Tasmanian Coastal Adaptation Pathways Project
Port Sorell – Report

SGS Economics & Planning

Tasmanian Coastal Climate Adaptation
Pathways Project
July 2012

Independent insight.

Independent insight.

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EXECUTIVE SUMMARY

This report informs residents and users of Port Sorell and the wider community about coastal risks in light of sea level rise resulting from climate change. It also considers ways to respond to risks while also considering the values of living in Port Sorell and other benefits such as beach recreation, fishing and swimming.

A better understanding of the issues and possible responses will help the community to make informed decisions to respond to sea level rise and its potential impacts.

This report has been prepared as part of the Tasmanian Coastal Adaptation Pathways study. The adopted pathway approach does not prescribe a one-size-fits-all solution, but as the word 'pathway' suggests, is a process to achieve adaptation responses in individual coastal areas.

The study area of Port Sorell is located on the northern coast of Tasmania and lies along the Rubicon Estuary. Within the study area are the Port Sorell and Shearwater beaches and foreshores, Pitcairn Street Bushland Reserve and the Port Sorell Conservation Area.

Coastal hazards

Port Sorell is potentially subject to coastal erosion (periodic or progressive), movement of the river mouth, flooding from the sea, flooding from peak river flows and erosion along the river banks. All of these events can occur under present day conditions, but are expected to change with rising sea levels and other climate change effects. Coastal hazards in Port Sorell are described in more detail below.

Freers Beach coastal erosion

A storm in 2011 caused significant erosion along Freers Beach. The beach was left with a steep erosion scarp as waves undercut the sand face. The erosion exposed old gabions understood to date from the 1970s. In addition to the gabions, there are remnants of four groynes and an offshore artificial reef.

The existence of these old, previously hidden protection works suggests erosion along this strip of coast was previously perceived to be a sufficient threat to warrant the investment in protection.

Movement of the river mouth

The movement of river mouths is common where the opening is through relatively soft sediment. For the Rubicon estuary, the opening between the land has been stable, with hard banks on the western shore at Hawley Beach, north of the study area, acting as a control point.

The main issue may be movement of the main flow channel within the estuary that can in turn affect the likelihood or severity of shore erosion. The western shoreline south of Hawley Beach is predominantly sand down to the outlet of Panatana Rivulet.

No specific evaluation of movement of the flow channels in the river has been undertaken for the current project, but it is noted as a potential issue to be monitored over time.

Coastal inundation

Sea height varies with tides, storms and regional wave effects. The combined effects can lead to extreme storm surges. The most extreme heights occur with a lower probability.

In addition to these effects, there are local influences such as local wind setup, local wave setup and local wave runup. Assessment of the likely effect of local wave setup for Port Sorell shows that wave setup can increase water height to 0.6 metres above Australian Height Datum[1] (AHD) for a 'once a year storm' and 1.1 metres above AHD for a 1% AEP (100 year ARI) storm. Even more extreme storms are possible. A lesser contribution of wave setup between 0.1 and 0.5 metres above storm tidal height might be appropriate for more sheltered estuarine locations of Port Sorell that are protected from open Bass Strait. Likely coastal inundation levels for storm seas are shown in the table below.

Likely coastal inundation levels for storm seas, present day

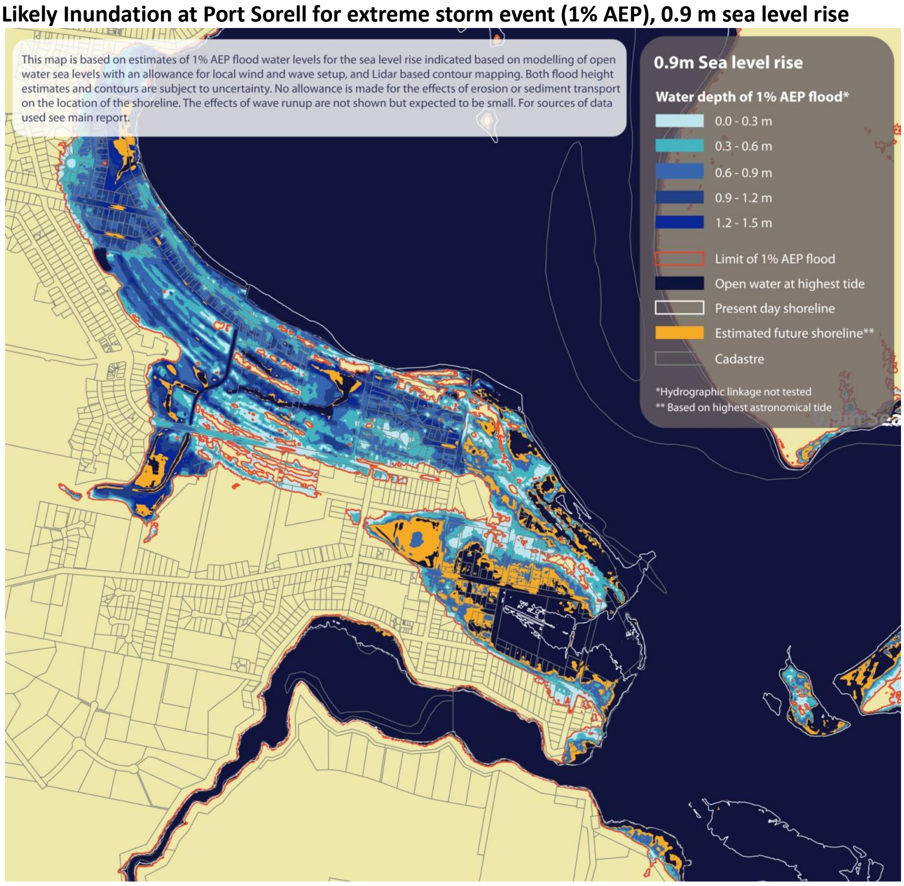
		Directly exposed to Bass Strait		Sheltered estuarine	
Average Return Interval	**Storm sea level (m)**	**Wave setup (m)**	**Indicative inundation level (m AHD)**	**Wave setup (m)**	**Indicative inundation level (m AHD)**
10 year ARI	1.88	0.8	2.68	0.26	2.14
50 year ARI	1.90	1.0	2.90	0.42	2.32
100 year ARI	1.93	1.1	3.03	0.5	2.43

Source: Pitt & Sherry

Coastal inundation with climate change

Future coastal inundation will increase as climate change causes sea level to rise. The map below illustrates where the coastline would be with a sea level rise of 0.9 metres, which is expected to occur by 2100. It also shows the depth of flooding as a result of a 1% AEP extreme storm event.

Likely Inundation at Port Sorell for extreme storm event (1% AEP), 0.9 m sea level rise



Source: SGS, 2011

[1] The Australian Height Datum (AHD) is a geodetic datum for altitude measurement in Australia. In 1971 the mean sea level for 1966-1968 was assigned the value of 0.000m on the Australian Height Datum at thirty tide gauges around the coast of the Australian continent. The resulting datum surface, has been termed the Australian Height Datum (AHD) and was adopted by the National Mapping Council as the datum to which all vertical control for mapping (and other surveying functions) is to be referred (Geoscience Australia)

River flooding

As a result of climate change, the probability of more intense rainfall is likely to increase (ACECRC[2], 2010). The peak flow rates associated with more frequent extreme events, such as 1% AEP river flood events, are likely to increase throughout the catchment, even without sea level rise. Rainfall driven floods may become more serious in the future. Rising sea levels will serve to aggravate river flooding near the mouth whether there is more intense rainfall or not. The worst case would be a combined high sea level from a storm, coupled with heavy runoff from an extreme rainfall event. The scale of this joint impact has not been estimated.

Riverbank erosion

Rising sea and estuary levels are likely to contribute to progressive erosion of sandy shorelines. Erosion was experienced in last year's storm that progressed further than any in recent years. However, the accretion of sand in front of protection works in the decades before the storm suggests that there has not been obvious progressive erosion in that period.

No specific estimate has been made of the likely extent of future erosion from sea level rise. Estimates indicate that a 0.9 m sea level rise would lead to between 45 and 180 m of erosion along the sandy shoreline between Hawley Beach and Panatana Rivulet if no protective action were taken. The low estimate of erosion would bring the shoreline to the front door of many of the dwellings along Shearwater Esplanade. The higher estimate would go well beyond the back boundary of these properties.

Current planning scheme mechanisms

The *Living on the Coast: Cradle Coast Regional Land Use Planning Framework 2010-2030* makes reference to mitigation and adaptation to climate change impacts under three of the strategy's themes: Wise Use of Resources, Places for People, and Infrastructure Provision. Policies under these themes address development in areas of coastal hazard; implementation of structure plans and regulatory instruments; promotion of guidelines and technical measures that will assist to reduce impact of current or future risk to places, uses and assets; hazard risk assessments; and contained settlement areas.

The Latrobe Planning Scheme addresses the impacts of climate change on coastal areas through Special Area Provisions, specifically Clause 7.3 Water Course Protection Area and Clause 7.8 Flood Plain Area. Clause 4.9 addresses Consideration of Applications for Planning Approval and ensures consideration of environmental risks prior to development.

There is little direction in the planning scheme on how the impacts of climate change on coastal areas are to be addressed, rather the provisions largely relate to riverine environments. The provisions are designed more for the protection of the waterways and are silent on the impact of hazards such as storm surge, flooding, sea level rise on life and property.

Cost of risks in the study area

As part of this study, an assessment was made of the properties at risk by inundation or sea level rise to 2100. Risk is the result of the total damage times the probability of an event happening. While the total damages of an event actually happening can be very substantial, the probability of it happening is often quite low. Therefore, the total risk (in $) may be substantially below the total damages of an extreme event.

Within Port Sorell, up to 290 residential dwellings have some present-day inundation risks[3]. Of those, 220 dwellings have less than 1% chance of inundation. By about 2050 (an expected rise of 0.25m), there will be 17 additional dwellings at potential inundation risk, and by about 2100 there will be an additional 48 dwellings at potential inundation risk, with most dwellings at present-day risk expected to flood frequently. Of those at inundation risk by 2100, more than 300 dwellings will be flooded by a 1% AEP (100 year ARI) event, with an average above-floor depth of 0.8 metres. The flood depth is most likely to range from 0 to 1 metre, with little chance of exceeding 1 metre.

[2] ACE CR C 2010, Climate Futures for Tasmania extreme events: the summary, Antarctic Climate and Ecosystems Cooperative Research Centre, Hobart, Tasmania.
[3] Risk, if not specified, refers to more than 0.01% chance of having an over floor flood.

The estimated cost of risk (in present day values) of coastal inundation to private dwellings is between approximately **$4.6 million and $6.8 million to 2100,** depending on whether owners continue to maintain their dwellings. If 1% AEP flood levels are 0.2 metres more than that estimated for the base scenario, then the total cost of risk would be between $11 million and $15 million.

By 2100, an extreme storm event (1% AEP) is estimated to cause $34.5 million worth of damage (base scenario, without structure depreciation) if the existing buildings or comparable ones are still in their current locations and elevations.

If nothing is done, a 1 metre sea level rise (expected around 2100) will result in a total land loss in Port Sorell of over 70 parcels with a value of **$8.5 million** based on present day valuation.

Values in the study area

People occupy and use areas near the coast, some of which are exposed to coastal hazards, because they derive value from doing so. In fact, coastal property values are typically higher than similar sized properties inland, showing the premium value placed on these areas. Other public, natural and economic values are major contributors of value from the 'use' of the coasts.

Property values

Properties in Port Sorell have significant value premiums due to their access and proximity to the beach and, to a lesser extent, access to the river front. Value derived purely from having beach front access is **$237,325**. To 2100, 324 properties would be affected by sea level rise and extreme storm events (1% AEP). Refusing any (re)development in the area potentially affected by sea level rise and extreme storms by 2100 could result in over $20 million worth of property value being lost over time.

Other values

The natural and environmental values of the Port Sorell area are significant and include wetlands, bird habitat, fish habitat and nursery and natural river waterways that improve water quality.

Sea level rise may result in the expansion of wetlands and lagoon areas. While this could most easily occur outside of the developed areas, some of the undeveloped areas enclosed by Port Sorell township, and in the longer term much of the golf course, would become wetlands if there were no interventions to prevent this.

Filling land, channelisation or hardening of river banks may reduce the water quality and also prevent wetlands from successfully migrating landward.

Social values in the study area involve beach related recreation and amenity, recreational fishing and river amenity and the golf course.

Economic activity in the area is related to the natural and recreational values of the beach and surroundings, including for tourists. Loss of the beach and poor water quality could have negative impacts on these economic activities.

Adaptation options

There are a number of adaptation options for Port Sorell that are potentially relevant to the impacts identified:

- Beach nourishment (provided a source of sand can be identified) ;
- Groynes, reefs and structures to reduce erosion;
- Construction of a hard revetment or sea wall;
- Protecting individual structures;
- Protecting properties prone to inundation with a levee;
- Redevelopment of structures in less vulnerable form (higher floor levels);
- Raising low lying residential areas, roads and services for long term occupation;
- Retreat.

Adaptation pathways

In preparation for community consultation, three different pathways for responding to climate change were developed:

- **Pathway 1. Early retreat, let nature take its course**
  This pathway allows maximum freedom for natural coastal processes to unfold, with a minimum of intervention or resistance from future development or coastal and flood protection works. Where erosion threatens structures, they would be removed. Where property is regularly inundated, it would eventually not be worth repairing and redevelopment in affected areas would not be permitted.
- **Pathway 2. Protect development while maintaining values of the area**
  This pathway protects property but only where that protection has a minimal impact on the values of the area important to the community. There is balance between protecting natural and shared community assets, and private property. There is also consideration of promoting and sustaining natural ecosystems in the face of climate change. This would include permitting wetlands to migrate inland in selected locations. In general, intensification of development in hazard areas would be discouraged unless it and the protection measures required clearly did not have any negative impact on natural and community values or were likely to have a positive effect.
- **Pathway 3. Protect existing and permitting future development to the maximum possible extent for as long as possible**
  This pathway concentrates on protecting the existing and future community and property using any available options. Intensification of development provides more contributors to any protection works, so some intensification is permitted where it does not compromise community values for the suburb. While natural areas may be affected, they may adapt in their own way or become modified in ways that the community accepts.

The community's perspective

Three adaptation pathways were investigated by the Port Sorell community at workshops held on Saturday May 19 with sessions held in the morning and the afternoon.

Interested residents and businesses were invited to register to attend the workshops. All three scenarios were available with each session lasting two hours, enabling an in depth investigation of the scenario. Over the two hours participants examined the following for the scenario they were investigating:

- The pros and cons and desirability of the scenario
- Whether they believed the scenario was plausible
- What if conditions change (eg. sea level rises faster or slower than anticipated, there are technological advances, or property prices rise or fall)
- Who decides
- Who pays

Over the entire day, about 40 community members attended the workshops. Also attending were the Mayor, two Councillors and observers from Council and State Government.

Prior to the workshops, an information night was held on Thursday 10th of May at the Port Sorell Memorial Hall, attended by about 100 members of the public. The information night was held to inform the community on the hazard and risk assessment and to introduce the pathways to be investigated at the Saturday workshops.

While some residents expressed a preference for Pathways 1 and 3, Pathway 2 was preferred overall, with participants of the workshop listing the following key benefits:

- The beach is retained for a significant time;
- It enables a continuation of the beach culture and active lifestyle;
- Natural values are mostly retained;
- Do-able: the existing groynes and off-shore reef or breakwater show these options work, and it appears to be an affordable pathway; and
- It buys time, and may enable the community to use future technological innovations and new solutions.

During the discussions about how to make the preferred pathways work, the attendants of the workshops identified the following key issues:

- Erosion at Freers Beach and stormwater drainage around Bluewater Crescent in Shearwater and around Mary's Creek. Participants expressed concerns about previous 'panic' repairs undertaken by Council after extreme storm events that lead to significant erosion at Freers Beach;
- Need for a drainage management plan;
- Need for a study for the wider Rubicon Estuary;
- Managing population growth in Port Sorell and Shearwater;
- Planning authorities should keep the community informed of risks;
- Need for requirements for any new development to ensure building structures will be safe;
- Migration of wetlands and the impact on property and land values;
- Need for local leadership and drive for coastal adaptation solutions, including a plan for funding mechanisms.

The way forward

Based on the findings of this study, and also to address any gaps in terms of knowledge, decision making and funding, the following recommendations were made:

- ***Local community and wider community values and objectives***
  Recommendation: To work with the state government to develop a framework for the development of coastal adaptation plans that have state backing and recognition, and balance the priorities of both the local and wider community.

- ***Understanding of current and expected hazards and adaptation works***
  Recommendation: To include modelling of rainfall driven flooding in conjunction with coastal inundation to better identify flood risk, as well as modelling drainage capacity in potentially flood affected areas that are developed or proposed for development.
  Recommendation: To undertake additional analysis of erosion risk, sediment transport within the estuary and the realistic options for erosion protection works including their likely effectiveness and impacts.

