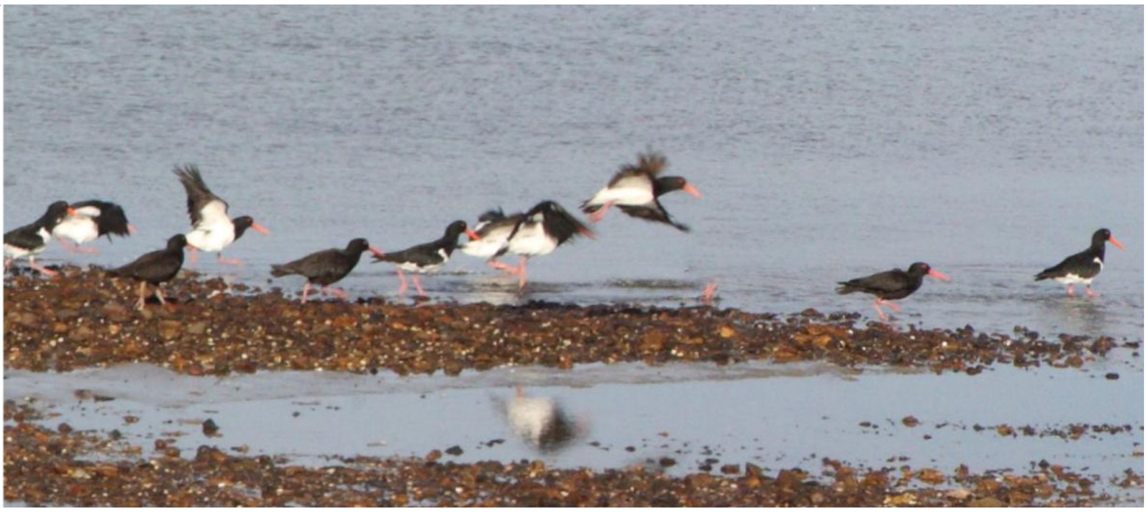
Lauderdale environmental assets:
assessment of climate change impact on coastal and marine areas



Jason Whitehead May 2012

Derwent Estuary Program

The Derwent Estuary Program (DEP) is a regional partnership between local governments, the Tasmanian State Government, commercial and industrial enterprises, and community-based groups to restore and promote our estuary. The DEP was established in 1999 and has been nationally recognised for excellence in coordinating initiatives to reduce water pollution, conserve habitats and species, monitor river health and promote greater use and enjoyment of the foreshore. Our major sponsors include: Brighton, Clarence, Derwent Valley, Glenorchy, Hobart and Kingborough councils, the Tasmanian State Government, Southern Water, Tasmanian Ports Corporation, Norske Skog Boyer, Nyrstar Hobart Smelter and Hydro Tasmania.

Report prepared by the *Derwent Estuary Program* (DEP), for the *Local Government Association of Tasmania* (LGAT) as part of the *Tasmanian Coastal Adaptation Pathways* (TCAP) *project* in the Lauderdale area.

Cover image: Pied Oystercatchers – taken by Luke Einoder

Summary
Climate change in the Lauderdale area is projected to cause impacts to marine and coastal environmental assets. The Tasmanian Coastal Adaptation Decision Pathways (TCAP) project identified, through discussion with the Lauderdale community that an acceptable response to climate change in the area should:

> ***'Protect existing development as long as practical while protecting property values in preference to natural processes'*** (TCAP pathway Scenario 3)

The scenario did acknowledge the important environmental value of the Lauderdale saltmarshes, as action options discussed and supported by the community included:

- Allow wetland to retreat inland onto public lands or rural zoned private lands with provision for tidal flushing where practical.
- South Arm Road to become a protective seawall, but also in some places engineered to allow tidal flushing to saltmarsh.

The TCAP pathway scenario 3 supports future management of the Lauderdale township, and surrounds, in a manner that enables both infrastructure and environmental asset protection, adaptation or mitigation. The Local Government Authority of Tasmania (LGAT) engaged the Derwent Estuary Program (DEP) to contribute to the Tasmanian Coastal Adaptation Pathways (TCAP) project in the Lauderdale area through the following report which:

- Identified six major environmental asset types, which loosely conform to specific geographic coastal and marine areas.
  - *Lauderdale & Roches sand dunes, threatened flora & fauna*
  - *Bambra Reef and Mays Point rocky shore: threatened seastars*
  - *Southern Lauderdale sub-tidal seagrass beds*
  - *Lauderdale and Roches Beaches and sub-tidal sand*
  - *Ralphs Bay tidal flats and foreshore*
  - *Lauderdale saltmarshes*
- Described the ecosystem services the environmental assets provide.
- Discussed how the environmental assets will respond to climate change, most notably to sea-level rise, in the context of TCAP pathway scenario 3. Land areas of high importance for environmental asset transgression as sea-level rises, have been identified south of Lauderdale.
- Prioritised the environmental assets and action options required for their perpetuity.
- Identified legal obligations relating to the management of the environmental assets.

It is acknowledged that specific environmental assets, such as threatened shorebirds are dependant upon the presence and condition of larger environmental assets, such as tidal flats and saltmarsh.

The changes within environmental assets projected in this document should not be used to justify development of these sites in a manner that would otherwise expedite their loss and prevent their transformation into new asset types. Instead, management effort should be made to improve their condition and function, as they have important ecosystem services to continue providing.

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2) Background

The Tasmanian Coastal Adaptation Decision Pathways (TCAP) project has been developing, through discussion with the Lauderdale community, an acceptable response to climate change in the Lauderdale area. Four future management scenarios were presented and discussed with the community that ranged in response from: *Scenario 1-Let nature take its course*; to *Scenario 4-Protecting existing and permitting future development to the maximum possible extent for as long as possible.* The Lauderdale community support the mid-range scenario 3:

> *TCAP Pathway Scenario 3*
> ***Protect existing development as long as practical while protecting property values in preference to natural processes***

Community discussion of scenario 3 included 'action options', some of which have implications for environmental assets in the Lauderdale area, such as:

- Controlled landfilling of certain areas to reduce inundation risk
- Beach sand nourishment
- Possible engineered groyne on the beach (or artificial reef offshore) to reduce coastal erosion
- Sand dune protection works
- Allow wetland to retreat inland onto public lands or rural zoned private lands with provision for tidal flushing where practical.
- Control impacts of leachate from the former tip as surrounding area inundated
- South Arm Road to become a protective seawall, but also in some places engineered to allow tidal flushing to saltmarsh

The Local Government Authority of Tasmania (LGAT) has engaged the Derwent Estuary Program (DEP) to contribute to the Tasmanian Coastal Adaptation Pathways (TCAP) project in the Lauderdale area through the following report which aims to:

- Identify coastal and marine environmental assets in the Lauderdale area, and the ecosystem services they provide.
- Describe how climate change or the actions options proposed within TCAP Pathway Scenario 3 alter these assets.
- Prioritise the environmental assets and develop action options required for their perpetuity.
- Identify legal obligations relating to the management of the environmental assets.

3) Current environmental assets & ecosystem services

This document identifies marine and coastal environmental assets that occur in the Lauderdale area. Some terrestrial based assets closely linked to the coast, have also been included (e.g. vegetation on coastal dunes). The current assets have been grouped into six major types, which loosely conform to specific geographic areas Figure 1 and Table 1. It is acknowledged that specific environmental assets, such as threatened shorebirds are dependant upon the presence and condition of larger environmental assets, such as tidal flats and saltmarsh. Each environmental asset has been assessed in the context of climate change and other threatening processes identified and discussed. A projection of chnages in the distribution and extent of the six major asset types with ~80cm sea-level rise by 2100 (Grose *et al.* 2010), has been provided (Figure 2). Projected changes in some assets beyond 2100 have also been discussed. One of the major threatening processes associated with sea-level rise are the proposed mitigation measures to protect infrastructure (TCAP Pathway Scenario 3) that will limit the ability of some environmental assets to transgress inland as sea-level rises.

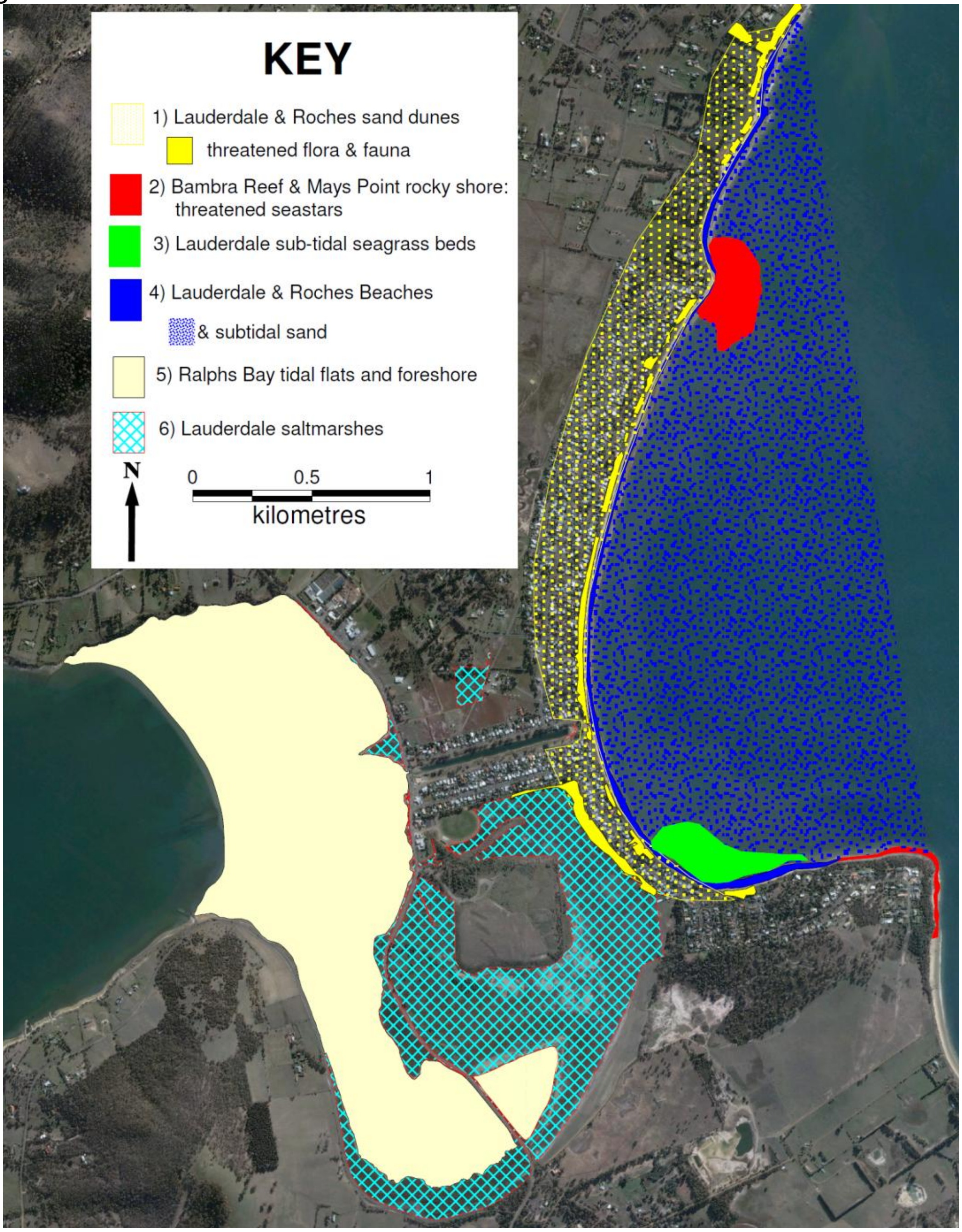


Figure 1. Six major environmental asset types in the Lauderdale area. Note: that other specific environmental assets (such as threatened species) occur 'nested' within the major asset types.

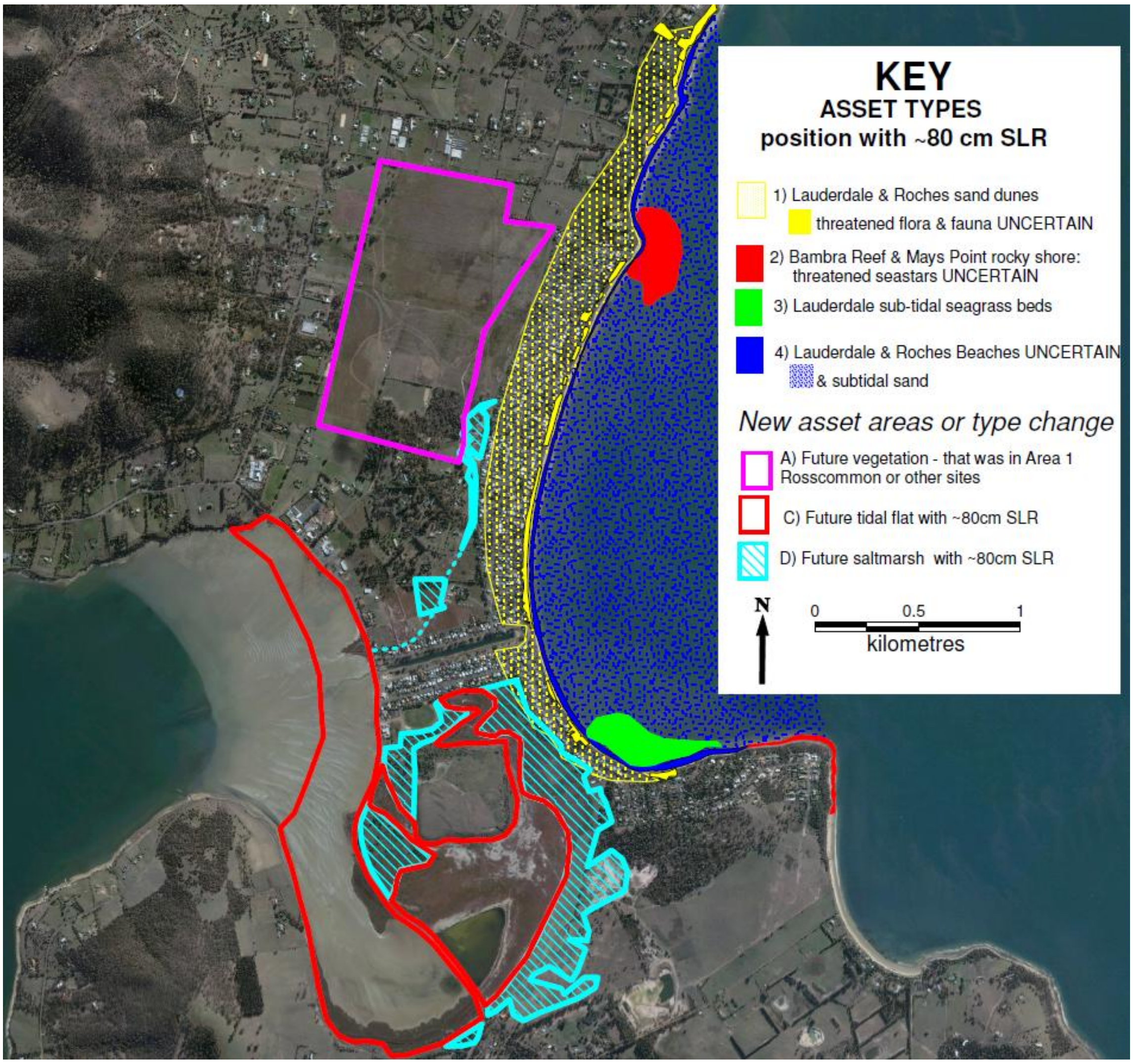


Figure 2. Projected position of major asset types in the Lauderdale area with ~80cm sea-level rise (SLR). Tidal flat and saltmarsh positions altered due to sea-level rise. Extent includes areas where landward transgression of these assets should be encouraged. The extent of these assets has been drawn in a manner consistent with TCAP Pathway Scenario 3, acknowledging that asset protection will prevent transgression in some areas. The future status of some assets remains uncertain or largely depends upon adaptation and mitigations strategies employed that are consistent with TCAP Pathway Scenario 3 (e.g. position of Lauderdale and Roches Beaches following coastal protection measures). It must be noted that environmental assets will need to be managed to allow transgression when sea-level exceeds ~80 cm beyond 2100.

Table 1. List of Natural Assets in Lauderdale

MAJOR ASSET area/type	Asset occurs on..	Nested assets	currently habitat for....	species or specific values (examples)	Ecosystem services
1) Lauderdale & Roches sand dunes, threatened flora & fauna	current & relict sand dunes	Relict & active dune landscape & aquifer	*assets listed below in this section*		Coastal storm protection, water aquifer water filtering (recreational water quality)
"	"	Vegetation communities	Tasvege DVC> & DGL> & assets listed below in this section	significant large mature trees within the vegetation communities	Lauderdale landscape (emergent trees), threatened species habitat
"	"	Flora	Threatened floral species lifecycle	Australian houndstongue*	
"	"	Fauna	Threatened birds & mammal species (foraging etc)	Swift parrot *# Eastern barred bandicoot *#	
A) Future vegetation - Roscommon or other sites	*Areas for future vegetation planting*	*grouped vege & threatened species*			*threatened species habitat*
2) Bambra Reef and Mays Point rocky shore: threatened seastars	rocky subtidal reef and rocky intertidal zone	Fauna	colony of threatened endemic seastars	Live bearing seastars*#	threatened species habitat
B) Future seastar habitat location - not identified	*Areas for future threatened species translocation*	*threatened fauna*			*threatened species habitat*
3) Southern Lauderdale subtidal seagrass beds	subtidal sands	Vegetation	seagrass lifecycle		nutrient cycling, Carbon capture, fish habitat & food web - recreational fishing links
"	"	Fauna	Fish & molluscs	Flathead & squid	recreational fishing
4) Lauderdale and Roches Beaches and subtidal sand	intertidal beach sands & subtidal sands	Beach landform			Coastal storm protection, water filtering, recreational landscape value
"	"	Fauna	Intertidal & sub-tidal invertebrates	bivalve *Paphies elongata*	nutrient cycling and food web -
"	"		Fish & molluscs	Flathead & squid	recreational fishing links
5) Ralphs Bay tidal flats & foreshore	current tidal flats & adjoing shoreline	Tidal flatland form	*assets listed below in this section*	water quality influence for nearby threatened Spotted handfish*#	nutrient cycling (denitrification)
"	"	Fauna	Shorebirds (nesting, roosting, foraging), many threatened & listed*#	Migratory & resident shorebirds (e.g. Pied oystercatchers)	tourism & recreational value; threatened & resident species habitat
"	"	Fauna	Fish	Flounder, goby & flathead	recreational fishing
"	"	Fauna & Microflora	Invertebrates & microphytobenthos	bivalve (*Katelysia scalarina*), diatoms	nutrient cycling
"	"	Vegetation	seagrass	seagrass possibly important for shark breeding success in Ralphs Bay	nutrient cycling, Carbon capture, shark breeding habitat (commercial fishing species)
C) Future tidal flat- Racecourse flats & areas south of Lauderdale	*Areas for future tidal flat*	*grouped tidal flat assets*	*Tidal flats in 2100 are currently saltmarsh*		*all services above*
6) Lauderdale saltmarshes	current saltmarsh	Vegetation communities	Tasvege ASS & ARS, *& assets listed below*	possibly very old *Tecticornia arbuscula* shrubbery	nutrient cycling, Carbon capture, tourism &recreational value
"	"	Flora	Threatened floral species lifecycle	Narrowleaf blowngrass*, Tall blowngrass*, golden dodder*	
"	"	Fauna	Moths	Saltmarsh looper moth* & Cheveron looper moth*	
"	"	Fauna	Shorebirds (nesting, roosting, foraging)	Threatened and listed fauna *# and import for resident shorebirds	tourism & recreational value; threatened & resident species habitat
"	"	Fauna	Invertebrates	molluscs, insects	nutrient cycling and food web - recreational fishing links
D) Future saltmarsh - Areas south of Lauderdale & north to Roscommon	*Areas for future saltmarsh* transgression	*grouped saltmarsh assets*	*Saltmarsh in 2100 are currently saltmarsh,* Tasvege DVC, & other		*all services above*

Notes

Tasvege DVC = Eucalyptus viminalis and E. globulus coastal woodland >
Tasvege DGL = Eucalyptus globulus dry forest and woodland >
Tasvege ASS = Succulent saline herbland
Tasvege ARS = Saline sedgeland/rushland

> = listed as threatened community NCA 2002
* = listed as threatened TSPA 1995
# = listed species in EPCA 1994

3.1) MAJOR ASSET type/area

Lauderdale & Roches sand dunes, threatened flora & fauna

3.1.1 Sand dune landform

The township of Lauderdale has been largely built upon a series of formerly vegetated sand dunes, running parallel to the Lauderdale and Roaches Beach shorelines (Figure 1 – yellow stippled area). The dunes were mapped by Davies (1958). Development in the area has dramatically altered or hidden these landforms except in undeveloped areas:

- directly bordering Lauderdale and Roches beaches, where dune processes of erosion and deposition are currently active,
- relict dunes inland of Roches Beach, where the density of urban development is lower, and
- a relict dune ridge adjoining the Racecourse Flats saltmarsh, west of Bayview Road.

3.1.2 Vegetation communities

The dunes bordering Lauderdale and Roches Beach remains an obvious dune landform structure, with some native vegetation (Figure 3) consisting of:

- *Eucalyptus viminalis and E. globulus* coastal forest and woodland (TASVEG: DVC vegetation community) and
- *Eucalyptus globulus* dry forest and woodland (TASVEG: DGL vegetation community).

Due to he extent of development, and loss of sand dune habitat, the remaining vegetation extent has become highly fragmented at Lauderdale. The DVC and DGL forest types are listed at a state level as threatened communities under the *Nature Conservation Act 2002*. They are considered to be 'inadequately reserved' at a statewide level (FPA 2005; Forest Conservation Fund 2007). The relict dune adjoining Racecourse Flats has a good cover of DVC vegetation.

3.1.3 Flora and fauna species

The DVC and DGL vegetation of the Lauderdale dunes provide habitat for a range of threatened species. *E. globulus* is a seasonal food tree for swift parrot (*Lathamus discolour*) listed as a threatened (endangered) species under the *Tasmanian Threatened Species Act* 1995 (TSPA) (Bryant and Jackson 1999), and are habitat for Eastern barred bandicoot (*Perameles gunnii)* listed as a threatened (vulnerable) species under the TSPA. The DVC vegetation here also supports a threatened (rare) floral species, Australian houndstongue *(Cynoglossum australe)*, listed under the TSPA. The larger emergent *Eucalyptus* trees add to the natural character of the coastal landscape, and contain hollows used by native birds (L. Einoder pers. comm.. May 2012). Most of the emergent older *Eucalyptus* trees within Lauderdale occur along the dune system bordering Lauderdale and Roches Beaches. A few remnant emergent trees remain on public and private land west of the beaches.

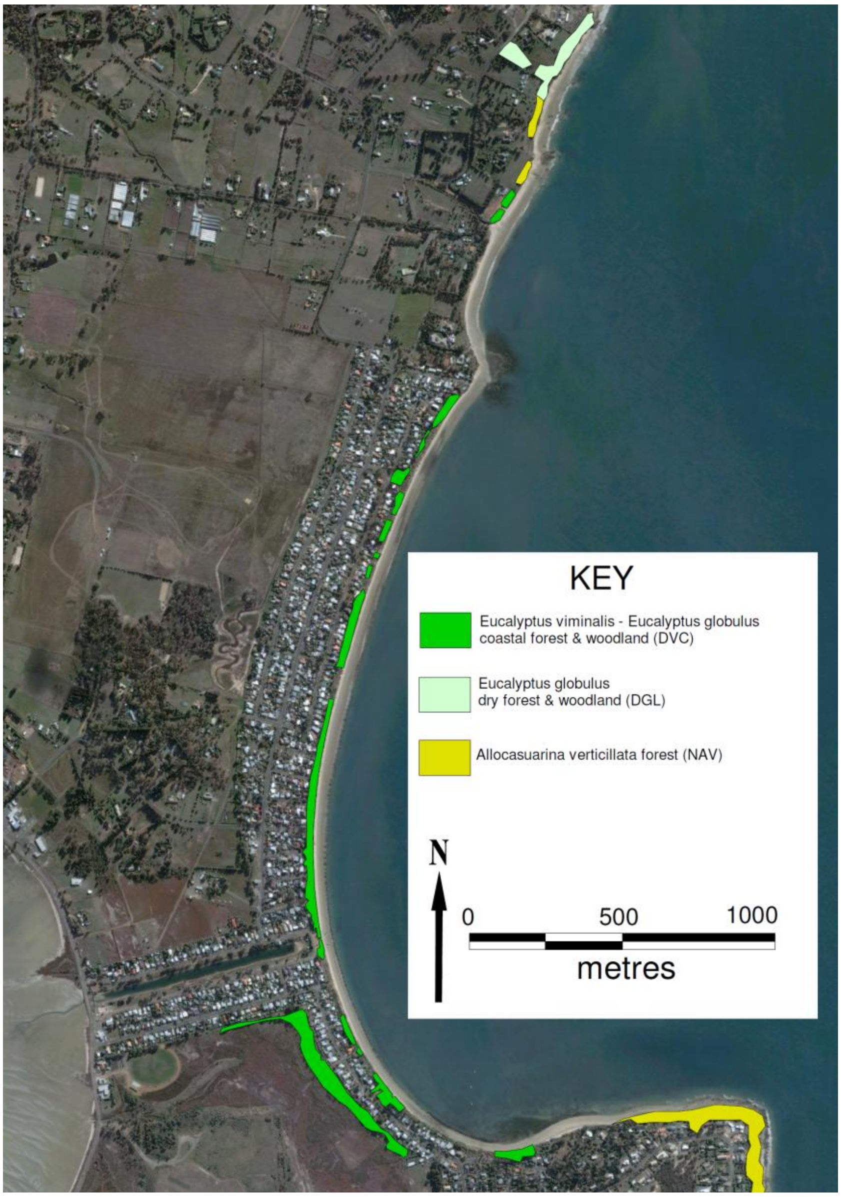


Figure3. Native terrestrial vegetation bordering Lauderdale and Roches Beaches. Reinterpretation of vegetation extent (TASVEG categories) by DEP interpretation from QuickBird satellite image from 2005.

3.1.4 Ecosystem service

The sand dune complex provide a number of ecosystem services.

- The Lauderdale and Roches sand dune complex provide an elevated substrate that is less prone to inundation, upon which most of the Lauderdale township has been constructed.
- The dunes provide infrastructure protection from wave damage.
- The dune sand has high water porosity and permeability, and as a result it is a good water aquifer, which assist the filtering of domestic water discharge and stormwater infiltration. Lauderdale is not yet on the piped sewer network, so domestic water infiltration occurs via septic and grey water trenches. The sand provides a water filtering service that contributes to good recreational water quality on Lauderdale Beach.
- The dunes are a ground water aquifer. Freshwater recharge of the aquifer comes from rain on pervious areas and stormwater and domestic water

infiltration. Freshwater recharge of the sand dune aquifer reduces marine saltwater ingress that may be harmful to mature native trees that are growing on the dunes.

- The dunes support threatened vegetation communities and species. The DVC vegetation in the Lauderdale area appears largely restricted to areas it can grow on the sand dunes.

<u>3.2) MAJOR ASSET type/area</u>

Bambra Reef and Mays Point rocky shore: threatened seastars

<u>3.2.1 Rocky Reef and intertidal areas</u>

A few areas of rocky reef and rocky foreshore occur at Bambra Reef and Mays Point. Ephemeral, low profile reefs also occur offshore in shallow sub-tidal depths, but appear prone to burial by moving sands (Figure 4). Bambra reef is low in profile and consists of fissured dolerite bedrock, creating tidal rock pools, and is strewn with detached boulders and cobbles. Mays Point has a narrow rocky intertidal area that does not extend far into the sub-tidal zone, and is backed by a steep coastal scarp.

<u>3.2.2 Fauna – Live-bearing seastar</u>

Bambra reef supports a large population of the endemic seastar, *Parvulastra vivipara*, listed as a threatened (vulnerable) species under the TSPA. They have live-bearing young (2 to 5 at a time) so the dispersal of this species is limited compared to water dispersed breeding species (Rowland 2000). *P. vivipara* are only known from ~11 separate colonies in Tasmania. The closest nearby colony occurs at Mays Point 2.5 km away. The last population estimate of *P. vivipara* at Bambra reef was ~17,505 individuals in 2000 (Rowland 2000).

The current area of available suitable habitat at Bambra reef for is critical for the survival of *P. vivipara* at this site. Past reef mapping data indicates considerable variability in reef extent as:

- 1,500m^2 in 2000 of which 450m^2 was suitable for *P. vivipara* (Rowland 2000)
- ~85,020m^2 pre-2001 (date not provided), from aerial photo interpretation (Barrett *et al.* 2001) – and illustrated in Figure 4.
- 19,660 m^2 in 2005, from Quickbird satellite image interpretation (this document) – and illustrated in Figure 4.
- 16,840 m^2 in 2010, or pre-2010, from interpretation of an unknown data source (Aquenal 2010).

The variation in the previously recorded extent of Bambra reef may reflect the low profile of the reef and susceptibility to partial sand burial, depending upon sand movement from storm erosion of the coast, and movement of sand through longshore drift and currents in the sub-tidal environment.

