



**University of South Australia**

**School of Natural and Built Environments**

**Institute for Urban Renewal**

## **Coastal Settlements Adaptation Study-**

## **Thompson Beach**

### **Framework Report**

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## GLOSSARY

### ADAPTATION

Adaptations are actions taken to help communities and ecosystems cope with actual or expected changes in climate conditions.

### AHD

AHD is an acronym for Australian Height Datum. When a measurement is accompanied with the letters AHD it indicates a height above mean sea level. Mean sea level was adopted in 1971 by the National Mapping Council of Australia at 0.00 AHD. For example, 3.2m AHD is 3.2 metres above mean sea level. AHD tide levels are different to the fishing charts which are called Chart Datum (CD). A subtraction of 1.45 metres from tide chart will give the correct AHD height.

### ARI

ARI is an acronym for Average Return Interval. ARIs, also known as return periods, are an estimate of the average interval of time between events of a certain magnitude. In relation to severe storm events the longer the interval the higher the storm surge height is predicted to be. For example, a 1 in 100 year ARI storm surge would be higher than a 1 in 50 year or 1 in 10 year ARI storm surge height. It is important to remember that this is just a statistical calculation and represents the long term theoretical average; there is nothing preventing a 1 in 100 year ARI flood happening twice in one week.

### DEM

DEM is an acronym for Digital Elevation Model. The digital elevation model used in this study was created from a aircraft that bounced millions of infra-red light beams to the ground and then created a digital topographical map. This digital map is combined with aerial photography and an operator can use a computer to check the height of land features.

### EROSION

Erosion is where action of the sea moves sand and vegetation from the shoreline so that the dune system is weakened. When the frontal dune system is significantly weakened it may completely erode away and the shoreline moves inland.

### STORM SURGE

A rise in the water level along the coast due to the action of the wind alone or its combination with the reduction of atmospheric pressure accompanying it. The effects of a storm surge are more severe when it occurs in conjunction with high tide.

# Introduction

## 1.1 Background

In May 2013 the District Council of Mallala (DC Mallala) commissioned the University of South Australia, School of Natural & Built Environments (UniSA) to undertake the Coastal Settlements Adaptation Study (CSAS). The aim of the study is to identify and evaluate potential sea level rise adaptation strategies for the coastal settlements of Parham, Webb Beach, Thompson Beach and Middle Beach.

## 1.2 Investigative framework

This study uses an adaptation of the Coastal Adaptation Pathways Decision Map developed by the Local Government Association of SA and University of South Australia for the Department of Climate Change and Energy Efficiency (Balston et al, 2012) to identify and analyse the threats posed by sea level rise. Each settlement is reviewed within the following framework:

1. Establish settlement history.
2. Analyse existing sea-flood protection.
3. Analyse impact of sea-flood scenarios.
4. Analyse emergency access and egress.
5. Establish profile of the assets at risk.
6. Explore liability issues.
7. Propose adaptation options.

## 1.3 The stages of the study

The study is conducted in three main stages:

### Stage 1: State of Play Report:

The *State of Play Report* contains the findings from steps 1-6 from the investigative framework and was endorsed by the Council at its Ordinary Meeting on 25 November 2013.

### Stage 2: Community Consultation:

Subsequent to completion of the draft *State of Play Report* the community was invited to contribute to the report at a public meeting at the Dublin Hotel on 10 September 2013 or in writing to DC Mallala. The findings from community consultation were integrated into the *State of Play Report* and the report was endorsed by the Council at its Ordinary Meeting on 28 October 2013.

### Stage 3: Propose adaptation options:

Taking into account the findings of the first two stages, this report represents Step 7 of the Investigative Framework - 'propose adaptation options'. These adaptation options are proposed within the following five categories of adaptation responses:

- **Protect:** use means such as construction of sea walls and levees, beach sand replenishment or installation of drainage swales to protect existing development;
- **Accommodate<sup>1</sup>:** use means such as raising buildings, protecting buildings from flooding, or employ warning and evacuation strategies;
- **Retreat:** abandon settlements and move development inland in the face of rising sea levels. The concept of 'retreat' is also known as 'planned retreat'.
- **Defer:** threats have been assessed and options analysed but there are valid reasons to wait until to a later date to act.
- **Do nothing:** ignore the risks and do nothing.

## 1.4 Reporting and consultation

While the scope of the Coastal Settlements Adaptation Study (CSAS) covers the four settlements of Parham, Webb Beach, Thompson Beach and Middle Beach, adaptation responses options available to each settlement are reported separately. This report contains the adaptation options for:

### Thompson Beach.

In preparing the adaptation options in this report the following agencies and individuals were consulted:

- DC Mallala Infrastructure Services Department, on 7<sup>th</sup> November, 2013.
- Coast Protection Branch, DEWNR, on 12<sup>th</sup> November, 2013.
- Geoff Fisher, Australian Water Environments (AWE), on 19<sup>th</sup> November, 2013. Geoff Fisher (AWE) also reviewed the adaptation proposals and offered technical advice.

## 1.5 Methodology

Adaptation responses in this study take into account: the nature of the threat, the protection of infrastructure, the safety of people, and the appropriate timing of response until 2100.

### 1.5.1 Adaptation responses that relate to the nature of the threat.

Other than depth of water, additional factors that influence the impact of a flood on a settlement are: the velocity of the water (speed), the duration of the flood (how long it lasts), and the topography of the settlement. How much warning is possible for possible flood is a factor that enables the settlement to prepare for the flood more effectively. The general characteristics of a sea-flood in the Mallala region are shown in **Table 1**.

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<sup>1</sup> Protection options in this study relate to the community as a whole and are generally measures that are taken to stop the flow of water into the community at its borders as a first line of defence. Measures that a resident might take to protect the water from entering their own dwelling are classed as accommodation options. The exception to this rule is when dwellings are situated on the shoreline itself.

**Table 1: Sea flood characteristics for DC Mallala coastal region.**

Flood characteristic	Mallala region
Velocity of water	Low, due to tidal action and ocean terrain
Direction of flow	From the west
Duration of flood	Short 1-2 hours
Warning	Predictable as flood normally relates to tide.

To contextualise the flood risk in the Mallala region, **Table 2** illustrates how insurance companies may discount their flood risk when adequate flood warning can be provided and the community is prepared to deal with a flood. For example, where the community is experienced and there is a greater warning time than 12 hours, the predicted actual cost of damages can be discounted by 0.4 (Victorian Government, 2000).

**Table 2: Proposed ratios of actual:potential damages (Victorian Government, 2000)**

Warning time	Experienced community	Inexperienced community
Less than 2 hour	0.8	0.9
2 to 12 hours	Linear reduction from 0.8 at 2 hours to 0.4 at 12 hours	0.8
Greater than 12 hours	0.4	0.7

Historically, storm surges that have threatened settlements in the Mallala coastal region have been in conjunction with the highest astronomic tide (often referred to as a king tide) which, in the majority of cases, provide a greater than 12 hour warning period. Based on historical data, the flood threat is normally related to predictions of high tides, likely to be of low intensity in relation to velocity of water, and of short duration.

Finally, adaptation responses are proposed and analysed using the three 1 in 100 ARI scenarios provided in the *State of Play Report* (**Table 3**). These scenarios assist in providing the context from which to make decisions relating to the viability and the timing of responses.

**Table 3: Sea flood scenarios for DC Mallala coastal region.**

Flood	2013	2050	2100
Storm surge (at king tide)	2.6m	2.6m	2.6m
Wave set up	0.1m	0.1m	0.1m
Wave run up	0.0m	0.0m	0.0m
Sea level rise	0.1m	0.3m	1.0m
Totals	2.8m AHD	3.0m AHD	3.7m AHD

## 1.5.2 Adaptation responses that relate to infrastructure and people.

### Infrastructure

In proposing adaptation responses, Councils are required to take the long view. For example, a house constructed today is likely to have a life span of 60 to 80 years, so future

risks from actions of the sea are required to be taken into account in current planning policies. Councils are also required to adhere to Coast Protection Board policy and advice. Such policy includes being able to demonstrate that development is capable of being protected for the sea-flood risk for the 1 in 100 ARI event adopted for 2050, but also that reasonable steps can be taken to adapt the development to the sea-flood risk for the 1 in 100 ARI event adopted for 2100 (Coast Protection Board, 2004).

