Turners Beach – Leith Coastal Adaptation Pathways

Final report

Central Coast Council, Tasmanian Climate Change Office

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SGS Economics & Planning

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1 INTRODUCTION AND AIM

1.1 This report

The aim of this report is to inform Council, residents and visitors of Turners Beach, Leith 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 Turners Beach and Leith 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 coastal hazards (inundation and 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 also exhibits 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 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 adapt to sea level rise. This section considers those options that are potentially relevant in the Turners Beach and Leith area. It describes three possible pathways for adaptation, each being distinct it the type of values it aims to maintain and the types of adaptation options associated with each pathway. The pathways are neither predictions nor recommendations.

This section also presents the results of the community workshops where the pathways were explored with members of the community to establish how things may change, how it would work and what would be a preferred pathway for adaptation.

The last section provides recommendations to Council on the way forward from here.

1.2 Project background

The Tasmanian Coastal Adaptation Decision Pathways (or TCAP) extension project is a project established with funding from the Department of Premier and Cabinet's Tasmanian Climate Change Office and the Australian Government's Natural Disaster Resilience Program (NDRP), administered in Tasmania by the State Emergency Services. The project is managed by the Tasmanian Climate Change Office (TCCO) working cooperatively with three local government areas: West Tamar, Waratah-Wynyard and Central Coast, each of which is contributing to TCAP through both financial and in-kind support.

The TCAP extension project will apply the earlier developed and applied TCAP methodology and develop coastal adaptation pathways for local communities. This will be done for the vulnerable coastal areas of Kelso, Somerset and Turners Beach-Leith. The pathways will be developed by progressing to Step 9 along a 15 step process for flexible community adaptation planning (refer to 1.3). The focus of the TCAP

extension project will be on short term adaptation pathways (to 2050), while also considering the longer term impacts (to 2100).

1.3 Coastal Climate Change Adaptation 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 presents 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 Central Coast 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. Review of the draft interim planning scheme for coastal 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 presents the results up to step 6.

1.4 Turners Beach and Leith – project site introduction

The study area of Turners Beach, Leith and part of East Ulverstone extends from the 'Fish Pond' at East Ulverstone in the west to the eastern tip of the residential area of Leith (this will be referred to as Turners Beach-Leith throughout the document). The study area consists mostly of a fairly narrow band along the coastline with the exception of the Forth River estuary that includes an area more land inward (Figure 1).

Just east of the 'Fish Pond' up to Claytons Rivulet is an area of land (here referred to as Maskells) that may be considered for future industrial use. Claytons Rivulet is known to be subject to flooding. Drainage of storm water has been an issue in this area in the past. In Turners Beach, a caravan park is situated along the foreshore behind the foreshore dunes. The study area also includes the residential area of Turners Beach. The area south of the rail and highway bridge over the Forth River primarily involves agricultural land with some residential uses along Turners Beach Road. Leith is a residential area at the eastern side of Forth River.

FIGURE 1 TURNERS BEACH AND LEITH STUDY AREA

1.5 Remainder of this report

The remainder of this report describes the findings so far for the Turners Beach and Leith study area. 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
- Results from the community workshops, including the preferred pathway
- Recommendations on the way forward from here

2 COASTAL HAZARDS

Turners Beach and Leith are potentially subject to coastal erosion (periodic or progressive), flooding from the sea, flooding from peak river flows and erosion along the river banks. All these risks can occur under present day conditions, but with rising sea levels and more extreme weather (including storm and rainfall) the intensity and frequency of extreme coastal events is expected to increase over time.

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 Turners Beach and Leith coastal erosion

The foreshores in the study area mostly consist of shingle beaches and rocky foreshores. Erosion issues have occurred in the past at the western end of the study area near the 'Fish Pond', and alongside the river banks near the river mouth of the Forth River.

The Turners Beach foreshore from the Forth River mouth to just beyond the Claytons Rivulet mouth is classified as 'open sandy shore backed by soft sediment plain – potential erosion and shoreline recession vulnerability' even though the beach is mostly shingle (Sharples, 2006[1]). The section between Claytons Rivulet and the 'Fish Pond' has not been classified on vulnerability and a site-specific assessment would be required to determine vulnerability. The 'Fish Pond' area is classified as 'open sandy shore backed by bedrock – potential beach erosion, lesser recession'. The Leith side of the Forth river mouth is classified as 'undifferentiated sandy shore – potential erosion vulnerability, type unclassified'. The majority of the Leith foreshore is unclassified, requiring site-specific assessment to vulnerability. Observations at the Leith foreshore reveal that the majority of the foreshores consist of bedrock and some shingles.

Erosion at the Forth River mouth at Turners Beach is evident from past protection works including the sand bags[2] that have been placed to protect the council road, the Esplanade. Also, bluestone rocks to a height of approximately 2 metres were installed seaward of the existing dune about seven years ago (Mowling[3], 2011). Fill has been placed seaward from the road for protection. Anecdotal evidence from community members indicates that a sediment management structure in the Forth River mouth was destroyed during a significant storm. After that, the evidence says, the sand spit at the river mouth disappeared and as a result of that a longshore drift has emerged, exacerbating foreshore erosion and being a risk for swimmers.

Anecdotal reports of erosion exist for the foreshore area close to the 'Fish Pond'.

[1] Sharples (2006) "Indicative Mapping of Tasmanian Coastal Vulnerability to Climate Change and Sea Level Rise, 2nd edition", DPIW, Tasmania,

[2] As recommended by Mowling (2011)

[3] Mowling, F. (2011), Initial assessment of the Forth River Estuary including recommendations on suitable risk management and erosion control methods.

Soft protection works at foreshore Forth River mouth Turners Beach

Erosion affecting trees (Forth River mouth Turners Beach)

Shingle beach at Leith

A report on coastal erosion in the Forth River Estuary (2011) by geomorphologist Frances Mowling, identifies shore line evolution resulting in unconsolidated geomorphic landforms including the Turners Beach mouth spit, the dune system and beach cobbles and blown sand.

Erosion is likely to occur at a higher rate at the foreshore on the corner of Boyes Street and the Esplanade as a result of the unconsolidated form of the bay head spit, the occurrence of wave refraction[4] and sea level rise. There exist knowledge gaps about tidal variations, seasonal variations in wave energy, extreme weather events, inshore bathymetry, changes in sediment deposits from the river and sea level rise and how all these aspects may impact on the erosion.

2.2 Coastal inundation

Sea water height varies with tides, storms and regional wave effects. The combined effects can lead to extreme storm surges and consequently inundation. The more extreme heights occur with a lower probability. Present day storm sea level heights for different probability/frequency are shown in Table 1, below.

TABLE 1 STORM SEA LEVEL PROBABILITY, PRESENT DAY

Average Return Interval (ARI)[5]	Annual exceedance probability[6]	Sea storm level height* (m AHD[7])
20 year ARI	5%	2.33
50 year ARI	2%	2.38
100 year ARI	1%	2.42
200 year ARI	0.5%	2.45

*Includes 30 cm free board and round up to nearest 0.1m

Source: M.J. Lacey, J.R. Hunter and R.E. Mount (2012), Coastal Inundation Mapping for Tasmania – Stage 2 Version 1; allowances for round-up and free board (June 2013)

The water height data includes a round-up of the estimate to the highest 0.1m to reflect a reasonable level of accuracy that can be expected for surveyors. The storm surge data also includes a 0.3m free board on top of the water heights to identify the flood hazard area.

In addition to storm surge effects, there are local effects such as local wind setup, local wave setup and local wave runup. These local effects have not been allowed for in the modelling since reliable data was not available. These local effects may roughly add between 0.3 and 1.1 metres to water height levels depending on how exposed or sheltered the foreshores are to the sea.

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 ±0.1m
- Actual floor heights may vary from the estimate by ±0.15m
- These errors may act to offset each other or may add together.

With a present day extreme storm event of a 1 in 100 year probability (1% AEP) the areas at risk of inundation are mostly rural properties, with a small number of residential properties at risk (Figure 2).

[4] Focussing of wave energy on a discrete segment of the shoreline can produce an erosion hot-spot that can persist for a period of decades or longer (Mowling after Galgano, 2007)

[5] 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.

[6] 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

[7] 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)

Areas most susceptible to coastal inundation (inundation due to sea level rise and storm surge) are the river mouth of Claytons Rivulet, the river mouth and upstream area of the Forth River, the 'Fish Pond' and parts of the Leith foreshore.

The map shows that an extreme 1% AEP storm event (a storm with a probability of occurring once every hundred years) at present day will likely affect a single residential property with a possible inundation depth of more than 0.3m, which is the minimum floor height for habitable buildings[8]. Such an event will likely flood a significant area of agricultural land at the Forth side of the highway. The waste water ponds are not expected to be overtopped.

Maskells Road drainage issues

The land located west of Turners Beach and east of Ulverstone, bounded by the Bass Hwy, Kilowatt Crt, Maskells Rd and foreshore incorporates some industrial uses. More industrial uses are proposed for the site. The land is low lying and has a history of low level flooding (2010[9]). The land is expected to be confronted with flooding and storm water drainage issues as a result of more intense use of the land. Existing rail culverts and outfalls have recently been upgraded to provide drainage capacity for future development of this land.

Wave action in large storms is sufficiently high to create surging within the existing channel to culverts some 40 metres back from the beach edge.

[8] Many existing habitable buildings have floor heights below 300 mm. Many existing structures have been built before the standard came into place.

[9] Author unknown (2011) Ulverstone East Drain Investigation. Final Report November 2010.

FIGURE 2 LIKELY INUNDATION DEPTHS AT TURNERS BEACH AND LEITH FOR AN EXTREME STORM EVENT (1% AEP), PRESENT DAY

Source: SGS (2013) based on M.J. Lacey, J.R. Hunter and R.E. Mount (2012), Coastal Inundation Mapping for Tasmania – Stage 2 V1; allowances for round-up and free board (June 2013)

2.3 (Forth) River Flooding

In addition to coastal flood risks, the study area has experienced river floods in the past at Claytons Rivulet and Forth River.

An extensive study was recently undertaken to identify river flood issues in the Forth River estuary, the Forth Flood Plan, Hydraulic Modelling Report[10]. The flood study was undertaken to identify the impacts of certain levees on surrounding flood levels during extreme events, considering current and future climate conditions. Apart from sea level rise projections, the study considered the anticipated changes in precipitation and river runoff. The hydraulic model (MIKE FLOOD) used flood hydrographs that were developed for the August 2007 flood event and for the 10% AEP and 1% AEP design rainfall events with climate change.

The report concluded that no properties in Turners Beach are currently at risk from flooding due to a 1% AEP rainfall event.

2.4 Coastal hazards with climate change

This section considers expected coastal hazards as a result of climate induced sea level rise of 0.2 metres compared to 2010 levels, which is expected to occur around 2050, and of 0.8 metres, which is expected to occur around 2100.

The hazard assessment does not consider other climate change impacts such as more frequent and more severe extreme weather events and river flooding events.

Coastal erosion

Rising sea levels are likely to contribute to progressive erosion of sandy and soft sediment shorelines. As a rule of thumb, landward erosion for open sandy beaches with breaking waves is between 50 to 200 times the increase of sea level rise. This is 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.

