



Rangitīkei Estuary

2026 broad-scale intertidal habitat mapping

July 2026

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Rangitikei Estuary: 2026 broad-scale intertidal habitat mapping

Prepared for
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Cover photo: Sea primrose (*Samolus repens*) herbfield on the mid-estuary intertidal flats, Rangitikei Estuary, January 2026.

All photos presented in the report are from the January 2026 survey unless specified otherwise.

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GLOSSARY

AA	Affected Area (OMBT metric)
AIH	Available Intertidal Habitat (OMBT metric)
aRPD	Apparent Redox Potential Discontinuity
CSR	Current Sedimentation Rate
DO	Dissolved Oxygen
EQR	Ecological Quality Rating (OMBT metric)
ETI	Estuary Trophic Index
HEC	High Enrichment Conditions
HRC	Horizons Regional Council
LCDB	Land Cover Data Base
NEMP	National Estuary Monitoring Protocol
NSR	Natural Sedimentation Rate
OMBT	Opportunistic Macroalgal Blooming Tool
QA/QC	Quality Assurance/Quality Control
SOE	State of the Environment (monitoring)
SSRTRE	Shallow, Short Residence-time Tidal River Estuary
TN	Total Nitrogen

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SUMMARY

In January 2026, broad-scale intertidal habitat mapping was undertaken in Rangitikei Estuary, one of several estuaries in Horizons Regional Council's (HRCs) long-term State of the Environment (SOE) monitoring programme. This report describes dominant intertidal substrate and vegetation, and compares findings with 2018 data. Key results are summarised below and assessed against condition rating criteria in the table.

- The Rangitikei Estuary remains a high-value tidal river estuary supporting extensive salt marsh and important ecological and cultural values. Broad-scale indicators showed no meaningful change in overall estuary condition since 2018.
- Salt marsh was rated 'Very Good', occupying 51.4% of the available intertidal habitat. However, historical assessment indicates that at least 50% of the estuary's natural salt marsh has been lost, primarily through changes in river morphology followed by reclamation, drainage and conversion to pasture.
- Mud-elevated substrate ($\geq 25\%$ mud) remained the principal ecological pressure, covering 61.1% of the available intertidal habitat, and receiving a 'Very Poor' condition rating, consistent with 2018.
- Despite very high nutrient inputs, the estuary's dynamic hydrology currently appears to limit the development of nuisance macroalgal blooms, with no opportunistic macroalgae or areas of High Enrichment Conditions (HEC) recorded, resulting in a eutrophication rating of 'Very Good'.

Broad-scale indicators	Unit	2018*	2026
200m terrestrial margin	% densely vegetated	40.5	45
Salt marsh	% of intertidal area	36.1	51.4
	% loss from baseline	baseline	15.3(↑)
	% loss from historic baseline ¹	Estimated >50%	Estimated >50%
Mud-elevated substrate	% AIH ² area ($\geq 25\%$ mud)	61	61.1
	% increase from baseline in AIH	baseline	0
Macroalgae (OMBT-EQR ³)	Ecological Quality Rating (EQR)	1	1
High Enrichment Conditions	ha	0	0
Estuary-wide indicators ⁴			
Sedimentation rate	CSR:NSR ⁵ ratio	-	1.8
Sedimentation rate	mm/yr	-	4.6

*2018 GIS layers QA/QC checked in 2026 - values may differ slightly from original report. ¹Natural extent estimate based on expert opinion; ²AIH (Available Intertidal Habitat) excludes salt marsh area; ³Opportunistic Macroalgal Blooming Tool (OMBT) scores have been updated following QA/QC; ⁴ Estuary-wide sedimentation indicators derived from catchment models (e.g., Hicks et al. 2019). ⁵CSR=Current Sedimentation Rate, NSR=Natural Sedimentation Rate. dash=no data.

Very Good	Good	Fair	Poor	Very Poor
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KEY RECOMMENDATIONS

Monitoring

- Continue broad-scale monitoring 10-yearly to track major changes in habitat and pressures on the estuary.
- If undertaking other fieldwork in or near the estuary, assess any readily observable indicators of degradation, e.g., macroalgal or microalgal blooms, vehicle disturbance, invasive plant presence/spread, salt marsh loss.

Management

- Continue catchment management programmes to reduce sediment and nutrient inputs to the estuary, with particular emphasis on erosion-prone parts of the catchment, and opportunities to improve riparian management.
- Protect remaining salt marsh from further modification; identify opportunities to restore historical salt marsh; develop a long-term strategy for the managed retreat of salt marsh under sea-level rise.
- Monitor and control *Phragmites karka* and other invasive plant species to minimise their spread into indigenous salt marsh communities; work with stakeholders to minimise vehicle access through sensitive salt marsh habitats and other vulnerable intertidal areas where avoidable damage is occurring.

1. INTRODUCTION

Estuary monitoring is undertaken by most councils in Aotearoa New Zealand as part of their State of the Environment (SOE) programmes. The most widely used monitoring framework is the National Estuary Monitoring Protocol (NEMP) (Stevens et al. 2025), which provides a scientifically robust, cost-effective and standardised approach for assessing estuarine ecological condition. The results establish a baseline against which future changes can be assessed and improve understanding of the effects of human activities on estuarine ecosystems.

The NEMP comprises two complementary survey approaches:

- Broad-scale mapping of intertidal habitats, typically undertaken every 5-10 years (Roberts et al. 2025b).
- Fine-scale monitoring of estuarine biota and sediment quality, undertaken at fixed sites and typically repeated at approximately five-year intervals following the establishment of a baseline (Forrest et al. 2025).

Together, these approaches are designed to detect changes in estuarine habitats (e.g., salt marsh and seagrass extent), assess symptoms of eutrophication (e.g., nuisance macroalgae, organic enrichment and anoxia), and evaluate changes in sediment condition resulting from nutrient enrichment, fine sediment accumulation, and contaminants.



Fig. 1. Location of Rangitikei Estuary, near Tangimoana.

Horizons Regional Council (HRC) has undertaken SOE monitoring of selected estuaries since 2016. On the west coast these include the Whanganui, Whangaehu, Rangitikei, Manawatū, Ōhau and Waikawa estuaries, while east coast monitoring has included the Tautāne, Wainui, Ākitio and Owāhanga estuaries. Smaller estuaries have been assessed through region-wide habitat mapping and vulnerability assessments (Robertson & Stevens 2016; Roberts et al. 2025a).

Broad-scale NEMP monitoring of Rangitikei Estuary (hereafter Rangitikei) commenced in 2018 (Stevens 2018). This report presents the results of repeat broad-scale intertidal habitat mapping undertaken on 27 January 2026 (Fig. 1). The survey assessed intertidal substrate, salt marsh, seagrass and macroalgal extent, and compared the findings with the 2018 survey. As the survey required the use of a small vessel, synoptic water quality measurements were also collected to provide additional context on estuarine condition.

2. OVERVIEW OF RANGITĪKEI ESTUARY

The Rangitikei catchment is dominated by sheep and beef farming, with smaller areas of dairying concentrated in the lower catchment (Fig. 2). Catchment geology comprises predominantly well-drained gravels in the lower catchment, transitioning to sandstone and other rock types in the mid and upper catchment. Hydrology has been modified by the Tongariro Power Scheme, reducing mean river flows by ~15% (Roberts et al. 2025a). Water quality monitoring of the Rangitikei River at McKelvies indicates poor water clarity, high turbidity and elevated total phosphorus concentrations (lawa.org.nz), reflecting the influence of catchment land use. Recreational water quality monitoring within the estuary has also recorded elevated *Escherichia coli* (*E. coli*) concentrations, resulting in a long-term water quality rating of 'Poor' (lawa.org.nz).

Despite these modifications, the estuary retains extensive fringing salt marsh and provides important habitat for indigenous fish and bird species. The tidal reaches of the Rangitikei are recognised as a Site of Significance - Riparian (SOS-R) under Schedule D9 of the Horizons One Plan (HRC 2026), reflecting the importance of its estuarine sand, gravel and tidal mudflat habitats for indigenous wading birds (Lambie 2007). Recreational use is high, with the estuary and

adjacent beach supporting activities such as boating, fishing, whitebaiting, hunting and vehicle access.

An Ecological Vulnerability Assessment (EVA) undertaken by Roberts et al. (2025a) identified Rangitikei as vulnerable to macroalgal blooms due to

elevated nutrient inputs from the catchment. However, the estuary's short residence time and high flushing capacity are likely to export much of the nutrient and sediment load to the coastal environment, reducing the likelihood of persistent macroalgal accumulations within the estuary.



Comparison of Rangitikei Estuary in 1939 (left) and 2026 (right), showing the transition of extensive lower estuary intertidal flats to vegetated habitats, changes in the river entrance and tidal channels, and surrounding land use. Historical imagery: Retrolens (AI-stitched mosaic); 2026 imagery: LINZ.

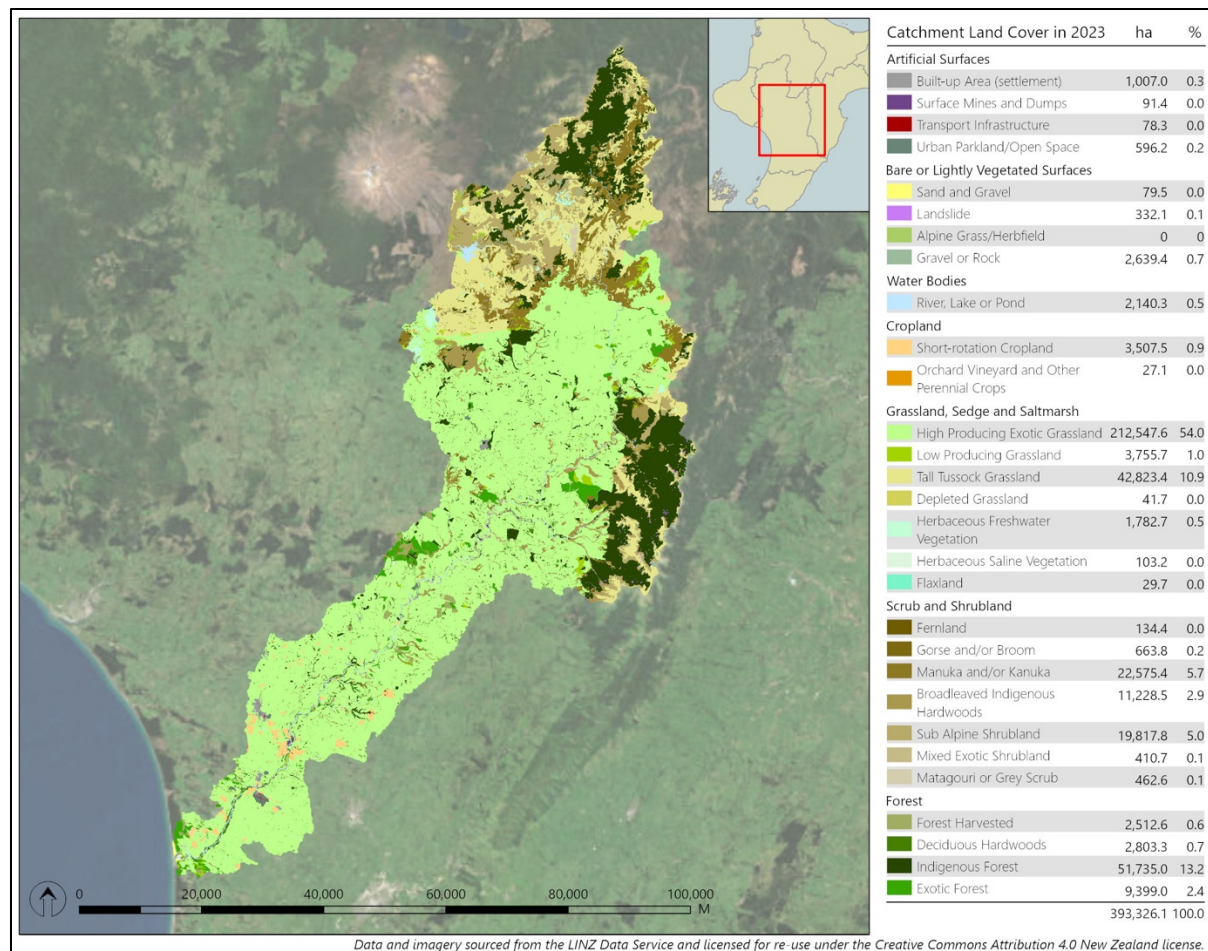


Fig. 2. Rangitikei Estuary catchment land use classifications from HRC. Catchment boundary from CLUES (v10.8).