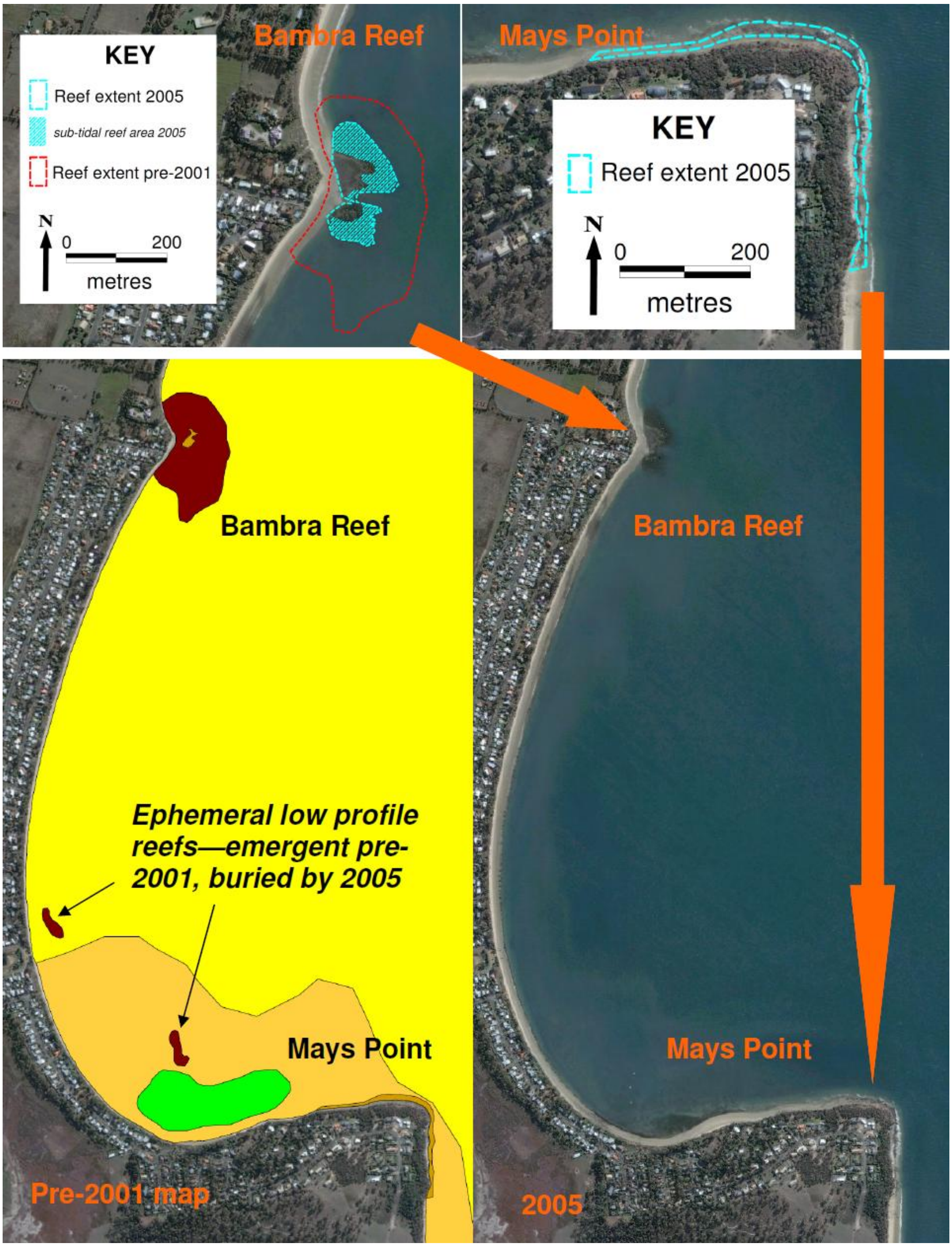


Figure 4. Rocky reef and intertidal areas near Lauderdale: Bambra Reef and Mays Point. Sub-tidal mapping (pre-2001) from Barrett *et al.* (2001) DARK BROWN = rocky reefs; TAN = rock intertidal; ORANGE = compact sand; YELLOW = sand; GREEN = seagrass. Reef area appears dynamic through time, with a reduction in sub-tidal reef area occurring due to burial beneath sand (2005 Quickbird satellite image).

3.2.3 Ecosystem service

Bambra Reef and Mays Point provide habitat for:

- two separate colonies of the threatened seastar, *Parvulastra vivipara*, and
- marine species, including recreationally caught shellfish and fish. The regional importance of Bambra Reef and Mays Point, for recreational fishing activities has not been quantified.

3.3) MAJOR ASSET type/area

Southern Lauderdale sub-tidal seagrass bed

3.3.1 Flora – seagrass

Seaward of Lauderdale Beach seagrass grows in shallow water depths <5m on sub-tidal sand (Figure 5). A dense seagrass bed occurs at the southern end of the Lauderdale beach at ~1.5m depth (Barrett *et al* 2001; Aquenal 2010a). The extent of dense seagrass was survey in 2001 and covered ~87000 m^2 (Barrett *et al* 2001). A subsequent resurvey in 2010, found that dense seagrass covered ~83980 m^2 and as such has retained its extent for the last decade (Aquenal 2010a). On closer examination in 2010, it was noted that an additional large area (1.229 km^2) of sub-tidal habitat off Lauderdale Beach was covered in occasional and very sparse seagrass. The current extent and condition of the Lauderdale Beach seagrass habitat is unknown, given that no mapping has occurred since a major storm event in July 2011. Storm events can cause wave scouring of shallow sub-tidal seagrass and burial by sediment eroded from the coast.

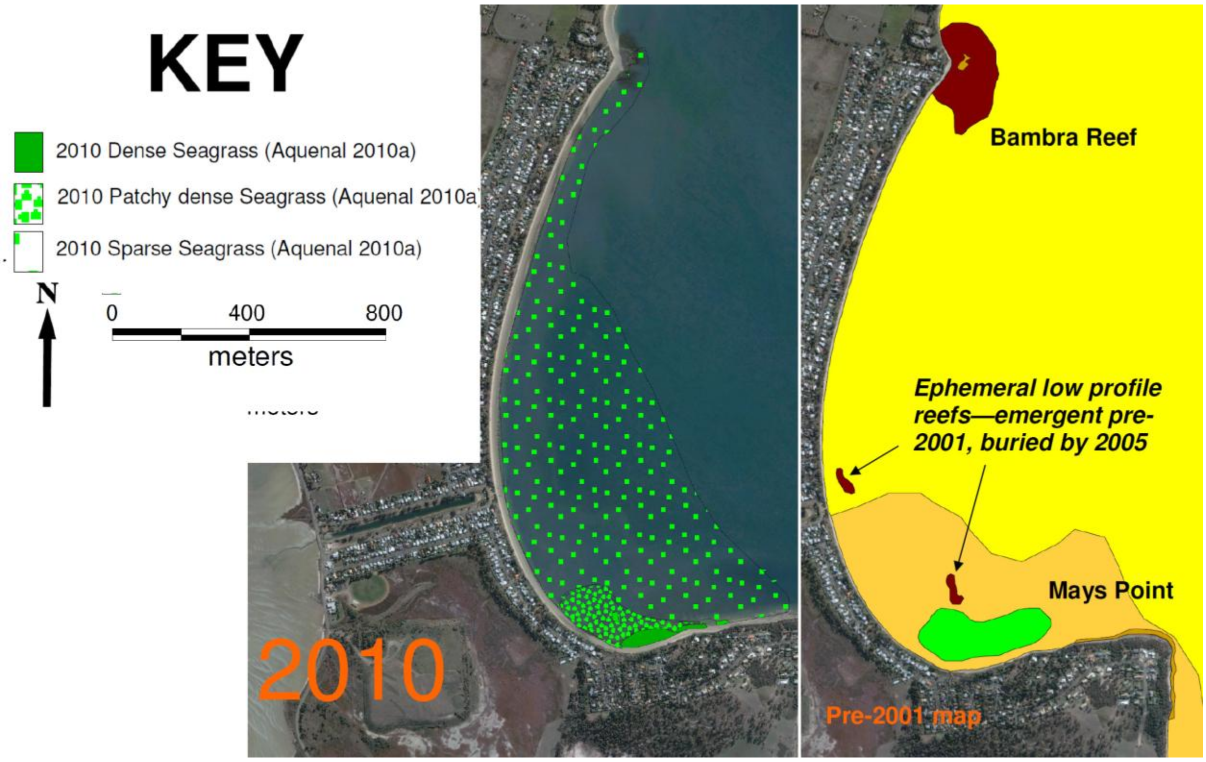


Figure 5 Aerial photo showing beaches and overlain with sub-tidal mapping data from 2010 (Aquenal 2010a) and pre-2001 habitat data from Barrett *et al.* (2001), DARK BROWN = rocky reefs; TAN = rocky intertidal; ORANGE = compact sand; YELLOW = sand; GREEN = seagrass. Note that the Pre-2001 mapping by Barrett et al. (2001) did not map the extent of sparse seagrass, which may have been present, and as a consequence only the dense seagrass distribution can be compared to that mapped in 2010 by Aquenal (2010a). Comparison of the maps (left and right) indicates that the areas of dense seagrass distribution has not varied greatly been mapping events.

3.3.2 Ecosystem service

Seagrass provides a variable suite of ecosystem services, including:

- Nutrient cycling and enhanced denitrification (Hemminga *et al.* 1991).
- Carbon capture (could be ~3.8 to 16 ton/year, if in a depositional area and based upon carbon burial of 45 to 190g C m^2/year (Duarte *et al.* 2005),
- Habitat for commercial and recreationally targeted species.

- Seagrass also interacts with sediment transport processes, increasing the energy needed to move sediment (de Boer 2007).

3.4) MAJOR ASSET type/area
Lauderdale and Roches Beaches and sub-tidal sand

3.4.1 Lauderdale and Roches Beaches
East of Lauderdale township are the Lauderdale and Roches Beaches, consisting of sand that extends out into the sub-tidal coastal environment. Longshore drift causes sand to move northward along the Lauderdale and Roches Beaches and shallow sub-tidal zone. Sand is sourced south of Mays Point from deeper water and the erosion of the coast. As the sand is transported around Mays Point a shallow sand lobe has formed that is projected off shore (Figure 6)

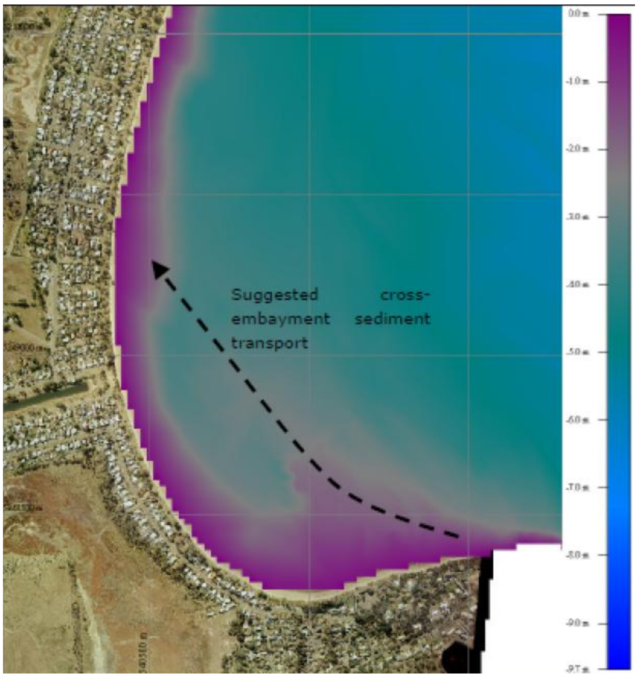


Figure 6. Topography of the seafloor off Lauderdale, illustrating a sand lobe on the northern side of Mays Point and the direction of longshore drift and sediment transport to the north (image from Carley (2012)).

3.4.2 Invertebrates
The invertebrate macrofauna was surveyed at 48 sites along Roches Beach in 2010 (Aquenal 2010b). No threatened species or introduced marine species were observed, and the macrofaunal communities were considered to be fairly typical for a beach in such a location (Aquenal 2010b). The intertidal fauna at Roches Beach was dominated by the bivalve *Paphies elongata*, which preferred the upper intertidal zone, and occurs within the sand to a depth of 30cm. This bivalve species is the largest biomass component in this ecosystem and are likely to be a prey item for fish and birds. The bivalve's bioturbation activity may also maintain habitat for associated biota.

3.4.3 Birds
Shorebirds, such as silver gulls, utilise the Lauderdale and Roches Beaches for foraging; however, roosting is minimal and nesting is unlikely given the high level of recreational use of the area.

3.4.4 Ecosystem service
The beach provides an obvious public recreational amenity. However, the beach also provides ecosystem service, such as:

- Water filtering, by filtering any surface (stormwater) and ground water (domestic water) from nearby urban areas of Lauderdale.
- Supporting the coastal food web. Beach invertebrates are food for commercial and recreationally targeted fish species (e.g. flathead) and provide food and habitat for other fauna (e.g. sea-birds and shorebirds).

3.5) MAJOR ASSET type/area

Ralphs Bay tidal flats and foreshore

3.5.1 Tidal flat and foreshore landscape
Where has the sand in the Lauderdale tidal flats come from?
The Ralphs Bay tidal flat sand has largely come from Fredrick Henry Bay/Storm Bay, where sand was deposited during the last glaciation after having been glacially eroded from inland Tasmania and transported to the coast by the River Derwent. Sea-level rise at the end of last glaciation enabled coastal processes to rework the sands into their current locations. For instance, the Lauderdale area was open water in the Pleistocene following sea-level rise, but wave refraction and longshore drift within Fredrick Henry Bay deposited sand here – creating the Lauderdale isthmus and tidal flats (Davies 1958). At times additional sediment supply may have been derived from the erosion of the surrounding coastal geology, but this is fairly resistant to rapid coastal erosion (e.g. Jurassic dolerite) or unlikely to produce much sand once eroded (e.g. Permian mudstone). A series of sediment cores collected across the tidal flat reveal that the formation of the Lauderdale isthmus had a complex erosion and depositional history that varied considerably over short horizontal distances (Cardno 2008a). The most recent tidal flat sand deposit varies in thickness from ~25cm at the upper intertidal edge to 2.0m thickness near the deeper edge to the west, terminating at 1.0m water depth in a slope rapidly descending to water depths of ~3.5m.

What physical processes modify and maintain the Lauderdale tidal flats?
Sediment cores reveal that once the tidal flat had formed at Lauderdale, the combination of aeolian, wind-wave, and tidal activity have maintained sediment supply and the geomorphic processes required for persistence of the tidal flats here. Sediment supply to the Lauderdale tidal flats come from:

- erosion and runoff from the immediate surrounding catchment,
- localised coastal erosion and nearby aeolian erosion,
- sediment from the River Derwent and regional Derwent estuary catchment erosion and runoff,
- reworking of the tidal flat and sub-tidal marine sediments due to water currents and waves.

The sediment depositional rate in Ralphs Bay has been estimated at between 0.5mm/year, based on modelling of immediate catchment inputs (using *model for urban stormwater improvement conceptualisation* (MUSIC) software in Cardno 2008a), to 2.05mm/year, based on relatively more accurate 210Pb dating of deposition rates within a sediment core collected in ~10m water depth 4km to the south-west of the tidal flats (Samson & Edgar, *unpublished data*). Accurate depositional rate measurements have not been made on the tidal flats.

Once sediment is in the marine environment it is either transported in suspension within the water column or via movement as a bed load. Transport occurs until deposition, but in tidal flat environments wind-wave and tidal flow can cause reworking of previously deposited sediments. The prevailing wind direction at Lauderdale is from the south-west (Figure 7), and appears to be accentuated by the local topography of the greater Ralphs Bay area (Cardno 2008a).

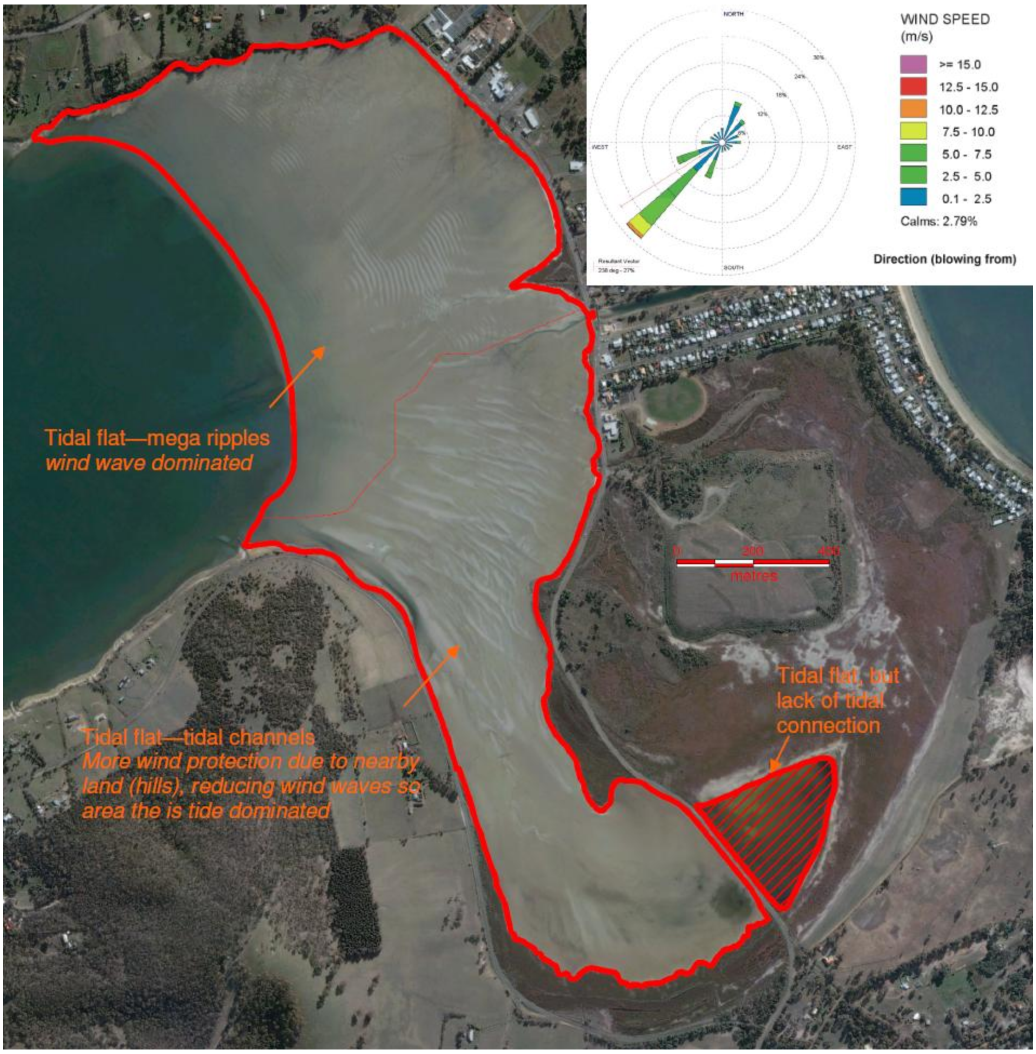


Figure 7. RED OUTLINED AREA = tidal flats. Lauderdale tidal flats, with three distinctive physical influences occurring. To the north the tidal flats are strongly influenced by prevailing SW wind direction (wind data collected from Lauderdale 2004-2008 in Cardno (2008b)). The northern tidal flats have distinctive mega-ripples associated with wind wave sediment remobilisation and transport. To the south, the tidal flats are protected from the prevailing south-west wind by land, so here sinuous tidal channel bedforms dominate. To the east of the South Arm Road causeway, an area of the southern tidal flat (RED STIPPLED AREA) has been cut off from tidal flow by the creation of the causeway.

Although there is only a short distance across Ralphs Bay for wind-wave development, the tidal flat area exposed to the prevailing south-west wind have wave influenced bed-forms (as visible in Figure 7). The southern areas of the tidal flat, which are less exposed to south-west wind-waves and have bed-forms more influenced by tidal channel development. Wave climate is caused by the local wind conditions and controlled by the physiographic setting, that is, fetch lengths and water depths. The seabed shear forces caused by waves may have significant impacts on the ecology of estuarine systems. Bed forces induced by waves have the ability to mobilise sediment and thereby biological function by suspending microphytobenthos into the water column where they are more readily available to filter feeding organisms (Bellchambers 1998).

Development in Ralphs Bay since European settlement has caused some changes to the shoreline (Cardno 2008a), such as:

- south Arm Road causeway has separated East Marsh Lagoon and Racecourse Flats from tidal connectivity to Ralphs Bay;
- creation of a spit of sand north of the entrance to the Lauderdale canal, which was the spoil from the construction of the canal in the 1920's;
- gabion basket shoreline protection works at Lauderdale;
- stormwater discharges at the shoreline creating ephemeral erosion channels (during heavy rains) and localised increased mud content of the tidal flat sediments (Cardno 2008a).

Stormwater receiving environment

The tidal flats, and adjoining Lauderdale canal, are the receiving waters for stormwater and other run off from the Lauderdale area. The location of stormwater outfalls is illustrated on Figure 8. The immediate Lauderdale catchment that drains onto the tidal flats is 661.5 Ha in size. The catchment sediment and nutrient inputs into Ralphs Bay were estimated using MUSIC software (Whitehead in Wild-Allen *et al.* (2009)) are the annual load estimates: sediment 200 ton/year; total phosphorous 0.5 ton/year; and total nitrogen 3.8 ton/year. The estimates are based upon the land use information put into the model (53.3 Ha urban, with 35% impervious surfaces; 216.4 Ha forest; and 392.8 Ha agriculture), derived from visual analysis of the 2005 Quickbird satellite image over the area. The model simulated a twelve month period, using daily 2003 rainfall data from Hobart airport. It is likely the model derived annual loads are over-estimates, as the model does not take into account water filtering throughout the Lauderdale area (in the grassy rural areas, saltmarsh and the open rural drainage network) and the infiltration into groundwater that occurs within sandier areas (as described in section 3.1.4).

Figure 8. Lauderdale tidal flats, canal & saltmarsh areas receiving stormwater. YELLOW TRIANGLES = stormwater outfalls. These areas may receive localised higher silt, nutrient, hydrocarbon, bacteria and litter loads associated with stormwater inputs. The hatched area, within the inset map, is the catchment area that contributes runoff to the tidal flat area.

3.5.2 Fauna - shorebirds

Shorebirds nest, roost and forage along the shoreline and on tidal flats at Ralphs Bay. The Ralphs Bay tidal flat is only a few kilometres from similar habitat elsewhere in the Derwent and Pittwater estuaries (including the Pittwater-Orielton Lagoon Ramsar site), and are collectively called the ‘Derwent Estuary – Pittwater Area (DEPA) (Figure 9). The DEPA is important for at least eight migratory (2 Charadriidae, 6 Scolopacidae) and six resident shorebird species (2 Haematopodidae, 4 Charadriidae) (Birds Tasmania records).

The migratory shorebirds species commonly observed at Ralphs Bay include:

- Red-necked stint (*Calidris ruficollis*),
- Curlew sandpiper *(Calidris ferruginea),*
- Double-banded plover (*Charadrius bicinctus*),
- Eastern curlew (*Numenius madagascariensis*),
- Bar-tailed godwit (*Limosa lapponica*),
- Whimbrel (*Numenius phaeopus*).

- Grey-tailed tattler (*Heteroscelus brevipes*)

The resident shorebirds species observed at Ralphs Bay include:
- Australian Pied Oystercatchers (*Haematopus longirostris*). cc
- Red-capped Plover (*Charadrius ruficapillus*).

Gauging the relative importance of the Ralphs Bay tidal flat within the broader DEPA region for shorebirds is region is extremely challenging, and requires a multi-year and intensive survey effort. The only study that has attempted to identify the regional importance of the Ralphs Bay tidal flats to shorebirds compared the % of all observations of bird species of a few sites surveyed on a limited number of occasions. From these observations the Lauderdale area appears to have relatively high importance to the local DEPA populations of migratory Double-banded plover (16.5%), Whimbrel (77.9%) and Grey-tailed tattler (100.0%) and resident Pied Oystercatcher (30.7%) (Cardno 2009). The DEPA is the southernmost destination in the East Asian-Australasian Flyway (EAAF), along which millions of Arctic-breeding migratory shorebirds travel to reach regular non-breeding grounds in Australia and New Zealand. Several of these species regularly occur in the DEPA. The DEPA is considered an internationally important site for one of these species, the Red-necked stint (Bamford *et al.* 2007). Another migratory species, the Double-banded plover breeds in New Zealand and migrates to south-eastern Australia in the southern hemisphere winter and has been observed in the DEPA (Birds Tasmania records, E Woehler *pers. comm.,* April 2009).

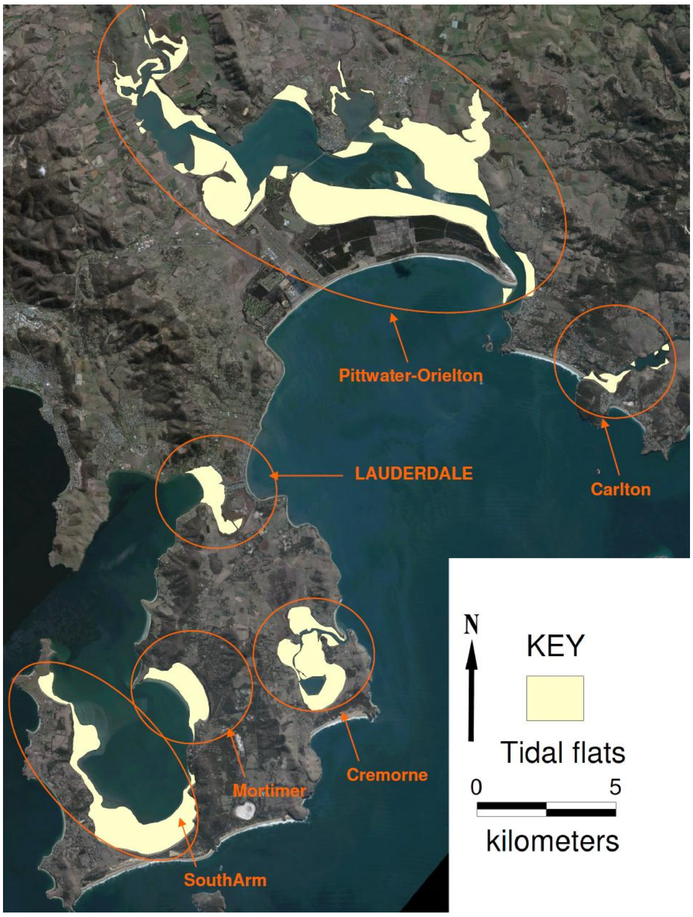


Figure 9. Tidal flat habitats within the Derwent Estuary – Pittwater Area (DEPA) utilised by wading shorebirds.

Annual surveys held on one day each summer, reveal a long-term decrease in the abundance of many of the migratory shorebirds observed in the DEPA. Most notably the Eastern curlew has experienced a decrease from the 1960s, to less than 25% of former numbers in 2003 and to 15% in 2008 (Reid & Park 2003, Mike Newman, *in* Olson (2008) – Figure 10). The decrease in migratory shorebird abundance in the DEPA is thought to be largely due to habitat loss throughout different parts of their flyway (Eric Woehler, *pers comm.,* April 2009). However, local habitat loss and other pressures are also likely to be contributing to this decrease.

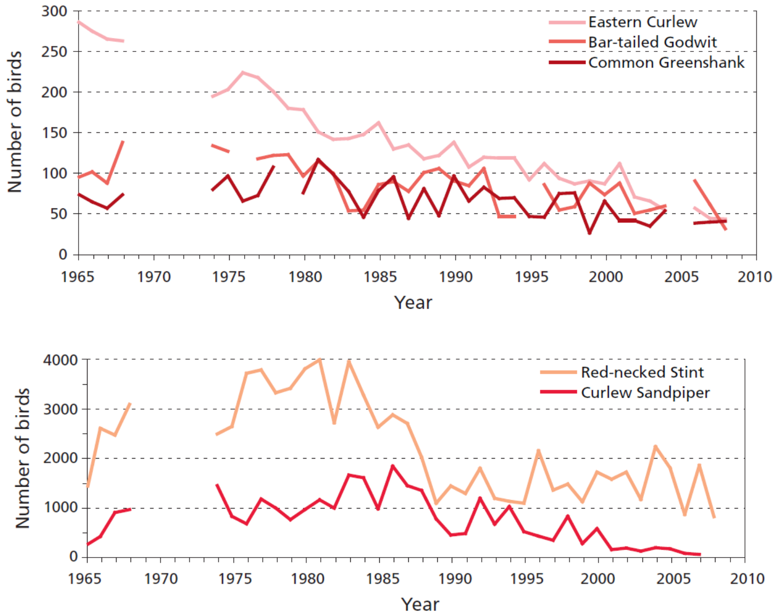


Figure 10. Trends in numbers of the five species of migratory shorebirds in summer counts in the Hobart area (sourced from Olson (2008))

The DEPA is nationally significant for a resident population of Pied Oystercatchers, which is one of the largest in Australia, and the second-largest in mainland Tasmania (Lane 1987). The DEPA Pied Oystercatcher numbers have increased dramatically over 40 years, but over the last decade there has been extensive variability and a slight decline in numbers (Figure 11).

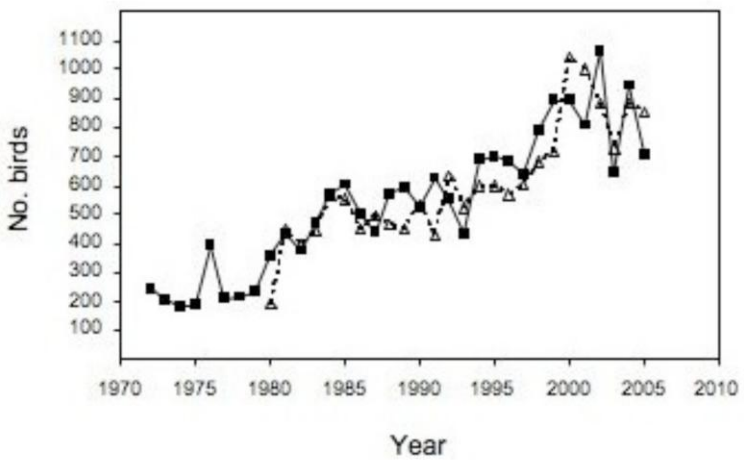


Figure 11. Trends in numbers of Australian pied oystercatchers observed in the Derwent estuary – Pittwater area during summer (solid line and winter (dashed) (data presented in Woxvold (2008))

Another commonly observed DEPA resident shorebird is the Red-capped plover. The Red-capped plover is the most common breeding species of wader in Tasmania (B.O.A.T. 1982). The effect of disturbance on breeding birds is complex, with differing effects with respect to stage in the breeding season, the type, intensity and duration of disturbance, and the availability of resources in the surrounding area (Aquenal 2008a). It is thought that disturbance to birds is only important when it has a fitness cost, through either reduced survival or fecundity (Gill *et al.* 2001). In Ralphs Bay human induced disturbance to shorebirds has included recreational uses of the foreshore. More recently, exceptional high tides have caused roosting birds (notably Pied Oystercatchers) to move onto South Arm Road where they have subsequently been killed by cars (Eric Woehler, *pers. comm.*, April 2009).

