NSW King Tide Photo Event Summary 2009

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ABSTRACT: The summer king tide forecast for 12 January was predicted to be the largest tide visible during daylight hours along the NSW coastline in 2009. This presented a wonderful opportunity for the NSW Department of Environment and Climate Change to launch a rather simple, though unique initiative to engage the broad community in photographing the peak of the king tide throughout the coastal zone.

The event was organised with two primary objectives in mind. Firstly, to engage the public in identifying areas currently vulnerable to tidal inundation state-wide and secondly, to raise community awareness about the current projections for sea level rise to the end of the century (approximately 90cm). The major take home message for the community monitoring the peak of the king tide was that all tide levels reached could well be 90cm higher by the end of the century. Alternatively, rare tidal water levels in 2009, such as king tide levels, are likely to be relatively common water levels by 2100.

The response from the broader community and the media was overwhelming. Over 4000 images from more than 250 photographers state-wide were captured around the peak of the high tide, covering areas along the open coast and within the estuarine margins of the state. The breakdown of participation was broad and varied including: staff from a range of State Government Agencies, Local Government Authorities, Catchment Management Authorities, volunteers from the State Emergency Service, local environmental groups, beachfront and waterfront property owners and a large contingent of the broader community. The event was so successful that the Commonwealth and other State Governments are looking at expanding the initiative on a national scale for 2010.

This paper will document the photographic exercise, the impacts highlighted by the state-wide imagery, processes by which the NSW Government will make the information collated available to the public and discuss future directions for improving the initiative.

1. INTRODUCTION

The coastal zone of NSW is a precious natural asset, home to a significant portion of the NSW population, the central drawcard of the NSW tourism industry and the peak economic margin in the country.

Within this area, the ever changing nature of the ocean tides, associated physical processes and the prospect of climate change driven sea level rise present significant challenges for coastal zone managers and the community alike.

The summer king tide forecast for 12 January was predicted to be the largest tide visible during daylight hours along the NSW coastline in 2009. This presented a wonderful opportunity to launch a rather simple, though unique, initiative to engage the broad community in photographing the peak of the king tide throughout the coastal zone with two primary objectives in mind:

- identify areas vulnerable to tidal inundation state-wide, capturing the tide level against revetments, seawalls, jetties and other marine infrastructure; and
- raise awareness throughout the wider community about the current projections for sea level rise to the end of the century (approximately 90cm). The major take home message for the community monitoring the peak of the king tide was that all tide levels reached could well be 90cm deeper with seawater by the end of the century. Alternatively, rare (“king”) tide water levels in 2009 are likely to be relatively common water levels by 2100.

2. EVENT CONDITIONS ON 12 JANUARY 2009

The prevailing weather conditions along the NSW coastline during the event were predominantly warm and sunny with low wind. Offshore wave heights varied along the coastline, but, were generally in the range of 1-1.5m significant wave height.

The Fort Denison tide gauge facility measured a peak water level of 1.96m above Tide Gauge Zero (TGZ) which equates to 1.035m AHD at 0850hrs EST. The peak water level measured was some 9cm lower than the predicted 2.05m. Based on analysis of the measured long-term data from Fort Denison, a water level of 1.96m above TGZ would be expected to be reached on average for approximately 22 hours per year. The predicted peak of 2.05m above TGZ would only be expected to be reached on average for 6.5 hours per year.

One of the primary reasons the measured tide was lower than the predicted tide at most locations within the NSW ocean water level recording network was due to the influence of a large high pressure system dominating much of the NSW coastline at the time of the king tide (refer Figure 2.1) which has the effect of depressing coastal sea levels.

