# Eco-hydrological Assessment and Restoration Plan for Burdens Marsh, Sloping Main Reserve, turrakana/Tasman Peninsula

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Nature Glenelg Trust

Report to the Tasmanian Land Conservancy

TASMANIAN LAND CONSERVANCY

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**Cover photo:**

Tidal gate and levee at the outlet of Burdens Marsh, August 2023 (photo: Bec Sheldon).

**Disclaimer**

## Acknowledgements

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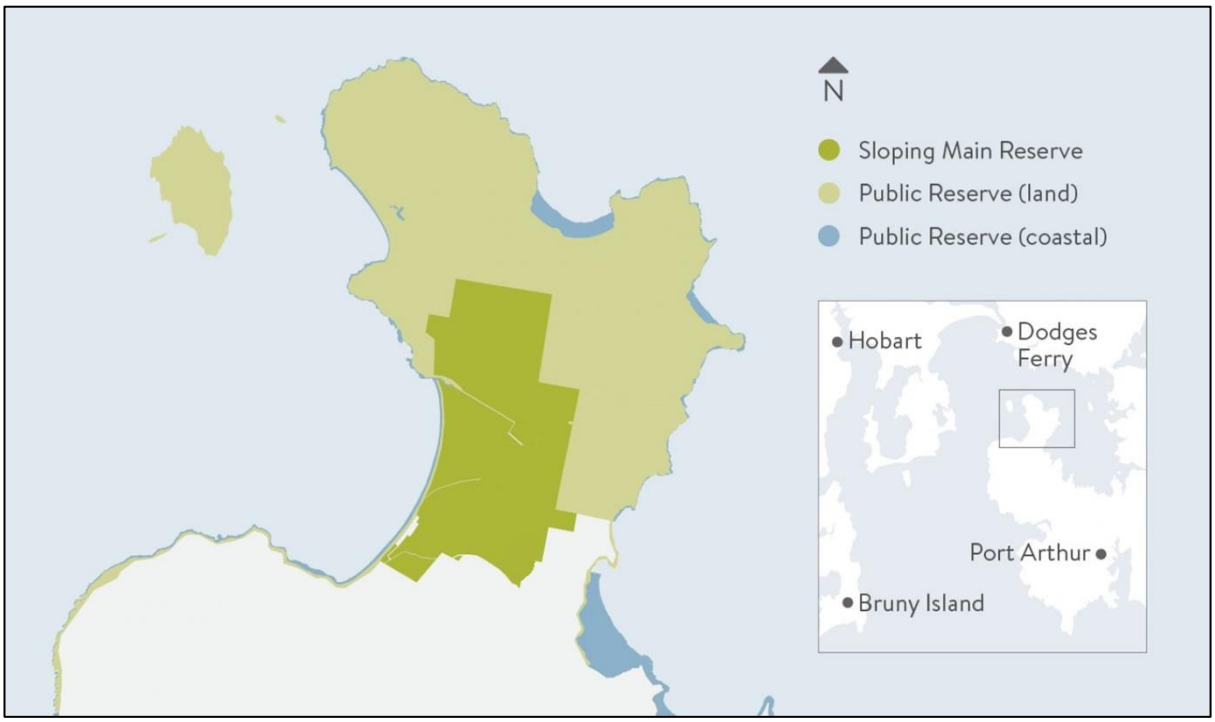
PURRYBURRY TRUST

# Executive Summary

## Background

Sloping (Slopen) Main Reserve was established by the Tasmanian Land Conservancy (TLC) in 2022 and expanded in 2023 through the purchase of Burdens Marsh, an adjacent area of saltmarsh habitat.




The Tasmanian Land Conservancy engaged Nature Glenelg Trust in 2023 to undertake an eco-hydrological assessment of Burdens Marsh, to investigate, document and assess historic changes to hydrology, trajectory of ecosystem condition, restoration objectives and opportunities to maintain and improve extant saltmarsh and wetland ecosystems.

Among many other similar projects across south-eastern Australia, NGT has previously worked on a project at the TLC's Long Point Reserve, adjacent to Moulting Lagoon (near Swansea), which commenced in 2021 and led to works in 2022/23.

## What is an eco-hydrological assessment?

Like many wetlands on Tasmania's east coast, Burdens Marsh is a site that has experienced successive impacts over the past 200 years. The eco-hydrological investigation process that is routinely conducted by NGT, involves taking a deep, comprehensive look at a wetland area and documenting this history of change. The process entails carefully combining the on-site evidence and modern mapping tools and resources, with the aerial photographic record, local knowledge of land management history, and archival reports, journals and maps.

Taking the time to explore and arrange this information into a timeline, enables us to describe the original state of a wetland more accurately, and explore when and why certain changes were made. This knowledge in turn allows us to concentrate on any hydrological (water management) issues that can be remedied today, to set the site on a positive trajectory of ecological recovery for the future.

Wetlands are especially forgiving and adaptive ecosystems, because of the fundamental role that flows and inundation patterns play in driving their ecology. NGT has had significant success with this using this approach over the past 12 years, restoring more than 60 wetlands across south-eastern Australia.

### A timeline of the complex history of Burdens Marsh

As summarised below, the assessment (outlined further in significant detail within this report) found that Burdens Marsh has been subjected to a series of hydrological changes dating back to the 1820s, which are having an ongoing impact on wetland ecology.

<table>
<tr><th></th><th>1.<br>saltmarsh<br>natural<br>ocean outlet</th><th>2.<br>main<br>saltmarsh<br>area</th><th>3.<br>Turners<br>Lagoon /<br>wetlands<br>east of<br>saltmarsh</th><th>4.<br>fresh<br>wetlands<br>south of<br>main<br>saltmarsh</th><th>5.<br>seasonal<br>southern<br>catchment<br>fresh<br>inflows</th></tr>
<tr><td>Pre 1820s</td><td colspan="5">Original site condition: prior to European colonisation and under the custodianship of the First Nations Traditional Owners, the Pydairreme clan of the Paredarerme (Oyster Bay) nation</td></tr>
<tr><td>Late 1820s - 1834</td><td>Unclear what, if any, changes were made, but artificial openings likely when required, linked to reclamation of the main saltmarsh area</td><td>First 115 acres of saltmarsh drained and farmed by J. T. Gellibrand at Sloping Main</td><td rowspan="5">No change to hydrology during this phase</td><td rowspan="5">No change to hydrology during this phase</td><td rowspan="3">No change to hydrology during this phase</td></tr>
<tr><td>1834 - 1848</td><td>Possible period of construction of first timber outlet gate / weir system at mouth of natural outlet</td><td>Gellibrand’s farm and building requisitioned by government and likely expansion of drainage works to cover more of the saltmarsh area before the Coal Mine lease.</td></tr>
<tr><td>1849 - 1877</td><td>The outlet is situated north of the fence constructed in 1849, situated in the ungrazed area that formed part of the Coal Mine lease. The outlet unlikely to have been managed during this time.</td><td>In 1849, a fence (with guard stations) to separate and secure the Coal Mine lease area was constructed E-W through the saltmarsh and beyond. Sheep grazing occurred south of the fence during this phase, but drains were not maintained.</td></tr>
<tr><td>1877 – c.1900</td><td rowspan="2">Artificial openings recommence. Whether the old gate weir system at the mouth was installed in 1830s/40s, or after 1877, it was rumoured later destroyed (burned) by Burden, before arrival of J. A. Price</td><td rowspan="2">A second attempt to farm the entirety of the main saltmarsh commences from 1877, likely using pre-existing convict drainage system. The main network of drains and levees in place by 1932 when J A Price purchases the land.</td></tr>
<tr><td>c.1900 – 1932</td><td>Major impact: flows largely diverted (to ocean) via new drain</td></tr>
<tr><td>1932 – 1960s</td><td>Artificial openings continue. Original gate system no longer present (only last couple of timbers visible) when J. A. Price purchases the land in 1932, and not replaced until c.1990</td><td>Little further drainage of the main marsh occurs in this phase</td><td rowspan="3">Major impact: wetlands drained into the sea, via Burdens Marsh since 1960s</td><td rowspan="3">Major impact: wetlands drained into the sea, via Burdens Marsh since 1960s</td><td rowspan="3">The existing artificial drain south of Burdens Marsh is re-established and better maintained</td></tr>
<tr><td>1960s – c.1990</td><td rowspan="2">Some additional minor drainage works through the main marsh completed to improve sheep grazing, and some new causeway embankments built for vehicle access, but most drains were not specifically maintained or altered.</td></tr>
<tr><td>c.1990 - 2021</td><td>Artificial openings continue. Current timber gate / weir and levee near outlet in place and operated to reduce depth and duration of inundation, and prevent tidal ingress</td></tr>
<tr><td>2022 - present</td><td>Artificial openings cease. Weir & levee near mouth still in place but not operated since TLC purchase</td><td>More water held for longer after rainfall events, due to change in outlet management philosophy</td></tr>
</table>

## A parallel timeline of hydrological impacts to Burdens Marsh

By carefully reviewing these modifications to Burdens Marsh and their impacts over time, it is possible to construct a more complete understanding of the natural hydrological regime of the wetland and how it has been altered.

To demonstrate the combined impact of these changes, the table below illustrates how the different hydrological inputs have changed over time, and how they have interacted with the site.

<table>
<tr><th></th><th colspan="3">Broad description of the hydrological regime of Burdens Marsh saltmarsh</th></tr>
<tr><th></th><th>Main saltmarsh area water regime</th><th>Contribution of fresh inflows</th><th>Condition of the natural outlet</th></tr>
<tr><td>Pre 1820s</td><td>Wide fluctuations in depth, extent and duration of inundation, driven by east coast Tasmanian climatic patterns, resulting in an extremely dynamic saltmarsh ecology, favouring species capable of tolerating or exploiting a wide range of conditions. Periods of temporarily brackish to fresh, deeper inundation, likely followed by periods of hypersaline tidal exchange, before mouth closure and more complete drying. This dynamic cycle, which is not a ‘fixed state’ was the natural water regime.</td><td>With local rainfall over the marsh complemented by seasonal inflows from the larger southern catchment after rainfall, Burdens Marsh could temporarily fill with fresher water, before either draining more rapidly via a mouth opening, or slowly drying down, before reverting to its prevailing, underlying saltmarsh character.</td><td>The mouth would have been highly dynamic with flows likely breaking through the sand berm at the mouth every time there were sufficient inflows, driven by the larger southern catchment. This means that periods of subsequent tidal exchange, after scouring of the mouth, were also likely to have been regular. During prolonged dry periods, outlet remains closed with no tidal exchange.</td></tr>
<tr><td>Late 1820s - 1834</td><td>The water management goal at this time of initial development (by Gellibrand), would have been to reduce the extremes of inundation experienced in the main central saltmarsh area. Through drainage and levees, combined with mouth management, saltmarsh hydrology would have been less dynamic during this phase.</td><td rowspan="2">Seasonal fresh inflows were not modified, with the full original catchment of Burdens Marsh available.</td><td rowspan="2">To protect the initial 115 acres of developed area (and likely expanded area of up to 400 acres in 1830s and 1840s) some form of management of the mouth was probable during this period, e.g. deliberate opening of the mouth to prevent deeper, sustained inundation after rainfall events.</td></tr>
<tr><td>1834 - 1848</td><td>After Gellibrand’s departure, expansion of his drainage scheme likely completed using convict labour, until the new Coal Mine lease fence bisects the saltmarsh in 1848.</td></tr>
<tr><td>1849 - 1877</td><td colspan="3">Reversion to the pre-1820s, highly dynamic eco-hydrological regime and recovery of native vegetation in Burdens Marsh, albeit with some pre-existing physical modifications (drains, embankments) remaining in-situ from the first attempt at saltmarsh development.</td></tr>
<tr><td>1877 – c.1900</td><td>Once again, the goal of water management during this new phase of development (after closure of Port Arthur), would have been to reduce the extremes of inundation experienced in the main saltmarsh area, through maintaining drainage, combined with more active mouth management.</td><td>Seasonal fresh inflows were not modified, with the full original catchment of Burdens Marsh available.</td><td rowspan="2">Management of the mouth occurred during this period e.g. deliberate opening to prevent deeper, sustained inundation. Original timber weir system at the mouth rumoured destroyed by Burden before 1913, presumably as it no longer worked as intended.</td></tr>
<tr><td>c.1900 – 1932</td><td rowspan="2">Property changes hands from Burden to McWilliams in 1913, and to J. A Price in 1932, although Price family may have leased for up to a decade earlier based on information passed down by Price family.<br>Major reduction in inflows from diverted southern catchment, likely leading to less frequent mouth openings (and reduced opportunities for tidal exchange). Overall, less variable / dynamic hydrology, to facilitate grazing of the saltmarsh. The lack of a weir at the mouth meant water regime was still more variable during this period.</td><td rowspan="2">Major change to water balance, with creek carrying main southern catchment flows diverted (to reduce inundation and provide water to timber mill), with a significant proportion of these flows lost to Burdens Marsh since that time.<br>However, over time this diversion drain is not maintained and becomes less effective.</td></tr>
<tr><td>1932 – 1960s</td><td>With no weir system, there was no way to prevent tidal ingress after artificial openings in this period. Pre-1950s, opening was done by shovel, and post-1950s, by tractor. In a ‘successful’ opening, flows scoured the outlet to sandstone bedrock, and tides would enter via the mouth for weeks, at times up to 2-3 months, subject to weather/rate of sand drift.</td></tr>
</table>

| | **Broad description of the hydrological regime of Burdens Marsh saltmarsh** | | |
|---|---|---|---|
| | *Main saltmarsh area water regime* | *Contribution of fresh inflows* | *Condition of the natural outlet* |
| **1960s – c.1990** | Renewed period of development and access improvement works done by F. J. Price, consolidating the reduced frequency, depth, extent and duration of inundation of Burdens Marsh. Renewed works to enhance/maintain diversion of the major freshwater southern catchment to the sea, likely impacting on frequency of mouth openings (hence reduced opportunities for tidal exchange).<br><br>The new water regime is entrenched, with much less variable / dynamic hydrology, to facilitate grazing of the saltmarsh. | Renewed works to enhance/maintain diversion of the major freshwater southern catchment to the sea. Ongoing loss of flows marginally offset by the concurrent artificial drainage of two smaller catchments inc. Turners Lagoon and fresh wetlands to the east and south into Burdens Marsh. Loss of adjacent, complementary fresh wetlands. | No weir system in operation at the mouth, but artificial openings to reduce depth and duration of inundation after heavy rainfall events still occurred as required, leading to some periods of tidal exchange in the saltmarsh.<br><br>During this period, preference was to manage outlet to remain tidal (open to sea) whenever possible, so that any catchment inflows would run to the sea and not deeply inundate the marsh. |
| **c.1990 - 2021** | Reduced frequency, depth, extent and duration of saltmarsh inundation with sea water, due to operation of the new weir to prevent tidal ingress.<br><br>Intensification of the general drying trend as a result of the new weir and levee preventing tidal ingress after artificial mouth openings.<br><br>Less dynamic hydrology overall, to accommodate ongoing farming (grazing) of the saltmarsh. | Catchment remains reduced, with a varying (but significant) proportion of natural fresh inflows still diverted away from Burdens Marsh. All water in low-moderate flows is diverted, but some water (up to 50% at peak flows) can still temporarily overwhelm the diversion drain's northern embankment in high flows after major rainfall events, allowing a portion of this water to still reach Burdens Marsh.<br><br>Adjacent freshwater wetlands remain artificially drained.<br><br>Ongoing absence of the bulk of seasonal southern catchment inflows being diverted, likely preventing a more regular, natural regime of mouth openings and subsequent periods of tidal exchange. | Artificial mouth openings continue. Current timber gate / weir structure and associated levee are constructed c.1990 and actively managed to prevent tidal ingress after artificial mouth openings. |
| **2022 - today** | Grazing of the main saltmarsh area ends with establishment of the TLC Reserve, and the long-term drying trend is partially reversed, through lack of active management of the natural outlet.<br><br>Despite this alteration to hydrology, ongoing impacts on saltmarsh ecology include:<br>(a) the change in micro-topography within the saltmarsh area (caused by drains and embankments),<br>(b) the reduction in fresh catchment inflows,<br>(c) the change in flow dynamics through the mouth, and<br>(d) the loss of ecological diversity and available habitat for species resident within and around Burdens Marsh, through the legacy drainage of important adjacent, complementary fresh wetlands to the south and east, inc. Turners Lagoon.<br><br>Less dynamic hydrology overall compared to the original eco-hydrological regime. | | Artificial mouth openings cease under TLC ownership / management, meaning outflows now rely on the wetland reaching sufficient depth for flows to be able to naturally breach and erode through the beach sand bar at the mouth of the outlet.<br><br>The disused weir and levee system risk ongoing reduction in tidal exchange as a result of an artificial constriction of flows (in both directions: outflows and inflows) and fish movement, with implication for the whole ecosystem, particularly piscivorous waterbirds. |

If the intention of the TLC in securing the protection and restoration of Burdens Marsh is to return the area to a state and eco-hydrological function that most closely resembles this original condition prior to the 1820s, then this table is a helpful way of deciding the elements that are required for determination of a future 'goal state' of the site.

## Articulating a future goal state for Burdens Marsh

In the case of a saltmarsh area like this, with highly variable and dynamic hydrology over time (including the time prior to its artificial modification), it is important to clarify that the original condition of Burdens Marsh, and the hydrological regime that underpinned it, was never static. The 'goal state' in this case is therefore better described and understood as being a range of conditions, rather than a fixed, idealised ecological state or outcome.

In summary, we should expect to see the ecological attributes of a site like Burdens Marsh, in all areas below high-water mark, shifting in character constantly over time in response to it being an inherently dynamic system with a highly variable hydrological regime. Under a restoration scenario, its hydrological regime may become even more dynamic as we attempt to reverse the various impacts described.

For the purpose of this assessment, the proposed *goal state* for Burdens Marsh, on the basis of the historic assessment and information provided, is a wetland where:

- Wide fluctuations in depth, extent and duration of inundation occur, driven by east coast Tasmanian climatic patterns, resulting in an extremely dynamic saltmarsh ecology below high-water mark, favouring species capable of tolerating or exploiting a wide range of conditions.
- Local rainfall over the marsh is complemented by episodic inflows from the large southern catchment after rainfall.
- There are periods of temporarily brackish to fresh, deeper inundation, likely followed by periods of hypersaline tidal exchange, before the mouth closes, leading to more complete drying and reverting to its underlying saltmarsh character.
- Adjacent complementary freshwater wetland habitats are healthy and vibrant.
- A dynamic hydrological cycle is reinstated, noting that the water regime at a site with these attributes cannot be maintained in a fixed or steady state.

To achieve this *goal state*, given the past 200 years of modifications to the site, its catchment and surrounds, this is a wetland where:

- Physical changes to the micro-topography of the saltmarsh area (caused by drains and embankments) have been repaired,
- Southern catchment inflows have been reinstated,
- The natural outlet to the sea is once again allowed to naturally breach, erode, open and close, as the prevailing climatic conditions dictate, without human intervention,
- Infrastructure (the weir and levee) that is impeding movement of freshwater and tidal flows, both in and out of the natural outlet to the sea, is removed and the landform restored; and
- Complementary fresh wetlands to the south and east, including Turners Lagoon, are restored to provide adjacent complementary habitats for wildlife, in doing so recovering the original ecological diversity, complexity and integrity of the wider Sloping Main Reserve.

## Restoration Options for Burdens Marsh

Based on this assessment, a hydrological restoration plan was developed to guide future management and potential restoration activities.

Key stakeholders, neighbours and members of the local community were consulted throughout the research and development of this plan, to create a shared understanding of the restoration strategy, as it emerged. Implementation of the plan will ensure that the key conservation targets for the site are maintained, enhanced and protected in perpetuity.

The restoration plan in this report outlines two options for TLC consideration within the Sloping Main reserve:

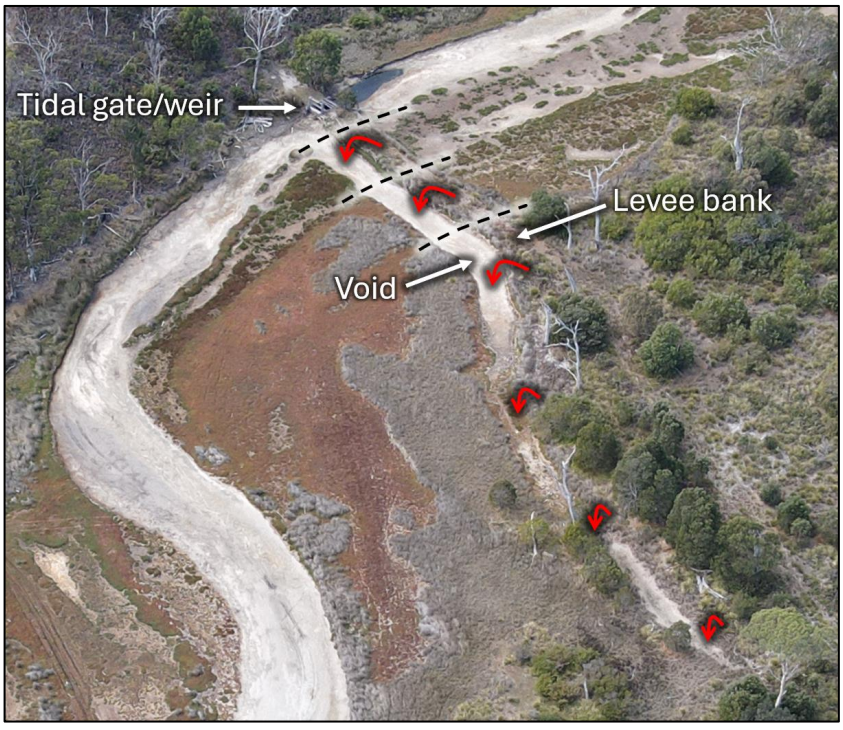
1. **Do Nothing:** which are two options associated with not remediating past physical changes to the site that are impacting upon wetland hydrology.
2. **Progressive wetland restoration steps within the TLC Reserve**: four steps (which can be tackled in stages) towards full restoration within the TLC Reserve, which will restore the landform and hydrological function of Burdens Marsh and adjacent wetlands to the east.

Beyond the reserve, two further actions (which can also be addressed in stages) are outlined in the report, that would result in the full restoration of all wetlands associated with Burdens Marsh, and the reinstatement of the southerly catchment that is currently diverted to the sea, away from the marsh. As these future potential actions fall outside of the TLC Reserve boundary and will not be specifically pursued by the TLC, NGT is willing to continue an independent discussion with the neighbour to explore whether progress is possible outside of the TLC's project.

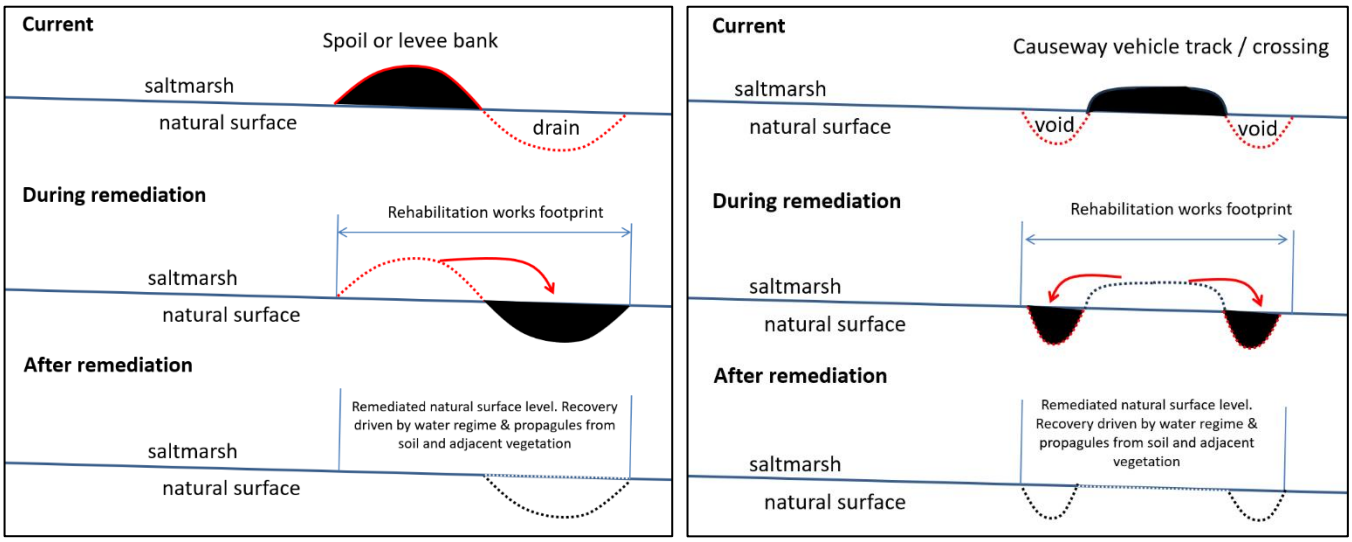
## Restoration Recommendations for Burdens Marsh

Nature Glenelg Trust recommends the endorsement of Option 2 by the TLC, which would involve undertaking landform remediation works to reverse the following impacts (in this priority order):

(1) **Tidal weir and levee removal** – to restore the condition / function of the saltmarsh natural outlet

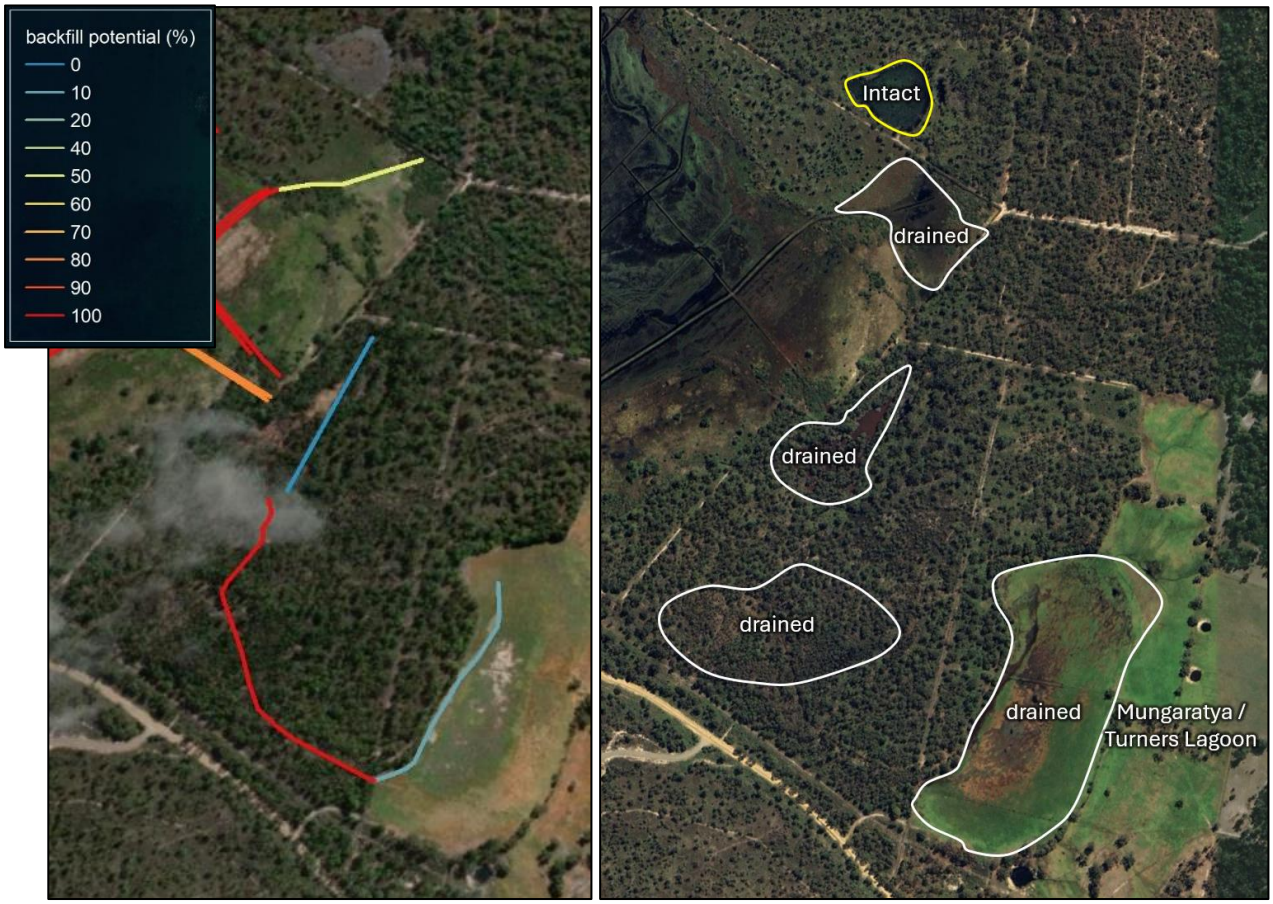


(2) **Removal of artificial drains, embankments and causeways** – to restore the movement and inundation patterns of water across the main saltmarsh area (as per these examples)




(3) **Turners Lagoon outlet drain backfilling** – to restore this deep freshwater marsh (as shown below)

(4) **Other drains to the east of Burdens Marsh** – to restore the chain of fresh wetlands east of the main saltmarsh area (also shown below).




**Drain backfill potential and approximate original extent of the chain of freshwater wetlands east of the main saltmarsh area at Burdens Marsh, including Turners Lagoon. All approximately marked wetlands are within the TLC's Sloping Main Reserve.**

# Table of Contents

## List of Tables



## Table of Figures

# 1. Introduction

## 1.1. Project Background

In July 2023, the Tasmanian Land Conservancy (TLC) extended the Sloping Main Reserve on turrakana/Tasman Peninsula via the purchase of Burdens Marsh, adding a further 235 hectares to the original 425-hectare reserve, with the reserve now totalling 660 hectares (Figure 1). Together with neighbouring Lime Bay State Reserve and the Coal Mines Historic Site, Sloping Main Reserve forms part of 2,220 hectares of contiguous conservation reserves on turrakana/Tasman Peninsula (Figure 2).

Burdens Marsh exists within the western parcels of the Reserve and contains areas of high conservation value, including one of the largest coastal saltmarsh complexes in Tasmania and 116 hectares of the nationally vulnerable '*Subtropical and Temperate Coastal Saltmarsh'* ecological community. The marsh provides important feeding and breeding habitat for waders and waterfowl and is unique in that it has a native vegetation buffer and gently sloping surrounds which provides the opportunity for future, seamless coastline and habitat migration in response to predicated sea level rise.

A series of legacy, convict-era and contemporary drains intersect Burdens Marsh, and a tidal gate/levee exists at the mouth of the marsh, at the foot of the Cardwell Range on the outlet channel to Frederick Henry Bay, where flows between the bay and the marsh were historically regulated to facilitate stock grazing, by reducing inundation and preventing tidal ingress with sea water.

The manipulation of natural hydrology and the fresh/saltwater interface over the past two centuries has likely influenced the current eco-hydrology of Burdens Marsh. Sea-level rise models predict that by 2050 parts of Burdens Marsh will be permanently inundated, and that the inundated area will double by 2100. As such, it is important to understand the trajectory of change in site eco-hydrology and to define management objectives for the marsh that capture the naturally dynamic nature of this environment and also take into consideration predicted sea level rise.

The TLC engaged Nature Glenelg Trust (NGT) to undertake an eco-hydrological assessment of Burdens Marsh to understand historic changes to hydrology, trajectory of ecosystem condition, restoration objectives and opportunities to maintain and improve extant saltmarsh and wetland ecosystems. Based on the assessment, a hydrological restoration plan was developed to guide future management and potential restoration activities. Key stakeholders, neighbours and members of the local community were consulted throughout the development of the plan to ensure that there was a shared understanding of the restoration strategy. Implementation of the plan will ensure that the key conservation targets for the site are maintained, enhanced and protected in perpetuity.


