SEA LEVEL RISE AND CLIMATE CHANGE IMPACTS FOR PLANNING A NEW HOSPITAL

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Abstract

A major new hospital is planned for Hobart, Tasmania. The hospital will occupy near-waterfront land which currently operates as a rail yard. Due to the critical nature of the facility and the expected long project life, high values for storm surge, future sea level rise and freeboard were applied as criteria for assessing the suitability of the site and for planning the new hospital. This paper details the methodology used to assess the risk due to sea level rise for the proposed new hospital. Furthermore it describes the limits of existing data in extrapolating to extremely rare events, and how with future sea level rise, what are presently considered to be extremely rare water level events will become commonplace. Adaptive management options for dealing with sea level rise on the site are presented, which includes a recommended freeboard in excess of normal building code requirements.

Key Words: Sea level rise, climate change, hospital, infrastructure, Hobart, Tasmania

Introduction

The Water Research Laboratory (WRL) of the University of New South Wales was commissioned by Pitt & Sherry acting on behalf of the Tasmanian Department of Health and Human Services to investigate extreme event water levels and the effects of climate change for a potential hospital site at Macquarie Point, Hobart, Tasmania. The site is currently a rail yard (Figure 1). An initial feasibility study was undertaken over a short time frame in the early stages of the project planning using preliminary information. The most obvious data found to be lacking was accurate ground levels. Data gaps were filled and a more comprehensive study was undertaken (WRL Technical Report 2007/35, Carley et al, 2007). The detailed study incorporated the following changes over the initial feasibility study:

- Results of a peer review by Worley Parsons (incorporating Patterson Britton and Partners).
- Accurate site topography data.
- More detailed bathymetry.
- A better definition of the site extents.
- A finalised version of the analysis of Hobart tide gauge data from Hunter (2007).
- Analysis of groundwater data collected from the site.