## People

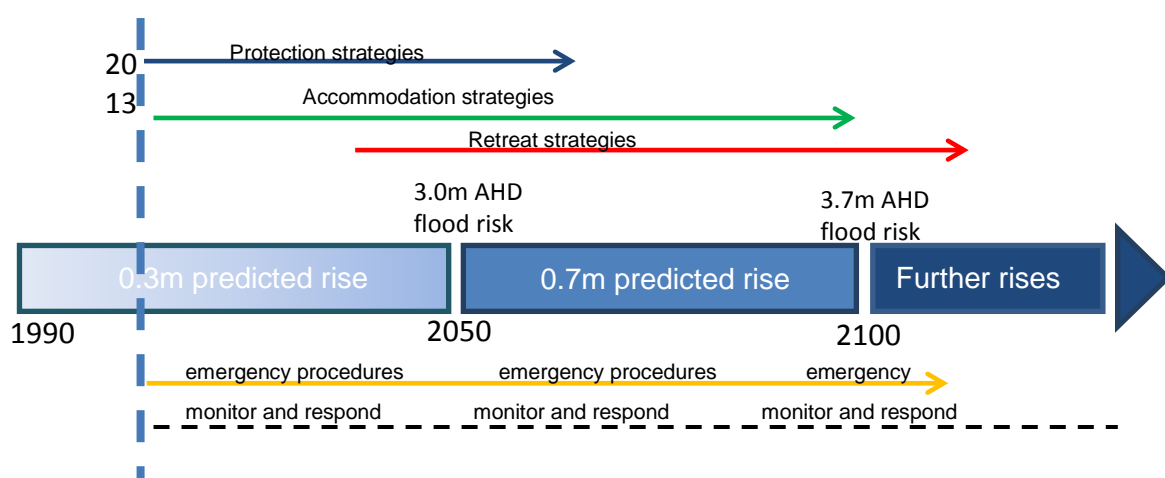
Adaptation responses are also required to take into account the safety of people in a flood event. These include warning and emergency procedures, the ability of people to be able to move safely away from the flood, and the ability of emergency vehicles and personnel to move into the settlement.

### 1.5.3 Adaptation responses that take into account time

The *State of Play Report* has analysed the possible impact of the three 1 in 100 ARI flood scenarios (2013, 2050, 2100) upon the settlements. It is proposed here to draw upon that data and deal with adaptation responses in the following order:

- What level of protection can be realistically provided (current threat, 2050 threat, 2100 threat)?
- Where protection falls short, what accommodation responses can be employed?
- Where protection and accommodation strategies fall short, what longer term retreat options should be employed (if any)?

Finally, responses canvassed within this report may be implemented over the coming decades but also may be contingent on each other. For example, a protection strategy employed now may mean that other accommodation strategies are not required until a later date. The limitation of a protection strategy may mean that accommodation or retreat strategies are required to cater for that shortfall later in the century (**Figure 1**).



**Figure 1: Adaptation responses are time related and sometimes contingent on each other but also contingent on the rate of sea level rise which is to be monitored over time (M. Western, 2013)**



## 2. Thompson Beach protection options

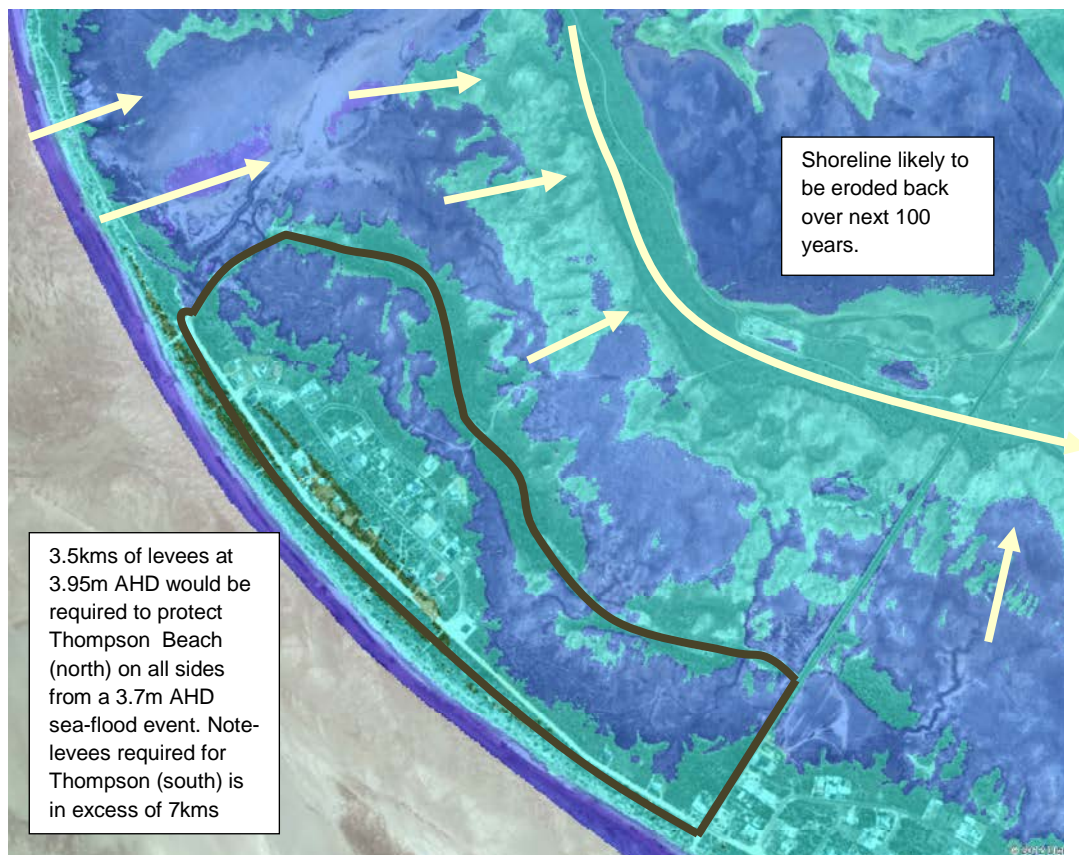
Note, any cost estimates provided below have been prepared based on very limited data and without engineering design calculations. They are therefore indicative only and have been prepared to assist council with the priority setting processes. They should not be relied on for budgeting or construction cost management purposes.

### 2.1 Protection options to cater for sea-flood risk at 2100 (3.7m AHD)

Should the 1 in 100 ARI sea-flood event of 3.7m AHD shown in **Figure 2** occur then:

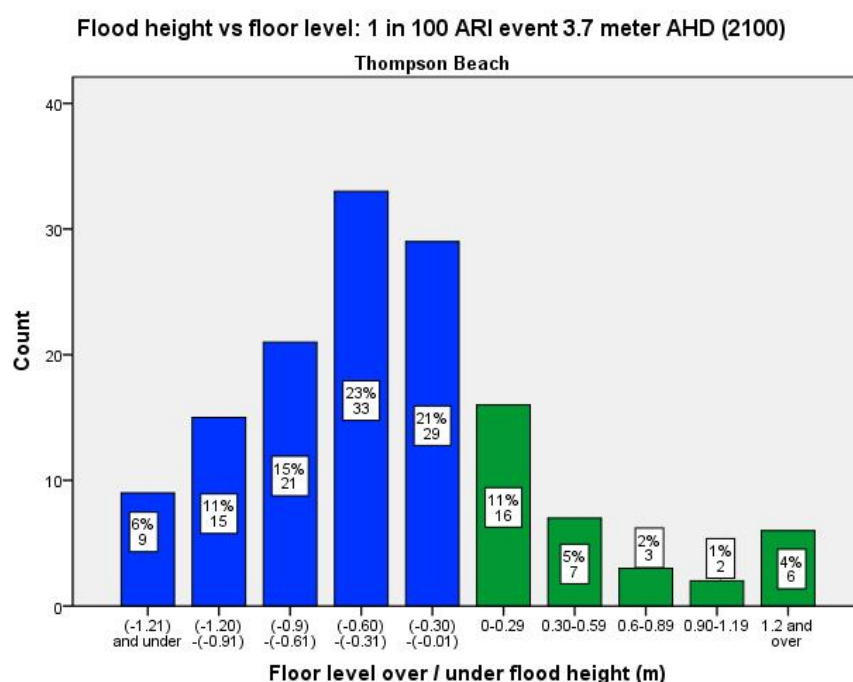
- The streets on the eastern side of Thompson (north) would be inundated to 1.0 m.
- The Esplanade Road in Thompson (south) would be inundated to 1.4m in places.
- Ruskin Road, the access road to Thompson Beach would be inundated to 1.0m.
- Most of the natural ground within the settlement would be inundated, with depths up to 1.4m

Further, should sea levels rise by 1.0m as predicted, the dunes north and south of Thompson Beach would likely erode away. This will occur due to two reason. First, the increase height of water would create new inlets that become wider over time until the frontal dune system eroded completely away. This is occurring already to the north of Thompson Beach (See **Figure 2**). Second, the increase height of water may increase the wave 'set up' and 'run up' (refer Table 3) thereby increasing the amount of erosion to the dunes (Geoff Fisher, AWE, 26.11.13).



**Figure 2: Thompson (north) map indicating sea-flood risk at 3.7m AHD and protection requirements at 3.95m**

To provide a contemporary context, if the existing dwellings in Thompson Beach were subject to 3.7m AHD inundation, 107 dwellings out of 141 total dwellings would have water over their floor levels (**Figure 3**).



**Figure 3: Flood height vs floor level: 1 in 100 ARI event 3.7m AHD (2100)**

While to implement protection levees as illustrated in **Figure 2** is possible in pure engineering terms, the erosion factor makes the proposal untenable as the dunes north and south of the settlement are likely to erode away, leaving the settlement as a promenade connected only by Ruskin Road and facing increased erosion of its defences as a result. Finally, if the sea level does increase as predicted, then there is nothing to suggest that it won't keep rising past 2100, thereby rendering the defences at 3.7m AHD ineffective.

### Conclusion:

To protect Thompson Beach with levees to cater for the 1 in 100 ARI event of 3.7m AHD is not viable and options that combine protection measures at lower heights combined with accommodation options should be considered in long term adaptation options for Thompson Beach.

