Southend adaptation strategy

Report prepared for Wattle Range Council

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Wavelength

seed consulting services

OLDFIELD CONSULTING AUSTRALASIA

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Executive Summary

The township of Southend is located at the southern end of Rivoli Bay, on the south-east coast of South Australia. The coastline of Southend has been increasingly subjected to coastal erosion and inundation risks. These impacts are likely to be exacerbated by climate change and associated sea level rise in the future.

The coastal assets, public land and infrastructure within the vicinity of the coastline at Southend are subjected to increased risk, and at this time, limited strategic mitigation measures have been put in place. Wattle Range Council (Council) has commissioned Wavelength Consulting (Wavelength) to develop a robust action plan (adaptation strategy) with specific priority pathways in light of economic, environmental and community considerations.

The study utilises the *Local Government Association Coastal Adaptation Decision Pathways Investigative Framework* in developing the overarching approach to the study. The primary objective of the study is to develop a workable action plan (adaptation strategy) for Council and other stakeholders such as State Government and private landholders, to address coastal management issues faced at Southend.

Coastal processes and hazards

Coastline recession has been a major issue at Southend since at least the early 1980s when erosion at the Lake Frome Outlet first threatened the Southend Caravan Park. The original Lake Frome drain has been documented as the primary cause of the recession in various studies. The prolonged flows from the Outlet drain have reportedly caused the loss of seagrass communities from the nearshore environment thus subjecting the coastline to increased wave exposure and compounding the erosion problems.

Training walls (groynes) were constructed either side of the Outlet in 1985 and 1987 (eastern and western sides respectively). Subsequently, significant build-up of the Western beach was observed, a reduction of sediment transported to the eastern beaches as the groynes potentially prevent (reduce) the natural west – east movement of sand.

In an attempt to reduce the rate of erosion on the eastern side of the Outlet, three groynes were constructed between 1993 and 1995 between Eyre and Leake Street. Whilst the groynes have slowed down the rate of erosion they appear to be relatively ineffective in their design and/or may not be an effective choice for mitigating coastal erosion in this area. The zone of erosion extends 2kms east from the Caravan Park (Fotheringham, 1984).

Coastal protection structures

The following protection structures have been identified within the study area:

- Boat ramp carpark rock revetment wall;
- Lake Frome Outlet groynes;
- Three rock groynes between Eyre St and Leake St;

The southern revetment of the boat ramp carpark and Outlet groynes are in poor condition and the Outlet groynes themselves are approaching the end of their design life. Remedial works are necessary to ensure these structures can maintain their functional purpose.

Coastal hazard mapping
Calculated setback distances and subsequent first pass mapping of coastal hazard lines were produced to identify areas prone to coastal erosion and provide a general guidance for the adaptation strategy. Consideration was given for local long-term erosion or accretion trends, as well as potential storm erosion, and likely recession due to sea level rise.

'Bathtub modelling' was undertaken to assess areas of risk to coastal inundation for the study area, this approach was adopted for the purpose of providing a first pass assessment of areas at risk to coastal inundation. A separate technical note has been prepared outlining the calculations undertaken to support the erosion and inundation mapping (Wavelength, 2017).

Asset and infrastructure risk profiling
An asset and infrastructure database was developed to identify the assets and infrastructure at risk to either coastal erosion or inundation for the given planning scenarios. The risk assessment identified a number of assets currently at risk to coastal erosion including the beach access stairs located at Eyre St, the undeveloped private allotments north of Leake St and the low-lying land subdivided for sale between Southend Access Rd and the Lake Frome drain is currently at risk to inundation via flows from the drain.

For the 2050 scenario, if a "Do Nothing" approach was taken a number of Council assets were identified at risk as was the Caravan Park and the Southend Sailing Club. By 2100, a number of private properties between Eyre St and Leake St were identified at risk to coastal erosion as were a number of sealed roads including the Southend Bridge that connects Eliza St to Cape Buffon Drive and subsequent storm water pipes and pits.

Community and stakeholder engagement
Two community workshops were held over the course of the study. Workshop attendees, mostly from the local community, were asked to participate in a number of small group discussions, informed by maps of coastal processes, inundation and erosion risk, to generate responses to specific questions tailored to the key objectives of each workshop. The two workshops assisted in developing an understanding of the community's priorities in terms of concerns and values and to inform the social component of the options assessment for various adaptation options.

Adaptation options assessment
The approach adopted for the options assessment was a two-staged approach. A first pass assessment was undertaken of all possible options to provide an initial screening and removal of unfeasible options to be disregarded for further assessment. The viable options where then assessed using a multi criteria analysis (MCA) approach to inform the adaptation pathway.

Based on the results from the options assessment, recommended adaptation pathways were developed for each coastal compartment for Southend showing the sequencing of options through time against identified planning and action triggers. The adaptation pathways assessment has highlighted two key areas of focus:

1. There are a number of actionable items (adaptation options) that require immediate attention; and

2. The analysis has identified retreat as the likely 'best practice' approach for the settlement as a whole for the long term planning horizon (end of the century).

Summary of recommended actions
The following presents a high level summary of recommendations for short term adaptation options to be adopted and further works required to support long term adaptation pathways (detailed summary presented in Section 10.4):

- Monitoring will be paramount to the success of implementing the adaptation strategy. As a minimum the cross shore profiles captured by DEWNR should be collated and reviewed annually and the coastal hazard maps updated every five years.
- The following recommended works are to be passed onto the relevant State government departments:
    - Boat ramp and car park rock revetment (DPTI) – upgrade and repair works

- Lake Frome Outlet and groynes (SEWCDB) –a key recommendation for this strategy is to support the SEWCDB to restrict flows from the Outlet. Further to this, it is recommended that an engineering study is commissioned to investigate the optimal design of the Outlet and groynes.

- Repair works to Eyre St beach access stairs (western side)
- Dune rehabilitation and control access to the dunes north of Leake St
- Improvements to land use planning and development controls
- A number of data gaps exist in relation to the assessment of Councils liability, further investigative works are required to assist Council in determining their potential exposure to legal and political liability.
- The planned retreat of the Southend Caravan Park, Southend Sailing Club and the bush camping sites located north of Leake St is recommended with the necessary planning works to begin imminently.
- Consideration may be given to the appropriate long-term management of Council assets. An audit of Council assets should be undertaken to inform if the asset should be 'managed to fail' or replaced and relocated inland.
- The analysis has identified retreat as the likely 'best practice' approach for the settlement as a whole for the long term planning horizon (end of the century), more specifically as the adaptation pathway for private property. Given the complexity of implementing such an approach a key recommendation of this study is to commission an investigation into the viability of implementing this approach. The following works would be required:
    - Develop a strategy document to outline the potential options and recommended method for managing a planned retreat of private properties and associated infrastructure (roads, lighting, stormwater).
    - Financial modelling to be undertaken to further confirm the viability of a managed retreat.
    - Staged community and stakeholder engagements to communicate findings and work towards stakeholder buy-in for the proposed adaptation pathway.

Further to the above, a number of data gaps have been identified as part of this project. The importance and relevance of these gaps in supporting the adaptation strategy including the required scope of works to subsequently fill the gaps are summarised in Section 10.5.

1 Introduction

1.1. Background

The township of Southend is located at the southern end of Rivoli Bay, on the south-east coast of South Australia (400kms south east of Adelaide). Southend was settled in 1842, and has a population of approximately 260 however is a popular tourist destination with increases in population during the summer months and holiday periods.

The coastline of Southend has been increasingly subjected to coastal erosion and inundation risks. These impacts are likely to be exacerbated by climate change and associated sea level rise in the future.

The coastal assets, public land and infrastructure within the vicinity of the coastline at Southend are subjected to increased risk, and at this time, limited strategic mitigation measures have been put in place. Wattle Range Council (Council) has commissioned Wavelength Consulting (Wavelength) to develop a robust action plan (adaptation strategy) with specific priority pathways in light of economic, environmental and community considerations. This project was jointly funded by the Coastal Protection Board (CPB), the Local Government Association of South Australia and the Council.

Figure 1: Southend locality plan

Figure 2: Study area

1.2. Approach

The study utilises the *Local Government Association Coastal Adaptation Decision Pathways Investigative Framework* in developing the overarching approach to the study. A number of stages were undertaken in developing the adaptation strategy in line with the Framework, as summarised below:

1. Data collation and review;
2. Coastal hazard mapping;
3. Review of coastal protection structures and strategies (including a review of history and performance);
4. Coastal asset and infrastructure risk profiling;
5. Asset costing and assessment of liability;
6. Community and stakeholder engagement; and
7. Adaptation option assessment and action planning

The primary objective of the study is to develop a workable action plan (adaptation strategy) for Council and other stakeholders such as State Government and private landholders, to address coastal management issues faced at Southend. In addition to this, a gap analysis was developed, outlining the required scopes of work to build on the adaptation strategy and fill critical data gaps. This gap analysis is presented in Section 10.5.

2 Coastal process and protection structures

2.1. Summary of coastal processes and hazards

Relevant historical reports, studies and correspondence between Council and the CPB have been reviewed. In addition to this, analysis was undertaken of 15 cross-shore profiles captured by the Department of Environment Water and Natural Resources (DEWNR) for the past 60 years within the study area. The specific locations and detailed analysis of the profiles is provided in the supporting technical note "Southend adaptation strategy – erosion and inundation mapping calculations" (Wavelength, 2017). A summary of coastal processes and subsequent coastal management issues at Southend is provided below and presented in Figure 3:

- The net sediment transport pathways are driven by the diffraction of waves around Cape Buffon, driving sediment towards the bay foreshores, with littoral drift directed toward the Lake Frome Outlet (Worley Parsons, 2015). East of the Outlet, the net sediment transport direction is considered to be northerly. However, the net littoral transport in this area is not strong (relative to the northern parts of Rivoli Bay e.g. Beachport). This is evidenced by the shoreline between the individual groynes east of the Outlet, which are closely aligned to the dominant wave angles. Further to this, given the shallow nature of Rivoli Bay the littoral zone (offshore extend of sediment movement) is considered to extend a significant distance offshore.

- Typical seasonal cross-shore (onshore-offshore) sediment transport occurs along the foreshore at Southend. Sand moves offshore during storm events (typically over the winter months) and is transported onshore again under calmer conditions (typically over the summer months). Sand is understood to be carried offshore around Cape Buffon in the winter months, where it moves further south along the coast and is effectively lost from Rivoli Bay (Worley Parsons, 2015).

- It should be noted that the importance of other hydrodynamic forces (beyond wave-driven currents) have been underplayed and are not well understood, particularly with respect to seasonal behaviours. The lack of supporting measured data in Rivoli Bay to quantify the hydrodynamic influences on coastal processes has been noted as a data gap for the Council to consider pursuing.

- Coastline recession has been a major issue at Southend since at least the early 1980s when erosion at the Lake Frome Outlet first threatened the Southend Caravan Park. This erosion prompted initial coastal studies, including the 1984 Southend Foreshore Erosion Study (Fotheringham, 1984) which reported erosion of up to 70m. The original Lake Frome drain (constructed in 1887) has been documented as the primary cause of the recession in various studies. The drain is reported to have prolonged periods of flow which carries sediment offshore, which is evidenced by a distinct sea-bed channel extending seaward from the Outlet for approximately 400m (Fotheringham, 1984). Further to this, the prolonged flows from the Outlet drain have reportedly caused the loss of seagrass communities from the nearshore environment (due to poor water quality), thus subjecting the coastline to increased wave exposure and compounding the erosion problems.

- Training walls (groynes) were constructed either side of the Outlet in 1985 and 1987 (eastern and western sides respectively). Subsequently, significant build-up of the Western beach was observed (accretion of up to 32m observed between 1988 and 1989). The beach has remained relatively stable since 2005. The Coastal Management Branch (CMB) of DEWNR reported the Outlet training walls may not be of optimum length as they potentially prevent (reduce) the natural west – east movement of sand, reducing sediment transport to the beach fronting the Caravan Park (CMB, 1994). Subsequent mechanical sand bypassing from Western beach to the Caravan Park beach has been required intermittently, however it is understood that bypassing hasn't been carried out for a number of years. Further to this, a significant volume of sand transported around the end of the western Outlet groyne appears to be trapped within the drain, and thus has not been allowed to replenish the beaches east of the Outlet.

- Despite sand replenishment works (CMB's reported expenditure of approximately $380K in total between 1983 and 2014), recession has continued on the eastern side of the Outlet since the construction of the Outlet groynes, and the Caravan Park continues to be threatened by erosion.

Recession of up to 14m in front of the Caravan Park was observed over the 29 year period (between 1988 and 2017).

- In an attempt to reduce the rate of erosion on the eastern side of the Outlet, three groynes were constructed between 1993 and 1995 between Eyre and Leake Street. Whilst the groynes have slowed down the rate of erosion they appear to be relatively ineffective in their design and/or may not be an effective choice for mitigating coastal erosion in this area. Typically, an effective groyne field would see substantial build-up of sand on the updrift (southern) side of each groyne. This has not been observed, with modest/negligible build-up of sand on the southern side of each groyne. Overall recession of approximately 8m has occurred in the vicinity of the groynes over the 17 years between 2000 and 2017.

- The zone of erosion extends 2kms east from the Caravan Park (Fotheringham, 1984). This is further supported in the review of the cross-shore profiles with recession observed in all profiles north of the groynes over the recorded periods. The greatest rate of recession observed is at profile 725038 (location shown in Figure 3) of 20m over a 15 year period (2002 – 2017).

- Inundation mapping was undertaken by the DEWNR in 2009 (DEH, 2009), the mapping highlighted present day and future inundation risks to the boat ramp car park and other low lying areas. Areas of identified risk include the area behind (landward of) the primary dune north east of Leake St, and the vegetated area directly behind Western Beach.

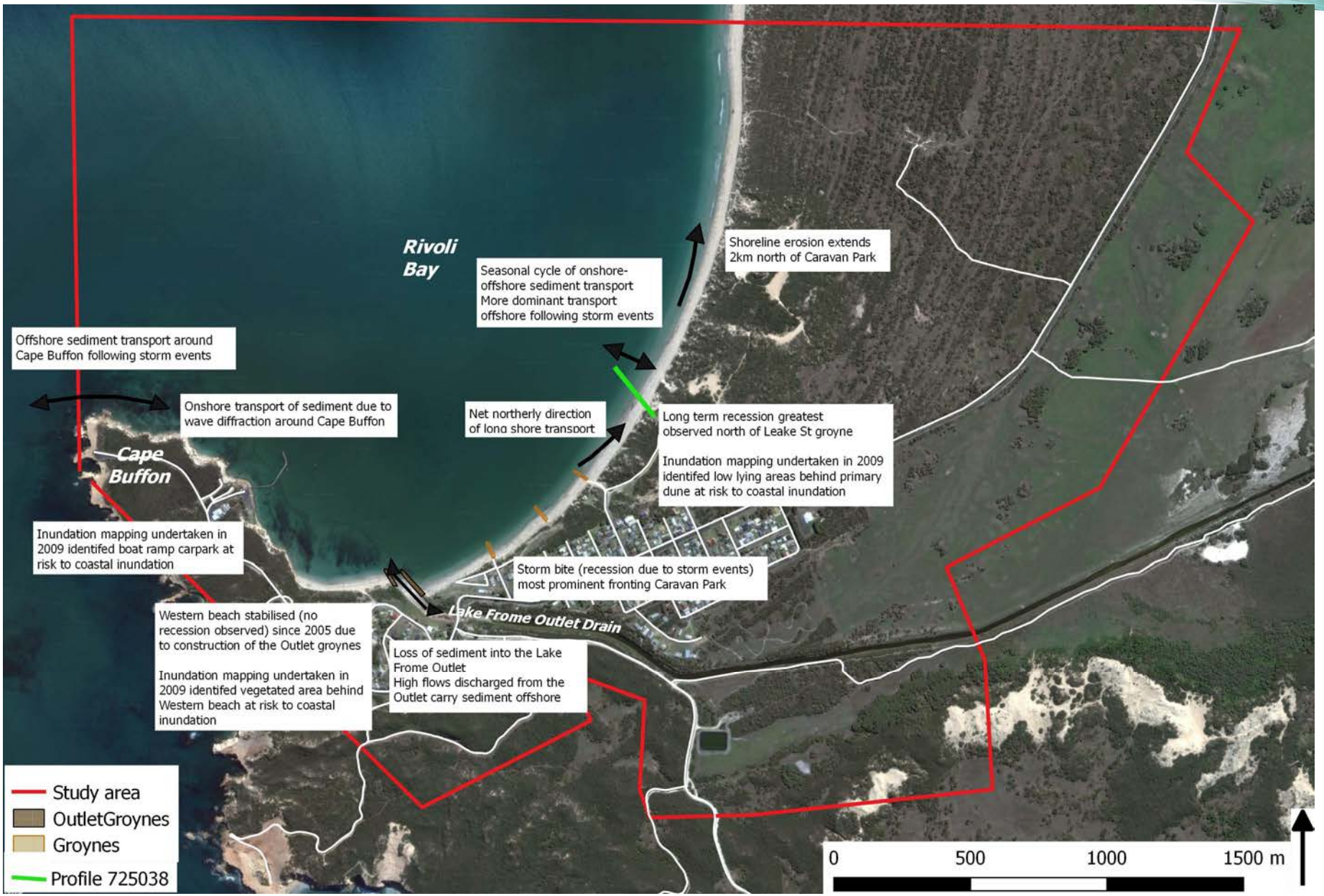


Figure 3: Overview of coastal processes and coastal management issues

2.2. Summary of coastal protection structures

The following protection structures have been identified within the study area, and are present in Figure 4:

- Boat ramp carpark rock revetment wall
- Lake Frome Outlet groynes
- Three rock groynes between Eyre St and Leake St

Whilst ad-hoc beach renourishment has been undertaken, no formalised strategy has been put in place and therefore has not been assessed as an existing protection strategy. Beach renourishment is further discussed as an adaptation option in Section 9.

