CoastAdapt

Data and datasets for coastal adaptation

Information Manual 3

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CoastAdapt

Available data, datasets and derived information to support coastal hazard assessment and adaptation planning

Information Manual 3

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Preface

In 2014, the National Climate Change Adaptation Research Facility (NCCARF) was commissioned by the Australian Government to produce a coastal climate risk management tool in support of coastal managers adapting to climate change and sea-level rise. This online tool, known as CoastAdapt, provides information on all aspects of coastal adaptation as well as a decision support framework. It can be accessed at www.coastadapt.com.au.

Coastal adaptation encompasses many disciplines ranging from engineering through to economics and the law. Necessarily, therefore, CoastAdapt provides information and guidance at a level that is readily accessible to non-specialists. In order to provide further detail and greater insights, the decision was made to produce a set of Information Manuals, which would provide the scientific and technical underpinning and authoritativeness of CoastAdapt. The topics for these Manuals were identified in consultation with potential users of CoastAdapt.

There are ten Information Manuals, covering all aspects of coastal adaptation, as follows:

1. Building the knowledge base for adaptation action
2. Understanding sea-level rise and climate change, and associated impacts on the coastal zone
3. Available data, datasets and derived information to support coastal hazard assessment and adaptation planning
4. Assessing the costs and benefits of coastal climate adaptation
5. Adapting to long term coastal climate risks through planning approaches and instruments
6. Legal risk. A guide to legal decision making in the face of climate change for coastal decision makers
7. Engineering solutions for coastal infrastructure
8. Coastal sediments, beaches and other soft shores
9. Community engagement
10. Climate change adaptation planning for protection of coastal ecosystems

The Information Manuals have been written and reviewed by experts in their field from around Australia and overseas. They are extensively referenced from within CoastAdapt to provide users with further information and evidence.

NCCARF would like to express its gratitude to all who contributed to the production of these Information Manuals for their support in ensuring that CoastAdapt has a foundation in robust, comprehensive and up-to-date information.

Executive summary

Importance of datasets for coastal management

Coastal management, particularly in a changing climate, rests on information from both the analysis of data and the modelling of coastal processes and the climate system. Data and information on coastal behaviour and on climate variables are to be found in many disparate sources and are embedded in a wide range of policies and decisions that relate to the coast. These data are used, for example, in tools to predict inundation and erosion, in planning guidelines about coastal setbacks, in engineering specifications for jetties and coastal protection works, in catastrophe models used by insurance companies and to plan evacuation routes in low-lying areas.

With climate change, careful consideration is needed where historic data are no longer adequate for planning and decision-making. Over time, climate change can increase the impacts of current hazards and can bring new hazards to a local area, such as in a shift from a stable to a receding beach. Increasingly, data on future climate and how that climate could affect the coast will need to be incorporated in hazard and risk assessments and coastal management policies and in how those policies are implemented by local councils.

Adequacy of available datasets

Australia has a number of very good datasets that can inform coastal hazard assessment and climate change adaptation. These include long-term records of weather variables and tides by the Bureau of Meteorology (BoM) and state governments, high-quality elevation data, nationally coordinated geomorphology datasets and regional sea-level rise projections information.

However, significant work is required to develop and make available all the datasets needed for coastal management in a changing climate. There is need for stronger coordination, including a networked repository to ensure that important coastal datasets are developed, accessible and designed for multiple purposes. Areas where further work is needed on coastal datasets include development of accessible long-term datasets from wave buoys, data on coastal sediment budgets and sediment transport and data to calibrate and verify coastal models to ensure that they are relevant to local conditions and properly reproduce reality. A priority is to address data gaps in areas showing signs now of vulnerability to shoreline recession.

Coastal and climate modelling tools help address data deficiencies and gaps in understanding how the coast may change in the future. Modelling approaches underpin a range of coastal management decisions; however, in many areas data are inadequate to ensure that model results are locally accurate.

Given the size of Australia's coastline, the largest opportunity for the provision of cost-effective data to manage growing coastal risks will come from satellites and remote-sensing techniques. Satellite data have already proved invaluable in the measurement of sea levels, waves, inundation risks and beach profiles. There is an opportunity, with effective national coordination, for such approaches to generate data needed to monitor and manage changes to the shoreline that will result from sea-level rise and possibly more intense storms.

Available datasets to assess coastal risks

Existing national and state datasets are adequate to support first-pass screening of coastal risks from climate change. The following tables outline useful datasets for coastal risk assessment and where to find further information in this manual. National managers of datasets are also identified where appropriate.

Table ES 1 datasets are readily accessible, easy to use and suited to first-pass risk assessments. In many instances, more detailed risk assessments will be possible through contribution from these datasets, for example the climate change projections, coastal compartments, geomorphology, infrastructure and satellite imagery datasets.

Datasets in Table ES 2 contain more technical data and are better suited to more detailed risk assessments involving qualitative analysis and hazard modelling.

Table ES 1 Available datasets suitable for first-pass risk assessments and for contribution to more detailed assessment.

Coastal element	Available dataset	For further information
Climate and climate change projections	**Climate change projections.** Climate Change in Australia website contains regional projections for a range of climate variables, including sea-level rise (CSIRO and BoM)	Section 5.1.1
	Tropical cyclones and East Coast Lows (ECLs). Datasets on cyclone tracks, behaviour and impacts (BoM), dataset on East Coast Lows (BoM)	Section 4.3
	Tides and sea level. The Australian Baseline Sea Level Monitoring Project (BoM)	Section 3.2.1
Coastal geomorphology	**Coastal compartments** (primary and secondary) and implications for scale of assessments and management (NCCARF CoastAdapt and Geoscience Australia)	Section 3.1.1
	Smartline Coastal Geomorphology maps on extents of shore types and their susceptibility to erosion (NCCARF CoastAdapt and Geoscience Australia)	Section 3.1.2
	Beach change. Aerial photography and photogrammetry data repository (Geoscience Australia)	Section 3.1.1
Coastal inundation and erosion hazard-prone areas	**Inundation-prone areas.** State government mapping of inundation-prone areas	Section 6.3.1
	Inundation risk from sea-level rise. Coastal Risk Australia – shows inundation from sea-level rise scenarios and allows users to explore inundation with own data (Cooperative Research Centre for Spatial Information)	Section 6.3.1
	Local government high-risk areas. National Coastal Risk Assessment identifies local governments with areas at high risk of inundation and erosion (Department of the Environment)	Section 7.2
	Erosion hazard areas. State government mapping of erosion hazard areas	Table 6.4, Section 6.4.1
	Regional generic erosion setbacks. Derived dataset of generic erosion setbacks for 30 regions around the Australian coast (Antarctic Climate and Ecosystems Cooperative Research Centre)	Table 6.6, Section 6.4.2
Coastal assets	**Buildings and infrastructure.** National Exposure Information System (NEXIS) providing location and metadata for buildings and some infrastructure (Geoscience Australia)	Table 7.1, Section 7.2
	Transport infrastructure. National Map contains location dataset of transport infrastructure (Australian Government)	Table 7.1, Section 7.2
	Satellite imagery, such as from Google Maps, enables visual identification of settlements and other assets in a local area	Section 7.1

Table ES 2 Additional available datasets suitable for more detailed coastal risk assessment.

Coastal element	Additional available dataset	For further information
Climate and climate change projections (also see datasets in Table ES 1)	**Climate change projections.** The Climate Change in Australia website contains tools that can be used to generate tailored regional projections for a range of climate variables, including sea-level rise (CSIRO and BoM)	Section 5.1.1
	Wind speed (daily, monthly) long-term records (BoM)	Section 3.4
	Temperature and rainfall. Climate Data Online – Long-term daily and monthly records (BoM)	Section 4.1, Section 4.2
	Extreme rainfall. Design rainfall data developed by BoM for engineering (Engineers Australia)	Section 4.2.1
	Tropical cyclone model suitable for damage assessment (Geoscience Australia)	Section 4.3
Elevation (topography and bathymetry)	**Topographic and bathymetry data.** Elevation Information System (ELVIS). Users can download the 1 second (~30 m) and 5 m elevation data (Geoscience Australia) Compiled bathymetric dataset (Geoscience Australia) Also see state government data portals	Section 3.1.3 Section 7.1
Geomorphology (also see datasets in Table ES 1)	**Smartline Coastal Geomorphology** on extents of shore types and their susceptibility to erosion (NCCARF CoastAdapt and Geoscience Australia)	Section 3.1.2
	Beaches. The Australian Beach Safety & Management Program database of over 12,000 beaches	Section 3.1.2
	Beach change. Aerial photography, satellite data and photogrammetry data repository (Geoscience Australia)	Section 3.1.1
Sea level and ocean	**Storm tide.** Derived map dataset for 1-in-100-year storm tide height (CSIRO)	Figure 3.8, section 3.2.2
	Wave buoys. Wave buoy data on significant wave height, period and direction (near-term data)	Table 3.2, section 3.3.1
	Wave model datasets (longer term and suitable for modelling), including from combined satellite data and historic sea records	Table 3.3, section 3.3.1
	Extreme waves. Derived map dataset for 1-in-100-year significant wave height (Antarctic Climate and Ecosystems Cooperative Research Centre)	Figure 3.9, section 3.3.2
	Ocean data. The Australian Ocean Data Network Portal contains a variety of ocean and coastal datasets (Integrated Marine Observing System)	Section 3.5

Table ES 2 Additional available datasets suitable for more detailed coastal risk assessment - *continued.*

Coastal element	Additional available dataset	For further information
Coastal hazards (also see datasets in Table ES 1)	**Inundation**. Coastal Risk Australia – tool allows users to explore inundation from sea-level rise, including from input of local data (Cooperative Research Centre for Spatial Information)	Section 6.3.1
	Setback for sea-level rise. Climate Change in Australia web tool provides allowances information for extreme sea-level and sea-level rise for sites around the coastline (CSIRO)	Section 5.2
	Catchment flooding. Australian Flood Risk Information Portal (AFRIP), which contains information and studies on catchment floods (Geoscience Australia)	Section 6.3.1
	Historic flooding. Water Observations from Space – historic extent of flooding captured through Landsat record (Geoscience Australia)	Section 6.3.1
	Design erosion. Derived dataset of suggested design erosion volumes (2 x 100-year average recurrence interval [ARI] storms) for 30 regions around Australian coast (Antarctic Climate and Ecosystems Cooperative Research Centre)	Table 6.6, section 6.4.2
Coastal assets (also see datasets in Table ES 1)	**Ecosystems**. National Map dataset on vegetation types (Australian Government) and datasets on environments of national significance (Department of the Environment)	Section 7.2
	Population. Range of datasets and information on population location, growth and demography (Australian Bureau of Statistics)	Section 7.2
	Buildings and infrastructure. National Exposure Information System (NEXIS) providing location and metadata for buildings and some infrastructure in precise areas affected by hazards (Geoscience Australia)	Section 7.2 and Annex A
	Satellite imagery, such as from NearMap, enables identification of settlements and other assets in a local area, with emerging analytic and trend identification capabilities	Section 7.1

For a number of coastal decisions, for example those with a short asset life, detailed modelling and data acquisition are not required. Experience has shown that coastal setbacks and foreshore reserves provide a buffer from many coastal hazards and protect assets located landward.

However, detailed studies will be required where decisions are essentially irreversible, critical assets for human safety are involved and/or there is significant investment, where there is a history of inundation or erosion, and in areas that could be significantly affected by climate change. Further information on datasets useful for risk modelling can be found in section 6.

Accessing, using and acquiring datasets

Many of the accessible datasets are not easy to interpret or use, and some are not straightforward to access. Decision-makers will often need technical assistance in the acquisition, ongoing management and storage of data. Data management planning is useful to ensure that datasets meet needs and are accessible and fit for purpose.

Section 2.3 provides a number of tips to follow when data need to be procured, including ensuring that there are no licensing constraints to the multiple use of data, describing data specifications to enable easy linkage to current GIS and seeking clear and detailed metadata covering when and how the data were collected and any limits to their use.

This Information Manual includes links to several online resources. All links have been accessed 1 June 2016.

1 Introduction

1.1 Why has this information manual been written?

This information manual has been written because stakeholder feedback has emphasised the significant challenges that many decision-makers face in accessing and using data for climate change risk assessments and to support adaptation. The purpose of this information manual is to:

- inform decision-makers on the importance of engaging with the scientific data on climate change and the coast that has relevance to their decision-making
- empower decision-makers to confidently access and use climate change data in adaptation planning and action.

The manual provides an overview of why data are important, what data are available and how data can be used in first-pass risk screening and hazard assessments. The focus is primarily on biophysical data and information relating to coastal processes, climate and climate change, elevation and geomorphology. These data are used in models that help us understand the coast, its dynamics and how it is changing. In addition, the manual identifies national datasets on social, economic and environmental factors relevant to understanding the consequences of coastal climate change.

The manual is intended to provide introductory information on data relevant to understanding coastal climate change risks and the need for adaptation. A number of links are provided to sources of more detailed information, and high-cost local decisions will require expert use of data and models that go beyond the scope of what can be provided here.

The manual generally uses the term 'data' to cover measured or quantitative estimates of variables and derived information, that is, data that are processed or refined to a form that can be useful.

1.2 Data in CoastAdapt

The CoastAdapt tool is supported by a number of information manuals that provide more technical details on key areas of coastal adaptation, including relevant data sources. For example, the information manuals Information Manual 1: Building the adaptation case, Information Manual 2: Understanding sea-level rise, and Information Manual 8: Coastal sediments and beaches include sections on where to access relevant data.

In addition, CoastAdapt provides a number of datasets that support coastal adaptation. Table 1.1 provides an overview of these datasets and a link to where they can be accessed.

Table 1.1 Physical coastal datasets available in CoastAdapt.

Dataset	Link	Comments
Inundation risk		
Sea-level rise projections	Sea Level rise and you http://coastadapt.com.au/sea-level-rise-information-all-australian-coastal-councils	Projected SLR for each coastal local council in Australia up to 2100
Inundation mapping	Sea Level rise and you http://coastadapt.com.au/sea-level-rise-information-all-australian-coastal-councils	Projected inundation mapping for coastal local councils in Australia with LiDAR, for mid and end-century and two greenhouse gas scenarios
Water observations from space	Shoreline Explorer http://coastadapt.com.au/coastadapt-interactive-map	An indication of the present-day flooding risk, based on satellite observations
Erosion risk		
Secondary coastal compartments map	Shoreline Explorer http://coastadapt.com.au/coastadapt-interactive-map	A basis for further analysis – not especially useful in itself
Expert knowledge on coastal compartments	Shoreline Explorer http://coastadapt.com.au/coastadapt-interactive-map	Qualitative expert description of each secondary compartment on landform, stability etc.
Smartline	Shoreline Explorer http://coastadapt.com.au/coastadapt-interactive-map	Geomorphology map of the Australian coastline presented as a segmented line tagged with attributes such as underlying geology and stability

2 Why are data important?

Key points:

- Climate and coastal data are embedded in a range of policy settings and decisions, and climate change will require new data to enable consideration of changing risks to society and the environment.
- The use of data to understand hazard behaviour and likely coastal responses to sea-level rise is a necessary precursor to understanding and managing coastal flood and erosion risks.
- However, for many local decisions, particularly where the planning horizon is <30 years and where robust coastal management policies are in place, new data may not be required. Many state government coastal management policies incorporate up-to-date science and allow for climate change.
- For major coastal investment and development decisions, professional practice and accountability call for robust consideration of risks, including the application of up-to-date and relevant data in inundation and erosion risk studies.
- The derivation and use of high-quality data in risk assessments will likely lead to reduced damage and maintenance costs over time.
- Data and information from monitoring activities can also enable the identification of longer term trends and can allow for new evidence to be incorporated into hazard mapping and plans.

2.1 Climate data are embedded in decision-making

Coastal management, particularly in a changing climate, is ultimately underpinned by field data. Data assist in optimising the design of coastal structures and constraining the cost of their construction. Data also assist in the conservation of natural resources and ecosystems in a changing climate and in understanding and managing increasing coastal hazards. Ultimately, good practice decision-making rests on a robust evidence base, including data from observations and modelling.

Climate data are embedded in a wide range of decisions in the coastal zone:

- Coastal setbacks in planning guidelines are informed by historic data on storm surges and beach recession.
- The engineering specifications for ports and jetties and of coastal protection measures, such as seawalls, draw on local wave climate and storm data.
- Models used by insurance companies to determine the coverage and cost of insurance for coastal properties are based on the frequency and severity of historic extreme weather events.
- The productivity of many fisheries is determined by sea surface temperatures and seasonal patterns in, for example, coastal currents.
- The design of stormwater drainage and outfalls is informed by sea levels.
- The elevation of evacuation routes in coastal floodplains, and thus community safety during flood events, is determined by the height of previous floods in the area.
- The strength of roof fastenings in the building code for northern Australia is informed by data on cyclonic wind speed.

The confidence that society can have in engineering and planning to ensure human safety and uninterrupted service delivery in the context of climate variability and change is a direct result of historic data collection investments. Data collected during and after Cyclone Tracy devastated Darwin in 1974 enabled reforms to the Building Code of Australia to be implemented in the early 1980s so that houses could withstand greater wind gust speeds. This meant that Queensland houses constructed after the reforms were adopted were less damaged by tropical cyclones, such as Cyclone Yasi in 2011, than those constructed before.

Many state governments employ coastal setback policies as a primary mechanism to manage coastal erosion and inundation hazards. Such setbacks are generally informed by data on historic extremes from monitoring programs. For many decisions, compliance with state policy on coastal setbacks is adequate for hazard management, and further consideration of data acquisition and analysis is not required. Where significant investment is planned in long-life coastal assets, such as protection works, or where risks are large, data are needed to:

- define and understand the current coastal processes that will act upon the infrastructure
- inform the design specifications of the infrastructure to ensure that it is resilient in a changing climate
- input to and calibrate models to test the sensitivity of the proposed construction to various climate and coastal conditions
- monitor the outcomes of construction, management and planning actions.

2.2 Need for new data with climate change

Climate change will need to be considered across the range of decisions underpinned by historic climate data. Of particular concern to planners and decision-makers, climate change can alter the type of climate hazards experienced in a local area, their spatial extent and the expected frequency and intensity of impacts on developed and natural assets. With climate change, decision-making cannot rely solely on historical hazards data; ongoing investment in data is required to properly track and manage changes in the coast.

With the increasingly uncertain future due to climate change, the need for long-term coastal datasets has been significantly increased. Data from regular monitoring allow identification of trends, provide the basis to test possible scenarios and to explore how complex coastal interactions could change with sea-level rise, and help identify future at-risk areas. Use of monitoring data to provide insights into how risks will change in the future can reduce the potential for assets to be inadvertently placed in harm's way (NCCOE 2012).

Of particular concern is the risk that climate change could trigger a change of state in the shoreline; that is, in the medium to longer term, accreting beaches can switch to becoming receding beaches. The site-specific nature of such beach responses emphasises the importance of local data and long-term monitoring studies to properly track beach changes, support decisions with a long asset life and assess the effectiveness of coastal protection measures.

Box 2.1 Peron Naturaliste Partnership Regional Coastal Monitoring Program

The Peron Naturaliste Partnership (PNP) is an incorporated collective group of nine local governments in the south-west of Western Australia: Bunbury, Busselton, Capel, Dardanup, Harvey, Mandurah, Murray, Rockingham and Waroona. The partnership region is vulnerable to the impacts of coastal climate change, with low-lying sandy coastal and shallow estuarine environments and high residential, commercial, recreational and ecological significance.

The PNP is delivering a regional coastal monitoring program (covering approximately 200 km of coast and estuarine areas) to generate the data and understanding needed to manage erosion and inundation hazards in the region. It includes consolidation of datasets, monitoring guidelines, and a 10-year action plan.

The program recognises that one size does not fit all. Monitoring activity needs to be tailored and informed by local development and other objectives, hazard areas, available resources and the capacity to upscale or downscale in response to coastal change. For example, the active management goals for Mandurah's northern beaches require annual surveys and beach profiles and monthly field photographs. In contrast, the setbacks and coastal protection works in Busselton allow for less frequent monitoring activity.

A number of lessons have been learned in the development of the monitoring program:

- It is not economically or logistically feasible to monitor all coastal and estuarine areas, and areas that require more frequent and finer scale monitoring need to be identified.
- Coastal sediment compartments (see section 3.1.1) can inform monitoring programs and priorities and enable local approaches to be nested within a regional approach.

Figure 2.1. Map of Peron Naturaliste Partnership region Source: Provided by Peron Naturaliste Partnership (http://www.peronnaturaliste.org.au).

- Managing datasets will be costly and time consuming, and training and council buy-in are required for implementing the monitoring action plan.

Asset management systems within each council could be updated to include coastal risk information and monitoring data.

Further information on the PNP can be found at http://www.peronnaturaliste.org.au.

Finally, in an increasingly litigious society, understanding key science findings and appropriate input data is important for professional practice and accountability. The potentially uncertain future projected by climate change only heightens the need for data as a duty-of-care obligation (Baker and Mackenzie 2011). We have already seen legal actions brought against councils and state governments with respect to decisions taken in light of potential climate change impacts, including where it was argued that climate change impacts on low-lying coastal land had not been considered. The advice of coastal experts can assist decision-makers where there is uncertainty.

2.3 Data management

Data are assets – potentially costly to obtain, but able to deliver considerable and ongoing benefits. With the rapid recent growth in digital data, mapping and data storage options, data management planning is important. A data management plan identifies how data and associated materials will be obtained, documented, stored, shared and disposed of. It can assist decision-makers through ensuring that data are well organised and accessible, that risks of data being misused are reduced, that data can be re-used appropriately and that relevant people can access the data they need.

The procurement of data can be complex, and in a climate change risk assessment or adaptation options analysis it is useful to consider whether any data will be generated that need to be managed. There are some key points relevant to data procurement that should be considered:

- Datasets that can be used repeatedly or by multiple users in an organisation can often justify the additional cost of procurement. It is useful to ensure that there are no constraints to multiple use in a licensing contract.
- Specification of the resolution and formatting of data sought is important, as is understanding where it can be readily overlaid with or linked to existing datasets and GIS tools.
- Metadata are important. A dataset with no metadata is like a tin can with no label. Metadata should describe the overall dataset, the time and location of collection, any points about the method of collection that impact on its use and any quality standards met. This ensures that it can readily be identified for future use when needed.