**Figure 1. Map of TLC's Sloping Main Reserve and associated land parcels.**

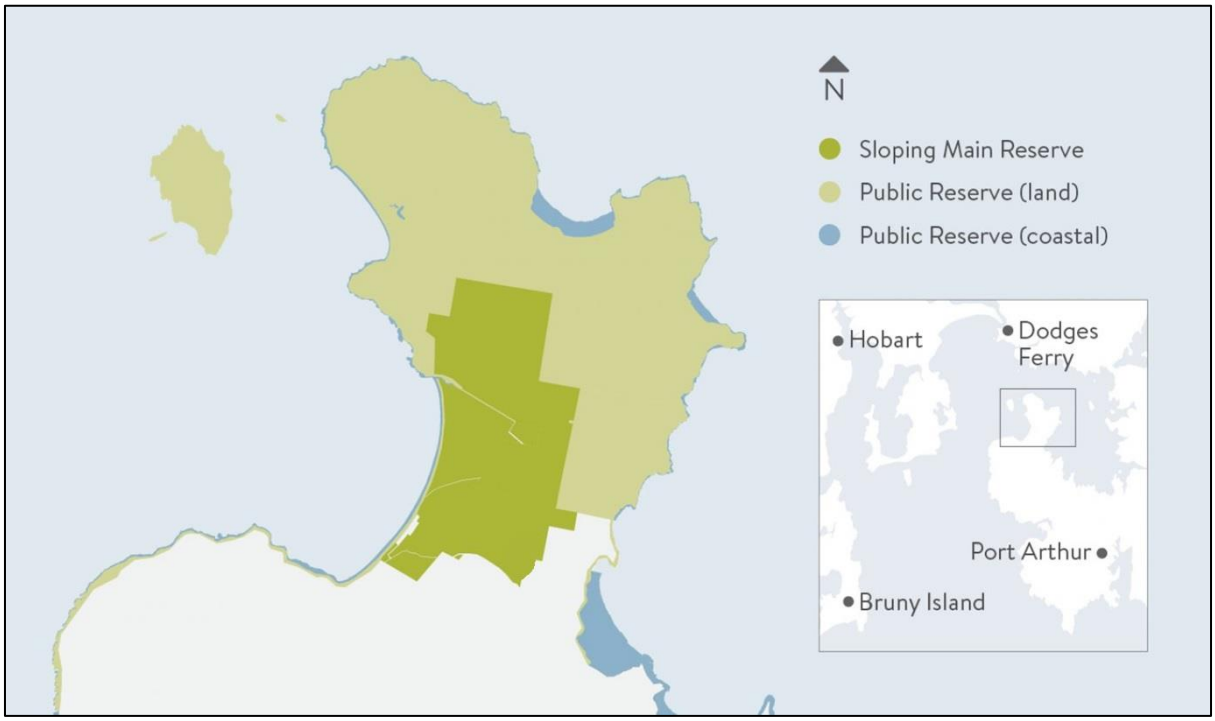



**Figure 2. Map of TLC's Sloping Main Reserve, in context of surrounding reserves. Source: TLC website** Sloping Main Reserve - Tasmanian Land Conservancy (tasland.org.au)

## 1.2. Project Objectives

NGT was engaged by the TLC to undertake an eco-hydrological assessment of Burdens Marsh, Sloping Main Reserve, to:

- determine historical and current eco-hydrological conditions of the site, through oral and written historic sources;
- document and assess physical changes to site eco-hydrology though time;
- develop and evaluate restoration options against both expected ecological outcomes and required management inputs;
- work closely with the TLC Conservation Science and Planning Team to define ecological objectives for the site;
- produce an eco-hydrological restoration plan that outlines the priority areas and recommended works to achieve restoration of the natural hydrology across Burdens Marsh and collates all project findings; and
- facilitate a community event with TLC staff to outline the findings of the restoration plan for Burdens Marsh.

In summary, the project intended to develop an understanding of site eco-hydrology, restoration opportunities and to identify restoration solutions that are feasible, across the complex of wetlands and saltmarsh at Burdens Marsh, which are capable of enhancing site values.

# 2. The History of Site Management and Eco-hydrological Change Across the Sloping Main Reserve

## 2.1. Pre-1803: Land Management Prior to European Colonisation

The Pydairrerme clan of the Paredarerme nation, a language group of the Oyster Bay region on the east coast of trouwunna/lutruwita (Tasmania), are the first peoples of turrakana / Tasman Peninsula and Forestier Peninsula (Wikipedia 2023). Abel Janszoon Tasman's (Figure 3) voyage of 1642 resulted in the first recorded European observations of evidence that people were present on the island that he named Van Diemen's Land (Heeres and Coote 1898), after making landfall near turrakana/ Tasman Peninsula. However, it was not until the 7th March 1772 that direct first contact took place between local Aboriginal people and a landing party led by the French explorer Marc-Joseph Marion du Fresne (Figure 3). This encounter turned violent, with the death of at least one Aboriginal person, in what is now known as Marion Bay on the Forestier Peninsula (Translator: Roth 1891).

**Figure 3. Portrait of Abel Tasman by Jacob Gerritsz Cuyp, 1637 (left) and Portrait of Marc-Joseph Marion du Fresne (right).**

Voyages by European (especially French and British) sea explorers over the next three decades would result in the mapping of the Tasmanian coastline and a number of non-violent exchanges with Aboriginal people, where a great deal of information was shared and recorded. However, in response to the ongoing level of French interest in the same area, the British established a colonial settlement in 1803 at Risdon Cove, moved a short time later in 1804 to present-day Hobart. This new settlement was the initial focal point for the European invasion of trouwunna/lutruwita and set the scene for the dramatic changes that followed, with devastating impacts for the traditional owners of the island, including the people of the Paredarerme nation who inhabited turrakana.

## 2.2. 1803-1833: A Period of Conflict and Colonial Land Occupation

In the first two decades after the establishment of the colonial town of Hobart, there appears to have been little interest from settlers in developing land on the Tasman Peninsula, which has large areas of steep terrain and forest. During this time, the rapidly growing number of arriving European settlers sought to occupy and introduce grazing livestock to the most productive native grasslands across the central-eastern (Midlands) region of Tasmania. By the early 1820s, additional excursions by settlers along the east coast to select land in areas unoccupied by Europeans, also led to a general eastward expansion of grazing enterprises and the establishment of new pastoral runs.

By 1830, the Tasman Peninsula had been identified as a secure location to establish a convict settlement at Port Arthur. As a convict settlement, the Tasman Peninsula had natural advantages for the new colony:

1. The security offered by a penitentiary "formed by nature". Being almost entirely vacant of people by this time (with the forced displacement of members the Paredarerme nation and few settlers present) and surrounded by the ocean, except for the narrow spit of sand connecting it to mainland Tasmania via Eaglehawk Neck, made this seem like an ideal choice for placing convicts to reduce the risk of them absconding and/or interfering with free settlers.
2. An abundance of wood resources, to meet the growing requirements of Hobart, which had strained its nearest supply of timber. Hence, in September 1830 (after earlier confirmation of the potential of the Tasman Peninsula in 1828), the order was given to set up a logging settlement, with the site of Port Arthur chosen "because it had a good fresh water creek, was sheltered, had a deep harbour, and was in the centre of a large supply of timber." (Thompson 2007).

At the time that this instruction was given, it appears that the Tasman Peninsula only had one European settler, Joseph Tice Gellibrand (right). In his notes on European settlement at Sloping Main, Tasmanian historian Malcolm Ward (2023) states that:

*"From 1816, Gellibrand was an attorney in London of not impeccable reputation. Van Diemen's Land was granted administrative independence from New South Wales, commencing with George Arthur's Lieutenant-Governorship. Gellibrand was appointed the colony's Attorney-General and travelled to Hobart Town with Arthur in 1824. Not long after arriving, Gellibrand fell out with the Lieutenant-Governor, being found to have associated with anti-government figures and publishers such as Robert Lathrop Murray and he was removed from office in 1826. He continued to practice law and acquired land in several parts of the colony before becoming part of the Port Phillip Association and eventually disappeared in the Port Phillip area in 1837, never found. His father, William Gellibrand was also in Van Diemen's Land and took up land at South Arm.*

*Gellibrand was never granted land on the Tasman Peninsula, but it appears he obtained a 'location order' and took up land there sometime in the late 1820s. At the time, settlers could apply to take up to 2,000 acres of land in a certain area, the area being proportional to their means. After they 'located' their land, the settler then applied for it to be granted to them, which required a government survey. For various reasons, including overwork and corruption, the surveyors usually took between two and eight years to undertake the survey and then to do the paperwork for the grant. During this time, settlers usually established their farms – building dwellings and ploughing fields etc., notwithstanding that during that time, they had no firm title. Until grant, they were not allowed to sell or 'deal' their land.*

*Gellibrand appears to have had a 300-acre farm (mostly undeveloped) on the Tasman Peninsula* (Tasmanian Archives a). *However, in 1830, Lieutenant-Governor Arthur moved to establish a convict settlement at what became known as 'Port Arthur' and didn't want any farmers or stock in the area, which might be used by escaped convicts. So that year, Gellibrand replied to a letter from the Surveyor-General (SG letter unpreserved) which noted*

*that the government wished to acquire his (Gellibrand's) 'location of land' in exchange for 3,000 acres of land somewhere else. Gellibrand agreed, writing that at the time, he had 40 acres of wheat planted, a quantity of potatoes sewn and a large barn 'just erected' (note: no mention of a house or cottage). After asking additionally for £1,500 for his crops, Gellibrand finally accepted an offer of 4,000 acres of land elsewhere – a very generous settlement. This appears to have been granted in sequential lots, both with G C Clarke at Chatsworth, near Longford* (Tasmanian Archives b).

*As an aside, 300 acres is an odd size for a block of 'location order' land. Gellibrand would have been 'of means' and this usually would have entitled him to the maximum grant of 2,000 acres. Such grants had to be taken as one block, except if an exception was given by the Surveyor-General or the Lieutenant-Governor. Given Gellibrand's falling-out with the Lieutenant-Governor, such indulgence would be unlikely to have occurred. How or why J T Gellibrand took a 300 acre location at Sloping Main remains a mystery, but the involvement of his father William, across the bay at South Arm, appears likely.*

*The Tasmanian Archives file CSO1/1/3 file 30 does not specifically state that Gellibrand's 300-acre farm was at Sloping Main, and no paperwork exists relating to Gellibrand having a 'location order' specifically for there, but other evidence suggests that this was the location of the farm in question.*

*First, his father William Gellibrand had settled at South Arm, and it would not be surprising for J T (or William) to take up land nearby, just across the bay.*

*Second, an 1833 map* (Figure 4) *shows some fields and the label 'Constable's station' at Sloping Main, and no other fields or farms west of Port Arthur Bay shoreline* (Tasmanian Archives c).

*Third, the first commandant of Port Arthur, Robert O'Hara Booth's journal records that he visited Sloping Main on a number of occasions* (Heard 1981). *In 1833 he referred several times to staying the night with 'the old man' and Dame at Gellibrand's at Sloping Main. The 'old man' may have been William Gellibrand, if referring to age, or Joseph Tice, although he is unlikely to have been staying there at this time. 'Dame' was 'Mother Kemble', referred to in other visits there. Mother Kemble has not been identified, nor why she was allowed to remain there, in spite of Arthur's policy of clearing the area of settlers.*

*The military took over the Gellibrand infrastructure at Sloping Main and a detachment was stationed there at least in 1836* (Thompson 2007). *Buildings at that time were a house, barn and stable* (Tasmanian Archives d)."

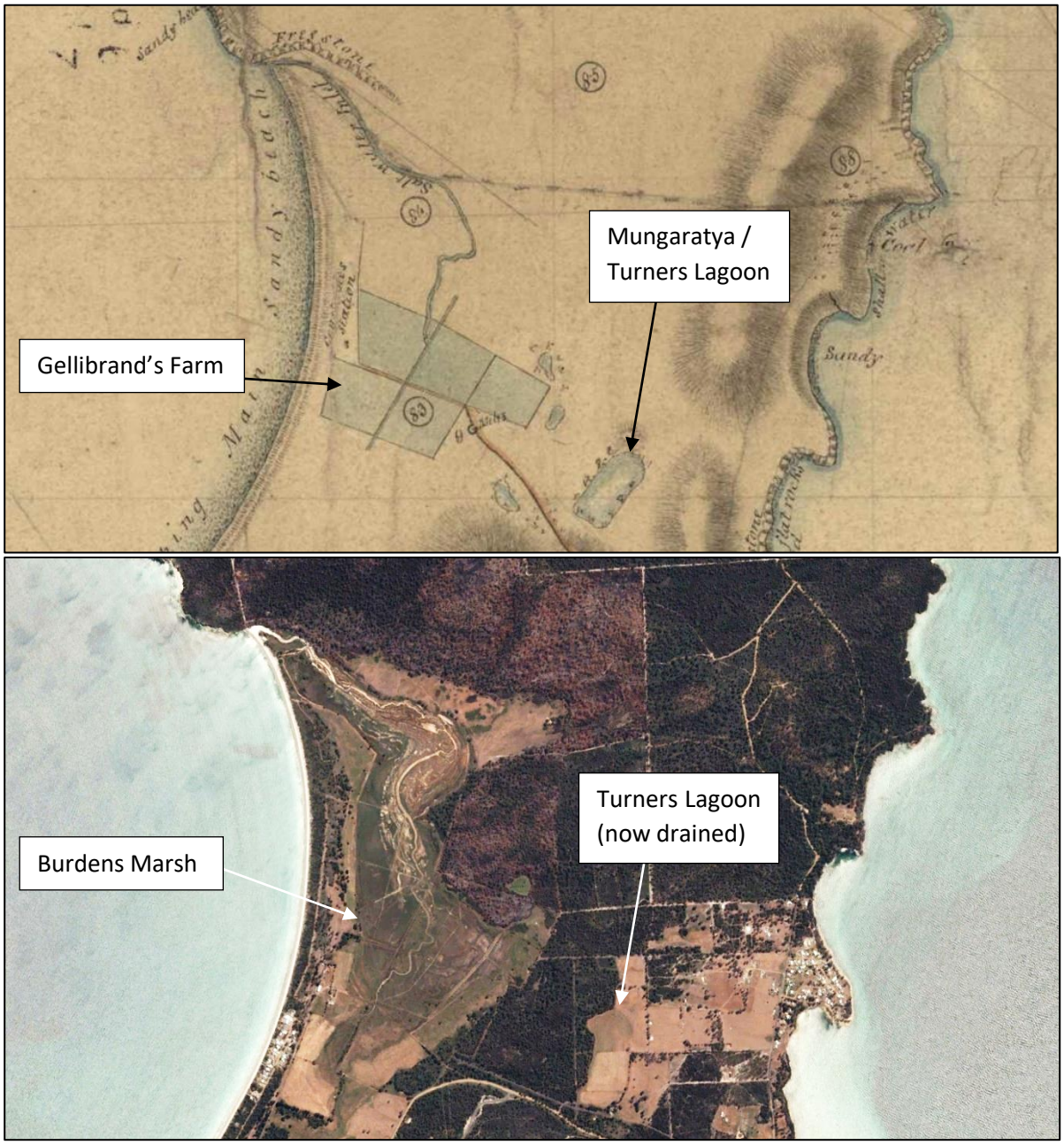



**Figure 4. Above: Map showing farm paddocks at Sloping Main in 1833, first established by J T Gellibrand (Hughes 1833). Below: the same area today, showing the location of Gellibrand's farm in relation to the saltmarsh area of Burdens Marsh and Turners Lagoon**

Interestingly, by using modern mapping tools to measure the size of the paddocks shown in the 1833 map, we can see that this blue shaded area consisted of 115 acres, or a little over a third of the 300 acres selected. This is consistent with Malcolm Ward's research (shared on previous pages) which indicates that the majority of Gellibrand's land holding was undeveloped at the time he was asked to vacate.

Confirmation of this site, as the location of Gellibrand's original land selection on the Tasman Peninsula, is made even more compelling by additional evidence from the archives in 1833. Despite the earlier instruction for all settlers to leave, at that time Gellibrand was still occupying land at Sloping Main with cattle loose on the Peninsula, frustrating the new commandant of Port Arthur, Captain Booth, who arrived at Port Arthur in March 1833 and wrote to his superior officer about the lingering situation in

October of that year. Governor Arthur replied to Captain Booth's complaint by stating that he had given clear instructions:

> *"that Mr Gellibrand's establishment on Sloping Main should be immediately removed. Intimate to that gentleman that after the repeated notices that he had received, any further delay in removing is now wholly out of the question, and it is at the present moment a matter of extreme necessity that he should forthwith withdraw his establishment as the Government are just about to form a working party on the spot."* (The Critic 2023)

The intention for Gellibrand's farm to be immediately requisitioned by the new convict settlement and utilised as a location for a working party was also clearly stated here, supported by the fact that a Constable Station was mapped in 1833, and hence already present at Sloping Main before Gellibrand's departure.

At that time, Gellibrand valued his improvements at Sloping Main at £1000. These *"improvements consisted in **draining a saltwater marsh**, fencing, ploughing, and building house, barns and stockyards"* (The Critic 2023). Here Gellibrand himself stated that he had drained a saltwater marsh, and provided a description of buildings that were consistent with many that were later drawn by a government surveyor at Sloping Main in 1836 (Figure 5).

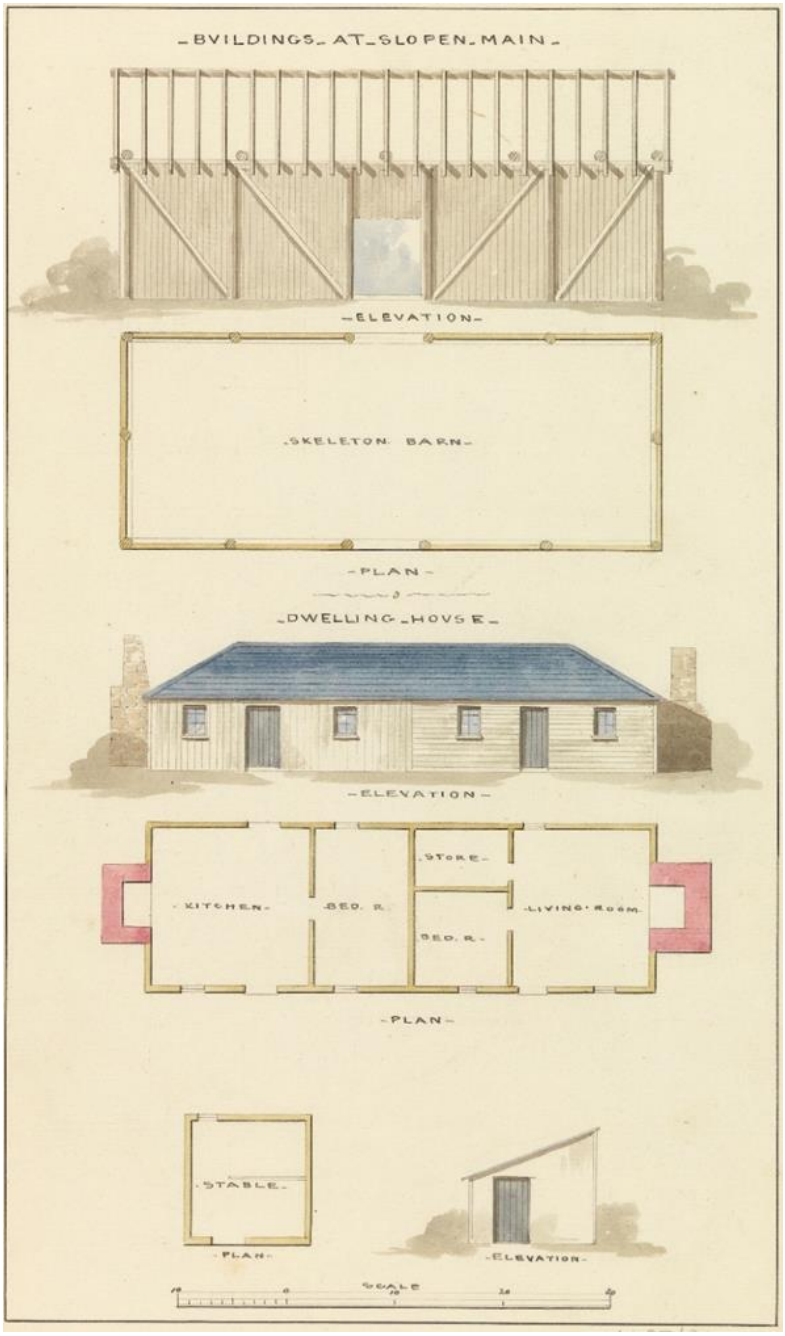



**Figure 5. Some of the buildings drawn at Slopen Main in 1836 (Tasmanian Archives d), not long after the time of Gellibrand's departure in c. 1833.**

On the basis of the information provided, the first phase of drainage and development at Burdens Marsh occurred in the late 1820s and early 1930s by J T Gellibrand, likely with the aid of convict labour. Thanks to the map of the area drawn by surveyor James Hughes in 1833, which appears to accurately outline the focal area for these works, we can more closely examine their extent, design and likely intent.

Interestingly, some form of evidence for almost all of these original drainage and/or fencing works remain evident in the landscape today (Figure 6, Figure 7).

**Figure 6. Gellibrand's farm paddocks at Sloping Main, as mapped in 1833 (left), and the aerial image of this area today (right), where some drainage features and paddock boundaries are still evident.**

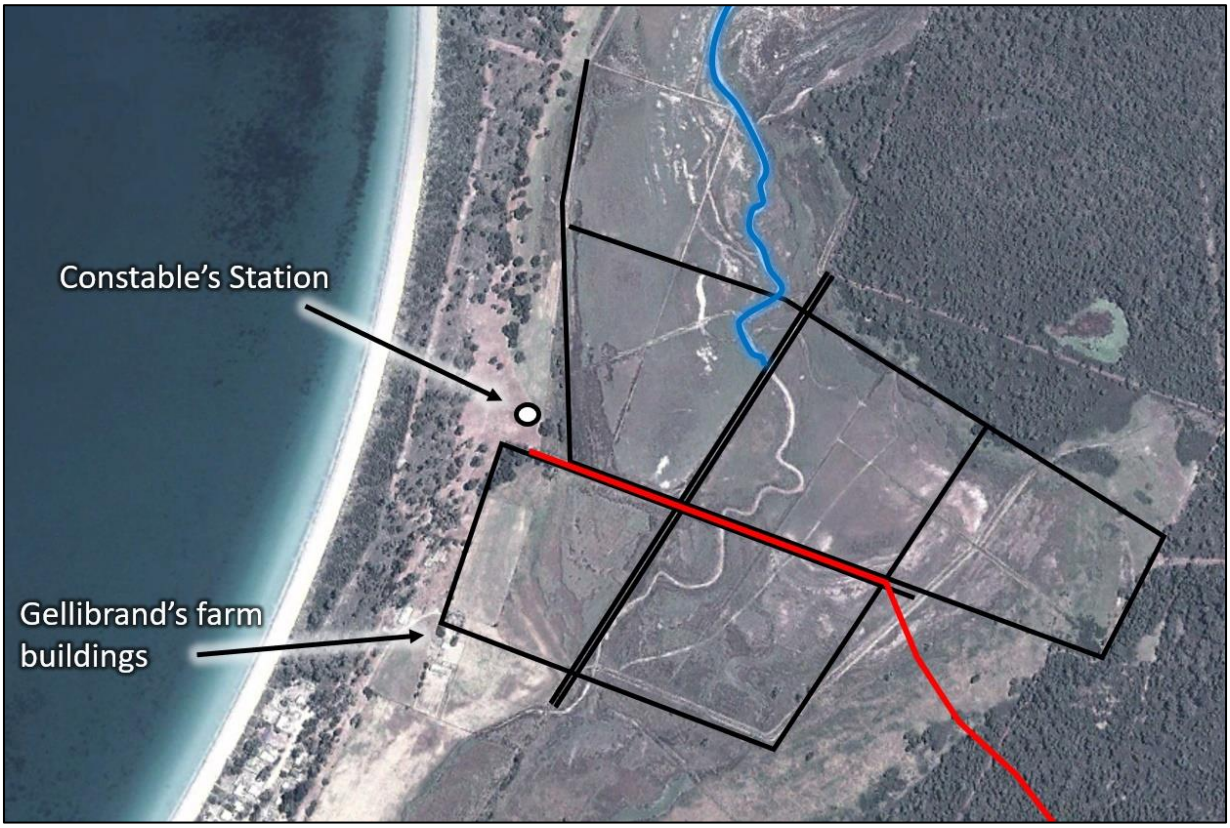



**Figure 7. Marked up modern aerial image to show the layout of the farm paddocks drawn on the 1833 map, likely set up by Gellibrand, just prior to the farm being requisitioned by the Colonial Government for use as part of the Port Arthur Penal Settlement. Paddock boundaries are marked in black, while the road across the saltmarsh to Port Arthur and/or Eaglehawk Neck is marked red. The saltmarsh outlet is marked in blue.**

The intent of this initial pattern of development by Gellibrand, appears to have been to begin to modify the hydrology of the central saltmarsh area, using methods of land reclamation widely implemented across Europe (and various colonial settlements around the world) during the 1800s. As shown in Figure 8, a series of feeder drainage ditches, either side of a main arterial drain were dug, providing both a land drainage service and generating the physical material required for creating raised embankments alongside each drain. These embankments provided a location around each paddock where fences could be established, and also serve to better control inundation of the reclaimed area, by seeking to confine the movement of water in low-medium flows events and/or tidal movements to the channels rather than across the wider saltmarsh surface. Reducing the frequency, duration and extent of inundation using these techniques, in some cases aided by the use of tidal gates and pumps, allowed for the conversion of vast areas of former natural saltmarsh globally.

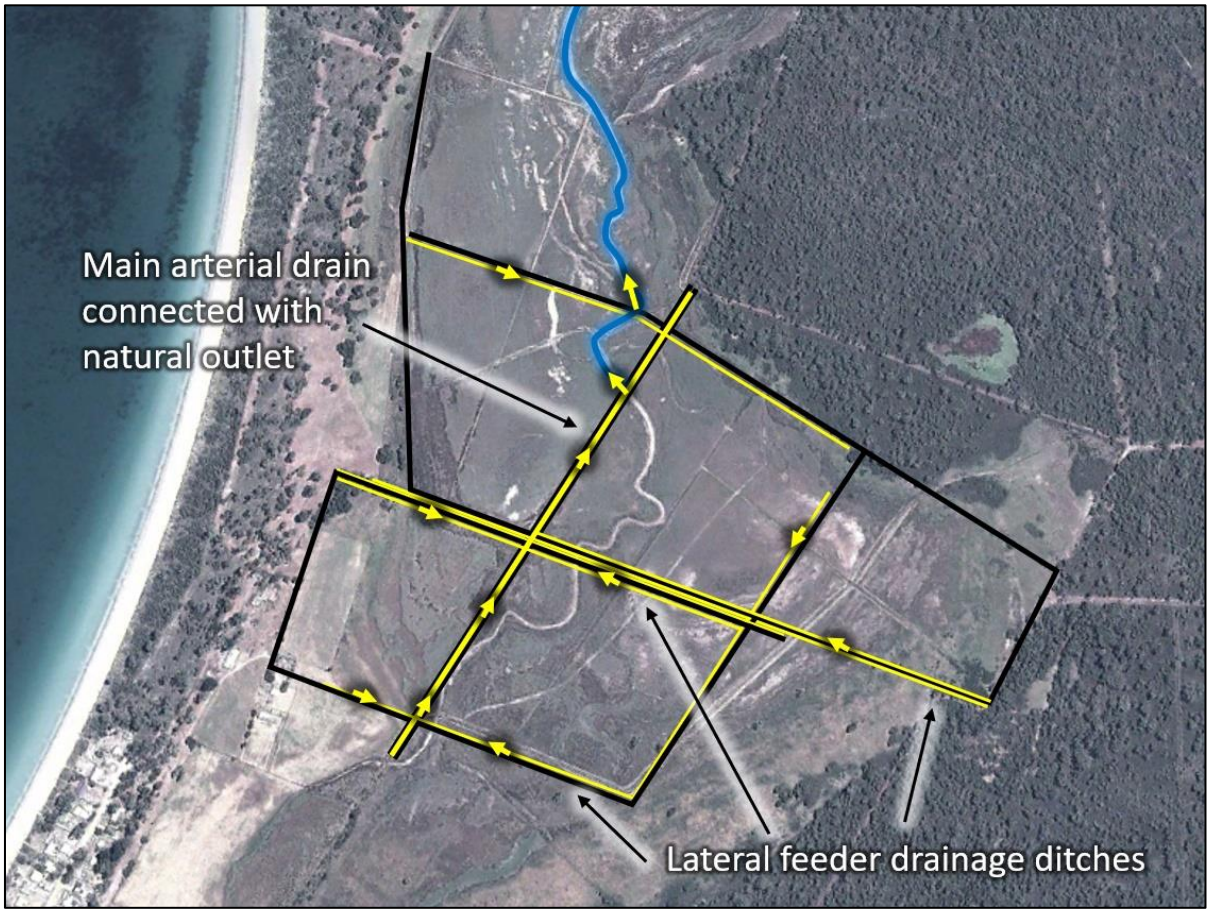



**Figure 8. Likely drainage configuration established by Gellibrand before 1834. Paddock boundary fences are marked in black, while inferred locations of original drains based on modern observation and LiDAR data are marked in yellow. The saltmarsh outlet is marked in blue and yellow arrows indicate direction of flow.**

Given the almost 200 years that have passed since these works were first completed (along with factors such as a minor increase in sea level, likely subsidence of the saltmarsh bed level due to trampling and oxidation of organic material, plus a lack of maintenance of the drains and embankments), it is very difficult to judge whether Gellibrand's original works can today be deemed a success. This question is also complicated by the fact that we don't actually know for certain what Gellibrand's original goal was for his land development project. Was it to improve the value and reliability of the area for grazing alone, or was he attempting to make it available for other forms of cultivation, or both? The suggestion that we have seen written by some authors that a dairy may have been envisaged for the area seems highly unlikely, given that people with this particular land use in mind tended to target the drainage of fresher wetlands (especially permanently wet, fresh groundwater dependent peatlands) rather than

these harsher brackish to saline saltmarsh environments. This key difference is something that would likely have been familiar to migrants with agricultural backgrounds from England where the drainage of peat fens had been underway for centuries.

While the saltmarsh has only been used for grazing over the past century (F. John Price, pers. com. 2023), it is interesting to note that the two southern paddocks from this original c.1830 farm area retain visual evidence that is suggestive of past cultivation, as shown in Figure 9. Could it be that these two paddocks, which together measure exactly 40 acres in area and are situated immediately adjacent to the original location of Gellibrand's farm buildings, correspond to the area that he indicated had been planted to wheat, as referenced from the archives by Ward (2023)? The lack of other cleared land in the vicinity at the time is reasonably compelling evidence, noting that at the time – in attempting cultivation (and whenever that occurred in the 1800s) – this area must have appeared to have very different agricultural potential compared to its appearance today.

**Figure 9. Evidence of soil cultivation (linear ploughing) that can still be seen in some aerial images, under the right light conditions, within the southern two paddocks set up by Gellibrand prior to 1834. The yellow line shows the outer boundary of the two paddocks and measures exactly 40 acres in area.**

Beyond the fact that an area appears to have been temporarily cultivated, we also know that saltmarsh itself more broadly was seen (and in some places continues to be considered) as valuable country in its own right for grazing, producing meat with particular properties that are considered a delicacy (Smith 2020), and for its pastoral value generally for sheep and cattle. Indeed, a report by Charles Meredith, Minister for Lands, reported in the early 1870s that Slopen Main was "a 'salt lick marsh' like the Salt Pan Plains, everything gets fat upon it" (Thompson 2007), indicating how saltmarsh country was positively viewed at the time. It would also help to explain why Gellibrand sought out this specific location on the Tasman Peninsula, when he had considerable freedom of choice, given few (if any) other settlers were present on the Peninsula in the 1820s.

Using subsequent events as a guide, we can also see that the livestock grazing potential of the saltmarsh continued to be valued by those who followed in Gellibrand's footsteps. The original drainage network

constructed by Gellibrand went on to be expanded across the rest of the saltmarsh (likely by convicts in the 1830s and 1840s, after he left), noting that the period between Gellibrand's departure and the arrival of the next free settlers in the late 1870s, corresponds with the convict phase on the Tasman Peninsula, and is considered in the next section.

## 2.3. 1834-1877: The Penal Settlement Phase at Sloping Main

Based on the information and sequence of events presented, it seems that despite the commencement of the Port Arthur Penal Settlement in late 1830, which resulted in concurrent orders being issued for the Tasman Peninsula to be vacated, Gellibrand stayed on at Sloping Main until at least the end of 1833.

With his departure likely occurring soon after in 1834, and the nearby discovery of coal east of Sloping Main at the time of Captain Booth's arrival in early 1833, the newly occupied farm nearby at Sloping Main appears to have become quickly integrated with the penal system in operation across the Tasman Peninsula. The first coal from the newly opened, and at that time convict-operated mine, was shipped to Hobart on the 5th June 1834 (Thompson 2007).

The immediate use and value of the Sloping Main farm at that time for the government's plans is supported by its prominent (and proportionally accurate) inclusion on the map from 1833. By this time the roads to Eaglehawk Neck and Port Arthur were in place, along with the Constable Station about 300m north of Gellibrand's former house and sheds, near the western end of the road, where it exited the east-west causeway situated between the drained saltmarsh paddocks.

Like many of the buildings from the convict era on the Tasman Peninsula that were dismantled (with materials salvaged for re-use), all that remains in the location of the former Constable Station at Sloping Main are a few fragments of leftover broken glass and crockery. However, a small item of additional, interesting corroborating evidence from the convict era that a friend of the former owner (Mr. F. John Price) discovered in the same location while metal detecting is shown in Figure 10.

**Figure 10. Part of a colonial-era badge found at the location where the Constable's Station was once situated near the saltmarsh area at Sloping Main. Photo: Mark Bachmann.**

From a wide range of primary source material reviewed from this phase, it would appear that a few additional changes occurred to the saltmarsh area over this 40 year period, as the systems of transport, communications, security, labour and various forms of primary production, construction and mining were established and evolved within the Penal Settlement across the Tasman Peninsula.

The maps from this period provide us with some useful clues.

Firstly, James Hughes' map from 1833 has an interesting sketch on it – a dashed line inserted after the map was completed – which shows an additional early path used to allow for direct travel between the Constable's Station at Sloping Main, and the new coal mine (Figure 11).