## 2.2 Protection options to cater sea-flood risk at 2050 (3.0m AHD)

In contrast to the 2100 flood scenario, protection options for Thompson Beach should be considered for the 2050 1 in 100 ARI flood risk (3.0m AHD) for the following reasons:

- Protection measures are feasible and likely to be effective (see Figures 4);
- Protection of development to cater for the 2050 flood scenario (3.0m AHD) is Coast Protection Board policy (Coast Protection Board, 2012);
- Installation of protection measures now will provide a 30-40 year time in which data can be tracked over time to assess the rate of change in sea level.
- Installation of protection measures now will provide a 30-40 year time frame in which accommodation measures can be implemented to cater for predicted sea level rises past 2050.

### 2.2.1. Protection options for Thompson Beach (north)

The frontal dune system of Thompson Beach (north) is at heights in excess of 3.0m AHD and provides sufficient protection. The levee system to the east of Thompson (north), including Ruskin Road is generally at 3.0m AHD, but some isolated points may be as low as 2.70m AHD. However, the levee system to the east is a secondary system to prevent water entering the settlement that has flowed through the dunes north of the settlement, and therefore in the short term, the height may be sufficient.

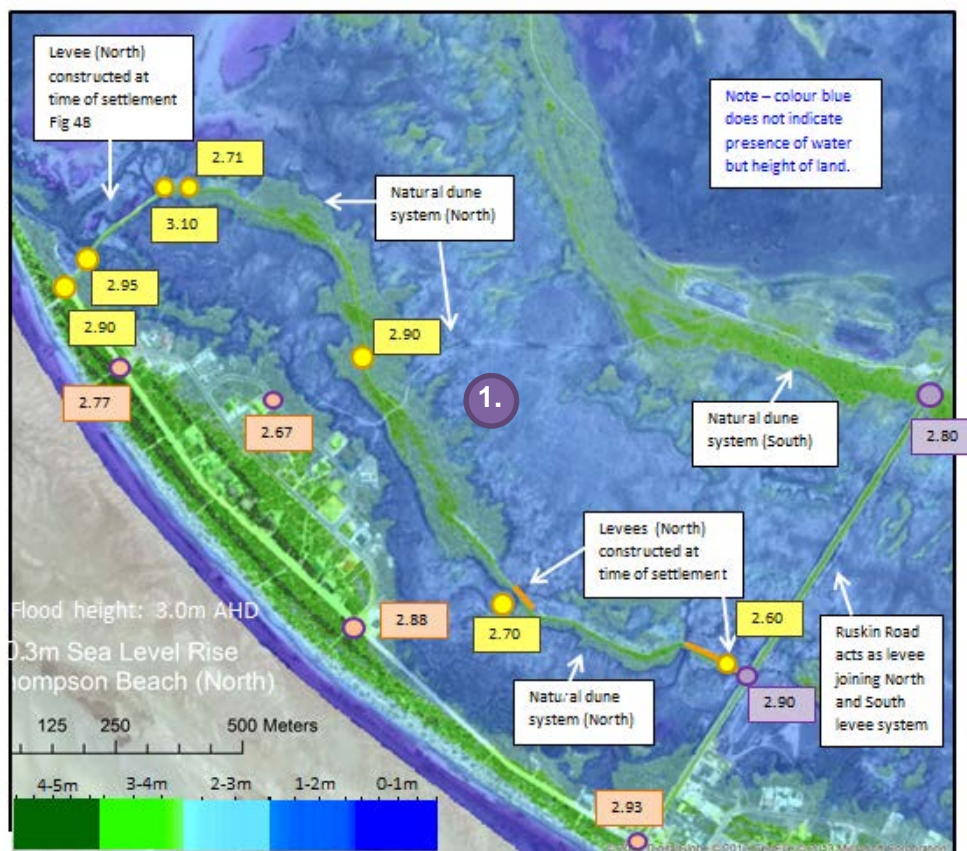
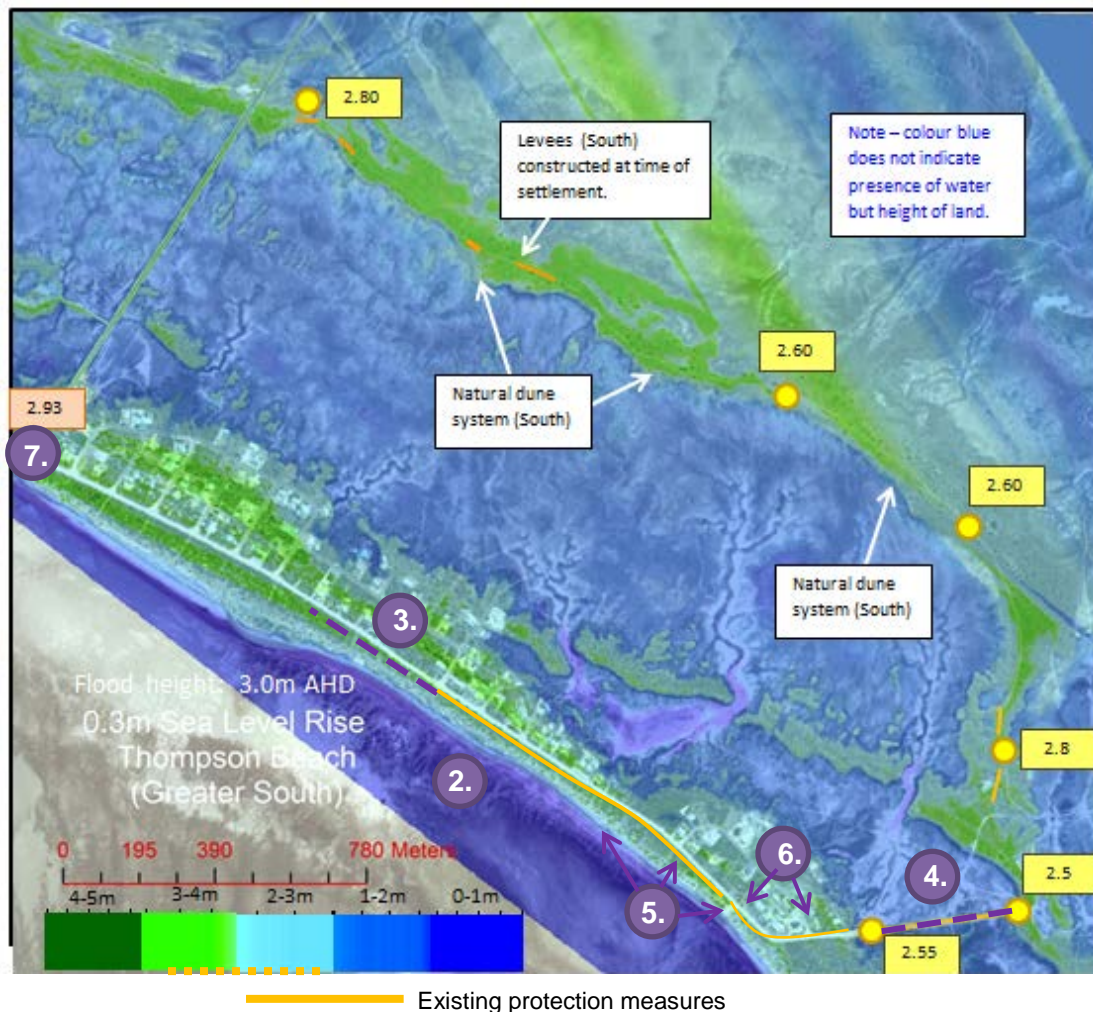


Figure 4: Thompson (north) - map indicating sea-flood risk at 3.0m AHD (2050 scenario)



1. Check heights and integrity of levee system to the east of Thompson (North). Raise low points as required.

## 2.2.2. Protection options for Thompson Beach (south)



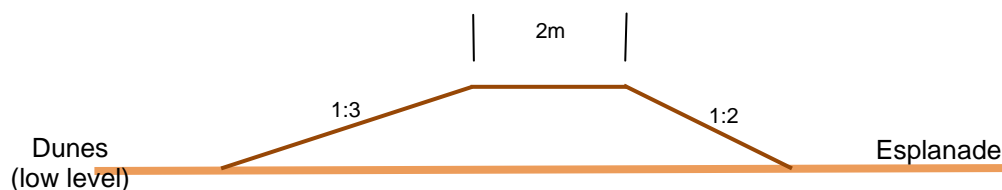
**Figure 5: Thompson (south) - map indicating sea-flood risk at 3.0m AHD (2050 scenario)**

2. Check height and integrity of existing levee and dune system on the west side of the Esplanade. A review of survey provided by DC Mallala Infrastructure Services Department and an onsite inspection suggests:

- The levee installed by the developer on the west side of the Esplanade from the corner of Petrel Crescent to the southern end of the Esplanade is at height 2.80m to 3.0m AHD.
- There is no levee between the corner of Petrel Crescent and where the line of Chat Court intersects with the Esplanade, and in places the dune is as low as 2.40m AHD.
- The dune height (there is no levee) between the point where the line of Chat Court intersects with the Esplanade to the corner of Ruskin Road is generally at 2.80m or above (but data missing between Plover Avenue and Stint Avenue).
- The above review indicates that generally Thompson Beach south is protected at 2.80m AHD (which is the current ARI 1 in 100 sea-flood risk) apart from the section

between corner of Petrel Crescent and where the line of Chat Court intersects with the Esplanade.