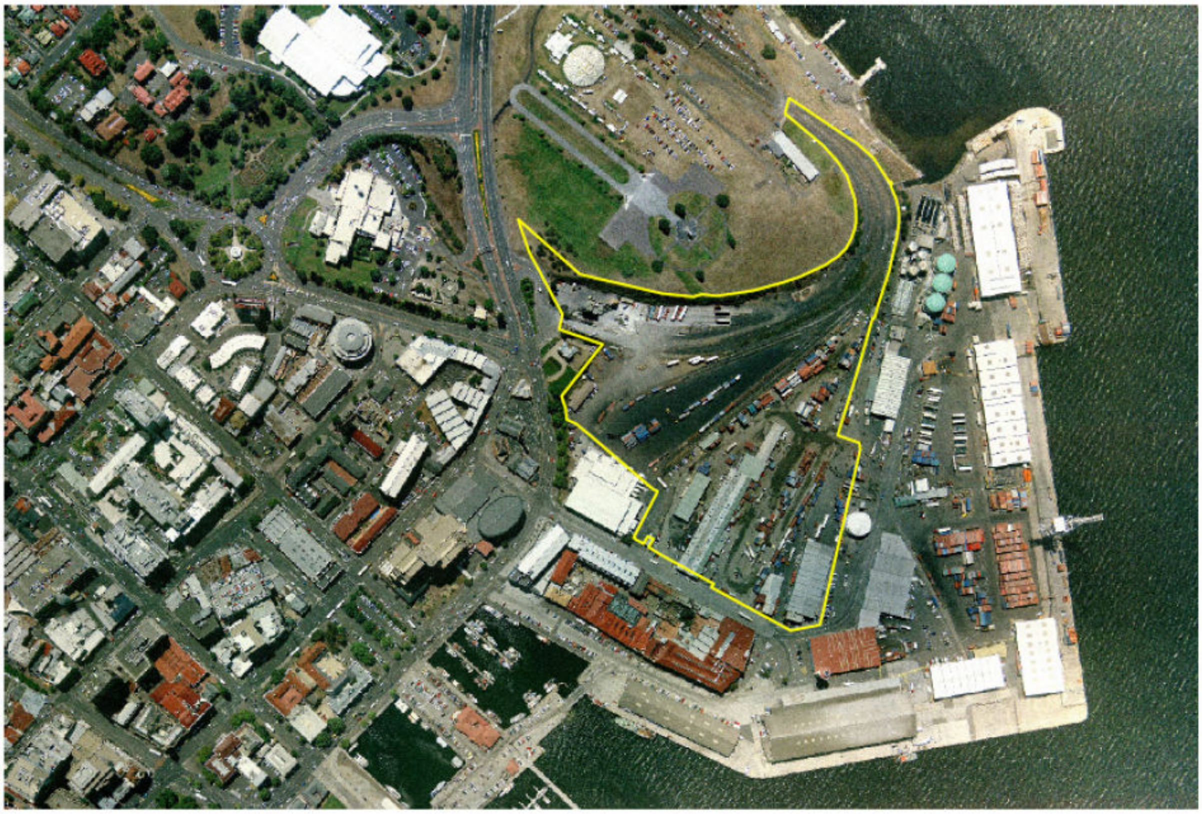

Figure 1: Site Extents

Probability, Planning Period and Foreseeable Events

Most designs in the coastal zone are concerned with a 100 year average recurrence interval (ARI) event, however, this has a 63% chance of being exceeded over a 100 year planning timeframe, so was considered inadequate for a critical facility.

Guidance was sought from the following sources:

- The Delta Committee (1962) from the Netherlands
- AS 4997-2005 Maritime Structures Standard
- Building Code of Australia (2007)
- NSW Floodplain Development Manual (2005)
- Federal Emergency Management Agency FEMA USA (2000)

Much of the literature on extrapolating coastal hazards to extremely rare events relates to nuclear power stations (eg Mai et al, 2002). The summary findings have been developed for a planning period to 2100 and for annual exceedance probabilities for extreme events of 1% (100 year average recurrence interval, ARI), 0.05% (2000 year ARI) and 0.01% (10000 year ARI). The use of a 10000 year ARI event for design, together with a freeboard, would allow for the uncertainty of many of the variables (see below).

Vulnerability of Site

Recent surveys show typical ground levels on the site are 4 to 6 m AHD (Australian Height Datum), and vary between approximately 2.8 and 8.5 m AHD for the section shown. The aerial photos, site survey and a site visit also show that substantial port buildings occupy most of the foreshore surrounding the potential hospital site (Figure 1). These buildings would substantially shelter the potential hospital site from direct wave forces.

Levels at the foreshore (mostly concrete wharf decks) seaward of the hospital site boundaries are typically 3.2 to 3.4 m AHD on the south facing portion, and 2.2 to 2.4 m AHD at the northern end of the eastern foreshore. The hospital site is set back at least 150 m from the south facing foreshore and most of the east facing foreshore, but a small portion is close to the foreshore in the north-east, where it is more sheltered and elevated.

Levels around the cenotaph behind the subject site are much higher at 20.5 to 22.2 m AHD. Chart datum, which is used in bathymetric charts and tidal predictions was changed for Hobart on 1 January 2006. The new Hobart chart datum is approximately -0.83 m AHD. The old Hobart chart datum was approximately -1.20 m AHD.

Climate Change - IPCC Global Sea Level Rise Projections

The following simplified scenarios for global sea level rise were developed from the latest IPCC (2007) publication. More extreme postulations exist, including up to 7 m sea level rise for the total ice melt of Greenland (IPCC, 2007) and 70 m if all the world's ice was to melt (GAGCC, 2006), but even if this did eventuate, the timescale is considered to be millennia. The IPCC publications represent the international consensus position for planning purposes. Uncertainties in future projections are due to both an imperfect understanding of the processes and unknown future global emissions of greenhouse gases.

Table 1: Adopted sea level rise scenarios

Scenario	Year and Sea Level Rise relative to 1990 (m)	
	2050	**2100**
"Mid" scenario	0.2	0.5
"High" scenario	0.4	0.9

Processes Considered in Assessing Inundation Levels

The following processes were considered in assessing the inundation level:

- Sea level rise
- Previous analyses of extreme water levels (Hunter, 2007)
- Barometric setup component of storm surge
- Local wind setup
- Ocean swell waves
- Locally generated wind waves
- Boat waves
- Tsunami
- Quantification of other climate change variables such as wind climate change projections and sensitivity
- Wave setup and wave runup.

An example of SWAN modelling of ocean swell is shown in Figure 2.