- ***A better knowledge of the environment***
  Recommendation: Prepare a detailed assessment of the environmental values of the areas around Port Sorell, including consideration of the likely changes that sea level rise and climate change will bring. Identify areas of high environmental significance that need consideration in any adaptation works, either to assist with the adaptation of the natural area or to ensure that adaptation measures to protect built assets do not adversely affect important natural areas.

- ***Longer term planning context***
  Recommendation: Review priority coastal areas of high value to the community for aesthetic, amenity or natural values that could not be protected from climate change impacts, if developed, without compromising these values. Amend the planning scheme to ensure development controls reflect this.

- ***Adaptation requires funding***
  Recommendation: That an approach be formulated to identify the budget required and the sources of funds to raise the money required. It is considered that this should be done on a staged basis over a period of about 5 years, with priority given to identification of and responding to erosion risks and sediment transport in the estuary.

1 INTRODUCTION AND AIM

1.1 Introduction

The aim of this report is to inform residents and users of Port Sorell and the wider community about coastal risks in light of sea level rise resulting from climate change. It considers ways to respond to risks while also considering the values of living in Port Sorell and other benefits such as beach recreation, fishing and swimming.

A better understanding of the issues and possible responses will help the community to make informed decisions to respond to sea level rise and its potential impacts.

The report starts with an overview of the potential coastal hazards (inundation, erosion) at the present day and expected changes in the future as a result of expected sea level rise. The report then describes the potential damages that may occur as a result of sea level rise and extreme storm events. It also describes how likely it is that damages would occur, now and in the future.

While coastal risks may increase over time, the area will maintain a range of specific values, such as access to the beach, which make it attractive to live and recreate there. In deciding how to respond to sea level rise it is important to not only consider the risks but also the values or benefits of using the land. The report therefore considers the benefits of the Port Sorell area, and any values that may be foregone if new development is prohibited or lost if existing development is required to retreat.

The final part of the report provides an overview of potential responses or options to respond to sea level rise. This last section considers those options that are potentially relevant in the Port Sorell area.

1.2 Background to this Report

This report has been prepared as part of the Tasmanian Coastal Adaptation Decision Pathways (TCAP) project. SGS has been engaged to assist the Local Government Association of Tasmania (LGAT), working with the Tasmanian Climate Change Office (TCCO) and the Tasmanian Planning Commission (TPC), and relevant Councils to develop future pathways for climate change adaptation in four coastal areas in Tasmania:

- Lauderdale (Clarence City Council),
- St Helens/Georges Bay (Break O'Day Council),
- Port Sorell (Latrobe Council) and
- Kingston Beach (Kingborough Council).

Funding for the TCAP project has been provided via the Australian Government's Coastal Adaptation Decision Pathways program, with matching contributions from project partners. Project partners include LGAT, TCCO, TPC, the four councils, Antarctic Climate and Ecosystems Cooperative Research Centre and the University of Tasmania.

The TCAP project aims to significantly improve the ability of Tasmanian decision makers and communities to plan and respond to likely futures for coastal communities. The results and lessons learnt from the four project sites can then be applied in other coastal areas.

This report summarises the coastal climate adaptation pathway work and findings so far for the Port Sorell (Latrobe Council) project site.

1.3 Coastal Climate Adaption Pathways

Based on previous and ongoing work, SGS developed guidelines for communities and states for coastal climate adaptation pathways. The adaptation pathways cover approximately 15 steps in total and present a consultative approach involving the community, local and other government, land managers and other key stakeholders. The pathway approach does not prescribe a one-size-fits-all solution, but, as the word 'pathway' suggests, is a process to achieve adaptation responses.

It is anticipated that this study will progress Latrobe Council to approximately step 9 of the 15 step pathway. The 15 steps are as follows:

1. Establish hazards and future sea level rise effects and map at the local/relevant scale
2. Interim planning scheme amendment in hazard areas
3. Assess assets at risk
4. Establish the expected cost of risk
5. Assess the value of occupation or use
6. First cut assessment of adaptation options and costs
7. Plan and implement necessary short term protection works in hazard areas
8. Establish preliminary policy and decision making framework
9. Strategic options assessment (Scenario Planning)
10. Detailed assessment of short listed options
11. Select preferred scenario
12. Establish financial framework
13. Revised 'final' planning scheme
14. Implementation
15. Review

Each section of this report relates to one of these 15 steps and this is identified at the start of each section. This report as a whole can be seen as a component of Step 6.

1.4 Port Sorell – project site introduction

The study area of Port Sorell lies along the Rubicon Estuary. Within the study area are the Port Sorell and Shearwater beaches and foreshores, Pitcairn Street Bushland Reserve and the Port Sorell Conservation Area. Freers Beach curves from the southern rocks of Taroona Point for 1.7 km to the south, then southeast to the 500 m entrance of the port. A road parallels the back of the beach, with several seawalls and groynes crossing the beach, including one at the southern end. Port Sorell Beach is further south. The beaches are at locations subject to tidal erosion.

FIGURE 1 PORT SORELL PROJECT SITE

1.5 This Report

The remainder of this report describes the findings so far for the Port Sorell project site. It covers:

- Current day and future coastal risks
- Current relevant planning scheme mechanisms
- Costs of risks in the study area
- Current property values, public benefit and other values in the project site
- Adaptation options with an introduction that explains what is likely to happen if nothing is done to manage current and future risks
- Possible adaptation pathways for the study area
- Findings from the community consultation meeting
- Overall recommendations to provide a way forward from here

2 COASTAL HAZARDS

Port Sorell is potentially subject to coastal erosion (periodic or progressive), movement of the river mouth, flooding from the sea, flooding from peak river flows and erosion along the river banks. All of these can occur under present day conditions, but are expected to change with rising sea levels and other climate change effects.

This section provides site specific information regarding these coastal processes and relates to Step 1 of the project's coastal adaption pathway process.

2.1 Freers Beach coastal erosion

A storm in 2011 caused significant erosion along Freers Beach. The beach was left with a steep erosion scarp as waves undercut the sand face. The erosion exposed old gabions understood to date from the 1970s. In addition to the gabions, there are remnants of four groynes and an offshore artificial reef.

The existence of these old, previously hidden protection works suggests:

- Erosion along this strip of coast was previously perceived to be a sufficient threat to warrant the investment in protection.
- Deposition of sand along this coast was sufficient to cover these works and most residents and council staff were not aware that they were there. The extent to which this was caused or assisted by the groynes and reef has not be evaluated.

FIGURE 2 PHOTOS OF PORT SORELL

Shoreline near East Esplanade

North end of Freers Beach

Freers Beach – north end no beach at high tide

Coastal armouring at Freers Beach, north end

Stream outlet, north end Freers Beach **Low lying infrastructure**

Shoreline near Mary's Creek **Coastal salt tolerant vegetation on tidal flats**

2.2 Movement of the river mouth

The movement of river mouths is common where the opening is through relatively soft sediment. For the Rubicon estuary, the opening between the land has been stable with hard banks on the western shore at Hawley Beach, north of the study area, acting as a control point.

The main issue may be movement of the main flow channel within the estuary that can in turn affect the likelihood or severity of shore erosion. The western shoreline south of Hawley Beach is predominantly sand down to the outlet of Panatana Rivulet.

No specific evaluation of movement of the flow channels in the river has been undertaken for the current project, but it is noted as a potential issue to be monitored over time.

2.3 Coastal inundation

Sea height varies with tides, storms and regional wave effects. The combined effects can lead to extreme storm surges. The most extreme heights occur with a lower probability. Present day storm sea level heights of different probability/frequency are shown in the summary table below.

TABLE 1 STORM SEA LEVEL BY PROBABILITY, PRESENT DAY

Average Return Interval (ARI)[4]	Annual exceedance probability (AEP[5])	Storm sea level (m AHD)
10 year ARI	10%	1.88
20 year ARI	5%	1.89
50 year ARI	2%	1.90
100 year ARI	1%	1.93

Source: Pitt & Sherry

In addition to these effects, there are local influences such as local wind setup, local wave setup and local wave runup. For Port Sorell, the likely effect of local wave setup has been assessed with the results presented in Table 2. Results show that wave setup can increase water height to 0.6 metres above Australian Height Datum[6] (AHD) for a 'once a year storm' and 1.1 metres above AHD for a 1% AEP (100 year ARI) storm. Even more extreme storms are possible.

A lesser contribution of wave setup between 0.1 and 0.5 metres above storm tidal height might be appropriate for more sheltered estuarine locations of Port Sorell that are protected from open Bass Strait.

TABLE 2 EFFECT OF WAVE SETUP ON STORM SEA LEVELS, PRESENT DAY

Average Return Interval	Directly exposed to Bass Strait	Sheltered Estuarine
1 year ARI	0.6	0.1
10 year ARI	0.8	0.26
50 year ARI	1.0	0.42
100 year ARI	1.1	0.5

Source: Pitt & Sherry

Likely coastal inundation levels for Port Sorell which consider both storm sea levels and wave setup are summarised in the table below.

TABLE 3 LIKELY COASTAL INUNDATION LEVELS FOR STORM SEAS, PRESENT DAY

		Directly exposed to Bass Strait		Sheltered estuarine	
Average Return Interval	**Storm sea level (m)**	**Wave setup (m)**	**Indicative inundation level (m AHD)**	**Wave setup (m)**	**Indicative inundation level (m AHD)**
10 year ARI	1.88	0.8	2.68	0.26	2.14
50 year ARI	1.90	1.0	2.90	0.42	2.32
100 year ARI	1.93	1.1	3.03	0.5	2.43

Source: Pitt & Sherry

[4] The Average Return Interval expresses the likelihood for an event to occur as the average number of times an extreme event would occur in a given timeframe.

[5] The Annual Exceedance Probability is a way to express the likelihood for an extreme event to occur. It refers to the probability of an event occurring in any given year.

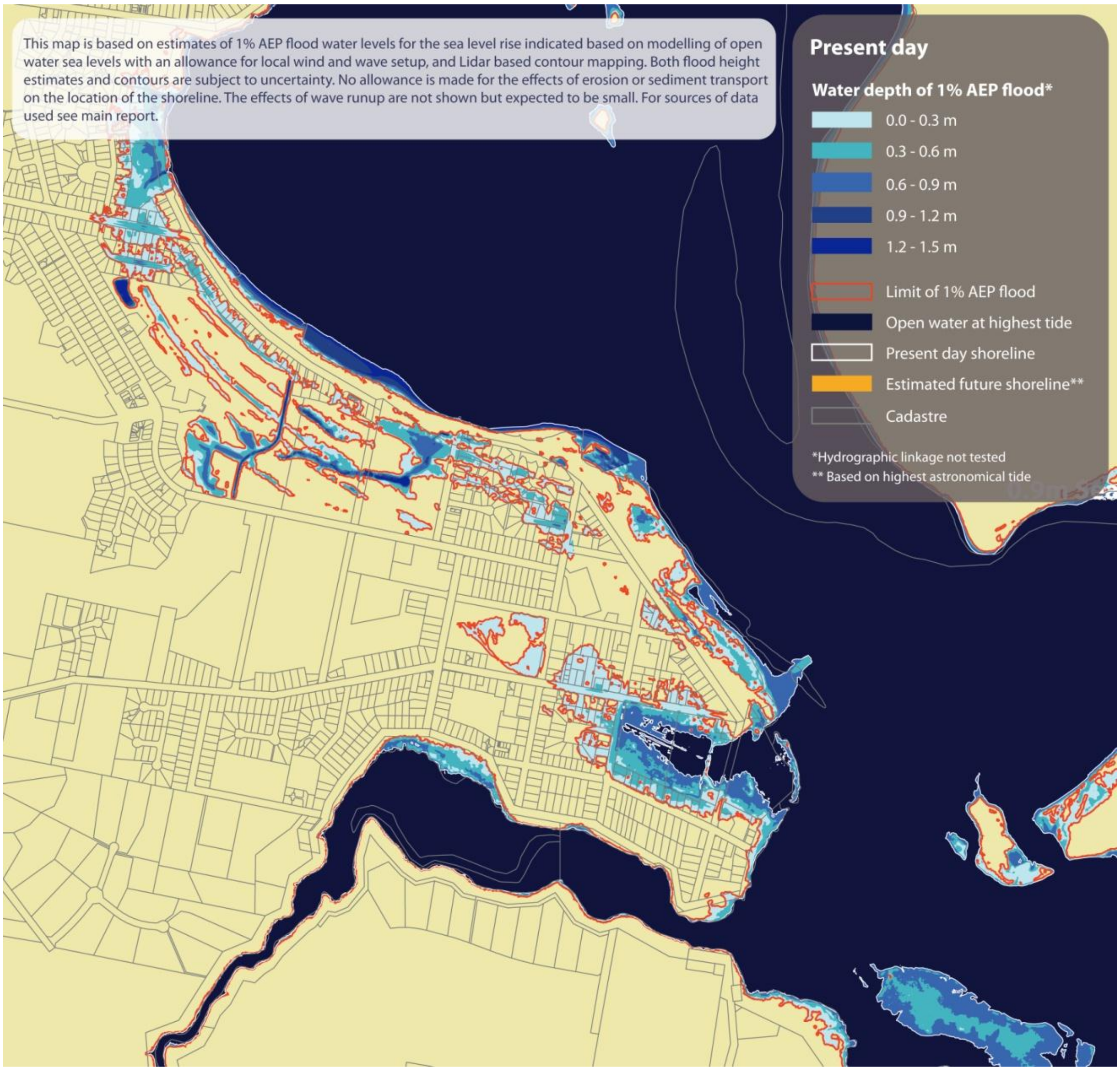
[6] The Australian Height Datum (AHD) is a geodetic datum for altitude measurement in Australia. In 1971 the mean sea level for 1966-1968 was assigned the value of 0.000m on the Australian Height Datum at thirty tide gauges around the coast of the Australian continent. The resulting datum surface, has been termed the Australian Height Datum (AHD) and was adopted by the National Mapping Council as the datum to which all vertical control for mapping (and other surveying functions) is to be referred (Geoscience Australia)

Note that all values are 'best estimates' and subject to inaccuracies:

- Inundation depths may vary from estimates by ±0.2m
- Land levels based on Lidar (best available mapping surface) may vary by ±0.2m
- Actual floor heights may vary from the estimate ±0.15m
- These errors may act to offset each other **or** may add together.

The map below shows current inundation levels for a 1% AEP extreme storm event.

FIGURE 3 LIKELY INUNDATION AT PORT SORELL FOR EXTREME STORM EVENT (1% AEP), PRESENT DAY



Source: SGS (2011)

2.4 Coastal inundation with Climate Change

Future coastal inundation will increase as climate change causes sea level to rise.
Table 4 shows the possible coastal inundation levels for storm seas for the present day, with a sea level rise of 0.3 metres[7] (likely by about 2050), and with a sea level rise of 0.9 metres (likely by 2100). The estimates are based on sea level rise projections by IPCC and are consistent with those used in other sites for the TCAP project.

