Draft Coastal Risk Management Guide:

Incorporating sea level rise benchmarks in coastal risk assessments

Department of
Environment, Climate Change and Water NSW

Submissions invited

Please send your submissions by email to coast.flood@environment.nsw.gov.au or posted to:

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1. Introduction

The NSW Government has adopted a Sea Level Rise Policy Statement (NSW Government 2009) to support adaptation to projected sea level rise impacts. The Policy Statement includes sea level rise planning benchmarks for use in assessing the potential impacts of projected sea level rise in coastal areas, including flood risk and coastal hazard assessment.

These benchmarks are a projected rise in sea level (relative to 1990 mean sea level) of 0.4 m by 2050 and 0.9 m by 2100 (DECCW 2009). The projections were derived from sea level rise projections by the Intergovernmental Panel on Climate Change (IPCC) and the CSIRO. These benchmarks will be periodically reviewed.

This Guide has been prepared to assist local councils, the development industry and consultants incorporate the sea level rise benchmarks in coastal hazard assessments. This includes coastal hazard assessments carried out as part of a coastal hazard study during a coastal zone management planning process or for assessing coastal hazard constraints for proposed coastal developments. The information in this guide updates the sea level rise information in the *NSW Coastline Management Manual* (NSW Government 1990). This information may also be useful for planners and designers of coastal infrastructure.

2. Sea level rise impacts in coastal areas

Of all the impacts from climate change, the projected rise in mean sea level is one of the most significant concerns for integrated coastal zone management. In addition to higher projected storm surge and oceanic inundation levels, a rise in mean sea level will also result in complementary recession of unconsolidated (sandy) shorelines.

Depending on the rate and scale of sea level rise, the environmental, social and economic consequences within low lying inter-tidal areas, in particular, are expected to be significant. In addition to open coast recession and higher inundation levels, salt water intrusion and landward advance of tidal limits within estuaries will, amongst other things, have significant implications for freshwater and saltwater ecosystems and development margins, particularly building structures and foundation systems within close proximity to the shoreline. Existing coastal gravity drainage, stormwater infrastructure and sewerage systems may become compromised over time as mean sea level rises. Sea level rise will also influence the entrance opening regimes for intermittently closed and open lakes and lagoons (ICOLLs). The level of protection provided by existing seawalls and other hard engineering structures will decrease over time due to the increasing threat from larger storm surges and inundation at higher projected water levels.

The adaptation to sea level rise will require careful planning and management into the future in order to minimise social, environmental and economic impacts.

Coastal erosion at Belongil Beach, Byron Bay

3. Coastal hazard assessment

The *Coastline Management Manual* (NSW Government 1990) identifies a range of coastal hazards, two of which will be directly exacerbated by sea level rise – shoreline recession and coastal inundation.

Coastal hazard studies or assessments commonly identify hazard limits or hazard lines, which define the estimated extent of land projected to be impacted upon by coastal processes and hazards over a defined coastal planning period. These studies can be used to define coastal hazard planning areas which are used in landuse planning and development assessment. The immediate hazard line represents the estimated landward extent of beach erosion from a design storm event plus any zone of reduced foundation capacity (Nielsen et al. 1992). Additional hazard limits are derived landward of the immediate hazard line to represent the expected beach recession landward over defined planning periods (commonly 50 or 100 years). This is illustrated in Figure 1.

The extent of the calculated recession plus any allowance for reduced foundation capacity can be used as a coastal hazard planning area. The predicted recession to 2100 should normally be the maximum extent of the coastal hazard planning area (the 2100 hazard line shown in Figure 1).

Sea level rise will increase the predicted recession over the adopted planning period, as described in section 4.3, resulting in a landward movement of the hazard lines, as illustrated in Figure 1. Coastal hazard studies should provide coastal hazard lines over the adopted planning period assuming both no sea level rise and incorporating sea level rise projections.

Coastal development at The Entrance

A ‘sea level rise planning area’ is to be defined in coastal hazard studies, for use in land use planning and development assessment. Future studies will therefore need to include 2100 hazard lines based on defining both a ‘coastal hazard planning area’ assuming no sea level rise and defining a 2100 hazard line incorporating sea level rise induced recession using the benchmarks. Both sets of lines will now be required to be determined for planning purposes. This will ensure consistent consideration of sea level rise in coastal hazard assessment for planning purposes.

Past coastal hazard studies have commonly determined 2100 hazard lines incorporating projected sea level rise. Where these studies have used the 2100 sea level rise benchmark, these hazard lines define the landward extent of the 'sea level rise planning area'. Where other sea level rise projections have been used, the hazard lines should be recalculated through a revised hazard definition study.

