University of Southern Queensland
Faculty of Health, Engineering & Sciences

Improving Surfing Conditions in Conjunction with Coastal Erosion Protection

A dissertation submitted by

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Abstract

The coast offers many benefits to the community, environment and economy. The numerous benefits that exist adjacent to the ocean help contribute to the popularity and value of our coastal regions. Surfing is just one of the many community benefits which incorporates the ocean into a recreational playground. The coast is also a transient boundary that exists between the ocean and the land. This region is subject to variations and Coastal erosion. Coastal erosion is most simply put as the advancement of the ocean across this boundary.

The general quality of a wave and the type of surfers it will attract can also vary. If these surfing parameters are adequate the chances of a quality surfing wave is increased. Surfing will in turn provide many benefits to the community and economy.

In some specific instances the actions which result from waves impacting with the coastline can cause coastal erosion. Due to the importance of the coastline it is often necessary to protect assets, infrastructure and community values. It is possible to defend against coastal erosion with various methods. In order to protect the coastline from the action of wave processes.

This report hopes to highlight an added consideration to maximise the benefits of coastal defence projects by incorporating surfing considerations. Surfing is dynamic and growing industry. By improving the surfing conditions during coastal management projects greater benefit to the community can be achieved.

The document provides an investigation of a coastal protection project at Narrowneck Gold Coast, Queensland and a sand bypass pumping project at Snapper Rocks Gold Coast Queensland. The Narrow neck project incorporated improved surfing conditions as a second objective after coastal protection as its main design criteria. Snapper Rocks was ultimately a sand by passing project which has become a world class surfing wave and is part of the Association of Surfing Professionals Annual World Competition Tour. The report also proposes some sites for future considerations works in relation to coastal protection and nourishment within the local Government region of Coffs Harbour, New South Wales.

This report was instigated after the author surfed at Narrowneck Beach Gold Coast Queensland. The swell had picked up and the stretch of coastline along Surfers Paradise was not offering much more than a solid closeout. After checking the surf conditions at Main Beach near Beach tower 40 off Macarther Parade, a consistent sand bank was notice to the south. This bank of sand was later found to be the location of the Narrowneck Artificial Surfing Reef, installed under direction form Gold Coast City Council.

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Limitations of Use

Certification of Dissertation

I certify that the ideas, designs and experimental work, results, analyses and conclusions set out in this dissertation are entirely my own effort, except where otherwise indicated and acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

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Signature

24/10/13

Date

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Glossary of Terms

AWACS	Australian Water and Coastal Studies
ASP	Association of Surfing Professionals
CLPS	Coastal Lands Protection Scheme
CCA	Comprehensive Coastal Assessment
CHCC	Coffs Harbour City Council
CZMP	Coastal Zone Management Plan
CZMS	Coastal Zone Management Study
ESD	Ecologically Sustainable Development
GCCC	Gold Coast City Council
GPR	Gross Region Product
ICM	International Coastal Management
NGCBPS	Northern Gold Coast Beach Protection Strategy
NODC	National Oceanographic Data Center
REF	Review of Environmental Factors
TRESBP	Tweed River Entrance Sand Bypassing Project
UW	University of Waikato, New Zealand
USQ	University of Southern Queensland, Australia

Chapter 1 Research ocean waves and how they contribute to Coastal Erosion

Introduction

In order to investigate coastal erosion it is important to understand the interactions that exist between the ocean and the coastline. This chapter will provide an introduction into the physical nature of the waves in the ocean. Explanations will also be given to define coastal erosion processes. The research will also provide details on typical ocean behaviours such as currents and wave patterns.

Water wave theory

Waves are a complex transfer of energy across the oceans surface and it is important to understand how they react with objects they encounter. These objects can include structures, variations in ocean depth and the shoreline in the region of Coastal Management. The significance to a wave parameter investigation is that no two waves are the same. This means that every wave has the capacity to display unique characteristics due to the numerous variables that are in effect to result in the wave being produced. Some of these factors which contribute to producing a wave will now be highlighted to help understand the interaction of waves and generation of currents along the shoreline.

The results from wave action on the shoreline that are focused on in this report are coastal erosion and surfing waves. Coastal erosion is a process which can affect the assets and infrastructure within the coastal zone and the recreational benefits that are provided. Surfing waves are one of the recreational benefits which, if the right requirements are in place, can occur in the coastal region. This investigation will now focus on the hydraulic aspect of oceans waves.

Ocean Waves

The waves in the ocean are broadly categorised as periodic progressive waves. Water waves are a combination of both transverse and longitudinal wave behaviour. Ocean waves are classed as some of the most complex processes that occur in the ocean (Sverdrup & Armburst 2009). Waves have the capacity to change our coastlines, provide recreational pleasures and cause commercial inconvenience.

Wave Origin

In order for a wave to be created in the ocean a force is required which is able to disturb the surface of the water. This force is normally termed the generating force. The generating force is the source of the energy transfer that is capable of producing waves. Once a wave is generated it will start to travel away from the initial point of disturbance (Sverdrup & Armburst 2009).

There is also a force that is known as the restoring force which will cause the water to return to its undisturbed sea level. If a water wave is relatively small the restoring force occurs from the surface tension that is present in the water surface. This is the elastic quality of the water due to the cohesive nature of water molecules. So waves which are small are affected by the water's surface tension.

Larger water waves experience a restoring force by the action of gravity. Although there is still the effect of water cohesion the restoring force of gravity is more dominant. Waves of this type are known as gravity waves (Chadwick, Morfett & Borthwick 2007).

Water waves typically result from the action of wind across the ocean's surface. Nature's wave factory is initiated with a shearing action and resonance process that results from the wind on the ocean's surface. The wind is one of the common sources of the generating force for water waves. This process occurs as the wind moves across the water's surface a drag is created that stretches out the water surface. The wind and the surface tension create small waves known as ripples or capillary waves. These initial waves are restored by surface tension.

When the wind moves over vast areas and varies in length, time and speed the water surface begins to develop a rougher nature that in turn becomes more susceptible to receive energy from the wind. As the wind continues to add energy the wave size becomes larger which results in the dominant restoring force changing from the surface tension to gravity (Sverdrup & Armburst 2009).

The waves which are produced can vary in height, length, period and direction. These waves are then able to transport their energy across the ocean and typically complete their journey on a coastline. As they travel waves may disperse and reduce in height while maintaining wave length and period. During storms waves are initially labelled as wind waves and as they disperse they are known as swell waves (Chadwick, Morfett & Borthwick 2007).

Waves of different frequencies travel at different speeds. Low frequency waves travel faster than high frequency waves. This is turn creates two key conditions, termed a storm sea condition and later a swell sea condition.

Due to the nature of periodic progressive waves the exact mathematic description is not a simple process. Generally for engineering purposes in deep water the Airy description form is utilised (Chadwick, Morfett & Borthwick 2007).

Airy waves

This wave description is also known as the linear or first order wave theory. The Airy wave is generally adequate for assisting in many coastal engineering applications. There are some simplifications in the calculations which occur as the process was derived from ideal fluid flow in two dimensions. The effects of viscosity, surface tension and turbulence only contribute to ocean waves in a minute manner hence the ability to make these simplifying assumptions

The equations below describe the horizontal (ζ) and vertical (ξ) components of the individual particle motions which actually describe an ellipse. Also u is the velocity in the x direction while w is the velocity in the z direction. These equations are for a particle at a mean depth of z below the still water level (Chadwick, Morfett & Borthwick 2007).

The following equations describe the path of particles which is actually an ellipse

$$\zeta = -\frac{H}{2}\left[\frac{\sinh k(z+d)}{\sinh kd}\right]\sin 2\pi\left(\frac{x}{L}-\frac{t}{T}\right)$$

And

$$u = \frac{\pi H}{T}\left[\frac{\cosh k(z+d)}{\sinh kd}\right]\cos 2\pi\left(\frac{x}{L}-\frac{t}{T}\right)$$

And the next equations outline the velocity components as the particles follow their elliptical motions

$$\xi = \frac{H}{2}\left[\frac{\sinh k(z+d)}{\sinh kd}\right]\cos 2\pi\left(\frac{x}{L}-\frac{t}{T}\right)$$

And

$$u = \frac{\pi H}{T}\left[\frac{\sinh k(z+d)}{\sinh kd}\right]\sin 2\pi\left(\frac{x}{L}-\frac{t}{T}\right)$$

These descriptions are graphically shown as the following which is based on the figures shown in Chadwick, Morfett & Borthwick (2007).

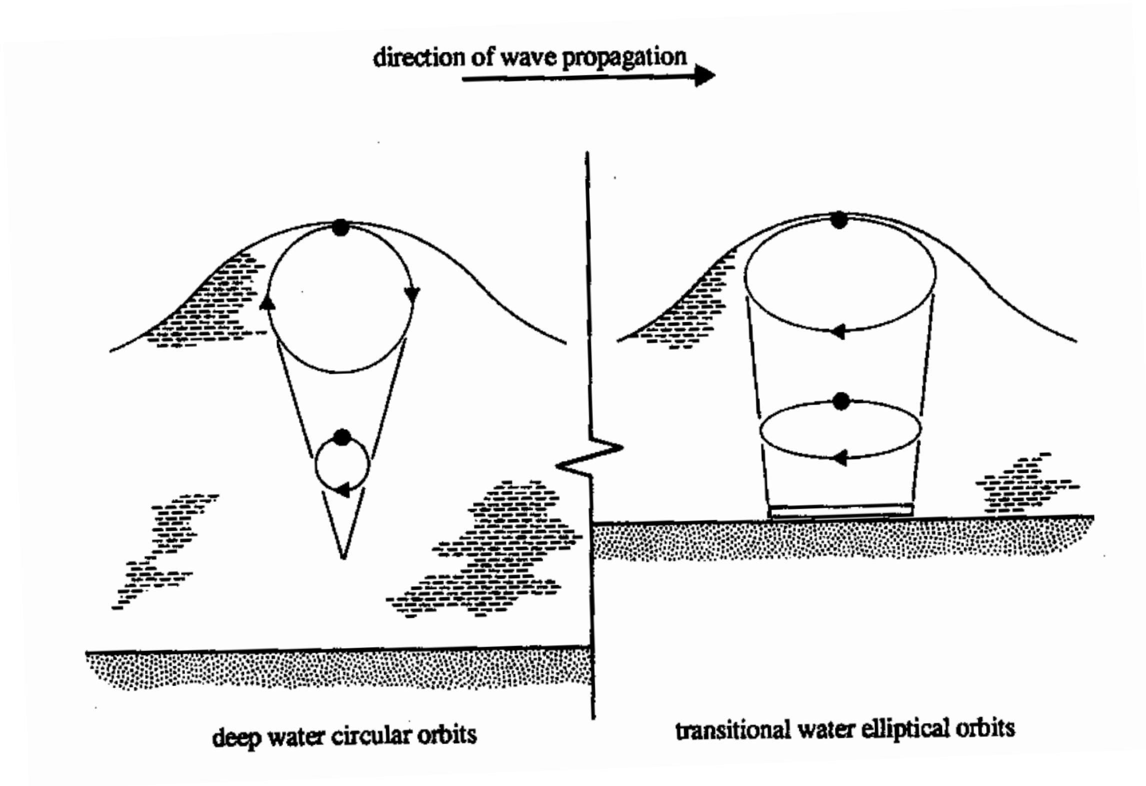

Figure 1 Particle Behaviour (sourced Chadwick, Morfett & Borthwick 2007)

The individual particle behaviour in deep water waves is likened to a circular movement. As the behaviour is described for particles at increasing depths under the water surface the radius of these circular orbits reduces. The particle movement at a depth of L/2 under the water surface is only 4% of the motion experienced on the water surface.

These equations have been displayed in order to demonstrate the motion of the individual water particles. This reduction explains the minimal impact of ocean waves in deep water on the sea floor. While helping to demonstrate the increased erosive effects in shallower water. These equations also reinforce the complex nature and behaviour of ocean waves (Chadwick, Morfett & Borthwick 2007).

The Airy wave equation applies only to situations where the wave height is relatively small compared to the wavelength and the water depth.

Wind Waves

Wind waves are identified as short crested, irregular and steep, there may contain a various frequencies and directions (Chadwick, Morfett & Borthwick 2007).

Swell Waves

Swell waves on the other hand are regular, long crested and are not actually as steep as wind waves they generally have a small range of low frequencies and directions (Chadwick, Morfett & Borthwick 2007).

Deep water

Deep water waves occur where the water depth is larger than half of the wave length. Mathematically this is when,

Equation 1-1 Deep water depth

$$d > L/2$$

Where d is the water depth (m)

A detailed study of this will deduce that in deep water the wave celerity and wave length is determined only by the wave period. This in turn explains why deep water waves disperse based on their frequencies (Chadwick, Morfett & Borthwick 2007).

Transitional water depth

The area which is located between the deeper ocean water and the shallow water where waves break is known as the transitional water depth. Mathematically this is described as,

Equation 1-2 Transitional water depth

$$0.5 > d/L > 0.04$$

Where d is the water depth (m)

L is the wave length (m)

Shallow water waves

Shallow water waves occur in depths where the following conditions occur

Equation 1-3 Shallow water depth

$$d/L < 0.04$$

Where d is the water depth (m)

L is the wave length (m)

This means that in the expression for the surface boundary condition

$$\tanh(kd) \approx 2\pi d/L$$

Therefore this expression is simplified down to

$$c = gTd/L$$

Which gives the expression for wave celerity

$$c = \sqrt{gd}$$

Wave Celerity

Eqn 1.1 $$c = \sqrt{gy}$$

Where

c is the wave celerity, the velocity of the wave relative to the flow (m/s) [Celerity is from the Latin and means swiftness]

g is the acceleration due to gravity g=9.80665 (m/s2)

y is the fluid depth (m)

The celerity of a shallow water wave is determined by the depth and unlike the deep water wave the celerity is not affected from the wave period. Another result of this behaviour is that shallow water waves are not frequency dispersive like waves in deep water.

Waves in shallow water or steep waves have a wave profile is more asymmetric, with high crests and low troughs. With this type of wave the celerity and wavelength are influenced by the wave height.

Waves approaching the shore

When a wave from deep water is travelling towards a coastline as the depth begins to decrease the wave motions are altered. These alterations are generally a reduction in the wave celerity and wavelength.

This in turn impacts on the direction of the wave crest and the wave height, energy is dissipated by the sea bed friction and when all components are right breaking occurs (Chadwick, Morfett & Borthwick 2007).

Wave Breaking

On a waves approach to the shore as it enters the shallow water region it begins to break. Waves most commonly form under the following conditions (Chadwick, Morfett & Borthwick 2007)

- A wave interacting with a current
- A barrier of some sort, natural or artificial
- The ratio of the wave height and water depth produces an unstable wave form

Waves will generally break when the following criteria are satisfied. The first condition is the wave's steepness and the second condition is the waves height compared to the water depth. These criteria can be derived from solitary wave theory. A solitary wave occurs when there is one wave with a crest and no trough.

Mathematically these limits are described as

Steepness

H/L <1/7

Breaking Index

this is ratio comparing the height to the depth

$\gamma = H / d = 0.78$

Normally γ can be between 0.4 and 1.2 subject to the slope of the beach.

