Blacksmiths Beach surf amenity assessment

By C D Drummond, J T Carley, K Vos and D Lanceman

WRL TR 2020/14, April 2020

UNSW Water Research Laboratory

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Executive summary

Overview

Blacksmiths Beach has a long surfing history, surfing heritage and surfing culture. Swansea-Belmont Surf Life Saving Club (SLSC) was formed in 1927 and the Nine Mile Beach Surfboard Club was formed in 1965.

Long-term surfers at Blacksmiths Beach NSW have reported a decline in surf quality, leading to the creation of the community group “Bring Blacksmiths Back”. Lake Macquarie City Council (Council) has developed a Coastal Zone Management Plan (CZMP) for its open coast, and is transitioning this into a Coastal Management Program (CMP). Council is seeking to examine changes in surf amenity over time, explore reasons for changes, and potential options to manage its future, with the aim to incorporate surfing amenity into the CMP.

Changes to beach and surf

An abbreviated list of points made by individuals includes:

- There were previously up to 17 named surf breaks between Awabakal Street and the breakwater. The sand profile underwater has steepened resulting in more of a shore break. The northern side of the breakwater in particular has deepened;
- The steep dune face also means that lifeguard/life saver access alongshore is sometimes not possible at high tide, compromising rapid response for rescues;
- The sand dunes also provide protection to the Blacksmiths settlement from storm erosion, wave runup, coastal recession and future sea level rise. Blacksmiths and the present surf club may be vulnerable to future sea level rise and extreme storm events, with wave overtopping of the dunes reported during previous major storms;
- “Bring Blacksmiths Back” want to restore surfing amenity as a gift/legacy to present and future generations.

Possible causes of change

Changes to surfing conditions may have eventuated due to changes in the cross shore profile (steepness), three dimensionality of breaking waves (banks and breakwater effects) or changes to the wave climate.

The report examines the plausibility of various factors which could change surfing conditions at Blacksmiths. These include:

- Channel adjustment to breakwater construction 130 years ago;
- Beach adjustment to breakwater construction 130 years ago;
- Beach adjustment to recent works to breakwater;
- Ongoing evolution of the beach after 6,000 years of steady sea level;
- Winnowing of fine sand through wave action;
- Porosity of breakwaters;

- Abrasion of sand grains, changes to shell production and content;
- Removal of heavy metals due to mining;
- Subsidence due to mining;
- Dune growth and/or dune vegetation;
- Sea level rise;
- Medium to long term wave climate changes;
- Rainfall.

With the entrance works (training walls and breakwaters) constructed from 1878, studies indicate that the system is still evolving and even without future climate change, may take 350 to 600 years to reach a stable equilibrium.

Options for improvement to surfing conditions and beach access

Short term options

For improved alongshore access, steep dune scarps can be reprofiled to a nominal angle of 34° (range 25° to 40°). Subject to ecological and botanical expertise, vegetation of the seaward portion of the dunes should consider low density species.

Dune cross section and planform designs are needed for this.

The following additional short term studies would improve the understanding of recent and longer term change:

- Collation of historic bathymetric studies;
- Analysis of historic bathymetric studies to examine nearshore change;
- Collection of additional bathymetric data.

Medium term options

The following medium term studies and actions are available to further understand or improve surfing amenity at Blacksmiths:

- Investigate the feasibility of a sand slug configuration placement for future dredging campaigns;
- If feasible, undertake monitored trial(s) of configuration placement of sand slugs as sand becomes available, including:
    - Bathymetric surveys;
    - Smart cameras;
    - Trial of drone based bathymetry monitoring;
    - Interviews with stakeholders;
    - Ongoing monitoring and analysis of beach change.

Long term Options

Subject to the monitored trials, the following options may enhance surfing amenity over the long term:

- Consider the development of a concept design for a sand transfer scheme;
- Consider surfing amenity in any breakwater alterations, which could arise due to damage, repairs or upgrade of the breakwater, noting that it is presently unlikely that removal (partial or complete) of the breakwater would be acceptable to the broader community;
- Integrate surf amenity into a Coastal Management Program, including synergies with other objectives, such as managing other coastal hazards.

Smart camera

As part of this project, a smart camera was installed on the lifeguard tower at Blacksmiths to quantify beach use with the development of machine learning techniques to count people in the camera images. The camera was initiated as part of this project, but has been integrated and further developed within the Smart Beaches project.

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1 Introduction

Blacksmiths Beach has a long surfing history, surfing heritage and surfing culture. Swansea-Belmont Surf Life Saving Club (SLSC) was formed in 1927 and the Nine Mile Beach Surfboard Club was formed in 1965.

Long-term surfers at Blacksmiths Beach NSW have reported a decline in surf quality, leading to the creation of the community group “Bring Blacksmiths Back”. Lake Macquarie City Council (Council) has developed a Coastal Zone Management Plan (CZMP) for its open coast, and is transitioning this into a Coastal Management Program (CMP). Council is seeking to examine changes in surf amenity over time, explore reasons for changes, and potential options to manage its future, with the aim to incorporate surfing amenity into the CMP.

The Water Research Laboratory (WRL) of the School of Civil and Environmental Engineering at UNSW Sydney was engaged by Council to undertake a surf amenity assessment.

The following tasks were completed:

1. A stakeholder meeting to engage with the local surfing community to discuss long term changes to the site and possible causes;
2. Creation of a time-lapse animation of collated aerial imagery for community consultation activities;
3. Analysis of the best available estimates of long term change using a remote sensing data ensemble;
4. Analysis of the plausibility of various postulated causes of changes to surfing conditions;
5. Presentation of case studies regarding surfing amenity; and
6. Installation of a short term camera monitoring deployment for tracking beach usage.

2 Community consultation

2.1 Community meeting

A meeting was held at Blacksmiths Beach Surf Life Saving Club (SLSC) on Wednesday 6 November 2019. The meeting was organised and chaired by Council's Mr Alexander Marshall and was attended by approximately 30 to 40 people. Attendees included:

- Long-term surfers from the community group "Bring Blacksmiths Back";
- Members of the local adaptation planning working group;
- Other community members;
- Council staff;
- State government staff;
- WRL engineers Chris Drummond and James Carley.

2.2 Key points made in community submissions

All attendees were given the opportunity to speak publicly at the meeting and/or speak privately to WRL's engineers after the meeting. Many attendees attested to having surfed at Blacksmiths for 30 to 50 years or more.

The following key points were made by individuals:

- The surf quality at Blacksmiths has deteriorated in recent years. There were previously up to 17 named surf breaks between Awabakal Street and the breakwater. The sand profile underwater has steepened resulting in more of a shore break. The northern side of the breakwater in particular has deepened.
- Postulated causes of deterioration include:
    - Dune vegetation, which is also associated with a steepened dune face.
    - Changes to the northern Swansea Channel breakwater.
    - Sand mining (removal of heavy minerals such as rutile, ilmenite and zircon).
- The steep dune face also means that lifeguard/life saver access alongshore is sometimes not possible at high tide, compromising rapid response for rescues.
- Swansea Channel, Salts Bay and Grannys Pool have changed substantially.
- The sand dunes also provide protection to the Blacksmiths settlement from storm erosion, wave runup, coastal recession and future sea level rise. Blacksmiths and the present surf club may be vulnerable to future sea level rise and extreme storm events.
- An easement exists north of the village that could potentially be used as a pipeline corridor for sand transfer between Pelican and Blacksmiths Beach.
- "Bring Blacksmiths Back" want to restore surfing amenity as a gift/legacy to present and future generations.

Management options suggested by community members included:

- Reprofiling sand dunes and removing vegetation or planting with lower density species;
- An offshore reef;
- Groynes;
- A sand transfer system from Swansea Channel and/or sand nourishment.

2.3 Presentations at community meeting

Presentations were made by WRL coastal engineers Chris Drummond and James Carley. Copies of these were provided to Council.

Presentations were also made by Phil Donoghoe on behalf of "Bring Blacksmiths Back" and Tony Blunden describing the forthcoming Smart Beaches project.

2.4 Additional issues raised after community meeting

Following the community meeting Council received an email on behalf of "Bring Blacksmiths Back" dated 11 November 2019", which is reproduced in Appendix A.

3 Historical changes to the site

3.1 Background

Many community members have reported that they have observed changes to the site – in both surfing conditions, the beach and Swansea Channel. This section aims to collate available scientific information regarding changes to the site, in order to contextualise community observations, seek explanations for observed change and provide insight into future change.

3.2 Information sources

WRL utilised the following sources of information:

- Published material as listed below;
- Aerial photos dating back to 1940;
- Satellite photos dating back to 1988;
- Nearmap images dating back to 2011
- Direct advice from Council staff through collating previous reports or personal knowledge.

3.3 Geological timescales

During the last ice age, sea level was about 120 m lower than present until about 20,000 years ago, whereupon it rose from 120 m below to the present level by 6,000 years before present (Figure 3.1), (Fleming et al., 1998, Fleming 2000, and Milne et al., 2005). Present sea level has been broadly stable for about 6,000 years. This means that present coastal planforms may not have had sufficient time to adjust. Many beaches, particularly those north of Newcastle (but many south of Newcastle) exhibit a *zeta* planform, which continues to deepen towards their southern end (Figure 3.2), independent of anthropogenic influence. The planform at Blacksmiths Beach is further complicated by the presence of Lake Macquarie, Swansea Channel and the training of the channel from 1878 (see below).

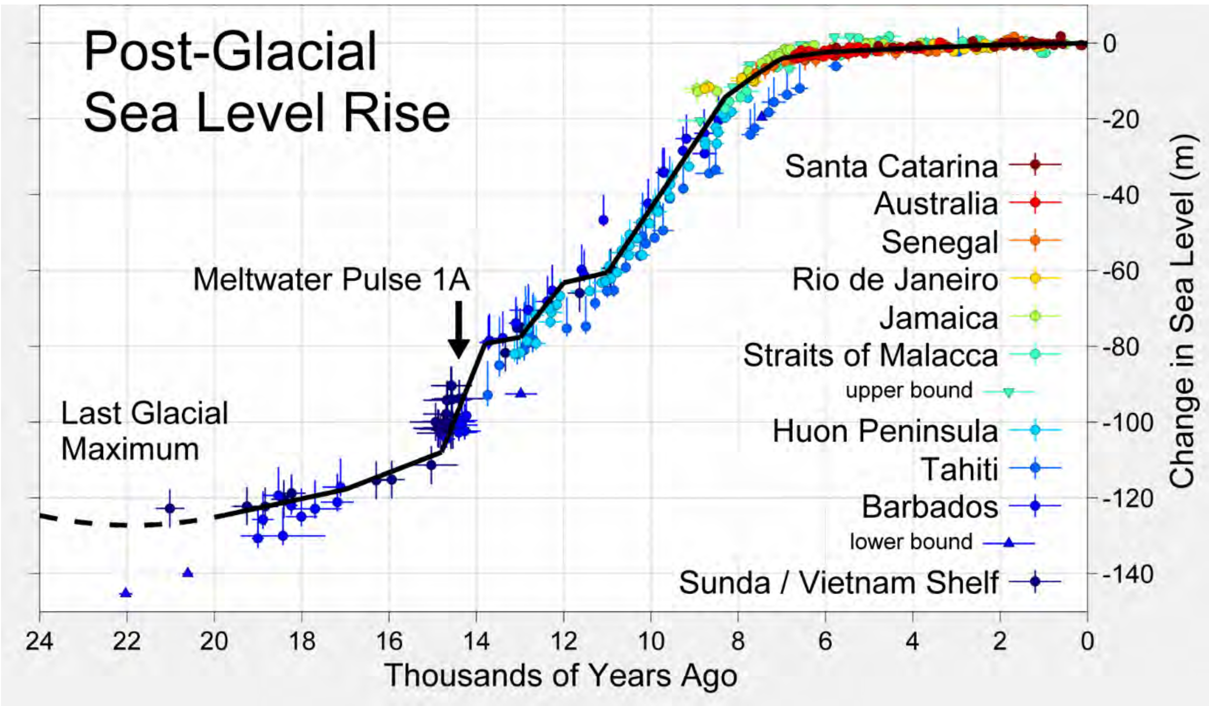


Figure 3.1 Historic sea level rise

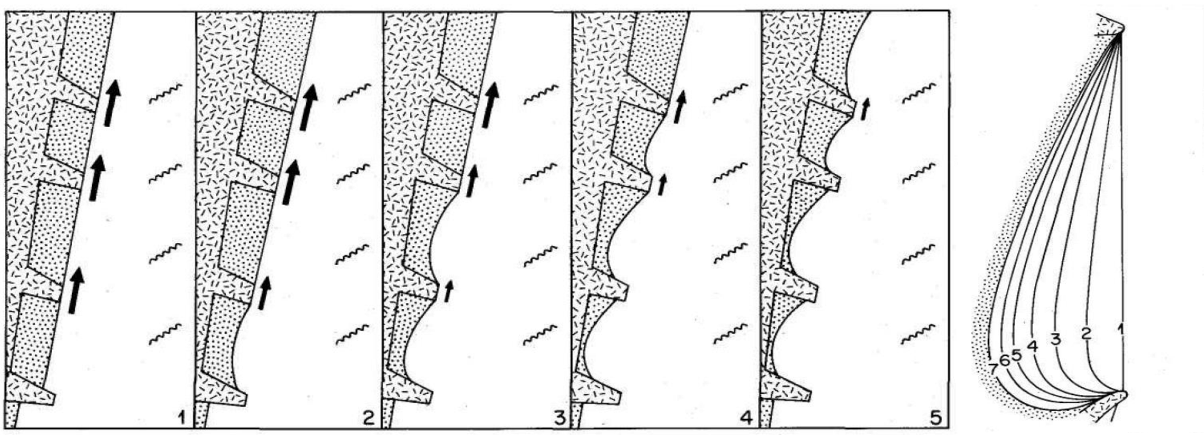


Figure 3.2 Evolution of beach planform (Stephens et al., 1981)

The geology of Blacksmiths Beach is shown in Figure 3.3. While the peninsula is now sufficiently wide to prevent a breach from oceanic erosion over the next 50 years, it is highly likely that it has been breached at some point in the past, prior to the training walls fixing the entrance in its present location. This spit breach and regrowth cycle is shown in Figure 3.4 and a likely breach site in 1861 is shown in Figure 3.5.

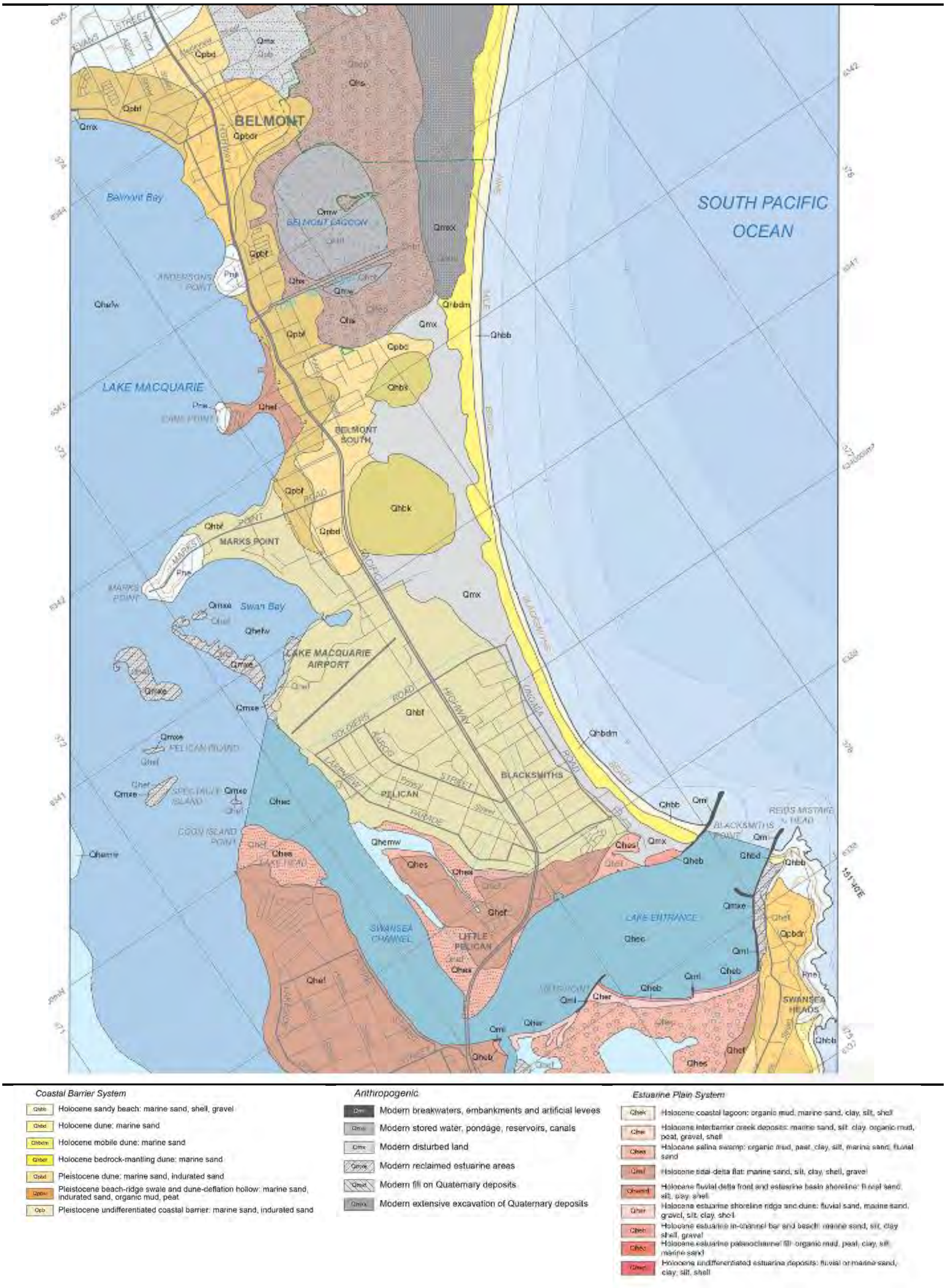


Figure 3.3 Geological mapping (extract from Geological Survey of NSW, 2016)