[7] The maps are based on sea level rise relative to 1990 levels as used by the IPCC using an estimate of 0.3 m for about 2050 and 0.9 m for about 2100. The maps accurately reflect this level of sea level rise for whatever date it may occur. Modelling of the cost of

TABLE 4 LIKELY COASTAL INUNDATION LEVELS FOR STORM SEAS, WITH SEA LEVEL RISE (AREAS DIRECTLY EXPOSED TO BASS STRAIT)

Average Return Interval	Storm sea level (m)	Wave setup (m)	Indicative inundation level (m AHD)
Present day			
10 year ARI	1.88	0.8	2.68
50 year ARI	1.90	1.0	2.90
100 year ARI	1.93	1.1	3.03
2050			
10 year ARI	2.05	0.8	2.85
50 year ARI	2.09	1.0	3.09
100 year ARI	2.15	1.1	3.25
2100			
10 year ARI	2.45	0.8	3.25
50 year ARI	2.60	1.0	3.70
100 year ARI	2.70	1.1	3.80

The following series of maps show two features for a given sea level rise:

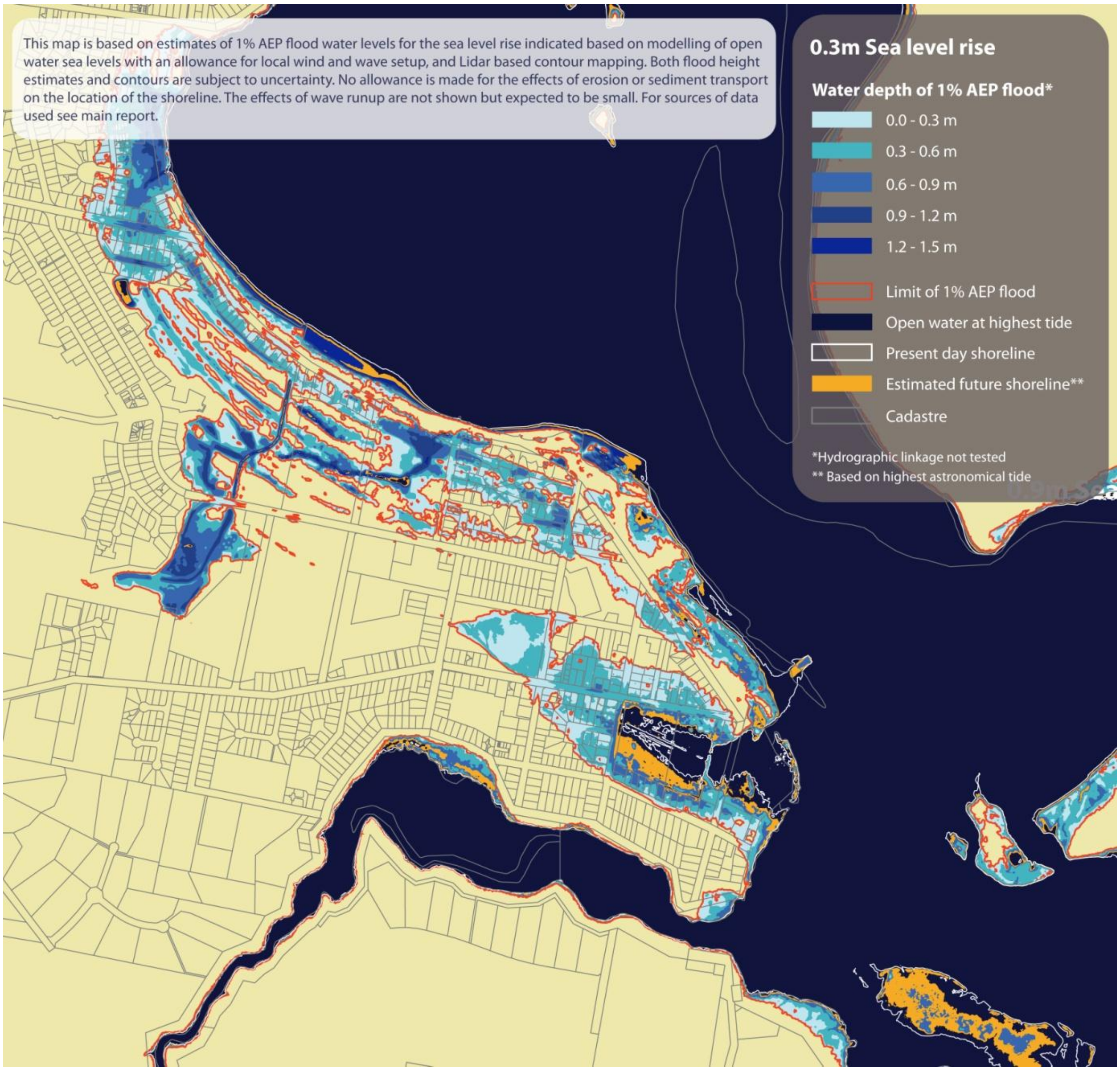
- The approximate shoreline given current topography assuming little or no significant erosion
- The area flooded in a 1% (100 year ARI) event with an indication of the depth of flood.

These maps have been produced for a sea level rise of 0.3 metres and 0.9 metres. These might be considered to be roughly 40 years and 80-100 years into the future. This corresponds roughly to the highest sea level rise rate estimated by the IPCC, Fourth Assessment Report and changes are relative to a baseline of 1990 levels. The current rate of sea level rise is just over 3 mm per year, double the average rate during the twentieth century and at the highest rate estimated by the IPCC.

The maps assume that the topography does not change with erosion of the movement of sand from wave action, which is clearly unrealistic. More likely, rising sea levels will cause progressive erosion of sandy shores if no action is taken. The dynamics of the estuary and mouth will also change, potentially leading to sand deposition and a rising bar in the entrance, with water depths in the entrance not increased as much as sea level rise would suggest. The dynamics of the sediment budget have not been evaluated.

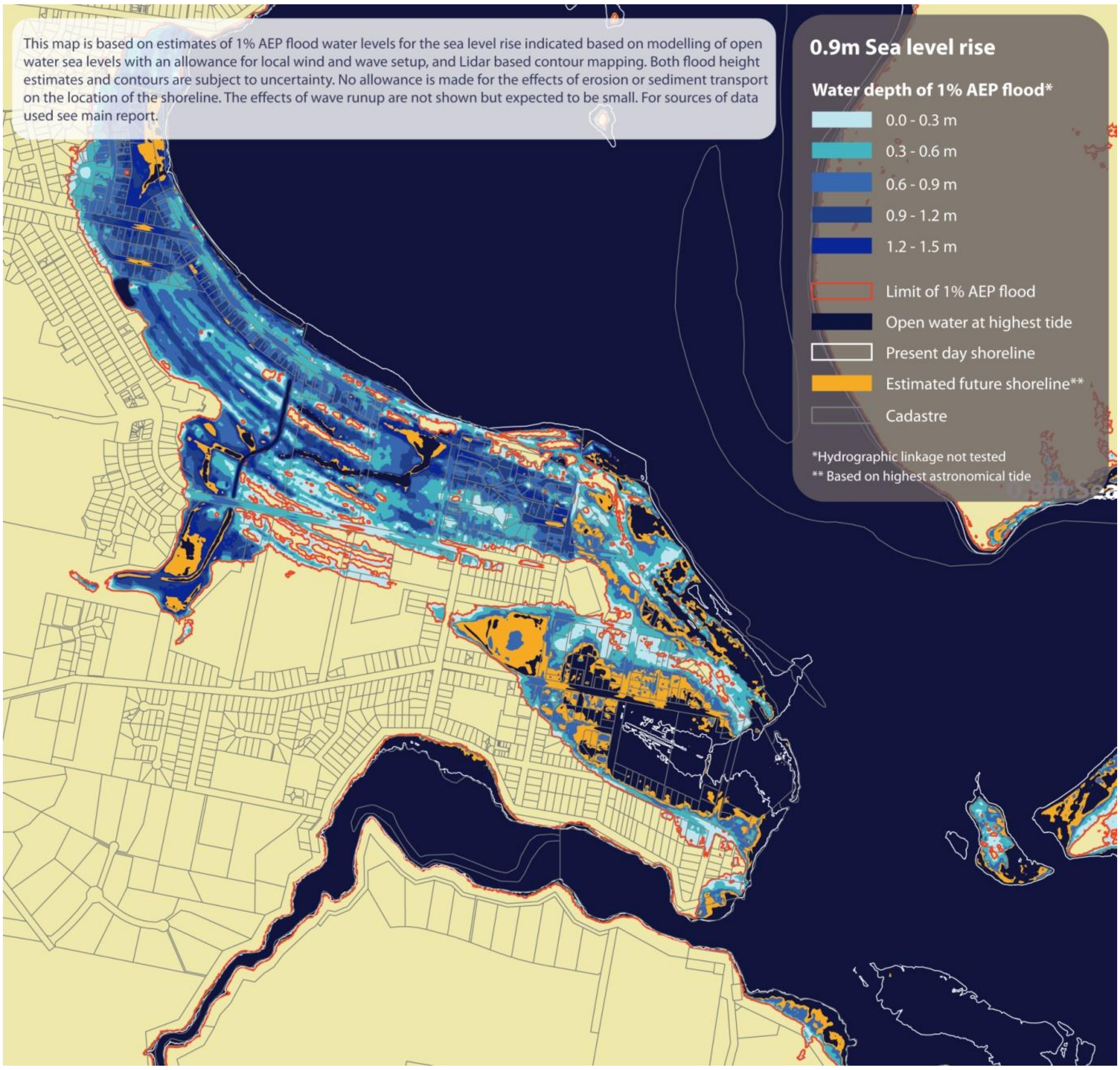
risk was done starting from today's sea level using a sea level rise of about 0.25 to 2050. A higher sea level of 1.0 m from today's sea level was used for 2100 based on a possible revision of future estimates. The modelling necessarily had to specify dates for these heights.

FIGURE 4 LIKELY INUNDATION AT PORT SORELL FOR EXTREME STORM EVENT (1% AEP), 0.3 M SEA LEVEL RISE



Source: SGS, 2011

FIGURE 5 LIKELY INUNDATION AT PORT SORELL FOR EXTREME STORM EVENT (1% AEP), 0.9 M SEA LEVEL RISE



Source: SGS, 2011

The maps suggest that there is already a risk of flooding for parts of the study area with an extreme storm event, particularly around Bluewater Crescent and Hawley Place, located to the north of Freers Beach, and residential areas of Port Sorell around Darling Street. With a sea level rise of 0.3 metres, inundation levels in those areas increase and there is more significant flooding around the golf course. With sea level rise to 0.9 metres, parts of Port Sorell will be in open water and there would be significant inundation inland from Freers Beach.

2.5 River flooding

As a result of climate change the probability of more intense rainfall is likely to increase (ACECRC[8], 2010). The peak flow rates associated with more frequent extreme events such as 1% AEP river flood events are likely to increase throughout the catchment, even without sea level rise. Rainfall driven floods may become more serious in the future. Rising sea levels will serve to aggravate river flooding near the mouth whether there is more intense rainfall or not. The worst case would be a combined high sea level from a storm, coupled with heavy runoff from an extreme rainfall event. The scale of this joint impact has not been estimated.

[8] ACE CR C 2010, Climate Futures for Tasmania extreme events: the summary, Antarctic Climate and Ecosystems Cooperative Research Centre, Hobart, Tasmania.

2.6 Riverbank erosion

As noted above, rising sea and estuary levels are likely to contribute to progressive erosion of sandy shorelines. Erosion was experienced in last year's storm that progressed further than any in recent years. However, the accretion of sand in front of protection works in the decades before the storm suggests that there has not been obvious progressive erosion in that period.

No specific estimate has been made of the likely extent of future erosion from sea level rise. For open sandy beaches with breaking waves, landward erosion of 50 to 200 times the height of sea level rise is considered possible based on a method known as the Bruun Rule. That is, a rise of say 1 metre could lead to erosion of 50 to 200 metres inland. The coastal dynamics behind this rule, which is sometimes contested even for open sandy beaches, does not apply to more protected sandy shores, but observations have suggested the extent in these situations is not dissimilar in practice.

If this rule of thumb applied, a 0.9 m sea level rise would lead to between 45 and 180 m of erosion along the sandy shoreline between Hawley Beach and Panatana Rivulet if no protective action were taken. The low estimate of erosion would bring the shoreline to the front door of many of the dwellings along Shearwater Esplanade. The higher estimate would go well beyond the back boundary of these properties.

Generally, dwellings in Port Sorell behind North and East Esplanade are less vulnerable to damage from erosion but some dwellings here may also be affected.

A more detailed assessment of the historic patterns and local dynamics of erosion would be required to make meaningful statements about erosion risk in the area.

3 PLANNING SCHEME MECHANISMS

This section describes how the current planning scheme deals with coastal risks in Latrobe. As part of Step 2 (interim planning scheme amendment in hazard areas) of the adaptation pathway process, the current planning scheme of Latrobe Council and relevant regional directions were reviewed.

3.1 Regional Context

As part of the regional planning initiative and the *Planning Directive 1 – The Format and Structure of Planning Schemes (May 2011)*, municipalities are working towards new planning schemes based on the new Planning Scheme Template for Tasmania. This will align future planning schemes including consistent zonings, layout and terminology. It is intended that the new planning schemes will take effect in 2012.

At the regional level, in October 2011, the Minister for Planning declared the *Living on the Coast: Cradle Coast Regional Land Use Planning Framework 2010-2030*. It sets common planning and development goals for the region. The strategy makes reference to mitigation and adaptation to climate change impacts under three of the strategy's themes: Wise Use of Resources, Places for People, and Infrastructure Provision.

The theme Wise Use of Resources includes the policy:

- 'minimise or avoid use or development in areas subject to high levels of coastal hazard'.

The theme Places for People includes the policies:

- 'Implement structure plans and regulatory instruments for each centre which – minimise exposure of people and property to unacceptable levels of risk to health or safety'.
- 'Recognise land exposed to future or enhanced risk is a valuable and strategic resource that should not be sterilized by unnecessarily excluding use or development'.
- 'Establish the priority for risk management is to protect the lives of people, the economic value of buildings, the functional capacity of infrastructure, and the integrity of natural systems'.
- 'Avoid new essential service, sensitive or inappropriately located use or development on undeveloped land exposed to or affected by a high level of existing likely future or enhanced risk, including from inundation and erosion by the sea, flooding, bush fire or landslip'.
- 'Limit opportunity for expansion of existing essential service, sensitive or inappropriately located use and development onto land exposed to or affected by an existing, likely future or enhanced level of risk'.
- 'Limit opportunity for redevelopment and intensification of existing essential service, sensitive or inappropriately located use or development on land exposed to or affected by an existing, likely future or enhanced level of risk unless the impact can be managed to be no greater or less than the existing situation'.
- 'Promote guidelines and technical measures that which will assist to reduce impact of an existing, likely future or enhanced level of risk and make existing strategically significant places, uses, development and infrastructure assets less vulnerable, including provision for protection, accommodation and abatement, or retreat'.
- 'Require a hazard risk assessment for new or intensified use or development on land exposed to an existing, likely future or enhanced risk, such assessment to address the nature and severity of the hazard, the specific risk factors for the proposed use or development, and the measures required to mitigate any risk having exceedance probability of greater than 1% at any time over the life of the development'.
- 'Ensure current and future landowners and occupiers are put on notice of the likelihood for a further or enhanced level of risk'.
- 'Rationalise or remove opportunity for housing in locations where oversupply is identified, and in locations where access, servicing, safety or impact are unacceptable'.
- 'Provide opportunity for housing in rural areas where – There is an acceptable level of risk from exposure to natural or man-made hazard'.

The theme Infrastructure Provision includes the policies:

- 'Promote compact contained settlement areas to – assist climate change adaptation and mitigation measures'.
- 'Promote infrastructure corridors, sites and facilities that – minimise exposure to likely risk from natural hazards'.

Other related Tasmanian Government initiatives include:

- The Tasmanian Planning Commission has also initiated the Tasmanian Coastal Vulnerability Project. The project aims to deliver GIS map layers identifying inundation and erosion risks in coastal areas under various climate change scenarios.
- The Tasmanian Planning Commission has established a Coastal Planning Advisory Committee to scope the advancement of the Tasmanian coastal planning framework.
- The Department of Primary Industries, Parks, Water and Environment (DPIPWE) has developed tools to assist with risk-based management and planning for infrastructure, assets and values in coastal zones[9].

3.2 Latrobe Planning Scheme 1994

One of the objectives of the Latrobe Planning Scheme, listed in Clause 2.2, is *"To maintain and improve the environmental quality and safety for the community"*.

The impacts of climate change on coastal areas are addressed in the Scheme through Special Area Provisions contained in Part 7 of the Planning Scheme, in particular:

Clause 7.3 Water Course Protection Area
Clause 7.8 Flood Plain Area

The purpose of **Clause 7.3 Water Course Protection Area** is "to control erosion and pollution, and to protect the natural drainage functions and botanical, zoological and landscape values of streams, rivers, wetlands or beaches within any such area".

The area covered under this clause is defined as the strip of land 30 metres wide measured from and above the high water mark of the Mersey, Rubicon and Franklin River and the Panatana Rivulet as well as the strip of land 5 metres wide measured from and above the high water mark of all other permanent water courses. Use or development of any allotment is prohibited in this area, however, exceptions are listed.

When determining whether to grant a permit for use or development of land within a Water Course Protection Area, the Planning Authority is to consider the impact of the proposal on the stability of the land, the minimisation of the clearing of vegetation, the earthworks to be carried out and the means of waste disposal plus the cultural significance of the area.

Clause 7.8 Flood Plain Areas are identified on the planning scheme maps. All uses and development proposed within the area are to be treated as Discretionary Uses.

Direction is also provided in Part 4 of the Planning Scheme 'Planning Approval' which includes Clause 4.9 Consideration of Applications for Planning Approval. This Clause lists issues the Planning Authority shall take in to consideration before granting or refusing a permit for any discretionary use or development. Relevant considerations include:

whether any part of the land is subject to:

- landslip, soil instability, or erosion
- ponding or flooding

whether the proposed use or development is satisfactory in terms of its siting, size and appearance in relation to:

- the natural environment

There is little direction in the Planning Scheme on how the impacts of climate change on coastal areas are to be addressed, rather the provisions largely relate to riverine environments. The provisions are designed more for the

[9] DPIPWE (2010), Tasmanian Coastal Works Manual: A best practice management guide for changing coastlines.

protection of the waterways and are silent on the impact of hazards such as storm surge, flooding, sea level rise on life and property.