Chadwick, Morfett & Borthwick (2007) have defined three main categories of wave breaking. These wave types can be approximated by the value of the surf similarity parameter, also known as the Iribarren no.

$$\varepsilon_b = \tan\beta / \sqrt{H_b / L_b}$$

Where $\tan\beta$ = beach slope and for

Spilling breaker $\varepsilon_b < 0.4$

Plunging breaker $0.4 < \varepsilon_b < 2.0$

Surging breaker $\varepsilon_b > 2.0$

These types are illustrated by Chadwick, Morfett & Borthwick (2007) as shown below

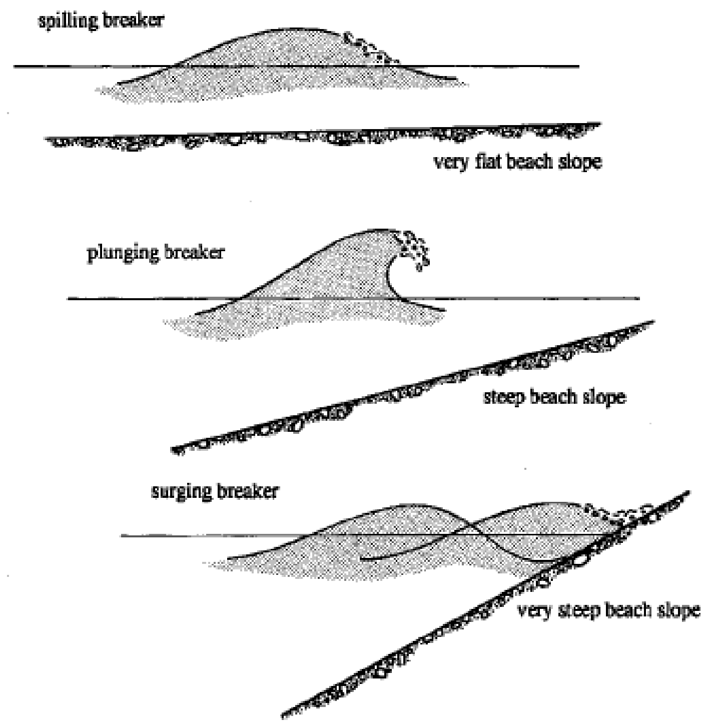

Figure 2 Types of Breaking waves (Chadwick, Morfett & Borthwick 2007)

Wave breaking depth

As a wave is approaching the shoreline the airy wave description is no longer applicable, this is due to the change in the waves profile which actually steepens. The wave will typically break when the follow equation is satisfied (Chadwick, Morfett & Borthwick 2007).

$$d_B \approx 1.28 H_B$$

Where d_B is the breaking water depth (m)

H_B is the breaking wave height (m)

Surf Zone

Once a wave has broken the area is known as the surf zone. It is in this zone that more complicated energy transformations occur. This zone is responsible for savage transport of beach material and powerful currents such as cross shore and longshore currents. Coastal structures will also add to the complexities in the wave motion inducing diffraction and reflection behaviours.

Wave groups in this zone are capable of producing secondary wave forms known as bound waves which have a smaller frequency and amplitude. In the surf zone these bound waves have been found to add to the process of sedimentation relocation, (Chadwick, Morfett & Borthwick 2007).

Seabed Friction

As waves travel towards the coast over the transitional and shallow region they will lose energy through friction with the sea bed. This process contributes to the erosive power of ocean waves (Chadwick, Morfett & Borthwick 2007). These energy losses can be approximated using linear wave theory. It is noted here only for completeness

The effect of waves on the coastline

Now that a brief introduction into ocean waves processes have been discussed the investigation will elaborate into typical consequences that occur on the coast line from the actions of ocean waves.

Coastal erosion

Coastal erosion occurs when the ocean removes sediment or rocks from their current location along the coast. This process is composed of short term variations and long term coastal erosion. As stated on SBS World News (2012) it is important to distinguish between the two types of actions which can occur along the coast. The two types of noticeable change which occur along the coast are termed short term shoreline change and long term coastal erosion.

Short term shoreline change

This is known as a short term adjustment to the normal coastline and occurs over relative short periods from days to a few years. It is readily evident after a storm event in which large waves diminish visible sand quantities on the beach. During this process sand is temporarily stored in the wave zone and the beach will generally be replenished at a later stage during more normal weather patterns. When material is deposited onto a coastline it is known as accretion (Rollason 2012).

Long Term coastal erosion

This process takes place over a longer period of time then Short term change and is noticeable over time frames from years to decades. The whole coastline can be seen to slowly move inland as long term erosion takes place (Rollason 2012).

Basic Geology

The geology of the coastline is an important factor in the capacity for coastal erosion. It incorporates the natural, non organic structure from which the coast line is constructed. The materials which form the coastline are introduced to assist explaining the some of the core factors for coastal erosion.

As described in the Earth’s Dynamic Systems (2001), rocks are classified into three basic groups which are based on the origin and formation process. The knowledge of the rock type allows an understanding on the rocks ability to with stand erosion processes. This report will focus mainly on sand holding beaches so no further discussion will be made into the results of hard natural rock structures like headlands.

Ocean Chemistry

The ocean is fed by the various rivers of the world. It is estimated that these rivers combined transport in excess of four billion tons of dissolved salts into the ocean every year. The National Oceanic and Atmospheric Administration have also calculated that a similar mass of salt converts to sediment on the ocean floor. This equality is what maintains the ocean at a stable salinity.

As rainwater falls to the earth it carries dissolved carbon dioxide that gets absorbs from the surrounding air. This combination of carbon dioxide and water produce carbonic acid. The carbonic acid results in the rain water becoming slightly acidic. The negatively charges atoms then begin to erode the surfaces of the rocks. The erosion creates ions, which are electrically charged atomic particles. Eventually these ions find their way into streams and rivers headed for the ocean (National Oceanographic Data Center 2013).

A portion of these ions are utilised by organisms in the ocean. The remainder contribute to the salinity of the ocean. This salinity is mainly attributed to the ions of chloride and sodium. These two elements account for 90 percent of the dissolved ions that exist in the ocean.

The result of this process leaves the ocean seawater at a salinity of around 35 parts per thousand. Which is equivalent to 3.5 percent of the weight of seawater comes from dissolved salts that the ocean contains. There is approximately enough salt dissolved in the ocean to cover the earth land surfaces 166 metres deep (National Oceanic Atmospheric Administration 2013).

Erosion from Ocean Waves

This section will focus on the result of ocean waves and how they contribute to coastal erosion. There are many other factors which result in Coastal erosion. Ocean waves are able to generate erosion in four main ways

- The interaction of the wave energy in the water against the shore is able to wear it away
- Particles of rock and sand are continued in the water as it collides with the shore
- The water action cause rocks and pebbles to collide and break up
- Acids in the sea slowly dissolve particle rock types.

Beaches are part of a natural barrier that helps to protect coast lines. The result of wave action on a beach is mainly reflective of the type of wave action and the type of material that exists on the beach. This means that the various results along any coastline can vary based on the factors which are contributing at that particular location. This can ultimately mean that there may be periods of excess sand deposits and periods of depleted sand quantities along a given shoreline.

Normal constant wave conditions

The beach will generally develop a stable slope on the sea bed which the overall total sediment movement is zero. This stable slope is proportional to the grain size and with an increasing grain size the sea bed slope will also increase. The bed slope is inversely proportional to the wave height as the wave height increases the bed steepness decreases (Chadwick, Morfett & Borthwick 2007).

Longshore Sediment Transport or littoral drift

When waves approach the shoreline at an angle that is not perpendicular to the shore line a current along the shore tends to develop. This current is capable of transporting sediment. The actual direction of this sediment movement is north or south depending on the wave approach angle.

This process occurs in the surf zone mainly where the water is from 3m to 12m depth.

This process undergoes natural cycles in which accretion and erosion result on the beach over extended time periods (Rollason 2012).

Cross Shore Transport

Cross shore movements occur more frequently during large swell occurrences. The process removes sand from the visible upper beach face and relocates it offshore. This process often results in the formation of a subaqueous bar. If a large storm events, combined with high spring tides occur during this time the beach is considerably vulnerable to damages. On the contrary intervals of small swells will generally manipulate the sand towards the shore. This process is often aided by Aeolian sand transport and combined the processes can restore upper beach face.

Cross-shore transport does not contribute to the overall net loss or gain of the sand within a beach system. The process may stretch over multiple years but the sand which is removed during these extreme storm conditions is cyclic in nature and will most likely be replenished (Rollason 2012).

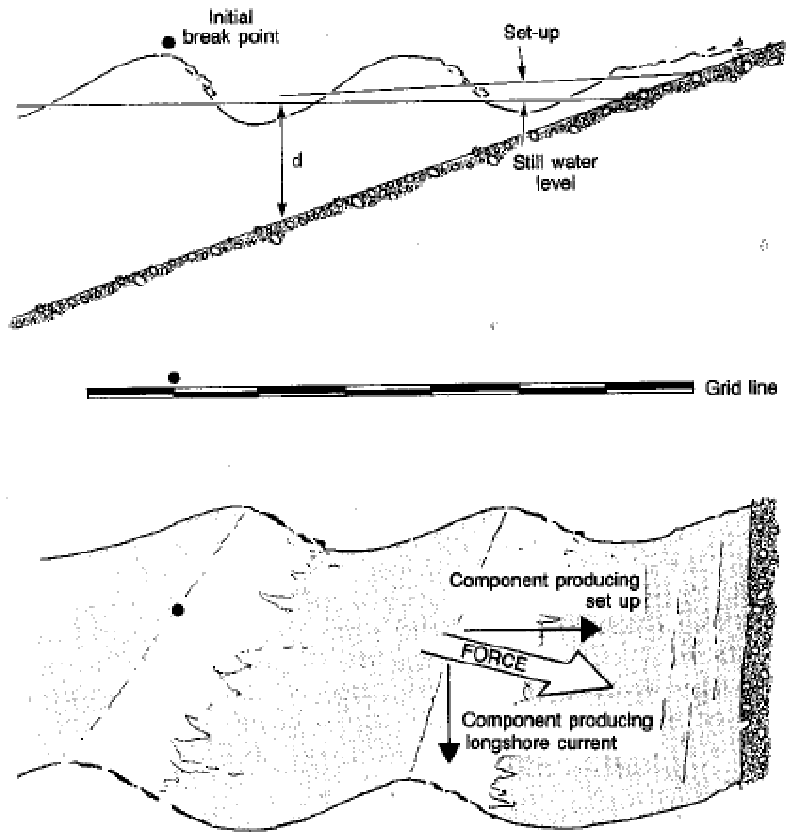

Figure 3 Currents in the Surf Zone (Chadwick, Morfett & Borthwick 2007)

Aeolian Sand Transport

Aeolian sediment transport refers to sediment that is removed due to the effects of the wind. The main areas which are affected are the upper beach face and the non-vegetated, exposed dune area. The fore dunes are generally built by the combination of dune vegetation and Aeolian sediment transport. As the action of the wind moves the sediment it is captured and stabilised by the vegetation within the dune area.

When the vegetation is lacking substantial cover or non existent sand may be lost to the back beach area, which in turn means that the buffer created from the dunes to provide storm protection is reduced (Rollason 2012).

Slug formations (sand)

Slug formations are a significant movement of sand quantities which can occur over changing time periods. It is a typically a combination of longshore sediment transport, periods of high wave and wind energy. The 'Slugs' of sand move around large objects such as headlands. The result from a 'Slug' process is a temporary imbalance in the available sediment. The up drift beach is in excess and the down drift beach is left with a significant decrease in the sand quantities. The process of longshore transportation is more frequent at lower energy levels.

In order for the beach system to maintain sediment equilibrium it is necessary that the total inflow and out flow into the system is balanced. This will ensure that the shoreline can sustainable alter between storm erosion and periods of recovery (Rollason 2012).

Radiation Stress or momentum flux theory

Radiation stress is the outcome which is generated from the process of wave set up and set down and longshore currents. This stress is defined as the 'excess flow of momentum due to the presence of waves' (Chadwick, Morfett & Borthwick 2007). It is produced from the circular motion of each particle of water influenced by waves. This circular motion results in an overall net force which moves in the direction of propagation.

Chapter Summary

The interactions that occur between the ocean and the coastline are complex with sediment movement is a common occurrence. This sediment movement can result in variations of sand quantities over periods of time. Coastal erosion is one of the results which can occur along the coastline in part from the actions and processes of waves.

Chapter 2 Research key legislation, Policies and guidelines relevant to the coastal zone in NSW

Introduction

Coastal Construction falls across many authorities and responsibilities. In order to determine the feasibility of a project it is important to comprehend the relevant legislative boundaries which are in place. In order to build a complete case a general concept of the law is covered followed by more in depth analysis.

A brief introduction into law and the policies and guidelines will be provided to ensure that all factors are taken into consideration for coastal erosion protection. The coast is a popular environment, there are many parties which are involved and affected by the management of the coastline. The legal responsibilities and obligations for coastal management are incorporated here for completeness with a focus on Coastal Management.

Introduction in legislation

The basic concept of the legal system and how it governs and protects out coastlines is described in this section of the project. As discussed in the University of Southern Queensland (USQ) Engineering Management, ENG3003 Study Book 2 (2013) the law can be described as the regulations which are acknowledged and enforced by the Courts of the nation.

Australian law is comprised from two sources

- Case law
- Legislation

Case Law

Case law has been built up over time and is reflective of cases which have been determined from the past. This means that across states case law can vary. As each state is responsible for new rulings as new situations arise. Courts must observe and adhere to relevant proceedings in case law (ENG3003 2013).

Legislation

Legislation is another source of Australian Law. This law is founded through Acts passed by the State and Federal Parliaments. Whereas case law is determined based on the cases in which the court is confronted, Parliament can proceed on legislation on any matter it see fit. Once Parliament adopts a bill and it becomes an Act it is part of our statute law.

Statute law can be amended or removed by Parliament. This is the reason that various Acts have amendments(ENG3003 2013).

Coastal Erosion

In Australia the management authority for coastal zones includes three levels of government, Commonwealth (Federal), State and Local. The commonwealth government is not able to provide direct constitutional power in the area of coastal management. The State coastal strategies typically contain the guidelines for coastal planning and management. The final responsibility falls onto the local governing authorities. The LGAs are the authority which orchestrates the majority of coastal management. The input includes taking State planning policies, management policies and legislation and transforming these into local directions while incorporating infrastructure, coastal maintenance and providing public safety (James 2000).

Coastal Protection

Coastal Protection is required to minimise the extra pressure on our coastal lines that occurs from the popularity, development and infrastructure on the coast. The need for planning is to balance the demands which exist from employment, living, facilities and transport in order to support the growing population, while maintaining the qualities that the coast has to offer (NSW P&O 2013).

In June 2001 the New South Wales Government released its $11.7 million Coastal Protection Package. The goal of this was to ensure the sustainability of the NSW beaches, headlands and Coastal features for the future. This announcement in 2001 also mentioned that as part of the planning and development along the NSW Coastal Zone, which happens under the Coastal Protection Act 1979, the following conditions must be satisfied (NSW P&O 2013).

- There is a ministerial direction for coastal protection
- NSW Coastal Policy
- State Environmental Planning Policy No. 71 – Coastal Protection
- State Environmental Planning Policy (Major development) 2005

Comprehensive Coastal Assessment (CCA)

This is another crucial component of the NSW Government's Coastal Protection Package. This is a package which has been designed to assist councils, government agencies and others to plan strategic land use. The toolkit draws on assessing the values that are incorporated in the NSW coastline. As Stated on the NSW Government Planning and Infrastructure website, these values include physical, biological, social and economic value of the State Coastline

Coastal Lands Protection Scheme (CLPS)

The CLPS is used to transfer significant lands to public ownership and ensures they have long term management and protection. The end result is that the Scheme promotes public access to coastal foreshores. Maintains the scenic value of the NSW coast and protects ecological sites of importance, whether regional, sate or even nation locations.