3. Install levee at height 3.25m AHD between the corner of Petrel Crescent and where the line of Chat Court intersects with the Esplanade (approximate length – 324 m) using levee profile in **Figure 6**. Note: this section of the Esplanade has low lying dunes to the west and therefore a levee with 1:3 batter ratio on sea-side is required.



**Figure 6: Thompson Beach (south) – typical cross section of levee.**

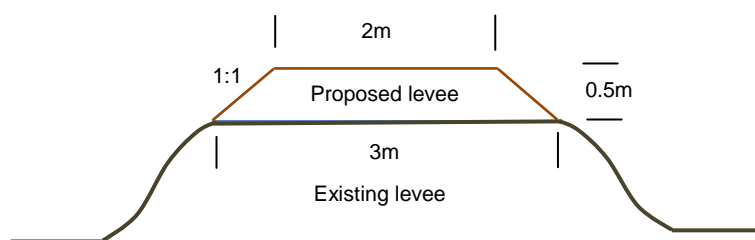
3. Preliminary cost calculation: Install levee to Esplanade Road (Figure 5)								
Location	Existing road elevation	Existing Ground elevation	Proposed levee height	Proposed levee length	Area of levee profile	Volume m <sup>3</sup>	*Cost per m <sup>3</sup>	Total Cost
Esplanade: Cnr Petrel Cr to the place where the line of Chat Court intersects.	2.30 – 2.50m AHD (northern)	2.40m	0.9m (varies)	160m	3.80m <sup>2</sup>	600m <sup>3</sup>	\$26	\$15,600
	2.60 – 2.80m AHD (southern)	2.7m (mean)	0.6m (varies)	160m	2.10m <sup>2</sup>	340m <sup>3</sup>	\$26	\$ 8,800
*Estimate: DC Mallala Infrastructure Services						Total		\$24,400

4. Increase the height from 2.50m AHD to 3.00m AHD of the man-made east-west levee installed by the developer to the end of the Esplanade (**Figure 7**).



**Figure 7: Thompson Beach (south) – man-made levee running east-west at 2.5m AHD.**

The existing levee is a secondary defence system that protects the rear of Thompson Beach (south) and is approximately 3m wide and 340m in length. Install as shown in **Figure 8**.



**Figure 8: Cross section of proposed levee to be installed on top of the existing east-west levee on southern end of the Esplanade.**

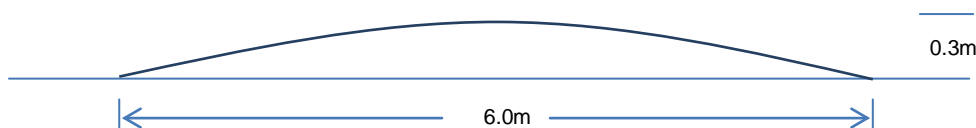
Note: Residents reported in public consultation that water had breached this levee. However, DC Mallala Infrastructure Services Department is unaware of such a breach and the author has made enquiries of residents but no one as yet has verified this event.

Note: The plans held at DC Mallala indicate that the original levee was intended to be installed at 3.0m AHD.

4. Preliminary cost calculation : Increase height of existing levee (Figure 5)							
Location	Existing levee height AHD	Proposed levee height increase	Proposed levee length	Area of levee profile	Volume m <sup>3</sup>	*Cost per m <sup>3</sup>	Total Cost
Existing levee running east-west from southern end of the Esplanade.	2.50m AHD	0.5m	340m	1.3m <sup>2</sup>	440m <sup>3</sup>	\$26	\$11400

\*Estimate: DC Mallala Infrastructure Services

5. Raise height of beach vehicle crossover in southern car park to 3.25m AHD in accordance with **Figure 9**.



**Figure 9: Example of section of beach vehicular crossover in southern car park.**

5. Preliminary cost calculation: raise vehicular beach crossover (Figure 5)							
Location	Existing height	To be raised	Width	Length	Volume m <sup>3</sup>	*Cost per m <sup>3</sup>	Total Cost
Southern car park	3.00m AHD	0.3m	16m	6m	10m <sup>3</sup>	\$30	\$300

\*Estimate: Mark Western

Check heights of walk way access ramps to beach and raise to 3.25m AHD as required.

6. Install the remaining sections of the levee as approved in DA 312/311/2011. Begin with the section (290 m) between the southern car park and the cul-de-sac at the southern end of the Esplanade as this is the most exposed to the south-west (Thompson Beach levee install has already been costed, refer DC Mallala Infrastructure Services Department).

7. Raise the level of the Esplanade Road between the corner of Ruskin Road and Sandpiper Drive to 3.0m AHD (75 m approximately). The purpose of this work is to provide a road surface at 3.0m AHD to connect with Sandpiper Drive and Shearwater Way which will provide 1.1km of north-south corridor to parallel to the Esplanade (see **Figure 10** below).

7. Preliminary cost calculation: raise portion of Esplanade Road (Figure 5)								
Location	Existing road elevation	Proposed road height	Road to be raised	Length	Width	Volume or area	*Cost per m <sup>3</sup> or m <sup>2</sup>	Total Cost
Corner of Ruskin Rd to Sandpiper Drive	2.80m end of bitumen to 2.4m AHD just south of Sandpiper cnr.	3.0m AHD	0.6 m / 2	75m	10m	225m <sup>3</sup>	\$20	\$4,500
				75m	10m	750m <sup>2</sup>	\$4	\$3,000
*Estimate:	DC Mallala Infrastructure Services					Total		\$7500

### 2.2.3 Protection options for north and south of Thompson Beach.

Maintaining a healthy dune system to the north and south of Thompson Beach is vital for the long term viability of the settlement. Small inlets that eventuate as a result of a storm surge are likely to become large inlets over time and more quickly erode the dune system away.

1. Check the dune system north and south of the settlement to identify any new incursions through the dunes. Close any recent inlets in the dune system by:

- Obtaining permission from Coast Protection Board, which permission can be given verbally (Comment, Murray Townsend, CPB, 14<sup>th</sup> November, 2013)
- Use local materials and fill with sand and brush.
- Revegetate with indigenous species;.
- Additional option: Use sand bags to provide stable base (Comment: Geoff Fisher, AWE, 20<sup>th</sup> November, 2013) .

Note: The existing incursion through the dunes north of Thompson Beach is likely to be too well established to be closed.

### 2.2.4. Other protection options

Council to establish a monitoring regime in which levees and dunes are monitored:

- After each inundation event greater than 2.50m AHD
- Annual sight inspections to assess possible weaknesses.
- Higher level engineering inspections once every 5 years (parameters of the inspections yet to be set).
- Aerial photography review and comparison every 5-10 years.

### 3. Thompson Beach accommodation options

#### 3.1 Accommodation option - prepare the community to be 'flood ready'.

As noted above (see p. 4), a community that is prepared to deal with a flood is likely to suffer much less in financial terms, and also less likely to suffer human tragedy. Further, a prudent community prepares for emergency events that may fall outside of its historical context as 'mother nature' does not necessarily adhere to ARI tables. The following are ways in which the community could prepare itself to be 'flood-ready':

##### 3.1.1 Implement general warnings of general flood risk.

DC Mallala to implement general warnings to residents about the general risk of flood. These warnings may include:

- Flood mapping and floor levels of dwellings made available to residents to allow them to more fully evaluate the flood risk to their property.
- New residents made aware of the risk of flooding in the Form 1 required as part of a real estate contract at time of purchase within the settlement.

##### 3.1.2 Implement warning systems for possible flood events.

Council and the Thompson Beach Residents Association (or other relevant community organisation) to implement flood warning systems such as:

- Community run warning systems to inform residents of upcoming king tides, either by installing a 'king tide warning' sign, sending tide charts to all residents, and/or utilising SMS or email to send messages to community members with king tide information.



- Implement systems to warn residents of predicted storms. For example, SMS and email storm warnings are available from the Bureau of Meteorology. It is also possible to receive a SMS warning from a tide gauge in the Port River once it exceeds a predetermined high level<sup>2</sup>. This may give half hour warning of a larger than expected storm surge.

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<sup>2</sup> This gauge is owned by Port Adelaide Enfield Council and there may be a charge associated with this service.



### 3.1.3 Develop and implement flood emergency management procedures.

Council and Thompson Beach Residents Association (or similar community body) to develop and implement flood emergency management procedures that may include:

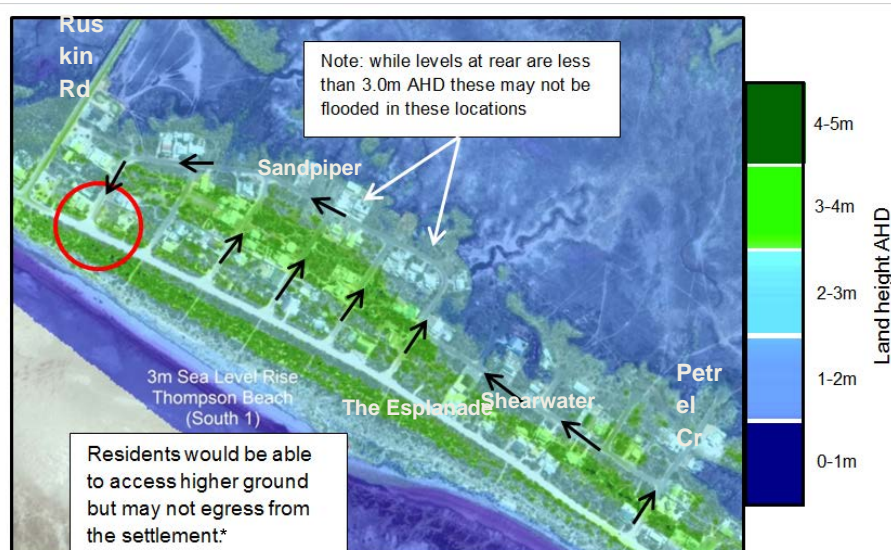
- Establishment of an emergency assembly point at corner of Ruskin Road (or other suitable place above 3.0m AHD) and mark the spot with a sign.