3. METHODS

3.1 OVERVIEW

Broad-scale mapping of substrate and vegetation was carried out on 27 January 2026. Fig. 4 (next page) shows the estuary area surveyed. The survey approach and indicators are summarised below and in Table 1, with further detail on sampling methods and analyses provided in Appendix 1.

3.2 BROAD-SCALE HABITAT MAPPING

Broad-scale mapping characterised the dominant intertidal substrates and vegetation types (summarised in Table 1), with the spatial extent and location of different habitat types, and temporal changes in features, providing valuable indicators of estuary condition. Mapping was based on updated NEMP methods (Roberts et al. 2025b), and additions by Salt Ecology described in Appendix 1.

The approach combined the use of aerial imagery, detailed field ground-truthing (e.g., annotation of aerial images, spot data on macroalgae (if present) and substrate type, and field photos), and post-field digital mapping using Geographic Information System (GIS) technology. Imagery used was ~0.1m/pixel resolution Manawatū Whanganui urban colour imagery flown by LINZ in 2026.

In 2026, QA/QC procedures described in Appendix 1, were applied through the phases of field data collection, digitising, and GIS data collation and processing. QA/QC procedures were also applied to existing GIS layers for 2018, with field codes, slivers, gaps, and overlapping polygons updated following the guidance provided in Roberts et al. (2025). These data

have been provided to HRC as a separate electronic output, with updated summary data presented in the current report.

The main broad-scale survey elements were as follows:

- Substrate mapping qualitatively classified sediments (e.g., mud, sand, gravel, cobble, bedrock) according to the scheme described in Table A1.2 of Appendix 1. As mud is a key stressor on estuary habitats, an important focus was to map the spatial extent of soft-sediment (mud and sand), with validation samples collected for quantitative laboratory analyses of grain size at eight locations (Appendix 2).
- Vegetation mapping characterised dominant features, namely salt marsh (e.g., rushland, herbfield, estuarine scrub) and, where present, seagrass (*Zostera muelleri*), and the occurrence and extent of algae species that can be symptomatic of estuary degradation. Particularly important among the latter are nuisance 'opportunistic' macroalgae that can 'bloom' in response to conditions such as excess nutrient inputs (e.g., species of *Ulva* and *Gracilaria*).

To assist with percent cover estimates of seagrass and opportunistic macroalgae (when present), NEMP visual rating scales and field guides, as shown in Fig. 3, were used. For macroalgae, if present, field data collection included wet-weighing of macroalgal biomass, to enable calculation of Opportunistic Macroalgal Blooming Tool (OMBT) scores. The OMBT is a multi-metric index that combines different measures of opportunistic macroalgal proliferation to inform ecological condition (see Table 1; Appendix 1; WFD-UKTAG 2014; Stevens et al. 2022).

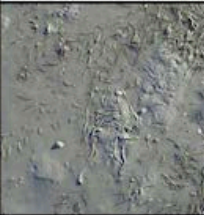
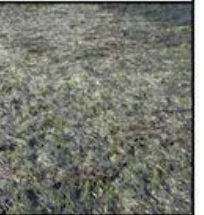
Very Sparse	Sparse	Low-Moderate	High-Moderate	Dense	Complete
					
1 to <10 %	10 to <30 %	30 to <50 %	50 to <70 %	70 to <90 %	90-100 %
					

Fig. 3. Visual rating scale for % cover estimates of macroalgae and seagrass. Modified from FGDC (2012).



Fig. 4. Estuary survey area (black outline). The location of sediment validation samples is shown in Appendix 2.

Table 1. Broad-scale indicators of estuary condition that are assessed by field mapping and related methods.

Indicator	General rationale	Method description
Terrestrial margin vegetation	A densely vegetated terrestrial margin filters and assimilates sediment and nutrients, is a buffer to introduced grasses and weeds, is an important food source and habitat for a variety of species and, in waterway riparian zones, provides shade that moderates stream temperature fluctuations, and improves estuary biodiversity.	Mapped based on areal extent and classified using the LCDB5 classes, dominant species are also recorded as metadata where known.
Substrate type	High substrate heterogeneity generally supports high estuary biodiversity. Increases in fine sediment (i.e., mud <63µm) can reduce heterogeneity, concentrate contaminants, nutrients and organic matter, and lead to degradation of benthic communities by displacing sensitive species including shellfish. Enrichment of muddy sediments (i.e., high TOC and nutrients; Table 2) can additionally fuel algal growth and deplete sediment oxygen.	Mapped based on areal extent and classified using a modified version of the NEMP system (see Table A1.2, Appendix 1). The improved classification framework, developed by Salt Ecology, characterises substrate type based on mud content and is supported by grain size validation samples. Substrate type is also recorded beneath vegetation.
Salt marsh	Salt marsh (vegetation able to tolerate saline conditions where terrestrial plants are unable to survive) is important in estuaries as it is highly productive, naturally filters and assimilates sediment and nutrients, mitigates shoreline erosion, and provides an important habitat for a variety of species including insects, fish and birds.	Mapped based on areal extent. Dominant salt marsh species are recorded and categorised into sub-classes (e.g., rushland, herbfield). Pressures on salt marsh (e.g., drainage, grazing, erosion) are also recorded.
Seagrass	Seagrass (<i>Zostera muelleri</i>) beds enhance primary production and nutrient cycling, stabilise sediments, elevate biodiversity, and provide nursery and feeding grounds for invertebrates and fish. Seagrass is vulnerable to muddy sediments in the water column (reducing light), sediment smothering (burial), excessive nutrients (primarily secondary impacts from macroalgal smothering), and sediment quality (e.g., low oxygenation).	Mapped based on areal extent, and percent cover recorded within each seagrass patch. Pressures on seagrass beds (e.g., sediment or macroalgae smothering, leaf discolouration) are also recorded.
Opportunistic macroalgae	Opportunistic macroalgae (primarily species of <i>Gracilaria</i> and <i>Ulva</i>) are a symptom of estuary eutrophication (nutrient enrichment). At nuisance levels, these algae can form mats on the estuary surface that can adversely impact underlying sediments and fauna, other algae, fish, birds, seagrass, and salt marsh. The Opportunistic Macroalgal Blooming Tool (OMBT) is a multi-metric index that combines different measures of macroalgae (see text) and is calculated as an indicator of ecological condition.	Mapped based on areal extent. Species, percent cover, biomass and level of entrainment are recorded in each macroalgae patch to apply the OMBT (WFD-UKTAG 2014). The application of the OMBT incorporates New Zealand-based improvements described in (Stevens et al. 2022).
High Enrichment Conditions	HECs characterise substrates with extreme levels of organic or nutrient enrichment (i.e., eutrophication). HECs are sediments depleted in (or devoid of) oxygen, which have a very shallow redox boundary (e.g., <10mm), an intense black colour in the sediment profile, and typically have a strong hydrogen sulfide (i.e., rotten egg) smell. Sediment samples are likely to have a quantitatively high nutrient or organic content (e.g., TOC >2%).	Mapped based on areal extent. The HEC metric is intended to highlight areas of severe enrichment that may require further investigation, e.g., sediment degradation within stable, entrained, high (≥50% cover) beds of opportunistic macroalgae, or within extensive surface microalgae or filamentous macroalgae growths.

3.3 ASSESSMENT OF ESTUARY CONDITION

In addition to the authors' expert interpretation of the data and summaries, results are assessed against 'condition ratings' for estuary health (Table 2), which are based on recent work conducted for the Ministry for the Environment (Stevens et al. 2024). These metrics assign different indicators to one of five colour-coded 'health status' bands, as shown in Table 2.

Salt marsh and seagrass rely on assessment of differences between current and baseline state, or natural historical salt marsh extent, if known. Data from Stevens (2018) were used as baseline state. To date, the natural historical extent of the estuary has not been quantified.



Salt marsh growing in firm sand in the lower estuary.



Moanaroa Conservation Area in the northern arm of Rangitikei.



Mud deposits along a middle estuary channel margin.

Table 2. Indicators and condition ratings used to assess results in the current report. See Glossary for definitions.

Indicator	Unit	Very Good	Good	Fair	Poor	Very Poor
Mapped indicators						
200m terrestrial margin ¹	% densely vegetated	≥80 to 100	≥50 to <80	≥25 to <50	≥10 to <25	<10
Salt marsh	% of intertidal area ¹	≥20	≥10 to <20	≥5 to <10	>0 to <5	≤0
	% loss from baseline ²	≤0	>0 to <5	≥5 to <10	≥10 to <20	≥20
	% loss from historic baseline ²	<20	≥20 to <40	≥40 to <60	≥60 to <80	≥80
Mud-elevated substrate	% AIH ³ ≥25% mud ¹	<1	≥1 to <5	≥5 to <15	≥15 to <25	≥25
	% increase from baseline ² within AIH ³	≤0	>0 to <5	≥5 to <10	≥10 to <20	≥20
Seagrass	% AIH ³ (≥1% cover)	----- No rating -----				
	% loss from baseline ² (≥50% cover)	≤0	>0 to <5	≥5 to <10	≥10 to <20	≥20
Macroalgae	OMBT ⁴ Ecological Quality Rating	≥0.8 to 1.0	≥0.6 to <0.8	≥0.4 to <0.6	≥0.2 to <0.4	<0.2
High Enrichment Conditions ^{1,5}	ha	<0.5	≥0.5 to <5	≥5 to <20	≥20 to <50	≥50
	% of AIH ³	<1	≥1 to <5	≥5 to <10	≥10 to <20	≥20
Modelled indicators⁶						
Mean sedimentation ratio ¹	CSR:NSR ⁷ ratio	1 to 1.1	>1.1 to <2	≥2 to <5	≥5 to <10	>10
Sedimentation rate	mm/yr	<0.5	≥0.5 to <1	≥1 to <2	≥2 to <10	≥10

1. Ratings taken from Stevens et al. (2024) except where noted below.

2. General guidance from previous reports (e.g., Stevens & Robertson 2014; Robertson et al. 2016; Robertson et al. 2017).

3. First measured baseline. Historic baseline estimated using expert opinion and sources like imagery, LiDAR, maps, and photos.

4. AIH = Available Intertidal Habitat - refers to the intertidal area outside of salt marsh.

5. OMBT = Opportunistic Macroalgal Blooming Tool.

6. The worse of the two ratings is used for High Enrichment Conditions.

7. Estuary-wide sedimentation indicators derived from catchment models (e.g., Hicks et al. 2019).

8. CSR = Current Sedimentation Rate; NSR = Natural Sedimentation Rate.

4. BROAD-SCALE RESULTS

A summary of the January 2026 broad-scale mapping survey is provided below. Supporting GIS files have been supplied electronically to HRC, with ground-truthing tracks and field photograph locations shown in Appendix 2. As no intertidal seagrass, opportunistic macroalgae, or High Enrichment Conditions (HECs) were recorded during the survey, these indicators are not discussed further, except for a brief consideration of benthic microalgae.

4.1 TERRESTRIAL MARGIN

Table 3 and Fig. 5 summarise the 200m terrestrial margin land cover surrounding the estuary, while Fig. 6 highlights changes to the estuary boundary since the 2018 survey, most notably the reorientation of the estuary entrance.



Pasture surrounded by tall fescue (*Festuca arundinacea*) in the eastern estuary margin.



Windswept māhoe (*Melicactus ramiflorus*) forming the dominant indigenous woody vegetation along the northern estuary margin.

Overall, dense vegetative cover accounted for 45% of the 200m terrestrial margin in 2026 and is rated 'Fair'. The margin is dominated by low- and high-producing exotic grassland (41.8%), occurring primarily as pasture along the eastern margin of the estuary. The northern and coastal margins support a mosaic of exotic pine forest (12.0%), broadleaved indigenous hardwoods (10.0%) and duneland (7.3%). The duneland is dominated by introduced marram grass (*Ammophila arenaria*), with smaller areas of the native sand-binders spinifex (*Spinifex sericeus*) and pīngao (*Ficinia spiralis*).



Coastal dune system including introduced species such as tree lupin (*Lupinus arboreus*) and marram grass (*Ammophila arenaria*).

Table 3. Summary of 200m terrestrial margin land cover, Rangitikei Estuary, January 2026.