With data increasingly being in a digital form, there are a range of data storage and backup options. Incorporating data in existing GIS tools and asset registers facilitates access and reflection in decision-making. Additional data storage may also be required, and there are many cloud providers offering some amount of free space with additional capacity available for purchase. Most include apps to enable synchronisation between the cloud, desktop, laptop and mobile devices. These include but are not limited to Dropbox (http://dropbox.com with 2GB for free); Google Drive (http://drive.google.com with 15GB free across Google Drive, Gmail and Google+ Photos); iCloud (http://www.icloud.com with 5GB for free) and ADrive (http://www.adrive.com with 50GB for free but also with lots of advertisements).

2.4 References

Baker and McKenzie, 2011: Local council risk of liability in the face of climate change – resolving uncertainties, 132 pp. Accessed 1 June 2016. [Available online at https://www.environment.gov.au/system/files/resources/d9b2f9cf-d7ab-4fa0-ab0e-483036079dc7/files/alga-report.pdf.]

NCCOE (National Committee on Coastal and Ocean Engineering), 2012: Guidelines for responding to the effects of climate change in coastal and ocean engineering. Vol. 1 of Guideline Series, Engineers Australia, 3rd edition. 75 pp. Accessed 1 June 2016. [Available online at https://www.engineersaustralia.org.au/sites/default/files/content-files/2016-12/vol_1_web.pdf.]

2.5 Further reading

Webb, R., and J. Beh, 2013: Leading adaptation practices and support strategies for Australia: An international and Australian review of products and tools, National Climate Change Adaptation Research Facility, Gold Coast, 105 pp. Accessed 1 June 2016. [Available online at http://www.nccarf.edu.au/sites/default/files/attached_files_publications/Webb_2013_Leading_adaptation_practices_support.pdf.]

3 Available data: coastal processes

"While some long term wind (BoM; 60 year) and wave datasets (for example NSW and Queensland Governments; 35 year) exist and are of immense value, much collected data around Australia is sparse, incomplete, random and unintegrated. Urgent action is required to establish or expand engineering-related coastal and ocean data collection programs around Australia." (NCCOE 2012, p. 44)

Key points:

- The coastal zone is a dynamic area where air, water and land interact, sometimes with high energy. Coastal processes, which describe elements of these interactions, can lead to changes in the coast at short-, medium- and longer term time horizons.
- Data across all components of the Earth–atmosphere system are needed to understand coastal behaviour and change and to support coastal management.
- Australia has a number of good datasets on coastal processes, including on geomorphology, tides and elevation (see Table 3.5).
- However, there are still gaps in datasets that will be important to fill in order to understand coastal behaviour. These include gaps in long-term datasets on wave direction, derived datasets on design events (or frequency) and datasets to detect morphological change.
- Models can help in areas where the data are poor, including through generation of long-term synthetic datasets. However, to reduce uncertainty and produce accurate results, models need to be calibrated and verified using data.
- Typically, important datasets to understand coastal processes and drivers span meteorological-oceanic variables (wind, waves and tides), geomorphology and morphological change and elevation.

3.1 Coastal landforms and geomorphology

Coastal geomorphology encompasses the study of coastal landforms and the processes that form them, especially those from waves, tides and currents that lead to the erosion, transport and deposition of sediments. It is underpinned by regional geology, which determines the orientation of the coastline, the width and slope of the continental shelf and the type and location of coastal landforms such as headlands, reefs and beaches.

Geomorphology can have a significant influence on the response of a particular shore to sea-level rise or other coastal hazards. Data available on geomorphology relevant to coastal hazard assessment include geomorphological classification data, information on coastal compartments that reflect dynamic sediment processes, and land and nearshore elevation data. The main sources of data on coastal landforms and geomorphology are state and territory governments, particularly land information agencies, and Geoscience Australia.

3.1.1 Coastal compartments and shoreline change

Coastal compartments have been identified around Australia to inform risk and erosion assessments. The compartments are defined by natural coastal landforms and by patterns of sediment (for example, beach sand) movement. There are three levels of compartments (see Figure 3.1), each suitable for different types of decision-making:

- primary level, based on the influence of large landforms and offshore processes; suitable for regional planning or large-scale engineering, such as ports
- secondary level, based on medium landforms and regional sediment processes; useful for smaller engineering or local planning decisions
- tertiary level, based on individual beaches; suitable for very small projects unlikely to restrict sediment movement, such as deciding the exact location of a groyne or seawall within a broader management plan.

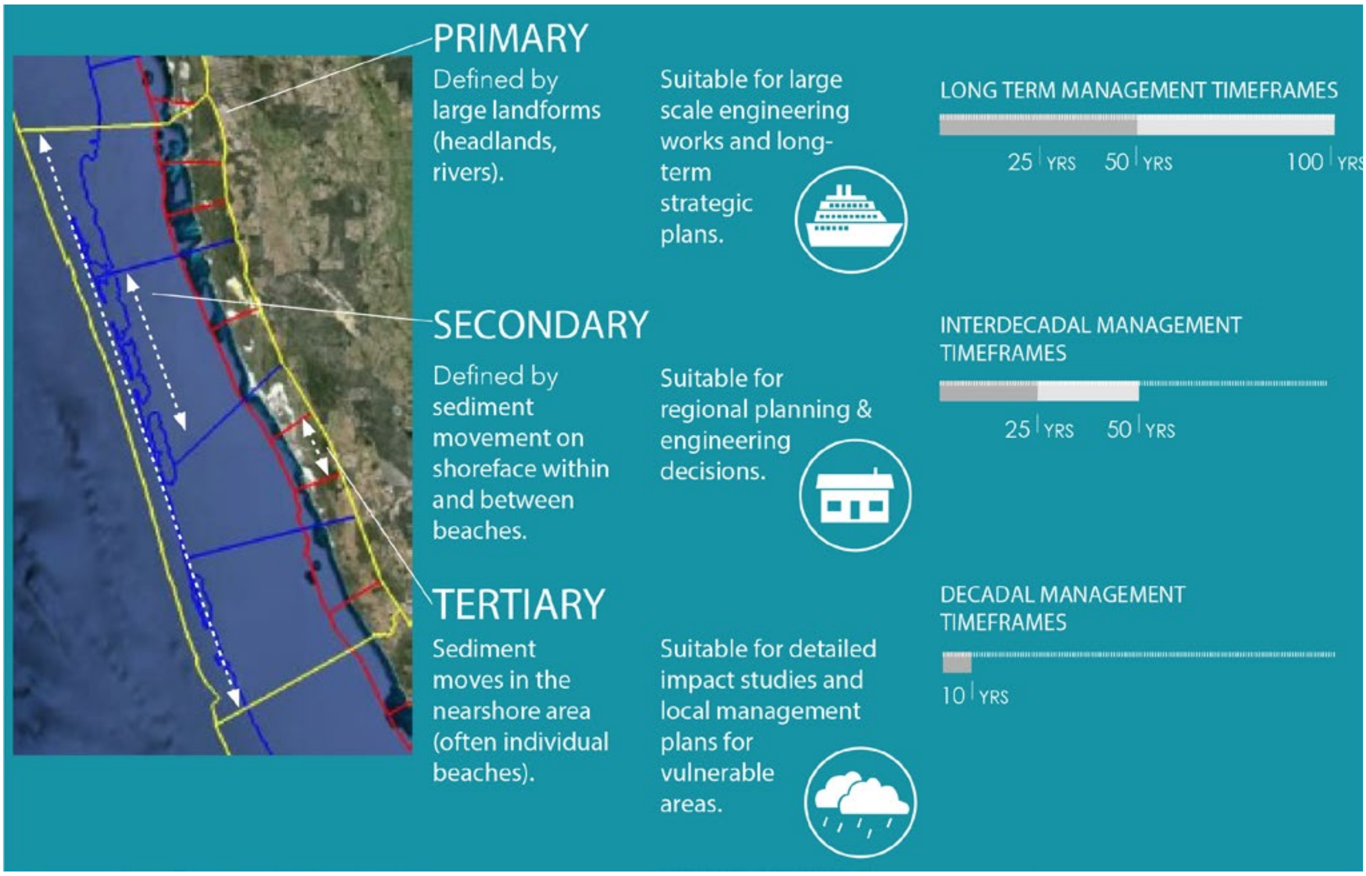

Figure 3.1 Coastal compartments scales, uses and timeframes. Source: Thom 2015 © Commonwealth of Australia 2016.

The coastal compartments approach was piloted in four areas with diverse morphologies: beaches around Perth, the Pilbara region in Western Australia, and Avoca Beach and Cabarita Beach in New South Wales (Eliot 2013; Mariani et al. 2013). It was found to be useful to inform risk studies, as it links processes operating at different scales and draws attention to the potential longshore consequences (erosion and accretion) of shore construction where sediment transport is interrupted.

CoastAdapt includes information (which can be found at "Datasets Guidance 1: Shoreline Explorer Present-day coastal sensitivity to flooding and erosion") on the susceptibility to change of each secondary compartment. Further information on the use of coastal compartments is in Information Manual 8: Coastal sediments and beaches, and on the mapping of coastal compartments at https://data.gov.au/dataset/primary-and-secondary-coastal-sediment-compartment-maps and http://www.environment.gov.au/climate-change/adaptation/publications/coastal-compartments-project-summary-policy-makers.

Understanding the rate of sediment transport is important for decisions that could interfere with transport processes, such as the construction of breakwaters, groynes or jetties. While there is not a consolidated dataset of sediment transport information, a number of studies have reported this information, for example in the Coffs Harbour region of New South Wales (75,000 m^3/yr, BMT WBM 2011), the New South Wales and Queensland border region (500,000 m^3/yr, Short and Woodroffe 2009), along the Gold Coast (400,000–800,000 m^3/yr depending on wave climate, Splinter 2010), Adelaide beaches (30,000–70,000 m^3/y, DEH 2005) and beaches around Clarence, Tasmania (60,000–90,000 m^3/yr, Carley et al. 2008).

Aerial photography provides a key source of information on shoreline change (see Figure 3.2). Photogrammetry involves the analysis of aerial photographs, which can be accessed from state governments and Geoscience Australia (http://www.ga.gov.au/scientific-topics/earth-obs/accessing-satellite-imagery/aerial-photography), with tools such as a stereocope to measure common points and changes between the photographs.

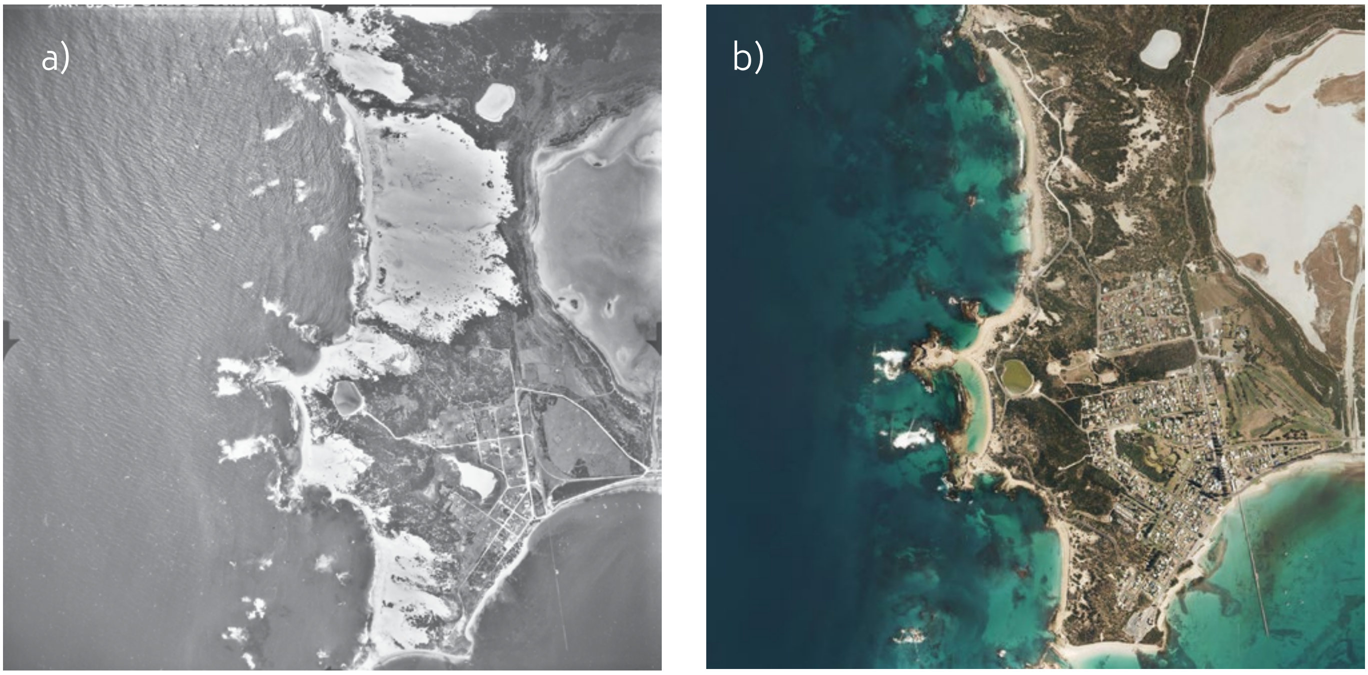

Figure 3.2 Aerial photographs of Beachport, South Australia, from (a) 1946 and (b) 2013, illustrating increased coastal development and natural revegetation of sand dunes, and other changes such as lake sedimentation, erosion, and loss of seagrass beds adjacent to the town resulting in the need for active management of the town foreshore eg. installation of a groyne field. Source: © Government of South Australia, Department of Environment, Water and Natural Resources.

There are limitations to the use of photogrammetric data for determining shoreline change (Kinsela and Hanslow 2013). The dates and coverage of air photography of beaches vary, and the extent to which dates align with storm events may affect how useful photographs are in looking at longer term trends. Older photography often has lower vertical and horizontal accuracy. Furthermore, it is difficult to accurately detect changes in the nearshore seabed from photographs.

Satellite and remote-sensed data are a growing resource for tracking and understanding coastal change. Baseline imagery can be obtained from sources such as Google Earth, and Geoscience Australia has Landsat data over all of Australia since 1987 (http://www.ga.gov.au/scientific-topics/earth-obs/satellites-and-sensors/landsat). With continued improvements in the precision and coverage of satellite data, and emerging analytic capabilities, there is the potential for more regular imagery and cost-effective mapping of shoreline change.

3.1.2 Geomorphology mapping and datasets

Smartline is a national geomorphology map, developed to facilitate access to consistent information on coastal geomorphology and to inform large-scale assessment of coastal risks. The map is derived from over 200 maps and datasets (examples shown in Table 3.1) spanning backshore profile and constituent materials, underlying geology and intertidal attributes. It allows users to discover information about geomorphological features down to 50 m in size. Data are presented as a segmented line, tagged with multiple attributes, which can be queried and analysed using GIS software.

Table 3.1 Smartline data types.

Dataset	Description
Backshore zone	The dominant landform type in the backshore zone extending 500 m inland of the upper limits of normal high tide wave wash; the first distinctive landform type immediately inland of the upper limits of normal high tide wave wash
Intertidal zone	The dominant and subordinate significant landform types or components in the zone between high-water mark and low-water mark
Subtidal zone	The dominant and subordinate significant landform type or component in the zone below low-water mark
Geology	Two categories describing the bedrock type underlying or exposed on the shore or underlying the subtidal and intertidal zones. Geology types are classified by lithology (rock type) and structure (e.g. deformation or fracturing)
Exposure attribute	Four broad categories defined by the degree to which they are exposed to open ocean swell wave energies
Stability class	Stability classes are characterised by particular landform types or groupings that have potential to physically respond to sea-level rise and other coastal processes in distinctive ways (including differing styles of erosion, accretion or stability). The main classes are muddy shores, sandy shores, sand-dune and beach-ridge coasts, coarse-sediment shores, undifferentiated soft-sediment shores, soft-rock shores, hard-rock shores and coral coasts
Metadata	Scale and source of data

Simplified data layers from Smartline which show the main landform types around the coast, supported by information on their susceptibility to erosion, can be accessed in CoastAdapt at link DS8. The more detailed Smartline mapping tool and datasets are available on the OzCoasts website, which is managed by Geoscience Australia (http://www.ozcoasts.org.au). Metadata and reports are also available, and users can also identify the source datasets for the Smartline maps. Information from Smartline, particularly on exposure to ocean swell waves and stability classes, can inform first-pass and second-pass risk assessments. The spatial and segmented format of Smartline also allows for linkage with other environmental, social or economic information relating to the coast.

Figure 3.3 shows an example of a coastal landform stability class map for the Pittwater–Narrabeen area of the New South Wales coast. It has been derived from Smartline by querying a range of landform attributes to generate a map showing attributes relevant to coastal stability in the region.

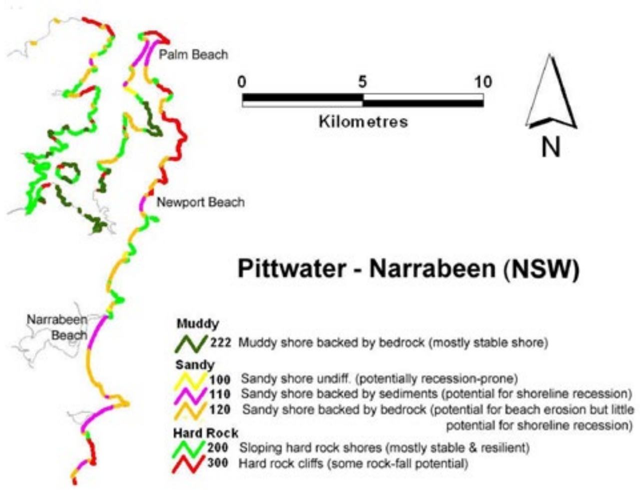

Figure 3.3. Coastal stability in Pittwater–Narrabeen area from Smartline. Source: Sharples et al. 2009.

The Australian Beach Safety & Management Program (ABSAMP) database (https://researchdata.ands.org.au/australian-beach-safety-program-absamp/428811) contains information on 12,219 beach systems, 2,615 barriers and 2,433 coastal drainage systems around the Australian coast. The ABSAMP database has been linked to the Smartline map via a common beach number field.

3.1 3 Elevation data – bathymetry and topography

Digital elevation data that describe Australia's landforms and seabed are essential for addressing issues relating to changes in sea level, including from climate change. The data are also important for disaster management, water security, environmental management, urban planning and infrastructure design. In particular, elevation data are critical to the identification of low-lying coastal lands at risk of inundation from sea-level rise and storm surge.

High-resolution elevation data have been collected by state governments and the Australian Government for developed parts of the Australian coast. Through the Elevation Information System (ELVIS) at http://www.ga.gov.au/elvis/, users can download a high-quality 1 second and 5 m elevation dataset, which is licensed under Creative Commons. An example of the use of this dataset in a tool to explore inundation from sea-level rise is provided in Box 6.1. Many local councils also have data on local landforms, including topographic data, contour mapping in GIS systems and land survey information.

Bathymetric data describe the depths and shapes of underwater terrain and are important for maritime transportation and for studies about the long-term effects of climate change on the coast. Bathymetric surveys can alert scientists to ongoing and potential beach erosion, sea-level rise and subsidence (land sinking). Scientists also use bathymetric data to create hydrodynamic models.

Bathymetry data are collected by state agencies responsible for ports, maritime transportation or fisheries. Geoscience Australia maintain a compiled record of bathymetric data, which can be accessed at http://www.ga.gov.au/scientific-topics/marine/bathymetry.

3.2 Sea levels

Water levels consist of regular tides, which arise largely from astronomical motions and are predictable; tidal anomalies from wind events and major storms; and sea-level rise. Sea levels are also influenced by larger climate processes such as the El Niño–Southern Oscillation (ENSO) and tend to be higher during La Niña and lower during El Niño conditions.

3.2.1 Average sea levels and tides

Along ocean coasts, tides produce a regular daily rise and fall of sea level that may range from a few centimetres to more than 10 m. Tidal fluctuations are important in the coastal zone and they affect, for example, the shoreward extent of wave action and the flushing of waters in estuaries, lagoons and bays. Figure 3.4 illustrates the large geographic variation in tides in Australia.

The Australian Baseline Sea Level Monitoring Project, managed by the BoM, is designed to monitor sea level around the coastline of Australia and to identify long-period sea-level changes. The project is supported by an array of SEAFRAME stations, which measure sea level very accurately and record meteorological parameters. The array consists of 14 standard stations and two supplementary stations (Lorne and Stony Point), which are owned by port operators. Figure 3.5 shows the location of the array. Data can be accessed from http://www.bom.gov.au/oceanography/projects/abslmp/abslmp.shtml.

State governments have installed a number of other tide gauges, often to support harbour operations and navigation for shipping.

Data from the tide gauge array and from satellite altimeters show that sea levels have been rising around Australia since at least the middle of last century. This is consistent with global measurements. Figure 3.6 shows historical sea-level measurements from Australia and the globe. Since the early 1990s, high-resolution satellite altimeter data has also been used to measure sea levels. Further information on observed changes in sea level can be found at http://www.climatechangeinaustralia.gov.au/en/climate-campus/australian-climate-change/australian-trends/.