Figure 4: Coastal protection structure location map

The performance and condition of the structures is summarised in the Worley Parsons report "Assessment of Existing Coastal Structures" dated October 2015. A site visit was undertaken by Wavelength on 9 September 2017 to confirm and build on the 2015 findings. The history, performance and condition of each structure is discussed in more detail below.

2.2.1. Boat ramp carpark rock revetment

The rock revetment surrounding the boat ramp carpark is under the jurisdiction of the Department of Planning, Transport and Infrastructure (DPTI), as is the boat ramp, car park and jetty. DPTI were unable to confirm in their archival search the date the rock revetment was constructed and where not able to provide supporting documentation for the design and conditions of approval. Notwithstanding this, it is understood the revetment was constructed at the time of the boat ramp to provide protection to the car park and land adjacent to the jetty.

The revetment wall immediately surrounding the jetty is in good condition, and appears to include a mix of basalt and limestone armour rock (Figure 5). The revetment north of the boat ramp is subject to direct wave attack diffracted around Cape Buffon, whilst the eastern facing wall is subject to oblique waves (Worley Parsons, 2015). The revetment is overtopped during storm events, with evidence of dislodged small armour stones and gravel thrown into the carpark.

The revetment south of the boat ramp is constructed of limestone and is in poor condition (Figure 6), with the underlying fill material exposed and subject to erosion from wave overtopping. At the southern end of the revetment, rock armour has been replaced in an ad-hoc fashion with concrete and building rubble (Figure 7).

Figure 5: Northern revetment (directly north of jetty)

Figure 6: Southern revetment (directly south of boat ramp)

Figure 7: Ad-hoc rubble placement - southern end of revetment

2.2.2. Outlet groynes

The Outlet groynes are under the jurisdiction of the South Eastern Water Conservation and Drainage Board (SEWCDB).

The initial intention of the Outlet groynes was to limit the recession of the shoreline to the east given the net sediment transport was observed from west to east. Modelling of the Outlet drain incorporating various design options was undertaken by the CMB and subsequently the CMB prepared the design requirements for the training walls as recommended by the CPB. The SEWCDB were to finalise the design to incorporate the recommendations. SEWCDB were unable to provide the original engineering drawings, documentation supporting conditions of approval or maintenance records at the time of this study.

The eastern groyne (training wall) was built in April 1985. It was accepted that this was a preliminary measure and that further works may be required. Erosion continued on the eastern side of the groyne and a significant build-up of the Western beach was observed, confirming the net sediment transport from west to east. Subsequently, the western training wall was constructed in 1987 to limit the loss of the sediment into the Outlet.

In terms of performance, whilst the groynes have achieved a significant build up and stabilisation of the Western beach, shoreline recession (erosion) continues along the coast east of the Outlet groynes. As outlined in Section 2.1, the groynes prevent or reduce the natural west – east movement of sand, depriving the beach fronting the Caravan Park (CMB, 1994) of sand. Further to this, a significant volume of sand transported around the end of

the western Outlet groyne appears to be trapped within the drain, and thus has not been allowed to replenish the beaches east of the Outlet.

The Outlet groynes are in poor conditions as described in the Rivoli Bay Coastal Study (Worley Parsons, 2015). In summary:

- Damaged and slumping rock armour observed at both the eastern and western groynes;
- The primary rock armour is limestone, with large areas of exposed core rock at both groynes;
- Exposed clay cap at both groynes, the 2015 inspection reported the clay core and capping of the eastern groyne was severely eroded especially on the more exposed northern side of the groyne (Figure 8), remedial works (additional rock placement) was evident in the 2017 site inspection (Figure 8);
- Ad-hoc repairs to groynes with concrete and building rubble has been carried out (Figure 9).

Figure 8: Left - Severe damage reported in 2015, eastern side of eastern Outlet groyne (Source: Worley Parsons, 2015) Right – remedial works as observed during 2017 inspection

Figure 9: Western Outlet groyne. Note poor condition of clay capping and core, use of concrete rubble to repair damage

2.2.3. Groynes between Eyre St and Leake St

In an attempt to reduce the rate of erosion on the eastern side of the Outlet, three groynes were constructed from 1993 to 1995 between Eyre and Leake Street. At the time of the study the tenure/management responsibility of the three groynes was unable to be confirmed, and this is considered a significant gap in the study given the potential liability risks the Council may be exposed to, as discussed further in Section 5. Further to this, supporting documentation such as engineering designs, the original development applications and subsequent conditions of approval were not able to be provided at the time of this study. This has been identified as a data gap for the study (Wavelength, 2017b).

Notwithstanding this, an archival search of the CMB's project files for Southend identified the following correspondence in relation to the rock groynes:

- A letter from the Minister of Environment and Planning to the President of the Southend Progress Association dated 5th May 1992 stated that the Council (District Council of Millicent at the time) had decided to trial a temporary groyne on the eastern side of the Outlet (Eyre St groyne). The letter outlined that a number of conditions (set by the CPB) were to be met prior to approval. The only condition outlined in the letter was the groyne be filled with sand at the time of construction to minimise downdrift erosion. This involved the ongoing bypassing of sand from the western beach.

- The CPB recommended in April 1994 that the Eyre St groyne be extended for testing prior to more groynes being constructed. However, the second groyne (Dashwood St) was built with timber at the time the Eyre St groyne was extended, and sand infilling of the beach between the groynes was undertaken post construction. By the time that the third groyne (Leake St) was constructed in 1995 (including additional sand infilling) a positive result from the extension of Eyre St groyne was noted.

In terms of performance, it is important to note that the intent of the groyne field was to slow down the rate of erosion. Analysis of cross-shore profiles in the vicinity of the groynes (refer supporting technical note; Wavelength, 2017) demonstrates that while the groynes have slowed down the rate of erosion, they appear to be inefficient in their design. Potential reasons why the groyne field has been inefficient include:

- They may be of insufficient in length, and the littoral drift zone extends significantly beyond the end of the groynes; and/or

- Cross-shore sediment transport is more dominant than alongshore processes.

A more detailed assessment of the sediment pathways would be required to confirm if lengthening the groynes would be effective.

The condition of the groynes is well documented in the Rivoli Bay Coastal Study (Worley Parsons, 2015) and summarised below:

- Eyre St groyne is in reasonable condition, constructed of a mix of limestone and basalt armour, generally good interlocking between armour on the northern side and head of the groyne. Dislodged armour, exposed core amour and repairs with concrete rubble are evident on the southern side (Figure 10).

- Dashwood St groyne is constructed of limestone primary armour, and bounded on the southern side by a vertical timber face. The groyne is in good condition, although smaller armour stones are exposed and some dislodged and deposited on the southern side of the groyne (Figure 11).

- Leake St groyne is constructed of basalt rock armour, bounded on the southern side by a timber wall. The groyne is in fair condition, and remedial works appear to have been undertaken since the 2015 condition assessment report undertaken by Worley Parsons. Limestone rock armour has been placed on the landward end of the northern side of the groyne where severe erosion and undermining was previously observed (Figure 12).

Figure 10: Dislodged armour, concrete rubble – southern side of Eyre St groyne

Figure 11: Dashwood St groyne, dislodged armour on southern side

Figure 12: Remedial works at the landward end of northern side of Leake St groyne. (Top photo source Worley Parson, 2015).

2.2.4. Summary

Of the protection structures discussed the Council may have an obligation to maintain the rock groynes between Eyre St and Leake St, however further investigation is required to confirm this. The potential liability for Council is discussed further in Section 5.

The boat ramp rock revetment and the Outlet groynes are under the jurisdiction of the State government (DPTI and SEWCDB respectively), not Council. Notwithstanding this, it is noted that the southern revetment of the boat ramp carpark and Outlet groynes are in poor condition and the Outlet groynes themselves are approaching the end of their design life. Remedial works are necessary to ensure these structures can maintain their functional purpose. This report will be provided to DPTI and SEWCDB for consideration of remedial works. Further to this, the adaptation options assessment will take into consideration the fate of the drain itself and the potential to shorten and or remove the Outlet groynes.

For each of the coastal protection structures a protection deficit report has been prepared (are presented in Appendix A). These include a summary of damage, repair recommendations, proposed remedial works and associated costs.

3 Coastal hazard mapping

A requirement of the Framework is to undertake coastal erosion and inundation mapping to identify the assets and infrastructure at risk. This mapping is subsequently used to inform the adaptation strategy. A separate technical note has been prepared outlining the calculations undertaken to support the erosion and inundation mapping (Wavelength, 2017), with a summary provided below.

3.1. Planning horizons

The following planning horizons have been adopted for this study:

- 2017 – current state of play, identifying immediate risks.
- 2050 – provides a medium-long term (33 years) outlook of risks, providing adequate time for adaptation strategies to be employed catering for the second half of the century, while allowing the time to monitor and verify projected erosion and inundation scenarios.
- 2100 – allows for transparency of potential risks by the end of century, informing short to medium term decisions

3.2. Sea level rise

When considering coastal inundation and long term recession effects and planning for coastal development, the state planning policy recommends an allowance of 0.3 m for sea level rise (SLR) to the year 2050, and 1 m by 2100.

An allowance of SLR for the 2017 scenario has also been applied on the premise that sea level has been rising in South Australia at a rate of 4.3mm per year (BoM, 2011), therefore an adjustment has been made of 0.1m (4.3mm x 27years = 116.1mm, rounded to 0.1m) to account for the SLR between the 1990 bench marks and present day.

To summarise, the sea level rise scenarios adopted for this study are as follows:

- 2017 – 0.1 m
- 2050 – 0.3 m
- 2100 – 1.0 m

3.3. Storm inundation parameters

CPB has provided storm induced inundation parameters for the 100 year ARI event for Southend, including the storm water level (referenced to 1990 benchmarks), wave setup and wave run-up.

3.4. Inundation mapping

3.4.1. Approach

'Bathtub modelling' was undertaken to assess areas of risk to coastal inundation for the study area. Bathtub models are elevation based, applying a deterministic level across a digital elevation model (DEM), to identify the areas below the given inundation scenario. There are a number of limitations to the bathtub model approach, as detailed in the supporting technical note (Wavelength, 2017). However for the purpose of providing a first pass assessment of areas at risk to coastal inundation, the bathtub model approach is considered sufficient.

Table 1 presents the coastal inundation parameters for the relevant planning horizons which will be applied for the coastal inundation mapping. It should be noted that terrestrial flooding was not considered in this assessment.

Table 1: Storm Inundation Parameters for Southend (AHD)

Parameter	2017 Scenario	2050 Scenario	2100 Scenario
100yr ARI Storm water level	1.4	1.4	1.4
Wave setup	0.1	0.1	0.1
Wave runup	0.5	0.5	0.5
Sea level rise	**0.1**	**0.3**	**1.0**
TOTAL	**2.1**	**2.3**	**3.0**

3.4.2. Results

The three coastal inundation scenarios presented in Table 1 were mapped using the airborne light detection and ranging (LiDAR) derived DEM with a horizontal spatial resolution of 2m and a vertical accuracy of 0.5m captured in 2008 (LCRDA, 2008). The results of this mapping exercise are displayed in Figure 13.

It is noted that the magnitude of the sea level rise projected this century is likely to result in significant shoreline erosion which may result in more significant inundation hazards. Nevertheless the inundation extents displayed in Figure 13 are considered to provide a reasonable indication of the broad extent of the potential coastal inundation hazards along the study area coastline.

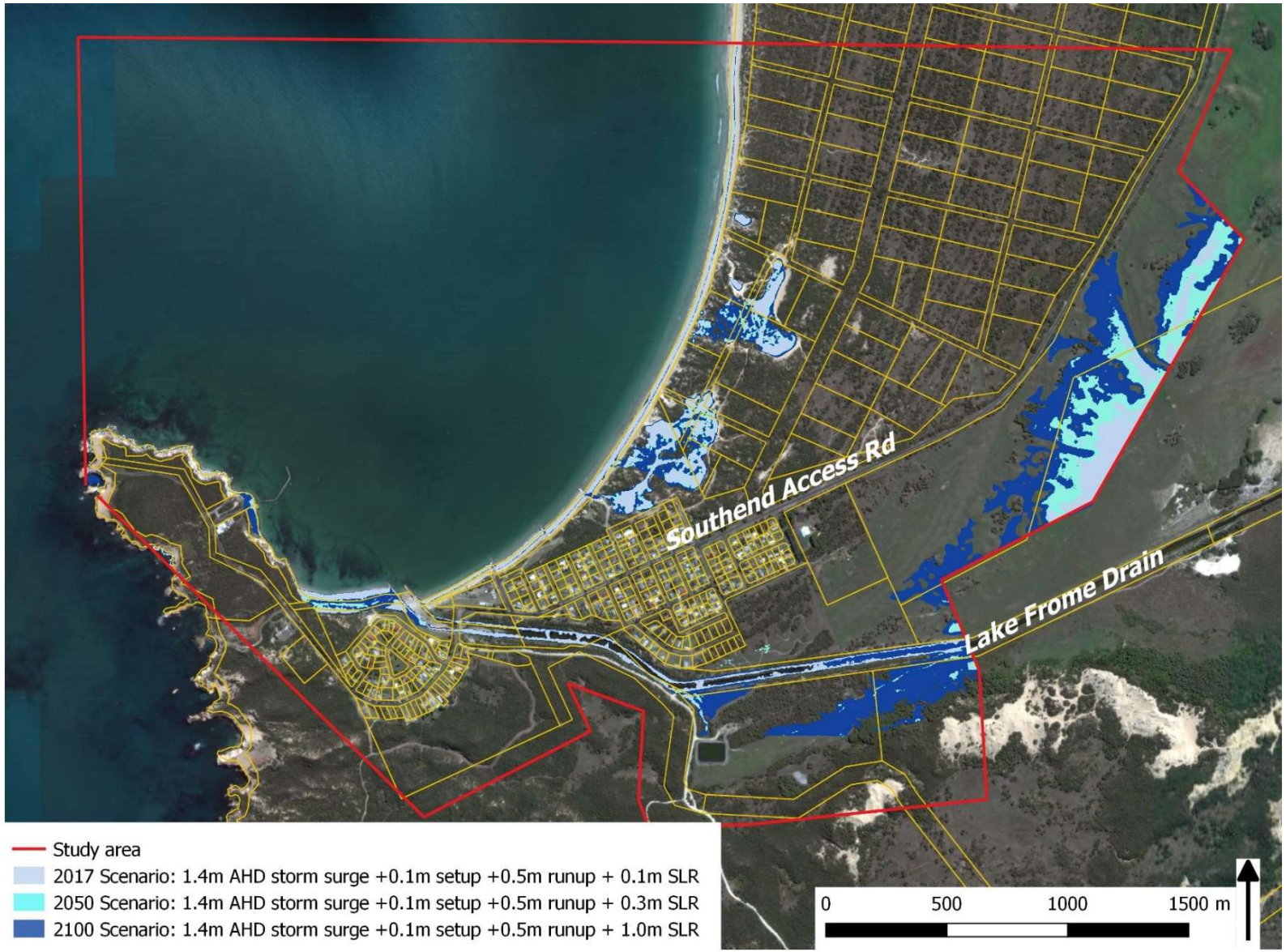


Figure 13: Coastal Inundation Mapping for 2017, 2050 and 2100 Scenarios

3.5. Erosion mapping

3.5.1. Approach

The CPB's policy for coastal erosion, flooding and sea level rise states that for consideration of erosion setbacks, estimates need to be made of the potential coastal retreat during the next 100 years. The policy recommends that local long-term erosion or accretion trends be considered, as well as potential storm erosion, and likely recession due to sea level rise (SLR) (CPB, 1992). These three factors have been considered in establishing the erosion mapping for the relevant planning horizons (2050 and 2100) and are discussed in more detail below:

- **Storm erosion (S1):** SBEACH (Storm-induced BEAch CHange) software was used to predict and analyse short–term, storm-induced erosion at the site. Model inputs including design storm conditions and results are presented in the supporting technical note (Wavelength, 2017).

- **Long-term erosion or accretion (S2):** analysis was undertaken of 15 cross-shore profiles captured by the DEWNR for the past 60 years. The profiles have typically been captured annually, and post-summer (April, May), locations and analysis is presented in the supporting technical note (Wavelength, 2017).

- **Recession due to sea level rise S3):** a Bruun factor was applied to provide a first pass assessment for setbacks due to sea level rise. On open coasts, the Bruun factor "rule of thumb" is typically in the range of 50 to 100 (Mariani et al, 2012). That is, coastal recession will be 50 to 100 times the SLR. By adopting this "rule of thumb" approach it provides a conservative approach to identifying areas potentially at risk.

It is acknowledged that a limitation to this study is the limited availability of field data to calibrate and verify the calculations set out in the supporting technical note. Given this, the calculated setback distances provide a first pass assessment of the areas at risk to inform the adaptation strategy, and are to be used as approximations only.