Nesting

The foreshore of Ralphs Bay, and nearby saltmarsh, are nesting areas for resident Pied Oystercatchers and Red-capped Plovers. Most Pied Oystercatcher breeding territories are discretely distributed with a preference for sandier shorelines. Density of breeding pairs depends upon quality of the site and competition, as Pied Oystercatcher breeding pairs are very territorial at the height of the breeding season. (Figure 12). At Ralphs Bay, there are typically eight nesting pairs/year with the majority of sites on the northern and eastern side of the bay and seaward of the road adjoining the Ralphs Bay tidal flats (Einoder, *pers. comm.* April 2012). Between five and eleven nest site were identified during 2006 and 2007 surveys, but not all were occupied (Aquenal 2008d). On the northern edge of the bay the nesting sites occur between the high tide mark and a coastal scarp. These are the preferred nesting sites in this area as they provide good connectivity for the flightless chick to walk out onto the tidal flats to feed (Einoder, *pers. comm.* April 2012). When the preferred nesting sites are occupied by dominant or established nesting pairs, sub-optimal nesting sites in the Racecourse Flats saltmarsh are occupied on the landward side of the road (see section 3.6.3). A 2007 survey of Red-capped Plover nesting sites, identified approximately three near the sand spit between the northern and middle tidal flat areas, and a further three south of East Marsh Lagoon (Aquenal 2008d).

Roosting

Targeted shorebird surveys in Ralphs Bay and the Pittwater area from 2004 to 2007 by Aquenal (2008b) identified that most roosting habitat in Ralphs Bay occurs on sand spits and beaches or in saltmarsh (see section 3.6.3). However, during summer Red-capped Plovers and Red-necked stints used exposed banks on the middle tidal flat (Figure 12) for roosting when tidal conditions were appropriate (Aquenal 2008b).

Foraging

The Ralphs Bay tidal flats must be viewed as one part of the DEPA habitat complex used by foraging shorebirds. Changes in use of foraging sites within the DEPA depends upon the habitat requirements and prey preference of the different shorebirds species. Factors influencing the suitability of a site for foraging shorebirds include:

- habitat type:
    - substrate type,
    - tidal flat profile and depth,

    - prey type abundance and availability,
- habitat access – affected by water depth:
    - tides, barometric pressure and local wind conditions,
- biological cycles:
    - stage of bird life cycle,
    - seasonality affecting migratory species presence or absence,
- habitat condition and level of disturbance:
    - changes to habitat caused by natural and human causes,
    - predators.

The most abundant foraging shorebird on the Ralphs Bay tidal flats is the Pied Oystercatcher (Aquenal 2008b). During surveys conducted in 2004, 2006 & 2007 this species was observed foraging here more than at other survey sites within the DEPA (Aquenal 2008b). The Ralphs Bay tidal flats are also important Winter foraging areas for Double-banded plovers and Red-necked stints (Aquenal 2008b). One study has revealed that foraging habitat preference occurs within the Ralphs Bay tidal flats for some shorebirds species (Aquenal 2008b). At Ralphs Bay Pied Oystercatchers spent a proportionately high amount of time foraging on the northern and middle tidal flats (87% of the time here in summer and 57% in winter) (Figure 12). It is here that they were observed harvesting the bivalve *Katelysia scalarina* (Harrison 2008). This observation has led to suggestions that this site may be preferred foraging grounds due to the improved foraging efficiencies associated with harvesting larger prey items (Harrison 2008). The number of Pied Oystercatchers using the southern tidal flats increased during the winter, possibly due to storms and high tides reducing the effectiveness of wading in the preferred, but more exposed northern and middle sectors. Observation of prey harvested revealed that *K. scalarina* are not as readily harvested in the southern extent of the tidal flats, instead Pied Oystercatchers primarily harvest polychaete worms here (Harrison 2008). There was also a slight north to south seasonal shift apparent in foraging effort over the tidal flats among a range of other shorebird species (Harrison 2008).

Although other wading species may have different prey preference to the Pied Oystercatcher, the majority of wading birds, such as Red-capped plovers, Double banded plovers, Bar-tailed and Red-necked stints also foraged primarily in the northern and middle tidal flats (Aquenal 2008b). There is a seasonal shift from using mainly inner shore habitat in winter, to using the outer (deeper) shore zones during spring and summer (Harrison 2008). During the winter, when access to intertidal prey resources was restricted by prevailing low pressure systems and higher low-tides, a range of prey species that are not profitable under good conditions were then accepted (Harrison 2008). During excessive high-tides and storm surges, some species will forage on the saltmarsh habitat (see saltmarsh section 3.6.3 for more detail).

Tidal flat bedforms (Figure 7) and physical processes in the bay may provide an explanation for the higher fpraging effort observed in the northern tidal flats by Harrison (2008), but this has not been studied. Wind waves that predominate over the northern tidal flats, could be causing the resuspension of microphytopbenthos growing here and increasing food availability for filter feeding organisms like *K. scalarina,* that appear to be the preferred prey item of Pied Oystercatchers.

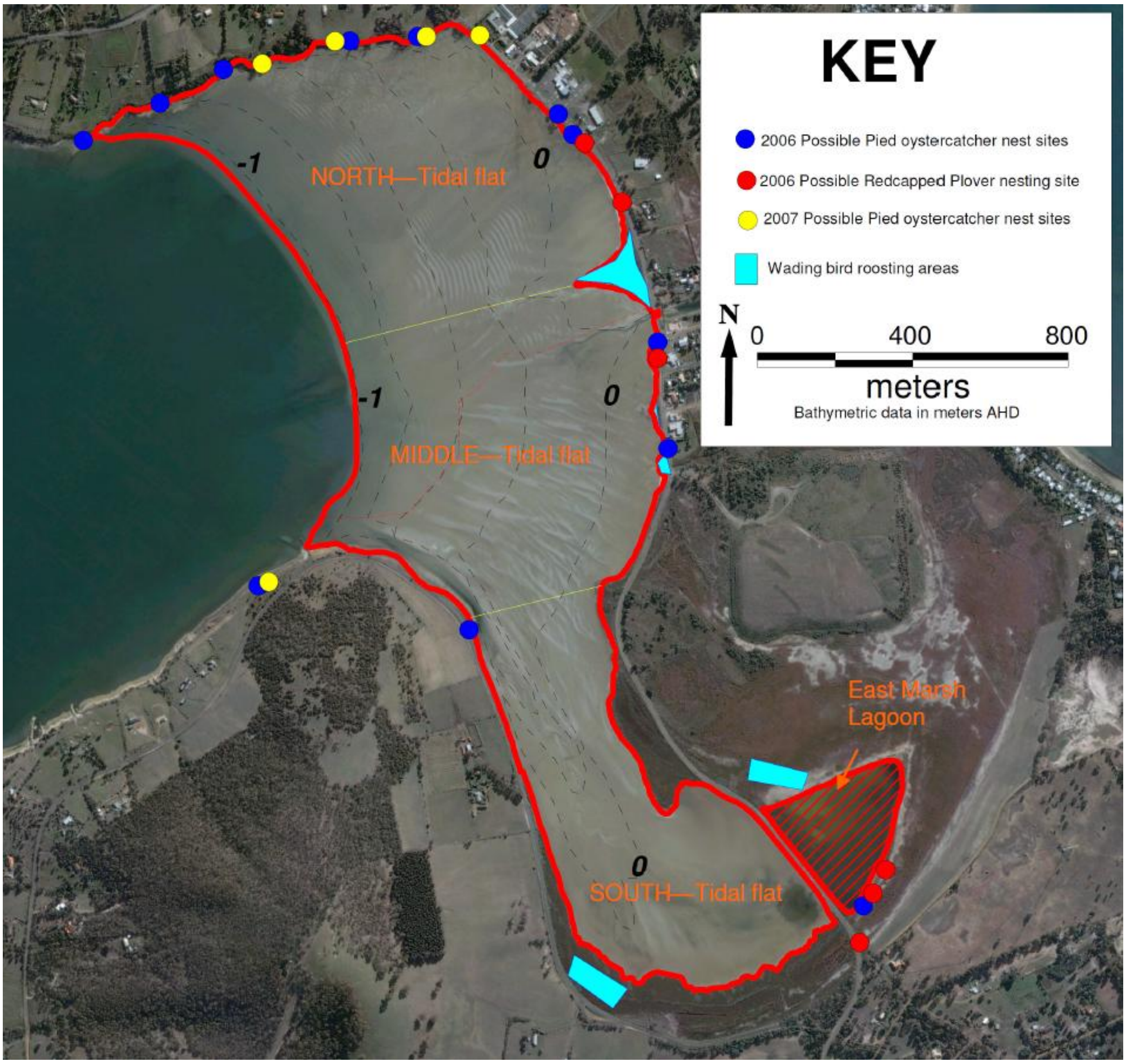


Figure 12. Tidal flat habitat areas as described in term of wading bird utilisation (north, middle and south). Possible nesting site information from Aquenal (2008d), roosting sites from Aquenal (2008b) and bathymetric data from Cardno (2008b) and Geocoastal (2009). Red dashed line delineates north and southern tidal flat areas that differ in dominant sediment bedform (texture difference visible in this 2005 quickbird satellite image).

3.5.3 Fauna – recreationally targeted fishing (notably flounder)

Several species of flounder occur in Tasmanian waters; the most frequently caught being the greenback flounder (*Rhombosolea tapirina*). Greenback flounder are a recreationally targeted fish species found on the tidal flats at Ralphs Bay. This area (along with other suitable flounder fishing areas throughout the Derwent estuary) supports up to 2% of the overall state recreational flounder harvest (Lyle 2005). Flounder are bottom dwelling fish that primarily feed on sandy tidal flat invertebrates living within the sediments, such as polychaetes and crustaceans. The Ralphs Bay tidal flats provide a foraging zone for juvenile flounder around diurnal/semi-diurnal tidal fluctuations (Aquenal 2008a). Seine netting fish surveys in 2006-07 over the tidal flats also captured a high number of gobys (*Tasmanogobius gloveri*) along with flounder (Aquenal 2008a). The tidal flat area was surveyed again in 2010 and was found to support a relatively high number of juvenile flounder relative to several other Derwent estuary sites (Lo 2011).

3.5.4 Fauna and microflora - invertebrates and microphytobenthos

The invertebrate fauna and algal microphytobenthos (MPB) are the basal levels of the food web that supports shorebird and fish that feed on the Ralphs Bay tidal flats. Invertebrate fauna have been surveyed here in 2006-07 (Aquenal 2008a) and the MPB in 2005 (Cook 2007). The MPB was found to have a homogeneous spatial distribution of biomass, although this was subject to some seasonal variation in species composition, abundance and productivity (Cook *et al.* 2007). The tidal flats provide substrate for a highly productive MPB, with the high to mid -intertidal zone supporting a greater algal biomass than the lower intertidal (Cook *et al.* 2007). The presence of MPB also influences sediment processes (notably nutrient cycling) and transport/remobilisation through the binding nature of organic material, notably MPB film on the tidal flat sediment surface.

The Ralphs Bay tidal flats support a healthy benthic invertebrate community (Aquenal 2008a). Analysis of invertebrate species richness indicated that the Derwent estuary sandy tidal flats (including Ralphs Bay) have mid-range values when compared to other locations throughout south-eastern Tasmania (Aquenal 2008a). The Shannon-Wiener diversity index is a measure of species richness with regard to the proportion of the total count contributed by each species; high index values obtained from the Derwent sites (including Ralphs Bay) indicate that the invertebrate communities generally consist of a range of species at similar densities rather than a mixture of highly abundant and rare species (Aquenal 2008a).

3.5.6 Flora - seagrass

Analysis of historic aerial photographs suggests that seagrass beds were formerly abundant on the Ralphs Bay tidal flats (Rees 1994) (Figure 13). The dominant seagrass species here in the past was most likely Eelgrass *Heterozostera nigricaulis* (formerly *Heterozostera tasmanica*) (Hughes and Davis (1989) in Aquenal (2008a)). No large or dense seagrass beds have been identified in sub-tidal or intertidal habitats of Ralphs Bay since 1970. A survey if the Lauderdale tidal flats in 2007 found a sparse patch of the seagrass, *Zostera Muelleri,* covering only 0.011 km^2 in the southern area of the tidal flats adjacent to East Marsh Lagoon, and occasional blades of very sparse seagrass *H. nigricaulis* in shallow sub-tidal habitats (2-7 m water depth) adjacent to the western extent of the tidal flat (Aquenal 2008a). Anthropogenic disturbances resulting in sedimentation and elevated nutrient loads are typically implicated in seagrass declines. Storm events can also cause localised loss of seagrass when either removed by high energy wave activity or buried by rapid sediment deposition. The specific cause or rate of seagrass loss from the Ralphs Bay tidal flats has not been identified. Monthly water quality monitoring data from Ralphs Bay, collected by the Derwent Estuary Program, has been used in biogeochemical modelling research at CSIRO that has identified suitable conditions now occur over the Ralphs Bay tidal flats for seagrass growth (Wild-Allen *et al.* 2009); however, it is not known why the seagrass has not fully returned.

Seagrass presence and condition can be influenced by anthropogenic changes to water quality, sediment dynamics, and water depth. The presence/absence of seagrass can affect tidal flat nutrient cycling rates (notably nitrogen), carbon capture, and sediment transport/remobilisation.

Nurseries for many small fish species tend to be concentrated in sheltered seagrass habitats since these are highly productive systems that provide food resources and suitable shelter for newborn and juvenile fish (Aquenal 2008a). Similarly, the abundance of small resident fish species is significantly higher in seagrass beds than in unvegetated habitats (Jordan *et al*. 1998). Loss of seagrass from the bay has most likely reduced fish diversity and abundance here. Studies in the 1940s and 1950s (Olsen 1954) record school shark pups in the greater Ralphs bay area. It seems likely that declines in seagrass may have prevented the ongoing use of the area by school sharks, as a pupping ground, although the area is still frequently used by juvenile school sharks (Aquenal 2008a).

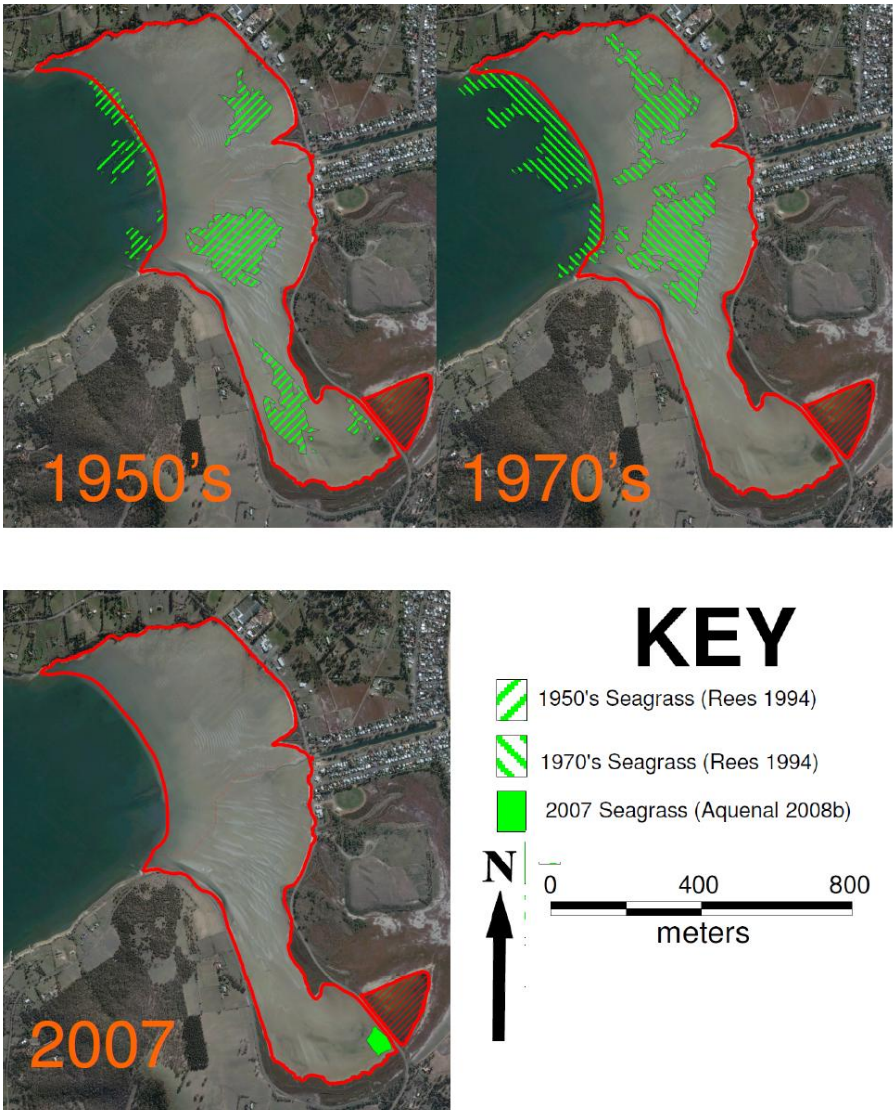


Figure 13. Tidal flat habitat areas (within RED OUTLINE) and historic seagrass coverage (GREEN), which has declined greatly since the 1970's and was largely absent from the tidal flats by the 1990's (Rees 1994). A small patch of seagrass was identified on the tidal flats in 2007.

3.5.7 Ecosystem service

The Ralphs Bay tidal flats and adjacent shoreline provide a diverse range of ecosystem services:

- The tidal flats are important for nutrient cycling. It is evident that the surface water sites in northern Ralphs Bay (including sites monitored over the tidal flats) have the lowest percentage of inorganic nitrogen present in Ralphs Bay.

Over the tidal flats, and nearby, inorganic nitrogen accounts for 4% to 22% of the total nitrogen present, whilst further from the tidal flats this increases to over 40%. This pattern may be attributable to denitrification processes occurring on the tidal flats, whereby bacteria remove nitrate and nitrite from the water column and reduce it to nitrogen gas (Koehnken 2008). This is one of the primary processes which removes nitrate from waterways and highlights the important ecosystem service provided by tidal flats.

- The tidal flats provide habitat for commercial and recreationally targeted fish species (e.g. flounder). In the past seagrass presence may have been linked to suitable school shark breeding habitat (Aquenal 2008a).
- There are a range of shorebirds using the area for nesting, roosting and feeding. At times up to 10% of the global population of Pied Oystercatchers can be observed at a single moment utilising the Ralphs Bay tidal flats and foreshore (Eric Woehler, *pers comm.,* April 2012)

3.6) MAJOR ASSET type/area
Lauderdale saltmarshes

3.6.1 Vegetation communities

The Lauderdale saltmarsh occupies an area of approximately 0.9km^2 and the vegetation communities were mapped in 2008 by NorthBarker Ecosystem Services for the Derwent Estuary Program, using 2001 aerial photos. The vegetation is dominated by *succulent saline herbland* (ASS – TASVEG category); 0.7 km^2, representing 88% of the Derwent estuary coverage of this vegetation type (NorthBarker 2008b). The next most dominant vegetation within the Lauderdale saltmarsh is *saline sedgeland/rushland* (ARS – TASVEG category) 0.2 km^2, representing 15% of the Derwent estuary coverage of this vegetation type (Figure 14). There is considerable variation in the dominant floral species within saltmarsh vegetation types ASS and ARS (see Figure 15 for comparison), which is largely due to salinity and drainage influences (Kirkpatrick and Glasby 1981). The Lauderdale saltmarsh is of regional significance, having the highest vegetation diversity across its profile from the seaward to landward edge when compared to other saltmarshes in the DEPA (Prahalad *pers comm.* May 2012).

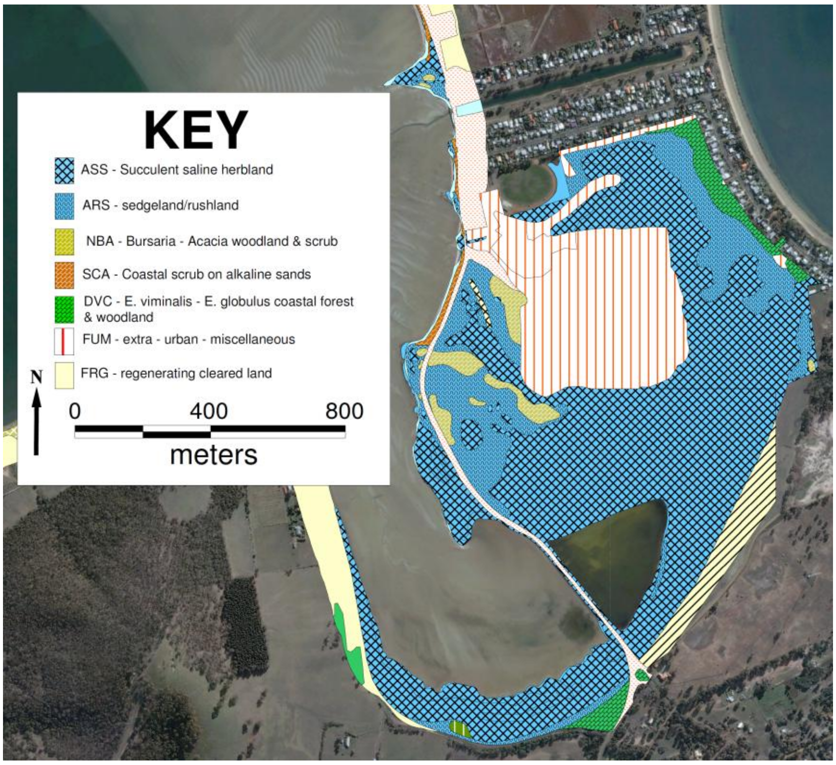


Figure 14. Vegetation of the Lauderdale saltmarsh, based upon TASVEG category interpretation on 2001 aerial photos (NorthBarker 2009).

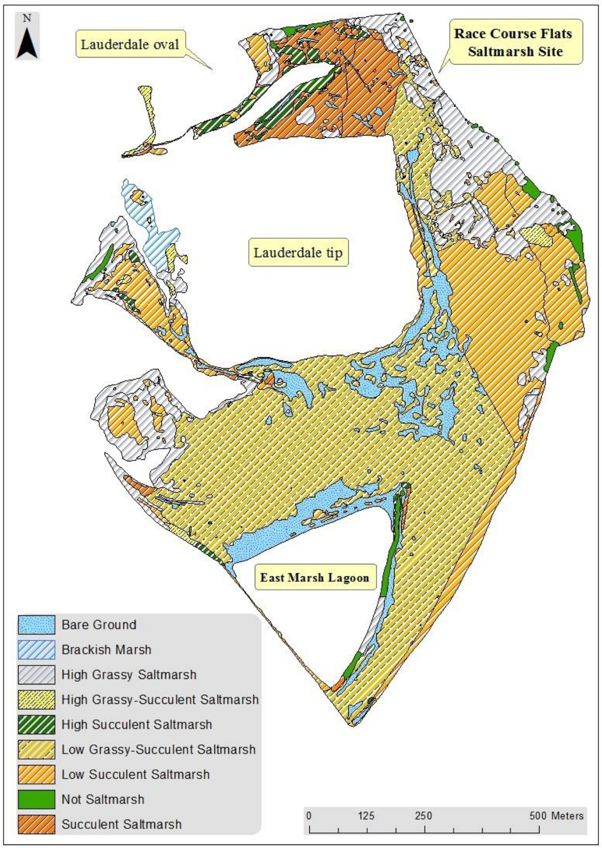


Figure 15. Greater variability occurs within the saltmarsh vegetation than is visible in the TASVEG mapping units. Compare to TASVEG mapping units in Figure 14 above from Prahalad (2012) (mapping area Racecourse Flats).

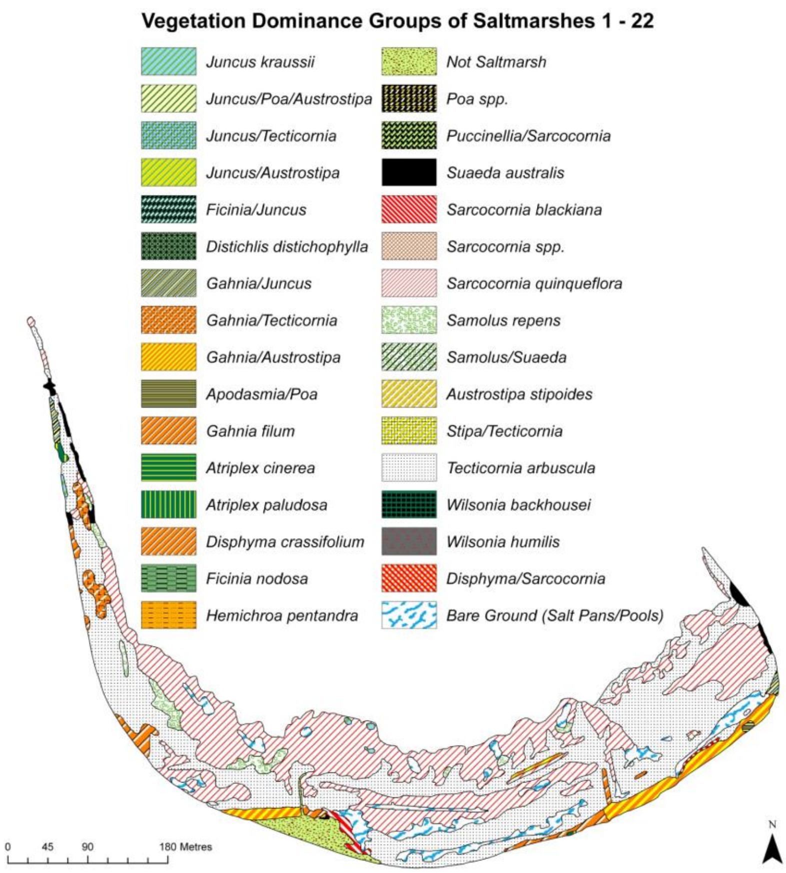


Figure 16. Greater variability occurs within the saltmarsh vegetation than is visible in the TASVEG mapping units (Prahalad 2009). Compare to TASVEG mapping units in Figure 14 above (mapping area southern Ralphs Bay).

Topographic & tidal height – affecting saltmarsh distribution

Variation within the saltmarsh vegetation is strongly correlated to drainage (largely influenced by variations in topography and water sources), and salinity (influenced by tidal flushing, evaporation, and freshwater surface and groundwater inputs) (Figure 17). The drainage and salinity influence on saltmarsh vegetation have been described by Kirkpatrick and Glasby (1981) (Figure 18) and Prahalad (2009) (Figure 19).

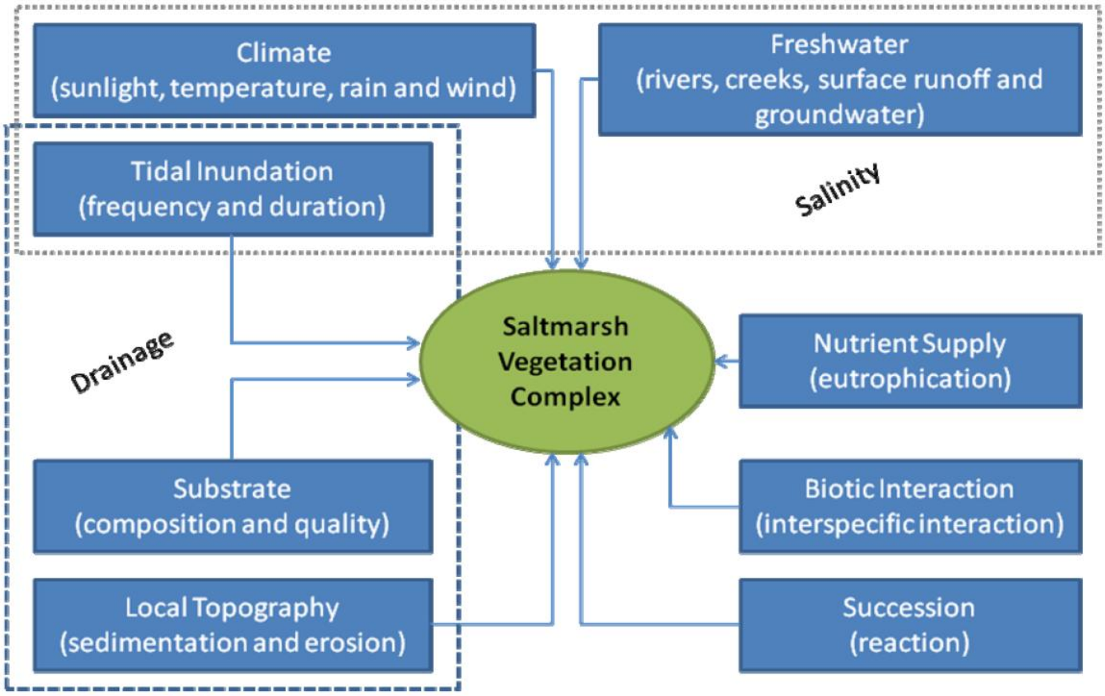


Figure 17. Major environmental factors considered to be of importance in determining structure and composition of the saltmarsh vegetation (figure from Prahalad (2009)).