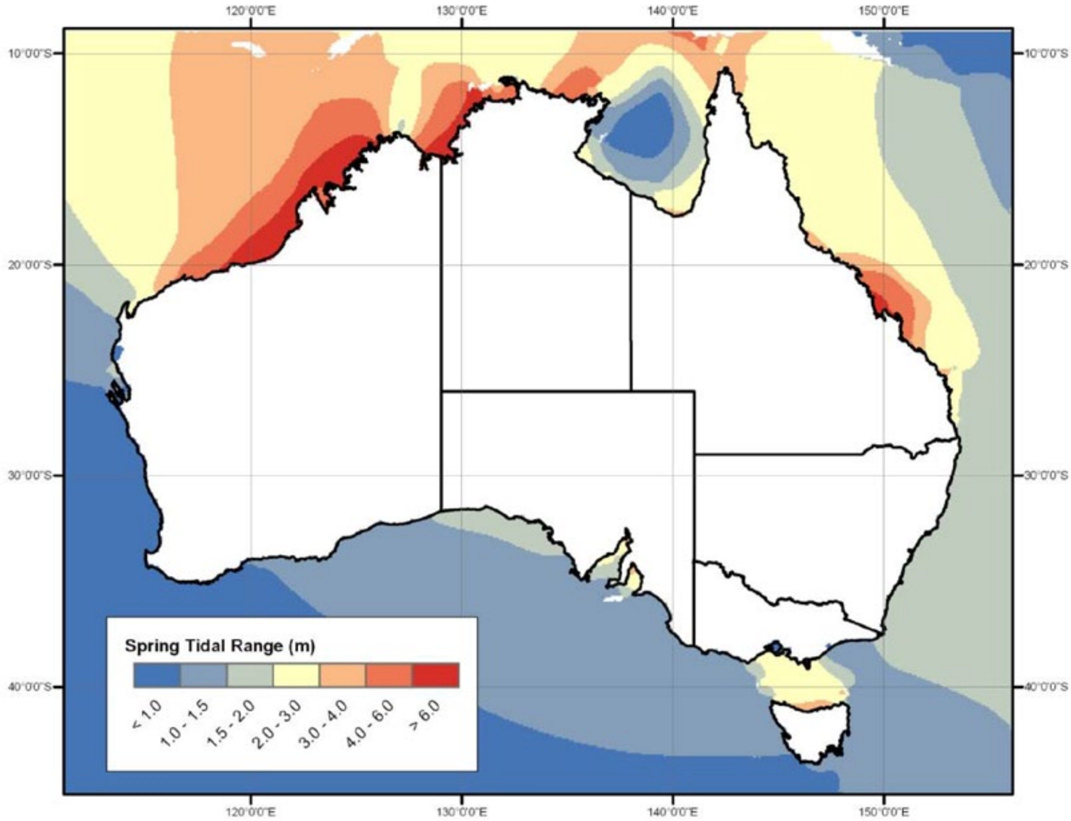

Figure 3.4 Spring tidal range showing the geographic variation in tides around Australia. Source: © Commonwealth of Australia (Bureau of Meteorology) 2016.

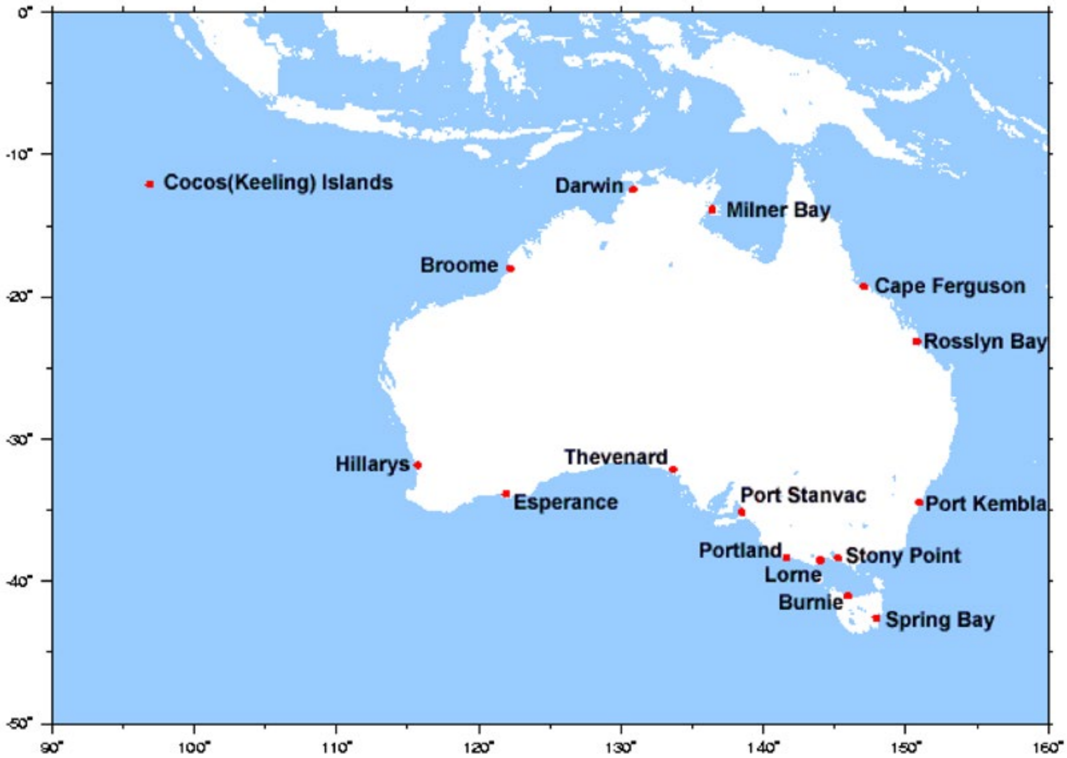

Figure 3.5 Australian array of sea-level monitoring stations. Source: © Commonwealth of Australia (Bureau of Meteorology) 2016. (http://www.bom.gov.au/oceanography/projects/abslmp/abslmp.shtml).

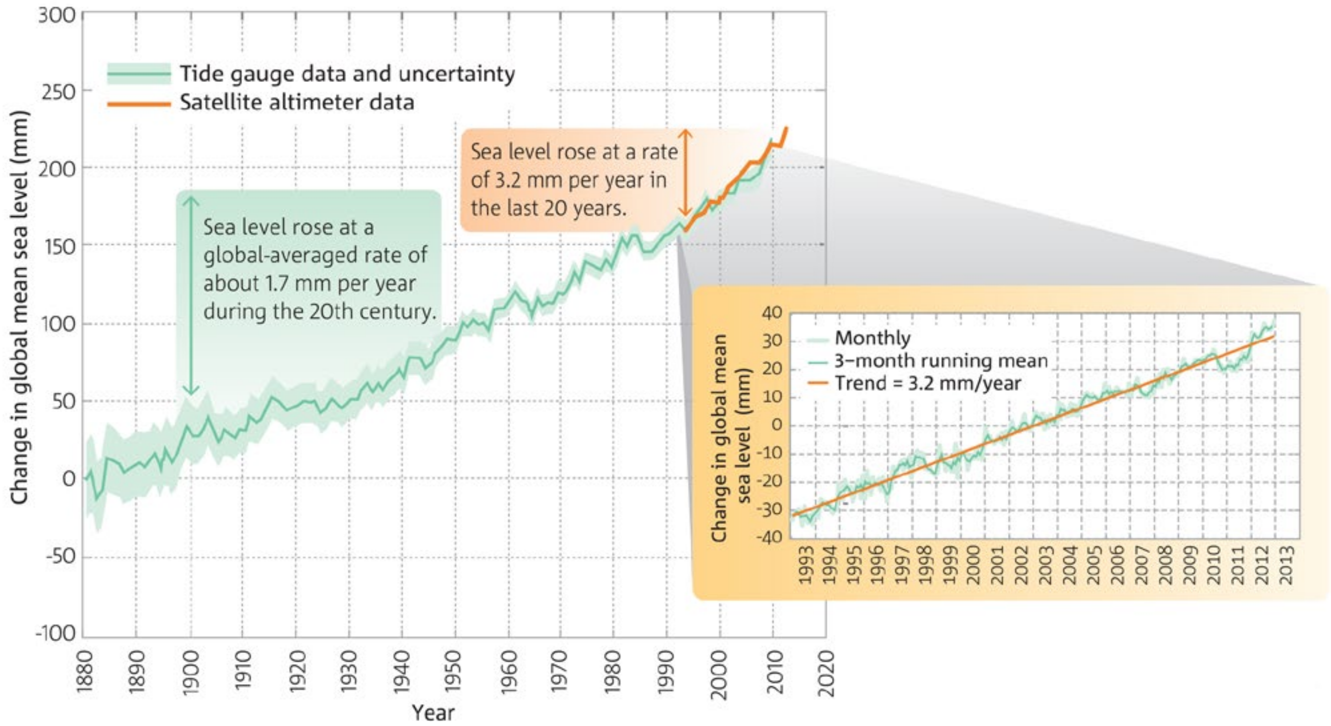

Figure 3.6 Historical sea levels from tide gauge and satellite altimeter data. Source: BoM, State of the Climate 2014, published by CSIRO and BoM. Graphic © CSIRO.

3.2.2 Storm tides

A storm surge is an increase in coastal water levels well above the normal high tide due to low atmospheric pressure and strong onshore winds. If the storm surge is combined with daily tidal variation, the combined water level is called the storm tide. Storm tide analyses have been undertaken in a number of locations to inform natural hazard assessment, long-term planning and emergency response.

A number of state governments collect storm tide information for regions at risk of storm tide inundation. The Queensland Government, for example, maintains a network of 24 storm surge tide gauges along the state's coastline. Their primary purpose is to record the magnitude of these storm tide events. However, as these events are quite rare, most of the time these gauges act as normal tide gauges. The sea-level information provided by the storm surge gauges are used to create storm tide maps that show the extent of coastal land vulnerable to tidal inundation; the data and maps are used when considering the evacuation of communities during cyclone events and for land-based planning purposes. Data (near real-time) can be accessed from https://www.qld.gov.au/environment/coasts-waterways/beach/storm-sites/.

Storm tide height data have also been generated from models for the whole of the Australian coastline. This is illustrated in Figure 3.7, which shows the 1-in-100-year storm tide heights evaluated from a hydrodynamic model hindcast over the period 1949–2009.

The highest storm tides occur on the north-west shelf due to the amplification of tides and surges over the wide shelf region, as well as across the tropics, Bass Strait and the Great Australian Bight. Lower storm tides occur on south-west and south-east coastlines due to the narrower continental shelf and smaller tidal range. In these narrow shelf margins, higher wave energy reaches the coast (McInnes et al. 2015).

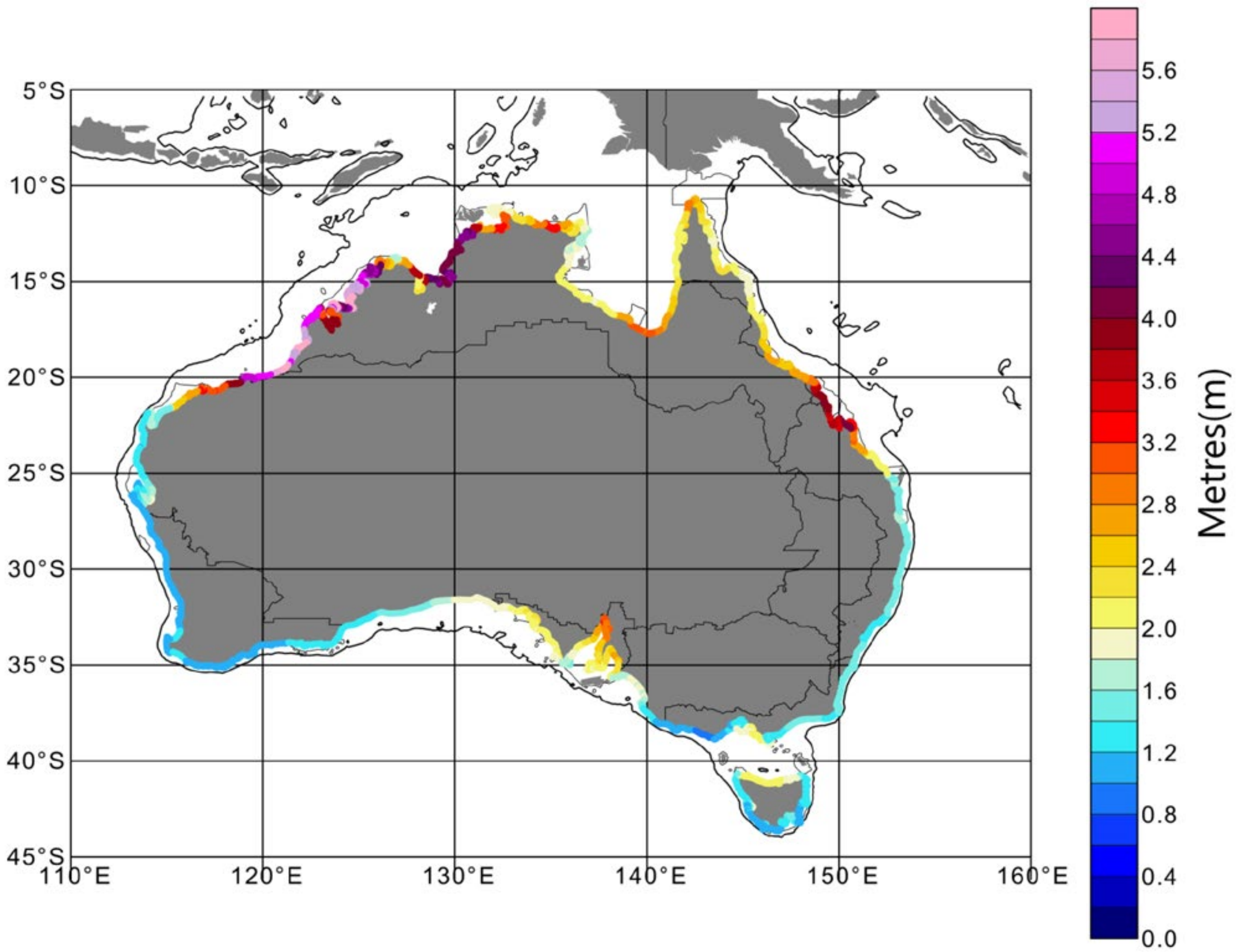

Figure 3.7 The 1-in-100-year storm tide height in metres (coloured dots) relative to mean sea level.

Note: From the hydrodynamic modelling study of Haigh et al. (2014). Also shown is the 150 m isobath. The return levels were estimated from modelled sea levels over the interval 1949–2009 by fitting a Gumbel distribution to the modelled annual maximum sea levels over the 61-year period. Source: McInnes et al. 2015.

3.3 Waves

Waves are a key energy input into the littoral zone and, together with currents, are responsible for coastal erosion and sediment transport. They are a primary force leading to modification of the coast and the creation of erosional and depositional landforms. Measurements of waves are a key input to models and studies of erosion and sediment transport as well as for the design of seawalls, harbours and other shoreline facilities. In most areas around Australia, data from the routine measurements of waves have only become available in the last 30 years.

3.3.1 Coastal wave data

The deployment of wave buoys since the mid-1970s provides robust data on wave conditions for many coastal regions. Data from wave buoys include wave height, wave period and, with more recent buoys, wave direction at up to hourly time intervals. The network of wave buoys is administered by relevant state government agencies and the BoM (Table 3.2). Data from wave buoys are not nationally coordinated, and data access is fragmented and subject to varying conditions.

Table 3.2 Accessible datasets from wave buoys.

Data manager	Description of dataset	Available to the public
Queensland Government	Wave monitoring data (height, direction and sea surface temperature) for last seven days at select sites Annual summaries of recorded wave data since 1970s	https://data.qld.gov.au/dataset/coastal-data-system-near-real-time-wave-data and http://www.qld.gov.au/environment/coasts-waterways/beach/waves-sites/ https://publications.qld.gov.au/dataset/wave-data-recording-program
Manly Hydraulics Laboratory, New South Wales	Offshore wave data at seven continuously recording sites off the NSW coast. Near real-time data on website; longer term data analysis services available	http://new.mhl.nsw.gov.au/data/realtime/wave/
Department of Transport, Western Australia	Wave data for seven buoys at near real-time; historical data available for region (by order)	http://www.transport.wa.gov.au/imarine/tide-and-wave-data-current.asp http://www.transport.wa.gov.au/imarine/searching-and-ordering-historical-data.asp
BoM	Wave buoy data for Cape du Couedic, South Australia and Cape Sorrell, Tasmania; archived data on request	http://www.bom.gov.au/climate/data-services/ocean-data.shtml

There are limitations to wave buoys datasets, in particular deployment durations, the sampling frequency of earlier instruments, periodic instrument failure (particularly during storms) and the relatively recent installation of directional buoy instruments. For example, the earliest deployment of directional instruments was from 1996 in Brisbane and 1991 in Sydney. For some regions, the data record length excludes particularly stormy periods, for example in the 1950–70s, and derived extreme value statistics may underestimate reality (Kinsela et al. 2014).

Wave models are required to generate nearshore and extreme wave heights, which are essential for understanding potential wave impacts on the coast. The models simulate wave conditions in response to applied climate conditions, such as from surface wind and air–sea temperature difference. The models can be used to infill observed datasets that contain missing values, to improve understanding of extreme events and to provide forecasts of wave conditions. A challenge in many areas is that the lack of local data means that modelled results cannot be calibrated or verified.

Table 3.3 summarises available wave model datasets relevant to the Australian region. While these datasets are accessible, they are complex and suited for use by ocean modellers or technical consultants.

It is possible to measure ocean waves from satellites, and a useful global database that has consolidated a lot of wave data from satellites is the globwave database, accessible through http://globwave.ifremer.fr/. While algorithms have been used since the 1990s to estimate significant wave height from satellites, performance is typically poor near the coast and coverage is patchy in space and time. The quality of these data will improve in coming years as more satellites are launched.

Table 3.3 Available wave datasets from models.

Wave dataset	Description	Where accessible
ERA-Interim	High-quality product; performs well in all comparisons. Well-understood dataset for climatological purposes. Duration 1979 to present	http://apps.ecmwf.int/datasets/data/interim-full-daily/levtype=sfc/
WAVEWATCH III (NOAA-MMAB)	Dataset performs reasonably well. Operational archives available (for past week) and historical archive. Duration 1997–2010	http://nomads.ncep.noaa.gov:9090/dods/wave/nfcens ftp://polar.ncep.noaa.gov/pub/history/waves
CAWCR Wave Hindcast (CSIRO/BoM)	Dataset performs well for Australia. Hindcast data available for three time periods. Duration 1979–2013 Report on dataset at http://www.cawcr.gov.au/technical-reports/CTR_070.pdf	https://data.csiro.au/dap/landingpage?pid=csiro%3A6616 https://data.csiro.au/dap/landingpage?pid=csiro:14240 http://doi.org/10.4225/08/523168703DCC5 http://doi.org/10.4225/08/55C99193B3A63
AUSWAVE Forecast (BoM)	Archives of point location data available from BoM to registered users on request. Duration 2012 onwards	http://www.bom.gov.au/nwp/doc/auswave/data.shtml to registered users
AWavEA (also from CAWCR wave hindcast)	More user-friendly dataset developed for renewable energy purposes. Duration 1979–2013	http://www.nationalmap.gov.au/renewables

3.3.2 Extreme wave data

Many parts of the Australian coast are periodically affected by coastal storms involving extreme wave events that, particularly when combined with high tide conditions, can cause coastal inundation and beach erosion, damage to property and marine structures and risks to public safety. Accurate estimation of the likelihood and magnitude of large wave events is essential for understanding and managing these risks. However, there remain significant knowledge gaps.

A coherent picture of Australian extreme wave climate has been derived using buoy data, wave model hindcasts and forecasts and tropical cyclone storm studies (Mariani et al. 2012). Figure 3.8 shows peak significant wave height around Australia for a 100-year average return interval (ARI) event. The values shown assume a 20 m water depth and reflect a one-hour time period at the peak of the storm event.

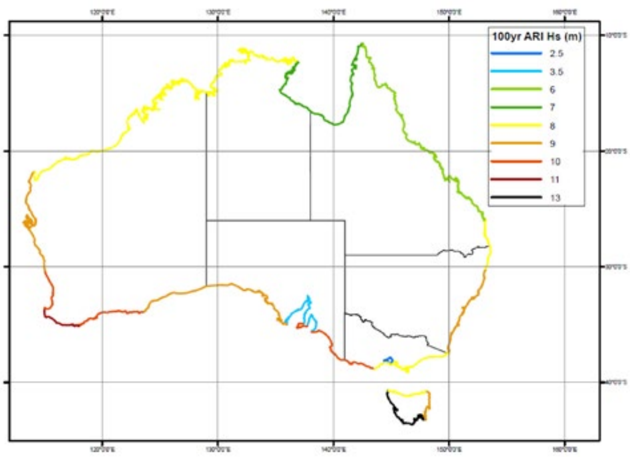

Figure 3.8. 100-year ARI significant wave height. Source: Mariani et al. 2012 © Antarctic Climate & Ecosystems Cooperative Research Centre 2012.

Recent research has found that derived estimates of storm energy provide a better measure of the erosive potential of storm events than significant wave height alone (Shand. et al 2011). Table 3.4 provides summary information on derived significant wave heights and energy levels for differing return periods.

Storm history can also be important for understanding extreme wave height for a location, and historic hazard studies can provide useful data and information on wave characteristics. For a number of locations, the stormiest period in recent history may precede data from wave buoys. For example, in Coffs Harbour in New South Wales, the years 1929, 1942, 1954–1955 and 1971 have been identified as stormy years, with 1967 being perhaps the stormiest year in the historical data with the largest wave height (BMT WBM 2011). The Coffs Harbour wave buoy was installed in 1976.

3.3.3 Wave set-up and run-up

Wave set-up and run-up levels relate to wave action on the shoreline (see Figure 3.9). Wave set-up refers to the increase in the mean water level towards the shoreline caused by wave action, and wave run-up is the rush of water up a beach after a wave reaches the shoreline. The concepts are important in that:

- the wave set-up level is the most representative inundation level for areas located away from the shoreline
- the wave run-up level is a predictor of dune overtopping and wave impacts on beachfront structures. Wave run-up and overtopping are usually quite site-specific and can contribute to beach erosion.

There are limited available data on wave set-up and run-up and, in their absence, wave set-up is often defined as proportional to wave height. As a general rule of thumb, wave set-up is taken to be around 15% of the offshore significant wave height as measured by wave buoys (Masselink and Hughes 2003).

Table 3.4 Summary of one-hour exceedance data for significant wave heights (H_s) with 90% confidence limits for sites around the Australian coast. Source: Mariani et al. 2012, after Shand et al. 2011.