Recognising these limitations, a conservative approach has generally been adopted throughout the calculations. A more robust dataset of wave data, water levels and spatial elevation data would provide further confidence to the mapping and has been identified in the gap analysis of the adaptation strategy (Section 10.5).

Mapping of coastal hazard lines were produced to provide a general guidance for the adaptation strategy and to identify areas prone to coastal hazards. It is acknowledged that best practices in coastal management industry are moving away from the use of coastal hazard lines, towards risk-based approaches. However, the conservative approach of mapping coastal hazard lines is considered sufficient for this study to provide a first pass assessment of areas at risk to coastal recession and erosion (Gordon, 2015).

3.5.2. Results

A summary of setback allowances from the proceeding information is presented in Table 2. The following coastal hazard lines were mapped for present day conditions, 2050 and 2100 as shown in Figure 14 - Figure 16:

- Immediate zone of wave impact (ZWI) (S1);

- Almost certain zone of recession (ZR) (S1+ S2);

- Likely ZR (S1+S2+S3 (BR50));

- Possible ZR (S1+S2+S3 (BR100));

The immediate ZWI hazard line was positioned based on the potential storm erosion (S1), relative to the Horizontal Setback Datum (HSD). The future hazard lines for the 2050 and 2100 scenarios were estimated by taking the immediate ZWI hazard line (S1 component) and adding the underlying long-term recession (S2) and recession due to sea level rise (S3).

Table 2: Summary of setback allowances for present day, 2050 and 2100

Location	Present Erosion setback (m) S1	Future erosion setback (m)					
		2050 Scenario			2100 Scenario		
		S1 +S2	S1 +S2 +S3(BR50)	S1 +S2+ S3(BR100)	S1+S2	S1 +S2+ S3(BR50)	S1+S2+ S3(BR100)
Section 1	15	15	30	45	15	65	115
Section 2	15	31.5	46.5	61.5	56.5	106.5	156.5
Section 3	15	31.5	46.5	61.5	56.5	106.5	156.5
Section 4	15	58	73	88	123	173	223

Figure 14: Coastal erosion hazard lines: Section 1

(Note: Coastal hazard Lines Immediate ZWI, 2050 Almost Certain ZR and 2100 Almost Certain are located in the same position)

Figure 15: Coastal erosion hazard lines: Section 2 and Section 3

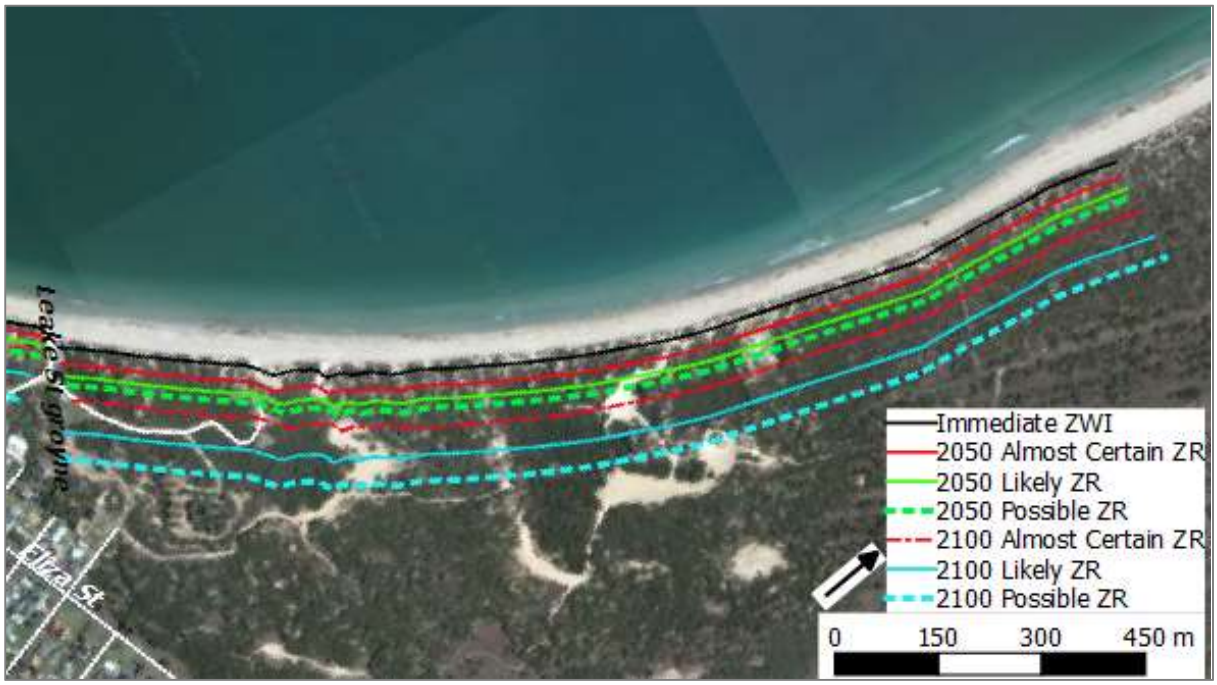


Figure 16: Coastal erosion hazard lines: Section 4

4 Asset and Infrastructure risk profiling

Analysis has been carried out to identify all the assets that may be at risk from coastal inundation or erosion (whether in public or private ownership). The developed risk profiles have subsequently been used to identify priority areas to inform the adaptation strategy.

4.1. Approach

An asset and infrastructure database was developed using a cadastre map (informed by the erosion and inundation maps presented in Section 2) to identify the assets and infrastructure at risk to either coastal erosion or inundation for the given planning scenarios. The asset and infrastructure database is presented in Appendix B, including asset descriptions in terms of construction materials, ownership information and asset values.

The asset database was separated into state owned, privately owned and council owned assets. Where ownership is currently unclear, they have been included under Council's assets as a conservative approach. Additional documentation will need to be sought by Council to inform potential liabilities, as discussed further in Section 5.

For developing inundation risk profiles for each of the planning scenarios, the Framework recommends that inundation maps (as presented in Section 2) are used to identify the greatest depth of flood for each of the assets at risk. This information is used to determine monetary values for each of the assets at risk using damage curves (as described further in section 6). Further to this, the Framework does not prescribe a method for evaluating the level of risk with regard to erosion.

Given a significant data gap of this study is the quality of the spatial data available, the gap analysis for this study outlines the recommendation to update the inundation mapping and subsequent depth of flooding information per asset when the LiDAR is made available (Section 10.5).

Further to this, the cadastre for the recent subdivision between the Southend Access Rd and the Lake Frome drain was not provided, therefore whilst this area is low lying and has been identified as an area at risk to coastal inundation an assessment for the subdivision was able to be undertaken. This has been identified as a data gap, scope of works required to fill this gap are detailed in Section 10.5.

A qualitative approach was developed to assess the magnitude of the risks associated with both erosion and inundation. The developed risk profiles will be used to identify priority areas to inform the adaptation strategy.

In determining the risk profiles, the likelihood descriptors assigned for erosion and inundation were slightly different and are discussed further below:

- As described in the supporting technical note (Wavelength, 2017b), for assessing coastal erosion, the coastal hazard line descriptors "Almost certain, "Likely" and "Possible" were adopted from the likelihood descriptors and the cumulative probability of an event occurring over a 60 year lifetime as developed by the Australian Geomechanics Society (AGS) in 2007, as presented in Table 3.

- In determining the likelihood descriptors assigned for the inundation risk profiles, they were determined based on the probability of the 100yr ARI event occurring for the relevant planning horizon, and assigning the relevant descriptor outlined in Table 3, for the three planning horizons:

    - **Present day scenario**: there is a 1% probability of a 100-year ARI event occurring within the year therefore an **Unlikely** likelihood descriptor was assigned;

    - **2050 scenario**: there is a 33% probability of a 100-year ARI event occurring in the next 33 years, therefore a **Likely** likelihood descriptor was assigned;

    - **2100 scenario**: there is an 83% probability of a 100-year ARI event occurring in the next 83 years, therefore an **Almost Certain** likelihood descriptor was assigned

The assessment of consequences for both erosion and inundation was based on a "Do Nothing" scenario and adopting the local government framework for coastal risk assessments in Australia developed for damage to infrastructure and services, and the environment (Wainwright, D. et.al, 2016), presented in Table 4. The subsequent likelihood versus consequence risk matrix is presented in Table 5 below.

Table 3: Likelihood descriptors (AGS, 2007)

Descriptor	Designated Annual Exceedance Probability	Designated cumulative probability of event occurring over design life of 60 years
Almost Certain	5%	95.4%
Likely	0.5%	26%
Possible	0.05%	3%
Unlikely	0.005%	0.3%
Rare	0.0005%	0.03%
Barely Credible	<0.0005%	<0.03%

Table 4: Consequence descriptors (AGS, 2007)

Descriptor	Approximate quantum of damage (cost)	Asset and Infrastructure - Description	Environment - Description
Catastrophic	>100%	Significant permanent damage and/or complete loss of the infrastructure and the infrastructure service Loss of infrastructure support and translocation of services to other sites	Very significant loss to the environment May include localised loss of species, habitats or ecosystems Extensive remedial action essential to prevent further degradation Restoration likely to be required
Major	40 to 100%	Extensive infrastructure damage requiring major repair Major loss of infrastructure service	Significant effect on the environment and local ecosystems Remedial action likely to be required
Medium	10% to 40%	Limited infrastructure damage and loss of service Damage recoverable by maintenance and minor repair	Some damage to the environment, including local ecosystems Some remedial action may be required
Minor	1% to 10%	Localised infrastructure service disruption No permanent damage Some minor restoration work required	Minimal effects on the natural environment
Insignificant	<1%	No infrastructure damage, little change to service	No adverse effects on natural environment

Table 5: Likelihood/Consequence Matrix (AGS, 2007)

Likelihood	Consequence				
	Catastrophic	Major	Medium	Minor	Insignificant
Almost Certain	Very High	Very High	Very High	High	Medium
Likely	Very High	Very High	High	Medium	Low
Possible	Very High	High	Medium	Medium	Very Low
Unlikely	High	Medium	Low	Low	Very Low
Rare	Medium	Low	Low	Very Low	Very Low
Barely Credible	Low	Very Low	Very Low	Very Low	Very Low

The likelihood and consequence descriptors assigned for each asset and planning scenario are presented in Appendix B. A summary for each of the categories (private, state and council) is presented in Table 6 – Table 8 below. It should be noted that only properties and assets identified at risk have been included in the Tables below. Further to this, the roads referenced related to the actual length of road, and subsequent footpath and kerb as shown for the relevant planning horizons as presented in Figure 17 – Figure 19.

Table 6: Risk profiles for privately owned assets

Address	Coastal Hazard	2017	2050	2100
17 Brides Dve	Erosion	no	no	**VERY LOW**
21 Bridges Dve	Erosion	no	no	**VERY LOW**
1 Eyre St	Erosion	no	no	**VERY HIGH**
3 Eyre St	Erosion	no	no	**VERY HIGH**
1 Mac Donald St	Erosion	no	no	**VERY HIGH**
2-4 MacDonald St	Erosion	no	no	**VERY HIGH**
2 Bonney St	Erosion	no	no	**VERY HIGH**
1 Bonney St	Erosion	no	no	**VERY HIGH**
2 Dashwood St	Erosion	no	no	**VERY HIGH**
1 Dashwood St	Erosion	no	no	**VERY HIGH**
2 Evelyn St	Erosion	no	no	**MEDIUM**
Private allotments (undeveloped blocks) north of Leake St	Erosion	**MEDIUM**	**VERY HIGH**	**VERY HIGH**
	Inundation	**VERY LOW**	**LOW**	**MEDIUM**
Private allotments (undeveloped blocks) between the Southend Access Rd and the Lake Frome Drain	Inundation	**Yet to be assessed**		

Table 7: Risk profiles for Council owned asset

Asset	Coastal Hazard	2017	2050	2100
Foreshore Reserve Bridges Drive - BBQ and shelter	Erosion	no	HIGH	VERY HIGH
	Inundation	no	no	MEDIUM
Foreshore Reserve Bridges Drive - Public Toilet	Erosion	no	no	VERY HIGH
Foreshore Reserve Bridges Drive - Effluent Disposal Point	Erosion	no	no	VERY HIGH
Foreshore Reserve Bridges Drive - Boardwalk	Erosion	no	MEDIUM	VERY HIGH
Foreshore Reserve Eyre Street - Foreshore stairs	Erosion	HIGH	VERY HIGH	VERY HIGH
Southend Caravan Park - Amenities Block	Erosion	no	VERY HIGH	VERY HIGH
Southend Caravan Park - Office	Erosion	no	VERY HIGH	VERY HIGH
Southend Caravan Park - Power Outlets	Erosion	no	VERY HIGH	VERY HIGH
Foreshore Reserve Eyre Street - Public Toilet	Erosion	no	VERY HIGH	VERY HIGH
Foreshore Reserve Eyre Street - Ladies Public Change Room	Erosion	no	VERY HIGH	VERY HIGH
Foreshore Reserve Eyre Street - Men's Public Change Room	Erosion	no	VERY HIGH	VERY HIGH
Cape Buffon Dr	Erosion	no	no	VERY HIGH
Bridges Dr	Erosion	no	no	VERY HIGH
Eyre St	Erosion	no	VERY HIGH	VERY HIGH
MacDonald St	Erosion	no	no	VERY HIGH
Bonney St	Erosion	no	no	VERY HIGH
Evelyn St	Erosion	no	no	VERY HIGH
Dashwood St	Erosion	no	no	MEDIUM
Leake St	Erosion	no	no	MEDIUM
Stormwater and sewerage	Erosion	no	no	MEDIUM
Sailing Club (Ownership yet to be confirmed)	Erosion	no	VERY HIGH	VERY HIGH
Bush camping sites (north of Leake St) (Ownership yet to be confirmed)	Erosion	no	MEDIUM	VERY HIGH
	Inundation	LOW	MEDIUM	HIGH

Table 8: Risk profiles for State owned asset

Asset	Coastal Hazard	2017	2050	2100
Boat ramp Carpark	Inundation	no	no	**MEDIUM**
Lighting (Electricity poles)	Erosion	no	no	**VERY HIGH**
Southend Bridge (connecting Eliza St to Cape Buffon Dve)	Erosion	no	no	**VERY HIGH**

4.2. Summary

4.2.1. 2017 Scenario

Below provides a summary of assets at risk for the present day scenario, if a "Do Nothing" approach was taken, location of assets at risk as shown in Figure 17:

- Immediate risks are identified for the two beach access arrangements either side of the Eyre St groyne due to storm damage.

- Three of the privately sold allotments within the coastal conservation areas north of Leake St are at risk to short term erosion due to storm events (as shown in Figure 17), and the shoreward boundary of the parcels of land are currently exposed to wave action. The allotments are also at risk to coastal inundation. Given the path of egress is likely to allow the water to quickly dissipate, the inundation risk is considered to be very low, and the primary risk for these lots is related to erosion (medium risk).

- The low-lying land subdivided for sale between Southend Access Rd and the Lake Frome drain is currently at risk to inundation via flows from the drain. Without the boundary extents for the allotments it is difficult to determine the magnitude of the inundation risks, Council will need to provide boundary extents for the parcels of land for sale to confirm risks.