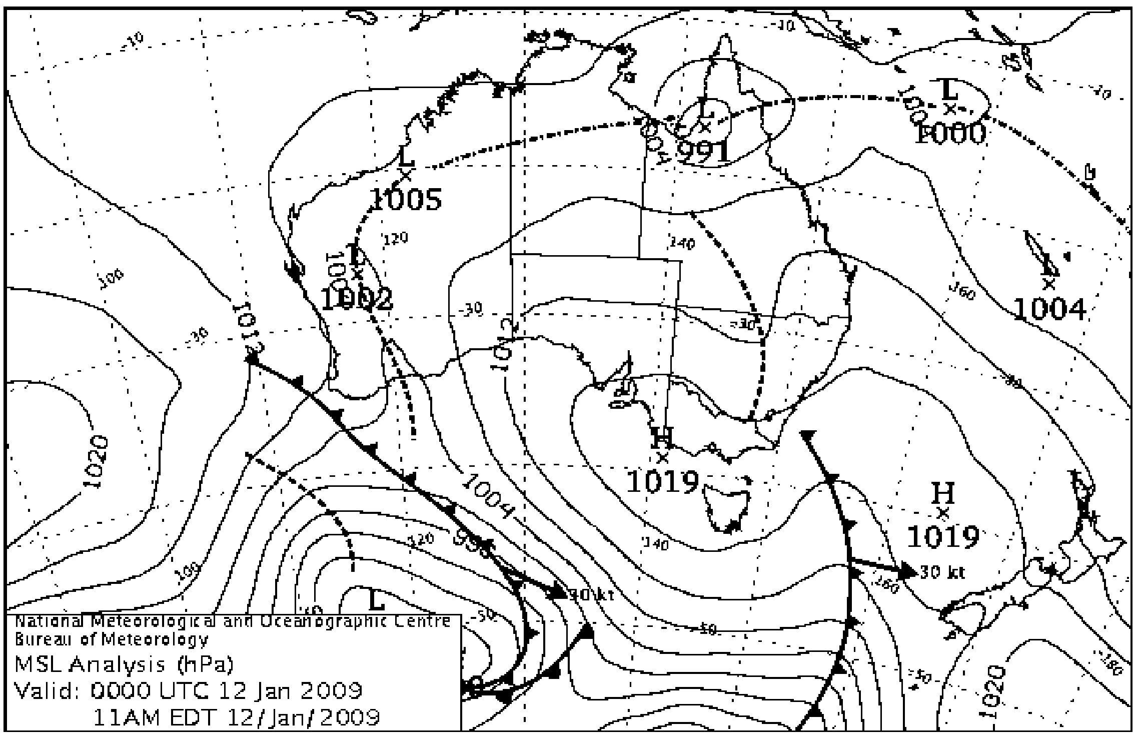

Figure 2.1 Synoptic Chart for 11AM EDT 12 January 2009 (Courtesy Bureau of Meteorology)

3. EXTENT OF COMMUNITY INVOLVEMENT AND PHOTO COVERAGE

The idea to photograph impacts from the king tide event was initially canvassed only six weeks prior to the event with the idea that we might be successful in covering some high priority sites. However, the sophistication and enthusiasm of the “coastal” community in NSW rapidly turned the exercise into a state-wide initiative.

Over 4000 images from more than 250 photographers state-wide were captured around the peak of the high tide, covering areas along the open coast and within the estuarine margins of the state. The breakdown of participation was broad and varied including: staff from a range of State Government Agencies, Local Government Authorities, Catchment Management Authorities, Manly Hydraulics Laboratory, Water Research Laboratory, volunteers from the State Emergency Service, local environmental groups, beachfront and waterfront property owners and a large contingent of the broader community.

The Department of Lands arranged for aerial photography around the high tide at selected priority locations to augment the on-ground coverage. In addition, beach imagery from the monitoring network of Coastalwatch cameras was also made available to DECCW to assist with this unique state-wide photographic exercise.

There was naturally a heavy concentration of photographic coverage in the Sydney Harbour basin, but, interestingly, the state-wide coverage was also significant in known vulnerable areas (refer Appendix C).

4. IMPACTS HIGHLIGHTED BY STATE-WIDE IMAGERY

The extensive photo imagery state-wide, pictorially captured the extent of threats from tidal inundation on the king tide, identifying many areas and assets that will become progressively more vulnerable over time as sea level continues to rise. Appendix A contains a brief sample of the photos received. The photographs of the peak of the king tide on 12 January 2009, highlighted the following key issues:

- ❒ localised tidal inundation penetrating through stormwater systems to impact upon private property, public reserves and local road networks;
- ❒ limited clearance between the peak water level and the crest of revetments and seawalls currently protecting waterfront properties, commercial precincts, public reserves and significant public infrastructure;
- ❒ widespread submergence of gravity stormwater drainage systems, fixed jetty and wharfage infrastructure, as well as public walkways, boardwalks, bicycle paths and carparks situated around the intertidal foreshores of the states estuaries;
- ❒ substantial narrowing of useable beach widths state-wide;
- ❒ overtopping of beach berm barriers where intermittently open and closed lakes and lagoons (ICOLLs) are currently closed to the sea;
- ❒ increased tidal currents within estuaries and larger rip systems on open coast beaches;
- ❒ inundation and destruction of nesting within endangered bird roosting sites (such as little terns);
- ❒ immediate threat to indigenous cultural heritage sites such as middens located with close proximity to intertidal margins;
- ❒ widespread proximity of tidal waters to sewer pump stations and associated rising main infrastructure;
- ❒ floor levels of numerous commercial premises and dwelling structures within 50cm of the king tide level around the state's harbour and estuarine foreshores; and
- ❒ wave action submerging and overtopping numerous public ocean bath facilities.

