occur

2.2.3 Routine (operational) monitoring

Monitoring sites/stations

Routine (operational) sampling locations are provided in Figure 2. Monitoring station locations are informed by depositional modelling outputs, existing habitat mapping data and, where possible, stations sampled during the seabed characterisation work have been included in the survey design (Bennett et al. 2025). These locations may be refined following the pre-development surveys.

Zone 1

Zone 1 sampling stations will comprise:

- At least three sampling stations at the pen edge for the farm block at peak production (or at the anticipated pen edge for pre-development surveys) in predicted areas of maximal effect. The operator may also choose to sample additional stations at the pen edge to capture local-scale variability.
- Two stations positioned along the Zone 1 boundary, corresponding to the edge of the predicted ZME footprint, to capture the extent of maximum farm effects for the farm at peak production.

- One station adjacent to each remaining farm to capture areas of possible accumulation[11] (Figure 2, indicated in orange; as per Giles et al. 2021) from neighbouring farms (even if they are not at peak production).

Zone 2

Zone 2 sampling stations will comprise:

- At least twenty monitoring stations distributed across the Zone 2 EQZ to characterise spatial gradients in environmental condition to assess the extent to which farm-related effects occur beyond the ZME (Figure 2).
- Ten of these stations are within the predicted primary footprints of the farms (e.g. within the 7 $g \cdot m^{-2}$ residual solids contour) to capture areas of possible accumulation, with the remaining ten placed along the Zone 2 boundary, particularly in the direction of the prevailing current (northwest / southeast). Monitoring stations will also be established in areas where farm blocks are not currently proposed, including the northernmost part of the site, to provide baseline and comparative data if farm locations are shifted over time.

Beyond Zone 2

Beyond Zone 2 sampling stations will comprise:

- Five stations located at the edge of the outer limit of effects (OLE; 0.7 $g \cdot m^{-2}$ residual solids footprint) boundary to capture the extent of predicted effects.
- Five stations at the outer boundary of Beyond Zone 2, which will inform the maximum spatial extent where farm-related effects may be detectable (Figure 2).

Reference stations

Reference stations will comprise:

- At least 10 stations[12] positioned at a distance of at least twice that of the predicted effects footprint in the relevant direction, accounting for Stage 2 development (Giles et al. 2021). Five indicative stations are provided in Figure 2, though the selection of reference sampling zones will be confirmed following the initial habitat mapping exercise.

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[11] Predicted depositional footprints from individual blocks overlap, meaning the effects cannot be considered independent for each farm. Deposition within any given block will be influenced by neighbouring blocks, including residual deposition from those stocked earlier in the production cycle.

[12] The environment outside of the farmed area is expected to be quite heterogeneous, so a relatively high number of reference sampling stations will be required to ensure that adequate statistical power for detecting farm-related effects is achieved. It will also provide the consent holder with clear benchmarks against which potential effects can be reliably assessed throughout the duration of farming operations.

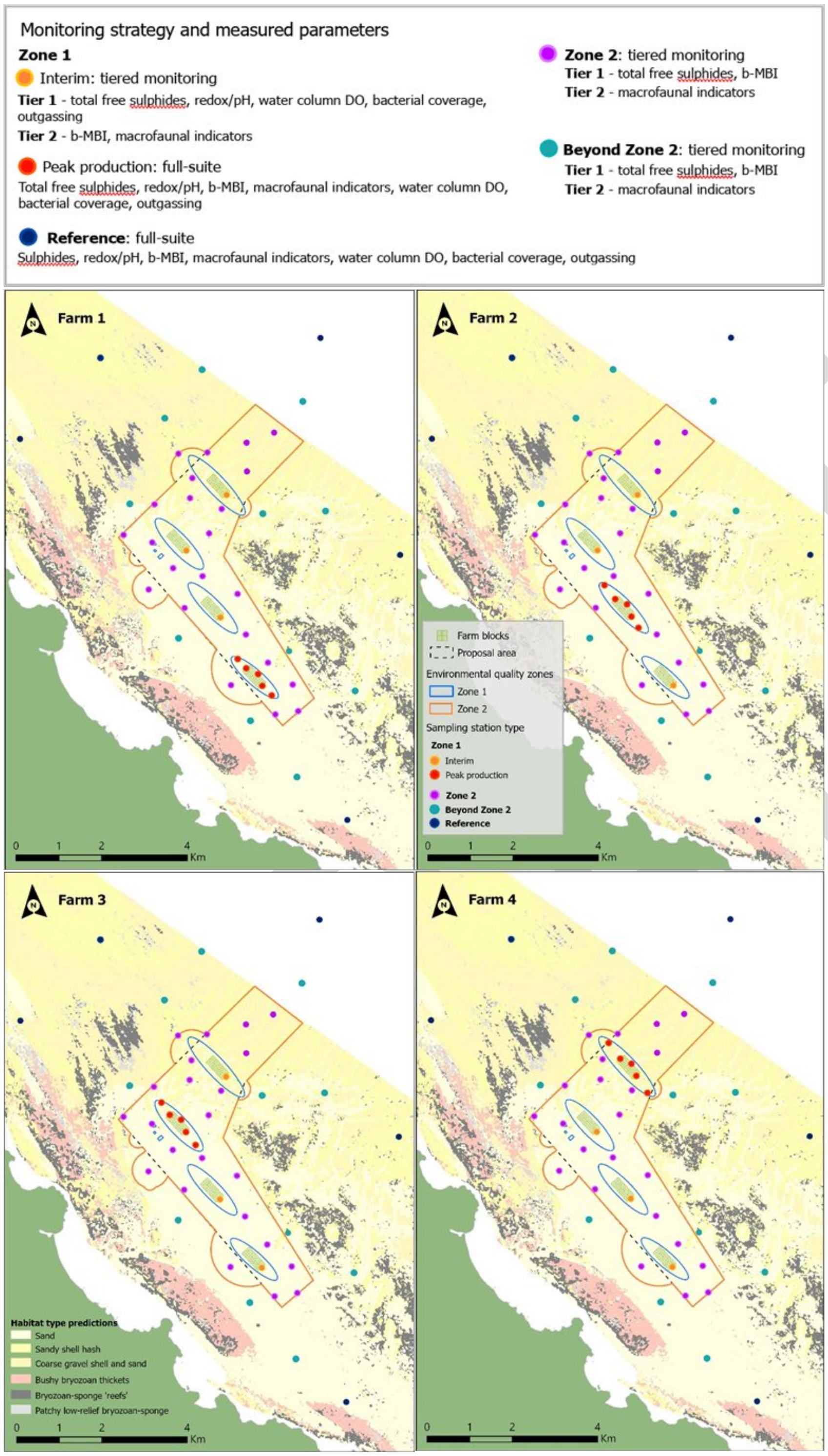

Figure 2. Indicative monitoring stations and sampling type required for Zone 1, Zone 2 and Beyond Zone 2 at peak feed input for each farm under routine (operational) monitoring. Reference station locations are shown for illustrative purposes; the number and final placement of stations will be defined through pre-development monitoring. Zone boundaries have been defined based on Stage 1 depositional modelling (see Bennett et al. 2025) and are shown in simplified elliptical form to support consistent station placement.

Survey design

For routine monitoring, a tiered monitoring strategy will be implemented. Indicators are grouped into Tier 1 and Tier 2 categories, with their application determined by EQZ and the operational status of the farm. In some case full-suite monitoring will be required, involving the collection and analysis of both Tier 1 and Tier 2 indicators. Tier 1 and Tier 2 indicators form the basis of the adaptive management trigger (AMT) framework (see Section 2.2.4 for adaptive management triggers), providing the primary measures used to detect and respond to changes in benthic condition. In addition to these indicators, several supporting parameters will also be measured to provide context for interpretation of results. These include qualitative sediment characteristics (colour, odour, texture), sediment organic content, and seabed imagery collected via drop-camera. While these parameters are not used directly for compliance assessment, they contribute important contextual information for understanding spatial patterns, interpreting indicator responses, and informing adaptive management decisions. Contaminant levels (e.g., zinc and copper) will also be measured within Zone 1 for compliance purposes and assessed against the default guideline values (DGVs) of ANZG (2018).

Tier definitions (general framework)

- Tier 1 indicators: provide rapid, cost-effective measures of near-field sediment condition and early signs of organic enrichment.
- Tier 2 indicators: provide a more detailed assessment of benthic community response and are used to confirm or characterise effects when Tier 1 triggers are exceeded.

Validation requirement for b-MBI

- Incorporation of this index requires validation against macrofaunal data over a minimum of two years of farm operation to confirm its relevance and sensitivity. During this validation period, macrofauna will be collected and processed alongside eDNA in all zones where b-MBI is applied. Following successful validation, b-MBI may be used as a standalone indicator in zones where appropriate. Any transition away from routine macrofaunal sampling and collection will require a review of this EMMP and a review of the AMT specified in the resource consent (as provided for by Condition Y of that consent), and macrofaunal samples may continue to be collected and archived until it is confirmed that they are no longer required.

Zone specific assignment of indicators

Because the sensitivity and monitoring objectives differ between zones, the classification of some indicators varies:

Zone 1

Tier 1: sulphides, redox/pH index, near-bottom DO, visual indicators (bacterial mat, outgassing).

Tier 2: macrofauna and bacterial eDNA (b-MBI) throughout the b-MBI validation process.

In Zone 1, where the tiered monitoring approach is used, b-MBI is treated as a Tier 2 indicator alongside macrofauna until validation is complete.

Zone 2 and Beyond Zone 2

Tier 1: sulphides, redox/pH index, near-bottom DO, visual indicators, and eDNA (b-MBI)

Macrofauna will continue to be collected and processed alongside eDNA for the first two years of farm operation while the eDNA method (b-MBI) is validated for this area. After validation, b-MBI remains the Tier 1 indicator, and macrofauna (and associated indicators) becomes a Tier 2 indicator that is collected and archived until it is confirmed that ongoing collection is no longer required. A review of the EMMP is recommended at that point to determine whether continued macrofaunal collection and archiving remains necessary. Any amendment proposed will require the process set out in Condition Y of the resource consent to be followed.

Tier 2: macrofauna

In these zones, b-MBI functions as the rapid Tier 1 indicator, with macrofauna (and associated indicators) retained as the higher-resolution Tier 2 tool.

Reference

Reference stations will be monitored using the full suite of indicators, including:

- Sulphides
- Redox/pH index
- Near-bottom DO
- Visual indicators (bacterial mat coverage, sediment outgassing)
- eDNA (b-MBI)
- Macrofauna (and associated indicators)

At reference stations, macrofauna will be collected and analysed alongside b-MBI for the first two years of farm operation while the eDNA method is being validated for this area.

Operational application of the monitoring framework

The routine survey design aligns with the rotational farming approach, in which peak production is staggered across the four farms. At any given time, only one farm block will operate at peak production, while the others remain at lower feeding intensity or in fallow. Accordingly, the tiered monitoring framework concentrates sampling effort on the farm block at peak production to validate modelled effects and characterise the benthic response to maximum enrichment. Concurrently, lower-intensity monitoring at 'interim' stations is maintained at the remaining farms to detect early indicators of change, verify recovery during low-feed or fallow periods, and ensure environmental conditions are preserved. This approach provides an efficient, risk-proportionate monitoring regime consistent with operational staging and predicted depositional patterns, targeting areas of highest predicted effect (Giles et al. 2021).