- Establish emergency evacuation routes that residents can use on foot that lead away from the source of the flood and to the emergency assembly point.

N.B. In Thompson Beach (north) the Esplanade road is generally at 3.0m AHD or above so it is likely that access will remain open in 3.0m AHD sea-flood.

In Thompson Beach (south), in the section between Ruskin Road and Petrel Crescent, residents can move away from the source of the flood and utilise Shearwater Way and Sandpiper Drive to exit, provided that 'Protection option 6' is installed (p. 12).



**Figure 10: Emergency exit pattern from 3.0m AHD flood event at Thompson Beach (south).**

\*Unless protection option 6 is implemented.

N.B. In Thompson Beach (south) in the section between Petrel Crescent and the southern point of Thompson Beach, residents have no way to exit the settlement apart from utilising the Esplanade (**Figure 11**).



**Figure 11: Emergency exit pattern from 3.0m AHD flood event at Thompson Beach (south).**

- Establish emergency evacuation routes that emergency vehicles can utilise to enter the settlement.

N.B. In Thompson Beach (north) the Esplanade road is generally at 3.0m AHD or above and therefore in a 3.0m AHD sea-flood emergency vehicles will be able to access.

In Thompson Beach (south), in the section between Ruskin Road and Petrel Crescent, emergency vehicles can utilise Sandpiper Drive and Shearwater Way provided that 'protection option 6' is installed (see **Figure 10**).

In Thompson Beach (south), in the section south of Petrel Crescent, emergency vehicles will be unable to access the southern portions of the settlement as the Esplanade may be inundated by 0.5m to 0.7m.

Options to solve the problem of egress of residents and entry by emergency service personnel in this section of Thompson Beach (south of Petrel Crescent) may include:

- Raise the road between Petrel Crescent and Heron Crescent (Distance of 600m)
- Establish an emergency assembly point in the southern section above 3.0m AHD.
- SES do have access to water craft but it is unknown how available these are and generally, helicopters are not available to access the area (Comment: Ben Birbeck, SES, 21<sup>st</sup> November, 2013).
- Adopt emergency procedures that include scenarios where evacuation from the settlement precedes the storm event, especially in cases where residents are young, frail or already known to sometimes require medical attention.

**Important note: these emergency procedures are only relevant to sea-flood risk of 3.0m AHD (2050 levels).**

### 3.1.4 Residents Prepare written Flood Emergency Action Plans.

Thompson Beach Residents Association (or other appropriate community body) to prepare a guide to assist residents to prepare Flood Emergency Action Plans and to educate new and existing residents of its contents. The Guide should include evacuation policies based on the level of warning, what each member of the household should do if flood waters enter the dwelling, and describe how each member will access the emergency assembly point. (Note, general access and egress into Thompson Beach via Ruskin Road will be available in a 3.0m sea-flood event). Thompson Beach Residents Association (or other appropriate community body) to encourage households to prepare emergency action plans and provide assistance if required.

## 3.2 Accommodation option- amend Development Plan policy.

Planning policy should ensure that:

- All new buildings (apart from minor structures such as sheds) are capable of being raised to 3.95m AHD (and not that they are capable of being raised to 1.25m above the standard sea-flood level).
- Site levels to be no longer required to be 'protected' from standard sea-flood risk level and sites should no longer be required to be 0.3m above the standard sea-flood risk. Substitute clauses should have the sense of 'managing' the site in relation to sea-flood risk.
- The requirement for practical measures to be available to 'protect' new development against additional sea level rise of 0.7 metres is removed and replaced with a clause that has the sense of 'accommodating' additional sea level rise.

Review the specifications of septic systems to be installed with new dwellings at Thompson Beach to ensure that these are adequate to cater for potential sea flood scenarios later in the century.

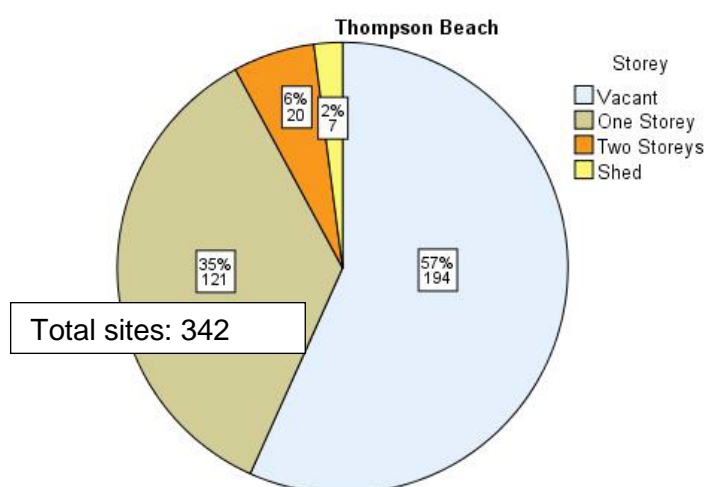
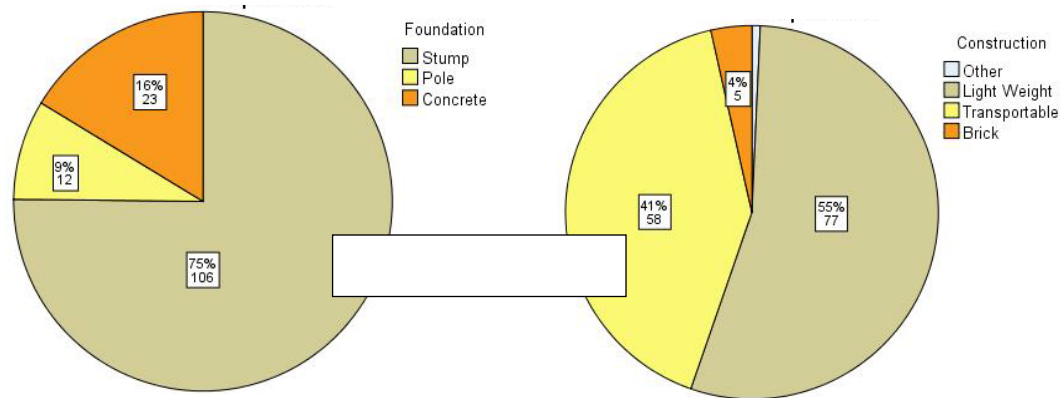


Figure 12: Profile of vacant/ occupied sites in Thompson Beach

### 3.3 Accommodation option - adapt existing buildings

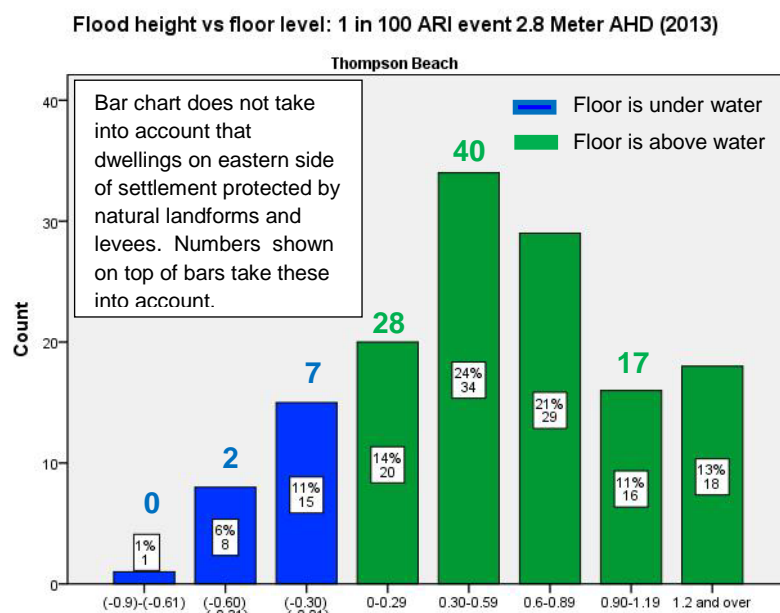
#### 3.3.1. Raise the floor level of dwellings.

The predominant housing construction in Thompson Beach is either light weight or transportable<sup>3</sup> and constructed on stumps or poles (**Figure 13**). Many of these dwellings would be capable of being raised if they are subject to inundation.



**Figure 13: Construction types in Thompson Beach**

The number of existing dwellings subject to inundation at the current predicted 1 in 100 ARI event of 2.8m AHD is 9-24 (**Figure 14**) with a likely damage bill to private property in current dollars at \$75,800 (but assumes the lower figure of 9, *State of Play Report*, p. 83). If a decision is made to do nothing about the protection options outlined above (p. 6-12) or a decision is made to defer for any length of time, then residents may choose to raise their dwellings. However, in this case, inundation is minor so residents may elect to wait until the sea level rises further.