Buoy	1 year ARI		10 year ARI		100 year ARI	
	H_s (m) (90% CI)	Cumulative Energy (MJh/m²)	H_s (m) (90% CI)	Cumulative Energy (MJh/m²)	H_s (m) (90% CI)	Cumulative Energy (MJh/m²)
Brisbane	5 (4.8,5.2)	0.85 (0.72,0.98)	6.6 (6.3,6.9)	1.85 (1.54,2.16)	8.1 (7.6,8.6)	3.03 (2.5,3.56)
Botany Bay	5.7 (5.5,5.9)	0.82 (0.74,0.9)	7.5 (7.2,7.8)	1.53 (1.37,1.69)	9.1 (8.7,9.5)	2.29 (2.05,2.53)
Eden	5.4 (5.2,5.6)	0.73 (0.66,0.8)	7.0 (6.7,7.3)	1.32 (1.18,1.46)	8.7 (8.2,9.2)	1.92 (1.72,2.12)
Cape Sorell	8.6 (8.3,8.9)	2.36 (2.09,2.63)	10.8 (10.2,11.4)	4.13 (3.61,4.65)	12.9 (12.1,13.7)	5.93 (5.16,6.7)
Cape d Cou	7.1 (6.8,7.4)	1.67 (1.42,1.92)	8.4 (8,8.8)	2.85 (2.39,3.31)	9.6 (9,10.2)	4.03 (3.36,4.7)
Cape Nat	7.5 (7.2,7.8)	2.06 (1.75,2.37)	8.9 (8.5,9.3)	3.64 (3.05,4.23)	10.1 (9.6,10.6)	5.23 (4.34,6.12)
Rottnest	6.9 (6.6,7.2)	1.63 (1.35,1.91)	8.5 (8.1,8.9)	3.24 (2.62,3.86)	10 (9.4,10.6)	5.04 (4.04,6.04)
Jurien Bay	6.2 (6,6.4)	1.23 (1.09,1.37)	7.5 (7.1,7.9)	2.02 (1.76,2.28)	8.6 (8.1,9.1)	2.78 (2.42,3.14)

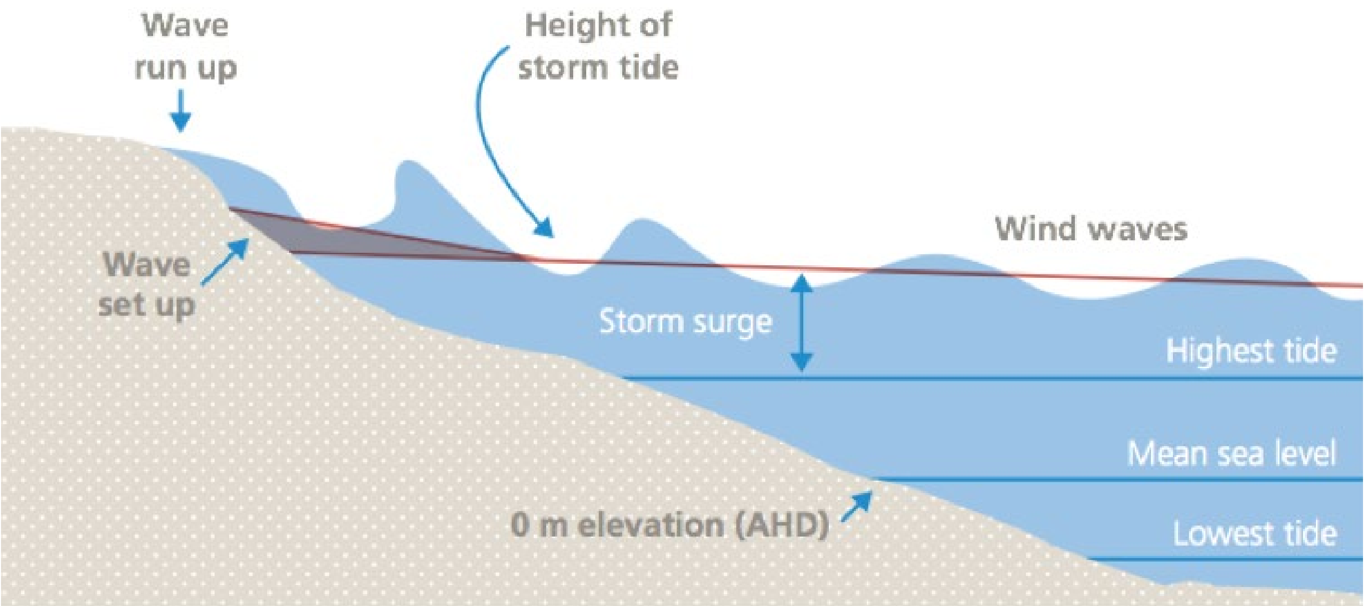

Figure 3.9 Components of wave set-up and run-up. Source: © State of Victoria (Department of Sustainability and Environment) 2012.

3.4 Wind

Wind directly influences storm surge, sea levels and local waves, and hence design criteria for structures. Information on wind climate is perhaps most important in areas at risk of tropical cyclones. Winds are also responsible for the transport of sand from the sub-aerial beach face into incipient foredunes, allowing for the growth of dunes and storage of sediment.

The BoM collects data on wind across Australia through anemometers and wind vanes near the ground surface. Typical data or information on wind includes wind speed measured at 9 am at a height of 10 m above the surface, generally averaged over the 10 minutes leading up to the time of observation to obtain a ***mean wind speed*** figure. These values may be averaged to obtain a long-term mean. The instantaneous measurement provides a ***gust speed*** (usually a three-second gust, because three seconds is the recording interval of commonly used instruments).

There is not a geographically comprehensive long-term, high-quality dataset of wind speed and direction measurements from anemometers over Australia, and consequently data from models are used in risk assessments, climate models or for engineering purposes. CSIRO has developed a dataset of daily near-surface wind speed for all of Australia by interpolating terrestrial anemometers measurements (McVicar et al. 2008). The dataset spans 1975–2006. Further information is at https://data.csiro.au/dap/landingpage?pid=csiro%3AWind_Speed.

Model inputs for 100-year ARI winds can be obtained from AS/NZS1170.2:2011 *Structural design actions Part 2: Wind actions* (https://telcoantennas.com.au/site/sites/default/files/POLICIES-AND-PRINCIPLES/Australian-New-Zealand-Standards/AS-NZS.1170.2.2011%20-%20Structural%20Design%20Actions%20-%20Part%202%20Wind%20Actions.pdf). The Standard has been revised to incorporate recent research and findings from investigations of damage following severe wind events in all regions of Australia. The current version of the Standard was released in July 2013.

3.5 Summary table of datasets on coastal processes

Table 3.5 Summary table of accessible datasets on coastal processes.

Sector	Description of dataset	Accessible by public
Geomorphology and shoreline change	Aerial photography and photogrammetry data and satellite images	http://www.ga.gov.au/scientific-topics/earth-obs/accessing-satellite-imagery/aerial-photography
	Australian Beach Safety & Management Program (ABSMP) database of over 12,000 beaches	http://www.ozcoasts.gov.au/coastal/beach_intro.jsp and https://researchdata.ands.org.au/australian-beach-safety-program-absamp/428811
	Coastal compartments (primary and secondary)	http://www.ga.gov.au/metadata-gateway/metadata/record/gcat_76502 and https://data.gov.au/dataset/primary-and-secondary-coastal-sediment-compartment-maps
	Smartline landform and coastal stability maps and datasets	http://www.ozcoasts.gov.au/coastal/rpts.jsp
Elevation	ELVIS – the Elevation Information System makes available a 1 second and 5 m elevation dataset from high-quality data	http://www.ga.gov.au/elvis/
Bathymetry	National 2012 multibeam dataset held by Geoscience Australia and gridded at 50 m resolution is available for download. Suitable for use by engineers and technical consultants for modelling and construction. Note, higher uncertainty in depths nearshore < 20 m	http://www.ga.gov.au/scientific-topics/marine/bathymetry for technical description http://www.ga.gov.au/scientific-topics/marine/bathymetry/50m-multibeam-dataset-of-australia-2012
Water level	The Australian Baseline Sea Level Monitoring Project	http://www.bom.gov.au/oceanography/projects/abslmp/abslmp.shtml
Storm tide	Data from Queensland Government and derived national model dataset	https://www.qld.gov.au/environment/coasts-waterways/beach/storm-sites/ and Figure 3.7

Table 3.5 Summary table of accessible datasets on coastal processes - *continued.*

Sector	Description of dataset	Accessible by public
Wave buoys	Near real-time and historical datasets available from state government agencies and the BoM (for two sites)	Queensland https://data.qld.gov.au/dataset/coastal-data-system-near-real-time-wave-data New South Wales http://new.mhl.nsw.gov.au/data/realtime/wave/ Western Australia http://www.transport.wa.gov.au/imarine/tide-and-wave-data-current.asp http://www.transport.wa.gov.au/imarine/searching-and-ordering-historical-data.asp Bureau of Meteorology http://www.bom.gov.au/climate/data-services/ocean-data.shtml
Wave model datasets	Long-term datasets derived from model hindcasts (CSIRO) and forecast (BoM)	http://www.bom.gov.au/nwp/doc/auswave/data.shtml https://data.csiro.au/dap/landingpage?pid=csiro%3A6616
Ocean variables	Range of datasets	https://portal.aodn.org.au/
Wind	Long-term dataset of wind speed interpolated from measurements	https://data.csiro.au/dap/landingpage?pid=csiro%3AWind_Speed

Note: Green-shaded datasets are suitable for qualitative as well as more detailed risk assessments; orange-shaded datasets are suitable for expert use in more detailed assessments.

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4 Available data: current climate

Key points:

- Australia has good quality datasets on temperature and rainfall collected by the BoM in many locations across the continent. Long-term datasets of average, maximum and minimum records can be found at the BoM's Climate Data Online website http://www.bom.gov.au/climate/data/.
- Reliable data on tropical cyclones since the 1970s – including their track, intensity and landfall – are available. The infrequent occurrence of tropical cyclones means that it has not been possible to develop a dataset on observed extreme storm tide heights from cyclone events, and model approaches are required in hazard assessment.
- Extreme rainfall data are critical for engineering and infrastructure, and Australia has derived robust data on rainfall intensity, frequency and duration.
- Information on fire weather, derived from temperature, wind speed, humidity and drought data, is also available from the BoM as trends and forecast warning.

4.1 Temperature

The BoM has a long-term record of temperatures across Australia that spans more than 100 years. The Australian Climate Observations Reference Network – Surface Air Temperature (ACORN-SAT) dataset has been developed to monitor climate variability and change in Australia. The ACORN-SAT network comprises 112 observation locations, or stations, across Australia. Data from ACORN-SAT are available from http://www.bom.gov.au/climate/change/acorn-sat/#tabs=Data-and-networks.

In the period of observational record since 1910, average surface temperatures have warmed by 0.9 °C, and this warming has been measured in all regions of Australia and across all seasons. The mean temperature changes have been accompanied by a large increase in extreme temperatures and by increases in the duration, frequency and intensity of heatwaves in many parts of the country. Further information, data and mapping of mean temperature and extreme temperatures can be found at the Climate Change in Australia website http://www.climatechangeinaustralia.gov.au/en/climate-campus/australian-climate-change/australian-trends/.

Sea surface temperatures are similarly increasing in the Australian region, with measured change of the same magnitude as land surface temperature changes (see Figure 4.1). Changes in sea surface temperatures around Australia are not uniform, with greater than global average recent warming in regions involving the southward movement of water, such as from the Leeuwin Current of the Western Australian coast and the East Australian Current off the coast of New South Wales, Victoria and Tasmania. Data on observed sea surface temperatures can be obtained from http://www.bom.gov.au/climate/data-services/ocean-data.shtml.

4.2 Rainfall

The BoM's website Climate Data Online (http://www.bom.gov.au/climate/data/) has reliable rainfall records dating back to 1900. These records span 6000 sites across Australia; data can be downloaded for a site, region or time period and include daily and monthly highest and lowest recorded values.

Australia's rainfall is highly variable, and average annual rainfall has increased since records began, particularly in the north-west over the warmer months from October to April. In recent decades, there has also been a decline in the rainfall in the south-west and south-east during the cool season. In the south-west, rainfall decline occurred as a series of step changes and resulted in a reduction in streamflow of more than 50% since the mid-1970s.

Through the BoM's Climate and Weather Extremes Monitoring System, data are also available on the highest daily rainfall levels. The data show that the area of the continent receiving very high rainfall totals (above the 90th percentile) on seasonal and annual timescales has increased (but not significantly) since the mid-twentieth century.

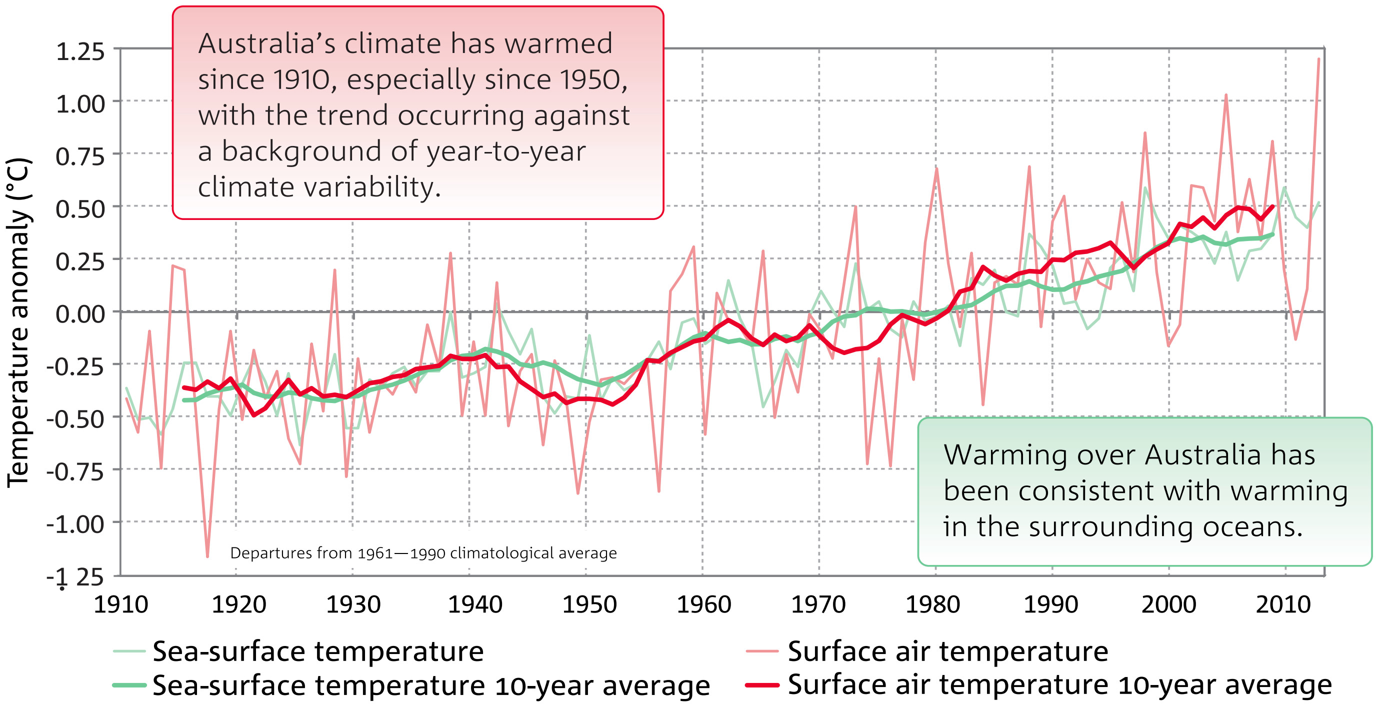

Figure 4.1 Time series of anomalies in temperature over Australia compared to the 1961–1990 average. Source: BoM, State of the Climate 2014, published by CSIRO and BoM.

4.2.1 Design and probable maximum rainfall

The BoM, in conjunction with Engineers Australia, provides design and probable maximum rainfall data needed to manage the impacts of extreme rainfall on engineering and infrastructure operations, to inform the design of new structures – such as gutters, culverts, bridges and drains – and for risk assessment. These data are suitable for use by engineers and technical consultants and can be accessed from http://www.arr.org.au/downloads-and-software/data/.

Design rainfall data are in the form of Intensity-Frequency-Duration (IFD) information, which represents the probability that a given average rainfall intensity will occur in a location. Charts of IFD show rainfall intensity and duration on the x and y axes and frequency information plotted in coloured lines. For example, in Figure 4.3 a 1-in-100-year rainfall event (or 1% AEP) would generate a rainfall intensity of 100 mm for one hour, whereas a 1-in-5-year event (or 20% AEP) would generate a rainfall intensity of just over 50 mm for one hour.

The BoM also provides Probable Maximum Precipitation (PMP) estimates for the design of large dams (http://www.bom.gov.au/water/designRainfalls/pmp/). PMP is the theoretical maximum precipitation for a given duration of storm that is physically possible at a particular geographical location. Hydrologists use a PMP magnitude, plus its spatial and temporal distributions, to calculate the Probable Maximum Flood (PMF) for any catchment of interest.

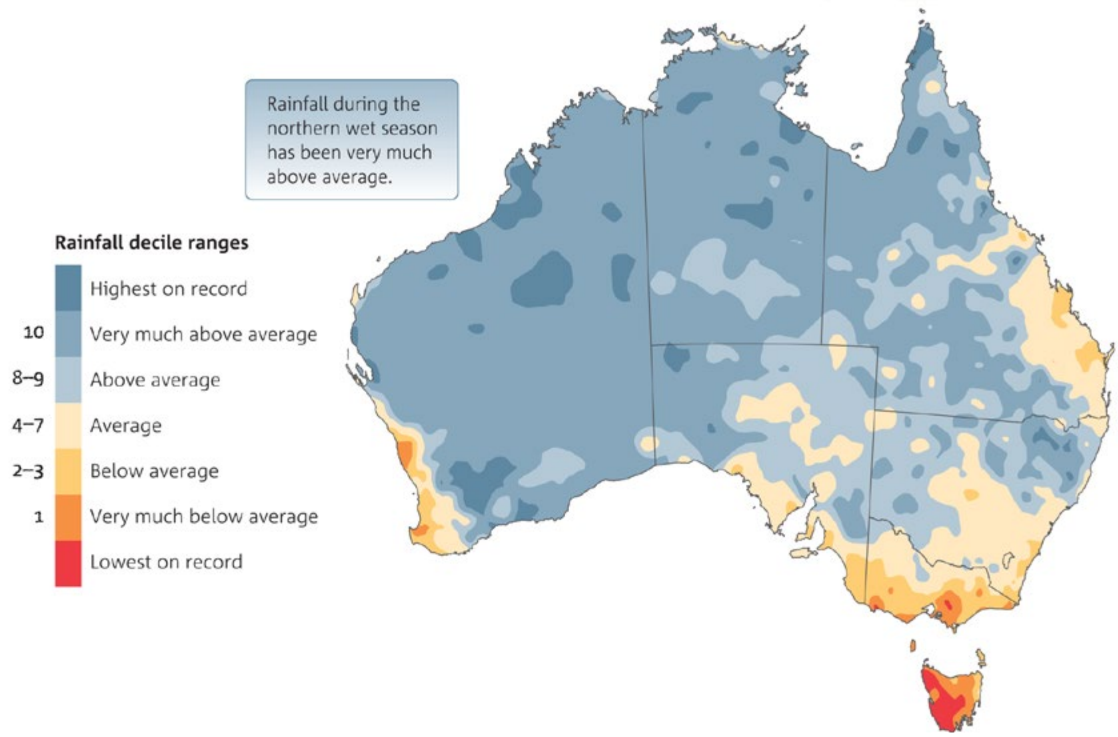

Figure 4.2 Northern wet season (October–April) rainfall compared to average levels since 1995–96. Source: BoM, State of the Climate 2014, published by CSIRO and BoM.

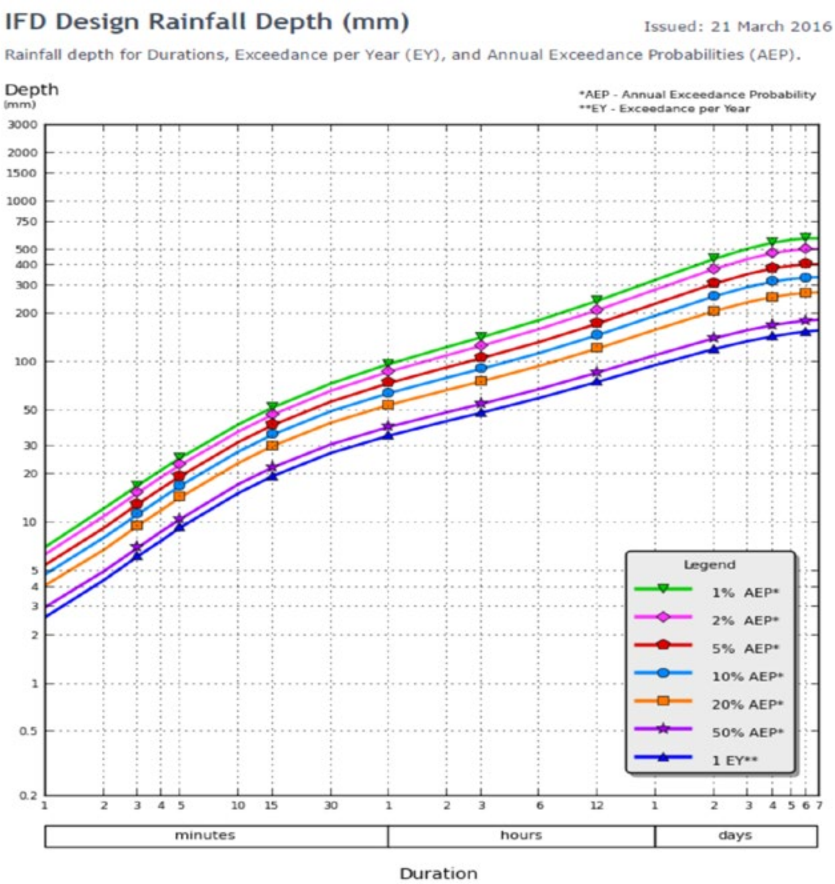

Figure 4.3 Intensity-Frequency-Duration graphic for rainfall in Brisbane. Source: © Commonwealth of Australia (Bureau of Meteorology) 2016.

4.3 Tropical cyclones and East Coast Lows

Reliable records of tropical cyclones began around 1970 with routine satellite observations, and demonstrate high annual and decadal variability in their numbers in the Australian region. The BoM has a database of tropical cyclones since 1970, including information on track and intensity such as wind speed (http://www.bom.gov.au/cyclone/history/index.shtml). This relatively short record of tropical cyclones, however, does not reveal any trend in numbers or intensity.

Tropical cyclones can be characterised by catastrophic wind speeds, storm surges and extreme rainfall and flooding.

