Estimation of the economic importance of beaches in Sydney, Australia, and implications for management

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Estimation of the economic importance of beaches in Sydney, Australia, and implications for management

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Abstract

This thesis sought to estimate the economic value of selected Sydney beaches, in order to provide the necessary information to allow local and State government agencies to identify the most appropriate management response to projected climate change impacts. Three case-study sites (Collaroy-Narrabeen, Manly Ocean Beach, and a combined site in the Hawkesbury River that included the Brooklyn Baths and Dangar Island) were selected via a weighted-criteria method using an expert panel. Valuation methods were selected in response to the key coastal management challenges in the region, vulnerability to inundation and shoreline recession.

A truncated negative binomial travel cost model identified consumer surplus values of between AUD$2.72 and $20.63 for a beach day, depending on the site under investigation and the specification of the cost parameter. These are similar to those in the published literature. Aggregate values are derived only for comparison with costs of management options, due to concerns about the quality of visitation information. These comparisons suggest a strong economic argument for beach nourishment at the case-study beaches.

The Contingent Valuation (CV) method was employed to estimate the willingness to pay (WTP) of beach visitors for prevention of climate change erosion at the case-study beaches. Screening and follow-up questions were employed to identify the influence of scenario rejection on WTP responses and values. Binary probit analysis of non-protest responses resulted in average WTP of AUD$116.27± 69.63 as a one-time donation. Comparison with previous studies is not possible due to difference in contingent scenarios and payment vehicles.

The Hedonic Pricing Method (HPM) was employed to identify price premiums for beachfront property in Collaroy-Narrabeen. Significant variation in beachfront price premiums is explained by the variation in erosion risk information linked to property titles. 'Risk-free' beachfront properties were subject to price premiums around 264%, relative to an average property in the sample. Properties in the central portion of the beach, which is subject to greater exposure to erosion, were subject to much lower premiums, in the order of 130%. These figures are substantially higher than those in the published literature, which is a function of the exclusivity of the Sydney beachfront property market.

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Dedication

This thesis is dedicated to my amazing wife Tina and my two beautiful and fascinating girls, Emily and Zoe

Acknowledgements

As with any doctorate, this research thesis has not been completed in isolation, and would not have been possible without the support of a large number of individuals and organisations. I would like to take this opportunity to thank those who have supported and assisted me in the course of my research, and apologise in advance for any omissions.

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I must of course give thanks to my supervisory team, without whom my thesis would never have progressed further than an identified area for future research effort. My primary supervisor was Associate Professor Dale Dominey-Howes from the UNSW Natural Hazards Research Laboratory. Dale, thanks first for giving me the opportunity to take on this project. It was a steep learning curve, and there were many challenges along the way. This thesis would not have been completed without your advice, support and encouragement.

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(DECC&W). This funding allowed me to employ and explore a range of new technologies, and to attend conferences and interact with a broader beach valuation community.

Stefan Hajkowicz from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) provided expert advice and review of key components, particularly the site selection process and the hedonic pricing application. The CSIRO additionally provided access to technical resources, project funding and scholarship support in the form of an Office of the Chief Executive (OCE) Postgraduate Studentship.

Deanne Bird and Beth Beveridge assisted greatly with collection of the survey data that forms the backbone of this thesis. I took on this thesis with the somewhat naïve belief that I would be spending the majority of my time at the beach talking to visitors, stopping only to surf and swim. The realities of the thesis process and of surveying onsite were completely different, and without the efforts of Beth in particular I would not have such a rich dataset of coastal recreation and valuation information. Thanks must also go to the NSW Department of Lands, for providing access to land valuation data that formed the basis of the hedonic pricing application.

I must also thank my extended family, who have supported and encouraged me through the process of discovering and refining my research interests. I promise I'll get a real job now! Lastly, but most importantly, I must give the biggest vote of thanks to my phenomenal wife, Tina. Without your support I would never have considered even submitting an application for the original scholarship, and certainly wouldn't have been able to complete this thesis. I am forever indebted. Hopefully this thesis will have gone some of the way to ensuring that the social and economic importance of beaches gains adequate recognition in coastal planning and management decisions, so that we can look forward to spending a lot more time on the beach together with the girls.

Abstract

This thesis sought to estimate the economic value of selected Sydney beaches, in order to provide the necessary information to allow local and State government agencies to identify the most appropriate management response to projected climate change impacts. Three case-study sites (Collaroy-Narrabeen, Manly Ocean Beach, and a combined site in the Hawkesbury River that included the Brooklyn Baths and Dangar Island) were selected via a weighted-criteria method using an expert panel. Valuation methods were selected in response to the key coastal management challenges in the region, vulnerability to inundation and shoreline recession.

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1 Introduction

This thesis estimates the economic values of selected beaches in Sydney, Australia. Broadly, the objective is to provide necessary economic information to allow coastal managers and decision-makers to consider appropriate responses to projected climate change impacts on the urban beach environment. Partnership with key end-users ensures that there is a strong policy-application focus throughout.

This chapter sets the framework for the thesis, by describing the research problem it seeks to address. This begins with discussion of the need for economic information, which leads to a more precise definition of the existing knowledge gap, and then to the primary research questions that evolved to address this information need. The chapter concludes with an outline of the thesis structure, which directs the reader to relevant sections for further elaboration of the issues introduced in the brief outline below.

1.1 Importance of beaches

Sandy beaches are complex and dynamic ecosystems that lie at the junction of the terrestrial, aquatic and atmospheric worlds. They provide a range of ecosystem goods and services (EGS), and are subject to influences over spatial and temporal scales from the interstitial to the global, the immediate to the geological. The global economic importance of coastal EGS has been estimated at approximately US$26 trillion per year in 1994 dollars (Martínez et al., 2007)[1]. The coastal zone provides around 77% of the world's total ecosystem goods and services (as estimated in the landmark paper by Costanza et al. published in *Nature* (Costanza et al., 1997)). While reservations about the methodology in the benefit transfer studies of this nature persist (Spash and Vatn, 2006), and sandy shorelines are a notable omission from the benefit estimates, the figures generated suggest that coastal systems underpin much of human economic activity.

[1] All dollar amounts generated in the course of this study are presented in 2008 dollars AUD. Other amounts are presented in their 'native' currency with the year noted where it is reported in the original text. They are not converted to current dollars or adjusted for exchange rates, as this would imply stable and consistent preferences across time and spatial scales, something which is not supported by previous studies on temporal stability of preference estimates (CARSON, R., HANEMANN, M., KOPP, R., KROSNICK, J., MITCHELL, R., PRESSER, S., RUUD, P. & SMITH, V. K. 1997. Temporal reliability of estimates from contingent valuation. *Land Economics*, 73**,** 151-163..

The services provided by beach systems act as a strong attraction for local residents. Small and Nicholls (2003) estimated that in 1990, 23% of the global population lived within 100kms of the shore, with three times the global average population density. They also demonstrated that densities are highest close to the shoreline and at low elevation (Small and Nicholls, 2003). This was despite the fact that extensive availability of unpopulated, low-elevation land at high latitudes reduced the weighted densities (population divided by available area at that elevation or proximity) for both low-elevation and coastal lands. Notwithstanding this statistical anomaly, more than 100 million people are thought to reside within one metre of mean sea-level (Zhang et al., 2004).

This effect is even more pronounced in Australia. Australians have a strong geographical affinity to the coast, with around 50% of residential addresses located within seven kilometres of the coastline, and around 6% in the zone that is less than five metres above mean sea-level and within three kilometres of the coast (Chen and McAneney, 2006). Population growth in the coastal zone has also rapidly outstripped that in other areas (Greve et al., 2000). This has resulted in rapid coastal development, which brings management challenges and also restricts the available adaptation options. The history of coastal management challenges is detailed in Chapter 2, with a particular focus on storm-induced erosion impacts.

The attractive nature of beaches also generates substantial tourism earnings, which are concentrated in coastal regions (Klein et al., 2004). These income streams are potentially threatened by changes in the quality and extent of the beach systems on which they depend (Jones and Phillips, 2007). Proxy data suggests that the economic importance of beach-related tourism in Sydney is significant, as outlined in section 2.6.1. Sydney is located on the coast in the south-eastern state of New South Wales (NSW), and is the most populous city in Australia. The location of Sydney is shown in Figure 1.1. Further detail on the location of case-study locations is provided in Chapter 2.

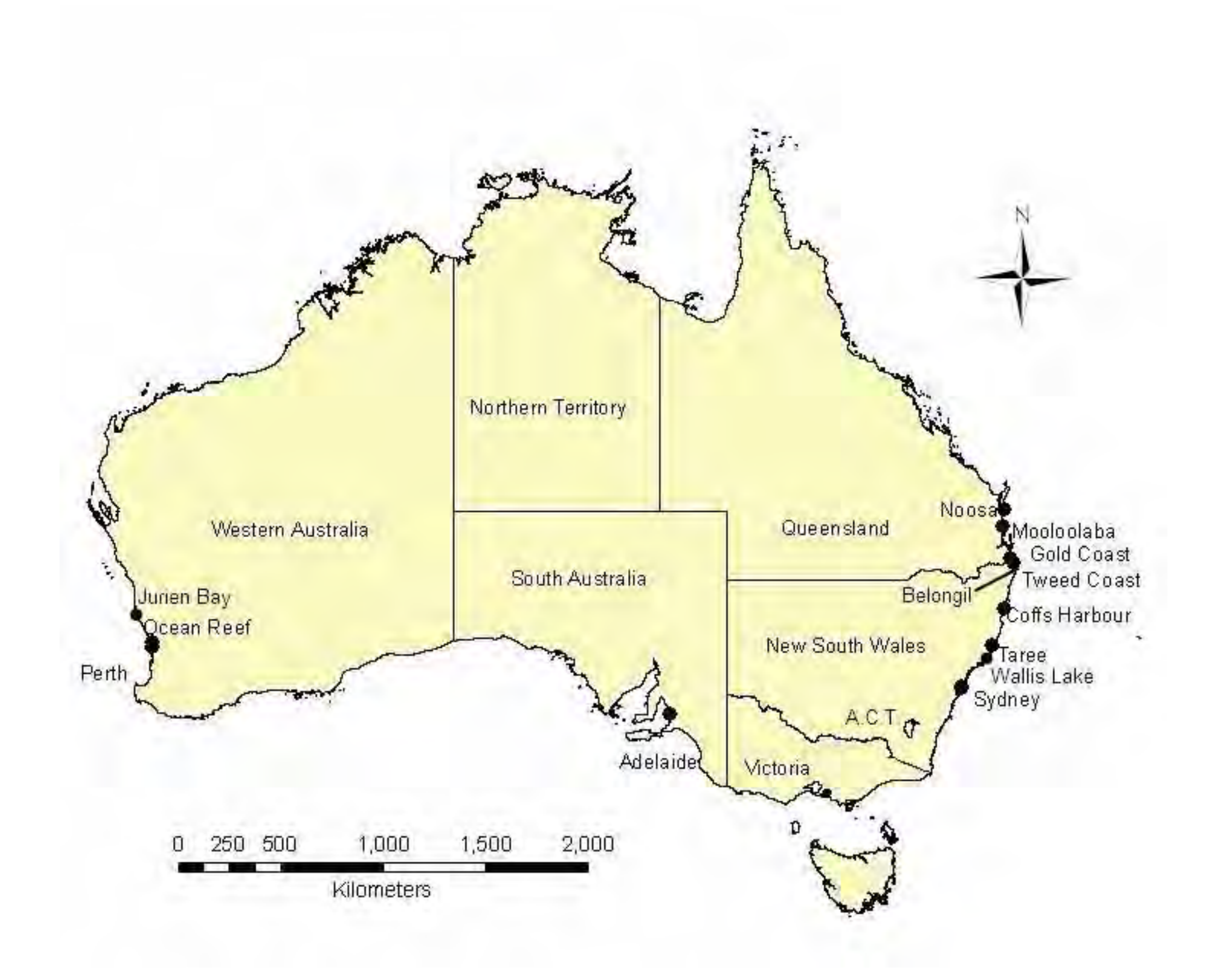

Figure 1.1Location of Sydney, and other previous beach valuation studies conducted in Australia, and referred to in the text of the thesis. (A.C.T. is the Australian Capital Territory) Figure adapted from Geoscience Australia.

1.2 Impacts of climate change

Climate change will have a range of impacts on the coastal zone, which will have far reaching consequences for coastal populations. Non-coastal populations will also be impacted by the economic consequences, given their scale. Estimates of the costs of climate change adaptation (CCA) in the coastal zone are difficult at large scales, given uncertainties and limited data availability (Nicholls and Tol, 2006). Despite these challenges, the United Nations Framework on Climate Change (UNFCCC) estimated coastal CCA measures would require US$11 billion by 2030 (UNFCCC, 2007). More recent work suggests that the residual (unavoidable) costs, once adaptation measures have been implemented and allowing for their benefits, may still be in the order of US$2-3 billion per year (Parry et al., 2009). Both estimates are in 2007 USD.

More locally, climate change is predicted to have a range of impacts on the coastal zone of Sydney. These range from higher sea-levels to increased storminess and variability of rainfall (DECC, 2008). Inundation and enhanced erosion loom as the greatest threats for the east Australian coast, and are typically the main considerations in coastal vulnerability assessments (Aboudha and Woodroffe, 2006). That focus is maintained in the current study. For a more detailed discussion of relevant climate change impacts on Sydney beaches and the policy context in which responses must be framed, the reader is referred to Chapter 2.

Whilst some uncertainty about climate change impacts persists, there is sufficient confidence and clarity for these impacts to be considered in planning and management. Sea-level rise is projected to exacerbate existing coastal hazards and management challenges. Interactions between heightened water levels and increased storm surges, among other impacts, will result in an increased likelihood of coastal erosion (McInnes et al., 2007).