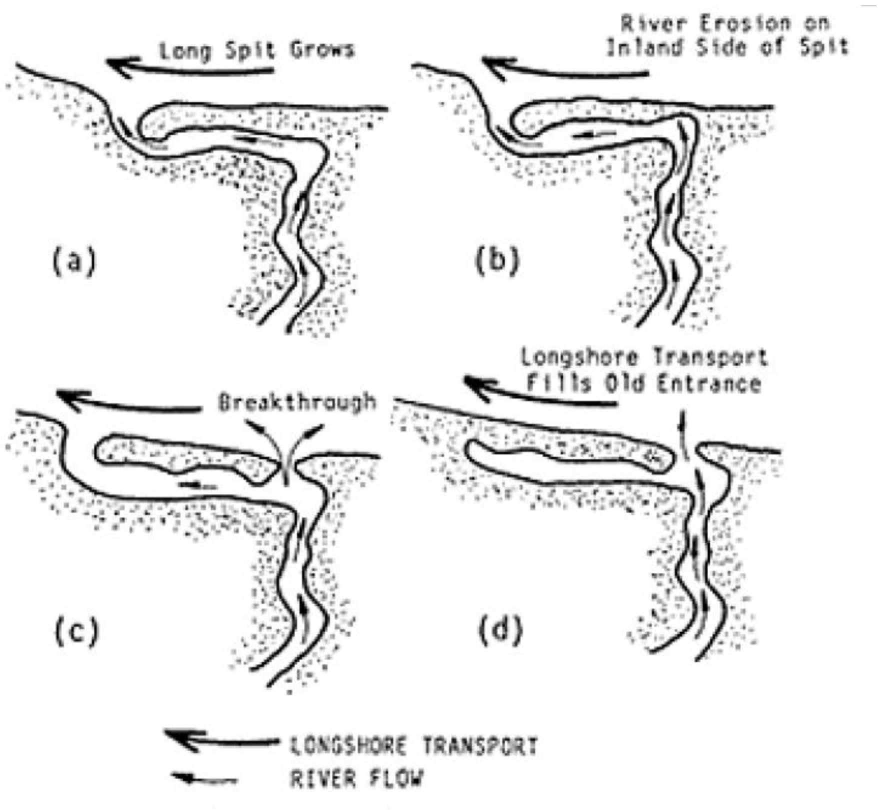


Figure 3.4 Breach of Spit (NSW Government, 1990)

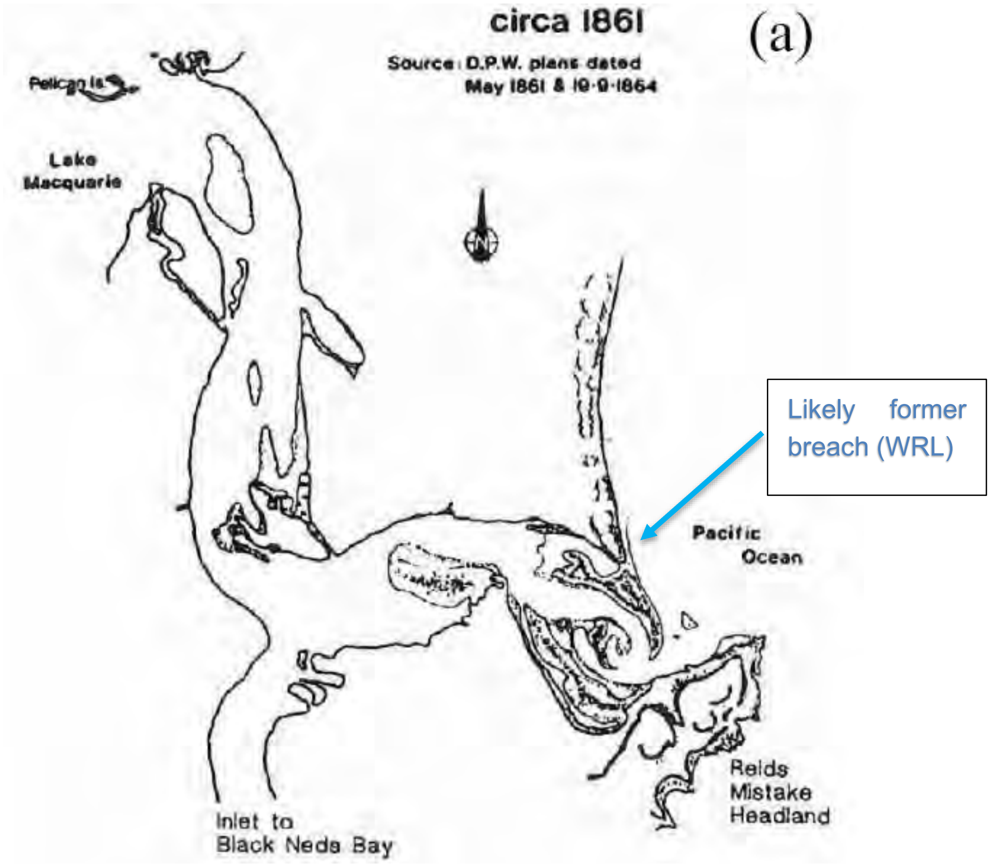


Figure 3.5 Previous potential breach at Blacksmiths (PWD survey 1861)

3.4 Breakwater construction

Illustrations of changes to the breakwaters and channels are shown in Figure 3.6. The following is a brief chronology:

- Prior to the breakwaters, it is reported that the entrance was choked with sand and could only be navigated by small boats;
- 1878 to 1887: Coltheart and James (1987) reported that the Swansea Channel (Lake Macquarie) breakwaters were constructed at a cost of £73,718;
- 1965-1967: Repairs were made between the bridge and Black Neds Bay;
- 1940-1991: No major breakwater changes;
- 1991-1994: Repairs/upgrades;
- 2015: Repairs/upgrades (as advised by Council, Soil Conservation Service, Fasius Civil):
  - Rock was placed in voids around the end of the breakwater to address safety issues, however, this did not result in lengthening of the breakwater;
  - Concrete capping added, but the height of breakwater itself was not changed;
  - Works were also carried out on the training wall in the section of the channel between Granny's Pool and the start of the breakwater to address breaching/overtopping of the training wall.

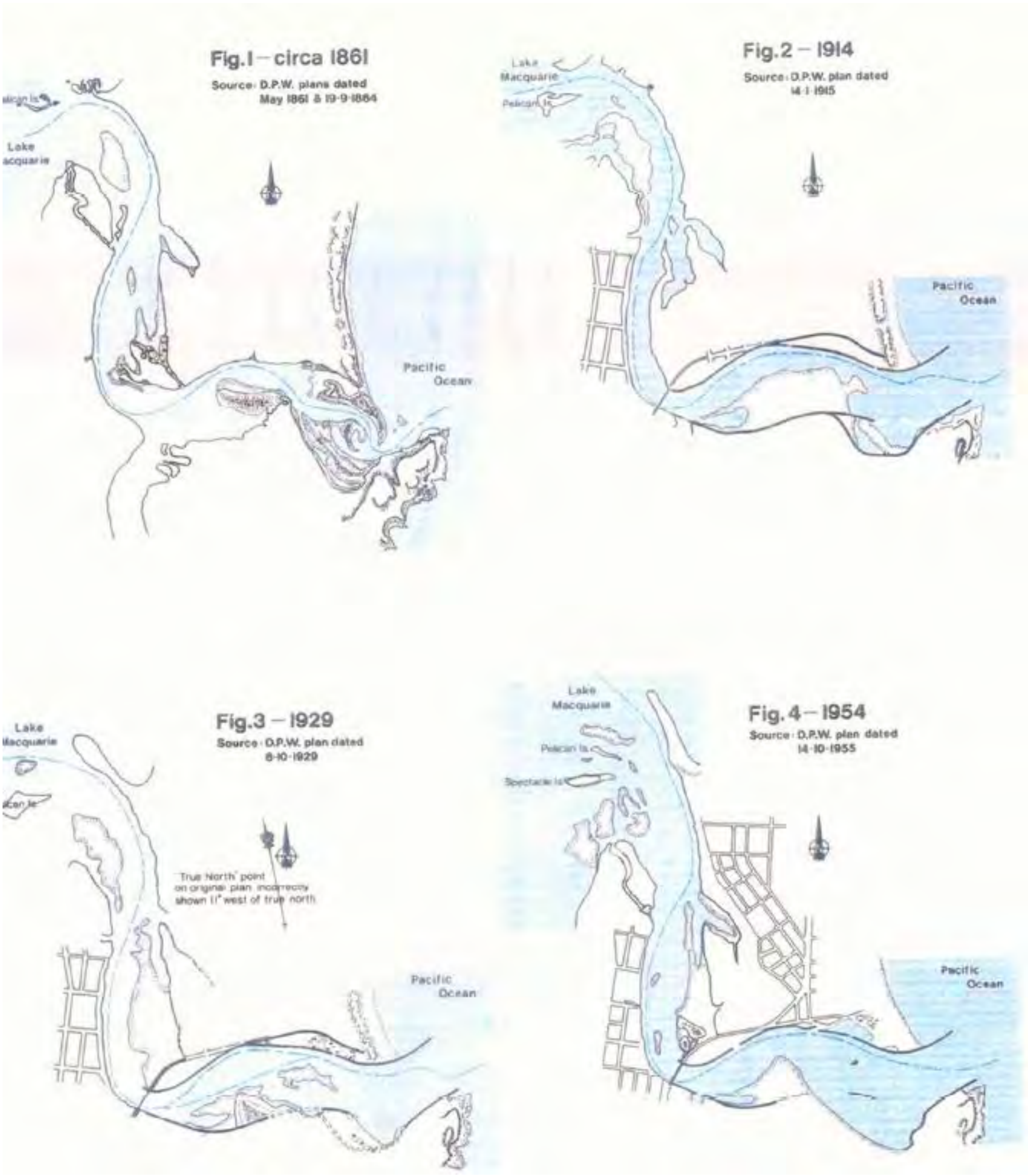


Figure 3.6 Changes in Swansea Channel since 1861

3.5 Channel behaviour

Analysis by Nielsen and Gordon (2015, 2017) estimated that Swansea Channel will continue to scour and deepen for another 350 to 600 years before stabilising to a new equilibrium (Figure 3.7). This new equilibrium is estimated to involve a channel cross sectional area of three to six times the present channel shape. With the bank armouring effectively limiting an expansion in width of the channel, this additional equilibrium area can only be gained through an increase in the depth to the channel bed.

The tidal range in Lake Macquarie is noted to be increasing (Figure 3.8) and will continue to do so, as increasing channel depth will reduce friction losses of tides. Independent of future sea level rise, the Lake's tidal range is predicted to double in approximately 80 years (Watterson et al., 2010). Future sea level rise will also further alter the lake and entrance dynamics.

Substantial erosion has occurred along the foreshore of Salts Bay. The drop off feature at Pelican has been noted to be migrating northward from 1961 to 1979 at a rate of 10.5 m/year (WBM, 2003).

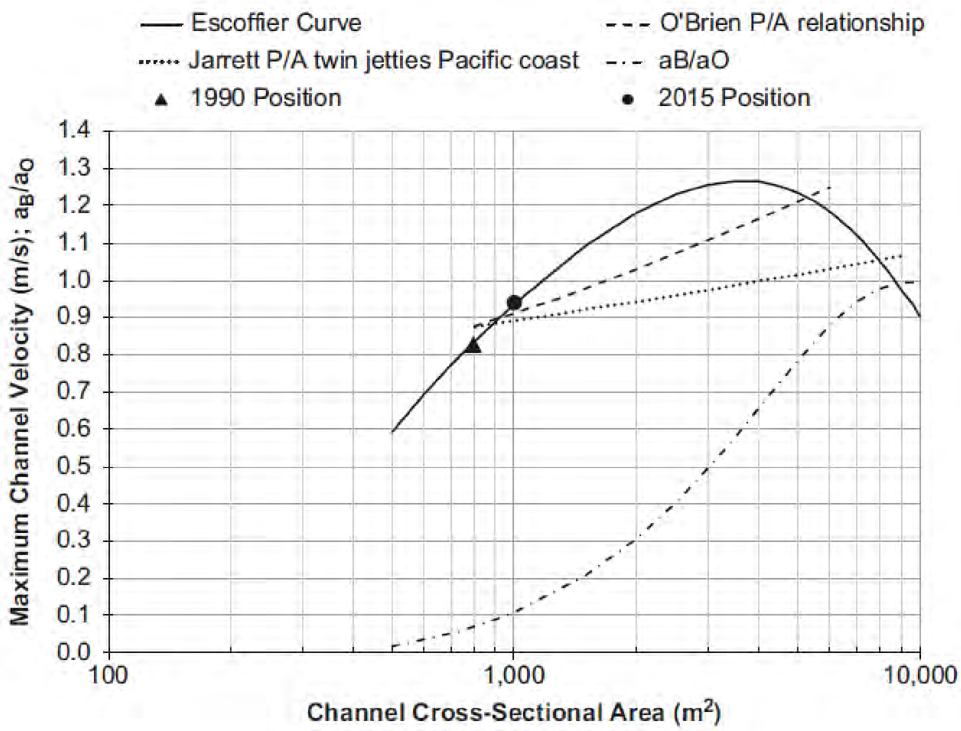


Figure 3.7 Escoffier diagram for Lake Macquarie (Nielsen and Gordon, 2017)

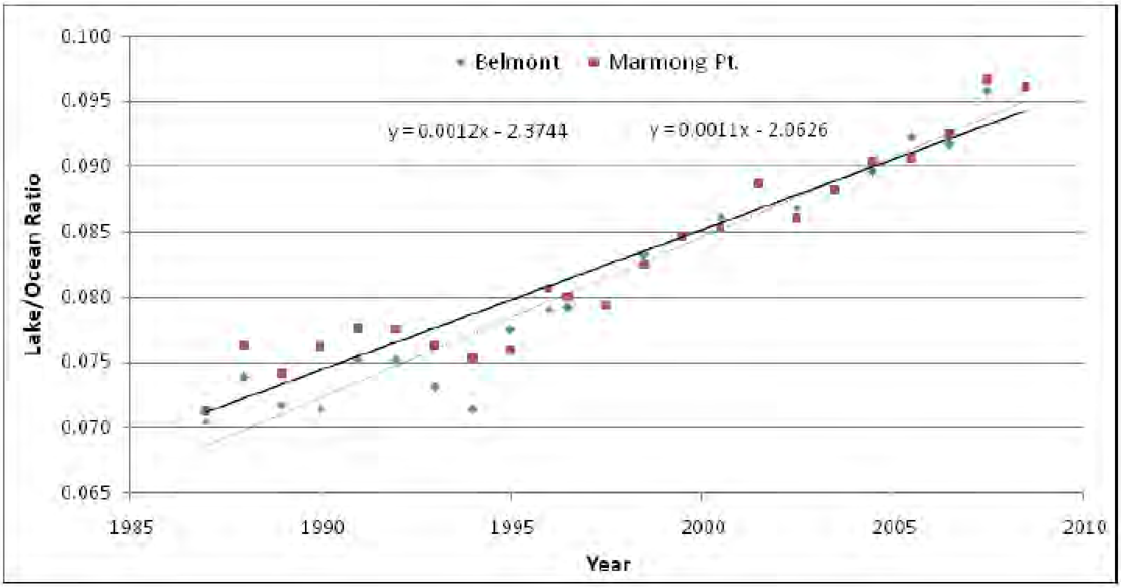


Figure 3.8 Change in lake tidal range ratio (Watterson et al., 2010)

3.5.1 Dredging

While the channel is generally enlarging, this is not uniform, so dredging is still required in some locations to maintain safer navigation. Council records of dredging from Swansea Channel are shown in Table 3.1 and Figure 3.9. The following information can be gleaned from the dredging records and their analysis:

- A total of 702,500 m^3 has been dredged from 1970 to 2020;
- Individual campaigns varied from 2,000 to 120,000 m^3;
- The average dredging campaign was 35,000 m^3, which is comparable with the Cronulla Sand Slug (Section 5.1) which utilised 45,000 to 50,000 m^3;
- From 1970 to 2020, the average annual dredged amount was 14,030 m^3/year;
- From 1970 to 2020, the average annual dredged volume increased by only 42 m^3/year (equivalent to about 0.3% per year), albeit with large differences between individual campaigns.