LCDB Class		%Margin
1	Built-up Area (settlement)	3.7
10	Sand or Gravel	7.2
16	Gravel and Rock	0.03
2	Urban Parkland/Open Space	0.9
20	Lake or Pond	0.03
21	River	0.4
40	High Producing Exotic Grassland	8.2
41	Low Producing Grassland	33.6
410	Duneland	7.3
45	Herbaceous Freshwater Vegetation	0.02
46	Herbaceous Saline Vegetation	0.06
5	Transport Infrastructure	0.9
51	Gorse and/or Broom	3.0
54	Broadleaved Indigenous Hardwoods	10.0
56	Mixed Exotic Shrubland	7.4
58	Matagouri or Grey Scrub	4.8
68	Deciduous Hardwoods	0.4
71	Exotic Forest	12.0
Grand Total		100
Total dense vegetated margin (LCDB6 classes 410 and 45-71)		46.0

Comparison with historical aerial imagery indicates substantial long-term changes to the terrestrial margin and estuary morphology. The main river channel has progressively migrated north and west from its 1939 alignment adjacent to Tangimoana (see photos on page 2 of the Overview), with a progressive transition of several former estuarine islands and salt marsh areas into terrestrial habitat as a consequence of sediment accretion and reduced tidal inundation. Subsequent reclamation, drainage and pasture development has resulted in widespread dominance by grassland (tall fescue; *Festuca arundinacea*). Extensive afforestation of the northern coastal dune system with exotic pine has further altered the character of the terrestrial margin, stabilising once dynamic coastal sand dunes.

As in the 2018 survey, the introduced reed *Phragmites karka* was recorded at several locations within and adjacent to the estuary margin, with the largest infestations occurring in side channels of the southern arm near Tangimoana. Given its invasive nature and ability to form dense stands, continued spread into the estuary has the potential to displace indigenous salt marsh vegetation and alter estuarine habitat structure.



Invasive reed *Phragmites karka* growing along the main tidal channel margin (top) and within the middle estuary (bottom).

Vehicle access was common throughout the terrestrial margin, providing numerous access points to the beach and estuary.



Examples of vehicle disturbance within the northern arm, including impacts to salt marsh and herbfield communities.

Historical reclamation and modification of estuarine wetlands and salt marsh have reduced the natural capacity of the estuary margin to filter nutrients and trap sediments. Ongoing vehicle disturbance, invasive species, erosion from river channel migration, and future sea-level rise all represent ongoing pressures on the remaining indigenous estuary margin habitats.



Active bank erosion resulting in the loss of salt marsh, with tall fescue (*Festuca arundinacea*) along the upper bank.

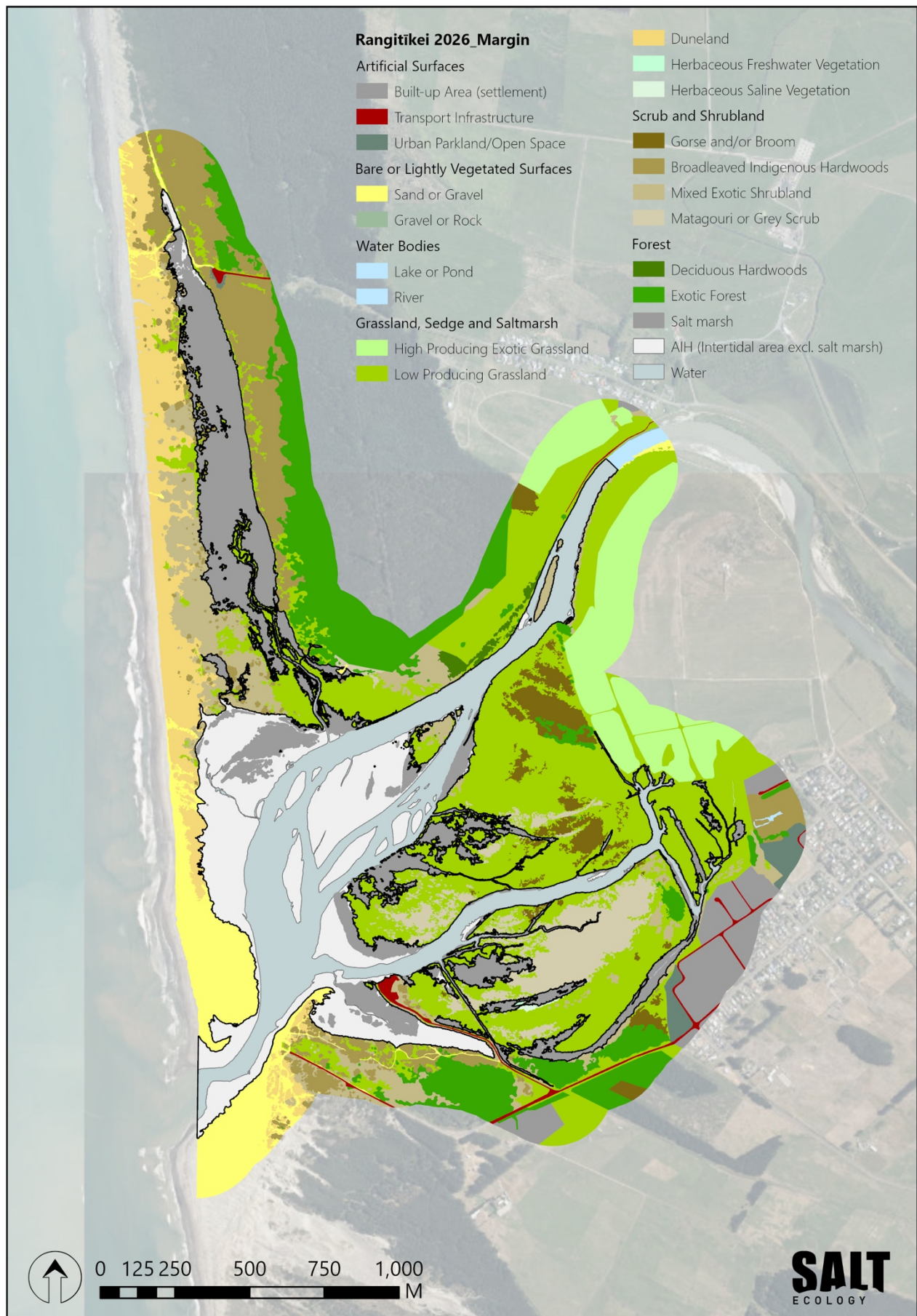


Fig. 5. Map of 200m terrestrial margin land cover, Rangitikei Estuary, January 2026.

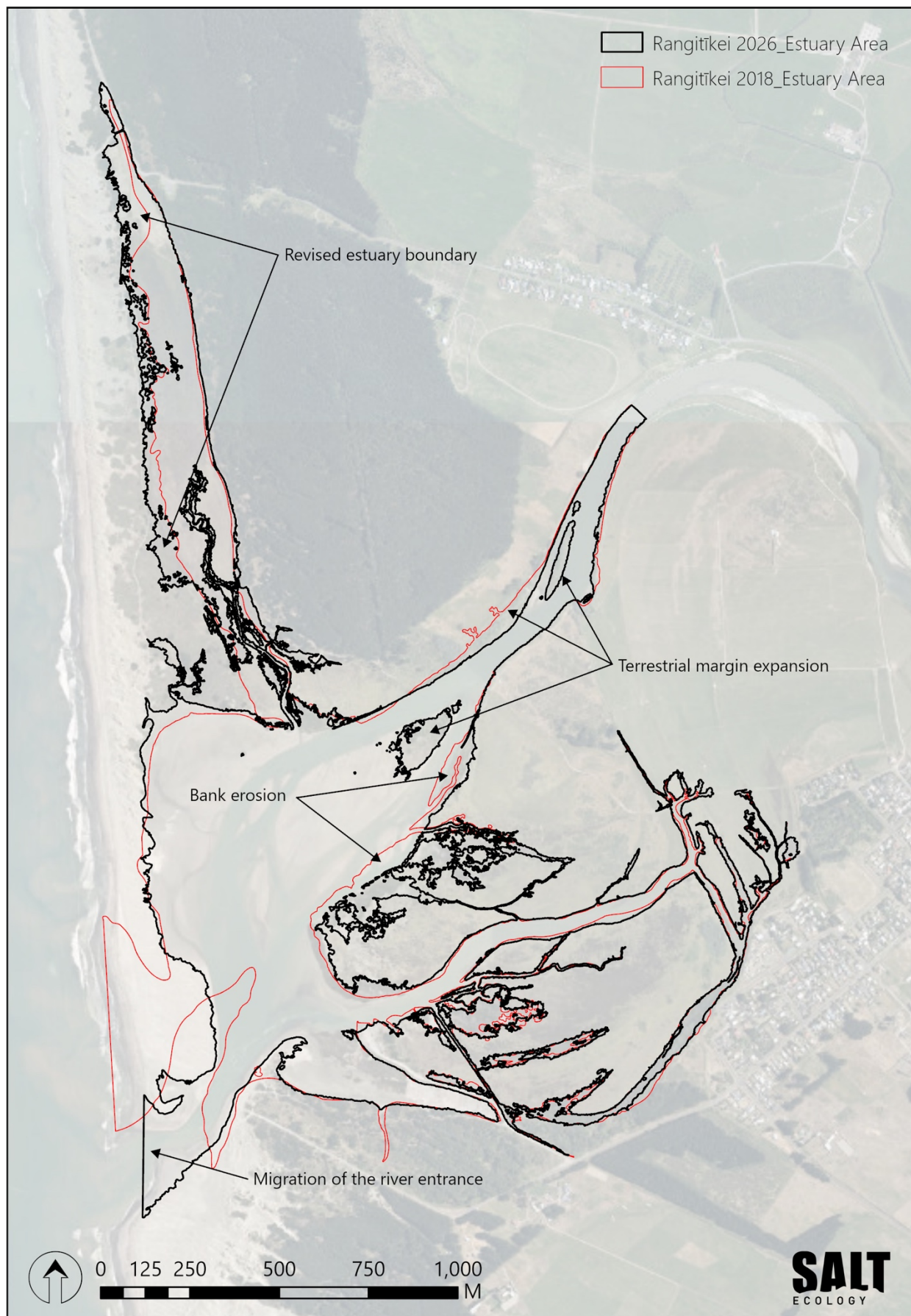


Fig. 6. Map highlighting key changes in the Rangitikei Estuary boundary between 2018 and 2026.

4.2 SALT MARSH

Dominant vegetation types are summarised in Table 4, with sub-dominant species listed in Appendix 3 and additional detail in associated GIS layers. In January 2026, Rangitikei supported 42.6ha of salt marsh, (Table 4; Fig. 7), comprising 51.4% of the 83ha intertidal area, most located within the northern arm and middle part of the estuary (Fig. 7).

Rushland was the dominant community (23.2ha; 54.5% of the total salt marsh area), comprising predominantly sea rush (*Juncus kraussii*), and forming extensive stands throughout the northern arm. Herbfield (6.3ha; 14.8%) was a distinctive feature of the middle intertidal flats and the upper reaches of the northern arm. Sedgeland (11.8ha; 27.8%), dominated by Caldwell's clubrush (*Bolboschoenus caldwellii*), was concentrated along the eastern estuary margin and the upper reaches of the southern arm tidal channels. Estuarine shrubland, dominated by salt marsh ribbonwood (*Plagianthus divaricatus*), was a minor component, confined to small pockets along the upper estuary margins, predominantly within the southern arm, and commonly present alongside sea rush. There was relatively little salt marsh along the lower western estuary margin where the extensive coastal dune system occupies much of the estuary edge. In contrast, the lower eastern intertidal flats supported a mosaic of rushland, sedgeland and herbfield, as well as extensive accumulations of woody debris. Vehicle tracks were widespread throughout accessible areas of the estuary and were observed traversing salt marsh habitats, particularly herbfield communities in the northern arm and across the southern intertidal flats (see photos on the next page).



Extensive sea rush (*Juncus kraussii*) rushland in the northern arm of the estuary

Table 4. Summary of salt marsh area (ha) and percent composition, Rangitikei Estuary, January 2026.

Class	Dominant species*	ha	%
Estuarine Shrub	<i>Plagianthus divaricatus</i>	1.3	3.0
Sedgeland	<i>Bolboschoenus caldwellii</i>	11.8	27.8
Rushland	<i>Juncus kraussii</i>	23.2	54.5
Herbfield	<i>Samolus repens</i>	6.3	14.8
Total		42.6	100

* See Appendix 3 for additional detail on sub-dominant species.