Coastal management in NSW

The legislative guidance for Coastal Management in NSW (Rollason 2012) is typically governed by

- NSW Coastal Protection Act 1979 and amendments
- NSW Coastal Policy (1997)
- State Environment Planning Policy No. 71 – Coastal Protection
- NSW Sea Level Rise Policy Statement (2009)
- Local Government Act 1993
- Environmental Planning and Assessment Act 1979 relating to coastal Protection
- the Environment Protection and Biodiversity Conservation Act 1999
- the Threatened Species Conservation Act 1995
- the Fisheries Management Act 1994; the National Parks and Wildlife Act 1974
- the Water Management Act 2000;

Land use planning in the coastal zone in NSW

- NSW Coastal Planning Guideline: Adapting to Sea Level Rise (DP, 2010)
- Coastal Design Guidelines for NSW (DP, 2003).
- State Environment Planning Policy (Infrastructure) 2007
- Coastal Protection Service Charge DECCW, 2010

The remaining policies relating to Coffs Harbour

- The NSW Coastal Planning Guideline: Adapting to Sea Level Rise, which provides guidance
  from NSW P&I for risk based planning for sea level rise;
- The Coastal Risk Management Guide – Incorporating sea level rise benchmarks in coastal
  hazards assessments, which provides technical guidance for assessing sea level rise
  Impacts using the NSW Sea Level Rise Policy Statement benchmarks, as used in the Coffs Harbour CHDS (Rollason 2012);
- The Coastline Management Manual (1990) which guided the commencement of the Coffs Harbour Coastal Zone Management Plan (CZMP), now superseded by the CZMP Guidelines.

A brief summary of the policies and guidelines

A brief summary of some of the legislations, policies and guidelines which are applicable to coastal management in NSW are discussed below.

NSW Coastal Protection Act 1979 and amendments

This document gives guidance on the use, possession and development within the coastal zone of NSW. Ecologically sustainable development was incorporated into the 2002 amended version.

This Act gives the Minister for the environment permission to direct a council that possess land in the coastal zone to develop a CZMP, and to direct a council on the way in which this document is prepared, accepted and even amended if required.

The main outcome of this Act is to ensure the protection of coastal environments for the current generation and those of the future (Rollason 2012).

NSW Coastal Policy (1997)

The NSW Coastal Policy exists to produce a consistent bench mark that can protect, reinstate and improve the natural environment. The policy consists of nine aims and the methods and actions required to achieving environmentally sustainable development in NSW. The nine goals of the NSW Coastal Policy are discussed below.

State Environment Planning Policy No. 71 – Coastal Protection (SEPP71)

The SEPP71 is used to protect and manage the natural, cultural, recreational and economic factors of the New South Wales coast. The document highlights Ecologically Sustainable Development (ESD) through suitable located development within the coastal zone. This policy was created under the Environmental Planning and Assessment Act 1979 to maintain the following processes in relation to coastal protection (Planning and Infrastructure, 2013)

- Construction in the NSW coastal zone is suitable and well located
- That Coastal Planning and Management has a logical, systematic planning process
- The assessment for development in the Coastal Zone is clear

NSW Sea Level Rise Policy Statement (2009)

This Policy Statement is to be used correctly with the legislation and policies which are already in place for coastal management.

The NSW Sea Level Rise Policy Statement (2009) enforces consistent planning standards which complements the planning standards for the projected sea rise up to 2100 which must be included in all forms of coastal assessment including development applications, coastal hazard definition studies and coastal zone management plans.

Local Government Act 1993

The Local Government Act 1993 creates local governments and allows them the authority to perform functions such as management, development, protection, restoration and conservation of the environment for the local government area

(Rollason 2012). These actions are to be carried out consistent with and in support of ecologically sustainable development.

Environmental Planning and Assessment Act 1979 relating to coastal protection

This legislation is the main NSW Act for planning and land use. It consists of systematic planning and assessment for NSW, and incorporates developing plans to stipulate land uses, through environmental planning instruments.

This Act develops three types of environmental Planning Instruments (EPI)

- Local Environmental Plans;
- Regional Environmental Plans; and
- State Environmental Planning Policies

The document objectives are

- proper management, development and conservation of natural and artificial resources,
- including agricultural land, natural areas, forests, minerals, water, cities, towns and villages
- for the purpose of promoting the social and economic welfare of the community and a better
- environment;
- • promotion and co-ordination of the orderly and economic use and development of land;
- • protection, provision and co-ordination of communication and utility services;
- • provision of land for public purposes;
- • provision and co-ordination of community services and facilities;
- • protection of the environment, including the protection and conservation of native animals
- and plants, including threatened species, populations and ecological communities, and their
- habitats;
- • ecologically sustainable development;
- • the provision and maintenance of affordable housing;
- • promotion of the sharing of the responsibility for environmental planning between the
- different levels of government in the State;
- • provision of increased opportunity for public involvement and participation in environmental
- Planning and assessment.

NSW Coastal Planning Guideline: Adapting to Sea Level Rise (DP, 2010)

This document outlines how sea level rise may be considered within land use planning development assessments. The guideline also advises that strategic land use planning to minimise developments in coastal risk areas. This evaluation occurs through utilising the Coastal Risk Management Guide line from DECCW (2010).

State Environment Planning Policy (Infrastructure) 2007

The State Environmental Planning Policy (Infrastructure) 2007 is also known as SEPP Infrastructure. This policy is constructed to ensure that there is a consistent planning outline for infrastructure and services throughout NSW. This also incorporates engagement of public authorities throughout the assessment period. In short the document provides greater flexibility in relation to infrastructure and services and more defined regulatory consistency and streamline efficiency.

SEPP infrastructure applies to ‘waterway or foreshore management activities’ which are defined by the NSW Legislation under Division 25 of SEPP 2007 as

(a) riparian corridor and bank management, including erosion control, bank stabilisation, engaging, weed management, revegetation and the creation of foreshore access ways, and

(b) in stream management or dredging to rehabilitate aquatic habitat or to maintain or restore environmental flows or tidal flows for ecological purposes, and

(c) coastal management and beach nourishment, including erosion control, dune or foreshore stabilisation works, headland management, weed management, revegetation activities and foreshore access ways, and

(d) coastal protection works, and

(e) salt interception schemes to improve water quality in surface freshwater systems, and

(f) installation or upgrade of waterway gauging stations for water accounting purposes.’

In section 129 of SEPP Infrastructure development as a result of waterway or foreshore management activities in the above instances can be carried out by or with authority from a public authority such as a council without consent on the land.

- Construction activities
- Scheduled maintenance work
- Unplanned emergency works which may result from flooding, storms and coastal erosion
- Works to provide environmental management

Therefore a Council is allowed to conduct foreshore management as long as a Review of Environmental Factors (REF) is completed under the Part 5 of the EPA Act in conjunction with any other approvals relating to the land. Other approvals may include regulations such as Crown Lands Act 1989, Fisheries Management Act 1994 and the Water Management Act 2000.

Coastal Protection Service Charge DECCW, 2010

In 2010 the former DECCW published the Coastal Protection Service Charge Guidelines that explain the Coastal Protection Service Charge. This is an a service to maintain and repair coastal protection works and to control the results of coastal protection works. The document explains how the funding can be used to protect private property when those property owners may benefit from the works.

The Marine Parks Act 1997 and the Solitary Island Marine Park

The objectives of this act are to

- protect the marine biological diversity, and habitats through the issuing of management systems for marine parks
- Ensure the ecological processes in a marine park are maintained
- Ensure that the use of fish, for commercial and recreational purposes is sustainable and the conservation of marine vegetation
- Provide the opportunities for the public to experience, enjoy and explore marine parks.

In summary the Marine Parks Act 1997 provides the opportunity to declare marine parks. Once a marine park has been created, the zoning plan is developed to ensure that the processes which occur in the marine park satisfy the objectives of the marine park.

Chapter Summary

The coastal region is governed by a number of legislative policies and guidelines. These policies have been included in the report to recognise the sensitivity and importance of the coastal region.

Chapter 3 Research the methods for minimising coastal erosion

This component of the project looks at methods to minimise coastal erosion. Coastal erosion is the natural process resulting from waves, tides or currents from the ocean interacting with the coastline. The two methods of coastal management which will be looked at are groynes and beach nourishment. It is also common for these two processes to be used complementing each other.

Coastal Defence

This is the term given to describe the concept of protecting against coastal hazards. There are two main topics that exist under the defence description. Sea defence is typically designed in order to minimise coastal flooding during high wave and sea conditions. Coastal protection is the title given to protecting an existing coastline from erosion.

The aim of this report is to discuss the coastal protection design and so no further discussion will be given to the design of coastal defence in relation to flooding mechanisms (Chadwick, Morfett & Borthwick 2007).

Groynes

Groynes are used to protect the shore by limiting longshore sediment transport. The effectiveness comes from altering the original plan profile of the beach by interrupting the long shore currents that are produced from wave action and to dissipate wave energy early in the surf zone process (Chadwick, Morfett & Borthwick 2007).

Beach nourishment

Beaches which are populated by sand are of great importance to the socio economic value. They are fantastic opportunities for recreational activities and enjoyment and the function as a buffer for the land from powerful wave actions.

Outside the main focus of this paper Cooke et al. (2012) also notes the significance of sandy beaches to the ecology of the local environment.

There are many factors which are natural and urban that are intruding on these sandy beaches. With sea levels rising and adverse weather patterns the shorelines can become battered and experience erosion. On the opposite side of the natural buffer between the water and the land is urban development (Defeo et al. 2009)

It is quite evident that beaches can experience periods of accretion and erosion. The times frames for these processes can vary from one storm event through too much longer time frames. (Cowell & Thom 1997). Bird (1996) concludes that 70% of the world's beaches are in a state of recession. This deficiency in sand volumes is compounded by the urbanisation of the coastal zone. The hard barrier of human construction actually limits a beaches natural ability to move inland during erosion processes (Nordstrom 2000). Komar even explains the disruption that results with the sediment processes which occur along the coast line. The end result of these combining factors is beaches become exposed to becoming deficient against the oceans energies and are left narrowed. This means that the public beach amenity and coastal infrastructure can be at risk (Finkl and Walker 2004)

There are strategies which can be implemented to help the beach recover and provide its natural defence system to the coast. One of these options is established setbacks from coastal areas for urban development which allows for a moving coastline. Cooke et al. (2012) discusses the options of hard and soft engineering processes. Hard engineering processes include seawalls and groynes. Seawalls act as a barrier between the ocean and the shoreline or coastal assets. Groynes are useful for trapping sediment and when implemented correctly contribute to beach accretion. The soft engineering processes incorporate artificial placement of sediments. These sediments may come from within the same coastal compartment. This process of sand deposit occurs in Coffs Harbour NSW when the jetty Harbour is dredged. The spoil is dumped either just outside the wave zone or on the dunes. This will be addressed later in the project. Finkl and Walker (2004) explain that is it common to use a combination of hard and soft engineering processes in relation to Coastal Management.

One typical location that requires a combination of both processes is when hard structures are used at river mouths as entrance training walls. These hard structures disrupt the littoral drift patterns and can result in sand deposits building up around the structure. This natural process can be reinstated utilising sand bypass pumps. Brunn (1996) concludes that the natural process can be restored to prevent sand deficiencies occurring as a result of these hard structures. The Tweed River Entrance Sand Bypassing Project (TRESBP) is an installation of this nature which is able to allow the natural movement of sand to continue northwards via a sand pumping network.

Soft engineering is often regarded as the preferred option for coastal management (Finkl and Walker 2004; Hanson et al. 2002; Thom 2003). Finkl and Walker (2004) suggest that the long term solution to shoreline erosion may not be achievable with only sand nourishment. Peterson et al, (2006) contributes that the efficiency and impacts of soft engineering processes and project success depends on, scale ad timing of project and the source location of sediments which are used to supply the nourishment material.

Soft Engineering

Cooke et al. (2012) conducted a review of Local Government in Australia in relation to beach nourishment practices. Of the 50 percent of LGAs that responded to the survey 64 percent had utilised the method of beach nourishment within the 10 years from 2001 to 2011. 60 percent of the LGAs were planning on implementing sand nourishment projects within the period from 2011 to 2017. From those who responded to the survey only 2 percent have never undertaken any type of nourishment projects. Cooke et al. (2012) also reports that the primary reason for beaches receiving a nourishment process was due to protecting coastal infrastructure (34%) and public beach amenity (26%). Further reasons were included such as maintenance of walkways (21%), ecological reasons (12%) and due to dredging works needing somewhere to be deposited (5%).

The next category of findings relevant to this research project was a summary of justification to the reason behind the nourishment works. The greatest was due to short term extreme storm events (36%) followed by long term littoral drift (31%). The remain works were due to approved and un approved coastal activities such as hard engineering structure like rock walls, river damming and lagoon opening and removal of coastal vegetation.

The final relevant information was determined by Cooke et al. (2012) was in relation to the orientation of nourishment placement. The greatest number (44%) was placed on the back shore. The next most frequent release location was the fore shore (37%) and then the near shore (14%). The least frequent location was at another location or offshore (5%).

The review by Cooke et al. (2012) also determined that there were nine locations where permanent sand bypassing equipment was located for the purpose of nourishment. These projects were of much larger size then the average of the projects previously discussed.

The main concept here is to reinstate the materials which were the beaches natural defence mechanism. It is quite typically left to the effects of wave action to distribute and place the material. The extent to this nature of refurbishment is generally influenced by the rate of depletion and the ability to source and supply suitable material.

If the replenish material is course then the original beach material it is likely that the beach profile will become steeper and if the nourishment material is of a finer nature the profile will be flatter. If addressed and completed correctly this process is regarded as one of the most environmentally friendly manner of providing coastal defence.

Chapter Summary

There a number of effective methods of coastal erosion protection. This brief introduction was provided to demonstrate the techniques used in the specific case studies conducted in chapter 5 of the report sand nourishment and groynes. The general goal is to breakup the currents and wave actions which have the capacity to remove substantial quantities of sand from the beach front which is the coast protection from the ocean.

This process of incorporating surfing conditions into coastal erosion protection would be possible across all forms of coastal erosion protection.

Chapter 4 Report on the variable factors that are involved in producing various types of surfing waves. Focused study on four (4) popular surf locations.

Introduction

This section will discuss the main factors which contribute to the surfability of waves and investigate four popular surf locations. Some general surfing terminology will be introduced to help grasp the surfing concepts. Some measureable criteria will be discussed for the quality of ocean waves in relation to surfing.

It is typical with many activates that a measurable criteria exist, such as the dimensions, across a soccer field (Government of Western Australia, Department of Sport and Recreation, 2013). This means that it is possible to determine the quality of a soccer field for a professional competition. Surfing does not occur on a fixed regular surface. The waves are all unique and so the ability to compare and categorise waves involves a common ground for comparison. With an activity such as surfing there are many aspects which attract different individuals, competitions and culture. This section will be discussing some measurable criteria in relation to surfing waves. Therefore some common surfing jargon will be introduced as well as interviews with profession surfers from Coffs Harbour. The purpose of this is to minimise any barriers which may be exist between people which are familiar with surfing and those which are not so familiar with surfing. This is to link between the technical engineering concepts and actual basic every day surfing terms. The purpose of this is to ensure that a common appreciation and understanding is achieved between end users, planners, designers and engineers.

James Walker (1974) clarifies "*Waves from various sources create surf with varying characteristics seasonally on a given shoreline*." A vital component of surfing is the waves and due to the nature of ocean waves they are all unique. At locations which are popular for surfing the waves are generally more consistent in the overall surfability. With this in mind not every wave is considered surfable and there are many factors which contribute to the surfability of ocean waves. By investigating some of the parameters which make an ocean wave fall into the broad category of 'surfable' it will allow a better opportunity to incorporate these aspects into designs in which surfing conditions are a consideration.

Surfing

Surfing involves complex variables and the final result to surfers of what would be defined as perfect wave is not an exact science. This section will also look at some common surfing styles and define some keys aspects. This will assist in categorising the selected surfing locations. The style of surfing will be limited to discuss the main stream short board as used in the Association of Surfing Professionals (ASP) and the long board or Malibu also as utilised in the ASP. Although there are many different categories of boards these two will be more closely discussed in this section due to the main stream popularity and in order to provide a reference point for discussion.