Extreme storm tide levels caused by tropical cyclones cannot be estimated solely on the basis of historically measured water levels because of the site-specific nature of storm surge response: there may be no measuring instrument where the cyclone occurs. This problem can be partially overcome by building a model that can re-create the observed tropical cyclone climatology and then generating long sequences of cyclone characteristics that can be used for local studies, for example storm tide heights. Importantly, the accuracy of the model predictions need to be verified by checking against observations such as long-term measurements of wind speed at airports.

Geoscience Australia has developed a cyclone model that has generated data for use in hazard assessments that spans cyclone behaviour over some 50,000 events. Further information can be accessed at http://geoscienceaustralia.github.io/tcrm/.

East Coast Lows (ECLs) are the primary cause of large ocean waves in New South Wales coastal regions, and there is also a strong connection between heavy rainfall and ECLs in the eastern Australian region (Dowdy et al. 2013). Information on ECLs can be found on the BoM's website at http://www.bom.gov.au/nsw/sevwx/facts/ecl.shtml and http://reg.bom.gov.au/climate/reg/escci/.

The BoM, as part of the Eastern Seaboard Climate Change Initiative (ESCCI), has developed a tool that includes maps and information linking historical ECL events with information on their impacts (location and intensity of heavy rainfall, severe winds, extreme waves and storm surges). Known as Maps and Tables of Climate Hazards on the Eastern Seaboard (MATCHES), the tool currently includes information on ECLs for the 1950–2008 period. MATCHES is accessible publicly through the BoM's registered users website.

Work led by Macquarie University, also as part of ESCCI, brought data from a wider range of timescales to develop a more comprehensive picture of ECL variability and climatic drivers (see http://www.climatechange.environment.nsw.gov.au/Impacts-of-climate-change/East-Coast-Lows/). The investigation found that storm activity in the 1950–1970s was higher than has been experienced over 1980–2015, meaning analysis based on satellite data alone does not capture the full range of ECL variability. Using paleoclimate data from tree rings, coral cores and cave deposits, it was also found that the 1600–1900 period saw more decades of significantly higher and more persistent storm activity than the twentieth century, due in part to the persistent La Niña–like mean state of the Pacific Ocean in the earlier time period (http://www.climatechange.environment.nsw.gov.au/Impacts-of-climate-change/East-Coast-Lows/Past-East-Coast-Lows).

4.4 Fire weather

Fire weather is derived from a combination of daily temperature, wind speed, humidity and drought known as the Forest Fire Danger Index (FFDI). Expert advice is suggested if a dataset is required on recent fire weather. An increase in fire weather has been measured across Australia over the past 40 years and is statistically significant in the south-eastern part of the country. Further information on recent trends in fire weather can be found on the Climate Change in Australia website (https://www.climatechangeinaustralia.gov.au/media/ccia/2.1.6/cms_page_media/168/CCIA_2015_NRM_TR_Chapter%204.pdf).

4.5 References

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5 Available data: future climate change

Key points:

- Data on future climate change are typically generated using global climate models (GCMs) in which the atmospheric greenhouse gases concentrations are gradually increased over time to simulate global warming.
- While uncertainty remains in climate projections, the models are regularly tested for their capacity to simulate historic and current climate.
- A key source of projected climate change data and information is the Climate Change in Australia website. These projections cover a range of variables at a number of time periods and spatial scales.
- For sea level, datasets have been developed on sea-level rise through to 2100 and on the allowances: how much the height of an asset would need to be raised to maintain the current risk level from high sea level events.
- How wave climate will be affected by climate change is not well understood, although projections suggest higher significant wave heights could impact Tasmania.
- Projections of tropical cyclones suggest that the overall number of cyclones hitting the Australian coast could decline. However, studies consistently suggest that the cyclones could become more intense and could track further south.
- Projected changes in intense rainfall are important for coastal communities in low-lying floodplains. Climate change projections indicate that the risk of extreme rainfall events will increase in all coastal areas, even when the annual mean rainfall is projected to decrease or remain the same.

5.1 Climate change projections

Climate change projection information is usually based on output from climate models driven by future scenarios of greenhouse gas emissions, aerosols and land-use change. Combining several model simulations into a model 'ensemble' allows for an assessment of uncertainty.

For the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, the scientific community defined a set of four new scenarios, the Representative Concentration Pathways (RCPs) (see http://sedac.ipcc-data.org/ddc/ar5_scenario_process/RCPs.html). The RCPs are used for running climate models and generating climate projections; each is representative of a range of economic, technological, demographic, policy and institutional futures:

- RCP2.6, which requires very strong emission reductions from a peak at around 2020 to reach a carbon dioxide (CO2) concentration of about 420 parts per million (ppm) by 2100
- RCP4.5, which demands slower emission reductions to stabilise the CO2 concentration at about 540 ppm by 2100
- RCP6.0, which assumes some mitigation strategies and technologies to lower emissions, resulting in a CO2 concentration of about 660 ppm by 2100
- RCP8.5, which assumes increases in emissions leading to a CO2 concentration of about 940 ppm by 2100.

5.1.1 Climate Change in Australia – regional projections 2015

CSIRO, in partnership with the BoM, has developed regional climate change projections for Australia's natural resource management (NRM) sector. The projections are based on understanding of the climate system, historical trends and model simulations of the future. The model simulations come from the four RCPs and 16 GCMs that have been tested against the observed climate of Australia. The website, http://www.climatechangeinaustralia.gov.au/, provides extensive guidance on use of model data, as well as overview information on climate change relevant to Australia.

Two types of data have been delivered in the 2015 regional projections for Australia, based on the global Coupled Model Intercomparison Project (CMIPs, now up to CMIP5), which are judged to perform well over Australia:

- projected future climate changes
- application-ready future climates, constructed by combining the projected future climate changes to the present-day observed climate.

Projected climate change information is informative for high-level impact assessment and is made available as described in Table 5.1. The changes are relative to 1986–2005 and are based on CMIP5 GCMs and downscaling where appropriate. Annual, seasonal and monthly changes are supplied for 20-year periods centred on 2030, 2050, 2070 and 2090 for most variables and RCPs.

Projections data are generally presented as bar plots that show the projected change or difference from the reference climate period (1986–2005). Each bar shows the range (10th to 90th percentile) of model simulations of 20-year average climate, and the middle (bold) line is the median value of the model simulations (20-year moving average climate); half the model results fall above and half below this line. The projection bar plots enable comparison of model responses to different RCPs.

Figure 5.1 shows the projections for the annual wettest day and the 20-year return level of the annual wettest day for regions around Australia. The figure shows that the risk of increased extreme rainfall (right-hand dark blue bar) exists in all regions of Australia and is a strong signal even where the annual mean rainfall is projected to decrease. This information is relevant to hazard and risk assessments in areas exposed to catchment flooding and where costly decisions about long-life assets such as infrastructure are being made.

Application-ready data are generated by combining projected changes with observed data. The baseline observed period is 1981–2010. These data can be used in detailed impact assessments, for example as input data to crop-climate models in agricultural assessments. Available datasets are listed in Table 5.2.

In addition, the Climate Change in Australia website makes available the Climate Futures tool, which enables users to explore the projected changes in two climate variables simultaneously. Users can explore projections for different averaging periods (e.g. monthly, seasonal, annual) and a range of climate variables for their region of interest, including mean, maximum and minimum temperature; rainfall and extreme daily rainfall (1-in-20-year event); drought; and wind speed. The tool can be accessed at http://www.climatechangeinaustralia.gov.au/en/climate-projections/climate-futures-tool/introduction-climate-futures/.

By displaying projected changes as a matrix of two variables, for example the changes in annual mean temperature and rainfall, model results can be sorted into different categories or 'climate futures', such as 'warmer and wetter' or 'hotter and much drier'. The tool produces a colour-coded table that shows the spread and clustering of the model results. Essentially, it allows the users to make their own evaluation of model uncertainty. Figure 5.2 provides an example of projections from the tool.

Table 5.1 Projected climate change data available from Climate Change in Australia. Source: CSIRO and Bureau of Meteorology 2015.

Variable	Annual		Seasonal		Monthly	
	Gridded	Area Avg	Gridded	Area Avg	Gridded	Area Avg
Mean temperature [A]	Green	Green	Green	Green	Green	Green
Maximum daily temperature [A]	Green	Green	Green	Green	Green	Green
Minimum daily temperature [A]	Green	Green	Green	Green	Green	Green
Rainfall [A]	Green	Green	Green	Green	Green	Green
Relative humidity [A]	Green	Green	Green	Green	Green	Green
Wet areal evapotranspiration [A]	Green	Green	Green	Green	Green	Green
Solar radiation [A]	Green	Green	Green	Green	Green	Green
Wind speed [A]	Green	Green	Green	Green	Green	Green
Extreme rainfall (intensity of 1-in-20-year event) [BCG]		Green				
Extreme wind (intensity of 1-in-20-year event) [G]		Green				
Drought [D]		Green				
Fire [E]		Green				
Sea-level rise (mean and extreme) [FH]		Green				
Sea surface temperature [H]		Green				
Sea surface salinity [H]		Green				
Ocean acidification [GH]		Green				
Tropical cyclone frequency/location		Blue				
Tropical cyclone intensity		Blue				
Snow		Blue				
Runoff and soil moisture		Blue				

Green = data available, blue = information in technical and cluster reports, white = data not available.

A Gridded changes will be available for individual climate models on the original climate model grid.

B Event is defined as 24-hour total rainfall.

C These data are considered an interim product and will be updated using higher resolution models and reported in the Australian rainfall and runoff (ARR) handbook.

D Standardised Precipitation Index, a probability index that considers precipitation only. Drought projections available for 20 models (RCP4.5 and RCP8.5) and 13 models for RCP2.6.

E Fire-weather data are supplied at 39 sites for three models.

F Data for 16 tide gauge sites, for a multi-model range defined by the 5th to 95th percentile.

G Not available for RCP6.0.

H No data for individual models but for a multi-model range defined by the 5th to 95th percentile.

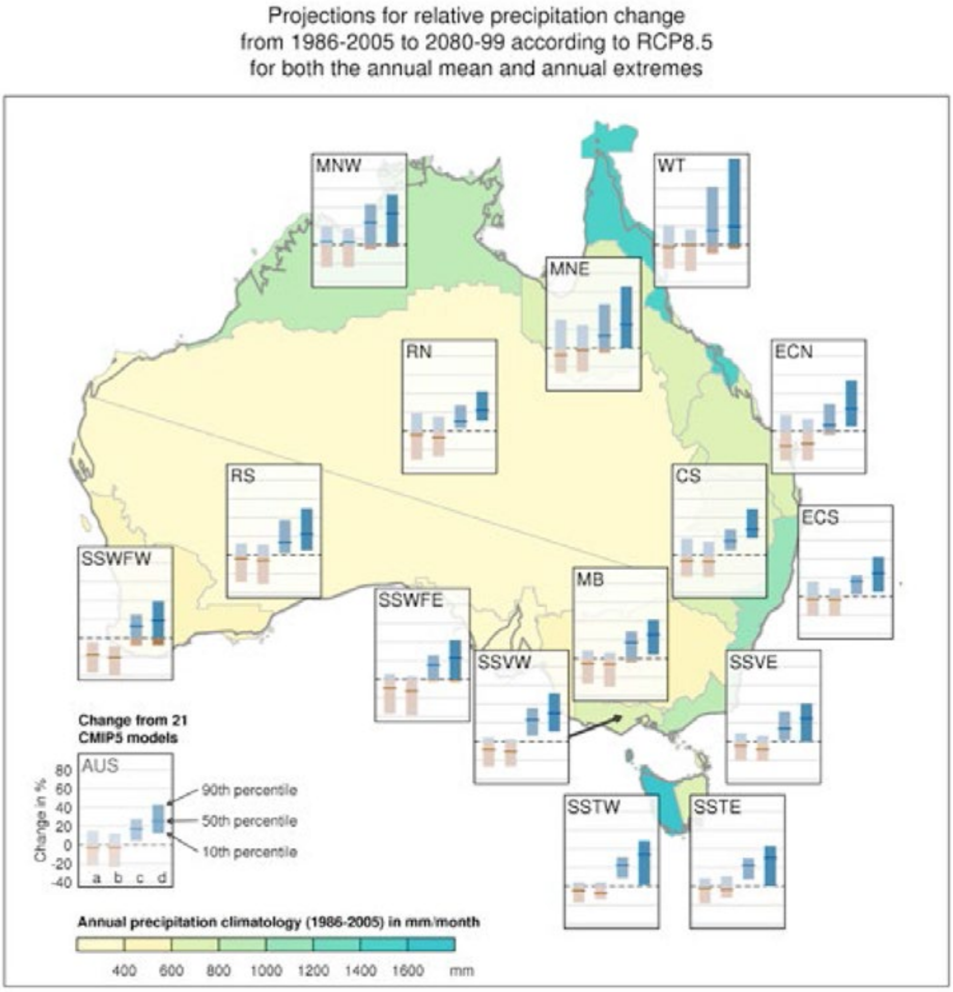


Figure 5.1 Projected changes in rainfall for Australian regions.

Notes: Figure shows median and 10th to 90th percentile range of projected change in daily rainfall for 2080–2099 relative to 1986–2005 for RCP8.5. Shown in each box from left to right is (a) the annual mean for the larger set of 39 models, as well as (b) the annual mean rainfall, (c) the annual wettest day, and (d) the 20-year return level of the annual wettest day rainfall calculated from a consistent subset of 21 CMIP5 models. Source: CSIRO and Bureau of Meteorology 2015 © Commonwealth of Australia 2015.

Table 5.2 Application-ready future climate data for 30-year periods centred on 2030, 2050, 2070 and 2090. Source: CSIRO and Bureau of Meteorology 2015 © Commonwealth of Australia 2015.

TEMPORAL SCALE	ANNUAL				SEASONAL				MONTHLY				DAILY	
SPATIAL SCALE	GRIDDED		CITY/TOWN[C]		GRIDDED		CITY/TOWN[C]		GRIDDED		CITY/TOWN[C]		GRIDDED	CITY/TOWN[C]
CLIMATE VARIABLE	AVERAGES	TIME-SERIES	AVERAGES	TIME-SERIES	AVERAGES	TIME-SERIES	AVERAGES	TIME-SERIES	AVERAGES	TIME-SERIES	AVERAGES	TIME-SERIES	TIME-SERIES	TIME-SERIES
Mean temperature (°C)[E]	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Maximum daily temperature[E]	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Minimum daily temperature[E]	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Days above/below/between temperature thresholds[A,E]	Green		Green		Green		Green		Green		Green			
Rainfall (mm)[E]	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Relative humidity (%)[H]	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Point potential evapotranspiration[D,J]											Green	Green		
Wet areal evapotranspiration (mm)[F]	Green	Green			Green	Green			Green	Green			Green	
Mean wind-speed (ms^{-1})[G]	Green	Green			Green	Green			Green	Green				
Solar radiation (Wm^{-2})[I]	Green	Green			Green	Green			Green	Green			Green	
Fire weather[B]			Green	Green										Green
Fire weather days above/below/between thresholds[B]			Green											

A Thresholds presented in days per year above 'XX' °C (days), for example.

B Forest Fire Danger Index (FFDI) for 39 sites. Also see Data Delivery Brochure.

C For availability of data for cities and towns see Data Delivery Brochure.

D Proxy for Pan Evaporation.

Baseline datasets (1981–2010)

E Australian Water Availability Project (AWAP) time series data (0.05° grid) (Jones *et al.*, 2009).

F CSIRO Land and Water dataset (Morton, 1983, Teng *et al.*, 2012) (0.05° grid).

G ERA interim reanalysis (0.75° grid), but daily gridded wind data have quality control problems (Dee et al., 2011). High quality daily wind speed data used in fire weather analysis were sourced from 39 sites—see Data Delivery Brochure.

H ERA interim reanalysis (0.75° grid), but daily humidity data at cities/towns have quality control problems (Dee *et al.*, 2011).

I ERA interim reanalysis (0.75° grid), but daily solar radiation data at cities/towns have quality control problems (Dee *et al.*, 2011).

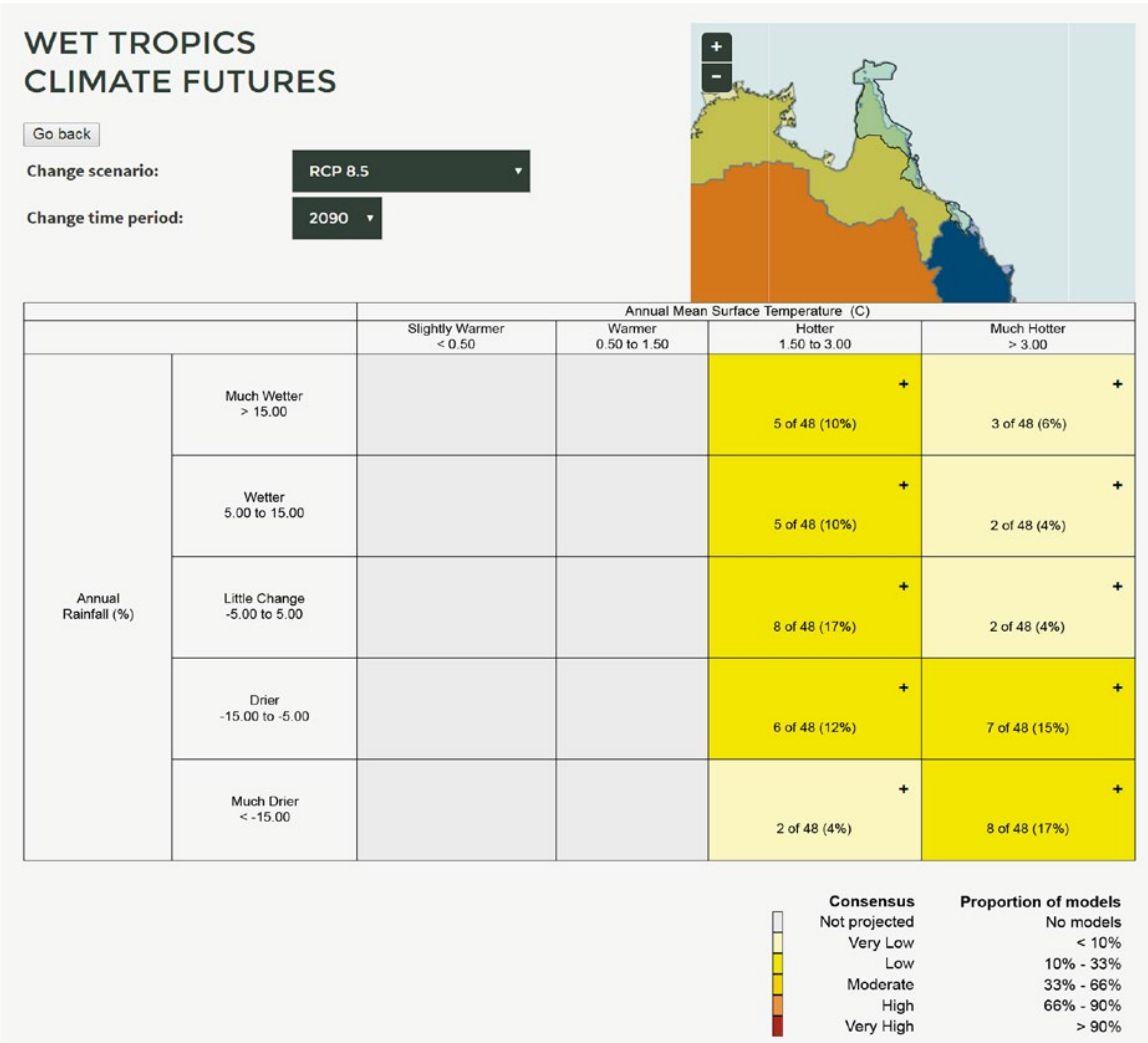
J Bureau of Meteorology high quality monthly pan-evaporation dataset (see Jovanovic *et al.* 2008).

Green = data are available, white = data are not available.

The matrix allows users to identify cases of particular relevance to their impact assessment, such as 'best case' and 'worst case' climate futures. It is also often possible to identify a 'maximum consensus' climate future for which most climate model results agree. For example, a study into the possible impacts of climate change on the incidence of mosquito-borne diseases in the wet tropics region of Queensland is likely to identify a much hotter and much wetter climate future as the worst case. In Figure 5.2 this future has a very low model consensus (3 out of 48 models), but it is a possible future with health implications that may need to be considered. The best case may be regarded as the 'hotter and drier' climate future, which has a low model consensus (6 out of 48 models). In this example there is no single 'maximum consensus' future, as both the 'hotter and little rainfall change' and 'much hotter and much drier' futures each have a low model consensus (8 out of 48 models).

5.1.2 Other regional climate change projections and data

In addition to the 2015 regional projections spanning all of Australia, there has been a range of climate change projections developed for regions in Australia. These are outlined in Table 5.3.



		Annual Mean Surface Temperature (C)			
		Slightly Warmer < 0.50	Warmer 0.50 to 1.50	Hotter 1.50 to 3.00	Much Hotter > 3.00
Annual Rainfall (%)	Much Wetter > 15.00			5 of 48 (10%)	3 of 48 (6%)
	Wetter 5.00 to 15.00			5 of 48 (10%)	2 of 48 (4%)
	Little Change -5.00 to 5.00			8 of 48 (17%)	2 of 48 (4%)
	Drier -15.00 to -5.00			6 of 48 (12%)	7 of 48 (15%)
	Much Drier < -15.00			2 of 48 (4%)	8 of 48 (17%)

Figure 5.2 Wet Tropics (Queensland) climate futures showing model consensus for RCP8.5 in 2090. Source: CSIRO and BoM 2015, © Commonwealth of Australia 2015, Bureau of Meteorology (http://www.climatechangeinaustralia.gov.au/en/climate-projections/climate-futures-tool/projections/).

Table 5.3 Climate change projection data sources in Australia. Source: NCCARF.