Salt marsh habitat naturally traps fine sediments, with 97.5% of the mapped salt marsh occurring on substrates with elevated mud contents ($\geq 25\%$ mud; Appendix 4). Salt marsh zones are therefore excluded when assessing substrate condition ratings (Table 2) to avoid skewing condition assessments due to salt marsh area.



Sedgeland, dominated by three-square (*Schoenoplectus pungens*) and Caldwell's clubrush (*Bolboschoenus caldwellii*).



Mixed salt marsh herbfield, including *Samolus repens* (primrose) and *Leptinella dioica*, on the middle estuary intertidal flats.

Based on current extent, salt marsh condition is rated as 'Very Good'. Comparison with the 2018 survey indicates a 15.3% increase in mapped salt marsh extent. However, much of this increase is attributable to improved mapping accuracy associated with higher-resolution aerial imagery and refinement of habitat boundaries, rather than expansion of existing salt marsh.

The historical extent of salt marsh has not been quantified, noting that direct comparison with pre-modification conditions is complicated by long-term changes in estuary morphology, including migration of the main river channel and estuary entrance. Nevertheless, historical aerial imagery highlights several parts of the estuary margin that have been reclaimed and converted to pasture. On this basis, the loss from the historical baseline has been estimated at >50%, corresponding to a condition rating of 'Fair' (Table 2).

Localised turf plant (*Limosella lineata*) communities (1.1ha) were recorded during the survey (Appendix 3), but are excluded from the salt marsh area summaries presented in Table 4 because turf plants are not currently recognised as a distinct salt marsh sub-class under the National Estuary Monitoring Protocol (NEMP). This is because turf plant communities occupy both brackish and freshwater-dominated zones, and differ in structure and function from the principal salt marsh communities. Their distribution has nevertheless been mapped to support future revisions to the NEMP classification framework.



Localised turf plant (*Limosella lineata*) community within the western middle estuary (top and bottom).



Mixed three-square (*Schoenoplectus pungens*) and club sedge (*Isolepis cernua*) at the head of the southern arm.



Examples of vehicle disturbance to herbfield communities in the northern arm (top), middle estuary (centre) and southern intertidal flats (bottom).

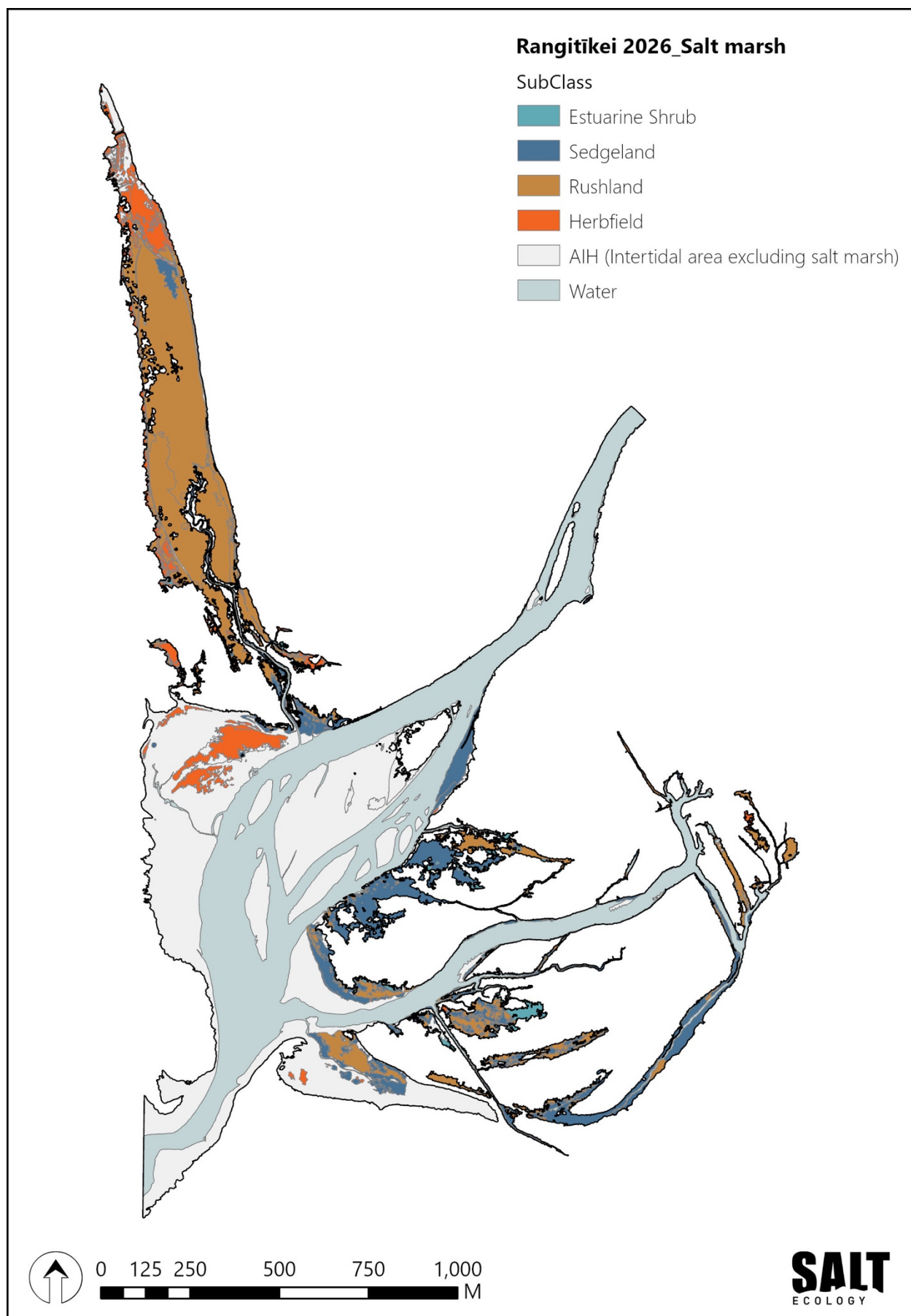


Fig. 7. Salt marsh sub-classes and their distribution, Rangitikei Estuary, January 2026. Salt marsh comprised 43.7ha (~54%) of the 83ha mapped intertidal area.

4.3 SUBSTRATE

In 2026, qualitative substrate classifications were made of intertidal areas, with classifications validated by analyses of sediment grain size (see Appendix 2). Dominant substrate within available intertidal habitat (AIH; the intertidal area excluding salt marsh) is presented in Table 5 and Fig. 8.

Substrate composition varied throughout the estuary. Mobile sands were prominent near the estuary mouth, while firm sand dominated much of the lower estuary. Firm muddy sand was the predominant substrate throughout the middle estuary and northern arm, becoming progressively softer along the margins of the main tidal channels where fine sediments accumulated. Apparent Redox Potential Discontinuity (aRPD) depth generally decreased with increasing mud content, implying reduced sediment oxygenation in finer substrates.

Field observations indicated that parts of the middle and lower estuary were subject to episodic deposition of fine sediment, with recent deposits of fine mud overlying sandy substrates (see adjacent photos). Such deposits likely represent periodic flood-driven sediment inputs that are subsequently redistributed or exported by tidal and river processes, with substrate classification reflecting prevailing conditions at the time of sampling, and changes expected to be temporal variable.

Table 5. Summary of dominant substrate in available intertidal habitat (AIH) outside areas of salt marsh, Rangitikei Estuary, January 2026.

Substrate Class	Features	ha	% AIH
Artificial substrate	Artificial boulder field	0.05	0.1
Coarse substrate	Gravel field	0.8	1.9
(>2mm)	Shell bank	0.3	0.7
Sand	Mobile sand	3.2	8.0
(0-10% mud)	Firm sand	9.5	23.5
Muddy Sand	Mobile muddy sand	0.2	0.4
(≥10-25% mud)	Firm muddy sand	1.6	4.1
	Soft muddy sand	0.1	0.2
Muddy Sand	Firm muddy sand	3.1	7.6
(≥25-50% mud)	Soft muddy sand	2.9	7.1
Sandy Mud	Firm sandy mud	11.6	28.7
(≥50-90% mud)	Soft sandy mud	5.2	12.9
	Very soft sandy mud	1.9	4.7
Total		40.4	100



Transition between mobile sand and soft, muddy substrate reflecting changing depositional conditions in the lower estuary.



Firm sandy mud (≥50-90% mud content) in the middle estuary.



Recent deposits of fine mud overlying sand in the middle estuary.



Soft sandy mud (≥50-90% mud content) in the middle estuary.

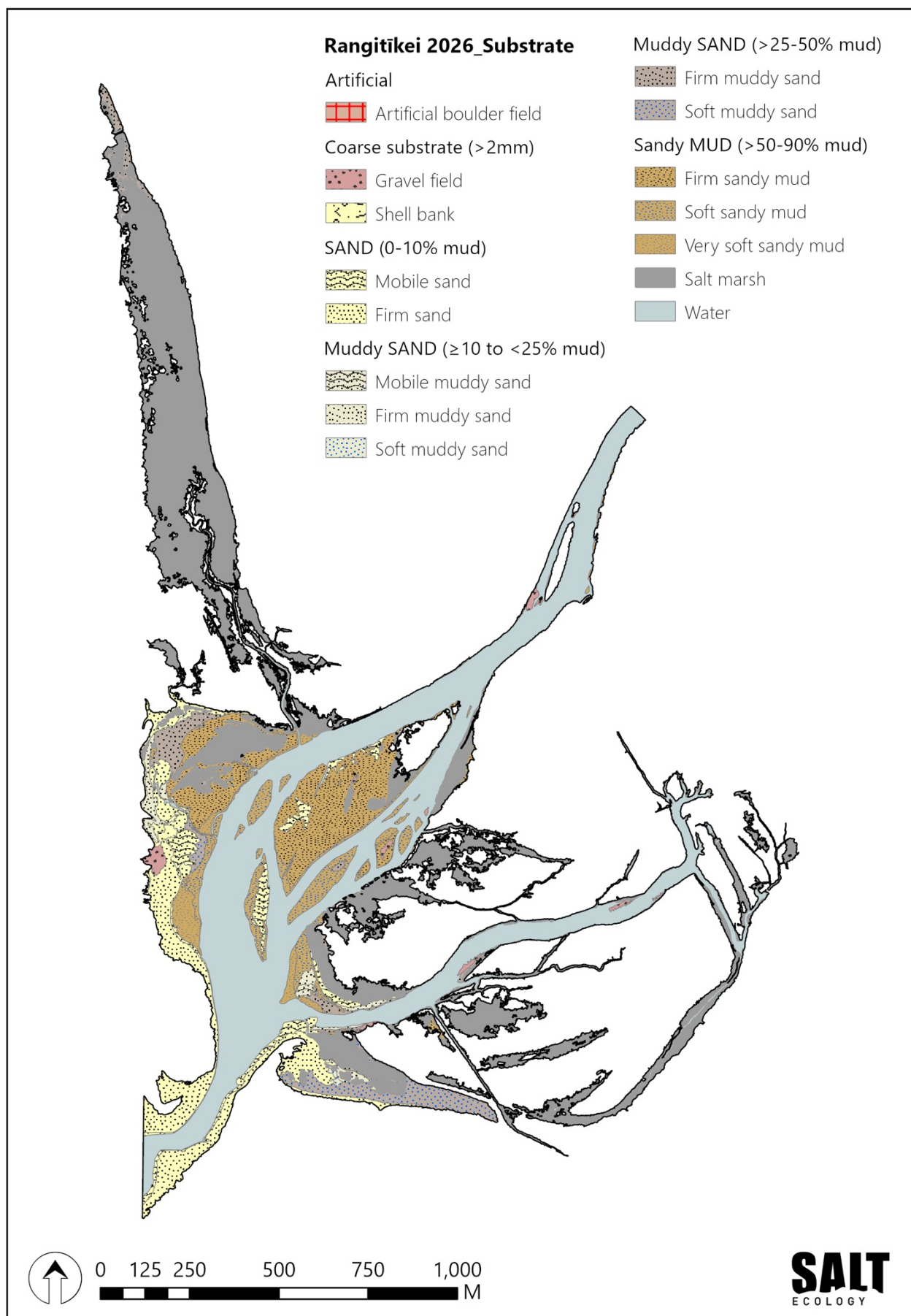


Fig. 8. Dominant intertidal substrate in the AIH (excluding salt marsh), Rangitikei Estuary, January 2026.

