Kingborough Council Shoreline Monitoring Program

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Cover Image: Eroding and unstable soft Tertiary sediment cliffs in the Gordon area. Matt Dell 2013

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Executive Summary

The *Kingborough Council Shoreline Monitoring Program* documents changes in shoreline position on numerous beaches within the Kingborough Municipality. The project was initiated after a large storm event on the 9th of July 2011 which resulted in substantial damage to both beaches and infrastructure along the south and south-east coasts of Tasmania. Significant erosion and shoreline retreat was observed by the authors at beaches stretching from as far west as Spain Bay in Port Davey, as far south as Prion Beach on the South Coast and east to Roaring Beach on the Tasman Peninsula.

The 2011 project acquired high resolution aerial photography for over 30 kilometres of coastline within the Kingborough and Clarence Municipalities. The data was processed using state of the art software and hardware to provide a precise location of shoreline position as well as detailed beach profile information. This information was then compared with historical aerial photographs which are the only consistent objective source of data we have to analyse the past nature and position of the beaches and associated shorelines.

The initial 2011 survey only covered limited beaches totalling less than 3 km within the Kingborough Municipality. The subsequent 2013 flights covered over 36 kilometres including shorelines at Taroona, Kingston, North West Bay, Trial Bay, Woodbridge, Gordon, Middleton, Great Bay, Adventure Bay and Bruny Island neck.

The results indicate that shoreline movement is highly variable within the investigated beaches. For example the level of seaward shoreline growth observed at Neck Beach and Adventure Bay on Bruny Island are the largest recorded in southern Tasmania and are at odds with the predominantly recessive trend observed in all other beaches previously studied by the authors.

The non-swell exposed beaches within the D'Entrecasteaux Channel and North West Bay also show a general recessive trend of between 1 and 20 metres which is primarily constrained by the backshore geology (Sharples and Donaldson 2014). The main areas of concern are shores backed by poorly consolidated recent alluvial and colluvial material or Tertiary Sediments which for the most part have exhibited a significant shoreline recession trend. These poorly consolidated and easily erodible shorelines constitute a high proportion of the vulnerable shores in North West Bay, Taroona and shorelines around Woodbridge, Middleton and Gordon.

It is recommended that beaches identified as having a clear recession trend such as be investigated more thoroughly than this first pass assessment. It is recommended that along with regular aerial flights, that a number of ground-based monitoring sites be established, particularly in areas where there is a clear recession signal which is obstructed view aerially by significant overhanging vegetation. This approach when combined with a more comprehensive assessment of historical shoreline behaviour from old aerial photography should provide a clear picture of past and future potential movements.

Introduction

Beginning on the 9th of July 2011 a large storm event pounded the west and south coasts of Tasmania with waves in excess of ten metres for approximately 54 hours. The long-period swell and associated surge resulted in a substantial storm bite with large quantities of sand removed from the beaches along much of the southern and south eastern Tasmanian coastline.

The beaches of Storm Bay and Frederick Henry Bay were hit particularly hard with wave heights exceeding three metres and storm bites of around ten metres measured at parts of both Seven Mile and Roches Beach (Figure 1).

Immediately after the storm event it was identified that there was a need to capture the resulting impacts using high resolution aerial photography for many of the beaches within the Derwent Estuary, Storm Bay and Frederick Henry Bay. The flights were flown on the 15th of July 2011. In total 1250 photographs were taken covering numerous beaches within the Clarence, Sorell and Kingborough Municipal areas.

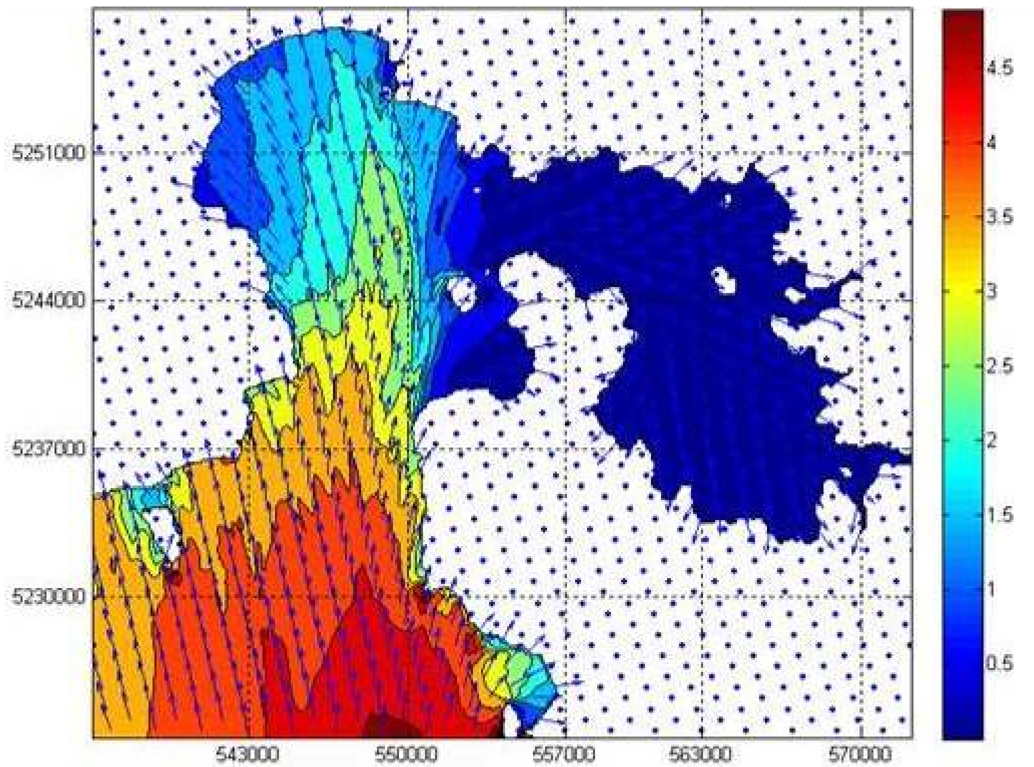

Figure 1 - Significant wave heights for Frederick Henry Bay 9 July 2011 (source: Water Research Laboratory, University of New South Wales, 2011).

The resulting 10-15cm resolution orthophotography provided a quick quantifiable representation of the resulting shoreline position and clearly identified the areas hardest hit by the storm event.

The subsequent 2012 and 2013 surveys were more comprehensive surveys focussed primarily on the beaches of the Clarence and Kingborough Municipalities. During this survey the beaches were intensively photographed with three or more flight runs so that an accurate representation of the shoreline position and beach structure could be established.

The data was processed in two stages. In the first stage orthophotographs were generated and the seaward extent of the vegetation line was extracted. The second stage was a computationally intensive analysis of the orthophotography which enabled the extraction of relative beach structure to help identify the current shorelines and provide a baseline for assessments of future structural changes of the shoreline.

This project is primarily a baseline monitoring project aiming to provide an objective set of accurate high resolution data from which decisions on future planning requirements and adaptation measures can be based. The data will support and strengthen the effectiveness of existing projects such as the *TASMARC* shoreline monitoring program.

The Study Area

The 2013 survey (Figure 2) aimed to cover extensive coastal areas identified as being vulnerable in previous studies by Sharples and Donaldson (2014 in press). The study area can be divided into two main geomorphic groups: low lying sandy shorelines and highly erodible soft sediment shorelines.

Using this classification the Kingborough Council (KC) acquired baseline images for the following beaches:

- Great Bay
- Adventure Bay
- Bruny Island neck
- North West Bay
- Trial Bay
- Peppermint Bay
- Gordon shoreline
- Taroona

Revisited shorelines:

- Kingston Beach

Kingborough Flightlines 2013 survey

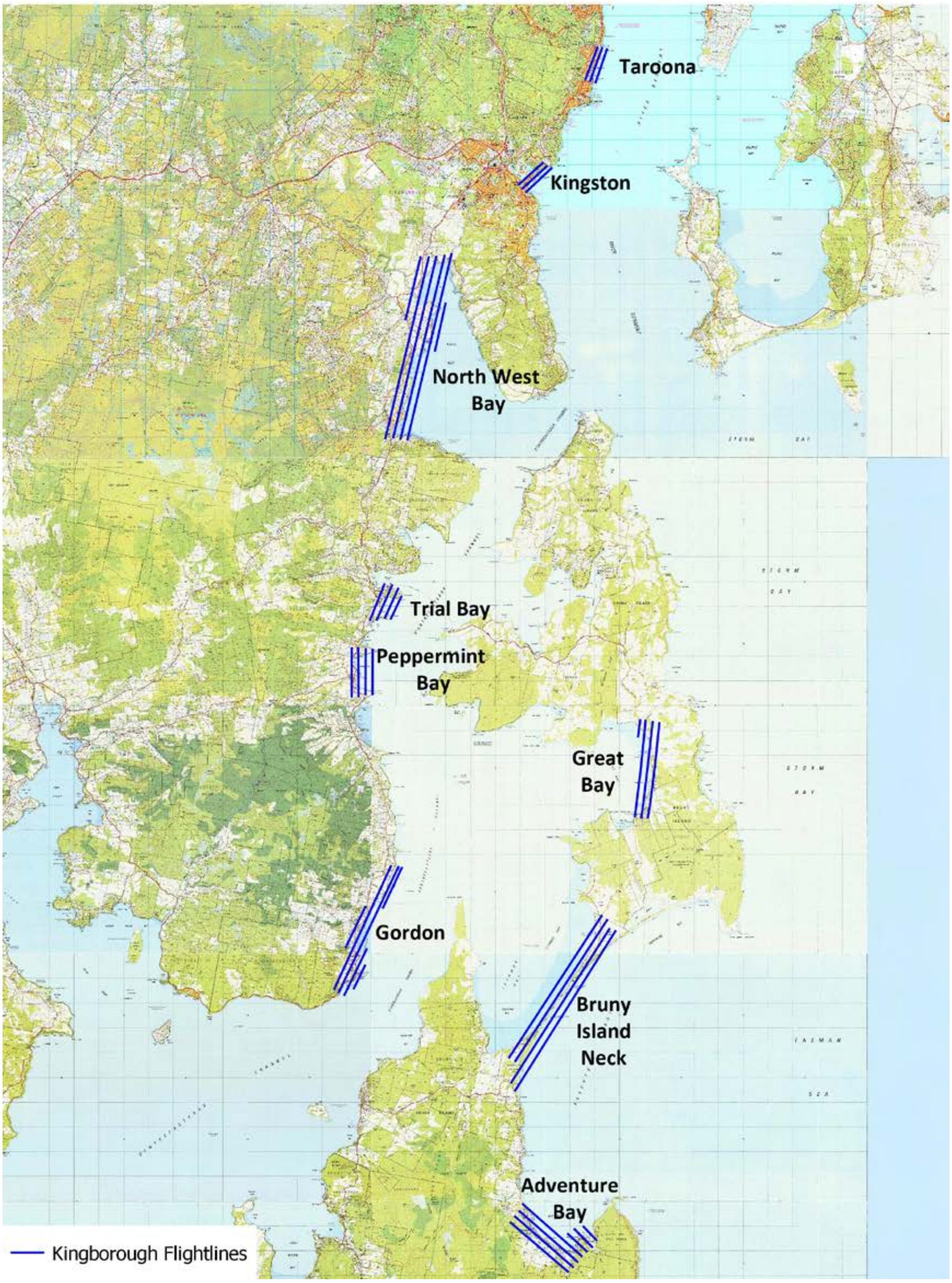

Figure 2 - Study area beaches and the 2013 flight lines for the Kingborough Council Shoreline Monitoring Program.

Wave Climate and Tide Regime

The southern coast of Tasmania is a high energy swell environment (Davies 1980). It is a very stormy region. Waves of less than two metres occur only 2% of the time and waves of greater than five metres occur 40% of the time (Chelton *et al.* 1981). Waves of greater than four metres regularly pound the coastline (Bureau of Meteorology 1995).

The study area has a micro-tidal regime with spring tides of greater than two metres. This tidal range is regularly amplified by high winds and large swells which cause areas of the beach and fore dunes that are normally beyond the reach of the tide and wave attack, to suffer significant erosion events. This effect is illustrated in Figure 3 below. The identified and labelled peaks correspond to a series of intense low pressure systems which pushed observed sea levels over 50cm above predicted levels during the storms in July 2011.