The monitoring approach varies by EQZ, as follows:

Zone 1

Zone 1 stations will be monitored using one of two approaches:

- Full-suite: Applied to farm in peak production (peak production stations, Figure 2). Tier 1 and Tier 2 indicators will be collected and analysed at all stations.

- Tiered: Applied to farms not stocked at peak levels or in fallow (interim stations, Figure 2). Both Tier 1 and Tier 2 indicators will be collected, but only Tier 1 indicators will be analysed. Tier 2 samples will be archived and analysed only if two or more Tier 1 indicators exceed trigger levels.

An example scenario of sampling in relation to farm block stocking cycles for Stage 1 is provided in Figure 3. The timing and sequencing shown are indicative only and will be confirmed based on actual farm development and stocking progression. In this scenario, full-suite monitoring will also be applied to a single early-phase monitoring event undertaken prior to the first farm reaching peak production. Farms at peak production (indicated by a single red star) will be monitored using the full-suite monitoring approach within three months of peak discharge, while farms not at peak stocking or those that are fallowed (indicated by double red stars) use a tiered approach at interim stations.

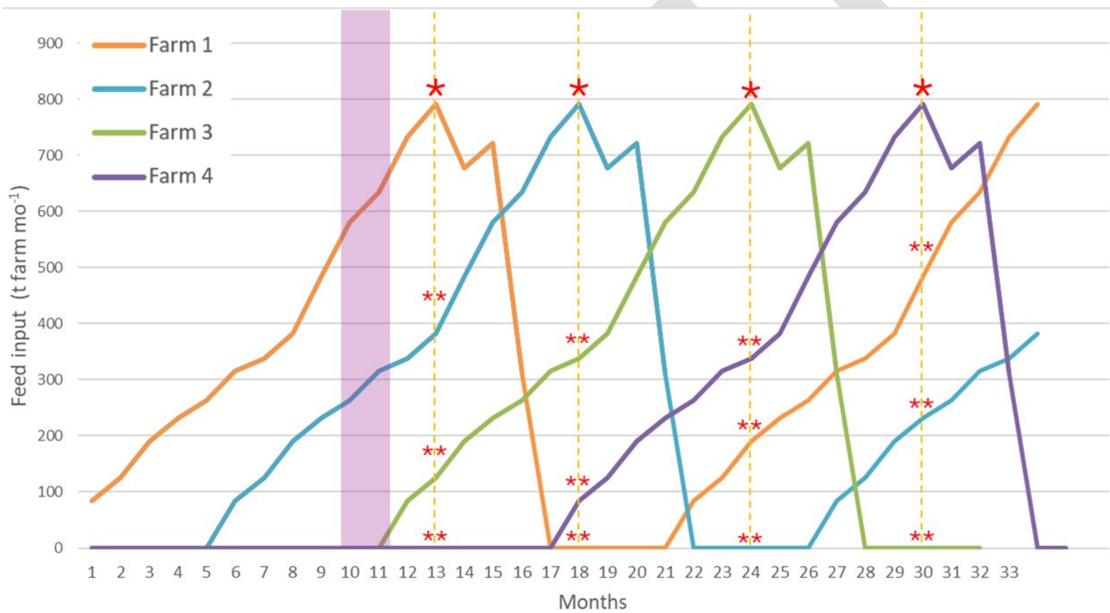

Figure 3. Representation of monitoring approach for Zone 1. The purple shaded area represents the window within which a single early-phase full-suite monitoring event will occur. The red asterisks (*) indicate the farm block at peak production that will undergo full-suite monitoring; the remaining stocked farms not at peak production (interim stations) will undergo a tiered monitoring approach (indicated by double red asterisks [**]).

Zone 2

Zone 2 stations will be monitored using the tiered approach (Figure 2, indicated in purple), whereby both Tier 1 and Tier 2 indicators will be collected, but only Tier 1 indicators will be analysed. Tier 2 samples will be archived and analysed when either or both Tier 1 indicators exceed trigger levels.

Beyond Zone 2

As for Zone 2 stations, the Beyond Zone 2 monitoring stations (Figure 2, indicated in blue) will be monitored using the tiered approach.

Reference stations

Reference stations will be monitored using the full-suite approach, whereby Tier 1 and Tier 2 indicators will be collected and analysed at all stations.

Example survey design scenario

Figure 2 illustrates monitoring station layout and type (e.g. peak production, interim) for each farm when at peak production over the course of Stage 1. In this configuration, monitoring stations are distributed to capture gradients in benthic condition from areas of maximum effect through to reference conditions, as described below. Station and total replicate numbers for Stage 1 monitoring are provided in Table 2.

- **Zone 1 AMA stations** (red): Three stations are positioned around the block in peak production to characterise areas of maximum effect, with two additional stations located on the Zone 1 boundary along the main current axis (northeast−southwest) to define the extent of effects.
- **Interim stations** (orange): One station is positioned adjacent to each remaining farm block to assess potential cumulative effects from neighbouring operations.
- **Zone 2 stations** (purple): Stations are positioned within the predicted primary footprint to capture areas of potential accumulation, and along the Zone 2 boundary (northwest–southeast) to detect the outer extent of farm effects.
- **Beyond Zone 2 stations** (teal): Stations are located at the OLE boundary and the outer edge of the Beyond Zone 2 area to assess the extent of farm-related enrichment effects. Ecological effects are generally not expected.
- **Reference stations** (dark blue): Stations are located outside the zone of farm influence to provide background conditions against which farm effects will be compared (note that five indicative stations are shown Figure 2).

Table 2. The number of sampling stations (Stations) and replicates (Reps) for each station and survey type during Stage 1 monitoring. The number of samples processed (Sample no.) required for each survey is also given. The survey design and replication strategy for routine monitoring may be refined following assessment of pre-development monitoring data to ensure that key sources of variability are adequately captured.

Zone and station type	Pre-development			Stage 1		
	Stations	Reps	Sample no.	Stations	Reps	Sample no.
Zone 1						
Before stocking	1 / farm*	3	12	–	–	–
Farm at peak production	–	–	–	5**	3	15
Interim farms (3)	–	–	–	1 / farm	3	9
Zone 2						
	23	**3**	**69**	**23**	**3**	**69**
Beyond Zone 2						
	11	**3**	**33**	**11**	**3**	**33**
Reference						
	10	**3**	**30**	**10**	**3**	**30**
Total samples (minimum)			*144*			*156*

*Assumes only one anticipated pen edge station is sampled in triplicate during pre-development monitoring.
**Assumes five pen stations (three at the pen edge and two at the Zone 1 boundary) are sampled in triplicate during Stage 1 monitoring.

2.2.4 Adaptive management triggers for sandy seabed

Adaptive management triggers (AMT) for sandy seabed habitats are provided in Table 3. These represent a precautionary set of thresholds, based on conservative application of indicators derived from existing soft-sediment monitoring frameworks in the absence of site-specific farming data (see McGrath & Bennett 2025). The AMT will be applied within an adaptive management framework and may be reviewed and refined (as provided for in consent conditions) as site-specific monitoring data are collected and understanding of indicator performance improves. Key indicators (e.g. b-MBI, AMBI) will be evaluated to confirm their suitability and sensitivity under local conditions.

Table 2. Guiding environmental principles, adaptive management triggers (AMT) indicators, associated thresholds and response triggers for sandy habitats. Under the tiered monitoring approach, Tier 1 indicators are to be used routinely to assess environmental impact and, when breached, should trigger Tier 2 surveys. $S^{2-}_{(UV)}$ = total free sulphides (ultraviolet spectrophotometry method), b-MBI = bacterial Metabarcoding Biotic Index, DO = dissolved oxygen, AMBI = AZTI's Marine Biotic Index, BQI = Benthic Quality Index, N = total abundance, S = taxa richness, H' = Shannon–Wiener diversity index, d = Margalef's diversity index, J' = Pielou's evenness.

Guiding principles – sandy habitats	AMT indicators and associated thresholds	Response trigger
Zone 1		
Peak production: full-suite monitoring		
Farm shall not become very highly enriched (**all areas < cf. ES 5**)	AMT for identifying very high enrichment (ES 5): • Quantitative indicators (station average): o S^{2-}_{UV} > 800 µM or standard method o Redox / pH index > 3.0 o b-MBI > 4.5 o Macrofaunal indicators (AMBI > 5.1, BQI < 2.6, expert judgement that other available indicators [e.g., N, S, H', J' and d] indicate very high enrichment) o Station average near-bottom water column DO < 90% reference o White, anaerobic bacterial coverage > 50%. • Visible free outgassing from sediments.	If two or more AMT indicators are triggered or visible free outgassing is observed, farm management response actions, as outlined in Section 4, should be initiated.
Interim stations: tiered monitoring		
Farm shall not become very highly enriched (**all areas < cf. ES 5**)	**Tier 1 AMT for identifying very high enrichment (ES 5):** • Quantitative indicators (station average): o S^{2-}_{UV} > 800 µM or standard method / in tandem for a while o Redox / pH index > 3.0 o Station average near-bottom water column DO < 90% reference o White, anaerobic bacterial coverage > 50% • Visible free outgassing from sediments. **Tier 2 AMT for identifying very high enrichment (ES 5, archived):** • Quantitative indicators (station average): o b-MBI > 4.5[13]	Tier 2 is triggered when any two or more Tier 1 indicators are triggered at any station or visible free outgassing is observed; archived Tier 2 samples should be processed. If Tier 2 indicators are exceeded, farm management response actions, as outlined in Section 4, should be initiated.

[13] Use of this index at and around the HAP site will require validation against macrofaunal data collected over at least two years of farm operation, after which it may be considered for use in place of macrofaunal indicators.

Guiding principles – sandy habitats	AMT indicators and associated thresholds	Response trigger
	o Macrofaunal indicators (AMBI > 5.1, BQI < 2.6, expert judgement that other available indicators [e.g., N, S, H', J' and d] indicate very high enrichment).	
Zone 2		
Zone 2 shall not become highly enriched (**all areas < cf. ES 4**)	**Tier 1 AMT for identifying high enrichment (ES 4):** • Station average: o S^{2-}_{UV} > 500 µM[14] or standard method. o b-MBI > 4.	Tier 2 should be triggered when either or both Tier 1 indicators are exceeded at the Beyond Zone 2 stations.
	Tier 2 AMT for identifying high enrichment (ES 4): Quantitative macrofaunal indicators (station average): o AMBI > 4.4* o BQI < 4.0* o Expert judgement that other available indicators [e.g., N, S, H', J' and d] indicate high enrichment.	Farm management response should be initiated when Tier 2 indicators are triggered (AMBI, BQI, expert judgement) at any Zone 2 station. *If only expert judgement available, indications of high enrichment = farm response action required. If AMBI and BQI can be calculated, then 2/3 indicators triggered = farm management response triggered.*
Beyond Zone 2		
Beyond Zone 2 shall not become moderately enriched (**all areas < cf. ES 3**) Minor enrichment permitted but not sufficient to cause ecological degradation or loss of biodiversity	**Tier 1 AMT for identifying moderate enrichment (ES 3):** • Station average: o S^{2-}_{UV} > 250 µM or, > upper 95% CI value for relevant reference stations or standard method. o b-MBI > upper 95% CI value for relevant reference stations.	Tier 2 should be triggered when either or both Tier 1 indicators are exceeded at the Beyond Zone 2 stations.
	Tier 2 AMT for identifying moderate enrichment (ES 3): Quantitative macrofaunal indicators (station average): o AMBI > upper 95% CI for relevant reference stations o BQI < lower 95% CI for relevant reference stations o Expert judgement that other available indicators [e.g., N, S, H', J' and d] indicate moderate enrichment.	Farm response actions should be initiated when Tier 2 indicators are triggered (AMBI, BQI, expert judgement) at any of the Beyond Zone 2 stations. *If only expert judgement available, indications of moderate enrichment = farm response action required. If AMBI and BQI can be calculated then 2/3 indicators triggered = farm management response triggered.*

**Only applicable at stations where macrofauna are sufficiently diverse and abundant for effective calculation of indices.*

[14] Point equivalent to approximately the transition between 'Moderate' and 'Poor' status based on international data published by Fisheries and Oceans, Canada, and Cranford et al. (2020), and as recommended in the Aquaculture Stewardship Council benthic monitoring whitepaper (ASC 2022). Assumes use of the UV spectrophotometry of sediment pore water method or equivalent value for the standard ISE method.

