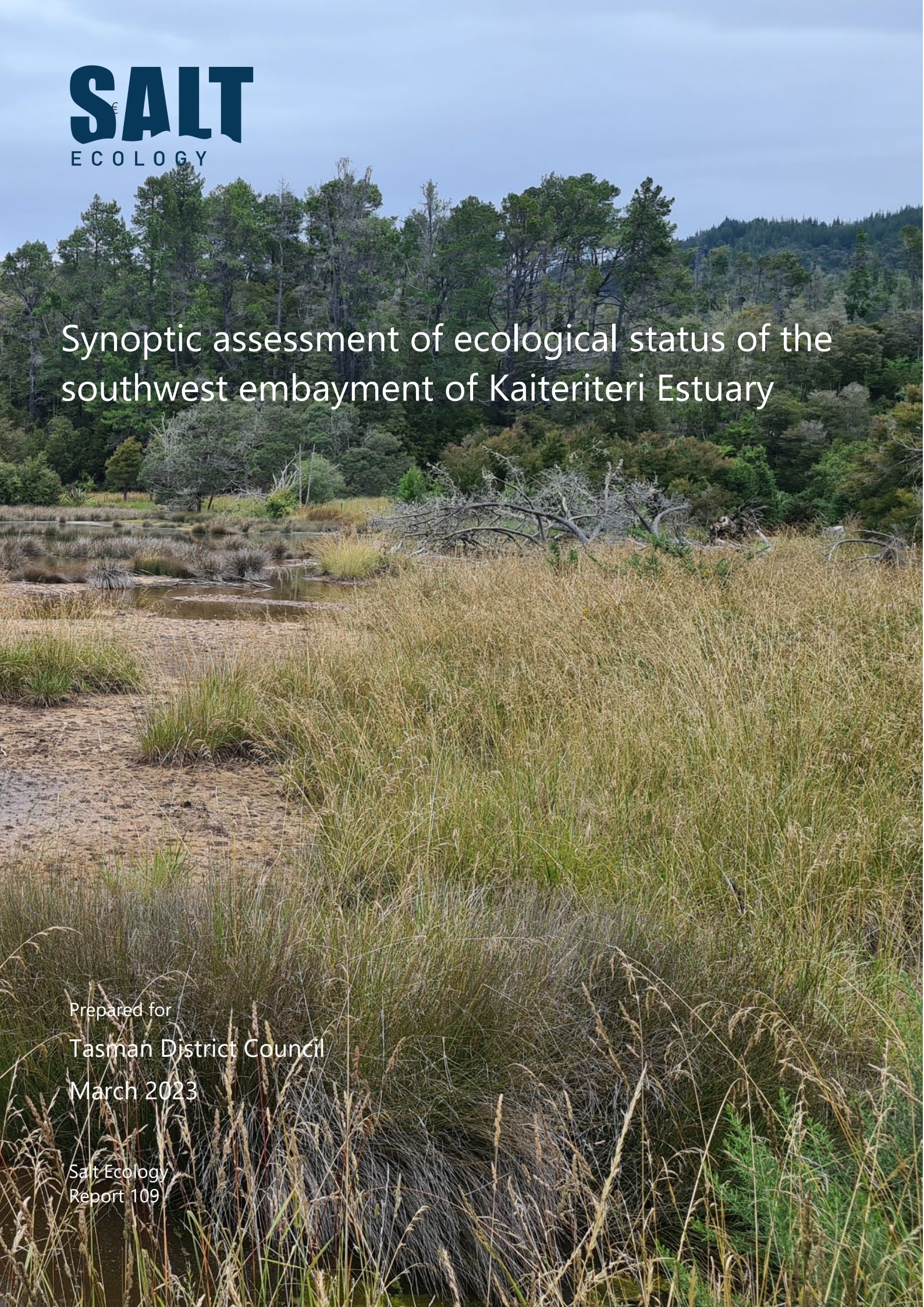

SALT ECOLOGY

Synoptic assessment of ecological status of the southwest embayment of Kaiteriteri Estuary

Prepared for

Tasman District Council

March 2023

Salt Ecology
Report 109

Cover photo: Kaiteriteri Estuary southwest embayment, February 2023

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Synoptic assessment of ecological status of the southwest embayment of Kaiteriteri Estuary