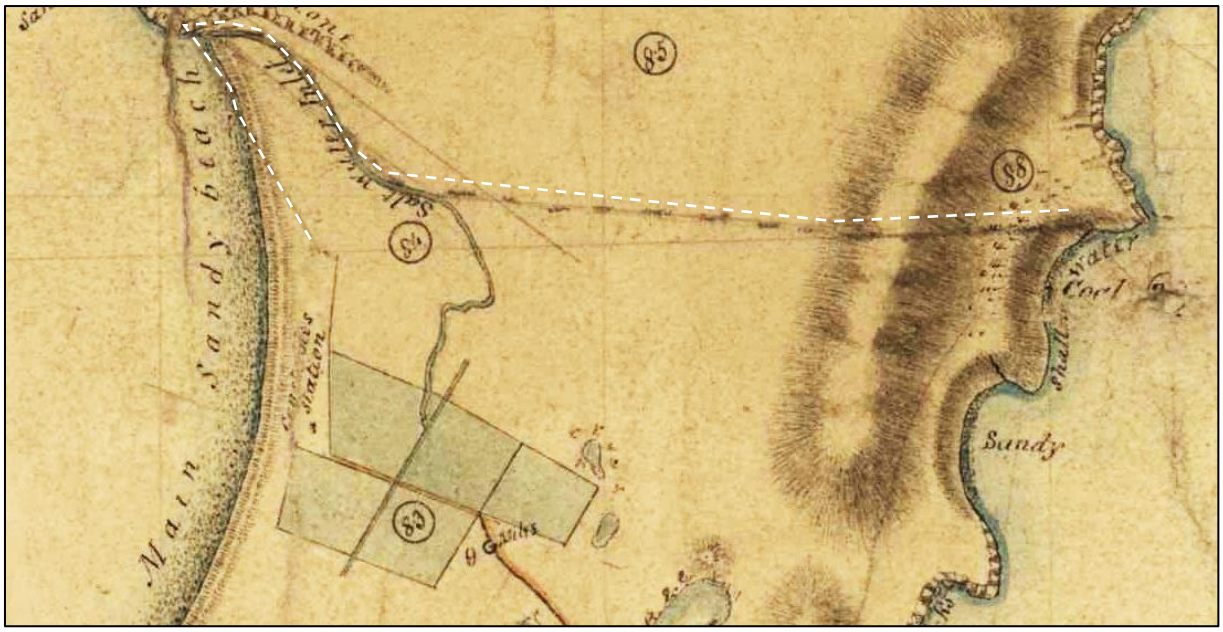



**Figure 11. Inset of Tasman Peninsula map by James Hughes in 1833, showing the first path established between the Sloping Main Constable Station and the coal mines. The path travelled around the northern side of the saltmarsh. A dashed white line has been placed above this route to highlight its location.**

We can interpret from this 1833 map that a more direct route across the saltmarsh to the coal mine was not immediately in place. This means that a crossing specifically for this purpose was not built until sometime after the first phase of drainage works and farm development.

Given the likely need for a more direct transport option to the site after Gellibrand's farm was requisitioned by the Colonial Government for the Penal Settlement, it seems that a crossing was built soon after. When the following map was printed in 1841 (Arrowsmith 1841), and consistent with the general location of tracks marked on other maps produced around the same time, we can see a network of tracks are in place to and from Sloping Main, connecting the farm and Constable Station there to various locations across the Tasman Peninsula Penal Settlement network.

Of note, by this time, there is a direct crossing from the Constable Station at Sloping Main across to the coal mine, which passes by the northern side of Turners Lagoon (Figure 12).

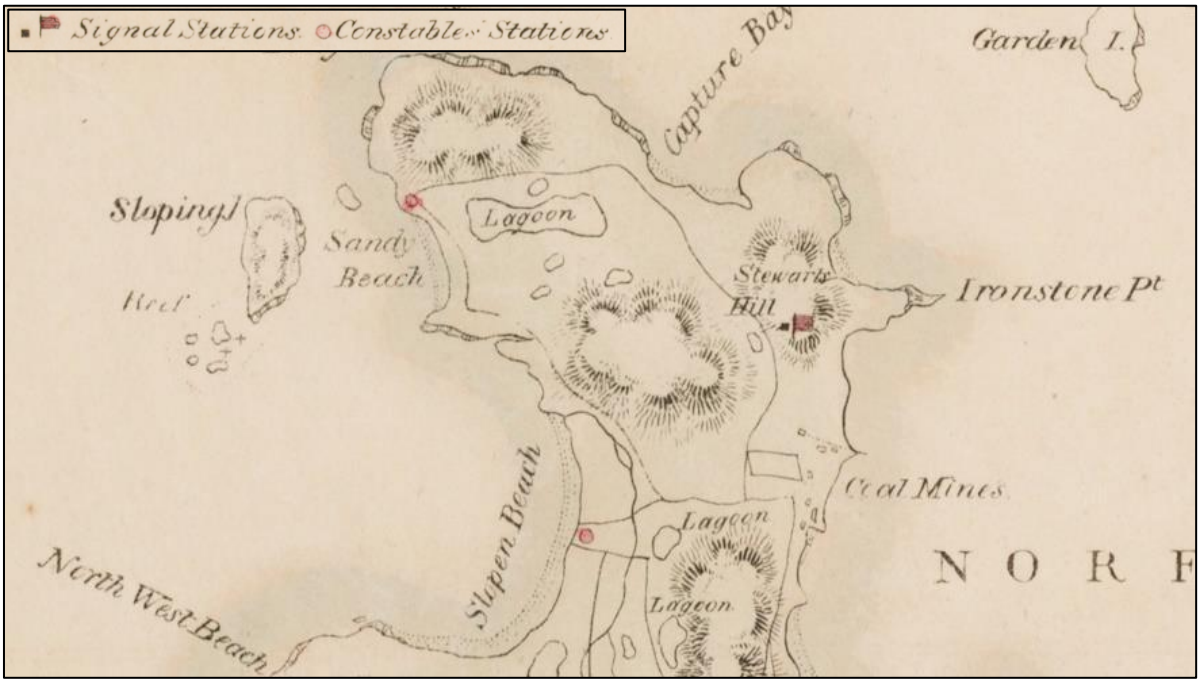



**Figure 12. Inset of Tasman Peninsula map by John Arrowsmith in 1841, showing the second path established between the Sloping Main Constable Station and the coal mines, directly through the saltmarsh.**

The location of the causeway that was excavated (using material gained by digging ditches either side of a raised mound) to create this diagonal track crossing is still evident today on the ground, as well as in the aerial imagery (Figure 13) and elevation data.

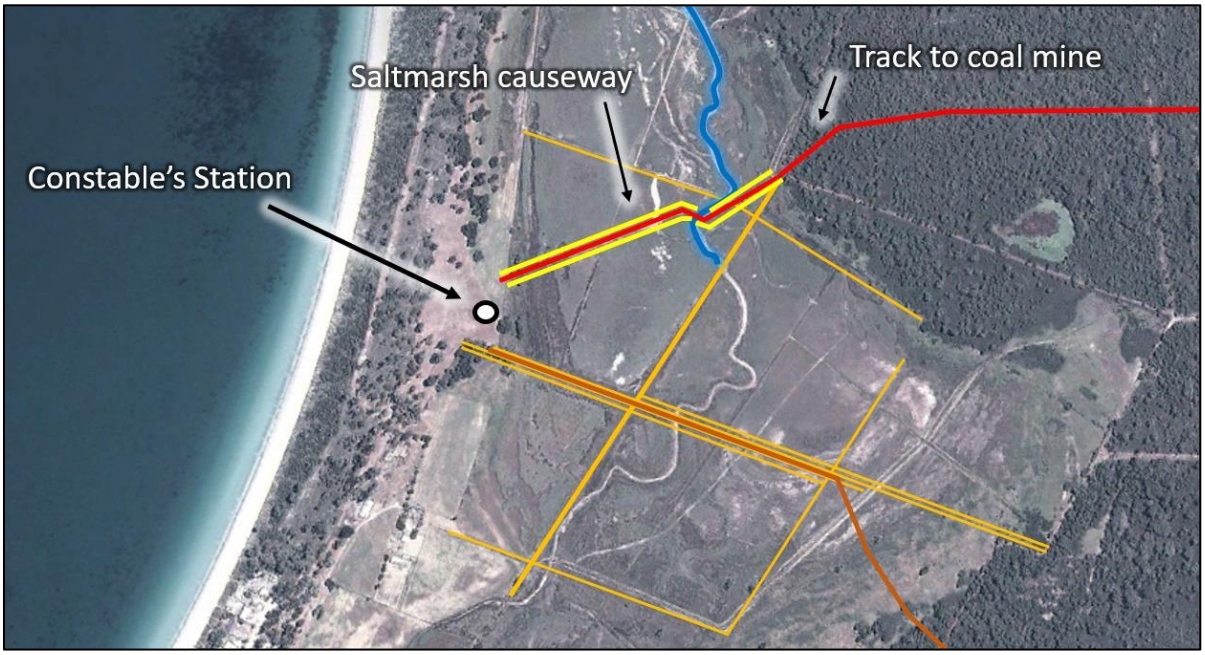



**Figure 13. Works that date to the mid-1830s through the saltmarsh, providing more direct access to the coal mines. The red line indicates the location of the new track, and the yellow lines are the ditches that were dug either side to gain the material required to create the causeway. Earlier works are marked in orange (drains) and brown (roads).**

We can readily infer that the primary purpose of these works was not further drainage, based on the alignment of the causeway relative to other surrounding works. However, despite not being its main purpose, the causeway embankment did serve to create an additional impediment to surface flows

longitudinally throughout the saltmarsh, reinforcing the design features of the east-west lateral drains and their associated embankments already in place by that time.

Although not having any apparent relevance to the hydrology of the saltmarsh at Sloping Main, it is interesting to note that a map produced in 1849 by James Calder (Figure 14), shows how a revised track and a fence was installed from coast to coast across the peninsula of land at Sloping Main, running east-west from Sloping Main beach to Salem Bay (south of the coal mine). This new boundary incorporated a further two Constable Stations in addition to the one already in place at Sloping Main Beach. A photograph of the modern ruins of the middle station, situated on the northern side of Turners Lagoon, can be found on page 230 of John Thompson's book (Thompson 2007).


**Figure 14. Inset of Tasman Peninsula maps by James Hughes in 1833 (above for reference), and James Calder in 1849 (Calder 1849) (below), showing the location of the fencing (hatched line) that was installed either side of the saltmarsh paddocks at Sloping Main. This created a fenced cordon with three Constable Stations spaced between Sloping Main Beach and Salem Bay.**

The fence appears to have played a role in managing the grazing and movement of livestock, which were brought to the Tasman Peninsula in increasing numbers, commencing in the 1840s, after a change in policy after 1841 (Thompson 2007). Increasing numbers of convict arrivals demanded a new focus on increasing agricultural output, aiming to meet the food production within the convict settlement, including the provision of fresh meat. Prior to that time prisoners were fed salted meat, and livestock were not approved for keeping on the Peninsula.

As well as a new program of clearing land to allow the planting and cultivation of grains and vegetable crops at a number of newly established Probation Station Farms around this time, keeping of domesticated animals was now generally permitted and their manure was collected for fertilising crops. However, of note, Gellibrand's old farm did not become one of the officially recorded Probation Station Farms, which leads one to the reasonable assumption that it was not in use at or around this time for any forms of more intensive farming.

However, the evidence on the ground is less clear-cut or conclusive, because the network of drains and embankments situated within Burdens Marsh was expanded – both to the north and south – well beyond Gellibrand's original 115 acre-fenced farm extent mapped in 1833, and those additional works have all the hallmarks (in terms of their design, configuration and construction method) of also being built by convict labour. With this in mind, it seems highly probable that the remaining network of drains across the marsh, was constructed by convicts and either completed before 1834 (but not mapped for some reason) or completed after 1834 by a convict working party overseen by the troopers stationed at Sloping Main in the decade after Gellibrand's departure. Perhaps after the livestock policy change in 1841, these extra works were ordered in preparation for the future establishment of a sheep station?

This timing corresponds with the fact that, a short time later in December 1846, not long before Calder's survey took place, the government advertised a tender for the supply of 1000 breeding ewes for a new sheep station at Slopen Main.

**COMMISSARIAT OFFICE.**

***Hobart Town, December* 31, 1846.**

**SHEEP.**

**Tenders will be received at this office, until 12 o'clock on Wednesday, the 13th proximo, for the supply of Sheep as follows, viz. :—**

**500 Breeding Ewes, 4 tooth, and 5 rams, 2 tooth, for the convict station at Fingal.**

**1000 Breeding Ewes, 2, 4, and 6 tooth, in equal proportions, for the new sheep station, Tasman's Peninsula.**

**All the Sheep to be of the Saxon and Merino breed, of the best description, and perfectly healthy. The contractor will be required to deliver them in the same state at the respective stations within three weeks from the date on which the acceptance of the tender is notified, and to produce a certificate to this effect from each Superintendent in charge. A competent person will, however, be appointed to inspect the sheep, previously to their leaving the contractor's own station.**

**The assistance of a Government vessel will be afforded to convey the sheep for Tasman's Peninsula across from the vicinity of the Carlton to the sheep station on Slopen Main.**

According to Calder's survey however, the sheep farm buildings were situated well to the south of Sloping Main. Interestingly, only a few landmarks were recorded on this map; features such as the coastline, tracks, railroads, jetties, the coal mine and the sheep farm location and the new fence at Sloping Main (Figure 15). In lead pencil, there are also notations about the number of acres written on the map, either side of the new fence.


**Figure 15. Inset of James Calder's 1849 map. Showing the location of the sheep farm outstation buildings relative to the fence at Sloping Main. Written in faint lead pencil in the centre of this image is a notation saying "7500 acres".** *Note that the road show here from the Sheep Farm to Saltwater River was called "Woolshed Road" and provided the overland point of connection during the convict era for movement between the coal mine in the north and Storm Cove to the south (off image) (pers. comm. F. John Price, 2024).*

North of the new fence at Sloping Main, is a similar note that says "5180 Acres to fence" (Figure 16), also implying a direct relationship with the newly established sheep run.


**Figure 16. Inset of James Calder's 1849 map. Showing the area north of the new fence at Sloping Main. Written in faint lead pencil in the centre of this image is a notation saying "5180 Acres to fence".**

Further corroborating evidence is presented on Page 93 of John Thompson's book, where he quotes a report from mid-1846, where Comptroller-General William Champ says: "preparations are being made by the erection of fences, etc., for a flock of sheep on Tasman's Peninsula, where there is a run of several thousand acres of excellent grazing land."

The timing of this statement is a perfect fit in the sequence of events, given that this is prior to both Calder's map being drawn in 1849 and the tender for sheep being called at the end of 1846.

It seems however that by 1848, the fence would serve another purpose, which would satisfactorily explain the 1849 presence of Constable Stations along its length for security against potential convict absconders heading north. That purpose was outlined in item 4 of the public tender (see below) that was called for the lease of the coal mine, namely: "*a fence will run across from Norfolk Bay to the sea on the other side (Sloping Main Beach), one mile from the opening of the principal shaft*" (Hobart Courier 1848).

# COMMISSARIAT.

## COMMISSARIAT OFFICE.

*Hobart Town, April* 3, 1848.

LEASE OF COAL MINES.

Tenders (in duplicate) will be received at this office, until 12 o'clock on Wednesday, the 10th proximo, from parties desirous of

Leasing the Coal Mines, at Tasman's Peninsula, from and after the 1st October next.

The tenders to state the rate of rent proposed to be given, and the following are the conditions under which the lease will be granted :—

CONDITIONS.

1. The mines will be leased for a period of not less than three nor exceeding nine years, with the understanding that either the lessee or the government shall have the power of relinquishing the lease after the expiration of the first three years, by giving one year's notice of the intention so to do.

2. Each tender must be accompanied by a letter signed by two responsible parties expressing their readiness to enter into a proper obligation for securing payment of the rent in quarterly instalments; and on acceptance of the most advantageous tender, the party making it will be required to execute a regular deed of lease, which will be prepared at his expense by the Crown Solicitor.

3. The lessee will have the use of the buildings (excepting those which may be required for a military or other barrack and stores) together with the steam engine, on condition that they shall not be damaged or deteriorated beyond what may be expected from fair wear and tear; and he will have to take over all tools and materials in use on the 1st October, both for the working of the mines and for bringing down the coal, at a valuation, to be fixed by two parties, nominated, one by himself the other on the part of the government, and an umpire to be chosen by these parties conjointly, to settle any dispute which may arise between them. The payment for such tools and materials must be made on delivery.

4. A fence will be run across from Norfolk Bay to the sea on the other side, one mile from the opening of the principal shaft, within which boundary no restriction will be enforced as to the working of existing or the opening of new shafts; but no communication whatever will be permitted beyond that boundary with either Tasman's or Forestier's Peninsula, unless by special permission, previously obtained, through the Comptroller General of Convicts.

5. Every breach on the part of the lessee, or those employed under him, of this or any other local regulation, made for the discipline of convicts, will, on being proved to the satisfaction of the civil commandant or visiting magistrate, render the lessee liable to a penalty of not less than two nor more than twenty pounds, according to the nature of the offence; such penalty or penalties being recoverable as an addition to the rent for the period in which the breach or breaches may occur.

6. The lessee will be restricted to the sale of coal from the shoot at the mine's jetty at a rate not exceeding eight shillings and sixpence per ton. He will have the use of the weigh-bridge, which, together with the waggons, must be open to the inspection of purchasers whenever required to be tested.

GEORGE MACLEAN, *Deputy Commissary-General.*

Opening up this portion of the Tasman Peninsula for a public lease was a major departure from Penal Settlement policy of the previous 18 years, and presumably justified this clear delineation of the new boundary on the ground for safety (with potential opening of new mines shafts to the north), security (with convicts to the south) and livestock management. This new boundary bisected Gellibrand's former farm paddocks and the wider drainage works in the saltmarsh at Sloping Main, and on the basis of the available information, it seems increasingly certain that livestock production discontinued for a period of years at Sloping Main after the removal of Gellibrand's cattle c.1834. Grazing only likely re-commenced on the drained saltmarsh area after 1841 (when the livestock policy changed), and presumably only continued to the south of the new fence after the sheep station was established c.1847.

This is relevant to the story of the saltmarsh at Sloping Main because it means that, aside from the construction of the causeway for traversing the saltmarsh, further drainage works (beyond Gellibrand's original scheme and any additional works completed by convicts in the decade after his departure) were not likely to have continued north of this new fence after 1847, because the land tenure had changed. This also suggests that deliberate mouth openings, given that this was also situated north of the fence, would have ceased, and this also explains what appears to be a phase where development for farming was abandoned at Burdens Marsh from this time until three decades later, when the penal settlement system at Port Arthur and across the Tasman Peninsula ended in the late 1870s.

After its establishment however, it seems that the new sheep station was quickly considered a success, and by the end of 1848 there were around 5000 sheep present, with suggestions made at the time that "the run might be extended so as to contain 3000 or 4000 more at least, and 200 to 300 head of cattle." (Thompson 2007). Within a few years, records show that extra sheep were moved to the Tasman Peninsula from other Penal Settlements as sheep farming at those locations was reduced or discontinued (Thompson 2007).

In an interesting turn of events, while a focus on timber harvesting continued and farming and land development as part of the convict settlement was ramping up, it was only a short time later in 1853 that convict transportation itself ceased. This led to a gradual decline in the convict population on the Tasman Peninsula from its peak in 1846, such that numbers had reduced to about a quarter of their maximum number by the 1870s.

In terms of information describing the condition of the saltmarsh area at Sloping Main during this time, we have the benefit of the following description by Shoobridge from a report dated 13th June 1862 which says:

> *"About half (of the marsh) is in the possession of the Government, the remainder being included in the land rented (since 1848) by the Coal Company, and consider it a very extensive and fine piece of land for grass meadows, capable, if well drained and prepared for clover and other grasses, of supplying food for fattening a great many sheep."* (Shoobridge (1862) as quoted in Thompson 2007)

This description indicates that the northern part of the saltmarsh within the coal mine lease area, as shown in Figure 17, continued to fall outside of the land utilised by and available to the Penal Settlement at that time. It also confirms that the saltmarsh has not been further developed (or the earlier works maintained) by this time, and also indicates that active management of the outlet probably did not occur during this period.

However, by 1870, there is an account provided of the Sloping Main farm consisting of 383 cattle including working oxen, calves and young stock and store animals; and 386 sheep, including breeding ewes on nearby Sloping Island (Thompson 2007). Whether this included the northern part of the Sloping

Main saltmarsh by that time is unclear but may be able to be determined by a more thorough investigation of the archives to see if the coal mine lease area was in any way modified before its eventual closure.


**Figure 17. Location of the boundary fence that once demarcated the coal mine lease (to the north) and the Penal Settlement managed land (to the south). Note how this divided the saltmarsh area at Sloping Main.**

A year later, in 1871, as the future of the Tasman Peninsula for private settlement was under consideration before a Committee of the House of Assembly, a report by James Boyd about this part of the Peninsula stated that "*the next block, to the west of the last [Saltwater River] up to the Coal Mines boundary, is the best on the Peninsula – about 4000 acres of good sheep and agricultural country; nearly all, except some on the ranges and along the coast, is suitable for pastoral purposes. The Coal Mines block is sandy and useless.*" (Boyd, J. (1981) as quoted in Thompson 2007).

Further, a report by Charles Meredith, Minister for Lands reported in the early 1870s that "*Slopen Main: Marsh 400 acres drained; it is a 'salt lick marsh' like the Salt Pan Plains, everything gets fat upon it. There*

*is a fresh water lagoon near it (Mungaratya / Turners Lagoon) and excellent timber in the vicinity."* (Meredith, C. (c.1873) as quoted in Thompson 2007).

A parallel report from around the same time by Government Surveyor Archibald Blackwood (under instruction from Charles Meredith) describes Sloping Main as follows:

> *"On Slopen Beach there is a beautiful marsh of from four hundred to five hundred acres, with good feed on it, and splendid black soil. It has been partially drained years ago. There is not a tree on some hundreds of acres of it. I rode over a good deal of it, and saw cattle feeding on it where I did not go, so that it cannot be so wet. There is a fence run through it.*
>
> *There are two small lagoons south of this marsh, with any amount of wild ducks on them."* (Blackwood 1873)

According to these accounts, more of the marsh may have been brought into agricultural use by the Sloping Main farm since the report of 1862, but it does not necessary sound like any new drainage works have taken place.

After its initial operation by convicts from 1833-1848, the nearby coal mine operation and lease continued in private hands from 1848 until its closure in 1877. This timing was not a co-coincidence, as the ongoing push that began in the 1860s to make the Tasman Peninsula available to free settlers, became a reality after the last of the remaining convicts were transported away and Port Arthur was closed in 1877. At that time, the process of land selection by free settlers began in earnest.

## 2.4. 1877-1946: The Early Land Selection Phase Until the First Aerial Photography

From 1877, the Tasman Peninsula became available for free settlers to select land for purchase under terms of credit provided by the government under the Waste Lands Act 1870 (this was later updated and replaced by the Crown Lands Act). The terms of credit for the selection and purchase of lower classes of unallocated Crown Land were generous, to encourage land development, but also came with a range of obligations and costs. The terms of credit offered by the government evolved over the years as indicated in Table 1.

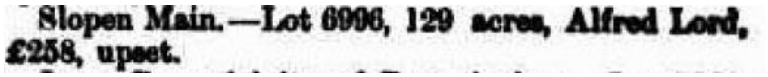
**Table 1. Terms of credit for purchase of Crown Land in Tasmania, 1857 – present.**

| Name of Act | Full purchase Price if using credit | Deposit | Terms of Credit |
|---|---|---|---|
| Waste Lands Act 1857 | 120% of agreed sale price (to allow for credit) | 20% of full purchase price on signing | Ten years of annual repayments of balance |
| Waste Lands Act 1870 | 133% of agreed sale price (to allow for credit) | 12.5% of full purchase price on signing | Fourteen years of annual repayments of balance |
| Crown Lands Act 1890 | 133% of agreed sale price (to allow for credit) | 12.5% of full purchase price on signing | Fourteen years of annual repayments of balance |
| Crown Lands Act 1903 | 133% of agreed sale price (to allow for credit) | 2.5% of full purchase price on signing | Fourteen years of annual repayments of balance |
| Crown Lands Act 1911 | 133% of agreed sale price (to allow for credit) | 2.5% of full purchase price on signing | Fourteen years of annual repayments of balance |
| Crown Lands Act 1935 | 133% of agreed sale price (to allow for credit) | 2.5% of full purchase price on signing | Fourteen years of annual repayments of balance |
| Crown Lands Act 1976 | Agreed sale price, but subject to interest over loan term | As set by Minister, payable upon signing | As determined by the Minister but not less than 4% for rural land |

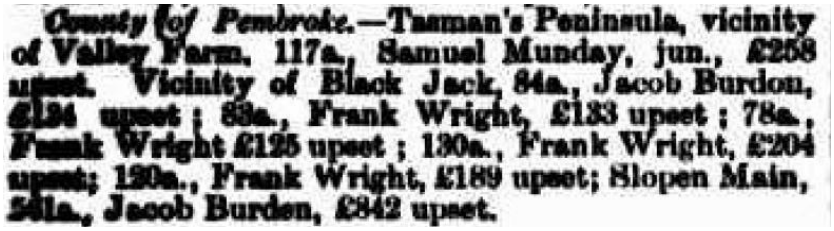
It is important to outline the terms of credit offered by the government for land purchase, because it explains a repeated pattern of delay between when land was first selected and surveyed for purchase, and the subsequent issuing of a purchase grant a number of years later. Under this form of freehold title, the grant could not be issued under the provisions in the Act until the land purchase debt had been repaid, and although that process could be brought forward, most people required the bulk, if not all, of their allotted repayment time. Further, if the debt was not repaid, the land purchase grant / freehold title could not be issued. With the credit terms in default, the land would be resumed as Crown Land and made available for re-sale.

In many cases, this quirk of the legislation gives a false impression of when land was first 'occupied' because the first owner was not granted freehold title until after they had met their obligations under the various iterations of the Acts in force. From 1877 until 1964, which covers the time when all the parcels of land were selected within the present-day TLC reserve at Sloping Main, the standard delay in the issuing of freehold title was 14 years, due to these terms of credit.

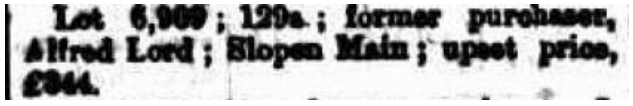
The first land selected on the present-day TLC Reserve at Sloping Main was 129 acres purchased by Alfred Lord at a government auction for Crown Lands (the land for sale that day was mostly situated on the Tasman Peninsula) on Friday 28th December 1877, for £258 (Hobart Mercury 1877).


Slopen Main.—Lot 6906, 129 acres, Alfred Lord, £258, upset.

The remaining parcels of land that comprise the saltmarsh at Sloping Main, were sold at a subsequent auction held on Wednesday 16th October 1878. This was the day that Jacob Burden, after whom Burdens Marsh is now named, secured 561 acres for £842 (Hobart Mercury 1878).


County of Pembroke.—Tasman's Peninsula, vicinity of Valley Farm, 117a., Samuel Munday, jun., £258 upset. Vicinity of Black Jack, 84a., Jacob Burdon, £134 upset; 83a., Frank Wright, £133 upset; 78a., Frank Wright £125 upset; 130a., Frank Wright, £204 upset; 120a., Frank Wright, £189 upset; Slopen Main, 561a., Jacob Burden, £842 upset.

The survey plan that allowed for these lots to be auctioned was drawn by District Surveyor George Innes in 1877, and the purchaser details were entered onto this plan (Figure 18). We can also see that Alfred Lord's name was crossed out, presumably after he defaulted on the credit terms offered to him in 1877. When on the 28th April 1883, the Office of Lands and Works advertised for sale a large number of Crown Lands that were by then in default, the list included the property previously selected by Alfred Lord (Hobart Mercury 1883).


Lot 6,909; 129a.; former purchaser, Alfred Lord; Slopen Main; upset price, £344.

Written across these lots in lead pencil on the survey plan are the words "*offered in default sale of 3/7/83*", but these lots were not sold at the time and were later reconfigured, with 25 acres of the northern portion selected and purchased in the name of Margaret Burden, Jacob Burden's wife, in 1905, with the balance not purchased until 1964.

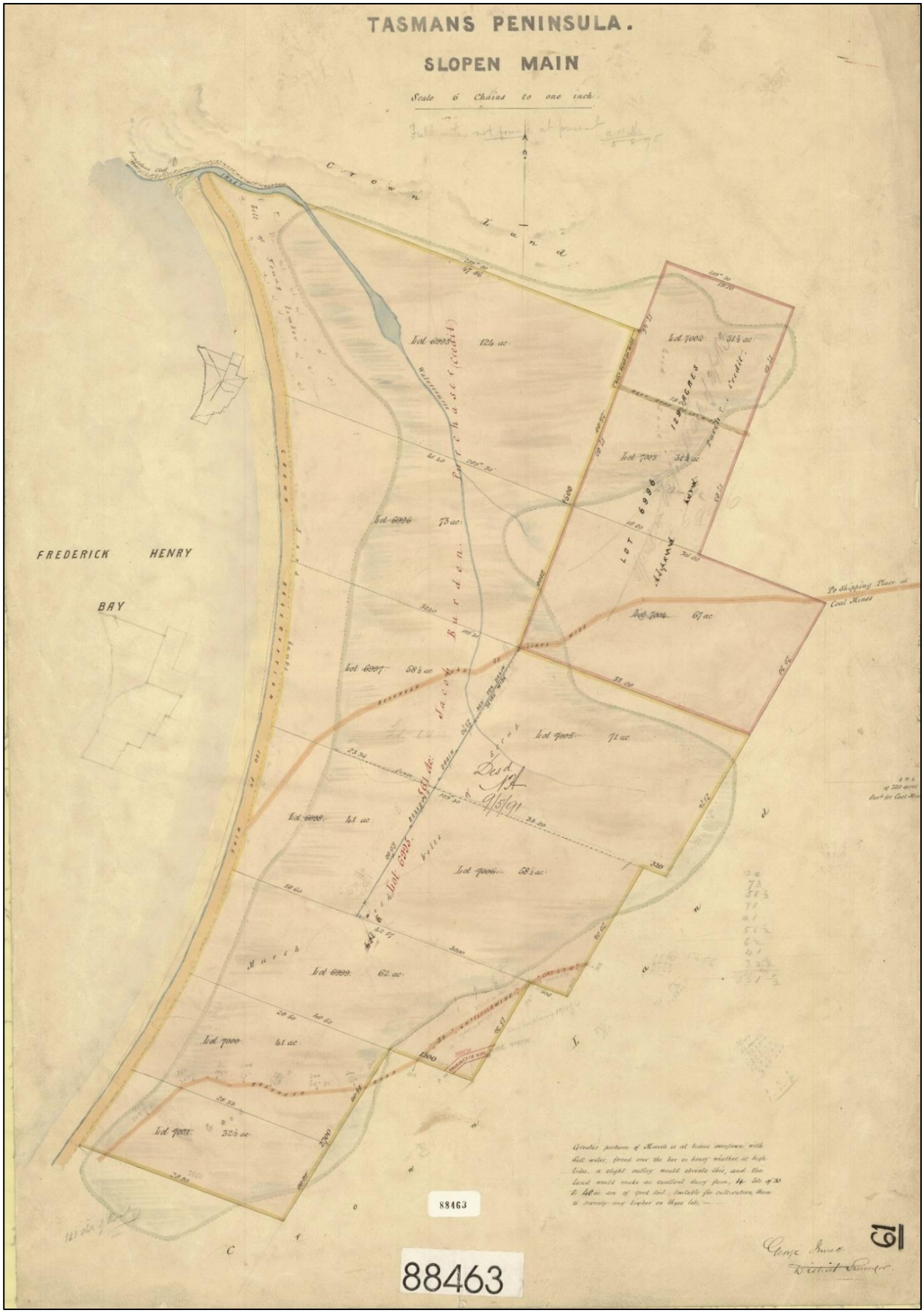



**Figure 18. 1877 survey plan for the saltmarsh at Sloping Main.**

In terms of features drawn on this plan, it provides a first detailed glimpse into the physical appearance and condition of the saltmarsh at Sloping Main, at the conclusion of the convict era in 1877. Key items of note include:

- The east-west fence through the middle of the saltmarsh is still present.
- The original arterial north-south drain dug by Gellibrand prior to 1834 is also still evident, with a surveyed drainage reserve indicating its location.
- The lack of cultivation in the former paddocks is apparent, with the following vegetation notation written across this central part of the saltmarsh area: "Marsh with belts of scrub".
- The outlet is shown as being open and flowing.
- A longer notation in the corner of the map says:

  > *"Greater portion of Marsh is at time overflown with Salt water, forced over the bar in heavy weather, as high tides, a slight outlay would obviate this, and the land would make an excellent dairy farm, 4 lots of 30 to 40 acres are of good soil suitable for cultivation, there is scarcely any timber on these lots."*

- In the centre of Jacob Burden's allotments there is a signed notation with the date 9/5/91, which likely indicates that the credit terms of the original land purchase were met on that date, almost 13 years after the auction. One month later, on 3rd June 1891, Jacob Burden was issued a Purchase Grant, formalising his freehold ownership of the land.