2.3 BIOGENIC HABITAT MONITORING

The farm layout has been designed to minimise deposition of farm-derived material on biogenic habitats. Minimising deposition of farm-derived material on biogenic habitat should ensure that adverse effects on the ecosystem function (defined as the role of habitat-forming taxa in providing structure, supporting biodiversity, and maintaining overall habitat condition) of biogenic habitat are avoided. While very low-level inputs may occur through resuspension, far-field deposition and accumulation are expected to be minimal and may not be readily detectable (Bennett et al. 2025). Monitoring of biogenic habitats is therefore undertaken as a precautionary measure to enable early detection of potential changes in ecosystem function. While some ecological uncertainty remains, particularly regarding the responses of key habitat-forming taxa to very low levels of organic enrichment in dynamic environments, the monitoring programme has been designed to be precautionary, sensitive to change, and capable of detecting early indicators of habitat deterioration relative to baseline and reference conditions. The framework incorporates multiple lines of evidence, quantitative assessments of habitat condition, and regular seabed surveys, providing an integrated approach suited to data-limited biogenic habitats. While monitoring occurs in a dynamic marine environment, operational challenges associated with such conditions can be effectively managed using appropriately equipped vessels and established survey technologies, including dynamic positioning systems and advanced ROV platforms. The monitoring and management framework is intended to remain adaptive, allowing refinement of methods as site-specific understanding develops and as new technologies and analytical approaches become available.

Sampling approaches

Video surveys

Video- and image-based survey methods are currently the most practical and cost-effective option for monitoring biogenic habitats, representing a well-established and readily deployable technology for characterising these habitats outside of the HAP site. Surveys will be undertaken using an ROV, drop-camera, video sled or other equivalent seabed-imagery collection method.

Surveys will involve repeat sampling of fixed transects, with transect start and end points located using vessel GPS and camera positioning systems. These transects will be repeat sampled as closely as practicable during each monitoring event to allow detection of changes relative to baseline and reference conditions. Along each transect, continuous video footage will be collected to characterise habitat extent, structure, and overall condition. In addition, still images will be collected as photo quadrats at predetermined intervals. Where image quality and colony distinctiveness allow, colonies may be tracked across monitoring events to measure growth and identify early signs of stress or partial mortality.

Analysis will comprise qualitative assessment of habitat condition from video footage, supported by quantitative analysis of organism cover, abundance, and colony-level condition derived from photo quadrats. Together, these indicators provide a sensitive basis for detecting changes relevant to ecosystem function. Metrics focused on key habitat-forming taxa capture shifts in structural complexity and the condition of the organisms that underpin ecosystem functioning, while community-level and colony-level observations provide early signals of change, such as altered species composition or declining tissue health. Habitat extent, condition, and associated observations will be recorded, with spatial location logged as accurately as practicable.

Parameters to be recorded from video transects include:

- extent of different habitats / dominant species
- density of dominant species
- presence of non-dominant species
- signs of poor heath (e.g. bacterial overgrowth, discolouration, dead patches)
- presence of any fish-farm derived material (exposure indicator)
- evidence of physical disturbance (e.g. dredging), to support contextual interpretation

Additional parameters recorded from still images include:

- counts of individuals
- percent cover of colonial organisms
- area of potentially unhealthy tissues
- evidence of physical disturbance
- organismal-level observations where identifiable, including recruitment, extent of living tissue, evidence of growth or expansion of colonies, and signs of disease or abnormal growth

Derived metrics:

The raw data collected from video transects and still imagery will be used to generate a suite of derived metrics that quantify changes in the condition of habitat-forming taxa, organismal-level health, and broader community structure. Together, these metrics inform assessment of ecosystem function by indicating whether habitat-forming taxa continue to provide structure, support biodiversity, and maintain overall habitat condition. These include:

- percentage cover of key taxa
- changes in community structure
- temporal changes in organismal-level condition (including growth, recruitment and early signs of stress) where repeat identification is possible

Interpretation of ecosystem function:

The derived metrics will be integrated to assess whether habitat-forming taxa continue to provide structure, support biodiversity, and maintain overall habitat condition, as required by the consent. This includes evaluating changes in structural complexity, the condition and persistence of habitat-forming taxa, and shifts in associated species that may signal emerging functional decline. This synthesis provides a clear basis for determining whether observed changes reflect natural variability or potential effects of farming activities.

Sentinel monitoring

During each biogenic survey sediment grabs will be taken from soft-sediment sentinel monitoring[15] stations at the boundaries of biogenic habitats to provide early warning if organic enrichment approaches habitat edges. This will also help determine whether observed changes in biogenic habitats are caused by farm activities.[16]

Monitoring sites/stations

Biogenic monitoring will be comprised of the following zones and stations:

- Six biogenic habitat sampling zones established in areas of biogenic habitat in the 'Beyond Zone 2' area (locations provided in Figure 4 indicated by circles). Biogenic monitoring will take place within these zones. The placement of these zones is based on pre-existing data (seabed imagery from habitat surveys, maps from predictive habitat modelling and results from Stage 1 depositional modelling; Bennett et al. 2025). The location of the monitoring zones may be refined during pre-development monitoring as more information on temporal and spatial variability between areas of biogenic habitat becomes available.
- At least 3 biogenic habitat reference sampling zones located outside of the 'Beyond Zone 2' area. Reference sampling zones must host communities that are ecologically similar to those being monitored within the Beyond Zone 2 area (outlined above), providing a valid basis for detecting potential farm-related effects. The selection of biogenic reference sampling zones will be confirmed following the initial (before pre-development monitoring occurs) habitat mapping exercise and may also be refined during pre-development data collection as more information on temporal and spatial variability between areas of biogenic habitat becomes available.
- At least one soft-sediment sentinel monitoring stations placed at the edge of each biogenic habitat zone (Figure 4).

[15] Advances in surface sampling technologies (e.g. SIBS-type devices) may eventually negate the need for separate sentinel stations by enabling direct, non-destructive sampling within biogenic habitats. Continued method development in this area is encouraged to strengthen monitoring capability across habitat types.
[16] For example, using farm-waste tracers such as terrestrial fatty acids to verify the presence of salmon waste.

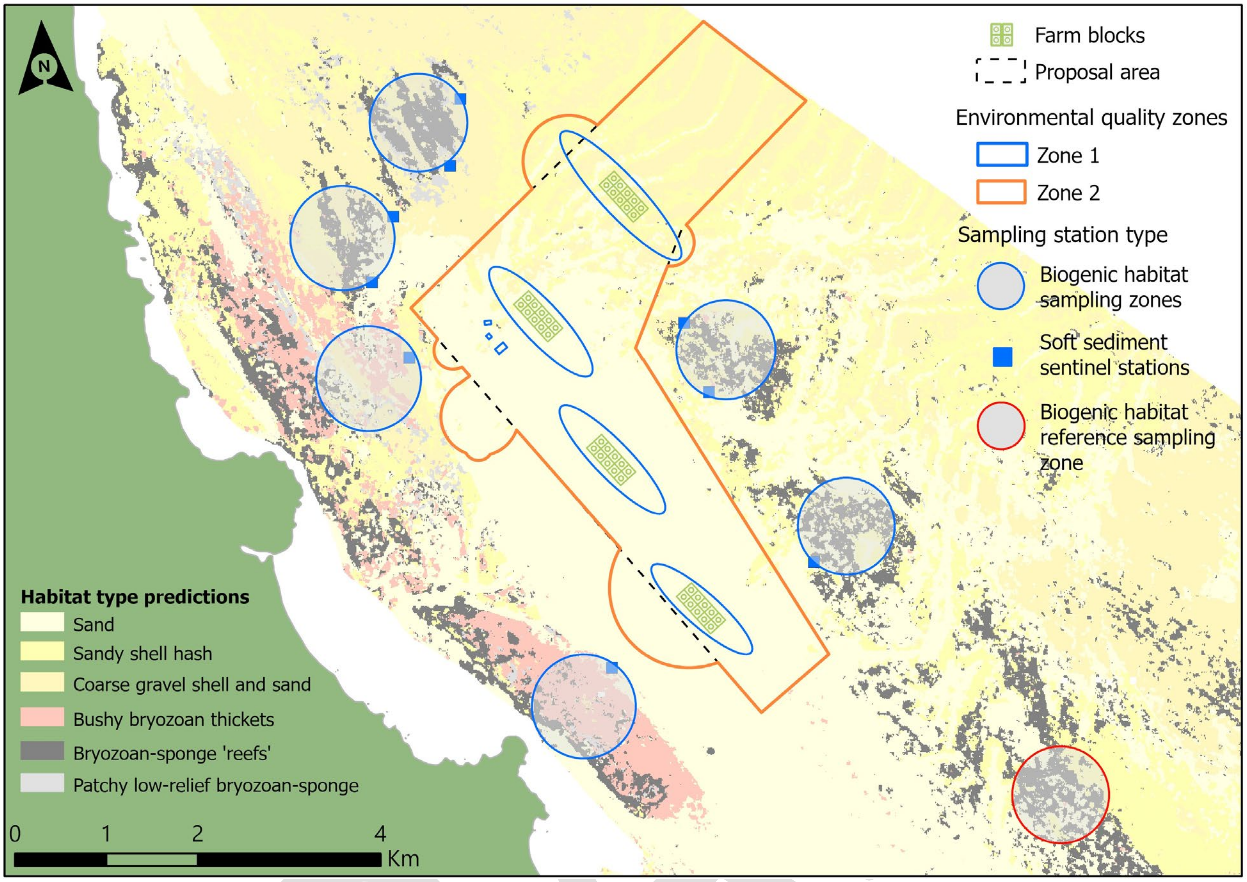

Figure 4. Indicative biogenic habitat sampling locations, where repeat transects may be established, with associated soft sediment sentinel stations in the Beyond Zone 2 area. Indicative reference station zone location shown for illustrative purposes; the number and final placement of reference stations will be defined through baseline monitoring.

2.3.1 Pre-development (baseline) monitoring

For the HAP, pre-development (baseline) monitoring will build on the existing body of information for the local seabed environment by providing targeted, site-specific data prior to farm establishment. This work is intended to refine the baseline dataset to a level that enables robust and defensible monitoring, including clear attribution of any future changes to farm-derived organic enrichment rather than natural variability and episodic disturbance events (storms or other extreme weather events). The pre-development monitoring phase is therefore a critical step in strengthening the monitoring framework, including refining target indicators and methodological approaches.