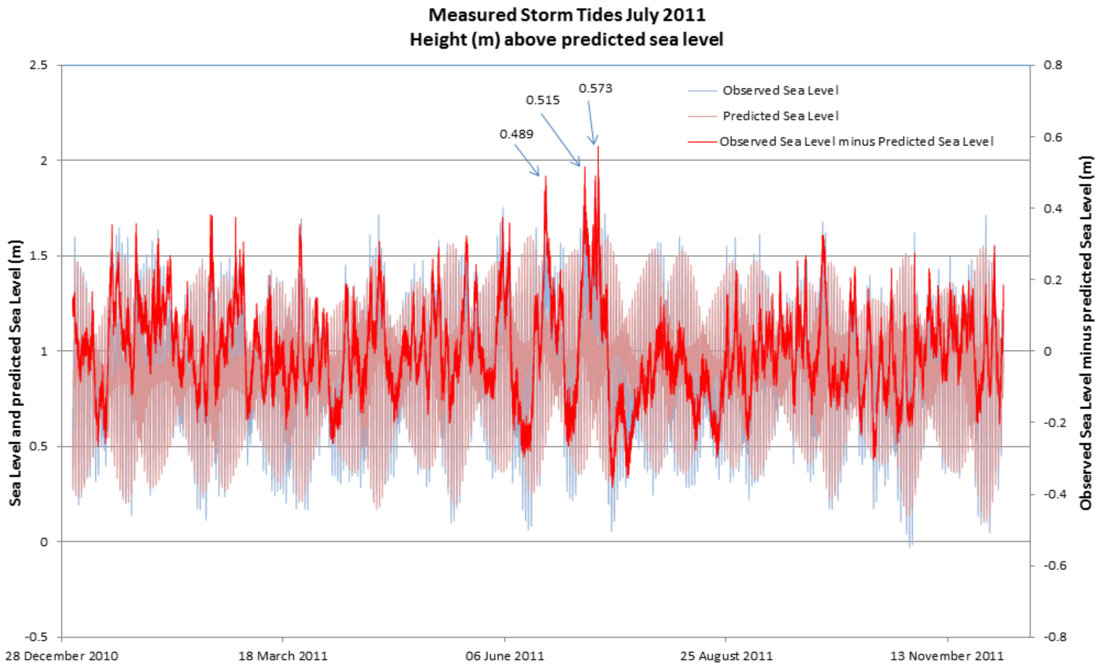

Figure 3 - Storm Tide peaks visible in tide gauge data from the 2011 Hobart Ports tide gauge data (Data courtesy of the Bureau of Meteorology 1995).

Geology and Geomorphology

The bedrock geology of the study area is principally Permian siltstones, Triassic sandstones and Jurassic dolerite. These rocks have been subject to normal faulting which has resulted in them being variably tectonically uplifted and dropped forming the typical undulating horst and graben landscape. The Permian and Triassic sedimentary rocks have been intruded in places by igneous Jurassic dolerite. Overlying the hard bedrock are Tertiary and Quaternary sediments as poorly consolidated alluvium, colluvium and coastal sediments (Forsyth *et al* 2005).

Previous studies (e.g. Davies 1980) have identified the dune and beach deposits within the study area as being of Holocene or Pleistocene (Quaternary) age.

Detailed geological and geomorphological descriptions for the beaches investigated in this report have not been included as a very comprehensive analysis of all vulnerable beaches will be included in Chris Sharples First Pass Coastal Hazard Assessment for Kingborough Local Government Area (*Sharples and Donaldsons 2014 in press*).

Methods

The project methodology used a combination of traditional photogrammetric techniques and modern computer vision techniques. The orthophotos and digital elevation models were generated through complex mathematical analysis of on ground features within the overlapping areas of vertical digital aerial photographs. A detailed flight plan was developed to ensure all beaches were completely surveyed and to ensure a minimum of three photographs contained any one point on the ground within the area of interest. Vertical digital aerial photographs of the selected beaches were collected using a Canon digital SLR camera from a Cessna 206 flown at an altitude of approximately 600 metres. These photos were then orthorectified using differential GPS (DGPS) located control points resulting in planar positional accuracy of +/- 10cm.

To better understand the long term trends in shoreline position historical orthophotos were scanned and orthorectified and their shoreline positions examined and digitised. It was not always possible to generate the orthophotos to the same accuracy as the modern equivalents and in some cases the photography was of such poor quality it is not suitable for use at all. For example, the pre-1960 orthophotos have a horizontal positional accuracy of +/- 1 to 5 metres depending on the scanning quality and scale of the photography.

The shoreline position was defined in this study by the most seaward position of continuous vegetation on the beach. The shoreline was hand digitised on the orthophotos at a scale of 1:200. The shoreline position for each time step and beach profile measurements, where available, were recorded along a series of 100 metre spaced transects located along the length of each beach.

The deliverable products for this project are orthophotos and shoreline position for all prescribed beaches and historical aerial photography coverage of North West Bay and its associated shoreline.

The project expands on the work of the *Shorewave Project* by Sharples *et al.* (2012 in prep). The *Shorewave Project* used scanned analogue aerial photographs that were orthorectified using the Climate Futures LiDAR Data as a base. This method was not a full photogrammetric reconstruction as all photos including the 1950's images were forced to fit over the 2005 LiDAR topography and as a result have a higher margin of error (+/- 1 metre) than results of this project. However the *Shorewave Project* covered beaches throughout Australia at more regular time intervals and provided a more in-depth analysis of the drivers of the observed changes in the shoreline with an analysis of long-term climatic and oceanographic datasets.

The results and findings of the *Shorewave Project* report will be incorporated into future annual shoreline monitoring reports once formally released.

The use of the 100 metre spaced points and transects for analysing was developed as part of the *Shorewave Project*. This technique allows for the semi-automated consistent sampling of data along the beach.

Methods control site – Adventure Bay

Adventure Bay is a low lying, east facing beach which has some of the highest housing density on Bruny Island. The usual control point coverage was extended to cover the full beach profile in conjunction with a *TASMARC* coastal survey conducted by Nick Bowden from the University of Tasmania.

To ensure a high level of accuracy of the produced orthophotography and Digital Elevation Models, features such as manhole covers, road markings and drains (which serve as ground control points) were identified and located to an accuracy of less than 1 to 2 cm with DGPS throughout the study areas (Figure 4). Complimenting the ground control were a series of reflective markers deployed along the length of the beach coincident with the position of the *TASMARC* survey points. These reflectors served as control to test the accuracy of the derived three dimensional beach profile models and the orthophoto accuracy.

The beach control reflectors revealed a horizontal accuracy of +/- 10 cm and vertical accuracy of +/- 30cm over the length of the beach. The maximum error was located in the middle of the beach where ground control was sparse.

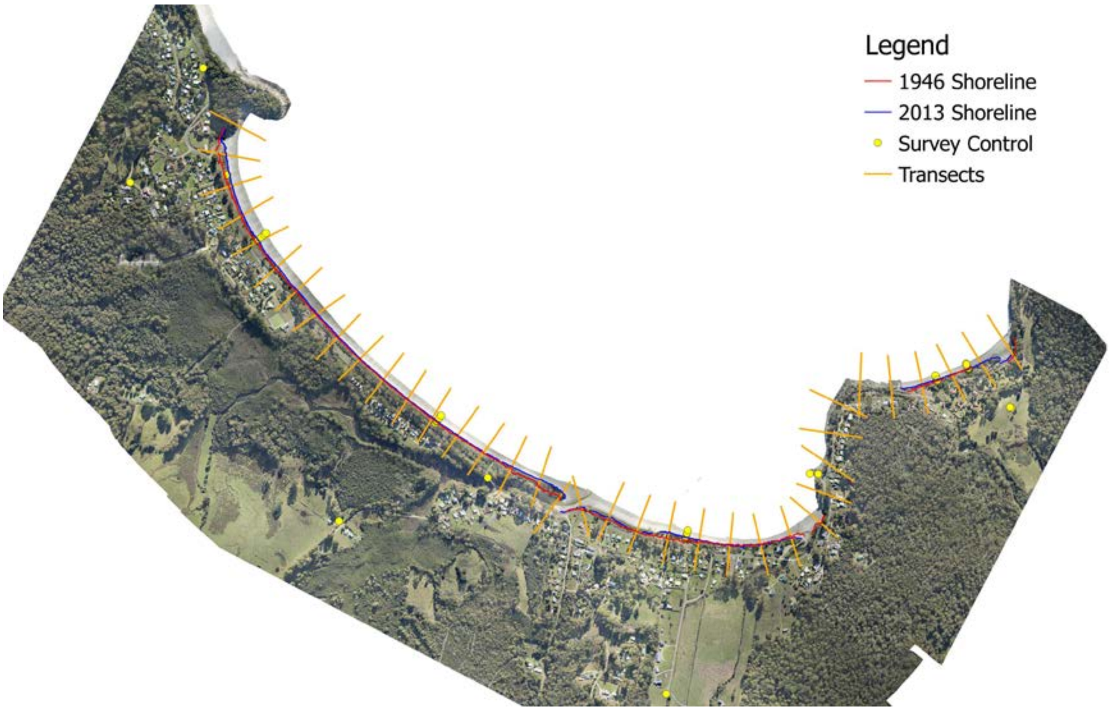

Figure 4 – Detailed overview of the Adventure Bay study site.

Results

This preliminary investigation of a selection of vulnerable shorelines in the Kingborough Municipality shows shoreline behaviour is highly variable and requires considerable further investigation and monitoring. Kingston Beach was the only beach resurveyed during the 2013 flights and it showed a general recovery trend with some incipient dunes and associated vegetation reestablishment evident in places along the beach. The initial scope of this study was restricted to the generation of 2013 shorelines for all study areas with a more detailed investigation of North West Bay. However the poor quality of the 1940's imagery for North West Bay made shoreline extraction difficult. Shorelines were extracted where possible. Preliminary historical shoreline assessments have been provided for the majority of other sites.

Bruny Island

Adventure Bay

The study area at Adventure Bay encompasses both Adventure Bay Beach and East Cove to the south. Adventure Bay is a 2.6 kilometre long, north east facing sandy beach which is bounded to the north by the Triassic Sandstone headland at Quiet Corner and Jurassic dolerite at the southern headland. East Cove is a small north facing beach bounded at either end by hard Jurassic dolerite headlands. Both Adventure Bay and East Cove are backed by extensive low lying sand plains.

The shoreline analysis at Adventure Bay Beach shows an average seaward growth of 7 metres between the 1940's and 2013 with a maximum recession of 7 metres at the southern end of the beach associated with Bligh's Creek and maximum shoreline growth of 21.5m recorded in the vegetation at the mouth of Captain Cook Creek (Figures 5 and 6).

Much of the observed seaward movement of the shoreline observed at Adventure Bay is closely associated with active Marram Grass (*Ammophila arenaria*) colonisation.

Due to the poor quality of historical photographs covering East Cove only two points were used in the beach movement calculations. These points show a shoreline growth trend averaging 4.4 metres. It is also notable that considerable vegetation establishment has occurred on the Eastern end of the spit where Dorloff Creek emerges. The preliminary measurements indicate the vegetated area of the spit has extended eastwards some 75 metres from its 1948 position.

It is recommended that the Adventure Bay study area be continually monitored as its low lying nature makes it particularly vulnerable to erosion and inundation during storm events potentially resulting in rapid changes in shoreline position.

Figure 5. Shoreline growth at Captain Cook Creek at north Adventure Bay.