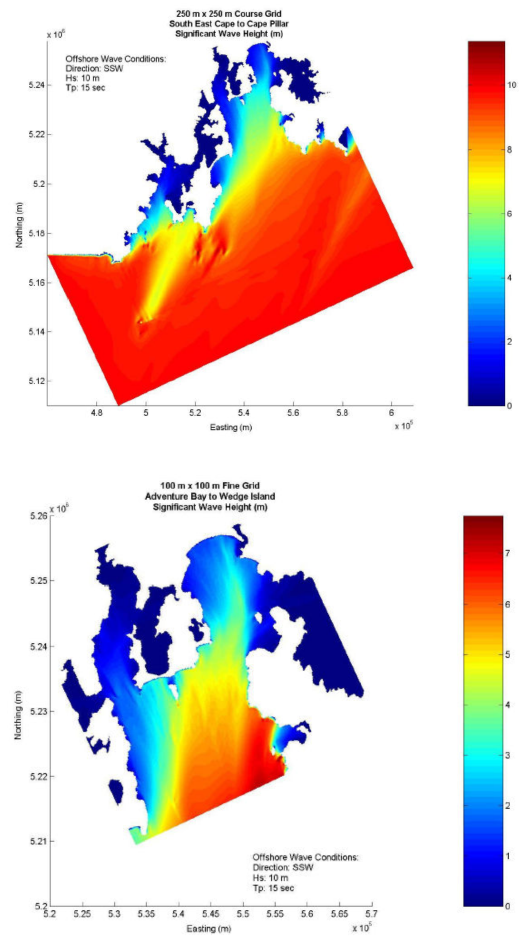

Figure 2: SWAN modelling of ocean swell penetration (250 m grid top, 100 m grid bottom)

Climate Change and Extreme Events - Best Estimate of Inundation Levels

For the mid range sea level rise scenario (0.5 m) in 2100, at highest astronomical tide the water level would be 1.3 m AHD which is below ground levels on the site. Storm surge and wind wave events would elevate the inundation level above this. The duration of the peak of these extreme inundation events would be 1 to 2 hours with the peak of the tide. As the hospital site is generally set back at least 150 m from the exposed south and east foreshores, and is protected by substantial port buildings, the design inundation level need not consider wave runup. The best estimate of extreme water levels derived in this study, including tide, storm surge, global sea level rise (mid scenario) but excluding wave runup are shown in Table 2.

Table 2: Best estimate of inundation levels

ARI (years)	Year and Inundation Level (m AHD)		
	2000	2050	2100
SLR		0.2	0.5
100	1.4	1.6	1.9
2000	1.7	1.9	2.2
10000	1.9	2.1	2.4

Climate Change and Extreme Events - Conservative Estimate of Inundation Levels

For the high range sea level rise scenario (0.9 m) in 2100, at highest astronomical tide the water level would be 1.6 m AHD which is below ground levels on the site. Storm surge and wind wave events would elevate the inundation level above this. The duration of the peak of these extreme inundation events would be 1 to 2 hours with the peak of the tide. As stated above, the hospital site is generally set back at least 150 m from the exposed south and east foreshores, and is protected by substantial port buildings, so the design inundation level need not consider wave runup. The conservative estimate of extreme water levels derived in this study, including tide, storm surge, global sea level rise (mid scenario) but excluding wave runup are shown in Table 3.

Table 3: Conservative estimate of inundation levels

ARI (years)	Year and Inundation Level (m AHD)		
	2000	2050	2100
SLR		0.4	0.9
100	1.4	1.8	2.3
2000	1.7	2.1	2.6
10000	1.9	2.3	2.8

Climate Change – Other Variables

Quantification from the IPCC is available for future sea level rise using a range of scenarios. Good quantification is also available for temperature. Within the resolution of current modelling, future changes to temperature, radiation and rainfall are not able to be differentiated between different sites in greater Hobart. Limited information is available regarding future change to extreme wind speeds (CSIRO, 2007) and generally relates to north-west to south-west winds, which are the most severe for Hobart. The site is most exposed to south-east winds. Limited sensitivity testing of future extreme wind projections was undertaken and found that the effect on inundation levels was minor and well within the freeboard suggested below.

Extreme Events - Tsunami

Detailed modelling is being undertaken by Emergency Services Tasmania and Geoscience Australia. No quantification has been provided in this paper. Approximately 47 tsunami events have been catalogued for Australia since 1858. The maximum tsunami runup reported in eastern Australia has been approximately 2 m. Evidence exists for past mega-tsunami and paleo-tsunami, but there is disagreement on the frequency and risk of these among experts in this field.

Site Preparation Works and Design Considerations - Adaptation Options

Most of the potential hospital site is above the inundation levels detailed above (Figure 3). It is recommended that an appropriate freeboard of at least 0.5 to 1 m be set over the design water level at the detailed design stage of this project to cover uncertainty in climate change and other variables. Should the lower portions of the site be utilised, a building can be built on ground below the inundation and/or wave runup level provided it is engineered to withstand the wave and/or hydrostatic forces. In the case of the proposed hospital, it must also be engineered to remain operational. Potential engineering solutions include designing a suitably strong structure, water resistant materials, elevating key components, a suitable seawall and suitable drainage which may include pumps at low levels. The potential hospital site has a typical setback to the waterfront of approximately 150 m on the exposed south and east shorelines. Protection from wind and swell wave impacts for the hospital site is premised on this setback being preserved by the continued presence of the port structures.