Pre-development monitoring will be undertaken using video surveys and soft-sediment sentinel monitoring stations within all zones (as indicated in Figure 4) over approximately two years, with a target of three sampling events per year, timed to capture temporal variability (including seasonality and storm events where practicable). This design will capture natural spatial and temporal variability in habitat condition and community composition and will help define the natural range of variability against which any future farm-related changes can be assessed.

Results from the pre-development monitoring phase will inform refinements to the routine monitoring programme, including optimising station locations where required. All refinements arising from the pre-development phase will be documented in a dedicated pre-development monitoring report prepared at the completion of this stage. This report will confirm the final locations of all sampling stations and reference sites and will identify any adjustments required to the routine monitoring programme

Video surveys

A minimum of five transects, each at least 100 m in length, will be surveyed using video per biogenic habitat sampling zone, including reference zones, for each survey (including pre-development and routine monitoring). Transects will be established during the pre-development monitoring phase. Surveys will be undertaken using an ROV, drop-camera or another equivalent seabed-imaging platform. All imagery will be acquired using artificial lighting to ensure consistent illumination and will include a scaling system (e.g., paired lasers) to enable quantitative assessment. In addition, still images will be collected as photo quadrats at predetermined intervals (e.g., every 5–10 m or at fixed time intervals while maintaining constant speed and altitude). Photo quadrats are defined here as downward-looking still images capturing a known and consistent seabed area, achieved using paired lasers or other scaling systems and a consistent camera altitude. These images provide quantitative data on organism cover, abundance, and colony-level condition. Where image quality and colony distinctiveness allow, individual colonies may be tracked across monitoring events to measure growth and identify early signs of stress or partial mortality.

Spatial variability in biogenic habitats is generally high, and to reliably capture change over time the same transects will be repeatedly sampled to track the communities within them with high spatial accuracy. Transect start and end points will be identified using GPS, with no physical markers deployed. High-accuracy real-time kinematic (RTK) topside GPS will be used to ensure transects can be re-sampled to within 2 m of the original location. Transect locations will be determined during pre-development monitoring.

Transect numbers and placement for subsequent pre-development surveys and for routine monitoring may be adaptively refined as pre-development survey data are analysed to ensure a statistically robust and appropriately sensitive monitoring design. If pre-development monitoring indicates that repeat sampling of the same transects is not feasible, sampling intensity will be increased to accommodate the higher variability, ensuring that potential adverse effects on biogenic habitats can still be detected early.

Sentinel monitoring

Triplicate[17] sediment grab samples will be collected from each soft sediment sentinel monitoring station during each survey (including pre-development and routine monitoring). During the pre-development period, both Tier 1 and Tier 2 indicators will be measured (see Section 2.2.4), to characterise natural temporal variability and to establish robust baseline conditions against which future changes can be assessed.

[17] Three replicates are proposed initially; however, additional replication may be required if higher variability is detected during baseline surveys.

2.3.2 Routine (operational) monitoring

Routine (operational) biogenic habitat monitoring will be conducted in tandem with sandy seabed sampling during periods of peak production for each farm (see Section 2.2.3 in sandy seabed monitoring for an example of this timing). During Stage 1, surveys will occur approximately every 6 months for the first 2–3 years while the site is developed, predicted depositional footprints are validated and system responses are clarified. Provided sufficient data are available to confirm that farm-related effects to biogenic habitats are minimal, the monitoring frequency may be reduced.

Except for timing and the specific variations outlined below, the survey design is consistent between pre-development and routine surveys.

Video surveys

Routine (operational) biogenic monitoring video surveys will be undertaken using the same methods outlined for the pre-development surveys. All transects will be those established during the pre-development monitoring phase and carried forward into the operational monitoring programme.

Sentinel monitoring

Triplicate sediment grab samples will be collected from each soft sediment sentinel monitoring station during each survey. Both Tier 1 and Tier 2 indicators will be collected during routine monitoring surveys (see Section 2.2.4), but only Tier 1 indicators will be analysed in alignment with Beyond Zone 2 AMT (Table 4, Section 2.2.4). Should moderate enrichment be detected at these sites, farm management response will be initiated.

2.3.3 Assessment framework

Given the limited precedent for organic enrichment effects on key taxa and the time required for such effects to become detectable, establishing AMT for biogenic habitats at this stage is premature. Instead, potential adverse impacts to ecosystem function will be assessed through multiple lines of evidence relative to background conditions and over time, allowing farm-related effects to be distinguished from natural variability interpreted within the context of broader ecosystem change. Where changes are detected that may be attributable to farm activities,[18] further investigation will be undertaken, including full quantitative analysis where required to assess causality, with a management response initiated where warranted (see Section 4).

Guiding environmental principles, indicators of adverse effects on ecosystem function, and associated response triggers for biogenic habitats are provided in Table 4. Key taxa identified in the context of the biogenic habitat around the HAP site are sponges and reef-building bryozoans (Bennett et al. 2025). These taxa perform key ecological functions, and reductions in their abundance may result in cascading effects on habitat structure and ecosystem processes.

Indicators for identifying adverse effects to ecosystem function

Percentage cover of key taxa and changes in community structure will be assessed using a before–after, control–impact (BACI)-type approach. This approach will quantify changes both over time (e.g. to baseline data) and

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[18] E.g. those observed at impact sites but not at reference sites.

relative to appropriate reference stations. Assessing percentage cover of key taxa alongside community structure will provide multiple lines of evidence to assess different aspects of ecosystem function. Expert judgement will also be used to determine whether conditions have materially changed from background, ensuring that potential adverse effects are identified early. Where a statistically significant deterioration is identified, a second tier of investigation will be undertaken, including additional targeted sampling and supporting lines of evidence (e.g. farm-waste tracers) to investigate the likely cause and determine whether the effects are attributable to farm activities.

In addition, taxa-specific observations will provide useful context for assessing communities, such as recruitment of new colonies, overall condition (presence and extent of living tissue) and presence of disease or notable areas of growth.

Table 3. Guiding environmental principles, indicators for identifying adverse effects to ecosystem function and response triggers for biogenic habitats.

Guiding principles – biogenic habitats	Indicators for identifying adverse effects to ecosystem function	Response trigger
No adverse effect sufficient to disrupt ecosystem function	**Video footage (video and still imagery) analyses** Quantitative: • Statistically significant change in the percent cover of key taxa relative to appropriate reference station(s)[19] • Statistically significant change in community structure (positive or negative) relative to appropriate reference station(s).[20]	If a statistically significant change in cover for key taxa or community structure is detected based on the BACI design and in conjunction with farm activities, farm management actions (Section 4) should be initiated.
	Qualitative • Presence of any fish-farm derived material • Evidence of physical disturbance.	Evidence of physical disturbance should be evaluated using expert judgement alongside other indicators, such as farm-waste tracers, to determine whether the farm or external forces (e.g. ship anchoring, oyster dredging) are the likely source.
	Habitat complexity • Statistically significant changes in the total area of habitat extent (m^2), structural complexity (rugosity), and / or seafloor composition (proportion of different substrate types) over time. [20]	If a statistically significant change in these parameters is detected based on the BACI design and in conjunction with farm activities, farm management actions (Section 4) should be initiated.
	Soft sediment sampling (sentinel stations) **Tier 1 AMT for identifying moderate enrichment (ES 3):** • Station average: o S^{2-}_{UV} > 250 µM or, > upper 95% CI value for relevant reference stations or standard method. o b-MBI > upper 95% CI value for relevant reference stations. **Tier 2 AMT for identifying moderate enrichment (ES 3):** Quantitative macrofaunal indicators (station average): o AMBI > upper 95% CI for relevant reference stations o BQI < lower 95% CI for relevant reference stations o Expert judgement that other available indicators [e.g., N, S, H', J' and d] indicate moderate enrichment.	If either or both Tier 1 indicators are triggered, expert judgement should be required to assess whether there is evidence of biogenic habitat impact before proceeding to Tier 2. If Tier 2 indicators are triggered (AMBI, BQI, expert judgement) at any of the Beyond Zone 2 stations, farm management response (Section 4) should be initiated. *If only expert judgement available, indications of moderate enrichment = farm management response triggered. If AMBI and BQI can be calculated, then 2/3 indicators triggered = farm management response.*

[19] Implies the use of a beyond BACI approach to test for a significant control vs impact interaction term. The same statistical design will be applied for univariate (change in the percentage cover of key taxa, total area of extent, habitat extent, rugosity) and multivariate analyses (change in community structure, seafloor composition).

3. WATER COLUMN MONITORING

The HAP is located in a high-energy, well-flushed region of Foveaux Strait characterised by strong tidal currents, minimal vertical stratification, and naturally elevated background nutrient concentrations arising from upwelling and mixing (SLR, 2025).[20] Hydrodynamic and water column modelling undertaken for the Water Column Assessment predicts that nutrient and dissolved oxygen (DO) effects from the farming activities will be small relative to natural variability.

Water column monitoring is therefore required for two primary purposes:

1. To verify that nutrient and DO concentrations in the water column remain within the ranges predicted by the Water Column Assessment; and
2. To detect any departure from predicted conditions at an early stage, so that adaptive management can be initiated in accordance with Section 4 of this EMMP.

Monitoring is described in the following sections for each of the three development stages:

1. **Pre-development**: 12 months prior to the commencement of farming activities.
2. **Stage 1**: one block of ten pens at each of the four farm sites and a maximum annual feed input of 15,000 tonnes.
3. **Stage 2**: two blocks of ten pens at each farm site and a maximum annual feed input of 25,000 tonnes.

3.1 MONITORING LOCATIONS

Three categories of monitoring sites are required:

1. Farm monitoring sites located near the farm blocks;
2. Embayment sites in nearby sheltered coastal waters that are sensitive to nutrient enrichment; and
3. Reference sites located in Foveaux Strait outside the area predicted to be influenced by the farming activities.

Indicative locations are shown in the Figures contained with Appendix 1, and final coordinates will be confirmed in consultation with the consent authority prior to the commencement of baseline monitoring.

Farm monitoring sites are positioned at each of the four farm sites (F1–F4) and comprise two distinct station types. Farm water quality stations (F1-WQ to F4-WQ) are located 800 m from the outer pen edge of each marine farm and are used for the collection of nutrient, chlorophyll-a, DO and supporting-parameter samples. Additional farm DO stations are located 300 m from the pen edge of each individual farm block, with one DO station established per block. Because the number of operational blocks differs between phases, the number of farm DO stations also differs: four DO stations are established with the commencement of Phase 1 (one per Stage 1 block, designated F1-B1-DO to F4-B1-DO), and a further four are added with the commencement of Phase 2 (one per additional Stage 2 block, designated F1-B2-DO to F4-B2-DO), for a total of eight farm DO stations at full development. The phasing of farm DO station establishment is set out in Section 3.4 and summarised in Table 5.

[20] SLR (2025). Water Column Assessment: Hananui Aquaculture Project. Report prepared for Ngāi Tahu Seafood Resources Limited by SLR Consulting New Zealand Limited.

For the farm water quality stations and farm block DO stations, the monitoring location used on any given sampling occasion will depend on the tidal state at the time of sampling. This reflects the strongly tidal nature of the receiving environment and ensures that sampling is undertaken on the predominant down-current side of the farm or block.

On a flood tide, the predominant flow direction is to the northwest. Farm water quality and farm block DO monitoring stations will be located northwest of the relevant farm site or pen block. These stations shall be identified by appending "-N" to the relevant site ID, for example, F1-WQ-N or F1-B1-DO-N.