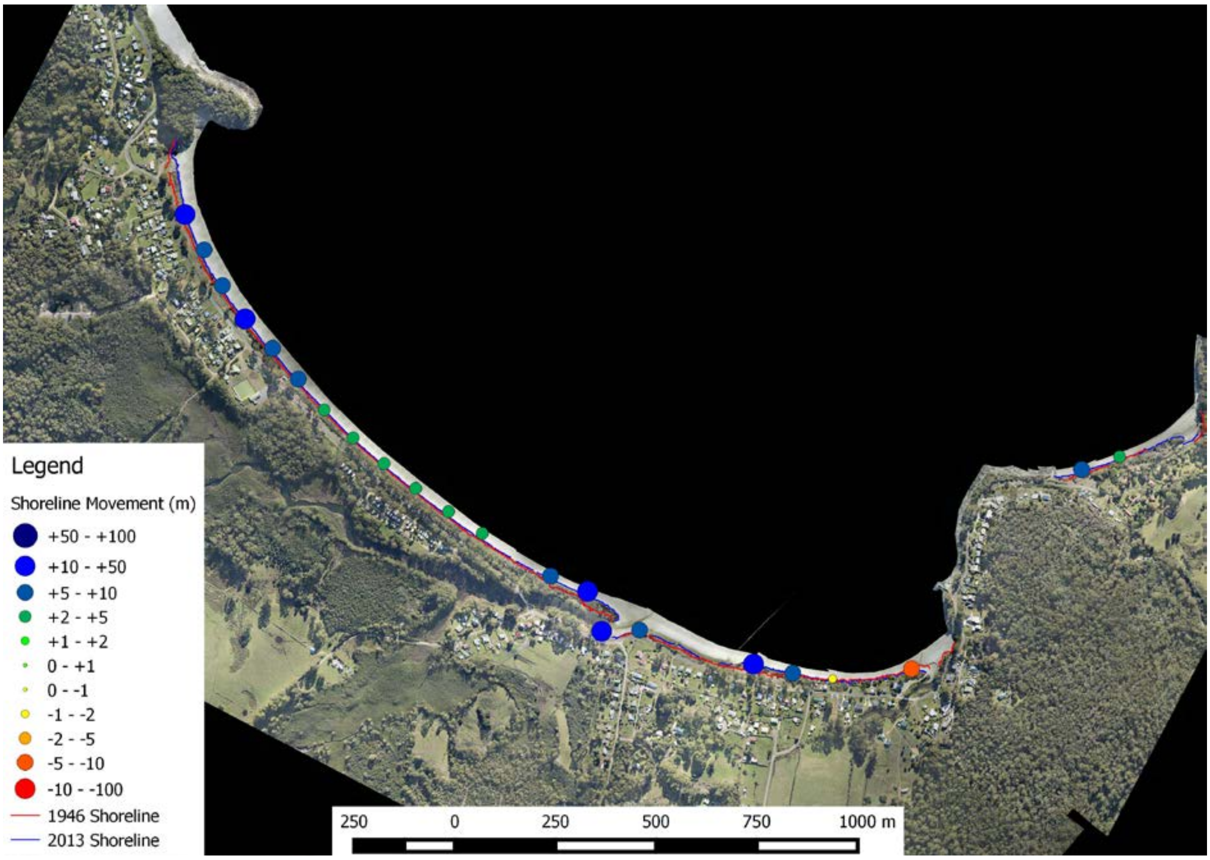

Figure 6. Shoreline movement at Adventure Bay

Great Bay

Great Bay is a west facing 3.5 kilometre wide deeply-embayed, shallow, swell-sheltered bay with a sandy shoreline underlain and backed by both soft poorly consolidated Quaternary and Tertiary sediments and hard Permian siltstones and mudstones (Forsyth *et al* 2005).

Shoreline analysis undertaken in the northern half of Great Bay shows an average recession of around 1 metre between the 1940's and 2013 with a maximum recession of 5.9 metres and maximum shoreline growth of 9 metres (Figure 8). It should be noted that the only significant growth seawards of the shoreline is associated with a small creek and road culvert which is effecting sediment deposition. The removal of these biased results doubles the average recession of the shoreline to close to 2 metres.

It is recommended that some additional DGPS surveying and a further analysis of historical aerial photography be undertaken to obtain a more accurate and complete coverage of the shoreline at Great Bay.

Preliminary modelling of inundation from the first pass digital elevation model shows parts of the road and low lying saltmarsh complexes will become inundated at the north end of Great Bay based on an indicative 2100 storm surge event of 1.87 metres above the current mean average sea level (McInness et al 2012)(Figure 7).

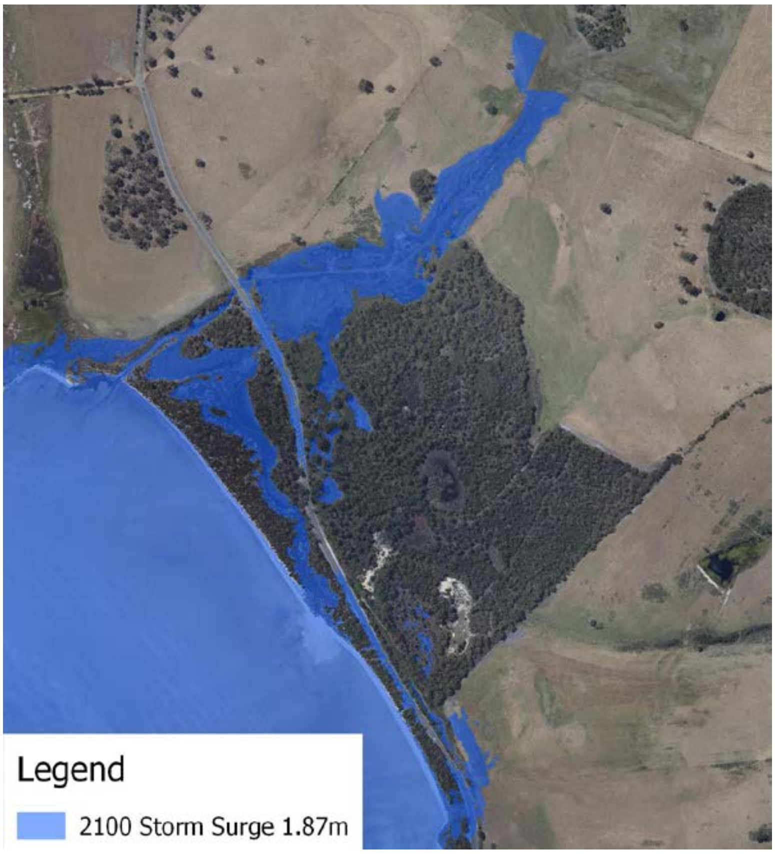

Figure 7. Potential inundation during a 2100 storm surge event.

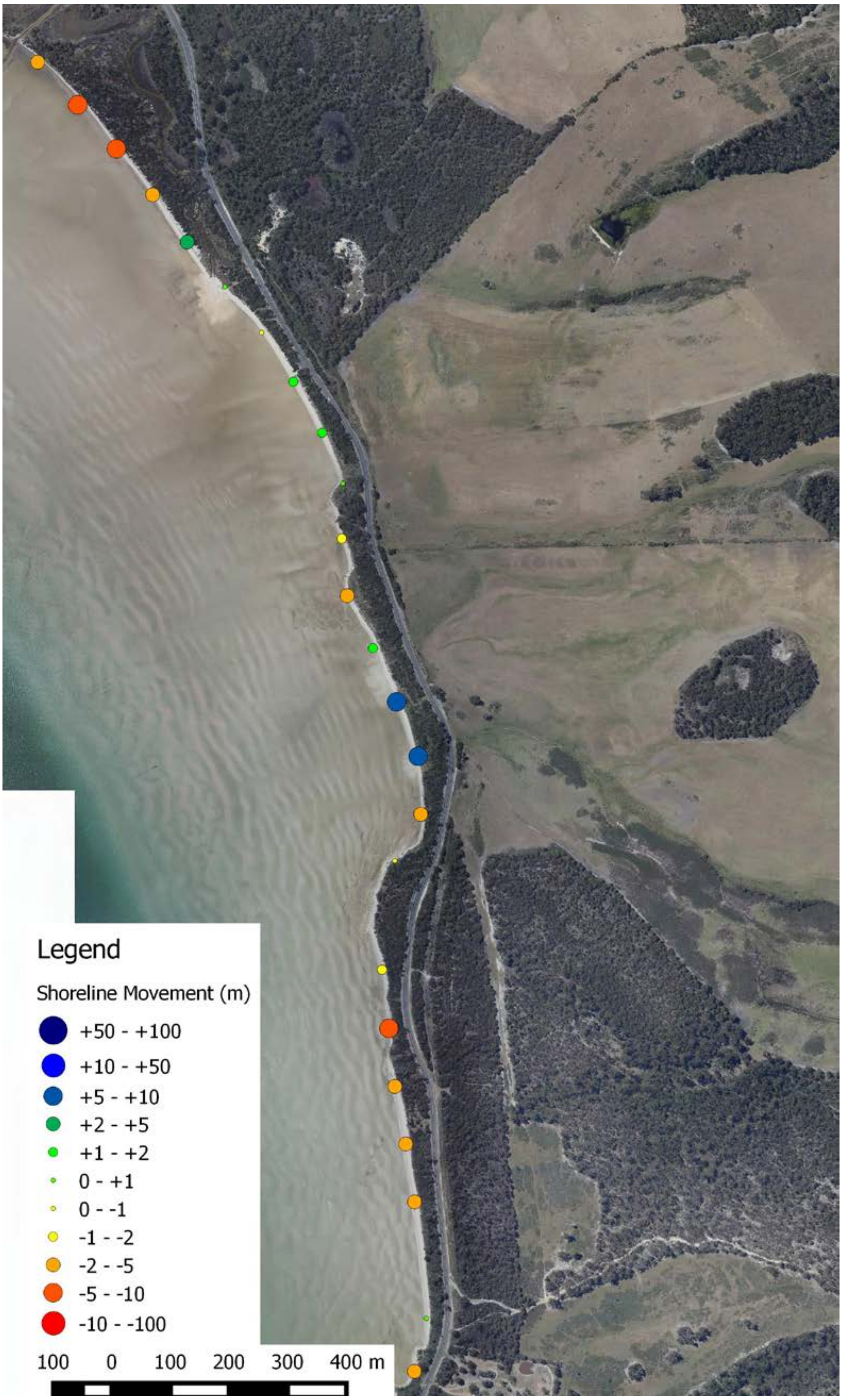

Figure 8 – Net shoreline recession at Great Bay 1946-2013.

Bruny Island Neck

The Bruny Island 'neck' is a long narrow sandy isthmus linking North and South Bruny Island. Sandy shores occur on both sides of the neck, but are exposed to significantly different wave climates and tidal influences. 1948 aerial photographs reveal that the narrowest part of the isthmus was an active, un-vegetated and low lying sand blow which at present appears to have been partially stabilised through the introduction of Marram Grass (*Ammophila arenaria*).

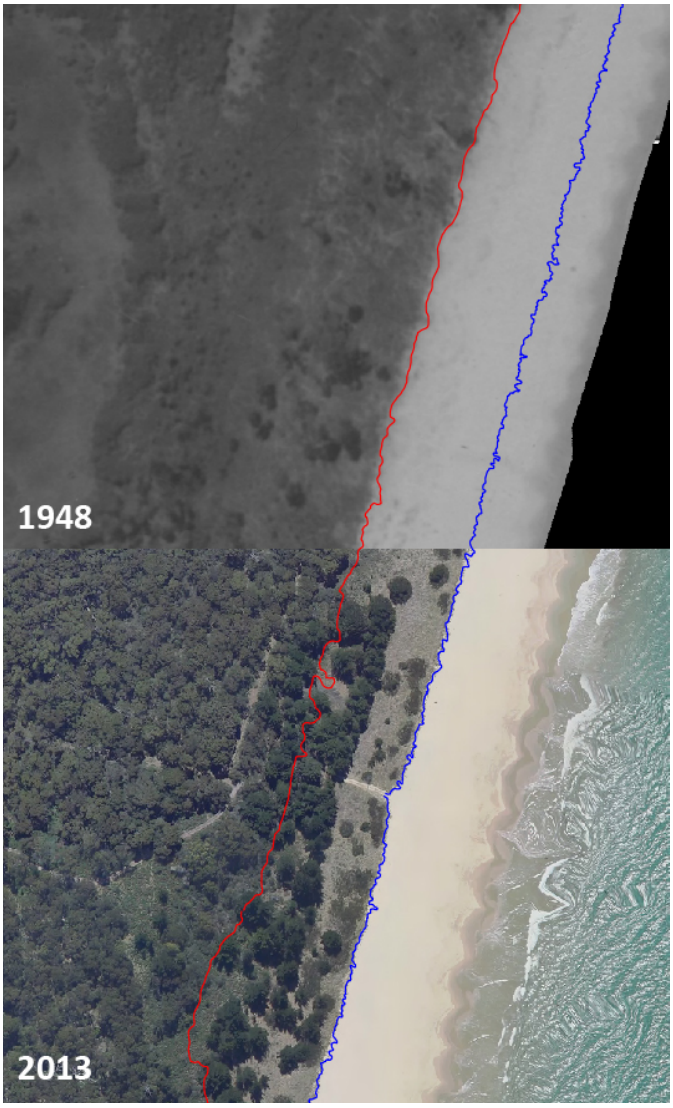

Figure 9 – Interpreted shoreline position changes from 1948 (red line) and 2013 (blue Line)

The analysis on the seaward facing shoreline with the southern half of Bruny Island neck shows an average seaward growth of 35 metres between the 1940's and 2013. A maximum recession of 16 metres recorded in Isthmus Bay on the western side of the neck and maximum shoreline growth of 75 metres is observed at the southern end of neck beach. The observed shoreline growth on the seaward side of the Bruny Island neck represents the most shoreline growth observed in any location the author has studied in Tasmania over the last 10 years.