Projections program	State	Developer	Greenhouse gas scenarios	Future time periods	Models and resolution	Variables	Output
Climate Change in Australia (2015)	All	CSIRO and BOM	RCP 2.6, 4.5, 6.0 and 8.5 (also B1, A1B and A2 SRES[1] scenarios)	14 time periods: 2025, 2030, 2035,...2090)	Up to 40 GCMs for the RCPs, up to 18 GCMs for SRES; RCMs, as well as statistical downscaling	Monthly, 3-monthly, 6-monthly and annual changes in up to 14 climate variables	http://www.climatechangeinaustralia.gov.au/en/climate-projections/climate-futures-tool/introduction-climate-futures/
AdaptNSW (NARCliM) (2011)	NSW and ACT	University of New South Wales	SRES high emissions scenario (A2)	2 time periods: 2020-2039 and 2060-2079	4 GCMs dynamically downscaled using 3 RCMs to 10km resolution	11 variables, some at hourly resolution	http://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW
Climate Futures for Tasmania (2010-2012)	TAS	Joint project between state government and Antarctic Climate and Ecosystems CRC	SRES A2 and B1	3 time periods 2010-2039; 2040-2069, and 2070-2099	subset of CMIP3		http://www.dpac.tas.gov.au/divisions/climatechange/climate_change_in_tasmania/impacts_of_climate_change
SA Climate Ready (2011)	SA	Goyder Institute	RCP 4.5 and 8.5	20-year time periods centred on 2030 (2020-2039), 2050 (2040-2059), 2070 (2060-2079) and 2090 (2080-2099)	6 'best' GCMs statistically downscaled to 27 weather stations in South Australia	Daily data for 6 variables	http://goyderinstitute.org/index.php?id=14 Report at: http://www.goyderinstitute.org/publications/technical-reports/
Consistent climate scenarios project (2012)	All	Department of Science, Information Technology, Innovation (Queensland Government)	Six SRES scenarios and two stabilization scenarios (450 and 550ppm)	2 time periods: 2030 and 2050	19 GCMs are statistically downscaled at a 25km by 25km resolution	Daily data for 6 variables	https://www.longpaddock.qld.gov.au/climateprojections/about.html
Indian Ocean Climate Initiative (IOCI) (2011)	WA	WA Government, CSIRO and BoM	SRES scenarios B1, A1B, A2	2 time periods: Mid-century (2047-2064) and end-of-century (2082-2099)	5 global circulation models (GCMs) are statistically downscaled for south-west WA (29 sites) and north-west WA (9 Kimberley sites and 10 Pilbara sites).	Daily rainfall and maximum and minimum temperature	www.ioci.org.au

[1] Scenarios developed in the 2000 Special Report on Emissions Scenarios developed by the Intergovernmental Panel on Climate Change for its Third Assessment Report.

5.2 Sea-level rise projections

Sea levels are rising globally and around the Australian coastline. There is a very high level of confidence that sea levels will continue to rise through this century and beyond, with projected sea levels at 2100 being up to 82 cm higher than 1986–2005 levels (Figure 5.3) (and possibly higher if a tipping point is reached which commits the Greenland ice sheet to irreversible melting – an unlikely but not impossible event). Sea-level rise is a significant concern for Australia, with about half the population living within 7 km of the coast (Chen and McAneney 2006) and a significant amount of industry and infrastructure located in the coastal zone (DCC 2011).

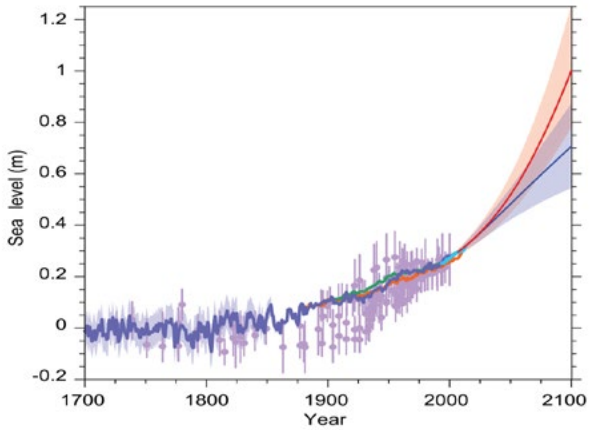


Figure 5.3 Compilation of paleo sea-level data, tide gauge data, altimeter data and central estimates and likely ranges for projections of global mean sea-level rise for RCP2.6 (blue) and RCP8.5 (red) scenarios, all relative to pre-industrial values. Source: Church et al. 2013.

The Climate Change in Australia website reports on regional projections of sea-level rise for the twenty-first century (CSIRO and Bureau of Meteorology 2015). For all scenarios, the rate of rise is larger during the twenty-first century than over the past four decades or over the twentieth century as a whole. Further information on sea-level rise is available in Information Manual 2: Understanding sea-level rise.

The CoastAdapt tool includes sea-level rise charts for all local government areas (LGAs) around the Australian coast. The charts include measured satellite data and tailored sea-level rise projections that reflect regional variability. An example for the Gold Coast is provided in Figure 5.4, with further information at link Datasets-Future.

Recent research has calculated allowances: estimates of the height that coastal assets would need to be raised to ensure that the likelihood of flooding in future remains the same as at present (Hunter 2012, McInnes et al. 2015). The value of this approach is in its alignment with frameworks for planning and decision-making. The allowances vary according to sea-level rise projections, model uncertainties and the variability of extreme sea levels. Data and information on allowances can be found at http://www.climatechangeinaustralia.gov.au/en/climate-projections/coastal-marine/marine-explorer/#.

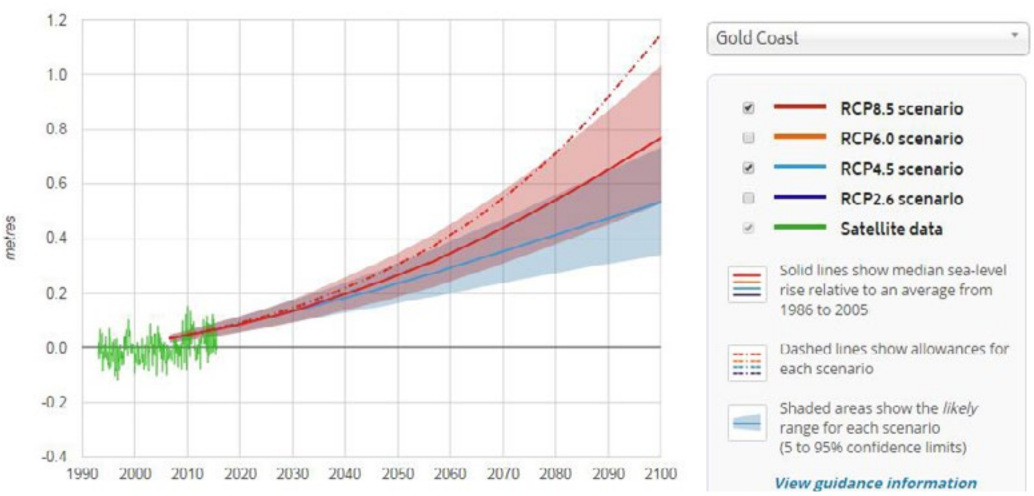


Figure 5.4 Observed and projected sea-level rise for the Gold Coast. Source: NCCARF CoastAdapt at Sea Level Rise and You © NCCARF 2016.

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5.4 Further reading

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6 Data for coastal hazard assessment

Key points:

- The data accessed to support hazard assessment need to align with the purpose of the assessment. Strategic or high-level assessments to qualitatively identify potential risks at regional scales can readily draw on national or state datasets and tools, as well as on local experience.
- Detailed numerical assessments using reliable data are needed for decisions affecting costly and long-life assets, where the consequences of failure are high.
- Adequate data and tools exist to assess inundation hazards at a high level. Detailed inundation assessments typically need to access data on current floods, ocean waves, elevation, bathymetry and sea-level rise; to employ models; and possibly to take observations and measurements, thus adding to the body of data available.
- Combined catchment flooding and inundation studies are important for communities in low-lying floodplains, as recent studies for some areas show a switch in dominant local risk from catchment flooding to flooding from the sea with climate change. Information about intense rainfall events is also needed for such assessments.
- While national datasets exist on coastal geomorphology which identify areas of potentially erodible coastline, detailed erosion hazard assessments are hampered because only few long-term datasets of morphological change exist that inform understanding of beach response to storm events.
- Shoreline recession due to sea-level rise could be very significant this century and impact on settlements, protective assets and infrastructure. Data and methods to quantify recession hazard are incomplete and imprecise. A priority is to address data gaps in areas showing signs now of vulnerability to recession.

6.1 Aligning data needs with type of hazard assessment

The amount and specificity of data required for a risk assessment depends on the purpose of the assessment and on the nature of any decisions arising. Where strong coastal management policies are in place that are informed by climate and other hazards, many coastal decisions only require simple assessment that draws on readily available information. These include coastal decisions with short time horizons and which are of low cost and effectively reversible ('low regrets' actions). Strategic risk assessments, designed to identify and communicate high-level risks to senior officials, can often be adequately developed using accessible national and state information and mapping tools.

On the other hand, the following characteristics of a decision would suggest that a detailed risk assessment is required, informed by accurate and locally relevant data:

- costly developments with a long asset life, that will need to function in a changed climate
- where the consequences of failure could be significant, for example an investment decision in a water treatment works, sewage works or dam
- the above decision features in combination with a location that has been subject to damaging coastal hazards in the past
- where regional climate change projections suggest that current coastal management assumptions and approaches are unlikely to be valid in the near-medium term.

Table 6.1 illustrates different levels of data required for different types of risk assessment.

Table 6.1 Data required for type of risk assessment. Further information on data requirements for a detailed third-pass risk assessment is at Annex B.

Assessment type	Objective	Data required
First-pass risk screening	Obtain a rapid overview of climate change risk and develop a preliminary understanding of scope of existing and future hazards; determine whether more detailed risk assessment required	Qualitative local historical experience. State and nationally available hazard datasets, regional climate change projections, including local sea-level rise information. Available data on location of assets of value, including settlements and infrastructure.
Second-pass risk assessment	Conduct a qualitative risk assessment using a standard risk-based approach to identify coastal hazards that may become problematic under future climate change	State and nationally available data and information on hazards and climate change projections relevant. Also draw on local quantitative studies and expert knowledge, such as from planners, engineers and emergency managers.
Detailed risk assessment	Conduct a risk assessment (quantitative and qualitative) to identify specific risks of different systems to future climatic hazards	Site-specific data (depending on the objective of the assessment) used in conjunction with state and nationally available datasets, modelling tools and local expert knowledge to understand exact scale of the risk. May be necessary to collect data and/or undertake modelling to extrapolate from limited observations.

6.1.1 Data needs and gaps audits

Should a first-pass risk screening or qualitative second-pass assessment identify the potential for significant local risks, it is important to have a good understanding of available data to know whether they are adequate to support local decision-making or a more detailed risk assessment. A data audit can help clarify data needs and gaps. Suggested are steps in a standard data audit:

1. Identify objectives of audit and any constraints such as time or budget. Examples of audit objectives could be to identify data needs for a detailed risk assessment or to assess the adequacy of available data to conduct a quick and inexpensive screening of future risk.
2. Document what data are available and relevant, including from broader scale state and national datasets and from reports on historic local events.
3. Analyse data to identify gaps and inconsistencies and determine whether data needs are met. The Engineers Australia coastal guidelines provide a useful framework to identify local coastal processes, against which data adequacy can be considered (e.g. see Table 7.1 in Information Manual 8: Coastal sediments and beaches).
4. Identify need for any data acquisition. Expert advice is recommended to define any data procurement, as a range of options may exist at widely differing costs (see section 2.3). Finally, consideration needs to be given to whether the benefits of greater knowledge and confidence from better quality data outweigh the costs.

6.2 Design events and hazard likelihoods

A key factor in more detailed hazard assessments is estimation of the likelihood of a hazard. Many hazard assessments calculate the average recurrence interval (ARI) of extreme events from observations, in order to understand exposure to risk. It is common practice in Australia to use the 100-year ARI storm or rainfall event for the design of coastal structures, as it is seen as a reasonable balance between initial capital cost and risk management.

Statistically, a 100-year ARI event has a 40% chance of being exceeded over a 50-year planning period and a 63% chance of being exceeded over a 100-year planning period (Carley et al. 2008). As a result, critical infrastructure is often constructed to a 500-year or higher ARI event. The Maritime Structures Standard (AS 4997-2005), for example, specifies a 1000-year extreme water level ARI for design of structures of high property value or high risk to people and a long working life (50 years or more). The Building Code of Australia requires design to a 500-year ARI for wind load on buildings, including freestanding, detached private housing.

The ARI for floods, wind speeds and temperature will potentially change significantly with climate change. The New South Wales *Coastal Risk Management Guide: incorporating sea-level rise benchmarks in coastal risk assessments* (DECCW 2010), for example, provides decision-makers with information on design ocean still-water levels (inundation heights) for 2050 and 2100 that incorporate sea-level rise. These are shown in Table 6.2.

6.3 Inundation hazard

Coastal inundation occurs when elevated sea levels lead to flooding of the land. It can be a short-term phenomenon as a result of storm surge or extreme tide, or it can be permanent when sea levels increase on an ongoing basis.

Table 6.2 Design ocean still-water levels at Sydney Harbour for 2010 and predicted levels for 2050 and 2100 incorporating sea-level rise. Source: DECCW 2010 ©State of NSW and Department of Environment, Climate Change and Water NSW.

Average Recurrence Interval (years)	2010 design still water levels (1) (metres AHD)	2050 design still water levels (2) (metres AHD)	2100 design still water levels (2) (metres AHD)
0.02	0.97	1.31	1.81
0.05	1.05	1.39	1.89
0.1	1.00	1.44	1.94
1	1.24	1.58	2.08
10	1.35	1.69	2.19
50	1.41	1.75	2.25
100	1.44	1.78	2.28

Note: The design still water levels are only relevant where full ocean tide conditions prevail. (1) Design still water levels for 2010 were derived from extreme value analysis of Fort Denison tide gauge data from June 1949 to December 2009 (after Watson and Lord, 2008). There are negligible tidal friction losses between the ocean and Fort Denison within Sydney Harbour; therefore, Fort Denison data provides an indicative representation of oceanic still water levels. The design still-water levels inherently incorporate allowance for all components of elevated ocean water levels experienced over this timeframe (including tides, meteorological influences and other water level anomalies); however, they exclude wave setup and wave runup influences. (2) Design still-water levels for 2050 and 2100 incorporate planning benchmark allowances for sea level rise with a reduction of 60 millimetres to accommodate the estimated amount of global average sea level rise that has occurred between 1990 and present. From satellite altimetry, this is estimated to be 3 millimetres/year (CSIRO, 2009). These design levels are indicative and provided for guidance only.

6.3.1 First-pass inundation hazard assessment

A first-pass screening or assessment of inundation hazard, drawing on available data and resources, can inform broader strategies or plans on the relative significance of likely risk in a region. A first step is to identify whether there are any state government maps or datasets of inundation hazard for your area (see Table 6.3). Then, particularly if there are no state maps, explore Coastal Risk Australia (see Box 6.1) and get familiar with what it can tell you. Information on sea-level rise can be obtained from the Climate Change in Australia website (http://www.climatechangeinaustralia.gov.au) and used in Coastal Risk Australia to get inundation extents for the time period of interest. Also consider any local history of inundation events, including reports assessing damage and other community impacts. Finally, relate the inundation information to the location of local housing and critical infrastructure, including plans for future development.

Datasets relevant to a first-pass inundation hazard assessment include:

- inundation hazard mapping released by state governments (see Table 6.3)
- the first-pass National Coastal Risk Assessment, which identified local governments at high risk of inundation (http://www.environment.gov.au/climate-change/adaptation/australias-coasts/national-coastal-risk-assessment)
- CoastAdapt maps of inundation for each local government area at link, and for further information Coastal Risk Australia, hosted by the Cooperative Research Centre for Spatial Information (http://www.coastalrisk.com.au), which shows inundation for the developed areas of Australia's coastline drawing on high-resolution Light Detection and Ranging (LiDAR) data and a simple bathtub model for inundation (see Box 6.1)
- historic flood information, available through the Australian Flood Risk Information Portal (AFRIP) (http://www.ga.gov.au/flood-study-web/#/search), which can be searched by keyword. While there are few studies in AFRIP that include climate change scenarios, the portal includes the Water Observations from Space dataset and it is a useful resource to identify local or catchment flood studies
- CoastAdapt projections of sea level rise for each coastal local council in Australia up to 2100 at link.

Table 6.3 State government mapping or datasets on coastal inundation hazard.

State	Type of mapping	Where accessible
Tasmania	High-, medium- and low-risk hazards mapped depending on number of houses exposed to sea-level rise (0.2 m and 0.8 m by 2100) or a 1% AEP	http://www.dpac.tas.gov.au/divisions/osem/coastal_hazards_in_tasmania
Queensland	Maps of combined storm tide with 100-year ARI and declared erosion-prone areas available free on request at property scale. Includes climate change factor of 0.8 m by 2100.	http://www.ehp.qld.gov.au/coastal/management/coastal_plan_maps.php
	Storm tide hazard spatial data are available for download.	http://qldspatial.information.qld.gov.au/catalogue/custom/search.page?q=storm+tide+hazard
	Information on the determination of storm tide inundation areas is available.	http://www.ehp.qld.gov.au/coastal/development/assessment/erosion_prone_areas.html
Victoria	Victorian Coastal Information Interactive Map showing sea-level rise of 20, 47 and 82 cm and storm tide of 100-year ARI. Intended for use at 1:75,000 scale.	http://mapshare.maps.vic.gov.au/gvh270hydra/

Box 6.1 Coastal Risk Australia – visualising inundation from sea-level rise

Coastal Risk Australia has been developed to help communicate the risks of coastal flooding associated with sea-level rise using Google Maps technology. The tool allows users to simply investigate the extent of coastal flooding under different climate change scenarios using new 5 m resolution digital elevation models (DEMs) derived from airborne LiDAR and available through ELVIS, and a bathtub inundation modelling approach. It covers the developed areas of Australia's coast.

Over 230 individual 1 m resolution airborne LiDAR surveys have been integrated into Version 1 of the seamless coastal DEM for each state, and these will be updated as more data become available. These capabilities have been developed through long-term investments and partnerships between the Cooperative Research Centre for Spatial Information, the Antarctic Climate and Ecosystems Cooperative Research Centre, Geoscience Australia, Department of the Environment, state agencies, industry and academia. The individual datasets are available for download from Geoscience Australia (http://www.ga.gov.au/scientific-topics/national-location-information/digital-elevation-data).

The tool allows users to investigate projected future sea-level rise scenarios for 2100 that also account for tidal variations. The scenarios are based on RCPs (link) and tide values:

- The low scenario aligns with RCP2.6 and includes sea-level rise of 0.55 m.
- The medium scenario aligns with RCP4.5 and RCP6.0 and includes sea-level rise of 0.63 m.
- The high scenario aligns with RCP8.5 and includes sea-level rise of 0.82 m.
- A further high-end scenario considers the top end of RCP8.5, with sea-level rise of 1.1 m.

Importantly, users can define their own sea-level rise to suit their assessment and time period. Users can also provide their own estimates of wave run-up and wave set-up and their own tidal value based on local knowledge by simply using the manual slider bar to adjust the overall height.

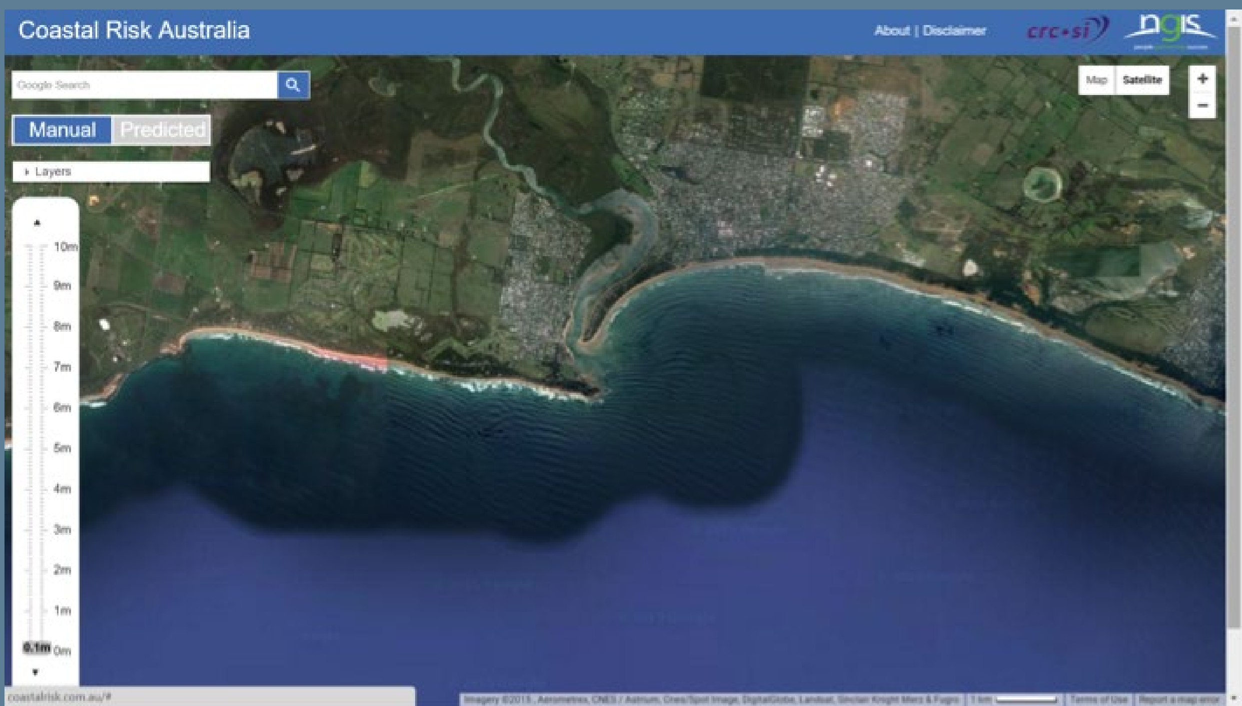

Figure 6.1 Example of Coastal Risk Australia scenarios. Source: Coastal Risk Australia (www.coastalrisk.com.au).