In response to these challenges, a number of policy documents have recently been released by the NSW Government. The NSW Department of Environment, Climate Change and Water (DECC&W) released the *NSW Sea-level Rise Policy Statement*, which called for consideration of sea-level rises of 40cm by 2050 and 90cm by 2100, relative to 1990 levels (DECC&W, 2009).

This is supplemented by the *NSW Coastal Planning Guideline: Adapting to Sea-level Rise* (NSW Department of Planning, 2010). Principle 6 of this Guideline requires that decisions about land use planning and development applications in the coastal zone should seek to:

> *"Implement appropriate management responses and adaptation strategies, with consideration for the environmental, social and economic impacts of each option."*

This leads us then to the process by which to select appropriate responses, and the need for economic information to inform that selection process.

1.3 Selection of management responses

In response to these challenges, some difficult decisions must be made about the use and management of coastal resources. In terms of the response to sea-level rise and associated shoreline recession and increased impacts of storm-induced erosion, these decisions are typically framed as a choice between the options of protection, adaption or relocation (Klein et al., 2001, IPCC, 1990). Each choice brings with it costs and benefits, hence there must be a clear consideration of both before a good decision can be made (Walsh et al., 2004).

For a number of reasons, ranging from the political to the practical, some form of coastal protection is likely for urban coastlines in Australia (Lipman and Stokes, 2003). Given the large investments this will entail, this in many instances involves the use of formal decision support tools, with the most prevalent in Australia being Cost Benefit Analysis (NSW Government, 2007). This method requires quantification of all the costs and benefits in monetary terms in order that the process adequately addresses environmental and social issues (Hanley et al., 2001b). Valuing environmental resources such as beaches is a potentially controversial issue, particularly given the strong cultural association of Australians with the beach (Australian Government, 2007). Nevertheless, all decisions require tradeoffs, and where these decisions involve environmental resources, logic would dictate that it is best practice to ensure that these tradeoffs are made with a sound understanding of the benefits and costs of each potential course of action.

Beaches provide a range of ecosystem goods and services, not all of which are captured in existing markets, either in a direct or indirect fashion. Thus the marketed value of beaches represents only a proportion of the total economic value (TEV) of the resource (Johnston et al., 2002, NSW Government, 2007). The concept of TEV is discussed in Chapter 2, and the non-market components of TEV which this project seeks to value are discussed further in Chapter 3.

1.4 Availability of economic information

Given the outlined need above, it is perhaps surprising to realise that there are no previous empirical beach valuation studies for the Sydney region. Economic values were estimated for the natural resources of the coastal zone of NSW, as part of the Comprehensive Coastal Assessment (New South Wales Department of Planning, 2006). Natural resources considered included fisheries (including aquaculture), forests, mineral resources, beaches, national parks, and water and agricultural resources. This project calculated that these resources had an annual use value of $850 million in 2005 AUD (NSW Government Department of Planning, 2006). Whilst this included a broad range of natural systems, the values highlight the importance of coastal resources to the NSW economy. The local-level case-study conducted at Wallis Lake identified recreation as a significant source of value, which could not be included in the broader-scale study due to a lack of visitation data. Hence the value of coastal and estuarine recreation is likely to have been underestimated. Beaches were among the most highly valued natural resources at all levels (NSW Government Department of Planning, 2006).

This means that current coastal planning and management decisions must be made with imperfect proxy data, or through transfer of benefit estimates from other studies through application of the Benefit Transfer method (BT). Even the availability of suitable studies for BT is a matter of some concern, given the paucity of previous beach valuation studies completed in Australia. These studies are reviewed in Chapter 2. The method is also the subject of much debate within the economic profession. Of particular relevance to the issue of beach valuation is the fact that the majority of beach valuation studies undertaken elsewhere in the world were completed at least ten years ago (Pendleton et al., 2007). This raises the issue of the temporal reliability of benefit estimates. Downing and Ozuna tested the reliability of transfers both temporally and spatially, and found that estimates were not comparable with direct estimates, even for the same sites in consecutive years (Downing and Teofilo Ozuna, 1996). Thus there must be serious reservations about the use of these estimates, except where there are clear distinctions between the magnitudes of costs and benefits.

This project therefore seeks to ***estimate the economic values of Sydney beaches, using a number of economic methods***. More detail on the research priorities are provided in the next section.

1.5 Research questions

Research questions were defined as a component of the study, rather than prior to commencement. This was a participatory process (Treby and Clark, 2004)directed by the intended end-users of the valuation data. Details of the key participants and the process are provided in Chapters 2 and 3.

The key economic questions which this thesis seeks to explore, and the tools that are applied to answer them, are:

- What is the existing economic importance of daytrip visitation and recreation at the case-study beaches? (Individual Travel Cost Method - ITCM)
- What aspects of beaches are drivers of tourism and recreation demand? (ITCM/Contingent Valuation Method - CVM)
- How will visitors respond to the absence of sand at the case-study locations? (Contingent behaviour)
- Are beach users willing to pay to prevent the loss of sand? (CVM)
- What is the affect of beach amenities on the local property market, and how are these influenced by erosion risk information and coastal planning zones? (Hedonic Pricing Method - HPM)

The thesis additionally seeks to explore the following questions:

- What can be said about the impact of climate change on the values previously identified?
- How will these values be affected by management interventions or coastal policy changes?; and
- What are the implications for current and future coastal management, with a focus on the Sydney region?

1.6 Thesis structure

Chapter 2 presents further information on the context of the study. This includes a brief summary of the biophysical setting within which the study is undertaken. This is followed by a summary of the climate change science, with a particular focus on the impacts considered most important. The policy context is also discussed.

Chapter 3 outlines the process of defining the scope of the study. This involves presentation of a detailed site selection model based on application of multi-criteria analysis (MCA). It defines the key coastal management issues to be considered, which inform the selection of appropriate valuation tools. Strengths and weaknesses of the various tools for answering the research questions outlined above are also discussed. The third chapter also includes a summary of the existing Australian beach valuation literature, with an assessment of the suitability (or lack thereof) of these studies for the process of benefit transfer. Review of the substantially more expansive international literature is also undertaken.This is followed by discussion of the development of the joint travel cost – contingent valuation model. This is followed by a description of the survey instrument and administration mode.

Chapter 4 Presents the results of the travel cost component of the survey methods. A negative truncated binomial model is applied to adjust for the biases introduced through onsite sampling of beach users. It begins with a discussion of the underlying theory. The chapter then necessarily turns to discussion of beach visitation records, which highlights the absence of necessary data for aggregate estimates of the economic value of beaches. It reviews the existing sources of beach visitation estimates for the Sydney region, and potential means of improvement. It is my view that visitation estimates are given insufficient consideration in the valuation literature, when they have the potential to influence resource valuation estimates to a greater extent than imprecise benefit estimates.

Chapter 5 discusses the contingent valuation component of the survey instrument. The chapter follows the same broad structure as Chapter 4, with an introduction to theory followed by review of critical survey design aspects, results and discussion. Novel aspects of the survey are then outlined, as the survey instrument employs greater use of qualitative responses than is typical of the beach valuation literature, and seeks to understand the drivers of beach visitation, and contingent behavioural responses to beach erosion. Survey results are then presented and discussed.

Chapter 6 presents the results of a hedonic pricing study, which explores proximity to coastal amenities, and incorporates analysis of the influence of location within erosion related risk areas and associated land use controls.

Chapter 7 considers the management implications of the valuation results presented in Chapters 4 through 6. It summarises the results of the study, and comparisons are drawn with previous beach valuation studies in Australia. To the extent possible, benefits and costs are compared for the key adaptation options. The chapter discusses the theoretical and practical challenges to implementation of management options are outlined. The chapter then attempts to address these through suggestion of both practical and novel potential solutions. The thesis concludes with discussion of the limitations of the current study, and opportunities for future research.

Appendices follow, which include supporting documents that are too lengthy or complex for inclusion in the body of the thesis. Details of appendices are provided in the Table of Contents.

1.7 Personal motivation

My personal motivation stems from an enduring love of the coastal environment. Having been introduced to fishing and wave riding at an early age, I have maintained a connection to the coastal region throughout my studies. I first studied Marine Biology, with an ecological focus. Having developed an understanding of the complexity of the natural environment, I then sought to understand the key threatening processes. It was to this end that I completed Masters level studies in Environmental Management, focussing on the management of nature-based tourism and open-access fisheries. This ultimately resulted in a need to understand the way in which resource allocation decisions are made in Australia. Given the predominant use of benefit-cost analysis, I was stunned to find the limited availability of environmental values relevant to Australian policy decisions.

The motivation to undertake this particular doctoral research project was ultimately derived of frustration stemming from a view that environmental science was not given sufficient consideration in the decision-making processes relating to the management of coastal ecosystems. This view was generated in part through a period spent in employment as a coastal planner in the Queensland State government. In this role I was involved in many meetings with other State government departments, and was frustrated by the fact that economic development concerns appeared to 'trump' ecological or social considerations. An additional highly important motivating factor was the opportunity to directly partner with the end-users of the valuation project outputs, to ensure that both the process and the results are immediately applicable.

2 Defining the problem

This chapter provides an overview of the context in which this study was undertaken. It is my view that insufficient consideration is given to the context for environmental valuation studies conducted in the coastal zone, with the result that the outputs of the studies may not be as useful as originally intended. Examination of the context also can assist in the selection or rejection of potential source studies for the benefit transfer (BT) process, although the usefulness of the BT approach must be questioned (see Section 2.11 for further discussion).

The chapter begins with discussion of the need for economic information in coastal management, as further justification of the themes explored in the introductory chapter. It then presents an outline of the research partners and key stakeholders. A brief discussion of the biophysical context is followed by a summary of climate change impacts, with a focus on sea-level rise and erosion. The focus is on natural impacts, although economic impacts are also discussed.

This leads to a discussion of adaptation options, which is followed by a brief description of the coastal management framework in NSW, with consideration given to the policy and funding mechanisms as the framework under which beach valuation is undertaken. This is followed by an analysis of the existing sources of economic information, including market information and published beach valuation literature from Australia. The chapter concludes with an assessment of the suitability of these studies for benefit transfer, and reiterates the need for empirical valuation studies.

2.1 Policy context – need for economic information

Valuing environmental resources such as beaches is a potentially controversial issue, particularly given the strong cultural association of Australians with the beach (Australian Government, 2007). Nevertheless, all decisions require tradeoffs, and where these decisions involve environmental resources, logic would dictate that it is best practice to ensure that these tradeoffs are made with a sound understanding of the benefits and costs of each potential course of action.

Whilst the open discussion of environmental valuation will always raise opposition, some form of internal valuation is implicit in the decision-making process. Costanza and Folke (1997, p50) note:

> *"we cannot avoid the valuation issue, because as long as we are forced to make choices, we are doing valuation" (Costanza and Folke, 1997)*

Given the complexity involved in comparing options which have potential impacts on employment, public health and ecological systems (for example), a means of converting these impacts into a single unit for easy comparison is highly desirable, to ease the conceptual burden on the decision-maker. This unit is termed a numeraire in economics, and could be anything from blue marbles to cases of beer, as long as all benefits and costs can be expressed in the chosen unit (Farber et al., 2002). The most commonly used numeraire is money, as most people make daily choices involving monetary transactions and therefore have a better idea of the tradeoffs they are making when stating their willingness-to-pay (WTP) for environmental projects.This is also a means of translating the opportunity costs (the loss of the next-best option) of selecting any alternative into a means that allows for comparison between those alternatives.

2.1.1 *Legislative requirement for environmental valuation in N*SW

Ecologically sustainable development (ESD) is a key component of environmental legislation of relevance to coastal management in NSW. It is defined with slight variations in each piece of legislation, and a definitive definition is not provided here. An essential component of any definition of ESD is the need to establish or improve linkages between the economy and the environment. One of the main reasons why valuation of environmental resources is an important component of ESD is because of the prevalent use of economic evaluation methods such as Cost-Benefit Analysis (CBA) in the assessment of investment of State Government revenue in Australia. These become important when the costs of coastal protection options are beyond the scope of local councils.

Clear guidelines for CBA are provided by the NSW Department of Treasury, including the appropriate discount rates and project periods (NSW Government, 2007). This method requires quantification of all the costs and benefits in monetary terms in order that the process adequately addresses environmental and social issues (Hanley et al., 2001b). Beaches provide a range of ecosystem goods and services (EGS), not all of which are captured in existing markets, either in a direct or indirect fashion. Thus the marketed value of beaches, represents only a proportion of the total economic value (TEV) of the resource (Johnston et al., 2002, NSW Government, 2007).

Other components of TEV (see Figure 2.1) include indirect or non-consumptive uses such as recreation and tourism, and values which do not require any form of contact with the resource. These are termed non-use values and. examples include deriving utility from knowing that a resource exists even without the intention to visit, knowing that the resource will be available for future generations, and knowing that the resource is available for potential use in the future. These are existence, bequest and option values, respectively (Goodman et al., 1998).

