

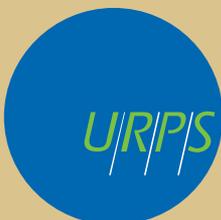


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# AdaptWest

Coastal Management  
Research Paper  
28 November 2014

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URPS in collaboration with SEED consulting and AECOM



# AdaptWest Research Paper Coastal Management

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28 November 2014

**Prepared for** City of Port Adelaide Enfield  
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## 1.0 Introduction

### 1.1. About AdaptWest

AdaptWest is a partner project between the Cities of Port Adelaide Enfield, Charles Sturt and West Torrens, the South Australian Government and the Australian Government to develop a Regional Climate Change Action Plan for Western Adelaide.

In 2013, an initial stage of work was completed comprising a social, economic and environmental profile of the Western Adelaide region, and collation of historical climate observations and future climate projections.<sup>1</sup>

The current stage of AdaptWest builds on this previous work and is being delivered through three main tasks:

- **Preparing the evidence base** - Identifying regional values and key decisions with potential to be impacted by climate change, and gathering information to better understand these values, decisions and impacts;
- **Undertaking the Integrated Vulnerability Assessment (IVA)** – Assessing the exposure, sensitivity, and adaptive capacity of the region to understand vulnerabilities and opportunities presented by climate change; and
- **Preparing the Adaptation Plan** – Identifying priority areas of focus and adaptation options, developing adaptation pathway maps, and determining key actions, roles and responsibilities.

AdaptWest has adopted five themes through which to consider the region and its vulnerability to climate change. These themes are:

- Assets, infrastructure and economy;
- Coastal management;
- Environment and open space;
- Social and community resilience and health; and
- Urban planning and development.

The project's methodology embeds the active participation of key stakeholders from the Western Adelaide region associated with each of the five themes. Specifically, this involves interactive stakeholder workshops associated with each project task, and direct stakeholder input to key project decisions relating to the focus of the project, the assessment of vulnerability, and preferred adaptation responses.

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<sup>1</sup> SKM (2013), *Western Adelaide Region Climate Change Adaptation Plan – Stage 1*

## 1.2. Values and key decisions

Two important aspects of the AdaptWest project's approach to vulnerability assessment and adaptation planning are the consideration of regional values, and key decision lifetimes.

Stakeholder input has driven the development of eight AdaptWest regional values, which will be used to focus the project toward those features or aspects of particular importance to the region, namely:

- Amenity and quality of life;
- A strong and connected community;
- Biodiversity;
- Coastal and riverine water quality;
- Coastal environment;
- Infrastructure and essential services;
- Management and use of stormwater; and
- Regional productivity and economic contribution to the state.

These values and the process of their development are described further in Section 2.4, and the values provide a point of reference throughout this research paper.

An important aspect of planning for regional adaptation is to understand the relationship over time between key decisions the region's stakeholders will make, and climate change impacts. In this context, a decision lifetime is the time taken to make a decision (lead time) plus the duration of that decision's implications (consequence time).<sup>2</sup>

Some decisions made by individuals or organisations have lifetimes that are shorter than the timeframes over which the major effects of climate change will occur (e.g. < 10 years). In contrast, there are decisions made today that have longer lifetimes (e.g. > 70-80 years) that will converge with the expected timing of some of the more significant projected impacts of climate change.

Early stakeholder input to the AdaptWest project has led to development of Figure 1.1, which summarises key decisions to be made among various stakeholder organisations and the region as a whole, and their lifetimes. Several of these decisions will be relevant across multiple project themes and regional values.

Consideration of key decision lifetimes will occur throughout the AdaptWest project, particularly in development of the **Adaptation Plan**.

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<sup>2</sup> Stafford Smith et al. (2011) *Rethinking adaptation for a 4°C world* in Philosophical Transactions of the Royal Society A, p. 197

**Figure 1.1: Western Adelaide key decision and decision lifetimes identified by stakeholders**



### 1.3. Purpose of the research papers

A research paper has been prepared for each of the five AdaptWest themes as part of the task of **preparing the evidence base**.

The papers are intended to be a resource to support completion of the **IVA** and development of the **Adaptation Plan**.

Each paper provides **targeted** information about the region in relation to the theme topic and regional values, and responds to the following IVA considerations:

- The current state of the region, in the context of regional values (Section 2.0);
- Exposure to climate hazards (Section 3.0);
- Sensitivity to climate hazards (Section 4.0), and
- The region's adaptive capacity (Section 5.0).

Development of the research papers has drawn particularly upon the *Western Adelaide Region Climate Change Adaptation Plan – Stage 1*, as well as additional relevant literature and interviews with key informants associated with the research paper theme where relevant.

## 2.0 Coastal Management in the Western Adelaide region

### 2.1. Overview

The coastal environment is a key feature of the Western Adelaide region, contributing significant environmental and social values such as habitat, recreation and tourism, and housing significant community assets and infrastructure.

The coastal environment consists of:

- **Environmental aspects:** the natural environment, including coastal, estuarine and natural resources
- **Social aspects:** amenity and quality of life, as derived from the coastal environment
- **Economic aspects:** Infrastructure, essential services and properties.

Unless indicated otherwise, all information in these sections is drawn from *Western Adelaide Region Climate Change Adaptation Plan – Stage 1*.<sup>3</sup>

### 2.2. Key stakeholders in coastal management

An important aspect of the AdaptWest project is the involvement of stakeholders to help identify, assess and prioritise the region's vulnerabilities to climate change and options for adaptation. Key stakeholders identified in the coastal management theme are:

- **Local governments** that provide services and facilities located on the coast. For example, community centres, open space and recreation facilities. Local governments are also likely to own and manage areas of coastal land and assets on this land, and have a significant responsibility for coastal areas.
- **State government agencies**, including the Coast Protection Board, the Department for Planning, Transport and Infrastructure, and the Department for State Development that regulate the conservation of environmental values and provide services and facilities located on the coast including coast protection infrastructure.
- **Commonwealth government and agencies** that set strategic policies in relation to climate change adaptation and coastal management and is also a provider of funding and investment for adaptation and coastal management.

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<sup>3</sup> SKM (2013)

- **Not for profit organisations**, in particular, those that are concerned with coastal conservation.
- **Community organisations and clubs** that provide services and facilities located on the coast and/or use those services and facilities provided by governments or commercial operators on or near the coast. For example, residents associations, local environmental groups and sports clubs.
- **Households, private property owners and individuals** who live in or own property in coastal areas and/or use services and facilities located on the coast.
- **Businesses** involved in provision of adaptation related services such as insurers.

## 2.3. Existing conditions

### 2.3.1. Environmental aspects

The coastal and estuarine environment is an important feature of the Western Adelaide region, and provides valuable ecosystem and biodiversity services. The northern boundary of the region borders the Barker Inlet and Port River Estuary, with the coastline to Gulf St Vincent providing the western boundary. The Barker Inlet and Port Adelaide River Estuary is the largest tidal inlet in Gulf St Vincent, and contains significant biodiversity, as outlined below.

The region contains areas of significant remnant dune vegetation, including the Tennyson Dune Reserve and Semaphore Park Dunes. The Tennyson Dune Reserve contains the most significant area of remnant dune vegetation along Adelaide's metropolitan coastline, while the Semaphore Park Dunes area, along with the Tennyson Dune Reserve, is the only other area of well-established native dune vegetation.<sup>4</sup>

A number of significant native fauna and flora species listed at a Federal, State and/or regional/local levels are present within the region, including 170 significant native fauna species and 90 significant native flora species identified. Numerous listed migratory and marine faunal species under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) exist along the coastline of the Western Adelaide such as the Southern Right Whale (*Eubalaena australis*) and the Southern Giant Petrel (*Macronectes giganteus*). The subtropical and temperate coastal saltmarsh along the coast of the City of Port Adelaide Enfield is an example of a federally threatened ecological community within the Western Adelaide Region. An example of federally threatened floral species along the coast includes the Coast Spider-Orchid (*Caladenia conferta*). Additionally, various open space marine areas provide significant habitat and sustenance for several flora and fauna species, such as the West Lakes recreational lake system, the Port River Estuary and Barker Inlet. The Barker Inlet and Port River Estuary also supports an extensive

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<sup>4</sup> Cordingley & Petherick (2006a), *Vegetation Management Plan Tennyson Dune Reserve Yaitya Worra (True Indigenous Sand)*; Cordingley & Petherick (2006b), *Vegetation Management Plan: Semaphore Park Coastal Reserve*

mangrove network and contains the world's most southern stand of Grey Mangrove. It is also a nursery area for a range of commercial fish species, and contains the State-protected Adelaide Dolphin Sanctuary.

Coastal and foreshore areas in the region vary substantially in their substrate, structure and the biodiversity services they provide. Unconsolidated mudflats, mangroves, sandflats and shallow/intertidal seagrass emergent are among the most significant providers of biodiversity services along the coastline.<sup>5</sup>

### 2.3.2. Social aspects

Social aspects of the coastal environment relate to recreation, amenity, culture, heritage, health and wellbeing.

Coasts and beaches provide significant open space to communities. Sandy beaches extend to around 20 kilometres from West Beach in the south to North Haven in the north. The Barker Inlet and Port River also provide coastal access in the form of wharves, mangroves, sandflats, mudflats and intertidal seagrass. Coastal areas also support a network of parks and recreational reserves, which provide areas for formal and informal recreation, sporting and leisure activities, contributing to amenity and providing a focus for social and community gatherings and tourism. Some of the parks and reserves along the coast include Wonga Park Reserve, Harold and Cynthia Anderson Reserve and Point Malcolm Reserve (which also contains the Semaphore Surf Life Saving Club). Golf courses are also present along the coastline, such as the North Haven Golf Club in Outer Harbor and the Adelaide Shore Golf Park in West Beach.

There are numerous places of Aboriginal significance associated with the water and coastal resources of the region. Pullen (2006) notes the significance of the mouths of the Torrens and Sturt Rivers to the Kaurna people.<sup>6</sup> Coastal dunes, samphire flats and mangroves are also noted as being of Aboriginal significance at locations including Mutton Cove, the Port coastline, Rosewater and Gillman dunes.

In addition to being of Aboriginal significance, the coastal areas also provide important services such as stormwater treatment which influence the health, safety and wellbeing of the community. For example, the Barker Inlet wetland system treats stormwater which then discharges to North Arm Creek before flowing into Barker Inlet Aquatic Reserve. Golf clubs also play a dual role as recreational facilities and stormwater retention basins.

### 2.3.3. Economic aspects

The coastal environment consists of many of the Western Adelaide region's largest economic centres and privately operated economic infrastructure. These include major private assets such as:

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<sup>5</sup> SKM (2013), p.133

<sup>6</sup> Pullen (2006), *Kaurna Cultural Heritage Survey*, cited in City of Port Adelaide Enfield (2007), *State of the Environment Report 2007*

- Energy infrastructure (power stations and transmission lines owned by SA Power Networks and Electranet respectively)
- Transport facilities and infrastructure, including
  - Maritime (Flinders Ports infrastructure, including the Port of Adelaide and 19 other wharves along Inner and Outer Harbor);
  - Rail, and;
  - Aviation (Adelaide Airport)

The coastal region in the City of Port Adelaide Enfield is also home large manufacturing industries, including:

- Adelaide Brighton Cement Limited, a cement and lime product manufacturer
- Shell Bitumen Plant, a global bitumen manufacturer and supplier
- Owen Illinois (OI), a glass product manufacturer.