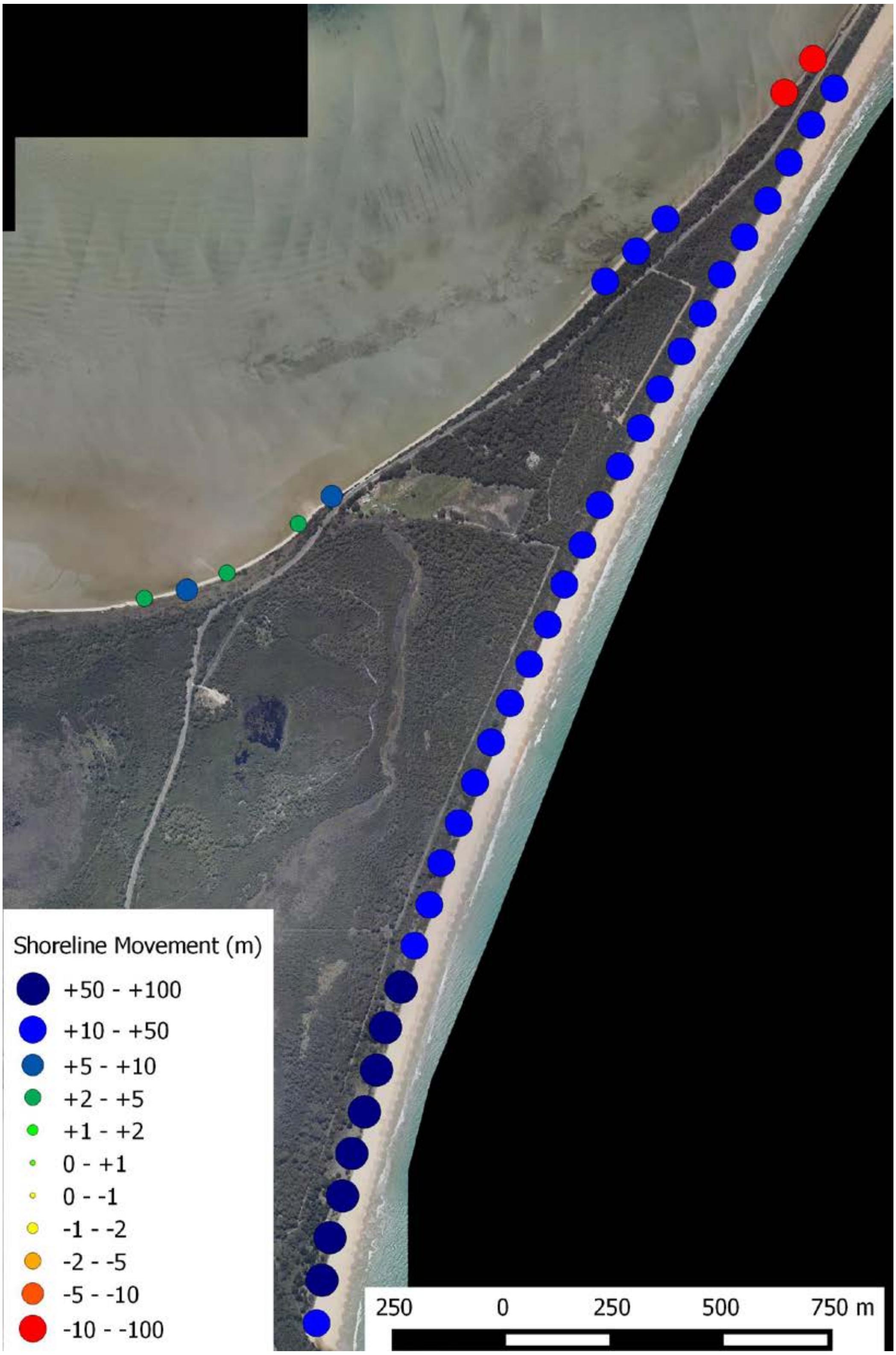

Figure 10 – Net shoreline recession from 1948 to 2013 at Bruny Island neck.

This seaward growth can be clearly seen on the aerial photographs (Figures 9 and 10) and directly correlate with an observed vegetation change from predominately native coastal vegetation to Marram Grass, and to a lesser extent at the southern end of the beach, introduced Radiata Pines

(*Pinus radiata).* The relatively large recession points observed in Isthmus Bay are directly adjacent to the hardening of the shoreline associated with the protection of the road. Increased rates of recession adjacent to shoreline hardening are very common (references). These initial results and personal observation the length of Isthmus bay indicate that there is considerable ongoing erosion through the narrow central part of Isthmus Bay, while the low sandy shoreline on the northern and southern extremities of the bay are relatively stable. As with the other sites this initial data should be used with caution as they are incomplete (the historical photos for the North of the study area have not been located) and the observations are for only a single time period.

North West Bay

North West Bay is a large seven kilometre long swell protected water body opening into the D'Entrecasteaux Channel extending from Howden in the north, to Conningham in the south. The geology and geomorphology are highly variable comprising Triassic Sandstone and Tertiary basaltic bedrock and poorly consolidated Tertiary and Quaternary sediments (Forsyth *et al* 2005). The geology and geomorphology of the area are described at length in Sharples and Donaldson 2014 (in press).

Both the 2013 and 1940's photogrammetry did not provide a clear, in-focus comprehensive coverage of much of the shoreline for North West Bay. This was due to a combination of light and sea conditions which compromised the image quality and the overhanging nature of the shoreline vegetation in the 2013 photography. The 1940's photography suffers from uneven exposure and generally poor image quality, but is also devoid of most of the large coastal trees now overhanging the coastline. It is recommended that further work be undertaken to source more appropriate aerial photographs of critical areas for a more accurate representation of historical shoreline positions. Where coverage does not exist or the vegetation is too dense as to extract the shorelines alternative methods such as fixed survey reference measurements, LiDAR or scarp monitoring via DGPS is recommended.

For the purposes of the study the North West Bay study area has been divided into smaller key areas that contained enough visible shoreline in both sets of photography to make an informed decision on the historical shoreline position and subsequent movements. The sparseness of digitised shorelines necessitated the measurement of most of the shoreline change manually rather than relying on semi-automated extraction from 100 meter spaced transects.

Howden to North West Bay River

The two kilometre south east facing stretch of shoreline between Howden and the North West Bay River is located in the north of North West Bay. The coastline is a mix of low coastal saltmarshes and unstable low scarps comprised of poorly consolidated Quaternary alluvium and colluvium and Tertiary sediment sequences (Forsyth *et al* 2005).

This shoreline showed a generally recessive shoreline response with a maximum recession of up to six metres observed in several places (Figure 11). There were a few small discrete pockets of observed shoreline growth associated with small permanent watercourses. It should also be noted that the observed shoreline position measured around the mouth of the North West Bay River will be highly variable due to the active water flow and associated sediment transport. The small island offshore to the north east of the North West Bay River shows a significant and consistent recession signal averaging around five metres.

Figure 11. Howden to North West Bay River shoreline movement

Dru Point and Beach Road

The shoreline surrounding Dru Point comprises both well consolidated Tertiary basaltic bedrock on the northern facing shore and poorly consolidated Tertiary and Quaternary sediments from near the Dru Point Playground to past Beach Road (Forsyth *et al* 2005).

A seaward growth of the shoreline averaging 2.7 metres was observed on all but one of the transect locations (Figure 12). The south-east facing shore surrounding the boat ramp showed moderate amounts of shoreline recession between 0.2 to 3 metres. From Beach Road north there has been considerable reclamation and coastal armouring exceeding 6 metres in places. The quality of the 1940's aerial photography is inadequate for a definitive shoreline to be extracted but there appears to be considerable colonisation of supratidal vegetation in the area. It is possible this vegetation is associated with increased nutrient loading from the wastewater treatment effluent discharged into the mouth of the North West Bay River.

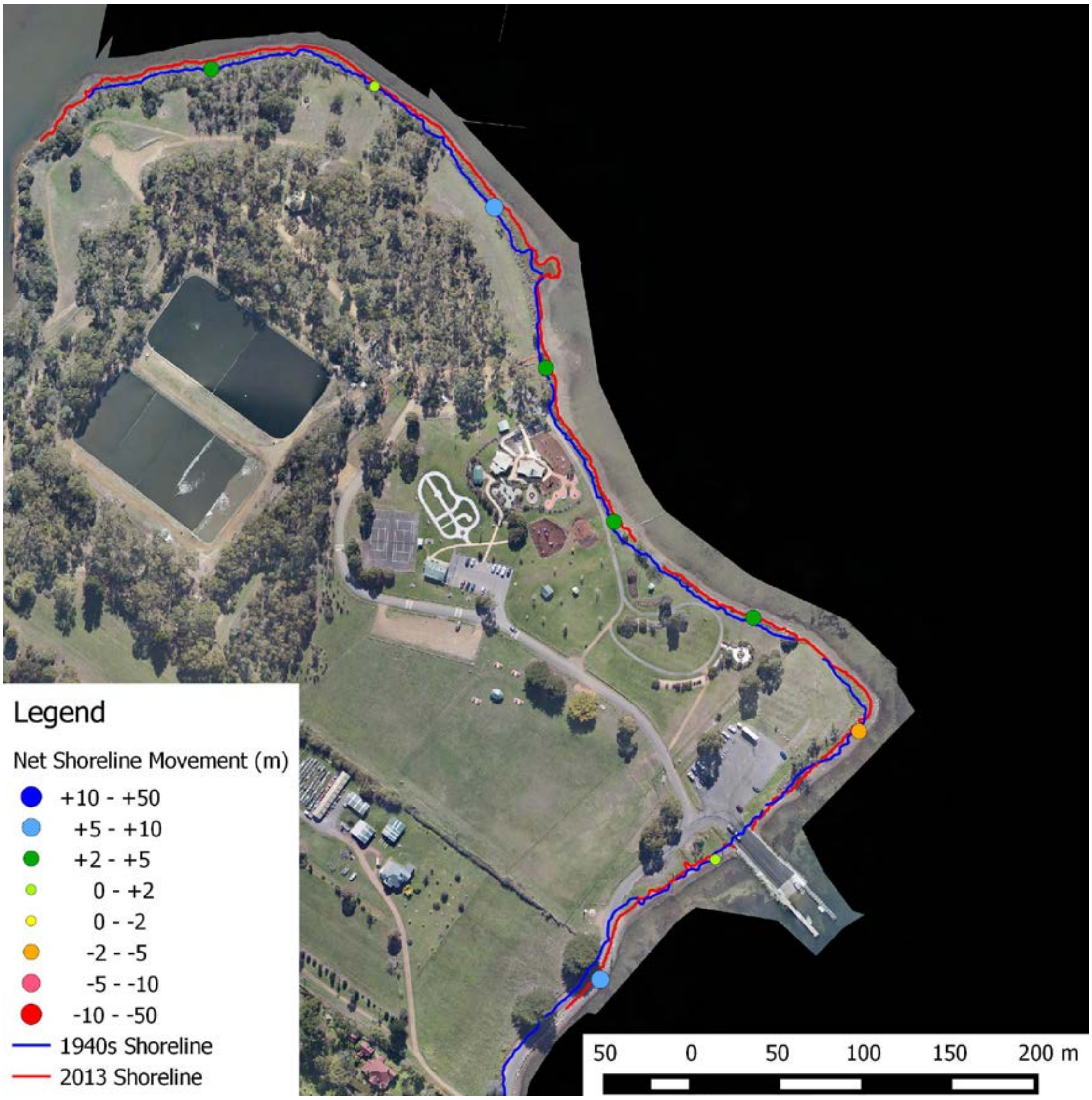

Figure 12. Dru Point shoreline movement.