Today it is difficult to determine conclusively whether Jacob Burden was responsible for any additional drainage works through the saltmarsh after 1878, or whether all the works were already completed in the earlier convict-phase. This is because:

1. While there is no concrete evidence that works to enhance the earlier (pre-1834) drainage of Burdens Marsh (as shown on the 1833 map), took place before 1847, the physical appearance of the additional drains through the main saltmarsh is highly suggestive. These drains and embankments are extensive, mirror the techniques used to build the earlier drains and would have required a vast amount of human labour to construct. Further, while this work is consistent with the capability of a convict work gang, it is not within the financial means of a sole farmer-settler, indebted to government for the land (having purchased under credit terms), noting that these works pre-date mechanical means for earthmoving.
2. Most of the early works undertaken by Gellibrand (with the exception of the main north-south drain) are not represented in the detail and notations on the 1877 survey plan, which means other convict-era works were also probably not mapped.
3. Given the land capability information noted by the surveyor, it is conceivable that Jacob Burden purchased the land with hopes of simply capitalising upon and reactivating the earlier drainage works, to realise an increase in the grazing potential of the land for his livestock.
4. The original drainage network was always considered to have been long established by the time that the Price family began farming at Sloping Main in the 1920s and purchased this area in 1932. Further, no major works were completed by them between 1932 and the 1940s, when the first aerial photographs of the area were taken.

This analysis allows us to more accurately date the remaining drainage works that were in place prior to the commencement of the photographic record in 1948, as shown in Figure 19.

**Figure 19. Summary of drainage works prior to the 1940s in Burdens Marsh. The orange lines are the original pre-1834 drains, while the yellow lines are the additional drains probably excavated by convict labour between 1834 and 1847. After 1878, Jacob Burden likely reactivated all pre-existing drains (which were unlikely to have been maintained since their construction). The tracks from the 1830s are marked brown and the green lines are the ditches either side of the 1830s coal mine crossing.**

Beyond the image to the north, the final drain extends north and then turns north-west towards the outlet. Older residents recall large timbers being visible at the outlet mouth after flows (periodically buried in sand) that indicate the location of an early gate system on the coast to prevent sea water from re-entering the drained wetland during high tides. When this gate system was built is uncertain, but it was either during the convict-era, or early in the time of Jacob Burden. As no diagrams or images exist of this structure, we are unsure of its design. Interestingly, it has also passed down in local knowledge that Jacob Burden destroyed (through burning) the bulk of the timber gate system at some time during his tenure, which doesn't prove he didn't build it, but does indicates that it was not serving its intended purpose. Prior to the destruction of the first weir system, its likely intent was to allow water to leave the saltmarsh after rainfall, but to prevent high tides from re-entering the drained saltmarsh via the eroded mouth. This type of system appears to have been later mimicked more effectively by F. John Price, when he constructed a new weir and levee system at a location further inland on the outlet creek c.1990.

## 2.5. 1940s-Present: Documenting the Final Phase of Development

The final phase of development in and around Burdens Marsh since the 1940s is aided by two factors.

Firstly, we have the benefit of the aerial photographic record to document changes over time since the 1940s, with a high degree of spatial accuracy.

Secondly, we are very fortunate that F. John Price (who has lived at Slopen Main his whole life), after his father (John Athol Price) purchased the property in 1932, has detailed knowledge of the management changes that have occurred on and around the property, that can be matched against and/or sit alongside the aerial photographic record. This puts us in a very privileged position for access to local knowledge that covers recent site history.

Some images and tools that help us interpret the modern state of the site are shown in Figure 20. On the left is the raw Digital Elevation Model (DEM) based on LiDAR, while the right image shows the locations of drains and embankments mapped in yellow, based on features visible in the DEM.

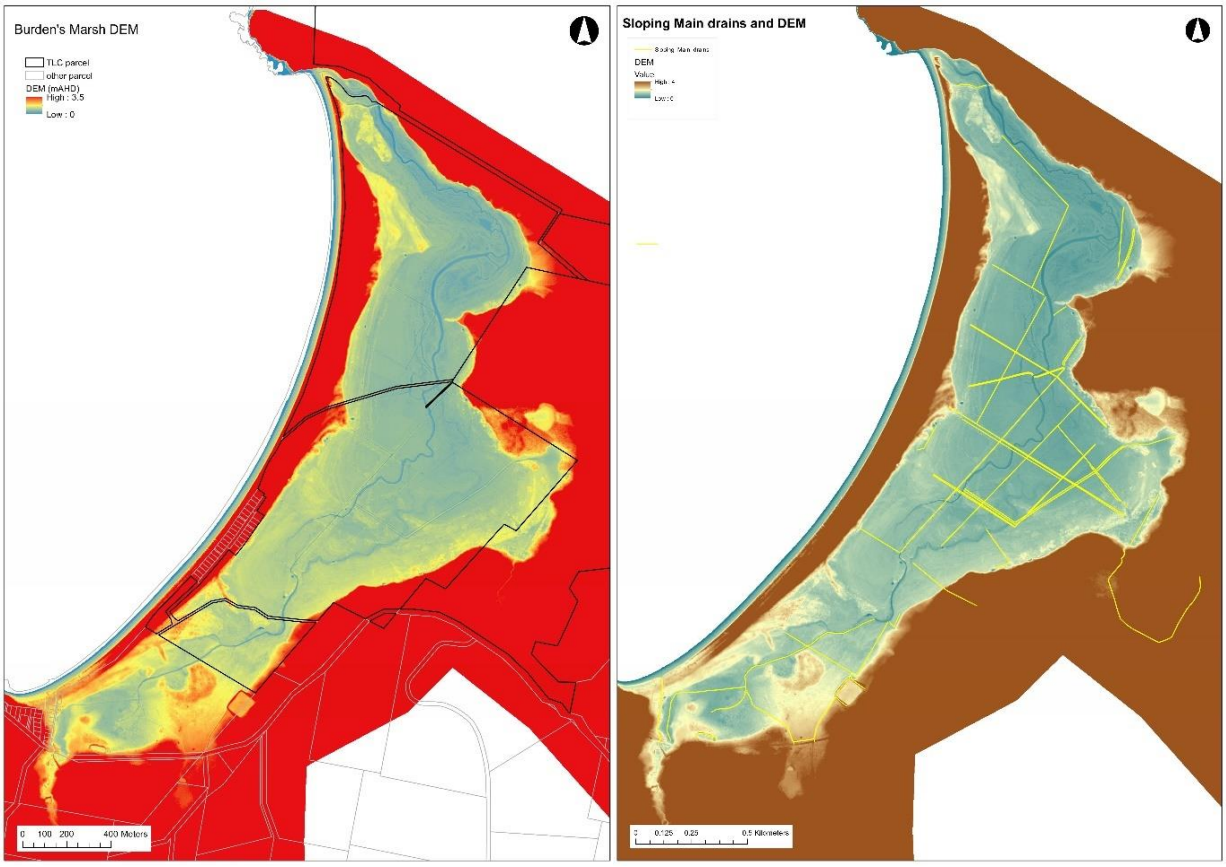



**Figure 20. Burdens Marsh DEM (left) and DEM with mapped drains and embankments overlain (right).**

Figure 21 shows how these features were classified from closer analysis of the aerial photographic record over time, and after ground-truthing of all features. This shows the year when any new works were first noted in the sequence of aerial photographs of the site that we have used for analysis (1948, 1975, 1985, 1995, 1996 and 2006).

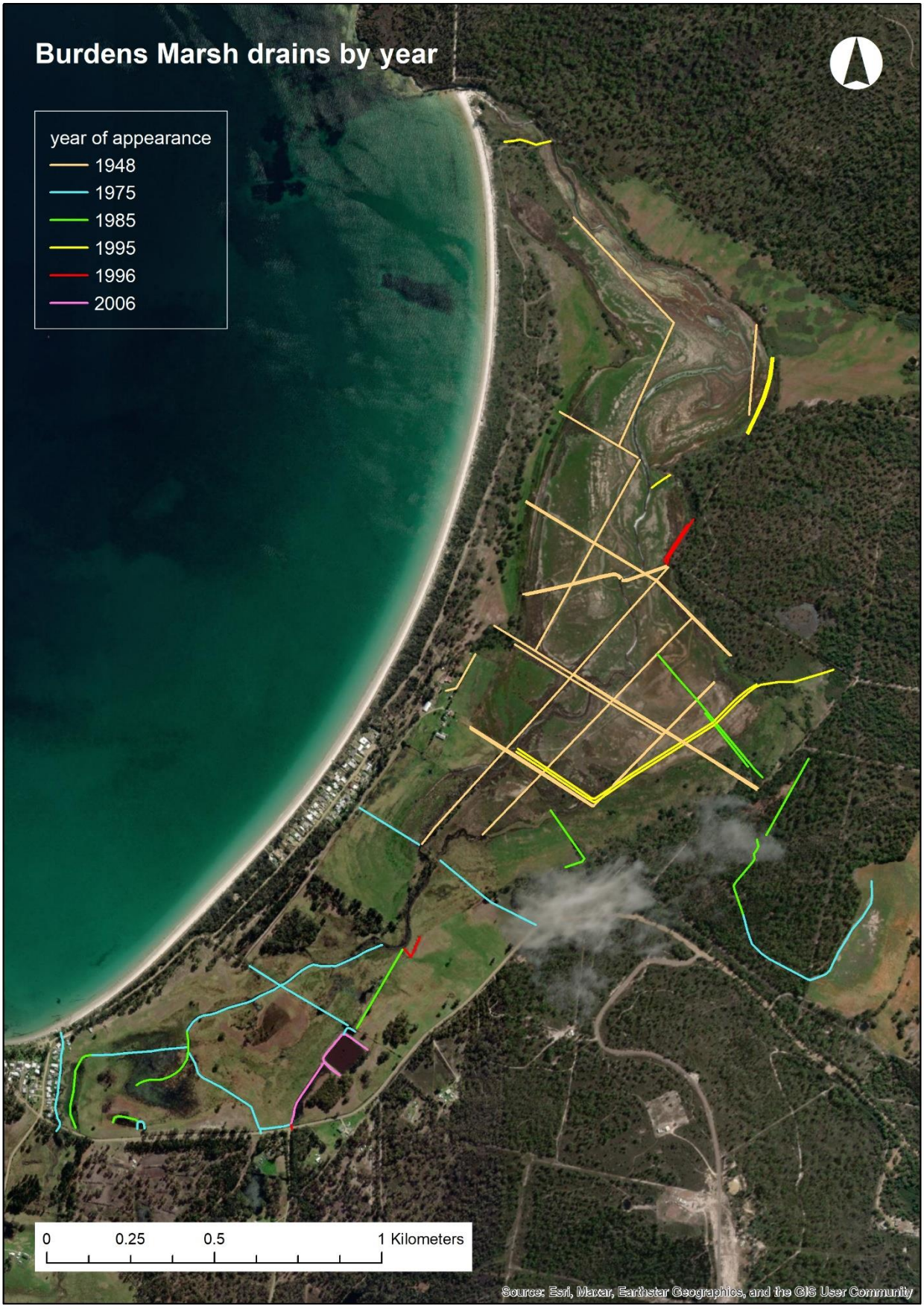



**Figure 21. Mapping of artificial drains at Burdens Marsh classified according to the year of the aerial image in which each drain first appears (noting that there is a significant gap of years between some images).**

The beige-coloured features that are mapped were those that were pre-existing in 1948 and have been discussed in detail previously. These works concentrated on the main central and northern saltmarsh areas, and their interaction with the ocean outlet. In this section, we will discuss the other works that were completed over time and their intended purpose.

### 2.5.1. The southern end of Burdens Marsh

The works at the southern end of Burdens Marsh (Figure 23) were completed progressively over time by F. John Price. John has detailed how he worked to improve the agricultural potential of the southern part of the property from the 1960s, through clearance and drainage activities. He has also explained how, as part of that phase of development in the 1960s, he sought to reduce flooding by enhancing (cleaning and deepening) a pre-existing diversion channel to the south of the wetland complex (indicated in Figure 23 as feature number 5).

The drain had apparently been constructed to capture and divert some of the flows from the catchment area to the south-east, away from Burdens Marsh in the decades prior (likely the very early 1900s). While reducing inflows to, and inundation of, the Marsh was a probable motivation for this work, the drain also led to a secondary lateral channel (since infilled) which diverted some of this flow to a 'waterhole' (an elongated deep trench) situated to the west (Figure 22).

**Figure 22. The original flow direction of the southern catchment into Burdens Marsh (blue arrows), was banked off (white dashed line), and this catchment has been diverted (red arrow) via an artificial bypass drain to the sea (red dashed line) since the early 1900s. The approximate location of the old waterhole/trench for the timber mill is shown in the orange circle. Photo: Mark Bachmann**

This water was used for the operation of a steam-driven timber mill near the former jetty at the southern end of Slopen Main Beach. While the mill apparently ceased to operate sometime around the depression period (1920s or 1930s), the nearby diversion drain to the sea remained in place, but was not maintained. Hence, while developing the southern part of the property for farming in the 1960s, John Price used machinery to clean this channel out, allowing him to improve its effectiveness and functionality (F. John Price, pers. comm. 2024).

Even in its modified state, this diversion drain does not divert all flows from this southern catchment away from Burdens Marsh. Although all low-to-moderate flows are directed down this drain to the sea, higher volume flows after heavy rainfall overwhelm the capacity of the drain and can result in as much as an estimated 50% of the flow temporarily spilling northwards out of the drain and along the natural flow-path towards Burdens Marsh during those events (F. John Price, pers. comm. 2024). Of course, as those larger flows recede, the drain once again becomes effective at diverting all remaining flows away to the sea. John estimates that these more intense episodic rainfall events capable of overwhelming the capacity of this drain happen on average once a year, with their specific frequency influenced by wider climatic patterns and trends.

In terms of the relative importance of this catchment to the hydrology of Burdens Marsh, John estimates that, under natural conditions, it may have provided the bulk of freshwater runoff to Burdens Marsh. Compared to other smaller catchments that feed Burdens Marsh north of this creek, he estimates that up to 90% of all off-Reserve catchment generated inflows to Burdens Marsh would have originated in this main southern catchment, prior to its modification. As a result, and although this feature is not situated within the TLC Reserve, its importance to the hydrology of Burdens Marsh cannot be understated.


**Figure 23. Mapped drains in the southern end of Burdens Marsh (numbers referred to in text).**

An explanation for the main drainage features labelled in Figure 23 is as follows:

1. Additional lateral drains were installed to enhance drainage of the southern portion of the main saltmarsh, building on earlier works.

2. New drains were dug, to reduce inundation within the two fresher wetlands upstream (south) of the main saltmarsh area. These wetlands were noted by Surveyor Blackwood in 1873 as follows: "there are two small lagoons south of this marsh, with any amount of wild ducks on them". Follow up works over the following two decades extended and made these drains more comprehensive.

3. A dam was constructed prior to 2006, designed to capture runoff from a small stream to the south, which is diverted towards the dam along a contour bank. This stream is estimated to have contributed approximately 10% of off-Reserve runoff to Burdens Marsh (F. John Price, pers. comm. 2024).

4. Once the dam is full, this contour channel flows backwards and overflows into the drain marked 4, from where it can join the main flow through the saltmarsh.

5. This artificial drain diverts a waterway that, although appearing to be a minor stream, is the most reliable off-site catchment area capable of generating significant flows to Burdens Marsh. In particular, this stream still produces important episodic flows for Burdens Marsh after heavy rainfall events, although the majority of this water is now directed to the sea at the southern end of Sloping Main Beach via the diversion drain marked. Based on observation, this stream is estimated to have originally contributed up to 90% of off-Reserve runoff to Burdens Marsh (F. John Price, pers. comm. 2024).

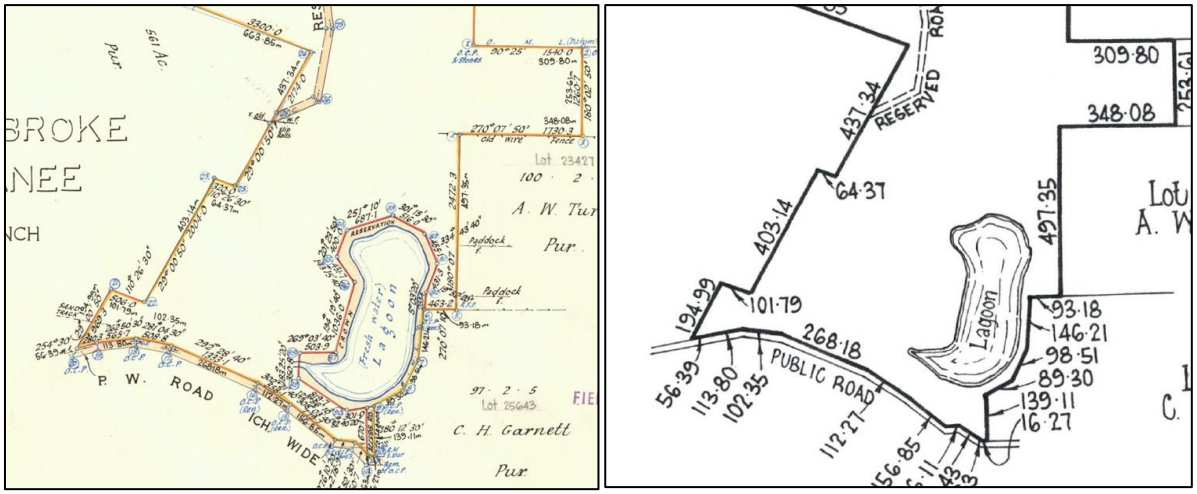
6. This smaller dam was constructed in two stages commencing in the 1960s.

### 2.5.2. The central portion of Burdens Marsh and fresh wetlands to the east

In 1964, John W.C. Wyett, selected the large parcel of unallocated Crown Land to the east of Burdens Marsh for a purchase grant, on similar credit terms to earlier iterations of the Crown Lands Act. Up until this time, John Athol Price, the owner at that time of Burdens Marsh, had a Crown Lease over this area that enabled him to occasionally graze it.

Interestingly, when this occurred, and despite Turners Lagoon being originally surveyed in 1964 (as shown in Figure 24) as a separate Crown Land parcel, this deep, fresh wetland area ended up being counted in the total grant area of 425.7 hectares. The new owner, J W C Wyett – encouraged by the requirements of the Crown Lands Act – then quickly proceeded to drain it, by making a deep cutting at its south-western corner (as shown in the DEM in Figure 25), to make the area available for grazing.

Although this area was technically never purchased by John Wyett from the government, because it was recognised within the land title area displayed on the land grant issued to him in 1979 (refer to Figure 24), the Tasmanian state government later officially recognised the Lagoon as forming part of the Tasmanian Land Conservancy property, in May 2024. For this reason, the Lagoon has been specifically included within the restoration plans for Burdens Marsh and the Sloping Main Reserve.




**1964 survey plan** **1979 land grant / title plan**

**Figure 24. The parcel of land that now makes up the TLC reserve, was revised in 2024 to included the Lagoon, as drawn on the 1979 title plan (rather than following the 1964 survey plan).**

John Price recalled that before it was artificially drained, Turners Lagoon was a deep wetland, that could fill to up to 6 feet in depth, or 'above his head'. Being a semi-permanent wetland, Turners Lagoon has a peaty substrate that is high in organic material and has caught alight on a few occasions during bushfires since the wetland was drained and has proven difficult to extinguish. Prior to drainage, this peat was more likely to remain saturated, offering a natural protection against burning.

The dramatic change in condition of Turners Lagoon is visible in both the aerial photographic record and the DEM (Figure 25).

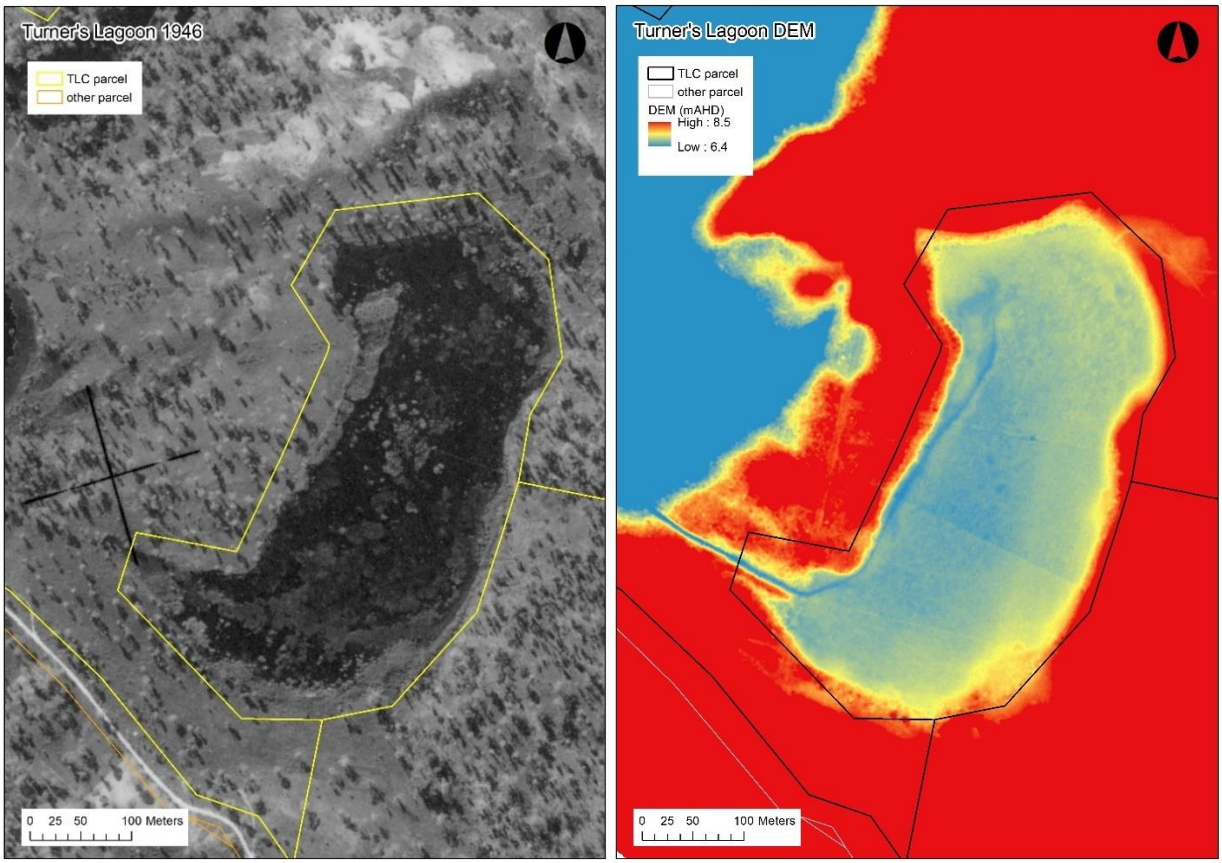



**Figure 25. 1946 aerial image of Turner's Lagoon (left) and contemporary DEM of the same area (right).**

As Figure 25 shows, in 1946 the wetland was not artificially drained and was full of water. The deep artificial drain however, cut to below the bed level of this wetland is clearly evident on the DEM and has had a major impact on the hydrology of this feature.

The drainage of Turners Lagoon has also created a series of knock-on effects, which are summarised in Figure 26 showing the changes to drainage over time in the central portion of Burdens Marsh and fresh wetlands to the east.

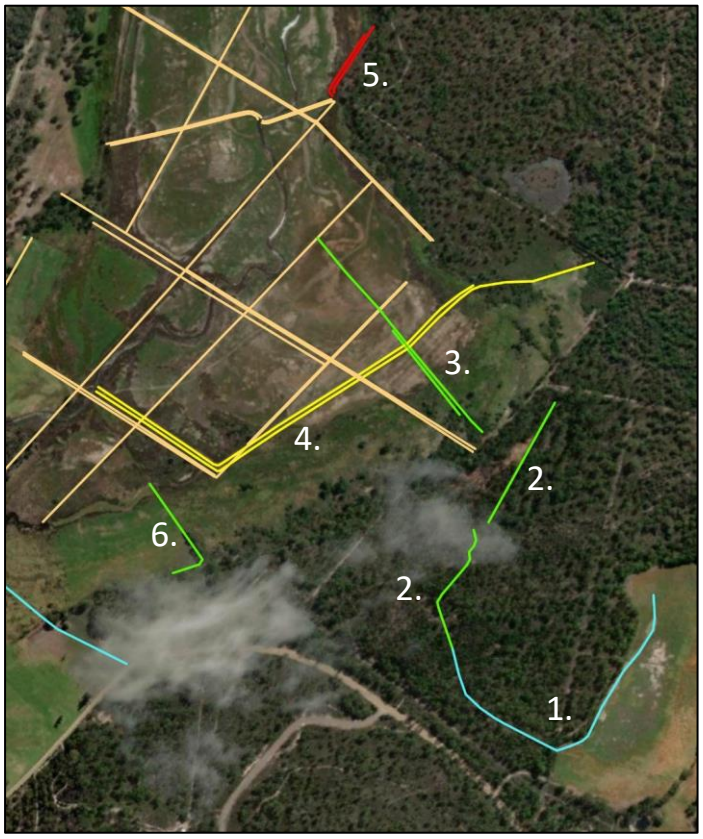



**Figure 26. Mapped drains in the central area of Burdens Marsh, including Turners Lagoon (numbers referred to in text).**

An explanation for the main drainage features labelled in Figure 26 is as follows:

1. The drainage of Turners Lagoon (foreground below) c. 1965 by J W C Wyett (Figure 27).

**Figure 27. Turners Lagoon (foreground right) drained c. 1965 and Burdens Marsh (background). Photo: Mark Bachmann.**

2. The subsequent drainage 10-15 years later of two further fresh wetland features (Figure 28) by J W C Wyett, now supplemented by the volume of water being discharged from Turners Lagoon.

**Figure 28. One of the fresh wetlands situated between Turners Lagoon and Burdens Marsh, drained c. 1980. Photo: Mark Bachmann.**

3. In response to 1. and 2., but around the same time as 2., John Price constructed a carrier drain across his paddocks to cope with the additional freshwater inflows coming from this series of three drained wetlands from the neighbouring property to the east.

4. A new vehicle causeway / crossing, with drainage channel either side (Figure 29), constructed by John Price c.1990.

**Figure 29. Vehicle causeway / crossing, with drainage channel either side, constructed c.1990. Photo: Mark Bachmann.**

5. A shorter additional vehicle causeway / crossing constructed by John Price c.1995.

6. An additional feeder drain constructed by John Price at the same time as 3.

### 2.5.3. The northern portion of Burdens Marsh and the ocean outlet


**Figure 30. Mapped drains in the northern area of Burdens Marsh (numbers referred to in text).**

An explanation for the main drainage features in the northern portion of Burdens Marsh labelled in Figure 30 is as follows:

1. A levee bank (Figure 31) and timber gate/weir system (Figure 32) were installed by F. John Price c. 1990, to allow for water to be released during periods of catchment flow through the saltmarsh, but then closed off to prevent ingress of high tides after those periods of high flow had eroded the sand bar over the mouth of the inlet (further downstream).

**Figure 31. Looking upstream over the levee bank and timber weir constructed c. 1990. Photo: Mark Bachmann.**

**Figure 32. Close up of the timber weir constructed c. 1990. Photo: Mark Bachmann.**

2. Vehicle causeway / crossing with ditch either side, and drainage works (Figure 33) constructed by John Price c.1990.

**Figure 33. Looking south along the vehicle access causeway constructed c. 1990. Photo: Mark Bachmann.**

## 2.6. Summarising 200 Years of Change Since European Colonisation

The main issues associated with land management interventions since European colonisation on the eco-hydrology of Burdens Marsh are summarised in Figure 34, across five themes.


**Figure 34. The key eco-hydrological issues: looking north over Sloping Main in 2023. Photo: Mark Bachmann.**

The key issues that will be addressed in Sections 5 and 6 of the report are:

1. The interruption of natural flows in both directions (both fresh and saline) via the outlet to the sea, as a result of the levee and gate system, alongside and in combination with, other upstream hydrological changes (Figure 35).

**Figure 35. The outlet to the sea at Burdens Marsh, showing the constriction caused by the levee and gate system.**

2. The installation of an artificial drainage and embankment network across Burdens Marsh, along with several raised causeway embankments (Figure 36).

**Figure 36. The central portion of Burdens Marsh, impacted by drains, levees and causeway embankments, some of which date back to the early 1830s. Photo: Mark Bachmann**

3. The artificial drainage of Turners Lagoon (3a) and three other small, fresh wetlands (3b, 3c and 3d) into Burdens Marsh (Figure 37).

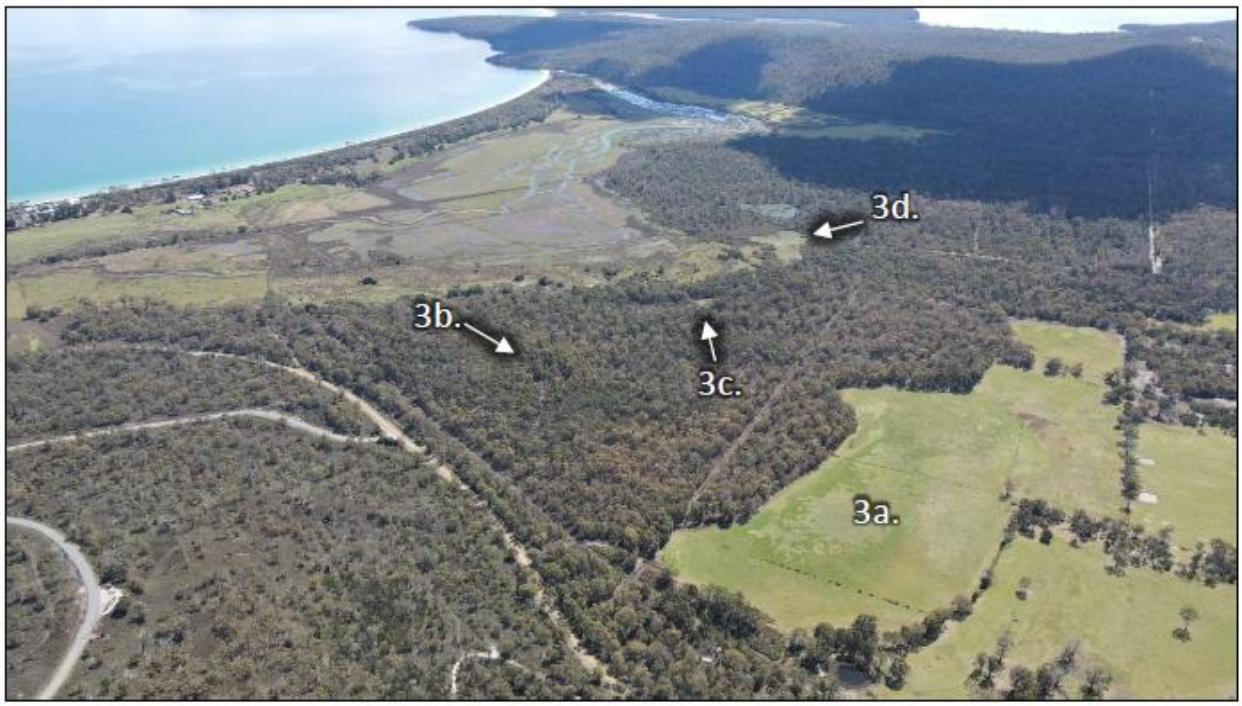



**Figure 37. The chain of fresh wetlands east of Burdens Marsh impacted by artificial drains since the 1960s include Turners Lagoon (3a) and three other smaller wetlands (3b, 3c & 3d). Photo: Mark Bachmann**

4. The artificial drainage of two fresher wetlands upstream (to the south of) Burdens Marsh saltmarsh. These are labelled 4a and 4b (Figure 38).


**Figure 38. The two artificially drained fresh wetlands situated south of the main saltmarsh area at Burdens Marsh (4a and 4b). Photo: Mark Bachmann**

5. The redirection of the southern catchment to the sea, away from Burdens Marsh (Figure 39).

**Figure 39. The original flow direction of the southern catchment into Burdens Marsh (blue arrows), has been banked off (white dashed line), with this catchment now diverted (red arrow) via an artificial bypass drain to the sea (red dashed line). Photo: Mark Bachmann**

Each of these issues have localised and system-wide impacts that will be explored as part of an examination of the options for (a) the repair of the physical wetland landform and (b) restoration of the eco-hydrological function, of Burdens Marsh (see Section 5).

### 2.6.1. Timeline of eco-hydrological change

To help understand the five main issues impacting upon site eco-hydrology, the material compiled in Section 2 is summarised in Table 2 below. This tabulated summary provides an understanding of when, and for how long, the changes that impact different parts of Burdens Marsh were initiated and have been in place.