The hazard areas that are identified are based on a rigid definition of the hazard area, that is, 30 metres wide measured from and above the high water mark of the Mersey, Rubicon and Franklin River and the Panatana Rivulet as well as the strip of land 5 metres wide measured from and above the high water mark. As this is not based on the detailed mapping of the hazard areas it is possible the hazard may be underestimated or overestimated. Further, the provision provides no guidance on the period of time over which the land is assessed to be at risk. As the high water mark in the tidal portion of the estuaries will continue to rise for centuries, areas not at risk now will be later.

Part 4 of the Scheme does require the Planning Authority to assess whether any part of the land is subject to landslip, soil instability, erosion or flooding and whether the development's siting, size and appearance is satisfactory in relation to the natural environment for all discretionary applications. However, there is no guidance on the acceptable levels of risk or for what time period.

4 COST OF RISK

This section assesses properties at risk of being affected by inundation or sea level rise to 2100. The total risk is expressed in net present value, which is the present day value (in $) of future costs and revenues (cash flows).

This section relates to Step 3 of the adaptation pathway process.

In reading this section it is important to define the term **risk**. Risk is the result of the **total damage** multiplied by the **probability** of an event happening. While the total damages of an event actually happening can be very substantial, the probability of it happening is often quite low. Therefore, the total risk (in $) may be substantially below the total damages of an extreme event.

The analysis on the costs of risks is presented here only for private properties. Infrastructure, public amenities, the golf course and open space also may be damaged by coastal inundation. The same level of information about the cost of damage as a result of flooding is not readily available for infrastructure as it is for dwellings. Further information may become available later in the project.

A description of the method to determine risks is provided in Appendix 11.

4.1 Inundation Risks

The key findings about inundation risks in Port Sorell are summarised below:

- Up to 290 residential dwellings have some present-day inundation risks[10]. Of those, 220 dwellings have less than 1% chance of inundation. Only five of those at present-day risk have an inundation probability of greater than 10%, with three of those dwellings located at the northern end of Rice Street.
- With a sea level rise of 0.25 m from today's levels (expected by about 2050), there will be 17 additional dwellings at potential inundation risk. The average inundation probability of those at present-day risk is expected to increase significantly from 1.2% (with no sea level rise) to 5%.
- With a sea level rise of 1 metre from today's levels (expected by about 2100), most dwellings at present-day risk would be flooded frequently, with an average annual probability of around 75%. The flood depth is most likely to range from 0 to 1 metre, with little chance of exceeding 1 metre.
- By 2100, there will be additional 48 dwellings at potential inundation risks. Up to 80% of those are within the more sheltered area of Port Sorell.
- Of those at inundation risk by 2100, more than 300 dwellings will be flooded by a 1% AEP (100 year ARI) event with an average above-floor depth of 0.8 metres.

The table below shows the estimated number of properties in Port Sorell that would be flooded above floor level by an event with a 1% annual exceedance probability (100 year ARI) at present day sea levels, with 0.25 metre sea level rise and with 1.0 metre sea level rise.

TABLE 5 NUMBER OF INUNDATED PROPERTIES[11] AND AVERAGE OVER-FLOOR DEPTH CAUSED BY 1% AEP FLOOD

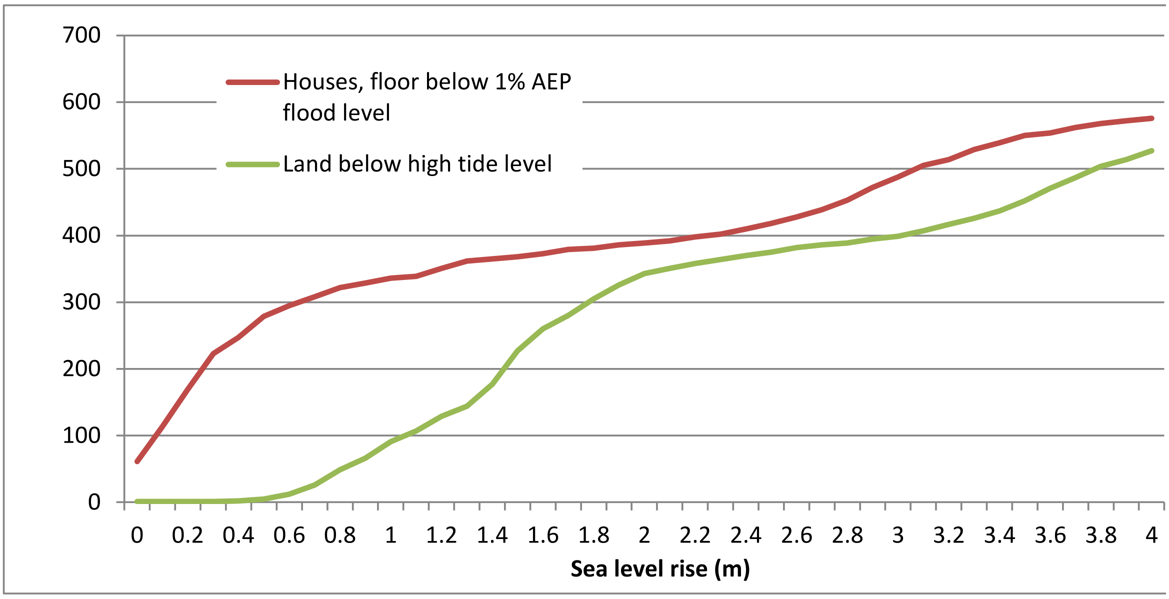
		Estimated No. of inundated properties	Average over-floor depth (m)
0.0	**(2010)**	65	0.17
0.25	**(2050)**	199	0.22
1.0	**(2100)**	311	0.79

Source: SGS estimates (2011)

[10] Risk, if not specified, refers to more than 0.01% chance of having an over floor flood.
[11] Includes residential properties with above floor level inundation depths only

As sea levels continue to rise, the numbers of properties at some risk of flooding does not increase as quickly after about 0.9 metres. While more properties are gradually affected, the biggest impact is the greater depth and frequency of flooding for properties already affected, and the fact that increasing land areas become permanently inundated. This trend is shown in Figure 6.

FIGURE 6 NUMBER OF HOUSES AFFECTED BY 1% AEP FLOOD AND LAND BELOW HIGH TIDE LEVEL, WITH VARIOUS SEA LEVEL RISES, IN PORT SORELL



Source: SGS (2012)

4.2 Property Risks

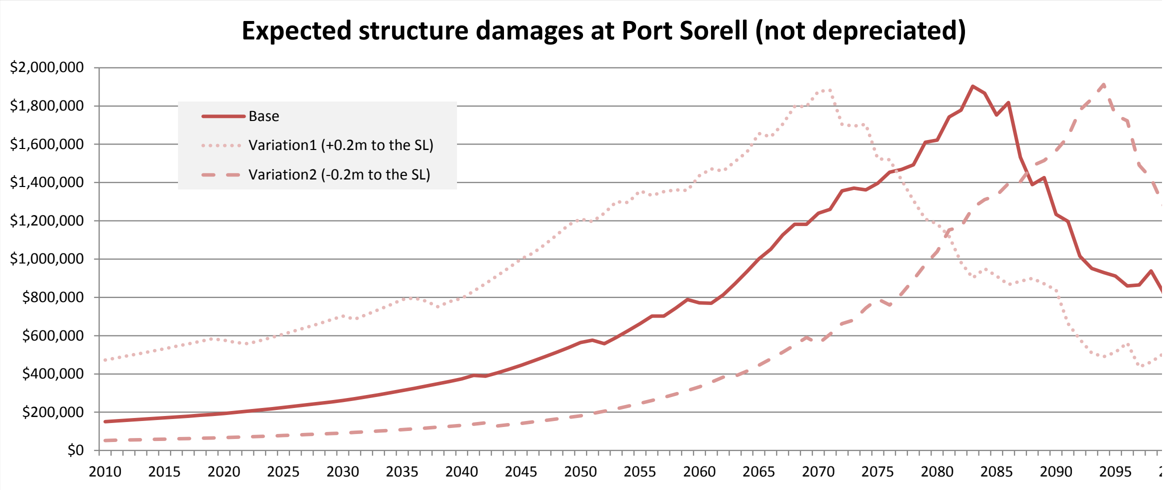
The charts below depict the expected risks (structure damages x probability) in dollar values over time. As there is some uncertainty in flood frequency estimates and the land elevation levels available, the risks to residential properties at Port Sorell over time were calculated according to three cases to test the sensitivity of the outcome to this uncertainty:

- Base case – based on the flood frequencies from Table 2 assuming land levels are correct
- Variation 1 – increasing the 1% AEP flood level estimates by 0.2 m relative to the land levels above the base case
- Variation 2 – decreasing the 1% AEP flood level estimates by 0.2 m relative to the land levels below the base case

Expected risk is calculated for each property within the study area for each year by considering likelihood/probability of different flood depths occurring and associated structure damages (derived from the damage curve) as sea levels rise. The total risk at Port Sorell is a sum of the risk to all properties. The figure below shows the expected risk to structures assuming the properties are fully maintained over time with a minimum level of depreciation in structure value (

Figure 7).

FIGURE 7 EXPECTED ANNUAL STRUCTURE DAMAGES (IN REAL DOLLARS) AT PORT SORELL, WITHOUT DEPRECIATION



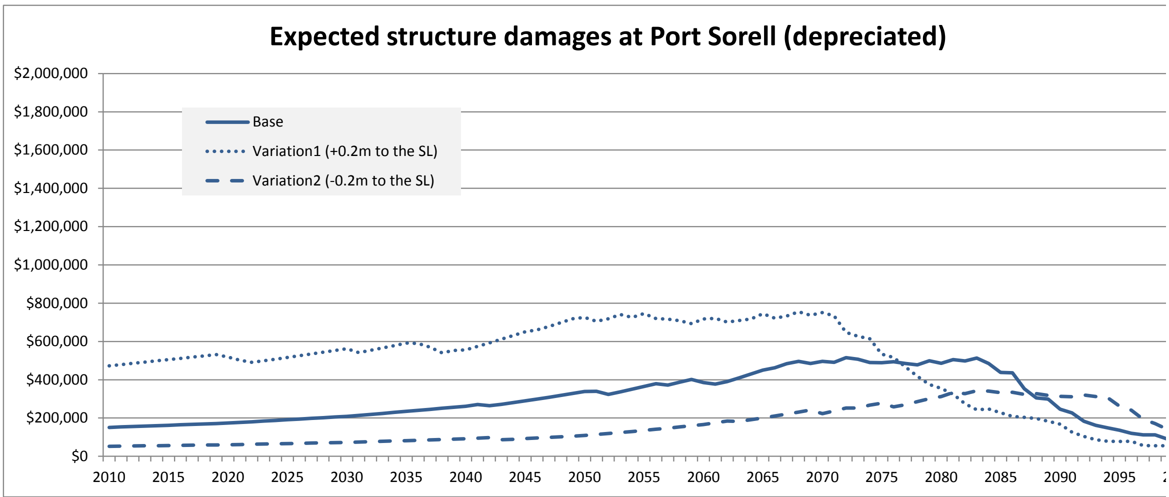
Source: SGS (2012)

The calculations assume that dwellings would be repaired to their previous condition after every flood until the expected annual damage reaches 10% of the replacement value in any one year. At that point the property is dropped from the calculation on the basis that it either would cease to be repaired (too much damage) or it would have been rebuilt in a non-flood vulnerable form (higher floors, flood proof construction).

If the properties are fully maintained and renewed over time, but not expanded or upgraded, with minimum level of depreciation in structure value, the expected structure damages at Port Sorell under variation 1 starts at around $500,000 in 2010, which is approximately $400,000 higher than variation 2. However, by 2100, the annual damage under variation 1 is expected to be $800,000 lower than the damage under variation 2. This is because more dwellings would have been abandoned or adapted properly to avoid future losses under the variation 1 than for variation 2 in 90 years.

If the structure value is assumed to be fully written off in 100 years (with 1% depreciation rate per annum), and no new investment in the affected dwellings, the expected damage per annum by 2100 is significantly lower and likely to range from $38,000 to $120,000 (Figure 8).

FIGURE 8 EXPECTED ANNUAL STRUCTURE DAMAGES (IN REAL DOLLARS) AT PORT SORELL, WITH DEPRECIATION



Source: SGS (2011)

The net present values (NPV) of these expected future coastal inundation structure risks are calculated using a real discount rate of 5% per annum and are provided in the table below (Table 6).

Without structure depreciation (i.e. assuming ongoing investment on maintenance and capital upgrade), the NPV of the future risks amounts to $6.8 million under the base case[12], with a wide range from about $3 million up to $15 million if the low and high variations are considered.

If the properties in Port Sorell are assumed to be fully depreciated in 100 years (i.e. not properly maintained and upgraded), the NPV of the structure risks is $4.6 million under the base case, with a range of between $1.7 million and $11 million.

We have classified the residential dwellings[13] in the study area into three categories:

1. The 286 dwellings with present-day inundation risks
2. The 70 dwellings with no present-day inundation risks but at risk with 1 m sea level rise
3. Those not at risk even with 1 m sea level rise.

Most of the flood risk expressed as NPV is incurred by the properties at present-day risk. The table below shows that the total risk to structures at present day risk is high compared to their value.

TABLE 6 NPVS OF TOTAL STRUCTURE DAMAGES, AND THEIR SHARE OF THE EXISTING STRUCTURE VALUES

		Category 1		Category 2		All
	Current value and count	**$47 million**	**286 dwellings**	**$10 million**	**70 dwellings**	**570 dwellings**
	Variations	**NPV of expected damages**	**% of existing capital value**	**NPV of expected damages**	**% of existing capital value**	**NPV of expected damages**
Without structure depreciation	*Base scenario*	$6,800,000	14%	$18,000	0.17%	$6,800,000
	Variation 1 (+0.2m to the SL)	$15,000,000	31%	$65,000	0.62%	$15,000,000
	Variation 2 (-0.2m to the SL)	$3,000,000	6.3%	$4,400	0.04%	$3,000,000
With structure depreciation	*Base scenario*	$4,500,000	10%	$5,700	0.05%	$4,600,000
	Variation 1 (+0.2m to the SL)	$11,000,000	24%	$22,000	0.21%	$11,000,000
	Variation 2 (-0.2m to the SL)	$1,700,000	3.7%	$1,400	0.01%	$1,700,000

Source: SGS estimates (2011)

The expected risk is significant in today's net present value terms, but the damage of an extreme storm event if it actually does occur would be much higher. Table 7 below shows that the potential damage caused by an extreme storm with a 1% annual probability could result in a total damage of around $34.5 million in 2100 under the base case if the dwellings are well maintained.

TABLE 7 TOTAL DAMAGES CAUSED BY 1% PROBABILITY FLOOD

	Variation	Total damages caused by 1% AEP (100 yr ARI) flood		
		2010	2050	2100
Without structure depreciation	Base case	$3,051,812	$11,314,675	$34,526,486
	Variation1 (+0.2m)	$9,252,703	$19,497,539	$38,155,550
	Variation2 (-0.2m)	$854,190	$4,021,447	$31,026,793
With structure depreciation	Base case	$3,051,812	$6,788,805	$3,452,649
	Variation1 (+0.2m)	$9,252,703	$11,698,523	$3,815,555
	Variation2 (-0.2m)	$854,190	$2,412,868	$3,102,679

Source: SGS estimates (2011)

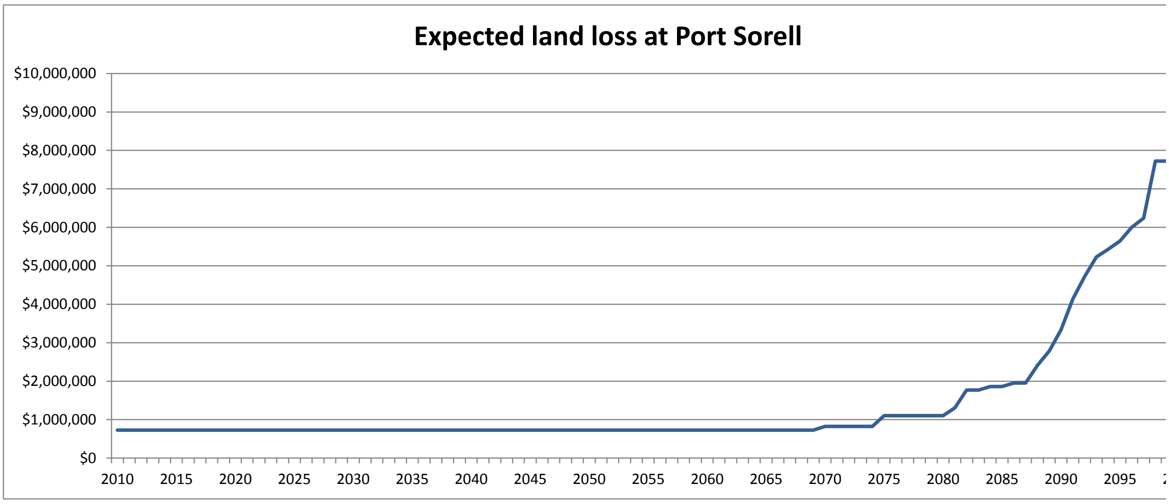
[12] It is the net present value of all the annual costs shown in Figure 7 up to 2100
[13] Includes residential properties with any depths of inundation (also below floor level flood depth)

These flood estimates are based on the effects of sea level rise on coastal inundation (from the sea). These estimates do not include cost of damage:

- To public infrastructure (roads, street lighting, water supply, sewer, damage to the sea wall, sports fields or other public amenities)
- From erosion most likely along Shearwater Esplanade
- To other commercial infrastructure (telephone, electricity supply)
- From river flooding events for all assets, which may be as large as flooding from the sea.