Baretta Beach

The small, shallow 200 metre long south east facing beach at Baretta is backed by very low lying and poorly consolidated Tertiary sediments (Forsyth *et al* 2005). The shoreline extracted from the 1940's photography reveals a general recession trend averaging around 2 metres when compared with the 2013 photos (Figure 13). The exception to this being the small centrally located creek whose mouth has changed position to the north east and the considerable reclamation and shoreline hardening of between 5 and 9 metres that has occurred in front of properties to the south of the sandy beach.

The low lying nature of this site makes it particularly susceptible to inundation during storm surge events as illustrated in Figure 14 for a projected 2100 1.87 metre storm surge event.

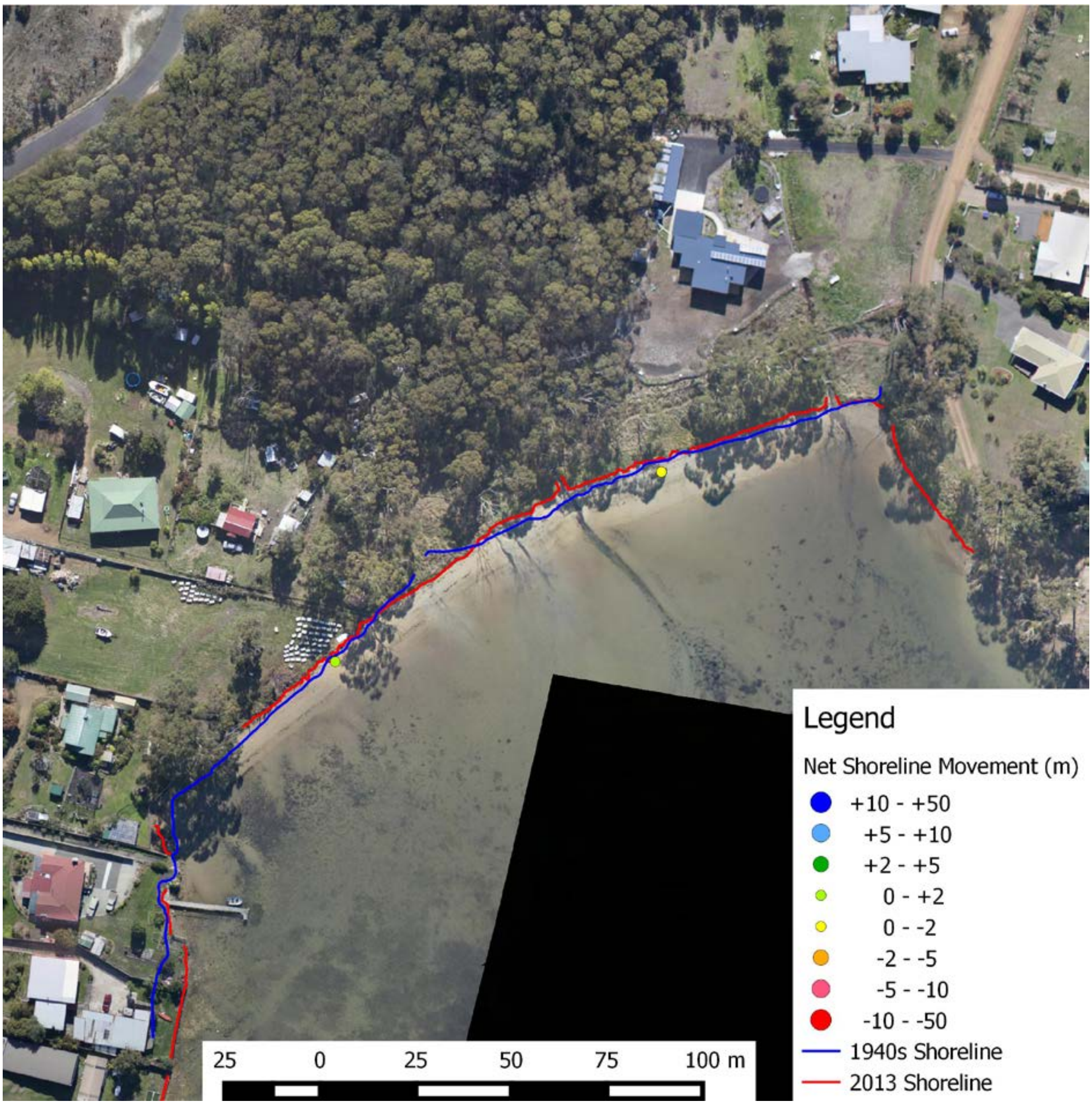

Figure 13. Shoreline movement at Baretta Beach.

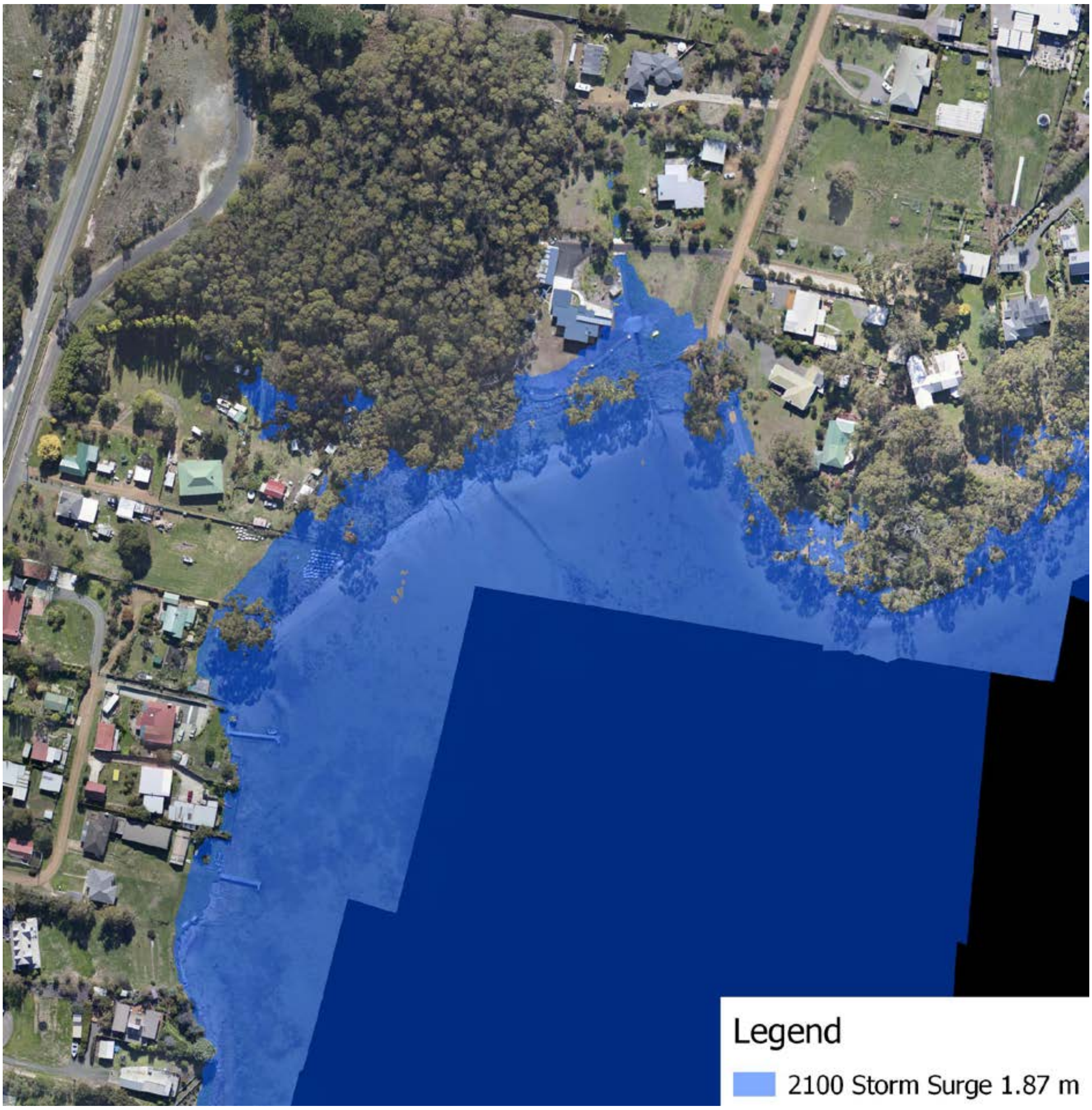

Figure 14. Predicted Storm surge extent at Baretta Beach based on 2100 IPCC Sea Level Predictions

North West Bay Marina

The geology backing the east facing shoreline around the North West Bay Marina is comprised of both poorly consolidated Quaternary and Tertiary sediments and a Quartzite headland which bounds a second small beach to the south of the Slipway.

The shoreline around the North West Bay slipway has been considerably altered and reclaimed with the original 1946 shoreline a maximum 170 metres inland from its current position (Figure 15). The coastline south of the marina shows a steady recession signal ranging from less than a metre to over 7 metres.

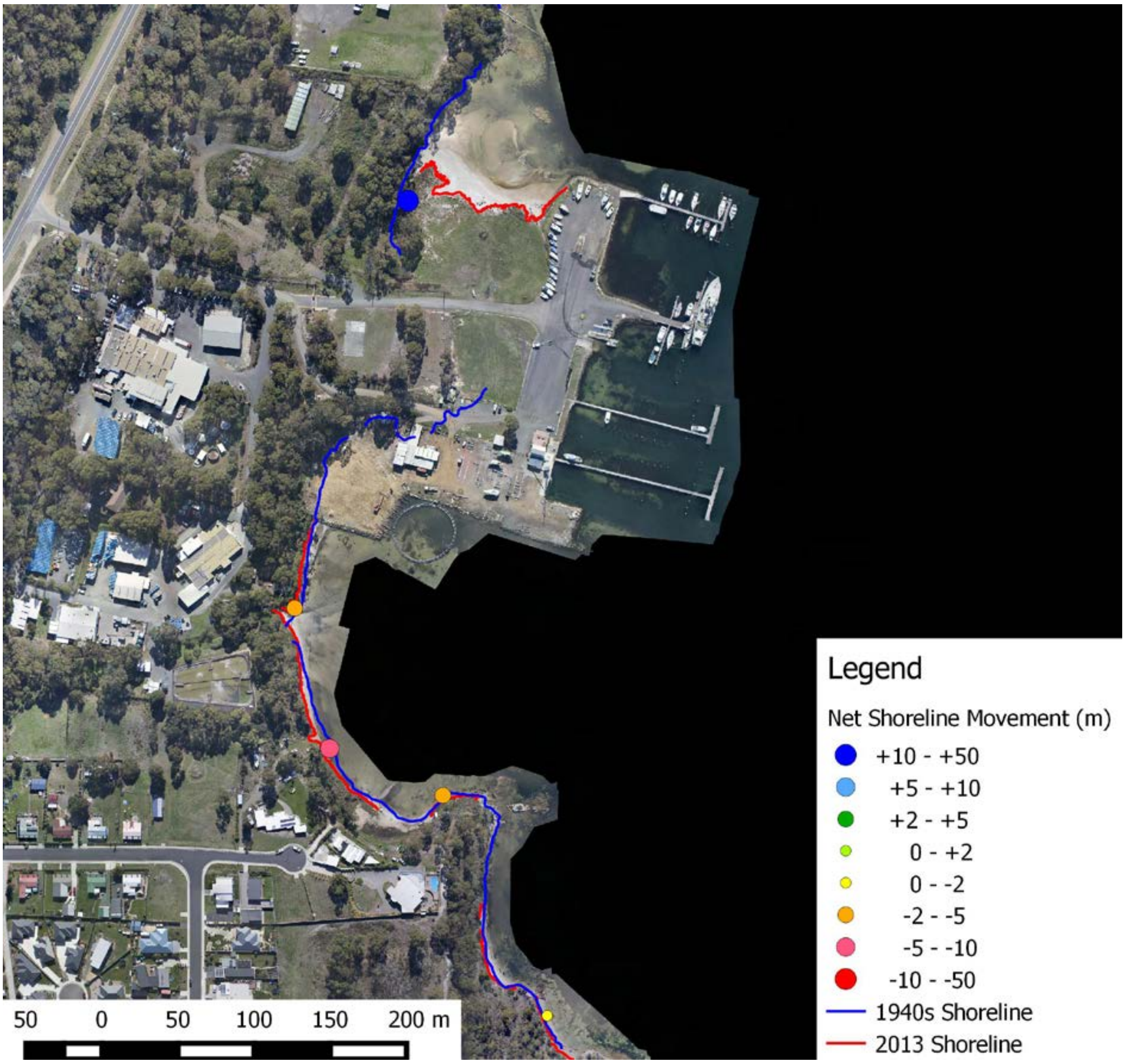

Figure 15. Shoreline movement around the North West Bay Marina

Peggys Beach

The 250 metre long east south east facing Quaternary sediments forming Peggy's Beach are backed and bounded to the north and south by headlands of Triassic Sandstone (Forsyth *et al* 2005). The southern half of the low lying beach showed a marked shoreward growth of up to 7.5 metres from 1946 although the area seems to have undergone significant alteration in the years preceding 2013 (Figure 16). Although the overhanging vegetation limited the extraction of measurement at the transect points, shoreline recession of up to 3 metres is observed through the middle and northern parts of the beach.