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for

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March 2023

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For the environment
Mō te taiao

SALT ECOLOGY

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ACKNOWLEDGEMENTS

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1. INTRODUCTION

Kaiteriteri Estuary in the Tasman District is a moderate sized (18.9ha) shallow, intertidally-dominated lagoon-type system, which includes an embayment on the southwest side cut-off from the main estuary by a causeway. The main estuary has a small freshwater input and almost completely drains at low tide, while the embayment only partially drains through concrete culverts under the causeway (Martin Farm Road). Previous synoptic and habitat mapping surveys have described Kaiteriteri Estuary as being in relatively good condition, even though considerable development for housing and exotic pine forestry has been undertaken in the catchment (Robertson & Stevens 2012; Stevens & Rayes 2018; Rayes et al. 2019).

Despite the good condition of the estuary overall, TDC has concerns regarding the degraded state of the southwest estuary embayment, which is located on the south side of the Martin Farm Road causeway (Fig. 1). One of the concerns relates to the presence of objectionable odours due to stagnating conditions along the embayment's western margin. An ecological survey of the wider estuary and coast undertaken in 2019 described this embayment as the Kaiteriteri Lagoon (Rayes et al. 2019), reflecting that water is retained across much of the area during low tide, despite the tidal sand flats in the adjacent estuary north of Martin Farm Road fully draining.

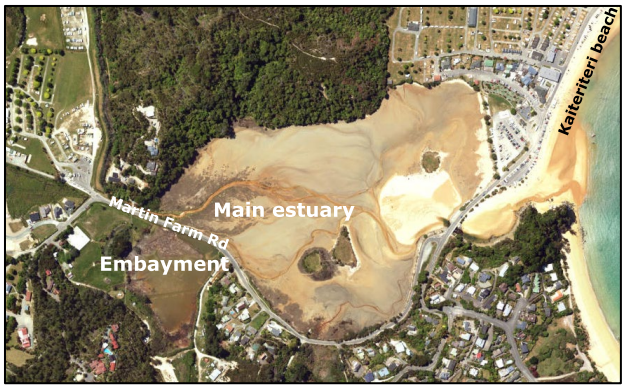


Fig. 1 Location of Kaiteriteri Estuary embayment

To better understand the present condition of the southwest embayment, TDC contracted Salt Ecology to undertake a preliminary qualitative assessment of the area, including an assessment of potential drivers of embayment condition and the scope for improvement. This report addresses these matters, considering historic changes in the embayment, the findings of a field visit on 28 February 2023, and an assessment of mitigation options.

2. SYNOPSIS OF HISTORIC CHANGES

The historic changes that have occurred in the wider embayment are pertinent to understanding the condition of the western margin. An impression of historic changes was gained from aerial imagery acquired from various sources. A selection of these images is provided in Figs 2-7.

Figs 2 and 3 indicate that the Martin Farm Road causeway was constructed between 1944 and 1947, at a time when the present-day embayment and reclaimed land to the west appears to have been dominated by salt marsh and was part of the main tidal estuary.

Images from about 1958 show the appearance of channels, presumably used to drain water from the embayment in order to convert it to farmland. The 1969 image shows multiple channels among what appears to be rough pasture and remnant salt marsh (Fig. 4).

Rough pasture is still evident through to 1980. Images from the early 2000's suggest that farming efforts were discontinued on the eastern half of the area with it returning to estuary. The land/estuary margin has remained similar from the early 2000's to the present day with reclaimed land remaining in the western half (Fig. 5) and the eastern half remaining an embayment connected to the estuary.

Photos taken over 2002-2006 indicate that there had been considerable re-establishment of previously lost salt marsh along the eastern side of the embayment, although salt marsh subsequently decreased between 2003 (Fig. 5) and 2011 (Fig. 6), with ponded water apparent in some areas. This decrease in salt marsh extent appears to be associated with the installation of five culverts beneath Martin Farm Rd in 2007, which was undertaken to "*improve stormwater drainage from the catchments on the south side of Kaiteriteri Inlet and improve tidal flow through to the lagoon…*" (TDC 2007).