In addition to the structure damages as a result of the over-floor flood, we have estimated the value (per Valuer General) of land lost once it is lower than the average high tide level (Figure 9).

FIGURE 9 EXPECTED LAND LOSS AT PORT SORELL



Source: SGS (2011)

If nothing is done, the area of residential land in Port Sorell will start to diminish noticeably from around 2070. By 2100 the total land loss is expected to exceed 70 parcels with a value of $8.5 million based on present day valuation. All of this land is within the area subject to present-day risk. The NPV of these losses is estimated to be around $880,000.

Comparison with acceptable levels of risk with no sea level rise

For risks that do not change over time, potential damage from events with an annual probability at or below 1% is often considered an **acceptable level of risk**[14]. A property that has a floor just at the 1% AEP flood level has an expected damage in any given year of 0.35% of the value of the structure[15]. On a structure worth $100,000 this corresponds to an expected annual damage of about $350 if exposed to this level of risk from inundation from the sea in Port Sorell.

Without sea level rise this value would remain the same each year. The lifetime NPV of risk would increase with the expected life of the structure to almost 5% of the structure value in the Port Sorell area. If it is assumed that the building depreciates over time, the value lost from a major flood would be less. The economic loss is only that of the depreciated value of the dwelling.

With sea level rise (about 1.0 m of sea level rise over the next 90 years) the risk of damaging floods increases every year. The risk rises particularly quickly in later years as the rate of sea level rise increases and many more flood

[14] Different acceptable levels of risk would be applied to different uses. A much lower level of risk would be used for a school or hospital compared to a boat shed or car port.

[15] It is normal to require a freeboard above the predicted flood level, usually of about 0.3 m. The expected damage for such a building could be even less, but the freeboard is often used to compensate for uncertainties in the estimate of actual flood levels.

events are expected to be damaging. In that case, the NPV rises continuously and can reach to about 23% of the structure value[16] in the Port Sorell area.

The result is a level of risk several times higher than that normally considered acceptable. If this risk remains unmanaged in any way, either the householder or the government will eventually be faced with the consequences of a flood. Insurance is unlikely to be available, and usually where a large amount of property is damaged, government is faced with significant costs for clean-up, recovery and assistance to 'victims'.

For many properties, the risks can be reduced to an acceptable level by increasing the floor level. For instance, for structures with an expected lifetime of less than 60 years, the required increase in floor height above the present day 1% AEP level is very modest, less than 0.2m.

For dwellings with floor levels above the current 1% AEP flood level, risks for the first few decades are significantly lower than for those at the 1% AEP level. After that time, risks increase significantly and it may be wise to protect the structures or alternatively to not reinvest in the property, depending on the remaining life expectancies.

Conclusion

The estimated cost of risk (in present day values) of coastal inundation to private dwellings is between approximately **$4.6 million and $6.8 million to 2100** depending on whether owners continue to maintain their dwellings. If 1% AEP flood levels are 0.2 metres more than that estimated for the base scenario, then the total cost of risk would be between $11 million and $15 million.

By 2100, an extreme storm event (1% AEP) is estimated to cause $34.5 million worth of damage (base scenario, without structure depreciation) if the existing buildings or comparable ones are still in their current locations and elevations.

In addition, some land parcels at present-day inundation risks would become permanently inundated if no protection work is undertaken to cope with the future coastal hazards. With a 1 m sea level rise (likely in 2100), more than 70 land parcels in the study area are likely to be lost, resulting in a total loss of $8.5 million (current day value).

The flood estimates are based on the effects of sea level rise on coastal inundation (from the sea) and ignore rainfall runoff floods from the river, which may be more frequent and more severe than coastal flooding. The extent of the river flooding has not been quantified.

In practical terms:

- Well maintained high quality buildings close to or below the 1% AEP flood level with a long expected lifetime would be well advised to invest[17] in flood protection measures such as flood skirts that can be deployed when required **and** to pay attention to extreme weather forecasts.
- The owners of buildings close to or below the 1% AEP flood level that are in poor to modest condition or buildings damaged by flood events should consider whether it is worth reinvesting in the existing building or demolishing and rebuilding at a level above the flood or in a form that is resistant to flood damage.
- All occupants in hazard areas with properties at some risk, even if only for extreme events with a probability below 1% AEP, should have and rehearse an emergency response plan.
- Governments have an interest in prohibiting redevelopment that will be affected by a higher than acceptable risk of damage during its lifetime, including discouragement of reinvestment in existing properties that are or will be at higher than acceptable risk over their lifetime. However, such risks can be addressed by raising dwellings by relatively modest amounts even for quite long lifetimes.

[16] For properties with a life expectancy of maximum 100 years
[17] Up to20% of the structure's depreciated value assuming a 50 yr lifetime. Less if shorter lifetime expected.

5 VALUES

In contemplating appropriate responses to sea level rise, it is important to also consider the benefits occupying hazardous areas contribute.

People occupy and use areas near the coast, some of which are exposed to coastal hazards, because they derive value from doing so. Coastal property values are typically higher than similar sized properties inland, showing the premium placed on these areas. Other public, natural and economic values are major contributors of value from the 'use' of the coasts.

If the planning response to sea level rise prevents all (re)development in areas potentially at risk, many of the values from using and occupying these areas would be foregone, while other natural values may or may not gain from excluding development.

This section describes the private property values and other benefits of Port Sorell's coastal location. The factors that drive differences in property values between blocks (eg a premium placed on waterfront blocks compared to inland blocks) are relatively easy to evaluate. However, the attractions of the suburb as a whole may be increased by the setting shared by all property in the suburb – the presence of a beach and natural areas as well as man-made amenities and services. Natural areas may enhance property value, but they also provide benefits to the wider community, as discussed below. However, these benefits are harder to evaluate – there is no clear market to demonstrate their value – and may be quite variable for different people.

The reporting in this section relates to the work undertaken and the findings so far in relation to Step 5 of the adaptation pathway process: Value of Coastal Hazard Areas.

Private property values

Residents in hazardous areas derive a private property benefit from living in these areas. In order to assess the potential impacts of climate change and adaptation measures on coastal properties, one needs to understand how significant the premium is for living there. Once established, it is possible to assess how this value (private premium) may change as a result of climate change and adaptation. For instance, planning measures to prohibit development in hazardous locations may result in loss of value due to loss of beach front access.

Regression analysis was undertaken to determine the contributions of various attributes to the value of land, such as lot size, proximity to the beach and proximity to services.

Other values

Additional analysis was undertaken to better understand the 'other' values of the coastal area. These different values affect different people in different ways and interact with each other. These other values are often of more intrinsic nature and include:

- natural values, such as natural beauty and habitat for threatened species;
- public or social values, such as enjoying and recreating at the beach, amenity values, exercise opportunities that promote an active and healthy lifestyle; and
- economic values, such as the number of jobs in coastal related economic activities such as commercial and recreational fishing and tourism.

5.1 Private Property Values

The following factors[18] determine and contribute to land value in Port Sorell:

- Lot area (square metres)
- Distance from local businesses (metres)

[18] Full definitions of these variables and their derivations are provided in the Appendix.

- Distance from water – ocean or river (metres)
- Elevation of land above mean sea-level (metres)
- Beach front access
- River front access.

Some of these variables, such as beach and river front access, may place the property in a potentially hazardous location.

The key findings of the analysis show that:

- The constant is the value of a lot when all other land attributes are zero. It can be interpreted as the average intrinsic value of land in the study area. In this case, the intrinsic value of **$118,816** represents 85% of the average value of the land parcel.
- Each square metre of lot area will on average, increase land value by **$15.70**. Considering that the average lot size is approximately 1098 square metres, the average contribution from the area is approximately $17,216 (i.e. 1098 square metres x the value of the coefficient at $15.70).
- Each metre distant from local businesses increases land value by **$54.20**. This result appears anomalous but is likely to be because resident owners place a premium being located away from the noise of business activity. Considering that the average distance from local shops is approximately 474 metres, the average contribution due to distance from local shops is approximately $25,665 (i.e. 474m x the value of the coefficient at 54.20).
- Each metre from water (ocean or river) reduces land value by **$42**. This implies that lots closer to water have greater value.
- Each metre of land elevation above average sea-level reduces land value by **$9,146**. This is likely to be because higher elevations in Port Sorell are located further away from the water.
- Value derived purely from having beach front access is **$237,325**. Interestingly, having beach front access is approximately 1.7 times the average property value at approximately $140,000. Put another way, this value will be lost without direct access to the beach. The large contribution (in relative terms) due to beach front access is an indication of the high premium placed by owners of coastal properties in the study area.
- Value derived purely from having river front access is **$27,898.60**. Interestingly, having river front access is approximately 20% of the average property value at approximately $140,000. Put another way, this value will be lost without direct access to the river and associated views. Given the difference in magnitude, it is clear that river front access is not valued as much as beach front access.

For Port Sorell, one residential property was identified as having land under the high tide level at expected sea levels by 2050 (with an assumed sea level rise of 0.25 metres). By 2100, and an assumed sea level rise of 1 metre, 68 properties would lie below the high tide level.

Approximately 15% of land value for these 68 properties is due to beach front access. In total, approximately $1,423,950 (or about $21,000 per lot) is attributable to beach front access. This is shown in the table below (Table 8).

When looking at the impact of an extreme storm event with a probability of experiencing a flood above floor height greater than 1% per year (1% AEP) the number of properties subject to flood risks increases. In 2010 (current), there are 75 properties subject to flood risk, in 2050 there will be 208 properties at risk and by 2100 there will be 324 properties at risk[19]. For the 324 properties at risk up to 2100, the value that is derived from having beach front access adds almost $20.5 million in total or approximately 34% of the total value.

TABLE 8 VALUE COMPOSITION FOR LOTS AT RISK DUE TO SEA-LEVEL RISE AND EXTREME STORM EVENTS (1% AEP) BY 2100

	Due to Sea Level rise		Flood risk of ARI 100	
	Land value ($)	Share of value (%)	Land Value ($)	Share of value (%)
Total value due to beach front access	$1,423,950	15%	$20,409,950	34%
Total value due to other attributes	$8,366,350	85%	$39,598,735	66%
Total estimated land value	$9,790,300	100%	$60,008,685	100%

Source: SGS (2011)

[19] The properties include those with above floor flood risks, both residential and other private properties (not infrastructure)

To entirely exclude future development on these properties, either if an owner wishes to extend or redevelop the existing structure, would largely destroy that land value for property where the structure is nearing the end of its service life. If such a policy was applied to land susceptible to inundation due to sea level rise, it is estimated that there would be a loss of approximately $1.4 million (or about $21,000 for each of the 68 lots) even if they were provided with 'inland' lots of a similar size. If the policy was applied to land susceptible to a 1% AEP storm event by 2100, it is estimated that there would be a loss of value of $20.4 million (or about $63,000 for each of the 324 lots) compared to inland lots. The remaining value lost would be attributed to other factors.

Put another way, if the objective is to reduce risk for the property owners at risk from sea level rise, it would be worth spending up to nearly $21,000 per lot in methods that reduce risk by the same amount but do not compromise the amenity achieved from a water front location, as an alternative to restricting development. For properties at risk of inundation from a 1% AEP storm event it would be worth spending nearly $63,000.

It should be noted that the study only took the impacts of sea level rise into account and did not include modelling of future river flooding (due to rainfall).

5.2 Other Values

Natural Environmental Values

The study area of Port Sorell lies along the Rubicon Estuary. Within the study area are the Port Sorell and Shearwater beaches and foreshores, Pitcairn Street Bushland Reserve and the Port Sorell Conservation Area. Freers Beach (also referred to as Shearwater Beach) has been awarded Tasmania's cleanest beach award as part of the Clean Beach Challenge.

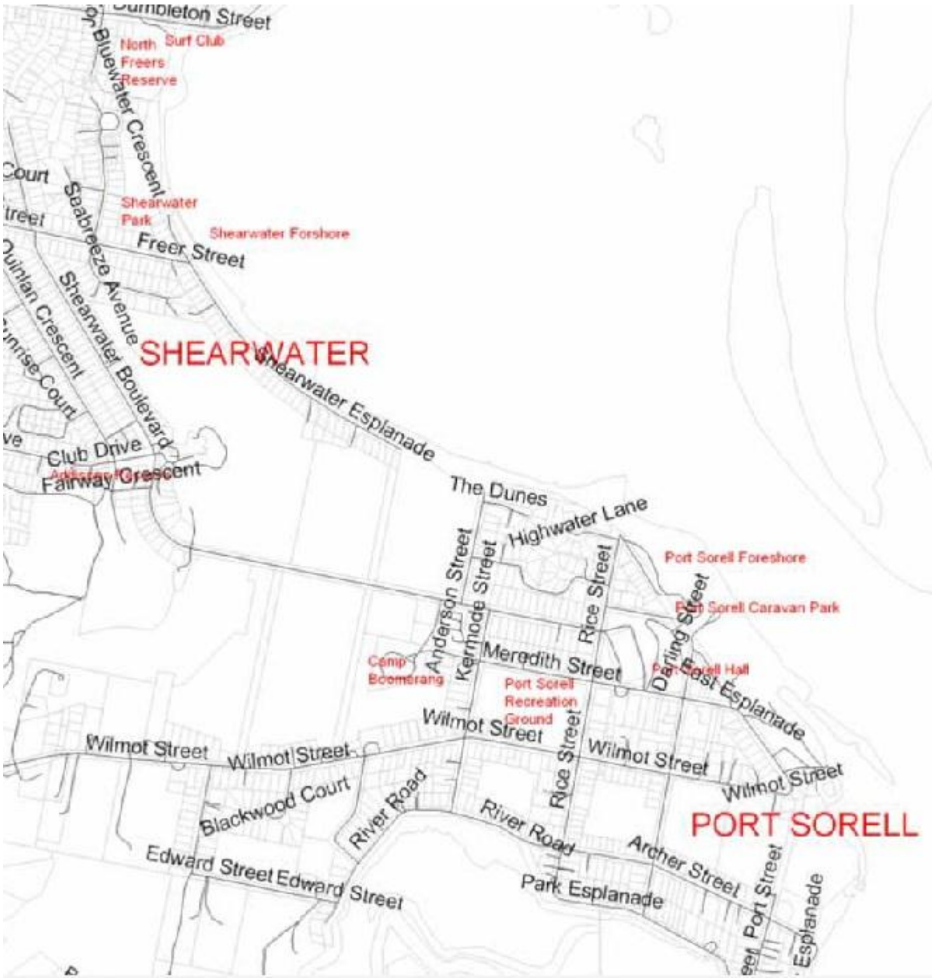
The Rubicon Estuary provides a range of estuarine coastal habitat, particularly wetlands and wading bird habitat. Much of this natural value has been degraded within the populated shoreline that is the focus of the study area. However, there is potential for future wetlands to colonise land areas that are currently above the high tide as sea levels rise.

Social and Public Values

The study area offers a range of recreational values, including enjoyment of natural values, swimming, fishing, wind surfing, walking and boating. There are two public jetties and the Port Sorell Memorial Hall which holds a fortnightly market. The Port Sorell Surf Life Saving Club is located at Freers Beach. Other areas to enjoy are the North Rubicon Reserve, Panatanu Rivulet and Pioneer Park. Figure 10 below provides an overview of what is available in the study area.

These values are enjoyed by the local population of about 3,500 residents in Port Sorell, Shearwater and Hawley Beach (as of Census day 2006). According to Latrobe Council, the population doubles during the summer season as a result of holiday makers.

FIGURE 10 RECREATION MAP PORT SORELL STUDY AREA



Source: Latrobe Council

Economic Values

Tourism is an important industry within the study area. In addition, the recreation values within the study area support the tourism industry in a wider area. The Tasmanian Visitor Survey does not separately identify Port Sorell as a tourism destination from Latrobe. However, a count of accommodation providers within the study area shows there are six B&B providers in the area, together offering 66 rooms or units, 178 camping sites and 148 beds at a school camp (the second school camp has closed down). There are more accommodation providers nearby, whose guests would likely also benefit from the values in the study area. There are also a handful of shops in the area.