On an ebb tide, the predominant flow direction is to the southeast. Farm water quality and farm block DO monitoring stations shall be located southeast of the relevant farm site or pen block. These stations will be identified by appending "-S" to the relevant site ID, for example, F1-WQ-S or F1-B1-DO-S.

The northwest and southeast stations are paired tidal-state stations for the same monitoring location, rather than additional independent monitoring locations. Only one station from each pair is sampled during any monitoring event, depending on whether sampling occurs on a flood or ebb tide.

Embayment and reference sites are fixed stations and do not vary according to tidal state.

Embayment sites are located in Port William/Potirepo, Horseshoe Bay and Halfmoon Bay. These embayments are of particular interest because they are characterised by lower flushing than the open Strait, are subject to other land-based influences, and have previously recorded potentially toxigenic phytoplankton species (*Pseudo-nitzschia* spp., *Heterosigma akashiwo*) in baseline sampling (SLR, 2025). Monitoring in these embayments is intended to confirm the modelled prediction that farming effects will have negligible effects on TN concentrations and will not materially alter phytoplankton biomass or community composition. It is acknowledged that these areas are influenced by other environmental factors, so interpretation and analysis will need to consider this and identify any potential causational linkages with the farming activities.

Reference sites are located within Foveaux Strait, outside the area predicted to be influenced by the farming activities, and are positioned to capture water masses representative of the wider environment. A minimum of two reference sites are required to provide robust comparisons for the evaluation of adaptive management triggers and compliance limits for TN, and to account for the possibility of one reference site being compromised by localised conditions on any given sampling occasion.

Table 5: Water column monitoring sites and the development stage at which they are required.

Site ID	Category	Purpose	Indicative Location	Development Stage*		
				Pre-development	Stage 1	Stage 2
F1-WQ F2-WQ F3-WQ F4-WQ	Farm water quality (800 m)	Verify near-field nutrient, DO, and chlorophyll-a predictions	800 m from outer pen edge	•	•	•
F1-B1-DO F2-B1-DO F3-B1-DO F4-B1-DO	Farm block DO (300 m, Stage 1 blocks)	Verify near-field DO predictions	300 m from outer pen edge	—	•	•
F1-B2-DO F2-B2-DO F3-B2-DO F4-B2-DO	Farm block DO (300 m, Stage 2 blocks)	As above, for additional Stage 2 blocks	300 m from outer pen edge	—	—	•
E1 – Halfmoon	Embayment	Detect enrichment, changes in phytoplankton biomass / composition, and potential HAB occurrence in a sheltered receiving environment	Halfmoon Bay	•	•	•
E2 – Horseshoe	Embayment	As above	Horseshoe Bay	•	•	•
E3 - Potirepo	Embayment	As above	Port William / Potirepo	•	•	•
Ref1, Ref2, Ref3	Reference	Establish reference conditions for AMT and compliance-limit evaluation	Foveaux Strait, outside the predicted zone of influence	•	•	•
Total active sites				10	14	18

* A "●" indicates that a station is active during that development stage; "—" indicates not active.

3.2 MONITORING PARAMETERS

The parameters listed in Table 6 are measured at each water quality site, excluding DO-only sites. The programme includes three primary parameters used to evaluate adaptive management triggers (AMTs) and compliance limits (TN, chlorophyll-a and DO) together with a suite of supporting parameters that enable interpretation of results, characterisation of the broader environmental context, and detection of changes in phytoplankton community composition, including potentially toxin-producing species.

Farm block DO stations are dedicated to in-situ profiling and do not include collection of water samples for laboratory analysis.

Table 6: Water column monitoring parameters by site type.

Parameter	Farm WQ, Embayments, Reference	Farm Block DO
Total nitrogen (TN)	●	—
Chlorophyll-a (chl-a)	●	—
Dissolved oxygen (DO)	●	●
Total ammoniacal nitrogen (TAN)	●	—
Nitrate + nitrite nitrogen (NNN)	●	—
Total phosphorus (TP)	●	—
Dissolved reactive phosphorus (DRP)	●	—
Phytoplankton species composition	●	—
Turbidity	●	—
Salinity/conductivity	●	●
Temperature	●	●
pH	●	—

3.3 SAMPLING FREQUENCY AND TIMING

Across all three stages, sampling is undertaken on a monthly basis at every active station. Sampling is required for at least 10 out of the 12 months, to allow for occasional missed months that may arise due to poor weather and/or other logistical or technical issues.

Monthly sampling provides up to 12 data points per annum at each station, which is sufficient to characterise the seasonal cycle in nutrients, phytoplankton biomass and DO, and to support statistical comparison between farm, embayment and reference sites. Monthly frequency is also consistent with the predicted magnitude and temporal scale of farming effects, which are expected to be small relative to natural variability and to persist over timescales longer than a single sampling event.

3.3.1 Pre-development (baseline) monitoring

Monthly water column monitoring is undertaken at all four farm water quality stations, three embayment stations and three reference stations (10 stations total) for a minimum of 12 consecutive months prior to the commencement of farming activities at any farm site. The 12-month minimum is required to capture the full seasonal cycle in nutrients, phytoplankton, and DO, and provides an improved understanding of the natural variability against which Stage 1 and Stage 2 results are interpreted. Where suitable, the existing 2018/19 and 2025 baseline characterisation data are to be incorporated into the baseline dataset. Farm DO stations are not active during the pre-development stage, as they are defined relative to operational pen-block locations; in-situ DO measurements at the farm water quality, embayment, and reference stations during the pre-development stage provide the broader DO baseline against which Stage 1 and Stage 2 DO data are interpreted.

3.3.2 Stage 1

With the stocking of salmon in the first block at each of the four farm sites, four farm DO stations (F1-B1-DO to F4-B1-DO) are established at 300 m from each block's pen edge. From the commencement of Stage 1, monthly monitoring is undertaken at the 10 pre-development stations and at the four new farm DO stations (14 stations in total). Each farm DO station becomes active with the deployment of its corresponding pen block; for the avoidance of doubt, no farm DO station is required to be operational prior to the stocking of salmon in the corresponding pen block.

3.3.3 Stage 2 or alternative stage

With the stocking of salmon in the second pen block at each of the four farm sites, a further four farm DO stations (F1-B2-DO to F4-B2-DO) are established at 300 m from the pen edge of each new block. From the commencement of Stage 2, monthly monitoring is undertaken at the 14 Stage 1 stations and at the four new farm DO stations (18 stations in total). As with Stage 1, each new farm DO station becomes active with the stocking of salmon in the corresponding pen block.

3.3.4 Tidal state

Sampling at farm water quality stations and farm block DO stations shall be undertaken at the tidally appropriate monitoring location, based on the tidal phase at the time of sampling.

On a flood tide, when the predominant flow is to the northwest, monitoring shall be undertaken at the northwest station for each relevant farm or block. These stations are identified using the suffix "-N". On an ebb tide, when the predominant flow is to the southeast, monitoring shall be undertaken at the southeast station for each relevant farm or block. These stations are identified using the suffix "-S".

Sampling shall avoid slack tide and the hour following slack tide. This ensures that samples are collected under representative conditions and on the expected down-current side of the farm or block, rather than during low-flow transitional periods when short-term localised concentrations may not be representative of the wider receiving environment.

3.4 SAMPLING METHODS AND EQUIPMENT

The following methods shall be used for water sampling and in situ profile measurements.

3.4.1 Water sampling

At each site, a depth-integrated water sample is collected from the surface to 15 m using a flexible hose sampler (tube sampler). The sampler is deployed vertically from the surface to 15 m, sealed at the top to retain the water column within the tube, and recovered to the vessel, where the integrated sample is transferred to sample bottles. This method is appropriate for the HAP site because the water column is well mixed with minimal vertical stratification, and a depth-integrated sample therefore provides a representative measure of water quality across the productive upper layer.

From the integrated sample, aliquots shall be transferred into suitable containers or jars provided or approved by the laboratory to be analysed for the parameters listed in Table 6.

Samples shall be kept chilled but not frozen and transported to an IANZ-accredited laboratory within laboratory-specified holding times.

3.4.2 In situ profiling

Temperature, DO, salinity/conductivity, pH and turbidity are measured in situ using a calibrated multiparameter profiler (CTD) deployed at each site. The profiler is lowered at a controlled rate (nominally 0.3–0.5 m/s) from the surface to approximately 2 m above the seabed and recovered, with measurements logged continuously on descent. Results are processed into 1 m depth bins for reporting. The "2 m above seabed" stopping criterion avoids contact with the benthos and minimises sensor fouling, while still capturing near-bed water quality.

3.4.3 Calibration and quality assurance

All field instruments are calibrated in accordance with the manufacturer's specifications, including pre-deployment calibration checks for DO (air saturation), pH (two- or three-point buffer check), and salinity (standard seawater or laboratory check). Calibration records, including date, standards used, pre- and post-calibration readings, and operator name, are retained for each deployment and made available to the consent authority on request.

3.4.4 Field records

For each sampling event, the field technician records the site ID, date, time, tidal state and phase relative to slack water, sea state, weather conditions, water depth, personnel, and any anomalies or deviations from the standard procedure. Field records are retained as part of the permanent monitoring record.

3.5 ASSESSMENT FRAMEWORK

Results from the water column monitoring programme are assessed against a two-level framework comprising adaptive management triggers (AMTs) and compliance limits. The AMTs and compliance limits apply, where an exceedance is identified and attributed to the farm activities.

Level 1 — Adaptive Management Triggers function as an early-warning mechanism. An AMT exceedance does not, of itself, represent non-compliance with consent conditions, but indicates that conditions may be departing from those predicted by the Water Column Assessment (SLR, 2025) and that further investigation or a precautionary operational response is warranted. Exceedance of an AMT triggers the Stage 1 response as set out in Section 4 of this EMMP.

Level 2 — Compliance Limits represent the regulatory thresholds above which effects are considered potentially significant. Exceedance of a compliance limit as a result of farming activities triggers the Stage 2 response as set out in Section 4 of this EMMP.

The two levels, together with the location at which each applies are summarised in Tables 7 and 8. All nitrogen and chlorophyll-a comparisons against reference sites are undertaken using concurrent ("same monitoring event") measurements to control for regional-scale variability in the receiving environment.

Table 7: Level 1 Adaptive Management Triggers.

Parameter	Evaluation location	Trigger
Total nitrogen	800 m from pen edge	Concentration >30 μg/L above the highest concentration measured at reference sites on the same monitoring event, on two successive monthly surveys.
Dissolved oxygen	300 m from pen edge	Concentration <6 mg/L on two successive monthly surveys.
Chlorophyll-a	Nearby sheltered embayments (Port William/Potirepo, Horseshoe Bay, Halfmoon Bay)	Concentration >3.5 μg/L on two successive monthly surveys.

Table 8: Level 2 Compliance Limits.

Parameter	Evaluation location	Compliance limit
Total nitrogen	800 m from pen edge	Concentration >50 μg/L above the highest concentration measured at reference sites on the same monitoring event, on two successive monthly surveys.
Dissolved oxygen	300 m from pen edge	Concentration <5 mg/L on two successive monthly surveys.
Chlorophyll-a	800 m from pen edge	Concentration >3.5 μg/L on two successive monthly surveys.