New erosion modelling and spatial data[11] enable properties that are susceptible to erosion at various levels of risk to be identified. The hazard bands low, medium and high identify areas of land that are susceptible to erosion:

- High hazard band: potential present day recession. Storm bite and consequent reduced foundation stability zone – 22 metres landwards from High Water Mark (HWM) or to natural recession limit
- Medium hazard band: potential shoreline recession to 2050 – 27 metres landwards of storm bite hazard zone or natural recession limit (i.e. 49 metres landwards of HWM or to natural recession limit)
- Low hazard band: potential shoreline recession to 2100 – 61 metres landwards of storm bite hazard zone or to natural recession limit (i.e. 83 metres landwards of (HWM)

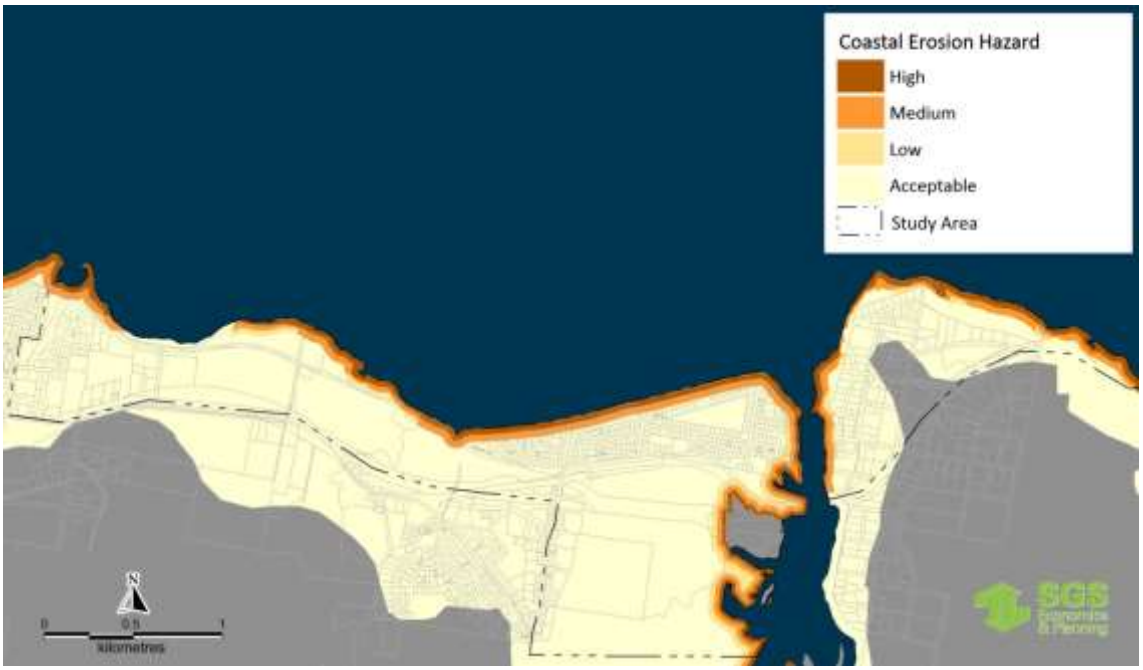
[10] Entura 6638, 28 July 2013, DRAFT

[11] C. Sharples, H. Waldorf & L. Roberts (July 2013) 'Coastal erosion susceptibility zone mapping for hazard band definition in Tasmania

The erosion susceptibility mapping takes into account the type of shoreline and the availability of any existing erosion protection works such as sea walls or groynes. It does not consider in detail the quality of these works and how likely they would be effective to protect against erosion over time.

The map below (Figure 3) displays the potential coastal erosion susceptibility hazard bands for Turners Beach and Leith.

FIGURE 3 POTENTIAL COASTAL EROSION SUSCEPTIBILITY AT TURNERS BEACH AND LEITH



Source: SGS (2013), based on C. Sharples, H. Waldorf & L. Roberts 'Coastal erosion susceptibility zone mapping for hazard band definition in Tasmania

The mapping takes into account the potential effects of sea level rise, but does not consider the potential effects of a trend with increasingly more frequent and more severe extreme storm events. Storm events lead to temporary higher sea levels and wave attack on higher elevations of the beach, dune and cobble berm, resulting in scarping and slumping of the dune and erosion of the beach (Mowling, 2011). More frequent and more severe storm events are likely to result in increased scarping and slumping of the dune and erosion of the beach.

Mowling identifies a few erosion 'hot spots' that are likely to continue to experience an accelerated rate of erosion and regression over the next fifty years.

Coastal inundation

Future coastal inundation risks will increase as climate change causes sea levels to rise. The coastal sea level rise mapping undertaken for Tasmania has adopted sea level rise allowances compared to 2010 for 2050 and 2100. Sea levels are projected to rise by 0.2 metres by 2050 and 0.8 metres by 2100. Table 2 below shows the projected water level heights for various types of events in 2010, 2050 and 2100.

While the impact of climate change is now fairly well understood within the scientific community, there is and will remain uncertainty in regards to the pace of climate change and related impacts such as sea level rise. Sea levels may rise slower or faster than projected.

TABLE 2 PROJECTED SEA HEIGHTS, 2010-2100

Annual Exceedance Probability (% AEP)	Present day / 2010	2050	2100
Sea Level Rise (m) compared to 2010	0.0	0.2	0.8
	(m AHD)	(m AHD)	(m AHD)
5%	2.33	2.53	3.13
2%	2.38	2.58	3.18
1%	2.42	2.62	3.22
0.5%	2.54	2.75	3.35

Source: SGS (2013) based on M.J. Lacey, J.R. Hunter and R.E. Mount (2012), Coastal Inundation Mapping for Tasmania – Stage 2 Version 1; allowances for round-up and free board (June 2013)

The estimates are based on the technique of Hunter (2012), observations of storm tides from the tide gauges at Hobart and Burnie, and regional projections of sea-level rise based on the IPCC A1FI emission scenario (Hunter et al., 2012). These allowances were added to the AEPs for 2010, to derive AEPs appropriate to 2050, 2075 and 2100. (Coastal Inundation Mapping Stage 2 V1, TPC, September 2012).

Climate change is also expected to result in more extreme weather events. This could mean that a 1% AEP event at present day may become a 5% AEP event by say 2050. The extent to which extreme events become more extreme and more frequent has not been taken into account in the coastal inundation mapping. As indicated earlier, the modelling does not consider local wave and wind conditions due to unavailability of data. The coastal inundation mapping must therefore be interpreted as conservative projections of future inundation hazards.

In regards to flooding a so-called 'bathtub' model was used, and low lying areas well back from the shore may not fill with the high tide associated with the storm event because the water cannot reach them (except through drainage pipes). Equally, if the extreme event is associated with rainfall, which is common, then these low lying areas are likely to flood from rainfall runoff that cannot escape because of high sea levels and so flooding is still likely. In fact, many of these areas are flood prone now due to limitations of drainage.

Figure 4 and Figure 5 show for a given sea level rise:

- The area flooded in a 1% AEP event
- The depth of inundation for a 1% AEP event

The maps have been produced using the coastal inundation data referenced above that assume a sea level rise of 0.2 metres and 0.8 metres. This is projected to occur by 2050 and 2100 respectively. The data include the round-up to the next nearest 0.1m and the freeboard allowance of 0.3m referenced earlier. The projected rate of sea level rise is approximately 5mm per year to 2050, and 12mm centimetres from 2050 to 2100.

The maps assume that the topography does not change with erosion and the movement of sand from wave action, which is likely to happen. Rising sea levels is likely to cause progressive erosion of sandy shores if no action is taken (previous section). If dunes are unconstrained by development and other interference, they would generally be expected to move inland and be higher than existing dunes. The dynamics of the estuary and mouth will also change, potentially leading to sand deposition, 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.

FIGURE 4FIGURE 4 LIKELY INUNDATION DEPTHS AT TURNERS BEACH AND LEITH FOR AN EXTREME STORM EVENT (1% AEP), 0.2 M SEA LEVEL RISE

FIGURE 5 LIKELY INUNDATION DEPTHS AT TURNERS BEACH AND LEITH FOR AN EXTREME STORM EVENT (1% AEP), 0.8 M SEA LEVEL RISE

Source: SGS (2013)

The maps show that a with sea level rise of 0.2 metre (at around 2050) an extreme event is likely to affect only a few (approximately three) residential properties with inundation depths of more than 300 mm.

Over time, while the sea level increases, more properties are expected to be at risk from an extreme storm event. An extreme 1% AEP event with a sea level rise of 0.8 metre is likely to affect approximately 44 residential properties with inundation depths of more than 300 mm.

Maskells Land drainage

The sea level rise and storm surge data suggest no developing inundation issues due to climate change with a sea level rise of 0.8 metres (expected around 2100). However, higher sea levels, especially during storm events, may undermine the effectiveness of drainage of storm water (from rainfall and non-coastal flooding) from the area to the Bass Strait. In fact, the drainage report on the site (2010[12]) suggests that 'due to sea level rise over the next century, it is likely that storm surges will be large enough to ultimately cause wave effects within the foreshore channels through the railway embankment. The invert level of the main rail culvert installed in December 2012 is at 3.00 AHD or just 0.20 m above the static storm surge level predicted for 2100'. Local wave runup and setup during an extreme event (not considered in the projections) on top of sea level rise and storm surge may therefore impact on the drainage capacity.

River flooding

As a result of climate change the probability of more intense rainfall is likely to increase (ACECRC[13] , 2010). There will be more frequent extreme events; for example what is a 1% AEP event at present day may become a 5% AEP event by 2100. 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 Forth River study has looked into the impacts levees could have on flooding, considering climate change impacts on the Forth River estuary. It found that a levee at the eastern side of the Forth River reduces the severity of flooding at the eastern side of the river near Harvest Moon but slightly increases flood risks at the western side, in the long term possibly affecting a small number of dwellings and overtopping of Forth Road, between Wilmot Road and Walker Street and Wilmot Road just south of the Forth Road/Wilmot Road intersection.

Upstream of the bridges, the river flooding risks exceed the risks due to storm surge. Flood levels are well above the coastal inundation levels upstream of the bridges. The Forth Flood Study is likely to provide more accurate flood estimates for the areas upstream from the bridges. In addition to depth, the higher river levels are likely to be associated with significant flow rates that would cause greater damage than damage just based on depth of inundation.

Most damage is to agricultural land, factory, road, (potential overtopping of) waste water ponds and other infrastructure which the SGS cost of risk model does not address.

River flooding at Claytons Rivulet is expected to exacerbate over time as a result of climate change. There is no data available on the extent of changing flood risks over time at Claytons Rivulet.

[12] Author unknown (2010), Ulverstone East Drainage Investigation. Final Report. November 2010.

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

3 PLANNING SCHEME MECHANISMS

This section contributes to **Step 2 of the 15 Step Community Adaptation Pathway:review of draft interim planning scheme for coastal hazard areas**. The section reviews the existing and proposed Central Coast planning scheme provisions and relevant state and regional directions on coastal hazards and climate change impacts for the Council area.