4.4 MACROALGAE AND MICROALGAE

No opportunistic macroalgae or High Enrichment Conditions (HECs) were recorded during the 2026 survey. Consequently, the estuary received an OMBT-EQR score of 1.0 (condition rating of 'Very Good').

The distribution and extent of benthic microalgae were also mapped during the survey (Table 6; Fig. 9). Microalgae ($\geq 1\%$ cover) occupied 1.5ha (3.7% AIH) and were predominantly present as low cover ($<30\%$) on fine muddy substrates along channel margins within the middle estuary, with occasional patches of high cover.

Microalgal films did not meet the criteria for High Enrichment Conditions (HECs) as underlying sediments had not become anoxic or organically enriched.

The combined macroalgae and microalgae results suggest that physical conditions (e.g., low salinity, strong currents, absence of hard substrate) limit the development of nuisance algae growths, despite elevated nutrient availability.

Table 6. Summary of intertidal microalgal cover, Rangitikei Estuary, January 2026.

Percent cover category	ha	% AIH
Sparse (1 to $<10\%$)	-	-
Low (10 to $<30\%$)	1.1	2.8
Moderate (30 to $<50\%$)	0	0
High (50 to $<70\%$)	0.1	0.2
Dense (70 to $<90\%$)	0.3	0.8
Complete ($\geq 90\%$)	-	-
Total	1.5	3.7



A sparse cover (1 to $<10\%$) of microalgae (green tinge) lining the channel margin in the middle estuary.



High cover (50 to $<70\%$) of microalgae in the middle estuary.



No macroalgae was present in the estuary in 2026.



Dense cover (70 to $<90\%$) of microalgae atop of very soft mud ($\geq 50\text{-}90\%$ mud) in the middle estuary.

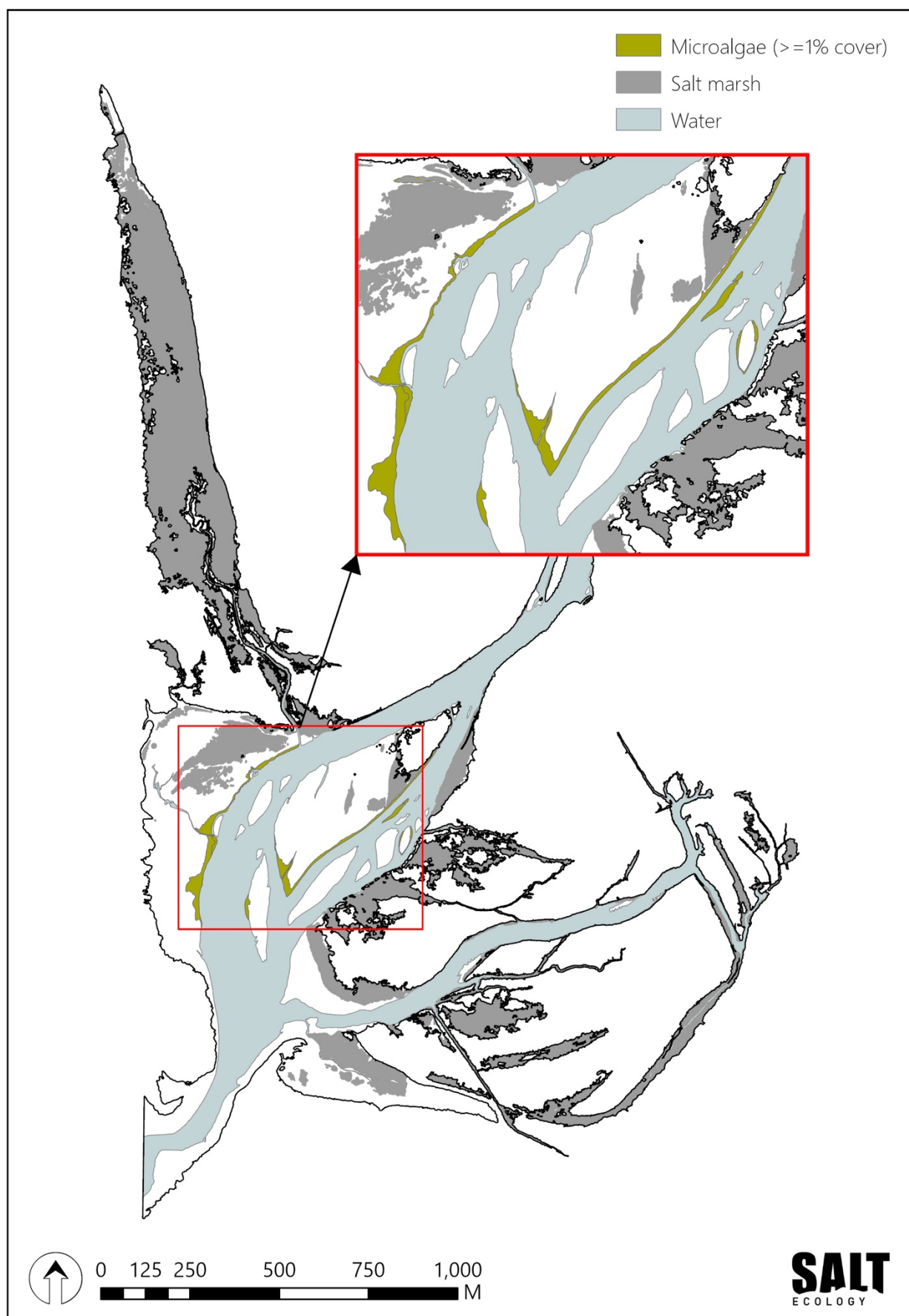


Fig. 9. Distribution of microalgae, Rangitikei Estuary, January 2026. Note, no macroalgae were recorded.

5. SYNTHESIS

A summary of key 2026 results is provided in Table 7, with results assessed relative to condition ratings and the 2018 survey in Table 8. Supporting data used to assess and interpret estuary condition were derived from catchment-scale nutrient and sedimentation models (CLUES 2018; Hicks et al. 2019) and are provided in Table 9.

Table 7. Summary of key broad-scale features, Rangitikei Estuary, January 2026.

a. Area summary	ha	% Estuary
Intertidal	83.0	65.8
Subtidal	43.1	34.2
Total	126.1	100
AIH (intertidal excluding salt marsh)	40.4	32
b. Key substrate features	ha	% AIH
Mud-elevated ($\geq 25\%$ mud)	24.7	61.1
c. Key habitat features	ha	% Intertidal
Salt marsh	43.7	53.9
d. Key enrichment features	ha	% AIH
Macroalgae ($\geq 50\%$ cover)	0	0
High Enrichment Conditions	0	0
e. Terrestrial margin	ha	% Margin
200m densely vegetated margin	135	45

Table 8 shows that Rangitikei was rated 'Very Poor' for mud-elevated substrate, 'Fair' for the densely vegetated 200m terrestrial margin, and 'Very Good' for the extent of salt marsh, the absence of opportunistic macroalgae, and the absence of High Enrichment Conditions (HECs). These ratings are the same as recorded in 2018, and as reflected in a recent Ecological Vulnerability Assessment of estuaries in the Horizons region (Roberts et al. 2025c) which identified Rangitikei as one of the highest ecological value estuaries in the region.

Despite these ecological values and its current level of protection, the estuary continues to be impacted by catchment-derived sediment inputs reflected through widespread mud-elevated substrates. In addition, field surveys identified several localised management issues, including vehicle disturbance of salt marsh habitats and the presence of the invasive reed *Phragmites karka* within, and directly bordering, the estuary. These matters are discussed further below.

5.1 SALT MARSH LOSS AND MARGIN MODIFICATION

Of the indicators assessed, the extensive salt marsh is one of the estuary's defining ecological features. It plays an important role in filtering runoff, trapping fine sediments, assimilating nutrients, supporting biodiversity, and attenuating floodwaters. Maintaining the existing extent and condition of salt marsh is therefore critical to preserving these ecosystem services and enhancing the estuary's resilience to future environmental change.

Table 8. Summary of broad-scale indicator ratings for Rangitikei Estuary, 2018 and 2026.

Broad-scale indicators	Unit	2018*	2026
200m terrestrial margin	% densely vegetated	40.5	45
Salt marsh	% of intertidal area	36.1	51.4
	% loss from baseline	baseline	15.3(↑)
	% loss from historic baseline ³	Estimated >50%	Estimated >50%
Mud-elevated substrate	% AIH ¹ area ($\geq 25\%$ mud)	61.0	61.1
	% increase from baseline in AIH	baseline	0
Macroalgae (OMBT-EQR ²)	Ecological Quality Rating (EQR)	1	1
High Enrichment Conditions	ha	0	0
Estuary-wide indicators ⁴			
Sedimentation rate	CSR:NSR ⁵ ratio	-	1.8
Sedimentation rate	mm/yr	-	4.6

*Existing GIS layers QA/QC checked in 2026 - values may differ slightly from original report. ¹Available Intertidal Habitat excludes salt marsh area; ²Opportunistic Macroalgal Blooming Tool (OMBT) scores have been updated following QA/QC; ³Natural extent estimate based on expert opinion; ⁴Estuary-wide sedimentation indicators derived from catchment models (e.g., Hicks et al. 2019). ⁵CSR=Current Sedimentation Rate, NSR=Natural Sedimentation Rate. dash=no data.

Very Good	Good	Fair	Poor	Very Poor
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Table 9. Supporting data to assess estuary ecological condition in Rangitikei Estuary, January 2026.

Supporting Condition Measure	
Mean freshwater flow (m ³ /s) ¹	72.3
Catchment Area (Ha) ²	393,389
Catchment nitrogen load (TN-t/yr) ¹	2063.5
Catchment phosphorus load (TP-t/yr) ¹	461.3
Catchment sediment load (KT/yr) ³	1169.2
Estimated N areal load in estuary (mg/m ² /d)	4482
Estimated P areal load in estuary (mg/m ² /d)	1002
CSR:NSR ratio ⁴	1.8
Trap efficiency (sediment retained in estuary; %) ⁴	1
Estimated rate of sedimentation (mm/yr) ⁴	4.6

¹Fraser (2021); ²Herzig et al. (2020); ³Vale and Smith (2023);

⁴Hicks et al. (2019)

Despite the extensive salt marsh that remains today, we estimate that at least 50% of the estuary's natural salt marsh extent has been lost. This estimate is considered conservative, as the earliest available aerial imagery (1939) shows the estuary had already undergone substantial modification at that time. Historical changes in river morphology and estuary configuration have played a pivotal role in shaping the distribution of salt marsh over time, with channel migration resulting in the erosion of some areas and the natural development of new intertidal habitats elsewhere. However, rather than these newly formed habitats being allowed to continue evolving naturally, much of the land created through channel migration was subsequently reclaimed and converted to pasture, preventing the re-establishment of extensive salt marsh and associated wetlands.

These historical changes have likely reduced the estuary's capacity to retain and stabilise fine sediments. Sediment trapping by salt marsh has been shown to decline exponentially as marsh area is reduced, resulting in greater sediment delivery to adjacent intertidal habitats (Donatelli et al. 2018). Furthermore, reclamation of salt marsh can alter estuarine hydrodynamics and promote progressive infilling over long timeframes before a new equilibrium is reached (van Maren et al. 2025). Together, these processes are likely to have contributed to the widespread presence of mud-elevated substrates now evident throughout much of the estuary.

Although broad-scale mapping indicates that the remaining salt marsh is in very good condition, several localised pressures, that are not captured by the condition indicators, are present. Recreational vehicle access was evident throughout the estuary, with repeated tracking through herbfield and rushland

communities in the northern arm, middle estuary and southern intertidal flats. While the spatial extent of damage was localised, repeated disturbance has the potential to reduce vegetation cover, fragment salt marsh communities, and create opportunities for weed establishment.

The continued presence and expansion of *Phragmites karka* since 2018 highlights an ongoing management issue for the estuary. This highly invasive reed has the potential to outcompete indigenous salt marsh vegetation, forming dense monospecific stands that alter habitat structure and ecological processes. As broad-scale mapping methods preclude precise quantification of changes since 2018, targeted monitoring and control are recommended to better understand its changing extent and limit further spread.

Notwithstanding these localised disturbances, no meaningful changes in the extent of salt marsh or densely vegetated 200m terrestrial margin were detected between the 2018 and 2026 surveys.



Tall fescue (*Festuca arundinacea*) bordering the estuary margin, replacing former salt marsh habitat and reducing the natural transition between terrestrial and estuarine ecosystems.



Invasive reed *Phragmites karka* newly established amongst indigenous salt marsh vegetation within the middle estuary.