General Surfing Terminology

In order to expand on the type of waves produced basic jargon typical to the surfing environment will be introduced and expanded on in this section. Scarfe et al. (2003) has done a detailed review on ‘The science of Surfing Waves and Surfing Breaks” which helps to strength the link between the world of physical surfing and the theoretical hydraulic concepts. This section will start with more basic descriptions that are part of surfer vocabulary and then will utilise ideas presented by Scarfe et al. (2003) to try and help link what is actually happening in the minds of science and the minds of surfers. The following is a list of basic surfing terms

Basic Wave descriptions or Surfing jargon

Some basic wave terms will be introduced before the detailed surfing parameter discussion.

Barrel

The wave results form a sudden decrease in depth. The wave face continues to stand up and falls cleanly over itself producing a circular tube. Almost the pinnacle position for any surfer is to position themselves under the top section of the wave as it leaves a hollow pocket for them. When this occurs for a surfer a typical description would be, tubbed, slotted, shacked, cave, Green room, or pitted.

Surfer Kian Shahar getting Barrelled

Closeout

This wave basically occurs for two reasons

- Moderately fast decrease in water depth at wave break zone
- The bank is basically perpendicular to the swell direction

This results in the wave being steep and hollow typically producing a barrel. As well as this wave form rather than pealing along the entire wave or a large section closes out. This is often the end of the surfing wave. The peal The surfing wave generally ends here. It is common for an advanced surf to perform an extreme manoeuvre.

Gentle peeling wave

This wave could be considered as a wave which exists mainly in a slight incline in the ocean floor. As the wave is produced the top section falls down the face of the wave in a crumbly pattern.

Left-Hander of Left

This wave is named from the surfers prospective. This means the surfer in the ocean facing the shore would travel along the wave in his current location to the left. An observer on the shore would witness the surfer travelling from the point they take off to the right as they ride the wave.

Right-Hander or Right

This wave is named from the surfers prospective. This means the surfer in the ocean facing the shore would travel along the wave from his current location to the right. An observer on the shore would witness the surfer travelling from the point the take off to the observers left as they ride the wave.

Peeling wave

This is explained in more detail in the following section in relation to wave surfability parameters. The peel angle is described by Walker (1974) as the angle between the crest of a swell and the broken white wash as it travels towards the shoreline. This will allow the surfer to travel along the face of the wave just in front of the white wash. This type of wave can best be demonstrated from an aerial perspective. Where it is evident from the white wash where the wave has been breaking. Another way to easily visualise would be showing a sequence of photos as a surfer progressed along a wave.

Basic Manoeuvres and Wave Riding terms

Fore hand

When the surfer is riding the wave and is generally positioned facing the wave. For a natural stance this would be riding a right-hander.

Backhand

When the surfer is riding the wave and is generally positioned with their back towards the wave face. For a natural stance this would be riding a left-hander.

Pocket

The location that is most frequently surfed as it provides the most powerful location on the wave face just in front of the peeling crest (Scarfe et al. 2003)

Natural Stance

This is when the surfer positions their right foot at the back of the surfboard. This means that on a right peeling wave the surfer would have their back to the shore. And if they were to travel left on a wave they would be generally facing the shore.

Goofy

This is when the surfer positions their left foot at the back of the surfboard. This means that on a right peeling wave the surfer would be facing the shore. And if they were to travel left on a wave they would have their back to the shore.

Carve

Generally a powerful fluid smooth turning term

Air

When a surfer and the surfboard leave the face of the wave. There are many variations of this advanced manoeuvres.

Front Side Air

An air or aerial in which the general direction of travel for the surfer is facing the wave

Back Side Air

An air or aerial in which the general direction of travel for the surfer has their back facing the wave

Switch-foot

The term given to swooping your natural front foot and back foot positions.

Stall

Deliberately reducing speed on the surfboard, usually by applying pressure to the back foot or placing a hand in the wave face. This is a typical action to allow the barrel time to catch the surfer.

Trim

The act of generating speed or moving across the wave.

Wave Section

Due to the nature of wave physics it is quite common for a particular surf brake to consist of a number of differing sections along the length of the breaking wave. For instance the wave my start off in a barrel (one section) change to a gentle peeling wave (separate section) and finish in a closeout (separate section). Scarfe et al. (2003) also extends this to incorporate the typical manoeuvres which may be performed on the varying sections of waves.

Surfing Wave Parameters

Due to the large number of variable factors that combine to produce surfing waves SCARFE et al. (2002 and 2003a) suggested the use of the following four variables was adequate for the purposes of surfing. Since the other parameters are incorporated within these four parameters. These main four parameters are introduced below.

Wave Height (Hb)

This is generally the most common description when wave properties are discussed. There are some variations in the way Oceanographers and surfers measure wave heights. Surfers often measure wave heights based on their perspective in front of the wave but it is often only an approximate height. Oceanographers adopt the scientific means, which measures the wave's height from the crest to the trough.

Wave Peel angle (α)

The angle between the crest of a swell and the broken white wash as it travels towards the shoreline (Walker 1974). This is clearly evident in an aerial view following a breaking wave. The peel angle can alter between 0 and 90 degrees for each section of a wave. Waves which have a low peel angle create a fast surf ride and waves with a high peel angle create a slower ride. Peel angle is also reflective of the typical type of surfing manoeuvre which is suitable to be performed along corresponding wave sections (Scarfe et al. 2002).

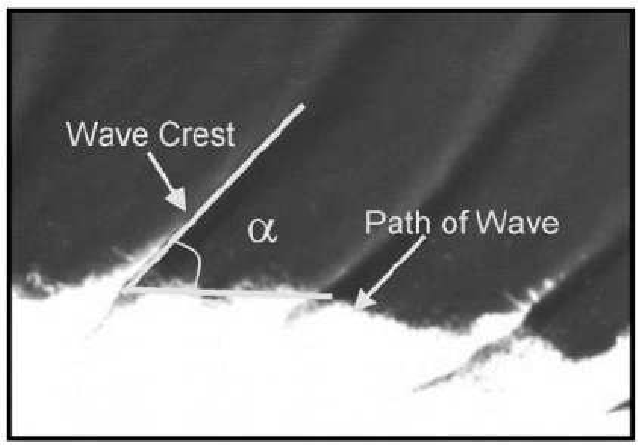

Figure 4 The peel angle, α, Mead, (2001)

Wave Breaking Intensity (B_I)

When the a wave breaks in the surf zone the breaking component may be described as spilling, plunging, surging or collapsing subject to the orthogonal seabed. Typically surfers prefer waves which have steep or plunging faces (Mead and Black, 2001c). These wave types are also able to provide the most powerful rides for surfers and increases the chances of a surfing enjoying a barrel. (Scarfe et al. 2003). There are many variations of plunging waves, Mead and Black (2001c).

A cubic curve was fitted to the barrel shape, which is scientifically labelled as the wave vortex. The ratio of the height and the width of the wave vortex is known as the vortex ratio. The Vortex ratio is a good indicator of the breaker intensity. Through regression analysis Mead and Black (2001c) showed that the following equation was a first attempt at quantifying wave breaker type.

Equation 4-1 Breaker Intensity

$$Y = 0.065X + 0.821$$

Where Y is the breaker intensity

X is the orthogonal seabed gradient.

It is also noted here that even though Mead and Black (2001c) breaker intensity equation is simplistic it is useful for quantifying the design characteristics of artificial reefs and to categorise between different surfing breaks. The span of results from Equation 4-1 Breaker Intensity, were classified by Mead and Black (2001c) as medium, medium/high, high, very high and extreme.

It is also important to note that the wind strength and direction can alter the breaking intensity. Generally speaking, winds which are offshore increase the breaking intensity and winds which are onshore or cross shore will lower the breaking intensity. The most favoured conditions for surfing are light offshore winds. This will increase the breaking intensity by delaying the wave breaking. The depth that the wave would normally break in is momentarily stalled until a region of shallower water. This is part of the reason for the increase in intensity. If the offshore winds are too strong the waves become difficult to catch (Scarfe et al. 2003) and the face of the wave can become distorted.

Wave Section Length (SL)

Due to the many factors which contribute to the peeling characteristics of a surfing wave it is quite common that even along one particular break the wave is divided into various sections. These differing sections are subject to various opportunities for surfers as they progress along the wave. A new section occurs when there is a change in the wave height (HB), peel angle (α), or breaking intensity (BL). The section length is the length that a particular section's characteristics are maintained. An example of a section type would be a barrelling section in which the wave has a steep plunging face and is hollow inside to allow the surfer to travel inside.

Wind Characteristics

The wind is another key variable in the capacity of a location to produce quality surfing conditions.

Offshore

The wind direction is moving from the land towards the ocean, perpendicular to the wave direction, this is generally the most sort after direction. This is a favourable condition in surfing, see wave breaking intensity above.

Onshore

The wind direction is moving from the ocean towards the land, again perpendicular to the wave direction. This is not generally a preferred wind direction in surfing, refer to breaking intensity description above.

Cross shore

The wind is moving basically perpendicular to the wave direction. This wind direction is not usually considered as ideal as the offshore conditions though it is possible that these conditions can still assist to deliver good waves.

Bathymetry

Bathometry describes the contours and shape of the sea bed. The performance of a surfing site are affected by the contours of ocean floor, the swell characteristics and the wind conditions (Walker, 1974). The bathymetry is one of the components which can be influenced during coastal erosion protection activities. This report will not go into more detail on this consideration but highlights the contribution by James Walker (1974, p 65) 'Local variations in the bottom render neighbouring sites different from each other'. These variations can ultimately affect wave breaking intensity, wave peel angle, and section length.

The sites which have been investigated in this report are all mainly sand based formations. This means that the bathometry is constantly changing as the ocean currents and wave actions shift and alter the sea bed below. This in turn means that the consistency of the wave surfability is subject to variation based on the sand distribution.

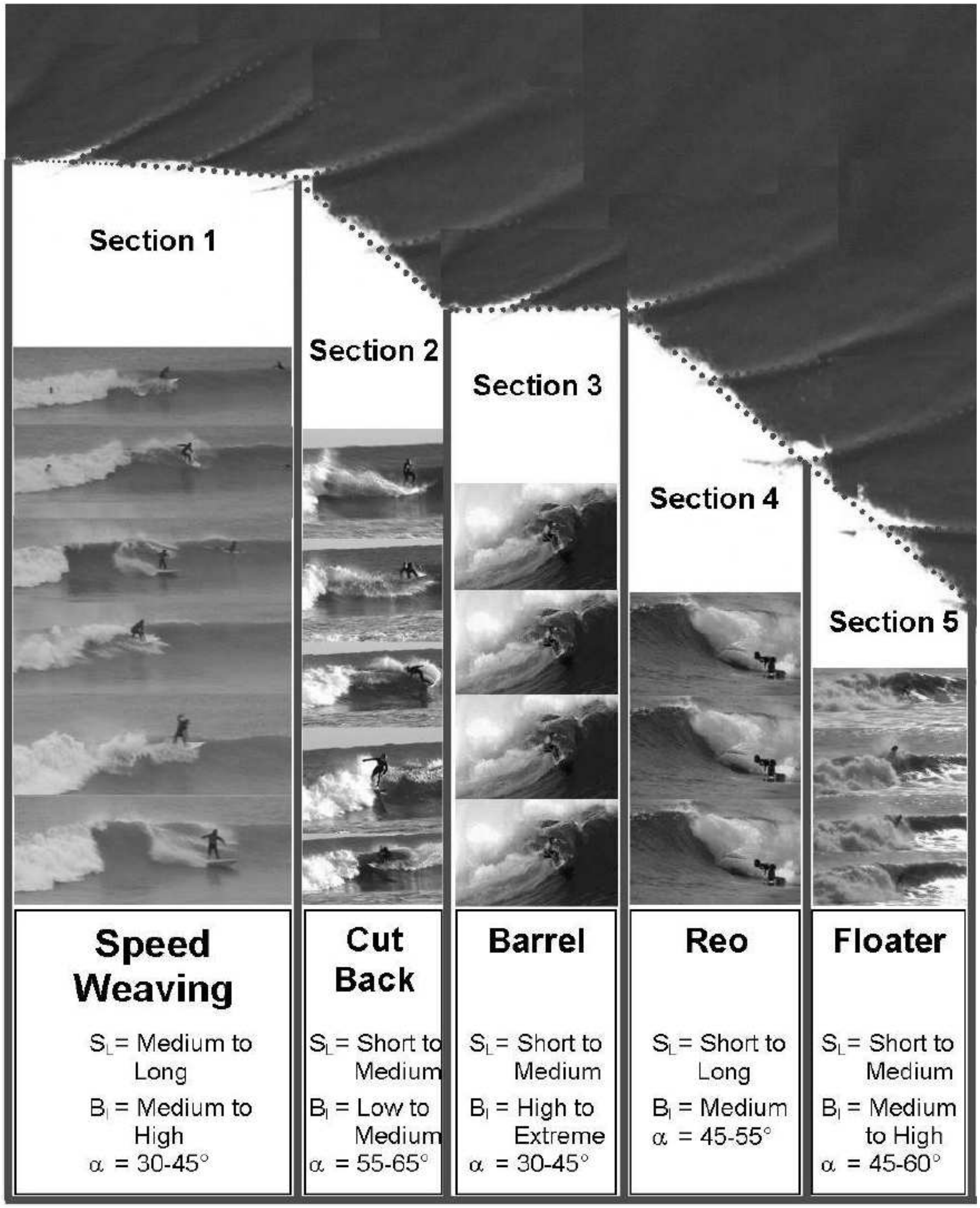

Figure 5 Configuration of wave sections for different types of manoeuvres, Scarfe et al. (2002)

Wave Surfability

The combination of the rate at which a wave peels and the breaker type determines the level of surfing ability which is required (Hutt, Black & Mead 2001). Generally this is demonstrated by the types of surfing manoeuvres which can be successfully completed (Scarfe et al. 2002). Waves at the same location are all individual and may display different characteristics

This highlights two key factors

1)Not all waves are considered suitable for surfing

2)Wave characteristics determine the ability of surfers' it will attract and the type of manoeuvres which are likely to be performed.

Popular

Popular Surf Site Investigations

The case studies will be carried out to try and demonstrate some opportunities which may exist for sites in the future based on the lessons learned in the past. The first site which will be investigated is Snapper Rocks on the Gold Coast, which is the result of a sand pumping system. The sand pumping system was installed to reinstate the natural sand movement which was hindered by the Tweed River Entrance Walls. The second site is Narrow Neck Artificial Reef, Gold Coast. This is a unique site in which coastal erosion protection was the main objective of the design criteria followed by a second objective of improving the surfing conditions. The next two sites are local to the Coffs Harbour area. The first site is Park Beach Coffs Harbour. It is located just to the north of the Harbour which encloses Jetty Beach. Inside the harbour on the southern breakwall there is also another infrequent popular surfing location. The location is termed as "Boat Ramp" as is a ride which starts slightly east of the mouth of the existing harbour boat ramp and continues in towards the shore along the southern breakwall. This wave is only active during extreme weather conditions. Both of these locations in Coffs Harbour are subject to coastal management works and it could be possible to incorporate improving the surfing conditions into future works.

These locations were selected as they are all popular surf locations. And the Coffs Harbour locations are areas which may be able to benefit from the process and lessons learnt at the Gold Coast. These locations will be briefly introduced below to assist with the professional surfer interviews and expanded on in the following chapter.

Narrowneck Artificial Reef

Narrowneck Artificial Reef is located on the gold coast between Main Beach and Surfers Paradise Beach. The beach itself exists on a long open stretch of coastline. The Artificial Surfing Reef only breaks in larger swells but the reef assists to hold the sand.

This means that the most common location for surfing actually occurs on the sand banks which develop due to the influence of the current disruptions caused by the artificial reef.