Figure 17: Assets at risk to coastal erosion or inundation (2017 Scenario)

4.2.2. 2050 Scenario

The following assets would be at risk to coastal erosion for the 2050 scenario, if a "Do Nothing" approach was taken, location of assets at risk as shown in Figure 18:

- The foreshore reserve at Eyre St and related structures (toilet and shower blocks);
- The Caravan Park and related structures (amenities block, office and power facilities);
- The Southend Sailing Club;
- The bush camping sites north of Leake St; and
- The coastal reserve at Western Beach including the BBQ, shelter and boardwalk

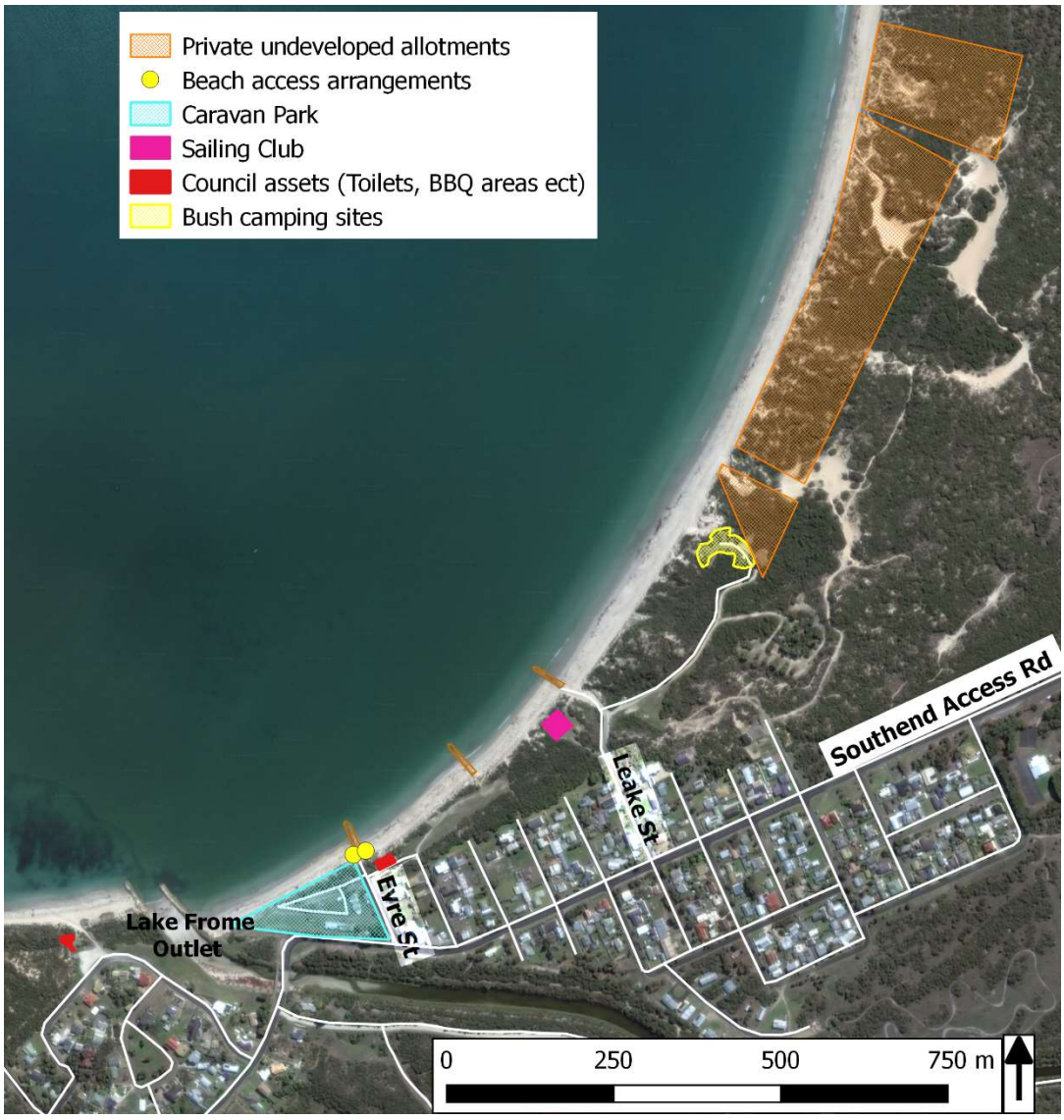


Figure 18: Assets at risk to coastal erosion or inundation (2050 Scenario)

4.2.3. 2100 Scenario

The following assets would be at risk to coastal erosion for the 2100 scenario, if a “Do Nothing” approach was taken , location of assets at risk as shown in Figure 19:

- A number of private properties between Eyre Stand Leake St including lighting which runs parallel to the front of properties at risk. Two private dwellings on Bridges Dve would also be at (very low) risk;
- A number of sealed roads including the Southend Bridge that connects Eliza St to Cape Buffon Drive and subsequent storm water pipes and pits;
- The complete extent of the Caravan Park and Eyre St reserve;
- The complete extent of the reserve behind Western beach including the toilet block and effluent disposal facility;
- Almost the complete extents of the three privately owned allotments in the coastal conservation area and the bush camping sites north of Leake St; and
- The boat ramp car park would be at risk of inundation. Given the path of egress is likely to allow the water to quickly dissipate, the consequence of the risk is considered to be very low.

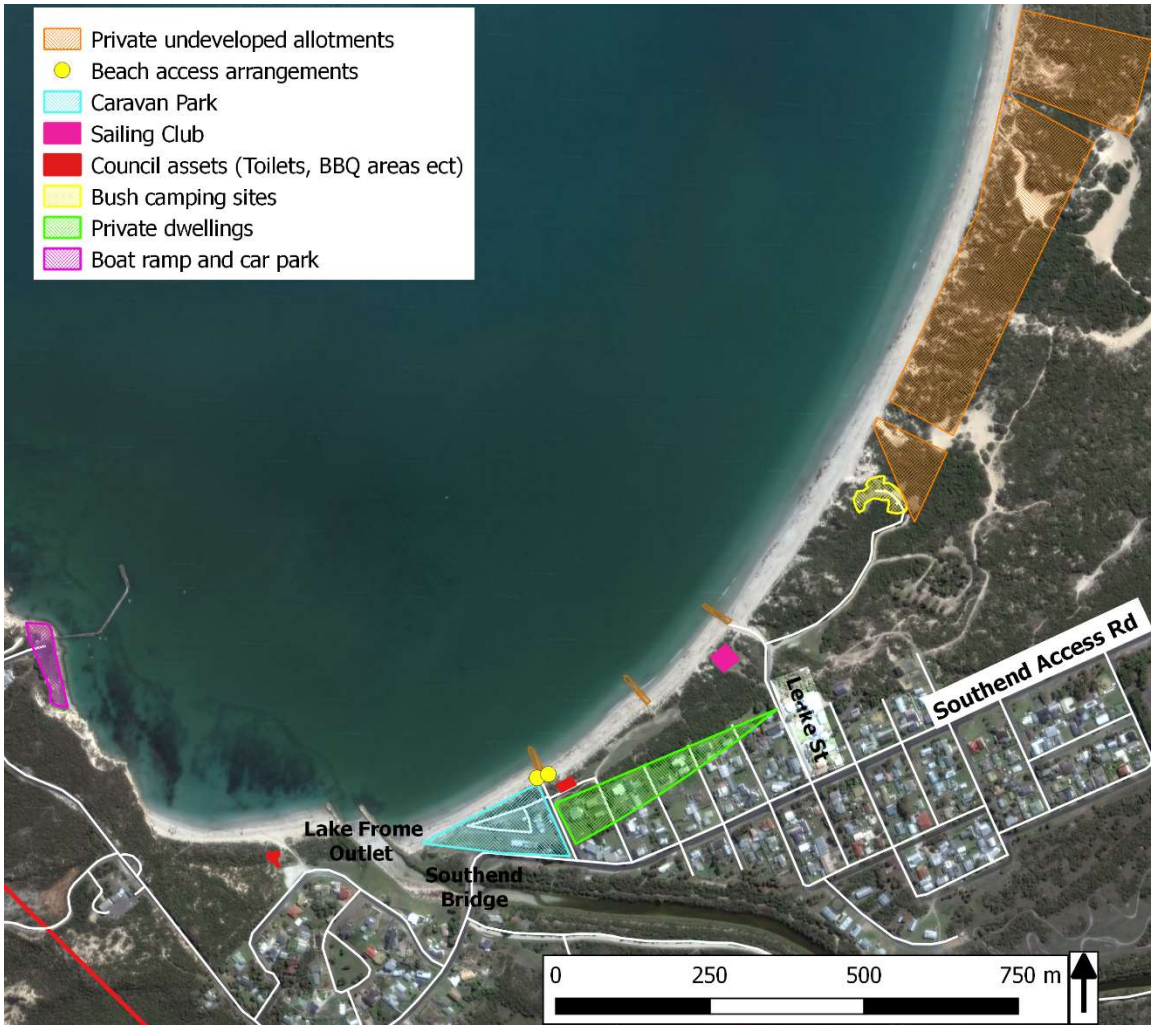


Figure 19: Assets at risk to coastal erosion or inundation (2100 Scenario)

5 Assessment of council's liability

Whilst the focus and intent of this section of the study is to provide an assessment of potential liability issues for Council, at the time of the study Council was unable to provide the detailed and historical information required in time to support an assessment of liability. It is understood that Council's intent is to undertaken archival searches to support the assessment outside of this study, therefore the following approach was adopted to assist Council with working towards an assessment of their liability:

1. Identify relevant policy frameworks to consider;

2. Identify what further investigative works are required to determine Council's exposure to legal liability

5.1. Current policy framework

Below provides a summary of the strategic planning policies and statutory framework in which Council are to work within when making coastal development decisions:

- **Current statutory framework - Development Act 1993 and CPB policy**

The South Australian CPB provides the state-wide policy for dealing with coastal matters. The Development Act 1993 and Development Regulations 2008 require Councils to refer new development in coastal zones to CPB for 'regard' or 'direction'. CPB policy since 1991 has been to advise Councils to set floor levels 0.25m above the one in hundred ARI event and an additional 0.3m to allow for sea level rise by 2050. New development should also be able to demonstrate how it will cater for an additional 0.7m sea level rise by 2100.

- **Local Development Plan**

The Council's Development Plan (consolidated 7th February, 2013) is the statutory policy document to manage new development in the region. A number of the Principals of Developmental Control for Coastal Areas are in line with the requirements of the CPB policy, including but not limited to:

18. *Development and its site should be protected against the standard sea-flood risk level which is defined as the 1 in 100 year average return interval flood extreme sea level (tide, stormwater and associated wave effects combined), plus an allowance for land subsidence for 50 years at that site.*

19. *Commercial, industrial, tourism or residential development, and associated roads and parking areas should be protected from sea level rise by ensuring all of the following apply:*

   a. *site levels are at least 0.3 metres above the standard sea-flood risk level*

   b. *building floor levels are at least 0.55 metres above the standard sea-flood risk level*

   c. *there are practical measures available to protect the development against a further sea level rise of 0.7 metres above the minimum site level required by part (a).*

21. *Development that requires protection measures against coastal erosion, sea or stormwater flooding, sand drift or the management of other coastal processes at the time of development, or in the future, should only be undertaken if all of the following apply:*

   a. *the measures themselves will not have an adverse effect on coastal ecology, processes, conservation, public access and amenity.*

   b. *the measures do not nor will not require community resources, including land, to be committed.*

   c. *the risk of failure of measures such as sand management, levee banks, flood gates, valves or stormwater pumping, is acceptable relative to the potential hazard resulting from their failure.*

d. *binding agreements are in place to cover future construction, operation, maintenance and management of the protection measures.*

22. *Development should be set back a sufficient distance from the coast to provide an erosion buffer which will allow for at least 100 years of coastal retreat for single buildings or small scale developments, or 200 years of coastal retreat for large scale developments (i.e. new townships) unless either of the following applies:*

23. *Where a coastal reserve exists or is to be provided it should be increased in width by the amount of any required erosion buffer. The width of an erosion buffer should be based on the following:*

a. *the susceptibility of the coast to erosion*

b. *local coastal processes*

c. *the effect of severe storm events (d) the effect of a 0.3 metres sea level rise over the next 50 years on coastal processes and storms*

d. *the availability of practical measures to protect the development from erosion caused by a further sea level rise of 0.7 metres per 50 years thereafter.*

24. *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.*

27. *Land should not be divided for commercial, industrial or residential purposes unless a layout can be achieved whereby roads, parking areas and development sites on each allotment are at least 0.3 metres above the standard sea-flood risk level, unless the land is, or can be provided with appropriate coastal protection measures.*

In addition to the above, the following additional policy and frameworks should be considered:

- Wattle Range Council Strategic Plan 2018 – 2021;
- Wattle Range Council General Environmental Policy (2010);
- Limestone Coast Regional Climate Change Adaption Plan
- Prospering in a Changing Climate: Climate Change Adaptation Framework for South Australia
- Limestone Coast Regional Plan (volume of the South Australian Planning Policy)

5.2. Investigative works required

A separate memorandum has been provided to Council outlining a number of areas in which Council may be exposed to legal liability in relation to assets and infrastructure identified at risk. The required investigate works and questions to be answered are outlined to assist in determining an assessment of liability.

It is recommended that once the further works are undertaken, legal counsel is sought to provide a more detailed assessment of potential legal exposure.

6 Monetary value of assets at risk

The purpose of this stage of the study is to determine a financial value for all of the assets that have been identified as at risk to coastal erosion or inundation and for which the Council considers it has some responsibility or liability. Given there is some conjecture of responsibility for some assets and private property until further investigative works have been undertaken these have also been included for consideration in the assessment, state owned assets have not been included in this assessment. Where the value of the asset was unable to be obtained, these have been listed as data gaps for Council to include at a later date.

6.1. Approach

Assessing the value of loss or damage in monetary terms depends on the nature of the problem (flooding or erosion), the sea level rise estimate, depth of flood and the nature of the affected asset. Damage curves are normally applied by insurance companies to assess flood damage to buildings. The extent of damage is normally expressed as percentage of total building value and depends on flooding depth (Middelmann-Fernanades 2009). There were no buildings identified to be at risk to flooding, only the BBQ and shelter located at the Bridges Drive foreshore Reserve by the end of the century, given these assets are at risk of erosion (2050) sooner than the identified risk of inundation (2100), the determination of damage due to coastal erosion is considered more relevant.

For determining the value of loss or damage in monetary terms for erosion, loss of land may occur separately from loss of buildings, with varying financial implications. However, in most erosion cases total loss of land and assets will be the eventual outcome. The approach adopted was to use the extent (%) of damage prescribed in Section 4 from the consequence descriptor multiplied by the value of the asset (as listed in Appendix B). As the consequence descriptors presents a range of damage extent (e.g. 40 - 100% for major damage), the maximum % was adopted to provide a conservative estimate.

Table 9 and Table 10 below provide a summary of the value of assets and the subsequent damage costs per planning scenario for privately owned and Council owned assets.

Table 9: Monetary value and subsequent damage costs for privately owned assets

Assets	2017 value - provided by WRC planning department	Damage Costs (per planning scenario)		
		2017	2050	2100
17 Bridges Dve	$240,000	NA	NA	$2,400
21 Bridges Dve	$295,000	NA	NA	$2,950
1 Eyre St	$290,000	NA	NA	$290,000
3 Eyre St	$180,000	NA	NA	$180,000
1 Mac Donald St	$840,000	NA	NA	$840,000
2 - 4 MacDonald St	$510,000	NA	NA	$510,000
2 Bonney St	$700,000	NA	NA	$700,000
1 Bonney St	$210,000	NA	NA	$210,000
2 Dashwood St	$660,000	NA	NA	$660,000
1 Dashwood St	$780,000	NA	NA	$780,000
2 Evelyne St	$265,000	NA	NA	$106,000
Private allotments (undeveloped blocks) north of Leake St	$116,000	$46,400	$116,000	$116,000
Private allotments (undeveloped blocks) between the Southend Access Rd and the Lake Frome Drain	Not assessed as property boundaries were not able to be provided by Council	Not assessed	Not assessed	Not assessed
TOTALS	**$5,086,000**	**$46,400**	**$116,000**	**$4,397,350**

Table 10: Monetary value and subsequent damage costs for Council owned assets

Assets	2017 vale - provided by WRC planning department	Damage Costs (per planning scenario)		
		2017	2050	2100
Foreshore Reserve Bridges Drive - BBQ and shelter	$22,000	NA	$22,000	$22,000
Foreshore Reserve Bridges Drive - Public Toilet	$44,850	NA	$44,850	$44,850
Foreshore Reserve Bridges Drive - Effluent Disposal Point	$10,247	NA	NA	$10,247
Foreshore Reserve Bridges Drive - Boardwalk	$118,800	NA	$118,800	$118,800
Foreshore Reserve Eyre Street - Foreshore stairs	$55,000	$5,500	$55,000	$55,000
Southend Caravan Park - Amenities Block	$319,304	NA	$319,304	$319,304
Southend Caravan Park - Office	$42,877	NA	$42,877	$42,877
Southend Caravan Park - Power Outlets	$43,833	NA	$43,833	$43,833
Foreshore Reserve Eyre Street - Public Toilet	$100,395	NA	$100,395	$100,395
Foreshore Reserve Eyre Street - Ladies Public Change Room	$66,240	NA	$66,240	$66,240
Foreshore Reserve Eyre Street - Men's Public Change Room	$66,240	NA	$66,240	$66,240
Cape Buffon Dr	$40,163	NA	NA	$40,163
Bridges Dr	$79,118	NA	NA	$79,118
Eyre St	$53,784	NA	$5,378.40	$53,784
MacDonald St	$29,722	NA	NA	$29,722
Bonney St	$29,722	NA	NA	$29,722
Evelyn St	$27,456	NA	NA	$27,456
Dashwood St	$10,752	NA	NA	$1,075.20
Leake St	$52,348	NA	NA	$5,234.76
Stormwater	$41,400	NA	NA	$16,560.0
Sailing Club*	$860,000	NA	$860,000	$860,000
Bush camping sites* (north of Leake St)	Not provided	TBC	TBC	TBC
TOTALS	**$2,114,251**	**$5,500**	**$1,744,917**	**$2,032,621**

* Ownership is to be determined

7 Community and stakeholder engagement

Two community workshops were held over the course of the study. The objectives of each workshop, the content covered, and the key findings are discussed in more detail below:

7.1. Workshop 1

The first community workshop was held on 25 October 2017 at the Southend Community Club and was attended by 26 people. The main focus of this workshop was to:

a) Discuss the coastal processes at play at Southend;

b) Present the results of the erosion and inundation mapping (as presented in Section 2), and subsequently identify the assets and infrastructure at risk;

c) Gain an understanding of the community's priorities in terms of concerns and values; and

d) Begin discussion regarding what actions could be taken in response to the identified coastal hazards.

Workshop attendees, mostly from the local community, were asked to participate in a number of small group discussions, informed by maps of coastal processes, inundation and erosion risk, to generate responses to the following questions:

1. Where have you observed erosion and inundation impacts?
2. What natural or built assets are of most importance to you along the Southend foreshore?
3. What questions do you have regarding how to interpret the erosion maps or inundation maps?
4. What impacts are most important to you?
5. What responses could help to address the project erosion and inundation risks?