5.2 MUDDY SEDIMENT

Mud-elevated substrate remains the principal broad-scale pressure affecting Rangitikei, with 61.1% of the available intertidal habitat classified as containing elevated mud content ($\geq 25\%$ mud), resulting in a 'Very Poor' condition rating. There was no meaningful change from the 2018 survey, indicating that fine sediment remains a persistent feature of the estuary with no detectable improvement over the monitoring period. The Horizons Ecological Vulnerability Assessment similarly identified excess sedimentation as one of the principal pressures affecting the estuary despite its otherwise high ecological values (Roberts et al. 2025c).

The widespread distribution of muddy substrates reflects the naturally high sediment load from the Rangitikei catchment, which delivers large quantities of fine sediment to the estuary during elevated river flows. Catchment modelling indicates contemporary sedimentation rates are approximately 80% higher than would be expected under an undisturbed (natural) catchment land cover, with a Current Sedimentation Rate to Natural Sedimentation Rate (CSR:NSR) ratio of 1.8. Based on the current modelled input, the estimated estuary-wide mean sedimentation rate is 4.6 mm/yr, which is classified as 'Poor' under the broad-scale indicator framework (Tables 8 and 9).



Erosion of recently deposited fine mud along the margin of the main tidal channel, lower Rangitikei Estuary.

Field observations supported these findings, with fresh deposits of fine sediment overlying sandy substrates throughout many parts of the middle and lower estuary. Elevated turbidity within the Rangitikei River, and localised riverbank erosion observed during the survey, further highlighted the ongoing delivery of catchment-derived sediment to the estuary.

Elevated muddy sediments have the potential to reduce the quality of intertidal habitats that underpin many of the Rangitikei Estuary's recognised ecological values. The estuary has been identified as having high ecological value due to its extensive salt marsh, the presence of significant bird and fish species, and its protected status. Continued increases in fine sediment deposition may reduce the quality and productivity of intertidal habitats that support these ecological values, reinforcing the importance of managing catchment-derived sediment inputs.



Turbid waters of the Rangitikei River and active riverbank erosion, illustrating ongoing catchment-derived sediment inputs to the estuary.

Extensive accumulations of woody debris were also present across the eastern lower estuary intertidal flats adjacent to the boat ramp, indicating the magnitude of material transported during flood events. While the woody debris itself is not a sediment source, it can trap fine sediments and locally smother or inhibit salt marsh establishment until redistributed or decomposed.



Deposit of driftwood smothering salt marsh in the upper tidal margin of the lower estuary.

5.3 NUTRIENTS

Catchment modelling indicates that Rangitikei receives high nutrient loads (Tables 8 and 9). However, the broad-scale surveys found little evidence of widespread eutrophication. No opportunistic macroalgae or High Enrichment Conditions (HECs) were recorded during either the 2018 or 2026 surveys, resulting in an OMBT-EQR score of 1.0 ('Very Good') in both assessments. Consistent with the Horizons Ecological Vulnerability Assessment, these findings indicate that the estuary's hydrodynamic characteristics moderate its response to elevated nutrient inputs (Roberts et al. 2025a). Strong tidal exchange, rapid flushing, frequent flood-scouring and elevated turbidity inhibit growths, and continually redistribute sediments and algal biomass, preventing the accumulation of opportunistic macroalgae despite relatively high nutrient availability (Plew 2024; Roberts et al. 2025a; Roberts et al. 2025c).

Although benthic microalgae are a natural component of estuarine ecosystems, their occurrence as dense mats in some areas in 2026 indicates that nutrients remain available to support primary production where conditions favour their development. Their predominance on fine muddy sediments along depositional channel margins suggests that local sediment accumulation and associated nutrient availability interact to promote microalgal growth. However, in the absence of opportunistic macroalgal blooms or associated High Enrichment Conditions (HECs), these observations do not currently indicate widespread eutrophication or organic enrichment within the estuary.

While current evidence suggests nutrient enrichment is not resulting in widespread ecological degradation, the estuary remains vulnerable to future changes. The Horizons Stage 2 risk assessment (Roberts et al. 2025b) identified the Rangitikei Estuary as a Priority 1 system for further nutrient investigation, reflecting uncertainty regarding whether proposed freshwater nutrient load reductions will be sufficient to maintain its ecological values over the long-term.

5.4 WATER QUALITY

Synoptic water quality was assessed at 10 sites across the estuary during the broad-scale survey (Appendix 5). At the time of sampling, the Rangitikei River flow at McKelvie's was 138.9m³/s (Fig. 10), approximately 96% higher than the mean daily flow over the preceding six months (71.0m³/s), indicating that the survey captured a relatively typical period of elevated freshwater discharge following summer low flow conditions.

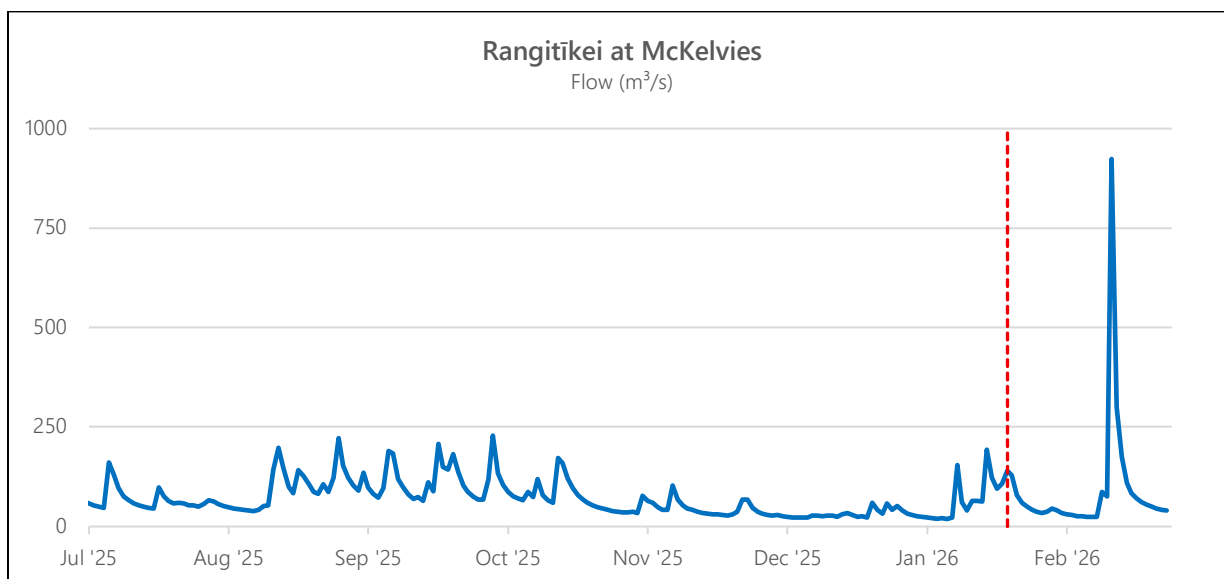
Water quality throughout most of the estuary was characteristic of a well-mixed tidal river system, with dissolved oxygen concentrations generally exceeding 8mg/L, and low chlorophyll-*a* concentrations across most sites. A notable exception occurred within the deeper reaches of the southern arm (Sites 8 and 9; Appendix 5), where vertical profiling identified a pronounced salt wedge. At these sites, fresh surface waters overlaid denser saline bottom waters, indicating restricted vertical mixing, with the greater water depths at these sites likely facilitating the persistence of the saline bottom layer.

The stratification coincided with a marked reduction in bottom-water dissolved oxygen, declining to ~2mg/L at Site 9, with surface waters remaining well oxygenated. Elevated surface chlorophyll-*a* concentrations were also recorded within the upper reaches of southern arm, suggesting that this area experiences longer water residence times and different hydrodynamic conditions than the well-mixed main channel. While low dissolved oxygen within the salt wedge is a recognised feature of stratified tidal river estuaries, prolonged or frequent periods of oxygen depletion have the potential to adversely affect aquatic fauna and alter biogeochemical processes within bottom sediments (Forrest et al. 2024).

Although these conditions appeared to be localised rather than representative of the wider estuary, they demonstrate that the southern arm is more susceptible to episodic water quality deterioration than the remainder of the estuary. Continued monitoring under a range of river flow and tidal conditions would help determine whether salt-wedge formation and associated bottom-water oxygen depletion are persistent features of this part of the estuary or occur only under specific hydrological conditions.



Water quality monitoring Site 8 within the upper reaches of the southern arm, Rangitikei Estuary.



Source: <https://envirodata.horizons.govt.nz>.

Fig. 10. Rangitikei River daily mean flows at McKelvies from July 2025 to March 2026. The timing of the broad-scale survey (27 January 2026) is indicated by the dashed red line and occurred prior to major flood event.

6. CONCLUSIONS AND RECOMMENDATIONS

Overall, the Rangitikei Estuary continues to support extensive salt marsh and retains many of the ecological functions and values that make it one of the region's most ecologically important estuarine systems. Although the estuary has undergone substantial historical modification through changes in river morphology, reclamation, drainage, and catchment development, it remains resilient, with broad-scale indicators showing generally favourable ecological condition and little change since the 2018 survey.

The survey demonstrates that the estuary's long-term condition will depend on protecting and enhancing the natural features that underpin its resilience. Continued efforts to reduce catchment-derived sediment and nutrient inputs, safeguarding and restoring remaining salt marsh, improving riparian and estuarine margins, and maintaining natural hydrological and geomorphic processes will all help ensure the estuary continues to support its important ecological, cultural and recreational values into the future. Based on the monitoring results described above it is recommended HRC consider the following:

Monitoring

- Continue comprehensive broad-scale estuary monitoring on a 10-year cycle to track long-term changes in habitat extent, estuary condition and key ecological pressures.
- Where opportunities arise during other field programmes, collect opportunistic water quality data (including vertical profiles of salinity, dissolved oxygen and chlorophyll-*a*) to improve understanding of the frequency and ecological significance of salt-wedge formation and associated bottom-water oxygen depletion, particularly within the southern arm.
- If undertaking other fieldwork in or near the estuary, complete a rapid estuary walkover (see Stevens et al. 2025) to assess readily observable indicators of changes in condition, such as macroalgae and microalgal blooms, vehicle disturbance, the presence and spread of invasive plant species (e.g., *Phragmites karka*), or conspicuous changes in salt marsh extent or condition.

Management

- Continue catchment management programmes aimed at reducing sediment and nutrient inputs to the estuary, with particular emphasis on erosion-prone parts of the catchment and opportunities to improve riparian management.
- Protect the remaining extent of salt marsh from further modification and, where practicable, identify opportunities to restore historical salt marsh and reconnect former estuarine wetlands that may enhance sediment retention and ecological resilience.
- Develop a long-term strategy for the managed retreat of salt marsh under sea-level rise where landform, hydrology, and land-use allow for salt marsh migration or re-establishment. A first stage to consider would be simple inundation modelling to assess potential salt marsh losses/gains and barriers to retreat (e.g., Crawshaw et al. 2022; Stevens 2023; Bulmer et al. 2024; Stevens 2024).
- Continue surveillance and, where necessary, undertake control of *Phragmites karka* and other invasive plant species to minimise their spread into indigenous salt marsh communities.
- Work with relevant stakeholders to minimise vehicle access through sensitive salt marsh habitats and other vulnerable intertidal areas where avoidable damage is occurring.



Carex litorosa within the salt marsh of the lower Rangitikei Estuary.



Undertaking water quality monitoring in the lower Rangitikei Estuary.



Flowering streaked arrowgrass (*Triglochin striata*), an indigenous salt marsh species characteristic of the Rangitikei Estuary.



Indigenous sand-binding *Spinifex sericeus* growing within the coastal dune system on the seaward side of the estuary.

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APPENDIX 1. SAMPLING METHODS, RANGITĪKEI, JANUARY 2026

The broad-scale habitat mapping methods largely follow the National Estuary Monitoring Protocol (NEMP) (Roberts et al. 2025b). The NEMP outlines a tiered monitoring approach for each indicator; the level of monitoring; and improvements to assessment, analysis and QA/QC elements. Any adjustments or additions to the NEMP are described in Table A1.1 and this appendix.

Table A1.1. Summary of broad-scale methods used in this report.