Snapper Rocks

This break is located at southern end of the Gold Coast. The break which is ridden by surfers starts at the southern most rocky point and can continue on as far as Kirra Beach which is over a kilometre away. This point was actually turned on with the installation of the Tweed River Entrance Sand Bypassing Project (TRESBP). As sand was transported just east of snapper rocks it began to be pushed into Rainbow Bay.

Snapper Rocks is also a sandy beach break which is nourished by the permanently installed TRESBP. This helps to maintain the consistency and surfability of the wave.

Coffs Harbour

Coffs Harbour is located on the Northern New South Wales Coastline close to 300km south of the New South Wales and Queensland Boarder. Coffs Harbour has a population of around 70 000.

Park Beach

Park Beach is one of the main patrolled surf beach in Coffs Harbour. The beach is a popular location for recreational activities such as surfing, swimming and fishing.

Park beach is located just north of the towns Jetty. The spot that will be investigated is just north of the mouth of Coffs Creek and the Island now known as Little Mutton Bird Island.

This break is basically subject to sand banks though it frequently has a peeling right resulting from the sand formations adjacent to the island.

Jetty Boat Ramp

The Jetty Boat Ramp is located on the southern wall of the main harbour. The boat ramp becomes surfable in extreme weather conditions. The wave peels along the rock wall when sufficient sand is deposited.

Professional Surfer Input and comments

Some Professional surfers will be interviewed in order to determine what they have experienced in relation to four breaks that this project is focusing on. The breaks are the Artificial Reef at Narrowneck Gold Coast Australia. Snapper Rocks or the ‘Super Bank’ starts at Snapper and can continue on until Kirra, Gold Coast Australia. The next two breaks occur at Coffs Harbour on the Mid North Coast of New South Wales. The first being Park Beach and the second is the Jetty boat ramp inside the man made harbour for which the town is named. This will also help provide insight into professional level surfers and their opinions on that waves which occur at the four sites which are to be investigated. This review can be compared to the technical information which is investigated in the following sections of this report. It is also important to note that every surfer has differing opinions and wave type preference and a unique style.

Professional Surfers

This section is to provide some insight into the surfing perspective of the four surf sites, Narrowneck Gold Coast, Snapper Rocks Gold Coast, Park beach Coffs Harbour and The Jetty Boat Ramp on the south wall of the harbour, Coffs Harbour.

Otis Carey

Otis was interviewed by Coffs Coast Focus (2013) in the story titled '*Local indigenous Surfer Otis Carey*.'

Otis is a local Coffs Harbour Surfer who released a surf film in 2013. As stated in the interview Otis heritage comes from his Nan who is from the Gumbaynggirr people and his Pop who was from the Bundjalung people.

Otis is a sponsored free surfer who has constantly pushed the boundaries of surfing. Otis started out his surfing career in competitions but "The boundaries and rules in comp surfing just weren't fuelling my happiness." Otis goes on to mention that he enjoys surfing with friends and spending time with family.

One of Otis' career highlights was making it into the semi finals of the Boost mobile air show in Bondi 2012.

Otis Carey Image courtesy of Stimages

Lee Winkler

Lee Winkler has been a surfer for more than 25 years and spent around 15 of those years as a World Professional surfer. Lee was also successful enough to make it into the Elite World Championship Tour. This put him in the club with other popular surfers such as Kelly Slater, Andy Irons, Dane Reynolds, Joel Parkinson, Jordy Smith and Mick Fanning.

Lee Winkler has been running his own surf school on the Coffs Coast for over six years. The surf school teaches and develops surfers from most basic introduction levels and concepts up through the levels of Performance Coaching.

In 2000 Lee Winkler received an Australian Sports Medal, presented by the Prime Minister at the time, John Howard. The medal was for Lee's contribution to the sport of surfing.

In his interview with Coffs Coast Focus (2013) Coffs Harbour Lee mentions his biggest achievements were qualifying for the World Championship Tour in 2002.

Wink also came runner up at the Rip Curl World Cup of Surfing at Sunset Beach in Hawaii in that first year. He also mentions that “In the big picture, surfing on the World Tour and going to childhood dream destinations and surfing the best waves in the world with just your friends really does exceed any trophy – so they are the real highlights.” (Focus 2013)

Lee Winker Image courtesy of Stimages

Harley Ingleby

Harley has been surfing since the age of 4. Harley was competing on both short boards and long boards near the end of his high school years. Harley’s preference was long board events which brought more satisfaction and had a strong peer connection.

Harley won his first WLT event at France in 2008. The next year Harley took out his first ASP WLT title. Harley rides surfboards shaped by local Coffs Harbour Shaper Billy Tolhurst (Harley Ingleby 2011).

Harley Ingleby Image courtesy of Stimages

Professional Surfer Interview Summary Table

Question	Otis Carey	Harley Ingleby	Lee Winkler
1) Have you surfed either of the following:			
Narrowneck gold coast artificial surfing reef	I can't say I've ever surfed Narrowneck artificial reef. I'm pretty sure I've never surfed it.	No	No
Snapper Rocks gold coast	Yeah I've surfed snapper rocks countless times, awesome surf spot	Yes	Yes
Park Beach	yeah surfed here many, many times	Yes	Yes
Coffs Harbour Jetty Boat Ramp	Yeah boat ramp is one of my favourite surf spots in Coffs!	Yes	Yes
2) How would you describe the waves at either			
Narrowneck gold coast artificial surfing reef	No	To be honest I've never laid eyes on it. I hear it improved the waves there.	NA

Snapper Rocks gold coast	In terms of wave quality snapper is amazing! you can get tubbed, you can do a million turns and you get big air sections at times. It’s an awesome surf spot.	World Class! Amazingly consistent and has made surfer migrate from around the world to be able to surf there.	Snapper is long duration right hand sand bottom point break. Following a hollow shallow barrelling wave and is world class when correct elements are in place.
Park Beach	I’d say ‘Parkies’ is an awesome spot too, long right hander’s and short intense lefts.	On its day a very high quality beach break. When the sand build up is good near the island it can be a short version of the Snapper Rocks.	Park beach is a unpredictable style of wave that fluctuates with variation of sand movement. Can be quite shallow at times although with sand flowing along our coastline in a northerly direction mutton bird island and the marina block that sand movement and this can be a detriment to this break.
Coffs Harbour Jetty Boat Ramp	short intense and dangerous	Very swell direction and sand dependant but one of the best waves around when it’s at its’ best!	Boat ramp is shallow breaking hollow right hand wave and is fun when sand build up is along the wall with combination of swells exceeding the 4-5 meter range.

Question	Otis Carey	Harley Ingleby	Lee Winkler
Could you see benefits in including the surfing conditions within the future planning at Park Beach or the Boat ramp. This is a common thought process in Gold Coast. The idea is more if the work is already happening i.e. dredging the main harbour for boats put the sand to use at park beach to also improve the surfing. And maybe if work is happening to the boat ramp we could achieve a design which suits surfers and boat users(possibly relocating into the inner harbour)	If the sand dredging stopped in Coffs boat ramp would be one of the best waves in the world. I've seen that place just as good as any sand bottom point I've seen travelling the world.	Absolutely has potential! I definitely side with the fact that surfers should be factored in when looking at these kind of plans. There are many more surfers using the Park Beach and Jetty area on a daily basis than recreational fisherman.	Having sand pumped from the vicinity of the harbour precinct is not only going to encourage the possibility of world class beach break on park beach it will be able to help regenerate the natural habitat of the sand dune area. The outrageous sand build up within the man made harbour walls should rightfully be filling the park beach sand dunes and until this sand is pumped in some way back on to park beach we will continue to see issues with this beautiful area.

Professional Surfer Interview Discussion

This interview was attempting to get the opinion of some professional surfers on the four surf sites investigated.

From the three surfers interview none of them had actually surfed Narrowneck ASR on the Gold Coast. Harley Ingleby did mention that he believes the surfing conditions have improved.

All these breaks are reliant on sand to provide a crucial component in the surfing waves. Even though Snapper is a world class wave it still requires many variable in order to produce the quality wave for which it is known.

As Lee Winkler mentioned by maintaining the natural sand movement around the Coffs Harbour Area it may be possible to not only replace the depleted natural sand quantities but produce a quality surfing wave at the same time.

The common factor that is required to improve the surfability of the sites investigated is sand. The consistency of Snapper could be contributed to the regular supply of sand. As suggested by Lee Winkler a similar situation occurs. The natural sand movement north is disrupted by the harbour, as will be discussed in chapter 5. It may be feasible to relocate this sand to the north of the harbour in a fashion similar to The TRESBPS.

Surfing reserves

In the 5th Western Australian State 2009 Coastal Conference a paper was presented 'Australian National Surfing reserves- Rationale and Process for Recognising Iconic Surfing Locations,'(Farmer & Short 2009). The purpose of this paper was to do three things for recognised surfing locations.

1) Formerly acknowledge the site as a significant surf location and quality

2) Acknowledge the link that exists between the surfers and particular surf sites

3)Contribute towards the sites protection to ensure it exists for future surfers

The paper also defines a surfer as anyone interacting with the surf for recreational purposes. Farmer & Short (2009) state that in 2005 only 1 of Australia's 10 000 plus beaches was reserved as a surfing location. At the time of presentation Farmer and Black (2009) share that Maroubra Beach, Angourie, Crescent Head and a string of Gold Coast Beaches, Burleigh Heads, Kirra-Snapper Rocks, were dedicated as National Surfing Reserves. This paper concludes that National Surfing Reserves Australia was founded to increase the number of National Surfing Reserves in Australia. An ongoing goal was to '*ensure the formal recognition and ongoing protection of Australian premier surfing sites.*'(Farmer Short, 2009, p 6).

Conclusion

There are a number of factors which contribute to surfability and surfer satisfaction of surfing waves. The Bathometry of surf break is a vital component in order to produce a quality surfing wave. The surf breaks which were discussed are heavily reliant on the sand formations as discussed by the professional surfers. The consistency of adequate sand in the correct formation can contribute to the consistency of a surfing break. This is evident at Snapper Rocks as the TRESBP supplies a regular supply of sand to maintain the ocean floors bathometry.

Chapter 5 Review the coastal erosion protection structures with respect to improved surfing conditions

This chapter will focus on four key locations in which coastal erosion management has assisted the surf conditions. These locations are the

Snapper Rocks

The Tweed River Entrance Sand Bypassing Project (TRESBP) is a combined operation involving the New South Wales and Queensland State Government. During the 1960's entrance training walls were extended to improve the access to the Tweed river entrance. After this construction beaches to the north of the Tweed River were eroded to such a degree that coastal defence systems had to be put in place to protect property and infrastructure. The core reason behind this was due to the restriction of the natural northerly transport of sand that the Tweed River Entrance Walls had created. By the 1990's so much sand had deposited south of the south wall that the entrance access was once again in jeopardy. In order to manage this coastal issue a sand pumping system was installed. The system was capable of delivering a supply of sand that was equivalent with the net rate of longshore drift. The system is a permanently installed sand pump that was commissioned in 2001. It basically consists of a sand pumping jetty south of the tweed river entrance, buried pipelines and a primary outlet to east snapper rocks. The system is occasion complemented by mobile dredging to ensure the navigation of the tweed river entrance (Dyson et al, 2001).

Snapper rocks inner near shore sandy seabed profile extremely dynamic. The delivered sand from the TRESBP works naturally around Snapper Rocks and along the southern Gold Coast beaches. This sand assisted to produce the alongshore bar on the west side of Snapper Rocks. This was very important in contributing to the high quality surfing wave known as the 'Superbank'. The break is so popular that it was ranked as one of the top ten surfing locations in the world and became the location for the Quicksilver Professional Surfing contest (Acworth & Lawson, 2011)

Figure 6 Snapper super bank development, May 2001 (Boswood et al., 2005)

Figure 7 Snapper super bank development, August 2002 (Boswood et al., 2005)

Figure 8 Beach and 'Superbank development May 2003, (Boswood et al., 2005)

Sediment Transport

It is estimated by Accworth and Lawson (2011) that 500 000 cubic meters of sand journeys along Letitia Beach due to longshore sediment movement processes. They also note that the sand movement rates vary depending on the factors such as, predominant wave climate, currents, and Geomorphological control features. Geomorphological features include heads and man-made structures such as the Tweed River entrance training walls. Aerial images are attached as appendix.

The sediment transport is also subjected to the cross-shore sediment transport. The TRESBO project is exposed to significant cross shore sediment movements. This type of movement is more common during large storm events (Dyson, Victory &Connor 2001).

TRESBP is the case of a successful system that has reinstated the natural sand mitigation movement, assisted vessel access into the Tweed River and assisted in the production of a world class surf break.

Narrow Neck Artificial Reef Gold Coast

Narrowneck beach is located on the gold coast between Main Beach and Surfers Paradise Beach.

The beach itself exists on a long open stretch of coastline. In order to stabilise the coastline and retain a consistent supply of sand for tourists and locals Narrowneck was identified as requiring coastal management works. This work was to be part of the larger Northern Gold Coast Beach Protection Strategy (NGCBPS) an instigation of the Gold Coast City Council (GCCC).

The longshore drift at Narrowneck moves sand northward along the beach. In order to stabilise the increases erosion to the visible portion of the beach the NGCBPS was produced in 1999. The primary objects of this project at Narrow Neck were defined by GCCC.

- Retain more sand along the Surfers Beach Esplanade which will provide extra sand in the storm buffer zone and will result in more open space for recreation
- To improve the surf quality and increase the recreational benefit to the community at Narrowneck by constructing a submerged reef that would protect the nourished beaches.

Design

In Jackson et al (2007) the reef has achieved its goals by retaining a wider nourished beach. The structural integrity has been satisfactory. For completeness it will be noted here that the geotextile material has been an excepted material by the diverse marine community (Jackson, et al. 2007).

The location has also experienced wave breaking at approximately 50% of the year on the actual reef. Jackson et al (2007) also noted that the waves tend to be more pilling as opposed to plunging throughout average conditions. The report also explains that when conditions are more favourable the wave break adapts a hollow, plunging breaker type. These favourable conditions include when there is large wave activity, low tides and offshore winds. The paper by Jackson et al, (2007) also suggests that the existing shore break often connects with the artificial reef break to produce longer rides than originally anticipated. These longer rides have been recorded using GPS data and seem to average around 150 to 250m, and have even been recorded to lengths of 270m. The actual ride times have been recorded to near 60 seconds (Jackson et al, 2007).

The inclusion of surfing into the design of the Coastal erosion protection structure was achievable since "Good coastal design and progressive peeling waves are compatible" (Jackson et al 2007). Jackson also goes on to say that Most of the groins that are on the Gold Coast are good surfing locations. With their designers always understanding that where waves break surfers will try and ride waves. The surfers may even include family and friends of the Coastal engineers and the engineers themselves. Early in the process AWACS were utilised by GCCC to do a formal literature review

(AWACS 1996). This review was able to conclude that many coastal protection structures around the world were acknowledged as good surfing spots. The results from this search also concluded that the an accepted understanding the requirements of surfing waves for short boards is available from engineers such as Kimo Walker and Bill Daily (Jackson, et al. 2007).

In order to address the second design criteria of “improved surfing conditions” while still maintain the reefs primary objects of the reef the design process was extremely detailed. The reef layout and design simulations were investigated by the University of Waikato, New Zealand (UW). The numerical models which were utilised included various 2D and quasi-3D numerical models. The models were calibrated from recorded data in the proposed region. Of particular interest was the original reef had been designed in a V type shape. This would seem to be a good design as the waves would be able to peel left and right from the initial breaking point and should produce a wave with a good level of surfability. The modelling deduced that this conventional shape would produce high seaward velocities over the crest of the reef. The International Coastal Management (ICM) who was the project manager selected by the GCCC deemed that this would be an unacceptable safety issue. The ICM suggested a split V design in order to minimise these simulated velocities. The adopted final design was one of quite complexity (UW 1998a).