Topography of the coastal zone places a major influence on saltmarsh distribution, which is considered to have its maximum landward edge corresponding to the height of the 1 in 100 year storm surge at 1.18m AHD in the Lauderdale area (Prahalad 2009; Prahalad *et al.* 2009). Changes in elevation over the saltmarsh have been modelled using the Climate Futures Airborne Light Detection and Ranging (LiDAR) Digital Elevation Model (DEM) Dataset that was compiled for the Climate Futures of Tasmania project by the Antarctic Climate and Ecosystems Cooperative Research Centre (ACECRC) and the State Emergency Service (Figure 20). A comparison between the topographic information in Figure 20 and the vegetation zonation in Figure 14 and 15 is largely consistent with the vegetation zonation in Figure 19 (of Prahalad (2009)). The zonation from the seaward edge changes from bare ground, to succulent saltmarsh (ASS), to saline sedges (ARS). The exception to Figure 19 being that on the landward edge of the Racecourse Flats saltmarsh there is *Bursaria – Acacia woodland/scrubland* (NBA) or *Eucalyptus viminalis – Eucalyptus globulus coastal forest and woodland* (DVC) rather than *Allocasuarina* woodland.

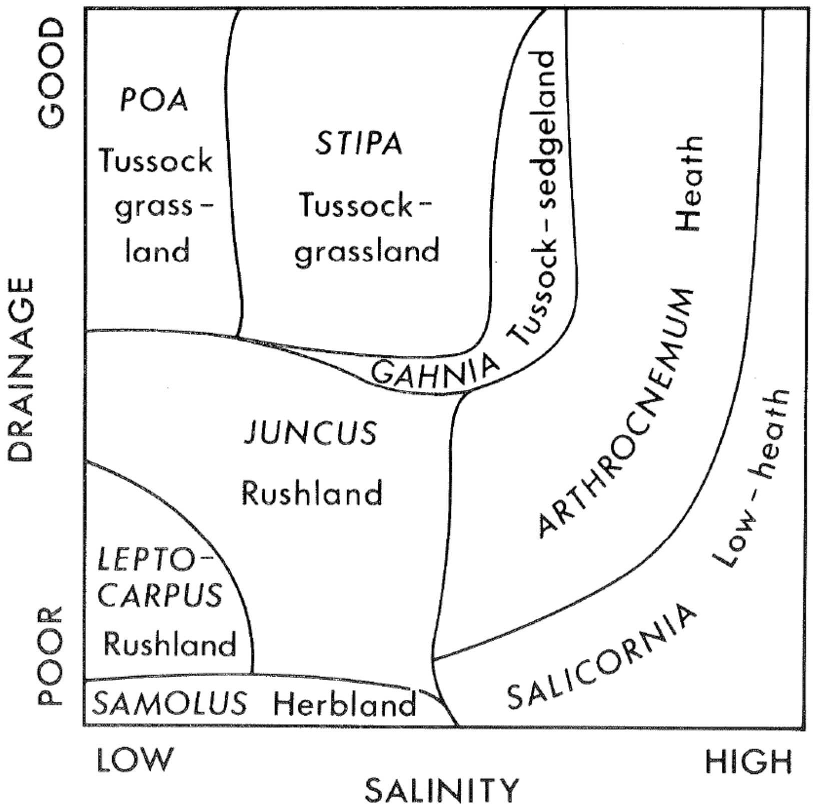


Figure 18. Relationship between the major south-east Tasmanian saltmarsh communities and the environmental relationships (salinity and drainage) as identified by Kirkpatrick and Glasby (1981). Note the name changes: *Salicornia* -> *Sarcocornia*; *Arthrocnemum* -> *Tecticornia*; *Stipa* -> *Austrostipa*; and *Leptocarpus* -> *Apodasmia* (Prahalad 2009)

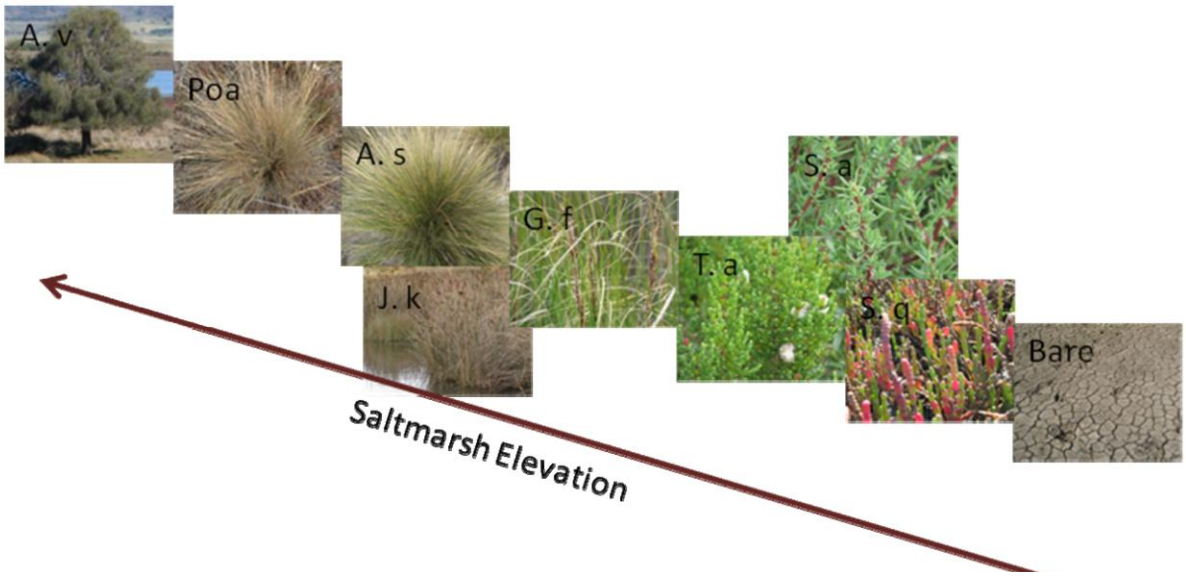


Figure 19. A hypothetical model of vegetation zonation for the south-eastern Tasmanian saltmarshes in relation to drainage (elevation). With increased elevation bare ground changes to *Sarcocornia quinqueflora* (S.q), *Suaeda australis* (S.a), *Tecticornia arbuscula* (T.a), *Gahnia filum* (G.f), *Juncus kraussi* (J.k), *Austrostipa stipoides* (A.s), *Poa* spp. (Poa) and terrestrial vegetation (e.g., *Alloscauarina verticillata* (information from Prahalad (2009)).

Figure 20. Topographic digital elevation model (DEM) of bare ground beneath the Lauderdale saltmarsh Australian Height Datum (AHS) - modelled using LiDAR data (map from Enesar consulting Pty Ltd 2007). The LiDAR is considered to have a vertical and horizontal accuracy of +/- 25 cm. Ground truthing of the DEM, on the seaward side of the South Arm Road indicated that median LiDAR ground elevation error from vegetated surfaces = 0.27 m and median error from bare surfaces = 0.02 m (Davidson 2010). However, relative accuracy of the LiDAR east of the South Arm Road needs to be verified.

Construction of the South Arm Road causeway through the Racecourse Flats saltmarsh and adjacent tidal flats has disrupted the drainage and prevents tidal flushing of the saltmarsh to the east of the causeway. Fresh water ponding can also occur in the saltmarsh, east of the causeway, after heavy rainfall events. Although there is a culvert beneath the causeway at East Marsh Lagoon, this is frequently blocked preventing almost all tidal exchange. West of the causeway, where tidal flushing has remained unaltered the saltmarsh is considered to be in a natural state and better condition, with a high representation of *Tecticornia arbuscula* in a shrub like form. It is thought that the *Tecticornia* shrubbery takes considerable time to develop; however, this needs to be confirmed through dendrochronological analysis. It is likely that saltmarsh east of the causeway has changed in a manner consistent with altered drainage and salinity (Prahalad 2012).

Groundwater interaction with saltmarsh

Groundwater is likely to interact with the Lauderdale saltmarsh. Some limited groundwater mapping has been undertaken from a series of monitoring wells established on the Racecourse Flats saltmarsh and areas north of the Lauderdale canal (Cromer and Stephens 1992; Environmental and Technical Services 2001; Anderson and Matthew 2008). South of the Lauderdale canal the groundwater can be divided into four types:

1) Low salinity, or fresh water, associated with the sand dunes adjacent to the eastern side of the Racecourse Flats (aquifer and recharge area described in section 3.1.1).
2) Freshwater associated with an aquifer recharge area south of the existing saltmarsh (Figure 21).
3) Very high salinity water associated with the saltmarsh and adjacent land. This is from saltwater ingress into the groundwater table from the surrounding marine environment (Figure 21). This may have surface expression (formation of saltpans) where there is evaporation of marine influenced ground waters.
4) Low salinity leachate from the former Lauderdale landfill site, whereby rain events enable freshwater recharge, assuming infiltration into the landfill if the protective cap has been breached and then is released from the landfill as leachate.

North of the Lauderdale canal the groundwater has been divided into two types:

1) Low salinity, or fresh water, associated with the coastal sand aquifer bordering Roches Beach (described in section 3.1.1). This water flows east and west, draining from the central area of the Lauderdale isthmus.
2) Low salinity (fresh) water associated with Quaternary sediments west of the Roches Beach fore-dune.

Figure 21. Hypothetical map of ground water movement around Lauderdale BLUE HASHED AREA = Lauderdale saltmarsh; BLACK DASHED AREA = possible extent of the fresh groundwater aquifer south of Lauderdale; BLUE CIRCLED AREAS = ephemeral freshwater marshes on land surface; BLUE ARROWS = freshwater recharge and movement direction; ORANGE ARROWS = direction of saltwater intrusion into the aquifer. Based on distribution of ground water bores, local geological information and topography.

There are a large number of groundwater extraction points north and south of the Lauderdale area (Figure 22); however, the effect of extraction south of Lauderdale on the nearby saltmarsh is not known. If fresh groundwater availability or flow is reduced due to reduced rainfall or excessive fresh groundwater extraction this can increase soil salinity, as saline groundwater penetrates further inland and at shallower soil depths (Thibodeau *et al*. 1998). In some places excessive groundwater extraction can potentially cause saltmarsh subsidence (Kennish 2001), but this risk has not been assessed at Lauderdale.

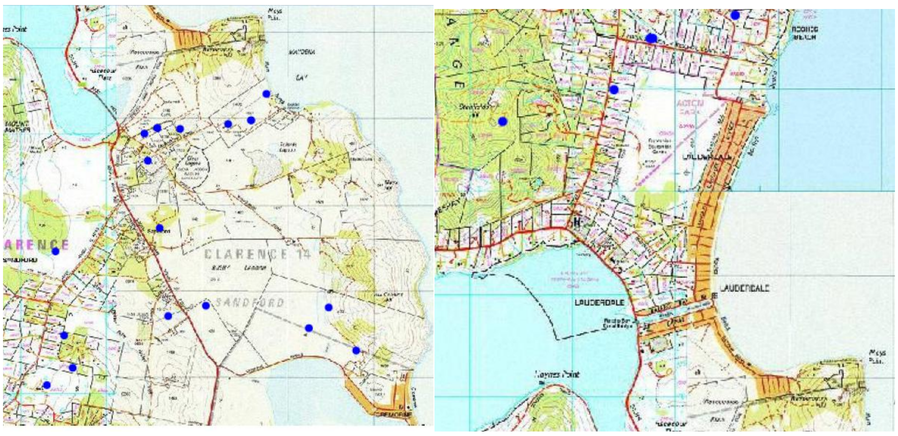


Figure 22. Blue dots represent known groundwater extraction bores for freshwater south (left image) and north (right image) of Lauderdale. The maps are available from *The Groundwater Information Access Portal* DPIPWE website (http://wrt.tas.gov.au/groundwater-info/ [cited 18-4-2012]).

Anthropogenic causes for loss of saltmarsh extent

During the recent past the saltmarsh has undergone anthropogenic loss in extent, and a likely change in floristic composition (Figure 23). The causes include:

- landfilling (e.g. Lauderdale landfill site) and past leachate release,
- urban and canal development,
- grazing,
- trampling (incompatible recreational use),
- loss of tidal connectivity due to South Arm causeway creation, and
- coastal erosion.

Figure 23. BLUE CROSS HATCHED AREAS = estimated loss of saltmarsh since development of Lauderdale township. PINK AREA = remaining saltmarsh (as of April 2012). The loss of saltmarsh has occurred due to various anthropogenic pressures. The remaining saltmarsh landward of South Arm Road has been altered floristically due to loss of tidal connectivity and anthropogenic pressures, which are also reducing habitat condition.

Previous monitoring around the former Lauderdale tip landfill site has identified leachate seeping out into the saltmarsh (Environmental and Technical Services 2001). The nutrient ammonia is one constituent of the leachate that has been found in high concentration (19 mg/L) in surface water on the southern side of the landfill site when sampled in March 2001 (Environmental and Technical Services 2001). Elevated nutrients in leachate from the landfill site my have caused localised eutrophic areas with excessive surface algal growth, resulting in saltmarsh loss and the formation of bare-ground areas where surface water now ponds after heavy rainfall (Figure 24). These are now saltpans, and their white appearance is due to salt formation due to evapotranspiration of the ponded water (Prahalad 2012). The salt is derived from surface inundation by seawater during storm surges, saline groundwater, or sea-spray. Leachate arising from the former Lauderdale tip is not thought to travel far enough within surface or groundwater to have a detectable impact on the surrounding marine environment (Anderson and Matthew 2008). Eutrophic conditions and associated nuisance algal growth has been noted periodically in East Marsh Lagoon (Aquenal 2008a), but it is unclear if leachate derived nutrients are contributing to this. Leachate release and movement may be very dependant upon the amount of rainfall upon the landfill, which may act as a recharge area for leachate. Leachate interaction with other groundwater types (described above) is not well understood. Creation of the landfill also disrupted the natural drainage of the saltmarsh, preventing surface water from draining away from the area northeast of the landfill, and has contributed to vegetation loss here (NorthBarker 2008).

Figure 24 Aerial photo (24-2-2012). Saltpans within surface depressions on the saltmarsh (red hashed areas) around the edge of the former Lauderdale tip landfill site. The surface depressions regularly become ponds during periods of heavy or frequent rainfall. The entire saltmarsh has been covered with water during periods of storm inundation.

There are five major stormwater drainage lines cut through coastal saltmarsh at Lauderdale (Figure 25). These drainage lines are associated with catchments of varying size and land uses, thus differ in pollutant loads that may be discharged or infiltrating into the saltmarsh. There are some obvious differences in the catchments and likely runoff pollutants:

- *Outfall 1* drains the largest area, at the head of the drainage network is an artificial freshwater wetland receiving urban and rural run off. This used to pass through an open drainage line (concrete construction) build within saltmarsh north of the Lauderdale canal. Over the last 18 month this saltmarsh has been largely landfilled and may now pose an acid sulphate soil risk (see section 4.6.1) to water quality at outfall 1.
- *Outfall 2* drains a small urban area, including the Lauderdale sports fields. Irrigation and possible fertilizer use on the sports field may contribute nutrients to the saltmarsh through which runoff from here drains. Excessive filamentous algal growth has been seen in the open drainage lines here consistent with high nutrient levels (Prahalad 2012).
- *Outfall 3* drains the eastern side of Racecourse Flats and may be influenced at times from leachate from the former Lauderdale tip.
- *Outfall 4* drains a multiple branched drainage line through the saltmarsh and receives runoff from an urban area and possible leachate from the former Lauderdale tip.
- *Outfalls 5 & 6* drain a rural paddock, with some surface drainage running from a small farm dam.

Diffuse surface flow onto the saltmarsh is expected to also occur from adjoining land.

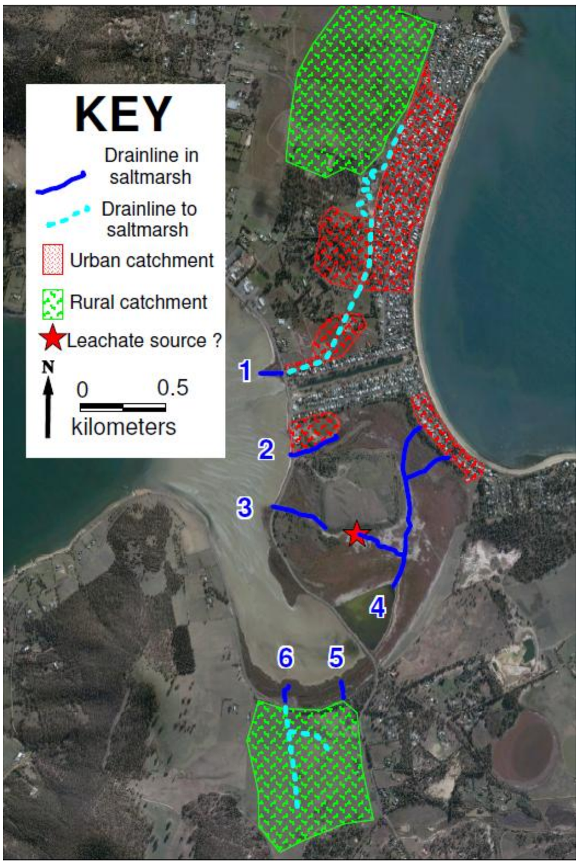


Figure 26 Drainage lines through saltmarsh and respective catchment areas, land use and possible leachate source. Numbers designate where drainage lines meet receiving waters.

3.6.2 Threatened flora

The known location of threatened (rare) flora species listed under the TSPA are illustrated in Figure 26. In the saltmarsh areas (ASS and ARS vegetation types) east of South Arm Road, the following species have been observed:

- narrowleaf blowngrass (*Lachnagrostis punicea ssp. filifolia*),
- tall blowngrass (*Lachnagrostis robusta*),
- golden dodder (*Cuscuta tasmanica*), and
- slender buttons (*Cotula vulgaris* var. *australasica*).

The narrowleaf blowngrass is confined to the Racecourse Flats saltmarsh, which is an important site for this species at a statewide level. There are few confirmed occurrences outside of this site (Whitehead 2010), although it is said to occur on states northeast and east coasts and elsewhere around Hobart (North Barker 2012). This area also appears to be of statewide importance for the presence of tall blowngrass (*Lachnagrostis robusta*). Golden dodder (*Cuscuta tasmanica*) also occurs within the saltmarsh, and at several landward sites. This species has ~10% of its' state observations within the Derwent foreshore (Whitehead 2010) and suitable habitat at Lauderdale is important for this species. The saltmarsh community contains two plants considered rare in Tasmania: candle saltmallow *(Lawrencia spicata*) and the many-stemmed bluebell (*Wahlenbergia multicaulis*) NorthBarker (2008), but neither are listed as threatened under the TSPA.

Amongst the saltmarsh on the seaward side of South Arm Road and Dorans Road are the threatened floral species:

- yellow sea-lavender (*Limonium australe*),
- fennel pondweed (*Stuckenia pectinata*) and
- tuberous tassel (*Ruppia tuberosa*).

It is uncertain if their distribution here indicates that they are restricted to the saltmarshes that have good tidal connectivity.

Other threatened floral species potentially exist amongst the Lauderdale saltmarshes, but have not yet been observed, such as roundleaf wilsonia (*Wilsonia rotundifolia*) (Enesar consulting Pty Ltd 2007).

3.6.3 Fauna -shorebirds

Nesting

Pied oystercatchers have a preference for nesting on sandier shorelines (above high watermark) on the seaward side of the Lauderdale road, but will nest amongst the saltmarsh on the landward side of the road within Racecourse Flats when the optimal sites are already occupied (see section 3.5.2). For example in 1991/92 five pairs of Pied Oystercatchers nested on Racecourse Flats. The Racecourse flats saltmarsh on the landward side of the South Arm Road is sub-optimal nesting habitat for Pied Oystercatchers as the non-flying chicks must cross the road to access tidal flats feeding areas on the, and are at increased risk of being hit by cars (Luke Einoder, *pers. comm.,* March 2012; Newman and Park 1992a in Woxvold 2008).. Adult birds may also leave chicks unattended more often when they are away foraging, leaving the chick at increased risk from predators.

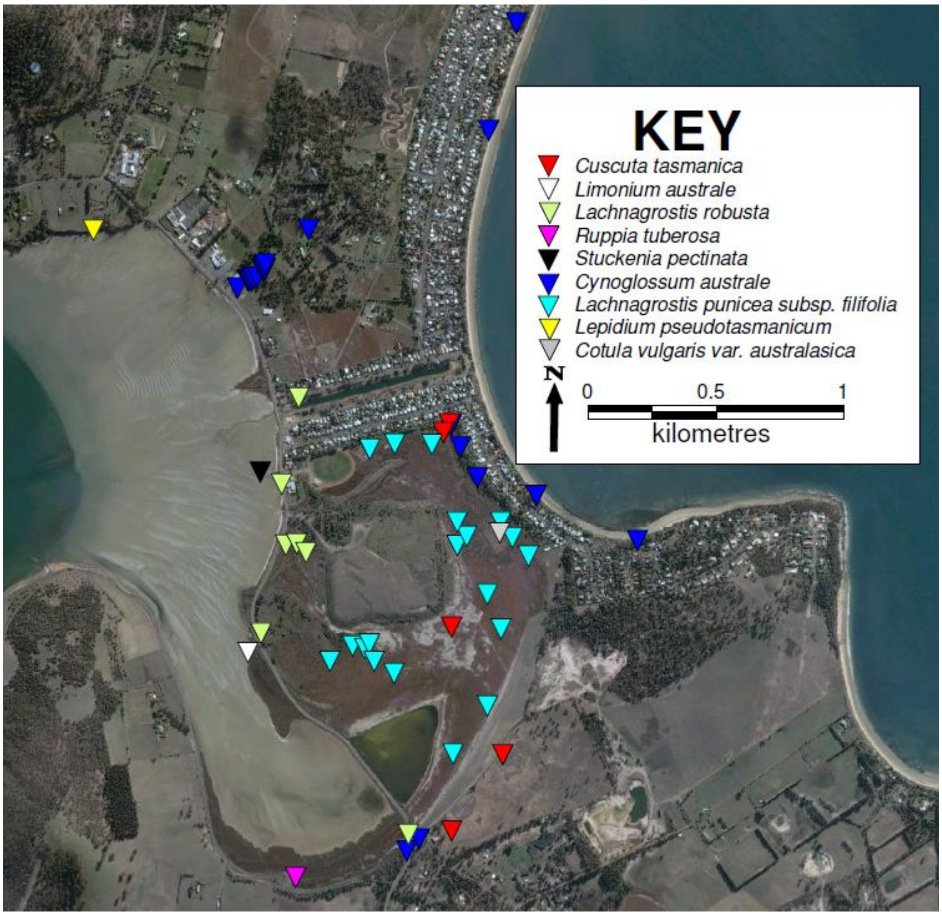


Figure 27 Known threatened flora observations (data from DPIPWE Natural Values Atlas 28-April-2012) and North Barker survey (May 2012) for the Derwent Estuary Program.

Roosting

Aquenal (2008b) identified five roosting sites in the Ralph Bay area. Four of the sites have connectivity with the tidal flat and occur seaward of roads, but one site occurs landward of the South Arm Road causeway on the unvegetated northern shore of East Marsh Lagoon. Some observed patterns in roosting site use include:

- During good to mild weather Pied Oystercatchers often roost in, and adjacent to, the manmade sand spit north of the Lauderdale canal and along the shoreline south of the canal.
- During storms and strong winds Pied Oystercatcher prefer roosting near vegetated saltmarsh areas along Dorans Road, Racecourse Flats and on bare ground near East Marsh Lagoon.
    - In the winter months Pied Oystercatchers form groups and huddle among saltmarsh vegetation to shelter from wind and weather.
    - Saltmarsh vegetation is typically low in height, so as to obtain wind protection, but still retain good sightlines so as to be able to see approaching predators such as dogs and cats (Einoder, *pers comm.*, April 2012).
    - However, roosting birds appear to avoid the higher saltmarsh vegetation types, such as the *Tecticornia arbuscula* shrubbery north of Dorans Road as this does not enable clear sightlines for observing approaching predators (Einoder, *pers comm.*, April 2012).

Foraging

Some shorebirds species, like Red Capped Plover, regularly forage for insects amongst the saltmarsh. Pied Oystercatchers will also forage amongst the saltmarsh, as will other wading shorebirds, when preferred tidal flat areas are inundated for prolonged periods (typically during extreme high tides or storm surges) (Einoder, *pers comm*., April 2012).

<u>3.6.4 Fauna - invertebrates</u>

The crustacean and mollusc species inhabiting the marsh surface at Lauderdale have been surveyed (Richardson *et al.*1997a). It was found that the species diversity at Lauderdale was similar to that from other south-eastern Tasmanian salt marsh sites.

Moths

Two moth species, listed as threatened (vulnerable) under the TSPA have been observed on the Lauderdale saltmarsh. These are the saltmarsh looper moth (*Dasybela achroa*) and chevron looper moth (*Amelora acontistica*). The salt marsh looper moth has been rarely identified outside of the Lauderdale saltmarshes. The chevron looper moth has also been recorded around the Lauderdale saltmarshes, and also at Cremorne near Pipe Clay Lagoon and at Kangaroo Island in South Australia (Parsons, in Enesar consulting Pty Ltd 2007). These moth species are nocturnal, are attracted to light sources and are likely to feed on the nectar of saltmarsh flowers, although their preferred plant foods have not been identified. It is possible that the larval stages may require woody native plant species from the fringing non-saltmarsh areas on which to feed and develop, and thus their survival is dependant upon both good saltmarsh and adjacent native vegetation (McQuillan, *pers. comm*. April 2012).

3.6.5 Ecosystem service

The Lauderdale saltmarshes provide a diverse range of ecosystem services:

- Habitat for threatened flora and fauna.
- Carbon capture (could be ~170 ton/year, if in a depositional area and based upon carbon burial of 210 C m^2/year within the existing 0.9 km^2 saltmarsh area (estimate based on information in Chmura *et al.* (2003)).
    - Saltmarsh capture carbon, but have very low methane emissions, and are considered to be one of the most valuable habitat types for storing green house gasses (Chmura *et al.* 2003).
- Nutrient and carbon cycling that contribute to tidal flat food webs in areas where there is tidal connectivity.
- Water filtering (from nearby catchment areas).
- Coastal protection from erosion wave activity.

4) Physical conditions required for perpetuity of natural assets

4.1) MAJOR ASSET type/area

Lauderdale & Roches sand dunes, threatened flora & fauna

4.1.1 Sand dune landform

Recent retreat of the dune system bordering the Lauderdale and Roches beaches has been documented (Sharples, *pers. comm.* March 2012; Carley 2012). Storm events cause erosion of the sand dunes, whilst deposition occurs between storm events, there has been a net loss of the dunes at a rate of ~8m (from the seaward edge) over the last 50 years (Sharples, *pers. comm.* March 2012). Rising sea-level is increasing the erosive effect of less intense storms, as wave run up more readily reaches the fore-dune and causes erosion.

4.1.2 Vegetation communities

Erosion of the sand dunes bordering Lauderdale and Roches Beaches is impacting upon threatened native vegetation communities growing here (DVC and DGL) as well as their associated threatened fauna and flora values. Sea-level rise may also increase the influence of seawater ingress into the ground water beneath the coastal dune complex, causing saltier ground water at shallower depths. Once Lauderdale is linked to the sewer network the household water previously released to septic and grey water infiltration trenches, will no longer be a source of freshwater into the ground water table and may exacerbate saltwater intrusion. Saltwater intrusion could harm mature trees that are growing on the dune complex if the saline water is in contact with their roots. A gradual decline in mature trees has also been noted from the Lauderdale area due to view enhancement from properties and risk abatement (danger from trees or limbs falling).

4.1.3 Future ecosystem services

The ecosystem services currently offered by the Lauderdale and Roches sand dunes in regards to wave and storm protection are in decline. Sand nourishment, if sustainable, may enhance dune protection in the short to medium near future. However, as sea-level rises the erosive ability of storms will increase in respect to the current beach and dune profile. Future erosion of the dune system will also result in removal of the native vegetation communities and associated threatened species values. The urbanised areas inland of the foreshore dune currently prevent natural dune transgression inland. Freshwater recharge of the dune aquifer will decline once Lauderdale is connected to sewer, and this may increase saltwater ingress and potential salinity risks to the native vegetation communities. Saline groundwater depth in the dune aquifer would also become shallower as sea-level rises.

4.1.4 Action options

Increases saltwater ingress of the sand dune complex ground water may be negated in part by the use of water sensitive urban design principles that encourages continued (or enhanced) use of infiltration of stormwater. Appropriate grey water disposal on individual properties may also assist in freshwater recharge of the sand dune aquifer.

To offset vegetation loss from the Lauderdale and Roches dunes complex it may be possible to revegetate areas inland, such as council owned land at Roscommon, (Figure 27). The revegetation of a large area of Roscommon is consistent with the 'Reserve Activity Plan' being prepared for the Clarence City Council. Revegetation efforts should begin in the near future to offset mature tree loss from the Lauderdale dunes (notably *E. globulus* used by swift parrots). The Roscommon soil type differs to that which developed on the sand dunes and the original vegetation was most likely *Eucalyptus amygdalina* coastal forest and woodland (TASVEG: DAC vegetation community). If the soil type at Roscommon is unsuitable for replanting DVC and DGL vegetation, other areas should be revegetated for these communities and new swift parrot habitat to offset future habitat loss from the Lauderdale sand dunes.

Figure 27. PINK OUTLINE = Roscommon (Clarence City Council land).