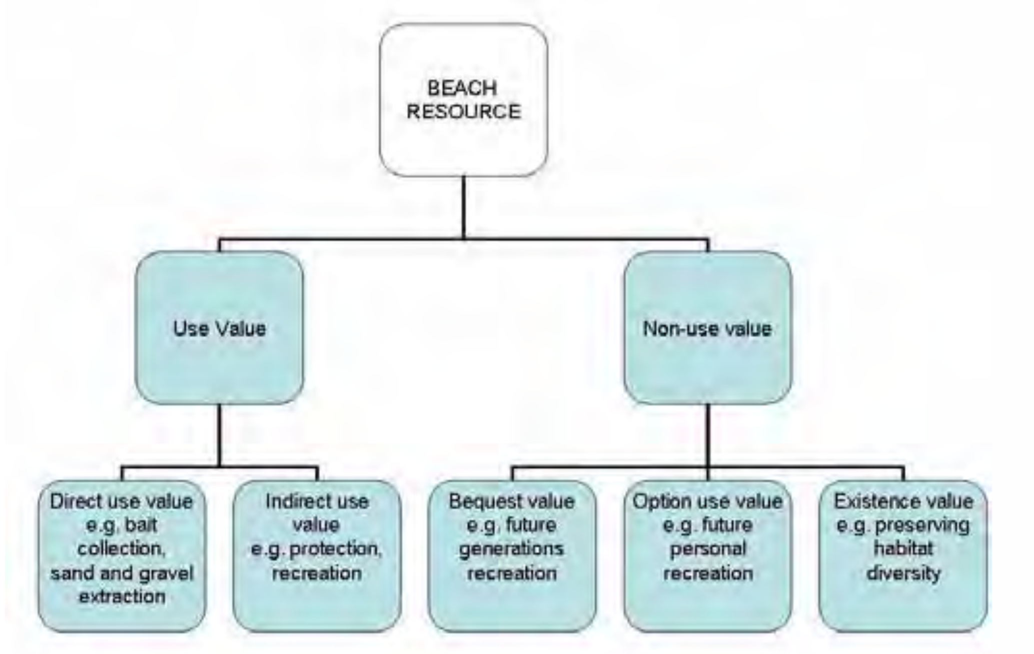

Figure 2.1 Components of value of a resource (Anning et al., 2009)

The sub-classification of these values is a matter of some uncertainty (Freeman, 1993), particularly with respect to option values and their place in the TEV framework. Strictly speaking, option value can be thought of as an insurance policy against future needs, or an application of the precautionary principle, which could sit outside the concept of Total Economic Value (TEV).

Failure to consider non-market values of natural resources can lead to these systems being undervalued in the decision-making process, which in turn can lead to undesirable outcomes such as reduced public access to the beach through private development or continued development of at-risk coastal locations (NSW Government, 1997).

The *NSW Coastal Policy 1997* explicitly highlights the need to more adequately value coastal resources (p16):

> *"A significant cause of environmental degradation in the coastal zone is the under-valuation of the environment and the long held belief that use of "commons", such as water resources, is free and unconstrained. The Coastal Policy promotes the need to fully value all the resources of the coastal zone when making decisions which affect coastal resources...." (NSW Government, 1997)*

There may be good reasons for the failure of existing markets to capture the TEV of a resource, including an absence of firm property rights, which limits the ability to trade the resource. This may be desirable in some cases, as private ownership of the beach, for example, would lead to great conflict. It has the potential, however, to lead to market failure, which results in externalities such as downstream pollution from agriculture or unsustainable use of renewable resources. There are two means of addressing this deficiency.

One means is to improve the valuation of environmental resources. The alternative method is to change the decision-making process so that it does not require valuation of all costs and benefits, such as Multi-Criteria Analysis (MCA) (Joubert et al., 1997, Brouwer and van Ek, 2004). Whilst CBA remains the primary means of economic appraisal in NSW, efforts must be made to quantify the value of environmental resources, and therefore ensure that they are adequately considered in the decision-making process. Without this valuation, the assumption is that the resources are without monetary value.

2.1.2 *Additional uses of environmental values*

In addition to the mandated use of economic values in decision-making, there are a number of potential applications of the results of environmental valuations in coastal management. A study on the role of economics in the management of the Great Barrier Reef Marine Park identified four potential applications. These were in:

> *"..allocating reefs amongst competing uses; designing economic instruments for management; monitoring the values of resources and uses; and in ensuring adequate funding of management" (Driml, 1994).*

These applications all have parallels in the management of beaches in the Sydney region, although the potential to use economic instruments for management funding is limited due to the open-access and public-good nature of the majority of beaches in Australia.

2.2 Project context - Management

2.2.1 *Project partners - The Sydney Coastal Councils Group (SCCG)*

This thesis is in a large part derived from a research project undertaken for the Sydney Coastal Councils Group (SCCG), which was supported by a Community Action Grant from the (former) New South Wales (NSW) Greenhouse Office, which is now part of the NSW Department of Environment, Climate Change and Water (DECC&W). The extended title of this grant was "*Quantifying the Value of Sydney (NSW) Beaches in order to assess cost / benefit of necessary coastal protection / abatement measures as a result of enhanced climate change impacts*". In essence, this was a "PhD by Consultation", with direct access and input into the coastal management process at the local, regional and State levels.

The SCCG is a voluntary Regional Organisation of Councils (ROC) which represents fifteen local Councils in the Sydney region with estuarine or ocean frontage. Further information on the structure and function of the group can be accessed via the SCCG website: http://sydneycoastalcouncils.com.au/. Figure 2.2 shows the extent of the SCCG member councils, and locations of the case-study sites, which are discussed in further detail in Chapter 3.

These council areas encompass 38 ocean beaches and approximately 100 harbour beaches. The organisation was established in 1989 in response to concerns about coastal water quality, and seeks to coordinate the actions of member councils to achieve more effective sustainable management of the Sydney coastal zone.

The *Sydney Coastal Councils Group Strategic Plan 2010-2014* lists the following outcome statements:

- The exchange of information on urban coastal management to member councils is coordinated and facilitated,
- Community awareness on matters related to the urban coastal management is enhanced,
- The role and capacity of member councils to manage the coastal environment is improved,
- Member Council interests are represented on issues in relation to regional and national coastal management,
- Sustainable and Integrated Coastal Zone Planning & Management is facilitated.

(SCCG, 2010)

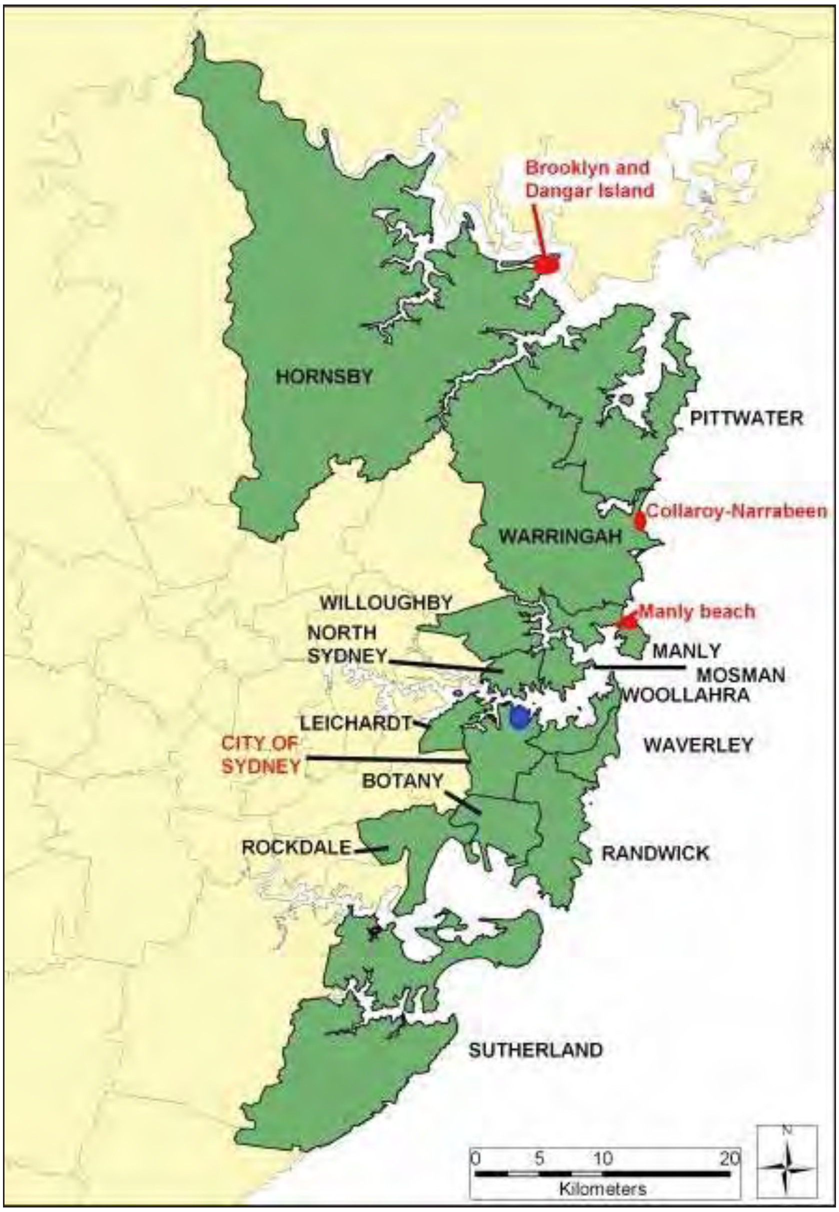

Figure 2.2 SCCG member councils and case-study site locations (labeled in red). Location of the Sydney CBD is marked in blue.

The partnership with the SCCG, and their inherent regional focus, provided substantial advantages and opportunities, but also a number of challenges in application, both of which are discussed throughout the thesis.

Much of the design process and research focus was determined by consultation with the stakeholders. Key among these was the Sydney Coastal Councils Group itself. Working with a regional organisation provided both opportunities and challenges. An aspect which encompassed both was the need to select case-study sites using an objective and equitable method, then select economic valuation tools in response to the desired information required from the study. The selection of these valuation tools is based upon the context in which the study is undertaken, hence the next section will detail the geomorphic character of Sydney beaches.

2.3 Geomorphic context

Sandy beaches cover more than 50% of the shoreline of Australia, for which estimates of length range between 12,000 and 30,000 kms, depending on the definition of shoreline (inclusion of estuaries etc.) and the degree of spatial detail (Thom and Short, 2006). There are over ten thousand beaches in Australia, which can be classified into fifteen morphological classes (Short, 2006).

The beach systems of Sydney have been described in detail by Short, in conjunction with various others (Short and Wright, 1981, Short, 2006, Short, 2007, Short and Hesp, 1982, Short and Trenaman, 1992). Exposed ocean beaches in Sydney are enclosed by headlands (see Figure 2.3), restricting the longshore movement of sand between beaches, although longshore transport is observed on the longer beaches, such as Collaroy-Narrabeen, shown in Figure 2.4.

Beaches in Sydney are wave-dominated, meaning that wave energy is more important in determining structure than tidal movements (Short and Wright, 1981). There are six beach morphologies used to describe the state of wave-dominated beaches in response to wave action (Wright and Short, 1983). The dissipative beach state is found in areas with high wave energy, and the reflective is found in locations with low energy. There are four additional rip-dominated intermediate beach states, which are the most commonly found in NSW (Short, 2007).

Figure 2.3 Freshwater beach, Sydney, showing typical 'pocket beach' morphology surrounded by elevated headlands. Source: Nearmap

The wave environment is highly energetic, with average annual significant wave heights (average of the largest one third of waves) of 1.59m and significant wave periods (average time between successive wave crests of the largest one third of waves in a given time period) of 7.98 seconds (Short and Trenaman, 1992). There is significant seasonal variation in wave heights and orientation, with summer dominated by relatively smaller waves from the east, and winter dominated by larger waves from a more south-easterly direction (Short and Trenaman, 1992).

Figure 2.4 Collaroy Narrabeen beach – aerial view. Narrabeen lagoon can be seen to the west of the Narrabeen peninsular. Long Reef headland in the south provides protection from large southerly swells. North Narrabeen headland forms a northern boundary.

2.3.1 *History of coastal management/erosion issues in Sydney*

The relatively low population of Australia, and concentration of that population within the major capital cities, means that much of the coastline is uninhabited. This means that there are few instances where beaches require management. Problems have arisen primarily on the urban coastlines, with a particular focus on the cities of Sydney, the Gold Coast and Adelaide. These locations are shown on Figure 1.1.

> *"With only a few exceptions, coastal development on the Australian coastline has been undertaken behind natural foredunes or at sufficient setback that relatively little of the coast is presently in need of protection, relatively few beaches are sustained by sand nourishment, and there are, comparatively, relatively few hard engineering structures." (Aboudha and Woodroffe, 2006)*

Nevertheless, the potential for both physical and economic impacts in selected locations, such as the northern beaches of Sydney, are substantial (Greve et al., 2000). The potential for coastal erosion is much greater during storm events, which may become more likely under climate change scenarios (West et al., 2001, Australian Government, 2009). The primary cause of erosion at Sydney beaches is through the influence of east coast lows – ECLs, low pressure systems that occur on average at least once per year, and which have the potential to cause storm surges, damaging surf with large-scale coastal erosion, heavy rainfall and destructive winds (BOM, 2007).

The most intense storm system to hit Sydney in recorded history occurred in 1974. This was actually a series of storm events, which resulted in massive erosion of beaches and widespread damage to coastal assets (Foster et al., 1975). Details of the damage incurred on the coast of NSW are provided in a number of texts, and are not reproduced in full here (Foster et al., 1975, McLean and Thom, 1975). This storm is typically used as the design event, that is the 1 in 100 Average Return Interval (ARI) storm event (one with an intensity recorded approximately every 100 years) for coastal engineering purposes. The effects of these storm events will be intensified by sea-level rise. Even under current conditions, severe storms (with average return intervals of 10-20 years) can result in beach erosion which can take 3-5 years to return sand volumes through natural accretion cycles (Short and Wright, 1981). Beach rotation may also become an issue, with projected changes in swell direction through climatic change and medium-term weather patterns such as the Southern Oscillation Index and El Niño-La Niña patterns recently being highlighted (Ranasinghe et al., 2004) Thus, it is the very existence of beaches which is threatened, as well as the amenities they provide.