**Figure 14: Thompson Beach - Flood height versus floor level in 1 in 100 ARI event 2.8m AHD**

<sup>3</sup> It is likely that in collection of data that 'lightweight' has been over applied rather than the 'transportable' category but this is of little consequence to the accommodation strategy proposed here.



It is anticipated over the next 30-40 years that many of the existing dwellings in Thompson Beach will be replaced by natural attrition. If the proposed protection options outlined above (p.10,11) are implemented then it is conceivable that a number will still remain with floor levels lower than the sea-flood risk at 2050. Residents could raise their dwellings to deal with the sea-flood threat subsequent to 2050 when the proposed protection options may not always protect the settlement from the sea-flood risk.

### 3.3.2. Raise the floor level of dwellings.

Other flood accommodation options that residents could employ are:

- To internally water proof buildings and raise electrical outlets above the predicted flood levels.
- To provide temporary flood barriers to the outside of dwellings when tides are predicted to be high. Examples from Blobel Flood Protections Systems are shown in **Figure 15** and **Figure 16** (Blobel Environmental Engineering, 2013)



**Figure 15:** Flood protection wall to divert water away from the house



**Figure 16:** Flood protection barrier to stop water entering the house

## 4. Thompson Beach Retreat Options:

The data from tide gauges at Port Stanvac and Thevernard have shown that sea has been rising in the region at an average of 4.3mm per year over the past 20 years. For the sea to rise 0.7m in the second half of this century as predicted would require an average rate of rise at 14mm per year. In reality this rate would be much lower than 14mm at 2050, and a much higher rate at 2100. Therefore, in decades of 2020s, 2030s, and 2040s it should be possible to monitor the rate of increase and adjust predictions accordingly. There are two possible scenarios that will emerge from the monitoring in this time frame:

- If the rate of change of sea level rise does not increase and the predictions for 2100 are suspected to be inaccurate, then at the very least as a result of implementing the adaptation strategies above, Thompson Beach would have become a far more resilient community and prepared for any unforeseen flood event.
- If the rate of change of sea level rise does accelerate and the predictions are likely to be accurate, then Thompson Beach can expect to be inundated far more frequently as the century approaches its close. Even though planning changes foreshadowed above mean that the floor levels of dwellings are above the flood levels, roads are likely to be frequently cut off and damaged, emergency vehicles frequently would not be able to enter the settlement, evacuation procedures may become part of life in Thompson Beach, and the safety of people may be at risk.

If such a situation eventuated, and to provide some context from a planning perspective, the District Council of Mallala Development Plan (consolidated 13/01/2013) states:

‘Development should not occur where essential services cannot be economically provided and maintained having regard to flood risk and sea level rise, or where emergency vehicle access would be prevented by a 1-in-100 year average return interval flood event, adjusted for 100 years of sea level rise’ (Control 26, p.33)

Therefore, if monitoring of sea level rise in the 2020s, 2030s and 2040s indicates that the rate of change is accelerating, then planning policy should ensure that all new buildings are capable of being removed. Policy should be developed so that a predetermined event triggers the removal of buildings, for example, when a certain sea level height is reached, residents may have 5 years (for example) to remove dwellings. It is important to note that this study is not recommending that such a change be made now, but that sea level rise be monitored over the coming decades and the change made when:

- It is recognised that the rate of sea level rise is accelerating<sup>4</sup>
- In time so that dwellings constructed now will be reaching the end of their life span when sea levels reach levels that may not be properly accommodated.

In conclusion, such a policy would allow residents the liberty to continue to develop their properties, but with the knowledge that the development may have limited life span and plan accordingly.

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<sup>4</sup> Caution: the rate of sea level rise is not constant and thus longer term trends should be employed to ascertain whether the rate of change is accelerating.

## 5. Thompson Beach Risk Analysis

Using the National Emergency Risk Assessment Guidelines (NERAG) (Australian Government, 2010) four risk statements have been generated for the Thompson Beach settlement. The risk assessment is completed taking into account existing protection and emergency procedures and for a sea-flood height that exceeds 2.5m AHD but less than 2.8m AHD, the latter being the current 1 in 100 ARI sea-flood event (See **Appendix 1** for full analysis).

### 5.1 Risks to People

#### Risk statement 1

*There is the potential that a storm surge exceeding 2.5m AHD but less than 2.8m AHD resulting from a south easterly to north-westerly wind combined with a king tide will cause floods to Thompson Beach (south), which in turn will cause impact on the residents.*

The analysis in **Appendix 1** resulted in a risk category assigned as ALARP 5 which is 'broadly acceptable' (see **Figure 17**). With implementation of warning and emergency procedures, the risk will be even more effectively managed. Should protection measures be installed at 3.0m AHD the risk would be well within the 'broadly acceptable' category for risk to human life.

### 5.2 Risks to infrastructure

#### Risk statement 2

*There is the potential that a storm surge exceeding 2.5m AHD but less than 2.8m AHD resulting from a south-easterly or north-westerly storm will cause floods to Thompson Beach (south), which in turn will cause damage to private infrastructure.*

The analysis in **Appendix 1** resulted in a risk category assigned as ALARP 5 which is in the 'broadly acceptable region'. Thompson Beach is generally protected at height of 2.8m AHD (apart from section on the Esplanade between corner of Petrel Crescent and corner Sandpiper Drive) Only nine to thirteen dwellings are predicted to have water over floor levels, these generally at minor levels. Installation of the protection works described above would improve this rating further.

#### Risk statement 3

*There is the potential that a storm surge exceeding 2.5m AHD but less than 2.8m AHD resulting from a south-easterly or north-westerly storm will cause floods to Thompson Beach (south), which in turn will cause damage to public infrastructure.*

The analysis in **Appendix 1** resulted in a risk category assigned as ALARP 4-5 which is in the 'tolerable region' trending towards the 'broadly acceptable region'. The main public infrastructure in Thompson Beach would be mainly confined to 'roads'. As the duration of the flood is short lived and the velocity normally low, damage to roads is likely to be low. There is no way to reduce the risk without implementing protection to the foreshore or by raising roads (the latter not regarded as cost effective).

### ALARP Principle

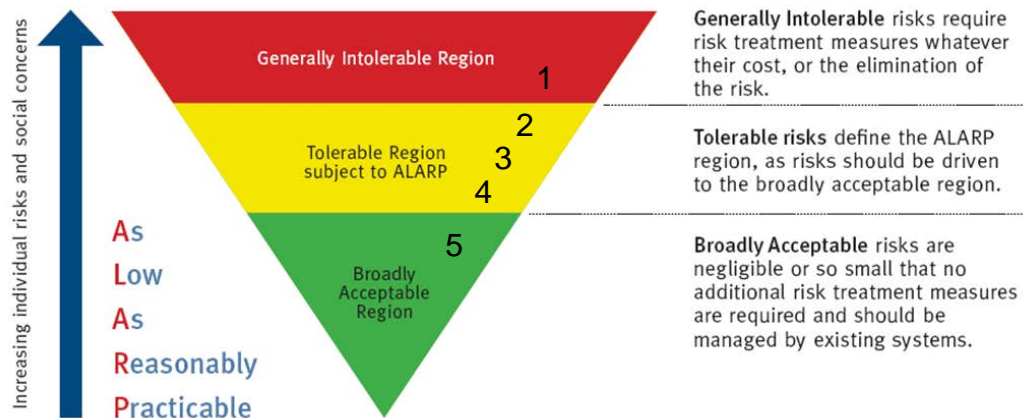


Figure 17: National Emergency Risk Assessment Guidelines – ALARP assessment.



## 6. Thompson Beach – Adaptation Costs (preliminary)

The cost estimates provided below have been prepared based on very limited data and without engineering design calculations. They are therefore indicative only and have been prepared to assist council with the priority setting processes. They should not be relied on for budgeting or construction cost management purposes. **Table 4** is a summary of all of the adaptation options for Thompson Beach grouped in categories of *protect*, *accommodate*, *retreat*.