<u>4.2) MAJOR ASSET type/area</u>

Bambra Reef and Mays Point rocky shore: threatened seastars

<u>4.2.1 Rocky Reef and intertidal areas & Fauna – Live-bearing seastar</u>

During erosive storm events sand is eroded from dune systems and transported to the shallow sub-tidal environments (Figure 28 – Bruun Rule), then transported northward with longshore drift. This process has the potential to bury Bambra Reef and the Mays Point rocky intertidal zone beneath sand and cause the loss, or partial loss of threatened seastars *P. vivipara*, at the these sites. *Parvulastra vivipara* produce live-bearing young, and thus have poor dispersal abilities, and given the isolation that exists between colonies this species would be unlikely to recolonise these sites if they were temporarily buried by sand.

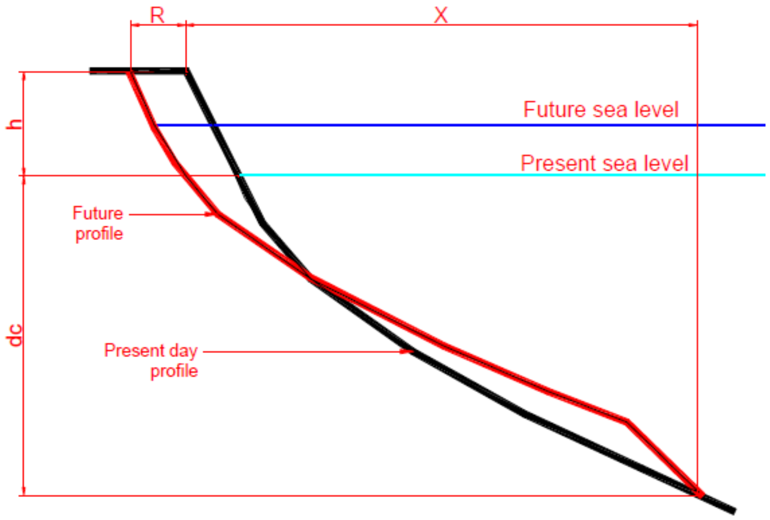


Figure 28. A hypothesis of changing profile of the Lauderdale and Roches Beaches due to sea-level rise and coastal erosion, based upon the Bruun Rule (which applies to sandy shorelines). Of relevance to the Bambra reef is the hypothesised increased depth of sand within the deeper water areas illustrated (shallow sub-tidal zone). Image from Carley (2011).

4.2.2 Future ecosystem services

Bambra Reef and Mays Point rocky intertidal zone are habitat for threatened species. The current observed variability in reef extent demonstrates that the *Parvulastra vivipara* colonies are vulnerable to sediment burial. The loss of these colonies would not signify loss of the entire species; however, as there are only 11 known colonies, each may have distinct genetic diversity. It is this potential diversity within the species that is at risk if the Bambra Reef and Mays Point colonies were to be lost.

4.2.3 Action options

It may be appropriate to translocate some individual *Parvulastra vivipara* from the Bambra Reef and Mays Point colonies to new sites that provide more secure habitat into the future, so as to preserve the potential genetic diversity that each colony may contain. Translocation has been successfully undertaken elsewhere (Prestedge 2001; Aquenal 2005). New sites will need to be separated from each other, and from existing colonies, so as to preserve potential genetic diversity that may exist between colonies. To assist the perpetuity of *Parvulastra vivipara* colonies at Bambra Reef and Mays Point efforts should be made to prevent negative impacts that could arise if water quality is reduced through sewerage spills, septic tank seepage or storm water runoff (Prestedge 1998)

4.3) MAJOR ASSET type/area

Southern Lauderdale sub-tidal seagrass beds

4.3.1 Vegetation- seagrass

Dense seagrass habitat occurs in shallow sub-tidal depths at the southern end of Ralphs Bay. Any excessive sand deposition within this zone may come from dune/foreshore erosion of Lauderdale Beach or Mays Beach to the south. Increases in sand from the south may change the shape of the sand lobe on the northern side of Mays Point (Figure 6), causing episodic burial of seagrass. As sea-level rises the light attenuation will increase at the current seagrass bed, this will cause a transgressive movement in the seagrass within the zone of optimal light conditions. Seagrass beds can also be prone to storm scouring from erosive wave action on the seafloor, poor water quality and human induced disturbance (e.g. boat anchor drag).

4.3.2 Future ecosystem services
The ecosystem services provided by seagrass here will continue in the future if seagrass is retained at this site through appropriate management.

4.3.3 Action options
Reducing human disturbance may increase the resilience of the seagrass community to climate change. Discouraging anchoring (or install seagrass friendly moorings) over the dense seagrass bed at the southern end of Lauderdale Beach, and also ensuring water sensitive urban design approaches are used in stormwater management in the adjacent area.

4.4) MAJOR ASSET type/area

Lauderdale and Roches Beaches and sub-tidal sand

4.4.1. Lauderdale and Roches Beaches
The future of the beach landform is largely dependant upon management actions proposed within the TCAP Pathway Scenario 3.

4.4.2 Future ecosystem services
The ecosystem services currently offered by the Lauderdale and Roches beach in regards to wave and storm protection are in decline. Sand nourishment, if sustainable, may enhance this ecosystem service protection in the short to medium near future. However, as sea-level rises the erosive ability of storms will increase in respect to the current beach profile. The ecosystem services provided by the intertidal and sub-tidal habitats to natural values will remain largely unchanged in the future if left natural & no beach nourishment or dune protection measures are installed. If coastal protection options are employed, the degree of ecosystem change will depend upon the specific protective measures used against coastal erosion.

4.4.3 Action options
If beach scraping is required to rebuild foreshore dunes, some recommendations have been made so as to avoid areas of high macrofauna density, such as the upper intertidal zone of Roches Beach, where the bivalve *Paphies elongata* is most abundant within the surface 30cm of the beach sands (Aquenal 2010b). It has been recommended by Aquenal (2010b) that regular invertebrate surveys should be undertaken on the beaches if coastal protection measures are employed, so as to assess the impact of the activity upon the beach.

4.5) MAJOR ASSET type/area

Ralphs Bay tidal flats and foreshore

4.5.1 Tidal flat and foreshore landscape
How the tidal flat will respond to sea-level rise depends upon sediment supply and future measures used for coastal protection. Possible scenarios include:

- Tidal flat transgression inland. This scenario would depend upon maintaining a sediment supply similar or greater than the current rate, and having suitable adjacent low topography areas for transgression to occur.
- The tidal flats stay where they are. This scenario would occur if the tidal flats were to accrete vertically, but depends upon the sediment supply increasing so deposition keeps pace with the rate of sea-level rise.
- Loss of tidal flats, due to lack of sediment supply or areas for transgression.

The following are some general geomorphological comments relevant to the tidal flat land form at Ralphs Bay.

Are the current tidal flats in equilibrium with the current environmental conditions?
Research illustrates a net erosion of the saltmarsh edge, bordering the south-eastern edge of the Ralphs Bay tidal flat (Prahalad 2009). Cycles of erosion and accretion of saltmarsh can occur, with cycles of storm erosion and calm weather, allowing saltmarsh accretion; however, a long term trend of net loss can occurs when there is a deficiency in sediment supply to maintain the current tidal flat profile (Marriotti & Fagherazzi 2010). It is likely that net erosion of saltmarshes at Ralphs Bay is being exacerbated by ongoing sea-level rise.

Will tidal flats occur here, or nearby, in the future as sea-level rises?
The rate of sea-level rise versus tidal flat sediment deposition, steepness of the surrounding topography and management of the coast and hinterland will determine if tidal flats will occur at Lauderdale in the future.

The rate of sea-level rise exceeds the estimated rate of deposition on the Ralphs Bay tidal flats and will result in a relative increase in water depth over the tidal flats. Tasmania is currently experiencing a sea-level rises of 3.3 ±0.4 mm/year (Grose *et al.* 2010). This exceeds the estimated sediment deposition rate of 0.5 to 2.05 mm/year (see section 3.5.1) If these sediment deposition rates are applied to the tidal flats, the sea-level will become relatively deeper here in the future, as the rate of sea-level rise exceeds deposition. The increased water depth will increase the erosive energy of wind waves on the existing foreshore. The erosion of some surrounding coastal areas by wave activity may contribute to tidal flat deposition, especially from the more erosion prone coastal areas (Figure 29). The areas are Quaternary sediments to the north of the tidal flats and erosion of elevated saltmarsh (as documented by Prahalad (2009)). Some coastal areas are very likely to be fortified against coastal erosion to protect the South Arm Road and built infrastructure (consistent with TCAP pathway scenario 3). This will prevent some the raised relict deposits of beach shingle & shells, mapped by Davies (1959), on the landward side the South Arm Road from contributing to coastal sediment supply to the tidal flats (Figure 29). Erosion of the remaining coastal areas around the tidal flats may be insufficient to sustain deposition at a rate consistent with sea-level rise. As a result, it is likely that the current tidal flats will be inundated by sea-level rise and deeper intertidal zone areas will become shallow sub-tidal habitats no longer exposed during low tide.

A sea-level rise of ~80cm has been projected for 2100 based upon a high green house gas emission scenario (Grose 2010). As sea-level rises the tidal flats could transgress landward onto low lying areas. The topography of the land is too steep in the north for this to occur. Much of the land east of the current tidal flats, although low lying, is occupied by built infrastructure assets, which under the preferred *TCAP pathway 3* are likely to be protected from sea-level rise and coastal erosion. The most likely area for tidal flat transgression is the Racecourse Flats saltmarsh and areas to the south of this location. Future tidal flat creation here will require connectivity to the sea, which is not present because of the South Arm Road causeway. As sea-level rises the loss of the tidal flats may be more acute in the northern and middle sections of the existing tidal flat extent, due to lack of future sediment supply and areas for transgression (Figure 30 and Table 2).

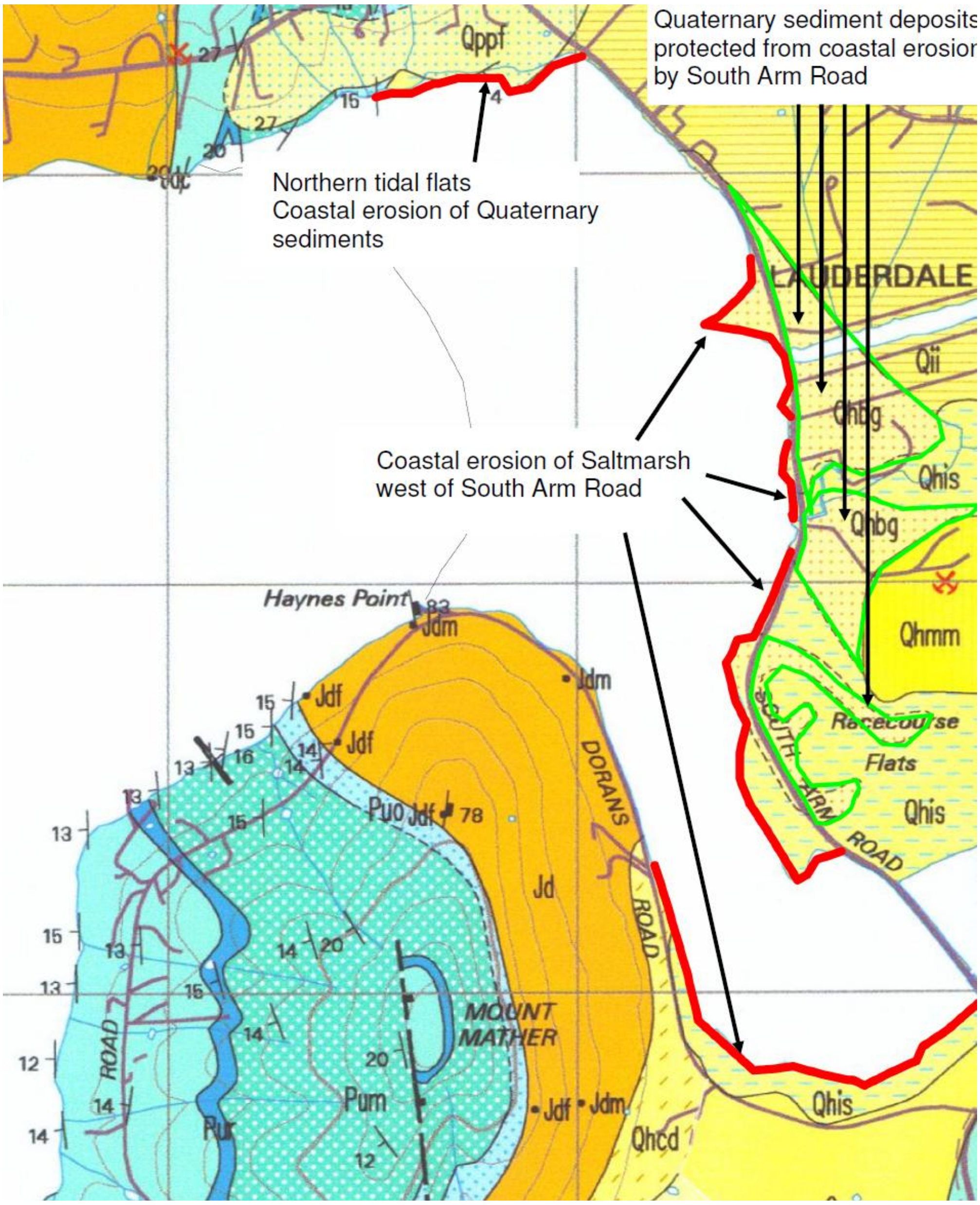


Figure 29. Areas of current coastal erosion of Quaternary sediments and saltmarsh, which may contribute to tidal flat sediment deposition (RED LINES). Quaternary sediments (Davies 1959) (GREEN OUTLINED AREAS) and saltmarsh east of the causeway may be protected from coastal erosion by South Arm Road and are unable to provide sediment to the tidal flats. Base map from Taroona 1:25000 geology map sheet 5224 produced by Mineral Resources Tasmania.

Figure 30. Current tidal flats and possible changes in tidal flat extent and configuration by 2100 with ~80cm sea-level rise (SLR). This projection assumes little sediment input to the tidal flats. As sea-level rises the western tidal flat areas will become sub-tidal habitat and the saltmarsh currently at the edge of the tidal flats will be future tidal flat areas. The projected 2100 tidal flat configuration assumes full tidal connectivity beneath the South Arm Road causeway (RED HASH AREA = area of tidal flat impacted if no tidal connectivity beneath the causeway). DASHED BLACK LINES = ~25cm bathymetry contours The Projected 2100 tidal flat configuration assumes that protective engineering work will occur with the vertical building up of the South Arm Road, north of the Lauderdale canal, so as to prevent coastal inundation and tidal flat transgression inland here (this is consistent with TCAP scenario 3).

Table 2. Estimated changes in tidal flat extent (current to 2100 based on ~80cm SLR)

	Current tidal flat (km2)	2100 tidal flat (km2)	change (km2)
Northern total	0.79	0.20	*- 0.59*
Southern - area west of causeway	0.80	0.77	*- 0.03*
Southern - area east of causeway	0.08	0.55	*+ 0.47*
Southern total	0.88	1.32	*+ 0.44*
TOTAL exclude east of causeway	1.59	0.97	*- 0.62*
TOTAL include east of causeway	**1.67**	**1.52**	*- 0.15*

Natural asset loss or modification will occur due to changed tidal flat configuration and size reduction

4.5.2 Fauna- shorebirds

The tidal flats and shallow waters of Ralphs Bay are of particular importance to shorebirds. The potential loss or reduction in tidal flats at Ralphs Bay may impact upon Whimbrel and Grey-tailed tattler, which are relatively rare in the DEPA and shows a preference for foraging in the northern area of the Ralphs Bay tidal flat. If this habitat area is lost, or reduced in size, these species could be lost from the DEPA (Cardno 2009) if no suitable habitat occurs in the future.

It has been hypothesised that a reduction in the extent of the Ralphs Bay tidal flats (through development) would cause displacement of some shorebirds to other coastal areas (Cardno 2009); and it has been assumed there would be little change in total bird numbers if suitable foraging habitat was available in other areas within the DEPA (Cardno 2009). However, the impact of sea-level rise is not a local event and has to be assessed at a DEPA scale to fully understand the effect on shorebird habitat and numbers. Initial findings suggest that adjacent saltmarsh habitat in the Pittwater Lagoon (within the DEPA), which has important shorebird values, will dramatically decline in the future due to coastal squeeze resulting from sea-level rise (Prahalad 2009). The potential sea-level rise impact on other tidal flats within the DEPA need to be assessed to fully understand the regional impact on shorebirds.

At Ralphs Bay the loss of the tidal flats may be more acute in the northern and middle sections of the existing tidal flat extent (Figure 30 and Table 1). These areas differ in their bedform, infauna, and utilization by shorebirds. The southern tidal flats currently appear less utilized by shorebirds, with apparent preferences for foraging currently occurring in the north and middle sections (Figure 12). With sea-level rise the tidal flats are expected to transgress over the existing Racecourse Flat saltmarsh and nearby low topographic areas, and are likely to be similar to adjacent southern tidal flats (in regards to bedform, aquatic flora and fauna). The result may be that in the future the Lauderdale tidal flat area will not be as productive for some wading shorebird species (e.g. Pied Oystercatchers); however, restoring tidal connectivity to the Racecourse Flats saltmarsh may improve carbon and nutrient cycling from the adjacent saltmarsh habitat into the tidal flat environment.

Rising sea-level will also impact upon bird nesting and roosting areas. The current thin strip of beach and saltmarsh on the seaward side of the road will diminish as sea-level rises. The roosting sites within saltmarsh west of the South Arm Road and north of Dorans Road (Figure 12) will become less satisfactory, or may be abandoned, by 2100 with loss of nearby saltmarsh and increased time of tidal inundation. (Figure 30). Episodic high tide events will also cause birds to roost closer to the South Arm Road, where they are at increased risk of being hit by vehicles. At Ralphs Bay the Pied Oystercatchers appear to have a preference for nesting along the northern shore adjoining the tidal flats (Figure 12). It was noted in section 3.5.2 that the preferred nesting sites have connectivity to the tidal flats (and are seaward of the South Arm Road) as flightless chicks have better access to the preferred tidal flat foraging areas. In the future, the preferred nesting sites may become squeezed against the steeper topography of the shoreline scarp (north of the tidal flats) and the South Arm Road (east of the tidal flats) due to sea-level rise. In response, there may be a future increase in the use of sites of lower quality for bird nesting activity on the Racecourse Flats saltmarsh.

4.5.3 Fauna – recreationally targeted fishing (notably flounder)

Greenback flounder are a recreationally targeted fish species found on the tidal flats at Ralphs Bay. This area (along with other suitable Derwent flounder fishing areas) supports up to 2% of the state recreational flounder harvest (Lyle 2005). It is noteworthy that at the time of a 2000/1 recreational fishing survey that the largest recreationally caught flounder numbers came from adjacent areas in Pittwater, Norfolk- Fredrick Henry Bay (24% of total harvest) and the D'Entrecasteaux Channel (33%) (Lyle 2005). A relative deepening of the water over the existing tidal flats may cause a loss of intertidal invertebrate beds that provide food for some fish, notably flounder and goby. The potential loss, or reduction, in flounder at Ralphs Bay may cause a deflection of flounder fishing effort to adjacent areas (assuming suitable habitat and fish numbers remain in these areas in the future).

4.5.4 Fauna - marine mammal stranding risk

The distribution of cetacean strandings recorded in the Derwent estuary since 1912 are maintained in the *Whalebase* database of the *Department of Primary Industries, Parks, Water and Environment* (DPIPWE) (Aquenal 2008a). The shallow tidal flats are the main area where previous strandings have occurred. Bottlenose dolphins (*Tursiops truncatus*) and Common dolphins (*Delphinius delphis*) have stranded on the southern tidal flats at Ralphs Bay. A relative deepening of the water over the existing tidal flats may alter the risk of stranding in the general area – it is unclear if this will increase of decrease.

4.5.5 Future ecosystem services

A future reduction and change in the tidal flat configuration may see a decline and alteration in a number of ecosystem services, notably: reduced denitrification capacity for the larger Ralphs Bay region (having flow on effects to values within and outside of the current study area). The larger Ralphs Bay region already experiences excessive filamentous algal growth on sub-tidal sediments, during winter, creating a habitat type unsuitable for the critically endangered spotted handfish *Brachionichthys hirsutus* (Aquenal 2008a). Reduced denitrification, due to reduced tidal flat extent, may exacerbate this threat.

A future reduction in tidal flat size would also reduce the habitat size for recreationally targeted fish species (e.g. flounder). A net loss in tidal flats at Ralphs Bay would also cause a localised reduction in foraging habitat for wading shorebirds, and increase wind-wave energy near coastal nesting sites (in particular the northern section of the bay that is most exposed to the prevailing south-westerly winds). The overall impact on shorebirds needs to be assessed in terms of what impacts would also be predicted to occur throughout the DEPA.

Increased coastal waves create coastal erosion risk to:

- roads and other infrastructure,
- edge of the Lauderdale tip landfill site,
- potential acid sulphate soils along the coast (Figure 31), and
- saltmarsh palaeosols (releasing carbon).

Sea-level rise, in areas of low wave energy and sediment deposition may enable:

- potential acid sulphate soil burial (reducing associated risk from oxidiasation), and
- saltmarsh palaeosol burial (storing carbon) (section 4.6.2 for more details).

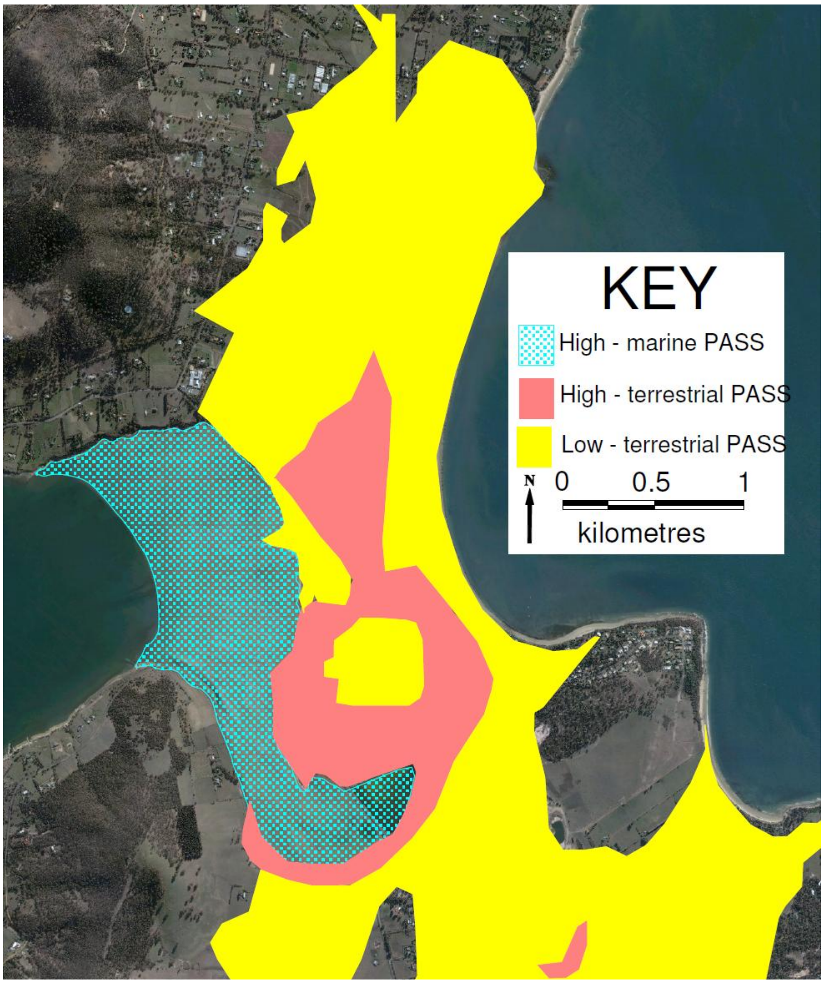


Figure 31. Map of Potential Acid Sulphate Soils in marine and terrestrial areas around Lauderdale. High PASS = >70% chance of occurring in mapping unit; Low PASS = 6 to 70% chance of occurring in mapping unit. Information from the LIST website:http://www.thelist.tas.gov.au/listmap/listmap.jsp?cookieteststate=check&llx=507800.0&lly=5238420.0&urx=544000.0&ury=5261900.0&layers=268 [cited 25-4-2012]

4.5.6 Action options

Site management should:

- Improve the tidal flushing beneath the South Arm Road causeway to enable healthy tidal flat habitat to occur east of the road, which can be more readily accessed by flightless shorebirds chicks for foraging.
- Explore infrastructure options that will enable flightless shorebird chicks to access the more extensive foraging areas west of the causeway so as to reduce the risk of birds being hit by vehicles.

4.6) MAJOR ASSET type/area

Lauderdale saltmarshes

4.6.1 Vegetation

Aerial photo analysis has illustrated that since 1975 the saltmarsh fringing the Ralphs Bay tidal flats has been lost at the seaward edge by up to 5-10m, and in some places >10m (Prahalad 2009). Wind-wave and storm erosion is considered the main physical process (coupled with increasing sea-level) and lack of sediment to sustain the current tidal flat profile. The erosion is occurring to the saltmarsh seaward of South Arm Road causeway and Dorans Road. This saltmarsh is in very good condition and contains the most extensive areas of a *Tecticornia sp.* shrubbery. The shrubbery is also present in the saltmarsh on the landward side of the South Arm Road causeway, where the saltmarsh is considered to be in poorer condition and floristically altered from it's natural state due to lack of tidal flushing. The extent of the shrubbery with Racecourse flats could be expanded with improved tidal flushing (V. Prahalad, *pers. comm.* June 2012).

The TCAP Pathway Scenario 3 identifies an inundation risk to infrastructure and suggests an option is the taking of sediment from public lands for landfill protective works. The Racecourse Flats area has a high potential for acid sulphate soils (Figure 31), so the taking of sediment from here for the use as landfill is not advisable. This can result in the leaching of acid from the soil, which can cause environmental harm and risk to some infrastructure (e.g. concrete construction). It is also noteworthy, that the TCAP Pathway Scenario 3 encourages landfilling north of the Lauderdale canal. Some previously undeveloped areas have been recently landfilled here, in particular those areas on saltmarsh having high potential for acid sulphate soils (Figure 32). Encouraging landfilling here within the TCAP Pathway scenario 3 may trigger the *Tasmanian Acid Sulfate Soil Management Guidelines* (see: http://www.dpiw.tas.gov.au/inter/nsf/WebPages/SWEN-83NVBG?open [cited 29-April-2012]). The guidelines are triggered here when there is dumping or filling of land with more than $500m^3$ of soil to a depth of greater than 0.5m, further site assessment and advice should be sought and acid sulphate soil management plans may be required from the property owners so as to minimise environmental harm.