Coastal inundation assessment should incorporate the increased still water levels resulting from sea level rise projections (see section 4.2).

The *Draft NSW Coastal Planning Guideline – Adapting to Sea Level Rise* (DoP 2009) provides detail about the consideration of this information in land use planning and development assessment.

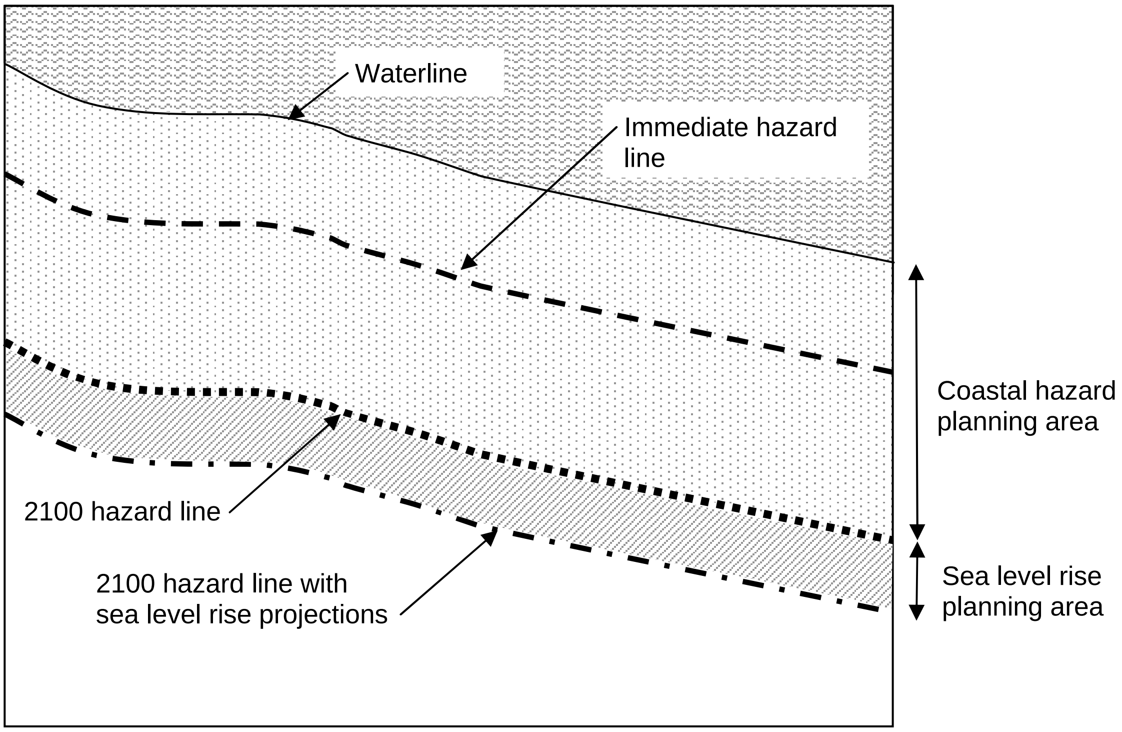

Figure 1 Hazard lines and planning areas

4. Application of sea level rise planning benchmarks

4.1 General

Increasing mean sea level over time will have two primary impacts within and adjacent to tidal waterways:

- increasing still water levels over time, and
- subsequent recession of unconsolidated shorelines.

In circumstances where physical coastal processes and/or the influence of tidal waters are required to be considered, it is recommended that the additional impact of projected sea level rise up to the planning benchmarks be considered. This will enable sea level rise to be appropriately considered in planning decisions, hazard mitigation strategies and infrastructure design.

Seawalls and coastal erosion at Belongil Beach, Byron Bay

Linear interpolation between the 1990 base sea level and the 2050 and 2100 sea level rise benchmarks can be used to estimate projected sea level rise for coastal planning horizons or asset life other than those corresponding to the benchmark years. For consideration of sea level rise beyond 2100, an additional 0.1 m per decade allowance can be used above the 2100 benchmark level. This approach assumes a linear rise beyond 2100 at rates equivalent to that projected for the last decade of the twenty-first century (2090–2100) and is consistent with the approach adopted in New Zealand (Ministry for the Environment 2008).

For practical implementation, the sea level rise benchmarks, which are generally referenced to 1990 mean sea levels, can be broadly related to the Australian Height Datum (AHD). Analysis of hourly water levels at Fort Denison (Sydney Harbour) over the period from January 1989 to December 1990 indicates a mean sea level over this period at approximately 0.060 m AHD.