Present day salt marsh has receded even further than in 2011, now being limited mainly to the embayment margins (Fig. 7). Considerable ponding of water is evident even at low tide, reflecting slow and incomplete drainage of embayment water. Among other factors, ponding of water is almost certainly the key contributor to the salt marsh recession that has occurred (see Section 3).

Fig. 2. Kaiteriteri Estuary in 1944 (source: http://retrolens.nz), before construction of the Martin Farm Road causeway. The wider embayment (approximated by red line) comprised mainly intertidal salt marsh.

Fig. 3. Kaiteriteri Estuary in 1947 (source: http://retrolens.nz). The Martin Farm Road causeway separates the southwest embayment from the main estuary.

Fig. 4. Kaiteriteri Estuary in 1969 (source: http://retrolens.nz). Embayment centre-left comprising rough pasture and remnant salt marsh. Drainage channels evident here appear in imagery as early as 1958. Rough pasture still evident through to 1980.

Fig. 5. Kaiteriteri Estuary in 2003 (source: Google Earth Historic Imagery). Half of the embayment (western side) remains in pasture, with much of the eastern half having reverted to salt marsh. A constructed channel (oval shape indicated by arrow) is evident.

Fig. 6. Kaiteriteri Estuary embayment in 2011 (source: Google Earth Historic Imagery) showing reduced salt marsh cover compared with 2003 (see Fig. 5), with the eastern and southern sections covered by ponded water.

Fig. 7. Kaiteriteri Estuary in March 2022 (source: LINZ Data Service – Tasman 0.3m Aerial Photos), showing that salt marsh has receded further since 2011, with only fringing areas remaining. The eastern and southern sections of the embayment are covered in ponded water.

3. CONDITION OF SOUTHWEST EMBAYMENT

3.1 CURRENT CONDITION

The site visit on 23 February focused on the western side of the embayment on the part of the estuary encompassed by land parcel Lot 1 DP 12554, which includes Kimi Ora Resort. This is the area where degraded conditions have been noted by TDC. Permission to survey the area was obtained from Kimi Ora.

Superficially, the area of interest has a degraded appearance due to terrestrial weeds around the margin of the estuary, a fallen pine tree, and a constructed channel that was likely originally intended as an artificial wetland. Except for sand-dominated sediments in tidally-elevated areas in the northwest corner of the embayment, the sediment in the western side of the embayment consists of soft mud in a layer 50-250mm deep that overlies a firm base. The base material comprises soil with an entrained root mass, and is probably a remnant of the pasture and salt marsh habitats that have come and gone over time (Figs 2-7).

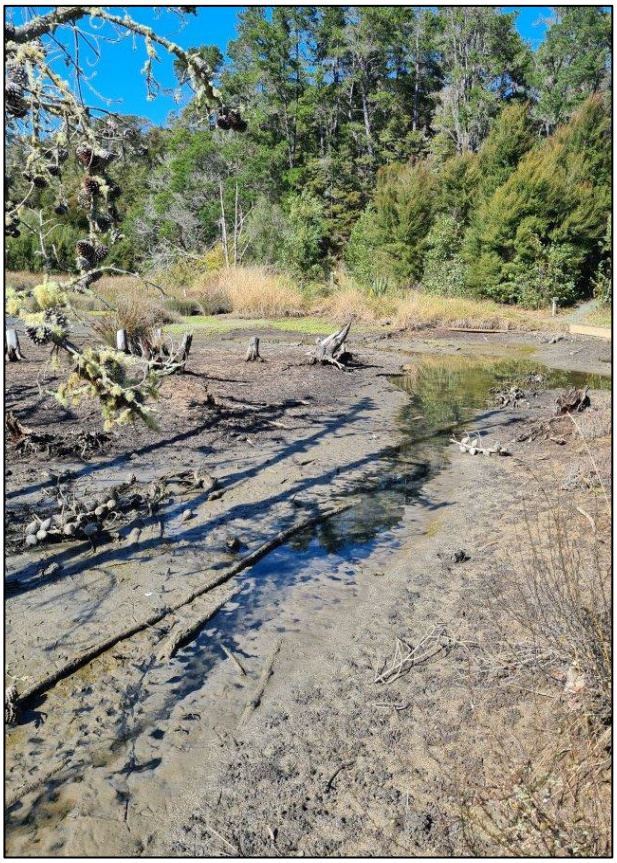
View of southwest embayment from Martin Farm Rd with rushland and sand-dominated sediments in northwest corner.