5. FUTURE DIRECTIONS

Despite the short lead in time to organise the state-wide photo event, the substantial level of engagement by the community, local councils and government agencies, coupled with the high level of media interest, clearly demonstrate the broad value of this inaugural initiative.

Although the peak water levels recorded on 12 January 2009 fell short of the predicted astronomical tide, the high water levels still exposed numerous areas vulnerable to tidal inundation state-wide. The images depicted in Appendix A provide coastal zone managers and the community with a broad pictorial insight into the scale and type of current vulnerabilities and the challenges that lie ahead in managing sea level rise. Notwithstanding the success of the exercise, there are clear opportunities to build on the information obtained, including the facilitation of the following forward directions:

- **Establishment of a general database of images collected linked to a GIS platform that is made available as a public portal for coastal zone managers.** DECCW are currently investigating the feasibility of facilitating such a portal through its website.

- **Targeting further future photo events of king tides in areas that were not covered during the 2009 exercise.** Although the public response was tremendous, the short lead in time to arrange the initiative inevitably meant that key areas of the state might have been missed the first time around. Indeed, whilst certain areas around the Sydney Basin and Central Coast were covered extensively, the coverage state-wide was mixed, with the lower and mid-north coast and far south coast experiencing comparatively lower coverage. Similarly, the coverage of various tidal waterways around the major river systems of the state was inconsistent.

- **Co-ordinated state-wide organisation.** Improved coverage could be achieved through the early co-ordinated engagement with all NSW Coastal Councils and Catchment Management Authorities.

- **National Coverage.** During the short lead in to the January photo event, DECCW were contacted by numerous members of the community in other states wishing to participate. It is clear that the benefits of the NSW initiative have equal value elsewhere, presenting an opportunity to progress similar, co-ordinated exercises in each of the other states which would provide a pictorial library of key vulnerabilities from a national perspective.

- **Use of measuring sticks to highlight visually the threat from projected sea level rise.** Future king tide photographic exercises would present a more powerful message if standardised measuring sticks depicting the height of projected sea level rise to the end of the century were employed.

- **Establish a network of photographic volunteers.** A state-wide core of volunteers involved in the king tide photo event could provide an ideal network that could be called upon at short notice to capture unusual events such as extreme beach erosion or inundation events.

6. CONCLUSIONS

The king tide photo event proved successful in engaging over 250 people capturing over 4000 images to provide a broad state-wide snapshot of areas and built assets currently vulnerable to the threat of tidal inundation.

In addition to capturing a wide pictorial library of images highlighting key vulnerabilities, the event was specifically tailored to raise public awareness about the additional threat from projected sea level rise into the future. The consensus of scientific information available at present, indicate the upper range of sea level rise projections could be of the order of close to a metre by the end of the century without significant greenhouse gas mitigation.

The summer king tide is the largest predicted tide for the year which would be visible during daylight hours. By photographing the king tide, the public were able to gain an understanding of how a relatively rare water level today could be quite common by the end of the century if sea level rise projections of the order of 90cm prove correct. For example, the 1.96m peak water level (above TGZ) recorded during the king tide event at Fort Denison is only reached or exceeded for approximately 22 hours per year at present. By the end of the century, assuming 90cm of sea level rise, a 1.96m water level could be reached or exceeded approximately 39% of the time, or alternatively, a total of almost 4.7 months per year.

Those taking part in photographing the peak of the king tide in their local areas had the opportunity to visualise the direct impacts of water levels being 90cm deeper by 2100.

Clearly the issue of planning to combat or accommodate sea level rise in coastal communities will present complex challenges for local communities and all spheres of government. The information gleaned from the king tide photo event provides a very valuable repository of catalogued images that provide a clear visual perspective on the many current threats and vulnerabilities posed by tidal inundation (refer Section 4) which will all be exacerbated by sea level rise.