The elevated backshore of Peggy's Beach means it should be more resilient to inundation from storm surge events providing the current shoreline does not continue to recede. It is recommended that a static survey marker similar to those used by *TASMARC* be established at the northern end of the beach.

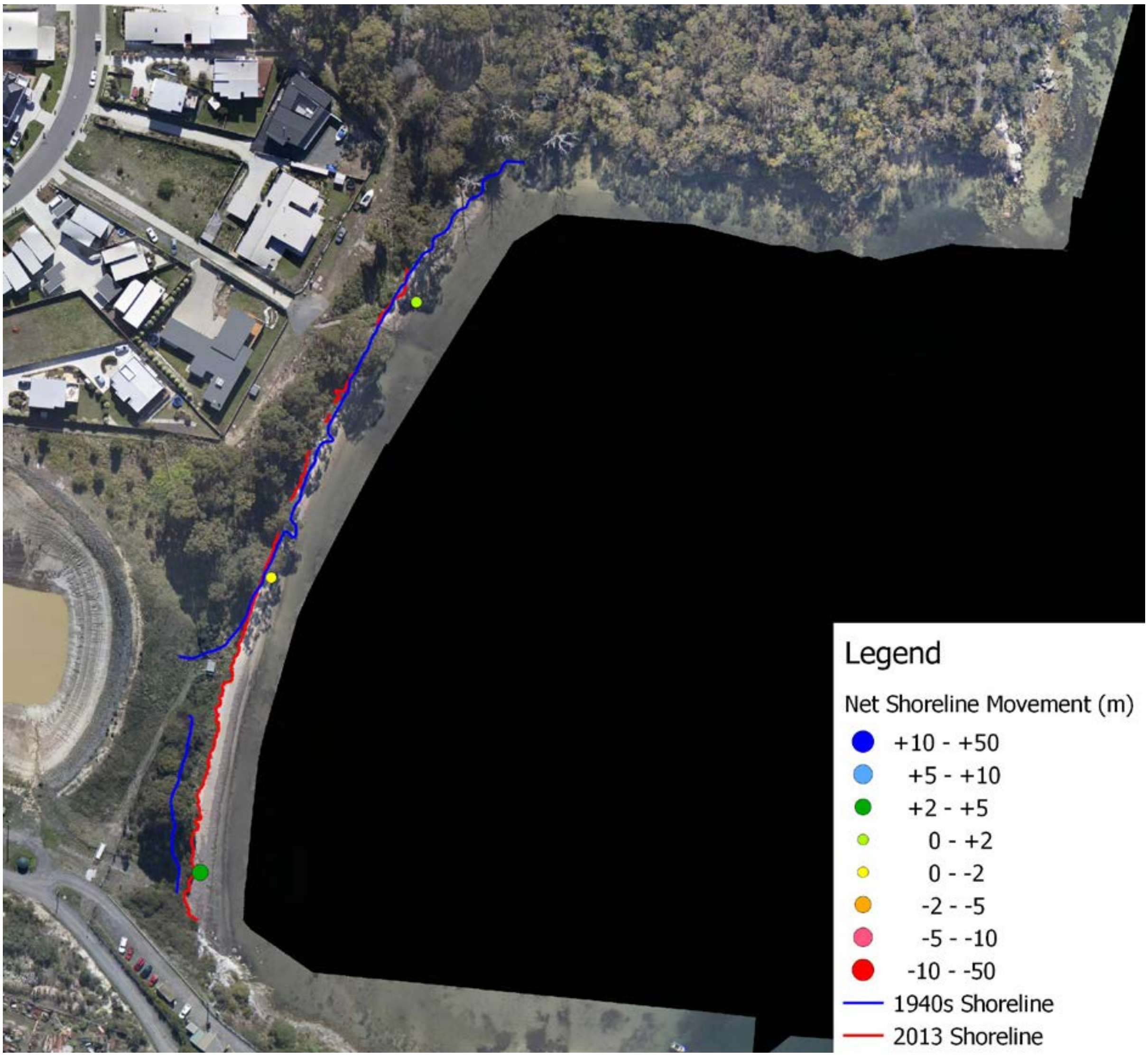

Figure 16. Shoreline movement at Peggy's Beach

Snug

The Snug study site comprises approximetely 1 km of sandy shoreline bounded to the west by Gillies and Pearsall Streets which is underlain by Triassic sandstones and poorly consolidated Quaternary sediments (Forsyth *et al* 2005).

The shoreline extending from the footbridge around to the mouth of the Snug River showed a consistent recession signal of between 0.1 and 5 metres (Figure 17). The low sandy beach at the end of Beach Road shows a seaward growth of over 15 metres in places from the 1940's aerial photographs. This growth can be attributed in part due to access to the jetty present in the 1940's and the establishment of Marram Grass. The southern end of the same beach exhibits considerable recession exceeding 10 metres in places, a figure that may have been significantly higher before the establishment of the Marram Grass.

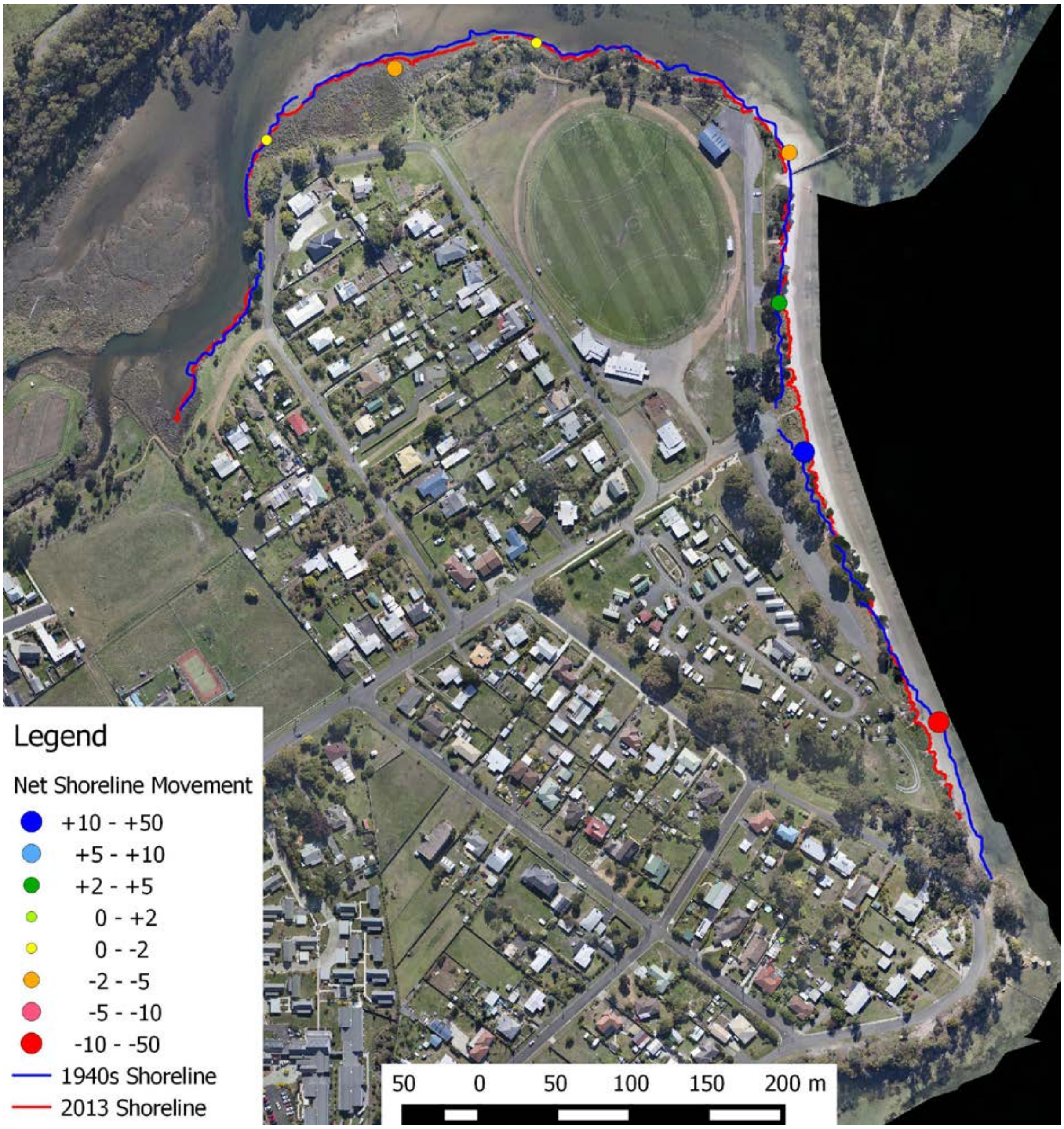

Figure 17. Shoreline movement at Snug

The low lying and poorly consolidated nature of the landforms at Snug combined with the proximity of the Snug River make it particularly susceptible to inundation during large storm surge events. Figure 18 shows the effect of a storm surge event based on the predicted sea level at 2100.

It is recommended that a combination of ongoing aerial monitoring and on ground surveys be undertaken at Snug to monitor shoreline recession particularly at the Southern end of the study site north from where Pearsall Street meets the coast.

Figure 18. Predicted Storm surge extent at Snug based on 2100 IPCC Sea Level Predictions

Trial Bay

Trial Bay is a 600m wide east facing bay which is a former quarry site that has been a popular picnic and boat launching site since the 1950's. The bay is bounded to the north by Jurassic dolerite and south by hard Permian mudstone bedrock shores while the head of the bay is comprised of colluvium and alluvium overlying poorly consolidated tertiary sediments (Forsyth *et al* 2005).