A summary of the key findings from the workshop are provided below, a complete summary of responses for each question is presented in Appendix C:

- The primary erosion and inundation impacts identified by attendees were the same as those described in the coastal processes map presented at the workshop, including:
    - Build-up of sand on the beach to the west of the Outlet groyne;
    - Erosion of sand from the beach to the east of the Outlet groyne; and
    - Long term recession in fore dunes north of Leake Street.
- The primary drivers of erosion are considered to be loss of seagrass within Rivoli Bay and the impact the groynes have had on erosion, especially the groyne on the east side of the Outlet.
- There was broad agreement about which assets were important, with a focus on the:
    - Jetty for commercial fishing;
    - Beaches for locals and in support of tourism (and conservation importance of the dunes);
    - Caravan Park and bush camping area; and
    - Sailing Club;
- In the short term, attendees were keen for the following options to be explored:
    - Repositioning or removal of groynes –remove the groyne on the west side of the Outlet, reposition the groyne on the east side of the Outlet, and potentially remove the remaining three groynes
    - Reduce outlet flows and weir structure on the Outlet
    - Seagrass restoration – deploy all measures necessary to re-establish sea grass beds

- Protect dunes – to the north of Leake St a large area of fore dunes experiences damage due to foot and vehicle traffic. The priority for this area is to reduce vehicle and pedestrian access, and increase revegetation efforts.
- More significant infrastructure options discussed were offshore breakwater; and sheet pile structure to reduce direct wave impact on the beach.

7.2. Workshop 2

The second community workshop was held on 4 December 2017 and was attended by 32 people, attendees were asked to participate in a number of small group discussions across four tables to generate responses to the following questions:

a) What are the constraints and benefits of potential response options such as do nothing, defer, accommodate, defend or retreat? and

b) What are the triggers for decision making?

To inform responses, participants were provided with A3 worksheets that described options and possible benefits and constraints for consideration. The options discussed were developed based on the community ideas from the first workshop and examples from industry best practice. A high level of findings is provided below, a complete summary of responses to the questions is provided in Appendix C. It should be noted that not all groups answered all of the questions.

- The option of defer and doing nothing in response to projected inundation and erosion risk was not favoured by any group.
- Retreat of infrastructure was considered to be an option primarily for public assets on council or crown land, but not for private property. Relocation of the Caravan Park was widely supported, although it was recognised that this could have flow on social and economic impacts. The Rivoli Bay Sailing Club was also identified for retreat at some point in the future.
- The defend option recorded the highest number of responses, more than double any other response option.
    - *Groynes* - Forty percent of the defend responses were in relation to the groynes. The general view was that with the exception of the groyne on the western side of the Outlet, all others are ineffective. There was no single consistent view on what should be done with the other groynes, with responses ranging from running them parallel to the beach, shortening them to redesigning the end of the groynes to better direct wave energy and removing them all together,
    - *Beach nourishment* – Nourishment of the beach with additional sand was generally regarded as an ineffective use of funds.
    - *Reduce Lake Frome outflows* - A reduction in Lake Frome flows from the drain into Rivoli Bay was widely supported.
    - *Seawall* - A seawall directly on the coast was discussed by a number of attendees. The timing of such a wall was questioned, with one comment suggesting that a “seawall is a last resort”.
    - Other suggestions were to restrict 4WD access to the dunes only and to construct an offshore breakwater. It was noted that a breakwater would come at significant cost.
- There were 23 responses provided to the question of what triggers should be considered to inform when options are implemented. The most commonly referred to triggers were erosion at the Caravan Park, loss of beach access and facilities at the Rivoli Bay Sailing Club; and loss of stairs or beach access. While not widely supported, there was a suggestion to set a trigger at a certain distance from private property, although the specific location of this trigger was not identified.

8 Coastal management best practice

There are a number of actions that represent good coastal management practice, which can be pursued by Council without the need for compromise or significant capital-raising. Such actions can improve resilience and preparedness for coastal risks without limiting the ability to change a management approach and without negative long-term impact should risks change in the future. These actions are discussed in more detail below and summarised as recommendation in Section 10.4.

8.1. Monitoring

The general approach to management of risks to existing assets and infrastructure is to wait until the risks have materialised to a level that is no longer considered tolerable (i.e. risk reaches a trigger level) before acting. Monitoring of key indicators is necessary to determine when this trigger has been reached. It is important that this trigger is established at a point before actual impacts to assets and infrastructure occur to enable sufficient prior-planning and the implementation of alternatives, especially in terms of community-dependent infrastructure. Monitoring of triggers at specific critical assets should be reviewed regularly to determine when a trigger is reached. The results of monitoring should also be analysed and published, and incorporated into reviews of coastal management plans (e.g. every 5-10 years). Monitoring should cover:

- Frequency and depths/extents of coastal inundation and erosion and recession of beach profiles, and dune condition (subsequently revision of coastal hazard maps) at least every 5 years; and

- Condition of the existing coastal structures

Assessment of monitoring results should involve trend analysis and proximity to pre-defined triggers. Monitoring results should also inform future re-analysis of hazards and risks as part of on-going risk management programs.

8.2. Land use planning and development controls

Development controls simply apply controls as appropriate to the type of development and likely hazard over the expected life of the development. Council's development plan outlines a number of Principals of Developmental Control for Coastal Areas in line with the requirements of the CPB policy (as presented in Section 5) which should restrict development from at risk areas. The inundation and erosion maps developed as part of this study (and updated as more monitoring data become available in the future) should be used to inform future decisions regarding development at Southend.

Further to this, whilst it is understood that coastal developments are directed to the CPB for comment, developments setback from the shoreline (potentially at risk to coastal inundation, such as the newly subdivided land between the Southend Access Rd and the Lake Frome drain) are not currently sent to any division of DEWNR for consideration prior to approval. It would be prudent to ensure that all new development within areas identified at risk to coastal erosion or inundation be directed to the CPB for regard prior to approval to ensure all potential coastal hazards are considered.

It is understood that the Southend Caravan Park lease agreement extends to August 2020. In line with the Local Development Plan principal for coastal areas, this agreement should not be extended beyond 2020 and the required steps taken to develop a suitable alternative location. Similarly for the Sailing Club, Council needs to confirm the exiting lease agreement for the land (and building) to understand the necessary steps required for relocating the Sailing Club building and associated infrastructure and sheds.

8.3. Dune rehabilitation and controlled access to dunes

Dune revegetation allows for ongoing retention of sand; as the vegetation traps the sand that would otherwise blow over the dunes. With time, dunes can increase in height as vegetation adapts to the dune profile. Dune vegetation also provides ecological benefits that promote a functioning breach ecosystem

This option would also involve protection of native coastal vegetation by way of controlling access to dunes for walkers, horseback riders and four-wheel drive vehicles. Controls may include fencing, formalising and controlling pathways, signage, etc.

There are large extents of exposed dune north of Leake St which would benefit from a revegetation campaign and controlled access in the form of fencing and limiting four-wheel drive vehicle access.

8.4. Restricting the flows from the Lake Frome Outlet

As discussed in Section 2.1, the Lake Frome drain has had adverse ramifications to the coastal environment since it was first constructed in 1887. Impacts include:

- Prolonged periods of flow carry sediment offshore, and out of the coastal system.
- The drain acts as a sediment trap, with sand transported around the end of the western Outlet groyne appears to be trapped within the drain, and thus has not transported to the beaches east of the Outlet.
- There is suggestion that the drain has impacted the water quality of the nearshore environment, causing the loss of seagrass communities, thus subjecting the coastline to increased wave exposure and compounding the erosion problems.

It is understood that the SEWCDB have acknowledged the detrimental impacts the flows have had on the coastal environment, and more specifically the water quality at Southend. In this regard, SEWCDB are currently assessing the option to redirect flows from the Lake Frome drain. A key recommendation for this study is for modification to be made to the Outlet to include a weir structure to restrict environmental flows and improve water quality. This may allow the seagrass community to re-establish over a prolonged period and prevent future sediment build up within the Outlet itself.

9 Adaptation options assessment

9.1. Options overview

The Framework sets out five parallel pathways or 'swimlanes' that may be taken to respond to the rising sea level threat to existing coastal developments as summarised below:

- Defend – the use of either (or both) soft and hard protection options to defend existing development. Protection measures such as seawalls, regular sand nourishment, levees, and dune revegetation will be considered.

- Accommodate – maintain the current level of use within coastal hazard areas and raise the tolerance to periodic storm surge inundation or erosion events by means of innovative designs for buildings and infrastructure, and remedial works (sand renourishment, revegetation) after storm events.

- Defer – coastal risks and adaptation options assessed and acknowledged however action deferred to a later date based on identified triggers for the required actions.

- Retreat – a planned and managed retreat involved the abandonment or relocation of settlements, moving development inland in the face of sea level rise and coastal recession. The Framework includes the buyout of properties at risk to avoid any future damage as a key part of the Retreat pathway.

- Do Nothing – Ignore the identified risks and no action taken.

Below provides an overview of how each adaptation option would play out for the study area. A more detailed assessment of each option in terms of economic, social and environmental benefits and constraints is presented in sections below.

9.1.1. Retreat

The retreat pathway aims to allow natural coastal processes to unfold as much as possible and with as little inhibition from development as possible in the future. New development within the coastal zone would be prohibited within high risk areas. Where possible, dunes would be restored or enhanced to maintain or create a buffer against storm erosion. This pathway will result in the loss of public and private land as beach environments migrate landward. Beach amenity and environmental values of coastal habitats would be largely retained or enhanced.

A retreat approach would entail the relocation of Council assets identified at risk. Consideration may be given to the appropriate long-term management of these assets given the remaining life of the assets may be approximately equivalent to the time when emerging hazards will affect the essential function of the asset. An audit of Council assets should be undertaken in terms of the remaining functional life in relation to the timeframe of the impending coastal hazard to inform if the asset should be 'managed to fail' or replaced and relocated inland.

The Framework includes the buyout of properties at risk to avoid any future damage as a key part of the Retreat pathway, therefore an assessment of liability and responsibility would be required to inform the retreat process for the private property identified in the area at risk. This includes both developed properties and the undeveloped allotments to the north of Leake St. In addition to this, the current land leased for the Caravan Park and Sailing Club would need be returned to the care and control of the appropriate governmental body and alternate sites for relocation of these facilities identified.

The Southend Bridge currently provides the only access to the private dwellings located on the western side of the Outlet drain and would need to be relocated.

9.1.2. Accommodate

The accommodate pathway aims to maintain the current level of use and allow occasional storm surge inundation or erosion events by means of innovative designs for buildings and infrastructure (including elevation of foundations, waterproofing and change in infrastructure uses). This pathway has limited application for Southend, as accommodate adaptation options are tailored to mitigating inundation risks and there are limited assets at risk to inundation at Southend, with coastal erosion the primary threat to the study area. Notwithstanding this, the below strategies would be applicable for adopting for Southend:

- Ensure all areas at risk to coastal inundation have sufficient freeboard to accommodate to 100yr storm surge to the end of the century;
- Limit new development from high risk areas and inform residents of potential risks;
- Repairing and maintaining all coastal structures (all rock groynes and rock revetment); and
- Extension of all groynes inland as the beach moves landward.
- Implement warning systems for possible flood events and establish flood emergency procedures (inform residents of upcoming extreme tides and storm events, install food depth markers, establish emergency point of assembly). Also implement warning systems for possible erosion including signage for unstable cliffs and beaches.
- Water proof buildings (raise electrical outlets above the predicted flood levels and provide temporary flood barriers to the outside of dwellings when flood risk is forecasted).

9.1.3. Defend

This option would require the construction and ongoing maintenance of a number of soft and hard defence strategies. A number of options that could be employed include:

- **Reconfiguration of the groyne field between Eyre St and Leake St** – repair and upgrade the exiting groynes, groynes would require to be extended a significant distance offshore and their orientation reassessed in order to be effective. Review of the storm modelling results for the cross-shore profile located within the vicinity of the groynes showed that the groynes would need to be extended a minimum of 50m to effectively capture the cross shore movement of sediment driven by storms.

- **Redesign of the Outlet groynes** – further to restricting the flows from the Outlet groyne (as discussed in Section 8), the repair and redesign of the groynes would require shortening and possibly realignment of both groynes to allow the east – west sand transport from the Western beach.

- **Beach nourishment –** a formalised strategy for replenishing the beaches east of the Outlet groyne from appropriate sand sources. Initially this may include bypassing of sand from the western beach and sand currently trapped in the Outlet drain. Subsequent nourishment works work require importing of sand from an external source.

- **Re-establish seagrass communities –** a formalised strategy for re-establishing the seagrass meadows/beds, in the attempt to trap sediment and reduce the wave energy reaching the beach, thus potentially reducing storm erosion. Preventing flow from the Outlet (as discussed in Section 8) could potentially allow the seagrass to re-establish overtime. Further to this, manual planting/seeding campaign with divers could be considered.

- **Offshore breakwater, onshore seawalls** - hard defence options provide the greatest certainty for protecting all assets for the long term, however significant capital and ongoing maintenance costs are associated with such coastal structures. Further to this, defence structures often create other coastal management issues, potentially shifting and exacerbating erosion issues downdrift. In this regard, significant consideration would need to be given to the detailed design requirements for such structures.

9.1.4. Defer

This option implies that nothing would be done unless repair works are needed and only adopting the option of accommodate, retreat or defend to be implemented at a point in time when an identified trigger level for actioning these. The rate of coastal erosion (shoreline recession) and inundation (flooding extents) would continue to be monitored to reconfirm the projected hazard maps. At a point in time which it is no longer feasible to defer action and a physical trigger is reached, the suggested pathways for accommodate, retreat and defend options outline above would be adopted. The need for monitoring to be adopted as part of good coastal management practice is recommend irrespective of the Defer pathway being adopted, as outline in Section 8.

9.1.5. Do nothing

Similar to retreat however this option implies no changes implemented between 2017 and 2100 and there is an acceptance of loss of all assets. Under this scenario Council would continue to repair and maintain only the infrastructure that they are responsible for, such as roads, lighting and stormwater. Doing nothing under the acceptance of liability scenario would mean that the Council covers the costs of damages for both Council and privately-owned assets.

For both scenarios (liable and not liable), it would be prudent to prevent further development in the township to reduce future costs.

9.2. Options Assessment

9.2.1. Approach

The Framework outlines the requirement to undertake the options assessment under the precursor that liability for Council and other stakeholders has been determined and legal or political duty is known. Given that several data gaps remain regarding the assessment of liability, at the request of Council the options have been assessed in light of best practice for the settlement as a whole (given economic, environmental and social considerations). Clarification of ownership and or financial liability will be investigated at a later date. The objective of this option assessment is to identify a clear pathway of priorities for relevant stakeholders.

Further to this, the Framework uses a financial modelling tool to assess the risks attached to each adaptation pathway. The financial modelling approach focuses on the monetary valuations of asset worth versus costs associated with construction and maintenance for a range of protection works. Monetary valuations that result from this approach are important, however they are not the only factor that must be considered when arriving at a decision to act. This financial modelling approach does not take into consideration other factors such as the comparative merit (or shortfalls) in respect to social, environment, overall flexibility and effectiveness of all adaptation pathways (not just protective works). Given this, financial modelling was not undertaken as part of this first pass assessment of priority pathways.

The approach adopted for the options assessment was a two-staged approach. A first pass assessment was undertaken of all possible options to provide an initial screening and removal of unfeasible options to be disregarded for further assessment. The viable options where then assessed using a multi criteria analysis (MCA) approach to inform the adaptation pathway.

MCA is a decision making tool intended for complex problems where there may be conflict between different solutions. It is often used in situations where multiple interpretations and perspectives are apparent and where different professions or disciplines may be involved in problem definition and resolution and the problem is framed in multiple ways. There are various interpretations of MCA but typically MCA will establish criteria against which a solution will be assessed and each alternative will be scored according to how well it meets each criteria.

9.2.2. First pass assessment

Not all options need to be assessed through a comprehensive evaluation. Certain options may be rejected through an initial screening approach because they contravene certain requirements. This approach is taken to focus the more detailed assessment on realistically actionable adaptation strategies.

The first pass assessment has screened the following adaptation options from further assessment, with justifications are provided below:

- The defend protection option of a seawall was removed from assessment in terms of defending the beach. This based on the reasonable assumption that a seawall would result in the loss of beach and is therefore not a viable option for protecting beach assets. Seawalls have only been considered as a viable option for protecting physical assets, e.g. Council and private property.
- Consideration was given to the likely success of a large-scale seagrass replanting campaign. In order to re-establish the seagrass communities it is likely that a number of environmental and metocean parameters supportive of seagrass growth would need to be recreated, including depths, light conditions, general water quality, hydrodynamic and wave conditions. If in fact these parameters could be recreated (which may not be feasible), success of such a planting campaign would remain highly unpredictable due to various biological factors. Therefore, large-scale seagrass replanting campaign has not been assessed as a viable adaptation option.
- The retreat option for beach and coastal conservation areas has not been assessed as an isolated option for these assets. The landward migration of coastal environments will be limited by the physical assets of roads and private property situated landward of the beach and coastal conservation areas. Retreat of the beach and coastal conservation areas is only viable option if retreat of all assets (public and private) is adopted.
- A do nothing approach was not considered a viable option for assessment in relation to private property, the Caravan Park, the Sailing Club, some council assets (roads, stormwater and lighting) and the Southend Bridge from Council or the communities perspective.

In addition to the above, Defer has not be assessed as a comparative pathway option. Instead, Defer will be adopted in the instances where an accommodate, retreat or defend strategy has been identified, but the trigger for actioning these options lies in the future.