The public engagement and media interest concerning this photographic initiative demonstrates the keen interest within the community regarding coastal zone management issues. This initial exercise provides a solid foundation upon which to build further initiatives (refer Section 5) and DECCW warmly commends the effort and enthusiasm of all the individuals and groups that volunteered their time to take part in this inaugural exercise.

7. ACKNOWLEDGEMENTS

DECCW would like to acknowledge the contributions from all photographers who kindly donated their time to capturing images of the peak of the high tide in their local areas. DECCW would also like to acknowledge the significant contributions from a range of parties that made the co-ordination of the project, acquisition of data and preparation of associated technical material possible, including: Dr John Church (CSIRO); Dr Kathleen McInnes (CSIRO); Dr Bill Mitchell (National Tidal Centre); Sarah Hesse (MHL); Matthew Smith (MHL); Gary Batman (Sydney Ports Corporation); Tony Nusco (Sydney Ports Corporation); Geoff Withycombe (Sydney Coastal Councils Group); and Chris Tola (Coastalwatch).

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APPENDIX A

Selected Photos King Tide Event
12 January 2009

In viewing the images from the King Tide event you are reminded that the water level depicted is currently exceeded for only about 22 hours per year (based on long-term data from Fort Denison). However, by the end of the century, assuming 90cm of sea level rise, the depicted water levels could be reached or exceeded approximately 39% of the time, or alternatively, a total of almost 4.7 months per year.

Similarly, all readers have the opportunity to visualise the impacts of tidal water levels which are projected to be up to 90cm deeper by 2100.

Figure A1. Submerged boardwalk at Ukerabah historic site, Tweed Heads. Photo: Lance Tarvey, DECCW.

Figure A2. Submergence of beach and public access at Manfred Street, Belongil Beach, Byron Bay. Photo: Ben Fitzgibbon, Byron Shire Council.

Figure A3. Tidal waters of the Richmond River penetrating back up through the stormwater system at Tamar Street, Ballina. Photo: Ballina Shire Council.

Figure A4. Tidal waters of the Wooli Wooli River penetrating into the rear of the Wooli Kiosk, River Street, Wooli. Photo: Wayne Jubb.

Figure A5. Tidal waters lapping at ground floor level of commercial premises, Coffs Creek, Coffs Harbour. Photo: Martin Rose, Coffs Harbour City Council.

Figure A6. Tidal waters lapping at the ground floor level of the Boat Shed Café, Tea Gardens, Myall River. Photo: Kevin Haskew.

Figure A7. Limited freeboard to crest of foreshore revetment along Brisbane Water Drive, Tascott, Brisbane Water. Photo: Phil Watson, DECCW.

Figure A8. Limited freeboard to floor levels at Pretty Beach, Brisbane Water, Central Coast. Photo: Fiona Lambell.

Figure A9. Wave action submerging Bilgola Ocean Baths.
Photo: Peter Marshall.

Figure A10. Significant reduction in beach width and public access at Southern end of Manly Beach. Photo: Rafiqul Islam, Manly Council.

Figure A11. Limited freeboard to crest of foreshore revetment structures at Kirribilli Point, Sydney Harbour. Photo: Adrian Turnbull, North Sydney Council.

Figure A12. Limited freeboard to hardstand walking areas at Harbourside, Darling Harbour. Photo: John Gan.

Figure A13. Wave action submerging Bondi Ocean Baths.
Photo: Dennis Gray.

Figure A14. Tidal waters lapping at the top of the foreshore revetment at the end of Bay Street, Double Bay, Sydney Harbour. Photo: Craig Morrison, Sydney Coastal Councils Group.

Figure A15. Limited clearance to top of seawall along foreshore at Batemans Bay, CBD. Photo: Lindsay Usher and Norm Lenehan, Eurobodalla Shire Council.

APPENDIX B

Background Technical Information on Ocean Water Levels and Tides

B. OCEAN WATER LEVELS AND TIDES

B1. Introduction
Ocean water levels are one of the key factors governing the vulnerability of coastal margins. At any given time, ocean water levels are continually influenced by meteorological (eg. winds, barometric pressure, El Niño and La Niña episodes) and oceanographic processes (eg. waves, currents) superimposed on the prevailing astronomical tide.