View of western margin of the embayment from Kimi Ora pathway, showing fallen pine tree and terrestial grasses and weeds.

Constructed channel west of the embayment, which first appeared in aerials in the 1980s. The Kimi Ora Resort pathway follows the embayment's western margin.

Sediments in muddy areas show strong symptoms of severe organic enrichment, in particular:

- A deep black colour throughout the sediment profile and in places at the sediment surface.
- A strong 'rotten egg' smell of hydrogen sulfide, which results from microbial decay of organic matter.
- Presence of yellow/green mats of microalgae, or white mats of sulfate-oxidising bacteria.



Black, anoxic surface sediments next to Kimi Ora walkway.

Soft muddy sediments along the blind channel entering the western margin of the embayment (top), and along the embayment margin (bottom), were highly anoxic, evident as black colouration with a strong hydrogen sulfide odour (rotten egg) when disturbed. In places yellow/green mats of microalgae, or white mats of sulfide-oxidising bacteria, were also present, which are indicators of extreme sediment enrichment.

The depth of the anoxic muddy sediments was approximately 50-250mm deep, and overlaid a firm soil base in which the root mass of former vegetation is still present.

Outside of the degraded areas of muddy sediment, the western side of the embayment has a margin of salt marsh vegetation comprising mainly rushland (searush *Juncus kraussii* and jointed wirerush *Apodasmia similis*) but also including small areas of herbfield, in particular bachelor's button (*Cotula coronopifolia)*, glasswort (*Sarcocornia quinqueflora)*, and slender clubrush (*Isolepis cernua)*.

Bachelors button and glasswort on the front edge of rushland along the western margin (top) and rushland with a terrestrial border of weeds and tall fescue (*Festuca arundinacea*; bottom)

A habitat map showing GIS layers for sediment type and salt marsh across the entire embayment was constructed from a combination of recent aerial imagery, maps produced by Rayes et al. (2019), ground-truthing undertaken along western side in February 2023, and related photographic records and observations (Fig. 8). In February 2023 we did not investigate the eastern two thirds of the embayment beyond the area owned by Kimi Ora, but it appeared superficially similar to the western side. Our preliminary assessment suggests that the overall embayment area of ~2.4ha consists of ~0.5ha of muddy and likely enriched anoxic sediments, with a fringing salt marsh covering an area of ~0.4ha.

3.2 DRIVERS OF EMBAYMENT STATE

The embayment has no regular catchment inputs such as perennial stream flows. Four 'blind' input channels that were identified in the field and/or from aerial photos are shown in Fig. 8. Some of these retained stagnant water and algal growths but none were flowing. These channels would potentially carry stormwater during heavy rain, and such events would also contribute direct stormwater runoff to the embayment.