TABLE 9 SUMMARY OVERVIEW OF OTHER VALUES

Value	Description	Quantity / Order of Magnitude
natural areas	beaches and foreshores, Port Sorell Conservation Area, Rubicon Estuary	Approx. 3 km beaches
enjoyment of natural areas	Enjoyment of natural values, swimming, fishing, wind surfing, walking and boating. Freers Beach is patrolled. Public infrastructure including jetties, public toilets, parks and reserves.	3500 residents, and about 2,000 tourists continuously during the summer season.
		The recreation values are enjoyed by a wider public from the region.
local businesses and tourism	The area contains a number of local shops, cafes, restaurants	Approx. 10 businesses
	Accommodation	Six providers offer 66 rooms/units, 178 camping sites and 148 camp beds.

Conclusion Coastal Values

Properties in Port Sorell have significant value premiums due to their access and proximity to the beach and, to a lesser extent, access to the river front. To 2100, 324 properties would be affected by sea level rise and extreme storm events (1% AEP). Many of these properties have direct beach or river front access or are located close to the beach. Properties with direct water frontage derive up to one third of their value from having river frontage, suggesting it would be worth investing significantly in protection (so far this has no adverse impacts on other values, and/or as far as the future planning regulations allow).

Refusing any (re)development in the area potentially affected by sea level rise and extreme storms by 2100 could result in over $20 million worth of property value being lost over time.

The natural and environmental values of the Port Sorell area are significant and include wetlands, bird habitat, fish habitat and nursery and natural river waterways that improve water quality.

Sea level rise may result in the expansion of wetlands and lagoon areas. While this could most easily occur outside of the developed areas, some of the undeveloped areas enclosed by Port Sorell township, and in the longer term much of the golf course, would become wetlands if there were no interventions to prevent this.

Filling land, channelisation or hardening of river banks may reduce the water quality and also prevent wetlands from successfully migrating landward.

Social values in the study area involve beach related recreation and amenity, recreational fishing and river amenity and the golf course.

Economic activity in the area is related to the natural and recreational values of the beach and surroundings, including for tourists. Loss of the beach and poor water quality could have negative impacts on these economic activities.

6 ADAPTATION OPTIONS

6.1 What if Nothing is Done?

Before discussing any options to adapt to projected impacts of sea level rise, it is important to consider what would happen if nothing is done. That is, what would the impacts be if nature takes its course and no measures are undertaken to manage the risks?

Erosion along Shearwater Esplanade may continue, with some cut and fill cycles but a significant risk of long term recession as a result of sea level rise. Parts of the coast have been armoured with large rocks, but eventually higher seas will undermine these with waves that overtop them. Without improved protection this will eventually damage the road and eventually the houses behind. The timing of this remains highly uncertain. Past initiatives to reduce erosion along this shoreline are evident: groynes, an offshore reef and the recently exposed gabions as well as sections to the north with rock revetment. These works suggest that erosion has been an issue here for some time, but that it has not progressed rapidly at least since these works were done.

Areas along the Esplanade and the low lying drainage line south of Wilmot Street would likely be affected by an extreme high tide/storm surge even with today's sea level, especially if high flows in the river add to flood levels. Some of this area would be under more than 300 mm of sea water and a slightly more extensive area with a lesser level of flooding. This could enter and damage buildings and contents. Over 220 houses are in the affected area for some present day risk of inundation hazard, but just a few dwellings in the area could be subject to more than 300 mm of flood depth in a 1% AEP flood. However, the maps do not take into account the potential additional contribution of rainfall, which has been a source of some localised flooding in the past.

By 2100, areas below about 2.0 m AHD will be inundated with most high tides under the scenario with expected sea level rise of about 0.9 m or more. The new 'natural' shoreline would be well inland from the present one in Port Sorell with some existing houses in the south east of the township being 'offshore'.

The present value of risk to and loss of property of not responding to sea level rise is about $9 million. This does not include infrastructure costs or other damages (lost economic activity). The estimated damage of an extreme 1% event actually occurring would be about $35 million with sea levels about 0.9 m higher by about 2100. The properties affected by sea level rise and extreme storm events up to 2100 are predominantly properties with water frontage or within close proximity of the water, but also include many low lying properties further inland in Port Sorell and the golf course at Shearwater. Even without flooding, low lying properties would become subject to effects from high water tables.

To 2100, about 70 properties would be lost because they would lie below the high tide level. Many of the remaining 200+ dwellings at present day risk would have been lost or replaced with less flood affected structures (higher floors or flood resistant construction). An additional 70 properties would become susceptible to 1% AEP extreme storm events. If nothing is done to reduce flood affected areas, over 200 dwellings would still face a level of risk that would likely be regarded as unacceptable.

Sea level rise may result in the expansion of wetlands and lagoon areas, potentially including much of the golf course that would become wetlands if there were no interventions to prevent this. Beach related recreation and amenity would be affected, as would the golf course. Fishing and marine recreation may not be affected.

Economic activity in the area related to the natural and recreational values of the beach and surroundings, including for tourists, may be affected by the loss of the golf course and beach amenity.

6.2 Options

This section reports on the work undertaken and preliminary findings relating to Step 6 of the pathway process: First cut assessment of adaptation options and costs.

There are many different options to adapt to the impacts of coastal impacts of climate change. The different options relate to different types of impacts resulting from erosion and inundation. The effectiveness of options varies considerably depending on characteristics of the coastal areas (such as sandy or rocky coast line) and the location-specific impacts of sea level rise.

In the case of Port Sorell, there are options that are potentially relevant to the impacts identified:

- Beach nourishment if a source of sand can be identified
- Groynes, reefs and structures to reduce erosion
- Construction of a hard revetment or sea wall
- Protecting individual structures
- Protecting properties prone to inundation with a levee
- Redevelopment of structures in less vulnerable form (higher floor levels)
- Raising low lying residential areas, roads and services for long term occupation
- Retreat.

Detailed descriptions of the following options are provided in the Coastal Adaptations report. Short descriptions are provided below.

Beach Nourishment

In the case of Port Sorell, there is limited evidence of long term erosion of the sandy shore to date. Beach nourishment can build up the bulk and height of the beach, replacing sand lost should erosion become progressive and providing a larger volume to prevent storm cuts from reaching vulnerable assets.

Beach nourishment may be used to retain some useable beach as a public amenity, in contrast to a sea wall where the beach may be lost in front of the sea wall at high tide and eventually all of the time. Nourishment brings additional sand into the local sand budget for the beach. The availability of a suitable source for sand would need to be investigated and is critically important for this to be practical.

Beach nourishment generally has the advantage of having no impacts on adjacent shorelines. Hard structures can often result in changes to coastal sediment dynamics and have impacts on adjacent areas, such as increasing erosion compared to the status quo. However, beach nourishment typically washes away after a period of time and requires replenishment.

Groynes, reefs and structures to reduce erosion

A number of structures have already been placed along Freers Beach to reduce erosion. These include a number of groynes, an offshore structure acting as a reef, gabions recently revealed by erosion in a storm and a rock revetment at the northern end of the beach. However, the current structures have been degraded since first installed and would require improvement or replacement to regain their designed effectiveness.

Groynes and offshore reefs can be designed to reduce wave impacts on the beach, reducing the erosion that results, or they can be designed to capture sediment movement along the shore, retaining sand that otherwise may be lost from the local sediment cell (or both).

It appears that both kinds of structures have been deployed with some effect, noting that the gabions placed some decades ago have only been revealed by the recent storm after being buried in sand after being placed.

Groynes are usually supplemented by sand nourishment at the time they are placed. If not, they can be particularly subject to scouring of sand on the leeward side, potentially aggravating erosion at these points.

A major consideration with these structures is that, by capturing longshore drift, they may deprive adjacent areas of sediment and cause erosion further along the coast. Appropriate assessment by a qualified coastal engineer would be essential before undertaking such works.

Sea wall

A sea wall is a structure that is designed primarily to resist wave action. As noted, there are already sections of the coast where gabions and rock revetments have been placed. The gabions have significantly deteriorated but the revetment has been relatively well maintained.

A properly designed and constructed sea wall can reduce the risks to properties and areas of the foreshore from the impacts of beach erosion and coastline recession hazards. Essentially, the structure withstands any erosive forces of waves and prevents further loss of sand from behind the structure.

They may be located at the top of the shore, out of reach of the water at low tide. Sometimes they may be partly or even fully covered with beach sand if there has been a period of sand accumulation since the wall was built, as has been the case of the buried gabions at Freers Beach for many decades. This may also be assisted by beach nourishment.

Very high water levels will cause waves to overtop a revetment or seawall. Having significant water flow or trapped water behind the sea wall may cause drainage problems or water logging resulting in erosion and structural instability. With sea level rise, coastal sea walls will need to be periodically increased in height. Revetments of large rocks may need maintenance after heavy storms. It will be possible to extend an existing sea wall if the foundations and sound are capable of withstanding additional loads. Otherwise, the existing wall will need to be demolished and a new larger structure built.

As noted with other coastal structures, sea walls and revetments ultimately restrict sediment transport and may have impacts further along the coast. A particular problem with these hard structures can be terminal scouring at the end point. This can be minimised if they continue along a sandy coast all the way along to a rocky shoreline.

Protection of Individual Properties

Protecting individual properties from erosion and inundation can be done in different ways:

- Flood barriers to protect existing dwellings from short term extreme events (not practical if water levels are permanently high)
- Piles or massive foundations to resist loss of foundation stability by erosion
- Elevated substructures (raised slab or floor, poles, non-inhabited ground floor) above flood levels
- Moveable dwellings
- Water proof or resistant construction not affected by temporary flooding
- Floatable dwellings.

Flood barriers either placed directly against the structures wall or free standing barriers can be used to protect existing dwellings. Most of the other options apply for new construction but could be used on extensions or where a building undergoes extensive renovation.

Protecting properties prone to inundation with a levee

While a few properties will be below the future sea level if sea level rises by 0.9m, most existing properties at risk will only be inundated by an extreme storm event, events which occur infrequently and where the peak water level usually last for only a few hours. Levee banks can provide protection against such flood peaks.

Along Freers Beach, the road may be raised to provide this protection. The Esplanade can be used in a similar way in Port Sorell.

A disadvantage of levees is that they may prevent rainwater from draining as freely and the drainage system may need adequate retention capacity or pumping to assist during peak storm events where local rainfall is also significant. A high levee can also block views and affect access to properties. A levee that is insufficiently high may fail if the storm surge overtops it and causes a breach, losing much of the protective value expected.

Raising low lying residential areas, roads and services for long term occupation

Raising the land level of developed low lying land, either with existing development or land planned for development, above the expected sea storm surge level is one of the most secure and sustainable responses to rising sea levels. Raising land also reduces the risks to structures and roads of high water tables that can reduce load bearing capacity and, if salty, affect services and structural integrity. In addition to built property, assets like the golf course may be raised as well. However, here the option may exist to use the developing wetlands as landscape features edging the course.

Typically the edge of the raised land would need some protection from erosion. For any new development or major re-development in inundation hazard affected areas this could be a requirement controlled by the planning scheme. Roads and services for the affected area would also have to be filled.

While raising land above the storm surge height can avoid inundation, it represents a complete obliteration of the existing flora and fauna in the filled area and may also have significant impacts at the source of the fill material. If not filled, the fringes of the river may provide retreat routes for significant wetland areas and habitat, and filling these areas would have more significant consequences on potential future environmental values.

If the filling is done in stages there may be issues where filled land could increase the flooding of adjacent unfilled land. Such a patchwork filling approach may create problems with drainage unless some considerable thought and planning is put in place to anticipate and manage this issue. An overall filling and drainage plan would be required to avoid the worst foreseeable problems.

Planned Retreat

Progressive retreat means the loss of private and other property. In spite of this, it may prove to be the lowest cost long term alternative available, especially if the cumulative cost of protection into the future is high. This is more likely to be the case if the rate of sea level rise is high and even adapted assets have a relatively short lifetime before becoming under threat.

The cost of planned retreat can be diminished to the cost of land if a process of planned disinvestment occurs, such as not redeveloping and/or extending existing properties.

7 ADAPTATION PATHWAYS

Community workshops were organised to explore different pathways to respond to projected changes, ranging from letting nature take its course to protect 'at all cost' and intensify development and land use patterns in risk prone areas.

In preparation to the community consultation, the following three pathway scenarios were developed to explore the future for Port Sorell:

1. **Let nature take its course**: This pathway allows maximum freedom for natural coastal processes to unfold, with a minimum of intervention or resistance from future development or coastal and flood protection works. Where erosion threatens structures, they would be removed. Where property is regularly inundated, it would eventually not be worth repairing and redevelopment in affected areas would not be permitted.

2. **Protect existing development as long as practical while protecting natural values**: This pathway protects property but only where that protection has a minimal impact on the values of the area important to the community. There is balance between protecting natural and shared community assets, and private property. There is also consideration of promoting and sustaining natural ecosystems in the face of climate change. This would include permitting wetlands to migrate inland in selected locations. In general, intensification of development in hazard areas would be discouraged unless it and the protection measures required clearly did not have any negative impact on natural and community values or were likely to have a positive effect.

3. **Protecting existing and permitting future development to the maximum possible extent for as long as possible:** This pathway concentrates on protecting the existing and future community and property using any available options. Intensification of development provides more contributors to any protection works, so some intensification is permitted where it does not compromise community values for the suburb. While natural areas may be affected, they may adapt in their own way or become modified in ways that the community accepts.

The pathway scenarios are not predictions or recommendations, but ways of imagining different futures based on a range of choices about how to respond to climate change effects. Many other variations are possible but these cover a wide scope of possibilities. All pathways are based on two principles:

- developing risk will be actively managed;
- people cannot be subsidised to occupy or use hazardous locations.

7.1 Pathway 1, Early Retreat, Let Nature take its Course

This pathway allows maximum freedom for natural coastal processes to unfold with a minimum of intervention or resistance from development or erosion and flood protection works. Where erosion or severe flooding threatens structures with failure in the short term, they would be removed if they cannot resist the hazard. Where property is regularly inundated, it would eventually not be worth repairing and be abandoned. Redevelopment in affected areas would not be permitted. Little if any new development would be allowed in hazard areas, and certainly no intensification of existing areas (subdividing existing residential blocks or intensifying rural residential areas). Property owners would be allowed to take action that extends the life of their existing structures by making it resistant to erosion or flooding (flood skirts, other waterproofing, underpin foundations), but only within their own property boundary, as long as it has no impact on adjacent areas. It would generally not be allowed to fill and raise land, to harden shorelines with rocks or concrete or even to undertake dune or beach nourishment. Owners would be responsible for clearing a site of structures etc if/when it is eventually abandoned.

How might things be with this scenario...

With nature taking its course, Freers Beach erosion is expected to proceed, with some cycles of rebuilding but a long term recession of perhaps 15m by 2050 and about 35m by 2100. About 40 to 50 properties might be at risk of loss by erosion from an extreme storm by 2100, currently valued at $20-$30 million.

Areas near the exit of Mary's Creek could be flooded by an extreme high tide/storm surge but, with today's sea level, relatively few houses are affected and depths are not great, generally less than 0.3m above floor levels. This does not include the potential extra contribution of rainfall, which has caused some minor flooding in the past.

Floods could enter and damage buildings and contents. About 65 houses are in the affected area **for present day** inundation hazard, with about 10 subject to more than 300 mm of flood depth. With relatively modest sea level rise of 0.3 m, some properties are expected to experience low level flooding every few years and the shoreline will encroach inland up the Marys Creek catchment. Even where floods do not come above floor levels, houses on properties that have high water tables may find that soil bearing capacity is affected and the structural stability compromised, leading to high repair costs or need to abandon.

With expected sea level rise of about 0.9 m, around 2100, areas below about 1.8 m AHD will be inundated with most high tides. The new 'natural' shoreline would move well into currently developed areas along Archer, Wilmot and Darling Streets, and Pioneer Park would be a tidal wetland. Existing houses would be 'offshore' if they still existed. Much of the golf course would become salt marsh and be subject to periodic flooding, including all dwellings along Shearwater Esplanade.

While this scenario presumes 'nature takes its course', in practical terms there are already some existing coastal protection works. These would be allowed to deteriorate, or any hazardous remnants removed if necessary. There has also been a proposal to develop the area between Wilmot and Archer Streets with proposed works to protect the area. Much of this land is already prone to being wet, with water tables quite near the surface and inundated at the higher tides. Areas where there has already been some fill may be less flood-prone than indicated by the maps, if the fill has been placed since the levels were measured in 2008. Under this scenario Council would need to establish and enforce 'no-fill' regulations, requiring removal of any future fill.