**Table 4: Summary of adaptation options with approximate costs.**

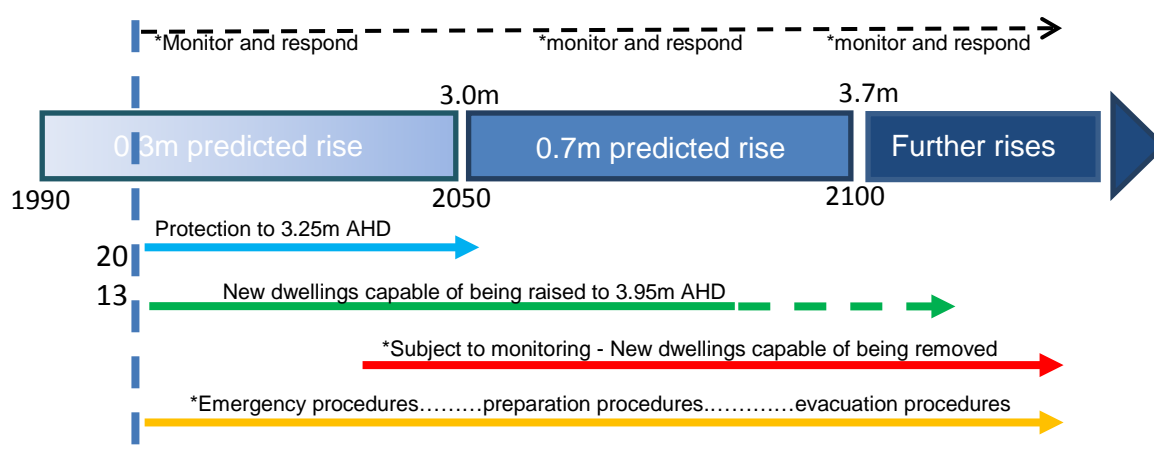
	Adaptation option	Approximate cost	Reference pp.
Protect	1. Check heights and integrity of levees and dunes – east of the settlement, and the front dune and levee south of Ruskin Road.	Not costed	8,9
	2. Install 320m of levee to the Esplanade at 3.25m AHD from Petrel Cr corner to where the line of Chat Cres that intersects the Esplanade.	\$24,400	10
	3. Raise the man-made east-west levee on the southern end of Thompson Beach from 2.50m to 3.00m AHD (secondary defence) – approx. 340 LM.	\$11,400	11
	4. Raise southern car park beach crossover to 3.30m AHD. Check height of beach access ramps and walkways and raise to 3.25m AHD if required.	\$ 300	11
	5. Install levee to 3.25m AHD to south-west corner between cul-de-sac in south to car park (290m approx) and then the remaining sections of the levee approved in 312/311/2011.	Already costed by DC Mallala	12
	6. Raise section of the Esplanade between corner of Ruskin Road and Sandpiper Drive to 2.8m/ 3.0m AHD.	\$7,500	12
	7. Implement monitoring regime to check existing levees and dune system north and south of the settlement. Evaluate whether the incursion through the dunes to the north of Thompson Beach can be closed.	Not costed	12
Accommodate	8. Implement emergency procedures – establish warning systems; establish emergency assembly point; establish evacuation policies; establish community and households emergency action plans.	Not costed	13-16
	9. Devise and implement planning policy that ensures: new dwellings are capable of being raised to 3.95m AHD; and site levels are not required to be raised.	Not costed.	16
	10. Adapt existing dwellings – residents to raise floor levels; utilise internal waterproofing; or temporary protection mechanisms.	Not costed.	17
Retreat	11. Subject to monitoring that demonstrates that the rate of sea level rise is accelerating, devise and implement planning policy that ensures that new dwellings are capable of being removed (once a predetermined trigger point has been reached, for example a particular AHD height).	Not costed.	19

Within all of these adaptation options is the option to 'defer' or 'do nothing'. In some cases, decisions will be made to defer an option because sea level rise has not yet taken place. For example, Thompson Beach is generally protected to 2.8m AHD. While this is not the 3.25m AHD recommended by the Coast Protection Board, 2.8m AHD is the current 1 in 100 ARI sea-flood risk level. Thus a decision to install a levee to the frontal dune could be deferred for a few years. 'Do nothing' may be a valid decision when the costs are prohibitive and outweigh the benefit. The option to raise the Esplanade has not been put forward in this study as an adaptation option for this reason.

## 7. Thompson Beach – Timing and Prioritisation

### 7.1 Thompson Beach – adaptation timing

**Figure 18** illustrates how the different protection, accommodation, and retreat options interrelate over time. Sea level rise and erosion are monitored over time and response made accordingly. Emergency procedures are always in place and amended according to the conditions. When protection measures become inadequate, accommodation options mitigate the risk. Subject to ongoing monitoring longer term decisions are made in relation to the viability of the settlement itself.



**Figure 18: The relationship of decision making on options to time**

### 7.2 Thompson Beach – adaptation prioritisation

Subject to Council and community input the following prioritisation is recommended for Thompson Beach:

**Table 5: Prioritisation and responsible entities for adaptations at Thompson Beach**

	Adaptation response	Risk rating and other priority factors	Suggested response time	Entity Responsible
1.	Implement emergency procedures which should be maintained even if protection options are implemented.	Such procedures are a wise response to living adjacent to an unpredictable threat as well as a way to educate the community about the potential for the threat to be increased.	Within 1 year	Council and Thompson Beach community
2.	Devise and implement planning policy that ensures all new buildings are capable of being raised to 3.95m AHD and sites are not required to be raised (check adequacy of sewer system specifications).	Some dwellings constructed now may still be in use in 2080-90 when the 1 in 100 ARI flood risk is 3.7m AHD.	Within 1 year	Council
3.	Implement monitoring systems	Reduces liability relating to	Within 1	Council

	to assess the state of levees (within the settlement and dunes (both in and north and south of the settlement)).	levees, and provides information about the state of the dune system so that breaches can be closed.	year	
4.	Check height and integrity of levee from Petrel corner to southern end. Check height and integrity of dune system between Ruskin Road and the Petrel corner.	Refer to survey provided by DC Mallala Infrastructure Services Department. Check height of levee top (use laser level). Ensure height is 2.8m AHD which is current 1 in 100 ARI event.	Within 1 year	Council
5.	Install protection levee at height of 3.25m AHD to west side of the Esplanade between the corner of Petrel Crescent and where the line of Chat Court intersects the Esplanade.	Refer survey provided by DC Mallala Infrastructure Services Department. This section appears to have no levee, whereas the original plans indicate that a levee should have been installed	1-2 years	Council
6.	Raise height of east-west man-made levee on southern end of Thompson Beach from 2.5m to 3.0m AHD (a secondary defence)	The original application plans show that this levee should have been installed at 3.0m AHD.	1-2 years	Council
7.	Check heights of beach access ramps – vehicular and pedestrian and raise provide 3.25m AHD protection where required.	Smooth and hard surfaces are more vulnerable than soft vegetated surfaces and these will become vulnerable sooner to SLR.	2-5 years	Council
8	Install the remaining sections of levee in DA 312/311/2011.	Current protection is generally at least 2.8m. Installation at 3.25 AHD will prepare for 2050 sea levels.	2-5 years.	Council
9.	Check the levee system to the east of Thompson Beach to ensure that protection is provided to 3.0m AHD (a secondary defence), and raise as necessary.	Original development application stipulated the rear defences at 3.0m AHD.	2-5 years	Council
10.	Subject to monitoring from the present until the 2020s- 2030s, should sea level rise accelerate to indicate more rapid rise, devise and implement planning policy that ensures all new dwellings are capable of being able to be removed once predetermined triggers have been realised.	Thompson Beach cannot be protected at 3.7m AHD levels. If sea level continues to rise then it will rise past 2100. The settlement may not be viable if it is continually inundated and repairs of roads and infrastructure become prohibitive.	15-25 years (depending on monitoring)	Council
11.	Dwellings are raised, or water proofed internally, or temporary protection strategies employed.	Community protection has become insufficient.	As required.	Residents

## 8. References

Balston, J.M., Western, M.D., Kellett, J., Wells, G., Li, S., Gray, A, 2012, *Climate change decision framework and software for coastal councils*, Local Government of Association of South Australia, Adelaide, SA.

Coast Protection Board (SA), 2014, *Coast Protection Board Policy Document: Revised 22 May 2012*.

District Council of Mallala Development Plan (consolidate 31/01/2013)

Blobel Environmental Engineering, 2013, *Flood protection – manual and automatic flood defence*, viewed at [http://www.blobel.com/e\\_html/02-02e-flood-protection.html](http://www.blobel.com/e_html/02-02e-flood-protection.html), on 12<sup>th</sup> December, 2013.

National Emergency Management Committee, 2010, *National Emergency Risk Assessment Guidelines*, Tasmanian State Emergency Service, Hobart.

Victorian Government, 2000, *Rapid Appraisal Method (RAM) for floodplain management*.

## 9. Appendix 1: Risk analysis utilising NERAG

### 1. Risk statement:

There is the potential that a storm surge that exceeds 2.5m AHD but less than 2.8m AHD resulting from the combination of a king tide and south easterly or north-westerly storm will cause floods to Thompson Beach, which in turn will cause impact on the residents (but not taking into account risk statement 2).

### Risk identification:

Source of threat	Storm surge entering community from the north (also over beach ramp)
Impact category	People
Prevention controls	Shell grit levees to north-west corner of settlement
Preparedness controls	No emergency procedures
Response	SES, ambulance, fire, police
Recovery	Pumping, draining water away. Repair of houses and roads.

### Credible consequence level to people:

'Insignificant' – near misses or minor injuries

### Likelihood of the event occurring:

'Likely'- two one in 20 ARI events in previous decade which is at 2.5m AHD. The current 1 in 100 ARI event is 2.8m AHD .

### Consequence Level:

Qualitative Risk Matrix

Likelihood Level	Consequence Level				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Medium	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possible	Low	Low	Medium	High	High
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Medium	Medium
Very Rare	Low	Low	Low	Low	Medium
Almost Incredible	Low	Low	Low	Low	Low

### Degree of confidence in the above assessment:

High confidence – extensive study conducted, historical data known, hazard known, and comprehensive knowledge of the receiving environment.