Indicator	Method
Substrate	Substrate was assessed using the intermediate level of monitoring described in the NEMP, incorporating additional substrate descriptors (e.g., texture – firm, soft, very soft) and classes (e.g., sandy mud and mud), which are aggregated in the NEMP. The changes, and a full list of substrate codes, is provided in Section A1.1 and Table A1.2. Substrate validation is required for fine unconsolidated substrate types (e.g., MS10, MS25). Briefly, a validation sample is collected from the surface 2cm and analysed for grainsize, and the qualitative classification compared with the mud fraction from the grainsize analysis (see Appendix 2 in Roberts et al. 2025b).
Salt marsh	Salt marsh was assessed using the comprehensive level of monitoring described in the NEMP, with measurements of salt marsh extent, sub-classes, and dominant species.
Seagrass	Seagrass, where present, is assessed using the intermediate level of monitoring described in the NEMP, with measurements of seagrass extent and percent cover.
Macroalgae	Macroalgae was assessed using the comprehensive level of monitoring described in the NEMP, with measurements of macroalgae extent, percent cover, biomass and entrainment.
High Enrichment Conditions (HEC)	Mapped based on areal extent where there are obvious low sediment oxygen conditions (e.g., black sediments with rotten egg smell), conspicuous surface growths of sulfur-oxidising bacteria, stable, entrained, dense (>50% cover) beds of opportunistic macroalgae, or the extensive presence of surface microalgae or filamentous-algae.
200m Terrestrial margin	Described in Section A1.2.
Catchment land cover	Described in Section A1.2.

A1.1 Estuary substrate classification and mapping

The NEMP designates substrate based on the dominant surface features present (e.g., rock, boulder, cobble, gravel, sand, muddy sand, sandy mud), with associated substrate codes and classification descriptors. Salt Ecology uses these classifications with one exception: the Sandy Mud (SM50; 50-100% mud) class is divided into two sub-classes – Sandy Mud (SM; ≥50-90%) and Mud (M; ≥90% mud). For national reporting these two sub-classes can be aggregated.

Salt Ecology also use lower-case abbreviations to designate sediment 'firmness' based on how much a person sinks:

- firm (f) - Sink 0 to <2cm "to sole of shoes"
- soft (s) - Sink 2 to <5cm "sole of shoes to ankles"
- very soft (vs) - Sink ≥5cm "above ankles"

Because this measure is highly variable between observers, it is only used as a supporting narrative descriptor of substrate type. Mobile (m) and artificial (a) substrate are classified separately.

Table A1.2. Modified NEMP substrate classes and field codes.

Consolidated substrate			Code	NEMP equivalent (depth of sinking)	
Bedrock		Rock field "solid bedrock"	RF	RF	Rockland
Coarse Unconsolidated Substrate (>2mm)					
Boulder	>256mm	Boulder field "bigger than your head"	BF	BF	Boulder field
Cobble	64 to <256mm	Cobble field "hand to head sized"	CF	CF	Cobble field
Gravel	2 to <64mm	Gravel field "smaller than palm of hand"	GF	GF	Gravel field
Shell	2 to <64mm	Shell "smaller than palm of hand"	Shel	Shell	Shell
Fine Unconsolidated Substrate (<2mm) – see footnotes					
SAND (S)	Low mud (0-10%)	Mobile sand	mS	MS	Mobile sand (<1cm)
		Firm shell/sand	fShS	FSS	Firm shell/sand (<1cm)
		Firm sand	fS	FS	Firm sand (<1cm)
		Soft sand	sS	SS	Soft sand (>2cm)
		Very soft sand	vsS	SS	Soft sand (>2cm)
Muddy SAND10 (MS10)	Moderate mud (≥10-25%)	Mobile muddy sand	mMS10	MS	Mobile sand (<1cm)
		Firm muddy shell/sand	fMShS10	FSS	Firm shell/sand (<1cm)
		Firm muddy sand	fMS10	FMS	Firm mud/sand (<2cm)
		Soft muddy sand	sMS10	SM	Soft mud/sand (2-5cm)
		Very soft muddy sand	vsMS10	VSM	Very soft mud/sand (>5cm)
Muddy SAND25 (MS25)	High mud (≥25-50%)	Mobile muddy sand	mMS25	MS	Mobile sand (<1cm)
		Firm muddy shell/sand	fMShS25	FSS	Firm shell/sand (<1cm)
		Firm muddy sand	fMS25	FMS	Firm mud/sand (<2cm)
		Soft muddy sand	sMS25	SM	Soft mud/sand (2-5cm)
		Very soft muddy sand	vsMS25	VSM	Very soft mud/sand (>5cm)
Sandy Mud (SM)	Very high mud (≥50-90%)	Firm sandy mud	fSM	FMS	Firm mud/sand (<2cm)
		Soft sandy mud	sSM	SM	Soft mud/sand (2-5cm)
		Very soft sandy mud	vsSM	VSM	Very soft mud/sand (>5cm)
Mud (M)	Mud (≥90%)	Firm mud	fM90	FMS	Firm mud/sand (<2cm)
		Soft mud	sM90	SM	Soft mud/sand (2-5cm)
		Very soft mud	vsM90	VSM	Very soft mud/sand (>5cm)
Zoogenic (living)					
Areas dominated (≥50% cover) by mussel, oyster or calcareous tubeworms.		Mussel reef	MUSS	Mussel	
		Oyster reef	OYST	Oyster	
		Tubeworm reef	TUBE	Calcareous tubeworms	
Artificial Substrate					
Introduced natural or human-made materials that modify the environment. Includes rip-rap, rock walls, wharf piles, bridge supports, walkways, boat ramps, groyne, flood control banks, flap-gates.		Solid Feature (e.g., boat ramp, seawall)	SF		
		Boulder field	aBF	Boulder field	
		Cobble field	aCF	Cobble field	
		Gravel field	aGF	Gravel field	
		Sand field	aSF	Firm/Soft sand	

Sediment firmness: Subjectively classified as 'firm' if you sink 0-<2cm, 'soft' if you sink 2-5cm, or 'very soft' if you sink >5cm.

Mobile: Sediment is firm but routinely moved by tidal currents or waves. Commonly characterised by having a rippled surface layer.

Sand: Sandy sediment that is granular when rubbed between the fingers and releases no conspicuous fines when sediment is disturbed.

Shell/Sand: Mixed sand and shell hash. See muddy sand sub-classes below for field guidance on estimating mud content.

Muddy Sand: Sand-dominated sediment that is mostly granular when rubbed between the fingers but has a smoother consistency than sand.

Sub-divided into two sub-classes based on estimated mud content (commonly validated by laboratory analysis of representative substrate);

i. **Moderate mud (≥10-25%) content:** Muddy fines evident when sediment is disturbed. Sediments generally firm to walk on.

ii. **High mud (≥25-50%) content:** Muddy fines conspicuous when sediment is disturbed. Sediments generally soft to walk on.

Sandy Mud (≥50-90% mud content): Mud-dominated sediment primarily smooth/silken when rubbed between the fingers, but retains a granular component. Sediments generally soft or very soft and only firm if dried out, or another component (e.g., gravel) prevents sinking.

Mud (≥90% mud content): Mud-dominated sediment with no obvious sand component. Smooth/silken when rubbed between the fingers. Sediments generally only firm if dried out, or another component (e.g., gravel underneath mud) prevents sinking.

A1.2 Catchment description and terrestrial margin mapping

Catchment land cover maps are constructed from the most recent Landcare Research Land Cover Data Base (currently LCDB5 2018/2019) using the catchment boundary from CLUES 10.8 (ESNZ). The dominant land cover has been classified based on the codes described in Table A1.3. Using the same broad-scale approach described in Section 6.2 of the NEMP, these same LCDB5 classes are used to “ground-truth” and categorise features within the 200m terrestrial margin of an estuary. The one exception is the addition by Salt Ecology of a new sub-class (410 – Duneland) to delineate coastal duneland from low producing grassland, due to the high value of duneland habitat.

Table A1.3. Landcare Land Cover Database (LCDB6) classes used in the mapping of terrestrial features.

Artificial Surfaces		Grassland, Sedge and Saltmarsh	
1	Built-up Area (settlement)	40	High Producing Exotic Grassland
2	Urban Parkland/Open Space	41	Low Producing Grassland
5	Transport Infrastructure	410*	Duneland
6	Surface Mines and Dumps	43	Tussockland
Bare or Lightly Vegetated Surfaces		45	Herbaceous Freshwater Vegetation
10	Sand and Gravel	46	Herbaceous Saline Vegetation
12	Landslide	Scrub and Shrubland	
14	Permanent Snow and Ice	47	Flaxland
15	Alpine Grass/Herbfield	50	Fernland
16	Gravel and Rock	51	Gorse and/or Broom
Water Bodies		52	Manuka and/or Kanuka
20	Lake or Pond	54	Broadleaved Indigenous Hardwoods
21	River	55	Sub Alpine Shrubland
22	Estuarine water	56	Mixed Exotic Shrubland
Cropland		58	Matagouri or Grey Scrub Forest
30	Short-rotation Cropland	Forest	
33	Orchard Vineyard & Other Perennial Crops	64	Forest - Harvested
		68	Deciduous Hardwoods
		69	Indigenous Forest
		71	Exotic Forest

*Duneland is an additional category to the LCDB classes to differentiate between “Low Producing Grassland” and “Duneland”.

A1.3. METHOD REFERENCES

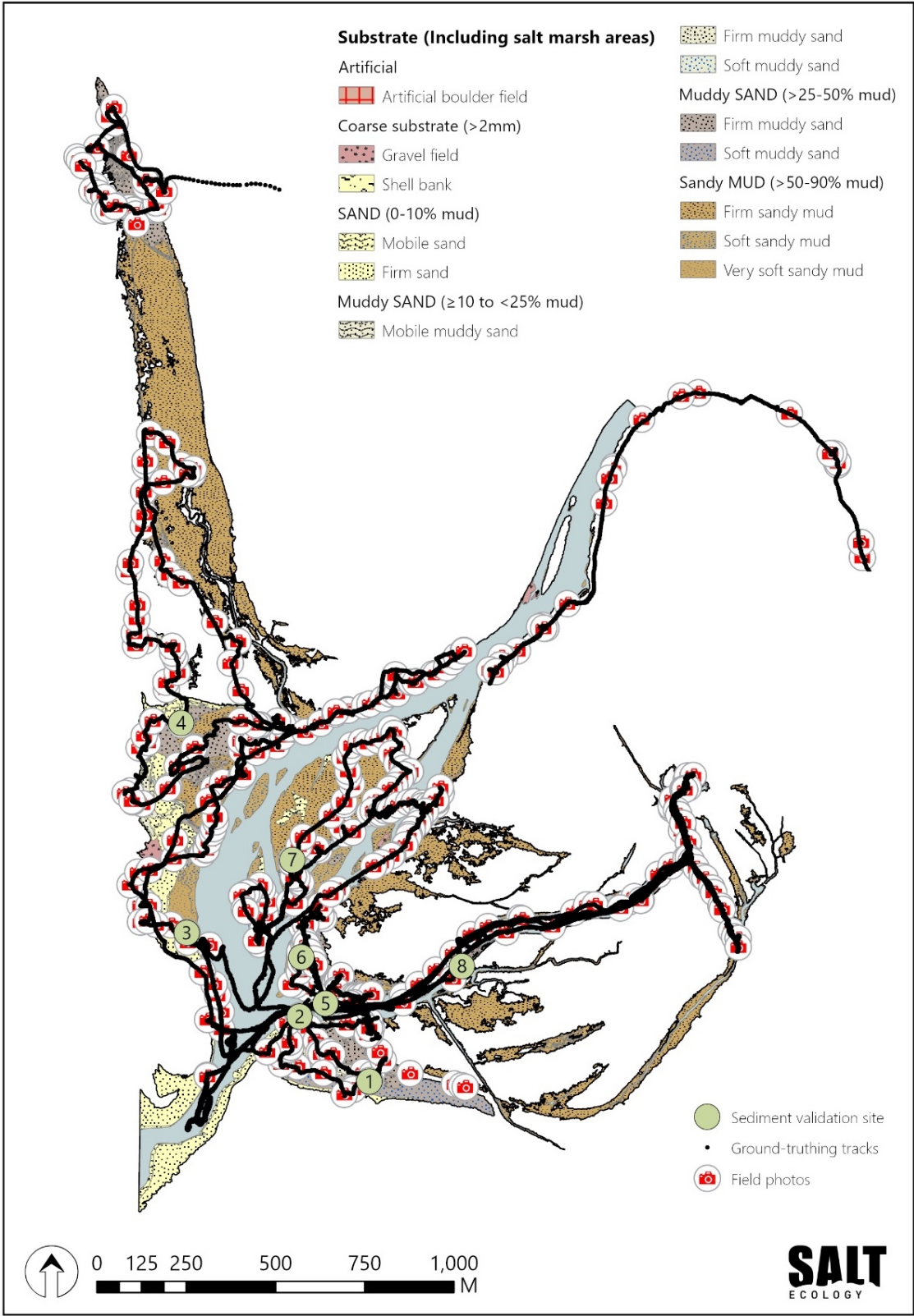
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APPENDIX 2. GROUND-TRUTHING AND SEDIMENT VALIDATION, JANUARY 2026



Sediment validation sampling was undertaken at eight sites (see above figure) to validate qualitative field estimates of sediment type against laboratory grain-size analysis of mud content. An acceptance tolerance of $\pm 5\%$ mud

content relative to the mapped substrate class was adopted, unless field notes specify the sample was taken because the substrate could not be accurately determined in the field (e.g., flood deposits overlying and/ or integrating into firm substrates). For any samples with differences >5%, photos of the sample site and field notes are revisited to assess the disparity and determine whether to change the field classification.