The region's coastal environment provides valuable ecosystem services which also contribute to the region's economy. For example, the mangrove and samphire systems directly contribute to the economic outcomes of the commercial fishing industry by providing a nursery function for fish populations in the area. The Barker Inlet and other coast areas support the State's fishing industry by providing a local source of employment.

Aside from the assets and infrastructure along the coast, the coastal environment's largest economic indirect contribution to the Western Adelaide region is to the tourism sector. Key tourism facilities include the Adelaide Shores complex at West Beach, which constitutes a caravan park, public boat ramp, sailing clubs and skating and biking parks. Tourism operations also take place at the Adelaide Airport (which is also a key tourism gateway to the region) in the form of large retail outlets and services. Perhaps most importantly, the natural coastal environment plays an important aesthetic role in tourism, with coastal regions such as the Adelaide Dolphin Sanctuary at the Port River Estuary and Barker Inlet, and fine sand beaches attracting tourists to Western Adelaide.

## 2.4. AdaptWest regional values, features and aspects

An important aspect of the AdaptWest project is the involvement of stakeholders to help identify, assess and prioritise the region's vulnerabilities to climate change and options to adapt.

The initial stage of this involvement was a workshop where representatives of the key stakeholder organisations identified the features of Western Adelaide that are important to their objectives and core functions and contribute to the vitality and functioning of the region and beyond. Stakeholders at this workshop identified the key decisions for the region summarised in Figure 1.1 (refer Section 1.2).

Additionally, the AdaptWest project team developed stakeholder input into a list of regional values, features and aspects that will form the basis of the Integrated Vulnerability Assessment.

Table 2.2 provides an overview of the regional values, features and aspects identified by stakeholders at the Values and Key Decisions Workshop to be of importance and the relationship between these values and coastal management in Western Adelaide.

**Table 2.2 AdaptWest values, features and aspects relating to coastal management**

<b>What we value in the Western Region</b>	<b>Features or aspects that relate to this value</b>	<b>Relationship to Coastal Management in Western Adelaide</b>
<b>Coastal environment</b>	Environmental values Community and recreation Tourism Assets and infrastructure	The coastal environment is a central component of the Western Adelaide region, contributing significant environmental, social and economic values such as habitat, cultural heritage, recreation, tourism, along with significant community assets and infrastructure.
<b>Biodiversity</b>	Gulf and marine biodiversity Coastal and dune biodiversity Riverine Ecosystem services Intrinsic value	The coastal and estuarine environment in Western Adelaide provides valuable ecosystem services and contains significant biodiversity, including: <ul style="list-style-type: none"> <li>- Areas of significant remnant vegetation.</li> <li>- Ecological communities and species of national significance, including saltmarsh and several bird species such as the White-bellied Sea Eagle and Little Egret.</li> </ul> <p>The Barker Inlet and Port Adelaide River Estuary supports an extensive mangrove network, contains the world's most southern stand of Grey Mangrove. It is also a nursery area for a range of commercial fish species, and is houses the Adelaide Dolphin Sanctuary.</p>
<b>Coastal and riverine water quality</b>	Port River River Torrens Gulf St Vincent	Adelaide's metropolitan beaches and coastal waters have been impacted by discharges from stormwater, industrial waste and

<b>What we value in the Western Region</b>	<b>Features or aspects that relate to this value</b>	<b>Relationship to Coastal Management in Western Adelaide</b>
	<p>Water Sensitive Urban Design (WSUD)</p> <p>Stormwater capture and reuse</p>	<p>treated effluent. This is mainly due to the growth of Adelaide's urban development population, which has contributed to increasing nutrients and other pollutants affecting water quality in sensitive coastal waters, such as Gulf St Vincent. WSUD has been a key planning tool integrated into stormwater and wastewater infrastructure design.<sup>7</sup> Additionally, riverine/estuarine areas are important environmental assets in the region. These cover the Barker Inlet, the Torrens Estuary and aquatic reserves.</p>
<b>Management and use of stormwater</b>	<p>Protection of homes</p> <p>Protection of infrastructure</p> <p>Water Sensitive Urban Design (WSUD)</p> <p>Stormwater capture and reuse</p>	<p>Stormwater flows from urban developments are often high in organic waste, industrial waste and nutrients. Management of stormwater, in particular its treatment and discharge from urban developments into marine environments, affects how coastal environments are managed. There are four catchments in the region, Port Adelaide, Dry Creek, River Torrens and Patawalonga. These catchments comprise urbanised and rural settings with engineered and natural formats. Several stormwater/flood assets are of significance in the area, including the Barker Inlet for ecological purposes, Breakout Creek Weir for storm surge protection, aquifer recharge schemes, gauging stations, and storm water reuse projects.</p>
<b>Infrastructure and essential services</b>	<p>Port facilities</p> <p>Adelaide Airport</p> <p>Water and wastewater treatment</p> <p>Power generation</p>	<p>Various key infrastructure assets and essential services lie along or within the vicinity of the coastal environment in Western Adelaide. Adelaide Airport lies within the City of West Torrens, adjacent to West</p>

<sup>7</sup> Department for Water (2011), *Stormwater Strategy: The future of stormwater management*; EPA South Australia (2009), *Changes in urban environments*

## Coastal Management in the Western Adelaide region

What we value in the Western Region	Features or aspects that relate to this value	Relationship to Coastal Management in Western Adelaide
	Transport Open space Defence industries Community facilities	Beach. Numerous water supply and sewerage pipelines owned by SA Water also extend across the Western Adelaide region, with sewerage pumped to Bolivar for treatment (eastern coast of Barker Inlet). Wetlands, both constructed and natural, are also present along watercourses discharging into coastal environments, e.g. Gilman wetlands and Apex Park wetlands. Infrastructure along the coast includes jetties (e.g. Henley Jetty) and Flinders Ports assets (e.g. Adelaide Container Terminal). Power stations and networks managed by SA Power and Electranet are also present along coastlines on Torrens Island and Outer Harbor.
<b>Regional productivity and economic contribution to the state</b>	Infrastructure and industries of State significance <ul style="list-style-type: none"> <li>- Port facilities</li> <li>- Adelaide Airport</li> <li>- Defence industries</li> <li>- Gillman industrial area</li> <li>- Tourism infrastructure e.g. Adelaide Shores</li> </ul> Adelaide Entertainment Centre	Among its other values, the coastal and riverine areas of the region house a significant proportion of the infrastructure and industries of State significance. These include public assets, facilities and infrastructure such as coastal assets (jetties, boat ramps and public tourism facilities), council owned buildings and community centres, stormwater infrastructure, port facilities, and major industries including Viterro Grain Facilities, Techport precinct, OI and Adelaide Brighton Cement. In addition to the contribution of hard infrastructure situated in coastal areas in Western Adelaide, the region's coastal environment provides valuable economic contribution to the State's fishing industry through the ecosystem services provided by the mangrove and samphire system, which provide valuable nursery grounds of the areas fish communities. The Barker

What we value in the Western Region	Features or aspects that relate to this value	Relationship to Coastal Management in Western Adelaide
		Inlet and other coastal areas also provide a source of employment.
<b>A strong and connected community</b>	Diversity Equity and social justice Vulnerable members of the community	Users of coastal areas are diverse and reflect the cultural, linguistic and demographic diversity of the region. While such diversity is considered to be a great strength, it also highlights the different decision making capacities of households and the need to ensure that diverse communication and information provision methods are used in order to meet the needs of all community members. The above-average rate of renting in the area is likely to influence the ability of households to affect change in their current living environment.  Additionally, ABS indicators suggest that the region's overall socioeconomic status is generally lower compared to the State average. <sup>8</sup> Many of the areas which are currently flood prone are in areas of greater socioeconomic disadvantage, further compounding vulnerability of communities in these areas.  As the region is also earmarked for significant population growth and urban renewal, empowering all members of the community to be informed about, and make decisions around coastal management will be increasingly important.
<b>Amenity and quality of life</b>	Safety and health Sport, recreation, entertainment and tourism facilities Coastal /water based recreation Open and green spaces	Coastal areas in the Western Adelaide region house numerous recreational and tourism facilities which contribute to a higher quality of life for residents and visitors. These include parks and reserves (Point Malcolm reserve), jetties (e.g. Henley Beach jetty), boat ramps (e.g. Adelaide Shore boat ramp). Beaches provide a significant

<sup>8</sup> Campbell Pages (2014) State of Our Community

What we value in the Western Region	Features or aspects that relate to this value	Relationship to Coastal Management in Western Adelaide
	Natural and historical environments	amount of open space and amenity for communities, with fine sand beaches extending almost 20 kilometres from West Beach in the City of West Torrens to North Haven in the City of Port Adelaide Enfield. The Adelaide Shores complex in West Beach is a key resort for visitors and locals in the Western Adelaide region. While providing stormwater retention services, golf clubs are primarily used for recreation, with the North Haven Golf Club and Adelaide Shores Golf Club located along the Gulf St Vincent coastline. Barker Inlet and the Port River estuary also provide access to the coast in the form of man-made wharves and naturally occurring mangroves, mudflats, sandflats and intertidal seagrass emergent. The Port River estuary also houses the Adelaide Dolphin Sanctuary, a key feature of amenity in the region which also contributes significantly to the tourism sector.

## 2.5. Key decisions

Consideration of the relationship between climate impacts and key decision lifetimes is another focus of the AdaptWest project (refer Section 1.2).

At the same workshop described in Section 2.4, stakeholders identified the key decisions for the region relating to the coastal management theme. These theme-specific key decisions are set out in Table 2.3, and contributed to the broader regional key decisions summarised in Figure 1.1 (refer Section 1.2).