Water ponded in blind channels connected to the embayment

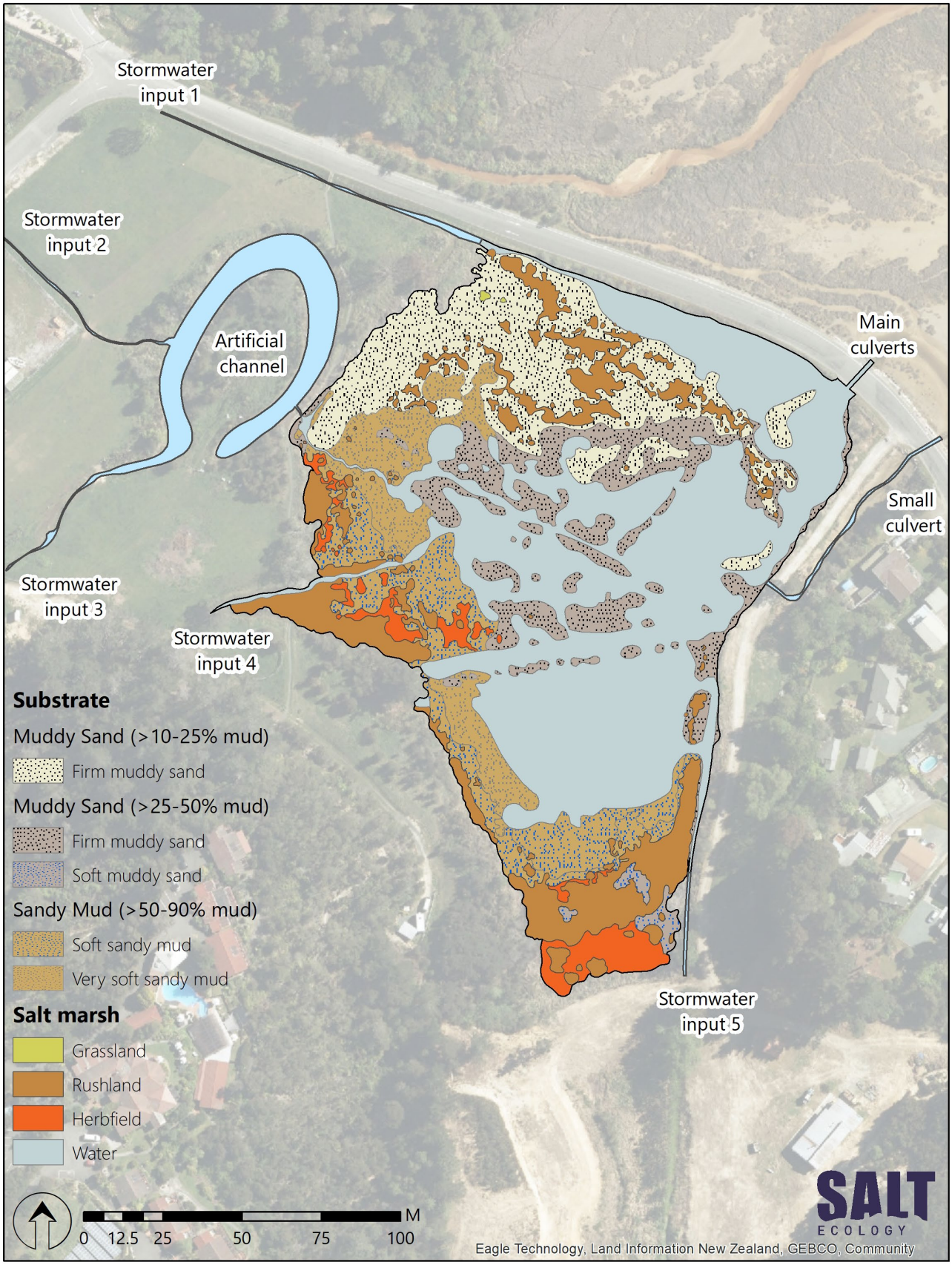


Fig. 8. Dominant salt marsh vegetation and sediment types in Kaiteriteri Estuary embayment. Constructed from a combination of recent aerial imagery, maps produced by Rayes et al. (2019), ground-truthing undertaken along western side in February 2023, and related photographic records and observations. Note that the embayment is connected to the main estuary by the main culverts under Martin Farm Road toward the northeast.

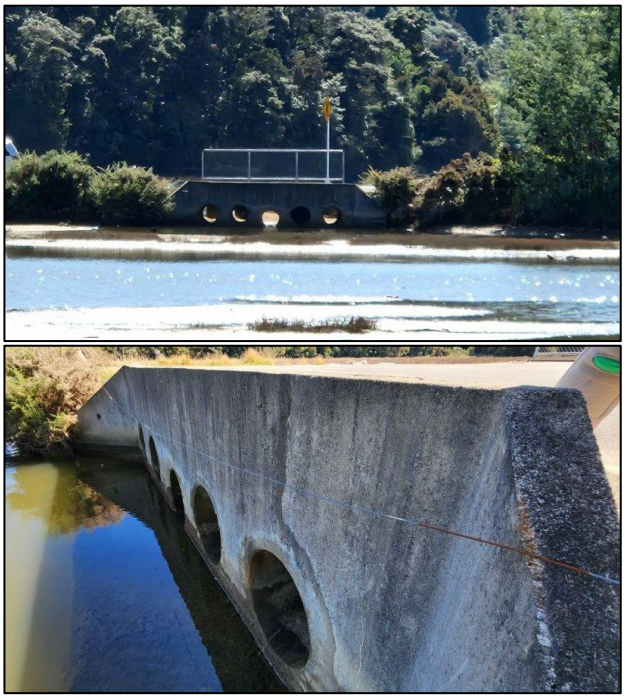
The degraded state of the embayment is most likely linked to historic changes in hydrology (i.e. variable water levels and present-day poor flushing) combined with historic reclamation, changes in vegetation over time, die-back of salt marsh habitat since the early 2000's, and contemporary sediment and nutrient inputs.