**Table 2. Summary of the established timeline of change, pre 1800s – present.**

<table>
<tr><th></th><th>1.<br>saltmarsh<br>natural<br>ocean outlet</th><th>2.<br>main<br>saltmarsh<br>area</th><th>3.<br>Turners<br>Lagoon /<br>wetlands<br>east of<br>saltmarsh</th><th>4.<br>fresh<br>wetlands<br>south of<br>main<br>saltmarsh</th><th>5.<br>seasonal<br>southern<br>catchment<br>fresh<br>inflows</th></tr>
<tr><td>Pre 1820s</td><td colspan="5">Original site condition: prior to European colonisation and under the custodianship of the First Nations Traditional Owners, the Pydairrerme clan of the Paredarerme (Oyster Bay) nation</td></tr>
<tr><td>Late 1820s - 1834</td><td>Unclear what, if any, changes were made, but artificial openings likely when required, linked to reclamation of the main saltmarsh area</td><td>First 115 acres of saltmarsh drained and farmed by Gellibrand at Sloping Main</td><td rowspan="5">No change to hydrology during this phase</td><td rowspan="5">No change to hydrology during this phase</td><td rowspan="3">No change to hydrology during this phase</td></tr>
<tr><td>1834 - 1848</td><td>Possible period of construction of first timber outlet gate / weir system at mouth of natural outlet</td><td>Gellibrand’s farm and building requisitioned by government and likely expansion of drainage works to cover more of the saltmarsh area before the Coal Mine lease.</td></tr>
<tr><td>1849 - 1877</td><td>The outlet is situated north of the fence constructed in 1849, situated in the ungrazed area that formed part of the Coal Mine lease. The outlet unlikely to have been managed during this time.</td><td>In 1849, a fence (with guard stations) to separate and secure the Coal Mine lease area was constructed E-W through the saltmarsh and beyond. Sheep grazing occurred south of the fence during this phase, but drains were not maintained.</td></tr>
<tr><td>1877 – c.1900</td><td rowspan="2">Artificial openings recommence. Whether the old gate weir system at the mouth was installed in 1830s/40s, or after 1877, it was rumoured later destroyed (burned) by Burden, before arrival of J. A. Price</td><td rowspan="2">A second attempt to farm the entirety of the main saltmarsh commences from 1877, likely using pre-existing convict drainage system. The main network of drains and levees in place by 1932 when J A Price purchases the land.</td></tr>
<tr><td>c.1900 – 1932</td><td>Major impact: flows largely diverted (to ocean) via new drain</td></tr>
<tr><td>1932 – 1960s</td><td rowspan="2">Artificial openings continue. Original gate system no longer present (only last couple of timbers visible) when J. A. Price purchases the land in 1932, and not replaced until c.1990</td><td>Little further drainage of the main marsh occurs in this phase</td><td rowspan="3">Major impact: wetlands drained into the sea, via Burdens Marsh since 1960s</td><td rowspan="3">Major impact: wetlands drained into the sea, via Burdens Marsh since 1960s</td><td rowspan="3">The existing artificial drain south of Burdens Marsh is re-established and better maintained</td></tr>
<tr><td>1960s – c.1990</td><td rowspan="2">Some additional minor drainage works through the main marsh completed to improve sheep grazing, and some new causeway embankments built for vehicle access, but most drains were not specifically maintained or altered.</td></tr>
<tr><td>c.1990 - 2021</td><td>Artificial openings continue. Current timber gate / weir and levee near outlet in place and operated to reduce depth and duration of inundation, and prevent tidal ingress</td></tr>
<tr><td>2022 - present</td><td>Artificial openings cease. Weir & levee near mouth still in place but not operated since TLC purchase</td><td>More water held for longer after rainfall events, due to change in outlet management philosophy</td></tr>
</table>

# 3. Eco-hydrological Assessment

## 3.1. Climate

Sloping Main endures a temperate, maritime climate. Temperatures range from an average high of 22 °C in summer to 13 °C in winter. Average annual rainfall is 530 mm however is highly variable with a weak seasonal cycle (Figure 40). Rainfall can come from westerly cold fronts, but a large proportion of the rainfall comes from easterly and northeasterly systems such as cutoff lows (Grose *et al.* 2010).

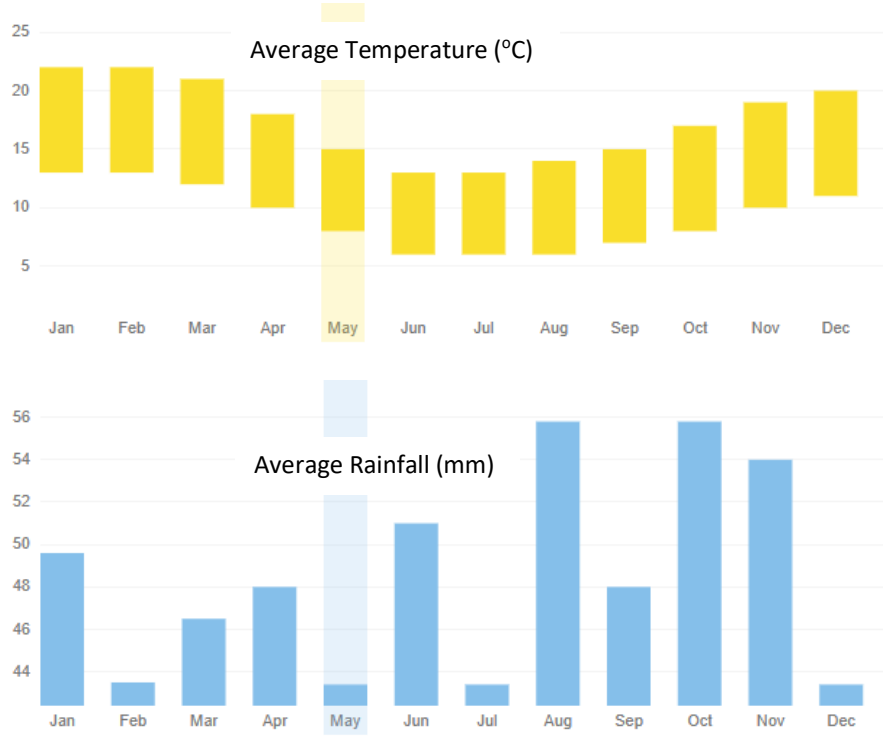



**Figure 40. Average monthly temperature and rainfall for the Tasman Peninsula. Source: Weather Trends.**

### 3.1.1. Climate change

Long-term average temperatures have risen up to 0.1 °C per decade and daily minimum temperatures have risen slightly more than daily maximum temperatures, which is similar across seasons. Average temperatures are projected to rise 2.6-3.3 °C out to 2100 (Grose *et al.* 2010). There has been a decline in average rainfall, with the decline strongest in autumn. The region experienced a significant drought in the period 1995-2009 (Grose *et al.* 2010). By 2100, the following changes in climate are expected under a high emissions scenario:

- Doubling of the number of days > 25°C (from 10-20 to 35)
- Increase in the temperature of very hot days
- Reduced frost risk days
- Doubling of the length of warm spells (from 4-5 days to 7-11 days)
- Increased ocean warming, particularly in autumn and winter
- Increased rainfall and rainfall intensity in all seasons (0-18 %)
- Potentially decreased drought frequency and severity
- Increased pan evaporation (up to 19 %)

**Sea level rise**

Sea level has been rising at a rate of 3-4 mm/year in recent years. Sea level could rise by 0.8 m by 2100 under a high emissions future climate scenario (Grose *et al.* 2010) (Figure 41). In terms of storm surge, a current 1:100 event could become a 1:50 year event by 2030 and a 1:2-6 year event by 2090 (Grose *et al.* 2010). Sloping Main beach is also identified as highly vulnerable to climate change (LISTmap – Foreshore climate change vulnerability NRM South).

Sea level rise poses a potential threat to the eco-hydrology and character of Burdens Marsh. Sea water is likely to penetrate further into, and more regularly inundate, the marsh, which will have significant impacts on the vegetation communities and their distribution. However, the wider landform and topography itself within the Sloping Main Reserve (with its gentling rising slope around the saltmarsh) provides the future opportunity for the seamless upslope migration of vegetation communities in response to sea level rise. This offers the reserve a degree of future ecological elasticity and resilience not available at many other saltmarsh locations around Tasmania, highlighting the strategic significance of the Sloping Main Reserve.

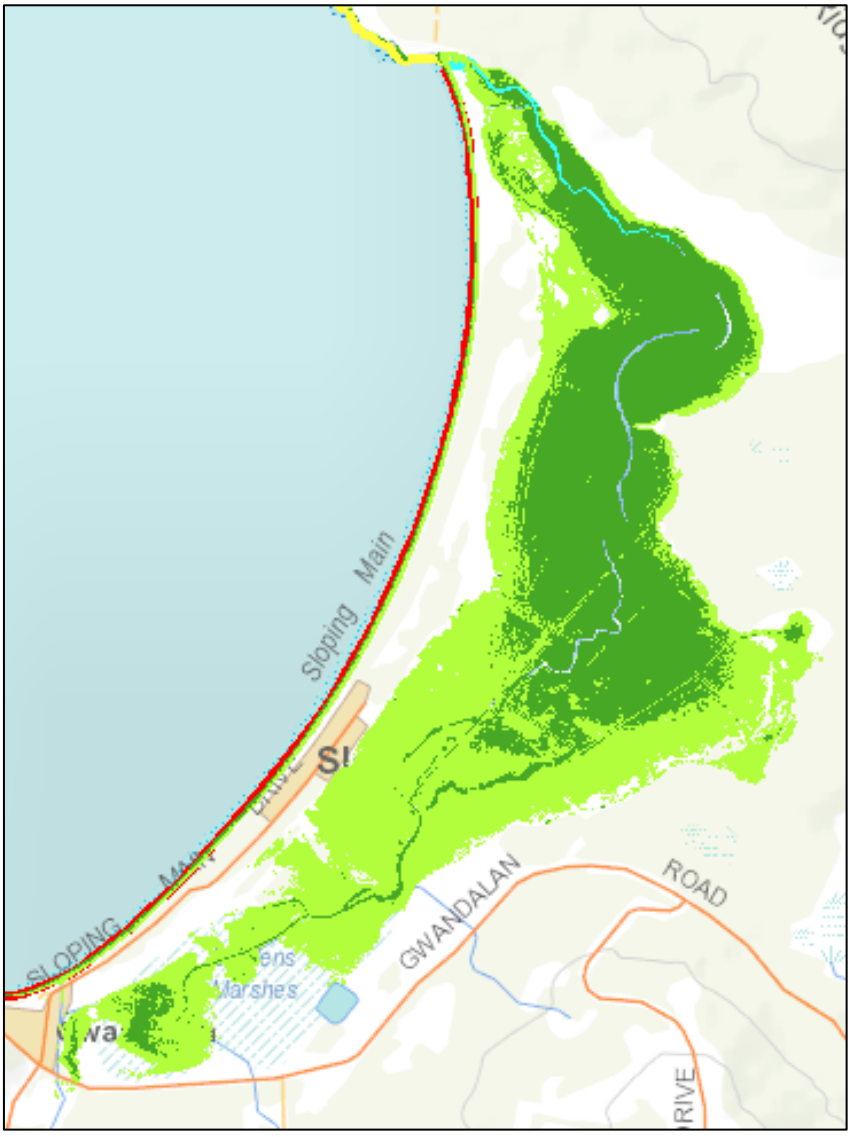



**Figure 41. Projected sea level rise at Burdens marsh (dark green to 2050 and light green to 2100). Source: LISTmap – Coastal Projected Sea Level Rise 20161201.**

## 3.2. Contemporary Hydrology

### 3.2.1. Burdens Marsh catchment

The Burdens Marsh catchment is approximately 20 km$^2$ in area (Figure 42). It captures flows south of the Cardwell Range, west of Coal Mine Hill and Saltwater River, north of Heathy Hill and east of Mount Wilmot. Minor inflows and runoff enter the mid and northern marsh from adjacent areas (including Turners Lagoon), whereas two delineated, though unnamed waterways, enter the marsh at the southern end. The most western of these is anecdotally purported to contribute the bulk (up to 90 %) of the inflow to the marsh complex. A number of both on and off stream small dams occur in the catchment, as do a number of small freshwater wetlands to the west of the marsh, together with the more significant Turners Lagoon.

Outflows from the marsh are discharged via a natural drainage channel that runs from mid-marsh to the outlet into Fredrick Henry Bay, in the north of the marsh.

The catchment is largely forested, with the western sub-catchment and low-lying areas cleared for pasture and grazing. The TLC property comprises approximately one quarter of the catchment and 80 % of the marsh area.


**Figure 42. Approximate boundary of Burdens Marsh catchment (yellow).**
**Source: LISTmap – CFEV Sub-Catchments.**

### 3.2.2. Frequency of inundation as indicated by remote sensing

The National Map tool of Geosciences Australia includes remote sensing data of surface water across Australia. The Digital Earth Australia (DEA) Water Observations Multi Year (Landsat) layers provide a statistical summary that combines all years (1986 to near present) of the DEA Water Observations product (Geoscience Australia 2024). The Water Summary statistic presents the percentage of cloud-free observations that were detected as wet by the Landsat satellite. The Water Summary data were used to create a map for the Burdens Marsh area (Figure 43). The Water Summary statistic combined across all years suggests that the southern half of Burdens Marsh is rarely inundated, with the exception of a small (c.2.5 ha) area in the far south-west (outside of the TLC property). Inundation appears to be confined to the northern part of the Marsh, with an area of c.65 ha inundated for 5-20% of observations, suggesting seasonal-to-occasional inundation.

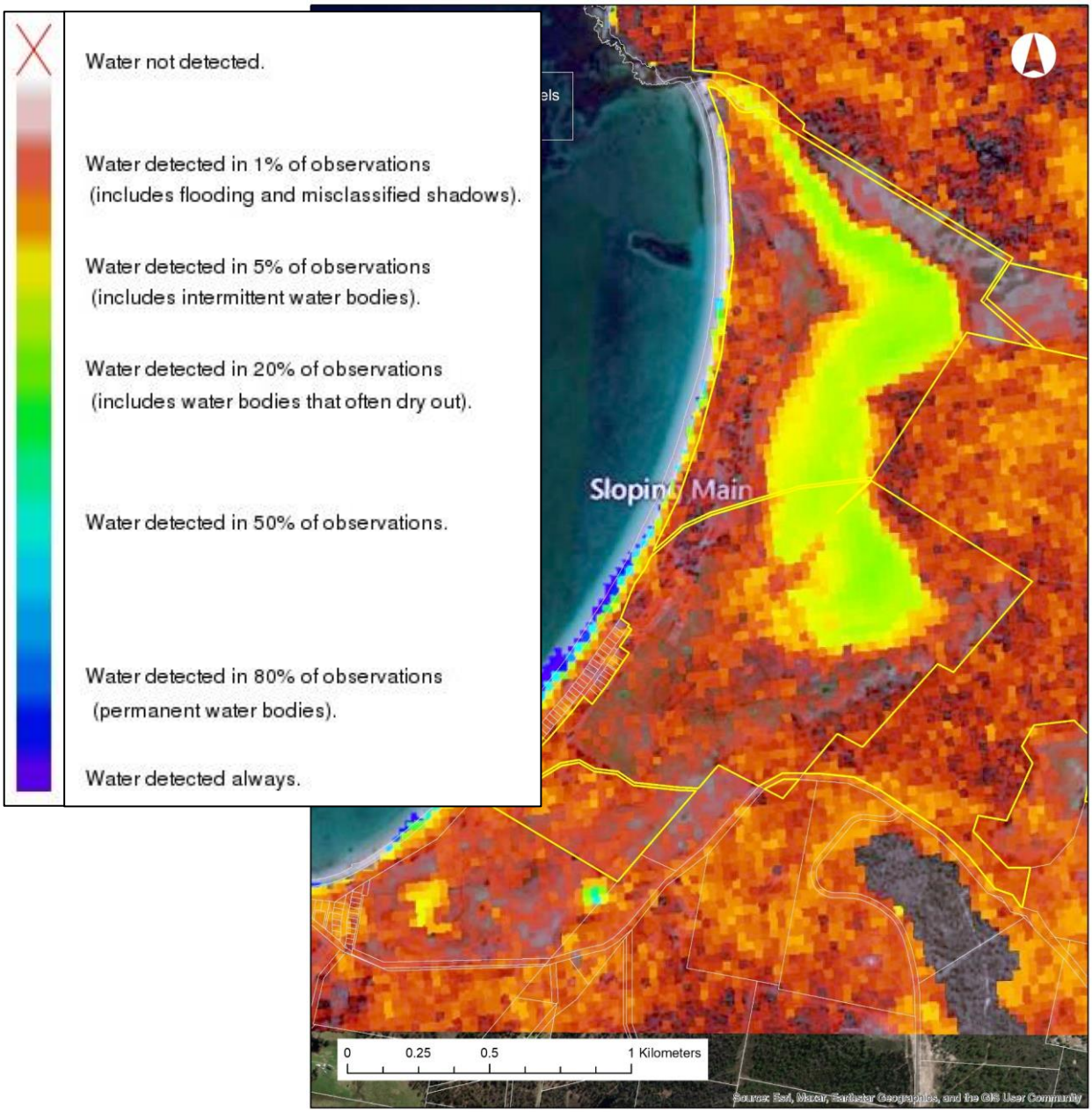



**Figure 43. DEA Multi Year Water Observation (Landsat) Water Summary 1986 to 2023 for the Burdens Marsh area (source: Geoscience Australia 2024).**

A more detailed examination of inter-annual variability of inundation is provided by the DEA Water Observation April to October Water Summary for viewed for each year individually. These winter-spring inundation summaries for the six most recent years (2018 to 2023) are presented in Figure 44. They suggest:

- there are dry years in which little to no inundation occurs within Burdens Marsh (e.g. 2019);
- the extent of inundation within Burdens Marsh varies between years, with some years (e.g. 2018, 2019, 2023) showing considerably reduced extent;
- the duration of inundation also varies between years, including between years with a similar extent of inundation. For example, inundation persisted longer in 2021 compared to 2022 despite a similar maximum extent being achieved.

It should be noted that the DEA Water Summary statistic may be conservative (likely to under-estimate the frequency of inundation) because cloud-obscured days are excluded from the dataset yet the cloudy times of year may be more likely to have water present than clear days. At a site like Burdens Marsh, which has a history of both freshwater inundation (from catchment flows) and saline inundation (from tidal seawater ingress), it is also important to note that Landsat data does not distinguish between different salinities of inundation – it simply recognises the appearance of water.

In summary, remote sensing indicates that Burdens Marsh experiences a water regime that is highly variable, both temporally (in duration, season, year) and spatially (in extent). This variability is likely a key ingredient that drives and/or maintains the floristic character and diversity of Burdens Marsh, with some plant species favoured in years of deeper, longer inundation and other species favoured in drier years. Equally, the marsh favours flora species that have a wide salinity tolerance, due to its dynamic historic inundation regime that includes both fresh and saline inflows. Finally, the infrequency of inundation in the southern half of Burdens Marsh is likely to reflect the effectiveness of artificial drainage, which efficiently directs water towards the lowest-lying (northern) portion of the marsh.

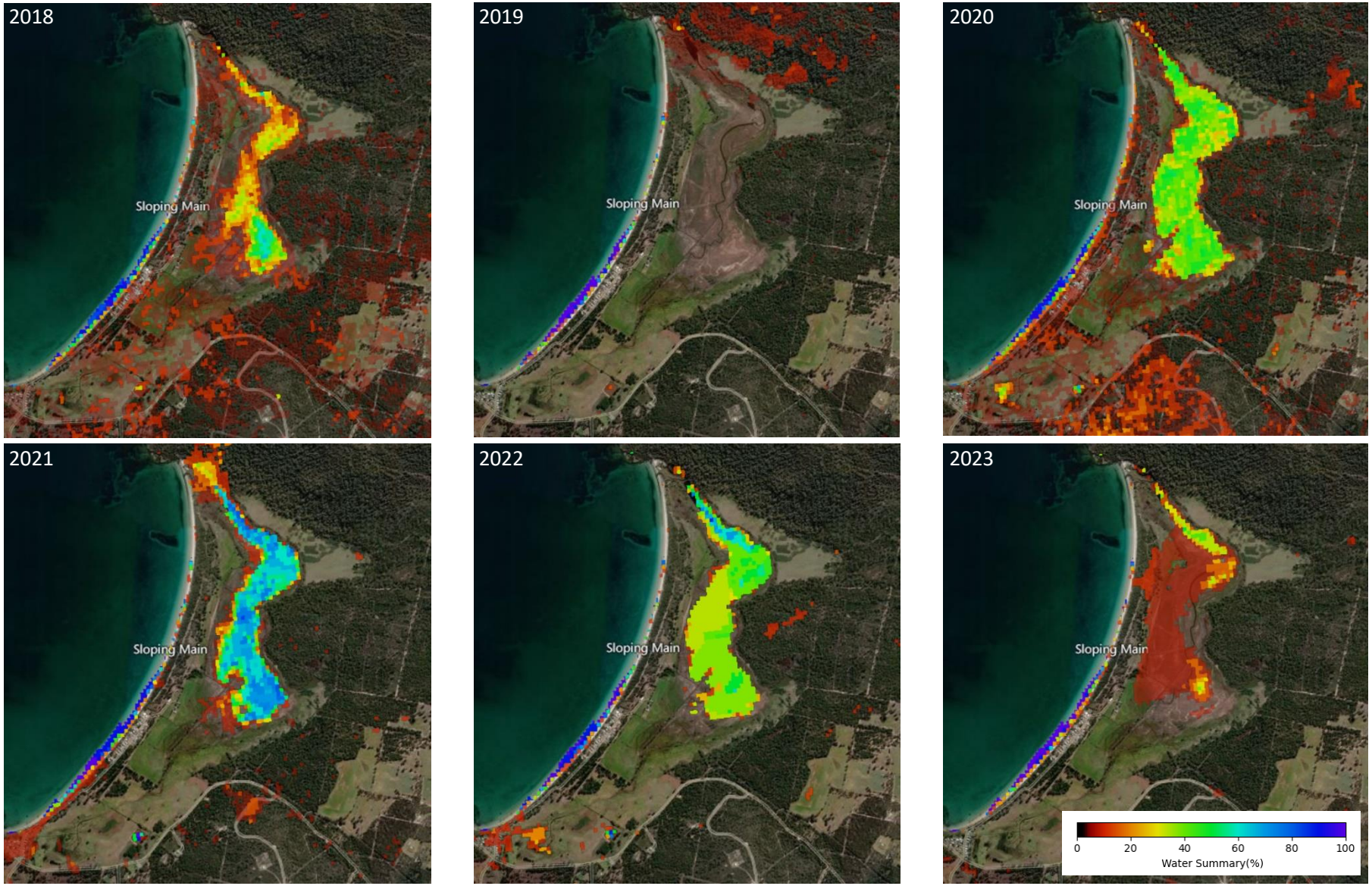



**Figure 44. DEA Water Observations April to October (Landsat) Water Summaries by year for 2018-2023 for the Burdens Marsh area (source: Geoscience Australia 2024).**

### 3.2.3. Tidal regime and water quality

Burdens Marsh exists at the dynamic interface of fresh and seawater inflows. Water quality data is not available for the broader catchment or from within the marsh, however, anecdotally under low catchment inflows, spring high tides have been observed to push far south into the marsh (to behind the original homestead). When significant freshwater inflows occur from the surrounding catchment to the south and the outlet is closed via the sand bar, the water quality in the marsh is expected to be fresh for extended periods.

Tides in Frederick Henry Bay range up to 1.25m but are typically between 0.5 and 1m. Subsurface tidal connection to and influence upon the marsh is unknown. Some degree of direct tidal connection of the marsh with the bay occurs most years when the status of the sand bar across the outlet permits this to occur, and subject to the management of the timber weir/gate structure constructed by F. John Price c.1990.

### 3.2.4. Soils, geology and hydrogeology

Burdens Marsh overlies Quaternary sediments comprised of sand gravel and mud of alluvial, lacustrine and littoral origins. The Cardwell Range to the north comprises quartz sandstone and ranges to the south, sequences of sandstone, siltstone and mudstone (Source: LISTMap Geology 250k). The marsh contains poorly drained soils with high salinity and high potential for acid sulphates. Organic soils have been modelled to occur in the freshwater wetlands to the east, including Turners Lagoon (where a peaty substrate has been observed). Organic soils are less likely within the marsh itself but potentially exist in the northern end.

Groundwater is likely to be shallow beneath the low-lying marsh (<5m) and groundwater flow is towards the marsh and the coast from the eastern, northern and southern areas. Several bores have been drilled to the far east and south of the reserve, mostly in the 1980s and 1990s with varied yield and standing water level (SWL) records. Yields ranged from 1-3.5 L/s and SWL from 6 to 12 mbgl from bores drilled into Permian formations (mudstone, sandstone and limestone) to the east at Turners Point (approximately 20 m elevation). Poorer yields have been recorded from Triassic formations (sandstone, siltstone and mudstone) west of Gwandalan at Black Jack Point and on Heathy Hill to the south (<1 L/s) (Source: LISTMap Groundwater bores and features).

## 3.3. Drain Mapping and Classification

Historic aerial imagery for the Burdens Marsh area was obtained from the Aerial Photo Viewer website of the Department of Natural Resources and Environment Tasmania. Images taken in the years 1948, 1975, 1981, 1985, 1995, 1996, 2006 and 2011 were obtained and georectified using ArcMap 10.8.1. Artificial drains observable in these images were mapped and the year of the aerial image in which they first appeared was noted. The results of this exercise are discussed in Section 2.5 above (Figure 21). The mapping extent included all TLC-owned land parcels and also included the parcel at the south-western (upstream) end of the marsh that remains under the ownership of Mr F. John Price. Preliminary mapping was validated via field observations on 21-22 September 2023. Discussion with former landholder John Price also confirmed the status of several drains and related features. A total of 19.68 km of extant drains and related features were mapped in Burdens Marsh and adjoining Turners Lagoon.

Several descriptors of the drains were also attributed via field observations:

- depth (m);
- width (m);
- backfill potential; and
- type.

Backfill potential describes the volume of spoil material, originally excavated and placed adjacent to the drain, that remains in situ, represented as a percentage of the volume of the drain itself. For example, a backfill potential of 100% implies that 100% of the material excavated when the drain was constructed is still present in a spoil mound, now typically densely vegetated, adjacent to the drain and therefore the potential to completely backfill the drain is high. In contrast, a backfill potential of 10% implies that only 10% of the material originally excavated remain in situ, 90% of the material likely lost to erosion and the potential to completely backfill the drain using the locally available material is low (Figure 45). Figure 46 shows all mapped drains classified according to backfill potential. Drains with a backfill potential of less than 100% cannot be completely backfilled and the decommissioning of these drains would involve the creation of a series of disconnected backfilled sections or blocks (to be filled/compacted to surface level) using the available material. Note also that in a small proportion of locations the vegetation that has established on the spoil mounds since original excavation includes large trees, which adds a complicating factor to the backfilling task.

In addition to age and backfill potential, the drains (and related features) were categorised as follows:

- "drain" excavated to create levee;
- dam wall;
- levee;
- minor scrape;
- mounded fenceline with "drain" each side;
- mounded former fenceline with "drain" each side;
- natural channel deepened, spoil not obvious;
- parallel with causeway;
- parallel with fenceline;
- road culvert;
- single drain, spoil both sides; and
- single drain, spoil one side.

**Figure 45. Drain in Burdens Marsh with a backfill potential of 100% (left) and 10% (right). Photos: Ben Taylor, 21/9/23.**

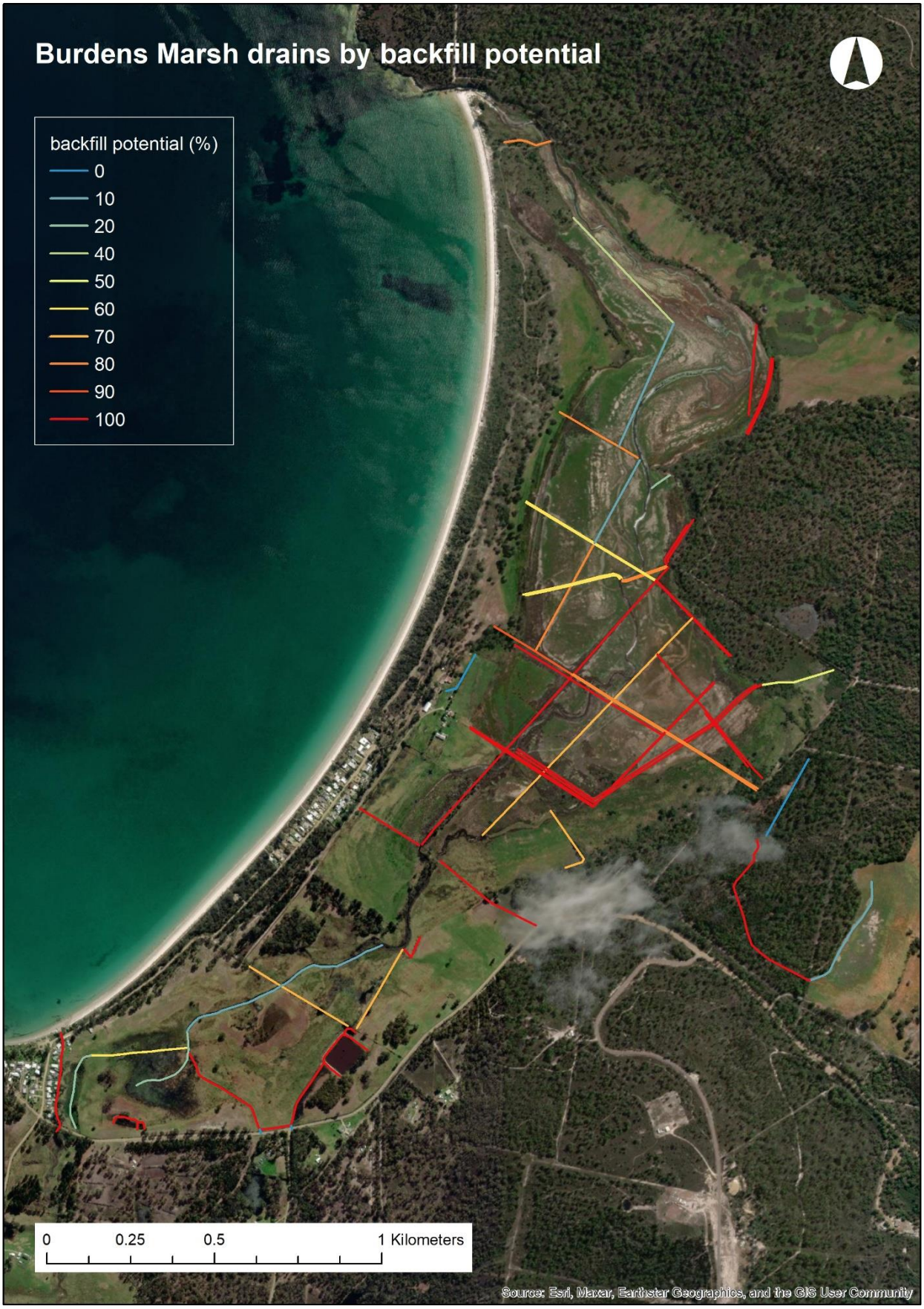



**Figure 46. Mapping of artificial drains at Burdens Marsh classified according to backfill potential.**

## 3.4. Vegetation Communities and Flora

Sloping Main Reserve contains exceptional conservation values, including nationally significant ecosystems such as the 116 hectares of Temperate Coastal Saltmarsh (nationally vulnerable) in Burdens Marsh - one of the largest saltmarshes with a intact native vegetation buffer in Tasmania.

The Burdens Marsh parcels contains approximately 188 hectares of native vegetation, consisting of nine vegetation communities. Other than saltmarsh, the property supports two other nationally listed vegetation communities, critically endangered *Eucalyptus ovata* forest and woodland and *E.ovata* heathy woodland, and four communities listed as threatened under the Tasmanian *Nature Conservation Act 2002*, the two mentioned above, as well as Lacustrine herbland and *E.viminalis-E.globulus* coastal forest and woodland (see Figure 47, over the page). Recorded rare or threatened saltmarsh flora species include *Hyalosperma demissum*, *Lepilaena preissii, Ruppia tuberosa, and R. megacarpa,* and it is also highly likely that the saltmarsh supports populations of additional rare aquatic plants such as *Limonium australe, Triglochin minutissima*, and *Phyllangium divergens*.

The extensive marsh is unique in that it contains an intact and gently sloping buffer that provides an important pathway for the movement of both species and ecological communities now and into the future, under projected sea level rise. The property also contains minimal weed cover, with the buffer area comprised largely of intact native vegetation. Detailed descriptions and locations of vegetation communities associated with the marsh are outlined in the Sloping Main Saltmarsh Property Assessment (TLC 2022).