**Table 2.3: Key decisions relating to coastal management**

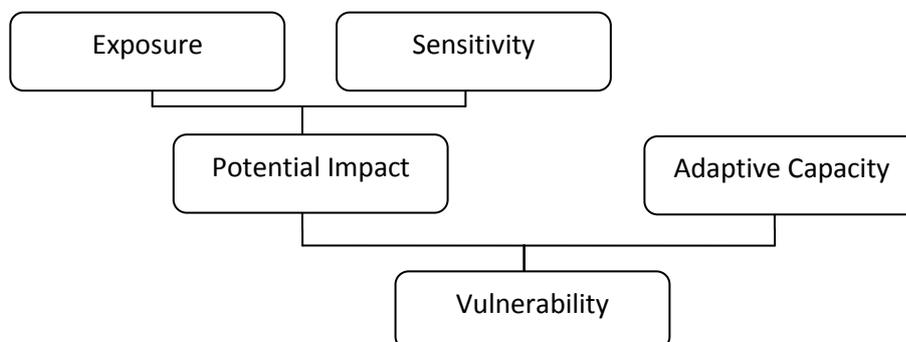
Decision lifetime	Key decision
Short lifetime decisions (0-10 years)	<ul style="list-style-type: none"> <li>• Surf Life Saving Clubs (SLSC)               <ul style="list-style-type: none"> <li>○ Community programs (education/events)</li> <li>○ Annual planning of patrol services</li> </ul> </li> <li>• Weed control programs (natural resources management (NRM))</li> <li>• Revegetation (budget and implementation)</li> <li>• Volunteer management and support (NRM and SLSC)</li> <li>• Sand recycling volumes (determined annually)</li> <li>• Dune restoration and saltmarshes</li> <li>• Government funding for coastal management (3 spheres of Government) and management of Torrens Lake and Barcoo Outlet</li> </ul>
Medium lifetime decisions (10-30 years)	<ul style="list-style-type: none"> <li>• SLSC members and patrol services (membership, assets, finances)</li> <li>• SLSC equipment selection and purchase.</li> <li>• Revegetation (planning)</li> <li>• Coastal site actions plans (NRM)</li> <li>• Investigations and monitoring (e.g. marine mammals, reef fish etc.)</li> <li>• Dune restoration and saltmarshes</li> <li>• Water quality</li> <li>• Marine Parks</li> <li>• Torrens Task Force Report (to be implemented)</li> <li>• Sources of additional beach sand</li> <li>• Third wetland for Torrens River (Tapleys Hill Road to outlet)</li> </ul>

Decision lifetime	Key decision
Long lifetime decisions (30+ years)	<ul style="list-style-type: none"> <li>• Club redevelopment/relocation (West Beach SLSC)</li> <li>• Sand recycling (capital infrastructure)</li> <li>• Where to maintain beaches (relates to funding)</li> <li>• Infrastructure design and locations</li> <li>• Development assessment</li> <li>• Development patterns and suburbs</li> <li>• Coastal urban sprawl (into undeveloped areas)</li> <li>• Development densification</li> <li>• Flood protection                             <ul style="list-style-type: none"> <li>○ Coastal retreat (existing developed areas)</li> <li>○ Coastal protection</li> </ul> </li> <li>• Government's 30 Year Plan (being reviewed currently)</li> <li>• Stormwater management                             <ul style="list-style-type: none"> <li>○ Floods</li> <li>○ Recycled water</li> </ul> </li> <li>• Future of Penrice Land (including impacts on Baker Inlet)</li> <li>• Future use of the Port River Harbour</li> </ul>

## 2.6. Preliminary identification of IVA indicators

The AdaptWest research papers are a resource to support completion of an IVA for the region. The IVA will assign scores against a range of indicators in relation to their exposure and sensitivity to climate variables, as well as the region's adaptive capacity (refer Figure 2.1, adaptive capacity is discussed further in Section 5.0). An IVA is a tool that helps to identify areas of vulnerability to the impacts of climate change and assists with identifying and prioritizing focus areas for adaptation action.

**Figure 2.1: Assessment of vulnerability in the IVA**



Based on the existing conditions in the region and their relationship to values, a list of suggested indicators that could be used to assess the vulnerability of coastal management in Western Adelaide has been developed, and is included in Appendix A.

These suggested indicators will be considered further by the AdaptWest project team in development of a list of regional indicators that will assist to identify vulnerabilities across the project themes and regional values.

## 3.0 Exposure factors

This section outlines the climate hazards that the region may be exposed to as a result of changing climatic conditions. The exposure of Western Adelaide to climate hazards is summarised in Table 3.1.

**Table 3.1: Exposure of Western Adelaide to potential climate hazards**

Climate hazard	Exposure of Western Adelaide
Increasing average temperature	Entire region exposed
Increasing frequency, intensity and duration of heatwaves	Entire region exposed
Declining average annual rainfall	Entire region exposed
Increasing rainfall intensity	Entire region exposed
Coastal and inland inundation caused by sea level rise /storm surge	Marine and coastal areas of the region exposed and inland areas where there are estuarine connections e.g. West Lakes, or where stormwater may be retained due to incapacity to discharge to the coast
Increased coastal recession due to accelerated erosion	Marine and coastal areas of the region exposed
Increasing temperature of Gulf waters	Marine and coastal areas of the region exposed
Increasing acidity of Gulf waters	Marine and coastal areas of the region exposed

Unless otherwise stated, the discussion of projected changes in climate below is based on a medium emissions scenario and median model outputs (often referred to as the “best estimate”). Baseline conditions refer to the period 1980-1999, which is the standard reference period identified by CSIRO and Bureau of Meteorology (BoM).<sup>9</sup>

### 3.1. Increasing average temperature

Temperatures in southern Australia have been increasing by about 0.2°C per decade since 1950<sup>10</sup> and are expected to rise further over the coming decades. By 2030, average annual temperatures are projected to rise by 0.6-1°C and by 2070 by 1.5-2°C compared with baseline conditions (ranging from 1-3°C under low to high

<sup>9</sup> CSIRO and BOM (2007-2014) *Climate Change in Australia*.

[www.climatechangeinaustralia.com.au](http://www.climatechangeinaustralia.com.au)

<sup>10</sup> CSIRO and BOM (2007-2014)

emissions).<sup>11</sup> Mean maximum temperatures are expected to increase greatly, particularly during summer months.<sup>12</sup> For example, average maximum February temperatures could increase from 28.2 °C to 32.7 °C.

### 3.2. Increasing frequency, intensity and duration of heatwaves

Heatwave typically describes a prolonged period of excessive heat, with common measures being the number of consecutive days over 35°C or 40°C. Three or more consecutive days where the average of daily maximum and minimum temperatures is greater than 32°C is a trigger used by the State Emergency Service for preparation of Extreme Heat Plans to mitigate the impact of extreme heat events on the community.<sup>13</sup>

The frequency of heatwaves with an average of the daily maximum and minimum temperatures of more than 32°C for 3 or more days is projected to increase from 1 in 20 years under current conditions to 1 in every 1 to 5 years (under high emissions or low emissions, respectively) by 2070. The duration of heatwaves will also increase by 2070, with projections suggesting that the region could experience periods of 5 to 6 days where an average of the daily maximum and minimum temperatures exceeds 32°C (1 in every 20 years).

With regard to intensity across each year, the number of days with maximum temperatures of 35°C or more is projected to increase from less than 15 to over 17 per year by 2030 and to over 35 by 2070 (high emissions, 50th percentile). Days with temperatures over 40°C are projected to increase from less than 2 per year to 2.5 per year by 2030 and over 10 per year by 2070 (high emissions, 50th percentile).

### 3.3. Declining average annual rainfall

Average annual rainfall is expected to decrease across the Western Adelaide region in the coming decades. Median projections are for rainfall to decline by 2-5% by 2030 and between 5-20% by 2070 throughout South Australia.<sup>14</sup>

Using information from meteorological stations in Western Adelaide, the most likely outcome under a medium and high emissions scenario is for average annual rainfall to decline by about 60 to 75 millimetres per year by 2070.<sup>15</sup>

Seasonally, a greater decline in rainfall has been predicted for spring than for autumn, however observations imply that autumn to winter rainfall patterns have changed and may be attributed to climate change impacts on atmospheric circulation patterns.<sup>16</sup>

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<sup>11</sup> CSIRO and BOM (2007-2014)

<sup>12</sup> SKM (2013) p.36

<sup>13</sup> SKM (2013) p.37

<sup>14</sup> CSIRO and BOM (2007-2014)

<sup>15</sup> SKM (2013) p.42

<sup>16</sup> SKM (2013) p.42

### 3.4. Increasing rainfall intensity

Extreme rainfall events are forecast to become more intense by 2070, particularly during spring and summer. Historically, the total daily rainfall that is exceeded only once per year on average (i.e. a 1 year average recurrence interval (ARI)) is 27 millimetres. Under a medium emissions scenario, the daily rainfall totals exceeded for 10 year and 100 year ARIs are 50 millimetres and 75 millimetres, respectively.

Under a high emissions scenario there is an increase in rainfall intensity with the 10 year and 100 year ARI events anticipated to rise from 50 millimetres and 75 millimetres, to 58 millimetres and 90 millimetres (respectively) by 2070.<sup>17</sup>

### 3.5. Coastal and inland inundation caused by sea level rise /storm surge

Global mean sea level rise for 2081–2100 relative to 1986–2005 will likely be in the range of 0.3 to 0.6 m for RCP4.5 and RCP6.0<sup>18</sup> (equivalent to a low to medium emissions scenario).<sup>19</sup> Tide gauging in the Western Adelaide region has found sea levels to be rising at a rate of 2.06 millimetres per year and 2.08 millimetres per year at the Inner Harbour and Outer Harbour areas respectively.<sup>20</sup>

Sea level rise could exacerbate exposure to non-climate specific threats such as land subsidence from natural causes and anthropogenic activities (e.g. landfill developments and large-scale groundwater extraction), and saline intrusion of aquifers.<sup>21</sup>

Sea level rise is also expected to intensify storm surge events. These are events where sea levels rise significantly above normal tide levels for a temporary period of time. Presently, the mean sea level at Outer Harbor is 0.13 m below the Australian Height Datum (AHD). However, the 100 year ARI water level for Outer Harbor based on current mean sea levels is 2.4 metres above AHD. This means that under a high sea level rise scenario, storm surge events could cause tides to reach areas that are presently 2.4 metres above AHD.<sup>22</sup>

### 3.6. Increasing coastal recession due to accelerated erosion

Coastal recession is defined as the landward retreat of a coastline. Coasts which are composed of erodible sediments (such as sand or mud) may retreat in response to sea level rise. The rate of change of coastal recession is dependent on many factors

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<sup>17</sup> SKM (2013), p.42

<sup>18</sup> RCP = Representative Concentration Pathway, as referred to in: IPCC (2013) *Summary for Policymakers*, Cambridge University Press

<sup>19</sup> IPCC (2000) *Summary for policymakers: Emissions Scenarios*, IPCC

<sup>20</sup> DEH (2005) *Adelaide's Living Beaches: A Strategy for 2005-2025*, Department of Environment and Heritage, p.54

<sup>21</sup> SKM (2013) p.60; DEH (2005), p.55

<sup>22</sup> DEH (2005) p.101

such as the rate of sea level rise, the resistance of the coast to erosion, effectiveness of any coast protective infrastructure, and longshore sediment movement.<sup>23</sup>

Most of the coast in the Western Adelaide region is highly erodible as it is comprised mainly of sand and mud. Areas along the coast of St Vincent's Gulf are unprotected and are therefore more susceptible to wave action. Coastal recession in the Western Adelaide region could be between 50m and 100m in a high sea level rise scenario (i.e. 1m) if no control measures are implemented.<sup>24</sup>

### 3.7. Increasing temperature of gulf waters

The best estimate of changing sea surface temperatures are for a 1.5 to 2°C warming of oceans off South Australia by 2070.<sup>25</sup> How this translates to changes in the shallower Gulf waters is yet to be seen. Past work found approximately equal rates of warming in the deep ocean waters of the Great Australian Bight compared with the mouth of Spencer Gulf (i.e. 0.11°C and 0.12°C per decade since 1950, respectively).<sup>26</sup>

### 3.8. Increasing acidity of gulf waters

The Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report suggests that the earth's oceans will become more acidic under all scenarios assessed. Projections for decreasing pH range from 0.06 to 0.32 by 2100, with a best estimate more likely to be in the order of a 0.2 pH unit decrease.<sup>27</sup> This compares with a 0.1 pH unit decrease that has already been experienced since the beginning of the industrial era 250 years ago.