Section 3.2 reviews relevant state and regional policies, projects or land use frameworks which address the effects of climate change on coastal areas. Section 3.3 reviews the interim draft Central Coast Planning Scheme and details any planning provisions that relate to the mitigation of climate change effects on coastal areas, while section 3.4 briefly looks at the current Planning Scheme as a means of comparison. Section 3.5 provides recommendations for Central Coast Council on planning scheme amendments that could be made prior to detailed scenario planning to better address coastal hazards and climate change risks.

3.1 Regional Planning Initiative

The Regional Planning Initiative covers three regional planning partnership projects: the northwest, northern and southern region. They have been established through agreements between the State Government, the respective councils and regional bodies. Central Coast Council is located in the northwest region.

Each region has prepared a regional land use strategy and all were declared in October 2011:

- Northern Region: Regional Land Use Strategy of Northern Tasmania
- Southern Region: Southern Tasmania Regional Land Use Strategy 2010-2035
- Northwest Region: Living on the Coast – The Cradle Coast Regional Land Use Planning Framework

These Strategies or Frameworks are statutory instruments meaning new planning schemes, planning scheme amendments or projects of regional significance must be in accordance with the frameworks. Each Council is now tasked with preparing new planning schemes that will be consistent with the regional land use strategies.

The regional planning initiative is supported by the State Government through Planning Directive 1 – The Format and Structure of Planning Schemes, released by the TPC in May 2011. The directive incorporates a new 'Planning Scheme Template for Tasmania' which Councils are to use to achieve consistent layout, zones and terminology of planning schemes.

Northwest Region

Living on the Coast: Cradle Coast Regional Land Use Planning Framework 2010-2030 was declared on 27 October 2011. Part C of the Framework, 'Cradle Coast Regional Land Use Strategy 2010-2030', includes direction to address mitigation and adaptation to climate change impacts. Directions are included under three of the strategy themes:

- Wise Use of Resources

- Places for People
- Infrastructure Provision

Wise Use of Resources

Chapter 2 of Part C of the Framework, 'Wise Use of Resources – respect for what is valued', includes Clause 2.8 Land Use Policies for Coastal Management. This provides direction for land use planning in adapting to the impacts of climate change to coastal areas.

Clause 2.8 Land Use Policies for Coastal Management
Relevant policies under this Clause include:

c. Minimise or avoid use or development in areas subject to high levels of coastal hazard

Places for People

Chapter 4 of Part C of the Strategy, 'Places for People –liveable and sustainable communities', includes relevant policies under:

- Clause 4.3 Land Use Policies for Managing Growth and Development;
- Clause 4.4 Land Use Policies for Protecting People and Property; and
- Clause 4.7 Land Use Policies for Housing Land – places to live.

Clause 4.3 Land Use Policies for Managing Growth and Development
Policies under 4.3.1 Urban Settlement Areas include:

g. Implement structure plans and regulatory instruments for each centres which –
   vi. Minimise exposure of people and property to unacceptable levels of risk to health or safety

Clause 4.4 Land Use Policies for Protecting People and Property
Relevant policies under this Clause include:

a. 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
b. 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
c. 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
d. 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
e. 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
f. 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
g. 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

h. Ensure current and future landowners and occupiers are put on notice of the likelihood for a further or enhanced level of risk

Clause 4.7 Land Use Policies for Housing Land – places to live
Relevant policies include:

e. Rationalise or remove opportunity for housing in locations where oversupply is identified, and in locations where access, servicing, safety or impact are unacceptable

h. Provide opportunity for housing in rural areas where –

vi. There is an acceptable level of risk from exposure to natural or man-made hazard

Infrastructure Provision

Chapter 5 of Part C of the Strategy, 'Infrastructure Provision – support for growth and development', includes Clause 5.3 Land Use Policies for Integrated Land Use and Infrastructure Planning.

Clause 5.3 Land Use Policies for Integrated Land Use and Infrastructure Planning
Relevant policies include:

c. Promote compact contained settlement areas to –

i. Assist climate change adaptation and mitigation measures

l. Promote infrastructure corridors, sites and facilities that –

iii. Minimise exposure to likely risk from natural hazards

3.2 Central Coast (Draft) Interim Planning Scheme 2013

Central Coast Council has drafted a new planning scheme using the new state planning template to align with the Living on the Coast – Cradle Coast Regional Land Use Planning Framework.

The interim Planning Scheme is still in draft form. The draft was submitted to the Tasmanian Planning Commission in December 2012[14]. It will be considered by both the Commission's Advisory Committee and the Minister for Planning regarding its suitability and compliance with the Act. The interim Planning Scheme will then be publicly exhibited.

The draft Central Coast Interim Planning Scheme uses Zone and Code Provisions for addressing coastal vulnerability.

3.0 Planning Scheme Objectives

In s3.1, the Planning Scheme recognises climate vulnerability on three separate occasions in its objectives, in regards to:

a) Coordinate sustainable use or development of land within the Central Coast municipal area in accordance municipal strategic principles, policies and actions contained in the following documents that contain coastal actions -

- Climate Change Action Plan
- Forth Local Area Plan

[14] An updated interim planning scheme has been released on 19 October 2013 and the final report will update to include the then most up to date version.

- Turners Beach Local Area Plan

iv. minimise likely risk to the community and the environment from use or development on land exposed to a natural hazard or environmental harm[15];

xx. recognise the cumulative and likely escalating impacts of climate change

Zoning

There are two zones in the interim planning scheme which relate to coastal vulnerability; the Environmental Living Zone and the Environmental Management Zone.

Due to the broad brush term of 'natural hazards' being used, coastal vulnerability or sea level rise is not mentioned specifically in any zone.

The need to prepare conservation reserve or hazard management plans when undertaking certain activities ensures that hazards need to be considered.

The Codes, and especially the Hazard Management Code (next section), provide more detailed definitions and requirements in regards to coastal hazards.

Codes

Codes set out standards for use and development for matters that are not confined to one zone and apply over and above zone provisions.

There are three new codes which include use and development standards that seek to minimise 'exposure to an unacceptable level of risk from a natural hazard'. The codes are the Change in Existing or Natural Ground Level Code, the Hazard Management Code and the Water and Waterways Code.

More detailed information on the codes is provided in Appendix 1.

The Hazard Management Code is quite comprehensive in detail, and separates out sea level rise and other coastal hazards for risk assessment. The risk assessment provided in the appendix also provides extra detail specific to coastal vulnerability. The planning scheme identifies independent sources for hazard identification. The code points to two key external documents:

- Mapping of Tasmania Coastal Vulnerability to Climate Change and sea Level Rise (2006)
- Coastal Inundation Map prepared for the Tasmanian Planning Commission (2011)

Although this provides scope for decisions within the Hazard Management Code to be updated when these two documents are updated, this isn't explicitly stated. A phrase added to the clause that requires applicants / assessors to refer to the most recent version of these reports would solidify this. This will reduce the need to amend a planning scheme with the inclusion of new hazard information every time it is released.

The codes do not indicate how to deal with developing risks over time, and how this relates to the expected lifetime of a proposed use or development. Fill may also impact on adjacent properties in regards to flood risks and stormwater drainage.

Comparison Central Coast Planning Scheme 2005

There are significantly fewer provisions in the Central Coast Planning Scheme 2005 that plan for coastal vulnerability than the draft interim planning scheme. The objectives of the planning scheme that relate to the coastal environment are limited to:

- Protecting the environmental qualities of the coastal and river systems.

[15] Natural hazards include bushfire, coastal erosion and inundation, flooding, and landslide; environmental hazards may include contamination of land as a result of a previous use

- Development of land and its use to be carried out in a way so as to minimise environmental harm.

Coastal vulnerability is captured only within the schedules of the planning scheme, namely:
- Schedule 1: Application Requirements
- Schedule 6: Land Stability
- Schedule 7: Coastal and Riparian

Recommendations

- Council to identify hazard areas for inundation due to sea level rise and coastal erosion vulnerability based on the most recent versions of any paper pointed to within the planning scheme.
- Overlay maps identifying the expected hazard areas are to be incorporated into the planning scheme where available.
- The Scheme refers to independent scientific sources in regards to identifying hazards. These sources tend to be reviewed and updated every few years, and as a result the planning scheme may need to be amended. The scheme could also include a statement that requires the most current revisions of these sources to be identified as the relevant source to consider in relation to a proposed use or development, thereby preventing the need for an amendment.
- More detailed specification of acceptable levels of risk including how risks may change over time is needed. This should then be related to the lifetime of the type of use or development. For example, the acceptable level of risk may differ between types of uses such as car ports compared to new dwellings and hospitals. The proposed use or development should be designed and built in such a way that it remains within an acceptable level of risk during the asset's lifetime.

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 and 4of the adaptation pathway process: assess assets at risk, and establish cost of risk.

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 dwellings. Infrastructure, public amenities, the caravan park 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.

4.1 Inundation Risks

The key findings about inundation risks in Turners Beach are summarised below:

- Two residential dwellings have some present-day above floor height inundation risks[16]. Both of these have relatively low inundation probabilities (1% and 5% respectively)[17].
- With a sea level rise of 0.2m from today's levels (expected by about 2050), three additional dwellings at a risk from inundation. The average inundation probability is also expected to increase substantially to 22%.
- With a sea level rise of 0.8m from today's levels (expected past 2100), 89 properties would be at some inundation risk, with an average inundation probability of 25%.
- Of these, 56 dwellings in Turners Beach would be flooded by a 1% AEP (100 year ARI) event with an average above-floor depth of 0.21 metres.
- 28 parcels of land would be lost, falling permanently beneath the high tide level.

The table below shows the estimated number of properties in Turners Beach 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 0.2 metre sea level rise and with 0.8 metre sea level rise. It also shows the average over-floor depth of flooding. With a 0.2 metre sea level rise, there is no change in the estimated number of inundated properties[18], but the average intensity of flooding increases from 0.05 metres to 0.25 metres, resulting in significantly higher expected damages.

[16] Risk, if not specified, refers to more than 0.01% chance of having an over floor flood.

[17] One property, 33 Boyes Street, was excluded from our analysis. This is because the land had an anomalously low elevation level, but was not sufficiently close to the beach to be at serious risk of present day flooding. Its inclusion would tend to exaggerate the inundation risk and expected damages.