The requirement for exceedance to be demonstrated on two successive monthly surveys before either an AMT or a compliance limit is triggered is intended to distinguish sustained departures from modelled conditions from short-term natural variability, and to reduce the likelihood of false positives arising from transient events (for example, storm-driven mixing, single-event sampling artefacts, or short-lived phytoplankton blooms unrelated to the farming activities).

Where an exceedance is identified and attributed to the farm activities, the response framework set out in Section 4 (Adaptive Management) of this EMMP applies. The actions to be taken upon exceedance, including reporting obligations, investigative requirements, and any operational changes, are described in that section and are not reproduced here.

4. ADAPTIVE MANAGEMENT

4.1 INTRODUCTION

This section sets out the framework for using monitoring results to identify, assess, and respond to emerging or confirmed adverse ecological effects associated with the HAP, if they were to occur, so that environmental risks are identified early and managed promptly by operational or effects-based responses (Adaptive Management). The management response will be proportionate to the nature, magnitude, persistence, and spatial extent of the observed or predicted effect, taking into account the likely cause of the exceedance and the level of ecological risk.

The adaptive management plan will be implemented through a two-stage approach.

4.1.1 Stage 1: Immediate operational responses

Stage 1 responses are precautionary management actions implemented when monitoring identifies emerging trends, early indicators of change, or a potential exceedance of a trigger threshold resulting from the farming activities. These responses are intended to enable early intervention before adverse effects become established, and will generally involve modifications to existing farm management practices rather than major changes to the farming operation.

4.1.2 Stage 2: Effects-based management measures

Stage 2 responses are applied where monitoring confirms an exceedance, or where results indicate that the nature, magnitude, persistence, or spatial extent of observed effects indicates that Stage 1 operational responses would be insufficient to adequately mitigate the effects. These responses represent a more substantive corrective intervention and may be implemented in addition to Stage 1 measures. The management measure or combination of measures adopted will be determined in response to the monitoring results, the likely cause of the effect, and the advice of a SQEP, so that the response is targeted and proportionate to the ecological risk identified.

4.2 ATTRIBUTION OF MONITORING RESULTS

Marine environments are naturally dynamic, and measured changes in seabed or water column conditions may arise from a range of processes that are unrelated to farming activities. For this reason, monitoring results will be interpreted using a weight-of-evidence approach before any exceedance of an adaptive management trigger or compliance limit is attributed to the farming activities.

The purpose of this approach is not to avoid or delay management action where farm-related effects are occurring. Rather, it is to ensure that responses are targeted, proportionate, and based on robust evidence that the observed change is linked to the activity being managed. Where monitoring results indicate a potential AMT or compliance limit exceedance, the consent holder will review the relevant data in consultation with a suitably qualified and experienced person. The review will consider the magnitude, duration, spatial pattern and timing of the observed change, the consistency of the result with model predictions, the relationship between affected and reference sites, and any relevant farm operational information, including stocking, feed inputs, fallowing, harvesting and recent changes in farm management.

4.2.1 Seabed

For seabed monitoring, attribution will consider whether the observed benthic response is consistent with the predicted depositional footprint, the expected gradient of enrichment from farm to reference areas, and the nature of the indicators that have changed. Determination of causality will also consider the spatial extent, magnitude, and temporal persistence of observed effects, together with any relevant natural or anthropogenic factors that may influence benthic conditions independently of farming activities.

For both sandy seabed and biogenic habitats, attribution will be supported through multiple lines of evidence where monitoring indicates potential deterioration from background conditions or unexpected responses. This may include targeted collection and analysis of physical samples to investigate whether observed responses are consistent with farm-related inputs, including analysis of flocculent material overlying biogenic habitats and detection of farm-waste tracers in sediments or tissue samples of key taxa. Expert judgement will be applied in interpreting the significance of observed changes and the likelihood of attribution to farming activities.

Where monitoring results identify divergence between predicted and observed environmental outcomes, further investigation will be undertaken to determine the causes of the discrepancy. Re-modelling and model recalibration will be undertaken when:

- observed depositional patterns diverge from predicted patterns;
- monitoring identifies environmental effects outside predicted zones or magnitudes;
- model assumptions are demonstrated to be inconsistent with observed site conditions; or
- operational inputs differ substantially from those assumed in the original modelling.

Where re-modelling is required:

- model inputs, assumptions, and calibration parameters will be reviewed and updated using Stage 1 operational and monitoring data;
- revised Stage 2 scenarios will be re-run using the updated model configuration; and
- the outcomes of the revised modelling will inform any decision regarding progression to Stage 2 (see Section 5.1.2).

4.2.2 Water column

For water column monitoring, attribution is particularly important because background conditions in Foveaux Strait are naturally highly variable. The Water Column Assessment identified that nutrient concentrations and phytoplankton biomass vary substantially in response to natural oceanographic processes. For this reason, the total nitrogen adaptive management trigger and compliance limit are assessed relative to concurrent reference-site concentrations, rather than against a fixed historical or absolute concentration. This approach allows farm monitoring results to be interpreted in the context of regional-scale water quality conditions at the time of sampling. Chlorophyll-a and DO results will also be interpreted in the context of supporting information, including phytoplankton composition, temperature, salinity, weather conditions, any evidence of regional bloom activity, and comparison with patterns observed in baseline and previous monitoring, including the occurrence and characteristics of phytoplankton bloom events in the embayments.

Where the available evidence indicates that an exceedance or adverse trend is likely to be related to farming activities, the relevant adaptive management response set out in this EMMP will be initiated. Where the cause is uncertain, the consent holder may undertake further investigation, increase monitoring frequency or spatial coverage, analyse archived samples, or implement precautionary operational responses while the cause is being resolved. Where the evidence indicates that the observed change is attributable to natural variability or another non-farm-related cause, this conclusion will be documented, including the supporting evidence and any recommendations for continued observation or follow-up monitoring.

4.3 IMMEDIATE OPERATIONAL MANAGEMENT RESPONSES

The greatest potential for adverse effects to occur is during peak production, when feed inputs and fish stocks are highest. Peak production coincides with the farm entering the harvesting phase, which inherently provides an immediate and effective operation management response by reducing the stock densities and feed inputs. As harvesting progresses, stocking densities are progressively reduced, and the transition from a growth feed regime to a maintenance regime results in a substantial reduction in feed inputs over an approximately six-month period.

Where monitoring indicates emerging trends, early indicators of change, or a potential exceedance of a trigger threshold in response to farming activities, operational management responses may be implemented to prevent further seabed and/or water column enrichment. Such responses may include:

- extending the fallowing period to allow additional seabed recovery;
- reducing the number of salmon stocked at the site during the stocking phase;
- adjusting/reducing stocking densities during grading to lower biomass; and
- reducing harvest size or initiating harvesting earlier than planned.

Depending on the phase the farm is at or entering will inform which responses would be undertaken. The outcome of each management response is to reduce feed inputs and organic loading, thereby minimising the risk of threshold exceedance.

4.4 EFFECTS-BASED MANAGEMENT MEASURES

Effects-based management measures are applied where monitoring confirms an exceedance, or where it is determined that immediate operational responses alone are insufficient to adequately mitigate observed seabed and water column effects. These measures represent a more substantive corrective response and are implemented where the nature, magnitude, persistence, or spatial extent of effects requires intervention beyond routine operational controls.

The selection and scale of effects-based management measures will be informed by multiple lines of evidence, including:

- the results of tiered seabed and/or water column monitoring;

- expert advice from a SQEP;
- an assessment of the likely causation and mechanisms driving the observed effects;
- observed recovery trajectories during fallowing periods;
- where appropriate, rerunning depositional modelling with updated inputs to refine understanding of the spatial footprint and associated risk;.

Together, these inputs ensure that the most appropriate and proportionate corrective course is identified, taking into account both short-term risk management and longer-term seabed recovery objectives.

The primary effects-based management tools available include the following, which may be implemented individually or in combination, depending on the circumstances.

4.4.1 Fallowing

Monitoring of seabed recovery during fallowing periods may indicate that the standard fallow duration is insufficient to achieve adequate recovery or to prevent the recurrence of exceedances. In such cases, the fallowing period may be extended to allow further recovery of sediment chemistry and benthic communities and to reduce the risk of future exceedance when farming resumes.

4.4.2 Reduction of farming intensity

Where immediate operational responses are insufficient, or where monitoring indicates that effects may recur under the approved production regime, farming intensity may be reduced for the next cohort and, if necessary, future cohorts. This differs from the short-term responses in Section 4.3, which are directed at reducing feed input or biomass within the current production cycle.

A reduction in farming intensity may include lowering stocking densities, reducing the number of fish stocked, reducing the target harvest size range, or otherwise adjusting the production strategy to reduce peak biomass and feed inputs. The scale, duration and location of any reduction will be informed by monitoring results, the likely cause and persistence of the effect, and advice from a SQEP.

4.4.3 Relocation of farms

Where monitoring and expert assessment indicate that seabed or water column effects cannot be adequately mitigated at the existing location, relocation of one or more farms may be required. This would be undertaken in accordance with Condition 83, and may involve movement of a farm within 500 m of the originally consented location or relocation to an alternative approved site, subject to the preparation and approval of a Farm Movement Plan (FMP).

In some circumstances, a combination of these corrective tools may be necessary to effectively address seabed effects and ensure ongoing compliance with environmental performance requirements.

Following the completion of an effects-based corrective management response, documentation will be provided to ES for review and approval. This will include supporting SQEP advice and report, and an outline of the proposed changes and their anticipated environmental outcomes. If required, a Farm Movement Plan (Condition 83) will also be prepared and submitted. This EMMP will be updated in relation to monitoring plans, if required, to ensure they remain fit for purpose and responsive to observed environmental effects.

5. ADDITIONAL MATTERS

5.1 BENTHIC MODELLING REVIEW AND VALIDATION FRAMEWORK

The following framework defines the requirements for ongoing model review, formal model validation, and re-modelling to support progression between development stages. The framework combines routine monitoring during Stage 1 operations with a formal validation assessment prior to any progression to Stage 2. This approach ensures that future predictions are informed by empirically tested, site-specific operational and environmental data.

5.1.1 Water column exclusion

Section 5 does not apply to the water column model.

Water column model validation is addressed through the routine water column monitoring programme described in Section 3. Water column results are assessed on a month-by-month basis against the relevant adaptive management triggers and compliance limits for total nitrogen, DO and chlorophyll-a. This provides a direct and ongoing test of whether monitored water column conditions remain consistent with the scale of effects predicted in the Water Column Assessment. Accordingly, a separate formal water column model validation framework is not required.

If water column adaptive management triggers or compliance limits are exceeded frequently, persistently, or in a pattern that indicates a departure from predicted effects, the consent holder will review the monitoring results and relevant supporting information to determine the likely cause. Where the review indicates that the exceedances may be attributable to farming activities, or that the original water column predictions may no longer be fit for purpose, further assessment may be undertaken. This may include targeted investigations, refinement of the monitoring programme, or repeat water column modelling where this is necessary to understand the cause and significance of the deviation from predicted effects.

Water column monitoring locations are linked to the location of the relevant farm or farm block. If a farm or block is moved in accordance with the consent conditions, the associated farm water quality and farm DO monitoring locations will move with it, retaining the same offset distances and tidal-state approach described in Section 3. Because water column conditions are dynamic and respond rapidly to changing hydrodynamic and operational conditions, legacy water column effects are not expected to persist at previous farm monitoring locations once farming activity has moved. Ongoing monitoring at locations referenced to the moved farm or block is therefore sufficient for assessing water column effects following relocation.