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<sup>23</sup> SKM (2013), p.61

<sup>24</sup> South Australian Coast Protection Board (1992), *Coastal Erosion, Flooding and Sea Level Rise Standards and Protection Policy*, Coastline, p.6

<sup>25</sup> CSIRO and BOM (2007-2014)

<sup>26</sup> Suppiah *et al.* (2006) *Climate Change Under Enhanced Greenhouse Conditions in South Australia*, CSIRO Marine and Atmospheric Research, p.5-6

<sup>27</sup> IPCC (2013) *Summary for policymakers*, University Press, p.25

## 4.0 Sensitivity factors

This section describes the potential sensitivities of AdaptWest coastal management values to climate hazards. Table 4.1 below outlines the coastal management values and the climate hazards which they are exposed to.

**Table 4.1: Potential sensitivities of coastal management values to climate hazards**

HAZARD  VALUE	Increased temperatures	Increased heatwaves (IFD)	Increased temperature of Gulf waters	Increased rainfall intensity	Reduced mean annual rainfall	Coastal inundation	Coastal recession
Coastal environment	-	-	X	X	-	X	X
Biodiversity	X	X	X	X	X	X	X
Coastal and riverine water quality	-	-	X	X	-	X	X
Stormwater management and use	X	X	-	X	X	X	X
Infrastructure and essential services	X	X	X	X	X	X	X
Regional productivity and economic contribution	X	X	X	X	X	X	X
Strong and connected community	X	X	-	X	X	X	X
Amenity and quality of life	X	X	-	X	X	X	X

### 4.1. A strong and connected community

The features and aspects related to this value are diversity, equity and social justice and vulnerable members of the community.

Given that diversity, equity and social justice are essential components of amenity and quality of life, a number of the sensitivities described in Section 4.2 are applicable for this value.

Community connectedness and local networks are essential for the wellbeing of the community. However, meeting spaces for communities such as beach foreshores are vulnerable to climate impacts such as sea level rise and coastal inundation. As

mentioned in section 4.5, foreshores are important places for social interactions, as they host many gatherings, community events and beach activities for the local community.<sup>28</sup> Coastal inundation from sea level rise can cause extended periods of inaccessibility to these areas and may also impact on the safety of beach users.

Additionally, there are flow-on effects to local communities from the losses of private assets and infrastructure. Sections 4.6, 4.7 and 4.8 outline the impacts upon significant power and water industrial assets which provide invaluable services to the community. Destruction and loss of functionality of these services due to coastal inundation and coastal recession can result in many of the costs to industry and business being passed onto users in the community. This may result in added financial stress to the community, possibly leading to deteriorating health.

## 4.2. Amenity and quality of life

The features and aspects related to this value are safety and health, sport, recreation, entertainment and tourism facilities, coastal and water based recreation, open and green spaces and natural historical environment.

From a safety and health perspective, severe weather may lead to wide-scale natural disasters such as flooding and bushfire. More extreme hot days and heatwaves increase the risk of heat-related illness and death, particularly among vulnerable populations like the elderly.<sup>29</sup> The 2009 heatwave resulted in a 14 fold increase in heat-related hospital admissions.<sup>30</sup> Algal blooms, in coastal and river environments, increased risk of water and food-borne infections and diseases, such as vector-borne diseases due to stagnant flood water (e.g. Ross River Virus) could also be expected.<sup>31</sup> Such impacts are likely to lead to increased demand on the health services sector and resource constraints due to damaged infrastructure.

Jetties and tourism infrastructure such as the Henley Beach Jetty and Adelaide Shores Boat Ramp are coastal structures which provide recreation and leisure for locals in the Western Adelaide region. However, they are at risk from coastal inundation due to sea level rise. The Semaphore Jetty is particularly at risk, due to its low-lying location, and may be subject to accelerated deterioration from more frequent storms and inundation. Accelerated corrosion of marina and jetty structures may also result in more frequent maintenance, possibly limiting their use by the public and affecting their quality of life as a result.

Beaches are a primary source of recreation and leisure for the Western Adelaide region. However, climate hazards such as coastal recession and dune erosion have significantly impacted upon the amenity of the beaches in the region. Southern and central beaches in the region such as West Beach experience persistent erosion from rising sea levels, while northern coastline areas such as Semaphore experience coastal deposition due to the movement of sand from south along the Gulf St Vincent coastline. Resultantly, many beach replenishment activities have taken place, where sand has been trucked and pumped from beaches where sand has

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<sup>28</sup> URPS (2014)p. 23

<sup>29</sup> AECOM (2013) p.45

<sup>30</sup> Steffen and Hughes (2011)

<sup>31</sup> Department of Environment, Water and Natural Resources (2012)

built up, to beaches with little sand.<sup>32</sup> Such activities are likely to affect the amenity of beach use, and in some cases, may prevent use of the beaches during maintenance works. As mentioned in section 4.5, coastal inundation due to sea level rise and increased sand movements could also affect the duration and frequency of use of many beaches along the Western Adelaide region coastline.<sup>33</sup>

### 4.3. Biodiversity

The features and aspects relating to biodiversity in the Western Adelaide region include gulf and marine biodiversity, coastal and dune biodiversity, riverine biodiversity, ecosystem services and intrinsic value.

Biodiversity across the Western Adelaide region largely consists of remnant vegetation due to urban development. As such, it is harder to manage impacts on biodiversity in the region, especially since areas such as golf courses and recreational facilities along West Beach are privately owned, limiting the government's ability to manage them.<sup>34</sup>

Nevertheless, biodiversity across marine, coastal and riverine areas are sensitive to all identified climate hazards. Some of the threats to biodiversity from climate hazards in the region include:

- Erosion of remnant vegetation from storm surge and intensified rain events
- Expansion of mangrove distributions in Mutton Cove, which minimises diversity and habitat
- Loss of nationally threatened species, including subtropical and temperate coastal saltmarsh, birds (e.g. Southern Giant Petrel, *Macronectes giganteus*) and whales (e.g. Southern Right Whale, *Eubalaena australis*) from sea level rise and storm surge on coastal habitats
- Increasing weed species and abundance and decreasing vegetative health due to warmer and drier conditions
- Increased salinity, pollution and turbidity levels due to diminishing streamflows from reduced rainfall
- Possible inland retreat of habitat due to coastal recession.

The impacts listed above are but a few of the many potential secondary impacts which may occur from climate change hazards. Intrinsic values are also affected by the reduction in biodiversity of the Western Adelaide region, in addition to the Aboriginal cultural, spiritual and ecological significance of the biodiversity resources. This includes coastal dunes, samphire flats and mangroves along Mutton Cove, the Port River coastline, Rosewater and Gillman dunes.

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<sup>32</sup> DEH (2005)

<sup>33</sup> SKM (2013) p.134

<sup>34</sup> SKM (2013) p. 115-119

Ecosystem services such as water quality improvement are also provided through natural wetlands, such as the Barker Inlet estuary. However, the Barker Inlet estuary is also susceptible to seagrass decline and degradation, and the rise of the weedy seaweed *Caulerpa taxifolia*.<sup>35</sup>

#### 4.4. Coastal and riverine water quality

The features and aspects relating to coastal and riverine water quality in the Western Adelaide region include the Port River, the River Torrens and the Gulf St Vincent. Additionally, the application of Water Sensitive Urban Design (WSUD) and the capture and reuse of stormwater are equally important aspects.

The primary threat to coastal water quality in the Western Adelaide region is the activation of coastal acid sulfate soils (CASS). These soils are present over 2.5 square kilometres of the Gillman area,<sup>36</sup> which encompasses parts of the Port River coastline, Port River estuary and Barker Inlet. Disturbances of the CASS from drainage and infrastructure development have previously caused the production of sulphides. The release of acid and metal ions in surrounding bodies of water deteriorates coastal water quality. In addition to water quality issues, when sulfidic materials are exposed to the atmosphere, noxious odours can occur as the drying sulfidic materials produce sulphur dioxide (SO<sub>2</sub>).<sup>37</sup> SO<sub>2</sub> is also a concern for human health at high concentrations (typically in confined spaces). SO<sub>2</sub> also impacts groundwater quality, leads to acidification.

Increased erosion due to sea level rise is considered a potential source of disturbances of CASS.<sup>38</sup> Other threats to coastal water quality include thermal discharges and pollution from surrounding human activities. While riverine water quality is also affected by acid sulfate soils in the Port River, rising temperatures produce an increased risk of algal blooms in sensitive riverine ecosystems.<sup>39</sup> This could lead to eutrophication from an overabundance of nutrients and degrade riverine water quality.

Water sensitive urban design (WSUD) and stormwater capture and reuse features are present across various parts of the Western Adelaide region. For example, wetlands were constructed around the Port River (Gillman Wetlands) and the River Torrens (Breakout Creek wetlands, Apex Park wetland) for the purpose of improving riverine water quality. They are, however, at risk from inundation due to rising sea levels, as they would be damaged and their functionality would diminish. This indirectly reduces riverine water quality in the region.<sup>40</sup>

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<sup>35</sup> SKM (2013) p. 121-122

<sup>36</sup> SA Coast Protection Board (2003), *A Strategy for Implementing CPB Policies on Coastal Acid Sulfate Soils in South Australia*, p. 5

<sup>37</sup> CSIRO (2008) *Acid Sulfate Soils in Barker Inlet and Gulf St Vincent Priority Region*

<sup>38</sup> Department of Sustainability and Environment (2009), *Victorian Coastal Acid Sulfate Soils Strategy*

<sup>39</sup> SKM (2013) p. 121-122

<sup>40</sup> SKM (2013) p. 121-122

## 4.5. Coastal environment

The features and aspects relating to this value include environmental values, community and recreation, tourism and assets and infrastructure. The coastal environment in the Western Adelaide region comprises the following environmental assets:

- Port River coastline;
- Estuaries, including the Barker Inlet and Port River Estuary;
- Aquatic reserves (e.g. Torrens Island Conservation Reserve);
- Coastal reserves, such as the River Torrens Estuary;
- Remnant sand dunes along the Gulf St Vincent coastline and Tennyson and West Beach<sup>41</sup>

The environmental assets of the region's coast, and the associated habitats and ecosystems they provide, are vulnerable to the effects of sea level rise, with global mean sea levels projected to rise by between 18 and 140 centimetres by 2100. The impact of sea level rise on the coastal environment will first be apparent during storm surge events, accelerating coastal erosion above natural rates.<sup>42</sup> This is particularly the case for sandy beaches, which compose 47 per cent of South Australia's beaches. Rising sea surface temperatures could also increase the risk of algal blooms in exposed areas and coastal reserves such as Mutton Cover on the Lefevre Peninsula<sup>43</sup>. Additionally, sea level rise are likely to exacerbate issues with existing acid sulphate soils in the region, particularly through Gillman Industrial Area.

Foreshores are important places for social gatherings, community events and activities, both for the local community and for the more than 1 million visitors to South Australia's beaches each year<sup>44</sup>. Community recreation and tourism assets such as the foreshore and associated infrastructure (accommodation, recreation etc.) could be affected directly through the loss of remnant sand dunes, such as those at Tennyson, Semaphore, South Semaphore, Largs Bay and North Haven. Increased movement of sand and longer periods of beach inundation could lead to reduced beach access and use, in addition to the decline in value and aesthetics of beaches in the region. Further, as temperatures and the incidence of heatwaves increase, so too will demand for access to the coast.