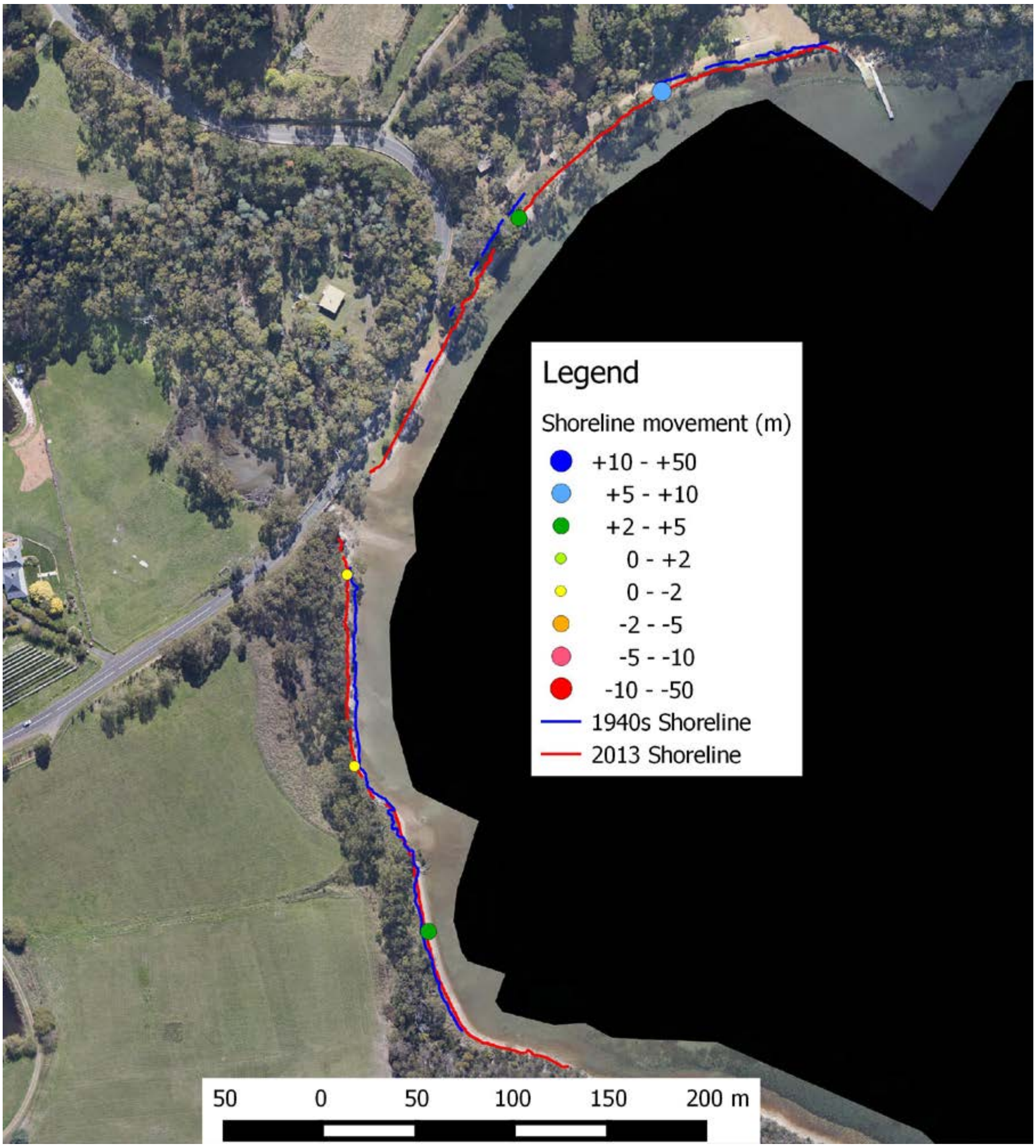

Figure 19. Shoreline movement at Trial Bay

The majority of the shoreline to the north of the turn-in is a reclaimed/reinforced shoreline and has shown no evidence of recession since the 1940's photography (Figure 19). A shoreline recession of between 1.5 to 5 metres is observed on small sandy and gravelly shoreline to the south of the bridge. The adjoining beach to the south has shown a shoreline growth of between 1 and 2.3 metres.

It is recommended that monitoring of the shore south of the bridge continue either as part of an integrated aerial survey or using a ground based static survey mark.

Peppermint Bay

Peppermint Bay is a 1.5 km wide east facing bay divided roughly in the middle by a small dolerite headland that houses the Marine Discovery Centre. The bay is bounded to the north by hard Cretaceous Syenites and Permian mudstones and to the south by hard Jurassic dolerite bedrock shores while the head of the bays are comprised of colluvium and alluvium overlying poorly consolidated tertiary sediments (Forsyth *et al* 2005).

The quality of the 1940's aerial photographs and considerable overhanging shoreline vegetation limited the capacity to effectively quantify the overall rate of shoreline movement for the whole study area based on the 100 metres spaced transect points.

However useful data was extracted manually from the digitised shorelines. The northern half of the bay showed a variable shoreline response with a shoreline recession of up to 3 metres recorded on the low colluvial shorelines between Schemers Creek and Perry Road. These low lying shorelines continue to exhibit small active erosion scarps (Figures 20 and 21).

A small area of seaward shoreline movement of up to 5 metres was observed on the alluvial plains to the north of Schemers Creek and up to 8 metres just north of the creek north of the school. The low lying alluvial shoreline south of Masons Creek, adjacent to the school showed, the most consistent recession signal ranging from around 0.5 to 12 meters.

Figure 20. Small erosion scarp in poorly consolidated sediments at Peppermint Bay

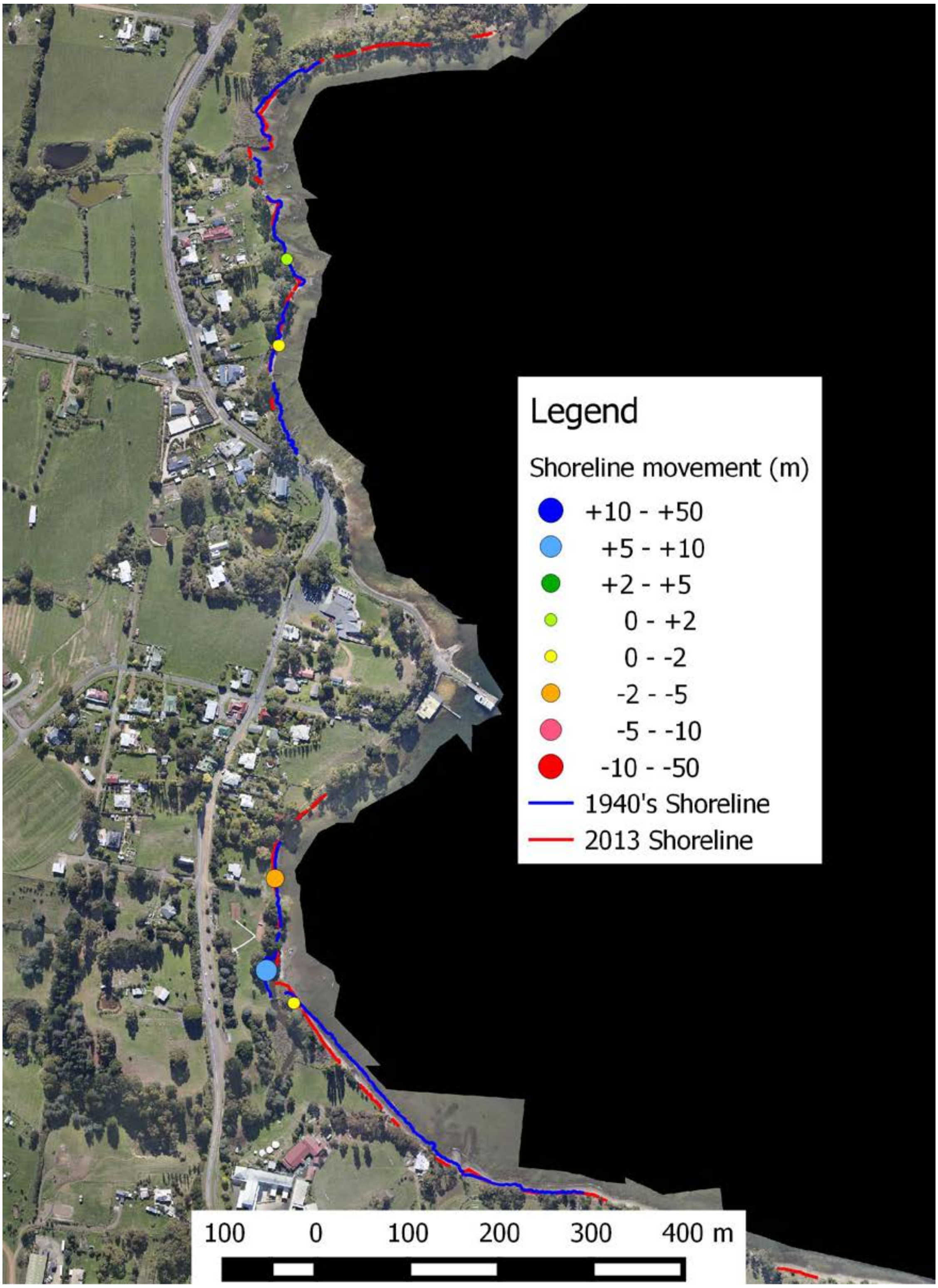

Figure 21. Shoreline movement at Peppermint Bay

Gordon

The 5 kilometre long shoreline stretching from Three Hut Point north to the jetty at Beach Road Middleton is of variable geology, comprised of cliffs and small scarps of Permian Sandstone and Tertiary Sediment and low lying Quaternary sediment beaches and sand plains (Forsyth *et al* 2005).

Substantial overhanging vegetation along much of this shoreline makes extraction of contemporary and historical shorelines difficult and a more comprehensive on-ground survey and monitoring effort should be undertaken particularly on the unstable coastal scarp between Gordon and Middleton.

At Three Hut Point the low lying Quaternary beach sediments have moved seaward and northwards between 1.8 and 12 metres since the 1940's. The east facing beach is variable in its response having receded around 10 metres close to where the road meets the coast and the spit shifting north-west over 12 metres from its 1940's position (Figure 22).

Figure 22. Shoreline movement at Three Hut Point

At Gordon the low lying coastal Quaternary sediments show a similar behaviour (Figure 23). The small north facing beach adjacent to the old sports oval has receded shoreward around 2 metres, while the more east facing low angle sandy shore extending northwards to Rookwood Creek has experienced considerable erosion in excess of 25 metres in some places. North of Rookwood Creek the shore is backed by a rapidly receding Tertiary sediment scarp which has receded between 7 and 14 metres.

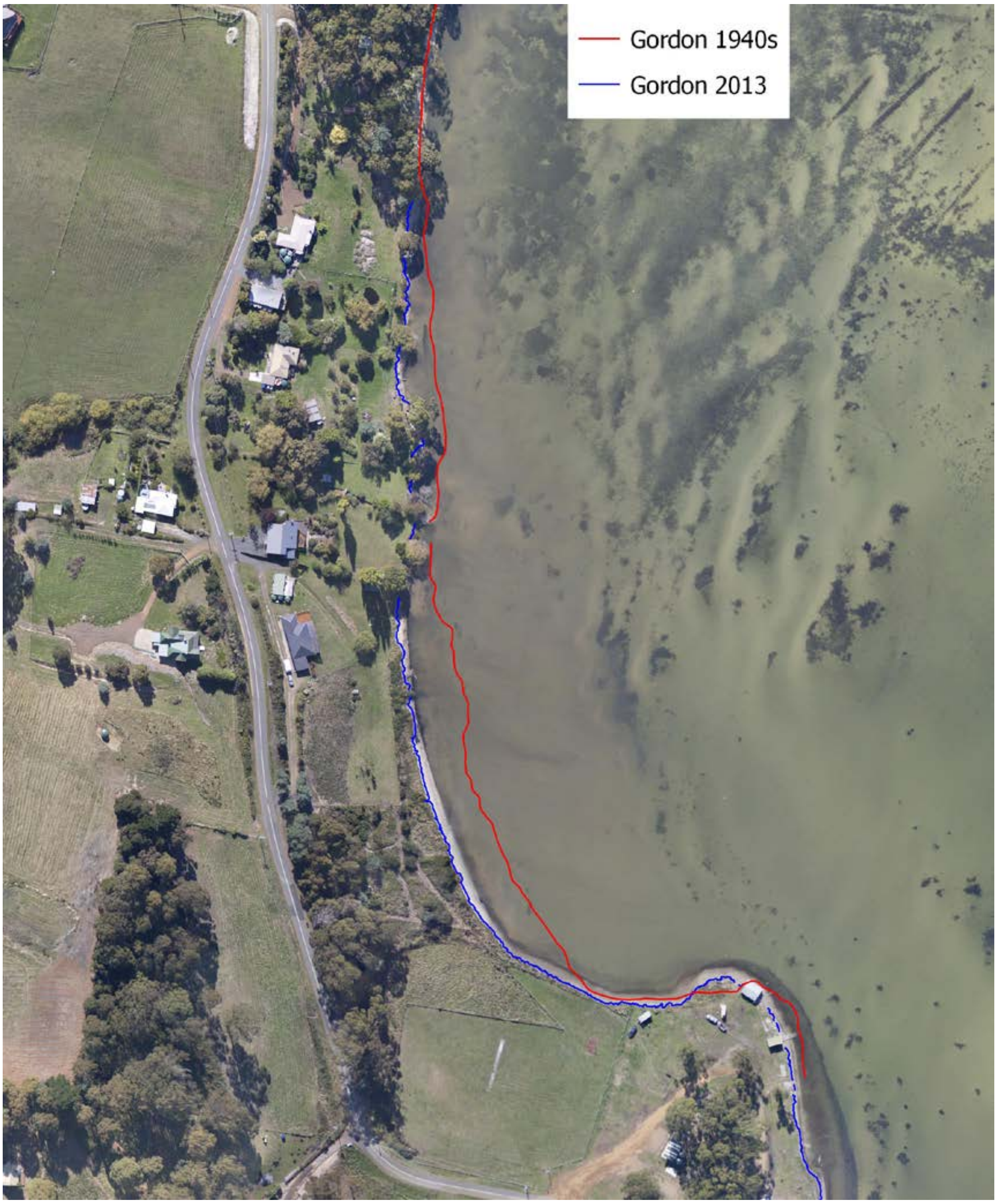

Figure 23. Shoreline movement at Gordon

Much of the shoreline to the north and south of McKay Rivulet is not visible from the air due to the collapse of numerous large trees along the eroding shoreline. The scarp is up to 8 metres high in places and the poorly consolidated sediments are actively eroding (Figure 24). The height and nature of the scarp recession necessitates some urgent and ongoing on-ground monitoring.