Of the eight sediment validation samples, six matched the original field-based substrate classification (unshaded), one was within the $\pm 5\%$ acceptance tolerance (shaded orange), and one did not match the mapped substrate class (shaded yellow with red text).

The non-matching sample was collected from a transitional area adjacent to a main tidal channel, where mud content increased towards the channel margin. Field notes recorded the site as being close to the upper threshold of the mapped substrate class, and laboratory analysis subsequently confirmed a slightly higher mud content than estimated in the field. Following a review of field photographs, site observations and laboratory results, the mapped substrate boundary was refined to better represent the observed transition in substrate conditions.

Overall, the high level of agreement between field-based substrate classifications and laboratory analyses provides strong confidence in the accuracy of the mapped substrate layer for the Rangitikei Estuary.

2026 sediment validation sample results.

Site	NZTM East	NZTM North	Sed firmness	Field code	Qualitative % mud	Mud (%)	Sand (%)	Gravel (%)	Result	Change made ¹
1	1789665	5536619	firm	MS25_50	25 to <50%	24.9	74.2	0.9	Within 5%	
2	1789491	5536815	mobile	S0_10	<10%	2.4	97.5	< 0.1	Match	
3	1789153	5537035	very soft	SM50_90	50 to 90%	79.8	20.1	0.1	Match	
4	1789138	5537623	firm	MS25_50	25 to <50%	40.6	59.3	0.2	Match	
5	1789542	5536837	firm	MS10_25	10 to <25%	32.2	67.7	< 0.1	Non-match	Boundary adjusted ¹
6	1789474	5536967	soft	SM50_90	50 to 90%	61	38.9	< 0.1	Match	
7	1789449	5537239	firm	SM50_90	50 to 90%	65.8	34.1	< 0.1	Match	
8	1789924	5536942	firm	MS25_50	25 to <50%	41.7	56.3	2	Match	

¹ Change made following a review of field photos and notes

APPENDIX 3. SALT MARSH RAW DATA, JANUARY 2026

Salt marsh Class, and dominant and sub-dominant species extent (ha). '-' indicates no sub-dominant taxa recorded.

Estuarine Shrub	1.3
Plagianthus divaricatus (Salt marsh ribbonwood)	
-	0.54
Apodasmia similis (Jointed wirerush)	0.04
Bolboschoenus caldwelii (Caldwell's clubrush)	0.04
Festuca arundinacea (Tall fescue)	0.06
Juncus kraussii (Searush)	0.59
Sedgeland	11.8
Bolboschoenus caldwelii (Caldwell's clubrush)	
-	1.66
Apodasmia similis (Jointed wirerush)	0.01
Festuca arundinacea (Tall fescue)	0.55
Juncus acutiflorus (Sharp flowered rush)	2.02
Juncus kraussii (Searush)	4.17
Plagianthus divaricatus (Salt marsh ribbonwood)	0.04
Samolus repens (Primrose)	0.31
Schoenoplectus pungens (Three square)	1.03
Schoenoplectus tabernaemontani (Lake clubrush)	0.07
Carex pumila (Sand sedge)	
-	0.03
Bolboschoenus caldwelii (Caldwell's clubrush)	0.05
Festuca arundinacea (Tall fescue)	0.02
Schoenoplectus pungens (Three square)	
-	0.65
Apodasmia similis (Jointed wirerush)	0.19
Bolboschoenus caldwelii (Caldwell's clubrush)	0.33
Festuca arundinacea (Tall fescue)	0.02
Juncus acutiflorus (Sharp flowered rush)	0.12
Juncus kraussii (Searush)	0.55
Samolus repens (Primrose)	0.02
Rushland	23.2
Apodasmia similis (Jointed wirerush)	
-	0.06
Bolboschoenus caldwelii (Caldwell's clubrush)	0.0004
Festuca arundinacea (Tall fescue)	0.02
Juncus kraussii (Searush)	0.8
Selliera radicans (Remuremu)	0.01
Juncus acutiflorus (Sharp flowered rush)	
Bolboschoenus caldwelii (Caldwell's clubrush)	0.04
Juncus kraussii (Searush)	0.92
Schoenoplectus pungens (Three square)	0.01

Rushland (continued)	
Juncus kraussii (Searush)	
-	0.18
Apodasmia similis (Jointed wirerush)	3.16
Bolboschoenus caldwelii (Caldwell's clubrush)	10.62
Cotula coronopifolia (Bachelor's button)	0.02
Festuca arundinacea (Tall fescue)	4.77
Ficinia nodosa (Knobby clubrush)	0.05
Juncus acutiflorus (Sharp flowered rush)	0.22
Plagianthus divaricatus (Salt marsh ribbonwood)	1.28
Schoenoplectus pungens (Three square)	0.08
Selliera radicans (Remuremu)	0.99
Herbfield	6.3
Atriplex prostrata (Orache, Creeping saltbush)	
Carex spp. (Sedge)	0.06
Cotula coronopifolia (Bachelor's button)	
Carpobrotus edulis (Ice Plant)	0.01
Selliera radicans (Remuremu)	0.43
Samolus repens (Primrose)	
-	0.6
Bolboschoenus caldwelii (Caldwell's clubrush)	0.02
Isolepis cernua (Slender clubrush)	0.1
Leptinella dioica	1.86
Selliera radicans (Remuremu)	1.47
Selliera radicans (Remuremu)	
-	0.02
Cotula coronopifolia (Bachelor's button)	0.05
Samolus repens (Primrose)	1.66
Triglochin striata (Arrow grass)	
Isolepis cernua (Slender clubrush)	0.02
Total	42.6
Turf Plant	
Limosella lineata (Mudwort)	
-	0.71
Atriplex prostrata (Orache, Creeping saltbush)	0.05
Samolus repens (Primrose)	0.31
Total	1.1

APPENDIX 4. SUBSTRATE RAW DATA, JANUARY 2026

Total estuary substrate, and substrate within salt marsh and macroalgae.

Sub-class	Feature	Intertidal		AIH		Salt marsh		Microalgae	
		ha	%	ha	%	ha	%	ha	%
Artificial Boulder	Boulder field	0.05	0.1	0.05	0.1	0	0.0	0	0
Gravel	Gravel field	0.8	0.9	0.8	1.9	0	0.0	0	0
Shell	Shell bank	0.3	0.3	0.3	0.7	0	0.0	0	0
SAND (<10% mud)	Mobile sand	3.2	3.9	3.2	8.0	0	0.0	0	0
	Firm sand	9.7	11.6	9.5	23.5	0.2	0.4	0	0
Muddy SAND (≥10 to <25% mud)	Mobile muddy sand	0.2	0.2	0.2	0.4	0	0.0	0	0
	Firm muddy sand	2.2	2.7	1.6	4.1	0.9	2.0	0	0
	Soft muddy sand	0.2	0.2	0.1	0.2	0.1	0.2	0	0
Muddy SAND (≥25 to <50% mud)	Firm muddy sand	11.2	13.5	3.1	7.6	8.2	18.7	0	0
	Soft muddy sand	2.9	3.5	2.9	7.1	0	0.0	0	0
Sandy MUD (≥50 to <90% mud)	Firm sandy mud	44.7	53.8	11.6	28.7	33.8	77.4	0.03	1.9
	Soft sandy mud	5.8	7.0	5.2	12.9	0.6	1.4	1.1	74.4
	Very soft sandy mud	1.9	2.3	1.9	4.7	0	0.0	0.4	23.7
		83.0	100	40.4	100	43.7	100	1.5	100

APPENDIX 5. SYNOPTIC WATER QUALITY DATA, 28 JANUARY 2026.

Condition ratings from Robertson et al. (2016). Dissolved oxygen (DO) is the one-day minimum criterion. Chl a is for a 90th percentile value, noting a single synoptic survey provides insufficient data to determine this.

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
Easting (NZTM)	1789221	1789285	1789200	1789816	1789790	1790067	1790343	1790555	1790561	1790540
Northing (NZTM)	5536573	5536726	5537014	5537379	5537404	5537060	5537097	5537240	5537251	5537427
Distance from mouth (km)	0.2	0.4	0.7	1.3	1.3	1.3	1.5	1.8	1.8	2.0
Surface water										
Depth (m)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Temp (oC)	18.2	17.8	16.1	16.6	16.4	19.3	22.4	22.6	22.1	22.6
DO saturation (%)	106.0	96.2	88.0	97.4	89.6	102.3	110.9	96.9	115.2	62.0
DO conc (g/m3)	9.7	9.0	8.7	9.5	8.8	9.1	9.5	8.5	10.1	6.5
Salinity (ppt)	0.07	0.06	0.08	0.06	0.05	0.15	1.15	1.39	0.97	1.72
Chl a (mg/m3)	1.8	2.0	1.6	1.4	1.6	2.5	34.0	19.0	42.0	0.0
Stratified	No	No	No	No	No	No	No	No	No	No
Bottom water										
Depth (m)	4	2	1.5	1.4	0.3	1.8	1.8	3.1	3.5	1.2
Temp (oC)	18.2	18.1	16.9	16.6	16.4	19.5	20.9	18.1	18	21.7
DO saturation (%)	106.9	87.2	90.0	94.8	89.6	94.4	116.0	30.9	22.0	84.5
DO conc (g/m3)	10.1	8.2	8.9	9.3	8.8	8.4	10.2	2.5	2.0	7.3
Salinity (ppt)	0.07	0.07	0.06	0.06	0.05	2.48	1.3	6.56	6.06	1.69
Chl a (mg/m3)	2.2	2.1	1.3	1.6	1.6	4.4	12.3	22.0	17.5	30.8

Site 1: Main river channel at the estuary mouth

Site 2: Lower main river channel

Site 3: Western tidal channel

Site 4: Deep section of the northern secondary tidal channel

Site 5: Upper braided section of the northern secondary tidal channel

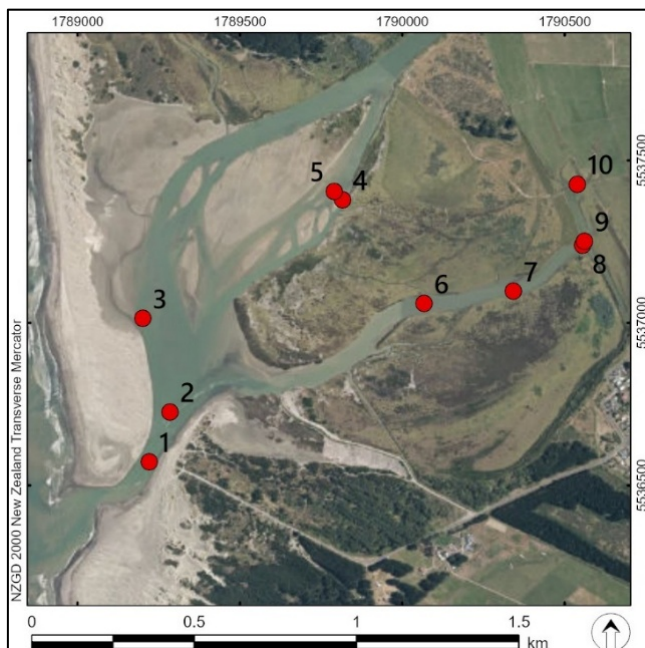
Site 6: Lower Southern Arm

Site 7: Mid Southern Arm

Site 8: Lower upper Southern Arm

Site 9: Upper Southern Arm

Site 10: Head of the Southern Arm





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