In addition to environmental values and community recreation and tourism, climate hazards also threaten the key industries and significant State economic infrastructure located in the region, also outlined in more detail later in this chapter. Major transport and economic infrastructure is situated on the region's coast, and is therefore susceptible to the impacts of sea level rise and associated erosion and coastal recession. These include the Port of Adelaide, which comprises a container terminal, various berths and jetties, with Semaphore Jetty being the lowest and most vulnerable. Other assets include Techport Australia, a 75 hectare estate servicing

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<sup>41</sup> SKM (2013) p. 121-122

<sup>42</sup> URPS (2014), *Defining the Sea Level Rise Problem in South Australia: Issues Paper*, p.21

<sup>43</sup> SKM (2013) p.123

<sup>44</sup> URPS (2014)p. 23

maritime and naval industries, over 506 commercial buildings, 692 light industrial buildings and up to 45 kilometres of rail.<sup>45</sup>

Other climate hazards such as increasing temperatures and increased rainfall intensity can also cause damage to assets and infrastructure of National and State importance, accelerating deterioration and increasing potential damage from the 100 year ARI storm tide to over \$180 million by 2100.

#### 4.6. Infrastructure and essential services

The features and aspects relating to this value include port facilities, Adelaide Airport, water and wastewater treatment, power generation, transport, open space, defence industries and community facilities.

As the aviation gateway to South Australia, the Adelaide Airport is an essential piece of infrastructure situated in the Western Adelaide region. Due to its location near the coastline of Gulf St Vincent and being surrounded by low lying areas, Adelaide Airport is vulnerable to flooding and inundation from storm events. It is also susceptible to increased wind and storm intensity, which are predicted to increase under projected climate scenarios. These impacts could cause disturbances to aircraft movement<sup>46</sup>. Similarly, the Port of Adelaide is the main service point for shipping into the State and is a central hub for transport infrastructure, including rail. Techport, the South Australian government's purpose build maritime and naval estate is also located within this area. Extreme weather events and sea level rise may lead to disruptions to the operation of the port including transport and supply chains. Such disruptions may have cascading effect throughout the State.<sup>47</sup>

Flooding as a result of more intense storm events is also likely to test the capacity of storm water systems to mitigate local and regional scale flooding. As discussed in Section 4.7, existing stormwater networks, such as those in the Port Adelaide catchment, are at increased risk of losing their ability to effectively transfer stormwater out to sea due to high downstream water levels. Failure of stormwater systems is likely to lead to increased costs both to address capacity and maintenance of the system itself and from damage to the surrounding urban area.

In addition to coastal inundation and potential associated infrastructure damage from storm surge and erosion, extreme heat will also place additional pressure on electricity transmission and distribution infrastructure in the Western Adelaide region, such as Torrens Island and Pelican Power Stations, which are both vulnerable to impacts such as sea level rise and salt water corrosion due to their location in Port Adelaide and adjacent to Port River respectively. Additionally, these and other power generation and transmission facilities may also be susceptible to destructive winds associated with projected increases in storm intensity and to increased demand from more frequent heatwaves. These factors could lead to accelerated

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<sup>45</sup> URPS (2014)p. 23; SKM (2013) p. 172

<sup>46</sup> Adelaide Airport (2014), *Adelaide Airport Preliminary Draft Master Plan 2014*

<sup>47</sup> AECOM (2013) p.28

depreciation of the power station's physical assets, as well interrupting operations and interfering with supply.<sup>48</sup>

#### 4.7. Management and use of stormwater

The features and aspects relating to the management and use of stormwater in the Western Adelaide region include the protection of homes and infrastructure, Water Sensitive Urban Design (WSUD) and stormwater capture and reuse.

Four catchments make up the Western Adelaide region. These are:

- Port Adelaide – a highly urbanised catchment and water course, containing an artificial lake
- Dry Creek – an ephemeral watercourse
- River Torrens – a mix of urban and rural catchments with a water course partly lined with concrete, an artificial lake created by a weir and an artificial outlet to the sea
- Patawalonga Creek - a mix of urban and rural catchments with primarily natural watercourses.

There are several features of the Western Adelaide region that provide protection to homes and infrastructure from major flooding and storm events. However, these features are at risk of direct seawater and/or subsequent stormwater inundation due to rising sea levels and increased rainfall intensity. For example, the existing stormwater network in the Port Adelaide catchment, of which a significant area of the catchment has been prone to frequent flood inundation, is at risk of losing its ability to transfer stormwater out to sea efficiently due to high downstream water levels. Being a highly urbanised area at a relatively low elevation, this suggests homes and infrastructure alike are at an increased level of risk from damage.

Additionally, parts of the Outer Harbor and Patawalonga Creek catchment are at risk of seawater and stormwater inundation respectively. However, studies have suggested that existing WSUD and stormwater reuse infrastructure, such as the Apex Park wetlands, play a dual role in that they also act as a buffer to prevent seawater from inundating surrounding residential areas.

Reductions in mean annual rainfall, increasing temperatures and heatwave exacerbation all contribute to lower water levels and reduced streamflow along River Torrens. Resultantly, necessary diversions for environmental flows through the River Torrens are reduced, further impacting the already degraded river.<sup>49</sup>

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<sup>48</sup> SKM (2013) p. 194

<sup>49</sup> SKM (2013) pp. 200-207

#### 4.8. Regional productivity and economic contribution to the State

The features and aspects relating to this value include infrastructure and industries of state significance, such as port facilities, Adelaide Airport, Defence industries, Gillman industrial area, tourism infrastructure and Adelaide Entertainment Centre.

Much of the region's industrial tracts and privately operated economic infrastructure is situated in or around the coastal area. These include major private assets such as energy infrastructure, maritime transport and logistics facilities (ports and wharves), rail infrastructure, Adelaide Airport, as well as significant industries including Adelaide Brighton Limited and OI.

As noted in Section 4.6, the Port of Adelaide is the main service point for shipping in the State. During 2012/2013, over 15.17 million tonnes of cargo moved through the port, with 10.37 million imported/exported to markets overseas<sup>50</sup>. Extreme weather events and sea level rise may lead to disruptions to the operation of the port including transport and supply chains.<sup>51</sup>

Potential climate hazards can also impact on infrastructure within the port area such as Techport Australia, previously mentioned above. Techport Australia is a \$300 million dollar, state owned estate servicing maritime and naval industries including shipbuilding facilities. These facilities could be affected by surface flooding from increased storm intensity and sea water incursions as a result of projected sea level rise. Both could lead to increased corrosion of physical assets and cause disruption and delays to operations.

Other assets with high economic contributions situated in the port include the Torrens Island Power station. As outlined in Section 4.6, this power station, along with other power and transmissions stations, including, Pelican Power Station, ElectraNet, SA Power Networks, Synergen Power and Osborne Cogeneration Plant, are susceptible to destructive winds associated with projected increases in storm intensity and to increased demand from more frequent heatwaves. Such factors could lead to disruptions to power supply and accelerated deterioration of physical assets leading to economic repercussions for the State.<sup>52</sup>

The Adelaide Airport forms a significant part of Western Adelaide's economy, as well as the South Australian economy. The Adelaide Airport services 7.5 million passengers a year and contributes around 2.1% of Gross State Product (around \$1.9 billion). There are numerous business, both retail and industrial, that are linked to this facility.<sup>53</sup> As noted in Section 4.6, Adelaide Airport is vulnerable to flooding and inundation from storm events, and seawater incursion could affect the output and growth of the facility.<sup>54</sup>

In addition to key industrial and transport infrastructure, climate impacts may also affect the region's productivity and economic contribution through impacts to tourism and associated tourism infrastructure.<sup>55</sup> Loss of remnant sand dunes, such as

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<sup>50</sup> Flinders Ports (2014)

<sup>51</sup> AECOM (2013) p.28

<sup>52</sup> SKM (2013) p. 194

<sup>53</sup> SKM (2013) p. 194

<sup>54</sup> Adelaide Airport (2014), Adelaide Airport Preliminary Draft Master Plan 2014

<sup>55</sup> URPS (2014),p. 23

those at Tennyson, Semaphore, South Semaphore, Largs Bay and North Haven and increased movement of sand could lead to reduced beach access and use, in addition to the decline in value and aesthetics of beaches in the region. A combination of coastal inundation and more intense storm activity could accelerate deterioration of recreational jetties such as those at Henley Beach, Grange, Semaphore and Largs Bay.<sup>56</sup>

The physical impacts discussed above, such as damage to buildings and structures, are likely to lead to flow on effects such as higher operating and maintenance costs and disruption to supply chains and delays, which could trickle down throughout the State.

In addition to impacts on hard infrastructure situated in coastal areas in Western Adelaide, the region's coastal environment provides valuable economic contribution to the State's fishing industry through the ecosystem services provided by the mangrove and samphire system which provides valuable nursery grounds for the area's fish communities. Biodiversity across marine, coastal and riverine areas are sensitive to all identified climate hazards, including erosion of remnant vegetation from storm surge and intensified rain events, loss of nationally threatened species, including subtropical and temperate coastal saltmarsh, from sea level rise and storm surge. These impacts could disrupt the ecosystem services currently provided by these areas. The Barker Inlet and other coastal areas also provide a source of employment. Extreme weather events and sea level rise may lead to disruptions in fishing operations.

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<sup>56</sup> SKM (2013) p. 182

## 5.0 Adaptive capacity factors

Adaptation is the process of adjustment to actual or expected climate and its effects, and in the case of human systems, seeks to moderate harm or exploit beneficial opportunities. Adaptive capacity is the ability to adjust to potential damage, take advantage of opportunities, or respond to consequences.<sup>57</sup>

In determining adaptive capacity, consideration is given to what extent a feature or function in its current form, with current practices in place, could continue to function and respond to the consequences and opportunities presented by expected future climate conditions (in the case of AdaptWest the projected climate in 2070).

In a regional context, adaptive capacity is complex and made up of a range of factors associated with systems, institutions, humans and other organisms. These factors can include natural attributes, physical infrastructure, technology, management plans and practices, funding, and governance arrangements. Social and cultural factors such as social capital, social networks, values, customs and perceptions also impact upon adaptive capacity; for example, the functionality of stakeholder relationships within governance arrangements, and whether barriers exist to implementing management practices on the ground.

A differentiation can be made between autonomous adaptation - an innate response to changes to systems, and planned adaptation – a conscious response to conditions that have or will change.<sup>58</sup> Adaptive capacity can be considered in a similar way, occurring 'naturally' (i.e. autonomously), or being deliberately developed (i.e. planned) to increase resilience to known and projected challenges.

The following discussion provides a brief overview of current features and conditions that contribute to Western Adelaide's adaptive capacity in relation to coastal management. Those living, working, providing services and doing business in the region are considered to be most knowledgeable about the region, and as such it is intended that this summary be tested, refined and built upon by the region's stakeholders as part of the collaborative IVA that will be undertaken in the next stage of the project.

The adaptive capacity of Western Adelaide coastal environments and infrastructure for the purposes of coastal management encompasses issues from technical and logistical capabilities to ideas of governance. Additionally, there are numerous studies and stakeholders who each play a role in coastal management and contribute to the adaptive capacity of the region.