During extreme ocean storm events, the combined influences of weather systems, tides and waves have resulted in wave runup on exposed ocean beaches measured as high as 7 metres above mean sea level at isolated locations. Inside estuaries, where ocean wave penetration is limited, water levels are comparatively lower, governed generally by meteorological conditions, local wind driven waves and the prevailing tide.

It is important to understand the contributions of each of these components (particularly during extreme oceanic storm events) in order to assess probable inundation levels for design, planning and management purposes.

In addition to these identified components contributing to elevated ocean water levels, currently measured and projected climate change induced sea level rise will have a significant bearing on design ocean water levels over future planning horizons.

B2. Astronomical Tides
The astronomical tide component of a given ocean water level is based primarily on the combined influences of the Sun and the Moon and their position relative to the Earth at a given point in time. The tide is in effect a very long period wave governed by the complex range of gravitational forces applied by the Moon and Sun which are also modified by the motion of the Earth. The Moon, with a gravitational influence almost twice that of the Sun, is the primary factor controlling the temporal rhythm and height of the tide.

The NSW coastal zone experiences semi-diurnal tides, which consist of two high and two low tides daily. A tidal cycle (high-low-high or low-high-low) takes approximately 12 hours and 25 minutes. A tidal day therefore is approximately 24 hours and 50 minutes. The reason the tidal day is longer than 24 hours is that the Moon orbits the Earth in the same direction that the Earth spins and whilst the Earth takes 24 hours to complete a full rotation, the Moon has moved slightly along its orbit. Thus the Earth has to spin a little further (for 50 minutes) before the same location on the Earth faces the Moon again. For this reason, the same tidal phase (eg. peak high tide) occurs 50 minutes later each day (MetEd, 2006).

The larger or “spring” tidal range (generally 1.8 to 2.2m) occurs every 14.5 days when the Moon is either full (or new) and results from the Sun, Earth and Moon falling into alignment, therefore combining their respective gravitational attractions on the ocean water surface.

B3. “King Tide” Phenomena
The term “king” tide has no particular scientific meaning, rather it is a common term coined to describe the highest “spring” tide. Whilst spring tides occur every 14.5 days on the full or new phases of the Moon, orbits of the Moon around the Earth and the Earth around the Sun, result in distinctly seasonal variations to the spring tide range.

The Moon has a slightly elliptical orbit around the Earth and therefore is closer to the earth at certain times, increasing the gravitational attraction on the ocean water surface as a result. Similarly, the Earth follows an elliptical orbit around the Sun being closer during the southern summer and farthest away during winter, creating distinct seasonal variations in the gravitational pull on the ocean water surface.

The spring tide ranges peak during the months of December, January and February and also during June, July and August. The highest spring tide occurring on the new or full moon during these seasons is colloquially termed the “king” tide. During the summer months the high spring tides occur during daylight hours whilst during the winter months, the high springs occur at night. For NSW, the predicted astronomical peak spring tide (or “king” tide) is usually higher than 2m above Tide Gauge Zero (TGZ) at Fort Denison (or 1.08m AHD).

The respective elliptical orbits of the Moon around the Earth and the Earth around the Sun are continually changing. As a result, the full cycle of principal tide producing forces (also known as a “tidal epoch”) is considered to be about 18.6 years. The current tidal epoch extends from 1992 to 2011. The Highest Astronomical Tide (HAT) predicted during this epoch at Fort Denison in Sydney is 2.08m above TGZ (1.155m AHD) which was predicted to occur on 4 June 2008 at 2038 hrs EST.

B4. Tidal Predictions

Tidal predictions are undertaken at over 90 locations around Australia by the National Tidal Centre (Bureau of Meteorology). Mathematical techniques involving the harmonic analysis of water levels observed over a sufficient length of time can isolate contributions from the various interactions between the Sun, Earth and Moon. The contributions from each particular process or gravitational interaction are known as tidal constituents, and each particular location on the planet will have site specific constituents including:

- M2 (accounts for gravitational and centrifugal forces caused by rotation of the Earth-Moon system);
- S2 (contribution from the Sun’s gravitational pull);
- K1, O1, P1 (account for declination changes in the Earth-Moon-Sun plane); and
- Numerous additional progressively weaker, astronomical constituents.

The National Tidal Centre consider some 114 tidal constituents when deriving predicted tides at specific locations around the Australian mainland. All tidal predictions are based on the tidal constituents, assuming central atmospheric pressure (1013 hPa) at mean sea level and exclude the influence of wave activity. By consequence, local meteorological and weather related phenomena can substantially impact on water levels resulting in measured still water levels (excluding wave impacts) that, depending on the nature of the local impacts, could differ from the predicted tide by as much as +60cm or -20cm.