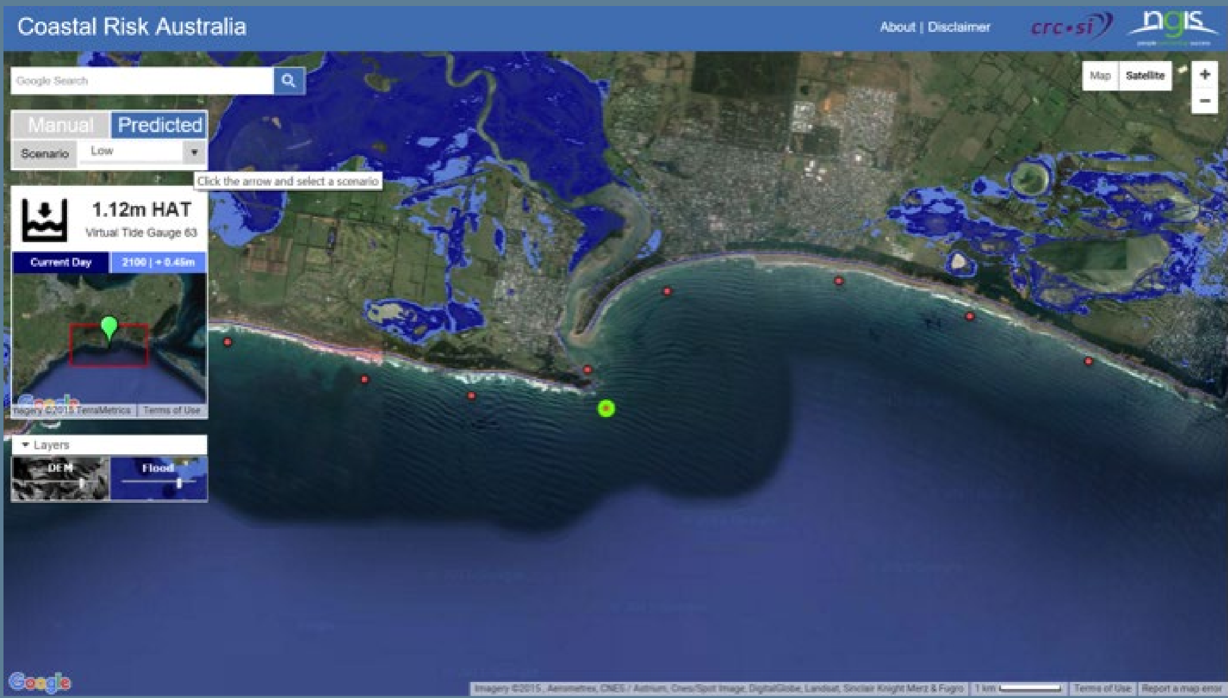

Figure 6.1 Example of Coastal Risk Australia scenarios. Source: Coastal Risk Australia (www.coastalrisk.com.au) - *continued.*

For simple assessments, bathtub approaches can indicate the general extent of low-lying assets potentially exposed to sea-level rise. Imagery, such as from Google Maps, can enable the visual location of assets such as buildings and infrastructure and is incorporated in Coastal Risk Australia.

While bathtub approaches may overstate risks in estuaries, due to an absence of modelling of tidal attenuation, they may underestimate risks on the open coast as more dynamic wave processes are not considered. In consequence, bathtub-approach outputs, which are the only ones readily accessible to general users, need to be critically evaluated in conjunction with expert knowledge of the region being studied.

Identification of the key drivers of local inundation is important for any hazard assessment. For example, the location of settlements on low-lying estuarine foreshores points to a potential hazard of combined tidal inundation, sea-level rise and catchment flooding. Areas in northern Australia may be exposed to inundation impacts from cyclone events, and areas of the central and south-eastern coastline may need to consider inundation risk from ECLs.

Other guidance documents for first-pass hazard assessments include the Australian Emergency Management Handbooks series guide *Managing the floodplain – a guide to best practice in flood risk management in Australia* (https://ema.infoservices.com.au/items/HB7-2ND), state government guidelines such as those of New South Wales (http://www.environment.nsw.gov.au/floodplains/StandardFloodplainRiskManagement.htm) and the guidelines for adaptation and coastal engineering released by Engineers Australia (https://www.engineersaustralia.org.au/sites/default/files/content-files/2016-12/climate_change_adaptation_guidelines.pdf).

Where a first-pass hazard assessment suggests the existence of significant risks, and where there is an absence of state government policies for coastal setbacks or buffers that protect coastal assets, more detailed approaches will be needed to assess inundation hazard, particularly where major development and investment decisions are intended. Such approaches are likely to involve inundation modelling, and experts are needed to do this work. Many inundation models have been developed by research agencies or technical consultants, and they are often not open source. A more detailed discussion of these models and their data requirements is beyond the scope of this manual.

6.3.2 Combined catchment flooding and sea inundation

In some coastal areas, there is a likelihood that extreme sea levels as a result of storm surge and wave set-up can combine with extreme rainfall events to produce water levels significantly higher than would result from individual events. This may be a consideration in low-lying areas around estuaries. Sophisticated hydrodynamic modelling approaches, including joint probability analysis to assess the implications of combined events on flood levels, are now available for use.

As noted in section 5 (Figure 5.1), climate change will bring a risk of more extreme rainfall events across Australia. In response, Engineers Australia have proposed that an interim guideline for considering climate change in rainfall and runoff set a 5% increase in rainfall intensity (or equivalent depth) per degree Celsius of global warming until more detailed information becomes available (Engineers Australia 2014). This can be used as a 'rule of thumb' in second-pass or more detailed risk assessments in the absence of local data.

Several recent studies have highlighted the significance of combined catchment and sea inundation modelling. For example, a hazard study of the Port Fairy township, which compared bathtub inundation with dynamic models, demonstrated the capacity of dynamic modelsto reveal the significance of wave overtopping with sea-level rise (Flocard et al. 2013). A study of existing and future flood risk due to sea-level rise for a number of intermittently closed and open lakes or lagoons in Shoalhaven local government area, New South Wales, found that the dominant risk will shift from catchment rain events to ocean-driven flooding as a result of sea-level rise. Further, flood damages will increase by up to tenfold in some areas for frequent flood events (Ghetti 2015).

6.4 Erosion and recession hazard

There are two main approaches to assessing coastal landform change: the engineering approach, which focuses on beach response to short-term storm processes; and the geomorphological approach, which focuses on long-term change. Further information on these approaches is in Information Manual 8: Coastal sediments and beaches

Increasingly, remote-sensing data can provide robust information on coastal landform change, both in response to short-term storm events and to detect longer term trends. Accessible visual information from satellites, for example in Google Earth and NearMap, can provide useful baseline data. Data from high-resolution sources, such as LiDAR surveys of shoreline topography and Ground Penetrating Radar imaging to understand the evolution of coastal landforms and their links to sea level, will likely become more cost-effective over time.

6.4.1 First-pass erosion hazard assessment

A first-pass assessment of erosion hazard is useful to inform broader strategies or plans on the relative significance of likely risk. As a first step it is important to be aware of any state government mapping of erosion-prone areas (Table 6.4). Then check information on coastal compartments mapping in CoastAdapt (link CoastAdapt datasets: present-day) to identify the susceptibility to change of relevant secondary coastal compartments, and check available aerial photography for any broad changes in beach profile (section 3.1.1, Table 3.5). The Smartline National Geomorphic Map (section 3.1.2) can then be accessed to identify specific areas of soft coast that could be susceptible to erosion. Historical studies published on the internet are also useful and can sometimes be identified through a simple internet search. Finally, the generic erosion setbacks in Table 6.6 provide a regional perspective on the possible long-term extent of erosion from sea-level rise.

Table 6.4 State government mapping or datasets of coastal erosion hazard areas.

State	Type of mapping or dataset	Where accessible
Queensland	Erosion-prone areas based on a range of factors, including short-term erosion from extreme storm events, long-term gradual erosion, dune scarp slumping, future sea-level rise from climate change, and a 40% safety factor.	https://www.ehp.qld.gov.au/coastal/development/assessment/erosion_prone_areas.html#erosion_prone_area_mapping
South Australia	Coastal Hazard Areas dataset. Coastal areas assessed as being at risk of flooding or erosion. Risk is determined by a geomorphic assessment of the coastal landscape. Hazard areas include i) storm surge hazard areas, ii) inland runoff flooding, iii) potential drift (vegetated sand dunes), and iv) actual drift (eroding sand dunes).	https://data.environment.sa.gov.au/NatureMaps/Pages/default.aspx http://location.sa.gov.au/lms/Reports/ReportMetadata.aspx?p_no=1145&pu=y&pa=dewnr
Tasmania	Coastal erosion susceptibility zone mapping, underpinned by geomorphic mapping.	http://www.dpac.tas.gov.au/divisions/osem/coastal_hazards_in_tasmania
New South Wales	Coastal erosion hot spots in 11 council areas, defined as areas where five or more houses and/or a public road are located in a current (or immediate) coastal hazard area.	http://www.environment.nsw.gov.au/coasts/coasthotspots.htm

A key question for any erosion or recession (see section 6.4.3) hazard assessment is determination of whether a beach is stable (or closed) or leaky and likely to lose sediment (Figure 6.2). Where there is an absence of a sediment source for replenishment, low-lying beaches can have difficulty recovering from clustered storm events. Information attached to secondary coastal compartment mapping in CoastAdapt can help identify such erosion hazard hot spots or areas likely to be fast responders to sea-level rise.

Establishment of a trend in beach change generally requires an observation dataset of at least 40 years, and there are very few areas around Australia that have such long survey datasets of beach change. Table 6.5 lists monitoring studies that have generated long-term datasets.

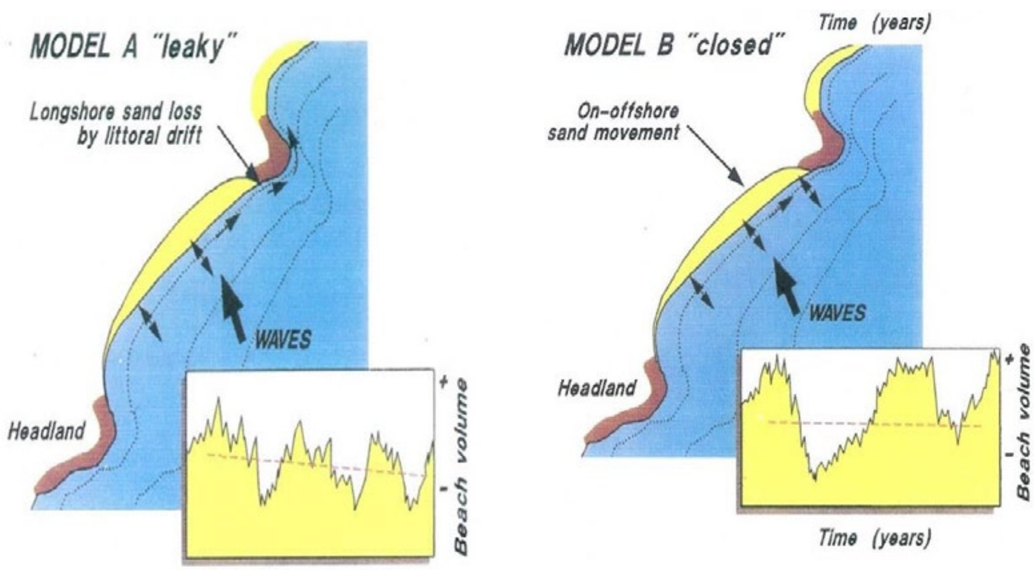

Figure 6.2 Illustration of closed and leaky beaches in a coastal compartments context. Source: Thom 1989.

Table 6.5 Monitoring studies that have generated long-term datasets on beach change or erosion.

Location	Dataset	Method	Reference
Moruya, NSW	Max. erosion relative to mean profile 158 m^3/m Max. erosion relative to most accreted profile 287 m^3/m	Surveys 1972–1988	Thom and Hall 1991
Tasmania	The Tasmanian Shoreline Monitoring and Archiving project covers profile changes of 30 beaches	Volunteer surveys measuring beach profile from fixed survey mark; from 2005	TasMARC http://www.tasmarc.info/
Gold Coast, Queensland	Effectiveness of beach nourishment	Hydrographic and topographic surveys, sediment analyses, aerial and ground photography, wave recording, nearshore current measurements	Murray et al. 1993
Scarborough, Western Australia	Beach width	Monthly measurements 1965–1981	Clarke and Eliot 1983

6.4.2 Erosion modelling

Where risks are considerable, the decision will be relevant for a long time or where significant investment in critical infrastructure is involved, more detailed hazard assessment – likely involving local erosion modelling – will be required. Erosion models can address the relative lack of data in many areas of the coast.

A range of erosion hazard models have been developed to assess beach erosion from storm events. The Storm-induced BEAch Change (SBEACH) model is a numerical cross-shore sediment-transport and profile-change equilibrium model developed by the US Army Corps of Engineers for estimating erosion of the beach and dunes by storms (Larson and Kraus 1989). SBEACH considers sand grain size, the pre-storm beach profile and dune height, plus time series of wave height, wave period and water level to identify sediment movement from individual storm events.

There has been some criticism of SBEACH, because it appears to underestimate storm erosion, particularly on those beach systems in northern NSW that experience a significant longshore transport component but also where rip circulation or beach rotation occur (Rollason et al. 2010). Some applications of the model have also not fully considered the local sediment system.

Nevertheless, SBEACH is a widely used model, and it has been verified for measured storm erosion on the Australian east coast (Carley 2001; Carley and Cox 2003). An example of the application of SBEACH, with a focus on identification of data needs, is in Box 6.2.

Box 6.2 SBEACH application to Clarence, Tasmania.

In assessing coastal hazards, climate change and adaptive responses to inform Clarence City Council, Water Research Laboratory (WRL) selected to use SBEACH for erosion modelling because of its good theoretical basis and extensive verification. Following is an overview of the steps taken to generate data inputs for the modelling.

Data inputs to SBEACH

Sand grain size

- Two single sand samples from near low-water mark were oven dried and sieved to AS 1289.3.6.1-1995. The median grain sizes were found to be 0.205 mm and 0.150 mm.

Beach profiles

- Beach profiles were developed from state government bathymetry combined with contours from Council's GIS system, supported by LiDAR-derived land profiles.

Water levels

- A spring tide time series was assumed, to which a tidal anomaly was added so that the peak water level corresponded to the ARI of the storm (1.44 m Australian Height Datum [AHD] for 100-year ARI, 1% AEP)

Wave heights

- Extreme offshore wave heights were derived from wave buoy data (not directional and of short record length) and the C-ERA-40 dataset (hindcast wave model data) to provide directional probability. ARI peak wave height values were determined for a one-hour duration storm event.
- SWAN modelling was used to quantify the change in wave condition from a deepwater boundary to the nearshore zone.
- Extreme local wind wave conditions were estimated using design wind velocities from AS/NZS 1170.2:2002 and wave hindcasting techniques.
- Design waves of 110-year ARI (1% AEP) were generated for each precinct, spanning wind and swell waves and including significant wave height and wave period.

Design erosion event and storm clustering

- A design erosion event for this project was taken to be 2 x 100-year ARI events, in recognition that it is often clusters, rather than a single storm, that cause major erosion. It also aligns with observations of design erosion volumes on well-monitored beaches from a sequence of lesser storms (e.g. Thom and Hall 1991).

SBEACH model results for Clarence

The following design erosion volumes are examples of the results from the SBEACH modelling for the Clarence assessment.

Location	Dune height	Storm erosion	Horizontal storm
	(m AHD)	(m^3/m above AHD)	erosion allowance (m)
Roches Beach	3.5	100	25
Cremorne Ocean Beach	6	80	15
Hope Beach	7	160	25
Mays Beach	6	50	10
South Arm Beach	8	60	10

Source: Extracted from Carley et al. 2008.

To facilitate consideration of likely erosion volumes in high-level hazard studies, a dataset of suggested design erosion volumes has been derived from the SBEACH model, the XBeach process model developed to assess erosion from extreme storm conditions on variable coastlines, and from engineering judgement (Mariani et al. 2012). Table 6.6 summarises this dataset for 30 zones around the Australian coast.

Timescale is a key issue for erosion risk, and different tools are suited to understand erosion over different time scales. SBEACH is particularly useful to identify sediment movement from single storm events, and, as noted in Box 6.2, it can be used to model the impact of a cluster of storms from which beach recovery can be slow. Other models are better suited to determine, for example, the time period and beach response to shoreline construction or to long-term sea-level rise (section 6.4.3).

Table 6.6 Suggested design erosion volumes and generic setbacks based on SBEACH, XBeach and engineering judgement. Note: Design volumes in m^3/m above AHD based on 2 x 100-year ARI storms and generic setbacks in m. Source: Derived from Mariani et al. 2012.

Regional coast	Design volume (m^3/m)	Generic erosion setback (m)	Regional coast	Design volume (m^3/m)	Generic erosion setback (m)
Weipa – Cape York Coast	80	108–129	West–South Tasmania Coast	250	80–127
Cairns Coast	80	108–129	Kingston – Goolwa Coast	200	75–114
Townsville Coast	80	108–129	Gulf St Vincent –Spencer Gulf Coast	50	105–122
Mackay Coast	80	108–129	Port Lincoln – Eucla Coast	250	80–127
Gladstone Coast (excl. Agnes Water)	50	105–122	Eucla – Cape Pasley Coast	250	125–172
Fraser – Gold Coast	200	75–114	Esperance Coast	250	125–172
Coffs Harbour – Tweed Coast	200	75–114	Albany – Cape Naturaliste Coast	250	125–172
East Gippsland Coast	200	75–114	Cape Naturaliste –Geraldton	150	115–147
South Gippsland –Mornington Peninsula Coast	200	75–114	Geraldton – Carnarvon Coast	150	115–147
Port Phillip Bay Coast	20	102–114	Cape Cuvier – North West Cape Coast	150	115–147
Lonsdale – Lorne Coast	150	70–102	Exmouth – Dampier Coast	80	108–129
Port Campbell – Portland Coast	200	75–114	Port Headland – Broome Coast	80	108–129
North Tasmania Coast	100	65–89	Kimberley Coast	80	108–129
East Tasmania Coast	150	70–102	Darwin – Arnhem Land Coast	80	108–129
Storm Bay	100	65–89	East Arnhem Land –Weipa Coast	80	108–129

6.4.3 Long-term recession from sea-level rise

Historical long-term shoreline recession has often been analysed using photogrammetric data, involving calculating volumes and dune positions, and then conducting linear regression techniques to determine movement of shoreline and dune positions. For example, Sharples (2007) examined long-term change at Roches Beach, Tasmania, for the period 1957–2007 using aerial photos from 1957, 1977, 1987, 2001 and 2005 and found shoreline recession of up to 12.5 m.

With continued sea-level rise from climate change, currently stable or accreting beaches could switch to being receding beaches in the future.

In the absence of local data, the Bruun Rule has often been used as a coarse first-order approximation for determining sea-level rise induced recession for planning purposes along the open coast (Ranasinghe et al. 2012). However, there are significant limitations with use of the Bruun Rule, particularly its assumptions that the nearshore is a closed system, that change is dominated by cross-shore processes, and that it ignores perturbations such as seasonal/storm fluctuations (Woodroffe et al. 2012). The reality that the Bruun Rule has been widely applied probably reflects its simplicity, rather than its appropriateness, and the lack of robust alternatives.

A number of improved methods have been developed to estimate shoreline response to sea-level rise. These are generally fairly complex models, which require expert engagement and derivation of datasets. A good description of these can be found in Woodroffe et al. 2012. Generic beach erosion setbacks have been estimated for 30 regions around the Australian coast using numerical modelling and engineering judgement. These are summarised in Table 6.6, but the full description includes an estimate of setback requirements from short-term erosion, recession from sea-level rise and dune stability. In the absence of other data, the generic setbacks can inform coastal management long-term decisions, but the limitations of data to verify model output need to be noted.

6.5 References

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6.6 Further reading

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7 Data for risk and vulnerability assessment and adaptation planning

Key points

- In addition to the data supporting coastal hazard assessment, risk and vulnerability assessment and adaptation planning require information and data on the social, environmental and economic assets of the coast.
- Much of the data on local coastal assets that are useful for vulnerability assessments are collected and managed by state and local governments. This includes information on land tenure and property boundaries, local settlements, population, community facilities, infrastructure, natural environments and cultural heritage sites.
- For the general user, relevant datasets may not exist or may be difficult to access. However, national datasets supplemented with satellite imagery and local expert knowledge are sufficient for a first-pass screening assessment.
- There are a number of national datasets that can be drawn on in vulnerability assessments, spanning such topics as buildings and transport infrastructure, water resources, population statistics and social indicators for the urban environment.

7.1 Types of data relevant to local vulnerability assessment

Assessing the vulnerability of the coast, and planning for adaptation, involves accessing data and information on coastal communities, economies, services, assets and environments exposed to climate change impacts. The responsibility for collection and management of data on the values of the coast generally resides with state governments and councils.

At a local scale, typical datasets that can be used in a vulnerability assessment, in addition to data on climate change and coastal processes and hazard probability and magnitude, include:

- land tenure and property boundaries
- type, number and location of major assets and infrastructure and information on damage from any historic events
- natural hazard-prone areas in the local government area or surrounding areas
- emergency evacuation routes and plans
- floodplain risk management plans
- socio-economic profile of the population in the council area and implications for demand on services
- main businesses operating in the council area
- ecosystems, refuges, fauna and flora present, particularly of ecological significance
- sites of cultural heritage significance.

Not all local governments will have all of these datasets, and many may be inaccessible or very difficult to access for the general user. However, for a first-pass screening assessment, using state and national mapping and satellite imagery (e.g. from Google Maps or NearMap) together with expert knowledge of the area under analysis will probably be sufficient. State government data portals (such as https://data.qld.gov.au for Queensland; https://data.environment.sa.gov.au/NatureMaps/ for South Australia and http://slip.landgate.wa.gov.au/Pages/SlipFutureHome.aspx and https://spur.wa.gov.au/better-business/walis-marine-group for Western Australia) contain a range of datasets that can be very useful.

7.2 National social, economic and environmental datasets

There are a number of datasets managed at the national level that could be useful in a risk or vulnerability assessment (summarised in Table 7.1). As previously noted (section 6.3.1), the National Coastal Risk Assessment provides information relevant to a first-pass risk screening, and the other datasets are relevant to more detailed qualitative or quantitative risk assessments.

The NEXIS is a tool decision-makers can use to identify assets of value in a local region subject to a coastal hazard, particularly if detailed local data are not available. An illustrative example of the output of NEXIS is given at Annex A. The NEXIS tool can be used to estimate the number and value of exposed assets in two ways:

- Where a hazard assessment has generated a spatial extent of inundation or erosion, this spatial extent or map can be provided to Geoscience Australia for overlay in NEXIS to generate a report.
- Users can access data from NEXIS through the Geoscience Australia website at statistical area 1 (SA1) scale, which is equivalent to an area housing around 400 people. SA1 boundaries can first be obtained from the Australian Bureau of Statistics Geography website: http://www.abs.gov.au/geography.