For further details on the erosion history of case-study sites, please refer to the extracts of the Coastline Management Plans for Manly Ocean Beach (hereafter, Manly or Manly beach) and Collaroy-Narrabeen included in the appendices (Appendix 1 and Appendix 2, respectively).

2.4 Climate change context

Climate change is likely to exacerbate the existing management challenges, and this understanding was a major motivation for this study. There are a range of potential climate change impacts, however, (as detailed in Table 2.1). It is therefore necessary to first define what is considered in this study.

Table 2.1 Direct and indirect climate change impacts on beaches. Adapted from Aboudha (2006)

Climate change (driver)	Principal direct physical and ecosystem effects	Potential secondary and indirect impacts
Sea-level rise	increased inundation of coastal zone	disruption of coastal economy, tourism impacts
	increased coastal erosion	displacement of residents in impacted areas
	increased risk of flooding and storm damage	damage to coastal infrastructure
	saline intrustion into surface and ground water	health impacts associated with water quality changes
Altered wave climate	increased wave runup	enhanced erosion
	altered erosion and accretion balance	
Storm frequency and intensity changes	increased wave heights, runup and storm surge	increased storm damage
	southward shift in cyclone zones	
Ocean acidification	impacts on reef-building corals	reduced storm protection function, less resilient and functional reefs

Beaches are complex systems which provide a range of EGS. Given the location of beaches at the interface between terrestrial, marine and atmospheric systems, they have the potential to be influenced by a suite of processes in response to climate change. These changes could include increased variability of rainfall, an overall reduction in rainfall, increased air and water temperatures, changes in ocean circulation and wave direction patterns, and increased storminess (CSIRO, 2002, Aboudha and Woodroffe, 2006, Ranasinghe et al., 2004). Indirect impacts could include increased algal growth, changes to terrestrial nutrient inputs to estuarine systems and disruption of the symbiotic relationship essential for the formation of coral reefs (Aboudha and Woodroffe, 2006). Each of these is associated with different ranges and degrees of uncertainty (IPCC, 2007a), which is a complicating factor for any climate change adaptation strategy (CSIRO, 2002).

2.4.1 *Coastal climate change vulnerability assessments*

A review of international assessments of climate change impacts on the coastal zone found that there was a primary focus on sea-level rise (SLR). Other factors are increasingly being recognised as equally or more important than the net change in sea-levels, such as changes in rainfall and storm patterns or wave orientation (Aboudha and Woodroffe, 2006). The impact of storms has been relatively poorly studied. Adaptive capacity of coastal ecosystems, and the adjacent human populations, may be completely different for gradual changes compared to extreme events.

The majority of assessments of coastal vulnerability to climate change in Australia have used some approximation of the 'Bruun rule' (Aboudha and Woodroffe, 2006, Bruun, 1962). This approach, while allowing for broad-scale application to identify critical areas for further studies, has been criticised for its simplicity and inherent assumptions. Application of the Bruun rule requires determining the closure depth[2], which is not applied consistently in highly energetic environments, even for the same beach system (Cowell et al., 2006). The method also fails to consider the importance of storms, and is applicable only in the absence of terminal structures such as seawalls, or offshore features such as submerged reefs which restrict the stylised adjustment of the shoreline described in the original paper by Bruun (Cooper and Pilkey, 2004, Bruun, 1962). Probabilistic or fuzzy methods can offer improvements over the Bruun rule, although these approaches are time and resource intensive, and have rarely been applied. Hence there is a lag between the current state of knowledge in

[2] Closure depth is *"the most landward depth seaward of which there is no significant change in bottom elevation and no significant net sediment exchange between the nearshore and the offshore"* (Kraus et al., 1992).

the coastal engineering and geomorphology professions, and those methods being applied by coastal planners and decision-makers (Cowell et al., 2006, Cowell and Zeng, 2003).

2.4.1.1 Uncertainty in climate change projections

The valuation of the benefits of coastal management projects designed to prevent or mitigate climate change impacts is really a measure of the (climate-change induced) damage costs that are avoided by the pre-emptive action. Therefore it is necessary to know what the future state would have been without the project (future status quo). This brings to bear issues of uncertainty in climate change science, an issue which has been discussed at length in the scientific and mainstream literature.

The main component of climate change considered in most predictions about the future state of beaches is an increase in sea-levels (Aboudha and Woodroffe, 2006). This is due in part to the increased certainty surrounding these projections, and in part because modelling of the impacts of sea-levels on beaches is relatively advanced in the coastal engineering field. Of greater importance for beaches in many wave-dominated environments is the influence of storms (BOM, 2007). These storms can generate waves much larger than the normal wave climate, and result in recession of a beach several orders of magnitude greater than those predicted by sea-level rises alone. For beaches located near the mouth of a river, creek or lagoon, the importance of rainfall also becomes paramount.

There is greater disagreement between models of future storm activity than those of sea-level rise, both in terms of frequency and magnitude (Australian Government, 2009). Hence there is some considerable uncertainty about the future state of the beaches, which presents problems for those wishing to estimate the avoided costs from these states. This is a particular issue in Australia, where the short recorded climactic history prevents unique challenges in estimating storm return intervals (Gourley et al., 2004).

The uncertainty associated with climate change impact assessments also increases with the move from the biophysical to the socioeconomic, as shown in Figure 2.5. This is known as the "uncertainty explosion" (Jones, 2000). Attempts to incorporate socioeconomic factors into vulnerability classification criteria are a step in the right direction. However, they can provide only a broad-brush assessment, and are unlikely to be useful for local scale decision-making (McLaughlin et al., 2002).

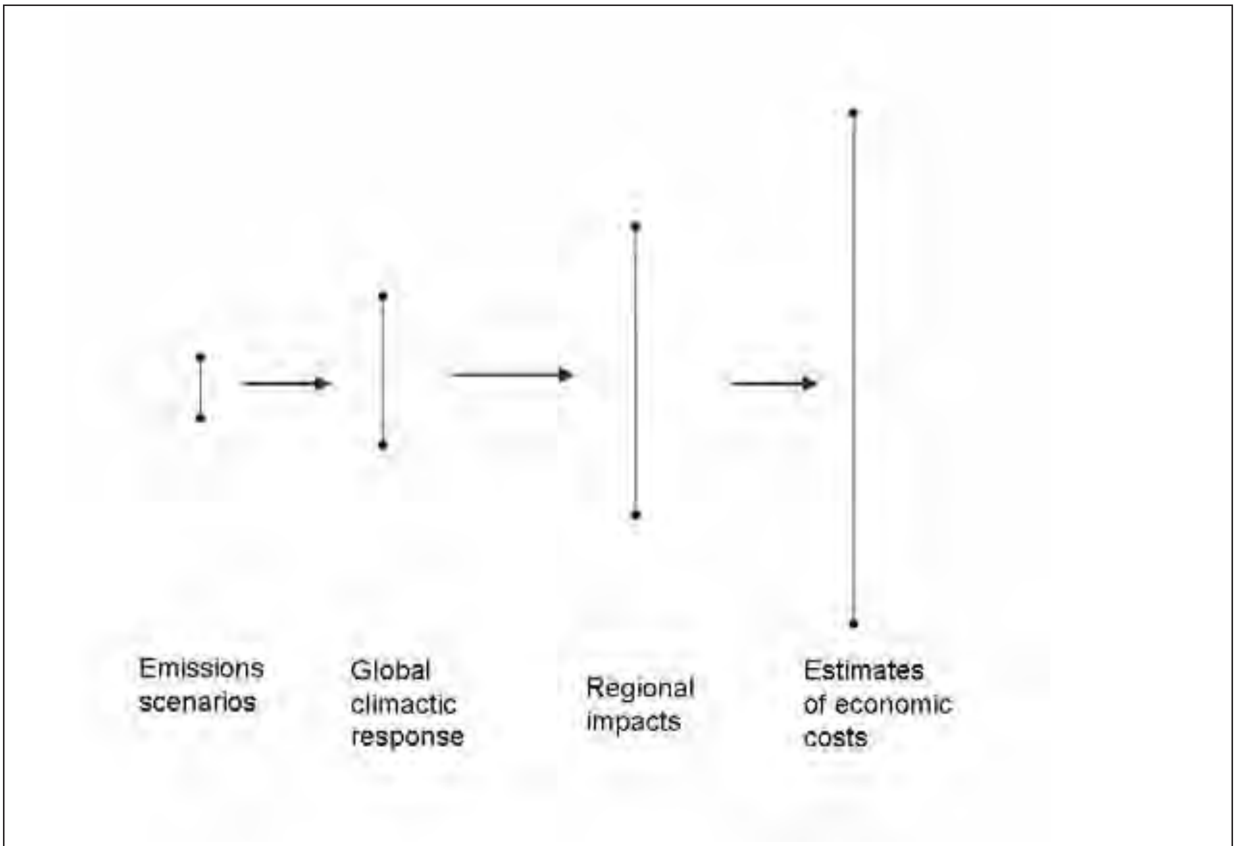

Figure 2.5 Range of uncertainty in climate change impact assessments. Adapted from the 'cascading pyramid of uncertainties' Edited after (Schneider, 1983).

The inability to know with certainty the likely state for comparison presents serious challenges for cost benefit analyses, to the extent that some authors have suggested the method may not be appropriate in this instance (Tol, 2003, Howarth, 2003). An alternative approach is to incorporate 'critical thresholds' into the valuation process, such that the value of exceeding or reaching critical points (expressed in climatic terms, such as maximum tolerable temperature etc) are the subject of the estimation process (Pittock and Jones, 2000).

For the purposes of this thesis, the climate change impacts which are of the greatest interest are those directly associated with sea-level rise, namely inundation and shoreline recession. This is in part because of the increased level of confidence in these projections (IPCC, 2007b), and also because these threats in themselves are sufficient to warrant concern for coastal managers (Walsh et al., 2004). Sea-level rise also has the potential to exacerbate the other climate change impacts (Church et al., 2006). A brief summary of the current state of science with regards to sea-level rise follows, to outline the context within which coastal management decisions must be made.

2.4.2 *Sea-level rise*

In 2007, the Intergovernmental Panel on Climate Change (IPCC) released the Fourth Assessment Report (AR4), which predicts that global sea-levels will rise (global SLR) between 18 and 59cm by 2090-2099, compared to 1999 levels (IPCC, 2007). As widely reported, this does not include the inputs due to melting of terrestrial ice sheets, as the climate science community could not agree on the magnitude or timing of this contribution. The IPCC estimates this will add approximately 10-20cm to global SLR (IPCC, 2007).

Superimposed on top of global eustatic[3] sea-level rise, regional variability is also important, but projections are subject to greater uncertainty (Christensen et al., 2007). In the case of south-eastern Australia, strengthening of the East Australian Current is likely to lead to a contribution of around 12cm of additional SLR, relative to the global average (McInnes et al., 2007). These additional amounts bring the upper end of the SLR projection envelope for the NSW coast to around 91cms.

On the east coast of Australia, this may be coupled with an increased frequency and intensity of large storm systems (Australian Government, 2009). These are likely to have a range of impacts, including shoreline recession and more frequent coastal flooding. This is likely to be enhanced by an increased variability and overall reduction in rainfall, which is likely to reduce the extent and capacity of coastal systems such as saltmarsh to mitigate flood impacts (AGO, 2006).

[3] Eustatic sea-level rise is the change in global average sea-level attributed to changes in the volume of the world's oceans.

More recent work by a prominent author on the most recent IPCC report, Stefan Rahmstorf, has suggested that sea-level rise may be significantly underestimated by the current climate models, with the results of his semi-empirical analysis suggesting a global eustatic sea-level rise of between 0.5m and 1.4m by the year 2100 (Figure 2.6) (Rahmstorf, 2007).

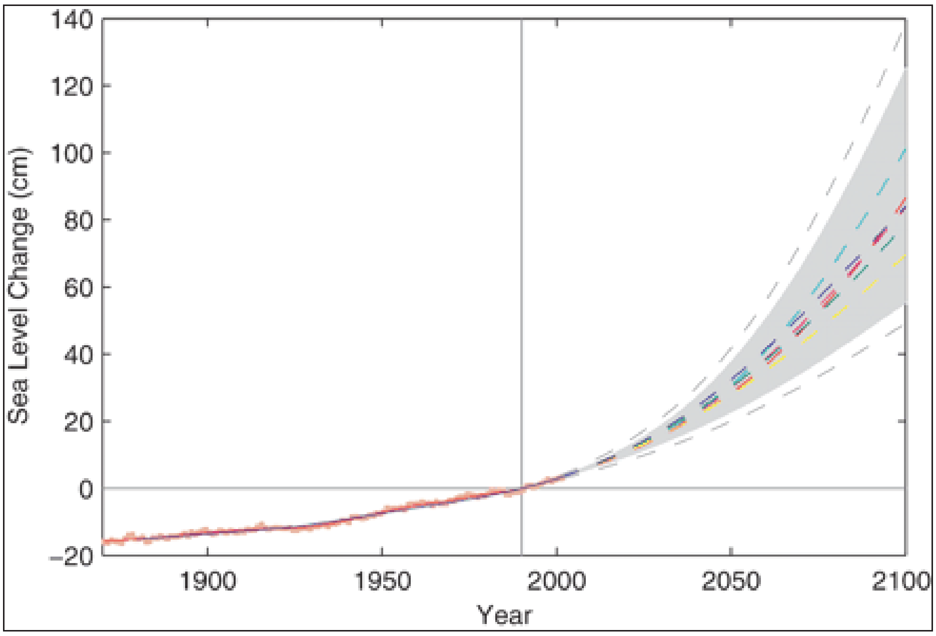

Figure 2.6 Sea-level rise projections based on the temperature change scenarios of the IPC Third Assessment Report (TAR). Dashed lines represent different temperature scenarios of the IPCC TAR, red line is the trend of observed sea-level, and grey area is the range

This was further updated by Grinsted et al., who extended a semi-empirical approach to the past 200 years, and also estimate future SLR by 2100. Their estimation (see Table 2, p469 in Grinsted et al., 2010) is that IPCC estimates of SLR may be only a third of the possible rate by 2090-2099,(Grinsted et al., 2010). This rate of SLR can only be explained by rapid decay of large ice shelves, which has been posited for Greenland, based on paleoclimatic records (Overpeck et al., 2006). Another recent study estimated the physical constraints on glacial supply of water to the ocean, based on the cross-sectional area of the glacier and potential flow rates, and found bounds that are consistent with these higher rates of SLR (Pfeffer et al., 2008).