A tidal anomaly is referred to as the difference between the measured ocean water level and the predicted tide.The tide gauge facility on Fort Denison has been recording ocean water levels since 1866 and is the longest continuous record of ocean water levels in NSW (Hamon, 1987). Based on analysis of water levels from Fort Denison spanning the timeframe 1914 to present, the largest tidal anomaly measured is 59cm and was recorded on 26 May 1974 during the most significant oceanic storm event on the historical record (MHL, 1997). Over this timeframe some 96.8% of the measured anomalies fall within the bandwidth between -10cm and +20cm (MHL, 2009). Typical processes and phenomena which can alter ocean waters relative to the predicted tide include: barometric pressure, winds, waves, El Niño-Southern Oscillation (ENSO), ocean currents and temperatures, coastal trapped waves and harbour seiching.

APPENDIX C

State-wide Photographic Coverage

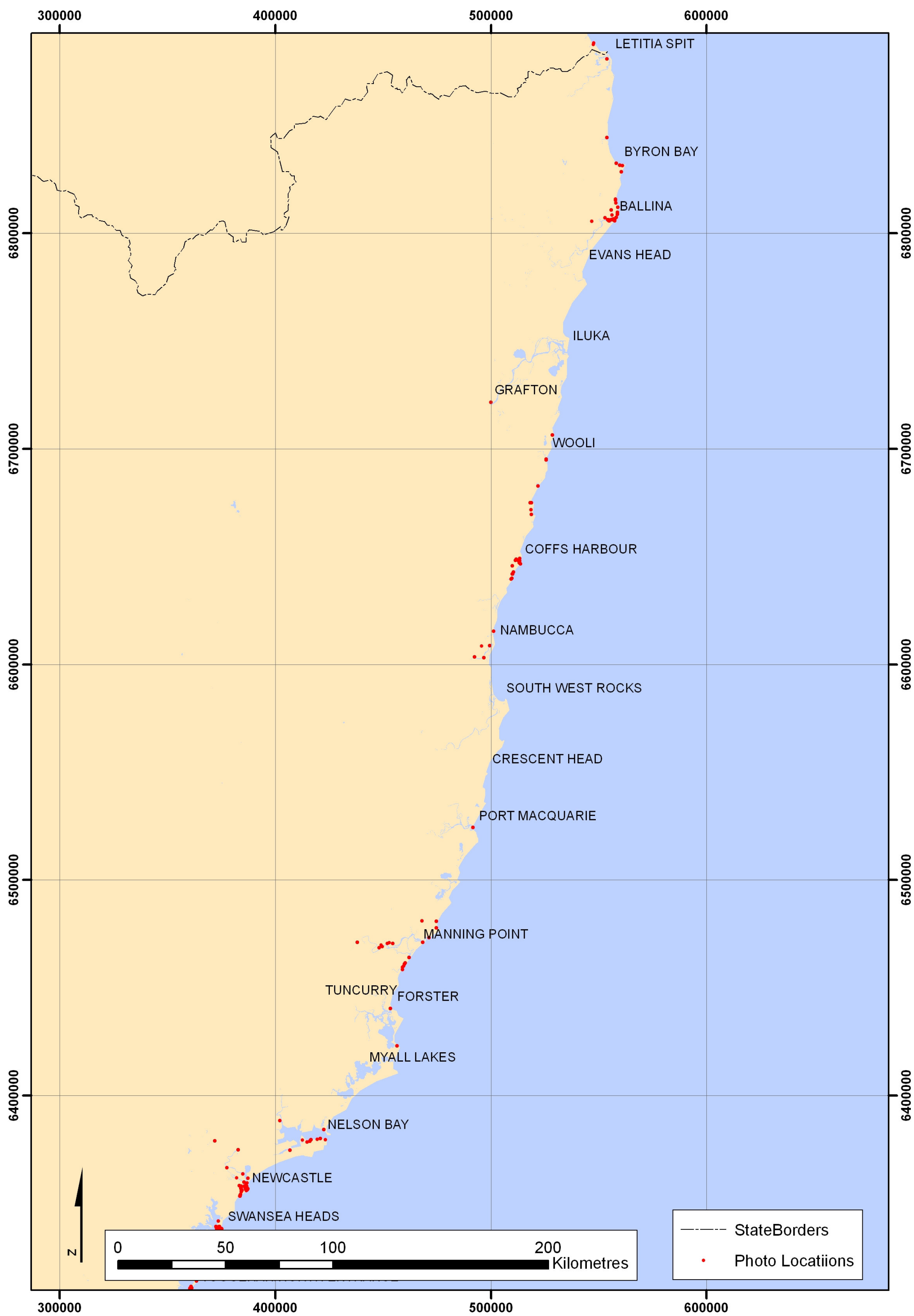

Figure C1. North Coast photographic coverage.