Jackson (2007) suggests that the design was adopted as it was deemed to be safer and would not result in excessive sand retention. This initial design was a deeper reef so that if it was determined that the reef needed to be raised it could be done with minimal effort compared to trying to lower an installed reef which was too high. This would ensure that the chance of litigation for surfers and boats users was at a minimum.

Narrowneck is a popular location and was one of the first artificial reefs to incorporate improved surfing conditions into the design. Although meeting it design criteria Narrow Neck has not gained the realms of a world class surf location it is still a popular location and a successful venture.

Surfers lining up at Narrowneck beach just north of the ASR photograph Peter Crawford 2013

Sequence 1, Surfers riding the shore break at Narrowneck beach just north of the ASR photograph Peter Crawford 2013

Sequence 2, Surfers riding the shore break at Narrowneck beach just north of the ASR photograph Peter Crawford 2013

Coffs Harbour Area Investigation

Coffs Harbour is located on the Northern New South Wales Coastline close to 300km south of the New South Wales and Queensland Boarder. Harris & O'Brien, (1998) explain that the Harbour was created before 1940, by connecting Mutton Bird Island and South Coffs Islands to the mainland. The northern concrete breakwater extends east and connects Mutton Bird Island to the main land. The southern Boarder of the Harbour is formed on a peninsula which curves northward towards Mutton Bird island. To the South of the harbour is a rocky outcrop which is Korffs' Islet (Millar, 1990). The whole region is mostly Coramba sandstone beds with basaltic and granitic formations producing some of the headlands and Islands (Korsch, 1980).

The Coffs Harbour area is subjected to the East Australian Current, which is linked to the South Equatorial Current in the South Pacific (Jeffrey, 1981). This current passes through the Great Barrier Reef towards a t34 degrees south latitude. Once this orientation is reached the current starts an anti-cyclonic journey to Lord Howe Island. Form here the current travel to Norfolk Island then to New Caledonia until it reaches the Coral Sea. (Rochford 1975). The result is small but consistent northward flowing currents which runs against the mainland. Also there is the south flowing East Australian Current. There are two locations where upwelling occurs, north at Evans Head and South at Laurieton (Millar 1990). Aerial images are attached as appendix.

Park Beach

The location has been exposed to sand nourishment at various times throughout the past. In 2007 the Part V (2007) report mentions that the placement of sand onto park beach will mimic previous natural conditions previous to the harbours construction.

The ongoing issue is that the total volume of sand nourishment does not equal the loss which is restrained in the harbour each year at 75 000m^3/annum (Rollason 2012).

Shoal Management Planning Program (2002) reports that in 1987 the PWD studies determined that since the construction of the harbour the entire longshore sand supply that should travel to Park Beach has been intercepted. The 1987 report also showed that no significant sand volumes are bypassing around the end of Mutton Bird Island. This has resulted in a deficiency at Park beach in the order of 0.5 m per annum.

Image of Park Beach and Little Mutton Bird Island courtesy of Stimages

Possibility of Dredge Spoil placement

Outside the scope of this report the author makes mention of simple yet practical method of incorporating extra value from dredging projects by placing the dredge spoils into specific formations. The paper is titled, HIS DUMP SITE, OUR PLAYGROUND; *a call for the configuration placement of dredge sand*. Although not a permanent solution to produce a quality sand bank, such as at Snapper Rocks with the fixed sand pumping the idea is very effective.

The idea formerly proposed by Pitt 2010 was that the sand was already being removed from the Port Hacking estuary, south of Cronulla. So if the sand was placed in a manner to improve the ocean bathometry to assist to produce a wave. This could be achieved by creating a shallow surfing bank that would support waves with good surfability given the correct external conditions such as swell and wind directions. The paper also mentions that the solution is not permanent by will bring increased benefit to the community and in effect is better value engineering option.

Coffs Harbour Jetty 'Boat Ramp'

The harbour has resulted in a disruption to the normal littoral drift. This was typically a volume of sediment of about 75,000 tonnes/year. The Sand flow has accumulated at the south side of the harbour and some 25,000 tonnes/year is deposited into the manmade harbour. The sand does not have the opportunity to travel around the harbour and results in Park Beach experiencing a depleted sand capacity. (Millar, 1990).

As was shown in the interview with local surfer's the Coffs Harbour Boat Ramp on the southern side of the Harbour was also named as a popular surf location. The location requires extreme wave events in order to be able to break. The Boat ramp is also utilised by the local fisherman and recreational users. There is not really a conflict that arises as the conditions which warrant the surf to be occurring mean that no boats are generally trying to launch as the wave height is too large.

Siltation at the boat ramp has been an ongoing problem. In 1995 Coffs Harbour City Council consulted Australian Water and Coastal Studies (AWACS) to investigate the issue. In 2004 a groin was placed to minimise the sand infilling and reduce swell action into the harbour.

The location of the boat ramp is in a zone of active sediment transport (AWACS 1995). Sand accretion around the boat ramp basin can be hazards for boat users. The shallow conditions are more favourable for the surfing community as stated by Otis Carey in the interview conducted in 2013.

There were some alternatives for the boat ramp issues considered in the report by AWACS (1995). These were identified as

- Routine maintenance of the existing boat ramp basin
- Maintenance dredging seaward side of the eastern groyne at the entrance of the boat ramp.
- Maintenance dredging and extension of the existing groyne at the entrance of the boat ramp.
- Multiple groynes along the inner eastern and southern breakwaters.
- Relocation of the boat ramp.
- Commercial dredging

The report also stated that all of the above solutions except relocation of the boat ramp required ongoing maintenance. The report makes no mention of the benefit to the community through the recreational activity of surfing.

Further on the report highlight the benefits to the Socio-economic considerations without making mention to the degrading of the iconic surf location. With engineering design it may be possible to solve the issue of the boat ramp sedimentation and the surf location. It may be more feasible over a 20 year period to move the boat ramp to the inner harbour or some other identified location where ongoing maintenance costs and effort will not be put to waste.

A key surfing spot as has been previously determined requires a number of key elements and would be a valuable asset to the City of Coffs Harbour. A boat ramp is an asset if it is well designed and located to minimise cost and to maximise safety. In the attempt to increase safety and minimise ongoing cost a revisit to this project is highly encouraged.

Geolink (2012) were engaged by CHCC to prepare an investigation into the issue with seiching /surging in the boat ramp basin. The report highlights previous investigations which researched the problem at the boat ramp location.

The summary that Geolink came to based on the previous reports was that a groin was 'unlikely to provide a suitable option' to the issues which were making the boat ramp unsafe. In order to solve the main safety issue with the boat ramp further investigation will be required. No matter what the final outcome it will be realistic to include the implications to the surfing conditions in the design.

Coffs Harbour Boat Ramp, Image courtesy of Danny Hill

From the image above it evident there are a number of surfers enjoying the wave running along the southern wall of the main harbour and across the entrance to the boat ramp. Aerial images are attached as appendix.

James Athorn, surfing Jetty Boat Ramp Image Courtesy of Warwick Appleton

In relation to surfing the jetty boat ramp becomes surfable in extreme weather conditions if the sand volumes increase. One of the key factors highlight is that the harbour regularly fills with sand along which migrates along the southern wall. Once again the sand nourishment on the correct alignment seems to be the key element that is available in the production of surfing waves

Conclusion

This chapter has reported on the surfing conditions which have been affected by Coastal erosion methods. Surfing is an activity which is often performed within the coastal region. From the sites investigated it is obvious that activities which occur in these locations will have an impact on the surfing conditions within the specific region and often as a consequence may affect an adjacent.

Chapter 6 Deduce the public safety factors which should be considered for sand groins based on Narrowneck Gold Coast.

Introduction

Local government holds a responsibility to the community it services. This chapter will take a look at the safety considerations which were incorporated into the design of the artificial surfing reef at narrow neck. The main purpose of this reef was to reduce beach erosion and the second objective was to improve the local surfing conditions. There are responsibilities on the owner to ensure that the product is fit for purpose and that there has been consideration for the safety factors.

This chapter will assist in the risk assessment that is required with regards to public safety for the purpose of coastal erosion protection construction through a sand filled groin.

Safety Aspects

In order to properly address the safety considerations it is important to notice that submerged artificial reefs in the near the coastline will attract a vast number of recreational activities. This is largely due to the popularity of these artificial processes and structures designed such that they are able to add to the recreational tourism value of the vicinity (Corbett, et al, 2005). Although this report is more focused towards the surfing aspect of coastal protection projects for the purposes of establishing the safety requirements Corbett (2005) has made a list of the specific type of recreational activities which may frequently occur and benefit from the conditions which are created during these processes.

- Typical beach users
- Swimming
- Surfing which incorporates, Body surfing, Body Boarding, Short Boarding (The main focus of this paper) Long Boarding, Kite Surfing, Surf Skiing and Kayaking.
- Boating
- Fishing
- Diving which is composed of Scuba Diving, Snorkelling and Spear fishing.

Due to the high potential for various activities it is vital that safety needs to be incorporated into the design and construction of these processes. It is also crucial that the risk assessment for artificial reef structures takes into account for the varying conditions.

It is also important to realise that there are a significant number of natural hazards that occur on natural beach breaks and in ocean rips. Natural rocky reefs also present potential hazards. Another concept is the fact that a reef system has the capacity to be limited to use during certain severe conditions. If conditions are extreme enough it may not even be possible to access the reef.

Construction and design

There are not a lot of established guidelines for the construction and design of these type of structures.

One consideration that was investigated for the Narrowneck reef was the possibility that the reef may actually become exposed during low tides. Since the reef is a fixed object the wave may pitch earlier then would normally happen on a slow grading incline of a beach break. This is typical of natural reefs and is more suited to the experienced surfer. This sucking dry effect would potentially be a great hazard to typically surfers who may be intending to surf at Narrowneck. It was also deemed that the current speeds would increase around and over the very shallow and quite possibly, exposed reef design. At Narrowneck the final height of the reef was lowered in the order of 1.5m to reduce this potential hazard. By the principle of wave breaking this would also reduce the wave size that would actually break on the reef.

Once the reef was installed it was important to capture realistic data to determine how well the project meet expectations and design criteria. Corbett et al, (2005) explains that the systems used to monitor the reef after construction included things such as observations of the wave breaking behaviour, ARGUS cameras to capture shoreline position, surveys and routine dive inspections. The ecology is not the main focus of this report but it is important to note that there were survey conducted that maintained the reef was a benefit to the ecology of the region(Jackson et al 2007). Part of the review of the functioning reef also included the input from the local surf life savers. The information that they collected consisted of typical beach usage, general conditions of the area and the number of rescues which were performed.

From a safety perspective the increased beach width has provided a safer environment for beach users. The data that the life guards recorded indicated that the use of the area increased some 20% while the rescues that were performed had decreased by 60%. The stretch of coastline at Surfers Paradise is quite often subject to a strong longshore current. This means that the sea floor does not always gradually increase in depth as the typical user enters the ocean. By incorporating the reef and breaking up these currents sand is encouraged to accumulate and overall contribute to a safer more predicable depth. This would typically be experienced on a small beach with a large sand population which often will comprise of a shallow grad on the ocean floor. The effect being that the waves are able to gently dissipate their energy. And users experience a more predictable seafloor gradient.

Construction Tolerances

The construction of Narrowneck Artificial Reef was achieved with large geotextile containers. The nature of this method of construction meant that the acceptable tolerances which would be experienced in construction were larger than the calculated theoretical model. This resulted in a physical model analysis that made a comparison between the realistic construction tolerances and the formulated 'theoretical' predictions.

The physical modelling showed that a higher breaking wave height was evident in the smoother profile. This was due to less energy lost from friction and turbulence throughout the process of breaking. The breaking location of the smoother profile also occurred closer to the shore then the rougher profile. There was not a significant difference in the wave breaker type which was produced.

This also meant that the profile which was less smooth would offer greater protection to the coast line. The lower wave heights produced by this realistic profile ensures that for the end users the structure is safer than it would be with a higher wave height.

Specific Risks at Narrowneck

Corbett et al, (2005) provides a finalised list of the potential risks and the management guidelines that allowed the risk to be maintained at an acceptable level. As relevant to this research exercise the guidelines address the structures using geotextile containers in locations such as dynamic coastlines. Although many of the risks would be applicable to all artificial reef type structures it is crucial to remember that the actual site specific conditions need to be addressed in a risk assessment. Corbett et al, (2005) suggests that this paper helps provide some guidelines and basic principles in doing risk assessments on these types of structures. It is also important to note that Corbett et al, (2005) paper is only indicative and further investigations will need to be conducted in order to address all the foreseeable safety issues.

Physical Impact with reef

As a surfer travels along a peeling wave the risk of a surfer hitting the bottom is quite relevant. Although the odds of this happening generally increase at low tide as the water depth is significantly lower than at high tide. The risk of a surfer colliding with an artificial reef such as Narrowneck is quite a realistic risk. The answer is not simply to increase the reef submerged depth as this will reduce beach protection and reduces the opportunity for waves to the transitional depth discussed in chapter 1. This will result in less frequency of breaking waves. On the contrary if the reef is too shallow then the potential for the reef to suck dry at lower tides exists. Corbett et al, (2005) suggests that there is little to govern the acceptable depth of water in relation to surfing. He continues to explain that the FINA regulations imply a depth 1.8m for diving into pools. This is a good reference depth but the surfer is generally not diving off the surfboard, rather awkwardly falling. The effect of the falling action means that the surfer is less likely to go as deep underwater. This combined with the lack of intentional vertical direction once again reduces the risk of serious injury resulting from hitting the reef. By actually impacting the bottom there is an increased chance of neck and spine injuries. The conclusion to this is that the reef would need to be much shallower to pose a high level risk then for an activity such as diving.

In relation to the actual depth of water during backflow under the wave trough physical modelling was utilised. Depending on the depth of the submerged reef this level could be quite shallow. If the crest at Narrowneck was 1.0m below the still water level resulted in the possibility of depths less than 0.3m were simulated with wave heights of 1.5m. The variation when the crest level was set 1.5m below the still water level resulted in a water depth limits of 1.2m and 0.9m. It was also calculated that if wave heights were in excess of 2m they would break before encountering the reef. This meant that that the later 0.9m would be the minimum depth which should occur on the Narrowneck Artificial Reef.

The behaviour of rips and currents is such that the potential for shallow depths is a possibility. Once constructed Narrowneck was found to display depths around 1m for waves of 1.5m in height. This has regularly been the pattern. It is also mentioned by Corbett et al, (2005) that the reef has been reported to have become exposed in large wave events. The term for this is sucking dry which actually means a component of the reef is no longer underwater.

Impact with reef within transitional zone.

This risk is more concerned with users impacting the reef once the wave has already broken. This situation is explained by Corbett et al. (2005) as a possible impact when a surfer is paddling through the white wash zone if they were possibly caught on the inside from a previous wave. In order to analysis this risk it is important to understand that there are a few variables which contribute to this situation becoming a reality. These variables are The Breaking wave type, location of the wave breaking, Breaking wave height, the and the depth of water.

As mentioned in chapter 5 the breaking type of wave can significantly influence the potential risk of an impact with the structure. Corbett et al. (2005) highlights the idea that a more spilling wave with a gradually pitch to breaking is considered a safer breaker type then a plunging wave. The spilling wave results from the gradual decrease in water depth up until the point where the wave actual breaks. The spilling wave will be very predictable to an experienced surfer and may not always seen as much of a challenge. The plunging wave is generated from a rapid decrease in water depth. This wave type is capable of creating more turbulence in the path of the broken white water. This in turn has the potential to produce a wave to satisfy the more advanced surfer with an increase speed of ride and chance of advanced manoeuvrers. With more speed a surfer has the capacity to produce more radical manoeuvres and the opportunity for the ultimate barrel is more frequent on such wave types (Scarfe et al. 2003).