New datasets that are relevant to climate change adaptation are also being developed on the sensitivity of buildings to extreme weather events such as floods. Geoscience Australia has developed datasets on the vulnerability of housing types to flood following the floods of 2011, with more than 880 houses surveyed in south-east Queensland. Further information on building damage databases is in Mason et al. 2012.

7.3 References

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Table 7.1 Publicly available national social, economic and environmental datasets relevant to risk and vulnerability assessment.

Sector	Information or dataset	Where accessible
Buildings and Infrastructure	**NEXIS – The National Exposure Information System** is managed by Geoscience Australia and contains information on the spatial location of residential, commercial and industrial buildings, as well as a range of associated information on building type and construction (example in Annex A). Data from NEXIS can readily be linked to or overlaid with other GIS or spatial data.	http://www.ga.gov.au/scientific-topics/hazards/risk-and-impact/nexis Aggregated information at statistical area 1 level (dwellings housing around 400 people) provided. Information for tailored areas provided on request.
	The **National Coastal Risk Assessment** (NCRA) overlaid a simple inundation (bathtub) model with data on buildings from NEXIS to identify local government areas with high numbers of residential buildings exposed to sea-level rise. A supplement to the NCRA identified road and rail infrastructure exposed to sea-level rise.	http://www.environment.gov.au/climate-change/adaptation/australias-coasts/national-coastal-risk-assessment Information provided for LGAs with high-risk levels
	The **National Map** contains a number of infrastructure datasets, including: • transport infrastructure – roads, railways, bridges, airfields and airports, lighthouses, marine infrastructure lines • waste management facilities and storage tanks • power lines.	http://www.nationalmap.gov.au
Boundaries	The **National Map** contains a number of boundary datasets, including local government areas, statistical local areas, states and NRM regions.	http://www.nationalmap.gov.au
Water	The **Australian Water Resources Information System (AWRIS)** is managed by the BoM and spans information about river flows and groundwater levels, water volumes in storage, water quality in rivers and aquifers, water use and restrictions, water entitlements and water trades.	http://www.bom.gov.au/water/about/wip/awris.shtml

Table 7.1 Publicly available national social, economic and environmental datasets relevant to risk and vulnerability assessment - *continued.*

Sector	Information or dataset	Where accessible
Vegetation, land use and ecosystems	The **National Map** contains a number of vegetation and land-use datasets, including: • native vegetation cover • cultivated land.	http://www.nationalmap.gov.au
	The **Species of National Environmental Significance** database is managed by the Australian Government (Department of the Environment) and contains maps and data that provide general information on the distribution of species related to the *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).*	http://www.environment.gov.au/science/erin/databases-maps/snes
Cities and urban areas	The **Australian Urban Research Infrastructure Network (AURIN**) is a one-stop online portal with more than 1200 datasets on: • demography, social indicators and economic activity • urban design and housing • health and quality of life • infrastructure and transport.	http://aurin.org.au/about/the-aurin-journey/ Available to researchers with an edu.au email address. Others with an interest can get an account from the e-Research Facilitator: jack.barton@unimelb.edu.au.
Population	The **Australian Bureau of Statistics** collects and makes available a range of datasets on population distribution and projections.	http://www.abs.gov.au/
Social, cultural and economic information	The **Australian Bureau of Statistics** collects and makes available a range of datasets including on: • health • labour force • education and training • cultural backgrounds or migrants • Aboriginal and Torres Strait Islander status. These data and information can be accessed at regional scales.	http://www.abs.gov.au/

8 Tips and traps

Several topics discussed in this manual contain key points for coastal managers. These are highlighted here as 'tips and traps'.

Data are assets that need management

Data on coastal features and hazards can be considered assets of increasing value in a changing climate. With climate change, local data are useful in tracking and managing risks such as from coastal erosion or inundation. Compiling existing data and information, such as hazard reports and maps, into a management system can facilitate its linkage to other relevant datasets and use in decision-making.

Existing data can inform first-pass risk screening

In many areas, existing national and state data and mapping products are adequate to support a first-pass risk screening, and no new investment in data is needed. While national hazard mapping cannot be used for local development or investment decisions, it is well suited to inform initial screening assessments to identify whether local or regional risks exist.

Consultants will likely be needed to interpret data

While a number of agencies monitor coastal variables, particularly at the state level, accessing ready-to-use datasets can be very difficult. Significant steps have been taken in recent years to make climate datasets accessible through the BoM and the Climate Change in Australia website, and the national and state governments are now working towards open data policies which will improve accessibility of data currently being collected. Nevertheless, many existing datasets are hard to find, are only made available on request and lack guidance on their interpretation. In many instances, consultants will be required to interpret and advise on relevant data.

Using consultants can be costly. It is useful to be well informed about the coastal area of interest and whether it has a history of hazards, in order to scope needed study outcomes before engaging a consultant.

Beware of assuming accuracy from modelling with incomplete data

Local hazard assessments generally draw on a number of models to identify likely inundation, erosion or recession extents under various scenarios. Typically, data on coastal processes and current and future climate are required as input to the models, and data are also required to verify and calibrate models. Unfortunately, gaps in datasets on such things as coastal geomorphology and extreme waves mean that model results often cannot be verified. Advice needs to be sought from providers of any model output on the extent of supporting data, assumptions made and confidence limits.

In the medium to longer term, local data will be needed to manage risks in highly vulnerable areas

The impacts of climate change on the coast are projected to increase in coming decades, with areas currently affected by coastal hazards likely to experience the effects of sea-level rise first. As hazards increase over time, data will be needed to track coastal change and the number and location of exposed assets. Obtaining quality baseline data, and developing a tailored and cost-effective monitoring program, can inform effective risk management measures and identify when a change in policy is required.

Not all methods for data collection are high cost

While much data acquisition can be costly, there are emerging opportunities for cost-effective generation of useful data for coastal management. The TasMARC program, for example, (http://www.tasmarc.info) involves monitoring of coastal change by community volunteers, and the King Tide Witness Project (http://www.witnesskingtides.org/) has delivered a range of visual information on areas affected by high-water events. The growing body of increasingly accessible satellite data, for example through such tools as Water Observations from Space by Geoscience Australia, also makes available data on coastal change since the mid-1970s.

With planning, lower cost methods for data collection can be built into monitoring programs for highly vulnerable areas.

Tips for procuring data

Where data need to be procured, for example for a detailed assessment of likely local hazards, there is benefit in taking steps in any contract to ensure that the data are fit for purpose and of high quality. It is useful to clarify with any consultant the local data that will be used, whether there are adequate data to calibrate any models and verify model results, and where derived data and assumptions will be used. In addition, to maximise the utility of any data procured it is useful to:

- undertake a data audit so that gaps in datasets and planned data acquisition align with needs and the most cost-effective option
- ensure that data can be used multiple times; while sometimes this may add cost to the project, this needs to be weighed against the benefit of having good baseline data that can be used in future projects to measure change
- describe formatting needs so that data can be readily incorporated in local GIS and other decision-support tools
- ensure that clear metadata are provided, including on when the data were collected, their resolution and any points relevant to their use.

Better data will not remove uncertainties in climate projections

Better data collection can help reduce some uncertainties in climate change projections, but it cannot remove them. This is because future climate change will depend on many things, including human behaviour and non-linear responses in the climate system, which are impossible to fully predict. It is important that uncertainty not be seen as an obstacle to adaptation.

Users also need to be aware that higher resolution data, such as from precise measurements of wave heights from wave buoys, does not necessarily improve the capacity of a model to accurately predict inundation.

Annex A. Illustrative use of NEXIS to identify assets in defined area

Geoscience Australia - Exposure Report

Australian Government
Geoscience Australia

ZEUS Event#: 9999

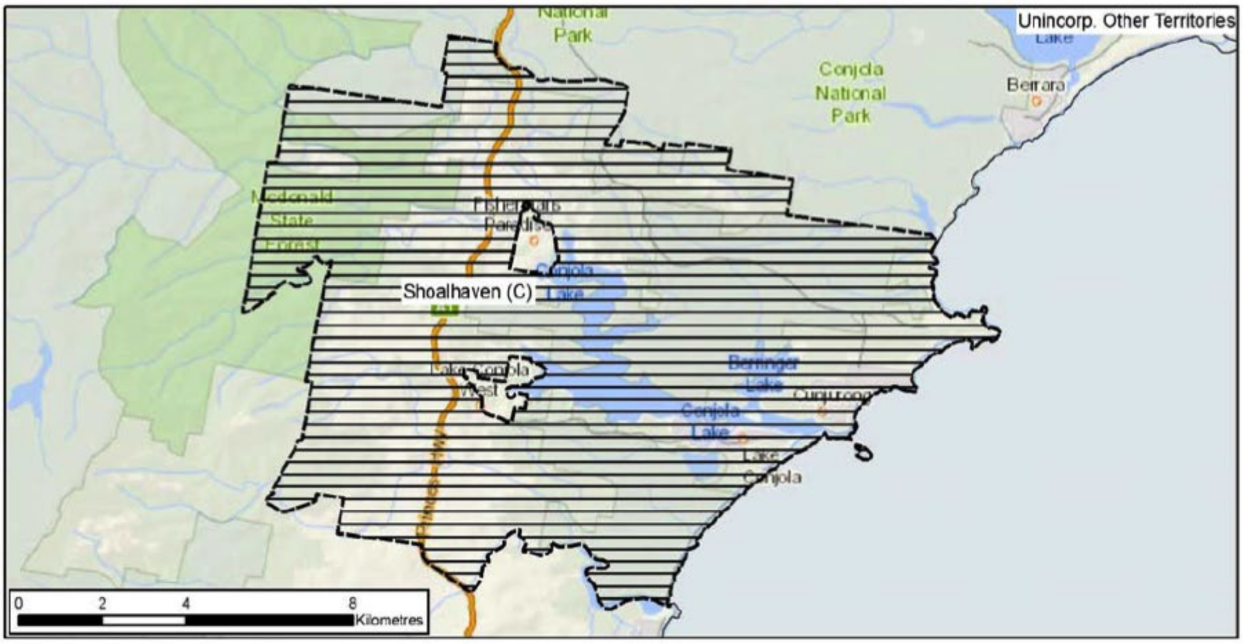
Event name: Lake Conjola Flood Study

Event type: Flood

Report Date: 10-03-2016 10:27:49

LGAs within the event footprint: Shoalhaven (C)

Localities within the event footprint: Conjola Park (L), Cunjurong Point - Manyana (L), Fishermans Paradise (L), Lake Conjola (L), Ulladulla



Building Exposure, V6.0 August 2015	
Residential	**Event**
Population count	1,163
Dwelling count*	1,456
Building count	1,453
Pre 1980 construction count	1,007
Reconstruction value	$431,740,000
Contents value	$160,260,000
Commercial	
Building count	2
Reconstruction value	$442,010,000
Industrial	
Industrial Building count	2
Reconstruction value	$31,110,000
2011 SEIFA IRSAD	
Dwellings in area with a SEIFA decile 10 score (most advantaged)	-
Dwellings in area with a SEIFA decile 9 score	-
Dwellings in area with a SEIFA decile 8 score	-
Dwellings in area with a SEIFA decile 7 score	-
Dwellings in area with a SEIFA decile 6 score	-
Dwellings in area with a SEIFA decile 5 score	171
Dwellings in area with a SEIFA decile 4 score	-
Dwellings in area with a SEIFA decile 3 score	1,285
Dwellings in area with a SEIFA decile 2 score	-
Dwellings in area with a SEIFA decile 1 score (most disadvantaged)	-
Dwellings in area without a SEIFA score	-

Dwelling estimates where residents:		
Demographic*	**Event**	**NSW (Av)**
Are all aged 65 or over	27.0%	17.7%
Includes persons aged 14 years and under	Not Avail	Not Avail
Includes an Indigenous person	1.6%	3.1%
Are a single parent family	3.3%	4.1%
Are in need of assistance for self-care activities	13.7%	9.5%
Include persons not proficient in English	0.0%	1.6%
Do not have access to a motor vehicle	1.3%	11.3%
No one has completed Year 12 or higher	23.1%	18.9%
Moved to the region in the last 1 year	9.0%	9.0%
Moved to the region in the last 5 years	20.5%	27.8%
Top 5 employing industry:		
Construction, Health Care Social Assistance, Accommodation Food Services, Education Training, Public Administration Safety		
Economic*	**Event**	**NSW (Av)**
Are low income ($1-599/week)	60.1%	38.5%
Are medium income ($600-$1,999/week)	38.5%	52.7%
Are high income ($2,000+/week)	1.3%	7.5%
Are in public housing	0.0%	6.0%
Are all unemployed	0.0%	0.9%

**Residential demographic and economic information is not provided for dwelling counts less than 20.*

Agricultural Exposure	
Agriculture Commodity Estimated Value 2013-14: $925,292	**Estimated Agricultural Area (Ha): 2,272**
Commodities include: Beehives, Cereals other purposes, Chickens layers, Cut flowers, Dairy cattle, Eggs, Goats, Horses other, Horses stud, Lavender, Lemons, Limes, Meat cattle, Oranges, Pasture for hay, Pigs, Sheep lambs	

Business Exposure, ABR 2015			
Number of businesses	**262**	**Number of Registered Charity Organisations:**	**1**
Accommodation and Food Services	11		
Administrative and Support Services	18	**Number of Primary Producers**	**15**
Agriculture, Forestry and Fishing	15	Agriculture and Fishing Support Services	<5
Arts and Recreation Services	4	Aquaculture	<5
Construction	85	Dairy Cattle Farming	-
Education and Training	8	Deer Farming	-
Electricity, Gas, Water and Waste Services	-	Fishing	-
Financial and Insurance Services	9	Forestry and Logging	-
Health Care and Social Services	13	Forestry Support Services	<5
Information Media and Telecommunications	1	Fruit and Tree Nut Growing	-
Manufacturing	8	Hunting and Trapping	-
Mining	1	Mushroom and Vegetable Growing	<5
Other Services	15	Nursery and Floriculture Production	-
Professional, Scientific and Technical Services	21	Other Crop Growing	-
Public Administration and Safety	3	Other Livestock Farming	-
Rental, Hiring and Real Estate Services	17	Poultry Farming	-
Retail Trade	11	Sheep, Beef Cattle and Grain Farming	9
Transport, Postal and Warehousing	9	*<5 - Primary producer information not provided for counts less than 5*	
Wholesale Trade	3		
Unclassified businesses	10		

Institution Exposure	
Education	**Event**
School - Pre/Primary	-
School - Secondary	-
School - Tertiary	-
School - Other (Combined, Special)	-
Health and Welfare	
Hospital - Public	-
Hospital - Private	-
Nursing Home	-
Retirement Home	-
Emergency Services	
Police Station	-
Fire Station	-
Ambulance Station	-
SES Facility	-
Rural/Country Fire Facility	3
Government Facilities	
Federal Court	-
Medicare Office	-
Centrelink Office	-
Diplomatic Facility	-
Consulate Facility	-
Major Defence Facility	-
Correctional Facility	-
Immigration Detention Facility	-
Local Government Offices	-

Infrastructure Exposure	
Transport	**Event**
Airport - Major Areas	-
Airport - Major Terminals	-
Airport - Landing Grounds	-
Road - Major (km)	57
Road - Arterial and Sub-arterial (km)	54
Railway - Station	-
Railway - Tracks (km)	-
Maritime - Major Port	-
Maritime - Ferry Terminal	-
Utility/Energy	
Power Station - Major Renewable	-
Power Station - Major Fossil Fuel	-
Transmission - Substation	-
Transmission - Electricity Lines (km)	-
Liquid Fuel - Refineries	-
Liquid Fuel - Terminals	-
Liquid Fuel - Depots	-
Liquid Fuel - Petrol Stations	1
Gas Pipeline (km)	-
Oil Pipeline (km)	-
Off-shore Extraction Platform	-
Waste Management Site	2
Waste Water Treatment Plant	2
Major Dam Walls	-
Telephone Exchange	-
Broadcasting Studios (Radio and TV)	-

Source: Generated from Geoscience Australia's National Exposure Information System (NEXIS): http://www.ga.gov.au/scientific-topics/hazards/risk-and-impact/nexis. © Commonwealth of Australia (Geoscience Australia) 2016.

Notes on data in NEXIS

The exposure report presents an overview of agricultural, building, business, demographic, institution and infrastructure exposure generated by Geoscience Australia's National Exposure Information System (NEXIS) for a specific event. The National Exposure Information System exposure information includes:

Agricultural Exposure: The list of agricultural commodities and estimated value is based on the Australian Bureau of Statistics (ABS) Value of Agricultural Commodities Produced (VACP) 201314, and Agricultural Commodity Estimates by Region 2011. http://www.ga.gov.au/metadata-gateway/metadata/record/gcat_82222

Agricultural Commodity value is obtained from ABS and is based on the intercensal 2013-14 financial year period.

Building Exposure: Residential, Commercial and Industrial exposure information is collated from a variety of best and publicly available data. Building reconstruction and contents values are adjusted to September 2014 costings. http://www.ga.gov.au/metadata-gateway/metadata/record/gcat_82220

Business Exposure: The Australian Business Register is a comprehensive database of identity information provided by businesses and other organisations when they register for an Australian Business Number (ABN). It provides information on the type of businesses, type of primary producers and notforprofit organisations by ANZSIC Classifications. The data is based on the main business location of the registration. https://abr.gov.au/About-us/Our-work/ABR-explained/

Demographic Exposure: Demographic exposure applies the ABS 2011 census statistics and Socialeconomic Indexes for Areas – Index of Relative Socioeconomic Advantage and Disadvantage (SEIFA IRSAD) to a NEXIS building location. Some areas cannot be assigned a score because the population is too small or the quality of the data is not good enough.

Institution Exposure: Institution asset data is collected through a variety of best available data. This data is either not available publicly because they are government departmental data and or commercially available data products.

Infrastructure Exposure: Infrastructure asset data is collected through a variety of best and publicly available data. http://www.ga.gov.au/scientific-topics/national-location-information/built-environment-and-exposure

The ABS Australian Statistical Geography Standard (ASGS) provides an approximation of officially gazetted Local Government Areas (LGA) 2015, as defined by each State and Territory, and Urban Centres and Localities (UCL) 2011 where population is greater than 200. http://www.abs.gov.au/websitedbs/D3310114.nsf/home/Australian+Statistical+Geography+Standard+(ASGS)

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For more information: http://www.ga.gov.au/scientific-topics/hazards/risk-and-impact/nexis.

Annex B. Key datasets for a more detailed third-pass risk assessment

The following table provides an overview of datasets likely to be relevant to detailed coastal risk assessments. Third-pass assessments require site-specific, high-quality data in order to provide sufficient detail at a scale relevant to decision-making. Deficiencies in available datasets can compromise the accuracy of model outputs and, ultimately, the quality of the risk information and mapping generated; it is important to clearly document gaps in data or where the datasets only span short time horizons.

Table AB Key data requirements for third-pass erosion and inundation hazard assessment.

Data type	Data needs for detailed assessment
EROSION HAZARD MAPPING	
Meteorological drivers (rainfall, winds, storms, weather patterns)	Long-term records and analysis
Topography	Topographic mapping with contours information of at least 0.25 m Light Detection and Ranging (LiDAR) Digital Elevation Model (DEM) where available
Bathymetry	Recent and high-resolution bathymetric charts derived from bathymetric LiDAR or multibeam hydrographic surveys Older charts (e.g. over 10 years old) can be validated with ground-truth measurements
Geology, geomorphology and sediment transport	Tertiary compartment–scale description of geomorphological, geological and dynamic features Determination of potential change of unstable landforms at the tertiary scale and mechanisms for beach/dune interactions Analysis of current and future (long-term) sediment transport and sediment budgets, including: • alongshore and cross-shore distribution of sediments • influence of rock and human interventions in the coast • role of nearshore currents
Shoreline movement	Beach surveys at hotspots and up-to-date shoreline movement plots to understand shoreline change and future beach response to sea-level rise at tertiary scale
Storm surge and water level	Historic analysis of storm surge heights associated with extreme weather events to determine average recurrence interval (ARI)
Waves	Projected storm wave heights for specified ARI and wave climate response to sea-level rise; to be accurate, wave datasets should cover a period of longer than 40 years
Sea-level rise scenarios	Projected sea levels for specified climate change scenarios

Table AB Key data requirements for third-pass erosion and inundation hazard assessment - *continued.*

Data type	Data needs for detailed assessment
Benthic habitats	Spatial distribution of sediments and seagrass communities to estimate sediment budgets and transport
Coastal assets	Spatial distribution of coastal assets of local and regional importance
INUNDATION HAZARD ASSESSMENT	
Meteorological drivers (rainfall, winds, storms, weather patterns)	Long-term records and analysis
Topography	Contours information of at least 0.25 m Topographic mapping, LiDAR DEM where available As the storm surge reaches shallow water and the complex nearshore environment, increasingly finer scale data are required
Bathymetry	Recent and high-resolution bathymetric charts derived from bathymetric LiDAR or multibeam hydrographic surveys As the storm surge reaches shallow water and the complex nearshore environment, increasingly finer scale data are required
Storm surge and water level	Historic analysis of storm surge heights associated with extreme weather events to determine ARI
Waves	Projected storm wave heights for specified ARI and wave climate response to sea-level rise; to be accurate, wave datasets should cover a period of longer than 40 years
Hydrology	River flooding hazard maps if available; important for developed low-lying estuarine areas
Sea-level rise scenarios	Projected sea levels for specified climate change scenarios
Coastal assets	Spatial distribution of coastal assets of local and regional importance

Source: Derived from Coastal Focus 2013.

Reference

Coastal Focus, 2013: Data & information gap analysis for coastal hazard & risk management. Gingin Dandaragan Coast (Hill primary coastal compartment). Document prepared for the Northern Agricultural Catchments Council, the Shires of Gingin and the Shire of Dandaragan, 93 pp. Accessed 1 June 2016. [Available online at http://www.nacc.com.au/wp-content/uploads/2015/05/Gingin-Dandaragan-CHRM-Data-Information-Gap-Analysis.pdf.]

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