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<sup>57</sup> IPCC (2013b) *Climate Change 2013: Working Group II: Impacts, Adaptation and Vulnerability – Glossary*

<sup>58</sup> IPCC (2007)

## 5.1. Physical factors

From a natural resources perspective, the adaptive capacity of the region's coastal systems primarily revolves around the protection of coastal regions from flooding and the integrity of beaches and dune systems.

The protection of coastal regions through constructing seawalls, floodgates and embankments and the maintenance of natural ecosystems are important adaptive capacity factors.<sup>59</sup> In acknowledgement of the increasing risk of damage to physical infrastructure in the region due to sea level rise, Port Adelaide Enfield Councils recently commissioned a study into the existing and future requirements of protective infrastructure.<sup>60</sup> The study examined the existing Port Adelaide River Seawall in sections and recommended upgrades to a number of sections due to erosion, and dilapidation of the protective infrastructure.

Embankments and floodgates have also been installed along the Port River to provide extra protection. In addition to the use of 'hard' infrastructure such as seawalls, Councils in the Western Region are also exploring protective measures that minimise the environmental impacts of sea level rise. This includes enhancing natural defences such as the restoration of mangroves along some areas of the study area. These factors, to a great extent, are already being implemented in the Western Adelaide region, with the construction of seawalls as a 'last line of defence' in areas such as Somerton Park, Henley Beach and Brighton.<sup>61</sup>

Constructed and natural wetlands along rivers and coastlines can also act as natural defences against storm surges.<sup>62</sup> Apex Park wetlands in the City of West Torrens and the Gillman Wetlands in the City of Port Adelaide Enfield are examples of these. However, it should also be noted that due to the high degree of disturbance in these coastal and estuarine areas, restoration back to a natural state is unrealistic. However, an approximation of the original system in target areas can act as a buffer against coastal erosion and provide other ecosystem services and environmental benefits.<sup>63</sup>

Maintenance of beach integrity and dune systems requires highly engineered solutions, including beach replenishment and dune protection in order to maintain adaptive capacity. The underlying theme of *Adelaide Living Beaches: A Strategy for 2005-2025* is the maintenance of sand and sand movements to protect dune systems, which in turn act as barriers for the protection of coastal infrastructure and residential areas. Dune buffers have been conserved in some areas such as the Tennyson Dune Reserve. Along the Gulf St Vincent coast in the Western Adelaide region, dune buffers have also been engineered to ensure storm protection against a storm twice as severe as the 1-in-100 year ARI storm. While fragmentation of the dune landscape, along with loss of conservation and cultural values has occurred in

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<sup>59</sup> Bardsley (2006), *There's a change on the way - An initial integrated assessment of projected climate change impacts and adaptation options for Natural Resource Management in the Adelaide and Mt Lofty Ranges Region*

<sup>60</sup> Tonkin Consulting (2014) *Port Adelaide/LeFevre Peninsula (Phase 2) Port Adelaide River Seawall Study, Volume 1*

<sup>61</sup> DEH (2005)

<sup>62</sup> Bardsley (2006)

<sup>63</sup> Tonkin Consulting (2014)

areas such as the Semaphore South dune reserve (in the City of Port Adelaide Enfield), there have been successful management techniques used to maintain the adaptive capacity of this area through a revegetation management plan.<sup>64</sup>

## 5.2. Other factors

Coordination of coastal planning and action across Commonwealth, State and local levels of government is an element of the Western Adelaide region's adaptive capacity. This incorporates strategic planning, technical standards, and ongoing management practices across all three levels of Government. Policies, plans and strategies in place in Western Adelaide that address the coastal environment and potentially contribute to the region's adaptive capacity are summarised in Appendix B.

The Commonwealth government contributes to coastal management at the national level by providing leadership, research, funding and policy direction, such as the Commonwealth Coastal Policy (1995) and the National Cooperative Approach to Integrated Coast Zone Management: Framework and Implementation Plan (2006).<sup>65</sup> Such contributions by the Commonwealth Government benefit the adaptive capacity of the Western Adelaide region through the provision of funding programs to empower State and local government capacity for coastal management, clear leadership and definition of roles and dissemination of information and research to assist the region manage its coastal environment.<sup>66</sup>

There are a range of existing arrangements and mechanisms in place in South Australia for managing the coastal zone that cover land use planning, natural resource management, climate change adaptation, emergency response and management of public assets. Local councils (City of West Torrens, City of Charles Sturt and City of Port Adelaide-Enfield) have significant responsibility for these arrangements.

Like other parts of the State, in the Western Adelaide region, coastal management policies are largely administered by the Coast Protection Board. The Coast Protection Board administers coastal management through two main policies – the Policy on Coast Protection and New Coastal Development (1991) and the Coastal Protection Board's Policy Document (2012).<sup>67</sup>

In addition to these main policies, an interpretive policy that sets technical and environmental standards for new developments along the coast and recommended actions for sea level rise was created. The 'Coastal erosion, flooding and sea level rise standards and protection policy' (1992) is an important technical standard based on significant amounts of historical data and experience and strongly supports the adaptive capacity of coastal management from a governance standpoint. It outlines the recommended sea level rise allowance for

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<sup>64</sup> DEH (2005)

<sup>65</sup> URPS (2014)

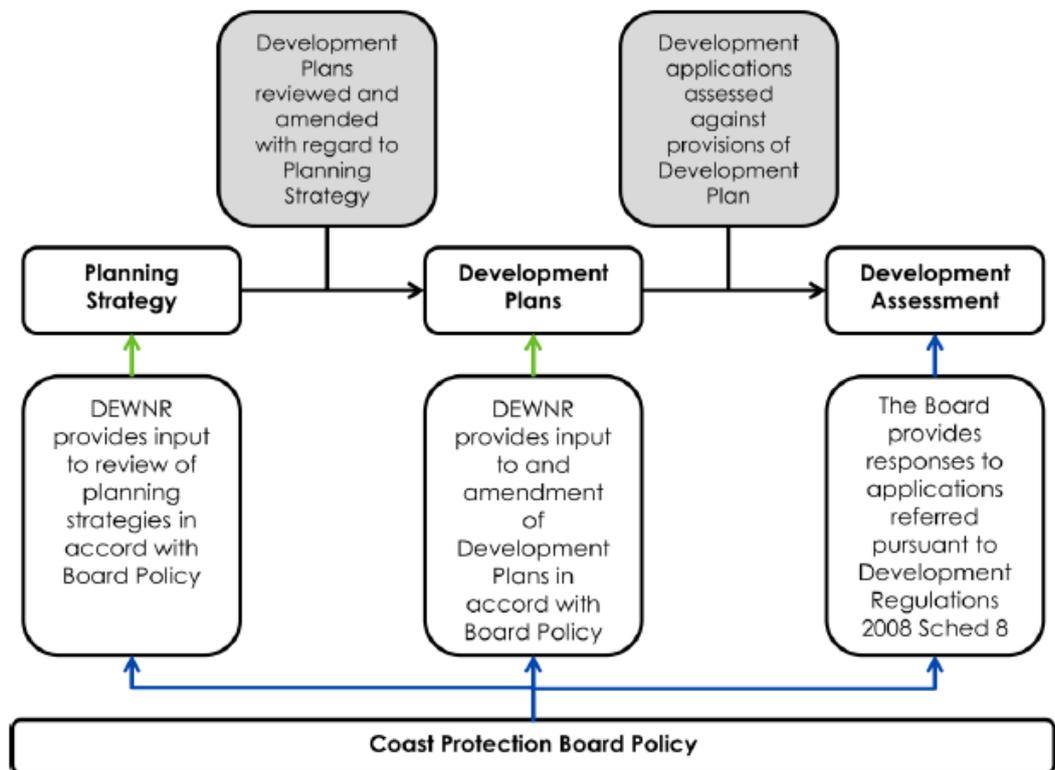
<sup>66</sup> URPS (2014)

<sup>67</sup> DEWNR (2014), *Policies and strategic plans*

future development, as well as issues of storm erosion and land subsidence from sea level rise.<sup>68</sup>

South Australia also gives legal effect to coastal policies by utilising existing mechanisms within the State's planning system. This integrated approach also facilitates strategic and long term planning, which contributes significantly to the region's adaptive capacity. Figure 5.2 outlines how Coast Protection Board Policy interacts with the existing South Australian planning system.<sup>69</sup>

**Figure 5.2** Coastal protection Board Policy and the planning system<sup>70</sup>



Despite these efforts to integrate coastal management and planning policy, coordinated implementation is not consistent across the State due to different Development Plan formats, and in some cases, deliberate rezoning decisions. Such inconsistencies may undermine adaptive capacity.<sup>71</sup> Additionally, the integrated nature of adaptation under the State Framework means that it is closely linked with other systems and planning processes. It has been noted that often there is a gap between "the integration expected of the planning system and the capacity of Government Departments to properly co-ordinate to deliver this."<sup>72</sup> Moreover, these

<sup>68</sup> SA Coast Protection Board (1992)  
<sup>69</sup> URPS (2014)  
<sup>70</sup> URPS (2014)  
<sup>71</sup> URPS (2014)  
<sup>72</sup> South Australian Expert Panel on Planning Reform 2014

other planning systems and processes can be time-consuming and resource intensive, which may be difficult to manage and reduce adaptive capacity. Responsibility for actions arising from regional adaptation planning can also be undefined, leading to significant barriers to implementation.<sup>73</sup>

To address these types of issues, a number of measures have been put in place in an attempt to clearly outline the strategic direction for coastal management and integrate it into existing initiatives. For example, the Coast Protection Board Strategic Plan 2009-2014, outlines actions primarily revolving around assembling, collaborating, engaging and supporting Commonwealth, State and local governments in:

- Gathering of data and information (e.g. preparing climate vulnerability assessments)
- Implementing strategies and policies (e.g. implementing the National Climate Change Adaptation Framework, particularly the acquisition of national coastal digital elevation model (DEM) and integrating coastal vulnerability assessments into policy).

There are a number of other key initiatives in South Australia which aim to provide policy guidance and integrate decision-making in relation to coastal management and support its adaptive capacity. These include:

- *The Adelaide Living Beaches: A Strategy for 2005-2025* is a key South Australian Government policy applying to Western Adelaide. It sets out a plan for future management of Adelaide's metropolitan beaches and includes measures for continued replenishment to maintain a sand foreshore and building gup dune buffers to protect coastal infrastructure.
- *Living Coast Strategy for South Australia*: is a framework which provides guidance for the integrated management of marine, estuarine and coastal environments in South Australia. It outlines four main actions involving developing a strategic vision for coastal development, protection of coastal assets, establishing effective development controls and establishing effective management of coastal lands. This strategy provides support and divides responsibilities between relevant stakeholders with regards to management of marine, estuarine and coastal environments.

The presence of a range of community groups within the region that can support on-ground coastal management works, such as the maintenance and restoration of vegetation in dune systems also contributes to the region's adaptive capacity. Groups include the Tennyson Dunes Group, Semaphore Park Coastcare, Coastal Ecology Protection Group, and the Friends of Gulf St Vincent.