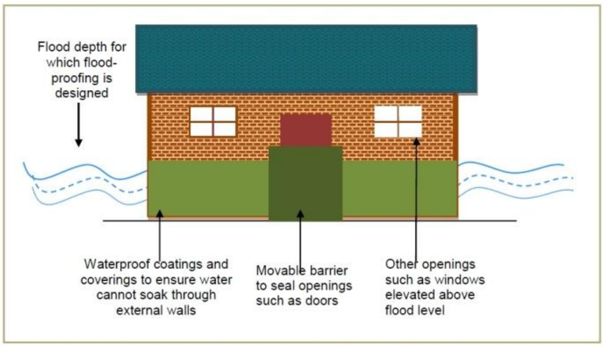
Increasingly, saline ground water would lead to a change in vegetation. Land between Pitcairn Street and Shearwater Esplanade would become a salt march. Non-salt tolerant terrestrial plants, including many trees and shrubs, would become stressed and woodlands over parts of the suburb would die off and be replaced by more salt tolerant species. Vegetation in salt affected areas would increasingly look like that along St Marys Creek walkway. Road access to some non-flood prone areas would be lost if roads were not raised and access along Shearwater Esplanade would need to be replace by rear entry to lots or by moving the road back into the front edge of properties. Generally, the esplanades in Port Sorell are higher than the adjacent land on which houses sit so they would be 'lost' at about the same time as the road.

Options likely to be adopted for this scenario

Major works and modifications to the landscape would not be permitted under this scenario. Most work would be involved in 'clearing away' and reconfiguring infrastructure to remain serviceable.

Wetlands move shoreward

Dune protection



Flood proofing for existing buildings
http://climatetechwiki.org/sites/default/files/images/extra/media%20image%202_10.jpg

Actions: 0- 10 Year Timeframe (indicative cost: $15,000 per year)

No.	Option	Responsibility	Cost
1	Hazard mapping and risk assessment advisory to alert residents/owners to risks	State/LC	Nominal
2	Amendments to the planning scheme to restrict development, filling of land, subdivision as described above	LC/State	Nominal
3	Dune protection works (planting, access pathways to maintain dune health but no nourishment)	LC/residents	$50,000
4	Emergency management plans	State/LC	Nominal
5	Advice to property owners on reducing damage from floods and erosion (new and existing structures)	LC/State	Nominal
6	Private action to reduce flood damage (e.g. flood skirts at say $10,000 per affected property)	Residents/ business	$100,000
7	Repair and maintenance of infrastructure after any flood, erosion events as required to maintain agreed service levels	State/LC	Increasing over time

Actions: 10- 40 Year Timeframe (indicative cost: $25,000 per year)

No.	Option	Responsibility	Cost
8	Disaster relief after major flood/erosion event to assist re-establishment elsewhere	State/Aust Govt	Increasing over time
9	Private action to reduce flood damage (e.g. flood skirts at say $10,000 per affected property)	Residents/ business	$500,000
10	Requirements to remove uninhabitable dwellings; rehabilitation of abandoned blocks	Landowner	$150,000
11	Wetland restoration; keep land clear for wetlands to retreat inland	State/LC	Uncertain
12	Infrastructure repair and modification to retain serviceability	LC/Water authority, etc.	Uncertain

Actions: 40+ Year Timeframe (indicative cost: $210,000 p/a assuming 50 year timeframe)

No.	Option	Responsibility	Cost
13	Private action to reduce flood damage (e.g. flood skirts at say $10,000 per affected property)	Residents/ business	$2 million
14	Maintenance of minimum service levels: new access roads where required.	LC/State	Not yet determined
15	Loss of value of abandoned land	Property owners	~ $8.5 mln

7.2 Pathway 2, Protect Development while maintaining Values of the Area

This pathway protects property but only where that protection has a minimal impact on the values of the area important to the community. There is balance between protecting natural and shared community assets, and private property. There is also consideration of promoting and sustaining natural ecosystems in the face of climate change.

This would include permitting wetlands to migrate inland in selected locations. In general, intensification of development in hazard areas would be discouraged unless it, and the protection measures required, clearly did not have any negative impact on natural and community values or have a positive effect.

Some modifications to the environment may be permitted. For example, part of a wetland might be excavated to provide fill to raise flood prone property but provision would be made elsewhere for wetlands to migrate inland. However, protection and adaptation options that result in changes to the character of the area that reduce its attractiveness and property value would not be pursued (eg sea walls).

How might things be with this scenario...

Beach nourishment could reinforce Freers Beach but the strong tidal flows coupled with storm waves make rapid sand loss likely. The (re)introduction of sediment management structures, such as groynes or offshore reefs, is likely to be necessary to retain any added sand and reduce sand replacement costs. Even with these structures there may be a need for some renourishment, which would vary both with the effectiveness of the structures and the storm conditions experienced. The addition of coastal structures would not be a major change to the character of Freers Beach as they have been there in the past. Groynes would be more visually intrusive than an underwater offshore reef. An underwater offshore reef may have the effect of building a sandbar between the current shoreline and the reef, either permanent or transient, may affect swimming and other beach activities. These structures may also offer additional or varied recreational opportunities, depending on the design objectives and costs.

If beach nourishment were to use sand from outside the coastal system (that is, well offshore or distant land based sources), the added sand may reduce the rate and extent of erosion. The ability to do this will depend on the availability, suitability, cost and environmental impact of taking sand from the source.

Eventually, even with further nourishment sediment management structures may become impractical due to cost, inadequate supplies of sand, environmental or other impacts of taking sand or the cost of maintaining or renewing the structures. At this point there would be some further progressive erosion and a shift toward retreat. However, some level of protection short of a sea wall may still be practical to limit ‘catastrophic’ damage.

Inundation of existing dwellings would be managed by raising perimeter roads to act as a protective wall against extreme storm surges from the estuary, controlling water entry to the river and creek outlets during storm surge events, and improved drainage with wider channels and retention ponds to deal with rainfall during storm surge events. Low lying properties would still need flood protection measures (eg flood skirts), and emergency planning until these measures were in place.

New development and redevelopments/major extensions would be required to be built with the floor above the expected maximum annual high tide for the lifetime of the structure plus a freeboard allowance, but could be subject to minor flooding if events overtop the perimeter roads. Filling low lying land would be encouraged in presently developed areas behind the road barriers except the identified drainage lines. However, priority areas for wetlands to retreat would also be identified and a clear path for advancement kept clear of roads and other obstructions. Some adjacent properties may need to be removed at the end of their service life and land purchased to permit this to occur. Two likely areas would be Pioneer Park and the low lying land between Port Sorell and Shearwater. The parks and actively used open spaces would need to be replaced with other facilities further inland.

In filled areas, levels would be controlled to ensure effective drainage patterns with land further from the drainage lines at higher levels than those on the edges. For smaller blocks, filling would be mandatory at the time of any building redevelopment. The drainage lines would become permanent open water ‘canals’ as sea levels rise.

Streets serving these raised areas would also be raised each time they were being rebuilt (ie within their normal service and renewal cycle) at an elevation that suited the adjacent blocks for their service life, in line with a progressive developing drainage plan. The plan would need to be quite prescriptive about filling and development to ensure it would be effective. In some cases dwellings may be built with floors elevated well above surrounding ground level on a ‘mound’ for some years, with the surrounding area filled later to manage drainage effects.

This approach would likely permit most of the existing suburban areas to continue to be occupied for most of this century or longer. Under this scenario if sea levels rise at rapid rates (say, more than 0.15 m per decade), either some retreat will be required or some development may need to float.

Options likely to be adopted for this scenario

Beach nourishment

Groynes

Floating dwellings

Offshore reef

Actions: 0- 10 Year Timeframe (indicative cost: $225,000 per year)

No.	Option	Responsibility	Cost
1	Hazard mapping and risk assessment advisory.	State/LC	Nominal
2	Amendments to planning scheme, controlling filling to raise land levels in any area potentially subject to inundation where development is permitted, but controlled so it does not adversely affect drainage of adjacent areas.	LC/State	Nominal
3	Design work for groyne or reef structure coupled with nourishment	LC	$100k
4	Installation of protective structures	LC	$1.5 m
5	Dune protection works (planting, access pathways to maintain dune health).	LC	$50,000
6	Emergency management plans.	State/LC	Nominal
7	Advice to property owners on resisting floods and erosion (new and existing structures)	LC/State	Nominal
8	Raising land with fill (100,000 m3 @ $5/m3)	Property owner	~$500,000
9	Repair and maintenance of infrastructure after any flood, erosion events as required, to maintain agreed service levels.	State/LC	Increasing over time
10	Private action to reduce flood damage (e.g. flood skirts at say $10,000 per affected property)	Residents/businesses	$100,000

Actions: 10- 40 Year Timeframe (indicative cost: $275,000 per year)

No.	Option	Responsibility	Cost
10	Raising roads	LC	$4.0 mill
11	Periodic dune nourishment and repairs to coastal structures	LC	$75k pa
12	Flood control gates to drainage and creek outlets	LC	$200k
13	Allow fill to be taken (sold) from low lying areas including some public lands to elevate developed land, creating wide channels with adequate drainage and retention capacity. Additional fill may be brought in to fill lower properties.	LC/property owners	$1-$2 million
14	Allow wetland to retreat inland onto public lands or rural zoned private lands with provision for tidal flushing where practical.	State/LC	nominal

Actions: 40 + Year Timeframe (indicative cost: $275,000 per year)

No.	Option	Responsibility	Cost
15	Periodic dune nourishment and repairs to coastal structures	Coordinate by LC	$150k pa
16	Keep Shearwater Esplanade open along Freers Beach by erosion control and elevation	LC	$1.5 mill.
17	Elevate other Esplanades with adequate drainage under or a bridge to wetland areas.	LC	$3.5 mill.
18	Raising land with fill (5,000 m3/yr @ $5/m3)	Property owner	~$25k pa
19	Potential longer term options: floating dwellings, floating roads		Uncertain

7.3 Pathway 3, Protecting Existing and Permitting Future Development

This pathway concentrates on protecting the existing and future community and property. It assumes that the rate and extent of change will be manageable using available options and that any necessary protection and adaptation options will be acceptable. Intensification of development provides more contributors to any protection works, so some intensification is permitted where it does not compromise community values for the suburb. For example, low lying rural residential areas may be permitted to subdivide, making it more cost effective to fill lots as a way of combating inundation, while allowing sufficient floodways to control runoff. While natural areas may be affected, they will adapt in their own way or become modified in ways that the community accepts.

How might things be with this scenario...

While sediment trapping structures (eg groynes, artificial reef) combined with beach nourishment can manage erosion risks on Freers Beach, potentially for many decades, assisting structures even with further nourishment may become impractical due to cost, inadequate supplies of sand, environmental impacts or the cost of maintaining or renewing the structures. At this point, the shoreline would be hardened to prevent ongoing erosion, with a sea wall or revetments. Some level of nourishment may still be practical to maintain a beach for a while, but in the long run, hardening an eroding coast with rising seas would lead to the loss of the beach entirely.

In spite of the likelihood of losing the beach, there may be some community support or even pressure to harden the shore, based on the expectation that it provides a very long term solution to shoreline erosion and recession. If such a sea wall is built, individual dwellings would not need to address the erosion hazard. This would reduce the difficulty and cost of building in this sought-after strip along the waterfront, as well as for property behind. Those that are sceptical about long term erosion, hence beach loss, occurring may find this option attractive. Some may value security with a promenade and a view as highly, or more highly, than a beach.

Inundation of existing dwellings would be managed by raising perimeter roads to act as a protective wall against extreme storm surges with a hardened face on the estuary side, controlling water entry to drainage outlets during storm surge events, or even closing them permanently, ensuring drainage into the expanded channels for runoff. These measures may be augmented in the short term where required by flood protection measures (eg flood skirts) for low lying structures and emergency planning. Perimeter protection may be assisted by pumping to discharge rainwater when required, although sandy conditions mean that land levels cannot be too close to mean sea level without requiring constant pumping.

New development and redevelopment/major extensions would be required to be built with the floor above the expected maximum annual high tide for the lifetime of the structure plus a freeboard allowance, but may be subject to minor flooding if events overtop the road or dunes. Land filling would be encouraged in all areas behind the road barriers except the identified drainage lines and retention basins. Levels would be controlled to ensure effective drainage patterns with land further from the drainage lines and basins at higher levels than those on the edges. For smaller blocks, filling would be mandatory at the time of any building redevelopment. Some further subdivision of larger blocks may make filling these more cost effective and add to the number of contributors to protection works.

Streets serving these areas would be raised each time they were being rebuilt (ie within their normal service and renewal cycle) at an elevation that suited the adjacent blocks for their service life, in line with a progressive developing drainage plan. The plan would need to be quite prescriptive about filling and development to ensure that it would be effective. In some cases dwellings may be built with floors elevated well above surrounding ground level on a 'mound' for some years, with the surrounding area filled later to manage drainage effects.

This approach should permit most of the existing suburban areas and some other intensified areas to continue to be occupied for most of this century or longer. In the longer term, if sea levels rise by 2, 3 or more metres, the protection works along Freers Beach may need to become larger and more sophisticated. This may only be supportable with more intensive development of the area. Given the time from now until when this need arises (potentially of the order of 100 years or more) it is not realistic to predict the priorities and values of the community at that time. Quite high densities may be seen as appropriate as well as being better able to support more expensive protection works.

All developed properties in hazard areas would need to fill their land. The elevated land would largely maintain the existing coastline, with little land lost to permanent inundation. Wetlands would generally not be allowed to advance into areas that are developed or surrounded by development. While this scenario proposes continued fill and shore armouring as the primary response, floating dwellings may also be used for some part of the area or to extend occupation of sheltered waterways acting as drainage points within the perimeter.

Options likely to be adopted for this scenario

Elevated coastal road, Holland

Sea wall (Sandy Bay)

Houses elevated and designed for water levels

Fill to raise land levels

Actions: 0- 10 Year Timeframe (indicative cost: $220,000 per year)

No.	Option	Responsibility	Cost
1	Hazard mapping and risk assessment advisory.	State/LC	Nominal
2	Amendments to planning scheme, controlling filling to raise land levels in any area potentially subject to inundation where development is permitted, but controlled so it does not adversely affect drainage of adjacent areas.	LC/State	Nominal
3	Design work for groyne or reef structure coupled with nourishment	LC	$100k
4	Installation of protective structures	LC	$1.5 m
5	Dune protection works (planting, access pathways to maintain dune health).	LC	$50,000
6	Emergency management plans.	State/LC	Nominal
7	Advice to property owners on resisting floods and erosion (new and existing structures)	LC/State	Nominal
8	Raising land with fill (100,000 m3 @ $5/m3)	Property owner	~$500,000
9	Repair and maintenance of infrastructure after any flood, erosion events as required, to maintain agreed service levels.	State/LC	Increasing over time
10	Private action to reduce flood damage (e.g. flood skirts at say $10,000 per affected property)	Residents/ businesses	$100,000

Actions: 10- 40 Year Timeframe (indicative cost: $275,000 per year)

No.	Option	Responsibility	Cost
11	Raising roads	LC	$4.0 mill
12	Periodic dune nourishment and repairs to coastal structures	LC	$75k pa
13	Flood control gates to drainage and creek outlets	LC	$200k
14	Allow fill to be taken (sold) from low lying areas including some public lands to elevate developed land, creating wide channels with adequate drainage and retention capacity. Additional fill may be brought in to fill lower properties.	LC/property owners	$1-$2 million

Actions: 40 + Year Timeframe (indicative cost: $445,000 per year)

No.	Option	Responsibility	Cost
15	If demand is strong, permit further subdivision and filling of additional residential areas.		Nominal
16	When protective structures assisted by beach nourishment cease to be effective or cost effective, provide protective rock structures or a sea wall along the beach		$16 mill+ ongoing
17	Keep Shearwater Esplanade open along Freers Beach by erosion control and elevation	LC	$1.5 mill.
18	Elevate other Esplanades Street with adequate drainage under or a bridge to wetland areas.	LC	$3.5 mill.
19	Raising land with fill (5,000 m3/yr @ $5/m3)	Property owner	~$25k pa
20	Potential longer term options: floating dwellings, floating roads		Uncertain

8 COMMUNITY CONSULTATION

8.1 The Workshops

Three adaptation pathways were investigated by the Port Sorell community at workshops held on Saturday May 19 with sessions held in the morning and the afternoon. The three pathways were:

- **Pathway 1 – let nature take its course (early retreat)**
  This pathway allows maximum freedom for natural coastal processes with a minimum of intervention or resistance from development and erosion and flood protection works.

- **Pathway 2 – Protect existing development as long as practical while maintaining values of the area**
  This pathway protects property but only where that protection has a minimal impact on the values of the area important to the community. There is a balance between protecting natural and community assets, and private property.

- **Pathway 3 – Protecting existing and permitting future development to the maximum possible extent for as long as possible**
  This pathway concentrates on protecting the existing property and future development. It assumes that the rate and extent of change will be manageable using available options and that any necessary protection and adaptation options will be acceptable.