Table 3.1 Swansea Channel dredging records

Year	Description*	Quantity
1970-71	Airport to Dropover, Disposal on Elizabeth Island	66,000
1977	'Study area'	22,000
1980	'Study area'	36,000
1981	'Study area'	25,000
1982	'Study area'	13,000
1986	Dropover	52,000
1990	Dropover	20,000
1996	Quantity not stated	
1998-99	Airport to Dropover, Disposal on Blacksmiths Beach	40,000
2000-01	Swan Bay South Entrance (Belmont Sands)	10,000
2003	Dogleg, Lake Macquarie Improvement Project Works	120,000
2006	Swan Bay southern entrance closure, Lake Macquarie Improvement Project Works	50,000
2010	Airport to Dropover, Sand removed from Naru Point	68,000
2012	Airport to Dropover, Disposal in channel and former 'Belmont Sands' site	35,000
2015	From drop over to bridge to design -3.5	80,000
2015 Dec	Dog leg	2,000
2016	Dog leg	2,500
2017	Drop over to bridge	30,000
2018	Dog Leg	10,000
2019	Dog Leg	10,000

*Data has been provided by Council – location specifics are not presented in this report

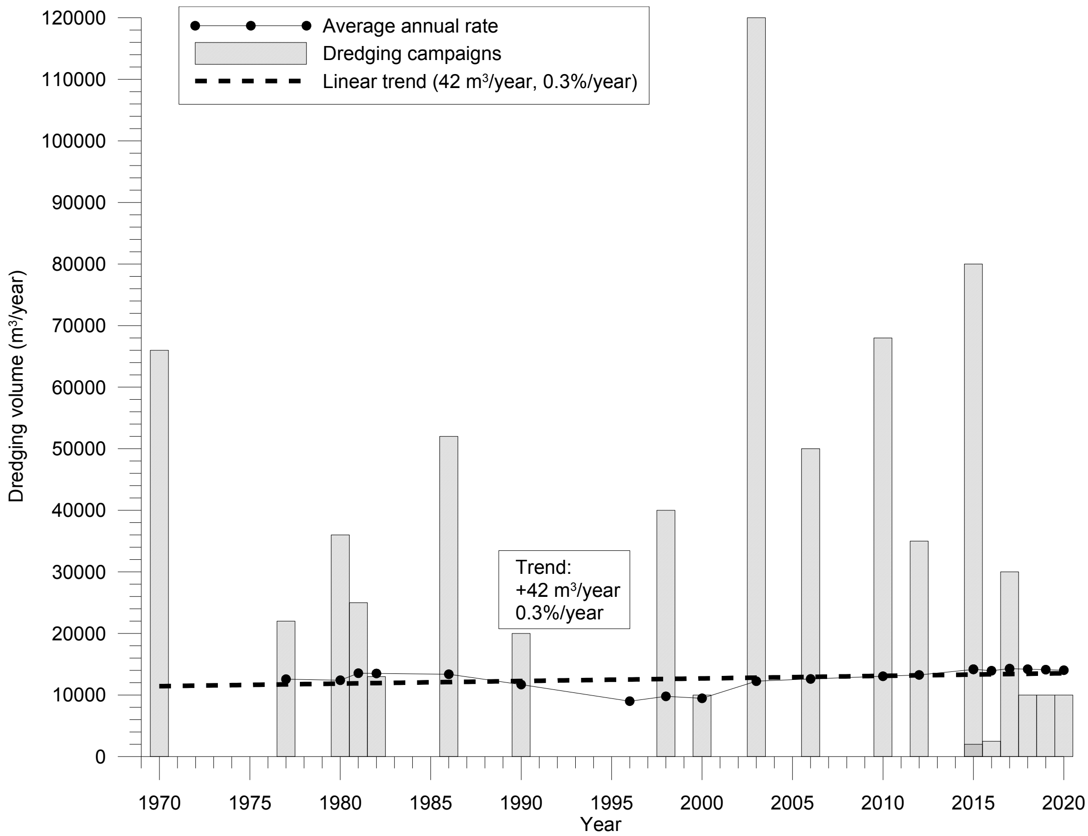


Figure 3.9 Council dredging records 1970 to 2020

3.6 Beach change

All available images from 1940 to 2019 have been collated and assembled onto a common georectified grid, with the still photos collated in Appendix B and a time lapse movie of these available at: https://www.youtube.com/watch?v=rnh8EpDcsB8

3.6.1 Aerial photos

It is reiterated that the "land" at the southern end of Blacksmiths was once mobile sand shoals at the mouth of Swansea channel, prior to training of the entrance from 1878.

It is clear that vegetation has advanced at the southern end of the beach since about 1991 (Appendix B). Changes in key features from select aerial photos are described in Table 3.2, noting that each photo may have been captured at different stages of the tide which may result in apparent differences.

Table 3.2 Visual descriptions of aerial photos

Date	Description
01/11/1940	Vegetation present in a reasonably smooth arc in southern 2 km of beach. Slightly wider sandy areas in southern 500 m. Mobile dunes about 2 km north of breakwater. Gap in northern training wall evident about 500 m from tip (Grannys Pool).
03/03/1950	Similar to 1940 with additional mobile sand in southern 500 m. Moderate to dense vegetation north of about Boiken St. Grannys Pool almost filled in (probably) with wind-blown sand.
30/07/1967	Similar to 1959 with additional sparse vegetation evident in southern 500 m. Pronounced gap in northern training wall evident about 500 m from tip (Grannys Pool). Moderate to sparse vegetation north of about Boiken St.
06/07/1969	Sparse vegetation extends almost to waterline in southern 500 m. Grannys Pool prominent.
01/07/1972	Sparse vegetation with mobile areas in southern 500 m. Moderate vegetation north of this (Boikon St). Grannys Pool partially infilled.
19/06/1974	Sparse vegetation with mobile areas in southern 500 m. Moderate vegetation north of this (Boikon St). Large gap in training wall at Grannys Pool causing infill.
27/05/1975	Sparse vegetation with mobile areas in southern 500 m. Moderate vegetation north of this (Boikon St). Grannys Pool scarcely evident.
17/11/1976	Similar to 1975, but sparse vegetation extends almost to waterline in southern 200 m. Grannys Pool evident with no major gap in training wall.
09/07/1979	Surf life saving clubhouse almost surrounded by mobile sand. Moderate vegetation north of this (Boikon St). Grannys Pool evident with small gap in training wall.
10/08/1980	Surf life saving clubhouse almost surrounded by mobile sand. Mobile sand south-east of Boiken St and Ungala Road intersection. Grannys Pool evident with small gap in training wall.
30/06/1981	First colour photo. Vegetation established around SLSC and south-east of Boiken St and Ungala Road intersection to breakwater. Grannys Pool evident with small gap in training wall.
27/04/1984	Previous vegetation destabilised south-east of Boiken St and Ungala Road intersection to breakwater. Sparse vegetation north of this. SLSC surrounded by mobile sand. Grannys Pool evident with small gap in training wall.
11/09/1987 to 1991	Pixelated early satellite photos unable to be processed visually.
11/08/1991	Moderate vegetation south-east of Boiken St and Ungala Road intersection to breakwater, almost extending to waterline at southern end. More landward alignment of vegetation north of SLSC area. Grannys Pool evident with small gap in training wall.
1991 to 1996	Pixelated early satellite photos unable to be processed visually.
29/11/1996	Dense vegetation in southern 300 m, and moderate vegetation south-east of Boiken St and Ungala Road intersection. Southern 300 m almost extending to waterline at southern end. Sparse seaward portion of vegetation north of SLSC area. Grannys Pool evident with small gap in training wall.
1996 to 1999	Pixelated early satellite photos unable to be processed visually.
19/09/1999	Dense vegetation in southern 300 m, and moderate vegetation north of this. Grannys Pool evident with small gap in training wall.
1999 to 2001	Pixelated early satellite photos unable to be processed visually.
14/09/2001	Dense vegetation in southern 300 m, and moderate vegetation north of this. Grannys

Date	Description
	Pool evident with small gap in training wall.
2001 to 2008	Pixelated satellite photos unable to be processed visually.
03/07/2008	Moderate to dense vegetation along beach. More seaward alignment in southern 300 m. Area of mobile sand along training wall about 1 km from tip. Grannys Pool evident but smaller, with small gap in training wall.
11/02/2011	First Nearmap image. Similar to 2008.
18/06/2011	Nearmap image, similar to previous.
15/07/2012	Nearmap image, similar to previous.
2012 to 2015	Numerous Nearmap and satellite images. Vegetation in southern 300 m is generally advancing seaward. Grannys Pool evident but generally small.
08/05/2015	Dense incipient vegetation evident seaward of main vegetation in southern 300 m. Grannys Pool larger. Wind-blown sand pathway to Grannys Pool reduced.
05/07/2016	Vegetation in southern 300 m is generally advancing seaward. Grannys Pool larger. Wind-blown sand pathway to Grannys Pool evident.
08/12/2018	Vegetation in southern 300 m is generally advancing seaward. Grannys Pool larger. Wind-blown sand pathway to Grannys Pool reduced.
04/03/2019	Triangular fillet of sand evident in southern corner. Vegetation line more landward in vicinity of SLSC (higher pedestrian use over summer?) Grannys Pool large with small gap in training wall. Wind-blown sand pathway to Grannys Pool reduced.
01/07/2019	Triangular fillet of sand evident in southern corner. Vegetation line more landward in vicinity of SLSC (higher pedestrian use over summer?) Grannys Pool large with small gap in training wall. Wind-blown sand pathway to Grannys Pool reduced. Reef about 500 m offshore from SLSC very prominent.
07/08/2019	As before, triangular fillet of sand evident in southern corner. Vegetation line more landward in vicinity of SLSC (higher pedestrian use over summer?) Grannys Pool large with small gap in training wall. Wind-blown sand pathway to Grannys Pool reduced. Reef about 500 m offshore from SLSC very prominent.

3.6.2 Shoreline position

Shoreline position for three transects was calculated using images from satellites and aerial photos from 1988 (Figure 3.10). This data was corrected for the tide at the time of the image before shorelines were extracted.

There is no strong long term trend, but several medium term cycles are evident. These appear to have some correlation with climate indices such ENSO (El Niño-southern oscillation), (Figure 3.11), in a similar manner to that observed at other locations in NSW in Harley et al., (2015).

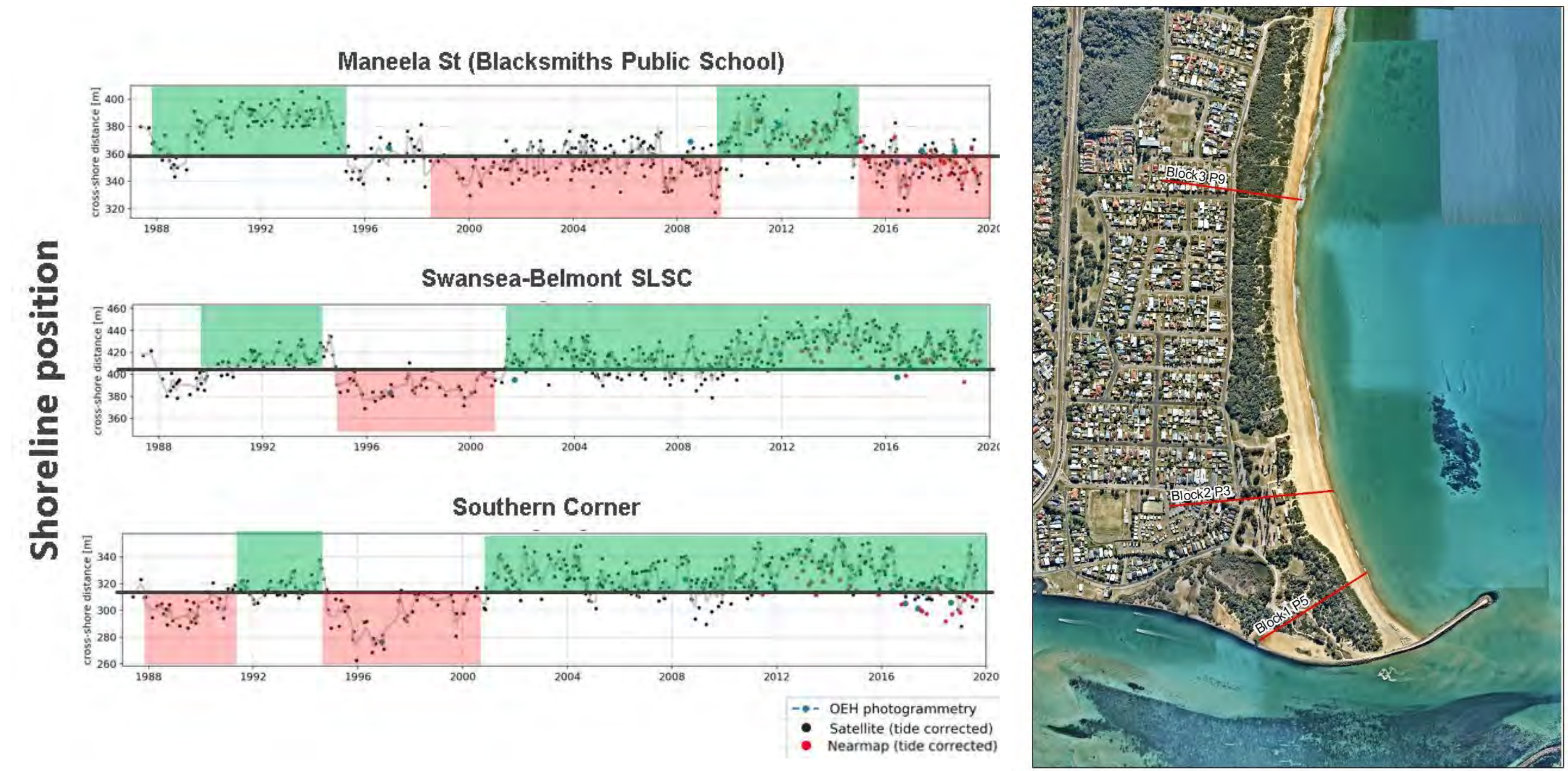


Figure 3.10 Beach width at three transects

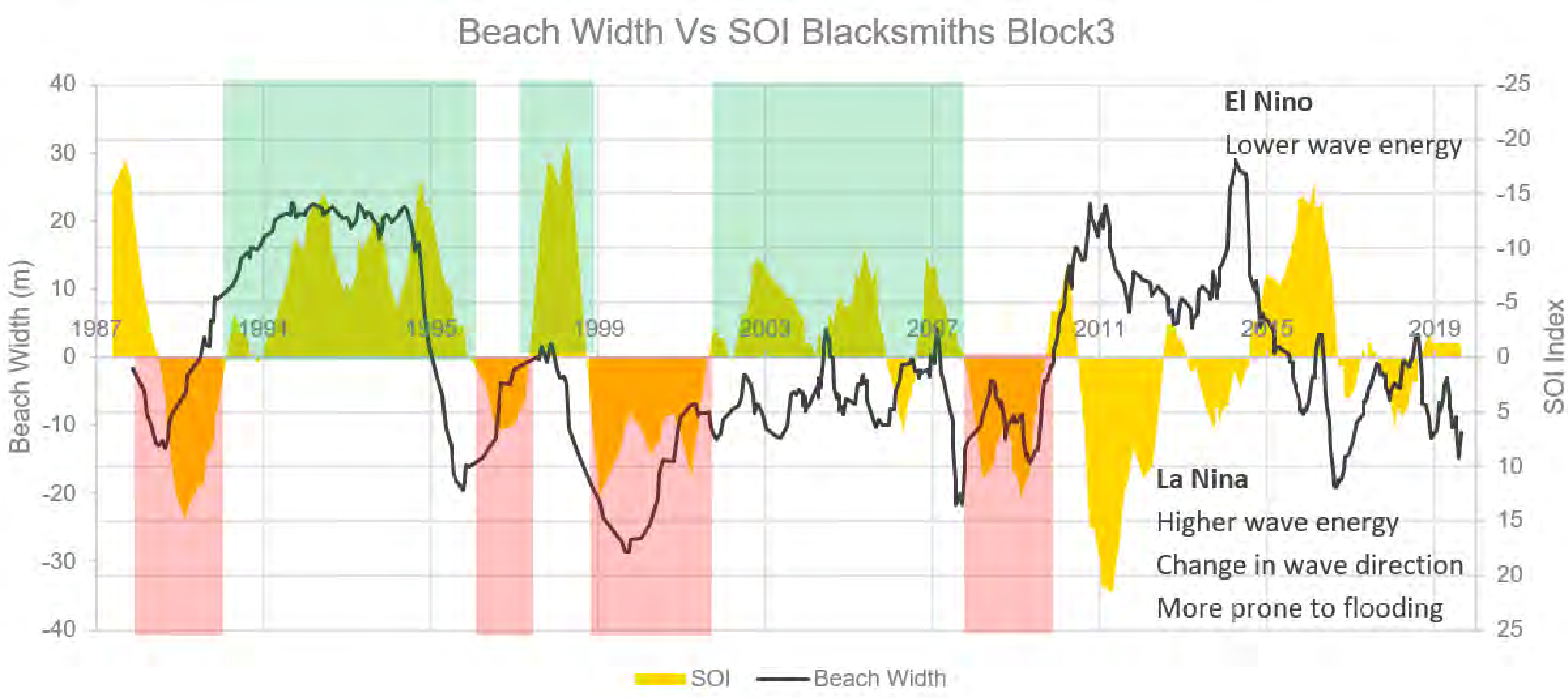


Figure 3.11 Plot of beach width at Blacksmiths SLSC versus SOI

4 Comments on changes to surf

4.1 Components potentially altering surfing conditions

There are three main components which may result in changes to surfing conditions:

- Cross shore profile slope and depth – this affects wave breaking intensity, and may result in a shore break only, or reforms, and sometimes wave reflections/backwash. The cross shore profile is also somewhat attuned to specific wave conditions (height and period). The only comprehensive measurements of this in Australia are on the Gold Coast, with the change there shown in Figure 4.1.