If a wave is too small to break on the structure then the risk of impact is significantly reduced and there is little risk of an assumed impact. If the waves are very large and are breaking well before the structure the turbulence experienced over the actual structure is much less than a wave which breaks on or near the structure. This is because once the wave breaks seaward of the reef crest the depth of water is increased at the break point. In terms of risk the steep plunging wave will also generate more turbulence and increase the risk of a surfer or recreational user impacting the reef itself.

In summary in order to deduce a safe depth for the reef the minimum depth of water that will occur needs to be determined. Corbett et al. (2005) Suggests that the minimum depth occurs when the largest wave breaks very close to the crest of the reef. This means that the design needs to incorporate the available information and determine the most relevant criteria to satisfy the design requirements.

Trapped under water due to voids in the reef

This risk occurs with natural and artificial reefs as there is the opportunity for a surfer or recreational user to become trapped in voids. Corbett et al. (2005) mentions that artificial reef structures need to be regularly maintained to ensure that the gaps are within an acceptable tolerance. The Artificial Reef at Narrowneck was composed of large geotextile mega-containers. As has been observed at Narrowneck it is generally accepted that these type of structures do not produce large gaps that would present a threat to the users of the recreational area. This ensures that with adequate monitoring the risk associated with being trapped in an Artificial Reef such as Narrowneck is quite minor.

Drowning due to ocean currents and rips

Rips are a common occurrence in the ocean. Typically in Australia life guards set flags up in the 'safest' location on the beach for swimming. The present of an artificial submerged structure will induce rips similar to shallow sand banks. These rips will always pose a threat to ocean users. The risk is minimised if the individual is appropriately educated. Natural rips on sand bars are also very variant in nature. Fixed structures such as headland, submerged rocks or artificial reefs will generally be safer as the rip currents which are experienced are generally more stable and consistent. This in turn means that they are considered safer.

Corbett et al. (2005) notes that the area typically selected for patrolled areas on the beach are inshore of the actual submerged Narrowneck Artificial Reef. The report also states that the reef has reduced records and deduces that the beach is safer due to the reef structure.

In order to produce rips which are less aggressive the initial crest level of the reef should be low, not extremely long and situated a fair distance offshore.

Marine Organisms

This is not the specific focus of this particular paper but it is part of the potential benefits which may result from Artificial Reefs.

Dangerous marine creatures are a risk to ocean users. The truth is these risks exist at natural reefs and throughout the oceans. Narrowneck Artificial Reef has become a residence for varying dangerous marine creatures. This being said the general residents are less aggressive sharks and stingrays. This does not mean that the risk is avoided but it is comparable to natural reef sites. This risk should be considered further as proposed location and construction material may attract varying degrees of marine species.

Vessel overturning due to shallow depths

As Reefs support a number of marine species they also have the potential to become desired fishing locations. One initial risk is that ocean vessels may want to anchor in these locations or even damage the structure itself.

As shoaling occurs over the reef the potential for waves to break and jeopardise the vessels floating capacity are a proposed threat. Corbett et al. (2005), states that the risk was minimised by issuing a notice to the mariners. This notice explains that the reef is a no anchor zone. This has also been visually enforced by installing three buoys to mark the zone where no anchoring is permitted

Conflicts between users

Any popular location may be subject to a large number of users. These users may potential get in the way of each other. As has been observed at Narrowneck Artificial Reef vessels and divers prefer to utilise the facility during calmer periods. On the contrary surfers are attracted to conditions which encourage wave breaking. This means that the conflict is naturally spaced out by the natural occurrences of the reef.

The possibility of disagreements between similar condition users still exists. It is often observed that there is a potential conflict between vessel users and divers. As noted in Corbett et al. (2005) divers are encouraged to act with caution and display diving flags and buoys. Vessels are also expected to maintain a level of caution in the vicinity of divers.

There is also a risk of conflicts between surfs or different craft and ability level. This is can usually be addressed as long as surfer obey the “Tribal Law” as discussed on the Surf-Etiquette website (2007). Which most simply put is a basic set of rules or guidelines which explains the accepted normal priorities and right of ways in a surfing line up.

To further minimise this potential risk Corbett et al. (2005) proposes that if the risk of conflict is deemed high, vessel exclusion zones could be considered.

Overcrowding and possible ‘rage’ outbursts

The risk of rage outbursts can occur at natural locations for surfing and fishing especially if overcrowding occurs. This risk is minimised by increasing the number of acceptable surf and fishing locations.

Conclusion

This chapter has raised some of the public safety criteria which would need to be incorporated into the design of surfing structures in the coastal zone. Surfing is known as a risk activity. With this in mind the risks of a properly designed, installed and maintained coastal structure would address most of the points which were investigated in the case study at Narrowneck.

Chapter 7 Assess the benefits of coastal erosion protection at key locations, including Narrowneck, Gold Coast.

Introduction

The purpose of this component of the project is to establish some measurable outcomes in order to support the idea of incorporating surfing conditions into coastal erosion protection and coastal projects in general. This section highlights the benefits which result from improved surfing conditions.

To help support the original concept a valuation will be analysed based on the results of surfing conditions. Some aspects of this valuation will look at popularity and surfability. One example case will be Snapper Rocks which with the construction of the Tweed River Entrance Sand Bypassing Project (TRESBP) has become a world class surfing break and possibly even one of the longest waves in the world.

The financial findings in the Climate Change Risks to Australia's Coast 2009 in relation to settlement and industry are discussed below. It was quite dominant that Australia's residential zones in coastal regions are subject to increasing hazards through climate change.

The study estimated that there is some 711 000 addresses that are situated within 3 km of the coastline and a level of less than 6m. The majority of these properties are not directly facing the open ocean. Instead they are located adjacent to rivers, lagoons and lakes.

Coastal Values and Popularity

Coastlines offer numerous benefits to the community, economy and ecology in which are located. The benefits to community incorporate recreational activities, life style and relaxation. Economic value exists from industries such as tourism, fishing, real estate and research. The ecology of the coastline describes the relationships' which exists between living organisms and their environment. The ecology is noted here as it contributes to the benefits which results from the coastline though this is not the main focus of this report.

In Australia the population is predominantly on the coast, with 81% living within 50 km of the Nations coastlines. The Department of Sustainability, Environment, Water, Population and Communities State of the Environment 2011 independent report stated that not only are the coastal populations growing faster than in land populations, over the next 15 years the coast is estimated to accommodate another million people.

Coffs Harbour

Across the eight patrolled beaches at Coffs Harbour in the 2011-2012 Christmas period the lifeguards patrol statistics indicated that 265,000 people had visited these beaches for swimming and other water based activities. Out of the eight main beaches which were patrolled at the time the beaches which had the highest usage rates were, Sawtell, Woolgoolga, Diggers and Park Beach (Rollason 2012). In chapter 4 Park Beach will be further investigated as one of the regions popular surfing locations.

A large portion of the economic values of the coastline is the beach itself (Rollason 2012). Other factors include tourism as it is a great contributor to employment. Tourism is able to bring potential revenue to food services, retail outlets, wholesale vendors, transport, accommodation and many other sectors of a local economy (Earthcheck, 2007).

It is suggested that in t 2008 – 2009 financial year the Gross Region Product (GPR) for Coffs Harbour was approximately 2.6 billion dollars (Lawrence Consulting, 2010a). This significant portion of revenue is due to tourism. With the typical daily spending per visitor estimated to be $430 dollars every day. This value contributed to 417.5 million dollars in the financial period of 2005 to 2006. This income represents more than 15% of the local GRP (Earthcheck, 2007).

During 2010 there were 35 commercial tour operators that were operating within the Coffs harbour Coastal Zone providing services in, Whale Watching and scenic tours, watercraft hire, charter fishing, charter scuba diving and surfing schools. This total revenue across these businesses contributed 2.3 million dollars annually (AgEconPlus, 2010).

It is important to note that the Coffs Harbour Tourism Strategy acknowledges the significance of the natural assets which exist in the area. Of significance to this report the strategy also notes that beaches and their facilities must be maintained in order to provide maximum gain to income from tourism dollars (Earthcheck, 2007).

The Coastal Zone Management Plan also makes mention of the dollar value return from commercial fishing and recreational fishing. The report has not considered the direct income from surfing in the Coffs Harbour region. It has mentioned it in conjunction with other recreational activities. For this reason an investigation into the value of surfing at the Gold Coast will be discussed.

Chapter summary

Due to the popularity and significance of our coastal regions they are of high value to society. When the coastline is eroding it may be necessary to protect assets and infrastructure and the communities' values.

Chapter 8 Conduct a brief study of the benefits and feasibility of improved surfing conditions at Gold Coast

It is estimated by Kampion (2003) that close to 20 million people around the globe are surfers. The valve of surfing was determined by Dolincar and Fluker (2003) to be worth approximately $8 billion dollars per annum. Nelson (2006) also states that although this is a incorporating things such as the general surf retail trade, Nelson still believes that it is underestimating the value recreational surfing.

Lazarow (2006) highlights the links between surfing and coastal natural resource management. As mentioned in Australian Bureau of Statistics 86% of our population dwell within a 30 minute drive to the beach.

As the popularity of surfing increases the value that is generated to the community increases. This is becoming ever more evident by policy makers and planners to ensure the preservation and enhancement of surf breaks (Scarfe et al 2003).

Narrow Neck

The Narrow Neck Artificial reef was a 9 million dollar venture in order to protect the beach from erosion. The volume of sand that was placed on Surfers Paradise beach was greater than 1.1 million cubic meters. This sand was dredged from Broadwater. As stated by the Gold Coast City Council 1.1 million cubic meters of sand would fill a football field to a depth of 220 meters of sand.

Gold Coast

The Gold Coast is a situated in the state of Queensland, it is mainly on the coast and has population approximately 500 000 people. It is located about 75 kilometres south of Brisbane which is the state capital of Queensland. The Gold Coast is a popular destination for both domestic and international clients. Raybould and Lazarow, (2008) conducted a study that concluded some 40 million trips to the beach occurred in 2007, with visitors contributing another 7 million visits to the beaches in the region. Some of the key factors that Lazarow (2006) attributes to the importance of the of the beaches on the Gold Coast are

- The boundary between the oceans power and the urban environment
- They are publicly owned and contribute to the areas recreational facilities
- Key component in tourism
- Environmental habitat

In an Australian Surfing Association report, Atkins (1992) noted that a value in the order of $AUD46 million per annum related to air surf travel. Also the Gold Coast Council (2002) identifies some 1,500 board riders were using Gold Coasts Beaches per day.

Lararow (2006) is able to estimate an assumed expenditure per surfer per year based on range of methods. The result is a figure between $AUD256 million to $AUD474 million. The next table is sated by Lazarow (2006) to be a more conservative expenditure on the actual Gold Coast with the values ranging from $AUD126 million to $AUD233 million.

Table 1 Participation and expenditure in surfing (Lazarow, 2009)

Source	Number of Surfers	Estimated number of surf sessions	Total estimated expenditure
Estimation 1 (based on Sweeney Report)	64 770	6 736 000*	$125 783 340+
Estimation 2 (based on Council data)	74 703	7 769 112*	$145 073 226+
Estimation 3 (based on collected data)	120 012	12 481 248*	$233 063 304+

*Based on 80% of total surfing effort = 104 sessions per year
+ Exact annual per capita estimate = $AUD 1 942

Lazarow (2006) concluded that each individual surf session cost ranged from $AUD18.67 to $AUD30.36. It is known that a number of other studies have placed a value on the cost of an individual surf session. These include Nelson and Pendleton (2006), Chapman and Hanemann (2001) and Tilley (2001) Gough (1999). The final range of values from these studies was estimated between $AUD23 to $AUD124. Lazarow (2006) also notes that the values in the table above are at the lower conservative side of the estimated expenditure by surfers. This information is also combined with the fact that Lazarow (2006) included the cost of equipment which is not always considered in the other studies which are referenced above.

Education Span of Surfers

Lazarow (2006) survey indicated a spread of ability within the interviewed survey community. The results attributed some thirty eight percent of surfers had tertiary qualifications. Twenty five percent of those interviewed were at the level of bachelor degrees and a final thirteen.

Employment Status

Lazarow (2006) also found out that from those involved in the survey, 78% of the people were employed. The spread of surfer household incomes composed of 33% of surfer households earning under $AUD40 000 per annum, 35% of surfer households earning from $AUD40 000 to $AUD60 000per annum and finally close to 23% earning an income of over $AUD80 000 per annum.

Commitment levels

The results of Lazarow (2006) interviews determined that some 60% of surfers have been surfing for over 10 years. More than 50% of the surfers make it to the beach for a surf between 2 and 3 times every week.

Chapter Summary

Based on the studies at the Gold Coast surfing has the capacity to bring increased benefits to the community. These benefits are not limited to one specific region bring benefit to the

Chapter 9 Conclusions

Summary

Location	Ongoing Issue	Suggest	Comments
Park Beach	Suffering from lose of sand due to the Harbour . Natural Sand Flow has been caught by the harbour and cannot readily travel north	Dredge by using either permanent pipe installation or temporary configuration sand placement .	Permanent dredging to Park Beach would have a greater chance of producing a consistent surfing location. Configuration placement will assist in restoring the depleted coast line at park beach and may improve the surf climate for unknown periods of time. The past efforts to dredge have not removed the same amount of sand that enters the harbour leaving the

Final Conclusion

This report has highlighted the basic considerations for the investigation of considering the surfing conditions in conjunction with coastal erosion protection. Coastal erosion protection is vital to protect community assets, values and infrastructure.

Improved surfing also has the potential to bring substantial benefit to the community. From the investigations it was demonstrated at Narrowneck that it is possible to 'improve the surfing conditions.' Snapper Rocks is now a world class surf break and the main objective was to maintain the natural sand mitigation. The lessons that were learnt at Gold Coast could be used to provide insight into the best way to proceed in the Coffs Harbour region in NSW. It is also suggested that both the dredge source sites and placement sites be investigated to complement the surfing community.

"Structures on the Gold Coast have always been designed with a knowledge of and consideration to the fact that, if a wave breaks on it, there will be surfers trying to catch the waves" (Jackson et al 2007 p. 2).

From the investigations at Coffs Harbour it is possible to consider the surfing conditions throughout the future coastal erosion protection works. Mainly by sand nourishment, either by configuration placement or permanent sand pumping.

This reports main goal was to incorporate surfing conditions into coastal erosion protection design there is added benefit for the community.

"Good coastal design and progressive peeling waves are compatible" (Jackson et al 2007 p.2).

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Appendix A Project Specification

FACULTY OF ENGINEERING AND SURVEYING

Eng4111/4112 Research Project
Project specification

FOR:	**PETER ALEXANDER CRAWFORD**
TOPIC:	IMPROVING SURFING CONDITIONS IN CONJUNCTION WITH COASTAL EROSION PROTECTION
SUPERVISORS:	Dr David Thorpe David Doyle, Coffs Harbour City Council
ENROLMENT:	ENG4111 – S1, Ext, 2013 ENG4112 – S2, Ext, 2013
PROJECT AIM:	To investigate the feasibility of improving surfing conditions during design of coastal erosion protection.
PROGRAMME:	Issue B.1, 14 August 2013

1. Research ocean waves and how they contribute to coastal erosion.
2. Research key legislation, Policies and guidelines relevant to the coastal zone in NSW.
3. Research the methods for minimising coastal erosion.
4. Report on the variable factors that are involved in producing various types of surfing waves. Focused study on four (4) popular surf locations.
5. Review the coastal erosion protection structures with respect to improved surfing conditions
6. Deduce the public safety factors which should be considered for sand groins based on Narrowneck, Gold Coast.
7. Assess the financial costs and benefits of coastal erosion protection at key locations, including Narrowneck, Gold Coast.
8. Conduct a brief study of the benefits and feasibility of improved surfing conditions at Gold Coast
9. Write and submit a project dissertation in the form required by the University of Southern Queensland

P. C. (Student) D. A. Thorpe D. Doyle (Supervisors)
24/10/13 23/10/2013 23/10/2013

Appendix B Wave Theory

Ocean waves are complex, natural energy transformations. The follow descriptions are some basic wave concepts to assist with grasping the concepts of ocean waves.