It is generally recognised that there is good policy and system architecture in place to support adaptation along the coast in South Australia

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<sup>73</sup> URPS (2014)

Key strengths of the system include:

- The land use planning system, which facilitates consideration of sea-level rise in strategic planning, policy development and development assessment. Strong policy guidance for addressing sea level rise is present in the Planning Strategy and Development Plans state-wide.
- The Coast Protection Board possesses significant data, knowledge and expertise in relation to coastal risks, has strong policy positions on new coastal development and coast protection works and provides advice and, in some cases, direction over coastal development proposals;
- Regional climate change adaptation planning occurring under the State Adaptation Framework is involving Local Governments and communities in understanding a range of climate risks,; and
- Natural resources management, emergency management, and public asset management systems in place in South Australia also have functions and mechanisms that support management of coastal risks and adaptation.<sup>74</sup>

While there are technical and policy capabilities in place which contribute to adaptive capacity, there are also barriers which limit adaptive capacity of coastal management systems. Constraints to managing coastal impacts in South Australia potentially arise from:

- Differing levels of understanding and support amongst communities and decision makers for addressing the impacts of climate change. This includes the capacity of decision makers to access and interpret risk information to inform what are often “on balance” decisions involving social, economic and environmental “trade-offs”;
- Decision makers’ understanding of their own roles and responsibilities and those of others in coastal risk management. This includes the misalignment between the stated objectives of coastal management systems and actions, and decisions which support such policies.<sup>75</sup> For example, a review of the South Australian planning system noted that that there were “difficulties in regional areas where planning staff wear multiple hats”, and “regional elected members alluded to difficulty in conducting their elected duties and serving as unbiased members of development assessment panels.”<sup>76</sup>
- Local interests and values that form the context in which decisions are made;
- Conflicts in understanding and dividing responsibilities, benefits and costs of climate change responses between public and private stakeholders;
- Limitations to the access and utilisation of a range of technologies for understanding projected climate impacts such as sea level rise;<sup>77</sup>

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<sup>74</sup> URPS (2014)

<sup>75</sup> URPS (2014)

<sup>76</sup> South Australian Expert Panel on Planning Reform 2013

<sup>77</sup> URPS (2014)

- The expense and spatial limitations associated with developing coastal protection infrastructure;
- The retreat of species (e.g. mangroves);
- The adjustments to space due to increased coastal development and fragmentation of ecosystems;<sup>78</sup> and
- Resource availability and local government liability where there is a common law limit on liability of local governments in civil litigation. As litigation involving Councils is “highly likely” to occur in the context of climate change as a result of their growing responsibilities around adaptation policies, there may be a further drain on resources that councils may not be able to insure against.<sup>79</sup> Such litigation could include, for example, liability for damage caused by natural hazards in coastal zones (e.g. flooding, storm surges), as a result of granting development approval.<sup>80</sup>

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<sup>78</sup> Bardsley (2006), *There's a change on the way - An initial integrated assessment of projected climate change impacts and adaptation options for Natural Resource Management in the Adelaide and Mt Lofty Ranges Region*

<sup>79</sup> URPS (2014)

<sup>80</sup> URPS (2014)

## 6.0 Summary of conclusions

The coastal and estuarine environment is an important feature in the Western Adelaide region, contributing significant environmental, social and economic values. These include social aspects such as recreation, amenity, culture, heritage, health and wellbeing, environmental aspects such as such as habitat and valuable ecosystem and biodiversity services and economic aspects as the location of significant economic centres and key infrastructure.

The coast and foreshore areas in the region provide a range of functions and services including:

- The abundant mangrove areas are valuable nursing grounds for fish while also providing stormwater treatment surfaces for the community;
- The 20km of sandy beaches in the region provide recreational, amenity, cultural, heritage, and health and wellbeing values;
- The area has numerous places of Aboriginal significance, particularly to the Kaurna people;
- Many of the region's largest economic centres and significant infrastructure are situated along the coast, including the port, energy, manufacturing and transport infrastructure; and
- Key tourism facilities including the Adelaide Shores complex at West Beach, boat ramps, sailing clubs and skating and biking parks and attractions such as the Adelaide Dolphin Sanctuary at the Port River Estuary and Barker Inlet, and fine sand beaches.

The coast of the Western Adelaide Region is likely to be sensitive to a range of future climate hazards the region will be exposed to. In particular, inundation from sea level rise and storm surge, coastal recession and dune erosion will impact the infrastructure, environment and activities undertaken along the coast.

The region's adaptive capacity in relation to coastal management is influenced by physical factors such as the protection of coastal areas from flooding and the integrity of beaches and dune systems. This includes the maintenance of beach integrity and dune systems through engineered solutions and construction of seawalls. While some physical infrastructure has been established in the region, the maintenance of natural ecosystems is critical to adaptive capacity. This is already evident in the Western Adelaide region, with seawalls as the last line of defence in areas such as Somerton Park, Henley Beach and Brighton, while constructed natural wetlands along rivers and coastlines are being increasingly utilised as natural defences against storm surges. While these wetlands are constructed and the high degree of disturbance to coastal and estuarine areas in the region means that they will not be restored to their natural state, there is consensus that in targeted areas constructed wetlands are effective as a buffer against coastal erosion while also providing ecosystems services and other environmental benefits.

Adaptive capacity in relation to coastal management in the Western Adelaide region is also highly influenced by the coordination of coastal planning and action across Commonwealth, State and local levels of government. While it is generally recognised that there is good policy and system architecture in place to support adaptation along the coast as well as technical and policy capabilities in place which contribute to adaptive capacity, there are also barriers which limit adaptive capacity of coastal management systems.

The exposure, sensitivity and adaptive capacity of Western Adelaide, including in relation to coastal management, will be further explored in collaboration with regional stakeholders through the IVA process.

## 7.0 References

Abel N, Gorddard R, Harman B, Leitch A, Langridge J, Ryan A, Heyenga S, Sea level rise, coastal development and planned retreat: analytical framework, governance principles and an Australian case study, *Environmental Science and Policy*, vol. 14, pp.279-288.

AECOM (2013), *Supporting evidence-based adaptation decision-making in South Australia: A synthesis of climate change adaptation research*, National Climate Change Adaptation Research Facility (NCCARF).

Bardsley (2006), *There's a change on the way - An initial integrated assessment of projected climate change impacts and adaptation options for Natural Resource Management in the Adelaide and Mt Lofty Ranges Region*

Campbell Pages (2014) State of Our Community Report, viewed 10 November 2014, <<http://www.campbellpage.com.au/wp-content/uploads/2014/03/State-of-Our-Community-Report-Western-Adelaide.pdf>>.

City of Port Adelaide Enfield (2007), *State of the Environment Report 2007*, City of Port Adelaide Enfield.

Cordingley, SP & Petherick, CE (2006a), *Vegetation Management Plan: Tennyson Dune Reserve Yaitya Worra (True Indigenous Sand)*, City of Charles Sturt, South Australia, viewed on 25th October 2014, <[https://www.charlessturt.sa.gov.au/webdata/resources/files/Vegetation\\_Management\\_Plan\\_-\\_Tennyson.pdf](https://www.charlessturt.sa.gov.au/webdata/resources/files/Vegetation_Management_Plan_-_Tennyson.pdf)>.

Cordingley, SP & Petherick, CE (2006b), *Vegetation Management Plan: Semaphore Park Coastal Reserve*, dCity of Charles Sturt, South Australia, viewed on 25th October 2014, <[https://www.charlessturt.sa.gov.au/webdata/resources/files/Vegetation\\_Management\\_Plan\\_-\\_Semaphore\\_Park.pdf](https://www.charlessturt.sa.gov.au/webdata/resources/files/Vegetation_Management_Plan_-_Semaphore_Park.pdf)>.

Commonwealth Scientific and Industrial Research Organisation (CSIRO) & Bureau of Meteorology (BOM) (2007-2014), *Climate Change In Australia*, in partnership with the Department of Climate Change and Energy Efficiency (DCCEE), viewed on 25<sup>th</sup> September 2014, <<http://www.climatechangeinaustralia.gov.au/>>.

CSIRO (2008) Acid Sulfate Soils in Barker Inlet and Gulf St Vincent Priority Region.

Department of Climate Change and Energy Efficiency (DCCEE) (2014), *Roles and responsibilities for climate change in Australia*, Australian Government, viewed on 5<sup>th</sup> September 2014, <<http://www.climatechange.gov.au/roles-and-responsibilities-climate-change-australia>>.

Department of Sustainability and Environment (2009), *Victorian Coastal Acid Sulfate Soils Strategy*, Victorian Government.

Department of Environment & Heritage (DEH) (2005), *Adelaide's Living Beaches: A strategy for 2005-2025*, Government of South Australia.

Department of Environment and Natural Resources (DENR) (2011), *Report on the Operation of the Climate Change and Greenhouse Emissions Reduction Act 2007*, Government of South Australia.

Department of Environment, Water and Natural Resources (DEWNR) (2014), *Policies and strategic plans*, Government of South Australia, viewed on 24<sup>th</sup> September 2014, <[http://www.environment.sa.gov.au/about-us/boards-and-committees/Coast\\_Protection\\_Board/Policies\\_strategic\\_plans](http://www.environment.sa.gov.au/about-us/boards-and-committees/Coast_Protection_Board/Policies_strategic_plans)>.

Department of Environment, Water and Natural Resources 2012, *Prospering in a Changing Climate: A Climate Change Adaptation Framework for South Australia*, Government of South Australia, accessed 22 September 2014.

Department for Water (2011), *Stormwater Strategy: The future of stormwater management*, Government of South Australia, viewed on 1<sup>st</sup> October 2014, <<http://www.environment.sa.gov.au/files/4a764047-86a8-44d0-94c3-a1db00b5a3a8/stormwater-strategy-report.pdf>>

Environment Protection Authority (EPA) South Australia (2009), *Changes in urban environments*, Government of South Australia, viewed on 1<sup>st</sup> October 2014, <[http://www.epa.sa.gov.au/xstd\\_files/Water/Information%20sheet/acws\\_urban.pdf](http://www.epa.sa.gov.au/xstd_files/Water/Information%20sheet/acws_urban.pdf)>

Intergovernmental Panel on Climate Change (IPCC) (2007), *Climate Change 2007: Working Group II: Impacts, Adaptation and Vulnerability – Glossary*, IPCC Fourth Assessment Report: Climate Change 2007, viewed on 1<sup>st</sup> September 2014, <[http://www.ipcc.ch/publications\\_and\\_data/ar4/wg2/en/annexessglossary-a-d.html](http://www.ipcc.ch/publications_and_data/ar4/wg2/en/annexessglossary-a-d.html)>.

Intergovernmental Panel on Climate Change (IPCC) (2013a) *Climate Change 2013: The Physical Science Basis*, Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

Intergovernmental Panel on Climate Change (IPCC) (2000), *Summary for policymakers: Emissions Scenarios*, A Special Report of IPCC Working Group III, viewed on 1<sup>st</sup> October 2014, <<https://www.ipcc.ch/pdf/special-reports/spm/sres-en.pdf>>.

Intergovernmental Panel on Climate Change (IPCC) (2013b), *Climate Change 2013: Working Group II: Impacts, Adaptation and Vulnerability – Glossary*, IPCC Fifth Assessment Report: Climate Change 2013, viewed on 1<sup>st</sup> September 2014, <[http://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-Glossary\\_FGD.pdf](http://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-Glossary_FGD.pdf)>.

Pullen A (2006), *Kaurna Cultural Heritage Survey, Audit and Directions Report*, prepared by GHD Pty Ltd for The City of Port Adelaide Enfield.