[18] Note that while three additional properties have some inundation risk, the probability is below 1% AEP for 0.2m sea level rise

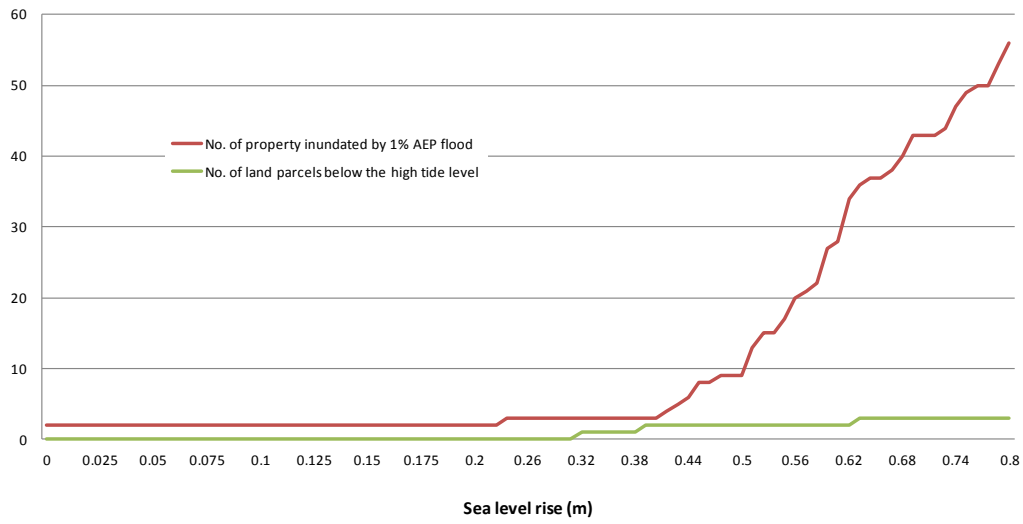
TABLE 3 NUMBER OF INUNDATED PROPERTIES[19] AND AVERAGE OVER-FLOOR DEPTH CAUSED BY 1% AEP FLOOD

		Estimated No. of inundated properties	Average over-floor depth (m)
0.0	**(2010)**	2	0.05
0.2	**(2050)**	2	0.25
0.8	**(2100)**	56	0.21

Source: SGS estimates (2013)

The numbers of properties at some risk of flooding begins to increase steadily at about 0.4 metres sea level rise. With an 0.8 metre sea level rise, there are a total of 56 properties at risk, about 10% of the properties surveyed. Three parcels of land are lost, falling permanently beneath the high tide level. 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 TURNERS BEACH



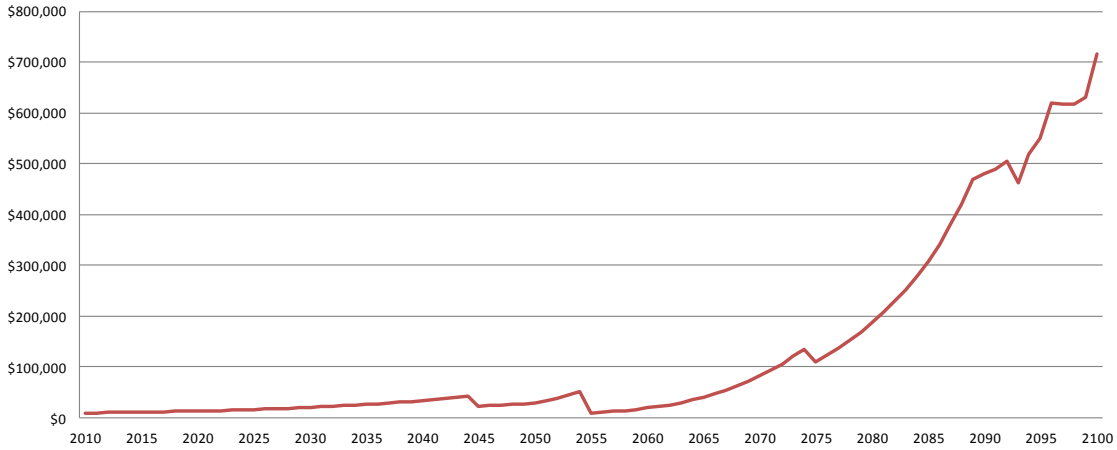
Source: SGS estimates (2013)

4.2 Property Risks

The charts below depict the expected risks (structure damages x probability) in dollar values over time. 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 Turners Beach and Leith 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).

[19] Includes residential properties with above floor level inundation depths only

FIGURE 7 EXPECTED ANNUAL STRUCTURE DAMAGES (IN REAL DOLLARS) AT TURNERS BEACH, WITHOUT DEPRECIATION

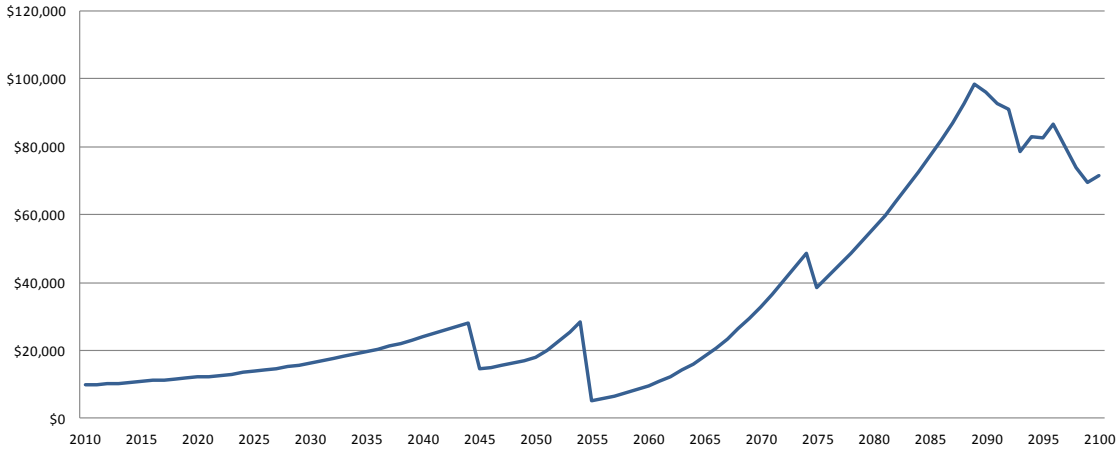


Source: SGS (2013)

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 Turners Beach start at just under $10,000 in 2010. They grow rapidly from 2055 onwards, peaking at approximately $98,000 in 2089 (Figure 8).

FIGURE 8 EXPECTED ANNUAL STRUCTURE DAMAGES (IN REAL DOLLARS) AT TURNERS BEACH, WITH DEPRECIATION



Source: SGS (2013)

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 4).

Without structure depreciation (i.e. assuming ongoing investment on maintenance and capital upgrade), the NPV of the future risk amounts to $595,000. If the affected properties in Turners Beach are assumed to be fully depreciated in 100 years (i.e. not properly maintained and upgraded), the NPV of the structure risks is $335,000.

We have classified the residential dwellings[20] in the study area into three categories:

1. The 2 dwellings with present-day inundation risks
2. The 109 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 long term risk (Table 4). The table below shows the total discounted value of risk over the next 100 years. Notably, the NPV of expected damages to the two dwellings at present day risk is actually higher than the current value of the dwellings. That is because it is assumed owners will continue repairing their property from inundation damage until severe flooding forces them to abandon it altogether.

TABLE 4 NPVS OF TOTAL STRUCTURE DAMAGES, AND THEIR SHARE OF THE EXISTING STRUCTURE VALUES[21]

	Present day risk		Long term risk		All
Current value and count	**$245,000**	**2 dwellings**	**$23,315,000**	**109 dwellings**	**554**
	NPV of expected damages	**% of existing capital value**	**NPV of expected damages**	**% of existing capital value**	**NPV of expected damages**
Without structure depreciation	$310,000	127%	$285,000	1%	$595,000
With structure depreciation	$250,000	103%	$85,000	0.4%	$335,000

Source: SGS estimates (2013)

It should be noted that the damage of an extreme storm event if it actually did occur could be much higher than the expected value. Table 5 below shows that the potential damage caused by an extreme storm with a 1% annual probability could result in a total damage of almost $6.5 million in 2100 if the dwellings are well maintained.

TABLE 5 TOTAL DAMAGES[22] CAUSED BY 1% PROBABILITY FLOOD

	Total damages caused by 1% AEP (100 yr ARI) flood		
	2010	**2050**	**2100**
Without structure depreciation	$60,000	$205,000	$6,465,000
With structure depreciation	$60,000	$125,000	$645,000

Source: SGS estimates (2013)

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:

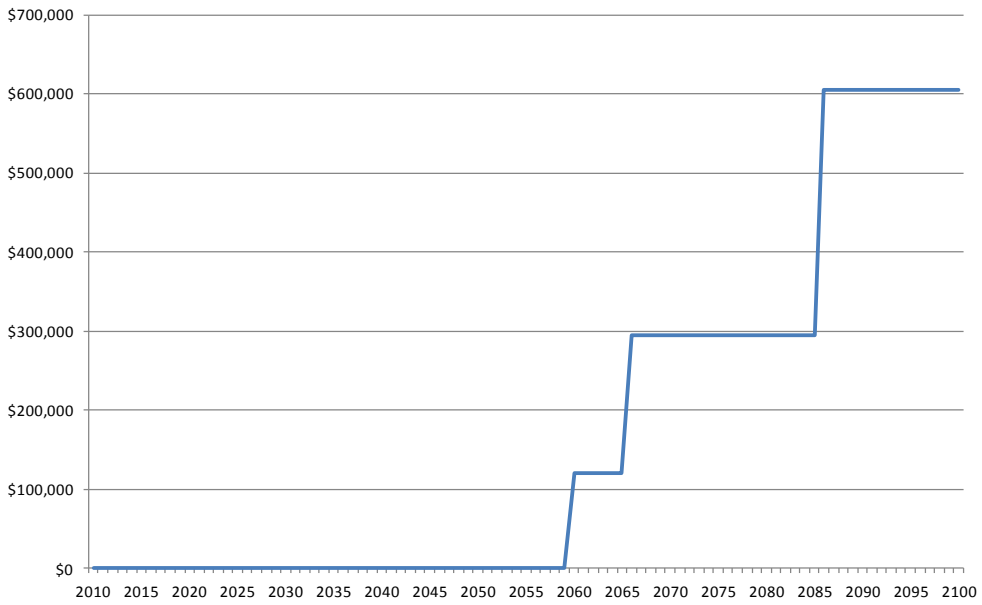
- To public infrastructure (roads, street lighting, water supply, sewer, damage to the sea wall, sports fields or other public amenities)
- From erosion
- To other commercial infrastructure (telephone, electricity supply)

[20] Includes residential properties with any depths of inundation (also below floor level flood depth)
[21] Amounts are rounded to the nearest $5,000
[22] Amounts rounded to the nearest $5,000

- 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 Central Coast Council) of land lost once it is lower than the average high tide level (Figure 9).

FIGURE 9 EXPECTED LAND LOSS AT TURNERS BEACH



Source: SGS 2013

Land loss at Turners Beach is expected to begin in 2060, at a projected 0.3 metre sea level rise. By 2100, the total loss is expected to comprise 3 parcels of residential land with a value of approximately $605,000 based on present day valuation. The NPV of these losses is estimated to be around $31,000.

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**[23]. A property that has a floor just at the 1% AEP flood level has an expected damage in any given year of 1.13% of the value of the structure[24]. On a structure worth $100,000 this corresponds to an expected annual damage of about $1130 if exposed to this level of risk from inundation from the sea in Turners Beach.

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 23.5% of the structure value in the Turners Beach 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 0.8 m 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 events are expected to be damaging. In that case, the NPV rises continuously to 2052, after which

[23] 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.

[24] 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.

buildings at risk of flooding are assumed to have been abandoned or rebuilt in flood-proof form. The lifetime NPV reaches about 37.6% of the structure value[25] in the Turners Beach area.

Conclusion

The estimated cost of risk (in present day values) of coastal inundation to private dwellings is between approximately **$335,000 and $595,000 to 2100** depending on whether owners continue to maintain their dwellings.

By 2100, an extreme storm event (1% AEP) is estimated to cause $6.5 million worth of damage (without structure depreciation) if the existing buildings or comparable ones are still in their current locations and elevations.