Prior to 2007, a restricted flow of tidal water entered the embayment via a small culvert to the northeast (Fig. 8). While this culvert remains today, tidal exchange to the embayment was enhanced in 2007 when five larger culverts (550-600mm diameter) were installed (see photos adjacent and 'main culverts' in Fig. 8). According to the TDC planning report on the consent application for culvert installation, the intent was to allow more efficient tidal flows to the lagoon and to prevent the build-up of stormwater and flooding of Martin Farm Road. It was hoped that improved tidal flushing would also help mitigate smells associated with stagnant water in the lagoon area during summer months (TDC 2007).

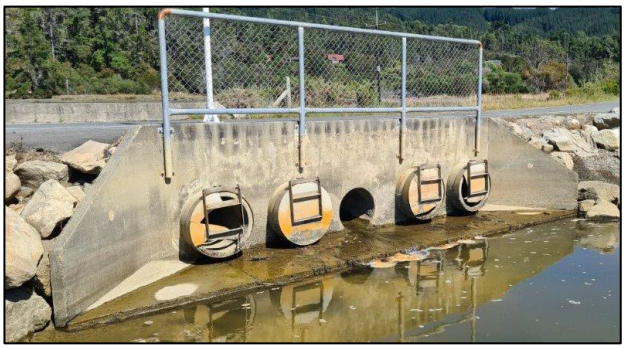
While the culverts will have improved tidal exchange, their design does not enable the embayment to fully drain, leading to a shallow layer of seawater that remains trapped at low tide. Drainage is impeded by the fact that four of the culverts were deliberately perched above the embayment bed level, with a single central culvert positioned at a lower tidal elevation to enable ongoing water outflow during low tide. The purpose in doing this was to "*retain the status quo in terms of high water levels and habitat values in the lagoon area*" (see discussion of these values in Section 4 below). Flap gates fitted to the four perched culverts were intended to prevent tidal water entry, with the gates intended to be open on ebbing tides and during heavy rainfall events when stormwater flows exceed the capacity of the lower central culvert.

The adjacent photos show that the flap gates on the four perched culverts are partially closed and/or broken, which will impede tidal water inflow and outflow. Furthermore, even though the central culvert is positioned lower in the tidal zone, it is insufficient to drain the entire volume of the embayment during tidal outflow. As well as leading to ponding of water across much of the embayment, the resulting present-day poor flushing means even low-level muddy sediment inputs from catchment disturbance, stormwater inputs and/or tidal inflow will be readily retained and deposited.

Salt marsh loss since the early 2000's has likely been caused or exacerbated by the ponding of water that has occurred since installation of the five culverts. Salt marsh typically grows in (approximately) the top 20% of the intertidal zone, where it experiences limited periods of inundation on each tidal cycle. Historic aerial imagery shows salt marsh has retreated following the culvert installation, likely reflecting the increase in water entering the embayment, resulting in an elevated water level and increased periods of salt marsh inundation (i.e. beyond its natural tolerance for being submerged).



Culverts from embayment side (top and middle), with only one flowing during the mid-outgoing tide.



Culverts at mid-outgoing tide on main estuary side (bottom), showing flap gates on the four culverts that are perched above the bed level. Only the central culvert is draining the embayment. The flap gates on the four perched culverts were partially closed and/or broken.

Salt marsh loss within the embayment further compounds the muddy sediment issue, as salt marsh traps fine sediments, which would have been released upon salt marsh dieback. Combined with poor flushing, this situation has led to muddy sediments being retained and dispersed across the embayment. Further, the dead salt marsh root mass, now buried below 50-250mm of muddy sediment, likely provides an organic matter source leading to enrichment of the surface

sediments (i.e. anoxia). Other inputs that may be contributing to the poor condition of the sediment include ongoing inputs of terrestrial detritus that accumulate in the artificial channel, and intermittent inputs of stormwater.