- Three dimensionality - peeling of waves, which is influenced by multiple factors:
  - "Banks" – the three dimensionality of the seabed (Figure 4.2);
  - Offshore features such as sand shoals, reefs and islands (e.g. the sand shoals offshore from Duranbah on the Gold Coast, and similar features offshore from Blacksmiths);
  - Nearshore features such as the rips, sand shoals, reefs, breakwaters, side reflected waves (e.g. Newport Wedge, California);
  - Peaky and straight swells;
  - Simultaneous swells from different directions.

- Climatic factors, such as:
  - Waves - changes to height, direction, period and the presence of simultaneous swells from different directions may directly influence surfing conditions and also change the underlying sand morphology;
  - Tides;
  - Storm surges;
  - Sea level rise;
  - Local winds.

4.2 Potential causes of changed surfing conditions

In the NZ Surf break management guidelines (Atkin et al., 2019), the sensitivity of various types of surf breaks is shown in Figure 4.3. Depending on interpretation, most of the breaks around Blacksmiths would be Type 3 to Type 5, and are thus in the most sensitive class.

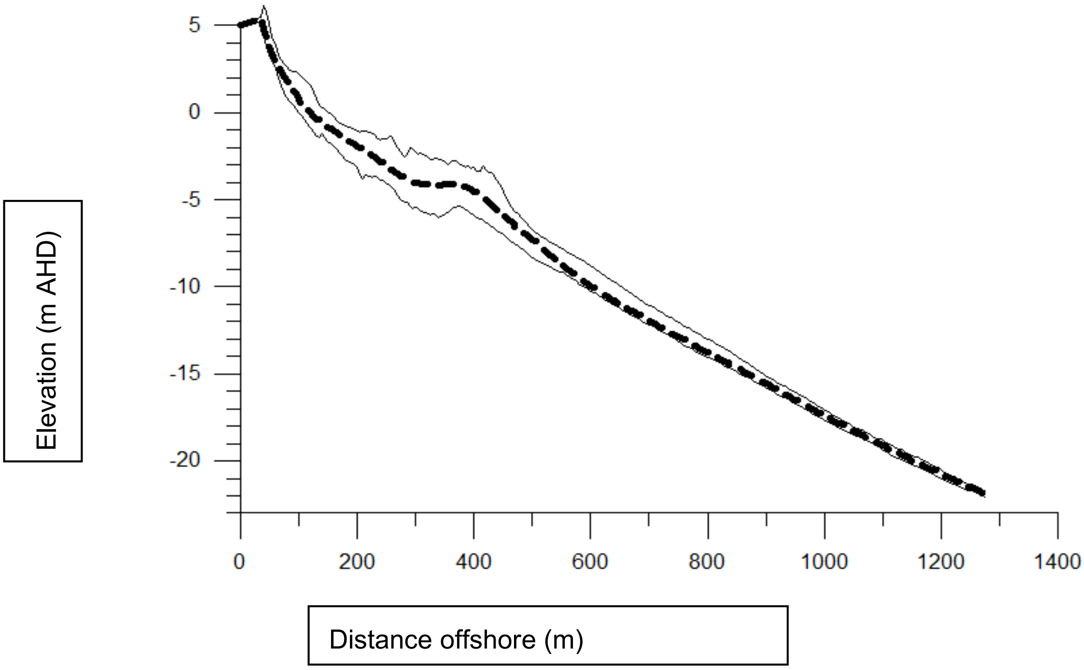


Figure 4.1 Envelope of surveyed (ETA63) profiles of Surfers Paradise (1976 to 1997)

Note: Transverse Bar and Rip as described in Short and Wright (1984), Source: Nearmap

Figure 4.2 Example of renowned three dimensional beach break – Woolamai VIC

Management Guidelines for Surfing Resources

Table 2.5: Surf Break Sensitivity Rating. It is commonplace in the marine environment for the seabed to be made of a range of particle sizes. These guidelines have not considered mud bottom breaks.

	Potential Break Type	General Material Size	Wave Quality Reliance on Sediment Transport Regime
1	Rock Ledge; Reef	Consolidated Rock	Low
2	Reef; Point		
3	Point; Beach; Delta		
4	Beach; Delta		
5	Delta	Fine Sand	High

Figure 4.3 Sensitivity of surf break type (Atkin et al., 2019)

A matrix of the likely impacts of various change factors and their postulated effect on surfing components for Blacksmiths is shown in Table 4.1. The likelihood has been graded from: almost certain; likely; possible; unlikely to implausible. This is based primarily on professional judgement. Due to the many complex processes, it may not always be possible to distinguish between *association* and *causation*.

Table 4.1 Postulated causes of changes to surfing

Change factor (below) and likely effect on surfing component (right)	Cross shore profile	Three dimensionality	Wave climate	Comments
Channel adjustment to breakwater construction 130 years ago	Likely	Likely	Implausible	Nielsen and Gordon (2015, 2017) estimated that Swansea Channel will continue to scour and deepen for another 350 to 600 years This new equilibrium is estimated to involve a channel cross sectional area of three times the present. The wide breakwater opening has allowed larger waves to enter, driving change in Salts Bay.
Beach adjustment to breakwater construction 130 years ago	Likely	Likely	Implausible	Channel deepening and sand transport away from beach likely leads to beach profile deepening due to linkages between these processes.
Waves or beach adjustment to changes to breakwater	Possible	Possible	Implausible	Changes to breakwater armour and core may alter waves and sand transport, but difficult to assess due to fine balance.
Ongoing evolution of the beach after 6,000 years of steady sea level	Possible	Possible	Implausible	Many beaches are still adjusting to an equilibrium profile after this event, however, this is probably small relative to breakwater impacts.
Winnowing of fine sand through wave action	Possible	Unlikely	Implausible	The finer sand may be separated and moved into channel, leaving behind coarser sand at a steeper slope (Figure 4.4).
Porosity of breakwaters	Likely	Likely	Implausible	Sand can flow through the breakwater.
Abrasion of sand grains, Changes to shell production and content	Possible	Unlikely	Implausible	Silica sand is not considered to abrade over human timescales. Of three samples known to WRL, shell content was 0%, 8%, 16%. Further quantification is unknown.
Removal of heavy metals due to mining	Possible	Unlikely	Implausible	Extent is uncertain, but removal of heavy metals would likely make the profile flatter, whereas anecdotally it has steepened.
Subsidence due to mining	Unlikely	Unlikely	Implausible	Beach area is considered to be outside mine subsidence zone (Figure 4.5).
Dune growth and/or dune vegetation	Unknown	Unlikely	Implausible	A steep dune face may sometimes limit alongshore access at high tides. A beach profile is usually separated into portions primarily formed by water/waves action rather than by wind action.
Sea level rise	Likely	Possible	Implausible	Historic ocean sea level rise (Sydney) about 1 mm/year since 1950; 1.3 mm/year since 1990; Belmont 2.5 mm/year since 1990.
Medium to long term wave climate changes	Likely	Possible	Likely	Wave climate changes with climate cycles have been observed on buoys, but any overall longer term trend is uncertain. El Nino years have a more southerly wave climate, whereas La Nina years have more east to north-east wave events. These subtle changes in wave direction could lead to periodic changes in surf amenity.
Rainfall	Unlikely	Possible	Implausible	Rainfall outflows may alter channel depth and the three dimensionality of the delta and bars.

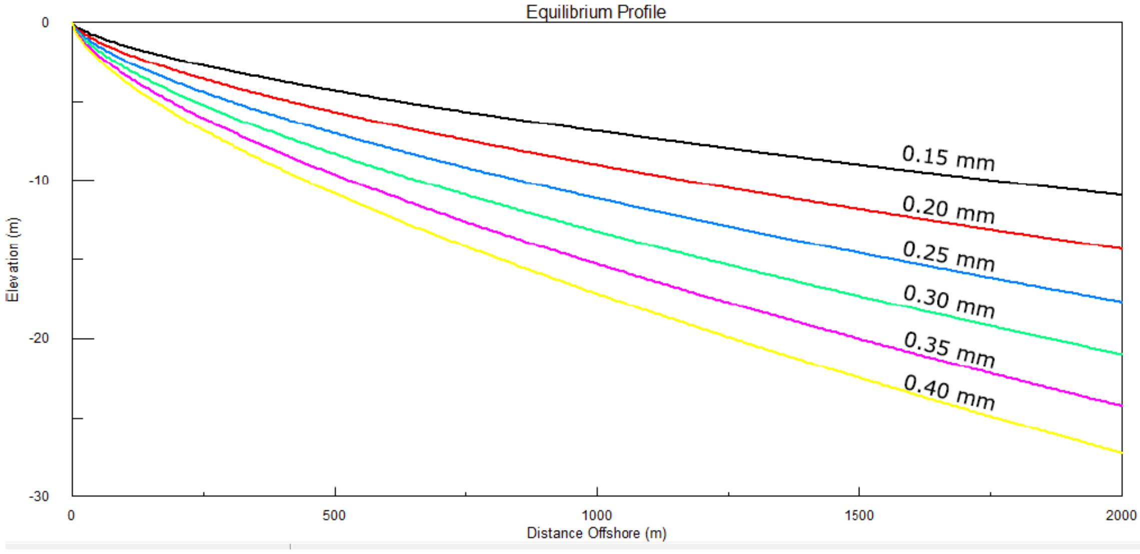
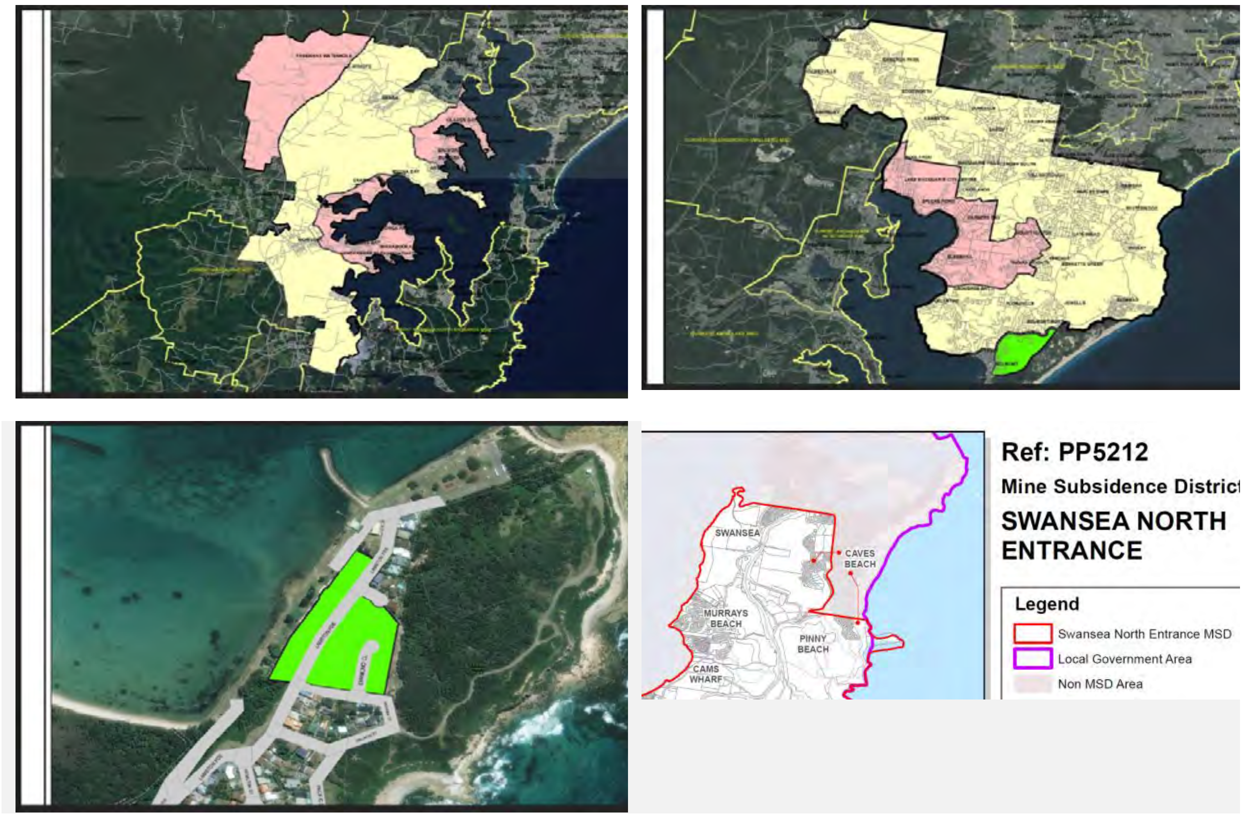


Figure 4.4 Equilibrium beach profile for various sand grain sizes



Notes: Sources: Newcastle Herald and NSW Mine Subsidence Board

Green represents the proposed new districts, yellow the existing districts, and pink the areas to be revoked.

Figure 4.5 Mine subsidence areas in vicinity of Blacksmiths

5 Case studies from other areas

5.1 Overview

The following case studies provide examples of areas where surfing amenity has been changed or managed, and examples where dune vegetation has been modified in response to community concerns. Each site has unique physical, environmental and socio-economic characteristics, so may not be directly transferable to Blacksmiths.

5.2 Cronulla sand slug, Sydney NSW

Information on the Cronulla “sand slug” has primarily been gained through work by Pitt (2010 and 2012) and the personal knowledge of WRL engineers. Sand from the surrounds of Cronulla Beach enters the Port Hacking (Figure 5.1) estuary where it shallows some parts of navigation channels. This natural infill of the predominantly unmodified estuary is consistent with that of many other NSW estuaries (Chapman et al., 1982). Periodic dredging is required to maintain navigability, with recent campaigns occurring in 2003, 2007 and 2010. This sand has traditionally been placed on Cronulla Beach as nourishment.