In addition, three 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 post 2100), 3 land parcels in the study area are likely to be lost, resulting in a total loss of $605,000 (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[26] 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.

[25] For properties with a life expectancy of maximum 100 years

[26] Up to 20% of the structure's depreciated value assuming a 50 yr lifetime. Less if shorter lifetime expected.

5 COASTAL VALUES

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 values of the study area.

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: assess the value of occupation or use.

5.1 Private property and assets at risk

Residents in coastal 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.

The total value of all residential properties in the study area is $265 million, The study area comprises 1,375 residential properties, some of which are at risk from coastal hazards at present day or in the future due to climate change. The average value of a property is $320,000.

Residential properties at risk of inundation

The previous section discussed in detail how properties in the study area are at risk of inundation with sea level rise. To 2100 there are likely to be 109 residential properties that will be at some risk of inundation. The total value of these properties is approximately $ 35 million (capital value).

Properties at risk of erosion

Based on the coastal erosion susceptibility data by Sharples et al it is possible to identify what properties may be at risk of erosion at present day, by 2050 with an expected sea level rise of 0.2 metre and by 2100 with an expected sea level rise of 0.8 metre.

Those properties of which the majority of land area is within a hazard band have been identified as susceptible to erosion. In total there are 45 residential and seven non-residential properties identified as susceptible to erosion:

- It shows that in total twelve land titles including residential (8), vacant residential (1,) rural-residential (2) and recreation area (1) properties are within the **low hazard** band. These properties are especially along the Esplanade, Lukin Street and Allport Street West.
- There are 33 residential properties identified within the **medium hazard** band. In addition, six non-residential properties are within the medium band: one residential vacant lot, a youth camp, a caravan park, a sport facility, a recreation area and a service station. Most properties (24) are along the Esplanade. Other properties are at Beach Rd, Clayton Rd, Fenton St, Heather Court, Lethborg Av and Turners Beach Rd.

- There is one property that lies within the high hazard band. This property is at Beach Rd.

Small sections of agricultural parcels south of the bridges are identified as susceptible to erosion. However, river flooding and erosion is likely to affect this land more than coastal erosion.

The total value of the 34 residential, developed properties[27] being classified as medium and high risk is approximately $ 17 million or an average capital value of $500,000 per property. The average land value is approximately $205,000.

The total value of the ten residential, developed properties being classified as low risk is approximately $ 4 million or an average capital value of $400,000 per property. The average land value for these properties is approximately $180,000.

The total value of all residential, developed properties in the study area is $265 million or an average capital value of $320,000 per property. The average land value for these properties is $125,000.

Generally speaking, those properties closest to the coast are more susceptible to erosion. Assuming other things being equal, the average capital value of properties closest to the beach is $100,000 above the average value of properties that are second closest to the beach. The difference is about $180,000 compared to all properties in the study area.

The average land value for properties closest to the beach is $25,000 above the average of properties that are second closest to the beach. The difference is about $ 80,000 compared to all properties in the study area.

This suggests that on average people are willing to pay a significant premium to own a beachfront property.

Infrastructure and other assets

In Turners Beach, the Esplanade, from the corner with Boyes St following the Forth River to the end of the Esplanade (Gables Park) is categorised as being within the medium hazard band, with some parts of the road being within the high hazard band. The Esplanade provides protection against erosion to properties at the southern side of the road. The public toilets (x2), boat ramp, picnic, playground and parking area along that part of the road are also within the medium hazard band. The public toilets and playground at the corner of the Esplanade with Turners Beach Rd (adjacent to the service station) is also within the medium hazard band.

In terms of inundation, there are limited Council assets at risk. While overtopping of sections of Council roads, such as Arcadia Av and Boyes St, is likely to occur with an extreme event, the events are not likely to impact significantly on the usability of the roads, at least not until 2050. However flooding may affect the stability of roads and increase maintenance costs.

A key asset at risk at the southern end of the bridges is the waste water ponds. Overtopping of the ponds during an extreme flood event will potentially result in contamination and pollution risks of the river and surrounding agricultural land. The value of the ponds is unknown and it is likely that the walls could be strengthened and heightened so it can at least operate to the end of its economic lifetime.

[27] Excluding vacant residential land, businesses, youth camp and caravan park

5.2 Other values at risk

Other values at risk are the shingle beaches, dunes and some low lying public park land, which may become wetland as sea level rises.

The study area offers a range of recreational values, including enjoyment of natural values, swimming, fishing, walking and boating. There is one public boatramp and several public toilets.

The caravan park offers the opportunity for many households to spend holidays in Turners Beach. Tourism is an important economic activity in the area. Potential loss of beaches due to possible protection works would likely to adversely affect some of the natural, recreational and economic values of the area.

Threatened fauna and flora

Threatened species data from the Natural Values Atlas identify the presence of threatened species in the study area (2009, Threatened Fauna Observations)[28].

In various locations of the study area's foreshore is part of the habitat of the shy albatross habitat, also a threatened species. The area around Claytons Rivulet within the study area is an identified habitat of the eastern barred bandicoot.

Other species with a conservation value (non-threatened) are the Tasmanian native hen found on the foreshore between the 'Fish Pond' and Turners Beach, pigweed at Claytons Rivulet (flora), prickly moses just east of Turners Beach (flora), prickly starwort on the beach at Turners Beach, spinifex in Turners beach dunes, short waterstarwort, coast speargrass, silver banksia and coast wattle at the Forth river mouth (flora).

5.3 Conclusions

Properties in the Turners Beach Leith study area 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, 109 properties would be at some level of risk from inundation due to sea level rise and extreme storm events. To 2100, there are in total 45 properties at some risk of erosion due to sea level rise and storm events.

Many of these properties have direct beach or river front access or are located close to the beach. The premiums of properties close to the waterfront are between $100,000 and $180,000 per property.

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

The natural and environmental values of the Turners Beach and Leith area are significant and include dunes, beaches, flora and fauna. Sea level rise may result in the development of wetlands.

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

[28] The sea in front of the foreshore between the 'Fish Pond' and Maskells Rd is an area that is identified as a site that has been visited by humpback whales a threatened fauna species, but this is unlikely to be affected by shore based activity or directly by other local influences.

Potential loss of beaches due to possible protection works would likely adversely affect some of the natural, recreational and economic values of the area.

6 ADAPTATION OPTIONS

6.1 What if nothing is done?

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?

Inundation (from west to east)

The western end of the study area is little affected by present storm surges. The 'Fish Pond' would be affected by a 1% AEP storm with inundation heights between 0.0 and 0.6 metres. No built structures would be at risk. Some minor localised flooding would occur with depths generally below 0.3 metres between the 'Fish Pond' and Turners Beach.

Over time, with sea level rising, flooding from a 1% AEP event would occur at the same localised spots, with the flooding covering a wider area and increased levels of inundation.

It is likely that drainage capacity from the Maskells Land industrial precinct could be impacted by rising sea levels in combination with storm events and local wave setup and runup effects.

Present day flood risks at Turners Beach mostly exist at the western end of the residential area where Claytons Rivulet reaches the foreshore, and the southern end close to the Bass Hwy at Arcadia Avenue due to flood water coming in from the Forth River mouth via the natural inlet south of the end of Lukin Street. Present day floods will likely affect a few properties, but with inundation depths mostly below floor level.

Over time, with sea level rising, more residential properties would be at risk from flooding, with flood levels generally below floor height by 2050 (except two dwellings), and approximately 56 properties with flood depths above floor height by 2100.

The rural area south of Bass Hwy and the strawberry farm north of the Bass Hwy are at present day risk from inundation by the sea and from the river. The waste water facilities are currently not at risk from overtopping. Over time, with sea level rising, the depth of inundation may become substantial with the majority of the area likely to experience a 1.5 metre depth of inundation from a 1% AEP storm (by 2100). From 2050 onwards, some residential properties along Turners Beach Rd south of the Bass Hwy would become at risk from inundation from extreme events too.

Parts of the Leith foreshore are at a current risk of inundation from an extreme storm event. Over time, with sea level rising, inundation depths at these locations is likely to increase, while the total area at risk would not expand much due to increased height of land landward.

In the short to medium term, flood risks with damage to residential properties are likely to remain low. To 2050, only two residential properties would be at risk of above floor height flooding in case of a 1% AEP event. With more sea level rise, to 0.8 m by 2100, the number of properties affected by flooding from a 1% AEP event would increase to 56.

Erosion (from west to east)

Erosion along the foreshores from 'Fish Pond' to the mouth of the Forth River may continue, with some cut and fill cycles but a significant risk of long term recession as a result of sea level rise. The 'Fish Pond' with its unique shape is likely to be eroded significantly.

A significant number of dwellings and the caravan park along the foreshore are likely to be at risk from erosion by 2050 (sea level rise of 0.2m). Erosion risk may increase at a higher pace at the corner of the Esplanade and Boyes Street, an area that has been identified as a possible erosion hotspot which may continue for decades.

Parts of the shoreline at the mouth of the Forth River have been protected by rocks, fill and soft protection measures, 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.

Erosion in the river mouth may be exacerbated by the flow of the Forth River, thereby affecting the river banks at an accelerated pace.

If nothing is done to manage the developing risks of erosion, dwellings between the foreshore and the esplanade, parts of the Council road (Esplanade) and eventually dwellings behind the road will be eroded.

While erosion at Leith will progress due to sea level rise, the impacts are likely to be small and no residential properties are expected to be at risk at least until 2050.

6.2 Options

The causes and factors contributing to erosion at Turners Beach and the area at the corner of the Esplanade and Boyes Road specifically are not yet fully understood. Therefore, suggested options may not be effective and additional technical work would be required to ground truth both the effectiveness and likely costs of the 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 Turners Beach and Leith, there are options that are potentially relevant to the impacts identified:

- Beach nourishment / shingle recharge or recycling if a source of shingle 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 these options are provided in the Coastal Adaptations report. Short descriptions are provided below.

Shingle recharge or recycling

Beach nourishment can build up the bulk and height of the beach, replacing sand or shingle 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 material into the local sediment budget for the beach. The availability of a suitable source for material would need to be investigated and is critically important for this to be practical.

Beach nourishment generally has the advantage of having limited adverse 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.

An important part of the beach in the study area consists of shingle, periodically topped with sand. Shingle recharge replaces the amount of shingle lost to erosion mostly after storm events with shingle from another source. Shingle recycling specifically refers to removing shingle from points on a beach where it is building up and moving it to parts where it has eroded away.

In the past, shingle has been removed in the ''Fish Pond''/Maskells Road area.The shoreline extending from the ''Fish Pond'' to Lillico straight is shingle and removing shingle from this area may have unwanted impacts as the area is sensitive to sediment movement. An alternative source would therefore be preferred.

Groynes, reefs and structures to reduce erosion

Groynes and offshore reefs are mostly applied to high value frontages influenced by strong long shore processes (wave induced or tidal currents) where nourishment or recycling are undertaken.

Groynes are best applied to shingle beaches or within estuaries. Groynes are especially applicable to exposed shorelines with a natural shingle upper beach. Groynes can also be useful in estuaries to deflect flows. The structural life for rock groynes is significant.

Groynes are applicable in combination with beach nourishment or shingle recharging/ recycling. Groynes encourage upper beach stability and reduce maintenance commitment for recycling or nourishment.