5.1.2 Stage 1 depositional model review and verification

Routine monitoring during Stage 1 will provide ongoing verification of modelled depositional patterns and predicted environmental effects. Monitoring results, including any exceedances of AMTs, will be used to identify whether observed environmental responses remain consistent with predicted effects and model assumptions.

Where monitoring identifies responses that are inconsistent with (i.e. worse than) predicted depositional patterns, effect magnitudes, or spatial extents, monitoring results will be reassessed against predicted depositional footprints and benthic response patterns to determine whether model assumptions remain appropriate. This will trigger further investigation and, where necessary, model review, recalibration, or adaptive management responses.

5.1.3 Depositional model validation requirements for progression to Stage 2

Progression to Stage 2 farming, involving the addition of a second block of 10 pens per farm site (B blocks) and an increase in feed discharge to 25,000 tonnes per year, will require completion of a formal model validation exercise.

The validation exercise will use Stage 1 monitoring and operational data, including actual feed inputs and measured environmental responses, to quantitatively and qualitatively assess the predicted accuracy of the depositional model under operational conditions.

The validation assessment will evaluate:

- the accuracy of predictive depositional patterns;
- the alignment between predicted and observed benthic effects;
- the appropriateness of model assumptions, parameters and calibration inputs;
- whether the model remains fit-for-purpose for predicting Stage 2 effects.

Progression to Stage 2 may be supported where:

- monitoring results demonstrate that environmental effects remain within predicted and acceptable limits during Stage 1 production, as demonstrated by compliance with consent conditions; and
- the validated model demonstrates adequate predictive performance for Stage 2 scenario assessment.

5.2 ANNUAL MONITORING REPORT REQUIREMENTS

An Annual Monitoring Report will be prepared by a SQEP following each full-suite monitoring event. The primary purpose of the report is to present the results of all environmental monitoring undertaken during the preceding monitoring year for each farm and the outcomes of associated compliance assessments, and to evaluate environmental performance relative to predicted effects.

The report will include the following:

- A summary of farm operations and environmental monitoring undertaken during the reporting period in accordance with consent conditions, including monitoring within the EQZ and in accordance with Appendix C of the resource consent;
- A summary and assessment of monitoring results, including compliance with consent conditions and AMT, and any exceedances or non-compliances identified during the reporting period;
- A comparison of observed environmental conditions against model predictions, including depositional patterns and the extent and relative magnitude of the ZME, primary footprint and OLE boundaries.

- An assessment of temporal trends, spatial patterns, and any cumulative effects identified through monitoring over time.
- Any recommendations for changes to the EMMP, modelling approaches, or farm management practices, including adaptive management responses where required;
- A record of any changes to monitoring methods, locations, timing, and frequency for the purpose of maintaining a continuous monitoring record; and

6. REFERENCES

[ASC] Aquaculture Stewardship Council. 2022. Whitepaper on standards for aquaculture impacts on benthic habitat biodiversity and function. Utrecht: Aquaculture Stewardship Council.

[ANZG] Australian and New Zealand Governments. 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Canberra (ACT): Australian and New Zealand Governments and Australian state and territory governments. https://www.waterquality.gov.au/anz-guidelines

Bennett H, Smeaton M, Floerl L, Casanovas P. 2025. Assessment of seabed effects associated with farming salmon offshore of northern Stewart Island / Rakiura. Nelson: Cawthron Institute. Cawthron Report 4195. Prepared for Ngāi Tahu Seafood Resources.

Cranford P, Brager L, Elvines D, Wong D, Law B. 2020. A revised classification system describing the ecological quality status of organically enriched marine sediments based on total dissolved sulfides. Marine Pollution Bulletin. 154:111088.

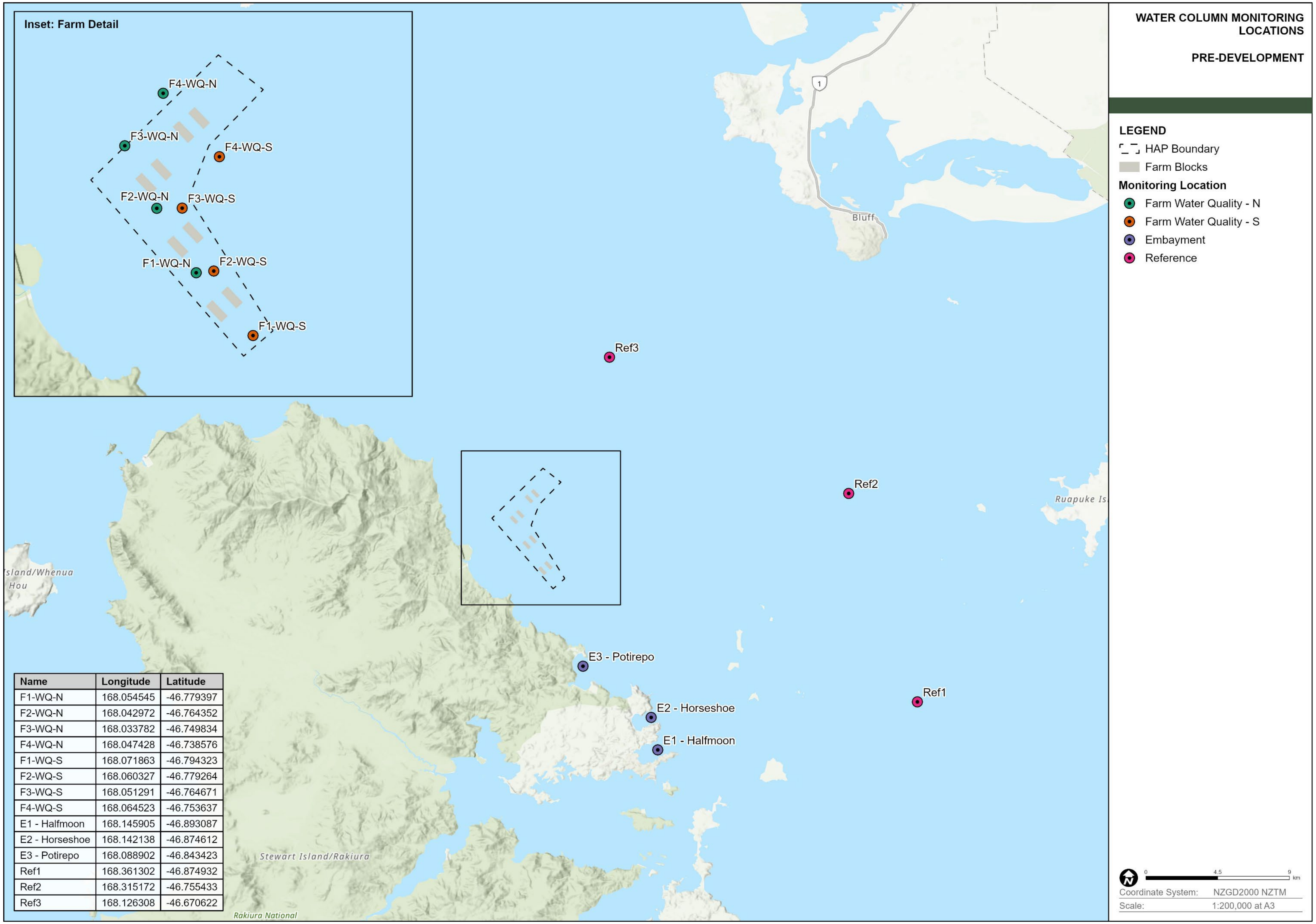
Fletcher L, Bennett H, Elvines D, Preece M, Broekhuizen N, Ford R, Heath P, Murray C, Jorgensen E, Wade O, et al. 2022. Best management practice guidelines for salmon farms in the Marlborough Sounds: Part 1: Benthic environmental quality standards and monitoring protocol (Version 1.2 August 2022). Wellington: Ministry for Primary Industries. New Zealand Aquatic Environment and Biodiversity Report No. 294.

Giles H, Baxter A, Taylor D, Elvines D, Neale D, Jorgensen E, James M, Bunce M, Broekhuizen N, Wade O, et al. 2021. Best practice guidelines for benthic and water quality monitoring of open ocean finfish culture in New Zealand. Wellington: Ministry for Primary Industries. New Zealand Aquatic Environment and Biodiversity Report No. 278.

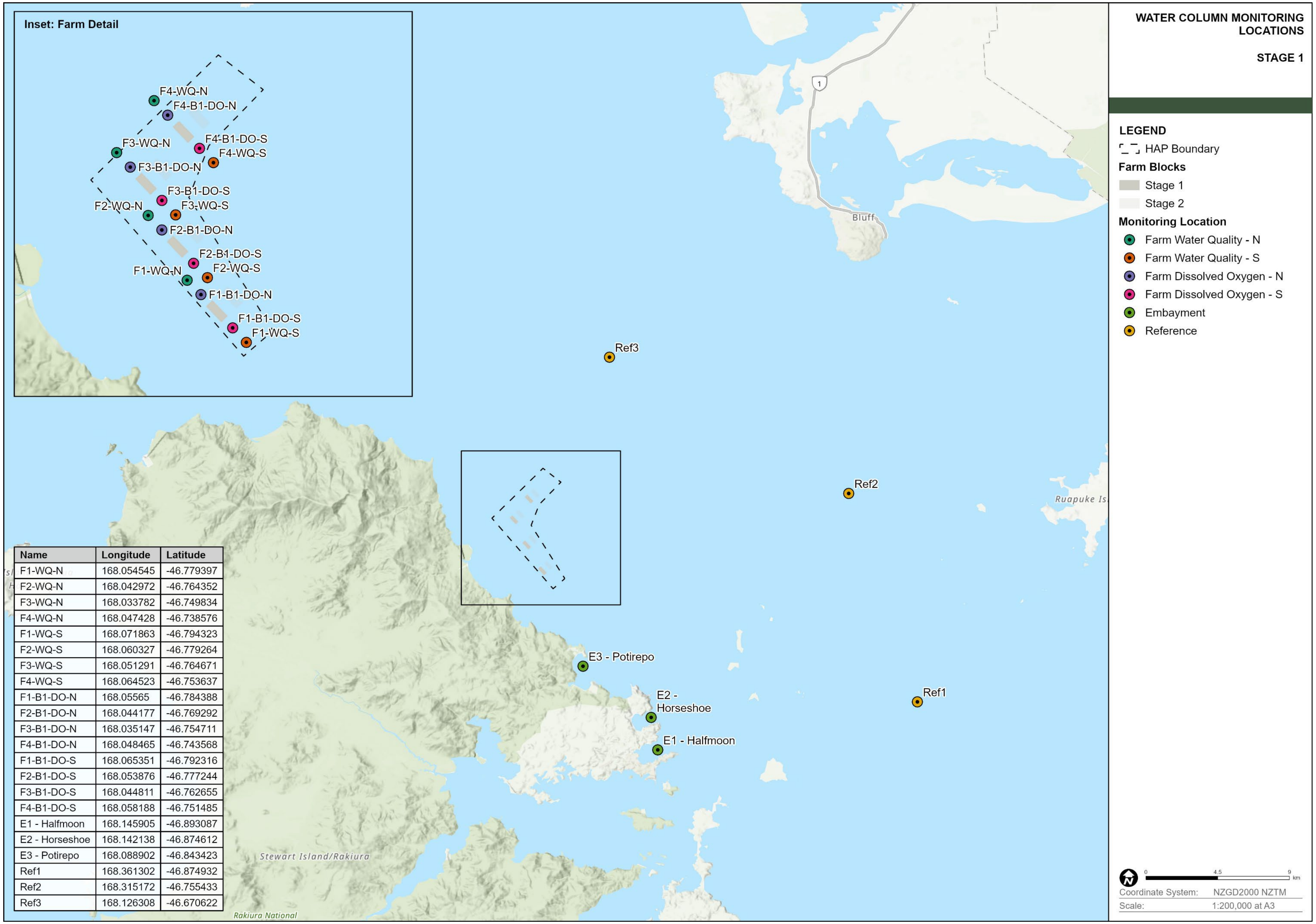
Keeley N, Dunlop K, Laroche O, Hansen PK, Angell IL, Rudi K. 2025. An approach for quantifying the influence of fish farm waste on hard-bottom habitats. Marine Pollution Bulletin. 217:118039.