Waves

A wave is the ability for energy to be transported or moved throughout space. As stated in University Physics (Halliday, Resnick & Walker, 2001) waves can form whenever a system is disturbed for its original state and if the disturbance is able to move from one area of the system to another.

Mechanical Waves

One common type of wave form is a mechanical wave. This wave type occurs whenever there is a medium for the wave to travel along. These wave types include ripples on a liquid surface, tremors generated from earthquakes and sounds. As these waves travel through the various mediums the particles they travel through are displaced according to the nature of the wave type. (Halliday, Resnick & Walker, 2001)

Electromagnetic waves

Waves do not always require a medium to travel along. Electromagnetic waves such as light, radio waves and ultraviolet radiation are able to transmit across distances with no mediums. These waves types will not be investigated further in this report. They are mentioned here to help understand the nature and types of waves that exist (Halliday, Resnick & Walker, 2001).

Longitudinal Waves

The particle motion in a longitudinal wave is parallel with the direction of the wave. A common example of longitudinal waves is sound waves which travel through the air particles which vibrate in backwards and forwards orientation in the direction of the wave (Halliday, Resnick & Walker, 2001).

Transverse waves

This title is given to waves whose particles travel perpendicular to the wave’s direction of flow. An example of a transverse wave occurs can occur on a string. If the end of the string was to be moved in periodic motion up and down a transverse wave would travel along the length of the string. The particles of the string are actually moving perpendicular to the waves actually direction. (Halliday, Resnick & Walker, 2001).

Periodic Motion

Periodic motion occurs whenever a pattern is repeated over and over such as a swinging pendulum, or the movements of the pistons in an engine. Periodic motion is a stepping stone in understanding the concepts of waves. When a body undergoes periodic motion it always has a central stable position of equilibrium. If this body is moved, such as a clock pendulum, a force drives the pendulum back towards its position of equilibrium. As this point is reached there is enough kinetic energy to allow the pendulum to pass the initial point of equilibrium and swing to the other side. Once again this process repeats.

The easiest kind of oscillation to describe is evident when the restoring force is directly proportional to the displacement from the point of equilibrium. Mathematically this means that Hooke's Law is obeyed and assuming no friction we have (Halliday, Resnick & Walker, 2001)

$$F_x = -kx$$

Where F is the restoring force units of N
k is the force constant, units of N/m
x is the displacement, units of m

A special type of periodic motion is simple harmonic motion.

Simple harmonic motion

A particle is said to move in simple harmonic motion if its behaviour is such that it moves in a straight line with its acceleration always directed towards a fixed point and its magnitude is proportional to its distance from the fixed point (Jones 1999).

In order to describe this mathematically we have

From this description the acceleration is given as

$$\frac{d^2x}{dt^2} = -n^2 x$$

The velocity is then represented as

$$\frac{d}{dx}\left(\frac{1}{2}v^2\right) = -n^2 x$$

$$\frac{1}{2}v^2 = \frac{-n^2x^2}{2} + c$$

When velocity, v = 0

Amplitude of motion, x = a

Solving for c

$$0 = \frac{-n^2a^2}{2} + c$$

$$c = \frac{n^2a^2}{2}$$

Therefore we have

$$\frac{1}{2}v^2 = \frac{-n^2x^2}{2} + \frac{n^2a^2}{2}$$

$$v^2 = -n^2x^2 + n^2a^2$$

Which can be simplified to

$$v^2 = n^2(a^2 - x^2)$$

In order to represent our displacement we have our velocity as

$$v^2 = n^2(a^2 - x^2)$$

$$v = \pm n\sqrt{a^2 - x^2}$$

$$\frac{dx}{dt} = \pm n\sqrt{a^2 - x^2}$$

Rearranging

$$\frac{dt}{dx} = \frac{\pm 1}{n\sqrt{a^2 - x^2}}$$

Solving for t gives

$$t = \pm\frac{1}{n} \times \cos^{-1}\left(\frac{x}{a}\right) + c_1$$

Now to determine c1 let t=0 at x=a we will have

$$0 = \pm\frac{1}{n} \times \cos^{-1}\left(\frac{a}{a}\right) + c_1$$

Which means

$$c_1 = 0$$

Therefore we have

$$t = \pm\frac{1}{n} \times \cos^{-1}\left(\frac{x}{a}\right)$$

$$\pm nt = \cos^{-1}\left(\frac{x}{a}\right)$$

Rearranging we have

$$\cos(-nt) = \frac{x}{a}$$

$$x = a\cos(nt)$$

Or if it was assumed that t = 0, x=0

$$x = a\sin(nt)$$

Finally our final displacement is given by

$$x = a\cos(nt) \Rightarrow x = a\cos(nt - \alpha)$$

$$x = a\sin(nt) \Rightarrow x = a\sin(nt - \alpha)$$

So finally we have

$$x = a\cos(nt + \alpha)$$

Where a , n and α are all constants

$$\frac{dx}{dt} = a \times -\sin(nt + \alpha) \times n$$

$$\frac{dx}{dt} = -an\sin(nt + \alpha)$$

$$\frac{d^2x}{dt^2} = -an\cos(nt + \alpha)n$$

$$\frac{d^2x}{dt^2} = -an^2\cos(nt + \alpha)$$

$$\frac{d^2x}{dt^2} = -n^2 a\cos(nt + \alpha)$$

Therefore we have

$$\frac{d^2x}{dt^2} = -n^2 x$$

Represents a particle moving in simple harmonic motion

Wave length

The wave length is the distance between identical repetitions in the wave, parallel to the direction of the wave's motion (Halliday, Resnick & Walker, 2001).

Amplitude

The amplitude, a of motion and is a measure of the distance from one extreme position to the centre of the oscillation. This means that under simple harmonic motion the particle will move between the values of the maximum and minimum amplitude (Halliday, Resnick & Walker, 2001).

$$-a \le x \le a$$

Period

The period is the time in which one full oscillation occurs, mathematically it is represented as (Halliday, Resnick & Walker, 2001)

$$T = \frac{2\pi}{n}$$

Frequency

The frequency, (f) is the number of unit oscillations made per unit time, mathematically shown as (Halliday, Resnick & Walker, 2001)

$$f = \frac{1}{T} = \frac{n}{2\pi}$$

Superposition

The principle of superposition states that when various effects occur simultaneously the net effect is composed of the sum of all the single effects combined (Halliday, Resnick & Walker, 2001).

Energy in a wave

Every wave is the movement of energy. In terms of a transverse wave on a string the energy in a wave travels along the string as each particle is moved from the equilibrium position. In this manner the energy is transported from one point to another. As shown in Fundamentals of Physics (Young, 2004) the average amount of energy which is transferred in all types of mechanical waves is proportional to the square of the amplitude and the square of the frequency. This means that with a mechanical wave if just one of the properties, say frequency doubles then the power of the wave will be four times as much. The same increase in energy occurs if the amplitude was to double.

Appendix C Professional Surfer Questions and Responses

The interviews were conducted with emails from the report author to the professional surfers and the contents of the emails have been reproduced for completeness.

Otis Carey

1) Have you surfed either of the following

- Narrowneck gold coast artificial surfing reef- I can't say I've ever surfed Narrowneck artificial reef. I'm pretty sure I've never surfed it.
- Snapper Rocks gold coast- Yeah I've surfed snapper rocks countless times, awesome surf spot.
- Park Beach- yeah surfed here many, many times
- Coffs Harbour Jetty Boat ramp- Yeah boat ramp is one of my favourite surf spots in Coffs!

2)How would you describe the waves at either •

- Narrowneck gold coast artificial surfing reef
- Snapper Rocks gold coast- In terms of wave quality snapper is amazing! you can get tubbed, you can do a million turns and you get big air sections at times. It’s an awesome surf spot.
- Park Beach- I’d say ‘Parkies’ is an awesome spot too, long right hander’s and short intense lefts.
- Coffs Harbour Jetty Boat ramp- short intense and dangerous.

3) Could you see benefits in including the surfing conditions within the future planning at Park Beach or the Boat ramp. This is a common thought process in Gold Coast. The idea is more if the work is already happening i.e. The natural sand movement that travels north is caught in the man made harbour. and dredging the harbour for boats put it to use to also improve the surfing. –

If the sand dredging stopped in Coffs boat ramp would be one of the best waves in the world.

I've seen that place just as good as any sand bottom point I've seen travelling the world.

Harley Ingleby

1) Have you surfed either of the following

- Narrowneck gold coast artificial surfing reef “NO”
- Snapper Rocks gold coast “Yes”
- Park Beach “Yes”

- Coffs Harbour Jetty Boat ramp "Yes"

2) How would you describe the waves at either

- Narrowneck gold coast artificial surfing reef. To be honest I've never laid eyes on it. I hear it improved the waves there.
- Snapper Rocks gold coast. World Class! Amazingly consistent and has made surfer migrate from around the world to be able to surf there.
- Park Beach On its day a very high quality beach break. When the sand build up is good near the island it can be a short version of the Snapper Rocks.
- Coffs Harbour Jetty Boat ramp. Very swell direction and sand dependant but one of the best waves around when it's at its' best!
-

3) Could you see benefits in including the surfing conditions within the future planning at Park Beach or the Boat ramp. This is a common thought process in Gold Coast. The idea is more if the work is already happening i.e. dredging the main harbour for boats put the sand to use at park beach to also improve the surfing. And maybe if work is happening to the boat ramp we could achieve a design which suits surfers and boat users(possibly relocating into the inner harbour)

Absolutely has potential! I definitely side with the fact that surfers should be factored in when looking at these kind of plans. There are many more surfers using the Park Beach and Jetty area on a daily basis than recreational fisherman.

Lee Winkler

1) Have you surfed either of the following

- Narrowneck gold coast artificial surfing reef
- Snapper Rocks gold coast
- Park Beach
- Coffs Harbour Jetty Boat ramp

Lee Winkler

"I have surfed Snapper , Park Beach and Boat Ramp."

2) How would you describe the waves at either

- Narrowneck gold coast artificial surfing reef
- Snapper Rocks gold coast

- Park Beach
- Coffs Harbour Jetty Boat ramp

Lee Winkler

- “Snapper is long duration right hand sand bottom point break / a following hollow shallow barrelling wave and is world class when correct elements are in place.”
- “Park beach is a unpredictable style of wave that fluctuates with variation of sand movement... Can be quite shallow at times although with sand flowing along our coastline in a northerly direction mutton bird island and the marina block that sand movement and this can be a detriment to this break.”
- “Boat ramp is shallow breaking hollow right hand wave and is fun when sand build up is along the wall with combination of swells exceeding the 4-5 meter range.”

3) Could you see benefits in including the surfing conditions within the future planning at Park Beach or the Boat ramp. This is a common thought process in Gold Coast. The idea is more if the work is already happening i.e. dredging the harbour for boats put it to use to also improve the surfing.

Lee Winkler

“Having sand pumped from the vicinity of the harbour precinct is not only going to encourage the possibility of world class beach breaks on park beach it will be able to help regenerate the natural habitat of the sand dune area. The outrageous sand build up within the man made harbour walls should rightfully be filling the park beach sand dunes and until this sand is pumped in some way back on to park beach we will continue to see issues with this beautiful area.’

Appendix D Location Overviews

Snapper Rocks 'Superbank' Overview'

Figure 9 Snapper SuperBank (Acworth and Lawson, 2011)

Snapper Rocks Sand Bypassing Jetty and Discharge Pipeline Layout

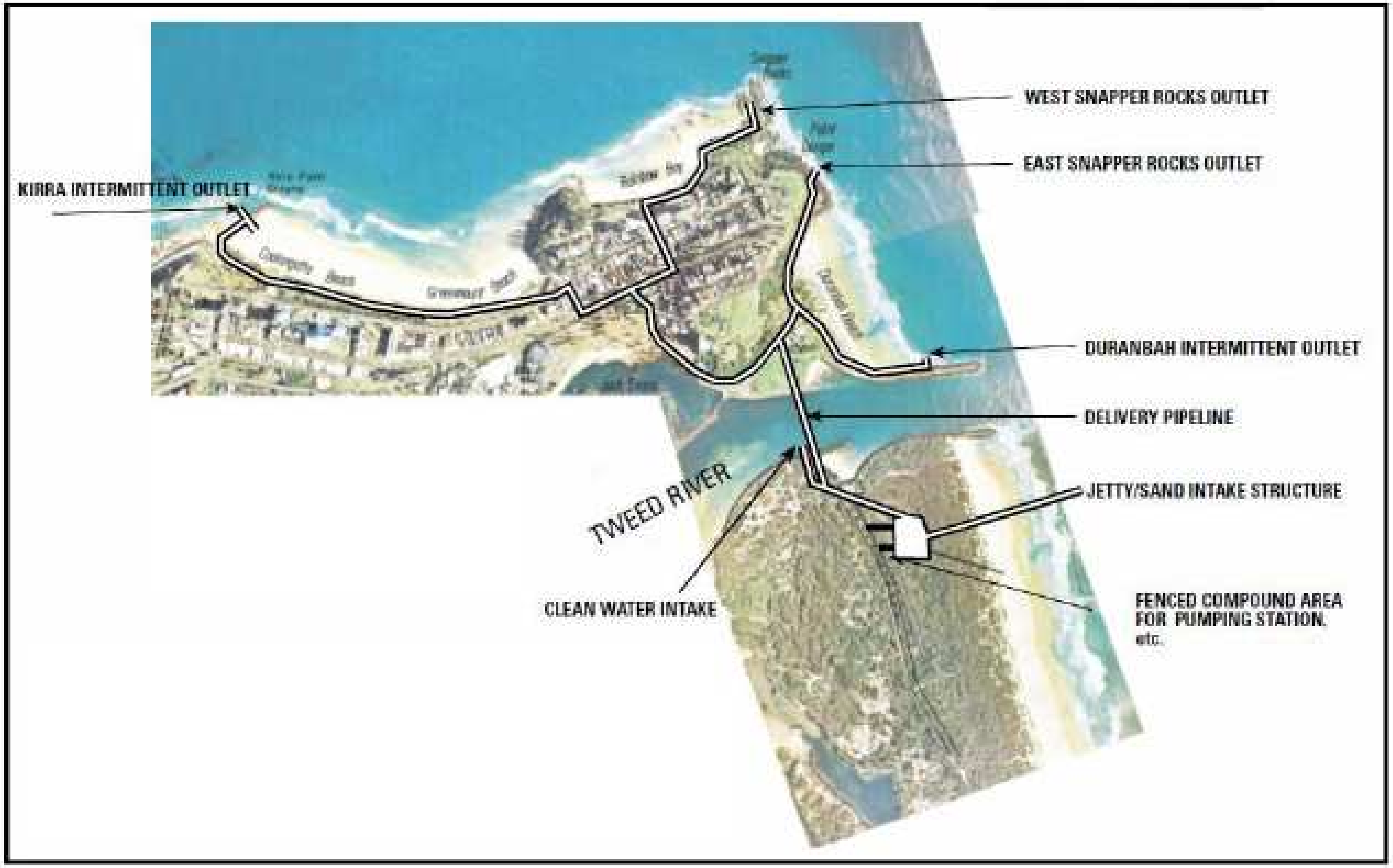

Figure 10 Sand Bypassing Jetty and Discharge Pipeline Layout (Acworth and Lawson, 2011)

Locality Map Park Beach

Figure 11 Locality Map: Park Beach, Coffs Harbour NSW 2450

Produced by CHCC

Detailed Map Park Beach

Figure 12 Detailed Map of Park Beach, Coffs Harbour NSW

Produced by CHCC

Jetty Boat Ramp

Figure 13 Detailed Map Jetty Boat Ramp, Coffs Harbour NSW

Produced by CHCC