Groynes may disrupt natural processes and public access along the upper beach. It is likely to cause downdrift erosion if the beach is not managed.

The costs for groynes are typically between $200,000 and $500,000 per structure, plus recycling (various sources, 2013[29]).

Sea wall or revetments

A seawall is a massive structure that is designed primarily to resist wave action along high value coastal property. A revetment is a facing of erosion resistant material, such as stone or concrete that is built to protect a scarp, embankment or other shoreline feature against erosion. Revetments are used to increase the stability of eroding foreshores.

[29] Clarence City Council, Old Bar Council, Scottish Natural Heritage (2013), http://www.snh.org.uk/publications/on-line/heritagemanagement/erosion/appendix_1.12.shtml

As noted, there are already sections of the coast where rock revetments have been placed. The bluestone revetment wall has deteriorated somewhat and was put in place nine years earlier, which suggests something about the need for high standards of design and construction to ensure durability of this option.

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 erosive forces of waves and prevents further loss of shingle and 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 shingle or sand if there has been a period of accumulation since the wall was built. This may also be assisted by beach nourishment/shingle recharging.

Revetments can sustain considerable damage without totally failing, but take up more foreshore space than more vertical seawalls. Rock revetments can be suitable for high wave energy environments, but the potential for scouring in the upper reaches should be considered carefully. Revetments may provide more opportunities to create habitat for marine and coastal wildlife and vegetation than vertical sea walls. They cause less wave reflection than seawalls and survive storms for longer, but generally require regular maintenance to keep their structural integrity.

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 soft 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 are at risk of inundation from a current extreme event, future extreme events will affect more properties, due to sea level rise. Such events occur infrequently and the peak water level

usually lasts for only a few hours. River flooding events may last longer, up to several days. Levee banks can provide protection against such flood peaks.

A levee could be raised to the south of Lukin Street to prevent flooding in the residential area around Arcadia Avenue. The rail line and Blackburn Drive appear to be high enough to not overtop even during an extreme 1% AEP event by 2100. Possibly, structural reinforcement may be required to prevent the rail infrastructure from being undermined. In addition a one way flow device may be installed to improve drainage (Entura, 2013).

In the longer term, likely past 2050, a levee could be raised to protect properties from flooding from Claytons Rivulet at the western end of Turners Beach residential area.

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.

A guideline for construction cost is $1.46 (AUD) million per meter height per kilometre length (Vafeidis et al., 2008).

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 from high water tables that can reduce load bearing capacity and, if saline, affect services and structural integrity.

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, raising land level could be a requirement controlled by the planning scheme. Roads and services for the affected area would also have to be raised.

While raising land above the storm surge height can avoid inundation, it represents an 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 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 (higher than the enjoyed benefits or values). 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

In preparation for the Council and community consultation in November 2013, the following three adaptation pathways have been developed to explore the future for Turners Beach and Leith. Often adaptation is interpreted as retreat or protect. Also, adaptation may be incorrectly seen as a one-off task with the result being 'we have adapted'.

Adaptation however is a long term process that can follow various pathways. The pathways consist of various adaptation options that are mutually reinforcing and/or complementary to each other, and implemented as required over time. Some adaptation options may be implemented simultaneously, while other options may be implemented sequentially. The pathways primarily consider the timeframe to 2050 with only some reference to the longer term to 2100.

For Turners Beach and Leith three main pathways were identified in preparation for the consultation:

1. **Let nature take its course and retreat early.** 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. 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. **Protect existing development and permit new 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 pathways 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.**

This means firstly that properties and assets must be managed in a way that they are exposed to acceptable levels of risk over the asset's lifetime. For dwellings, infrastructure and services, it is generally accepted that these must be built and designed to withstand a once in a hundred year extreme (1% AEP) event.

Secondly, this means that those who benefit from adaptation works should also contribute to the costs in an equitable way. It also means that those who pay should have a say about adaptation options and pathways.

With climate change, it will be unsustainable to continue to subsidise people who choose to occupy or use hazardous locations in the medium to short term with hazards projected to increase in many ways in all parts of the country. Arguably, current property owners were not fully aware of the potential risks at the time they invested in the area, and some short term works may be provided to enable property owners, residents and operators to consider their future plans.

7.1 Pathway 1 Let nature take its course and retreat early

This pathway allows maximum freedom for natural coastal processes to unfold with a minimum of intervention or resistance from existing or new 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. Filling and raising land would generally not be allowed, nor would hardening shorelines with rocks or concrete or even dune or beach nourishment.

How might things proceed with this pathway?

With nature taking its course, Turners Beach erosion is expected to proceed, with some cycles of rebuilding but a long term recession of perhaps 23 to 49 metres from the current High Water Mark by 2050 and 50 to 83 metres by 2100. About 34 residential properties might be at risk of loss by erosion from an extreme storm by 2050, currently valued at $17 million. Most dwellings are in Turners Beach between the foreshore and the Esplanade. The site where the caravan park currently is would also be at risk from erosion. There has been a proposal to develop the caravan park into a residential area. Under this pathway, further subdivision and development would not be permitted in hazard zones.

Residential properties along Arcadia Avenue and adjacent to the area between the southern end of Lukin Street and Boyes Street would be susceptible to flooding, initially mostly of below floor level flood depths. From 2050 onwards, private property protection works could enable residents to continue to live there while managing risks to an acceptable level. Road access to some properties along Arcadia St would be lost during an extreme event.

Flooding near Claytons Rivulet is not expected to affect residential properties by 2050 (slr 0.2 m) but is expected to affect them by 2100 (slr 0.8 m). 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 the need to abandon.

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.

Increasingly, saline ground water would lead to a change in vegetation. The area between the southern end of Lukin Street and Boyes Street would become a saltmarsh. Non-salt tolerant terrestrial plants, including many trees and shrubs, would become stressed and woodlands over parts of the township would die off and be replaced by more salt tolerant species.

The rural land south of the Bass Hwy and the strawberry farm would become increasingly wet and are likely to turn into wetlands by 2050. The waste water pond is expected to withstand a 1% AEP extreme

event without overtopping by 2050, but towards 2100 the facility would need to be removed in order to manage risks to an acceptable level.

The Maskell Land industrial estate is not within the hazard zone for sea level rise and erosion, and storm water drainage works would be allowed to prevent future drainage issues.

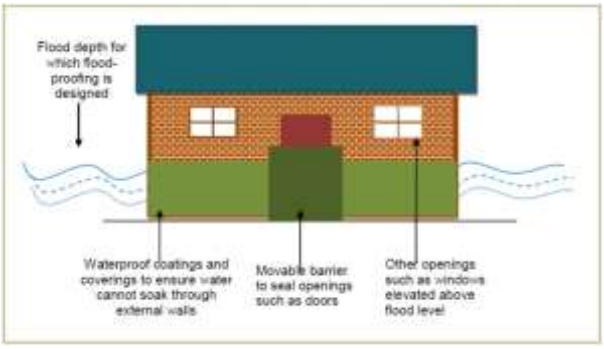
Leith would see increasing parts of its coastline subject to extreme storm events and erosion. Private properties are not expected to be affected and the shoreline can freely move landwards to 2050 and 2100.

This plan would likely see most of the study area still occupied to 2100, with some areas required to commence retreating from about 2050 onwards.

Likely options within this pathway

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 develop and move shoreward



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

Dune vegetation protection

Action plan and indicative costing

Actions: 0-10 Year Timeframe (indicative cost $ 8,000 per year excl. infrastructure upgrades)

No	Option	Responsibility	Cost
1	Monitor rate of erosion and storm bite events	C	$ 30,000
2	Planning scheme amendment to restrict development, filling and subdivision	C/State	Nominal
3	'Soft' dune protection works (vegetation and access pathways)	C/residents	$ 50,000
4	Emergency management plans	State/C	Nominal
5	Advice to property owners on individual risk management measures	State/C	Nominal
6	Repair and modification of infrastructure after any flood, erosion event as required to maintain agreed service levels	State/C	Increasing over time

Actions: 10-40 Year Timeframe (indicative cost $ 37,000 per year excl. infrastructure upgrades)

No	Option	Responsibility	Cost
1	Monitor rate of erosion and storm bite events	C	$ 90,000
2	Emergency management plans update and review	State/C	Nominal
3	Advice to property owners on individual risk management measures	State/C	Nominal
4	Repair and modification of infrastructure after any flood, erosion event as required to maintain agreed service levels	State/C	Increasing over time
5	Disaster relief after major flood/erosion event and assistance to re-establish elsewhere	Federal/State	Increasing over time
6	Private, individual action to reduce flood damage risks	Property owners	$ 340,000
7	Requirements to remove uninhabitable dwellings; rehabilitation of abandoned blocks	C/property owners	$ 680,000
8	Allow wetland to develop	C	Nominal

7.2 Pathway 2 Protect existing development as long as practical while protecting natural community values

This pathway protects property but only where that protection has a minimal impact on the values of the area important to the community, such as the beach and the dunes. 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 develop and 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 potentially 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 generally sea walls that threaten beaches).

How might things proceed with this pathway?

Beach nourishment or shingle recharging could reinforce Turners Beach. The introduction of sediment management structures, such as groynes or offshore reefs, is likely to be necessary to retain shingle and reduce recurrent recharge costs. The frequency of recharging or renourishment depends on the effectiveness of the structures and the storm conditions experienced. Groynes would be more visually intrusive than an underwater offshore reef. An underwater offshore reef may have the effect of building a bar between the current shoreline and the reef, either permanent or transient, and 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 nourishment were to use shingle from outside the coastal system (that is, well offshore or land based sources), the added shingle 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 shingle from the source.

Eventually, recharging and sediment management structures may become impractical due to cost and frequency, inadequate supplies of material, environmental or other impacts of supplying shingle 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. The beach and dunes would be retained as they migrate landwards.

Soft revetments as currently in place at the mouth of Forth River near the corner of the Esplanade and Boyes Road will protect the road and dwellings until the frequency of works and related costs become impractical.

Inundation risks of existing dwellings would be managed by raising Arcadia Ave. and the corner of Boyes St and Arcadia Ave. to act as a protective wall against extreme storm surges from the Forth estuary.

This work would be done in conjunction with normal renewal cycles for these roads. Improved drainage with wider channels would deal with rainfall during storm surge events near Maskells Rd and in Turners Beach. Low lying properties would still need flood protection measures (eg flood skirts), and emergency planning until these measures were in place. Filling low lying land would be encouraged in presently developed areas behind the road barriers except the identified drainage lines. 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.

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.

The area between the southern end of Lukin Street and Boyes Street and undeveloped land around Claytons Rivulet would be allowed to become a wetland area. The rural land south of the Bass Hwy would over time become wetter. Improved drainage canals are likely to allow the land to be used for agricultural purposes for a few more decades. Eventually the land would turn into wetland.

Leith would see increasing parts of its coastline subject to extreme storm events and erosion. Private properties are not expected to be affected and the shoreline can freely move landwards to 2100.

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.