### Confidence Table

Confidence Criteria	Low Confidence	Moderate Confidence	High Confidence
Data/Information	Neither community nor hazard specific; anecdotal only	Community or hazard specific; validated historical or scientific	Community and hazard specific; validated historical and scientific
Team knowledge	Neither hazard nor process (risk assessment) specific	Hazard or process specific	Hazard and process specific
Agreement	Neither on interpretations nor on ratings	On interpretations or ratings	On interpretations and ratings

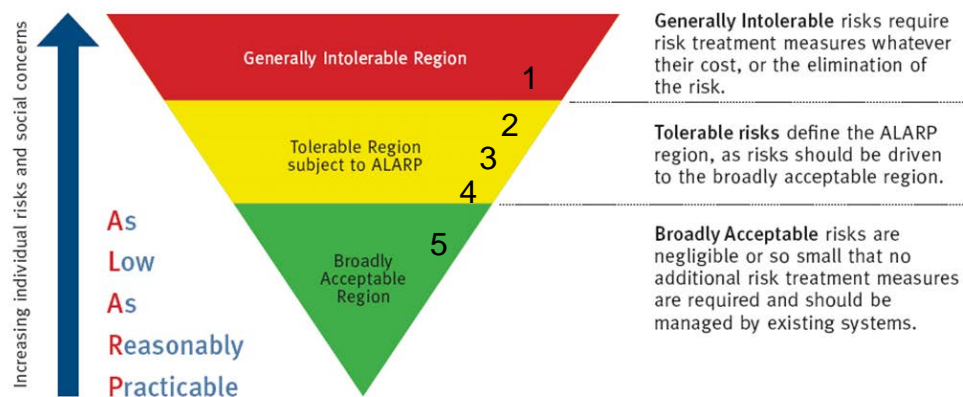
### Classification of risk tolerability:

#### Risk Tolerability Tables

##### High Confidence Level

Likelihood Level	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	4	3	2	1	1
Likely	5	4	3	2	1
Possible	5	5	4	3	2
Unlikely	5	5	4	3	3
Rare	5	5	5	4	3
Very Rare	5	5	5	5	4
Almost Incredible	5	5	5	5	5

#### ALARP Principle



### Conclusion:

Risk category is ALARP 5 which is 'broadly acceptable'. With implementation of warning and emergency procedures, the risk will be even more effectively managed. Should protection measures be installed at 3.0m AHD the risk would be well within the 'broadly acceptable' category for risk to human life.

## 2. Risk statement:

There is the potential that a storm surge greater than 2.5m AHD and less than 2.8m AHD resulting from a south-easterly or north-westerly storm will cause floods to Thompson Beach, which in turn will cause damage to private infrastructure.

### Risk identification:

Source of threat	Storm surge
Impact category	Infrastructure – dwellings/sheds
Prevention controls	Shell grit levees provided to north west corner and part way along the northern boundary. Frontal dune assessed as being of suitable height.
Preparedness controls	None relating to infrastructure.
Response	SES, ambulance, fire, police
Recovery	Pumping, draining water away. Repair of houses.

### Credible consequence level:

Private Infrastructure – ‘insignificant’. Only 9-13 houses are predicted to have water over floor levels with most at .3 m depth over floor.

### Likelihood:

Likely (maybe possible) – two events in last decade have approached 2.5m AHD. One in one hundred is 2.8m AHD.

### Consequence Level:

**Qualitative Risk Matrix**

Likelihood Level	Consequence Level				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Medium	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possible	Low	Low	Medium	High	High
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Medium	Medium
Very Rare	Low	Low	Low	Low	Medium
Almost Incredible	Low	Low	Low	Low	Low

### Degree of confidence in the above assessment:

High confidence



### Confidence Table

Confidence Criteria	Low Confidence	Moderate Confidence	High Confidence
Data/Information	Neither community nor hazard specific; anecdotal only	Community or hazard specific; validated historical or scientific	Community and hazard specific; validated historical and scientific
Team knowledge	Neither hazard nor process (risk assessment) specific	Hazard or process specific	Hazard and process specific
Agreement	Neither on interpretations nor on ratings	On interpretations or ratings	On interpretations and ratings

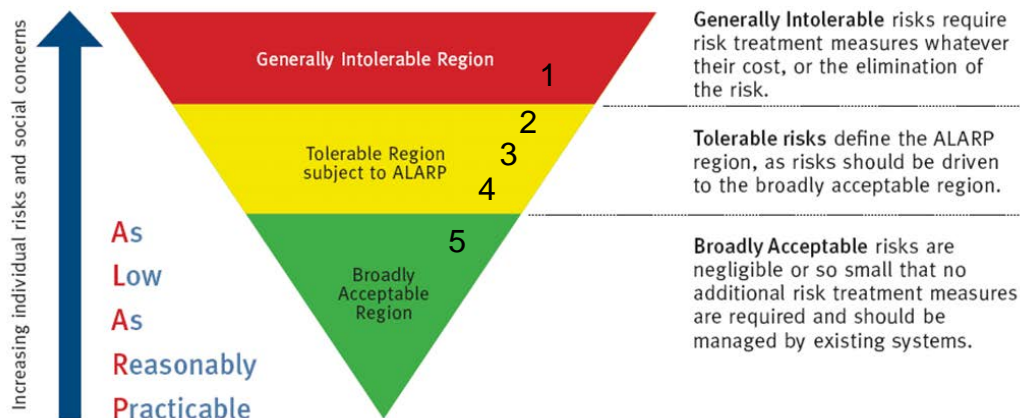
### Classification of risk tolerability:

#### Risk Tolerability Tables

##### High Confidence Level

Likelihood Level	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	4	3	2	1	1
Likely	5	4	3	2	1
Possible	5	5	4	3	2
Unlikely	5	5	4	3	3
Rare	5	5	5	4	3
Very Rare	5	5	5	5	4
Almost Incredible	5	5	5	5	5

#### ALARP Principle



### Conclusion:

Risk category is ALARP 5 which is in the 'broadly acceptable region'. Only four dwellings are predicted to have water over floor levels. Installation of the protection works described above would improve this rating further.

### 3. Risk statement

There is the potential that a storm surge exceeding 2.5m AHD but less than 2.8m AHD resulting from a south-easterly or north-westerly storm will cause floods to Thompson Beach, which in turn will cause failure or damage to public infrastructure.

#### Risk identification:

Source of threat	Storm surge
Impact category	Infrastructure – primarily roads. Other infrastructure likely to remain unaffected. Power lines above ground.
Prevention controls	Shell grit levees provided to north west corner and part way along the northern boundary. Frontal dune assessed as being of suitable height.
Preparedness controls	None relating to infrastructure
Response	SES, ambulance, fire, police
Recovery	Pumping, draining water away. Repair of roads.

#### Credible consequence level:

Private Infrastructure – ‘minor’ to ‘insignificant’

#### Likelihood:

Likely (maybe possible) – two events in last decade have approached 2.5m AHD. One in one hundred is 2.8m AHD.

#### Consequence Level:

**Qualitative Risk Matrix**

Likelihood Level	Consequence Level				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Medium	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possible	Low	Low	Medium	High	High
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Medium	Medium
Very Rare	Low	Low	Low	Low	Medium
Almost Incredible	Low	Low	Low	Low	Low

#### Degree of confidence in the above assessment:

High confidence

**Confidence Table**

Confidence Criteria	Low Confidence	Moderate Confidence	High Confidence
Data/Information	Neither community nor hazard specific; anecdotal only	Community or hazard specific; validated historical or scientific	Community and hazard specific; validated historical and scientific
Team knowledge	Neither hazard nor process (risk assessment) specific	Hazard or process specific	Hazard and process specific
Agreement	Neither on interpretations nor on ratings	On interpretations or ratings	On interpretations and ratings

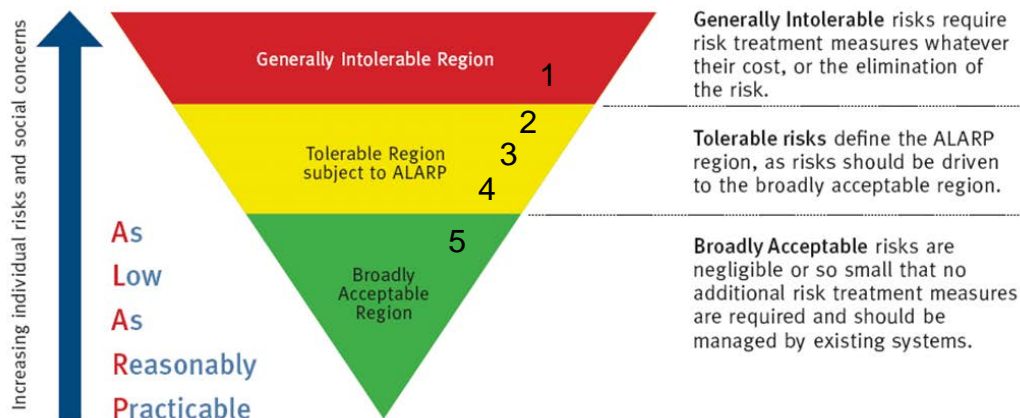
## Classification of risk tolerability:

### Risk Tolerability Tables

#### High Confidence Level

Likelihood Level	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	4	3	2	1	1
Likely	5	4	3	2	1
Possible	5	5	4	3	2
Unlikely	5	5	4	3	3
Rare	5	5	5	4	3
Very Rare	5	5	5	5	4
Almost Incredible	5	5	5	5	5

#### ALARP Principle



## Conclusion:

Risk category is ALARP 5 which is in the 'tolerable region' and should be driven further to the 'broadly acceptable region'. There is no way to reduce the risk without implementing protection to the foreshore or by raising roads (not cost effective).