Figure 24. Eroding Tertiary sediments close to McKay Rivulet

Taroona – Cartwright Point to Dixons Point

This section of coast is predominately shallow to steep bedrock scarps and cliffs between 2 and 20 metres high comprised primarily of Tertiary Sediments. The shoreline and localised geology is very unstable and has in the past been subject to landslips and is particularly susceptible to shoreline erosion resulting in slumping, cliff retreat or collapse (Leaman and Cromer 1976, Donaldson 1977).

The overhanging trees and thick ground covering vegetation along the active cliffs made the extraction of shoreline positions difficult and alternative methods of shoreline evaluation and monitoring will have to be undertaken on these highly erodible sites.

Historical aerial photography will need to be sourced for this section of coast before any preliminary assessment of historical shoreline movement can be undertaken.

Kingston Beach

The Kingston Beach study site is a southeast-facing shoreline that is bounded by Permian mudstone headlands to the northeast and southwest (Forsyth *et al* 2005). The study area is broadly divided into two separate beaches, Tyndall Beach to the north of Browns Rivulet mouth, and Kingston Beach to the south of the rivulet mouth. Tyndall Beach is a 300 metre long sandy beach backed by steeply rising hard Permian mudstone cliffs and divided from Kingston Beach by the Browns Rivulet Estuary. Kingston Beach is a 1 km long low sandy beach backed by a roughly 1 metre high seawall along its full length.

There was little change in shoreline position observed between the 2011 and 2013 flights although a seaward expansion of Marram Grass was observed at several places along Kingston Beach. The Kingston Beach shoreline can be expected to remain fairly static given the seawall restricts shoreline retreat at present sea level heights. Historical aerial photography will need to be sourced for Tyndall Beach before any preliminary assessment of historical shoreline movement can be undertaken.

General Discussion

This project and past work show that the beaches within the Kingborough Municipality have changed significantly over the last 60+ years, although this varies between consistent recession in some cases to large seaward shoreline growth and episodic or cyclic variation around an equilibrium position in others.

The use of historical aerial photography and the information that can be gleaned from them are the only consistent objective source of data we have to analyse the past nature and position of the beaches and associated shorelines. This study has, where possible, used this historical information to provide a context for the current shoreline position. This data should be used with caution as it provides only a single snapshot at one point in time and the shoreline position can have grown and receded during the interval between photos. For a more complete understanding of past changes in shoreline position a more complete analysis of the historical orthophoto record at suitable beaches (e.g. Adventure Bay, Snug, Isthmus Bay and Great Bay among others) should be undertaken in conjunction with static on ground monitoring points such as those used in the *TASMARC* Project.

A different monitoring methodology should be investigated along those shorelines with excessive overhanging shoreline vegetation. A combination of oblique and vertical aerial photography combined with ground based photogrammetric monitoring and static on ground monitoring points, transects and RTK GPS surveys is suggested. These techniques are far more cost effective than LiDAR surveys which could also be undertaken for small sections of the coast identified as being a significant threat to surrounding dwellings of infrastructure.

Indicative inundation scenarios based on 2100 IPCC predicted sea levels under storm surge conditions have also been provided for selected sites outside of the currently available LiDAR coverage's. These preliminary models indicate large areas of low lying coastal land will become inundated during storm surge events. Such events have the capacity to dramatically increase the rate of shoreline erosion at these sites. The elevation models that these models were derived from were produced during the production of the orthomosaics. These digital elevation models have a very high horizontal accuracy +/- 10 cm and a slightly higher vertical accuracy of +/- 25 cm so should be used as an indicative guide. The accuracy of these inundation models can be substantially increased with increased surveyed ground control points.

The data and maps provided along with this report have been produced to enable easy visualisation and interpretation of the changing nature of the shoreline. It is envisaged that the planners will be able to develop methodologies for management of the affected areas based on the data provided. As an example in areas where significant shoreline retreat or potential inundation are recorded a development buffer zone could be put in place prescribing building setbacks, minimum floor heights above sea level or shoreline hardening.

Future Work and Recommendations

A number of sections of coastline within the Kingborough Municipality are exhibiting a clear ongoing recession trend. It is recommended that these shorelines which include Great Bay, Woodbridge, Bruny Island Neck, Gordon, North West Bay and Taroona receive continuing ongoing annual surveying. This will help develop an accurate picture of the shoreline movement and will identify beaches exhibiting similar characteristics to the well-studied Roches Beach where orthophotos at ten separate time intervals show definite increasing recession trend since 1977. Within the municipality there are still a number of shorelines not covered by this study that are either very low lying and are at risk of recession or are already exhibiting signs of shoreline recession. These include a number of shorelines on Bruny Island, between Tinderbox and Howden, Hinsby Beach and Oyster Cove. It is recommended that some thought be given to budgeting for a first pass assessment of these beaches.

Now a comprehensive set of contemporary orthophotographs have been developed for all the current primary study sites some effort needs be made in the generation of historical sequences of photos to establish a record of beach behaviour and rate of beach oscillation. The work of Sharples *et al*. 2012(in prep.) produced detailed comprehensive time series datasets at intervals of around 10 years for Roches Beach, Clifton Beach and part of Barilla Bay. Presently there are no multiple time interval historical records for any beaches within the Kingborough Municipality. A more comprehensive historical record will provide further context for the current shoreline position, will help define the rate of shoreline recession and will provide a lasting record of historical land use change and coastal development. Consideration should be given to the priority beaches and extra budgets assigned for their completion.

This project and several other projects being run by the Spatial Sciences Department and the Blue Wren Group at the University of Tasmania have encouraged other municipalities to engage in a wider more regional approach to shoreline monitoring and coastal hazard mapping. Sorell Council in particular has several areas of ongoing concern within Pittwater and at Carlton Beach and Primrose Sands. Clarence City Council has undertaken yearly survey flights and is keen to acquire more shoreline data and historical photo sequences to assist in their ongoing coastal hazard mapping work.

The first three surveys conducted in 2011, 2012 and 2013 have established a sound methodology for the rapid collection and collation of baseline shoreline position information derived from digital aerial photographs. Work is currently underway to enhance and further automate the capture and processing of the imagery.

The ground control network used in this survey was temporary and will need to be upgraded, maintained and expanded upon if the project is to continue into the future. Many of the beaches in the municipality are sparsely developed and do not contain the infrastructure needed to establish permanent and comprehensive ground control network. Such a process would need to involve placing markers on privately owned land, fence posts or buildings to assist in the accurate generation of orthorectified imagery. This work could be incorporated into future surveys of coastal council infrastructure.

Where possible repeated annual aerial surveying should occur during summer months where it is possible to eliminate the shadows cast by the dune scarps or dune vegetation. This shadowing can affect the clarity of the aerial photography which in turn affects the clarity of the vegetation line and accuracy of the derived three dimensional models. For rapid response flights before or after major events it is recommended that shorter flights throughout the day be used to minimise shadowing on east, west and south facing beaches.

Figure 25 – Summer 2013 (left image) and Winter 2012 (right image) comparison of steep section of Beach.

References

Bureau of Meteorology., 1995.

Davies, J.L. 1980. *Geographical Variation in Coastal Development*. (2nd ed.), Longmans, London.

Chelton, D.B., Hussey, K.J. and Parke, N.E. 1981. *Global satellite measurements of water vapour, wind speed and wave height*. Nature. 294; 529-532.

Donaldson, R.C., 1977: *Foreshore instability near Taroona High School*; Unpublished Report 1977/41, Tasmania Department of Mines, 8 pp.

Farmer, N., 1981: *Kingborough*; Geological Atlas 1:50,000 Series, Sheet 8311N, Geological Survey of Tasmania, Department of Mines, Hobart.

Fletcher, A. & Newman, M., 2010: Studies of the Australian Pied Oystercatcher in South-East Tasmania 1964-2009; *Stilt*, Vol. 58, p. 24-33

Forsyth, S.M., Clarke, M.J., Calver, C.R., McClenaghan, M.P., Corbett, K.D., & Vicary, M.J., (compilers), 2005: *Geology of Southeast Tasmania*; Edition 2011.1, Digital Geological Atlas, 1:250,000 Scale Series, Mineral Resources Tasmania.

Hemer, M.A., 2012: Research Scientist, Centre for Australian Weather and Climate Research.

Hennecke, W.G., & Cowell, P.J., 2000: GIS Modeling of Impacts of an Accelerated Rate of Sea-Level Rise on Coastal Inlets and Deeply Embayed Shorelines; *Environmental Geosciences*, Vol. 7(3), p. 137-148.

Leaman, D., 1972: *Hobart*; Geological Atlas 1:50,000 Series, Sheet 8312S, Geological Survey of Tasmania, Department of Mines, Hobart.

Leaman, D.E., & Cromer, W.C., 1976: *Marine Erosion at Taroona*; Unpublished Report 1976/68, Tasmania Department of Mines. 3 pp.

McConnell, A., 1996: *Seven Mile Beach Protected Area Management Plan: Geodiversity and Cultural Heritage: Resources and Management;* Unpublished report to Hepper Marriott Associates and Jerry De Gryse Pty. Ltd. for the Seven Mile Beach Management Plan, August 1996.

McInnes KL, O'Grady JG, Hemer M, Macadam I, Abbs DJ, White CJ, Bennett JC, Corney SP, Holz GK, Grose MR, Gaynor SM & Bindoff NL.,2012. Climate Futures for Tasmania: extreme tide and sea level events technical report, Antarctic Climate and Ecosystems Cooperative Research Centre, Hobart, Tasmania

Sharples, C., 2000. *Fort Direction Environmental Assessment: Geoconservation and Earth Hazards*; Unpublished Report to Inspiring Place Pty. Ltd, for an Environmental Assessment of Fort Direction, South Arm, for the Commonwealth Department of Defence, June 2000.

Sharples, C., 2010. *Shoreline Change at Roches Beach, South-eastern Tasmania*, *1957-2010*. Technical Report to the Antarctic Climate and Ecosystems Co-operative Research Centre., 101 pp.

Sharples, C., and Donaldson, P., 2012: *An Identification of Geomorphic Hazard and Geoconservation Value Issues for a Proposed Golf Preserve Development, Seven Mile Beach, Southern Tasmania*; Unpublished report to the Golf Preserve Pty. Ltd., June 2012.

Sharples, C., Mount, R., Hemer, M., Puotinen, M., Dell, M., Lacey, M., Harries, S., Otera, K., Benjamin, J. and Zheng, X., 2012 *in prep. The Shorewave Project: Development of a Methodology for Coastal erosion Risk Analysis under Climate Change, integrating Geomorphic and Wave Climate Data Sets*. Unpublished report to Commonwealth Department of Climate Change and Energy Efficiency, by the Blue Wren Group, School of Geography and Environmental Studies, University of Tasmania.

Short, A.D., and Trembanis. A. 2000. *Beach oscillation, rotation and the Southern Oscillation, Narrabeen Beach, Australia*. Proceedings of the 27th International Conference on Coastal Engineering. Sydney 16-21, July 2000, Vol. 1, Paper no. 4.

Watt, E.J., 1999. *The Morphology and Sediment Transport Dynamics of the Seven Mile Beach Spit*. Unpublished Honours Thesis, School of Geography and Environmental Studies, University of Tasmania.

Trenhaile, A.S., 2011: Predicting the response of hard and soft rock coasts to changes in sea level and wave height; *Climatic Change*, Vol. 109, p. 599-615.