Likely options within this pathway

Beach nourishment

Groynes

Action plan and indicative costing

Actions: 0-10 Year Timeframe (indicative cost $ 56,000 per year excl. infrastructure upgrades)

No	Option	Responsibility	Cost
1	Monitor rate of erosion and storm bite events	C	$ 15,000
2	Planning scheme amendment controlling filling so it does not adversely affect drainage or adjacent properties	C/State	Nominal
3	Emergency management plans	State/C	Nominal
4	Advice to property owners on individual risk management measures	State/C	Nominal
5	Repair and modification of infrastructure after any flood, erosion event as required to maintain agreed service levels	State/C	Increasing over time
6	Beach nourishment / shingle recharge (Claytons Rivulet to Forth River)	C/property owners	$ 500,000
7	Groyne or underwater reef design work	C/property owners	$ 15,000
8	Implementation of soft temporary sediment management structures	C/property owners	$ 30,000

Actions: 10-40 Year Timeframe (indicative cost $ 73,000 per year excl. infrastructure upgrades)

No	Option	Responsibility	Cost
1	Monitor rate of erosion and storm bite events	C	$ 45,000
2	Emergency management plans - update and review	State/C	Nominal
3	Advice to property owners on individual risk management measures	State/C	Nominal
4	Repair and modification of infrastructure after flood, erosion event as required to maintain service levels	State/C	Increasing over time
5	Periodic beach nourishment / shingle recharge	C/property owners	$ 1,500,000
6	Implementation and maintenance of hard sediment management structures	C/property owners	$ 350,000
7	Private, individual action to reduce flood damage risks	property owners	$ 20,000
8	Soft revetments	C/property owners	$ 100,000
9	Raising roads (Arcadia Av and Boyes St)	C/property owners	$ 160,000
10	Filling of residential properties (re- and new development)	property owners	$ 20,000

7.3 Pathway 3 Protect existing development and permit new development to the maximum possible extent for as long as possible

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 proceed with this pathway?

Sediment trapping structures (eg groynes, artificial reef) combined with shingle recharging can manage erosion risks on Turners Beach potentially for many decades. Assisting structures with recharging may eventually become impractical due to cost, inadequate supplies of shingle, 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 shingle recharging 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 and dunes entirely.

Hardening of the shore would protect the community from shoreline erosion and recession for a long time (but not indefinitely). A sea wall would reduce the need for individual properties to address erosion hazards. Some may value security with a promenade and a view as highly, or more highly, than a beach. The costs of a sea wall, to be borne by those who benefit from it, are substantial and may be beyond the carrying capacity of the existing community. Significant intensification of development would be a means to generate sufficient ability to pay.

Hardening the foreshore is likely to be required at the corner of the Esplanade and Boyes Street and along the Forth river mouth before 2050. More extensive hardening along the foreshore would be required from around 2050 and 2100.

Inundation risks of the residential area near Claytons Rivulet would be managed by a levee to act as a protective wall against flooding during extreme storm surges. Stormwater drainage within the residential area would need to be managed by allowing for drainage canals and possibly a retention pond to be used during extreme storm events when drainage into the sea is not possible.

Inundation risks from the Forth estuary via the natural inlet south of the end of Lukin Street would be managed by a levee and controlled stormwater outfall off the end of Lukin Street, around the park adjoining to the raised rail line. Where necessary, the raised rail line would need to be reinforced to prevent undermining and ensure it acts as a protection wall for the residential area. This would protect the Arcadia Av and surrounding residential area from flood risks. Storm water drainage canals and retention ponds would manage drainage during extreme storms. These protection works are likely to be required after 2050. The main stormwater drain pipe goes along Arcadia Av. Design of storm water drainage would need to consider levels and capacities.

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. Land filling would be encouraged in all areas behind road barriers and levees except 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. The existing minimum lot size is 650 sqm, which according this pathway may need to be reconsidered to allow for increased development to ensure affordability of the protection works required.

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 residential areas and some other intensified areas to continue to be occupied for this century or longer. In the longer term, if sea levels rise by 2, 3 or more metres, the protection works along Turners 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.

The existing levee around most of the rural land south of the Bass Hwy and the strawberry farm would need reinforcement within the short term to reduce the frequency of river and storm surge flooding to allow for continued agricultural use. To cover or distribute the cost burden, some of the land close to Turners Beach Rd and possibly the strawberry farm could be filled and allowed for higher value uses such as industrial, rural residential and residential subdivision. This land currently acts as a buffer between the Bass Hwy and Turners Beach.

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.

The costs of this pathway are likely to increase significantly from 2050 onwards, requiring foreshores to be hardened along the entire Turners Beach foreshore.

Likely options within this pathway

Dyke with coastal road, Holland

Sea wall (Sandy Bay)

Houses elevated and designed for water levels

Fill to raise land levels

Action plan and broad costing

Actions: 0-10 Year Timeframe (indicative cost $ 72,000 per year excl. infrastructure upgrades)

No	Option	Responsibility	Cost
1	Monitor rate of erosion and storm bite events	C	$ 15,000
2	Planning scheme amendment to control filling for land at risk of inundation in a way it does not adversely affect drainage or adjacent properties.	C/State	Nominal
3	Emergency management plans	State/C	Nominal
4	Advice to property owners on individual risk management measures	State/C	Nominal
5	Repair and modification of infrastructure after any flood, erosion event as required to maintain agreed service levels	State/C	Increasing over time
6	Beach nourishment / shingle recharge (Claytons Rivulet to Forth River)	C/property owners	$ 500,000
7	Groyne or underwater reef design work	C/property owners	$ 15,000
8	Implementation of soft temporary sediment management structures	C/property owners	$ 30,000
9	Raising roads (Arcadia Ave. and Boyes St)	C/property owners	$ 160,000

Actions: 10-40 Year Timeframe (indicative cost $ 108,000 per year excl. infrastructure upgrades)

No	Option	Responsibility	Cost
1	Monitor rate of erosion and storm bite events	C	$ 45,000
2	Emergency management plans - update and review	State/C	Nominal
3	Repair and modification of infrastructure after any flood, erosion event as required to maintain agreed service levels	State/C	Increasing over time
4	Periodic beach nourishment / shingle recharge	C/property owners	$ 1,500,000
5	Implementation and maintenance of hard sediment management structures	C/property owners	$ 175,000
6	Hardening of foreshore, revetment wall at Esplanade/Boyes Rd	C/property owners	$ 1,500,000
7	Filling of residential properties (re- and new development)	property owners	$ 20,000

The levee and stormwater outlet at Lukin St is expected to be required after 2050, which is beyond the timeline considered in the above cost estimates. It is worth noting that the costs of such a levee (assuming 150 metres length, 3 metres high) could be between $600,000 and $800,000.

7.4 Community workshops

Three adaptation pathways were explored by community members from the Turners beach and Leith community at workshops held on Saturday 30 November 2013 with sessions held in the morning and the afternoon. A total of approximately 62 people attended the workshops (mostly community members and approximately seven Council staff and Elected Members) and most attendees participated throughout the day.

The community workshops started with an informative section presenting the project findings, responding to questions and explaining the remainder of the day which included two rounds of workshop sessions.

Each participant was given the opportunity to attend two workshops, one in the morning and one in the afternoon. Three sessions, each exploring one adaptation pathway, were run simultaneously in the morning and in the afternoon.

The three pathways were:

1. **Let nature take its course and retreat early.** 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. 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. **Protect existing development and permit new 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.

All participants were informed that the pathways 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. All pathways are based on two principles:

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

Each workshop session lasted up to two hours, enabling an in-depth investigation of the pathway. At the start of each session the participants were asked to read the flyer explaining the pathway, the types of adaptation options likely to be adopted and how things may be different with that pathway. After that the workshop moderator summarised the pathway and answered any questions before starting to explore the pathway.

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

After exploring these questions participants were asked what pathway they think is a realistic option for the Turners Beach and Leith study area.

7.5 Workshops summary and preferred pathway

The community members clearly expressed that they like where they live and that the beach, the community and the natural values are important reasons for the area's attractiveness.

A majority of the participants of the workshops expressed a preference for adaptation pathway 2. Approximately 80% to 90% of the participants of the pathway 2 sessions expressed a preference for this pathway, while similar views were expressed during the pathway 1 and 3 sessions. Key strengths of this pathway according to the community members are:

- It addresses current day erosion issues, especially at the 'erosion hotspot' at the Turners Beach foreshore and the mouth of the Forth River, (re-)establishing sediment management structures such as groynes.
- It protects financially vested interests as it maintains community values while, at least for the medium term, protecting private properties as well. Natural values are also reasonably well off (at least compared to pathway 3).
- It buys the community some time to prepare and plan for adaptation in the longer term. It also provides the flexibility to later on 'upgrade' to pathway 3 if that is what the future community prefers.

It was generally seen as a doable and middle of the road approach. It was also mentioned that maybe the risk of catastrophic failure would be less compared to both pathways 1 and 3.

Negative aspects of pathway 2, as raised by the community members, included impacts on the visual amenity and natural values compared to present day[30] and pathway 1, possibly impacting on tourism and recreation as well. As time goes by and with sea levels continuing to rise, this pathway would still result in the need retreat in the long term, or to 'upgrade' to pathway 3, and as such may represent a waste of costs on temporary measures.

Pathway 1 was generally seen as a pathway that is possibly most cost-effective, while at the same time community members were of the view that some form of compensation would be justified for those property owners having to retreat, irrespective of the principle not subsidise people to occupy hazardous locations. Key benefits of this pathway are that the natural character of the beach was retained while natural values would be allowed to move landward. Important negatives for this pathway as raised by the community members include that pathway 1 would result in falling property prices, increase of socio-economic issues, loss of property, loss of community values and gradual loss of infrastructure and services to the area.

The most important benefit of pathway 3 is that it protects private properties and infrastructure, and more security to residents. Protection would concentrate development in this area without the need to develop other areas. Important issues with pathway 3 include the loss of the character of the area both in terms of natural values (loss of the beach) and in terms of the community, as this pathway would require intensification of development and would attract households who can afford to contribute to the high costs of protection. At the same time, property owners with low incomes (but capital rich) would be forced to leave the area. There was a significant view that pathway 3 was an extension of pathway 2, and that the community could make up its mind later.

[30] Note however, that the 'present day' without doing anything to manage the risks is not an option

7.6 How to make it work? Community perspective

The community members agreed that residents and decision makers need to start planning for adaptation now and to manage the risks.

Community education and consultation
It was generally agreed there was a need to inform and educate the community about climate change, how it may affect their community and the need to manage the risks.

Decision making and funding for adaptation
The community members expressed the view that there should be coordination between layers of government (local, State and Federal) and the property and land owners. Council was the generally accepted party to provide this coordination.

Decision making would need to occur in consultation with the property owners, as they are also expected to contribute to the costs of adaptation. Decision making would need to be informed by results from monitoring and review of coastal risks over time and to agree on certain trigger points to implement options. This should all be encapsulated in a long term strategic adaptation plan. Such a plan would need to include indicative timelines and more detailed costings[31]. There was recognition that it could be costly to select the best technical options and be confident enough that it would work, not fail and not have adverse effects.

The community members wondered if there would be a basis for compensation for property loss in the long term (when pathway 2 results in retreat). In the long term this would not be the case on the basis of the principles of managing risks and no subsidies for occupying hazardous locations.