9.2.3. Preliminary cost estimates

Order of magnitude capital and recurrent annual (maintenance) cost estimates for each of the options has been prepared to inform the options assessment and are included in the MCA results (Table 12 –Table 15). The cost estimates presented are to be used as a guide only, more detailed costings should be developed prior to any of the adaptation pathways being pursued. Cost estimates were developed under the following assumptions and limitations:

- Costings associated with retreat are based on acquisition of current market value of the asset (as provided by Council). Consideration for disruption in people's life, market price fluctuations and legal costs may mean significant variations have not been considered. Also, to encourage residents to retreat, it is possible that additional monetary incentive's may need to be paid, which has also not been included
- Costs presented for defend and accommodate options do not include costs associated with pre works such as detailed design, approvals and environmental impacts assessments.

- The construction and maintenance costs for the “hard” defend options have been estimated based on meterage costs for coastal structures in similar coastal environments. Lengths of each structure have been dictated by the required length to protect the asset being assessed.
    - Seawall capital costs estimated at $6,000 per m. Maintenance costs $20 per m per year.
    - Offshore breakwater capital costs at $10,500 per m. Maintenance costs $80 per m per year.
- Beach nourishment costs have been calculated on the basis of $20 per m^3 on the assumption sand would be required to be sourced externally. Volumes for nourishment were estimated from the mean high water mark, and the assumption is nourishment would be required annually.
- Costings based on 2017 value and costs. These costings are reflective of a point in time and given the timeframes for many actions are medium to long term, costings will need to be revised prior to commencing works.

9.2.4. Multi criteria assessment

The aim of the MCA is to provide a straightforward overview of the options. It is aimed at presenting quickly and clearly the benefits and trade-offs of a particular option, to assist in the selection of a preferred option(s). The results of the MCA act to inform the adaptation pathway rather than dictate an absolute approach. The assessment criteria and the scoring that was adopted to inform and evaluate the MCA are presented in Table 11 below.

The assessment was broken down into coastal compartments (as defined in Section 2). Analysis of viable options was undertaken by asset type rather than the coastal compartment as a whole as it is acknowledged that in many instances a range of adaptation responses may be appropriate given varying physical, social, economic or environmental triggers (e.g. a trigger for action in response to private property may be different than for council assets, such as beach access stairs, BBQ areas etc.).

Triggers have been established for two categories, for when physical action on the ground is required (ACTION TRIGGER) and for the planning and pre-works required for the action to be implemented (PLANNING TRIGGER).

The benefits and constraints of each option were discussed with Council, the community and the CPB to inform the assigned scoring against the key criteria. The workshops held with Council and the community also informed the triggers for action.

Table 11: MCA scoring guide

Score	Criteria					
	Capital costs	**Recurrent costs (per annum)**	**Environmental impact**	**Community acceptability (social impact)**	**Flexibility (reversible/ adaptable in future)**	**Effectiveness**
1	Little to no cost (<$50K)	Little to no cost (<$30K)	Will benefit the environment	Is very politically palatable, acceptable to community. Likely to benefit the community.	Option can be easily adapted for future circumstances or would not negatively impact future generations.	Options provides a long term solution for mitigating coastal hazards (inundation or erosion)
0	Moderate cost ($50K - $500K)	Moderate cost ($30K - $100K)	No net impact (potentially some benefits however also some negative impacts)	Likely to be acceptable to some (but not all)	Option is reversible or adaptable but at considerable cost/effort	Option will provide some benefit in the short term however will require further resources / changes to be effective over the long term.
-1	Very expensive (>$500K)	Very expensive (>$100K)	Will impact negatively on the environment	Unlikely to be acceptable to community and politically unpalatable	Option is irreversible once implemented, option limits alternative options in future.	Option does not provide a long-term solution, only effective in the short term.

9.2.5. Results

The results for the MCA options assessment for each of the three coastal compartments are presented in Table 12 – Table 14 below.

Table 12: MCA Results – Coastal compartment: Western side of Outlet groynes (including Western beach)

ASSET TYPE	ASSET AT RISK	OPTION TYPE	OPTION	Capital Cost	Capital Cost	Recurrent Cost (p.a)	Recurrent Cost	Enviro Impact	Community Acceptability	Flexibility	Effectiveness	TOTAL	TRIGGER
Coastal protection structures	Boat ramp and carpark rock revetment	Accommodate	Repair and maintain	$388,400	0	<$5,000	1	0	1	0	1	**3**	Now
		Do Nothing	Asset remains as is and left to deteriorate	0	1	0	1	0	-1	0	-1	0	
Environmental	Western beach and Foreshore Reserve fronting Bridges Drive	Defend	Beach nourishment (17 000m^3)	$0	1	$340,000	-1	1	-1	1	0	**1**	**PLANNING TRIGGER:** 2050 Likely ZR is realised **ACTION TRIGGER:** Council to action when shoreline recession threatens public safety and use of each assets
		Defend	Offshore breakwater (350m)	$3,675,000	-1	$28,000	1	-1	0	0	1	0	
		Do Nothing	Accept the loss of the asset	0	1	$0	1	0	-1	0	-1	0	
Council owned assets	Board walk, shedding, BBQ, public toilets and effluent disposal	Retreat	relocate inland	$195,900	0	NA	1	1	0	1	1	**4**	**PLANNIG TRIGGER**: 2050 Almost Certain ZR is realised **ACTION TRIGGER:** 2050 Likely ZR is realised
		Defend	offshore breakwater (350m)	$3,675,000	-1	$28,000	1	-1	1	0	1	1	
		Defend	beach nourishment (17 000m^3)	$0	1	$340,000	-1	1	-1	1	0	1	
		Do Nothing	accept the loss of the asset	0	1	0	1	0	-1	0	-1	0	
		Defend	seawall (380m)	$2,470,000	-1	$7,600	1	-1	0	-1	1	-1	
	Bridges Dve	Retreat	relocate inland	$79,118	0	0	1	1	-1	1	1	**3**	**PLANNING TRIGGER:** 2100 Likely ZR is realised **ACTION TRIGGER:** Council to action when shoreline recession threatens public safety and use of Bridges Dve.
		Defend	beach nourishment (34,000m^3)	$0	1	$680,000	-1	1	-1	1	0	1	
		Defend	offshore breakwater (350m)	$3,675,000	-1	$28,000	1	-1	1	0	1	1	
		Defend	seawall (380m)	$2,470,000	-1	$7,600	1	-1	0	-1	1	-1	

Table 13: MCA Results – Coastal compartment two: Between Outlet groynes and Leake St

ASSET TYPE	ASSET AT RISK	OPTION TYPE	OPTION	Capital Cost	Capital Cost	Recurrent Cost (p.a)	Recurrent Cost	Enviro Impact	Community Acceptability	Flexibility	Effectiveness	TOTAL	TRIGGER
Coastal protection structures	Outlet groynes	Defend	Redesign (shorten and refurbish outlet groyne)	$480,000	0	<$5,000	1	0	1	0	0	**2**	Now
		Retreat	Removal of outlet groynes	$340,000	0	$0	1	0	0	0	0	1	
		Do nothing	Asset remains as is and left to deteriorate	$0	1	$0	1	0	-1	0	-1	0	
		Accommodate	Maintain and repair	$1,247,600	-1	<$5,000	1	0	-1	0	-1	-2	
	Three groynes between Leake St and Eyre St	Defend	Redesign (length all three groynes 50m offshore)	$555,000	-1	<$5,000	1	0	1	0	0	**1**	Now
		Retreat	Groynes are removed	$290,000	0	$0	1	0	0	0	-1	0	
		Do Nothing	Groynes remain as is and left to deteriorate	$0	1	$0	1	0	-1	0	-1	0	
		Accommodate	Maintained repair	$71,000	0	<$5,000	1	0	-1	0	-1	-1	
Environme	Beach and coastal reserve	Defend	Beach nourishment (30,000m^3)	$0	1	$600,000	0	1	-1	1	0	**2**	Now
		Do Nothing	Accept the loss of the asset	$0	1	$0	1	0	-1	0	-1	0	
		Defend	Offshore breakwater (760m)	$7,980,000	-1	$60,800	0	-1	0	0	1	-1	
Council and State owned assets	Eyre St access arrangements	Accommodate	Maintain and repair	$19,700	1	<$5,000	1	0	0	1	0	**3**	Now
		Defend	Beach nourishment (6,000m^3)	$0	1	$120,000	0	1	-1	1	0	2	
		Defend	Offshore breakwater	$1,575,000	-1	$12,000	1	-1	0	0	1	0	
		Do Nothing	Accept the loss of the asset	$0	1	$0	1	0	-1	0	-1	0	
	Eyre St reserve toilet and shower blocks and BBQ are	Retreat	Relocate inland	$230,000	0	$0	1	1	0	1	1	**4**	**PLANNING TRIGGER:** 2050 Almost Certain ZR is realised **ACTION TRIGGER:** Council to action when shoreline recession threatens public safety and use of each assets
		Defend	Beach nourishment (18,000m^3)	$0	1	$360,000	0	1	-1	1	0	2	
		Defend	Offshore breakwater(290m)	$3,045,000	-1	$23,200	1	-1	0	0	1	0	
		Do Nothing	Accept the loss of the asset	$0	1	$0	1	0	-1	0	-1	0	
		Defend	Seawall (290m)	$1,885,000	-1	$5,800	1	-1	0	-1	1	-1	
	Roads, lighting, storm water	Retreat	Relocate inland	Not costed	-1	$0	1	1	-1	1	1	**2**	**PLANNING TRIGGER:** 2050 Likely ZR is realised **ACTION TRIGGER:** 2100 Almost Certain ZR is realised
		Defend	Beach nourishment	$0	1	$1,690,000	-1	1	-1	1	0	1	
		Defend	Offshore breakwater	$4,095,000	-1	$31,200	1	-1	0	0	1	0	
		Defend	Seawall	$2,600,000	-1	$8,000	1	-1	0	-1	1	-1	
	Southend Bridge	Retreat	Relocate inland	Not costed	-1	$0	1	1	-1	1	1	**2**	**PLANNING TRIGGER:** 2050 Likely ZR is realised **ACTION TRIGGER:** 2050 Possible ZR is realised
		Defend	Beach nourishment (48,000m^3)	$0	1	$960,000	-1	1	-1	1	0	1	
		Defend	Offshore breakwater (300m)	$3,150,000	-1	$24,000	1	-1	0	0	1	0	
		Defend	Seawall (300m)	$1,950,000	-1	$6,000	1	-1	0	-1	1	-1	
Private	Private properties between Eyre St. and Leake St	Retreat	Relocate inland	$4,170,000	-1	$0	1	1	-1	1	1	**2**	**PLANNING TRIGGER:** 2050 Likely ZR is realised **ACTION TRIGGER:** 2100 Almost Certain ZR is realised
		Defend	Beach nourishment	$0	1	$1,690,000	-1	1	-1	1	0	1	
		Defend	Offshore breakwater (390m)	$4,095,000	-1	$31,200	1	-1	0	0	1	0	
		Defend	Seawall (400m)	$2,600,000	-1	$8,000	1	-1	0	-1	1	-1	
	Caravan park	Retreat	Relocate inland	$4,800,000	-1	$0	1	1	0	1	1	**3**	**PLANNING TRIGGER**: NOW **ACTION TRIGGER:** Implement as soon as planning and preworks compete
		Defend	Beach nourishment (11,000m^3)	$0	1	$220,000	0	1	-1	1	0	2	
		Defend	Offshore breakwater (300m)	$3,150,000	-1	$24,000	1	-1	0	0	1	0	
		Defend	Seawall (300m)	$1,950,000	-1	$6,000	1	-1	0	-1	1	-1	
	Sailing Club	Retreat	Relocate inland	$830,000	-1	$0	1	1	0	1	1	**3**	**PLANNING TRIGGER:** NOW **ACTION TRIGGER:** Council to action when shoreline recession threatens public safety and use sailing club
		Defend	Beach nourishment (11,000m^3)	$0	1	$220,000	0	1	-1	1	0	2	
		Defend	Offshore breakwater (223m)	$2,341,500	-1	$17,840	1	-1	0	0	1	0	
		Defend	Seawall (223m)	$1,449,500	-1	$4,460	1	-1	0	-1	1	-1	

Table 14: MCA Results – Coastal compartment three: North of Leake St

Asset Type	ASSET AT RISK	OPTION TYPE	OPTION	Capital Cost	Capital Cost	Recurrent Cost (p.a)	Recurrent Cost	Enviro Impact	Community Acceptability	Flexibility	Effectiveness	TOTAL	TRIGGER
Environmental	**Beach and coastal conservation area**	Defend	Beach nourishment (90,000m^3)	$0	1	$1,800,000	-1	1	-1	1	0	**1**	
		Do Nothing	Accept the loss of the asset	$0	1	$0	1	0	0	0	-1	**1**	
		Defend	Offshore breakwater (1.5km)	$15,750,000	-1	$120,000	0	-1	0	0	1	-1	NA
	Bush camping blocks	Retreat	Relocate inland	Not costed	1	$0	1	1	0	1	1	**5**	**PLANNING TRIGGER:** 2050 Likley ZR is realised **ACTION TRIGGER:** 2100 Almost Certain ZR realised
		Defend	Beach nourishment (34,000m^3)	$0	1	$1,360,000	-1	1	-1	1	0	1	
		Defend	Offshore breakwater (350m)	$3,675,000	-1	$28,000	1	-1	0	0	1	0	
		Do Nothing	Accept the loss of the asset	$0	1	$0	1	0	-1	0	-1	0	
Private	**Private Allotments north Leake St**	Retreat	Relocate inland	$118,000	0	$0	1	1	-1	0	1	**2**	**PLANNING TRIGGER:** now **ACTION TRIGGER:** 2050 Almost Certain ZR is reliased
		Defend	Beach nourishment (52,000m^3)	$0	1	$1,040,000	-1	1	-1	1	0	1	
		Defend	Offshore breakwater (900m)	$9,450,000	-1	$72,000	0	-1	0	0	1	-1	
		Defend	Seawall (920m)	$5,980,000	-1	$18,400	1	-1	0	-1	1	-1	

10 Recommended adaptation pathways

Based on the collated information throughout the course of this project, recommended adaptation pathways have been developed for each coastal compartment for Southend showing the sequencing of options through time against identified planning and action triggers and are presented in the sections 10.1 - 10.3 below. The adaptation pathways assessment has highlighted two key areas of focus:

3. There are a number of actionable items (adaptation options) that require immediate attention, and have been reiterated in the summary of recommended action (section 10.4) ; and

4. The analysis has identified retreat as the likely 'best practice' approach for the settlement as a whole for the long term planning horizon (end of the century). Adopting such an approach will be inherently complex to implement and will require careful management to minimise impact on the future viability of the coastal community. In this regard, resources and funding should be prioritised towards the planning works required, as discussed further in section 10.4.

Further to the above, a number of data gaps have been identified as part of this project. The importance and relevance of these gaps in supporting the adaptation strategy including the required scope of works to subsequently fill the gaps are summarised in Section 10.5.

The developed adaption pathway maps also present the stakeholders responsible for actioning each item, where further work is required (the assessment of liability or planning and pre works to assess feasibility of retreat option) 'to be assessed (TBA) has been assigned.

10.1 Adaptation pathway – coastal compartment one

The sequence for recommended adaptation pathways for coastal compartment one is presented in Table 15 below.

Table 15: Adaptation pathways map – coastal compartment one

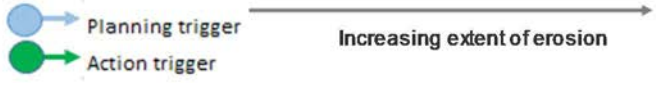
			TRIGGERS				
			1	2	3	4	5
		Ownership	Now	2050 Almost Certain ZR	Physical threat to use and pubic safety of Council assets	2100 Likely ZR	Physical threat to use and pubic safety of Bridges Dve
Coastal management	**Action required**						
Monitoring	• Annual review of DEWNR cross shore profiles (725008 - 725010) • Five year review of coastal hazard mapping	Council					
Asset at risk	**Action required**						
Car park rock revetment	• Provide recommendation to DPTI for required repair and upgrade works, specifically to southern revetment armour.	DPTI					
Council assets (board walk, shedding, BBQ, public toilets and effluent disposal)	• Council to undertake asset audit, consider remaining life of asset and equivalent time of emerging hazard to determine long term management (relocation or loss). • Execute planned retreat of Council asset	Council					
Bridges Dve	• Planning and approval for diversion of Bridges Dve • Diversion of Bridges Dve	Council					

10.2 Adaptation pathway – coastal compartment two

The sequence for recommended adaptation pathways for coastal compartment two is presented in Table 16 below.