This range appears to be supported by recent observations of sea-level, which indicate that the rate of rise is accelerating (Church and White, 2006, Rahmstorf et al., 2007). Given the observed sea-level rise (shown by the red trend line in Figure 2.6), sea-levels are already tracking towards the upper end of the range of projections from the Third Assessment Report (TAR) (Rahmstorf et al., 2007). This is a cause for some concern, as the thermal inertia of the oceans means that sea-level rise will begin slowly and then accelerate (Walsh et al., 2004).Thus we may experience greater rates of SLR than we are currently anticipating, even under the most pessimistic emissions scenarios.

While some uncertainty about the exact magnitude of sea-level rise persists, the direction of change is clear, and the precautionary principle requires action even in the absence of scientific certainty (Brundtland, 1987). This principle, which is a key component of Ecologically Sustainable Development (ESD), is a key objective of much environmental legislation and policy in NSW, and Australia in general, and hence there is a legislative requirement to respond to sea-level rise. This was detailed in section 2.1.1

2.4.3 *Regional scale impacts and implications for coastal management*

Downscaling of global estimates of SLR is challenging at regional scales, and near impossible at local scales (Wilbanks and Kates, 1999). This is a problem, because the cost-benefit analysis of measures to address climate change impacts is typically done at a local scale (Aboudha and Woodroffe, 2006).

Sea-level rise represents a chronic and unidirectional threat to coastal management, particularly in urban areas where the management options are restricted due to practical or political reasons (Hayward, 2008). This serves to increase the vulnerability of these areas to climate change. Nicholls and Lowe state the problem thus:

> *"Urbanised sandy coasts may also be vulnerable if development is concentrated too close to the shoreline, primarily due to the large costs of maintaining a sandy beach for both recreation and protective purposes. These costs are often highly uncertain." (Nicholls and Lowe, 2004)*

Shoreline recession is directly related to the level of sea-level rise. Estimates of shoreline recession on unconsolidated coastlines are generally in the order of 50-100 times the vertical sea-level rise (Aboudha and Woodroffe, 2006, Bruun, 1962)). This has been termed the Bruun rule, and it has been used extensively in coastal planning (Cowell et al., 2006). More recently, advanced techniques incorporating technologies such as inshore wave modeling, digital altimetry, probabilistic shoreline translation models and GIS platforms have provided a more precise means of estimating shoreline recession (Hennecke and Cowell, 2000, Hennecke et al., 2004). Nevertheless, the Bruun rule provides a means of rapidly assessing the threat to beaches in Sydney, to understand the importance of managing for climate change impacts.

2.5 Policy definition of climate change impacts

Whilst climate change science and shoreline modelling have progressed to the extent that there are locally-specific estimates of shoreline recession for use in development, policy has lagged behind, through adoption of outdated methods for estimating coastal hazard zones. The NSW Government recently released guidance on the use of sea-level rise (SLR) projections in planning for climate change adaptation, in the form of the Sea-level Rise Policy Statement. This document outlined benchmarks to be used in climate change planning of a 40cm rise by 2050 and a 90cm rise by 2100, relative to 1990 mean sea-levels. The simplistic yet widely implemented Bruun rule (Bruun, 1962) is employed to estimate coastal hazard zones, within which different planning restrictions are applied. Even at the lower end of the spectrum, recession of the magnitude suggested by the Bruun approach would result in significant threats to public infrastructure, private homes, and coastal reserves (Hennecke et al., 2004).

2.6 Potential economic impact

Chapter 12 of the TAR prepared by the IPCC provides a summary of the relevant science and broader impacts of climate change for the Australian coast. This is summarised by Pittock (Pittock, 2003), and is not reproduced here.

Given recent advances in modelling of shorelines under conditions of uncertainty, the likely (range of) costs of mitigation and adaptation are relatively easily understood and quantified. The cost of not undertaking these measures is less clear. For example, is the loss of beaches likely to result in tourism losses that are less than, equal to, or greater than the costs of a program designed to prevent the loss of these beaches? What will be the social and cultural impacts of the erosion of sand from local beaches?

2.6.1 *Tourism importance of beaches*

Previous studies have demonstrated strong linkages between the state of beaches and tourism revenue in coastal cities (Phillips and Jones, 2006). Raybould and Mules (Raybould and Mules, 1999) performed a cost-benefit study in 1999 of a proposed beach management program for the Gold Coast (shown on Figure 1.1), which required large scale beach nourishment and ongoing maintenance over a 25 year period. In order to determine the economic impacts of beach erosion, they compared tourism revenue in periods immediately after known erosion events with the 'expected' revenue based on reference years with no significant erosion. The studies suggested that erosion events with recurrence frequencies of 5, 10, 25 and 50 years would result in 2%, 5.5%, 13% and 20% reductions in annual tourism revenue, respectively. The authors suggested that the proposed project would reduce the impact of these erosion events, and hence generate 'savings' in lost revenue. These savings were related to the costs of the proposed project, which resulted in a benefit-cost ratio of at least 17 to 1, using relatively conservative factors in the analysis (Raybould and Mules, 1999).

Tourism revenue generated by Sydney beaches is an, as yet, unquantified source of income for the resident communities at local, regional and state level. In the year ending June 2008, Sydney received just over 26 million visitors, with total visitor expenditure of $11.4 billion (Tourism NSW, 2008). In 2001, a survey of international tourists in Sydney determined that, depending on the country of origin, between 20 and 56% (average 36.3%) of visitors visited Bondi beach. This represented total international visitor numbers of just over 1 million (Battye and Suridge, 2002). This level of international visitation is greater than that for many small countries. It is likely that domestic visitation is also high, as visiting the beach ranks highly as a motivation for travel amongst domestic tourists in Australia. Visiting the beach was the second most popular activity for domestic travellers in the 2002 National Visitor Survey (Riley and Marshall, 2002). It is likely that these visits represent a desire for recreation opportunities, but also a desire for nature-enhanced cultural activities, such as eating fish and chips on a beach or coastal promenade. Hence there is a strong economic argument for preservation of the beaches of Sydney, even without consideration of non-use values.

2.6.2 *Influence of beach amenities on the Sydney property market*

Australia is a highly urbanised, highly coastal country, with approximately 80% of residents residing within three kilometres of an estuary (Chen and McAneney, 2006). The coastal zone has experienced particularly rapid development over the past few decades, which has led to increased challenges relating to management pressures and potential liability (Pittock, 2003). Coastal properties at risk from erosion or flooding over the next century in NSW were valued at $1 billion in 2005 and this figure increases yearly due to property value increases and intensified coastal development (Pyper, 2007). Table 2.2. shows the relative increase in Sydney property prices over the past 17 years, broken down by region. Whilst these figures are not corrected for inflation, they nevertheless represent substantial increases. The definition of the regions themselves is not of primary importance, except to note that two case-study sites in the current study (Manly and Collaroy-Narrabeen) are located on the Northern beaches, whilst the third (Brooklyn and Dangar Island), is located outside the regions listed in the table.

Table 2.2 Increases in Sydney property prices (Source: Australian Property Monitors

Region	Coastal region (Y/N)	Median house price July 1993 (1993 $AUD)	Median house price July 2010 (2010 AUD$)	Percentage change 1993-2010
Inner west	N	208000	870000	318
City and East e.g. Bondi, Coogee	Y	290000	1210000	317
Northern beaches e.g. Manly, Collaroy, Narrabeen	Y	277500	1025000	269
Lower North	N	368000	1330000	261
Sydney average	**N/A**	**188050**	**626444**	**233**
South West	N	120000	397000	231
South e.g. Cronulla	Y	218000	701000	222
West	N	127000	405250	219
Upper North Shore	N	250000	793250	217
Canterbury Bankstown	N	166000	500000	201

Coastal property prices in the Sydney region indicate that there is a strong preference for proximity to the ocean. It can also be seen that the primary driver of house price increases is an increase in land value, rather than a change in the quality of housing stock. The increase in land value of these properties over the past decade has occurred at a faster rate than the typical property in Sydney (NSW Land and Property Management Authority, 2009). Over the period 1996-2005, the land value for a typical property in Manly (13m by 40m in size) increased in value from $304,000 to $1,250,000. This represents a more than threefold (311%) increase in nine years, though is not corrected for inflation. Over the same period, the average increase for representative properties in Sydney was 276%, again uncorrected (NSW Land and Property Management Authority, 2009). Differences in figures presented in the text and in Table 2.2 stem from the fact that Table 2.2 is showing median house prices, whereas the figures quoted above consider only the land value, and are average figures for a typical property.

2.7 Potential adaptation options

In response to the threat outlined above, there are a number of options for managers of coastal resources. These are, essentially, to protect, to mitigate or adapt, or to relocate (retreat). In the views of a number of coastal scientists, led by the outspoken Orrin Pilkey, there is no need for management intervention even in the event of coastal development, and retreat should be the favoured option (Pilkey and Dixon, 1998). In my view this is an unrealistic expectation, and may not be the most economically efficient. Relocation over short time frames is an impractical response for highly developed coastal areas, and where there are extensive built assets.

Rapid increases in coastal land prices in recent years also means that voluntary acquisition of these properties is not a practical response over any significant spatial scale, a weakness identified in the *NSW Coastline Management Manual 1990* (s5.1 (d) *Voluntary purchase*) (NSW Government, 1990). There are also legal challenges (both literal and figurative) when land owners hold firm property rights on coastal property, even when subject to coastal planning conditions (Gilmore, 2007).

Adaptation is also difficult. Whilst it is possible to ensure that new structures comply with appropriate design guidelines (Coastal Council of NSW, 2003), it is not often practical to retrofit pre-existing structures. Hence, practical, financial, legal and cultural limitations dictate that protection is the most likely response in Sydney (Lipman and Stokes, 2003).

There are two major classes of coastal protection options: hard and soft. Hard measures include the construction of seawalls, groynes, artificial reefs and breakwaters. Soft options are rehabilitation of natural dune systems, and beach nourishment. For a more detailed discussion of protection options see Section 5.2 of the *NSW Coastline Management Manual 1990*. Example images of the different options are found in Appendix D6 of the same document (NSW Government, 1990). Example images of the major protection types (namely seawalls, groynes and nourishment) are provided in Figures 2.7., 2.8 and 2.9 respectively.

Figure 2.7 Manly beach, showing vertical terminal seawall. Source: Manly Council

Figure 2.8 Groynes at Palm beach, Gold Coast, Australia. Source: [**http://www.goldcoast.com.au/article/2011/01/02/279745_gold-coast-news.html**](http://www.goldcoast.com.au/article/2011/01/02/279745_gold-coast-news.html)

Figure 2.9 Beach nourishment, Ocean City, New Jersey, Source: [**http://marine.rutgers.edu/geomorph/oceancityfill.jpg**](http://marine.rutgers.edu/geomorph/oceancityfill.jpg)

Both groups of responses require significant public expenditure, and hence there must be an examination of the benefits and costs of all management options (Hennecke et al., 2004). Importantly from a management perspective, the costs of coastal protection options are often beyond the financial capacity of individual Local Governments. This means that applications must be filed for external funding, which requires an additional stage of economic evaluation, with more detailed analysis often required (NSW Government, 1990, NSW Government, 2007).

2.8 Appraisal context - Coastline Management Program

The process of coastal management in NSW is guided broadly by the *NSW Coastal Policy* 1997 (NSW Government, 1997), with specific technical advice contained with the *NSW Coastline Management Manual 1990* (NSW Government, 1990). Despite being two decades old, this manual outlines the potential for climate change to enhance impacts of existing coastal hazards.

Coastal management in NSW is essentially the role of local governments, with funding and technical support provided by the State government, through the Department of Environment, Climate Change and Water (DECC&W). Policy and planning advice is also provided by the Department of Planning (DoP). In effect, the policy documents suggest that the work required for locally relevant recession estimates is not required before planning restrictions should be applied.

Cost Benefit Analysis (CBA) is the primary decision support tool employed in assessing the expenditure of funds at the State and Federal levels within Australia Whilst numerous authors have highlighted the limits of CBA in an environmental policy context (Bernd, 2004; Turner, 2007) and argued for the use of alternative appraisal tools such as Cost Effectiveness Analysis (CEA) (Zanou, 2004) and Multi-criteria Analysis (MCA) (Hajkowicz, 2007) which do not strictly require environmental valuation, CBA remains the dominant means by which coastal management alternatives are chosen. Its use is mandated in most states, with clear guidelines on the appropriate project timeframes and discount rates to be employed (New South Wales Government, 1997). As such, and given that the focus of this thesis is the estimation of economic values rather than the selection of coastal management alternatives, alternative appraisal tools are not discussed further.