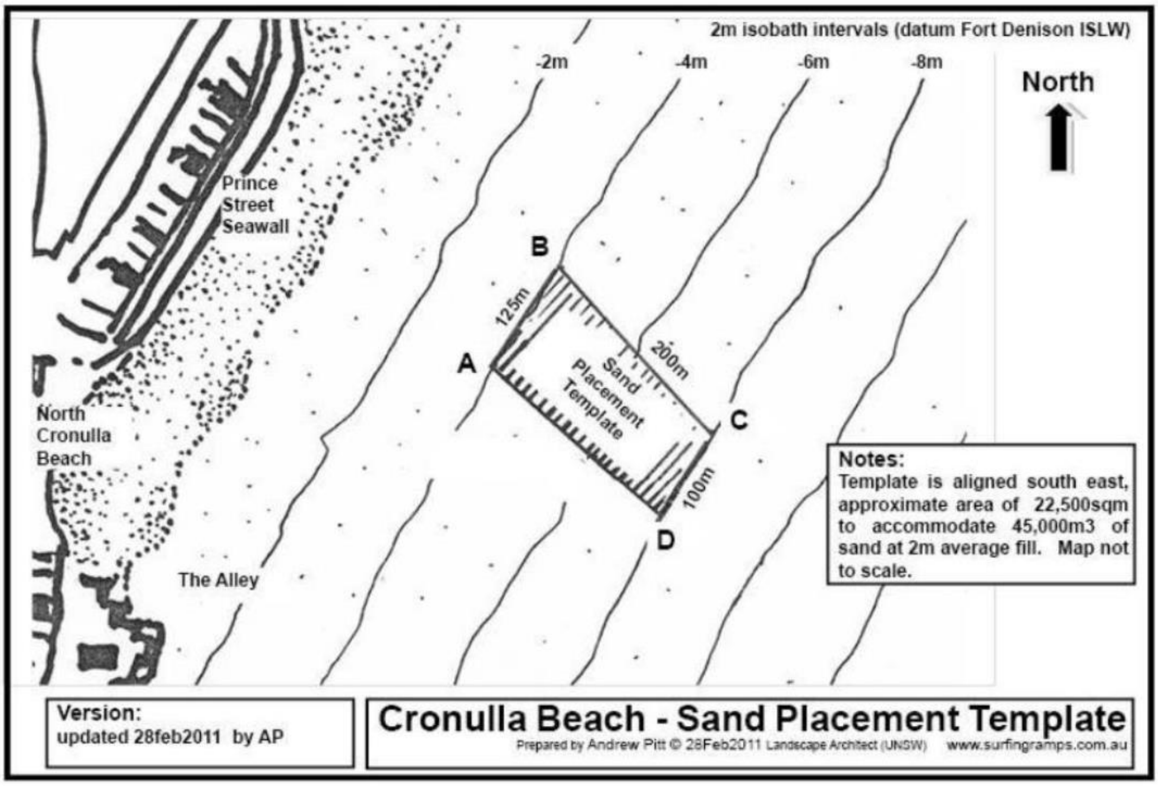
Figure 5.1 Cronulla embayment (Google)

In the 2010 campaign, 45,000 to 50,000 m^3 of sand was placed in a mound (“configuration placement”) offshore from the Prince Street seawall at North Cronulla. The mound was designed by Andrew Pitt, with a geometry intended to be beneficial to surfing (Figure 5.2). It was placed 200 to 500 m offshore, in water that was about 4 to 8 m deep (at low tide) prior to placement.

The intention was for the mound to pre-condition the incoming swell and create more peaky waves in its lee. Except during very large swells, surfing would not take place on the mound itself. Pitt based this concept on the numerous bombora influenced surf breaks around Australia, whereby an offshore feature creates three-dimensionality ("peakiness" and peeling waves) into the surf zone, where there would otherwise be closeouts.

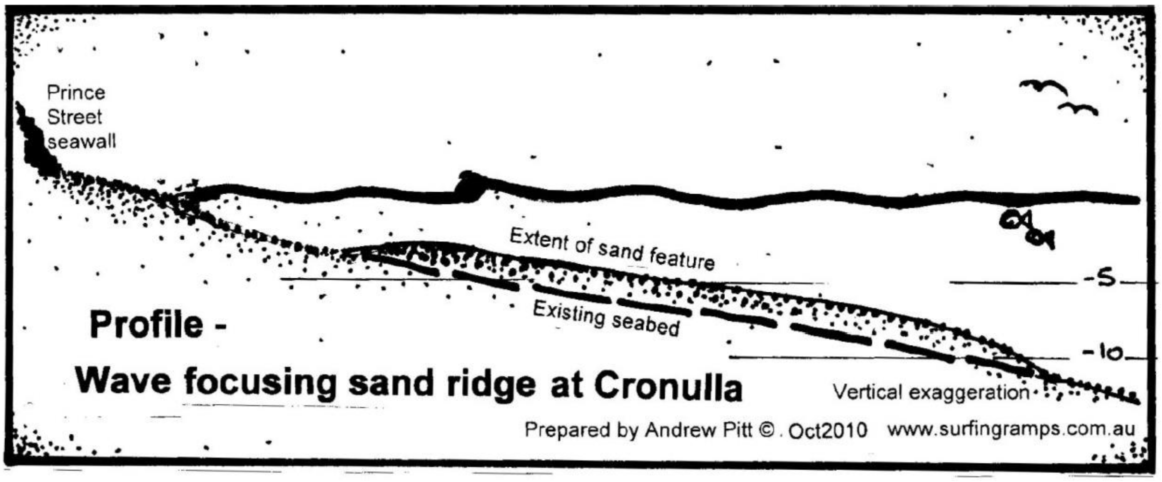
An earlier cross section from Pitt (2010) is shown in Figure 5.3, noting that the cross shore extent of this was reduced in the adopted design.

The works were undertaken from June to September 2012. The *Faucon*, a Gold Coast based trailing suction hopper dredger can be seen transporting sand in Figure 5.4. The surf from a good day (Tuesday 14 August 2012 - prior to completion) is shown in Figure 5.5. Pitt (2012) reported that the best month was August 2012, and that the sand slug had a positive impact on surf quality from July to October 2012, a life exceeding 4 months.



Pitt (2012)

Figure 5.2 Plan view of Cronulla sand slug



Pitt (2010)

Figure 5.3 Early version of cross section of Cronulla sand slug

(McQuade Marine)

Figure 5.4 Dredger Faucon travelling from Port Hacking to North Cronulla

Image 1. ***Slug-Fest!*** **Tuesday 14th August 2012, North Cronulla,** fantastic wave breaking patterns in the lee of the temporary sand slug feature, plenty of peaks. Set, peeling left and right, local surfers called it a 'Slug-Fest'. Photo, One Shut Eye

Figure 5.5 High quality surf on Cronulla sand slug

5.3 Woonona, Wollongong NSW

Descriptions of proposed modifications and/or monitoring to the sand dune at Woonona, Wollongong NSW are provided in Beardsmore et al., (2014) and Gangaiya et al., (2017). Woonona is also the site of an excellent surf break. Pitt (2009) included it in his list of bombora controlled beach breaks.

As described below, a targeted dune vegetation program was undertaken in 1986, with dune vegetation changes shown in Figure 5.6. The earliest aerial photo dates to 1948, and the extent of dune vegetation prior to this is unknown. During the preparation of a coastal zone management plan (CZMP), community concerns were raised regarding excessive dune height, scarping, sightlines for lifeguards and surf life savers and public amenity.

Figure 5.6 Aerial photos of Woonona vegetation change (Gangaiya et al., 2017)

Beardsmore et al., (2014) stated:

The issues identified though the stakeholder consultation process were grouped into two categories. The first category related to the current state of the dunes and vegetation conflicting with the recreational use of the beach. Key issues in this category were:

- Deterioration of line of sight for lifeguards/lifesavers due to the height of the vegetated dunes;
- Reduction in recreational amenity due to storm scarps and a reduction in beach width due to encroaching dune vegetation;
- Degradation of beach access ways; and
- The presence and extent of native vegetation, in particular Coastal Wattle *Acacia sophorae*, which had been planted on the dunes.

The second category related to the precautionary measures required if there was management interference with the dunes and vegetation. Key issues in this category were:

- Ensuring that any proposed dune or vegetation modification action did not increase the risk from coastal hazards and processes;
- To consider the biodiversity value of the dune vegetation; and
- Conduct a community engagement program to improve understanding of the role of dunes and vegetation in the coastal environment.

Beardsmore et al., (2014) summarised the project:

The local government area of Wollongong City Council has approximately 60 km of coastline, which includes 17 patrolled beaches. Use of the beach for various recreational activities is fundamental to the way of life for many local residents, as well as important for tourism. Vegetated areas on dunes at the back of these beaches are presumed to have been cleared following European settlement in the 1800's and the early 1900's. In the 1980's, in response to issues such as wind-blown sand and coastal erosion, an extensive program of re-vegetation was undertaken along many of Wollongong's beaches. As a result, the vegetation is now well established, and in many cases extends seaward over twice the area originally planted. Many in the community are now concerned about the impact of the dune vegetation on the beach amenity for recreational purposes and public safety.

In response to these concerns, Council has prepared a Dune Management Strategy for the patrolled beaches. This Strategy aims to achieve a balance between the need to provide a safe and desirable recreational area and the biodiversity value of the vegetated dunes and their role for protecting infrastructure assets. Some of the management options proposed, such as removal of some of the frontal vegetation and reshaping the dunes, are controversial, and had mixed reactions from the community and regulatory authorities. Nevertheless, Council made a decision to trial this option and monitor its progress to inform future management works.

The first location where vegetation removal and reshaping work has been undertaken is Woonona Beach. The coastal hazard assessment, design and approvals process, stakeholder engagement and implementation of on-ground work are presented. On-going monitoring and management, as well as the lessons learnt from this project are discussed and how they can help inform future management of dune vegetation.

Gangaiya et al., (2017) stated:

Dunes are important for coastal protection, but their presence can sometimes be seen as conflicting with the recreational use of the coastline. In June 2014, in response to community concern, Wollongong City Council, a local government authority in southeast Australia, took the unconventional step of removing vegetation and re-profiling the foredune in a section of Woonona Beach to improve beach width and sightlines. A series of cross-sections in the re-profiled and adjacent unmodified areas have been surveyed monthly since July 2013, to help determine the impact of the intervention on beach and foredune topography. These show that immediately after re-profiling, considerable additional lower beach width was gained, and there was little accretion on the foredune that had been re-profiled. However, after 8 months, the importance of the re-profiling in maintaining lower beach width is less clear, and an incipient foredune is emerging at the new vegetation line, with about half the volume of sand removed during re-profiling re-deposited in this area. After 21 months, lower beach width gain from re-profiling had disappeared, and the volume of sand deposited on the new incipient foredune is more than the volume removed by the re-profiling. The results are discussed in terms of whether the short-term outcomes achieved by the re-profiling are being compromised, and what on-going management will be required to maintain these over the longer term. This study highlights the challenges facing coastal managers trying to balance conflicting community objectives at beaches backed by vegetated dunes.

5.4 North Narrabeen, Sydney NSW

Following major storms in 1974, the NSW Government undertook a Beach Improvement Program in the late 1970s and early 1980s. In a similar philosophy to The Netherlands, soft coastal protection, rather than hard seawalls was pursued where practicable. This soft protection usually took the form of dune construction and/or revegetation, which also had ecological benefits. The dune vegetation also reduces wind blown sand being carried onto public and private infrastructure, with this trapping increasing the dune height by several metres in places.

North Narrabeen is one of Australia’s most iconic surf breaks and was declared a World Surfing Reserve in 2009.

During consultation in master planning for the reserve, the then Warringah Council was approached in 2012 by a coalition including North Narrabeen Boardriders and North Narrabeen Surf Life Saving Club (SLSC) regarding the management of the dune.

They had the following concerns regarding the dunes:

- Sightlines were no longer available between North Narrabeen SLSC clubhouse and the most dangerous areas of the beach – the lagoon mouth, due to sand and/or vegetation growth. This prevented the casual after hours surveillance by life savers using their clubhouse which underpins many rescues.
- The surf could not be seen from the car park and surrounding public spaces, noting that this is a World Surfing Reserve.
- The dune face was dangerously steep (Figure 5.7).
- The steepness and size of the dune was adversely affecting surf quality.

It should be noted that the sand dune provides an erosion buffer to the SLSC clubhouse, car park and other infrastructure (Figure 5.8), while the vegetation reduces wind blown sand burying infrastructure. Therefore, complete removal of the dune or vegetation is not feasible unless the infrastructure is relocated further inland.

In conjunction with stakeholders, WRL developed a dune reshaping scheme which was undertaken in 2013 and involved the following elements:

- Reduce the dangerously steep front face (Figure 5.9) by mechanically regrading to approximately its angle of repose (34°, 1V:1.5H), with a suggested upper limit on the graded slope of 40°;
- Reduce the dune crest in places, and redistribute it into a natural profile, within the following constraints:
    - No significant increase to the erosion hazard to the SLSC clubhouse or car park;
    - Keep the dune crest above the wave runup level for 100 year Average Recurrence Interval (ARI) conditions.
- Revegetate with low rise species, in a staged program, to prevent complete destabilisation.

Figure 5.7 Steep dune at North Narrabeen, July 2013 (James Carley)

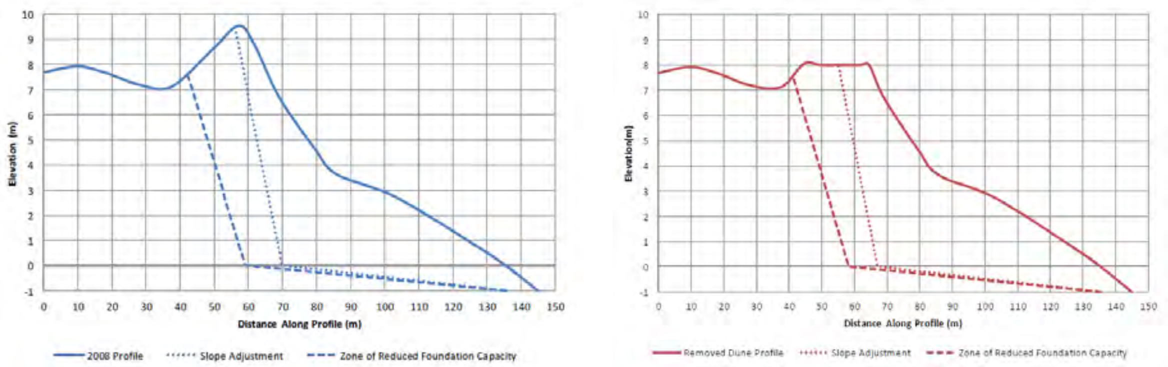


Figure 5.8 Consequences of removal of steep dune crest at North Narrabeen (WRL, 2013)

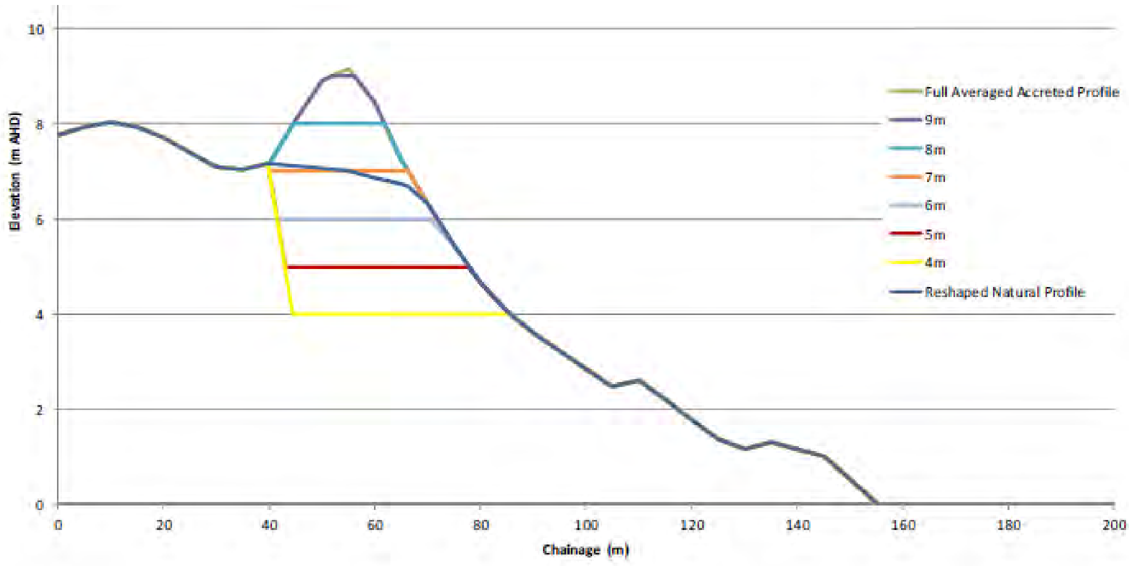


Figure 5.9 Options for dune reshaping at North Narrabeen, (WRL, 2013)

The steep seaward face was reduced (Figure 5.10) and sightlines between the SLSC clubhouse and danger areas of the beach have now been restored, as have those for viewing the surf from the car park and surrounding public spaces. Surfrider Foundation Australia (2013) had listed North Narrabeen on their list of endangered waves, and expected that the dune alterations would improve the surf quality.

Figure 5.10 Reshaped dune, April 2015 (James Carley)

5.5 Aramoana Spit, Dunedin New Zealand

The following text and Figure 5.11 is an extract from Atkin et al., (2019).

> “The Spit at Aramoana is one of the 17 Surf Breaks of National Significance. The wave quality is largely determined by the way in which waves are preconditioned by offshore bathymetry.