Finally, the quality of the shallow, ponded water is probably poor and highly variable; for example, ranging from hypersaline on hot days when evaporation is high, to relatively low-salinity during heavy rainfall. High water temperatures during the day also likely promote microalgal growth on the sediment surface. This water quality variability may play a role in the decline in sediment condition, and potentially other biota such as the estuary macrofauna that would otherwise naturally occur. For example, pipi and cockles are widespread and abundant in parts of the main estuary north of the causeway (Rayes et al. 2019) but would be highly unlikely to inhabit the embayment.

4. SCOPE TO IMPROVE THE DEGRADED STATE

Based on the main estuary area to the north of Martin Farm Road, the natural state of the embayment probably consisted of coarse granite sands. This sediment type is present only in the elevated northwest corner of the embayment, where the sediments have a small mud component but are nonetheless sand-dominated. Improvement of the current situation can be considered from several perspectives:

- Ensure that conditions do not degrade further.
- Remediate the anoxic mud that has accumulated.
- Restore the embayment to a more natural state in which salt marsh cover is extensive and tidally connected to the main estuary.

Underpinning all three outcomes is improving the flushing of the embayment. Removing the flap gates from the four culverts would improve tidal exchange, but the perched nature of all but one of the culverts means that ponded water will remain. We suggest that TDC consider undertaking an engineering assessment to determine the works that would be required to achieve complete tidal flushing of the embayment. Among other matters, such an assessment would involve:

- Determining the number and/or size of culverts required to enable tidal water exchange without a significant lag.
- Ensuring the invert of the culverts was at least as low as the sediment bed level of the embayment, noting that the bed level may lower if existing mud is gradually eroded by increased tidal water flow.

The latter assessment would require a survey of tidal elevation across the embayment, as well as determination of the depth of the mud layer in areas not assessed in the survey described in this report (i.e. the central and eastern side of the embayment).

Note that the extent and duration over which the accumulated mud layer would naturally erode and disperse with improved tidal flushing is unclear.

Improved flushing and dispersal of the anoxic mud would likely provide the opportunity for salt marsh to naturally re-establish provided the bed height was suitable. As noted above, a key driver of present salt marsh loss is that it cannot tolerate inundation for extended periods (which occurs currently due to a combination of water ponding, and a lag in draining due to the constricted flows). Accordingly, it may be necessary to undertake minor recontouring earthworks to recreate suitable salt marsh habitat, remove some of the accumulated mud layer (if it does not naturally flush out), and/or undertake active planting to facilitate restoration of historically lost salt marsh habitat.

Salt marsh, and coarse granite sand habitats of the main Kaiteriteri Estuary and stream that runs parallel to the western end of Martin Farm Road

One of the considerations for returning the embayment to be a more fully connected part of the estuary is the expected improvement in ecological value that will arise compared to the present situation. Despite decreases in estuary extent and salt marsh since prior to 1944, and issues with the current degraded sediments, the present-day embayment still retains a habitat with its own values of interest. This includes a diverse and abundant bird fauna, which is more conspicuous than in the tidal part of the main estuary (Rayes et al. 2019) due to ponded water retention, and at least three lowland freshwater fish species, namely eels (*Anguilla* species), inanga (*Galaxias maculatus*) and giant bully (*Gobiomorphus gobioides*).

However, the species that confer these values also occur in the wider estuary, or have alternative habitat that is locally available. As such, although restoration of the embayment to a more natural state would alter the present values, they would not be lost and in many instances would be enhanced. Given the widespread degradation of estuary margins and embayments regionally and nationally, it is considered more desirable on balance to restore the Kaiteriteri embayment to a situation that better reflects its historic values, in which it is dominated by salt marsh habitat that is tidally connected to the main estuary.

5. RECOMMENDATIONS

We recommend that TDC consider in greater detail the remediation options for the degraded state of the embayment, which would involve assessing:

- The engineering requirements (e.g. culvert number and size) to achieve complete tidal flushing of the embayment and to remove the anoxic mud that has accumulated.
- The bed level of the embayment and depth of the accumulated mud layer, and works required to ensure the bed level is suitable for natural re-establishment (or active planting) of salt marsh.

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