4.2 Design still water levels

Table 1 provides an estimate of design ocean still water levels for the NSW coastline for varying average recurrence interval (ARI) events for 2050 and 2100 that incorporate provision for sea level rise. It is recommended that these levels be used in the design of maritime structures, determining oceanic inundation/wave runup levels and for oceanic and hydrodynamic modelling processes where full oceanic tidal conditions are expected.

Where tidal conditions less than the oceanic range prevail (e.g. inside constrained estuarine environments), Table 1 does not apply and locally-derived design still water levels would have to be determined on a site-specific basis taking into consideration the sea level rise benchmarks for oceanic conditions.

4.3 Recession of unconsolidated shorelines

It is widely acknowledged that unconsolidated (or erodible) shorelines will recede in response to an incremental rise in mean sea level over time. Bruun (1962, 1988) proposed a simple two-dimensional model to estimate the amount of associated shoreline retreat which can be approximated as the product of the active profile slope and the amount of sea level rise. There are limitations associated with the Bruun Rule for use throughout the coastal zone for determining foreshore recession due to sea level rise (Ranasinghe et al. 2007). Nevertheless, until more sophisticated methodologies are available, the Bruun Rule approach is recommended for estimating the likely width of shoreline recession attributable to sea level rise.


Coastal erosion at Collaroy/Narrabeen beach

For NSW open coast situations, the active profile slope has generally ranged in the order of 1:50 to 1:100. The use of active profile slopes in the Bruun Rule outside this range should be appropriately qualified and explained. There are several theoretical approaches available for determining the likely seaward limit of the active profile for use in establishing the offshore profile slope for the Bruun Rule. The approach proposed by Hallermeier (1981) is recommended in the absence of readily available information on active profile slopes at a location under consideration. Once the active profile slope has been established, the shoreline recession due to sea level rise can be estimated by multiplying this slope by the 2050 and 2100 sea level rise benchmark.

For estuarine foreshores, it is recommended that the recession due to sea level rise can be estimated for planning purposes using the same general approach with relevant average foreshore slopes inferred or estimated from survey information.

Table 1 Design ocean still water levels for 2050 and 2100 incorporating projected sea level rise

ARI (years)	2009 design still water levels 1 (m AHD)	2050 design still water levels 2 (m AHD)	2100 design still water levels 2 (m AHD)
0.02	0.965	1.305	1.805
0.05	1.045	1.385	1.885
0.1	1.095	1.435	1.935
1	1.235	1.575	2.075
10	1.345	1.685	2.185
50	1.415	1.755	2.255
100	1.435	1.775	2.275

Notes:

1. 2009 design still water levels derived from extreme value analysis of Fort Denison tide gauge data from June 1914 to December 2008 (after Watson & 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), but, exclude wave setup and wave runup influences.
2. The design still water levels for 2050 and 2100 incorporating the planning benchmark allowances for sea level rise with a reduction of 60mm to accommodate the estimated amount of global average sea level rise that has occurred between 1990 and present. This is estimated at approximately 3mm/year from satellite altimetry (CSIRO 2009).
3. The design still water levels advised in Table 1 are only relevant where full ocean tide conditions prevail.

Coastal erosion at Old Bar

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Further reading

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Glossary

active profile slope	The slope of the portion of a beach (including the underwater section) which has active sediment movement.
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
coastal inundation	Coastal inundation can refer to two types of phenomenon. Properties immediately fronting the coast can be affected by wave runup. Others in low lying areas adjacent to the coast can be inundated as a result of elevated ocean water levels and overtopping of dunes by wave runup.
sea level rise planning area	The area of land between the 2100 hazard line calculated assuming no sea level rise and the 2100 hazard line calculated using the 2100 sea level rise benchmark.
shoreline recession	A net long term landward movement of the shoreline caused by a net loss in the sediment budget.
storm surge	The increase in coastal water level caused by the effects of storms. Storm surge consists of two components: the increase in water level caused by the reduction in barometric pressure (barometric setup) and the increase in water level caused by the action of wind blowing over the sea surface (wind setup).
still water levels	Average water surface elevation at any instant, excluding local variation due to waves and wave set-up, but including the effects of tides and storm surges.
wave runup	The vertical distance above mean water level reached by the uprush of water from waves across a beach or up a structure.
wave setup	The increase in water level within the surf zone above mean still water level caused by the breaking action of waves.
zone of reduced foundation capacity	Zone located adjacent to and landward of an erosion escarpment in unconsolidated dunal systems where beach erosion events can undermine unprotected structures.