Primarily, waves are focussed on the terminal lobe of the ebb tidal delta at the entrance channel to Otago Harbour; secondarily wave crests are modified on a historical nearshore spoil ground. The main threat to the surf break at Aramoana is the disposal of material in the nearshore spoil ground. Disposal began here in the early 1980s, at which time some of the best surfing conditions were reportedly experienced. Early in the 21st century there was a general concern that Aramoana was no longer providing the high-quality surfing waves that it had in the past. It was considered by some that continual addition of sand not only impacted the secondary preconditioning processes, but that the embayment had become over-full with sand forming a large shallow platform in the nearshore. After objections to a consent for increased disposal quantities a working party was formed comprising of representatives from Te Runanga Otakou, Kati Huirapa Runanga ki Puketeraki, Department of Conservation, Otago Regional Council, Surfbreak Protection Society, South Coast Board Riders Association, Aramoana Conservation Trust and Port Otago Limited. The working party agreed to a 3-year temporary permit with greatly reduced disposal at the nearshore site, combined with a monitoring and modelling investigation to determine the impacts of nearshore disposal at Aramoana. No dredge material was placed at Aramoana for the first 2 years, during which time it was perceived by all parties involved that surfing conditions had improved."

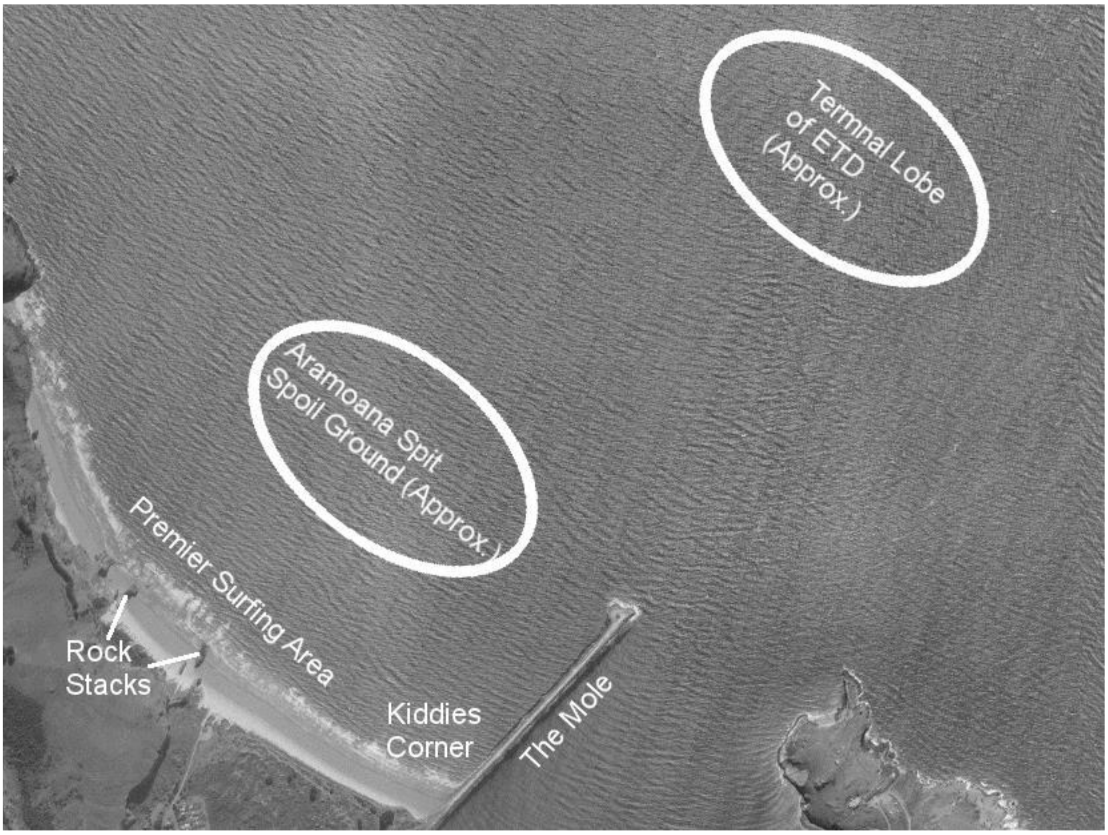


Figure 5.11 Aramoana Beach (Source: Atkin et al., 2019)

5.6 Sebastian Inlet, Florida USA

WRL engineers do not have first hand knowledge of Sebastian Inlet, Florida USA (Figure 5.12), but are aware of changes to surf conditions there through various surfing media.

Florida Department of Environmental Protection (2000) noted:

"The first attempt to cut a man-made inlet in the Sebastian area was made in 1886, but a hurricane closed the inlet. Since that time, numerous efforts to establish and stabilize the inlet for navigation have occurred over the years resulting in the construction of jetties and a sand trap."

The previous iconic surf break (Figure 5.13) was on the northern side of the northern breakwater. Wikipedia and SITD (2020) report that there were six unsuccessful attempts to cut and create a trained entrance channel between 1872 and 1905, with a seventh effort in 1918 and an eighth in 1924. All early attempts at opening/training were resisted by the US Army Corps of Engineers on the grounds of inadequate technical rigour and the absence of a funding stream for future maintenance. An engineered scheme was completed in 1948. The northern breakwater ("jetty") was overhauled and extended by 500 feet in 1968-1969. Extensive maintenance and capital dredging projects have continued from 1948 to the present day.

SITD (2020) reported that in 2002, the northern breakwater ("jetty") was renovated and extended, and has since survived major hurricanes. Surfer Magazine (2017, below) attributes the deterioration in surf quality to this 2002 renovation.

Notwithstanding the difficulties, a 2013 study (cited in SITD, 2020) estimated that the annual positive economic impact of Sebastian Inlet (which only exists due to having breakwaters/training walls) was US$200 million.

Note curved northern breakwater

Figure 5.12 Sebastian Inlet, Florida USA (Google)

Supplied by Shaun Tomson

Figure 5.13 Sebastian Inlet surf, Florida USA

Surfer Magazine (2017) reported:

> "Of all the waves that have been dramatically altered over the years, perhaps none has had a larger impact on surf culture than Sebastian Inlet. In the late '60s, when the Army Corps of Engineers went to work extending the small jetties at Sebastian to prevent erosion and keep the channel clear for boats, they inadvertently created the best sandbar in Florida. In the decades that followed, Sebastian became ground zero for high-performance surfing — not just in Florida, but in the entire United States. On a good day, First Peak was a thick, wedging right with hundreds of talented surfers in the water abiding by a pecking order not dissimilar to the one at Pipeline. Sebastian was the venue for one of the first airs completed on a surfboard in the '70s, and it groomed surfers like Kelly Slater, Lisa Andersen and CJ Hobgood, who would go on to win 16 world titles combined. Unfortunately, in the early 2000s, repairs and renovations to the jetty caused First Peak to disappear. "I miss Sebastian, truly," Kelly Slater told SURFER. "I'd do anything to bring it back to its glory."

Florida Department of Environmental Protection (2018) noted:

> "Sebastian Inlet is a man-made tidal inlet that was constructed in its present position in 1948, … Sebastian Inlet State Park encompasses both the north and south sides of the inlet. Maintenance dredging of the channel and sediment impoundment basin (sandtrap) occurs regularly, with placement of suitable material on the downdrift beaches south of the inlet. The Department adopted the Sebastian Inlet Management Study Implementation Plan in March 2000, which prescribed a bypassing requirement of 70,000 cy per year… The Department convened a new Technical Advisory Committee (TAC) in June 2004 …, the TAC recommended an updated bypassing objective of 90,000 cy on an average annual basis."

5.7 Other case studies

A detailed presentation of further case studies is beyond the scope of this project. Other locations known to WRL which could be further researched include:

- Whangamata, NZ;
- Mundaka, Spain;
- Mangamanu, NZ;
- Stockton, NSW;
- Noosa, QLD;
- Palm Beach, QLD.

6 Management options

6.1 Short term options

For improved alongshore access, steep dune scarps can be reprofiled to a nominal angle of 34° (range 25° to 40°). Subject to ecological and botanical expertise, vegetation of the seaward portion of the dunes should consider low density species.

Dune cross section and planform designs are needed for this.

The following additional short term studies are recommended:

- Collation of historic bathymetric studies;
- Analysis of historic bathymetric studies to examine nearshore change; and
- Collection of additional bathymetric data.

6.2 Medium term options

The following medium term studies and actions are available to further understand or improve surfing amenity at Blacksmiths:

- Investigate the feasibility of a sand slug configuration placement for future dredging campaigns;
- If feasible, undertake monitored trial(s) of configuration placement of sand slugs as sand becomes available, including:
    - Bathymetric surveys;
    - Smart cameras;
    - Trial of drone based bathymetry monitoring;
    - Interviews with stakeholders;
    - Ongoing monitoring and analysis of beach change.

6.3 Long term options

Subject to the monitored trials, the following options may enhance surfing amenity over the long term:

- Consider the development of a concept design for a sand transfer scheme;
- Consider surfing amenity in any breakwater alterations, which could arise due to damage, repairs or upgrade, noting that it is presently unlikely that removal (partial or complete) of the breakwater would be acceptable to the broader community;
- Integrate surf amenity into a Coastal Management Program, including synergies with other objectives, such as managing other coastal hazards.

7 Beach usage monitoring

A camera based monitoring system was installed by WRL onto the Blacksmiths Beach lifeguard tower to quantify beach usage and qualitatively monitor surfing amenity. The camera was initiated as part of this project, but has been integrated and further developed within the Smart Beaches project. This custom camera system transmitted images in real-time every 15 minutes during daylight hours between 10 November 2019 and 19 March 2020. Monitoring of the site continued for four months until the camera system was stolen.

A field of view was chosen for the camera that faced south towards the breakwater to document any iconic surfing conditions off the end of the breakwater if they occurred. While this field of view maximised the alongshore coverage of the beach for beach user counting, it did not include coverage of the primary patrol area immediately in front of the SLSC building.

Figure 7.1 Camera field of view (top), example of automatic beach user detection on oblique camera view (bottom left) and WRL BeachStat camera system (bottom right)

7.1 Methodology

The WRL BeachStat monitoring system is a low-cost camera based system that combines state of the art machine learning with cutting edge image processing to quantify beach usage and track changes to the position of the shoreline. This system uses a custom trained machine learning model specifically designed to count beach users in imagery based on over 10,000 manual annotations. To improve the reliability of the results of the system, detection of beach users was limited to those located on the dry beach area only. This excluded surfers and swimmers in the water, which are much more difficult to reliably detect as they are often obscured and have a much smaller pixel footprint in the images. It should be noted that a number of factors outside WRL's control can affect detection accuracy including sun glare, occlusion and lens obstructions such as water droplets.

The results of the automatic people detection analysis were reviewed by WRL staff and manually edited as needed to account for incorrect detections. It should be noted that the automatic people detection model is not optimised for detecting large crowds of people (i.e. >30 people) and so results should be considered conservative.

7.2 Duration of a visit

The camera and analysis counts instantaneous users, but does not identify or track them. There are some data sources for instantaneous and/or daily totals of beach users in other jurisdictions, however, there is very limited data available for the typical duration of a beach or pool visit available to WRL.

The only data known to WRL is contained in Anning (2012) and the City & County of Honolulu (2018). Anning undertook specific on-site and online surveys for users of Manly Ocean Beach (Sydney) and Collaroy-Narrabeen Beach (Sydney). The City & County of Honolulu (2018) undertook user surveys associated with upgrading a derelict ocean pool in the vicinity of Sans Souci Beach, Waikiki, Hawaii.

The following durations were estimated:

- Manly Ocean Beach:
    - Average: 2.5 hours
    - ± Standard deviation: 1 hour to 4 hours
- Collaroy-Narrabeen Beach:
    - Average: 2 hours
    - ± Standard deviation: 0.5 hour to 3.5 hours
- Sans Souci Beach, Waikiki:
    - Average: 3.9 hours

The best available data indicates that a typical beach visit would last for 2 hours and could typically range from 0.5 to 4 hours.

WRL has provided the collected data for Blacksmiths Beach as person-hours. If an actual average visit time was 2 hours, the total patronage in person visits would be halved, while if average visit time was half an hour the total patronage in person visits would be doubled.

7.3 Beach visitation results –November 2019 to March 2020

Blacksmiths Beach received approximately 8,100 person-hour visits between 10 November 2019 and 19 March 2020, with the daily data shown in Figure 7.2 . This equates to an average of approximately 1,300 person-hour visits per month or 68 person-hour visits per day. A maximum of 443 person-hour visits was observed on Sunday March 8, shown in Figure 7.3 . In fact, most of the days with highest patronage were between 28 February and 8 March, during the NSW State Surf Life Saving Championships that is held annually at Blacksmiths Beach. It is likely that true visitor counts would have greatly exceeded the numbers calculated during this period as the camera view did not capture the primary beach area combined with obstruction of the camera view marquees associated with the event. The 2020 event which lasted 2 weeks was reported to attract 6,000 competitors from across NSW, along with 600 volunteer officials and up to 15,000 family and spectators (Newcastle Herald).

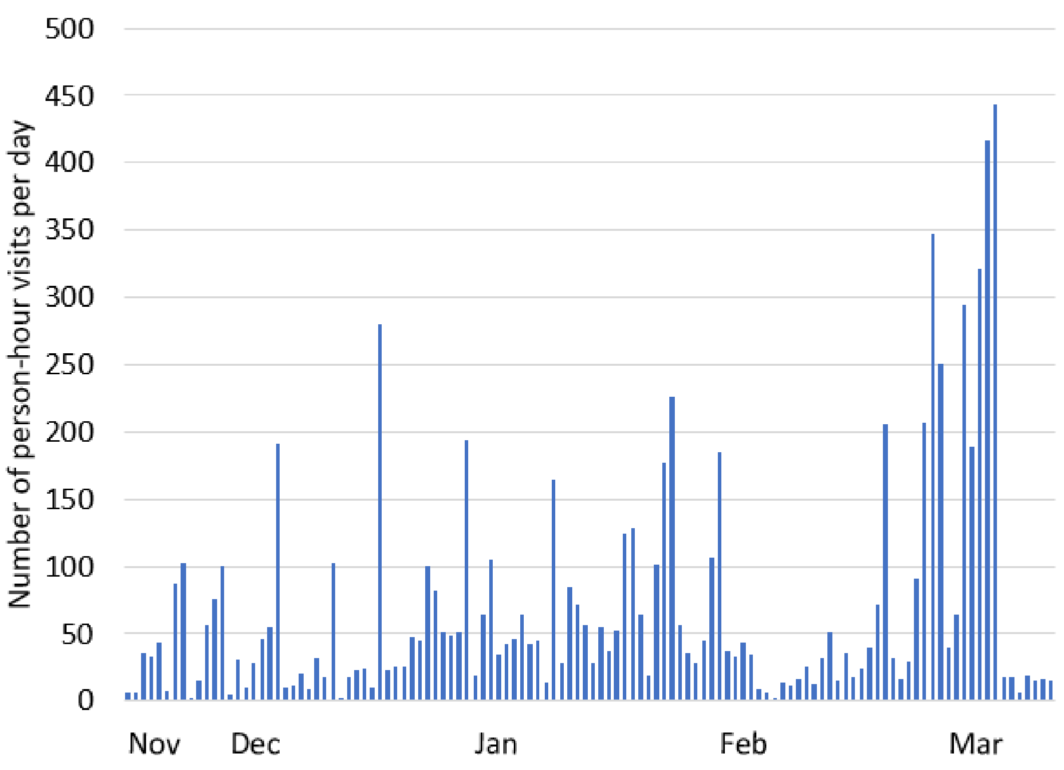


Figure 7.2 Blacksmiths beach person-hour visits per day, 10 November 2019 to 19 March 2020

Figure 7.3 December 21 – busiest day between November 10, 2019 and March 19, 2020 at Blacksmiths Beach

7.3.1 Impact of Month of Year on Beach Visits

Beach visits were relatively consistent throughout the monitoring period between November 2019 and February 2020. However, a significantly greater number of people visited Blacksmiths Beach in March compared to the other months surveyed, almost certainly due to the NSW Surf Life Saving Championships drawing large crowds to Blacksmiths Beach. An average of 130 person-hour visits per day occurred in March, compared to approximately 40 in November, 50 in December, 70 in January and 60 in February (Figure 7.4).