Interested residents and businesses were invited to register to attend the workshops. All three scenarios were available with each session lasting two hours, enabling an in depth investigation of the scenario. Over the two hours participants examined the following for the scenario they were investigating:

- The pros and cons and desirability of the scenario
- Whether they believed the scenario was plausible
- What if conditions change (eg. sea level rises faster or slower than anticipated, there are technological advances, or property prices rise or fall)
- Who decides
- Who pays

Over the entire day, about 40 community members attended the workshops. Also attending were the Mayor, two Councillors and observers from Council and State Government.

Prior to the workshops, an information night was held on Thursday 10th of May at the Port Sorell Memorial Hall, attended by about 100 members of the public. The information night was held to inform the community on the hazard and risk assessment and to introduce the pathways to be investigated at the Saturday workshops.

8.2 Workshops Summary and Preferred pathway

Participants of the workshops brought forward a wide range of pros and cons for the three pathways. While some participants expressed a particular preference for pathway 1 and 3, most participants leaned towards pathway 2.

Pathway 1 was seen as a reasonable pathway which confronts the community with reality. It was however felt that retreat should be more phased out and gradual, with relatively soft protection works such as groynes and beach nourishment to slow the process, which resembles a shift towards pathway 2. Relocation and compensation of lost property and infrastructure were debated with the participants being divided, and ultimately accepting that if applied nationwide, it would be financially unfeasible to compensate for retreat.

While some participants expressed a strong preference for pathway 3, most participants disliked the significant change of the character of the area, most notably the loss of the beach. The beach is fundamental to the culture, lifestyle and attractiveness of the area. Although a promenade could provide some amenity, it was felt that ultimately this pathway would adversely impact on the local economy (tourism) and property values. During a workshop for pathway 3, participants proposed an alternative pathway than described in the community brochure, with a dyke or levee protecting the estuary from extreme storm events.

Pathway 2 was preferred overall, with participants of the workshop listing the following key benefits:

- The beach is retained for a significant time;
- It enables a continuation of the beach culture and active lifestyle;
- Natural values are mostly retained;
- Do-able: the existing groynes and off-shore reef or breakwater show these options work, and it appears to be an affordable pathway; and
- It buys time, and may enable the community to use future technological innovations and new solutions.

8.3 How to make it work? Community perspective

Current day risks

Participants of the workshops (across the three pathways) expressed concerns about current day issues, most notably erosion at Freers Beach and stormwater drainage around Bluewater Crescent in Shearwater and around Mary's Creek.

In regards to erosion, participants expressed concerns about previous 'panic' repairs undertaken by Council after extreme storm events that lead to significant erosion at Freers Beach. A plan should be prepared to respond more adequately, preferably a response that does not involve a rock wall, but softer works such as groynes and underwater reefs. Beach nourishment was also considered as a short term measure, with some arguing there would be a significant amount of sand available within the system.

It was felt that there is a need for a drainage management plan. Extreme rainfall events in combination with high tides have resulted to stormwater flood issues in the past. Especially the fairly new development at/around Bluewater Crescent is an area of concern.

Wider estuary study

Related to current day risks, and also to possible adaptive responses, there was a fairly wide consensus that there is a need for a study of the wider Rubicon Estuary. There is, and always has been, a lot of sediment movement in the estuary. Some of the historic protection works had been covered up by sand for many years and forgotten about by many residents until the works became exposed again in recent years. Silting of the river was mentioned as a related issue. There were also concerns about the possible detrimental effects of possible works in the study area would have to more upstream locations.

New development; requirements and information

The community of Port Sorell and Shearwater is one of the fastest growing residential communities in Tasmania. Some participants expressed concerns about managing population growth and new development in light of sea level rise.

Four out of 15 participants at one workshop (pathway 2 morning session), mainly living in and around the fairly new development of Bluewater Crescent, expressed the view that if they had known what they know now, they would not have bought their properties at the time. The groups agreed that planning authorities should inform property owners and possible buyers about any hazards, and specifically the results of this study. It was also suggested that any newcomers should be required to set funds aside when buying a property to pay for any future adaptation works.

There was a wider concern about possible new development in the area in light of the information about sea level rise. Until it is better understood what the long term strategy towards sea level rise would be, some expressed the view that Council should adopt a precautionary approach towards any new developments. Others indicated there should be stringent requirements for any new development, to ensure the built structures would be safe (for their remaining lifetime) and there would be no adverse impacts on existing development.

Migration of Wetlands

Some concerns were expressed about allowing wetlands to migrate as sea levels rise. In practice, wetlands would follow a migration path over time, affecting several properties. Some properties would have to be allowed to become wetland. In some cases, property owners would not be able to prevent this from happening, i.e. would not be allowed to fill up their land even if the owner would be willing to spend his/her own funds to do so. To enable the migration it may be required for Council to change planning conditions. If existing development rights would be reduced, or if existing structures would need to be removed, properties affected would likely encounter a substantial value loss. This loss would be the result of changed planning conditions and not of sea level rise. There would arguably be a case for some level of compensation if it affects all or most of the property.

Local leadership

The participants expressed the view that the local community, together with Council, should show leadership towards coastal adaptation and that solutions should be locally driven. Suggestions were made to create an ongoing community working group and that Council should make decisions in consultation with the community and with input from experts.

There was an underlying concern that involvement by State or regional authorities would result in less influence, less understanding of local issues, less money to spend ‘on the ground’ and more bureaucracy. It was however also agreed that the State could offer capabilities, skills and advice to inform local plans.

It was suggested that Council would need to incorporate coastal adaptation in its annual budget, in line with other recurrent tasks. While it was mostly agreed that general rates would not be the sole basis for raising funds to meet this budget element, there was no clear consensus of how funding should be raised. While there may be some external, Federal or State funding available for risk assessment and possibly feasibility studies for options, there are no Federal or States funds available for actually undertaking coastal adaptation works. This is in line with the study’s principle to not subsidise people to occupy hazardous locations in the long term. A transition period should however be considered as the current residents arguably were not aware of the impacts of sea level rise.

9 WHERE TO FROM HERE?

This section provides overall conclusions on the project, the assessments, and the community consultation findings. In broad terms in provides direction to the way forward from here. Many lessons have been learned, but also, it is clear many gaps in terms of knowledge, decisions making and funding still exist. The following conclusions will illustrate this and also suggest possible ways to address issues. Interestingly enough, the findings are largely true for the other three case study areas too. The consistency in findings supports us in our conviction that some of the issues can and should be addressed collectively and at a State (or even national) level.

Local community and wider community values and objectives

The people from the local community attending the community workshops have made it clear that they place a priority on the protection of property, even if it requires some modification of the local environment. In general there was concern to keep the key amenity values, typically the beach but with some mentioning other aspects. However, given real threat to property, most supported significant interventions to avoid property loss.

However, the wider community has an interest in protecting environmental values that may provide important ecosystem services (fish breeding, water filtration and nutrient reduction, etc.), habitat, particularly for threatened species. Protecting these values may in some cases make protecting property more difficult, more expensive or entirely impractical, potentially raising tensions between local interests and those of the wider community.

State and Federal legislation in some cases addresses these wider interests. Also State and sometimes Federal agencies and other stakeholders from outside the area will need to support the chosen direction for it to be effective. For them to do so, any actions must be consistent with the legislative and other obligations of their organisations.

A process for agreeing a plan and reconciling different interests has been proposed in a paper prepared to 'reality check' the proposed pathway for Lauderdale in Clarence: *Decision Making and Funding for Coastal Adaptation*. This proposes that an adaptation management plan would be developed and formally adopted under a State government framework. The process would have parallels with the development of a planning scheme with opportunities to make representations and appeals, and input from state agencies and review by an authority to confirm compliance with relevant legislation. By having State backing, it would reduce the burden on Local Government for any impacts arising from implementing the plan. The content of this paper would equally apply to Port Sorell, or any other community in Tasmania facing similar issues.

At present the State does not enable such a plan to be prepared and recognised.

Recommendation: To work with the state government to develop a framework for the development of coastal adaptation plans that have state backing and recognition, and balance the priorities of both the local and wider community.

Understanding of current and expected hazards and adaptation works

The hazards from inundation from the sea have been documented by the project for present day and for sea level rise of 0.3 and 0.9 m. However the additional impact of flooding from peak rainwater runoff either locally or from higher in the catchment was not well established. This would require more detailed modelling of the runoff dynamics of the catchment and was not part of the project.

Although locations subject to erosion were identified, the extent or timing of the hazard was also not well established and the dynamics of sediment movement within the estuary and likely evolution of erosion risk remain poorly assessed. Thus the overall hazard is arguably understated.

Coupled with the limited assessment of erosion hazards, the impacts works to resist erosion would have on the dynamics of the area including the likely impacts on sediment transport, environmental changes and impacts on the wider coast and nearby coastal development are poorly understood. For examples in the Clarence work, these impacts were explored in the 'reality check' stages after the community workshops. The experience from Lauderdale (Clarence) shows that it takes significant investigation to get a good understanding of erosion risk and sediment transport. This is essential both to identify effective strategies to mitigate erosion risk and to have a clear understanding of the impacts of these strategies, not only on the erosion risk but wider impacts. The complexity in tidal estuaries partly exposed to open water is even more complex.

Recommendation: To include modelling of rainfall driven flooding in conjunction with coastal inundation to better identify flood risk, as well as modelling drainage capacity in potentially flood affected areas that are developed or proposed for development.

Recommendation: To undertake additional analysis of erosion risk, sediment transport within the estuary and the realistic options for erosion protection works including their likely effectiveness and impacts.

A better knowledge of the environment

It is important to gain an understanding of the impact of any interventions on the wider estuary including impacts on the ecosystem services, threatened species and environmental amenity values. Areas with high environmental values need to be identified as well as their likely response to sea level rise and other climate change effects.

Where areas that have high environmental values are identified, assessment should identify the practical options to support their continued viability. In some cases there may be no action that can ensure they continue to provide environmental services or critical habitat. In other cases, development or adaptation initiatives may either reinforce of undermine their continued existence. While not all natural environments can be preserved, the most valuable should be clearly identified and supported to the extent possible, even where property protection is given a priority.

Recommendation: Prepare a detailed assessment of the environmental values of the areas around Port Sorell, including consideration of the likely changes that sea level rise and climate change will bring. Identify areas of high environmental significance that need consideration in any adaptation works, either to assist with the adaptation of the natural area or to ensure that adaptation measures to protect built assets do not adversely affect important natural areas.

Longer term planning context

The strong desire to protect existing investments suggests an important reason not to allow development in areas where environmental modification is likely to have undesirable impacts. It would be highly desirable to review the planning scheme in coastal areas within the LGA to ensure that development is not permitted in any areas of environmental significance that would be affected adversely by new development seeking to protect itself in the future.

Once it is accepted that there are few critical environmental values remaining in an area, the imperative to protect property becomes even more elevated. The debate then turns to the amenity merits of one or another form of protection. For developed areas, filling a raising low lying land subject to inundation has practical but relatively few environmental or even amenity issues. For eroding coasts, once the limits of protection via beach nourishment are reached, effective erosion protection works are generally intrusive and change the character to the beach. This will deter those seeking natural beaches from the area but may remain attractive to those accepting breakwater, groynes, and other coastal works such as promenades along hardened coasts. As natural beaches become less common, they are likely to be more highly valued – and protected. It may be desirable to identify those undeveloped beaches most highly regarded by the wider community and protect them for the long term by prohibiting development within potential erosion zones. For existing development behind highly attractive beaches, it will be much harder to limit redevelopment or resist the demands to protect existing properties.

Recommendation: Review priority coastal areas of high value to the community for aesthetic, amenity or natural values that could not be protected from climate change impacts, if developed, without compromising these values. Amend the planning scheme to ensure development controls reflect this.

Adaptation requires funding

Both the recommended investigations above and the works required for adaptation will require significant funds. Clarence City Council has spent close to $500,000 to date and the most recent investigations further changed the recommended response significantly from that suggested by earlier, less detailed work. It appears that there are few shortcuts to achieving a good understanding of the local issues that need to be addressed to adapt to climate change in a responsible way.

Under the principle put forward in the TCAP project that there will be no subsidy to assist people to occupy hazardous locations, and consistent with the recommendation of the report on funding and decision making, it is expected that the funds would be raised substantially by a special rate levies on property within the identified hazard areas. Some transition assistance may be available from national or state programs to support climate change adaptation, emergency planning or other relevant programs.

Recommendation: That an approach be formulated to identify the budget required and the sources of funds to raise the money required. It is considered that this should be done on a staged basis over a period of about 5 years, with priority given to identification of and responding to erosion risks and sediment transport in the estuary.

APPENDIX 1 COST OF RISK – METHOD

The method used to determine the present value of expected damages associated with coastal inundation risks in Port Sorell (and the other project sites) is as follows:

1. Estimate the elevation level of each property within each project site, by overlaying the Geocoded National Address File (G-NAF) points to the earth surface image (LiDAR DEM[20])
2. Obtain the present-day water surface profile of each area that gives the depth of forecast coastal floods (and riverine floods in some areas) by their return interval or exceedance probability
3. Add the expected sea level rise over time to derive the future water surface profile
4. Derive the current and future inundation depth from floods of certain frequencies by differencing the water surface with the earth surface plus the floor height above the ground
5. Estimate the expected costs of inundation risks over time, in consideration of the likelihood of occurring different flood events and potential damage at different depths (damage curve)
6. Discount the expected damages over time back to today's value.

[20] Digital elevation model representing the surface heights of the land, measured through the light direction and ranging (LiDAR), similar to "radar" but using infrared laser light pulses instead of radio pulses

Without sea level rise, this value would remain the same each year. The lifetime NPV of risk would increase with the expected life of the structure.

Column 2 of the table summarises the NPV (expressed as a % of the replacement value of improvements, using a discount rate of 5%) of the expected lifetime damage for different lifetimes.
With a longer lifetime the amount of expected damage increases, but beyond about 40 years, the increase is greatly reduced by discounting and it levels out at about 7%. This provides a benchmark against what is typically considered to be an acceptable risk for dwellings.

FIGURE NPV EXPECTED COST OF RISK, WITH AND WITHOUT SEA LEVEL RISE, (WITH FLOOR AT 1% AEP FLOOD LEVEL IN 2010)

Length of time (yrs)	No sea level rise	With sea level rise	Increase in floor level for similar risk as no sea level rise (m)
10	2.0%	2.8%	0.06
20	3.1%	4.9%	0.08
30	3.8%	6.7%	0.96
40	4.2%	8.4%	0.12
50	4.5%	10.2%	0.14
60	4.7%	12.2%	0.16
70	4.8%	14.8%	0.19
80	4.8%	18.4%	0.22
90	4.8%	23.0%	0.26

If it is assumed that the building depreciates over time, the value lost from a major flood would be less. The economic loss is only that of the depreciated value of the dwelling[21].

If the same dwelling is exposed to about 1.0 m of sea level rise over the next 90 years, the amount of expected damage increases each year as the probability of damaging floods (or the depth of a flood of a given probability) increase. The expected damage in a given year rises particularly quickly in later years as the rate of rise increases and many more flood events are expected to be damaging. In that case, the NPV rises continuously as shown in the third column, the rising damage offsetting the effects of discounting.

The result is a level of risk several times higher than that normally considered acceptable, and increasing the longer the life of the structure. If this risk remains unmanaged in any way, the probability of a damaging flood event is quite high, and insurance is unlikely to be available. Either the householder or the government will eventually be faced with the consequences of a flood. Usually where a large amount of property is damaged, government is faced with significant costs for clean up, recovery and assistance to ‘victims’.

The right hand column of the table shows how much higher a floor must be today to give an equivalent NPV risk of damage over a given period with sea level rise to one that is at 1% AEP level with no sea level rise, again without depreciation. The extra height required will be directly related to the intended or expected life of the dwelling: a short lived structure will only have to be a bit above the present day 1% AEP flood level as sea levels will not rise much in the short term; a long lived structure will need to be higher to deal with longer term higher rises. Because of discounting, damage far in the far future is not weighed as heavily as damage in the near future. This gives a much lower increase in floor height for a structure with a 90 year expected lifetime than might be suggested by an expected sea level rise of say, 1.0m by 2100.

Overall, it shows that for structures with an expected lifetime of less than 60 years, the increase in floor height above the present day 1% AEP level is very modest, less than 0.2m. For comparable levels of risk in terms of NPV of

[21] If the building is damaged and needs to be repaired, the cost of the repairs would be the replacement cost, but the occupant ends up with a partially renewed structure.

property damage up to 90 years, increased floor height of about 0.26 m would be required, still well less than the expected sea level rise of 1.0m.

For dwellings with floor levels above the current 1% AEP flood level, risks for the first few decades are significantly lower than for those at the 1% AEP level. This is then offset by much higher risks in the later years. While the present value of those future risks is low because of discounting, in practical terms the annual probability rises well above 1% and it would be wise to protect the structure at that time if it still had a significant service life or not to reinvest and allow it to depreciate in the later part of its life.

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