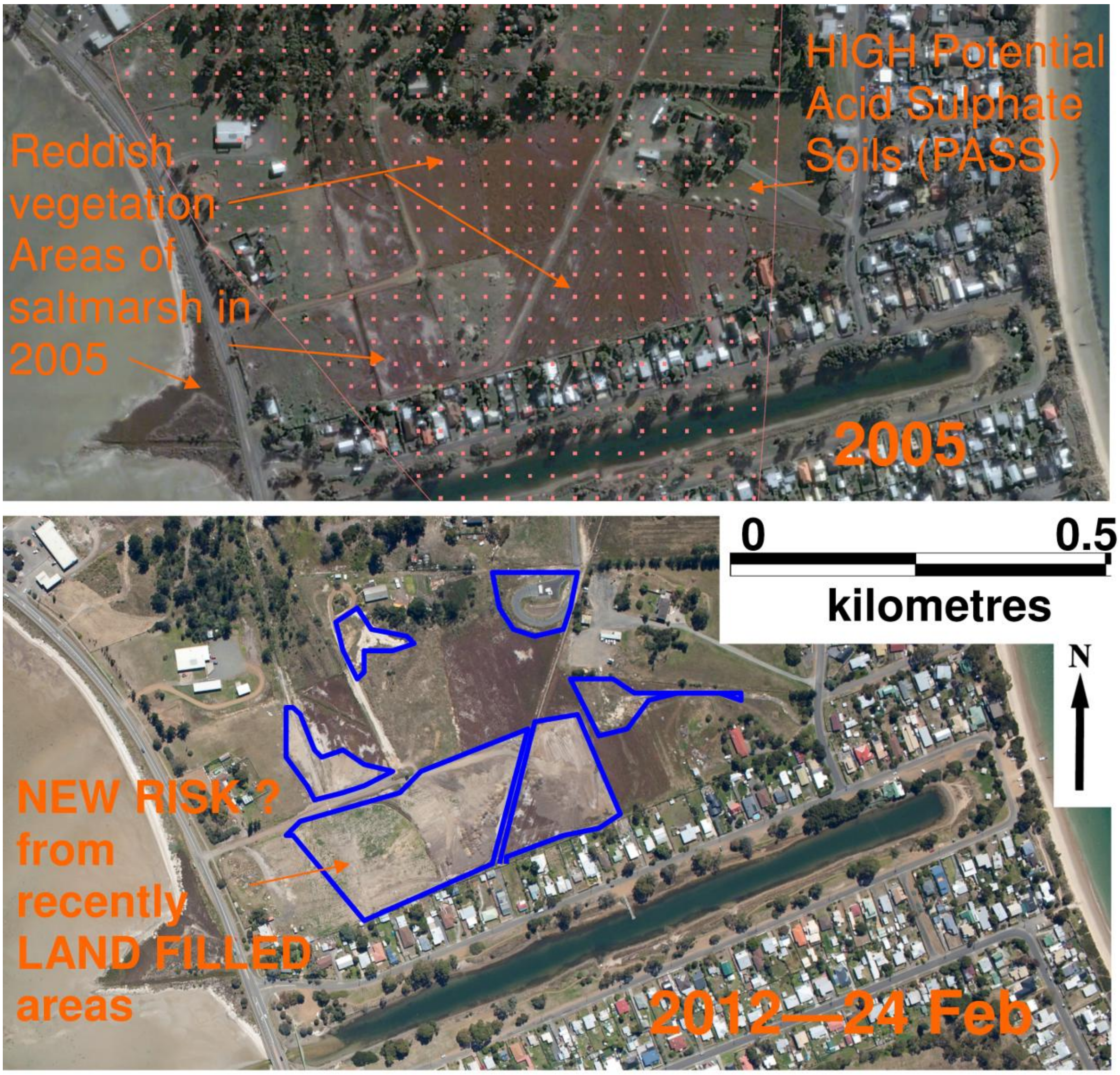
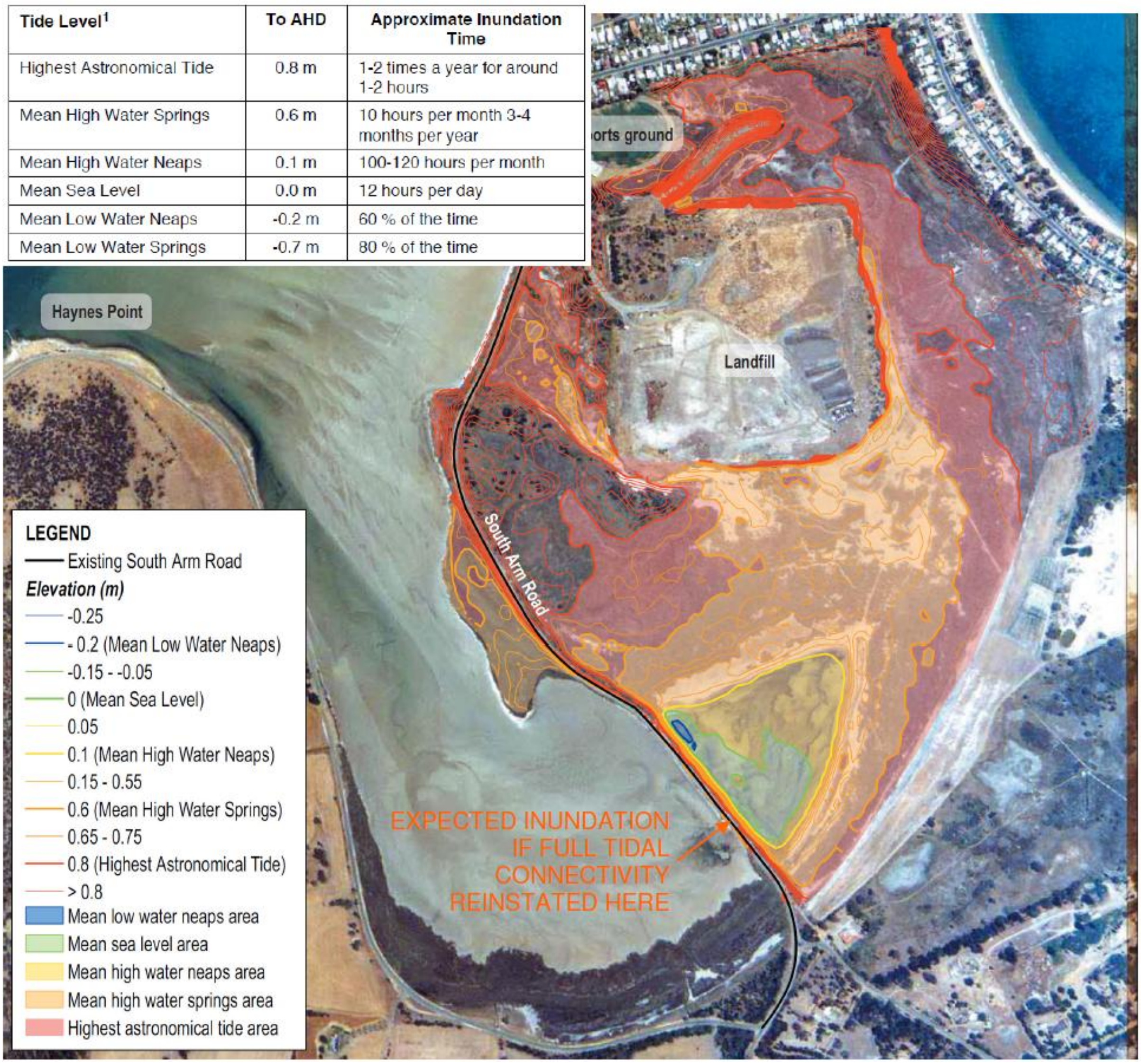


Figure 32. Map of saltmarsh areas (2005) recently landfilled (as of 24 Feb 2012) and that may now pose an acid sulphate soil risk to infrastructure and the environment (unless site assessment undertaken).

Previous analysis has identified the frequency of inundation (excluding storm and wind set-up effects), during an annual tidal cycle if a bridge were built to enable full tidal connectivity (Figure 33). The frequency of inundation to the edge of the Lauderdale landfill would be 10 hours per month (3-4 months a year) during High Water Spring Tides, and 1-2 hours (1-2 times a year) during the highest astronomical tide (Enesar consulting Pty Ltd 2007). Inundation to the edge of the Lauderdale landfill (former tip), may compromise the protective sediment cap over the tip if wind fetch wave erosion occurs. Erosion combined with increased inundation may also increase leachate mobilisation.



Tide Level[1]	To AHD	Approximate Inundation Time
Highest Astronomical Tide	0.8 m	1-2 times a year for around 1-2 hours
Mean High Water Springs	0.6 m	10 hours per month 3-4 months per year
Mean High Water Neaps	0.1 m	100-120 hours per month
Mean Sea Level	0.0 m	12 hours per day
Mean Low Water Neaps	-0.2 m	60 % of the time
Mean Low Water Springs	-0.7 m	80 % of the time

Figure 33. Coloured zones over the Racecourse Flats saltmarsh identify areas inundated during particular heights within an annual tidal cycle if full tidal connectivity installed (e.g. bridge beneath the South Arm Road causeway) (map modified from Enesar consulting Pty Ltd 2007 and topographic information from LiDAR).

The hydrology of the wetlands has also been altered by the presence of the landfill, causing water to pond after heavy rainfall to the north-east of the fill (North Barker 2008). The installation of appropriate drainage lines may be required, especially before full tidal connectivity reinstated to improve the vegetation condition here.

Future saltmarsh habitat areas

It is possible to map future saltmarsh extent inland by adding projected sea-level rise heights to the 1/100 year storm surge height. A projected sea-level rise of 82cm by 2100 has been modelled from high greenhouse gas emissions scenario (Grose *et al.* 2010). Based upon this projection, the landward extent of saltmarsh around Lauderdale by 2100 would be at an altitude of 200 cm AHD. A 200 cm AHD contour line has been created using LiDAR data having ±25cm accuracy (Prahalad *et al.* 2009) and the corresponding projected saltmarsh distribution is illustrated in Figure 34. A sea-level rise of 90cm could see saltmarsh transgression further into Roscommon (Figure 35). The projected saltmarsh extent consistent with TCAP

Pathway Scenario 3, is illustrated in Figure 36, and excludes those areas where infrastructure protection and landfilling is likely to occur.

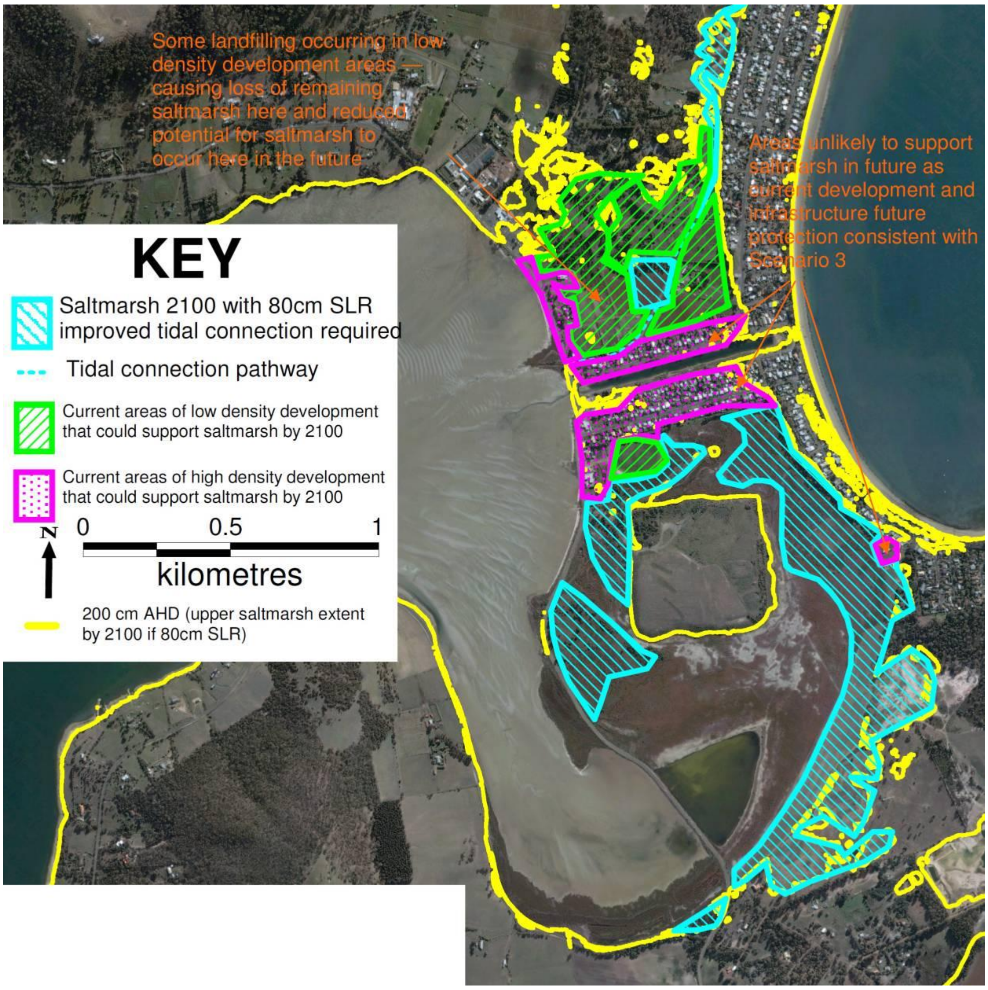


Figure 34. Map of projected saltmarsh extent in 2100 if ~80 cm sea-level rise (SLR) to illustrate other areas where saltmarsh could establish if allowed to. Infrastructure protection consistent with TCAP pathway scenario 3 will prevent saltmarsh establishing upon areas that currently have high density development. Landfilling is current occurring over saltmarsh remnants, north of Lauderdale canal, within the region identified as currently low density development.

It would be assumed that transgression of the Lauderdale saltmarsh inland would also enable associated natural values and threatened species to also transgress inland. Some consideration needs to be given to this process as a number of threatened species have been identified on the Lauderdale saltmarsh. It could also be possible that some natural assets and threatened species will be displaced or locally lost by saltmarsh transgression by 2100, such as the:

- *Eucalyptus viminalis and E. globulus* trees (TASVEG: DVC vegetation community) on the north-eastern and eastern edge of the current Racecourse Flats saltmarsh.
  - Threatened species occurring within the DVC vegetation, but not observed in the saltmarsh (e.g. Australian hounds tongue *(Cynoglossum australe*) may also be displaced or lost from this site.

Consideration should be given to areas where these non-saltmarsh natural values can also transgress. Some values may be little effected by saltmarsh transgression, such as the threatened flora golden dodder (*Cuscuta tasmanica*) occurring within former grazing land now used by Broadcast Australia for antennae installation, south of Racecourse Flats (Whitehead 2010). This species has also been observed within the Racecourse Flats saltmarsh; however, some effort should be made to determine what is its' habitat preference.

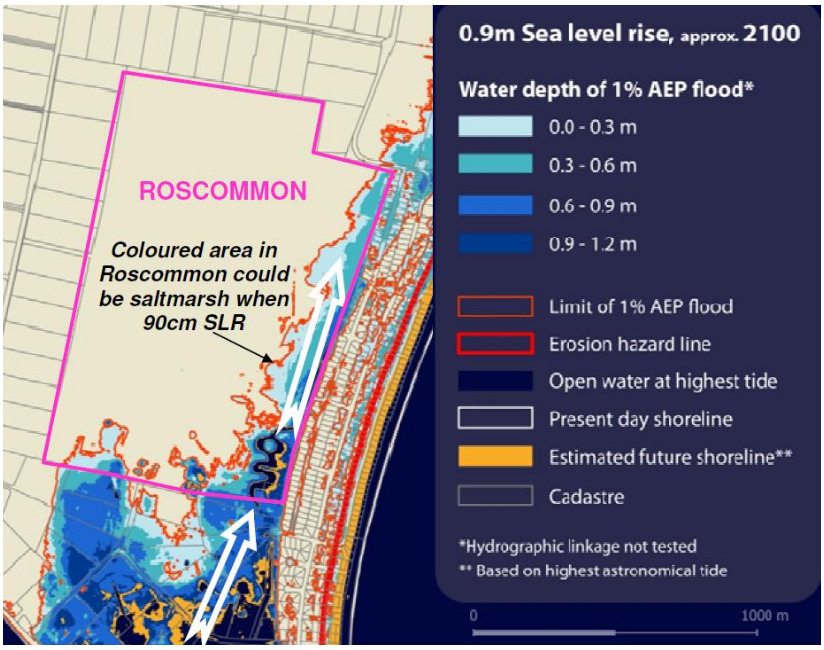


Figure 35. Clarence Council land (Roscommon) outlined in pink. The orange line in Roscommon signifies the 1/100 year storm surge height combined with 90cm SLR (height information from LiDAR). This line is also the projected upper limit of saltmarsh vegetation corresponding with a 90cm SLR. White arrows indicate a possible saltmarsh transgression pathway into Roscommon, if connectivity is allowed. The eastern 'coloured' side of Roscommon could support saltmarsh when 90cm SLR, but this saltmarsh would most likely have poor connectivity with the remaining Lauderdale tidal flats due to infrastructure protection consistent with TCAP Pathway Scenario 3. The long term future of any saltmarsh that may develop on Roscommon could also be compromised at a later date if the dune complex to the east is unable to protect the saltmarsh from wave action. This situation would occur if sea-level rises over the dunes or coastal erosion causes their loss (map modified from SCS Economics and planning (2012)).

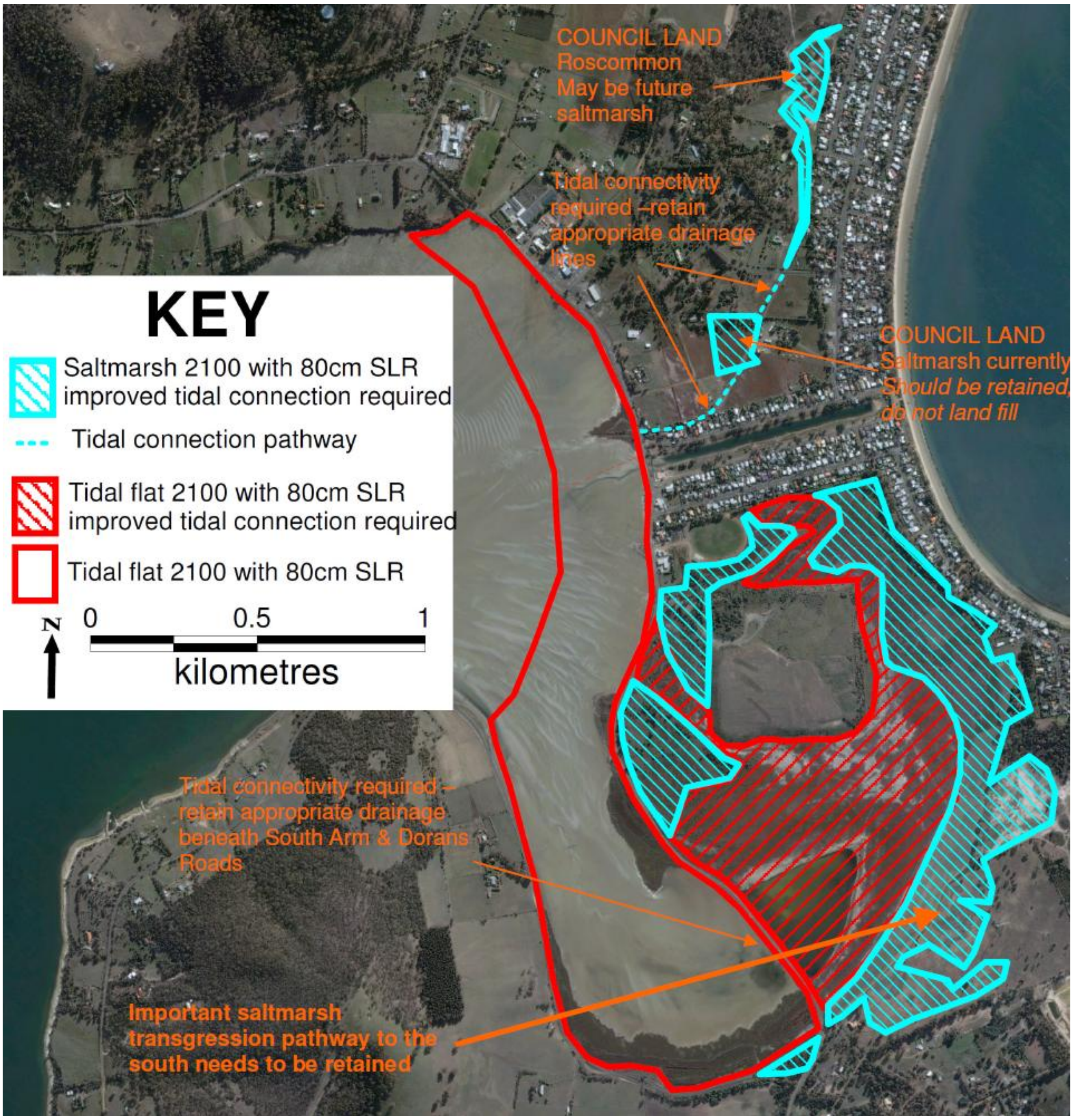


Figure 36. Map of projected saltmarsh extent in 2100 if ~80 cm sea-level rise (SLR). Important transgression pathways, with connectivity to existing saltmarsh, occur on the southern side of the Racecourse Flats saltmarsh. North of the Lauderdale Canal, some existing saltmarsh occurs on council land, and should be retained. Saltmarsh should be encouraged to colonise council land within the Roscommon. However, the northern sites are unlikely to support shorebirds as there will be no connectivity to the tidal flats and unclear if threatened moth species (currently occurring at Racecourse Flats) will also occupy the northern site.

4.6.2 Future ecosystem services

Saltmarshes can act as effective carbon storage areas; however, the effectiveness of their ability to capture carbon in the long term depends upon subsequent erosion or deposition processes that determine if the carbon is reworked and released back into the environment or buried and effectively captured into the future. Sediment processes in the northern section of the Lauderdale tidal flats have been studied through the collection of sediment cores, varying in depth from 3.3m to 7.6m (GeoCoastal 2009). The changes in sediment types down the cores reveal that in the past terrestrial palaeosols had formed during relatively lower sea-level stands in the past, and that in some places have been preserved beneath marine and intertidal sediments. However, there is a lack of horizontal continuity within these palaoesol horizons, illustrating erosion processes have also occurred. This observation is relevant for assessing the likelihood of carbon within existing saltmarsh soils becoming buried (thus capturing the carbon) or being eroded (releasing the carbon). The horizontal extent of saltmarsh erosion has been documented within Prahalad (2009), but vertical depth or removal also needs to be assessed. This assessment will determine the future long term effectiveness of this habitat to capture and store carbon.

Saltmarsh also provides habitat for shorebirds and threatened moth species. A net loss, change in condition, or loss of structure (e.g. loss of *Tecticornia arbuscula* shrubbery) may impact upon some of these ecosystem services. The amount and condition of saltmarsh also affects its ability to cycle nutrients and carbon to adjacent tidal flat food webs, which are linked to recreationally targeted fish species (e.g. flounder). The presence of saltmarsh also provides coastal protection from wave activity, but the effectiveness of this service is in decline along the seaward edge of South Arm Road and Dorans Road.

4.6.3 Action options

Action is required to protect and improve the condition of the remaining saltmarsh habitat in the Lauderdale area, and retain areas for them to transgress into in the future.

- Creation of a management plan for saltmarshes in the area may assist targeting resources and priotising the actions that are required.
- Tidal connectivity needs to be re-established beneath the South Arm Road causeway to enable elements of the better condition saltmarsh flora (notably the *Tecticornia* shrubbery) to re-establish at Racecourse Flats and to enable saltmarsh to transgress inland. Management considerations need to be made now for protecting and improving the condition of the remaining saltmarsh and fringing native vegetation.
    - To improve the tidal connectivity to Racecourse Flats saltmarsh an engineering solution is required beneath the South Arm Road causeway.
    - On ground work to install tidal connectivity beneath the causeway will need to be undertaken with consent and cooperation from the Tasmanian *Department of Infrastructure, Energy and Resources* (DIER) (who manage and maintain the South Arm Road causeway) and Clarence Council (owners of Racecourse Flats).
    - A community communication strategy is required to proceed and accompany the timing of any on-ground work. There is community awareness that the East Marsh Lagoon currently becomes eutrophic and public complaints are regularly made about the smell of rotting organic mater here. Increased tidal flushing should reduce the risk of eutrophication; however, previous efforts to open existing pipes beneath the causeway have resulted in some members of the public blocking the pipes.
    - Full tidal connectivity is a desirable outcome for the saltmarsh, as is the creation of healthy tidal flat habitats east of the South Arm Road causeway, but until risks associated with frequent inundation to the

edge of the Lauderdale landfill can be fully assessed and mitigated – installing a smaller tidal amplitude (e.g. height of Highest Astronomical tide not to exceed 0.5 m AHD) to East Marsh Lagoon may be appropriate. There are examples from interstate where shallower tidal amplitudes have been engineered and installed to saltmarshes, which have been cut off from the sea due to road causeways (e.g. Mutton Cove saltmarsh in South Australia (Cook and Coleman 2003)). A similar engineering approach could be initially undertaken at Lauderdale to manage the tidal flushing of East Marsh Lagoon and improving the Racecourse Flats saltmarsh, until risks associated with the Lauderdale landfill are assessed and rectified (if required). This option should be taken before full tidal flushing reinstated. The following steps may be applied:

  - Reassess the topography of the saltmarsh and surrounding land (improve upon current Lidar data), so inundation levels can be assessed in greater detail.
  - Identify an appropriate initial partial flushing regime, which poses little risk to the Lauderdale landfill and will improve habitats east of the South Arm Road causeway.
  - Install partial flushing measures and undertake communication strategy.
  - Monitor habitat changes from partial flushing and risks to landfill.
  - Prepare site for full tidal flushing by installing mitigation measures (if required) to reduce risk to the Lauderdale landfill site.
  - Gradually increase to full tidal connection at a rate that enables natural asset adjustment.

- Reduce human disturbance of the saltmarsh. Review current user activities (e.g. motor bike and pushbike use, dog walking, horse riding, walking area). Prevent off- road vehicle use (through fencing, signage, changed user behaviour and use of the area, increase policing if some user activities prohibited).
- Improving fringing non-saltmarsh vegetation, which may be important for completion of the life cycle of some saltmarsh species.
- Prevent landfilling of remaining saltmarsh, especially Racecourse Flats and council land north of the Lauderdale canal.

To enable saltmarsh transgression inland at Lauderdale the appropriate land use planning measures need to be put in place. On option would be the creation of a ‘natural coastal processes’ planning layer, or incorporating this concept into existing or future planning scheme revisions. For further discussion on this see Whitehead (2011). Land use planning and hydraulic management considerations need to be made so as to enable saltmarsh transgression and preservation of associated natural asset into the future, well beyond 2100 with the identification of ‘long term refugia corridors’ through which the saltmarsh and tidal flats can transgress (Figure 37). As this occurs some existing asset areas will change, for example by 2100 some forest areas near Racecourse Flats will become saltmarsh, and current saltmarsh areas will become tidal flats. There will also be subtle transitions within specific asset types (e.g. changes within saltmarsh vegetation consistent with changes in drainage and salinity).

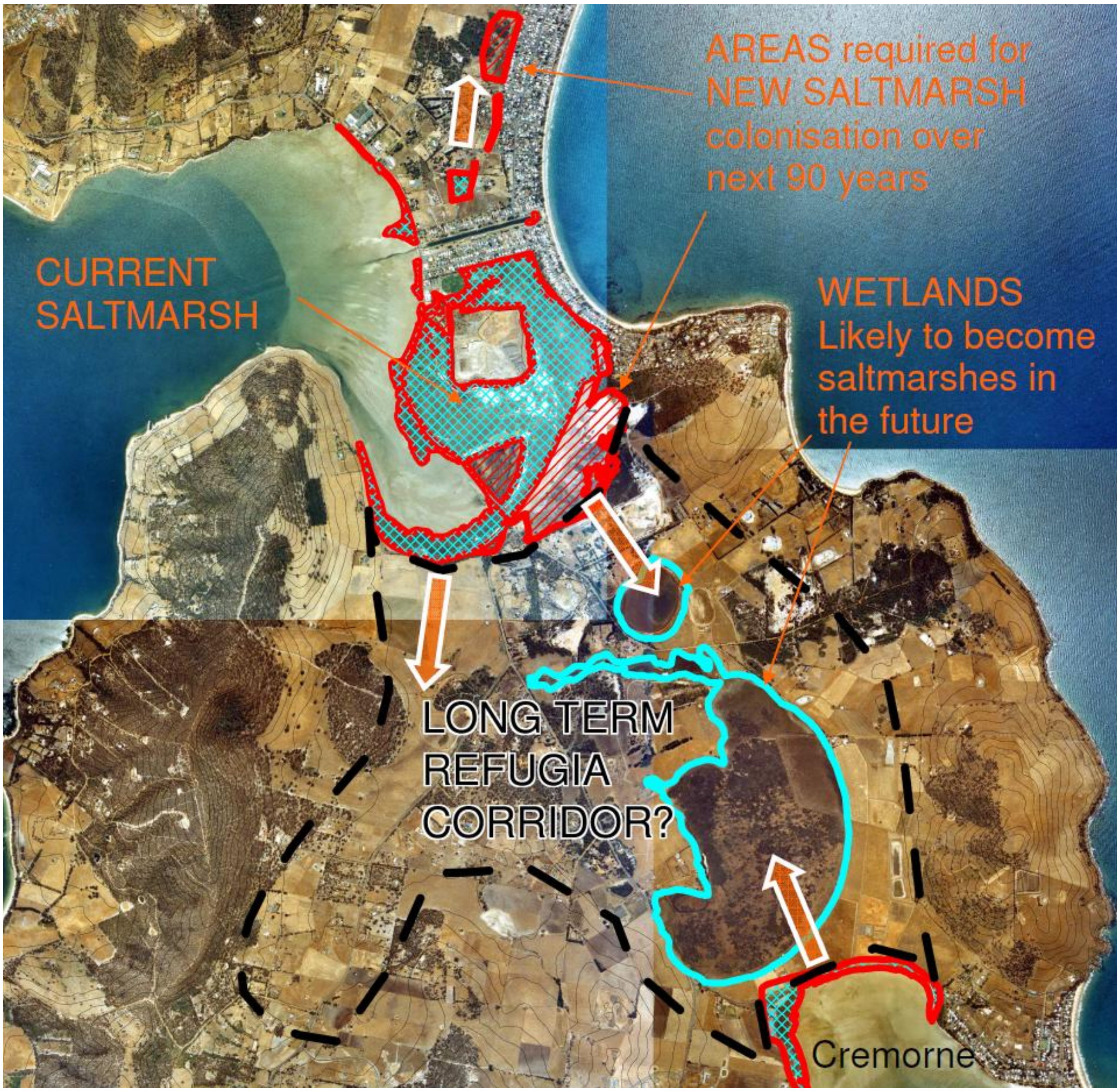


Figure 37. Map of current and projected saltmarsh extent, with arrows indicating direction of vegetation transgression inland, colonising new areas as sea-level rises. The Lauderdale saltmarsh is located within a regional landscape, but its long term future beyond 2100 will depend upon land use that enables transgression in the future, perhaps via a long term refugia corridor. This would enable the Lauderdale saltmarsh habitat to move through time into areas that are currently fresh/brackish wetlands, and that are likely to become ideal saltmarsh habitat in the future. Connectivity in the landscape may assist transgression of threatened species and other natural values associated with the Racecourse Flats saltmarsh. There is also scope for some northward movement of saltmarsh into the Roscommon area.

5) Legal and planning framework considerations

The report has demonstrated the variable natural asset types occurring within the Lauderdale area. Today these assets occur across a range of tenures, but in the future it is increasingly likely that natural assets will need to transgress onto private properties (Whitehead 2011). The different tenures on which the natural assets occur create a challenge for co-ordinating current and future management of these assets. The following list identifies some legal obligations relating to the protection of natural values.

5.1 Relevant international agreements

- *World Conservation Union Red List of Threatened Species* (IUCN 2007)
- *Japan–Australia Migratory Birds Agreement* (JAMBA)
- *China–Australia Migratory Birds Agreement* (CAMBA).

The 'Ralphs Bay Racecourse Flats Bird Habitat' was listed in 1996 on the Register of the National Estate. It met the criteria of National Estate significance on the basis of potentially supporting rare saltmarsh flora and fauna communities and providing habitat for a large number of bird species, including migratory birds listed under the Japan–Australia Migratory Birds Agreement (JAMBA) and the China–Australia Migratory Birds Agreement (CAMBA) (Enesar consulting Pty Ltd 2007). However, as of 2006 the Register has not been updated and it was intended that places on the Register of the National Estate would be considered for inclusion in appropriate Commonwealth (or State/local) heritage lists. This has not occurred for the 'Ralphs Bay Racecourse Flats Bird Habitat'.