Notes: Grid co-ordinate system is Map Grid of Australia (MGA).

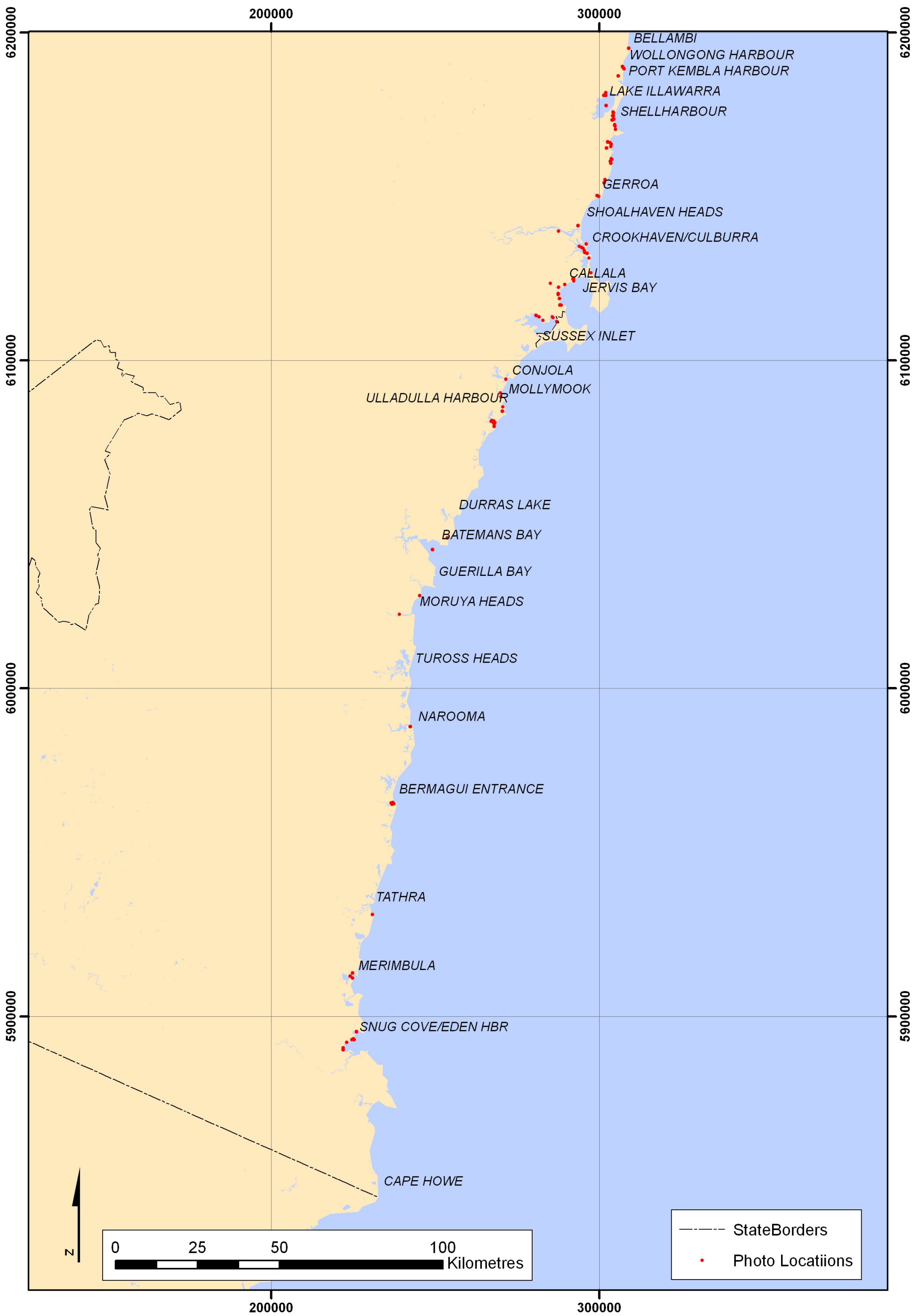

Figure C2. South Coast photographic coverage.