A CBA appraisal involves the following primary tasks:

- Definition of the project or policy
- Identification and quantification of all the effects of the policy, both intended and unintended (externalities)
- Estimation of the costs and benefits of these effects, from a societal perspective
- Discounting of costs and benefits to a common reference frame
- Comparison of benefits and costs through various measures of economic efficiency including Benefit-Cost Ratio, Internal Rate of Return, and Net Present Value (BCR, IRR, and NPV respectively).

This thesis touches briefly on Step 1 and 2, in that it defines a hypothetical project to prevent erosion. The main focus of the thesis is on the third step, quantification of the benefits of 'the project', through providing estimates of avoided costs. It should be noted that true avoided costs can only be estimated with a defined impact scenario, such as a 10% reduction in beach visitation. The valuation aspect of this thesis is therefore is the first step in defining the economic importance of Sydney beaches.

2.9 Economic information sources

Having established the need for economic information to support coastal management decisions, it is necessary to discuss the potential sources of this information. There are three main means of estimating the economic importance of Sydney beaches: use of existing market information, transfer of benefit estimates or function from similar studies conducted elsewhere, or empirical non-market valuation studies at the policy site. The latter option is the approach taken in this thesis. The first two options are discussed below, in order to outline their ineffectiveness in addressing the research questions. The empirical valuation methods employed are discussed further in Chapter 3.

2.9.1 *Market information*

The two market-based approaches potentially applicable to valuation of beaches are examination of replacement costs and defensive expenditure (Australian Government, 1995). These methods are not considered useful for the current study, for a combination of practical and theoretical reasons. These are discussed below.

2.9.1.1 Replacement costs

If a community chooses to replace something, then the costs of replacement are a measure of the welfare provided by the thing they replace. In the case of beaches, replacement costs after a storm give a measure of the value placed upon that resource by those funding or undertaking the work. It should be noted that this represents a minimum bound of the value of the resource, and that the total value of the beaches may be many times this figure (Australian Government, 1995).

There are a number of challenges with estimating the replacement value of a beach. The first arises in determining the quantity of sand which has been removed, and the volume which should be replaced. To perform an accurate assessment would require detailed photogrammetric and bathymetric surveys. Given that these information sources are not available for primary assessments of coastal hazards, their availability for valuation projects seems unlikely. Additionally, the loss of sand may not be permanent, but merely be a relocation offshore, with sand recovery taking place over an extended period. Thus estimating the replacement costs would involve either: some measure of determining 'permanent loss' of sand from the system, with only this volume to be replaced, or a vast overestimate of the value of the 'lost' resource. There may also be issues with the assessment of these values as relevant to considerations of societal welfare, as much of the benefit of these activities could accrue to a small number of beachfront residents (Bell, 1986). The value (cost) is also highly sensitive to timing and volume of sand placement activities (Muñoz-Perez et al., 2001). Hence the use of replacement costs in valuing beach resources is rejected on theoretical and practical grounds.

2.9.1.2 Preventative expenditure

Construction of seawalls and sand nourishment fall into the category of preventative expenditures. Given that the focus of this study was on the value of beaches, protection costs relating to seawall infrastructure developments are not examined. Ultimately, terminal structures will result in loss of sand from the beach environment, due to issues of scouring and wave reflection (Klein et al., 2001). It is challenging to derive accurate estimates of the protective services provided by beach nourishment activities, and there is some debate about whether they are effective and efficient in providing this protection (Charlier and De Meyer, 1995). In addition, there have been no instances of beach nourishment at the case-study locations, although at Collaroy-Narrabeen sand is periodically returned to the beach after excavation of the lagoon entrance for flood management purposes. This operation is shown in Figure 2.10.

Figure 2.10 Sand replenishment at Collaroy. Source: Daylan Cameron, Warringah Council

2.10 Chapter conclusion

This chapter has presented the contextual argument for the need for economic information about Sydney beaches, in order to inform the management response to climate change impacts, and examined the existing sources of information. Having concluded that these sources are not applicable or appropriate for benefit transfer, this leads us to the need for empirical beach valuation studies. This in turn leads us to the next chapter, which defines the scope of those studies.

3 Defining the research scope

Given the broad nature of the initial research proposal, definition of the project context is necessarily followed by a definition of the research scope. Typically a beach valuation project is undertaken in response to a defined impact, or to assess the economic justification of a defined project. This thesis was undertaken in the absence of both of these factors. To the best knowledge of the author, this is the only empirical environmental valuation study where the selection of case-study sites, the identification of research priorities, and the selection of valuation methods to respond to those priorities have all been completed as part of the study itself, rather than externally defined prior to commencement of the study. Hence it was necessary to determine what exactly was to be valued, and to what end the results were to be used. These have substantial influence on the selection of appropriate non-market valuation methods, and particularly in designing survey-based methods such that they provide answers in a form that is of greatest use in policy and decision-making. The chapter therefore presents information that will be of use to coastal managers considering all aspects of a coastal resource valuation study.

3.1 Definition of scope

This section details the process of defining the research problem. This begins with the basic yet critical task of defining the spatial extent of the resource to be valued, providing an answer to the question "What is a beach?". This is followed by definition of the key research gaps, and selection of case-study sites that permit exploration of those questions. This is undertaken though a formal site selection process, using a panel of coastal management experts. The section concludes with selection of appropriate valuation tools to respond to the identified research questions. Detailed discussion of the methods, and a review of their application in beach valuation studies internationally, is reserved until the next chapter.

3.1.1 *Defining the spatial extent*

Whilst seemingly intuitive, identifying the exact resource and extent to be included in the analysis is a critical step in beach valuation studies which is often glossed over. The definition of a beach has large implications in the calculation of environmental values (Brenner, 2007). Beach width has been used extensively in the valuation literature as a proxy for beach quality (Pompe and Rinehart, 1995, Rinehart and Pompe, 1994), so inclusion of broad dune systems or adjacent open space in the definition of a beach will influence the imputed quality of the beach. Given the dynamic nature of undeveloped open ocean coastlines, the spatial extent of any definition based on land cover (i.e. area of exposed sand at the time of aerial photography or satellite imagery) is also highly variable. An example of the change in beach width is shown in Figures 3.1a and b, which are taken from a fixed location above Collaroy-Narrabeen beach, at the same time of day and at approximately the same time in the tidal cycle. Whilst the images were taken only 10 weeks apart, it can be seen that the beach width differs markedly.

This variability does not lend itself to easy comparisons of benefits and costs, as the expression of value in a "per-unit-area" measurement results in the perverse implication that as a beach is eroded (becomes scarcer) the total value of the beach is reduced. This is counterintuitive to standard economic theory of supply and demand, where scarce resources are valued more highly (Wooldridge, 2006).

Figure 3.1(a) Wide beach at Collaroy. Image taken at 12pm, Tuesday May 29th, 2007. Source: Water Research Laboratory

Figure 3.1(b) Narrow beach at Collaroy. Image taken at 12pm, Friday July 20th 2007. Rock protection clearly exposed. Source: Water Research Laboratory.

Different spatial definitions also have the potential to influence the range of potential value streams, as they will in turn dictate the range of ecosystem types included (Wilson et al., 2005). Beaches are complex systems which provide and perform a range of ecosystem functions. These translate to ecosystem goods and services (EGS) where they intersect with needs and desires of humans. The EGS provided by any ecosystem can be classified into four groups: supporting, regulating, provisioning and cultural services (de Groot et al., 2002, UNEP, 2006). Without this interaction, these functions do not have any economic value, as they do not affect social welfare or individual utility in a measurable way. A number of authors have detailed the EGS provided by coastal systems (Costanza et al., 1989, de Groot et al., 2002). More detail is provided for the coastal EGS provided by mangroves and coral reefs, which are the most highly studied of coastal ecosystems (Baan, 1997, IUCN, 2005).

Beaches also have functional ecological links with both terrestrial and marine systems, namely the surf zone, estuaries or coastal lagoons and dune systems (Short and Hesp, 1982). Recognising that the definition of a beach will influence those habitat types considered, Wilson et al. (Wilson et al., 2005) state that beaches provide the following ecosystem services: "disturbance prevention, soil retention, biological control, habitat functions, aesthetic information, recreation, cultural and artistic information and spiritual and historic information." Of these services, only disturbance prevention (property protection from storm surges and other natural hazards), aesthetic information and recreation have been valued in detail (Wilson et al., 2005). This is due in part to the challenges in determining both the baseline data and quantifying changes in the ecological functions necessary to place values on these changes. Ecosystem services were specifically excluded from the goods under consideration in this valuation project. There are also some substantial data gaps which limit the application of ecosystem economics to beach environments, most notably scientific quantification on the services provided by these systems. Given these limitations and constraints on the thesis length it is not practical to include the ecosystem economics literature. This remains an area of beach valuation which requires further research effort.

3.1.2 *Definition used in this study*

For the purposes of this project, a beach is defined as per The *NSW Coastal Protection Act 1979* (s55A):

> " ***beach*** *means the area of unconsolidated material between the lowest limit of tidal or lake water level and the highest level reached by wave action."*

and expanded thus, based on the advice of the BMWG:

> *"This area is expanded seaward to the furthest extent of breaking waves. Reefs and rocky outcrops are specifically excluded. The terrestrial extent is to the landward boundary of the beach reserve, or to the first hard structure which restricts the natural function of the unconsolidated material. Roads and parking areas are excluded from the beach area".*

This is a restrictive definition of a beach, which excludes many coastal ecosystems, and the goods and services that are derived from them. It hence narrows the focus to a small component of Total Economic Value (TEV). The TEV of an environmental resource is composed of use values (direct and indirect) and non-use values (existence, bequest, option) (King, 1995). See Figure 2.1 for a graphical representation of the components of TEV.

Whilst this has the potential to limit the benefit estimates, limiting the complexity of the environment to be valued also increases the suitability of valuation methods which are based on random utility theory such as choice modelling and recreational site choice models (Adamowicz et al., 1994).

3.2 Site Selection Process

Often beach valuation studies are developed either in response to a defined policy (or research) objective, for example assessing the economic justification of proposed beach nourishment activities (Edwards and Gable, 1991), or sites are selected on the basis of an available data set (Parsons and Noailly, 2004) that permits exploration of an application of interest. In this case it was necessary to first select sites.

Working with a regional organisation provided the opportunity to select the most appropriate case-study sites, but also meant that the selection process should be based upon an objective and transparent process. The SCCG represents 15 local Councils in the Sydney region with estuarine or ocean frontage. These council areas encompass 38 ocean beaches and approximately 100 harbour beaches. The site selection process was designed to be as rigorous and as objective as possible, and to ensure that the selections were aligned with both the requirement of the grant supporting the project and the desires of the SCCG member councils.

A formal site selection process based upon multiple-criteria analysis (MCA) was therefore suggested. Multiple criteria analysis is a decision support tool which assists in the selection of outcomes when selection criteria are in different units. It involves the selection of appropriate decision criteria and weighting of these criteria in terms of their importance to the decision under consideration (Robinson, 2001). Alternative options are then scored in terms of their performance against the decision criteria. The MCA method has widespread application in environmental planning problems (Hajkowicz and Collins, 2007, Hajkowicz and Wheeler, 2008).

3.2.1 *Identifying potential case-study sites*

The first stage in the selection of case-study sites is to determine the pool of potential candidates. Invitation to nominate sites was distributed to the General Manager and Mayor of each SCCG member council, to ensure that nominated sites would be drawn from Councils which had high-level support for the project from within the organisation. In response to this invitation, nominations for case studies were received from nine of the fifteen SCCG member councils. A total of nine ocean sites and five estuarine or harbour sites were nominated, with some councils nominating multiple sites within their Local Government Area (LGA), as can be seen in Table 3.1. Interviews with representatives from the nominating councils were conducted in August 2007, to gauge the level of available data and potential assistance available from the nominating Local Council, and to discuss aspects of the site which may influence the application of environmental valuation tools. For example, a remote location with limited access points may be easier to sample via survey-based approaches. The interview process resulted in a total of six ocean and three estuarine sites being included in the site selection process. Final sites included in the site selection process are highlighted in Table 3.1.

Table 3.1 Sites nominated as potential case-study sites

Nominating Council	Site name	Ocean or Estuarine
Sutherland Shire Council	Bate Bay beaches	Ocean
Warringah Council	Collaroy-Narrabeen beach	Ocean
Manly Council	Manly beach	Ocean
Pittwater Council	Palm beach	Ocean
Randwick City Council	Coogee beach	Ocean
	Maroubra beach	Ocean
Waverley Council	Bondi beach	Ocean
	Bronte beach	Ocean
	Tamarama beach	Ocean
Rockdale City Council	Lady Sandringham beach - Dolls Point	Estuarine
Manly Council	Manly Cove	Estuarine
Hornsby Shire Council	Brooklyn Baths, Dangar Island, Pelican Point	Estuarine

3.2.2 *Defining decision criteria*

In order to ensure objectivity in the site selection process, decisions about what criteria should be used to select the case-study sites, and the relative importance placed on each criterion to be applied, were referred to the SCCG Beach Management Working Group (BMWG). The members of this group represent coastal management experience and expertise in Local Government, State Agency (Department of Environmental and Climate Change or DECC, now the Department of Environment, Climate Change and Water or DECC&W), academic institutions and community groups.

At a meeting held on the 23rd of August 2007 members of the BMWG identified critical coastal management issues in the Sydney region. It was suggested (initially by representatives of DECC, with support from other delegates) that the most important information requirements for coastal management in the Sydney region were an understanding of the economic value of beaches in urban environments, and a value for the recreational amenities those beaches provide (with particular focus on the issue of public access), and that sites should be selected with the objective of investigating these key knowledge gaps. A number of site selection criteria were suggested by the group to achieve these objectives, and also to facilitate the success of the project. It should be noted that the focus of the group was on ocean beaches, and harbour or estuarine beaches were not included in this process. The process of selecting harbour beaches was a simple assessment of suitability, and is described in 3.6.6 below.