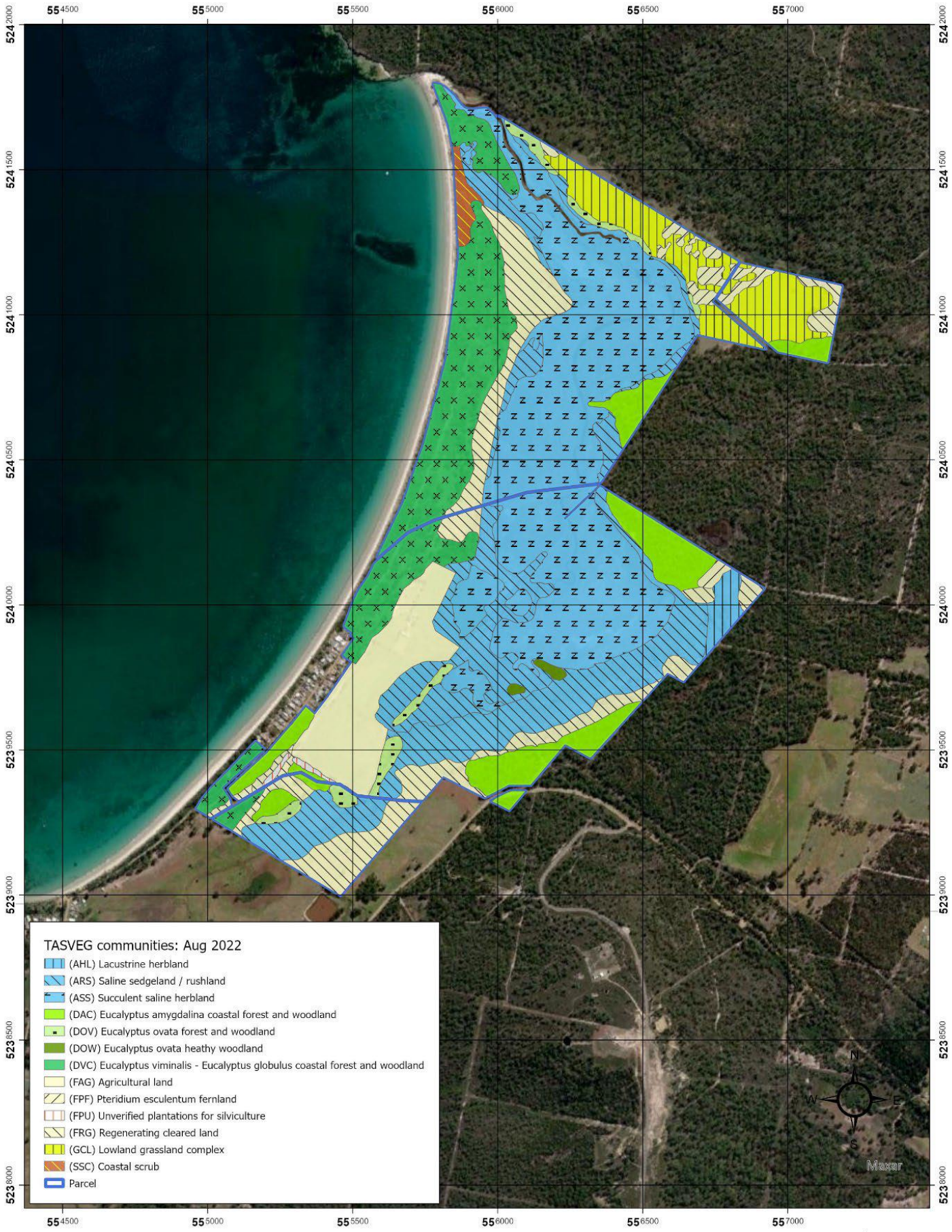



**Figure 47. Preliminary vegetation community mapping at Burdens Marsh (TLC 2022).**

## 3.5. Fauna

Burdens Marsh saltmarsh is likely to provide important temporal and seasonal habitat for a variety of wetland and migratory fauna, while the diversity of surrounding eucalypt forest and open sedgeland/grassland habitats likely supports a suite of terrestrial fauna of conservation significance. The marsh is significant for waterfowl and waders, which have been observed to both breed and feed at the site in considerable numbers (Dr. V. Prahalad pers comm. July 2022, in TLC 2022).

Migratory waders such as the double-banded plover (*Charadrius bicinctus*) have been recorded in the area, while vulnerable hooded plovers (*Thinornis cucullatus*) are present along Sloping Beach. White-bellied sea eagles (*Haliaeetus leucogaster*) and wedge-tailed eagles (*Aquila audax fleayi*) are also likely to occur over the marshland and reside in adjacent habitats.

The diversity of open grasslands and sedgelands includes several marsupial lawns – areas of high soil moisture that support high numbers of herbivores, including Tasmanian pademelons (*Thylogale billardierii*), red-necked (Bennett's) wallabies (*Macropus rufogriseus rufogriseus*) and bare-nosed wombats (*Vombatus ursinus*). Additional fauna species that have been detected by the TLC through camera detection at Sloping Main include the Tasmanian devil (*Sarcophilus harrisii*), spotted-tailed quoll (*Dasyurus maculatus*), southern brown bandicoot (*Isoodon obesulus*), long-nosed potoroo (*potorous tridactylus*), brushtail possum (*Trichosurus vulpecula*), ringtail possum (*Pseudocheirus peregrinus*) and echidna (*Tachyglossus aculeatus*). Habitat for the green and gold frog (*Litoria raniformis*) also exists on the property in the small, eastern freshwater wetlands, which is habitat that would be expanded and enhanced through hydrological restoration (TLC 2022).

## 3.6. Cultural Heritage

The reserve and its surrounds are known to be rich in both recent convict-era European heritage and extensive Aboriginal cultural heritage. This includes sites such as living sites (middens), artefact scatters, post and rail fences, brick kiln, and convict buildings. Given the location of the property and the surrounding landscape it is believed that there is a high likelihood of undetected Aboriginal cultural heritage being present, although no cultural or historic heritage sites exist currently on any heritage registers.

Now situated within the recently revised boundary of the TLC Reserve, Mungaratya / Turners Lagoon, is the largest and deepest of surrounding freshwater wetlands and we have been advised is an important feature to First Nations people. A formal heritage assessment is recommended to understand heritage values and identify any mitigation measures (if and where required) prior to hydrological restoration works being implemented.

# 4. Eco-hydrological Monitoring and Baseline Conditions

The eco-hydrological assessment focused on understanding the links between hydrology and ecology and identifying potential improvements that can be achieved from hydrological restoration works, which typically aim to restore flows and remediate the physical landform and how it interacts with, conveys, or retains flows. To identify hydrological restoration opportunities and measure the outcomes of any future restoration works, an eco-hydrological monitoring plan was developed and implemented.

## 4.1. Monitoring Objectives

The objectives of the eco-hydrological monitoring at Burdens Marsh were to:

- Collect baseline (pre-restoration) information on the vegetation, water quality and water regime to characterise the site before potential future restoration works and better understand the impact of previous hydrological manipulations.
- Determine opportunities for positive improvements in water regime to improve the condition of vegetation and conservation values of the site.

Key eco-hydrological questions guiding the monitoring plan included:

- What is the current water level and salinity regime across the site, and how might these change post restoration?
- What role do freshwater catchment inflows play in the water regime and how do they move through the site?
- What is the approximate loss of fresh inflows to the marsh from the southern seaward drain?
- What role do tidal inflows play in the water regime and how do they move through the site, and how might these change post restoration?
- What influence is the tidal gate and associated levee having on the water and salinity regime?
- What is the current distribution of vegetation communities across the site and how might these shift post restoration?

## 4.2. Monitoring Locations and Parameters

The monitoring program includes quantitative monitoring:

- In-situ, continuous monitoring of surface water level (SWL, units: mAHD) and electrical conductivity (EC, units: mS/cm) at the outlet, on either side of the tidal gate/levee structure; and behind the homestead in the central area of the marsh. Surface water level is also being monitored below the culverts, downstream of the road that crosses the main seaward drain which drains the primary source of freshwater catchment inflows away from Burdens Marsh. This will enable assessment of the hydrological relationships between various areas of the marsh and establish baseline water regimes.
- Vegetation monitoring in the form of three transects and numerous plots at sites established along the upper, mid and lower marsh. Species and cover were recorded at these sites. These data will enable the identification of any shift in species along an east-west gradient over time (especially in response to changes in salinity and water regime).

The program also includes qualitative monitoring:

- Photo-points established perpendicular to each of the water monitoring sites to record changes in water regime and vegetation in associated areas.
- Observational accounts.

Monitoring locations for Burdens Marsh are summarised in Figure 48 and Table 3.


**Figure 48. NGT eco-hydrological monitoring locations at Burdens Marsh.**
***Note logger = surface water level and electrical conductivity (salinity) monitoring site (except BM_04 which only consists of a water level logger).***

**Table 3. Summary of Burdens Marsh eco-hydrological monitoring sites.**
***NB - photo points were established at water monitoring locations and typically involved two photos at each site – one looking north upstream and one looking south downstream. Photo points were monitored to link water levels to vegetation extents and to collect baseline data to support pre and post restoration works.***

| Logger ID | Site Name | Easting | Northing | Objective |
|---|---|---|---|---|
| | | MGA 2020 | | |
| **Water level and electrical conductivity loggers** | | | | |
| BM_01 | Main drainage channel – behind homestead | 555819 | 5239807 | Determine water regime and water quality in the mid marsh area. |
| BM_02 | Tidal outlet - downstream gate | 556012 | 5241680 | Determine the influence of the tidal gate/levee structure on water regime and water quality in the northern marsh area. |
| BM_03 | Tidal outlet – upstream gate | 556027 | 5241617 | |
| BM_04 | Seaward drain – southern marsh | 554546 | 5238736 | Estimate the magnitude of freshwater catchment inflows currently being diverted via drainage to sea and away from Burdens Marsh in the southern marsh area. |
| **Vegetation transects** (start and end coordinates are provided) | | | | |
| Transect 1 | Southern marsh | 555895<br>556772 | 5240163<br>5240051 | Collect baseline data to support pre and post restoration works.<br><br>Determine shift in wetland and saltmarsh vegetation communities over time in key areas of interest. |
| Transect 2 | Mid marsh | 556061<br>556631 | 5241133<br>5241135 | |
| Transect 3 | Northern marsh | 555951<br>556130 | 5241445<br>5241545 | |

## 4.3. Monitoring Analysis and Results

### 4.3.1. Hydrology

Water level and electrical conductivity (proxy for salinity) loggers were installed in August 2023 (note BM_04 was installed later in December 2023, as a result of preliminary investigations and drain mapping).

Mid-marsh water levels were approximately 0.4 m deep upon logger installation (BM_01). Following this they showed a single point of rise following a high rainfall event in October 2023, then continued to recede from this date onwards. The marsh was dry at this site from December through until the latest logger download in April 2024, with some minor, short-lived inundation coincident with higher rainfall days in January and March 2024 (Figure 49).

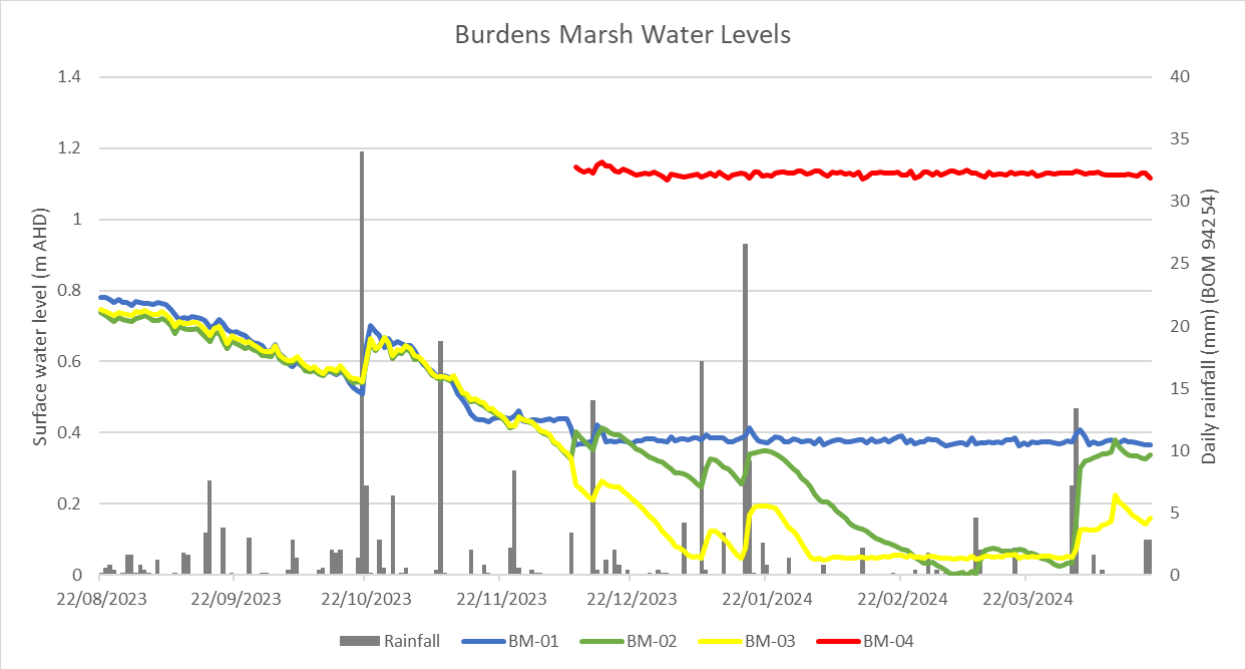



**Figure 49. Water level monitoring results from Burdens Marsh, August 2023 – April 2024.**

Once the wider marsh had dried out in December 2023, water levels either side of the weir/levee at the outlet (i.e. BM_02 and BM_03) started to deviate from trend previously similar to the mid-marsh logger site (BM_01).

Water levels on the coastal side of the weir (BM_02) remained higher than on the inland side of the weir (BM_03) until March 2024, suggesting that tidal ingress is currently being retarded by the weir.

Responses to rainfall events appear to be greater at the outlet sites than mid and southern marsh sites once the marsh has dried out. This is likely due to the continuous saturation of soils in the northern area of the marsh where groundwater is predicted to be very shallow and sub-surface tidal connection is likely. The mid marsh is approximately 0.4 m higher than the outlet sites and the mid marsh approximately 0.7m lower than the southern marsh or upper catchment (Figure 49).

No significant water level rises occurred in the upstream culvert site (BM_04), indicating zero flow events between the time it was installed in December 2023 and the most recent data collection in April 2024.

### 4.3.2. Water quality

Salinity was consistent between the mid and northern marsh areas until the broader marsh dried out in December 2023. Salinity remained constant either side of the weir/levee structure up until the point where the main marsh area became dry (December 2023). On the inland side of the weir (BM_03), salinity then increases, likely reflecting evapo-concentration processes. There were some short-lived freshening events, linked to episodic, high rainfall events experienced in January and March 2024. On the coastal (tide-influenced) side of the weir (BM_02), salinity remained more constant (Figure 50). This provides further evidence that, as expected and consistent with its design, the weir is retarding tidal ingress, despite its dilapidated condition. Further investigation is required to determine whether this reflects seasonal changes in sea level and salinity.

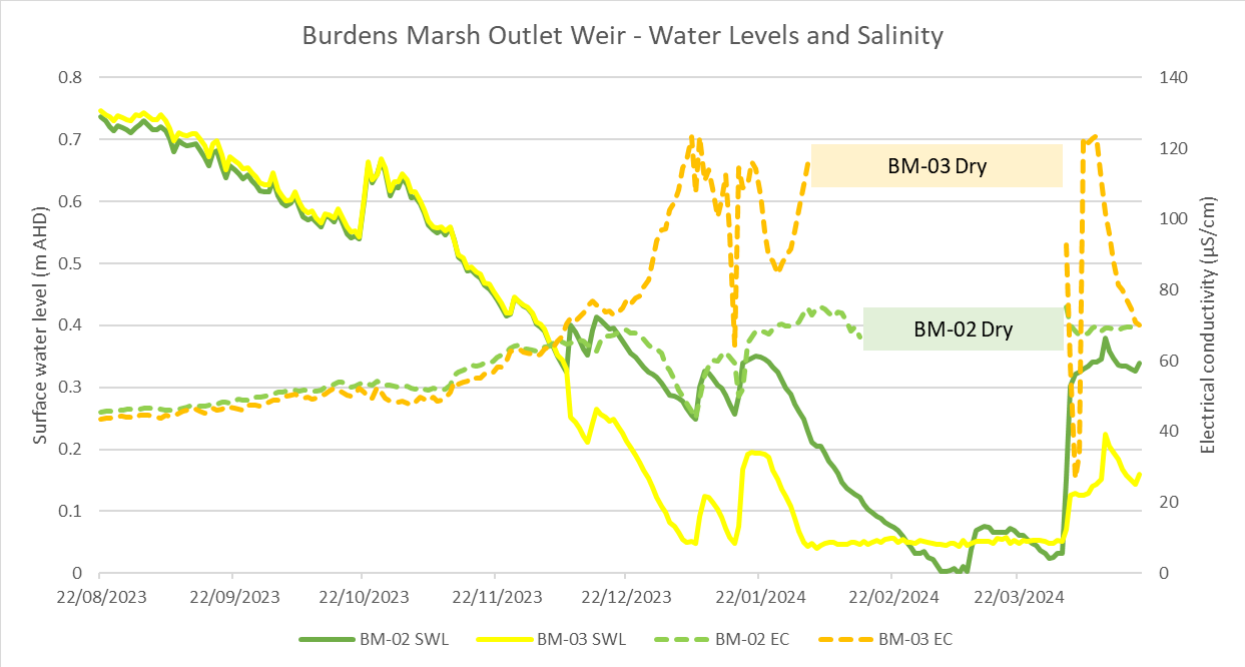



**Figure 50. Salinity monitoring results from Burdens Marsh, August 2023 – April 2024.**

### 4.3.3. Vegetation

Vegetation plots and transects were sampled on the 9th – 11th of January 2024 by NGT, TLC and Dr John Aalders. Transects were positioned to capture current and any future change to ecotones across the saltmarsh from west to east in the upper, mid and lower marsh areas. Vegetation data collection methods followed those employed at Long Point by NGT in 2021 and in saltmarsh areas across Tasmania by Dr. John Aalders, previously of the University of Tasmania (Aalders *et al*. 2019). Plots were 2 x 1 m in area and were arranged central to the transect (1m either side) and 1m to the east. The north-western and south-western corners of all plots have been permanently marked on the ground via a pair of short wooden pegs painted with aqua tips.

All transects typically traverse saline rushland at the higher elevation ends and saline herbland in the lower, central marsh area. Bare ground constitutes a large component of cover in most plots but ranges from 1-100%. A species with wide salinity and inundation tolerances, *Juncus kraussii* dominates the overstorey in the saline rushland community. The saline herbland community is dominated by *Sarcocornia quinquefolia,* with common associates such as *Isolepis cernua* and *Triglochin striata*, and also indicates that the saltmarsh can experience wide fluctuations in hydrological regime (in terms of depth, duration and water quality).

Vegetation presence and percent cover data compiled during the baseline survey is presented in Appendix 1.

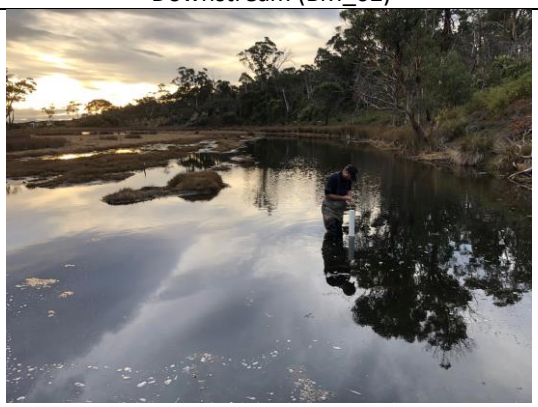
This dataset will provide a robust, easily resampled dataset with which to measure any future change in vegetation across the marsh in response to proposed restoration works.

### 4.3.4. Photo points

Photo points were taken at water monitoring sites in order to capture broad change in water levels and associated vegetation communities. Photo points have so far been taken at the outlet and mid marsh sites in August and December 2023, and April 2024.

Table 4 provides an overview of photo-point monitoring images to date. The drying of the marsh experienced from December onwards is evident at all sites. A thick cover of algal mats was present at the mid marsh site (BM_01) in August 2023. This then covered the ground as the water level receded in December 2023 and was in the process of degrading in April 2024 as dry conditions persisted.

**Table 4. Overview of photo-point monitoring, Burdens Marsh, August 2023-April 2024.**

| Date | Monitoring Site | |
|---|---|---|
| | Tidal outlet – Upstream (BM_03) | Downstream (BM_02) |
| Aug 2023 |  |  |
| Dec 2023 |  |  |
| April 2024 |  |  |

| | Mid marsh drain (BM_01) - Upstream | Downstream |
|---|---|---|
| Aug 2023 |  |  |
| Dec 2023 |  |  |
| April 2024 |  |  |

### 4.3.5. Incidental observations

Incidental flora and fauna observations made in the marsh and surrounding areas during our field investigations include the following:

- Latham's snipe, one of Australia's rarest waterbirds, were observed on adjacent private land in the southern area of marsh in September 2023.
- Remnants of at least two Black swan nests were recorded in the central area of the marsh, likely following the large inflow events and extended duration of inundation in 2021 and 2022.
- A Masked-lapwing nest with eggs was recorded in the north-eastern areas of the marsh in September 2023.
- Hooded plovers have been sighted several times on Sloping Main beach.
- An antechinus, likely to be a state vulnerable Tasman Peninsula Dusky Antechinus (*Antechinus vandycki*), was sighted proximal to the small, freshwater wetlands situated between Turners Lagoon and Burdens Marsh, also in September 2023.

# 5. Restoration Options Assessment

## 5.1. Defining a 'goal state' for Burdens Marsh

By carefully reviewing the modifications to Burdens Marsh and their impacts over time, it is possible to construct a more complete understanding of the natural hydrological regime and how it has been altered. To demonstrate the combined impact of these changes, Table 5 illustrates how the different hydrological inputs have changed over time, and how they have interacted with the site.

**Table 5. Summary of changes in the hydrological regime of key areas in Burdens Marsh since the 1800s.**

<table>
<tr><th></th><th colspan="3">Broad description of the hydrological regime of Burdens Marsh saltmarsh</th></tr>
<tr><th></th><th>Main saltmarsh area water regime</th><th>Contribution of fresh inflows</th><th>Condition of the natural outlet</th></tr>
<tr><td>Pre 1820s</td><td>Wide fluctuations in depth, extent and duration of inundation, driven by east coast Tasmanian climatic patterns, resulting in an extremely dynamic saltmarsh ecology, favouring species capable of tolerating or exploiting a wide range of conditions. Periods of temporarily brackish to fresh, deeper inundation, likely followed by periods of hypersaline tidal exchange, before mouth closure and more complete drying. This dynamic cycle, which is not a 'fixed state' was the natural water regime.</td><td>With local rainfall over the marsh complemented by seasonal inflows from the larger southern catchment after rainfall, Burdens Marsh could temporarily fill with fresher water, before either draining more rapidly via a mouth opening, or slowly drying down, before reverting to its prevailing, underlying saltmarsh character.</td><td>The mouth would have been highly dynamic with flows likely breaking through the sand berm at the mouth every time there were sufficient inflows, driven by the larger southern catchment. This means that periods of subsequent tidal exchange, after scouring of the mouth, were also likely to have been regular. During prolonged dry periods, outlet remains closed with no tidal exchange.</td></tr>
<tr><td>Late 1820s - 1834</td><td>The water management goal at this time of initial development (by Gellibrand), would have been to reduce the extremes of inundation experienced in the main central saltmarsh area. Through drainage and levees, combined with mouth management, saltmarsh hydrology would have been less dynamic during this phase.</td><td rowspan="2">Seasonal fresh inflows were not modified, with the full original catchment of Burdens Marsh available.</td><td rowspan="2">To protect the initial 115 acres of developed area (and likely expanded area of up to 400 acres in 1830s and 1840s) some form of management of the mouth was probable during this period, e.g. deliberate opening of the mouth to prevent deeper, sustained inundation after rainfall events.</td></tr>
<tr><td>1834 - 1848</td><td>After Gellibrand's departure, expansion of his drainage scheme likely completed using convict labour, until the new Coal Mine lease fence bisects the saltmarsh in 1848.</td></tr>
<tr><td>1849 - 1877</td><td colspan="3">Reversion to the pre-1820s, highly dynamic eco-hydrological regime and recovery of native vegetation in Burdens Marsh, albeit with some pre-existing physical modifications (drains, embankments) remaining in-situ from the first attempt at saltmarsh development.</td></tr>
<tr><td>1877 – c.1900</td><td>Once again, the goal of water management during this new phase of development (after closure of Port Arthur), would have been to reduce the extremes of inundation experienced in the main saltmarsh area, through maintaining drainage, combined with more active mouth management.</td><td>Seasonal fresh inflows were not modified, with the full original catchment of Burdens Marsh available.</td><td rowspan="2">Management of the mouth occurred during this period e.g. deliberate opening to prevent deeper, sustained inundation. Original timber weir system at the mouth rumoured destroyed by Burden before 1913, presumably as it no longer worked as intended.</td></tr>
<tr><td>c.1900 – 1932</td><td rowspan="2">Property changes hands from Burden to McWilliams in 1913, and to J. A Price in 1932, although Price family may have leased for up to a decade earlier based on information passed down by Price family.<br>Major reduction in inflows from diverted southern catchment, likely leading to less frequent mouth openings (and reduced opportunities for tidal exchange). Overall, less variable / dynamic hydrology, to facilitate grazing of the saltmarsh. The lack of a weir at the mouth meant water regime was still more variable during this period.</td><td rowspan="2">Major change to water balance, with creek carrying main southern catchment flows diverted (to reduce inundation and provide water to timber mill), with a significant proportion of these flows lost to Burdens Marsh since that time.<br>However, over time this diversion drain is not maintained and becomes less effective.</td></tr>
<tr><td>1932 – 1960s</td><td>With no weir system, there was no way to prevent tidal ingress after artificial openings in this period. Pre-1950s, opening was done by shovel, and post-1950s, by tractor. In a 'successful' opening, flows scoured the outlet to sandstone bedrock, and tides would enter via the mouth for weeks, at times up to 2-3 months, subject to weather/rate of sand drift.</td></tr>
</table>

| | **Broad description of the hydrological regime of Burdens Marsh saltmarsh** | | |
|---|---|---|---|
| | *Main saltmarsh area water regime* | *Contribution of fresh inflows* | *Condition of the natural outlet* |
| **1960s – c.1990** | Renewed period of development and access improvement works done by F. J. Price, consolidating the reduced frequency, depth, extent and duration of inundation of Burdens Marsh. Renewed works to enhance/maintain diversion of the major freshwater southern catchment to the sea, likely impacting on frequency of mouth openings (hence reduced opportunities for tidal exchange).<br><br>The new water regime is entrenched, with much less variable / dynamic hydrology, to facilitate grazing of the saltmarsh. | Renewed works to enhance/maintain diversion of the major freshwater southern catchment to the sea. Ongoing loss of flows marginally offset by the concurrent artificial drainage of two smaller catchments inc. Turners Lagoon and fresh wetlands to the east and south into Burdens Marsh. Loss of adjacent, complementary fresh wetlands. | No weir system in operation at the mouth, but artificial openings to reduce depth and duration of inundation after heavy rainfall events still occurred as required, leading to some periods of tidal exchange in the saltmarsh.<br><br>During this period, preference was to manage outlet to remain tidal (open to sea) whenever possible, so that any catchment inflows would run to the sea and not deeply inundate the marsh. |
| **c.1990 - 2021** | Reduced frequency, depth, extent and duration of saltmarsh inundation with sea water, due to operation of the new weir to prevent tidal ingress.<br><br>Intensification of the general drying trend as a result of the new weir and levee preventing tidal ingress after artificial mouth openings.<br><br>Less dynamic hydrology overall, to accommodate ongoing farming (grazing) of the saltmarsh. | Catchment remains reduced, with a varying (but significant) proportion of natural fresh inflows still diverted away from Burdens Marsh. All water in low-moderate flows is diverted, but some water (up to 50% at peak flows) can still temporarily overwhelm the diversion drain's northern embankment in high flows after major rainfall events, allowing a portion of this water to still reach Burdens Marsh.<br><br>Adjacent freshwater wetlands remain artificially drained.<br><br>Ongoing absence of the bulk of seasonal southern catchment inflows being diverted, likely preventing a more regular, natural regime of mouth openings and subsequent periods of tidal exchange. | Artificial mouth openings continue. Current timber gate / weir structure and associated levee are constructed c.1990 and actively managed to prevent tidal ingress after artificial mouth openings. |
| **2022 - today** | Grazing of the main saltmarsh area ends with establishment of the TLC Reserve, and the long-term drying trend is partially reversed, through lack of active management of the natural outlet.<br><br>Despite this alteration to hydrology, ongoing impacts on saltmarsh ecology include:<br>(a) the change in micro-topography within the saltmarsh area (caused by drains and embankments),<br>(b) the reduction in fresh catchment inflows,<br>(c) the change in flow dynamics through the mouth, and<br>(d) the loss of ecological diversity and available habitat for species resident within and around Burdens Marsh, through the legacy drainage of important adjacent, complementary fresh wetlands to the south and east, inc. Turners Lagoon.<br><br>Less dynamic hydrology overall compared to the original eco-hydrological regime. | | Artificial mouth openings cease under TLC ownership / management, meaning outflows now rely on the wetland reaching sufficient depth for flows to be able to naturally breach and erode through the beach sand bar at the mouth of the outlet.<br><br>The disused weir and levee system risk ongoing reduction in tidal exchange as a result of an artificial constriction of flows (in both directions: outflows and inflows) and fish movement, with implication for the whole ecosystem, particularly piscivorous waterbirds. |

If the intention of the TLC in securing the protection and restoration of Burdens Marsh is to return the area to a state and eco-hydrological function that most closely resembles this original condition prior to the 1820s, then this table is a helpful way of deciding the elements that are required for determination of a future 'goal state' of the site.

In the case of a saltmarsh area like this, with highly variable and dynamic hydrology over time (including the time prior to its artificial modification), it is important to clarify at the outset that the original condition of Burdens Marsh, and the hydrological regime that underpinned it, was never static. The 'goal state' in this case is therefore better described and understood as being a range of conditions, rather than a fixed, idealised ecological state or outcome.

In summary, we should expect to see the ecological attributes of a site like Burdens Marsh, in all areas below high-water mark, shifting in character constantly over time in response to it being an inherently dynamic system with a highly variable hydrological regime. Under a restoration scenario, its hydrological regime may become even more dynamic as we attempt to reverse the various impacts described.

For the purpose of this assessment, the proposed 'goal state' for Burdens Marsh, on the basis of the historic assessment and information provided, is a wetland where:

- Wide fluctuations in depth, extent and duration of inundation occur, driven by east coast Tasmanian climatic patterns, resulting in an extremely dynamic saltmarsh ecology below high-water mark, favouring species capable of tolerating or exploiting a wide range of conditions.
- Local rainfall over the marsh is complemented by episodic inflows from the large southern catchment after rainfall.
- There are periods of temporarily brackish to fresh, deeper inundation, likely followed by periods of hypersaline tidal exchange, before the mouth closes, leading to more complete drying and reverting to its underlying saltmarsh character.
- Adjacent complementary freshwater wetland habitats are healthy and vibrant.
- A dynamic hydrological cycle is reinstated, noting that the water regime at a site with these attributes cannot be maintained in a fixed or steady state.

To achieve this 'goal state', given the past 200 years of modifications to the site, its catchment and surrounds, this is a wetland where:

- Physical changes to the micro-topography of the saltmarsh area (caused by drains and embankments) have been repaired,
- Southern catchment inflows have been reinstated,
- The natural outlet to the sea is once again allowed to naturally breach, erode, open and close, as the prevailing climatic conditions dictate, without human intervention,
- Infrastructure (the weir and levee) that is impeding movement of freshwater and tidal flows, both in and out of the natural outlet to the sea, is removed and the landform restored; and
- Complementary fresh wetlands to the south and east, including Turners Lagoon, are restored to provide adjacent complementary habitats for wildlife, in doing so recovering the original ecological diversity, complexity and integrity of the wider Sloping Main Reserve.

## 5.2. Restoration Objectives

Restoration works at Burdens Marsh would include addressing physical changes to site topography, by repairing all modified landforms and restoring eco-hydrological function. Based on a workshop held between NGT and the TLC during the course of the project, the overall agreed aim is to reinstate a more natural hydrological regime and salinity gradient across the Marsh.

Specific agreed eco-hydrological restoration objectives identified for Burdens Marsh are to:

1. Maintain, protect and enhance ecological diversity and condition by reducing the impact of drains, levees and the weir on water and salinity regimes and the associated distribution and vigour of saltmarsh and wetland vegetation communities.

2. Influence the current trajectory of ecological change by:
    a. improving water retention in the various wetland landforms and slowing the current speed of freshwater movement (caused by artificial drainage) through the Marsh to the sea,
    b. improving connectivity of tidal flows (which are currently artificially impeded) to the Marsh, and
    c. restoring freshwater catchment inflows (that are currently diverted away) back to the Marsh.

NGT's restoration philosophy aims to restore natural landforms and hydrology, to set a site on a long-term, self-sustaining trajectory of ecological recovery. Although this can involve a degree of short-term re-disturbance of areas where works have previously occurred (where, for example, remedial earthworks are required to remove banks, spoil and infill artificial channels), this approach ultimately leads to a situation where no further interventions and minimal management inputs over the long-term are required.

NGT adopts a philosophy for our wetland restoration work that, wherever possible:

- protects and enhances remnant ecological values,
- seeks to restore, as closely as possible, pre-European hydrology, and
- applies a design principle of 'set and forget' that minimises the construction or use of any new infrastructure that requires ongoing operation and maintenance.