Notes: Grid co-ordinate system is Map Grid of Australia (MGA).

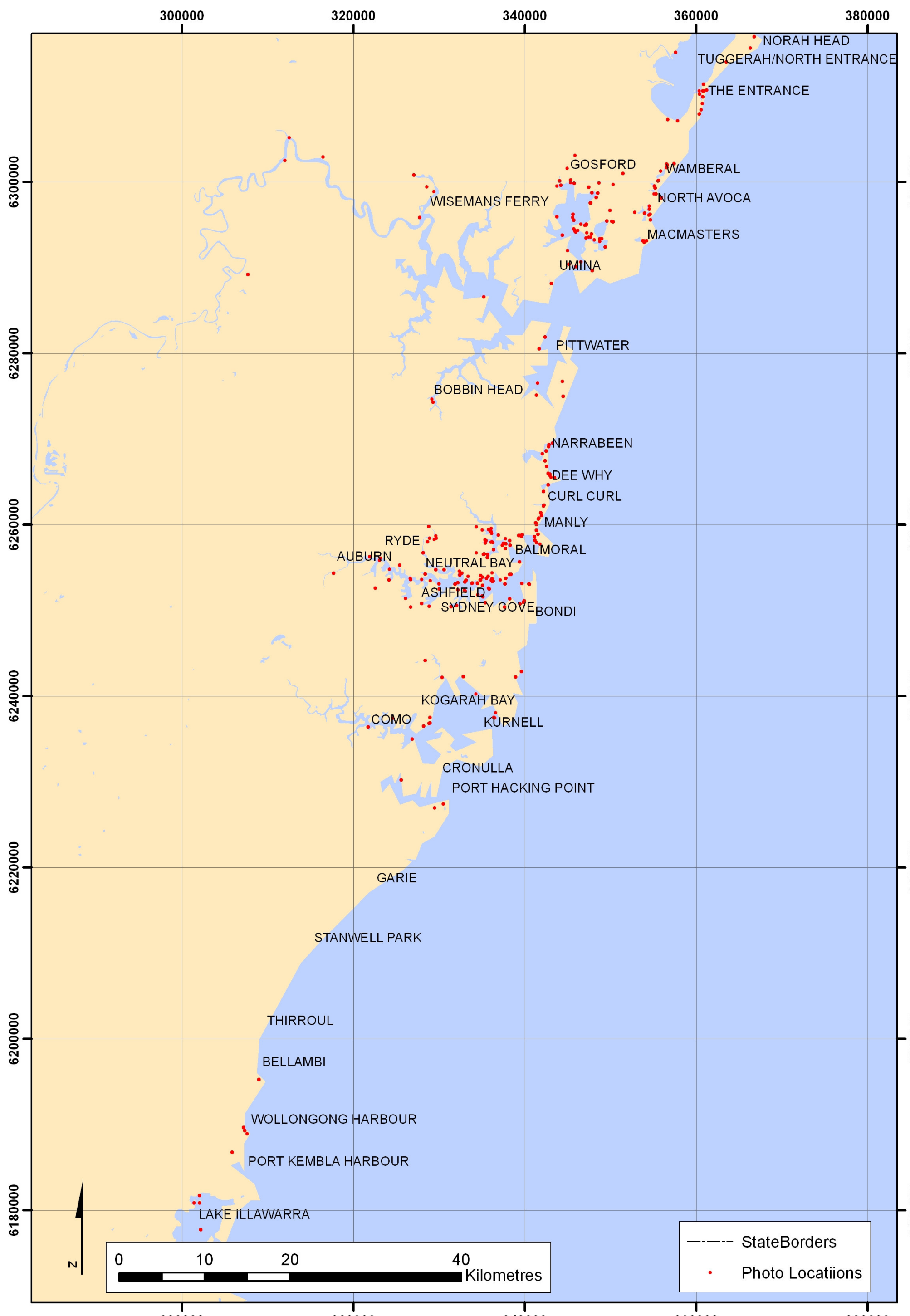

Figure C3. Greater Metropolitan Region of Sydney photographic coverage.

Notes: Grid co-ordinate system is Map Grid of Australia (MGA).