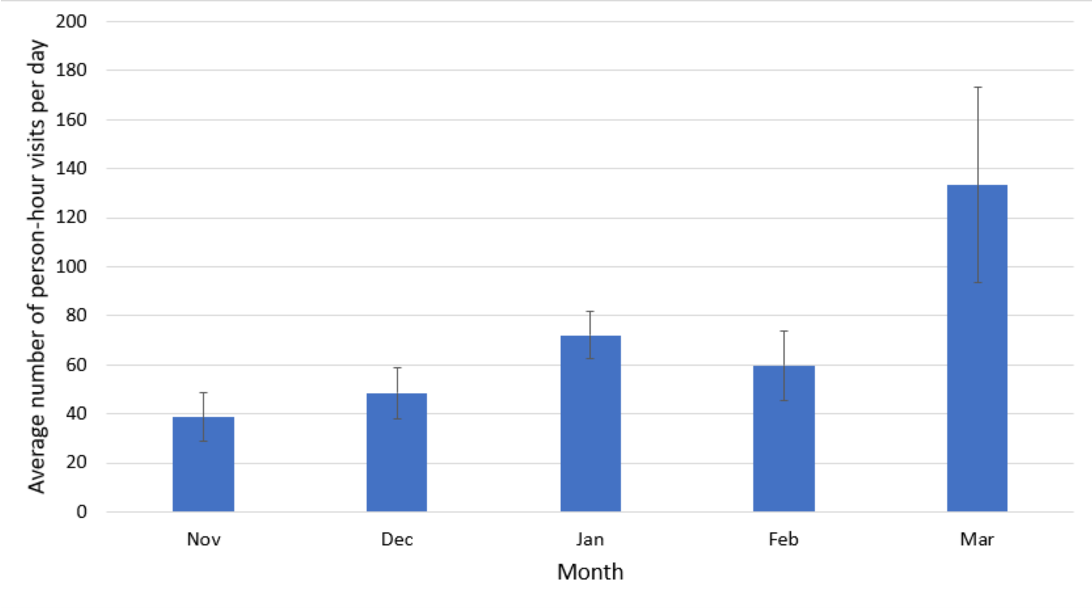


Figure 7.4 Average (± standard error) number of person-hour visits per day at Blacksmiths Beach for the months November 2019 to March 2020

7.3.2 Impact of Day of the Week on Beach Visits

The average number of person-hour visits per day of the week is shown in Figure 7.5 . All weekdays (Monday to Friday) had relatively similar numbers of visitors, however there was a slight preference beach visitations to occur on Wednesdays and Fridays (~60 person-hour visits per day) rather than Mondays, Tuesdays and Thursdays (~40 person-hour visits per day). Weekend days had significantly greater numbers of visitors, with an average of 115 and 125 person-hour visits on Saturday and Sunday respectively. Weekend numbers were strongly influenced by the NSW State Carnival event that was largely held on these days.

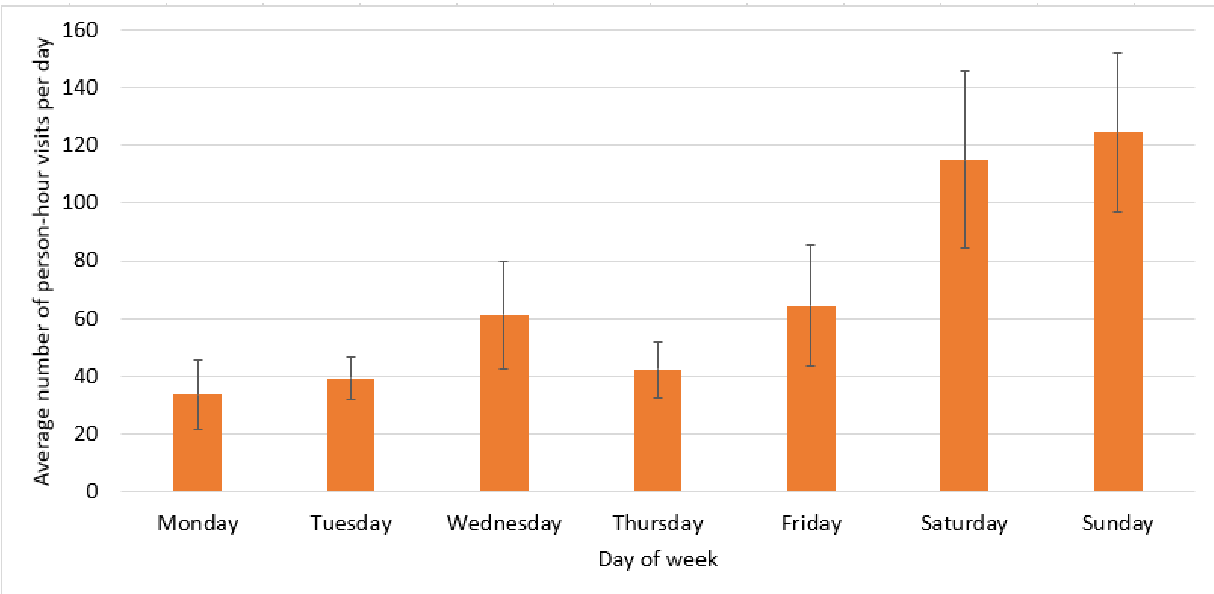


Figure 7.5 Average (± standard error) number of person-hour visits per day of week at Blacksmiths Beach

7.3.3 Impact of Time of Day on Beach Visits

There was a clear preference for beach visitation to occur in the late morning (10 am to 11 am). The most popular time of day to visit Blacksmiths Beach was 10 am, when there was an average of 15 person-hour visits per day. However, beach visits were relatively consistent at all other times between 9 am and 5 pm, with averages of 4 - 7 person-hour visits per day for each of these hours (Figure 7.6).

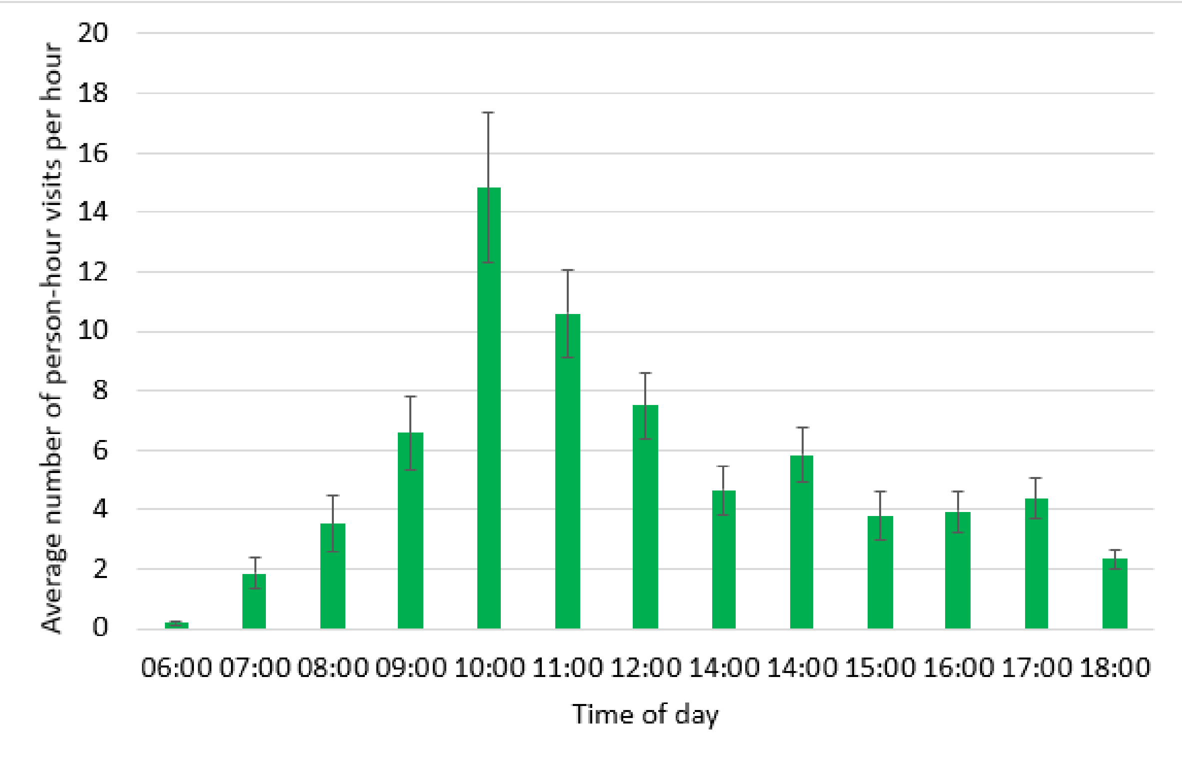


Figure 7.6 Average number of person-hour visits at Blacksmiths Beach per hour, November 10, 2019 to March 19, 2020

8 Conclusion/Summary

This section is repeated in the Executive summary at the front of this report.

8.1 Overview

Blacksmiths Beach has a long surfing history, surfing heritage and surfing culture. Swansea-Belmont Surf Life Saving Club (SLSC) was formed in 1927 and the Nine Mile Beach Surfboard Club was formed in 1965.

Long-term surfers at Blacksmiths Beach NSW have reported a decline in surf quality, leading to the creation of the community group “Bring Blacksmiths Back”. Lake Macquarie City Council (Council) has developed a Coastal Zone Management Plan (CZMP) for its open coast, and is transitioning this into a Coastal Management Program (CMP). Council is aiming to incorporate surfing amenity into the CMP.

8.2 Changes to beach and surf

An abbreviated list of points made by individuals includes:

- There were previously up to 17 named surf breaks between Awabakal Street and the breakwater. The sand profile underwater has steepened resulting in more of a shore break. The northern side of the breakwater in particular has deepened;
- The steep dune face also means that lifeguard/life saver access alongshore is sometimes not possible at high tide, compromising rapid response for rescues;
- The sand dunes also provide protection to the Blacksmiths settlement from storm erosion, wave runup, coastal recession and future sea level rise. Blacksmiths and the present surf club may be vulnerable to future sea level rise and extreme storm events;
- “Bring Blacksmiths Back” want to restore surfing amenity as a gift/legacy to present and future generations.

8.3 Possible causes of change

Changes to surfing conditions may have eventuated due to changes in the cross shore profile (steepness), three dimensionality of breaking waves (banks and breakwater effects) or changes to the wave climate.

The report examines the plausibility of various factors which could change surfing conditions at Blacksmiths. These include:

- Channel adjustment to breakwater construction 130 years ago;
- Beach adjustment to breakwater construction 130 years ago;
- Beach adjustment to recent changes to breakwater;
- Ongoing evolution of the beach after 6,000 years of steady sea level;
- Winnowing of fine sand through wave action;

- Porosity of breakwaters;
- Abrasion of sand grains, changes to shell production and content;
- Removal of heavy metals due to mining;
- Subsidence due to mining;
- Dune growth and/or dune vegetation;
- Sea level rise;
- Medium to long term wave climate changes;
- Rainfall.

With the entrance works (training walls and breakwaters) constructed from 1878, studies indicate that the system is still evolving and even without future climate change, may take 350 to 600 years to reach a stable equilibrium.

8.4 Options for surfing amenity and/or beach access

8.4.1 Short term options

For improved alongshore access, steep dune scarps can be reprofiled to a nominal angle of 34° (range 25° to 40°). Subject to ecological and botanical expertise, vegetation of the seaward portion of the dunes should consider low density species.

Dune cross section and planform designs are needed for this.

The following additional short term studies are recommended:

- Collation of historic bathymetric studies;
- Analysis of historic bathymetric studies to examine nearshore change;
- Collection of additional bathymetric data.

8.4.2 Medium term options

The following medium term studies and actions are available to further understand or improve surfing amenity at Blacksmiths:

- Optimise the design of a sand slug configuration placement for future dredging campaigns;
- Ongoing monitored trials of configuration placement of sand slugs as sand becomes available, including:
    - Bathymetric surveys;
    - Smart cameras;
    - Trial of drone based bathymetry monitoring;
    - Interviews with stakeholders;
    - Ongoing monitoring and analysis of beach change.

8.4.3 Long term options

Subject to the monitored trials, the following options may enhance surfing amenity over the long term:

- Consider the development of a concept design for a sand transfer scheme;
- Consider surfing amenity in any breakwater alterations, which could arise due to damage, repairs or upgrade of the breakwater, noting that it is presently unlikely that removal (partial or complete) of the breakwater would be acceptable to the broader community;
- Integrate surf amenity into a Coastal Management Program, including synergies with other objectives, such as managing other coastal hazards.

8.5 Smart camera

As part of this project, a smart camera was installed on the lifeguard tower at Blacksmiths to quantify beach use with the development of machine learning techniques to count people in the camera images. The camera was initiated as part of this project, but has been integrated and further developed within the Smart Beaches project.

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Appendix A "Bring Blacksmiths Back" email

Following the community meeting Council received an email on behalf of "Bring Blacksmiths Back" dated 11 November 2019". The text of the email is reproduced below.

"For our group the important outcome of the report will be to identify and acknowledge the following,

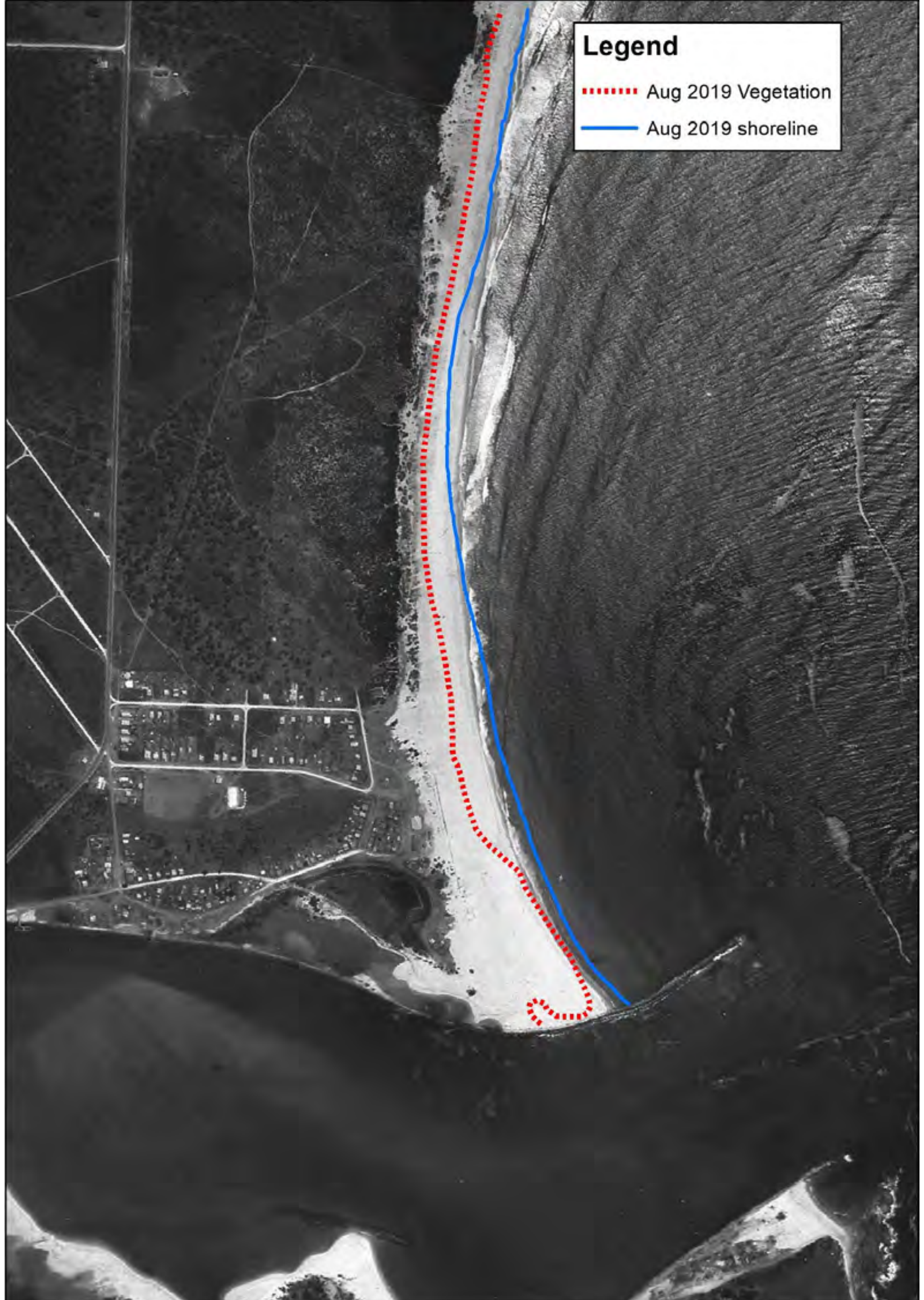
a) Identify Loss of Surfing Amenity at Blacksmiths Beach.
b) Acknowledge Blacksmiths Beach has a surfing history, heritage and culture with Swansea Belmont SLSC formed in 1927 and the Nine Mile Beach Surfboard Club formed in 1965.
c) Identify the loss of inshore sand banks and a permanent drop in the depth of the inshore seabed floor has resulted in our loss of surf amenity.
d) Acknowledge the contributing cause as the breakwater upgrade, extension, widening and raising and encroaching shoreline frontal dune vegetation is stopping the natural cyclic movement of sand back into the surf zone.
e) Support a permanent Swansea Channel dredging program with sand transfer system to nourish Blacksmiths Beach.
f) Develop a LMCC Surf Break Management Plan to recognise and value the LMCC Surf Breaks as an asset for economic and environmental benefits.
g) The new LMCC Coastal Management Program being developed could include this new LMCC Surf Break Management Plan a first for NSW Local Government.
h) Our group Bring Blacksmiths Back to be recognised and included in the development of a LMCC Surf Break Management Plan and be included in the Pelican/Blacksmiths LAP group meetings.
i) Address the immediate safety concerns of beach access in emergency rescue events. Recommend removing shoreline frontal dune vegetation south to the Breakwater and north to Awabakal Avenue immediately."