In summary, wherever possible, we will not recommend or support high intensity future management options (e.g. deliberate ongoing water level manipulation) as part of our restoration proposals. Natural hydrological variability in response to climatic trends is a fundamental driver of natural wetland ecology and building site resilience, so removing (or reducing) the influence of artificial drivers that impact on that natural balance, remains our restoration objective – even at more modified sites.

High level interventions such as developing and operating weir structures have not been included in this assessment, as these were deemed to be inconsistent with the ecological objectives and restoration philosophy described, and noting that the existing weir system is in poor repair. Restoration actions focus on short-term, moderate level interventions which will lead to long-term natural regeneration outcomes that will spontaneously occur in a passive manner over time.

## 5.3. TLC Reserve Restoration Options

With the exception of Option 1, the remaining options involve taking active steps (across a spectrum of actions of increasing total efficacy) towards full restoration. The five key eco-hydrological issues identified in Section 2.6, provide the focus of the progressive restoration steps outlined in this section. Expected ecological outcomes and management inputs are explored further for each step in the restoration process.

For additional relevant detail, please refer to the restoration plan in Section 6.2, permit requirements in Section 6.4 and the estimated costs and steps outlined in Appendix 2.

### 5.3.1. Option 1: The 'Do Nothing' Scenario

Although seemingly a passive option, it is important to clarify that the 'Do Nothing' scenario is still a proactive choice from a management perspective, as it will result in the retention of all existing infrastructure, and hence the legacy of past interventions that are impacting upon site eco-hydrology. Beyond retaining the infrastructure, the 'Do Nothing' option also requires a choice to be made about whether there will be active management (and maintenance) of that infrastructure.

It is also important to note that the 'Do Nothing' scenario is quite a significant departure from the management of the last 200 years because, aside from any implications for water management, grazing livestock have also been removed since the TLC land purchase occurred. There is a possible risk of terrestrialisation of vegetation communities (e.g. shrub encroachment) within wetland areas that the grazing regime may have been suppressing. This process has broad ecological consequences and has been observed by NGT in other similar settings, where the underlying hydrological regime has been altered (and where those changes resulted in reduced depth and duration of inundation). Because destocking has occurred, this is relevant to both Options 1a and 1b, however Option 1b is preferable to help mitigate this risk.

**Option 1(a): Do Nothing, with active management of existing infrastructure**

The prior management regime over decades of farming involved deliberate mouth openings when water levels were elevated in Burdens Marsh, as per Figure 51, and, once the saltmarsh was drained, restriction of subsequent tidal ingress (through the then-scoured outlet) via artificial closure of a timber weir (the most recent iteration of this system was installed c. 1990). Combined with the diversion of the catchment area to the south of the saltmarsh away from Burdens Marsh (since the 1960s), this management regime maintained the saltmarsh area in an artificially dehydrated state for more prolonged periods that would ordinarily occur under natural conditions.

**Figure 51. The saltmarsh area of Burdens Marsh, full of water after heavy rainfall in October 2022. These are the conditions when the previous management regime would require an artificial mouth opening to drain the wetland. The artificial levee and weir location can be seen in the bottom right of this image. Photo: Rob Blakers.**

**Option 1(b): Do Nothing, with no management of existing infrastructure**

Considering the natural values and restoration options identified during the planning process, TLC would not consider Option 1a. Hence, for the purposes of this assessment, we will consider that under Option 1b, the 'Do Nothing' scenario would see existing infrastructure remain in-situ, but be left unmanaged.

Under this option, the wetland would fill when there is sufficient rainfall to do so, be sustained at a higher level for a more extended period of time, and only have any prospect of emptying if and when the sand berm over the mouth of the outlet naturally breaches and scours, releasing the impounded water, or after drying down through a period of lower rainfall through seepage and evaporation. Of note, the presence of the weir and levee system (installed c. 1990 near the outlet) is designed in a way that will continue to inadvertently cause a constriction of flows, if left closed and unmanaged. Along

with the diversion of the southern catchment away from Burdens Marsh, these factors will continue to have an impact upon the nature and frequency of any future natural mouth openings under Option 1b.

Although this 'Do Nothing' scenario is a significant departure from the previous regime of active management of the outlet for farming, and will have some eco-hydrological benefits, it still leaves the site in a significantly modified state – where the amplitude of natural hydrological variability within Burdens Marsh will be significantly curtailed. This includes decreased tidal exchange, loss of freshwater inflows from the broader catchment and major changes to site topography within the main saltmarsh area that have broad impacts on flows, inundation level, duration, extent and water quality, and hence the distribution and character of saltmarsh communities. These impacts are likely to be further exacerbated under future climate scenarios, including projected sea level rise.

The 'do nothing' scenario results in a range of ecological impacts that will likely slow the potential trajectory of ecological recovery towards a more natural, dynamic and self-sustaining state.

***Review of Option 1(b): Do Nothing, with no management of existing infrastructure***

Assumptions

- That the saltmarsh community at the site could continue to be broadly supported (i.e. maintained at current status quo) via this option, notwithstanding the challenges highlighted.

Pros

- Minimum expenditure required

Cons and risks

- Impacts to site eco-hydrology from existing drainage and impaired tidal connection are likely to continue and potentially exacerbate under future climate scenarios.
- The long-term drying trend is likely to continue - site eco-hydrology is set to change in response to long-term drying and increase in episodic drought and flood phases, despite annual average rainfall slightly increasing overall.
- Threatened wetland and saltmarsh communities will remain under threat on a trajectory of declining condition.
- The existing weir at the outlet acts as a potential barrier to fish migration.
- Even if it was desirable to maintain site ecology exactly as it was when purchased in 2022, the water and salinity regime that was in place prior to purchase will not be maintained under the 'Do Nothing' scenario, because the active management of the outlet and weir infrastructure is not being continued. Hence, even the 'Do Nothing' scenario would drive the saltmarsh into a new eco-hydrological state.

Costs, timeline and feasibility

- Minimal management intervention and low ongoing costs required (weed control and vegetation monitoring).

### 5.3.2. Option 2: Progressive restoration options 2(a)-2(d) within the TLC Reserve

Determining and describing the hydrological function of any wetland requires an assessment of its landscape and catchment context, irrespective of land tenure. Hence the full extent of the Burdens Marsh wetland landform and the upstream catchment areas are included in this options assessment, noting that some of these areas fall outside of land currently owned by the TLC. For long-term restoration planning of modified wetlands, documenting and understanding these issues, and where relevant seeking to cooperate and work with neighbours, is an essential consideration that also applies at Burdens Marsh.

The options for the active restoration of Burdens Marsh are presented below as a progressive series of implementation steps for the TLC's consideration, grouped and prioritised in a logical way. Should the TLC endorse the suggested approach for the restoration of Burdens Marsh but be constrained by the available restoration budget, the four steps (2a-2d) within Option 2 can be implemented gradually over time, in sequential order.

The broader catchment restoration options presented in the subsequent section (5.4) would require negotiation with and consent of neighbouring landholders, and whilst presented here, are considered outside the scope of the current investigation for TLC. However, to realise the eco-hydrological recovery potential of Burdens Marsh, as described in the previous sections, progressively working (including with neighbours) towards full restoration, through implementing the full suite of actions (both within and outside the current TLC Reserve) is recommended as a worthwhile, long-term aspirational goal.

The staged approach outlined in this report recognises that immediate, complete restoration is not necessarily going to be feasible due to financial constraints or the need to negotiate with neighbours, and enables the TLC to initially focus on implementing effective management options on the current Sloping Main Reserve.

**Option 2, Step (a) Remove outlet weir infrastructure and Option 2, Step (b) restore topography of saltmarsh area within TLC Reserve**

The initial priority for on-ground works that has been identified, is to address hydrological modifications impacting saltmarsh areas on the TLC property.

These works would result in a fully restored connection with tidal exchanges after natural mouth openings, and involve repairing the land surface (topographic) profile and broader saltmarsh landform. Given the importance of micro-topography in saltmarsh environments, this will drive a trajectory of recovery in the distribution of habitats by restoring a more natural hydrological regime to this area.

This first component of Option 2 would involve implementation of the following steps:

a) **Ocean outlet rehabilitation:**

Removal of the tidal weir structure and associated levee (which risks constricting natural fresh outflows to the sea, and interrupts tidal exchange after natural mouth openings), to enable recreation of natural outlet geomorphology.

b) **Saltmarsh landform rehabilitation:**

Removal of artificial channels and associated levee embankments or causeways (through backfilling) across Burdens Marsh, to repair landform topography. This step would result in recreation of natural geomorphology and hydrology within the main saltmarsh area, allowing flows to spread laterally and for inundation patterns at lower levels to be governed by micro-topography within the complex.

***Review of Option 2: Step 2(a) Remove outlet weir infrastructure, and Step 2(b) restore topography of saltmarsh area within TLC Reserve***

Assumptions

- Restored areas will achieve a broad hydrological regime approaching underlying pre-drainage conditions, in terms of the interaction between topography and inundation patterns.
- Existing values will be maintained and enhanced.

Pros

- Removes legacy infrastructure, saving on future management and maintenance costs.
- Although ideally done all at once (due to equipment mobilisation costs), can also be undertaken in stages, if required, starting with Option 2(a), and progressing to Option 2(b).

- Improves connectivity with tidal flows (inflows and outflows) by recreating the natural outlet landform.
- Improves hydrological regime of saltmarsh areas.
- Recreates near-natural geomorphology of the marsh bed, resulting in increased capture and storage of water in the marsh system and reduced direct runoff.
- Is respectful to, and builds trust with, the adjacent landholder, by:
  - not immediately seeking to negotiate wider restoration options.
  - continuing to support the broader marsh complex being used for a combination of primary production and conservation.
- Achieves partial marsh restoration, i.e. reinstatement of natural inundation patterns and improved tidal connectivity for the TLC's property after natural mouth openings.
- Provides the site with the ability to be resilient and adapt seamlessly to climate change and sea level rise, without requiring ongoing human intervention or management.
- Does not compromise or impact upon later implementation of subsequent options.

Cons and risks

- Due to only partial restoration being achieved, freshwater inflows from the south remain compromised and will continue to impact on:
  - the regularity and nature of flows through the natural ocean outlet, and hence rates of tidal exchange.
  - the freshwater/saltwater interface in the central and southern areas of the Marsh.
- Only partial drain backfilling may be able to be achieved in areas where spoil banks are absent and compromised.
- Passage for migratory fish may become more opportunistic, in the absence of regular, deliberate mouth openings occurring, although connectivity will still be provided after natural mouth openings due to high flows and any subsequent periods of tidal connectivity.
- Removal of the weir and levee structure in its entirety removes with it the potential for in-situ storytelling of recent hydrological modifications.
- Unknown, but potential seasonal impact of eastern wetland restoration on access track between Turners Lagoon and Burdens Marsh (presumably low risk, however this track was established post-drainage). There is the potential to access Burdens Marsh via a north-south track closer to Turners Lagoon.

Costs, timeline and feasibility

- Likely to be achieved in 1-3 years (subject to available budget and environmental conditions).
- High cost (refer to Appendix 2).
- Permits and approvals (refer to Section 816.4) may be required from state and local government, but likely to be granted on the basis that only previously disturbed ground will be re-disturbed to undertake site restoration works.

**Option 2, Step (c) restore Turners Lagoon and Option 2, Step (d) restore freshwater wetlands to the east of the saltmarsh**

Completion of Options 2(c) and 2(d) (in addition to Options 2(a) and 2(b)), would provide full restoration of site eco-hydrology across all areas of the wetland complex within land managed by the TLC.

The steps outlined in Options 2(a) and 2(b) should be completed prior to, or in conjunction with, the steps outlined below for Options 2(c) and 2(d). This approach would over time recreate near-natural geomorphology and fully repair all drain, levee and causeway footprints across TLC managed land, which would also result in the restoration of a chain of fresh wetlands to the east of Burdens Marsh, including Turners Lagoon.

This further component of Option 2 would involve implementation of the following steps:

c) **Turners Lagoon restoration:**
Infill/block the outlet drain that has dehydrated this previously deep, freshwater marsh.

d) **Restoration of additional freshwater wetlands:**
Continuously backfill the rest of the drain that exits Turners Lagoon along its path, and restore other freshwater wetlands in the vicinity of this drain.

***Review of Option 2, Step (c) and Option 2, Step (d):***

Assumptions

- Restored deep freshwater marsh and shallow freshwater wetlands will have natural function reinstated (consistent with pre-drainage before the 1960s).
- All existing values will be maintained and enhanced.

Pros

- Complete restoration of the natural landform on the entire TLC Reserve would be achieved.
- Provides for the restoration of complementary wetland habitats adjacent to the core saltmarsh area, that add value to the overall ecological function and complexity of the TLC Reserve.

Cons and risks

- Reduces the speed and volume of freshwater flows into the saltmarsh off the artificially drained wetlands to the east, by restoring their natural sill levels. A slower, more natural rate of discharge of groundwater from these restored wetlands however is likely to result from restoration.
- Does not address loss of flows from larger southern catchment area, still diverted to the sea.
- Potential seasonal impact on the track network in the forested area where the drain is situated.
- Need to undertake remediation works with care in and around regenerated woodland/forest.

Costs, timeline and feasibility

- Can be achieved within 1-3 years (subject to on-ground conditions), and (subject to funding) would ideally be undertaken in conjunction with Options 2(a) and 2(b).
- Moderate cost (refer to Appendix 2).
- Permits and approvals (as outlined in Section 6.4) may be required from state and local government, but likely to be granted on the basis that only previously disturbed ground will be re-disturbed to undertake site restoration works.

## 5.4. Potential wider actions to achieve broader catchment restoration

Completion of complementary future works on adjacent private land – with the consent of neighbours – would provide full restoration of site eco-hydrology across all areas of the wider wetland complex that have either a direct or indirect impact on the values within the TLC Reserve.

The steps outlined in Option 2 should be implemented prior to implementing the steps outlined below for Potential Actions 3(a) and 3(b). This approach would, over time, reinstate near-natural geomorphology of the entire continuous wetland complex, and result in the reinstatement of the significant seasonal inflows to Burdens Marsh that have been lost since the southern catchment had the majority of its flows diverted to the sea in the early 1900s, via a drain that was later cleaned out and

enhanced in the 1960s. Return of these flows will increase the regularity of more dynamic flow events through Burdens Marsh. This includes both temporarily filling with fresh water, but also subsequent mouth openings caused by those filling events scouring the sand berm over the mouth, which then also results in more frequent opportunities for subsequent exchanges of tidal flows between the ocean and the main saltmarsh area. These conditions would allow the area to revert to a near-natural hydrological regime, most like the state of the site prior to the 1820s.

Potential Actions 3(a) and 3(b) can be implemented independently of each other, or concurrently, but for either to proceed, the support and consent of the adjacent landholder (and previous owner of Burdens Marsh) would be required. As these future potential actions fall outside of the TLC Reserve boundary and will not be specifically pursued by the TLC, NGT is willing to continue an independent discussion with the neighbour to explore whether progress is possible outside of the TLC's project.

The area that covers Potential Actions 3(a) and 3(b) is situated immediately to the south of the TLC Reserve boundary (Figure 52).

**Figure 52. The artificially drained fresh wetlands situated south of the main saltmarsh area at Burdens Marsh (centre/top), and the drain that diverts the southern catchment to the sea (bottom left), are the subject of Potential Actions 3(a) and 3(b). Photo: Mark Bachmann.**

### 5.4.1. Potential Action 3(a): Restore catchment inflows from the south to Burdens Marsh, via works on adjacent land with consent of neighbours outside of TLC Reserve

This option would seek to reinstate the flow-path that has been intercepted since the early 1900s, which historically discharged water into the southern end of Burdens Marsh, from a catchment to the south-east. To facilitate this outcome, this option would require changes to be made to redirect water before it enters the diversion drain. An assumption with this option is that the rest of the existing diversion drain, and its spoil embankment would be left in place, to offer an ongoing drainage and flood protection service to the properties along its southern edge.

In addition to the tasks for Option 2, Potential Action 3(a) would involve:

- **Southern waterway flows reinstatement**:

  Redirection of seasonal catchment inflows that currently drain directly to sea, to allow this water to flow back into Burdens Marsh along the natural, historic flow path. If this option is

not undertaken concurrently with Potential Action 3(b), this would result in these flows following artificial drains on the property to the south of the TLC Reserve, before discharging into Burdens Marsh, on the TLC Reserve.

***Review of Potential Action 3(a):***

Assumptions

- No detrimental effects will be caused by redirecting these flows away from the short artificial drain that currently carries these flows to the sea.
- This catchment was a significant contributor to the natural hydrological regime of Burdens Marsh.

Pros

- Complete re-instatement of the original catchment to Burdens Marsh would be achieved.
- Provides the site with the best chance to build resilience and adapt to climate change. Sea level rise may increase the salinity of Burdens Marsh through increased tidal exchange, however, this will be offset by restoring freshwater catchment inflows and migration of wetland communities upslope (given the topography of the site) in response to future water level changes.
- Removes barriers to flow, maximises likelihood of future tidal exchange and species migration.
- Reduced risk of flooding to southern shacks, adjacent to the artificial diversion drain, which will no longer have to carry catchment flows in major rainfall events.

Cons and risks

- Careful consideration will need to be given in the design of flow redirection works, given the close proximity to shacks, however maintaining the existing drain downstream of the diversion point will negate this risk.

Costs, timeline and feasibility

- Requires landholder consent for the passage of flows through adjacent private land.
- Low cost, subject to specific (yet to be determined) requirements of any works in proximity to the road.
- Permits and approvals (as outlined in Section 6.4) likely to be required.
- Feasible within 3-5 years, subject to landholder consents, approvals and availability of funding.

### 5.4.2. Potential Action 3(b): Restore the wider marsh complex south of saltmarsh, via works on adjacent land with consent of the neighbour outside of TLC Reserve

This potential action could involve restoration of the fresher, privately owned wetlands of Burdens Marsh, situated between the diversion point outlined in Potential Action 3(a) and the southern TLC property boundary, subject to the support and consent of the adjacent landholder. It could also include a review of the dams on that property and their impact on flows to these wetlands.

Although not as critical as the previous steps (Option 2, Steps (a) – (d), and Potential Action 3(a)) for the recovery of the bulk of biodiversity values and hydrological function within the TLC Reserve, this option recognises the ongoing value and restoration potential of these two wetlands, which form part of the wider Burdens Marsh wetland complex and landform. This potential action is therefore included in this assessment, to offer a future long-term vision for Burdens Marsh that considers the diversity of habitats across the wetland complex in its entirety.

In addition to the tasks for Option 2 and Potential Action 3(a), Potential Action 3(b) would involve the following:

- **Restoring two freshwater wetlands**:

  Backfilling or regulating artificial drains to restore the extent, depth and duration of inundation in the fresh wetlands situated on the property south of the TLC-owned portion of Burdens Marsh.

If preferred by the landholder as a way of testing the outcome of this option, this step could also be initially undertaken as a fully reversible and adjustable trial, by using sandbag geofabric weirs to regulate the wetlands without any immediate requirement to undertake permanent works.

This step would result in recreation of near-natural hydrology to the entire wetland system, allowing inflows (which would be enhanced via Potential Action 3(a)) to be conveyed naturally and provide maximum benefit to wetlands along the restored flowpath.

Subject to landholder interest and consent, this action could also be undertaken independently of Potential Action 3(a), and would still result in significant benefits to these wetlands. This action can also be completed alongside the current land use of sheep grazing, and would not require any change in management or stocking rates.

***Review of Potential Action 3(b):***

Assumptions

- Restored southern, fresher portion of Burdens Marsh will recover and function as natural (pre-drainage).
- All existing values will be maintained and enhanced.

Pros

- Complete restoration of Burdens Marsh and adjacent wetland areas would be achieved.
- Maximises the wetland area available to support a diversity of species and habitats and includes a more complete natural salinity gradient along the length of the marsh.
- Provides the site with the best chance to build resilience and adapt to climate change.

Cons and risks

- Careful consideration of inundation levels associated with restoration works will require final validation, given proximity to smaller, private properties.
- Potential minor reduction in the agricultural value of this farming land in the south of the complex through increased depth, duration and extent of wetland inundation, which is a legitimate consideration for the neighbour. Risk can be better managed through the use of adjustable trial structures, but is also offset by increase in feed growth (‘green pick’) for livestock later in the season due to increased soil moisture in the restored wetland areas.

Costs, timeline and feasibility

- Requires landholder consent to restore wetlands on private land adjacent to the TLC Reserve, but this is an activity that can be discussed and pursued by NGT independently, if not considered within the TLC’s remit for this project.
- Vey low cost of works (for a trial), or moderate cost for permanent works.
- Permits and approvals may be required.
- Timing can be immediate (for a trial) but is dependent on the interest and willingness of the neighbour to consider this option.

# 6. Restoration Plan

A detailed restoration plan is outlined below for the four steps associated with Option 2, which are focused on the TLC Reserve. Progression of broader catchment restoration opportunities will be explored by NGT with adjacent landholders, outside of this report and assessment.

## 6.1. Works Philosophy and Methodology

Where possible, all existing drainage and levee footprints across Burdens Marsh will be targeted to reinstate natural geomorphology and surface elevations.

Voids and drains will be backfilled with material redistributed from existing levee embankments, elevated earthen causeways and spoil heaps. In a small number of locations (e.g. west of Turners Lagoon) woody vegetation has established on the spoil mounds since original excavation. Backfilling work will be undertaken in the most sensitive manner possible, with appropriately qualified contractors operating under NGT supervision, to limit the area of restoration disturbance and avoid the need to bring fill in from off site (as was previously achieved in 2022 and 2023 at the TLC's Long Point Reserve).

Where insufficient fill is available to achieve continuous backfilling, the decommissioning of these drains will involve using the available material to create a series of disconnected backfilled sections or blocks (to be filled/compacted to surface level). This would still achieve the hydrological objective of removing artificial impediments to flow across the natural, original elevation of the saltmarsh surface, eliminate the hydrological impact of the artificial channels, and maximise the reinstated surface area available for saltmarsh vegetation to re-establish upon.

Under this scenario, the areas of channel that are not backfilled will appear as a series of discontinuous pools. An example of this process is shown below in Figure 53, at a location where saltmarsh rehabilitation works were completed by NGT at Long Point Reserve in 2023, and saltmarsh vegetation recovery is now underway.

***Before levee removal*** ***After works - 2023*** ***One year of recovery - 2024***

**Figure 53. Example of similar saltmarsh works at TLC's Long Point Reserve, where the levee bank no longer retained sufficient material for continuous channel backfilling, but the hydrological objective was still met. Photos: Mark Bachmann.**

### 6.1.1. Selection of appropriate plant and equipment

Liaison with a preferred earthworks contractor will involve the selection of the most appropriate plant and equipment for the job, including different sizes of excavator and the option to access additional, specific, fit-for-purpose machinery if required. This is in consideration of factors like: ground wetness, accessibility, width and type of machine tracks, as well as the weight and reach of the machine.

Subject to conditions at the time of the works, a smaller, lightweight, low-impact rubber tracked excavator may be required to access the lower saltmarsh areas.

## 6.2. Hydrological Restoration Plan for TLC Reserve

In Section 5.3.2, Option 2 outlines the potential steps involved in the restoration of wetlands within the TLC Sloping Main Reserve. These steps are explored in detail below to provide specific guidance for future landform rehabilitation / hydrological restoration works, should this plan be adopted by the TLC for implementation.

### 6.2.1. Action 2(a) - Ocean outlet rehabilitation

The general condition of the outlet from Burdens Marsh to the sea at the time of writing, is shown in Figure 54.

**Figure 54. The ocean outlet from Burdens Marsh in autumn 2024, with the focal area for remedial works indicated. Photo: Mark Bachmann.**

Remediation of the landform at this location would involve removal of the tidal weir structure and associated levee (which risks constricting natural fresh outflows to the sea, and interrupts tidal exchange after natural mouth openings), to enable recreation of natural outlet geomorphology.

A more detailed, annotated oblique view of the tidal weir structure and associated levee is shown below in Figure 55.

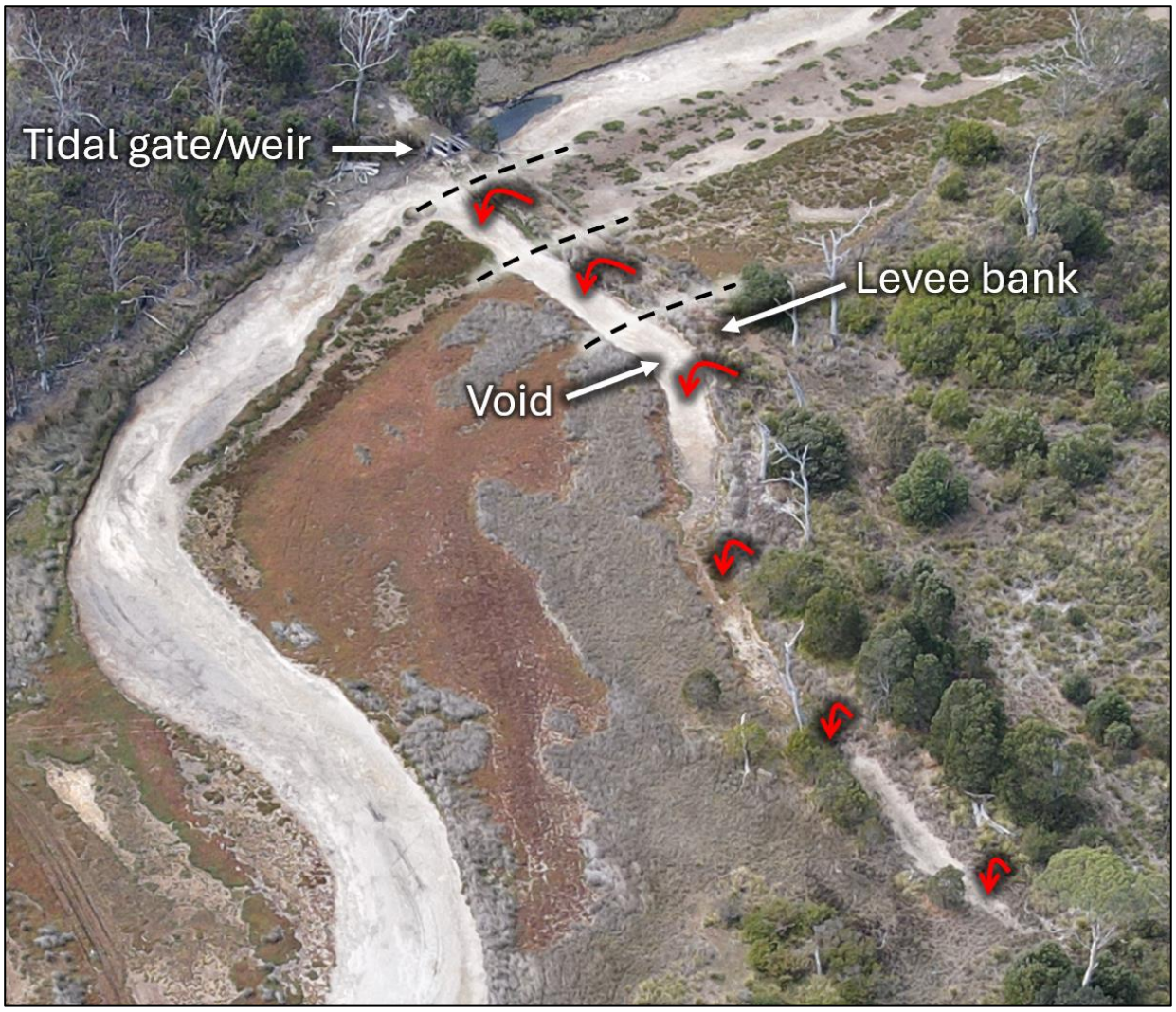



**Figure 55. The remedial earthworks required at the ocean outlet from Burdens Marsh. See text for explanation of notations. Photo: Mark Bachmann.**

The above diagram shows the works required to remediate the natural outlet, namely:

- removal of the tidal gate/weir
- removal of the levee bank, and redistribution (red arrows) of the levee bank material into the void that was created at the time of its construction (c. 1990).
- the dashed black lines show the natural contours that will be tied into, to recreate the original bank profile and allow future accommodation of variable flows in either direction.

Once these works are completed, the only location that will control the water level and flows between Burdens Marsh and the ocean, will be the sand berm that naturally builds up near the beach between flow events. In conjunction with the works proposed here, it is recommended that monitoring of outlet condition and water level in Burdens Marsh continue. This will be especially important when high inflows occur after a prolonged dry period, when sand build up at the mouth could lead to a high, temporary water level in the marsh. Artificial mouth openings are only recommended to occur if there is an imminent risk of inundating infrastructure on the TLC Reserve or adjacent land.

### 6.2.2. Action 2(b) - Saltmarsh landform rehabilitation

A broad overview of the main saltmarsh area, showing the complex network of historic artificial drains and embankments is provided in Figure 56.

**Figure 56. Looking over the main saltmarsh area from the south to north (above) and north to south (below). The artificial works are in straight lines, while the meandering flow lines are natural. Photos: Mark Bachmann.**

A map is provided in Figure 57 to show the location and type of all of the past earthworks that continue to impact site hydrology. The design specification, size and function of these works are highly varied.


**Figure 57. An overview of drain and embankment types across the saltmarsh area, earmarked for remediation.**

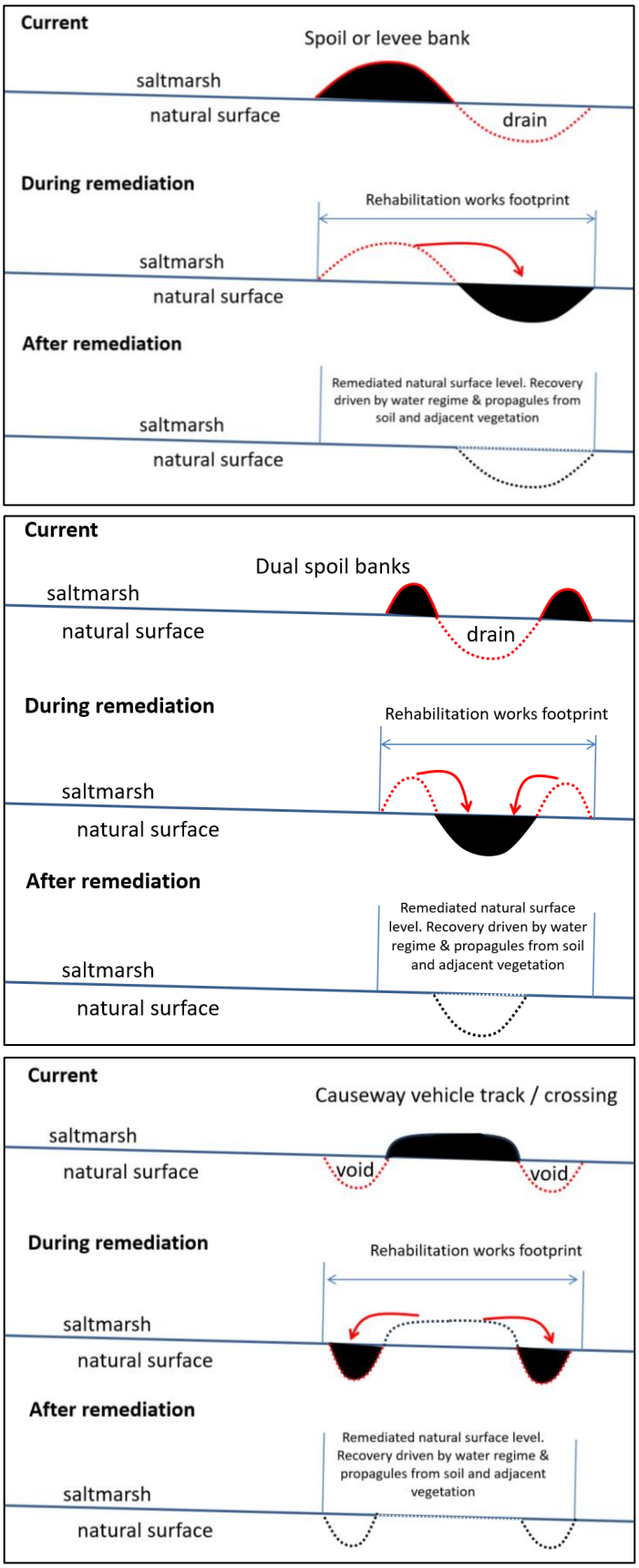
Based on the classification of legacy earthworks in the saltmarsh outlined in Figure 57, there are three basic designs that summarise the majority of the works. Cross-sections that illustrate these methods for how the saltmarsh landform has been modified, and the actions required to remediate the natural surface profile, are shown below in Figure 58.

**Figure 58. Three cross-sections that illustrate common scenarios encountered within the saltmarsh of Burdens Marsh, where artificial drainage and embankment works have occurred. Each example also shows the landform remediation methods to be adopted.**

**(1) Single drain with single spoil or levee embankment**

**(2) Single drain with dual spoil banks**

**(3) Single raised causeway embankment, with dual voids**



Finally, as shown in Figure 59, our site investigation indicates that the preferred method of continuous channel backfilling will be achievable for many of the drains/voids across the main saltmarsh area. For any works where insufficient fill remains, consistent with Section 6.1, the remediation method employed will be determined by quantity of material available next to each drain/void, and the goal will be to achieve functional restoration of hydrology to the saltmarsh landform. The work is proposed to be completed in a manner that minimises machinery movements and time spent on the saltmarsh, by starting in the north and moving in a general southern direction, working on all artificial features and achieving the best possible final backfilling outcome for each, based on the amount of spoil available.