McGrath E, Bennett H. 2025. Recommendations for seabed monitoring at the proposed Hananui salmon farming area. Nelson: Cawthron Institute. Cawthron Report 4195. Prepared for Ngāi Tahu Seafood Resources.

7. APPENDIX 1 – WATER COLUMN MONITORING MAPS



Name	Longitude	Latitude
F1-WQ-N	168.054545	-46.779397
F2-WQ-N	168.042972	-46.764352
F3-WQ-N	168.033782	-46.749834
F4-WQ-N	168.047428	-46.738576
F1-WQ-S	168.071863	-46.794323
F2-WQ-S	168.060327	-46.779264
F3-WQ-S	168.051291	-46.764671
F4-WQ-S	168.064523	-46.753637
E1 - Halfmoon	168.145905	-46.893087
E2 - Horseshoe	168.142138	-46.874612
E3 - Potirepo	168.088902	-46.843423
Ref1	168.361302	-46.874932
Ref2	168.315172	-46.755433
Ref3	168.126308	-46.670622



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F3-WQ-S	168.051291	-46.764671
F4-WQ-S	168.064523	-46.753637
F1-B1-DO-N	168.05565	-46.784388
F2-B1-DO-N	168.044177	-46.769292
F3-B1-DO-N	168.035147	-46.754711
F4-B1-DO-N	168.048465	-46.743568
F1-B1-DO-S	168.065351	-46.792316
F2-B1-DO-S	168.053876	-46.777244
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F4-B1-DO-S	168.058188	-46.751485
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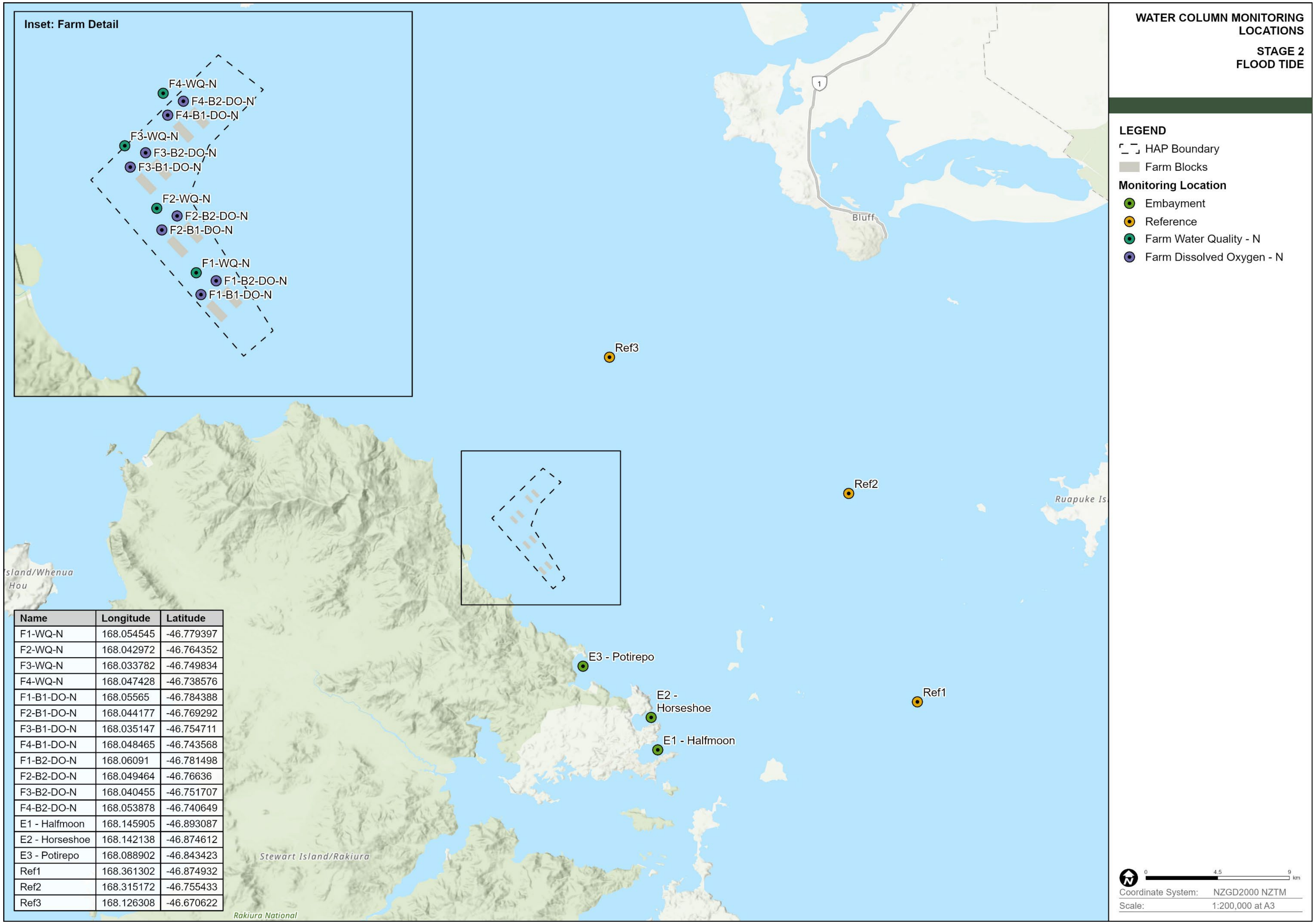

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F1-B1-DO-N	168.05565	-46.784388
F2-B1-DO-N	168.044177	-46.769292
F3-B1-DO-N	168.035147	-46.754711
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F3-B2-DO-N	168.040455	-46.751707
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E1 - Halfmoon	168.145905	-46.893087
E2 - Horseshoe	168.142138	-46.874612
E3 - Potirepo	168.088902	-46.843423
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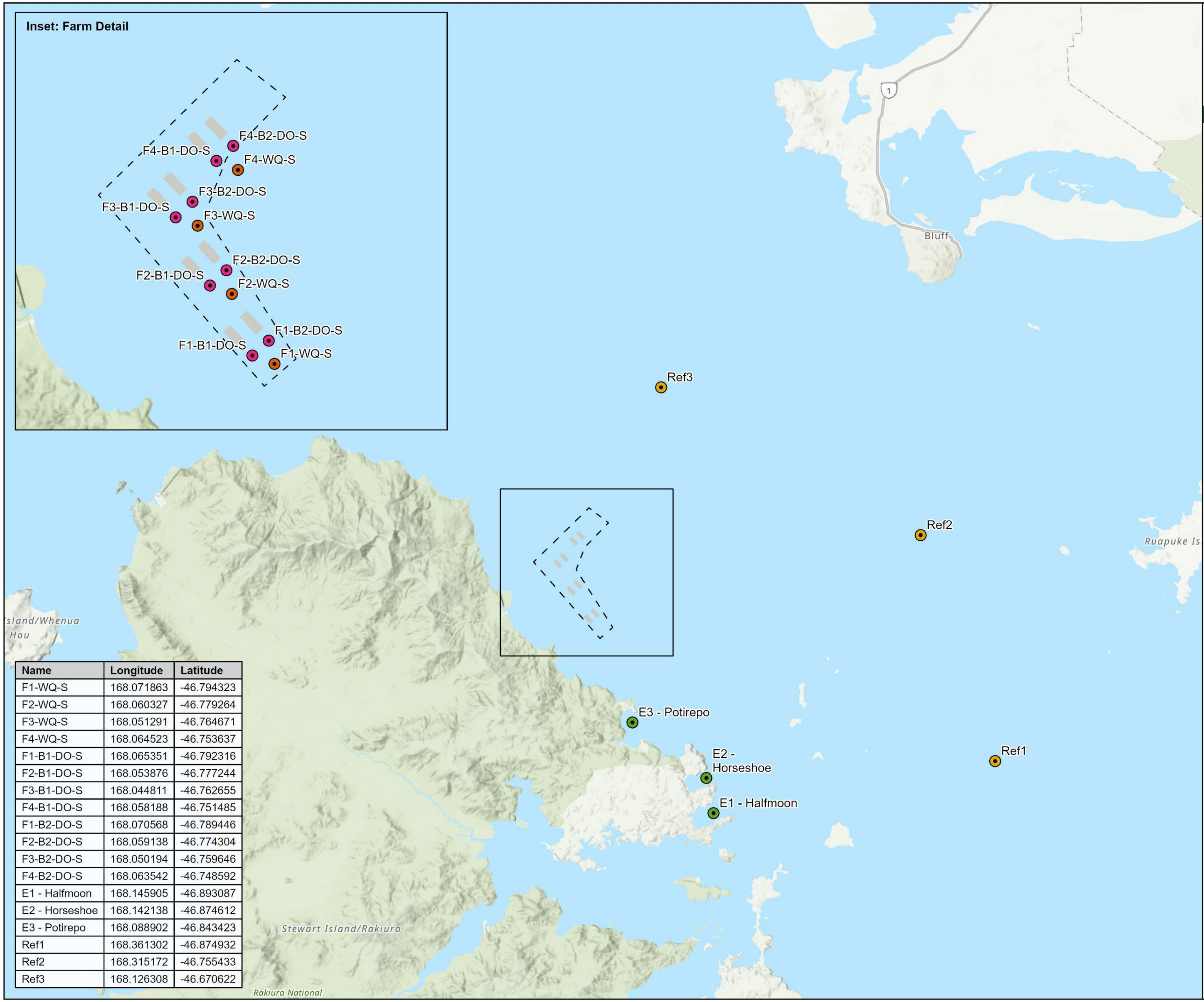
Ref2	168.315172	-46.755433
Ref3	168.126308	-46.670622

WATER COLUMN MONITORING LOCATIONS

STAGE 2
EBB TIDE



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F1-B1-DO-S	168.065351	-46.792316
F2-B1-DO-S	168.053876	-46.777244
F3-B1-DO-S	168.044811	-46.762655
F4-B1-DO-S	168.058188	-46.751485
F1-B2-DO-S	168.070568	-46.789446
F2-B2-DO-S	168.059138	-46.774304
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E2 - Horseshoe	168.142138	-46.874612
E3 - Potirepo	168.088902	-46.843423
Ref1	168.361302	-46.874932
Ref2	168.315172	-46.755433
Ref3	168.126308	-46.670622

LEGEND

- HAP Boundary
- Farm Blocks

Monitoring Location

- Embayment
- Reference
- Farm Water Quality - S
- Farm Dissolved Oxygen - S

0 4.5 9 km

Coordinate System: NZGD2000 NZTM
Scale: 1:200,000 at A3