Beneficiary pays
It was generally accepted that subsidies should be avoided in the longer term, but only once everyone knows about the risks and obligations to fund protection. Some level of support was fair for existing residents who were not aware of the risks. It was also agreed that the costs need to reflect the benefits (such as protection) and that the wider community should contribute to the costs resulting in wider community benefits.

[31] This requires more detailed research into adaptation options and the feasibility and costs within the specific situation in the study area.

8 WHERE TO FROM HERE?

This section provides overall conclusions on the project, the assessments, and the stakeholder consultation findings. In broad terms it provides direction to the way forward. 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 other case study areas too (both the first TCAP and the TCAP Extension project of which Somerset is part of). 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.

Community and Council engagement

The community members indicated Council would be the most appropriate body to coordinate planning and decision making for adaptation in the study area..

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 Turners Beach/Leith, or any other community in Tasmania facing similar issues.

At present the State does not provide a framework to 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.

Local leadership and a coordinated approach

Council is probably best positioned to take a leadership role in driving a coordinated approach to adaptation. This means Council would be best positioned to set up and drive a local adaptation management plan. In taking such a role, it is important that Council adheres to and clearly communicates two core principles for sustainable adaptation:

1. Developing risks will be actively managed
2. People/parties cannot be subsidised to occupy or use hazardous locations

Thus, there is a clear distinction between taking on responsibility for coordinating, implementing and administering an adaptation management plan (Council's role) and responsibility to protect private property and pay for adaptation (not Council's role). Council should work together with the community and support them so they can adapt over time.

It is further important for Council to engage, in addition to the community and local stakeholders, with regional and State agencies and other relevant stakeholders.

Recommendation: For Council to take a local leadership role in coordinating and administering adaptation management in the study area, and to consistently communicate and consult with the community and relevant stakeholders.

Longer term strategic planning and monitoring

The hazards from inundation and potential erosion have been documented by the project for present day and for sea level rise of 0.2 and 0.8m. However, the projected impacts of erosion are still fairly uncertain and depend on detailed (geomorphological) studies of specific locations (especially around the slsc) and impacts of the Forth River.

This work would also inform decision making on (the feasibility) of any adaptation options such as beach nourishment and groynes or other sediment trapping options. The community expressed a strong desire to retain the beach and natural amenities in the area.

To minimise future exposure to risk, especially if pathway 1 or even 2 is adopted, future new development in areas at considerable risk would need to be minimised and be allowed only if certain criteria are met.

Recommendation: Ensure a framework is adopted to ensure appropriate research is done to make decisions on the basis of evidence.

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.

Appendix 1 Planning Codes

Clause E3 Change in Existing or Natural Ground Level Code

The purpose of this provision is to minimise impact of change in existing or natural ground level.

Development Standards for the Change in Existing or Natural Ground Level Code are provided in Clause 3.6.

Objective: Change in the existing ground level or the natural ground level by cut or fill are to minimise likely adverse impact on the physical, environmental, cultural, and amenity features of land or for inconvenience or risk to adjacent land.	
Acceptable Solution	Performance Criteria
A1 Cut or fill must – a) not be on land within an area of likely risk from a landslide hazard;	P1 Cut or fill must - b) be assessed in accordance with Code E6 as being unlikely to trigger, spread, or intensify risk of landslide.

Clause E6 Hazard Management Code

The purpose of this provision is to –

a) identify likely areas of risk for use or development on land exposed to natural or environmental hazard;
b) minimise likely social, economic, and environmental costs associated with exposure of use or development to an unacceptable level of risk from a natural or environmental hazard;
c) minimise likelihood for use or development to trigger, spread, or intensify a natural or environmental hazard;
d) apply controls to manage likely risk that are proportional to the type, intensity, and anticipated life of use or development

This Code applies for use or development on land in an area exposed to likely risk from a natural or environmental hazard because of –

a) coastal inundation and erosion by sea level rise or storm surge[32] if –
   i. shown on the planning scheme map;
   ii. (if no area is shown on the planning scheme map) land within landforms defined as vulnerable to erosion or regression in Indicative Mapping of Tasmania Coastal Vulnerability to Climate Change and sea Level Rise (Sharples 2006); or
   iii. below 5.0m AHD; or
   iv. Shown on the Coastal Inundation Map prepared for the Tasmanian Planning Commission 2011.
c) Flooding[33] from a watercourse, wetland or stormwater disposal system if –
   i. shown on the planning scheme map; or

[32] TPC has advised it is to initiate preparation of a mandatory common provision by a Code for coastal flooding and erosion
[33] Draft Planning Directive – Statewide Codes – *Flood Prone Land Code* (2011) awaiting panel decision and Ministerial approval

land within the overland flow path for the 1% annual exceedance probability flood in a watercourse, wetland or stormwater disposal system

d) landslide[34] shown on the Landslide Hazard Map prepared by the Department of Premier and Cabinet

A definition of terms is provided in Clause 6.3, including definitions for "critical use", "hazard risk assessment", and the difference between high, medium, low and acceptable levels of likely risk. The full definition of terms can be found in the appendix of this document.

Use Standards for the Hazard management Code are provided in Clause 6.5.

Objective: The level of likely risk from exposure to a natural or environmental hazard is to be tolerable for the type, scale, and intensity of each use	
Acceptable Solution	Performance Criteria
A1 a) The site must be within an area for which there is an acceptable level of risk; or b) The use must not be a critical use, vulnerable use or hazardous use on land within an area exposed to a level of likely risk that is not an acceptable level of risk unless a hazard risk assessment indicates there is an insufficient increase in the level of risk to warrant any specific hazard reduction or protection measures	P1 a) There must be a hazard risk assessment if - i. critical use, vulnerable use or hazardous use on a site within an area exposed to a low level of likely risk; or ii. any use on a site within an area exposed to a medium level of likely risk or an area exposed to a high level of likely risk; and b) The hazard risk assessment must indicate – i. there is an insufficient increase in the level of risk to warrant any specific hazard reduction or protection measures; or ii. a hazard management plan to demonstrate a tolerable level of risk can be achieved and maintained for the type, scale and intensity of the development; and c. If the hazard management plan involves land external to the site, the consent in writing of the owner of that land must be provided to enter into a Part 5 agreement to be registered on the title of the land and providing for the affected land to be managed in accordance with the hazard management plan b) There must be – i. an overriding benefit to the community; and ii. no suitable alternate site; if - i. critical use on a site within an area exposed to a medium level of likely risk or a high level of likely risk; or ii. vulnerable use or hazardous use on a site within an area exposed to a high level of likely risk

Use Standards for the Hazard management Code are provided in Clause 6.6.

Objective: The level of likely risk from exposure to a natural or environmental hazard is to be tolerable for the type, scale, and intensity of each development	
Acceptable Solution	Performance Criteria
A1	P1

[34] Draft Planning Directive – Statewide Codes –*Landslide Code* (2011) awaiting panel decision and Ministerial approval

a) The site must be within an area for which there is an acceptable level of risk; or b) If the site is within an area exposed to a low level of likely risk development must – i. be an alteration or addition to an existing building or a minor building, structure, or work; ii. be infill or redevelopment; or iii. be subdivision to create not more than 3 new lots by infill within an area of established use; or c) A hazard risk assessment must indicate there is an insufficient increase in the level of risk to warrant any specific hazard reduction or protection measures	a) A hazard risk assessment must indicate a hazard management plan to demonstrate a tolerable level of risk can be achieved and maintained for the type, scale and intensity of the development if the site is within - i. an area exposed to a low level of likely risk and development is for – a. a critical use, a vulnerable use or a hazardous use; b. a new building, structure or work; c. subdivision to create 3 or more new lots; d. subdivision to extend an existing highway; or ii. an area exposed to a medium level of likely risk and development is for - a. alteration or addition to an existing building or a minor building, structure, or work; b. infill or redevelopment for a purpose permitted within an area of established use; or c. subdivision to create not more than 3 new lots by infill within an area of established use; d. subdivision to extend an existing highway; e. a critical use, a vulnerable use or hazardous use; or iii. any development on a site within an area exposed to a high level of likely risk; and b) if the hazard management plan involves land external to the site, the consent in writing of the owner of that land to enter into a Part 5 agreement to be registered on the title of the land and providing for the affected land to be managed in accordance with the hazard management plan

Clause E12 Water and Waterways Code

The purpose of this provision is to assist protection and conservation of a water body, watercourse, wetland or coastal shoreline area for –

a) ecosystem diversity and habitat value of native flora and fauna;
b) hydraulic capacity for water quality, yield, water table retention, flood flow, and waste water assimilation;
c) economic and utility importance to primary industry, settlement, industrial, irrigation and energy generation purposes;
d) aesthetic and recreational use

Development Standards for the Water and Waterways Code are provided in Clause 12.6.

Proximity to a water body, watercourse or wetland [35]

[35] Clause 6 removes the exemption for operation of the planning scheme for use or development on land within 30m of a watercourse or wetland. In the event use or development occurs within 30m of a watercourse or wetland the use or development is prohibited unless the planning scheme includes provisions for assessment.

Objective: Development within or adjacent to a water body, water course or wetland is to have minimum impact on a) the ecological, economic, recreational, cultural significance, water quality, and physical characteristic of a water body, watercourse or wetland; b) the hydraulic capacity and quality of a water body, watercourse or wetland for ecological viability, water supply, flood mitigation, and filtration of pollutants, nutrients and sediments; c) function and capacity of a water body, watercourse or wetland for recreation activity; and d) aesthetic features of a water body, watercourse or wetland in the landscape	
Acceptable Solution	Performance Criteria
A1 Development must not – a) occur within 30m of the shoreline of a water body, watercourse or wetland; or b) involve any use or development partly or wholly in, over, on or under the water body, watercourse or wetland	P1 The nature, scale, and intensity of development within 30m of the shoreline of a water body, watercourse or wetland; or partly or wholly in, over, on or under a water body, watercourse or wetland must – a) include adequacy and appropriate measures to minimise or manage risk to the function and values of a water body watercourse or wetland[36], including for – iv. disturbance and change in natural ground level, including by cut or fill; ix. modification of a natural drainage channel xi. level of likely risk from exposure to natural hazards of flooding and inundation; and xii. community risk and public safety

Development in a seashore area

Objective: The coastal zone and sea-shore are protected against likely adverse impact on economic, ecological, scenic, cultural, and recreation values and processes of the coast while facilitating use dependent for operational efficiency on a coastal location.	
Acceptable Solution	Performance Criteria
A1 Development must be – b) an existing building or work wholly or partly in the sea-shore area; i. risk management, emergency or rescue purposes; or ii. public access and recreation	P1 Development must: h) not have immediate or cumulative adverse effect for – i. tidal, wave, current, or sediment movement processes; ii. coastal landforms, seabed, and other geomorphic features, including sand dunes and mobile landforms; iv. drainage from a water course, wetland, ground water, flood, stormwater, or tidal water; viii. exposure to or increased risk from a natural hazard, including sea level rise, storm surge, or inundation as a result of climate change; ix. coastal protection and rehabilitation works required to address erosion, instability, regression, or inundation; x. collection, treatment, and disposal of waste, including bilge waters and excavated or dredged sediment; xii. public safety and emergency services;

[36] Regard is to be had to the level of compliance to the methodologies and recommendations of the current edition of Wetlands and Waterways Works Manual DPIPWE 2003;

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