In addition to the use of freeboard, detailed design of the hospital should consider design options which may provide protection for design of events larger than those considered in this study.

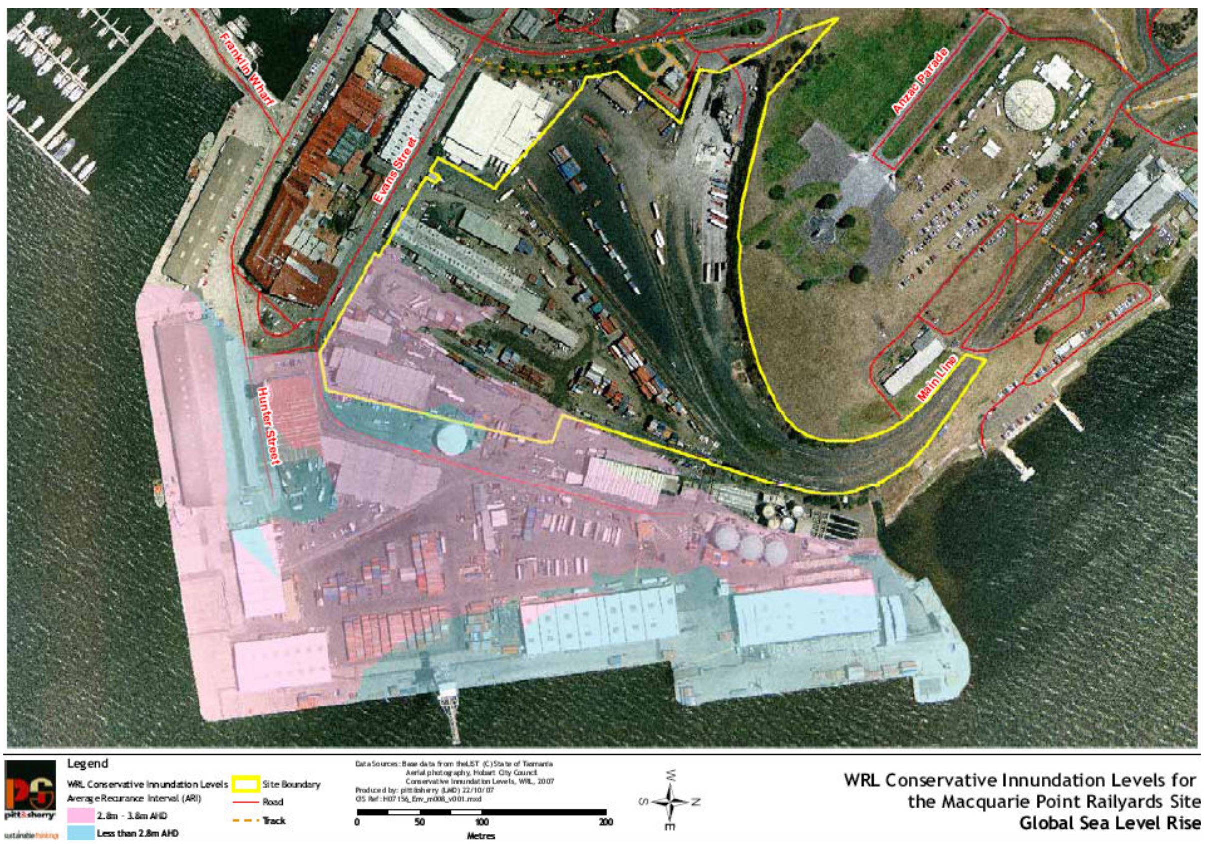

Figure 3: Likely extents of site inundation for conservative scenario

Conclusion

A major new hospital is planned for Hobart, Tasmania. The hospital will occupy near-waterfront land which currently operates as a rail yard. Due to the critical nature of the facility and the expected long project life, high values for storm surge, future sea level rise and freeboard were applied as criteria for assessing the suitability of the site and for planning the new hospital.

The summary findings have been developed for a planning period to 2100 and for annual exceedance probabilities for extreme events of 1% (100 year average recurrence interval, ARI), 0.05% (2000 year ARI) and 0.01% (10000 year ARI). The use of a 10000 year ARI event for design, together with a freeboard, would allow for the uncertainty of many of the variables.

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