SA Coast Protection Board (1992), *Coastal erosion, flooding and sea level rise standards and protection policy*, Government of South Australia.

SA Coast Protection Board (2003), *A Strategy for Implementing CPB Policies on Coastal Acid Sulfate Soils in South Australia*, Coastline, vol. 33, p. 5

South Australia's Expert Panel on Planning Reform 2013, *What we Have Heard So Far*

SKM (2013), *Western Adelaide Region Climate Change Adaptation Plan – Stage 1: Final Report*, Sinclair Knight Merz (SKM).

Stafford Smith, M, Horrocks, L, Harvey, A, and Hamilton, C (2011), *Rethinking adaptation for a 4°C world*, in *Philosophical Transactions of the Royal Society A*, 369, pp.196-216, p. 197

Steffen, W and Hughes, L (Climate Commission) (2011) *The Critical Decade: South Australian impacts*, Commonwealth of Australia, accessed 21 September 2014

Suppiah, R, Preston, B, Whetton, PH, McInnes, KL, Jones, RN, Macadam, I, Bathols, J and Kirono, D (2006), *Climate change under enhanced greenhouse conditions in South Australia*, CSIRO, viewed on September 1<sup>st</sup> 2014, <[https://www.sa.gov.au/\\_data/assets/pdf\\_file/0005/16727/CSIRO\\_FullReport\\_CCgreenhouse\\_conditions\\_2006.pdf](https://www.sa.gov.au/_data/assets/pdf_file/0005/16727/CSIRO_FullReport_CCgreenhouse_conditions_2006.pdf)>.

Tonkin Consulting (2014) *Port Adelaide/LeFevre Peninsula (Phase 2) Port Adelaide River Seawall Study, Volume 1*

URPS (2014), *Defining the Sea Level Rise Problem in South Australia: Issues Paper*, prepared for the Local Government Association of South Australia in partnership with Climate Change Unit, Water & Climate Change Branch, DEWNR and Coast Protection Board.

## Appendix A: Suggested IVA indicators

Primary indicator	Secondary indicator	Coastal management values							
		A strong and connected community	Amenity and quality of life	Biodiversity	Coastal and riverine water quality	Coastal environment	Infrastructure and essential services	Management and use of stormwater	Regional productivity and economic contribution
Biodiversity	Adverse impact on distribution and populations of marine flora			✓					
Biodiversity	Proportion of terrestrial flora species that are threatened (regional, state)			✓					
Buildings	Condition of built cultural heritage (e.g. heritage buildings, bridges, monuments, public art)		✓						
Buildings	Condition of public realm (street scapes, street trees, paving, drinking fountains, public art)		✓						

Primary indicator	Secondary indicator	Coastal management values							
		A strong and connected community	Amenity and quality of life	Biodiversity	Coastal and riverine water quality	Coastal environment	Infrastructure and essential services	Management and use of stormwater	Regional productivity and economic contribution
Buildings	Increased urban density impact on individual wellbeing		✓						
Buildings	Condition of public buildings (incl. Schools, libraries, hospitals)						✓		
Buildings	Demand for emergency evacuation centres and facilities						✓		
Buildings	Demand for heat refuges						✓		
Communications networks	Percentage of down time for telecommunications infrastructure						✓		
Community planning and development	Quality of cycling and walking infrastructure (e.g. footpaths etc.)						✓		

Primary indicator	Secondary indicator	Coastal management values							
		A strong and connected community	Amenity and quality of life	Biodiversity	Coastal and riverine water quality	Coastal environment	Infrastructure and essential services	Management and use of stormwater	Regional productivity and economic contribution
Community planning and development	Frequency of public transport service interruptions						✓		
Education	School attendance		✓						
Education	Ability to access educational and lifelong learning facilities						✓		
Education	Internet access						✓		
Emergency management	Demand for emergency services						✓		
Existing social capital	Rates of volunteerism	✓							
Existing social capital	Participation in organised sport, church or community group in local area	✓							

Primary indicator	Secondary indicator	Coastal management values							
		A strong and connected community	Amenity and quality of life	Biodiversity	Coastal and riverine water quality	Coastal environment	Infrastructure and essential services	Management and use of stormwater	Regional productivity and economic contribution
Existing social capital	Level of support from family, friends and neighbours	✓							
Land assets	Condition of natural cultural heritage (e.g. scar trees, heritage vineyard, springs, rivers, burial grounds)		✓						
Land assets	Quality of active recreation and sporting sites (outdoor - ovals, courts, pools, lawn bowls)		✓						
Land assets	Quality of open space (predominantly green space)		✓						
Land condition	Beach erosion					✓			

Primary indicator	Secondary indicator	Coastal management values							
		A strong and connected community	Amenity and quality of life	Biodiversity	Coastal and riverine water quality	Coastal environment	Infrastructure and essential services	Management and use of stormwater	Regional productivity and economic contribution
Land condition	Condition of the Barker inlet					✓			
Land condition	Dune erosion					✓			
Land condition	Inland area affected by soil erosion					✓			
Landscape fragmentation	Area of native vegetation cover outside of DEWNR reserves			✓					
Local government services	Property values						✓		✓
Mental health	Impact on children < 12 years of age		✓						
Mental health	Impact on people aged over 65 years and at risk		✓						

Primary indicator	Secondary indicator	Coastal management values							
		A strong and connected community	Amenity and quality of life	Biodiversity	Coastal and riverine water quality	Coastal environment	Infrastructure and essential services	Management and use of stormwater	Regional productivity and economic contribution
Mental health	Impact on people who require assistance for core activities		✓						
Pest plants and animals	Impact of pest plant and animal threats to the marine environment			✓					
Pest plants and animals	Impact of pest plant and animal threats to the terrestrial environment			✓					
Physical health	Impact on children < 12 years of age		✓						
Physical health	Impact on people aged over 65 years and at risk		✓						
Physical health	Impact on people who require assistance for core activities		✓						

Primary indicator	Secondary indicator	Coastal management values							
		A strong and connected community	Amenity and quality of life	Biodiversity	Coastal and riverine water quality	Coastal environment	Infrastructure and essential services	Management and use of stormwater	Regional productivity and economic contribution
Public safety	Levels of anti-social behaviour		✓						
Quaternary sector	GRP from education and training								✓
Quaternary sector	Impact on people choosing to live and work in the region								✓
Recreation	Participation in organised sport, church or community group in local area		✓						
Secondary industries	Costs of waste management								✓
Secondary industries	GRP from manufacturing								✓
Service networks	Condition of wastewater management assets						✓		

Primary indicator	Secondary indicator	Coastal management values							
		A strong and connected community	Amenity and quality of life	Biodiversity	Coastal and riverine water quality	Coastal environment	Infrastructure and essential services	Management and use of stormwater	Regional productivity and economic contribution
Service networks	Delivery of potable water (condition of pipes and water quality)						✓		
Service networks	Frequency of electricity supply disruption						✓		
Social inclusion/exclusion	Impact on children < 12 years of age	✓							
Social inclusion/exclusion	Impact on people aged over 65 years and at risk	✓							
Social inclusion/exclusion	Impact on people who require assistance for core activities	✓							
Social inclusion/exclusion	Levels of anti-social behaviour	✓							



Primary indicator	Secondary indicator	Coastal management values							
		A strong and connected community	Amenity and quality of life	Biodiversity	Coastal and riverine water quality	Coastal environment	Infrastructure and essential services	Management and use of stormwater	Regional productivity and economic contribution
Tertiary industries	Tourist accommodation occupancy rates								✓
Transport networks	Condition of jetties and boat ramps						✓		
Transport networks	Condition of rail						✓		
Transport networks	Condition of roads						✓		
Vegetation communities	Condition and extent of native vegetation by vegetation type (Allocasuarina forest and woodland)			✓					
Vegetation communities	Condition and extent of native vegetation by vegetation type (Coastal shrubland)			✓					

Primary indicator	Secondary indicator	Coastal management values							
		A strong and connected community	Amenity and quality of life	Biodiversity	Coastal and riverine water quality	Coastal environment	Infrastructure and essential services	Management and use of stormwater	Regional productivity and economic contribution
Vegetation communities	Condition and extent of native vegetation by vegetation type (Eucalypt Forests and Woodland)			✓					
Vegetation communities	Condition and extent of native vegetation by vegetation type (Fernland/herbland)			✓					
Vegetation communities	Condition and extent of native vegetation by vegetation type (Samphire shrubland)			✓					
Water	Groundwater quantity and quality (salinity and PH) – local GMA				✓				
Water	Surface water quantity and quality – Coastal/estuaries				✓				



## Appendix B: Policies and plans contributing to adaptive capacity

## Appendix B: Policies and plans contributing to adaptive capacity

**Plans, policies and strategies contributing to adaptive capacity**

<b>Plans, policies and strategies</b>	<b>Commonwealth Government</b>	<b>Government of South Australia</b>	<b>City of Port Adelaide Enfield</b>	<b>City of West Torrens</b>	<b>City of Charles Sturt</b>
National Climate Change Adaptation Framework 2007	x				
Decision tools - Local Adaptation Pathways Program	x				
Adapting to Climate Change in Australia Position Paper 2010	x				
South Australia's Strategic Plan		x			
SA Planning Strategy - 30 Year Plan for Greater Adelaide		x			
Tackling Climate Change: SA's Greenhouse Strategy 2007-2020		x			
Coast Protection Board Strategic Plan 2009 – 2014		x			
Policy on Coast Protection and New Coastal Development 1991		x			
Coast Protection Board Policy Document 2012		x			
Coastal erosion, flooding and sea level rise standards and protection policy 1992		x			

## Appendix B: Policies and plans contributing to adaptive capacity

Plans, policies and strategies	Commonwealth Government	Government of South Australia	City of Port Adelaide Enfield	City of West Torrens	City of Charles Sturt
State/Regional NRM Plans (under NRM Act 2004)		x			
Adelaide and Mt Lofty Regional NRM Plan (under NRM Act 2004)		x			
Adelaide's Living Beaches Strategy 2005 – 2025		x			
Prospering in a Changing Climate: A Climate Change Adaptation Framework for South Australia, 2012		x			
Flood Inundation and Hazard Mapping Study for Brown Hill and Keswick Creeks, 2003		x			
State Emergency Management Plan, 2014		x			
Zone Emergency Management Plan (to be completed)			x	x	x
Strategic Infrastructure Plan for South Australia, 2004/05 – 2014/15		x			
LGA SA Climate Change Strategy 2008-2012		x	x	x	x

## Appendix B: Policies and plans contributing to adaptive capacity

<b>Plans, policies and strategies</b>	<b>Commonwealth Government</b>	<b>Government of South Australia</b>	<b>City of Port Adelaide Enfield</b>	<b>City of West Torrens</b>	<b>City of Charles Sturt</b>
<b>City of Port Adelaide Enfield (PAE) City Plan 2010-2016</b>			x		
<b>PAE Environment Strategy for a Sustainable City 2009-2014</b>			x		
<b>PAE Development Plan</b>			x		
<b>City of Charles Sturt (CS) Community Plan 2027</b>				x	
<b>CS Development Plan</b>				x	
<b>WT Climate Change Action Plan 2009-2014</b>					x
<b>WT Development Plan</b>					x