3.2.3 *Weighting of criteria*

During the process, some BMWG members raised serious concerns about the use of MCA in the selection of case-study sites. Previous experience of two BMWG delegates with the evaluation method led to the view that the method, particularly the weighting of criteria, was too subjective and overly sensitive to outlier responses. It was also felt that it was a difficult cognitive exercise to place numerical weightings on individual criteria. Concerns were also raised that the weighting process would result in the selection of two very similar sites, which was undesirable given the need for transferability of the valuation results and methodology.

An alternative approach was suggested, whereby a refined list of criteria (selected by the BMWG and listed below) was circulated via email to the BMWG delegates, and ranked by the BMWG members in terms of their importance in selecting sites that allow investigation of the key coastal management issues in the region. The refined list of criteria would then be used in a hierarchical manner to divide sites into groups (tourism iconic, relatively natural etc.). These groups could then be ranked in terms of their suitability for environmental valuation and their scores against the essential criteria. The criteria identified for site selection were:

- Coastal Hazard Definition Study has been completed for the site
- site is an iconic tourism destination (significant domestic and international tourism)
- site is a significant regional surfing destination
- vulnerability to inundation/direct impacts of sea-level rise
- vulnerability to coastal processes
- presence of private infrastructure in coastal hazard zone (at the time the hazard definition study was completed)
- presence of public infrastructure in coastal hazard zone (at the time the hazard definition study was completed).

A survey was subsequently distributed to members of the BMWG (including those that were unable to attend the meeting), asking them to rank these criteria in terms of importance. A simple ordinal ranking system was employed, based on previous work which has suggested that decision makers often struggle with fixed point scoring (Hajkowicz et al., 2000), and to reduce the conceptual burden and increase the response rate. This survey instrument is provided as Appendix 3.

Additional criteria to be used in the selection of sites were suggested, and included in consideration of nominated sites:

- one site should be an iconic tourism destination
- one site should be an iconic surfing location.

3.2.3.1 Criteria weighting results

Responses were received from nine panel members. This represented less than half the members of the BMWG, with no responses received from some organisations, so the extent to which the results are representative of those of the entire group may be questionable, although it should be noted that the results of the selection process did not align with the responses received by members of the organisation with the highest response rate. It is also recognised that in some cases the responses submitted by an individual may represent the views of more than one representative on the BMWG, although this could not be included in the analysis. More than half of the responses received were from representatives of SCCG member councils. Each response was given equal value in the analysis. Anonymous responses are shown in Table 3.2.

The responses showed a high degree of variability. The responses had a maximum potential range of 6 (1 being the highest ranking, and 7 being the lowest), with two criteria displaying a range of 4 ranking positions, three criteria displaying a range of 5 ranking positions, and two criteria displaying the maximum range of 6 ranking positions. The results of the ranking survey were compiled and analysed, with the results displayed in Table 3.3.

Simple measures were used, as the small sample size does not justify more detailed analyses. Rankings were converted to cardinal weights (Wc) through estimation of their distance from the worst value, divided by the possible distance, using the formula below:

$$Wc = \frac{7 - Ranking}{7 - 1} \qquad \textbf{[3.1]}$$

This process allocates the highest ranked option as 1, essentially following the Max100 process assessed as most effective by Bottomley and Doyle (Bottomley and Doyle, 2001). Measures of vulnerability to coastal processes and inundation, were identified as the two most important issues, which reflects a risk management focus. The presence of public infrastructure was considered slightly more important than the exposure of private infrastructure. Iconic surfing status is the criteria ranked lowest.

Table 3.2 Ranking responses from BMWG members and technical advisors

Respondent #	Organisation	Hazard definition study completed	Iconic tourism destination	Iconic surfing destination	Vulnerability to inundation	Vulnerability to coastal processes	Private infrastructure	Public infrastrcture
1	State Agency	2	6	7	3	1	4	5
2	State Agency	7	1	2	4	3	5	6
3	Local Government	5	6	7	2	1	3	4
4	Local Government	3	5	6	2	1	7	4
5	Regional Council Organisation	6	5	7	2	1	3	4
6	Local Government	4	7	5	2	1	3	6
7	Local Government	1	4	7	6	5	3	2
8	Community	No response	4	6	1	2	5	3
9	Local Government	7	1	2	4	6	5	3

Table 3.3 Compilation of ranking responses

Criteria	Weighted average	Ranking	Normalised weight (%)
Hazard definition study completed	0.44	5	12.39
Iconic tourism destination	0.44	6	12.39
Iconic surfing destination	0.26	7	7.32
Vulnerability to inundation	0.69	2	19.44
Vulnerability to coastal processes	0.78	1	21.97
Private infrastructure	0.46	4	12.96
Public infrastructure	0.48	3	13.52

3.2.4 *Site scoring*

Once the criteria had received weightings from the ranking process above, these weights must be placed against values. That is, the sites must be scored in terms of their performance against the criteria. It was initially suggested that the sites for consideration should be named, and the Working Group members could rank the sites against the refined list of essential criteria. Delegates from councils with nominated sites indicated that they would be unable to participate in the process in an objective manner.

Every attempt was made to ensure the site scoring process was objective, through the use of quantitative information wherever possible. The process relied on the best available information, including liaising with technical experts from the Beach Management Working Group (members who did not participate in the ranking process), websites, published studies and communication with external sources such as Tourism NSW, Surf Life Saving Australia, and information gathered in the meetings conducted between the author and representatives from nominating councils in August 2007.

The lack of information required to determine scores for each site (e.g. a reliable figure for visitation, detailed coastal engineering studies etc.) was a major impediment. This required construction of proxy indexes for some criteria and these are presented in the next section. Whilst some beaches were very well understood in some areas, without comparable figures for all beaches, the scoring process required some expert judgement. This was unsurprising given that the lack of information on the usage and value of coastal resources is the rationale behind this project. Of particular note was the absence of reliable visitation figures for most beaches. This suggested an additional avenue of research for the project, namely using novel means of estimating visitor numbers, and relating this visitation to environmental characteristics likely to be affected by climate change. Some discussion of potential sources of visitation data, and an assessment of quality, is provided in Chapter 4.

A particular impediment was the lack of uniformly available information on the vulnerability of nominated sites to the key risks identified as most appropriate in the ranking process. It is also noted that what information does exist is often not easily accessible. This was particularly true of the most highly weighted criteria, namely vulnerability to coastal processes and inundation. Whilst there is now broadscale information available to assess the vulnerability of coastal locations through the National Coastal Risk Assessment (Australian Government, 2009), this information was not available at the time site selections were being conducted. Historical records, engineers reports, and technical advice from DECC staff and academic experts were used in order to rank the beaches against these criteria.

The advice provided by BMWG technical advisors[4] was that there was likely to be high correlation between those sites for which Coastline Management Plans (CMP) had been completed, and those that were most vulnerable to coastal processes and inundation. It was suggested that this would be particularly true of those beaches for which CMPs had been completed prior to the 2005 amendments to the *Coastal Protection Act 1979*, which led to the inclusion of the metropolitan region in the coastal zone. Hence the implicit importance placed on the existence of Coastline Hazard Definition Studies was higher than indicated by the ranking process, as the completion of these studies was used as a proxy indication of the enhanced vulnerability of those sites. Ultimately, it was decided to restrict the sites under consideration to those for which Coastline Hazard Definition Studies had been completed. This was in part due to the ease of access of information about vulnerability to coastal processes, and also with consideration of the funding requirements of the NSW Coastline Management Program, which were mentioned in Chapter 2 and are explored in more detail in Chapter 7.

3.2.5 *Proxy data indices used in site selection*

The presence or absence of coastline hazard definition studies was a categorical variable, given a value of 1 for presence, 0 for absence, and 0.5 for geophysical studies which had been completed but were not in the form of a hazard definition study.

To estimate importance of the sites as a tourism destination, some measure of visitation would ideally be used. In the absence of this information, the number of hostels and hotels in the local government area was used to estimate visitation (ABS, 2007).

[4] P.Watson, B.Thom personal communications September and October 2007.

For public infrastructure (PubInf), the three measures used in construction of the index were the presence of ocean pools or baths (OP), the number of surf clubs (SC), and the percentage of the beach length that is backed by an exposed terminal seawall structure (SW%). These factors were combined in the following fashion (Equation 3.2):

$$PubInfScore = (OP + SC) * SW\% \qquad [3.2]$$

For surfing importance (SI), the proxy index was a summation of the number of surf clubs, the number of surf websites with cameras located at the site, a binary measure of whether the beach plays host to international competitions, and a factor which indicates whether the site is classified as a surfing reserve. The last factor was given a score of 0.5 if the site had been nominated, and a score of 1 if the site had been formally classified.

3.2.6 *Results of the weighted ranking process*

This ranking process was combined with an assessment of their suitability for a range of environmental valuation techniques. This assessment used criteria such as the presence of clearly defined site boundaries and visitor concentration points. These aspects were assessed for each potential case-study location through site visits, taking note of features such as local geography and the number and position of public transport terminals.

From the available information, and using the relative priorities identified in the ranking survey, the following ocean beaches were selected (in order of suitability):

- Collaroy-Narrabeen
- Bate Bay
- Manly
- Bondi

Given the desire expressed by the BMWG to select sites with differing management considerations and to select a site with significant (predicted) beach-related tourism income, Manly was selected as the second site, rather than the Bate Bay beaches. This selection allowed for examination of the key coastal management issues. Thus the Ocean beaches selected were:

- Collaroy-Narrabeen
- Manly

See Figure 2.2 for locations of the case-study beaches, and Figure 3.2 and Figure 3.3 respectively for aerial images of the selected sites.

Figure 3.2 Aerial view of Collaroy-Narrabeen. Narrabeen lagoon can be seen to the west of the Narrabeen peninsula. Source: Nearmap

Figure 3.3 Aerial view of Manly beach and surrounds. Source: Nearmap

3.2.7 *Selection of estuarine case-study location*

Due to the regional focus of the SCCG, it was decided by the BMWG that one of the case-study sites should be a harbour or estuarine beach, to reflect the member council location. For the estuarine or harbour beaches, only three sites were considered suitable for the site selection process (following combination of Brooklyn Baths and Dangar Island), so the detailed process described above was not possible or necessary. One site was deemed ineligible, given that it is within the same LGA as a selected ocean site (Manly Cove beaches).

Of the remaining two sites, one (Dolls Point, Rockdale) was considered too difficult to define spatially, as it represented a small section of a much longer beach system. This beach is around ten times longer than the average harbour or estuarine beach in the Sydney region, which substantially limits the potential for transferring the results to other beaches at a later stage in the project. It was also subject to complex management arrangements linked to key transport infrastructure.

The third site was therefore selected, and represents both a site with regional recreation importance and a site with residential development immediately adjacent to the beach. This site is a combination of Brooklyn Baths and Bradley's beach on Dangar Island, in the Hornsby Shire approximately 1 hours drive north of the Sydney CBD. See Figure 2.2 for locations. Both beaches are regionally important and well patronised. One beach is highly modified and intensively managed (Brooklyn Baths, Figure 3.4), whilst the other is more natural, and low elevation of beachfront properties means it is vulnerable to shoreline recession impacts of sea-level rise (Dangar Island, Figure 3.5).

Figure 3.4 Aerial View of Brooklyn, showing the bathing enclosure to the right of the image. Also visible is the Hawkesbury River train station and Brooklyn Marina to the left of the image. Source: Nearmap

Figure 3.5 Aerial view of Dangar Island. Bradley's beach is on the southern side of the island, in the centre of the image. Source: Nearmap

3.2.8 *MCA for Comparison*

Given the effort that was invested in collecting the required data for ranking of the sites against the criteria, I decided to use the MCAT program to check whether a formal MCA approach would select the same case-study sites. The analysis was undertaken with Multi Criteria Analysis Tool (MCAT), a software tool developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) (Marinoni et al., 2009).

This program utilises compromise programming to determine the relative distance of scores from the maximum, minimum or theoretical optimum (Zeleny, 1973). The utility derived from each alternative '*j*' (in this case each different case-study beach) is therefore given by equation 3.3:

$$u_j = \left[\sum_{i=1}^{n} w_i^c \left(1 - \frac{f_i^+ - f_{ij}}{f_i^+ - f_i^-} \right) \right]^{1/c} \qquad \textbf{[3.3]}$$

Where j is the alternative, i represents the score of the alternative against the criterion, w is the weight given to that criterion. The numerator in the round brackets is the distance of the alternative's score from the ideal value, whilst the denominator is the range from the best to the worst. This has the effect of normalising the scores. Whilst MCAT includes the potential to incorporate non-linear transformations, these were not employed. Given the numerous other assumptions required in the construction of the indices, assumption of linearity in the criteria is considered minor.

3.2.9 *Populating the MCAT matrix*

Defining a quantitative measure of the exposure of the sites to coastal processes, essentially erosion, required construction of an index of exposure, which was then multiplied by a measure of the frequency of storm waves from each direction. The swell directions considered were southerly, easterly and north-easterly, as these are the most common swell directions recorded in Sydney (Short and Trenaman, 1992).

The orientation of the beach was determined from aerial photography, with beaches assigned an 'exposure' score calculated by dividing the total length of the beach by the length that could directly receive swells from a given direction. This was multiplied by a 'threat' factor, which combined the frequency of waves from the given direction with the frequency with which those waves exceed three metres in significant wave height.