Table 16: Adaptation pathways map – coastal compartment two

			TRIGGERS				
			1	2	3	4	5
		Ownership	Now	2050 Almost Certain ZR	Physical threat to use and pubic safety of Council assets	2050 Likely ZR	2100 Almost Certain ZR
Coastal Management	**Action required**						
Monitoring	• Annual review of DEWNR cross shore profiles (725001, 725004, 725006, 725007, 725028, 725029, 725031) • Five year review of coastal hazard mapping	Counci					
Restrict flows from Lake Frome drain	• Liaise with SEWCDB regarding redirecting flows	SEWCDB					
Assets at Risk	**Action required**						
Lake Frome Outlet and groynes	• Recommendation to SEWCDB to commission engineering study to determine optimal redesign of Outlet and groynes (including design of weir structure, repair and shortening of the Outlet groynes) • Recommendation to SEWCDB to implement redesign of Outlet groynes	SEWCDB					
Eyre St beach access stairs (western side)	• Undertake repair works (provide armour rock along dune toe & backfill dune slope)	Council					
Southend Caravan Park	• Seek alternate site for Caravan Park, proceed with planning and approval requirements • Implement planned retreat of Caravan Park	TBA					
Southend Sailing Club	• Undertake investigative works regarding current jurisdiction (and/or terms of agreement) of land. • Proceed with required planning and approval works required for planned retreat of Sailing Club • Implement planned retreat of Sailing Club	Council TBA TBA					
Private properties and associated roads, stormwater and lighting	• Commission investigation (including financial modelling) into the viability of retreat strategy and test against defend strategies • Undertake planning and approvals required for planned retreat • Execute planned retreat of private property and associated roads, stormwater and lighting	Council TBA TBA					
Council assets (Eyre St Reserve public toilets and change rooms)	• Council to undertake asset audit, consider remaining life of asset and equivalent time of emerging hazard to determine long term management (relocation or loss). • Execute planned retreat of Council asset	Council					
Southend Bridge	• Undertake planning and approvals for relocation of Southend Bridge • Implement planned retreat of Southend Bridge	State					



10.3 Adaptation pathway – coastal compartment three

The sequence for recommended adaptation pathways for coastal compartment three is presented in Table 17 below.

Table 17: Adaptation pathways map – coastal compartment three

Coastal Management	Action required	Ownership	TRIGGERS 1 Now / 2 2050 Almost Certain ZR / 3 2050 Likely ZR / 4 2100 Almost Certain ZR
Monitoring	• Annual review of DEWNR cross shore profiles (725033, 725038, 725070, 725072) • Five year review of coastal hazard mapping	Council	
Dune rehabilitation and control access to dunes	• Implement fencing and signage to restrict access to the dunes for walkers, horse riders and 4W drive vehicles • Dune revegetation campaign planting native coastal vegetation in exposed areas	Council, State and Community	
Assets at risk	**Action required**		
Undeveloped allotments north of Leake St	• Commence preworks for planned retreat • Execute planned retreat	TBA	
Bush camping area north of Leake St	• Seek suitable alternative location for bush camping blocks, undertake planning and approval works • Relocate (abandon) bush camping sites	TBA	

10.4 Summary of recommended actions

The following presents a summary of recommendations for short term adaptation options to be adopted and further works required to support long term adaptation pathways:

- Monitoring will be paramount to the success of implementing the adaptation strategy. As a minimum the cross shore profiles captured by DEWNR should be collated and reviewed annually and the coastal hazard maps updated every five years. Further to this, it is important to note that coastal adaptation is an ongoing process and the strategy itself should be reviewed approximately every five years, over which time any updates to the understanding of coastal hazard risk for Southend or changes to planning policies in SA would need to be considered. Where new information or methods become available that significantly modify the understanding of the coastal hazards, then adaptation within coastal compartments would need to be reviewed again as part of the ongoing monitoring and review process.

- The following recommended works are to be passed onto the relevant State government departments:

    - Boat ramp and car park rock revetment (DPTI) – upgrade and repair works (costings provided in Appendix A):

        - Place additional top-up armour rock to crest on the northern side of boat ramp;

        - Upgrade the entire rock revetment south of boat ramp given core exposed due to loss of primary armour rock cover and armour rock substituted by building rubble;

        - Upgrade of boat ramp itself, place new concrete topping slab to ramp surface.

    - Lake Frome Outlet and groynes (SEWCDB) – whilst it is understood the SEWCDB have begun investigating redirecting the flows from Lake Frome, a key recommendation for this strategy is to support the SEWCDB to restrict flows from the Outlet. Further to this, it is recommended that an engineering study is commissioned to investigate the optimal design of the Outlet and groynes. More specifically, the design (and costing) of a weir structure and shortening of the groynes to allow west – east sediment migration. It should be noted that shortening the groynes will not completely prevent the ongoing erosion experienced on the eastern beaches and will in fact result in a reduction of the beach width on the western beach. Further to this, the groynes are at the end of their design life and are in poor condition (as documented in Section 3). Required repair works should be delayed if possible, until the engineering study is finalised and the fate of the groynes determined.

- Repair works to Eyre St beach access stairs (western side), more specifically remedial works to slumping of the western side of the stairs, provide armour rock along dune toe and backfill dune slope (costings for remedial works presented in Appendix A).

- Dune rehabilitation and control access to the dunes north of Leake St, funding and resources allocated towards a revegetation campaign and controlled access in the form of fencing, signage and designated controlled access points to the beach.

- It would be prudent to also ensure that all planning decisions in the future are in line with the recommendation of this adaptation strategy and that the coastal hazard maps developed as part of this study (and as more monitoring data become available in the future) are used to inform future decisions regarding development at Southend.

- A number of data gaps existing in relation to the assessment of Councils liability, further investigative works are required to assist Council in determining their potential exposure to legal and political liability. The required works to inform an assessment of liability has been provided to Council in a separate memorandum.

- The planned retreat of the following assets is recommended with the necessary planning works to begin imminently:

    - Southend Caravan Park – it is recommended that the lease for the current site is not renewed beyond the current agreement (ending August 2020) and that a suitable alternate site is sought. Once the alternate site is determined, the amenities block and caretaker's office at the current site will need to be decommissioned and the current site returned to the care and control of Council and future development restricted from this site.

    - Southend Sailing Club – it is understood that the land is in fact Crown Land under the care and control of Council however the building is owned by the Sailing Club. Further work is require to understand the term of the current agreement with the Sailing Club and the necessary steps to execute a planned retreat. Once a suitable alternate site is identified, the current site should be returned to the care and control of Council and future development restricted from this site.

    - Whilst action is not required until the 2050 Likely ZR is realised, consideration will need to be given for the relocation of the bush camping sites located north of Leake St. These sites will be more frequently exposed to coastal inundation and under threat to erosion as an increase of 0.3m of SLR is realised.

- Consideration may be given to the appropriate long-term management of Council assets given the remaining life of the assets may be approximately equivalent to the time when emerging hazards will affect the essential function of the asset. An audit of Council assets should be undertaken in terms of the remaining functional life in relation to the timeframe of the impending coastal hazard to inform if the asset should be 'managed to fail' or replaced and relocated inland.

- The analysis has identified retreat as the likely 'best practice' approach for the settlement as a whole for the long term planning horizon (end of the century), more specifically as the adaptation pathway for private property. Given the complexity of implementing such an approach a key recommendation of this study is to commission an investigation into the viability of implementing this approach. The following works would be required:

    - Develop a strategy document to outline the potential options and recommended method for managing a planned retreat of private properties and associated infrastructure (roads, lighting, stormwater). An assessment should be made of all potential risks, costs and constraints of adopting this approach;

    - Financial modelling to be undertaken to further confirm the viability of a managed retreat. The modelling should be tested against hard engineering defend strategies (extending the rock groynes, onshore seawall and offshore breakwater) in light of the likely effectiveness of each option and the subsequent environmental and social impacts.

    - Staged community and stakeholder engagements to communicate findings and work towards stakeholder buy-in for the proposed adaptation pathway.

    Changes to the three rock groynes between Eyre St and Leake St should be deferred until the above works is undertaken, the rationale for this is as follows:

    - Whilst the current design of the groynes is relatively ineffective they are in fact helping 'hold the line' to a degree and removal of the groynes altogether would exacerbate erosion along the eastern beaches.

    - For the groynes to be more effective they would be to be extended at a significant distance offshore, the capital cost for construction alone would be in excess of $500K. Given this, it would be prudent to establish the adaptation approach for the settlement as a whole (specifically private property) prior to committing to such a significant expenditure.

10.5 Data gaps

The adaptation strategy has identified a number of data gaps. It is recommended that these gaps are filled to support the strategy and the future action plan. Data gaps, their relevance to the strategy and scope of works required to fill the data gap are presented in Table 18 below.

Table 18: Data gap to support adaptation strategy

Item No.	Item	Relevance	Scope of work
1	**High resolution spatial data**	A coarse DEM was used to establish the coastal erosion and inundation maps to inform the adaptation strategy. These are to be used as a first pass assessment of hazards only. Finer resolution spatial data would provide greater confidence in the coastal hazard maps and subsequently the adaption strategy.	Once the LiDAR data is provided to Council (understood to be early 2018), coastal hazard maps should be revised and subsequent changes made to the adaptation strategy (including depth of flooding information per asset).
2	**Measured metocean data including bathymetric surveys**	A dataset of measured waves and current data would provide further confidence in understanding the coastal processes at play, in particular the influence of seasonal currents on sediment transport processes.	Commission metocean data collection and bathymetric survey campaign, ideally to capture seasonal profiles of conditions in winter and summer months. Further to this, investigate cost and assess cost-benefit of undertaking semi-regular bathymetric surveys (every 1-2 years).
3	**Coastal structure ownership (three rock groynes between Eyre St and Leake St)**	At the time of the study the jurisdiction of the three groynes was unable to be confirmed, this is considered a significant gap in the study given the potential liability risks the Council may be exposed to. Further to this, the supporting documentation such as engineering designs, the original development applications and subsequent conditions of approval were not able to be provided at the time of this study.	Undertake archival search and interviews with previous members of Council and the CPB to establish asset ownership, conditional of approval and any breaches of approval to determine Council's potential liability and to inform future coastal management decisions.
4	**Supporting information for liability assessment**	A number of data gaps exist in relation to the assessment of Council's liability, further investigative works are required to assist Council in determining their potential exposure to legal and political liability.	The required works to inform an assessment of liability have been provided to Council.
5	**Spatial extent of subdivision between Southend Access Rd and Lake Frome Drain**	The cadastre file outlining the boundaries of the subdivision were not able to be provided at the time of this study. Therefore the level of risk to each allotment to inundation was not able to be provided.	Council to obtain spatial file delineating boundary extents of subdivision. Subsequent updates to inundation mapping, risk register and adaptation strategy to be made accordingly.

6	**Asset ownership –Southend Sailing Club**	The jurisdiction and or terms of lease agreement was unknown at the time of this study, therefore assessment of liability was unable to be determined. An understanding of asset ownership would provide further confidence in the viability of the proposed adaptation pathway proposed.	Council to undertaken investigative works to determine asset ownership and/or understand terms of arrangement (if any). Updates to the adaptation strategy to be made accordingly.
7	**Asset ownership – bush camping sites north of Leake St**	The jurisdiction and or terms of lease agreement for the bush camping sites is currently unknown, asset value is also not known. Evaluation of potential liability and damage costs were unable to be provided.	Council to undertaken investigative works to understand current arrangement for bush camping sites. Updates to the adaptation strategy to be made accordingly.

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Appendix A: Coastal protection structures - defect and repair costing report

Southend Adaptation Study
Assessment of damage & repair
BOAT RAMP CARPARK REVETMENT

STRUCTURE	DAMAGE	REPAIR RECOMMENDATION
North of boat ramp	Minor damage to crest	Place additional top-up armour rock to crest, 70 m
South of boat ramp	Poor condition Core exposed due to loss of primary armour rock cover Armour rock substituted by building rubble	Reconstruct entire revetment - 120 m
Boat Ramp	Surface concrete spalling & cracking	Place new concrete topping slab to ramp surface, 24 x 7.5 x 150 thk, incl reinforcement

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Southend Adaptation Study
Estimate of Cost
BOAT RAMP CARPARK REVETMENT

CONSTRUCTION WORKS

Item No.	Description	Unit	Quantity	Rate, $	Amount, $
1	**PRELIMINARIES**	Item	Sum	-	35,310
2	**NORTHERN REVETMENT**				
2.1	Supply primary armour rock	t	340	60.00	20,400
2.2	Place primary armour rock to crest	t	340	40.00	13,600
					-
3	**SOUTHERN REVETMENT**				-
3.1	Remove existing substandard primary armour rock & dispose	t	1980	25.00	49,500
3.2	Trim exposed batter	m^2	480	15.00	7,200
3.3	Supply & place geotextile	m^2	550	11.00	6,050
3.4	Supply & place secondary armour rock	t	1110	100.00	111,000
3.5	Supply & place primary armour rock	t	830	100.00	83,000
					-
4	**BOAT RAMP**				
4.1	Sand-blast existing concrete surface of boat ramp	m^2	190	23.00	4,370
4.2	Place & finish concrete topping slab, 150mm thk, incl. SL81 mesh reinforcement	m^2	190	305.00	57,950
	TOTAL TO SUMMARY				**$ 388,380**

Southend Adaptation Study
Assessment of damage & repair
OUTLET GROYNES

STRUCTURE	DAMAGE	REPAIR RECOMMENDATION
Western Outlet Groyne	poor condition	place new armour rock over existing faces and on groyne crest, over the entire groyne length, incl. geotextile on bare core faces. Rock size to be determined by detailed design
	clay core exposed, temporary repair with building rubble	length = 50m
Eastern Outlet Groyne	very poor condition	place new armour rock over existing faces and on groyne crest, incl. geotextile on bare core faces. Rock size to be determined by detailed design
	severe erosion of armour rock and core	length = 120m
	clay core exposed, temporary repair with building rubble	

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Southend Adaptation Study
Estimate of Cost
OUTLET GROYNES

CONSTRUCTION WORKS

Item No.	Description	Unit	Quantity	Rate, $	Amount, $
1	**PRELIMINARIES**	Item	Sum	-	113,420
2	**GROYNE No. 1**				
2.1	Supply & place geotextile	m^2	300	11.00	3,300
2.2	Supply primary armour rock	t	2640	60.00	158,400
2.3	Place primary armour rock to groyne faces and crest	t	2640	40.00	105,600
3	**GROYNE No. 2**				
3.1	Supply & place geotextile	m^2	1080	11.00	11,880
3.2	Supply primary armour rock	t	8550	60.00	513,000
3.3	Place primary armour rock to groyne faces and crest	t	8550	40.00	342,000
	TOTAL TO SUMMARY				**$ 1,247,600**

Southend Adaptation Study
Assessment of damage & repair
BEACH ACCESS STRUCTURES

STRUCTURE	DAMAGE	REPAIR RECOMMENDATION
STAIRWAY No. 1 (East of Eyre St groyne)	good condition	no action needed
STAIRWAY No. 2 (West of Eyre St groyne)	good condition	
	dune erosion/slumping west of stairway	provide armour rock along dune toe & backfill dune slope

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Southend Adaptation Study
Estimate of Cost
BEACH ACCESS STRUCTURES

CONSTRUCTION WORKS

Item No.	Description	Unit	Quantity	Rate, $	Amount, $
1	**PRELIMINARIES**	Item	Sum	-	943
2	**STAIRWAY No. 1 (East of Eyre St groyne)**				
	no action				
3	**STAIRWAY No. 2 (West of Eyre St groyne)**				
	Armour rock to toe of dune	t	106	85.00	8,976
	Backfill dune slope	m^3	18	25	450
	TOTAL TO SUMMARY				**$ 10,369**

Southend Adaptation Study
Assessment of damage & repair
BEACH GROYNES

STRUCTURE	DAMAGE	REPAIR RECOMMENDATION
Groyne No. 3 (Eyre St)	good condition	Minor top-up of armour on southern side. Monitor over next decade to determine need to raise crest for sea level rise length = 55m
Groyne No. 4 (Dashwood St)	good condition	Minor top-up of armour on northern side. Monitor over next decade to determine need to raise crest and outer end of groyne for sea level rise. Consider adding new armour rock on south side of timber wall in the future length = 65m
Groyne No. 5 (Leake St)	fair condition	Minor top-up of armour on northern side at landward end. Monitor over next decade to determine need to raise crest for sea level rise particularly at outer end of groyne length = 56m

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Southend Adaptation Study
Estimate of Cost
BEACH GROYNES

CONSTRUCTION WORKS

Item No.	Description	Unit	Quantity	Rate, $	Amount, $
1	**PRELIMINARIES**	Item	Sum	-	6,500
2	**GROYNE No. 3 (Eyre St)**				
2.1	Supply & place geotextile	m^2	0	11.00	-
2.2	Supply primary armour rock	t	180	60.00	10,800
2.3	Place primary armour rock to groyne faces and crest	t	180	40.00	7,200
					-
3	**GROYNE No. 4 (Dashwood St)**				-
3.1	Supply & place geotextile	m^2	0	11.00	-
3.2	Supply primary armour rock	t	210	60.00	12,600
3.3	Place primary armour rock to groyne faces and crest	t	210	40.00	8,400
3	**GROYNE No. 5 (Leake St)**				-
3.1	Supply & place geotextile	m^2	0	11.00	-
3.2	Supply primary armour rock	t	260	60.00	15,600
3.3	Place primary armour rock to groyne faces and crest	t	260	40.00	10,400
	TOTAL TO SUMMARY				**$ 71,500**