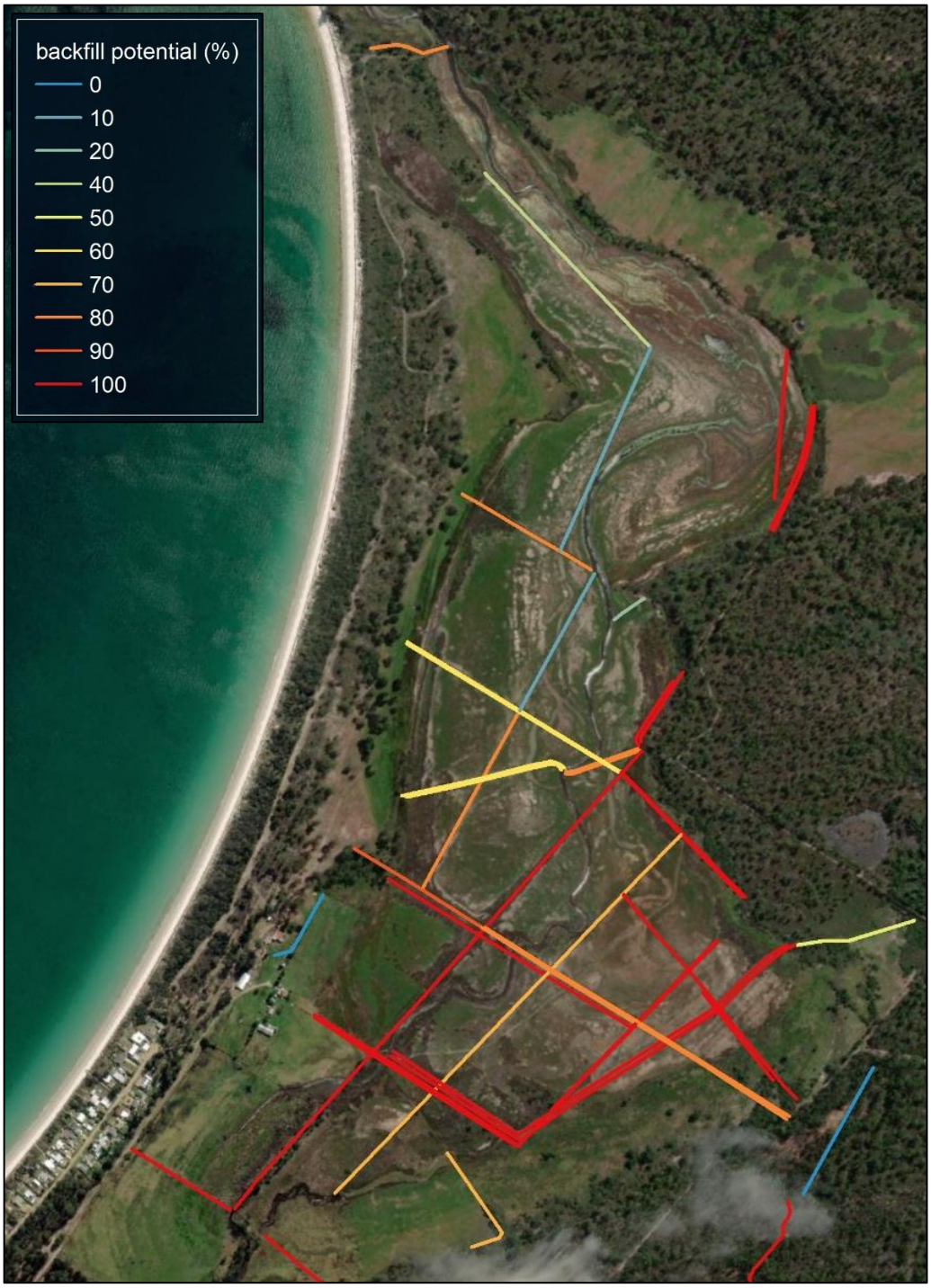



**Figure 59. A closer view of drain/void backfill potential across the saltmarsh area that is earmarked for remediation.**

### 6.2.3. Action 2(c) - Turners Lagoon restoration

The restoration of Turners Lagoon would simply involve backfilling (or blocking) the outlet drain at its south-western corner. As shown in Figure 60, the artificial outlet cutting through elevated forested land to the west of the lagoon has sufficient spoil material available to achieve full remediation and continuous backfilling. Whether continuous backfilling is completed however is subject to further discussion between the TLC and NGT; namely, a trade-off between short-term impacts to regenerated (50-60 year old) vegetation on the spoil banks, versus the ability to achieve complete remedation of the physical landform (drain removal) and trigger long-term native vegetation recovery that will remain in perpetuity. Note that all sections of this drain having a direct hydrological impact will require backfilling.

In contrast, the shallow drain across the bed of the lagoon has virtually no remaining spoil material, likely as a result of it being very shallow, trampling (compression) by livestock, and oxidation of the small amount of peaty spoil material generated when this shallow drain was created. However, this does not create any practical issues, because the backfilling and blocking of the artificial outlet and the depth of lagoon will make the shallow drain across the bed of the lagoon ineffectual.

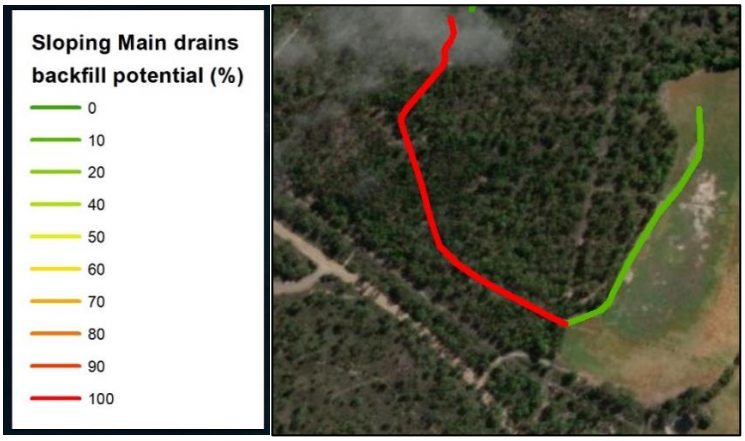



**Figure 60. Drain backfill potential across Turners Lagoon and its artificial outlet.**

For an oblique easterly view of the works area (with the drains colour coded in the same way as above), and an impression of the the future restored extent of Turners Lagoon, see Figure 61.


**Figure 61. Future potential restored extent of Mungaratya / Turners Lagoon, and location of outlet drain (red) requiring remediation. Photo: Mark Bachmann**

### 6.2.4. Action 2(d) - Restoration of additional freshwater wetlands

Downstream of Turners Lagoon, a chain of additional shallow freshwater wetlands that have also been impacted by artificial drainage works, would have their natural hydrological regime restored through drain backfilling.

As shown in Figure 62, one of these wetlands is breached by the continuation of the main artificial drain exiting Turners Lagoon. The other two wetlands are impacted by drains that connect with the lateral drains that terminate in the saltmarsh area to the west.

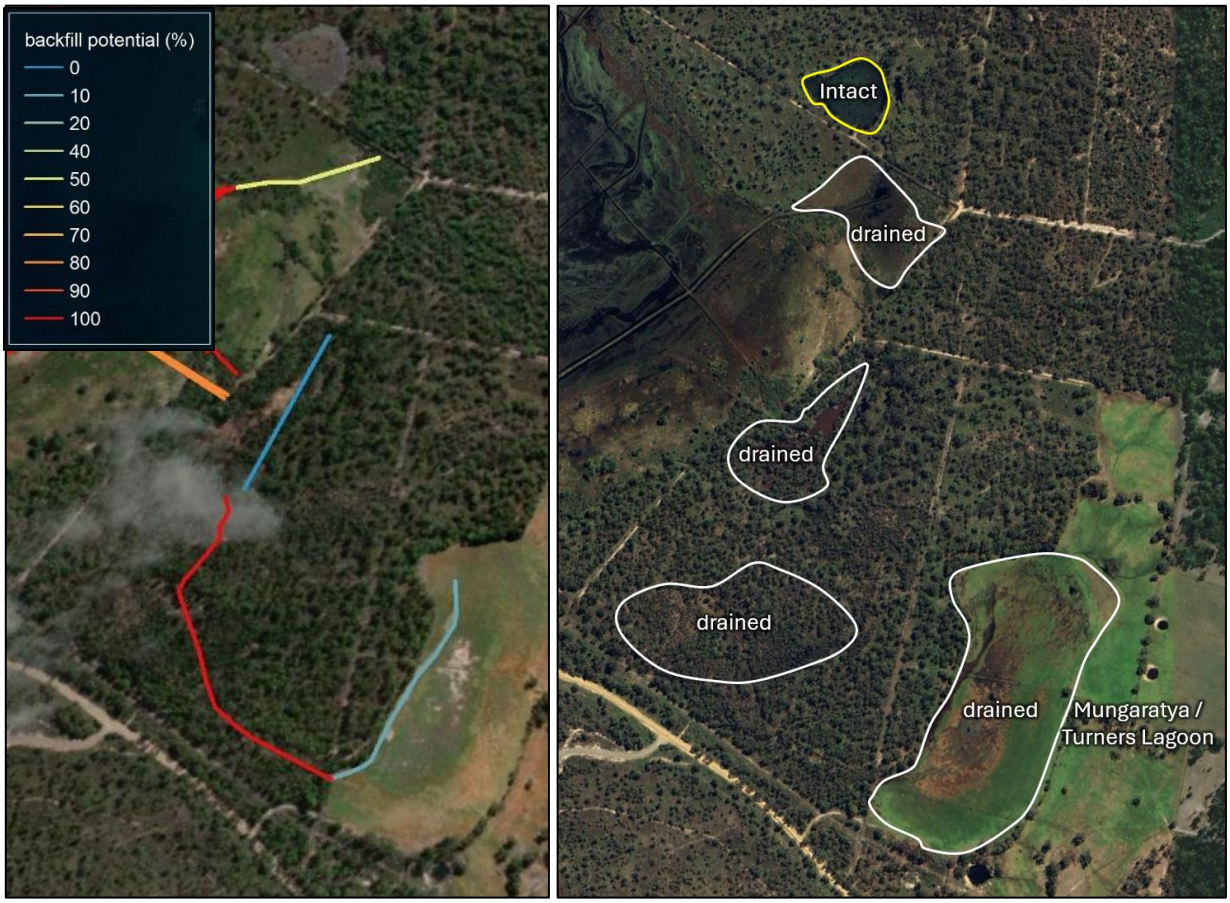



**Figure 62. Drain backfill potential and approximate original extent of the chain of freshwater wetlands in the vicinity of Turners Lagoon, east of the main saltmarsh area at Burdens Marsh. All marked wetlands are within the TLC's Sloping Main Reserve.**

Because of the forested vegetation character of this area, the spoil banks adjacent to some of the drains in this portion of the reserve that require backfilling have experienced woody vegetation regrowth on the excavated soil over a period of up to 60 years (since their construction). Landform remediation works in this area will therefore necessitate the removal of native vegetation in some areas where it has established on previously disturbed, excavated ground within the original drainage works footprint.

As previously discussed, whether continuous backfilling of this drain is completed is subject to further discussion between the TLC and NGT, noting that – at a minimum – all sections of this drain having a direct hydrological impact will require backfilling.

## 6.3. Works Prioritisation and Timing

All works will be completed in an order and manner that minimises traffic movements across the site, and with equipment (i.e. rubber tracked excavators where applicable) that minimises physical impact. The specific order of works at each location will be dictated by site conditions, access and other requirements, after site induction and consultation with the contractor.

Subject to funding availability, the works are recommended to occur in the priority order outlined below.

(1) Tidal weir and levee
(2) Main saltmarsh area
(3) Turners Lagoon outlet
(4) Other drains impacting the chain of fresh wetlands east of the main saltmarsh area

All works would be guided, directed and completed under full, continuous supervision by NGT, and be completed by operators experienced in undertaking sensitive environmental works, with access to a variety of machinery provided by the contractor. Contractor input and knowledge of the capabilities of their machines will be incorporated into adaptive decision making while the works are underway, whilst remaining consistent at all times with the remediation philosophy and guidance outlined in this plan.

### 6.3.1. Contingency plans

Subject to weather and site conditions, as well as additional factors outlined in this plan (e.g. permits and approvals), a provision may be made in future project agreements to allow for works to be carried over multiple seasons, if necessary to achieve the most environmentally sensitive on-ground outcome.

Should all the works not be able to be completed in their entirety during the current project, NGT will ensure that the maximum amount of remedial work possible is completed for the budget made available by TLC. Under such a scenario, this restoration plan will remain a live document and further funding will be sought in future to complete any outstanding tasks or works.

## 6.4. Permits and Approvals

Restoration works are specifically targeted at improving the health, extent of and habitat availability for nationally threatened communities and species associated with Burdens Marsh. As such, there is no current requirement or intention to seek referral to the Australian Government under the *Environment Protection and Biodiversity Conservation Act 1999*, however a self-assessment may be completed to demonstrate how the works are consistent with the requirements and intent of the Act.

There may however be a requirement to obtain permits or approvals under Tasmanian legislation prior to works. The main and/or most likely requirements to facilitate the delivery of proposed restoration works are outlined below.

### 6.4.1. Aboriginal and historic heritage

Whilst no known Aboriginal heritage has been recorded for Burdens Marsh, it is highly likely that the site and adjacent wetlands contain significant Aboriginal heritage. Aboriginal heritage has been recorded in areas immediately surrounding the property (including shell middens and artefact scatters). Given the location of the property and the surrounding landscape it is believed there is an increased likelihood of undetected Aboriginal heritage being present. A desktop assessment undertaken by Aboriginal Heritage Tasmania has requested that a site assessment by an authorised Aboriginal Heritage Officer be

undertaken to identify sites of significance and inform restoration planning. There is an unconfirmed kitchen midden site on the eastern boundary of the marsh.

Any contractors working on site must be briefed on this issue and all works must be supervised to comply with heritage requirements. If any Aboriginal sites (i.e. shell material, artefacts) are unearthed once works begin, then works are to cease, and Aboriginal Heritage Tasmania will be immediately contacted, and an Unanticipated Discovery Plan will be completed.

Likewise, there are no historic heritage sites listed in state heritage registers or local planning schemes, however preliminary site investigations undertaken in 2018 by Port Arthur Historic Site Management Authority archaeologists, upon request by the former landowner, have identified several locations of historic heritage interest. These include convict buildings, tracks, post and rail fencing, brick kiln and kitchen midden. These sites exist in areas peripheral to the marsh and are typically outside of planned works areas.

### 6.4.2. Water Management Act 1999

NGT has consulted with the water regulator, NRE Tasmania's Water Management and Assessment Branch and there are no issues of concern with the proposed works associated with Options 2(a) and 2(b) under the *Water Management Act 1999*, as these areas all pertain to tidally-influenced areas not subject to regulation under the Act.

However, at the time of drafting this report, we are awaiting further advice on any requirements to implement Options 2(c) and 2(d) – restoration of Turners Lagoon and associated freshwater wetlands. As this pertains to a freshwater inflow source, these works may be subject to approvals under the Act.

### 6.4.3. Tasman Council planning scheme

Burdens Marsh is subject to a number of special overlays under the Tasmanian Planning Scheme – Tasman, including:

- Future coastal refugia area
- Waterway and coastal protection area
- Priority vegetation area
- Bushfire prone area
- High to medium coastal inundation hazard band

The activities we seek to undertake are well aligned with conservation of the site and aim to reinstate the natural landform and hydrological regime of the saltmarsh and associated wetlands. This will provide the site with resilience to climate change and allow for unimpeded sea level rise and improved areas of coastal refugia. We do not expect any of the restoration works to have any short or long-term impact on adjoining properties. Increased water in the landscape would help mitigate bushfire risk. Impact on native vegetation will be minimal and short-lived as works will be undertaken within existing footprints (the majority of spoil heaps are still in place to enable near complete drain backfilling). There is no intention to bring new soil onto site or move soil around the site to fulfill restoration actions.

Further, the remedial works will allow for recolonisation and seamless expansion of the threatened saltmarsh community across its former extent. The capacity of saltmarsh vegetation to re-establish in degraded areas is directly correlated to the frequency of inundation (Laegdsgaard, 2002). Sites close to the low water mark (which typifies most of the proposed on-ground work areas) and subject to regular

inundation may regenerate relatively quickly, while those closer to the high water mark and subject to irregular inundation may take several years to regenerate.

Exemptions for restoration works under the Tasmanian Planning Scheme exist and are being explored to facilitate the proposed restoration works at Burdens Marsh. Implementation of the restoration plan may meet the provisions for exemption under Clause 4 of the Tasman planning scheme. The works are likely exempt from a planning permit as determined via self-assessment in that the works meet the provisions under clause 4.4.3 vegetation rehabilitation works: *d) the implementation of a vegetation management agreement or a natural resource, catchment, coastal, reserve or property management plan or the like, provided the agreement or plan has been endorsed or approved by the relevant State authority or a council.*

TLC may wish to have the plan sighted and acknowledged by NRE Tas to comply with local government planning requirements, or alternatively, pursue a planning permit application for assessment by Council.

If in future, approval is required from NRE Tas under the *Water Management Act 1999* for the restoration of Turners Lagoon (Option 2(c)), then this would negate the need for approval via Council under the planning code for that particular activity.

### 6.4.4. Other

**Natural Resources and Environment Tasmania**

Given anticipated Council planning code exemptions and in the absence of a covenant, it is not expected that any approval or permit is formally required from Conservation Assessment or Threatened Species services, however, it is recommended that the TLC inform representatives of these sections within NRE Tas of restoration plans out of courtesy and to provide an opportunity to discuss any concerns prior to implementation.

It may also be prudent to have Conservation Assessment services sight and acknowledge the restoration plan so that it complies completely with the exemption provided for under the Tasman Council planning scheme (see 6.4.3 above).

**Parks and Wildlife Service**

Parks and Wildlife are responsible for managing the beach and tidal inlet area within the Sloping Main Conservation Area, and Lime Bay State Reserve, both adjacent the TLC Reserve. It is likely that access across Parks managed land will be required for implementation of Option 2, Step 2(a) (tidal weir and levee restoration works). If this access option is required, a Reserve Activity Assessment (RAA) will need to be completed for the Parks and Wildlife Service. Further liaison with regional Parks staff will occur to discuss restoration plans, once finalised, to enable works in this shared area of the reserve to occur.

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# Appendix 1. Vegetation Transect and Plot Data

Braun-Blanquet cover scale: 1 = <1%, 2 = 1-5%, 3 = 5-25%, 4 = 25-50%, 5 = 50-75%, 6 = >75%. Note >100% cover per plot was possible due to vegetation layering.
Vegetation communities (TasVeg 4.0 codes): DVC= *Eucalyptus viminalis - Eucalyptus globulus* coastal forest and woodland, ARS= Saline sedgeland/rushland, ASS= Succulent saline herbland, DAC= *Eucalyptus amygdalina* coastal forest and woodland, AHL= Lacustrine herbland, FRG= Regenerating cleared land

| **Transect n.** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Plot n.** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 | 5 | 6 | | 6 |
| **Johns plot n.** | | | | | | | | | | | | | | | | | | | | | | | | BMPF2 | | BMPF3 | BMPF4 | | BMPF5 | BMPF6 |
| **Veg community** | DVC | ARS | ARS | ASS | ASS | ARS | ASS | ASS | ASS | ASS | ASS | ARS | DAC | AHL | FRG | FRG | ARS | ASS | ASS | ASS | ASS | ARS | ARS | ARS | DVC | ASS | ASS | ARS | ASS | ARS |
| Bareground | 3 | 2 | 2 | 3 | 3 | 4 | 3 | 4 | 1 | 5 | 3 | | 1 | 3 | 3 | 3 | 4 | 6 | 3 | | | 4 | 3 | 3 | 4 | 6 | 3 | | | 4 |
| Litter | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Acetocea vulgaris* | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | |
| *Anthoxanthum odoratum* | 3 | | | | | | | | | | | | | | 4 | 3 | | | | | | 1 | | | | | | | | |
| *Aotus ericoides* | | | | | | | | | | | | | | | 3 | | | | | | | | | | | | | | | |
| *Atriplex prostrata* | | 2 | 3 | | | 3 | | 3 | | | | | | | | | 2 | | | | | | 3 | 2 | | | | | | 1 |
| *Baumea juncea* | | | | | | | | | | | | 2 | | | | | | | | | | | | | | | | | | |
| *Brachyscome graminea* | | | | | | | | | | | | 1 | | | | | | | | | | 1 | | | | | | 1 | | |
| *Centella cordifolia* | | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Circium valgare* | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | 1 | | |
| *Cotula coronopifolia* | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | |
| *Distichlis distichophylla* | | 1 | | | | | | | | | | | 2 | | | | | | | | | | | | | | | | | |
| *Eryngium vesiculosum* | | 1 | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | |
| *Eucalyptus viminalis* | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | |
| *Ficinia nodosa* | | | | | | | | | | | | 3 | | | | | | | | | | | | | | | | | | |
| *Hibbertia prostrata* | | | | | | | | | | | | | | | 3 | | | | | | | | | | | | | | | |
| *Holcus lonatus* | 3 | 3 | | | | | | | | | | 1 | | | | 2 | | | | | | 1 | | | | | | | | |
| *Hypochaeris radicata* | 1 | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | |
| *Isolepis cernua* | 2 | 2 | | | 2 | | 2 | 2 | 3 | | | | 3 | 3 | | 4 | 1 | | 1 | | | | 1 | 2 | | | | | 1 | |
| *Juncus kraussii* | | 5 | 6 | | | 3 | | | | | | 4 | 2 | 1 | | | 5 | | | | | 6 | 3 | | | | | 5 | | 6 |
| *Juncus sp.* | | | | | | | | | | | | | | | | | | | | | | | | 6 | | | | | | |
| *Lachnagrostis adamsonii* | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | |
| *Lachnagrostis sp.* | | | | | | 1 | | | | | | | | 1 | 3 | | | 1 | | | | 1 | | | | | | 1 | | |
| *Leontodon saxatilis* | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | |
| *Leptinella reptans* | 4 | | | | | | | | | | | 5 | 2 | | | 1 | | | | | | 4 | | | | | | 5 | | |
| *Lobelia anceps* | 1 | 1 | | | | | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | |
| *Lomandra longifolia* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Pimelea linifolia* | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | |
| *Plantago coronopus* | | | | | | 1 | | | | | | | 1 | 1 | | | | | | | | | | | | | | 2 | | |
| *Poa sieberiana* | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Pteridium esculentum* | | | | | | | | | | | | | | | 4 | | | | | | | | | | | | | | | |
| *Samolus repens* | | | 2 | | | | | | | | | 1 | 1 | | | | 2 | | | | | | | | | | | 2 | | |
| *Sarcocornia blackiana* | | | | | | | | | | | 3 | | | | | | | | | | | | | | | | | | | |
| *Sarcocornia quinqueflora* | | 2 | 2 | 4 | 6 | 3 | 5 | 5 | 6 | 4 | 4 | | | | | | 3 | 4 | 6 | 5 | 6 | | 4 | 5 | 0 | 2 | 6 | | 6 | 3 |
| *Schoenus nitens* | 2 | 2 | | | | 3 | | | | | | | | | | 3 | | 1 | | | | 1 | | | | | | | | |
| *Selliera radicans* | | 3 | 2 | | | | | | | | | 2 | 5 | 4 | | 3 | 3 | | | | | 2 | | | | | | 2 | | |
| *Senecio sp.* | 1 | 3 | 1 | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Sonchus sp.* | | 1 | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | |
| *Spergularia tasmanica* | | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | |
| *Stenotaphrum secundatum* | | | | | | | | | | | | | | | 3 | 3 | | | | | | | | | | | | | | |
| *Trifolium sp.* | | | | | | | | | | | | | | | | 3 | | | | | | | | | | | | | | |
| *Triglochin striata* | | | | 2 | 1 | 1 | 2 | 2 | 2 | | | | 2 | 1 | | 1 | | 1 | 1 | 1 | 1 | | 1 | | | | 1 | | 2 | |
| *Vellereophyton dealbatum* | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | |
| *Vulpia sp.* | | | | | | | | | | | | | | | 2 | | | | | | | | | | | | | | | |
| *Wilsonia backhousei* | | | | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Algae mats | | | | | | | | | | | | | | | | | | | | | | | | | | 6 | | | | |
| Unknown sp. 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | 3 | | |
| Unknown sp. 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Unknown sp. 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | |

## Appendix 2.

Table summarising details for each of the assessed restoration options.

Management and feasibility ratings and descriptions:

| | |
|---|---|
| **Management inputs** | H - >5km of drain and/or 2+weeks backfilling and supervision<br>M - 1-5km of drain and/or 1-2 weeks backfilling and supervision<br>L - <1km of drain and/or < 1 week backfilling and supervision |
| **Feasibility** | H - simple to achieve, few special considerations<br>M - moderate level of complexity, some special considerations<br>L - high level of complexity and many special considerations |

| | | | | | | | | | Expected ecological outcomes for key values | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Option** | **Step** | **Description** | **Objective** | **Management inputs** | **Feasibility** | **Adverse outcomes/ Special considerations** | **Cost** | **Permits/legal** | **Saltmarsh** | **Rushland** | **Waders/waterfowl** | **Wetland communities** | **Infrastructure** |
| 1 | a | **Do nothing, with active management of existing infrastructure** | Maintain the status quo. Artificially regulate water levels in the marsh and tidal ingress. | M - active management of outlet via artificial openings and closure of timber weir | M - would require onsite, manual manipulation of weir and mechanical excavation of outlet at required times (most years). Weir would likely require upgrading due to its deteriorating condition. | Potential ongoing trajectory of terrestrialisation of the marsh now that stock have been removed. Ongoing declining trajectory of saltmarsh and ecosystem health. Potential fish barrier remains in place. Reduced connectivity with both freshwater inflows and tidal exchange. Constriction on inflows and outflows. | <$20k p.a. ongoing, plus eventual weir replacement | Yes, would require Parks approval for mouth openings on their land | Ongoing, long-term declining trend in condition of saltmarsh. Continued reduction in inundation extent and duration. Regular outflows to sea but restricted inflows. | Ongoing, long-term declining trend in condition of peripheral rushland areas. | No change to wader or waterfowl communities or habitat provision | Ongoing long-term declining trend of wetland diversity and condition | No change to surrounding infrastructure or adjacent properties |
| | b | **Do nothing, with no management of existing infrastructure** | Maintain status quo. Allow freshwater outflows and tidal inflows to occur when made possible via local and climatic conditions | L - ongoing weed control and site monitoring | H | Ongoing declining trajectory of saltmarsh and ecosystem health. Potential fish barrier remains in place. Reduced connectivity with both freshwater inflows and tidal exchange. Constriction on inflows and outflows. | N/a | N/a | Some improvement in inundation depth, extent and duration. Reduced connection to tidal exchanges. Constricted inflows and outflows. Ongoing reduction in the natural variability of hydrology. | Continued reduction in inundation extent and duration. | Some improvement in habitat diversity and availability for wader and waterfowl communities | Ongoing long-term declining trend of wetland diversity and condition | No change to surrounding infrastructure or adjacent properties |
| 2 | a | **Ocean outlet rehabilitation** | Restore natural connection to outlet to facilitate tidal inflows and outflows | L -remove levy and weir structure. Recreate natural outlet landform. | H - would need to access during dry conditions/closed outlet periods | Due to primary catchment inflows still being compromised from the southern end, tidal connection may still be limited despite restoration of natural outlet and landform. Will require consultation with Parks for access. | <$20k | Yes | Improved connection of saltmarsh with tidal inflows and outflows. Improved condition of saltmarsh through increased dynamics in hydrology. | Improved connection with tidal inflows and outflows. Improved condition through increased dynamics in hydrology. | Improved connection of saltmarsh with tidal inflows. Improved habitat in northern end of Marsh. | Ongoing long-term declining trend of wetland diversity and condition | Removal of weir and potential fish barrier. |
| | b | **Saltmarsh landform rehabilitation** | Restore landform and natural hydrology on TLC Reserve. Hold water in the Marsh by improving lateral flows. Prepare saltmarsh to receive local rainfall and natural tidal events. | H - remove ~15km of drains/levees | M - need to consider partial backfill of some areas based on in-situ spoil availability | Due to primary catchment inflows still being compromised from the southern end, full hydrological restoration cannot be achieved, however local catchment inflow will be better retained within the Marsh. | <$100k | Yes | Improved connection of saltmarsh with tidal inflows and localised freshwater inflows. Improved condition of saltmarsh via increased inundation extent and duration. Recreation of natural geomorphology and hydrology. | Improved connection of rushland with tidal inflows and localised freshwater inflows. Improved condition via increased inundation extent and duration. | Improved connection of saltmarsh with tidal and localised freshwater inflows. Improved habitat in northern end of Marsh. | Ongoing long-term declining trend of wetland diversity and condition | No change to surrounding infrastructure or adjacent properties. Some loss/modification to fencing/access roads/causeways on TLC property. |
| | c | **Turners Lagoon restoration** | Restore Turners Lagoon deep freshwater marsh. Improve wetland condition and diversity. Hold water in the landscape. Restore peripheral wetland habitats | M - continuous backfill of main drain connecting Turners Lagoon to freshwater wetlands and Burdens Marsh. May require revegetation of terrestrial areas to fast-track restoration and manage weeds. | M-H - some vegetation that has established on spoil banks will require temporary disturbance | Will require some removal of vegetation which has colonised spoil banks. Need to consider the original, natural flow path from Turners Lagoon to Burdens Marsh. Minor reduction in freshwater inputs to Burdens Marsh from restored wetland areas. | $20-50k | Yes | Minor reduction in freshwater inputs to Burdens Marsh from restored wetland areas. | Minor reduction in freshwater inputs to Burdens Marsh from restored wetland areas. | Restored diversity and extent of freshwater wetland habitat | Restoration of large, deep freshwater marsh and associated smaller freshwater wetlands. Increased wetland diversity and condition | No change to surrounding infrastructure. |
| | d | **Restoration of eastern freshwater wetlands** | Restore natural catchment of small, freshwater wetlands, east of Burdens Marsh. Improve wetland condition and diversity. Hold water in the landscape. Restore peripheral wetland habitats | M - continuous backfill of drains in and out of wetlands. May require revegetation of terrestrial areas to fast-track restoration and manage weeds. | M-H - some vegetation that has established on spoil banks will require temporary disturbance | Will require some removal of vegetation which has colonised spoil banks. Need to consider the original, natural flow paths from wetlands to Burdens Marsh. Minor reduction in freshwater inputs to Burdens Marsh from restored wetland areas. | | | | | | Restoration of smaller freshwater wetland habitats. Increased wetland diversity and condition | No change to surrounding infrastructure or adjacent properties. |
| 3 | a | **Restore catchment inflows from the south to Burdens Marsh, via works on adjacent land with consent of TLC's neighbours** | Restore key catchment inflows to the Marsh complex and allow water to flow along natural, historic flow paths. | M - use the most appropriate location to divert flows away from artificial bypass drain. Assumes existing spoil embankment behind private properties will remain in place for flood protection. | M - need to carefully assess infrastructure impacts. May require new culverts under road to reinstate natural flow path. | Need to secure agreement with adjacent private property owner to enable this step. Considerations dependent on road and drainage modifications required for preferred option. Need modelling to test impact to surrounding shack and road infrastructure. | <$20k, for works only | Yes | Improved connection of saltmarsh with primary freshwater inflows. Improved hydrodynamics of the site. | Improved connection of rushland with freshwater inflows. Improved hydrodynamics of the site. | Restored areas of freshwater habitat. Increased water inundation extent and duration in the landscape. | Restoration of primary freshwater inflows to Marsh complex. Increased aquatic vegetation extent and condition throughout southern Marsh. | Increased inundation of private land on adjacent property and potential loss of productivity for gazing. Potential loss of fencing/access infrastructure. Reduced flooding risk to road and adjacent properties. |
| | b | **Restore the wider marsh complex south of saltmarsh, via works on adjacent land with consent of TLC's neighbour** | Restore landform and natural hydrology. Hold water in the Marsh by improving natural flows. Restore large freshwater wetland habitats. Restore catchment inflows. Increase diversity of wetland communities across the Marsh complex. | M-H - recreation of natural flow paths through the Marsh and infilling of artificial, connecting drainage channel and wetland drains. | M - need to consider partial backfill of some areas based on in-situ spoil availability | Need to secure agreement with adjacent private property owner to enable this step. | $20-50k, for works only | Yes | Improved connection of saltmarsh with localised and secondary freshwater inflows. | Improved connection of rushland with freshwater inflows. | Restored areas of freshwater wetland habitat. Increased water inundation extent and duration in the landscape. | Restoration of two large freshwater wetlands. Increased wetland diversity and condition. Improved extent and condition of aquatic vegetation in restored drainage channels and natural flow paths. | Increased inundation of private land on adjacent property and potential loss of productivity for gazing. Potential loss of fencing/access infrastructure. |