5.2 Relevant Commonwealth Act

- *Environmental Protection and Biodiversity Conservation Act* 1999 (EPBCA)

At a national level, the Commonwealth EPBCA includes provisions for listing and protecting critical habitats (such as Ramsar wetlands), nationally listed threatened communities and species and listed migratory species. None of the habitats in the Lauderdale area are currently listed in this manner; however, saltmarsh habitats have been nominated for listing as a threatened community type under the EPBCA. The outcome of this nomination is still pending at the time of preparing this document. The EPBCA lists Ramsar sites as a matter of national environmental significance, and therefore provides a statutory framework for protection of the nearby Pitt Water/Orielton Lagoon Ramsar site values. Potential climate change impacts upon the Lauderdale tidal flats and saltmarsh may increase pressure upon the nearby Ramsar area if birds are displaced to this site.

The EPBCA is triggered if there is deemed significant impact to nationally listed species. An EPBCA Protected Matters report created from the Lauderdale area (Figure 38) contains 41 threatened species and 51 migratory species (**Appendix 1**), including some notable species mentioned within this document:

threatened species (mentioned in this document):

- Live-bearing seastar (*Parvulastra vivipara),*
- Swift parrot (*Lathamus discolour*)

- Spotted handfish (*Brachionichthys hirsutus)*
- Eastern barred bandicoot (*Perameles gunnii*

migratory bird species (mentioned in this document):

- Red-necked Stint (*Calidris ruficollis*)
- Curlew sandpiper *(Calidris ferruginea)*
- Double-banded Plover (*Charadrius bicinctus*)
- Eastern Curlew (*Numenius madagascariensis*)
- Bar-tailed godwit (*Limosa lapponica*)

other listed marine species: shorebird and dolphins (mentioned in this document):

- Red-capped Plover (*Charadrius ruficapillus*)
- Bottlenose dolphins (*Tursiops truncatus*)
- Common dolphins (*Delphinius delphis*)

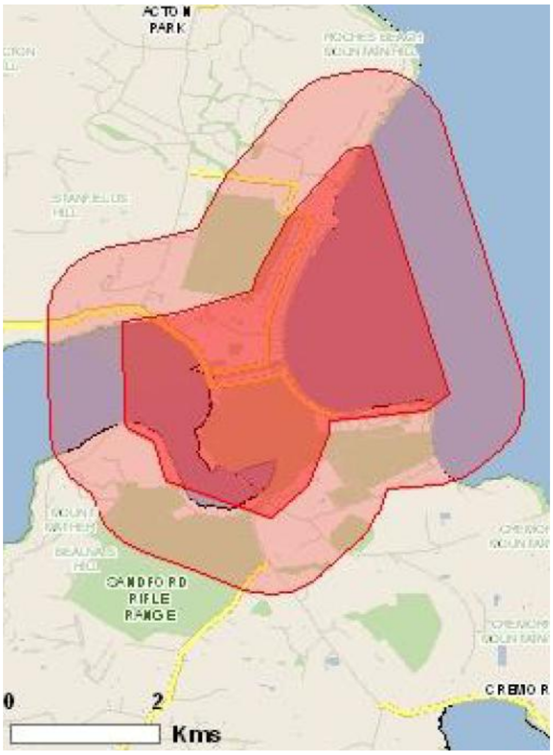


Figure 38. Area covered by EPBCA Protected Matters report. Created for this document on 30-April 2012 using the website: http://www.environment.gov.au/epbc/pmst/index.html [cited 30-April-2012)

Habitat improvement (e.g. reinstalling tidal flushing to Racecourse Flats) or climate change mitigation (sand nourishment of Lauderdale and Roches Beaches) would need to be assessed to determine if they would cause significant impacts to EPBCA listed species.

EMPCA is relevant for actions causing environmental harm or nuisance. Examples where this becomes relevant for actions taken under climate change mitigation, as described in TCAP Pathway Scenario 3, may include: poor water quality in receiving waters that may arise from lack of sediment erosion control measures during landfilling or problems from acid sulphate soil disturbance due to landfilling or excavation. Such landfilling activities should be consistent with Tasmanian *Sediment and Erosion Control Guidelines* and *Acid Sulphate Soil Guidelines*.

5.3 Relevant Tasmanian Acts

- *Threatened Species Protection Act* 1995 (TSPA),
- *Living Marine Resources Management Act* 1995 (LMRMA),
- *Nature Conservation Act* 2002 (NCA),
- *National Parks and Reserves Management Act* 2002 (NPRMA) and associated regulatory documents.
- *Forest Practices Act 1985* and *Forest Practices Regulations 2007.*
- *Crown Lands Act 1976* (CLA)
- *Ralphs Bay Conservation Area (Clarification Act) 2006* [RBCA(CA)]
- *Regional Forest Agreement (Land Classification) Act 1998* [RFA(LC)A]
- *Land Use Planning and Approvals Act 1993*
- *Environmental Management and Pollution Control Act 1994 (*EMPCA*)*
    - *Environmental Management and Pollution Control (Underground Petroleum Storage Systems) Regulations 2010*.

The TSPA includes provision for declaring habitats to be critical to the survival of native flora or fauna, but no communities in the Lauderdale are currently listed in this manner. Several flora and fauna species occurring in the Lauderdale area are listed as threatened under the TPSA. Habitat improvement (e.g. reinstalling tidal connectivity to Racecourse Flats) and climate change mitigation (e.g. earthworks to protect infrastructure) are activities that may come under assessment by the TSPA.

The NCA allows for the declaration of land (including estuarine and marine areas) as reserves for the protection of flora, fauna and associated habitats and describes the criteria for classifying land as specific reserve types. The NPRMA includes provisions for management of these reserves, including the formulation of management plans. The LMRMA includes provisions for the establishment of marine resources protected areas and protected habitats, however no protected areas or habitats have been proclaimed in the Lauderdale area. The NCA is currently viewed as the primary tool for declaration of marine protected areas. The Ralphs Bay Conservation Area was initially declared a reserve under the CLA, and was subsequently re-classified as a Conservation Area under RFA(LC)A. However, the RBCA(CA) was established to clarify the area of the Ralphs Bay Conservation Area, and as a result the tidal flats at Lauderdale are now categorised as a Conservation Area under the RFA(LC)A. However, a statutory management plan currently does not exist for this Conservation Area.

The NCA offers protection to listed threatened native vegetation communities (under schedule 3A of the Act). Of relevance to natural assets in Lauderdale are the listed woodland communities:

- *Eucalyptus viminalis and E. globulus* coastal woodland (TASVEG: DVC)
- *Eucalyptus globulus* dry forest and woodland (TASVEG: DGL)

Climate change sea-level rise is projected to cause the conversion of some areas of listed DVC into saltmarsh. Coastal erosion may also cause the loss of the DVC and DGL in some areas. Clearing and conversion of NCA listed communities' means deliberately removing all or most of a threatened native vegetation community from an area of land. It may be that climate change conversion is not viewed as deliberate conversion, and this does not require preparation of a Forest Practice Plan (FPP) by the land manager. The NCA threatened communities listing includes wetland and the saltmarsh *Saline Aquatic Herbland* (AHS), but currently not the TASVEG saltmarsh types at Lauderdale, which are *succulent saline herbland* (ASS) and *saline sedgeland/rushland* (ARS); however, the listing status of ASS and ARS could change in the future if nominated for inclusion under the NCA.

5.4 Relevant Tasmanian Policies and Strategies

- *State Policy on Water Quality Management 1997*
- *State Stormwater Strategy 2010*
- *State Coastal Policy 1996*
- *Draft Southern Tasmania Regional Land Use Strategy*
- *NRM Strategy for Southern Tasmania*

The overarching principles and objectives for water quality management in Tasmania are provided in the *State Policy on Water Quality Management 1997*. The main legislation controlling water quality in Tasmania is EMPCA. The Lauderdale landfill (former tip site) is also regulated by the Tasmanian Environmental Protection Authority under EMPCA and the current site managers (Clarence City Council) are required to do this under existing permit conditions. The permit conditions may require revision so as to reduced environmental risks that would arise from inundation and wave erosion of the Lauderdale landfill due to flooding and sea-level rise.

Specific regulations also have an important role in protecting the quality of Tasmania's water resources, for example, the *Environmental Management and Pollution Control (Underground Petroleum Storage Systems) Regulations 2010,* which is relevant where this infrastructure occurs in Lauderdale. The *State Stormwater Strategy 2010* is a tool design to reduced negative effects of stormwater runoff. The strategy recommends ways to improve stormwater management in new areas of development and established urban, commercial and industrial areas. The management of stormwater through water sensitive urban design has been mentioned in the current document (to help reduce saline groundwater intrusion) and is consistent with the *State Stormwater Strategy.*

The *NRM Strategy for Southern Tasmania* recognises in relation to community awareness that action is needed to:

> *Specific Action 6) raise stakeholder awareness about the need to consider climate change impacts on current and future natural resource management practices, including the development of appropriate adaptation strategies* and

In relation to managing threats to natural assets from climate change, specific actions are needed to:

> *Specific Action 10) Develop regional-scale climate change scenarios for use in climate change risk and vulnerability assessments and develop targeted adaptation strategies.*
> *Specific Action 11) Conduct a comprehensive cost-benefit analysis of the nature of opportunities to mitigate the adverse impacts of climate change on natural resource condition.*

*Tasmanian State Coastal Policy 1996 a*pplies to State Waters and the coastal zone Under the *State Coastal Policy Validation Act 2003*, a reference in the State Coastal

Policy 1996 to the coastal zone is to be taken as a reference to State waters and to all land to a distance of one kilometre inland from the high-water mark.
The Act states that "State waters" has the same meaning as in the *Living Marine Resources Management Act 1995,* which is:

> a) any part of the territorial sea of Australia adjacent to the State within 3 nautical miles of the baseline by reference to which the territorial limits of Australia are defined for the purposes of international law; and
> b) the marine or tidal waters on the landward side of any territorial sea of Australia adjacent to the State but not within the limits of the State

Some of the *State Coastal Policy* points that are relevant to the disturbance of existing tidal wetlands and saltmarshes, and landfilling of adjacent coastal areas that may support these habitats in the future:

> State Coastal Policy Point 1.1.1.
> *The coastal zone will be managed to ensure sustainability of major ecosystems and natural processes.*
>
> State Coastal Policy Point 1.1.2.
> *The coastal zone will be managed to protect ecological, geomorphological and geological coastal features and aquatic environments of conservation value.*
>
> State Coastal Policy Point 1.1.9.
> *Important coastal wetlands will be identified, protected, repaired and managed so that their full potential for nature conservation and public benefit is realised. Some wetlands will be managed for multiple use, such as recreation and aquaculture, provided conservation values are not compromised.*
>
> State Coastal Policy Point 1.1.10.
> *The design and siting of buildings, engineering works and other infrastructure, including access routes in the coastal zone, will be subject to planning controls to ensure compatibility with natural landscapes.*
>
> State Coastal Policy Point 2.1.3.
> *Siting, design, construction and maintenance of buildings, engineering works and other infrastructure, including access routes within the coastal zone will be sensitive to the natural and aesthetic qualities of the coastal environment.*
>
> State Coastal Policy Point 2.1.5.
> *The precautionary principle will be applied to development which may pose serious or irreversible environmental damage to ensure that environmental degradation can be avoided, remedied or mitigated. Development proposals shall include strategies to avoid or mitigate potential adverse environmental effects.*

The STCA (2011) *Southern Tasmania Regional Land Use Strategy 2010-2035* was declared by the Minister for Planning pursuant to Section 30C of the *Land Use Planning and Approvals Act* 1993, following its endorsement by the 12 Southern Councils and Southern Tasmanian Councils Authority in June 2011. New planning schemes, (or any future amendments thereto) will be required to accord with the Strategy, which states:

C 2 Ensure use and development in coastal areas is responsive to effects of climate change including sea-level rise, coastal inundation and shoreline recession:

C 2.3 Identify and protect areas that are likely to provide for the landward retreat of coastal habitats at risk from predicted sea-level rise.

5.5 Clarence Planning Scheme 2007

The Clarence Planning Scheme 2007 has state policy considerations, such as the *implementation of state coastal policy*

Where the planning authority determines that a proposed use or development would be inconsistent with the State Coastal Policy, that use or development ism unless prohibited by this scheme and notwithstanding any other provision of the scheme, a use or development which the planning authority has a discretion to refuse or permit.

The Clarence Planning Scheme also includes planning overlays, of relevance to natural assets and there future management relating to climate change. The following discussion relates specifically to saltmarsh areas, notably the important saltmarsh refugia areas to the south of Racecourse Flats.

- *Coastal management (CM)*

The immediate coastal area ~50m above high water mark appears to be captured within the CM overlay (e.g. Figure 39). Conditions relating to the CM over lay area include (point 7.3.2 permit requirement):
(ii) All development within 50 metres of any tidal flat, saltmarsh or lagoon, excluding rehabilitation and conservation activities, aquaculture, works, structures and demolition associated with access to the water or foreshore.

The width of the CM overlay only captures a narrow coastal wetlands and saltmarshes, whilst more extensive saltmarsh areas, as occur at Lauderdale, are not included in this overlay. Some development activities are allowed within the CM overlay area, which are exempt from planning permit requirements, such as the construction of minor structures.

Point 5.1.2 *The following development is exempt from the provisions of this scheme subject to Clause 3.1.11:*

(g) Minor domestic buildings or structures within the curtilage of a residential development including garden sheds, glasshouses, rubbish receptacles or other such minor structures for the domestic needs of the occupants provided that: ….."

Once minor structures are built, there is no restriction on how long these may occupy site and thus their presence, maintenance and protection from sea-level inundation may occur to the determent of sensitive coastal habitats. A limited time frame or inundation related trigger for the removal of such structures may be warranted.

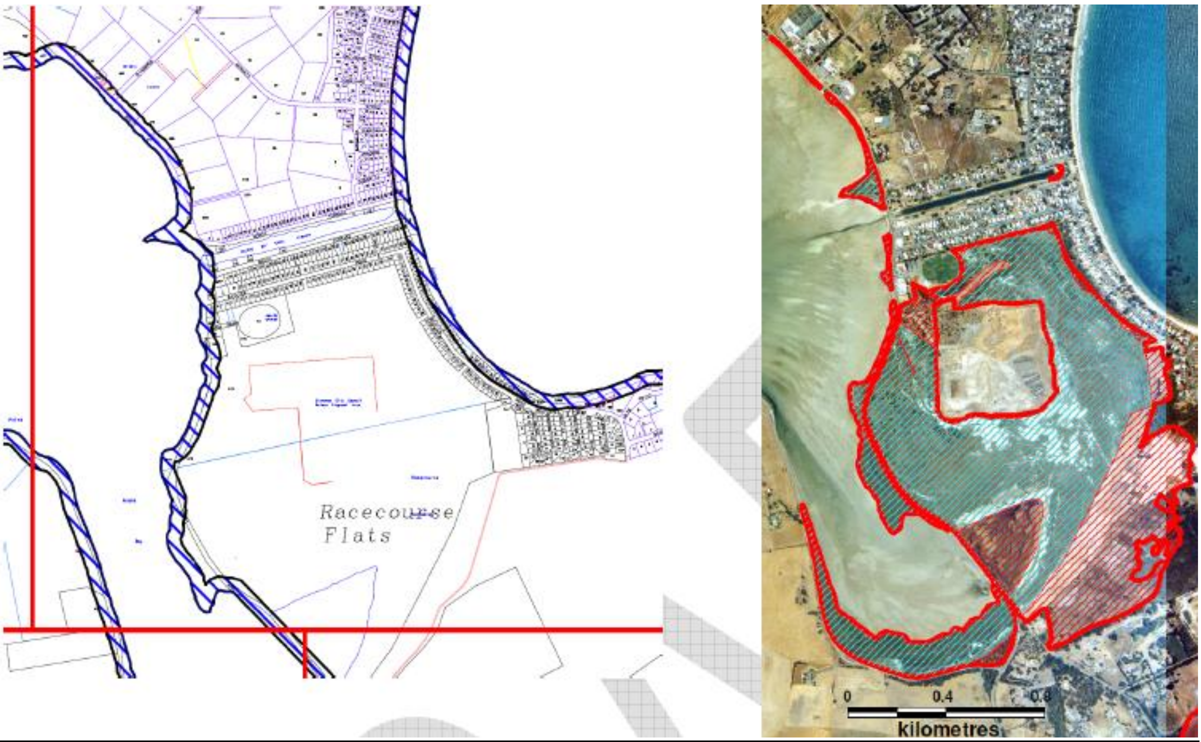


Figure 39. *Left hand side* BLUE HATCHED AREA = Coastal management (CM) overlay (Lauderdale example).*Right hand side* BLUE hatched = Current sensitive coastal habitat (i.e., current saltmarsh extent). RED hatched = Near future (2100) sensitive coastal habitat based on 110cm sea-level rise (Whitehead 2011).

- *Subject to inundation (SI)*

A lot of areas of current saltmarsh and projected future saltmarsh (with 110cm SLR) occur in the Clarence SI overlay (Figure 40). Conditions relating to the SI overlay area include (point 7.2.3 permit requirement):
(a) A permit is required for all use and development. The application must be considered as a Discretionary Development in accordance with Clause 3.1.8.

However, some activities that would be detrimental to current saltmarshes, and low lying areas where they may transgress to in the future do not require planning permits (such as):
(b) The permit requirement does not apply to:
(v) Any work or maintenance which in the opinion of Council or other public authority responsible for drainage in the area is necessary to prevent or alleviate flood damage to property.
(vi) Any stream improvements, drainage or water supply works.

Furthermore, a permit application requirements must demonstrate that (point 7.2.4):
In addition to the Application Requirements under Clause 3.2.1 an application for use or development under this overlay is required to be accompanied by a report, from a suitably qualified person, demonstrating that (based on a 1 in 100 year event):
(b) Any habitable areas of a dwelling will not be subject to inundation; …"

Landfilling of the coast is one option that may be able to prevent a building being subject to the 1 in 100 year inundation height; however, landfilling may contravene the State Coastal Policy. Other points within the State Coastal Policy may also be triggered through coastal development (notably native vegetation conversion and earthworks). Landfilling in low lying coastal areas may also contravene best practice within the *Tasmanian Acid Sulphate Soils Management Guidelines* (see: http://www.dpiw.tas.gov.au/inter/nsf/WebPages/SWEN-83NVBG?open [cited 1-May-2012])

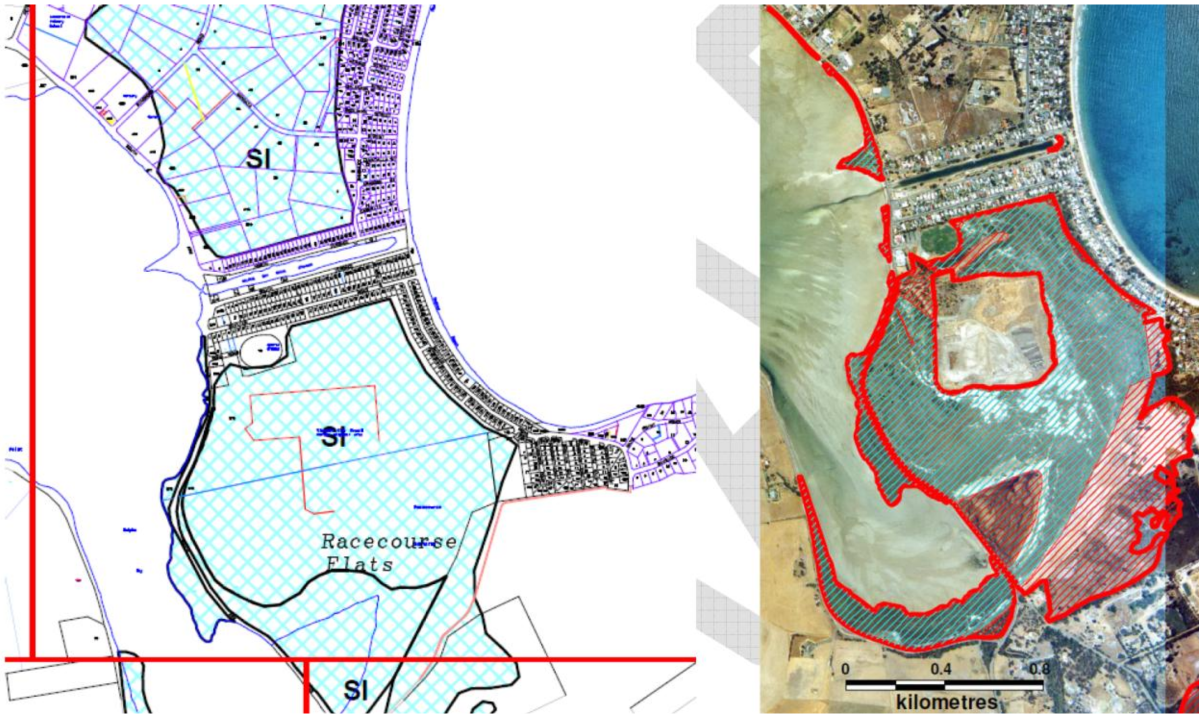


Figure 40. *Left hand side* BLUE CROSS HATCHED AREA = Subject to inundation (SI) overlay (Lauderdale example).*Right hand side* BLUE hatched = Current sensitive coastal habitat (i.e., current saltmarsh extent). RED hatched = Near future (2100) sensitive coastal habitat based on 110cm sea-level rise (Whitehead 2011).

- *Land Potentially affected by sea-level rise and storm surge (SLSS)*

The purpose of the SLSS overlay (e.g. Figure 41) is as follows (point 7.4.1):
(a) To implement the Planning Policy Framework.
(b) To control impacts on coastal infrastructure and development from sea-level rise and storm surge.

Conditions relating to the SLSS overlay area include (point 7.4.3 permit requirement):
(a) A permit is required for all use and development. The application must be considered as a Discretionary Development in accordance with Clause 3.1.8.

The area occupied by the SLSS overlay is not the same area as current saltmarsh and projected future saltmarsh (with 110cm SLR) extent. Some development activities are allowed within the SLSS overlay area, which are exempt from planning permit requirements, such as the construction of minor structures.
(b) The permit requirement does not apply to:
- Development exempted from the Scheme in accordance with Section 5.1.2.
Point 5.1.2 *The following development is exempt from the provisions of this scheme subject to Clause 3.1.11:*

(g) Minor domestic buildings or structures within the curtilage of a residential development including garden sheds, glasshouses, rubbish receptacles or other such minor structures for the domestic needs of the occupants provided that: …..”

Once minor structures are built, there is no restriction on how long these may occupy the site and thus their presence, maintenance and protection from sea-level inundation may occur to the determent of sensitive coastal habitats. A limited time frame or inundation related trigger for the removal of such structures may be warranted.

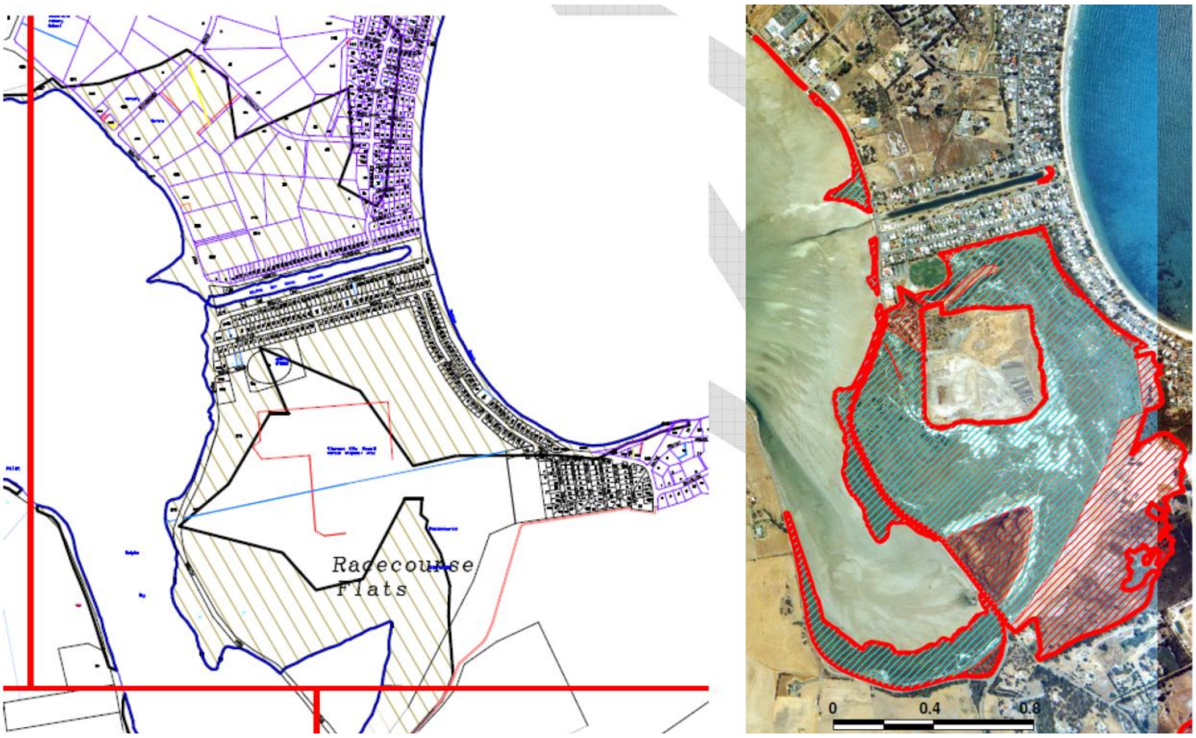


Figure 41. *Left hand side* BLACK HATCHED AREA = Land Potentially affected by sea-level rise and storm surge (SLSS) overlay (Lauderdale example).*Right hand side* BLUE hatched = Current sensitive coastal habitat (i.e., current saltmarsh extent). RED hatched = Near future (2100) sensitive coastal habitat based on 110cm sea-level rise (Whitehead 2011).

- *Vegetation Management (VM)*

Vegetation management may apply to activities within the Vegetation Management (VM) overlay (e.g. Figure 42).

(a) A permit is required to remove, destroy or lop any native vegetation. The application must be considered as a Discretionary Development in accordance with Clause 3.1.8.

There are a number of vegetation removal scenarios where the permit requirement does not apply; however, exemption to not include wetland or saltmarsh clearance. The exemption does apply to stock grazing, when applied would be detrimental to saltmarsh habitats:
(b) The permit requirement does not apply to:
(vii) The removal, destruction or lopping of native vegetation as a result of grazing by stock.

The retention of a native vegetation buffer around ‘wetlands’ has been identified, although this may also be allowed to experience exemptions, such as disturbance allowed due to grazing, which would be incompatible with saltmarsh transgression into the buffer zone.

(c) Vegetation should be retained:
(ii) Within 30 metres of a waterway, natural watercourse or wetland.

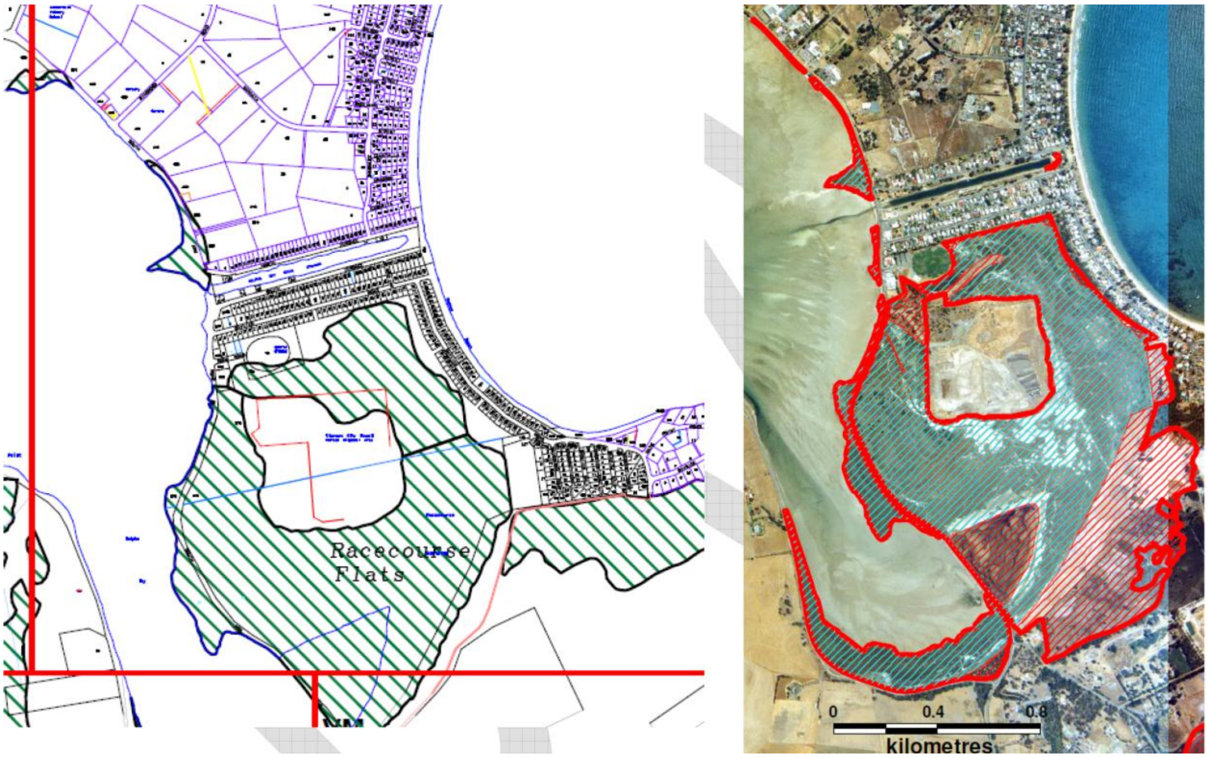


Figure 42. *Left hand side* GREEN HATCHED AREA = Vegetation Management (VM) overlay (Lauderdale example).*Right hand side* BLUE hatched = Current sensitive coastal habitat (i.e., current saltmarsh extent). RED hatched=Near future (2100) sensitive coastal habitat based on 110cm sea-level rise (Whitehead 2011).