Appendix B: Asset risk register

Asset Information				Inundation			Erosion						
Asset ID	Asset	Description	Value	2017 Unlikely	2050 Likely	2100 Almost Certain	Present Day - Zone of Wave Impact Almost Certain	2050 Almost Certain	2050 Likely	2050 Possible	2100 Almost Certain	2100 Likely	2100 Possible
Councils Assets and Infrastructure													
1	Foreshore Reserve Bridges Drive - BBQ and shelter	Timber framed structure with corrugated sheeted roof, concrete floor with two timber picnic setting and brick BBQ with single hotplate	$22,000			Insignificant (MEDIUM)				Major (HIGH)		Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)
2	Foreshore Reserve Bridges Drive - Public Toilet	Timber framed structure with corrugated sheeted roof, concrete floor, male/female toilet	$44,850									Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)
3	Foreshore Reserve Bridges Drive - Effluent Disposal Point	Plastic 'Dump-Ezy' covering with concrete pad, two bollards and a water tap	$10,247										Catastrophic (VERY HIGH)
4	Foreshore Reserve Bridges Drive - Boardwalk	Timber walkway with balustrading from car park to BBQ and shelter	$118,800							Minor (MEDIUM)		Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)
5	Foreshore Reserve Eyre Street - Foreshore stairs	Two sets of timber stairs with balustrading from car park to beach area	$55,000				Minor (HIGH)	Major (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)
6	Southend Caravan Park - Amenities Block	Male/female facility with laundry	$319,304						Major (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)
7	Southend Caravan Park - Office	Main office structure	$42,877						Major (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)
8	Southend Caravan Park - Power Outlets	Power outlets for powered sites, each outlet had four points	$43,833						Major (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)
9	Foreshore Reserve Eyre Street - Public Toilet	Rendered structure with gabled roof and two unisex toilets on a concrete floor	$100,395					Minor (HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)
10	Foreshore Reserve Eyre Street - Ladies Public Change Room	Rendered structure with flat roof and a concrete floor	$66,240					Minor (HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)
11	Foreshore Reserve Eyre Street - Men's Public Change Room	Rendered structure with flat roof and a concrete floor	$66,240					Minor (HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)
12	Cape Buffon Dr	Sealed road	$40,163									Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)
13	Bridges Dr	Sealed road	$79,118										Catastrophic (VERY HIGH)
14	Eyre St	Sealed road	$53,784					Minor (HIGH)	Major (VERY HIGH)	Major (HIGH)	Major (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)
15	MacDonald St	Sealed road	$29,722									Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)
16	Bonney St	Sealed road	$29,722										Catastrophic (VERY HIGH)
17	Evelyn St	Sealed road	$27,456										Catastrophic (VERY HIGH)
18	Dashwood St	Sealed road	$10,752										Minor (MEDIUM)
19	Leake St	Sealed road	$52,348										Minor (MEDIUM)
20	Stormwater and sewerage	Stormwater pipes and pits	$41,400										Medium (Medium)
21	Sailing Club	Timber and brick two storey building with two water tanks	$860,000					Medium (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)
22	Bush camping blocks (north of Leake St)	Cleared camping sites, ownership unknown	Not provided	Minor (LOW)	Minor (MEDIUM)	Minor (HIGH)			Minor (MEDIUM)	Medium (MEDIUM)	Major (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)

Asset Information				Inundation			Erosion						
Asset ID	Asset	Description	Value	2017 Unlikely	2050 Likely	2100 Almost Certain	Present Day - Zone of Wave Impact Almost Certain	2050 Almost Certain	2050 Likely	2050 Possible	2100 Almost Certain	2100 Likely	2100 Possible
Private Assets and Infrastructure													
1	17 Bridges Dve	Private Dwelling	$240,000										x-insignificant (VERY LOW)
2	21 Bridges Dve	Private Dwelling	$295,000										x-insignificant (VERY LOW)
3	1 Eyre St	Private dwelling	$290,000									Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)
4	3 Eyre St	Private dwelling	$180,000										Catastrophic (VERY HIGH)
5	1 - 3 Mac Donald St	Private dwelling	$840,000									Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)
6	2 - 4 MacDonald St	Private dwelling	$510,000									Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)
7	2 - 4 Bonney St	Private dwelling	$700,000									Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)
8	1 Bonney St	Private dwelling	$210,000										Catastrophic (VERY HIGH)
9	2 Dashwood St	Private dwelling	$660,000										Catastrophic (VERY HIGH)
10	1 Dashwood St	Private dwelling	$780,000										Catastrophic (VERY HIGH)
11	2 Evelyne St	Private dwelling	$265,000										Minor (MEDIUM)
12	Some privately owned undeveloped allotments in the coastal conservation block east of Leake St	Private dwelling	$116,000	Insignificant (VERY LOW)	Insignificant (LOW)	Insignificant (MEDIUM)	Insignificant (MEDIUM)	Medium (VERY HIGH)	Major (VERY HIGH)	Major (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)	Catastrophic (VERY HIGH)
13	Private allotments between the Southend Access Rd and the Drain	Private dwelling	Not assessed as cadastre boundaries for sub division not provided										
State Government Asset and Infrastructure													
1	Boat ramp	Concrete slab	Not provided	Minor (LOW)	Minor (MEDIUM)	Minor (HIGH)							
2	Boat ramp carpark	Bitumen laydown area	Not provided			Insignificant (MEDIUM)							
3	Electricity pole (lighting)	More specifically, running parallel to the shorefront properties between Eyre St and Leake St	Not provided									Major (VERY HIGH)	Catastrophic (VERY HIGH)
4	Southend Bridge	Bridge connecting Eliza St to Cape Buffon Dve, crossing Lake Frome drain	Not provided										Catastrophic (VERY HIGH)

Appendix C: Community consultation summary

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Appendix C – Community Consultation

Workshop One

Below provides a summary of responses for the questions put forward at the first community consultation workshop:

1. Where have you observed erosion and inundation impacts?

- The primary erosion and inundation impacts identified by attendees were the same as those described in the coastal processes map presented at the workshop, including:
    - Build-up of sand on the beach to the west of the Outlet groynes (Western Beach);
    - Erosion of sand from the beach to the east of the Outlet groynes; and
    - Long term recession of the dunes north of Leake Street.
- There was concern raised about the validity of the Worley Parsons report and its accuracy. Regarding sediment movement. The main issue raised was the view that the report does not account for the erosion and accretion processes that operate differently during summer and winter, influenced by currents in Rivoli Bay and storm events during winter months.
- Aside from debate about the true nature of erosion and deposition, the primary drivers of erosion are considered to be:
    - Loss of seagrass in Rivoli Bay – While there was strong agreement about the importance of the seagrass in reducing erosion, there was conjecture about what has caused it, which is attributed to both freshwater flows from the Lake Frome Outlet and the direction of flow as a result of the installation of groynes.
    - Groynes – Not all groynes affect the movement of sand equally, but there was general concern about the impact they have collectively had on erosion, especially the groyne on the east side of the Outlet.

2. What natural or built assets are of most importance to you along the Southend foreshore?

There was broad agreement about which assets were important, with a focus on the:

- Jetty for commercial fishing;
- Beaches for locals and in support of tourism;
- Caravan park;
- Sailing club;
- Bush camping area; and
- Conservation importance of beaches and dunes.

3. What questions do you have regarding how to interpret the erosion maps or inundation maps?

There were few questions or clarifications about how to interpret the erosion and inundation maps. This followed a comprehensive explanation of how they were generated and how to interpret them. Based on observations of conversations, the reasons for the lack of questions is likely to include:

- A view that sea level rise impacts were exaggerated;
- Inundation further inland will not happen because of a lack of flow paths; and
- Timeframes of 2050 and 2100 were too distant to be relevant to current day decisions.

4. What impacts are most important to you?

This question did not receive much discussion. The focus was clearly on impacts related to the priority built and natural assets described in question two.

5. What responses could help to address the project erosion and inundation risks?

Potential response options were the most commonly discussed issue, being addressed at multiple agenda items, even when they were not the intended focus of the discussion at different points during the workshop.

In the short term, attendees were keen for the following options to be explored:

- Repositioning or removal of groynes – There was a desire to remove the groyne on the west side of the outlet, reposition the groyne on the east side of the outlet, and potentially remove the remaining three groynes. An option was put forward to create a “hook” groyne on the west side of the outlet, whereby the west side groyne would be shortened and then rocks added to create a hook, which would direct flows to run in a parallel direction to the beach, in the direction of the natural current;
- Reduce outlet flows – This would involve infrastructure measures by the South Eastern Water Conservation Drainage Board that would redirect flows from Lake Frome toward Lake George;
- Seagrass restoration – Deploy all measures necessary to re-establish seagrass beds, such as reducing flows from the Lake Frome outlet and redirecting flows through the outlet groynes;
- Weir structure on the outlet – The purpose of a weir on the Lake Frome outlet would be to reduce freshwater flows into Rivoli Bay during summer;
- Protect dunes – To the north of Leake St a large area of fore dunes experiences damage due to foot and vehicle traffic. The priority for this area is to reduce vehicle and pedestrian access, and increase revegetation efforts.

More significant infrastructure options proposed were:

- Offshore breakwater; and
- Sheet pile structure to reduce wave impact direct on the beach.

Workshop Two

Below provides a summary of responses for the questions put forward at the second community consultation workshop.

Table 1 and Table 2 provide the verbatim comments from the worksheets in response to question one and two respectively.

1. What are the constraints and benefits of potential response options such as do nothing, defer, accommodate, defend or retreat?

Do nothing

The option of doing nothing in response to projected inundation and erosion risk was not favoured by any group. This was because of the impacts that are already being experienced. One group noted that it was important to take a "measured approach to high risk areas first". It was also noted that do nothing was not an option because the primary existing erosion measures have been ineffective on much of the Southend beach.

Defer

Defer was not favoured as an option due to the current impacts that are already being experienced along the coastline at Southend. One group said "Can't defer any longer".

Defend

The defend option recorded the highest number of responses, more than double any other response option.

- *Groynes* - Forty percent of the defend responses were in relation to the groynes. The general view was that with the exception of the groyne on the western side of the Lake Frome outlet, all others are ineffective. There was no single consistent view on what should be done with the other groynes, with responses ranging from running them parallel to the beach, shortening them to redesigning the end of the groynes to better direct wave energy.
- *Beach nourishment* – Nourishment of the beach with additional sand was generally regarded as an ineffective use of funds. This is because previous nourishment efforts had been eroded quickly once heavy wave action impacted the beach during storms.
- *Reduce Lake Frome outflows* - A reduction in Lake Frome flows from the drain into Rivoli Bay was widely supported. This is based on the view that freshwater flows into the Bay have caused a loss of sea grass beds, which in turn has caused increased wave action and erosion along the coastline. Even if freshwater flows are reduced, such as by redirecting them to Lake George, it was recognised that restabilising seagrass beds will take a significant amount of time.
- *Sea wall* - A sea wall directly on the coast was discussed by a number of attendees. A similar structure at Portland was cited as an example of where this approach has been used successfully. The timing of such a wall was questioned, with one comment suggesting that a "seawall is a last resort". While not recorded on the worksheets, there was significant discussion at the workshop among attendees noting that a seawall would likely lead to the loss of beach and that its construction would also distribute wave energy elsewhere on the coast, possibly leading to erosion issues at other locations.

- Other suggestions were to restrict 4WD access to the dunes only and to construct an offshore breakwater. While not reflected on the worksheets, there was significant discussion regarding the concept of an offshore breakwater, the aim of which would be to reduce wave energy and erosion on the shore side of the structure. It was noted that a breakwater would come at a significant cost and depending on its location, would likely distribute wave energy to other parts of Rivoli Bay, possibly leading to increased erosion at those sites. Another concern highlighted was the potentially significant ongoing maintenance (dredging) costs of a breakwater.

Accommodate

A commonly discussed accommodate option was ensuring that residents are aware of potential future risks. It was suggested that:

- residents should be informed of future risks;
- new development should be limited in high risk areas; and
- planning regulations should be reviewed for high risk areas

There were no other commonly cited accommodate options.

Retreat

- Retreat of infrastructure was considered to be an option primarily for public assets on council or crown land. One comment suggested that "Its ok for council assets but who is going to compensate for private assets?".
- Recent impacts to the dunes in front of the caravan park, which prompted the removal of the cabins, were cited as reasons for moving the caravan park to another location. This was widely supported, although it was recognised that this could have flow on social and economic impacts. Some locations for another site for the caravan park were discussed and it was suggested that private investment may be an alternative to the council taking responsibility for establishing a new site.
- The Rivoli Bay Sailing Club was also identified for retreat at some point in the future. While not currently impacted by erosion, the front of the Sailing Club is located at a point that is considered to be *almost certain* to be impacted by erosion by 2050, with the entire site of the clubhouse *possibly* within the zone of recession by 2050.

2. What are the triggers for decision making?

There were 23 responses provided to the question of what triggers should be considered to inform when options are implemented. Discussion regarding triggers was informed by the erosion and inundation maps.

With the exception of inundation of the bush camping area, all triggers were related to erosion. The most commonly referred to triggers were:

- Erosion at the caravan park;
- Loss of beach access and facilities at the Rivoli Bay Sailing Club; and
- Loss of stairs or beach access at various locations across the coast

Of the triggers listed above it was noted that erosion at the front of the caravan park and the loss of stairs and beach access had already occurred in some locations.

While not widely supported, there was a suggestion to set a trigger at a certain distance from private property, although the specific location of this trigger was not identified. Other triggers that were discussed include:

- Loss of stable beaches;
- Erosion of dunes;
- Loss of sea grass;
- Damage to major infrastructure leads to less visitors; and
- Less people going to beaches causing a loss of facilities.

Table 1: Response to worksheets 1, 2, 3 and 4. NB. The comments are verbatim from the worksheets.

Option	Table	Comment
Do nothing	1	Doing nothing is not an option - erosion is a big problem on the foreshore and is already damaging property and assets (private and on council/crown land)
	2	Groynes are doing something, good for front beach, detrimental for the other beaches
	2	Not a realistic option
	2	Groynes are not trapping sand
	2	Taking action has consequences, sometimes long term
	3	Do not want to do nothing
	3	Take measured approach to high risk areas first
	4	Do not agree to do nothing
Defer	1	Not a future problem. Doing something is better than doing nothing.
	2	Already know what happens if do nothing
	3	Put the stair case somewhere else
	3	Stop the erosion
	4	Cant defer any longer
Defend	1	Moving groynes around to see what impact it has - don't lengthen but consider different end designs
	1	Consider spurs on the groynes. Removal of others not a big expense.
	1	Divert drain to Lake George to encourage sea grass to regenerate.
	1	Onshore concrete stone and concrete wall similar to Portland is proven to curb erosion. Look at other places to see what works.
	1	Sand relocation is only a small band aid that can disappear in one storm and doesn't address the issue that causes the erosion in the first instance.
	1	Erosion around Cape and PO Rock is natural and should be left alone.
	2	Turn groynes inshore to run parallel as breakwaters. This would provide direct protection from NW storms)
	2	Reducing outlet groynes has limited benefit for expenditure
	2	Changing (shortening) outlet groynes not supported (due to effect on West Beach). And sand might not go to eastern beaches
	2	Seawall is a last resort

Option	Table	Comment
	2	Support for an offshore structure (nearshore, about end of groynes)
	2	Nourishment is a waste of money and is ineffective.
	3	Restrict flow o drain by putting a weir in place
	3	Drain is required first then fix sea grass
	3	Sea wall
	4	Restrict flows from drains
	4	Redesign the outlet groynes i.e. shorten move/shift reangle
	4	Restrict 4WD access to dunes only
	4	Redesign groynes between Leake and Eyre St, lengthen by 50m.
	4	Did not agree to formalising the beach nourishment strategy.
	4	Try groynes first and wait and see
	4	Breakwater cost is likely to be a constraint
Accommodate	1	Changing groynes could work, but repairing the existing groynes cant fix erosion.
	1	Limit new development is easy and simple to do and could be used in conjunction with defence options
	2	Freeboard not considered a valid option
	2	Inform residents of risks in some areas
	2	Pretty big buffer from areas of erosion impact
	2	53 storm took out at least 40 yards of beach
	3	People in coastal flood areas know they need to accommodate
	4	Inform residents of potential risks
	4	Planning regulations for at risk residents
	4	Weir at the outlet as a preventative measure
Retreat	1	Not an option because the foreshore is worth saving
	1	Same as do nothing
	1	Caravan Park could easily be relocated. Don't know about making people spend money to shift their assets.
	2	Caravan park beach is highest priority
	2	Beach access points - yacht club access is the most important
	2	Caravan Park land is highlight valued - don’t want to lose it. This is an important buffer to the Bridges - Cape Buffon Drive
	2	Table not concerned about the yacht club
	2	Beach is critical to the community
	2	Keep the beach to protect infrastructure
	3	Its ok for council assets but who is going to compensate for private assets
	4	Caravan Park relocation - potential for private investment
	4	Sailing Club groyne restructure

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Table 2: Response to triggers identification. The comments are verbatim from the worksheets.

Table	Already reached	Physical	Economic	Social	Environmental	Description
1		x				Erosion at caravan park
1	x				x	Dune erosion
1		x				Flooding of bush camping area
1	x	x				Access steps damaged (already occurred)
1				x		Population growth will lead to increased property prices and demand for protection
1		x				Set an erosion line at a certain distance from private property that triggers action
2					x	Unsafe beach access
2	x	x	x	x	x	Loss of stable beaches
2		x	x	x		Loss of beach access from Caravan Park shelter at Eyre St
2		x	x	x		Loss of beach access from the Sailing club
2	x	x	x	x	x	Loss of seagrass
2			x			Damage to major infrastructure leads to less visitors
2				x		Less people going to the beaches / loss of facilities
3			x			Removing the Caravan Park will affect the shop
3				x		Loss of sailing club
3		x				Stairs at sailing club and Eyre St need replacing
4			x			Cabins removed from beach front
4					x	Erosion
4				x		End of Eyre St picnic table
4		x	x	x		Loss of sailing club
4		x				Loss of stairs on beach
4			x			Loss of stairs on beach
4		x				Defence mechanisms not working