Appendix B Compilation of aerial photos

Blacksmiths Beach Morphology, vegetation and human modifications over time

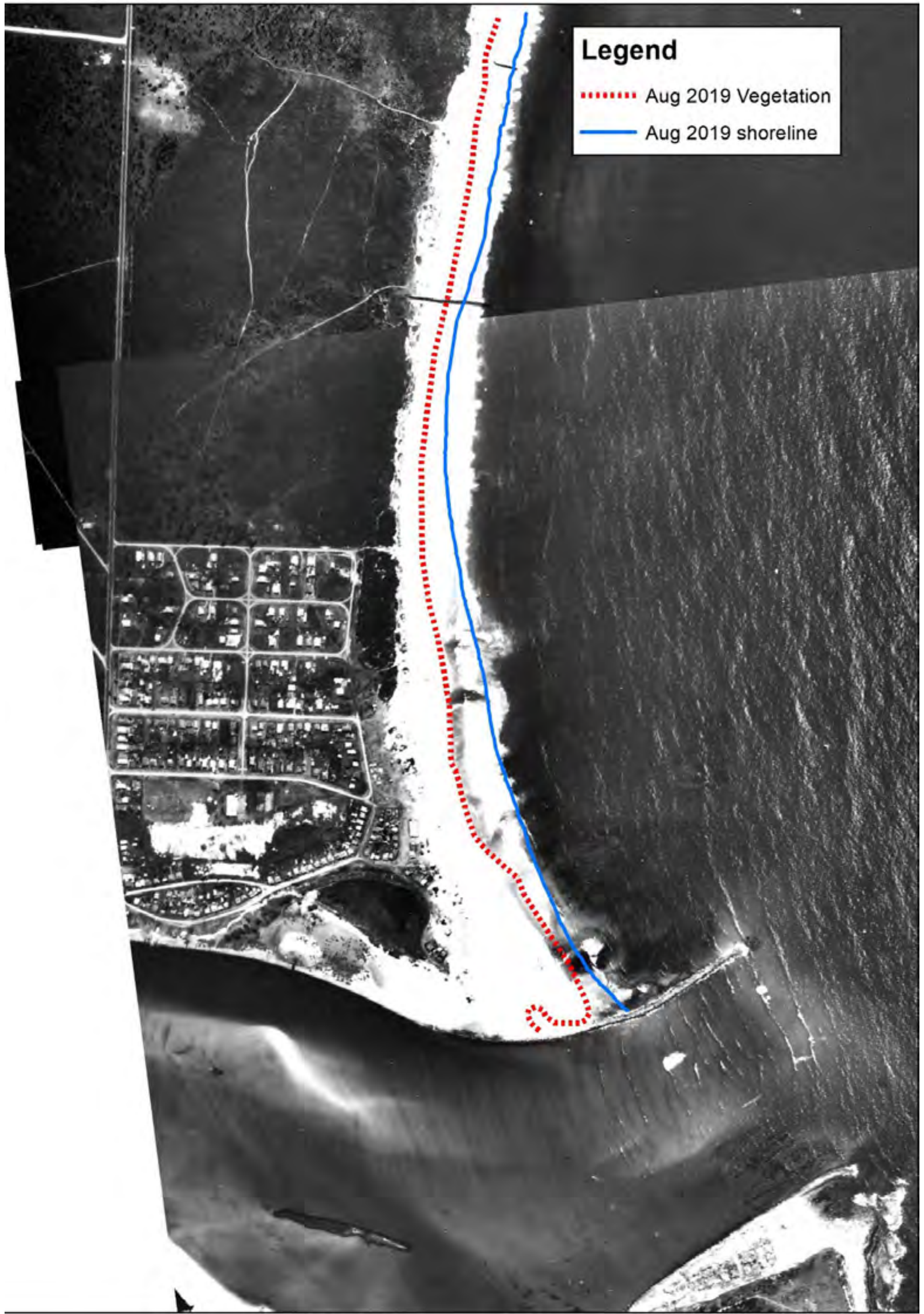
1940

- Breakwater was approx. 12.5m shorter
- End of breakwater was 17m wide (now 29m)
- Rest of the breakwater practically identical
- Beach adjacent to breakwater till around 500m from breakwater was much less wide (~40m) than present
- Around 500m-1300m from the breakwater, the beach was generally 20-30m wider
- Around 1300-2000m from the breakwater, the beach was approximately the same width as present day
- Significantly less vegetation than present



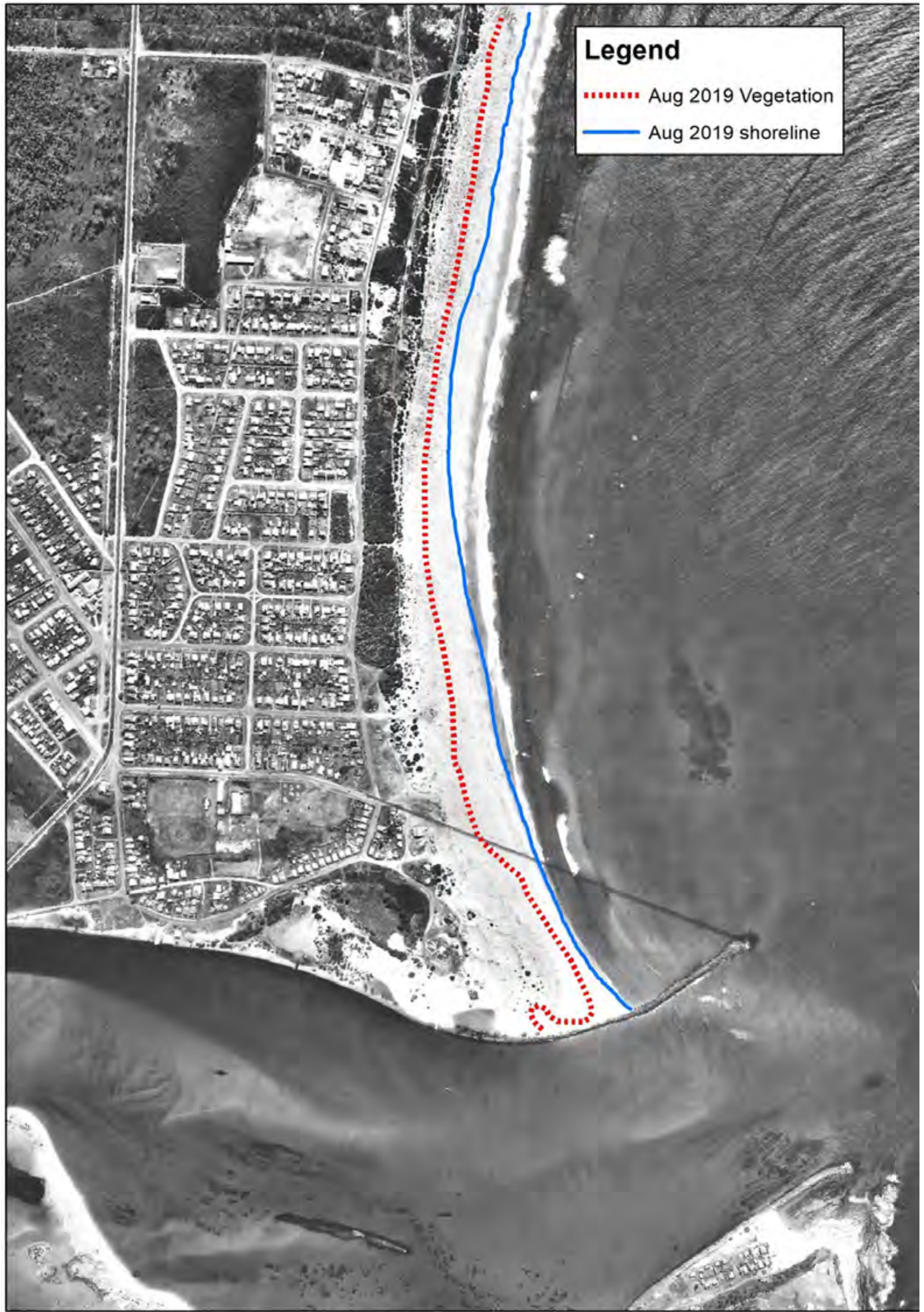
1950

- Erosion of southern end of beach
- Removal of vegetation on central/northern parts of beach



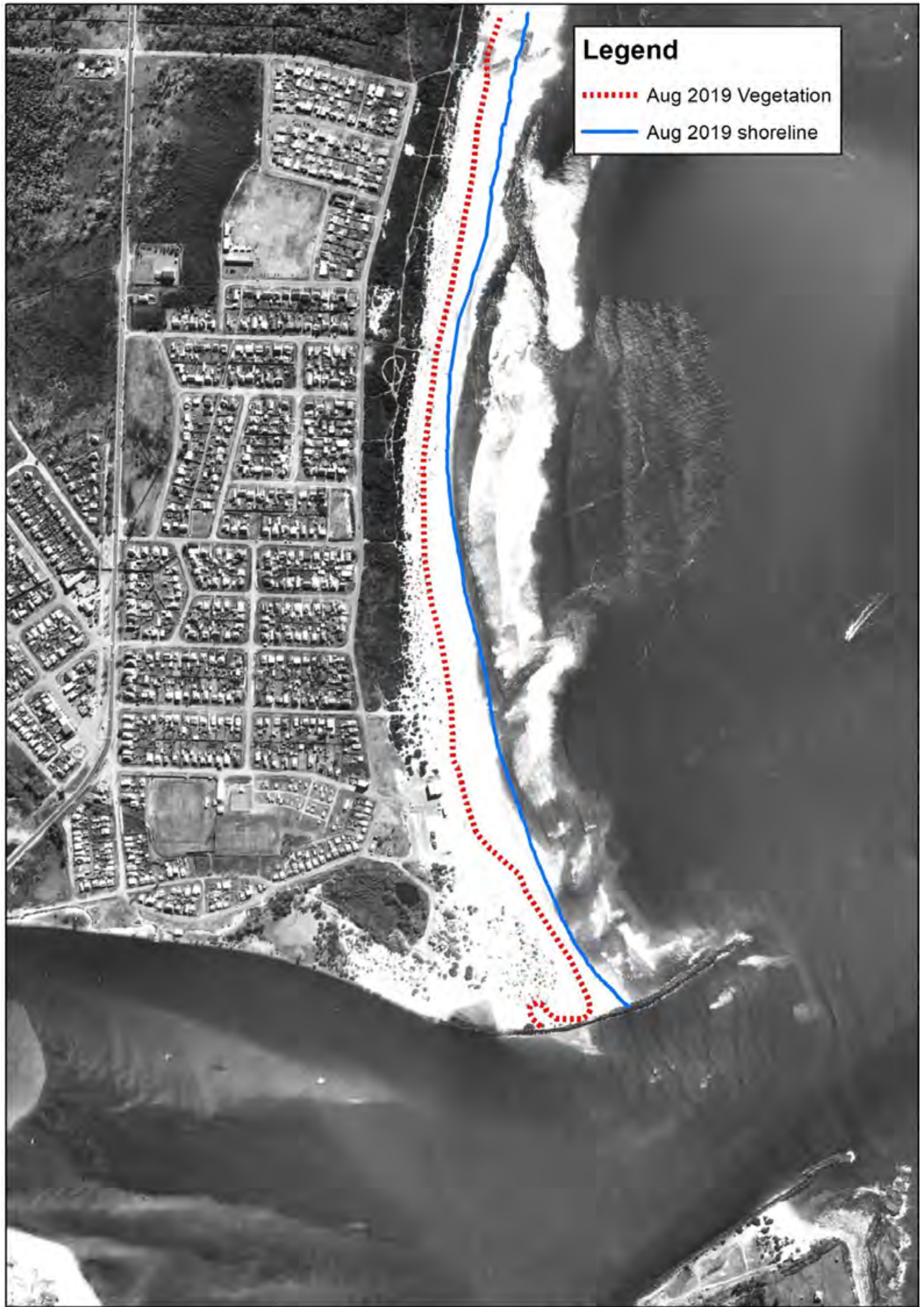
1959

1965



1969

1974



1981

1991

- Revegetation of southern end of beach
- Breakwater is the same as in 1940

1994

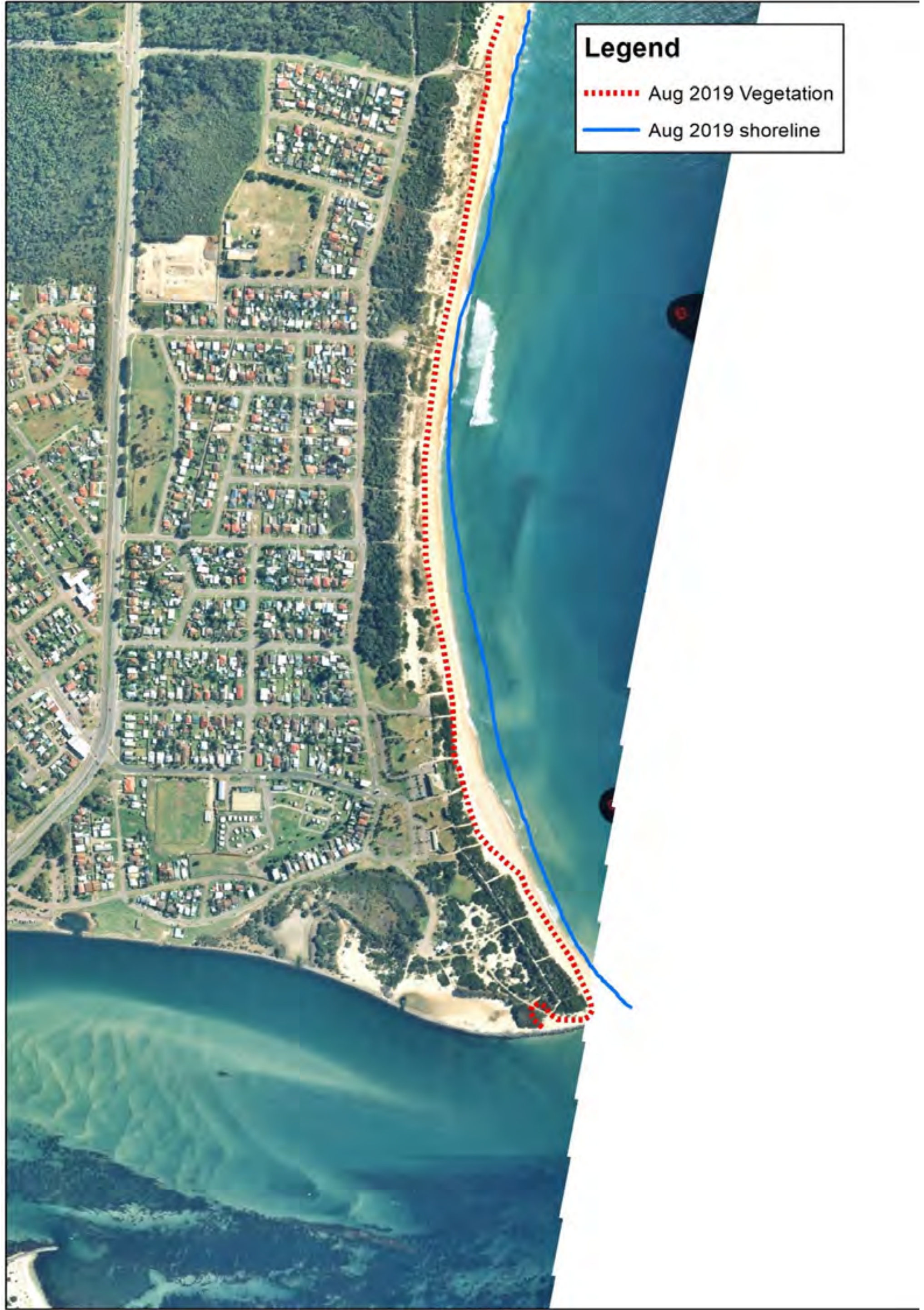
- Breakwater upgrade sometime between 1991 and 1994

1996

- Beach erosion

1999

- Extensive dune rehabilitation
- Beach very eroded



2006

- Sediment accretion since 1999

2011

2012

2013

- Sandbar morphology at times – waves breaking out far from shore and at different angles in these conditions

2014

2015

- Breakwater upgrade – same length and width since 1994, just 1m higher and concrete path

2016

2017

- Sandbar morphology at times

2018

2019