Future planning scheme revisions will need to include planning maters relating to the transgression inland of natural assets with sea-level rise in accord with *Southern Tasmania Regional Land Use Strategy* point:

> C 2.3 *Identify and protect areas that are likely to provide for the landward retreat of coastal habitats at risk from predicted sea-level rise.*

6) Conclusions and major assets prioritised for action

This document identifies marine and coastal environmental assets that occur in the Lauderdale area. The assets have been grouped into six major types, which loosely conform to specific geographic areas (Table 3). It is acknowledged that specific assets (such as threatened species) occur nested within the major asset types. In the future some assets are projected to move (transgress inland), and as this occurs the major asset types will change at certain locations. The changes within specific asset types identified in this document should not be used to justify development of these sites that would otherwise expedite their loss and prevent their transformation into new natural asset types. Instead, management effort should be made to improve their condition and function, as they have important ecosystem services to continue providing. The following conclusion includes a prioritisation of the major actions required for each of the major asset types and that are required to increase the assets resilience to climate change, enable transgression inland, or be relocated to new sites where they can continue to survive and provide ecosystem services. The prioritisation in this document is a first pass assessment, and is based upon urgency for action and likely loss of environmental assets if action not undertaken.

6.1) MAJOR ASSET type/area

Lauderdale & Roches sand dunes, threatened flora & fauna

RISK

The Lauderdale dunes are eroding (~8m over the last 50 years) due to storm damage exacerbated by sea-level rise (Sharples, *pers. comm.,* March 2012). Erosion of the Lauderdale dunes is causing the loss of threatened vegetation communities growing here, which consists of:

- *Eucalyptus viminalis and E. globulus* coastal forest and woodland (TASVEG: DVC vegetation community) and
- *Eucalyptus globulus* dry forest and woodland (TASVEG: DGL vegetation community).
-

Emergent *Eucalyptus* trees within the threatened vegetation growing on the dunes add greatly to the landscape character of Lauderdale and provide habitat for threatened species (e.g. Swift parrots). Emergent *Eucalyptus* trees on the dunes are at risk from coastal erosion, salt water ingress into their root zone, and removal for abatement of personal injury or property damage. The DVC vegetation community is only found in Tasmania, and is generally confined to sandy coastal areas that formed in the Holocene and Pleistocene, such as back-dunes, sand spits and tombolos (Harris and Kitchener 2005) and as such is at high risk from sea-level rise and coastal erosion throughout most of its range.

Sea-level rise will cause the saline groundwater table beneath the Lauderdale sand dunes to become shallower and closer to the root zone of threatened vegetation communities growing here and will cause loss of less salt tolerant vegetation and larger trees with deeper roots. This risk may be exacerbated once the sand dune aquifer experiences a decline in freshwater recharge due to Lauderdale domestic water being piped to a waste water treatment plant and no longer discharged via filtration trenches on individual properties.

ACTION - MODERATE PRIORITY
The management of the Lauderdale dunes and their supporting vegetation remnants are very much linked to the Lauderdale and Roches Beach foreshore protection options raised in TCAP Pathway Scenario 3. These measures will prolong the current position of the foreshore dune and supporting vegetation, thus this asset type has been given a moderate priority rating for immediate action.

The risk of a rising saline groundwater table beneath the Lauderdale sand dunes damaging threatened vegetation can be reduced through reuse of onsite grey water (which should be an option explored and residence encouraged to use) and the use of water sensitive urban design (WSUD) principles for stormwater management. WSUD is highly recommended, so as to enable freshwater infiltration to the sand dune aquifer, through the use of fully grassed swales and detention basins. Areas that lack curb and gutter should be retained in this fashion, and those areas already developed in this manner should have WSUD features retrofitted. The use of concrete inverts within the swales, to expedite stormwater conveyance, should also be avoided if possible.

Future revegetation - Roscommon or other sites

ACTION - MODERATE PRIORITY
In the future, beyond 2100, the survival of the vegetation on the Lauderdale dunes is doubtful. Revegetation efforts should be made soon at an appropriate alternate site to ensure the threatened vegetation communities and mature trees (for swift parrot use) are present in the future to offset habitat loss from the Lauderdale dunes. It has been acknowledged that nearby Roscommon may be unsuitable for DVC and DGL vegetation type re-establishment, due to differences in soil type; therefore, an alternate revegetation site may be required. Revegetation efforts at an alternate site; however, will not address a change in the character of Lauderdale, which would arise from the loss of the larger remnant *Eucalyptus* trees from the dunes.

<u>6.2) MAJOR ASSET type/area</u>

Bambra Reef and Mays Point rocky shore: threatened seastars

RISK
The Bambra Reef and Mays Point rocky intertidal zone are habitat for two separate colonies of live-bearing seastars (*Parvulastra vivipara*), which are threatened Tasmanian endemic species, of which there are only eleven known colonies in existence. The seastars have little ability to disperse between reefs, as they do not travel across sand and do not disperse gametes or offspring by water. Poor dispersal and an inability to move away from rocky habitats, means that Bambra Reef and Mays Point are essentially isolated ‘island-like’ habitats for the live-bearing seastar colonies that may have resulted in genetic variation between colonies.

The Bambra Reef and Mays Point intertidal zone are low in profile and prone to temporary sediment burial, arising from the deposition of sand eroded from coastal dune and beaches during storm events, which could cause local extinction of the live-bearing seastar colonies at these sites. The loss of any given colony may result in loss of the genetic diversity within the species.

ACTION - HIGH PRIORITY
It has been deemed of high priority to retain these rocky habitats in good condition for the threatened seastars and to monitor the populations at both sites. It is of high importance to identify a trigger for management action, and determine appropriate management action steps if the colonies are at risk of localised extinction due to sediment burial. The effect of sand nourishment or groyne construction coastal works (proposed in TCAP Pathway Scenario 3) needs to assess altered risk level to threatened live-bearing seastars caused by altered sand deposition over these rocky habitats. The Bambra Reef and Mays Point areas also need to be managed so as to retain good water quality (avoid placement of stormwater outfalls near these sites), and prevent human disturbance (possible collection of threatened seastars).

Future seastar habitat location

ACTION - HIGH PRIORITY
It is a high priority that appropriate sites be identified for potential translocation of the threatened seastar (*Parvulastra vivipara*), through the movement of some individuals from Bambra Reef and Mays Point, for the establishment of insurance colonies. Translocation risks to the current colonies and also to the native fauna and flora at the potential translocations sites needs to be assessed. If the risk of sediment burial and loss of the colonies at Bambra Reef and Mays Points are high, such that a trigger for management action (translocation) now exists, this action should be deemed a very high priority. The regulatory aspects of site assessment and permitting for potential translocation of a threatened species have not been covered in this document.

6.3) MAJOR ASSET type/area

Southern Lauderdale sub-tidal seagrass bed

RISK
A dense seagrass bed ~84, 000 m^2 in area off the southern end of Lauderdale Beach provides spawning substrate and habitat for a number of marine species and assists in denitrification, nutrient processing and carbon capture. Seagrass extent has dramatically declined throughout south-eastern Tasmania since the 1970's (Rees 1994) and effort should be made to prevent further decline and promote seagrass recovery. The southern Lauderdale seagrass bed is likely to experience episodic sediment burial arising from the deposition of sand eroded from coastal dunes and beaches during storm events, or movement in a sediment lobe that forms off Mays Point due to long shore sediment transport. The resilience of the seagrass to episodic sediment burial will depend upon the condition of this habitat type.

ACTION - MODERATE PRIORITY
Management of the dense seagrass bed off the southern end of Lauderdale Beach should be aimed at increasing resilience against climate change related impacts (most likely episodic sediment burial events). The resilience of seagrass is increased by ensuring water quality is good (low nutrient loads to avoid excessive epiphytic algal growth that reduce seagrass photosynthesis). Good water quality can be retained through the use of water sensitive urban design principles for managing stormwater runoff from the adjacent urban areas. The resilience of seagrass is also

improved by reducing physical disturbance that is associated with anchor or boat chain mooring drag. It may be appropriate to discourage anchoring or mooring at the southern end of Lauderdale Beach. If this area is popular for boat anchorage and fishing, it may be appropriate that 'seagrass friendly moorings' (or similar structures) be installed for community use, but it would be necessary to identify who would purchase and maintain such infrastructure. Increasing the resilience of the seagrass beds has been given a moderate priority in comparison to actions needed for the maintenance of other major environmental asset types in the Lauderdale area.

6.4) MAJOR ASSET type/area

Lauderdale and Roches Beaches and sub-tidal sand

RISK

Management of Lauderdale Beach, so as to retain this feature into the near future, through coastal works has been raised as part of TCAP Pathway Scenario 3. The potential coastal works may have benefits for retaining the dune system and protecting associated foreshore vegetation (discussed in Section 6.1). However, some measures to maintain the beach (e.g. beach sand scraping from the intertidal zone to rebuild the fore-dune) may be deleterious to some sand fauna.

ACTION - LOW PRIORITY

Managing the Lauderdale or Roches Beaches for the benefit of the sand biota has been given a low priority, compared to action required for the perpetuity of the other major environmental asset types in the Lauderdale area. The sand biota are not unique to Lauderdale or Roches Beaches and will still be well represented on beaches elsewhere that are left in a natural state and allowed to transgress inland with sea-level rise.

6.5) MAJOR ASSET type/area

Ralphs Bay tidal flats and foreshore

RISK

The Lauderdale tidal flats are important habitat for wading shorebirds. The Derwent Estuary Pittwater Area (DEPA), which includes the Ralphs Bay tidal flats, provides habitat for at least eight migratory shorebird species (four are listed for protection under the *Environmental Protection and Biodiversity Conservation Act* 1999) and six resident shorebird species (Birds Tasmania records). The migratory species are listed under international agreements aimed at ensuring habitat protection for their survival, such as the *Japan–Australia Migratory Birds Agreement* (JAMBA) and *China–Australia Migratory Birds Agreement* (CAMBA). The Ralphs Bay tidal flats, relative to other DEPA tidal flats, appear to be of high importance to migratory Double-banded plover, Whimbrel and Grey-tailed tattler (Cardno 2009). The DEPA is internationally significant for resident Pied Oystercatchers, supporting some of the largest numbers of this species in Australia and the second-largest in mainland Tasmania (Lane 1987). At times up to 10% of the global population of Pied Oystercatchers can be observed foraging on the Ralphs Bay tidal flats (E. Woehler, *pers. comm.*, March 2012). Another commonly observed resident shorebird at Ralphs Bay is the Red-capped plover (B.O.A.T. 1982). The northern extent of the Ralphs Bay tidal flat appears to be the favoured foraging area for many shorebirds, notably Pied Oystercatchers who also appear to have a preference for nesting on the adjacent foreshore where there is good connectivity for their flightless chicks between the nesting and tidal flat foraging areas (Harrison 2008; Aquenal 2008b).

Sea-level rise will cause a relative decline in the extent of the northern tidal flats and loss of the adjacent preferred nesting areas due to coastal squeeze and increased exposure to wind driven waves. Pied Osytercatchers breeding at the site will likely move to the less optimal Racecourse Flats saltmarsh, east of the South Arm Road causeway. This move is likely to result in a decline in breeding success of Pied Oystercatchers at Lauderdale because the chicks will be:

- raised in less preferred saltmarsh foraging areas,
- at increased risk of being hit by vehicles if they attempt to walk from nesting areas in the saltmarsh to foraging areas on the tidal flats west of the causeway, and are
- exposed to predators when left unattended by parent birds that fly away to forage on the tidal flats west of the causeway.

The Ralphs Bay tidal flats also contribute to denitrification and nutrient removal processes that improve nitrogen levels throughout the greater Ralphs Bay region. A net decline in the overall extent of the tidal flats by 2100 may cause a decline in denitrification within the region; however, establishment of seagrass (which assists denitrification) on sub-tidal areas that were formerly tidal flats may see this ecosystem service retained. There is currently a lack of sub-tidal seagrass in Ralphs Bay, although it was extensive here in the 1970s' (Rees 1994).

ACTION – VERY HIGH PRIORITY
Future development at Lauderdale should not reduce the existing tidal flat extent as this habitat is important for shorebirds and provides a range of important ecosystem services (e.g. nutrient removal). A very high priority action is the restoration of tidal flushing beneath the South Arm Road causeway to the tidal flats of East Marsh Lagoon. This will reduce eutrophication of the lagoon and improve the condition of this tidal habitat for foraging shorebirds that may increasingly nest in the Racecourse Flats saltmarsh. A management plan needs to be created for the Lauderdale Racecourse Flats and East Marsh Lagoon and funding sourced to improve the tidal flushing beneath the South Arm Road causeway. Restored tidal connectivity is required to enable the establishment of healthy tidal flat habitat east of the road, which can be more readily accessed by flightless shorebirds chicks for foraging. Breeding success is likely to increase amongst the shorebirds if they can nest in areas of saltmarsh that have direct connectivity to preferred tidal flat foraging areas.

It has been acknowledged that restoring tidal flushing to the Racecourse Flats area could potentially increase risks associated with the Lauderdale land fill (e.g., erosion at the base of the landfill slope and potential leachate release and mobilisation) and it is essential that these potential risks be investigated and managed. It is proposed here that partial tidal flushing be restored until the risk to the Lauderdale landfill can be assessed and mitigated (if required) prior to full tidal connectivity being restored (discussed in Section 6.6).

Attention is also needed to improve the condition of the existing Ralphs Bay tidal flats so as to encourage the return of seagrass here and on the adjacent shallow sub-tidal sediments. The value of encouraging seagrass re-establishment here would include:

- increase nutrient removal
- increase carbon storage,
- increase sediment capture, which may extend the longevity of current tidal flat position.
- In the past seagrass beds in Ralphs Bay provided breeding habitat for commercially important school shark (Aquenal 2008a). Return of seagrass to the bay may encourage school shark breeding here again.

Management of stormwater entering Ralphs Bay should be consistent with WSUD principles to reduce sediment and nutrient loads that may be harmful to seagrass, natural tidal flat sediment and biological processes.

Future tidal flat- Racecourse Flats & areas south of Lauderdale

ACTION – VERY HIGH PRIORITY
Restoring tidal flushing to Racecourse Flats beneath South Arm Road will assist the creation of healthy tidal flats adjoining the saltmarsh, and will provide foraging and nesting habitat connectivity beneficial to resident shorebirds that may increasingly nest here as sea-level rises and displaces them from current nesting areas adjacent to the northern Ralphs Bay tidal flats. Restoring tidal flushing beneath South Arm Road will enable tidal flat transgression over the Racecourse Flats saltmarsh, and areas south of Lauderdale, as sea-level rises. This is the most achievable direction for future tidal flat development consistent with TCAP Pathway Scenario 3; however, a long-term planning solution is required to enable tidal flat transgression to occur south of Lauderdale beyond 2100 (see Section 6.6).

<u>6.6) MAJOR ASSET type/area</u>

Lauderdale saltmarshes

RISK
The Lauderdale saltmarsh is of regional significance within the DEPA, having the highest vegetation diversity across its profile from seaward to landward edge (Prahalad 2009). The regional significance of the Lauderdale saltmarsh will increase in the future, as there will be major saltmarsh loss from nearby areas such as Pittwater and Orielton by 2100 due to sea-level rise and coastal squeeze (Prahalad 2009). This will have a regional impact on shorebirds within the DEPA and other species that live in and use saltmarsh habitat. The future loss of saltmarsh from Pittwater emphasises the importance of encouraging saltmarsh retention and transgression at Lauderdale. Specific values of global and regional significance within the Lauderdale saltmarsh include:

- The saltmarsh looper moth (*Dasybela achroa*) listed as threatened (vulnerable) under the *Tasmanian Threatened Species Act* 1995 (TSPA), may have its only extant population at Lauderdale. It is likely that this species is dependant upon the survival of the Lauderdale saltmarsh and that this saltmarsh needs to have connectivity with adjoining woody vegetation (e.g. Acacia) for development of its larvae.

- Two threatened (rare) plants species (listed under the TSPA) appear to be confined to saltmarsh areas, these are: narrowleaf blowngrass (*Lachnagrostis punicea ssp. filifolia*) and slender buttons (*Cotula vulgaris* var. *australasica*).
- Shorebirds roosting, nesting (when optimal sites elsewhere are unavailable) and foraging (typically when tidal flats are inundated or chick hatched in saltmarsh areas).

ACTION – VERY HIGH PRIORITY
Urgent action is required to prevent the current Lauderdale saltmarsh and associated natural values from declining in condition or being lost, due to inadequate tidal flushing. A management plan to improve the condition of these assets is required, and should support very high priority actions that:

- Improve current saltmarsh condition at Racecourse Flats by restoring tidal flushing.
- Improve condition and increase extent of fringing woody native vegetation (e.g. Acacia species) on the landward side of the saltmarsh, which is likely to be of critical important for larval development of threatened moth species that feed on the saltmarsh.
- Prevent landfilling of remaining saltmarsh, especially at Racecourse Flats and council land north of the Lauderdale canal.
- Reduce human disturbance of the saltmarsh. Review current user activities (e.g. motor bike and pushbike use, dog walking, horse riding, walking area). Prevent off- road vehicle use (through fencing, signage, changed user behaviour and use of the area, increase policing if some user activities are prohibited).
- Undertake weed management and reduce grazing (e.g. exclude rabbits).

A very high priority action is to restore tidal flushing beneath the South Arm Road causeway, which will improve the condition of the Racecourse Flats saltmarsh and tidal flats. Before full tidal reconnection is installed, only partial tidal-flushing should be allowed until the leachate risk from the former Lauderdale landfill is reassessed and mitigation measures in place (if required). Restoring tidal flushing to Racecourse Flats will require funding and the following action steps:

- Reassess the topography of the saltmarsh and surrounding land so inundation levels can be assessed in greater detail and used to decide upon an appropriate tidal flushing regime.
- Identify an appropriate initial partial tidal flushing regime, which poses little risk to the Lauderdale landfill (former tip) associated with leachate mobilisation and landfill erosion, and will improve tidal flat and saltmarsh habitats east of the South Arm Road causeway.
- Install partial tidal flushing measures
    - On ground work requires consent and cooperation from the Tasmanian *Department of Infrastructure, Energy and Resources* (DIER) (who manage and maintain the South Arm Road causeway) and Clarence Council (owners of Racecourse Flats).
    - A communication strategy is required prior to and during any on-ground work associated with installation of new pipe work beneath the South Arm Road causeway. East Marsh Lagoon currently becomes eutrophic and public complaints are regularly made about the smell of rotting

organic mater here. Increased tidal flushing should reduce the risk of eutrophication; however, previous efforts to open existing pipes beneath the causeway have failed due to deliberate blocking of these pipes.

- Monitor habitat changes arising from partial flushing and risks to the Lauderdale landfill.
- Prepare site for full tidal flushing by installing mitigation measures (if required) to reduce risk associated with the Lauderdale landfill site.
    - Install measures to reduce risk from leachate mobilisation
        - prevent rainwater recharge and ground water into the landfill
        - create leachate treatment options if required
    - prevent wind-wave erosion of the Lauderdale landfill
    - Ensure appropriate drainage exists on the north-eastern side of Racecourse Flats, where the landfill site causes retention of surface water runoff.
- Gradually increase full tidal flushing to Racecourse Flats at a rate that enables natural asset adjustment.
    - A transition to full tidal flushing should also be accompanied by certainty that future saltmarsh will be able to transgress inland, south of Lauderdale. This will ensure that restoring full tidal flushing does not result in coastal squeeze and loss of the saltmarsh as an increasing area of the Racecourse Flats saltmarsh will become tidal flat habitat in the future.

Future saltmarsh - areas south of Lauderdale & north to Roscommon

RISK

It is of critical importance that areas be retained for saltmarsh transgression inland in the future. It is of very high importance for the saltmarsh vegetation to retain connectivity to tidal flats at their seaward edge (for shorebird use, nutrient cycling, and tidal flushing) and woody vegetation at their landward edge (for survival of threatened moth species). In the near future, to 2100, those areas south of the current Lauderdale saltmarsh will provide the only location where the habitat continuum (tidal flat - saltmarsh – woody vegetation) can be locally achieved. A long term habitat refugia, linking up with existing wetlands between Lauderdale and Pipeclay Lagoon, can provide a long term future transgression pathway option for saltmarsh and associated environmental assets. Land use planning or other land management strategies (e.g. such as acquisition or covernancy), will need to enable saltmarsh transgression south of Lauderdale, otherwise the saltmarsh, tidal flats and their associated environmental assets will be lost as sea-level rises and these habitats become squeezed against areas:

- where infrastructure or property is protected against inundation,
- inappropriate land use (e.g. stock grazing and vehicle use), and areas of
- naturally steep topography.

The area of Roscommon, to the north, can also support saltmarsh development in the future. However, the habitat here will not have connectivity to tidal flats, due to suitable areas being occupied by infrastructure that is likely to be protected from inundation (consistent with TCAP Pathway Scenario 3). Some existing areas of saltmarsh north of the Lauderdale canal, could provide a pathway for tidal flushing and connection to Roscommon, but are currently being landfilled. Drainage needs to be designed between areas of this landfill so as to enable tidal connectivity to Roscommon in the future and the landfilling activities occurring here also need to be consistent with the *Tasmanian Acid Sulphate Soil Guidelines.* Beyond 2100, saltmarsh may develop at Roscommon, but this would then be at risk of being lost if inundation levels exceed the Lauderdale and Roches beaches sand dune height, and then expose the saltmarsh to wave activity and erosion. Roscommon may not provide as a secure long term saltmarsh habitat refugia compared to the areas south of Lauderdale.

Currently the *Clarence Planning Scheme 2007* mapping overlays and planning codes enable development to proceed within the sensitive coastal habitat areas needed for saltmarsh transgression south of Lauderdale in the near (2100) and long term future. There is a high risk of the loss of the Lauderdale saltmarsh beyond 2100 unless the is appropriate inclusion of the need for transgression areas withinland use planning

ACTION – VERY HIGH PRIORITY
It is of critical importance that the Clarence Planning Scheme accommodates planning map overlays and planning codes that enable the transgression of natural coastal habitats and processes into the long term future at sites such as southern Lauderdale. It is a very high priority that local planning measures be put in place for important areas needed for the transgression of saltmarsh in the near (2100) and long term future at Lauderdale.

Future Clarence planning schemes amendments are required to accord with the following *Southern Tasmanian Regional Land Use Strategy* (STCA 2011) regional policy:

C 2 *Ensure use and development in coastal areas is responsive to effects of climate change including sea level rise, coastal inundation and shoreline recession*

> C 2.3 *Identify and protect areas that are likely to provide for the landward retreat of coastal habitats at risk from predicted sea-level rise.*

Areas available for saltmarsh transgression to 2100 have been identified throughout much of southern Tasmania and the Lauderdale area (Prahalad 2009; Prahalad *et al.* 2009; Whitehead 2011; Prahalad and Pearson, in prep), and a long term (post 2100) saltmarsh refugia corridor has been identified south of Lauderdale (Whitehead 2011); however, relevant planning map overlays and planning codes do not currently address this issue in the *Clarence Planning Scheme.* To assist development of appropriate planning measures, in 2011 the Derwent Estuary Program created a discussion paper presented to the Tasmanian Planning Commission, Southern Tasmanian Council Authority and local councils bordering the Derwent (Whitehead 2011). The paper recommended uptake of a mapping overlay for planning, called the 'natural coastal processes overlay', and the development of appropriate planning codes that would apply to areas identified as important for current saltmarsh and future saltmarsh transgression as sea-level rises. The overlay was created with principals similar to TCAP Pathway Scenario 3, allowing for protection of existing infrastructure from inundation, and included recognition and discussion of planning codes that could apply to three different land categories of importance to saltmarsh, which are:

1) Current sensitive coastal habitat (notably current tidal wetlands complex and saltmarsh extent).
2) Near future (2100) sensitive coastal habitat (notably 2100 saltmarsh extent, but excluded areas where infrastructure currently exists).
3) Long term refugia corridors for saltmarsh.

The overlay areas could be flexible, so as to enable the land categories to be moved landward as sea-level rises, or adjusted as future sea-level and storm surge projections improve. Different planning codes could apply to the different land categories, but to enable development of such codes there needs to be discussion about land use in the near future (2100) and long term refugia corridors, which should identify:

- The achievable balance between natural and built assets.
- What development is allowed in future sensitive areas required for coastal habitat transgression. If development is allowed:
    - what triggers or timeframes could be a condition of development approval within the planning codes that decide when planned retreat of infrastructure and site restoration occurs?
    - how will future planned infrastructure retreat and site restoration be funded?

The DEP, with the help of others, are exploring some of the following options to improve protection and management of our sensitive coastal habitats into the future:

- Improved public knowledge as to the value of saltmarshes
- An application for inclusion of the *Succulent saline herbland* (ASS), vegetation type as a threatened community type covered under the *Nature Conservation Act 2002*.
- Options for private land conservation covenants, through the DPIPWE Protected Areas on Private Land Program (PAPL) and the Tasmanian Land Conservancy.
- Explore options for purchasing critically important areas that are currently in private ownership.

It is a very high priority that a clear state policy is needed that leads to the creation of land use planning measures that will enable landward transgression of natural coastal habitats and processes.

Table 3. List of Natural Assets in Lauderdale - PRIORITY for ACTION for manageing climate change

MAJOR ASSET area/type	Asset occurs on..	Nested assets	currently habitat for….	species or specific values (examples)	PRIORITY of ACTIONS at LOCATIONS
1) Lauderdale & Roches sand dunes, threatened flora & fauna	current & relict sand dunes	Relict & active dune landscape & aquifer	*assets listed below in this section*		**MEDIUM - retrofit WSUD on urbansied dunes retain freshwater recharge**
"	"	Vegetation communities	Tasvege DVC> & DGL> & assets listed below in this section	significant large mature trees within the vegetation communities	
"	"	Flora	Threatened floral species lifecycle	Australian houndstongue*	
"	"	Fauna	Threatened birds & mammal species (foraging etc)	Swift parrot *# Eastern barred bandicoot *#	
A) Future vegetation - Roscommon or other sites	*Areas for future vegetation planting*	*grouped vege & threatened species*			***MEDIUM- revegetate with Tasvege DCV & DGL & encourage flora & fauna assets***
2) Bambra Reef and Mays Point rocky shore: threatened seastars	rocky subtidal reef and rocky intertidal zone	Fauna	colony of threatened endemic seastars	Live bearing seastars*#	**HIGH - monitor current habiats size and population**
B) Future seastar habitat location - not identified	*Areas for future threatened species translocation*	*threatened fauna*			***HIGH - translocate subset of population to retain genetic diversity***
3) Southern Lauderdale subtidal seagrass beds	subtidal sands	Vegetation	seagrass lifecycle		**MEDIUM - reduced human disturbance (anchor drag) improve water quality**
"	"	Fauna	Fish & molluscs	Flathead & squid	
4) Lauderdale and Roches Beaches and subtidal sand	intertidal beach sands & subtidal sands	Beach landform			**LOW - sand nourishnment & beach retention to retain habitat (could have impacts)**
"	"	Fauna	Intertidal & sub-tidal invertebrates	bivalve *Paphies elongata*	
"	"		Fish & molluscs	Flathead & squid	
5) Ralphs Bay tidal flats & foreshore	current tidal flats & adjoing shoreline	Tidal flatland form	*assets listed below in this section*	water quality influence for nearby threatened Spotted handfish*#	**VERY HIGH - reinstall tidal connectivity beneath causeway to Racecourse Flats**
"	"	Fauna	Shorebirds (nesting, roosting, foraging), many threatened & listed*#	Migratory & resident shorebirds (e.g. Pied oystercatchers)	
"	"	Fauna	Fish	Flounder, goby & flathead	
"	"	Fauna & Microflora	Invertebrates & microphytobenthos	bivalve (*Katelysia scalarina*), diatoms	
"	"	Vegetation	seagrass	seagrass possibly important for shark breeding success in Ralphs Bay	
C) Future tidal flat- Racecourse flats & areas south of Lauderdale	*Areas for future tidal flat*	*grouped tidal flat assets*	*Tidal flats in 2100 are currently saltmarsh*		***HIGH - manage areas now to enable habitat transgression***
6) Lauderdale saltmarshes	current saltmarsh	Vegetation communities	Tasvege ASS & ARS, *& assets listed below*	possibly very old *Tecticornia arbuscula* shrubbery	**VERY HIGH - reinstall tidal connectivity beneath causeway to Racecourse Flats**
"	"	Flora	Threatened floral species lifecycle	Narrowleaf blowngrass*, Tall blowngrass*, golden dodder*	
"	"	Fauna	Moths	Saltmarsh looper moth* & Cheveron looper moth*	
"	"	Fauna	Shorebirds (nesting, roosting, foraging)	Threatened and listed fauna *# and import for resident shorebirds	
"	"	Fauna	Invertebrates	molluscs, insects	
D) Future saltmarsh - Areas south of Lauderdale & north to Roscommon	*Areas for future saltmarsh* transgression	*grouped saltmarsh assets*	*Saltmarsh in 2100 are currently saltmarsh,* Tasvege DVC, & other		***VERY HIGH - manage areas now to*** **enable habitat transgression**

Notes

Tasvege DVC = Eucalyptus viminalis and E. globulus coastal woodland >
Tasvege DGL = Eucalyptus globulus dry forest and woodland >
Tasvege ASS = Succulent saline herbland
Tasvege ARS = Saline sedgeland/rushland

> = listed as threatened community NCA 2002
* = listed as threatened TSPA 1995
\# = listed species in EPCA 1994

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