These were combined using the following formula, with VCP the abbreviation for the 'Vulnerability to Coastal Processes' criterion:

$$\textbf{VCP} = d + \sum \left(E_s * F_s * S_s\right) + \left(E_e * F_e * S_e\right) + \left(E_{ne} * F_{ne} * S_{ne}\right) \qquad \textbf{[3.4]}$$

where E is exposure (as a relative percentage of total beach length), F is the frequency of waves from that direction, and S is the frequency of 'storm waves', with a significant wave height of over three metres. A subscript S indicates southerly, E indicates Easterly, and NE indicates North-easterly. These data populated the decision matrix of the MCAT program, with other criteria using the proxy measures identified above.

3.2.10 *Results of the MCAT ranking process*

The results of the MCAT process and the hierarchical method employed using expert judgements were almost identical. Collaroy-Narrabeen was selected as the most appropriate site, with Manly selected second. Sensitivity analysis can easily be performed within the MCAT program. This was undertaken to test the sensitivity of site selections to changes in weights assigned to the criteria. Graphs of the sensitivity of each proposed site to variations in weighting on each selection criteria are included in Appendix 4. Results were found to be highly robust, with equalisation of weights and variation over large percentages having little or no impact on the prioritisation of the case-study sites selected. The results of equalisation of weights for the decision criteria can be seen in Figure 3.6. It is clearly shown that the relative 'benefit' of the two ocean beach case-study sites selected is substantially greater than that of the non-selected sites.

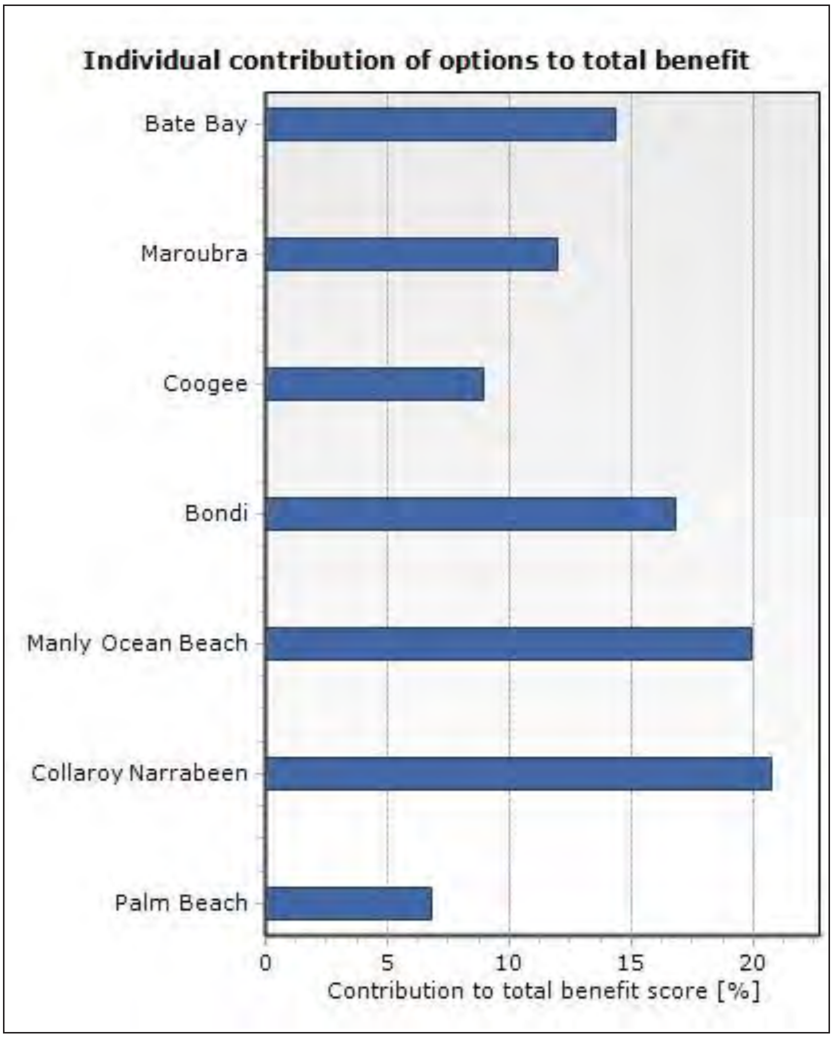

Figure 3.6 Normalised benefit scores for beaches in the site selection process. Image generated by MCAT.

3.2.11 *Comments on the ranking process*

The variability in responses received indicates the presence of disparate views, even within a group with similar areas of expertise and interest. The BMWG initially expressed a fair degree of reluctance to use a structured decision-making process, preferring to rely upon expert judgement to select the most appropriate sites. It is interesting to note that the sites which were selected through process outlined above are identical to those sites which were used in the original grant application, indicating that the use of either process would have had the same result, with considerably less effort on the part of the candidate! This indicates both that the panel of experts were good judges of the most appropriate sites. It also suggest that the site selection method, whilst not as objective as originally intended, identified the sites which best encompassed the key coastal management issues, as defined by end-users. It is therefore considered to have been a worthwhile exercise in defensible transparent site selection.

3.2.12 *Representativeness of case-study sites*

The beaches nominated as case-study sites were significantly longer than the average beach length in the Sydney region (2085m and around 865m respectively), and significantly different from the non-nominated sites (Short, 2007). This means that in many cases there is significant variability along the length of the beach in terms of exposure to threats, development status, surf quality and hazards, and transport and service availability. Whilst this reflects the priorities of the end-users, it may place limitations on the transferability of results.

3.3 Selecting appropriate valuation methods

In response to the key coastal management issues selected by the BMWG, appropriate valuation methods must be selected to address the key information gaps. This section provides a brief overview of the models selected, with subsequent sections to provide a more detailed discussion of the origins of each method, the advantages and limitations of each model, the sub-types, and the particular strain of model selected.

3.3.1 *Introduction to environmental valuation methods*

Non-market valuation has been undertaken in their various forms for more than 50 years, and there has been much debate over the theoretical basis, advantages and disadvantages of the various methods. There are two main classes of valuation methods, those which rely on relationships between the good to be valued and other marketed goods, and those that require the construction of a hypothetical market. These are known as revealed preference approaches, and stated preference approaches.

3.3.2 *Stated preference methods*

Stated preference methods are also known as direct valuation methods, as people are directly asked their willingness to pay (WTP) for a desired change, or their willingness to accept compensation (WTA) for deterioration in the quality of a good.

3.3.3 *Revealed preference methods*

Revealed preference methods are also known as indirect methods, as they require the calculation of values from the values of other goods. Alternatively they are known as surrogate market methods, as the calculation of value of the good in question requires defining a relationship between that good and a surrogate good which is valued in the market. Revealed preference models rely on actual behaviour, and are therefore not subject to the same degree of theoretical criticism as stated preference models. They are, however, not able to capture non-use or existence values, and therefore provide an estimate of the lower bound of the value of a resource.

3.3.4 *Stated vs Revealed debate*

Whilst there has been widespread acceptance of revealed preference methods, and equally widespread criticism of stated preference methods, both ultimately rely on subjective judgements by the valuer (Smith et al., 1986). Stated preference methods are also able to estimate benefits derived without direct or indirect use of the resource, such as existence, bequest and option values. Environmental valuation studies conducted only on resource users will, unless carefully designed, only determine the expenditure and consumer surplus associated with on-site activities.

Stated preference methods therefore provide a more holistic valuation than revealed preference methods, and remain an essential component of any attempt to determine the total economic value of an environmental resource. Bennett summarised the role of contingent valuation eloquently in the early eighties, and concluded that it:

> *"is not perfect…It is however, an attempt to gain a more or less objective valuation of a benefit which in the past has been at best subjectively valued by the deciding politician or bureaucrat, or at worst been completely ignored." (p235) (Bennett, 1982)*

It should be noted that while stated preferences have the potential to value non-use values, this does not always mean that this potential is fully realised. Even where surveys are accurately designed, there is a tendency for non-use values such as bequest values to be disregarded or underestimated (White and Lovett, 1999). This does not capture all of the private or social benefits or costs of recreation (Schreyer and Driver, 1989, Kearney, 2002). This is likely to result in a significant underestimation of the social benefits accruing from setting aside area for recreation (Navrud and Mungatana, 1994). Non-market commodities, such as social benefits from recreation, can be more economically significant than the profits generated through commercial resource use (Lockwood et al., 1992).

3.3.5 *Tools to answer research questions*

Further discussions with the project partners, and consultation with the BMWG, refined the research questions that framed the scope of research. The key questions which this thesis seeks to explore are:

- What is the existing economic importance of daytrip visitation and recreation at the case-study beaches? (RQ1)
- What aspects of beaches are drivers of tourism and recreation demand? (RQ2)
- How will visitors respond to the absence of sand at the case-study locations? (RQ3)
- Are beach users willing to pay to prevent the loss of sand? (RQ4)
- What is the affect of beach amenities on the local property market, and how are these influenced by building design criteria and coastal planning zones? (RQ5)
-

The thesis additionally seeks to explore the following questions:

- What can be said about the impact of climate change on the values previously identified?
- How will these values be affected by management interventions or coastal policy changes?; and
- What are the implications for current and future coastal management, with a focus on the Sydney region?

Appropriate valuation tools are suggested by the research questions, and are essentially self-selecting. Estimation of tourism revenue (RQ1), and to a lesser extent visitation, suggest some form of travel cost model. A desire to better understand the magnitude of visitation of Sydney beaches led to attempts to develop a beach visitation model. This process is described further in Chapter 4. Understanding the drivers of beach choice (RQ2) and response to site quality changes (RQ3) requires either an attribute-based site choice model (Random Utility or Hedonic Travel Cost), or direct sampling via a contingent visitation survey instrument.

Given the concurrent desire to gather stated preference information regarding willingness to pay for erosion prevention, a contingent valuation instrument was employed. The survey instrument includes questions about beach choice, and gathers qualitative responses about previous experience with and future responses to beach erosion. This satisfies the research questions RQ2-RQ4. This was incorporated with the travel cost method in a survey that was administered to beach visitors both online and onsite. The combined survey instruments used in the online and onsite surveys are provided in full as Appendices 5 and 6, respectively, and details of the contingent valuation survey design process are discussed in Chapter 5.

Satisfactorily answering research question 5 (RQ5) requires a hedonic pricing approach. Further details on data sources and methodology are contained within Chapter 6.

3.4 Valuing recreational use – the travel cost method

The travel cost method (TCM) was selected to answer RQ1.The particular model applied in this project is an Individual Travel Cost Model (ITCM). The exact methodology employed is explained further in Chapter 4.

3.4.1 *Underlying theory and origins*

The method was originally proposed by Hotelling in a letter to the US National Parks Service, as a means of valuing recreation at natural sites (Hotelling, 1949). Clawson (Clawson, 1959), and Clawson and Knetsch (Clawson and Knetsch, 1966) expanded up on the suggestion by Hotelling (Hotelling, 1949)

The theory behind the TCM is that people will not take a trip unless utility (welfare/happiness) they gain from the trip is more than the trip costs. These expenses include travel costs, onsite costs, and time. In empirical surveys (normally on-site surveys of resource users e.g. fishermen), people are asked the origin of their trip and onsite expenditure, and the number of trips they take in a given time period. It is also possible to construct a TCM using visitation records, such as those maintained by protected area managers. The assumption is that visitation will decrease with increasing distance from the site, as this will result in increased travel costs both financially and in travel time.

From this, the (inferred) demand curve for recreation at different prices can be constructed and the value of the environmental resource is estimated. This method can also be used to investigate the effect of increases in costs (such as raising the entrance fee of a national park) on visitor numbers and thus overall revenue.

A simple formula for travel cost calculations is given by equation 3.5:

$$Q_i = f(C, T, O, Q, S, X_i) \qquad [3.5]$$

Where Q_i is the number of trips taken by individual 'i', C is measure of travel cost, T is travel time, O is the onsite costs, Q is a measure of the quality of the site, and S represents the quality and trip costs of any substitute sites, and X_i is a vector of individual characteristics. This vector may include personal income, employment status, education level, gender and age.

3.4.2 *Advantages and limitations*

A key advantage of the TCM is that it is a revealed preference method, based on actual behaviour. It also provides information that can assist in selecting management options, through estimating the effect the alternatives will have on visitation, and thus economic revenue. The method also has advantages in the fact that the data requirements are relatively small and easily obtainable for managed natural areas, at least for the original ZCTM.

Travel cost has not been applied often in urban environments, as there is insufficient variation in travel costs for them to be a significant determinant of visitation (Edwards and Gable, 1991). Hence estimating a demand curve is problematic, as the curve is flat. This leaves aside the issues of travel time, which may vary substantially more than the monetary costs. This is particularly true in congested cities such as Sydney. With consideration of all travel costs, including onsite costs and travel time, it is possible to apply a travel cost approach even to visitors from nearby locations (Lockwood and Tracy, 1995). It is also possible to examine the tradeoffs that individuals make between choice of travel modes to determine the value of this time, given the implicit time and cost attributes that are linked to the alternative forms of transport. Hence, the method has substantial potential for application under these conditions (Lockwood and Tracy, 1995).

3.4.3 *Previous applications of TCM in beach valuation*

This section presents a broad overview of the previous applications of travel cost methodology in a coastal context. The focus is on the international peer-reviewed literature, and is restricted to consideration of the main climate change impact of interest in the current study, erosion and the impact on visitation. This is not intended to be an exhaustive review, as there are now numerous value database studies available which serve this purpose. Notable sources include the Environmental Valuation Reference Inventory (EVRI, https://www.evri.ca/Global/Splash.aspx) maintained by Environment Canada (with assistance from other government partners such as the US EPA and Australian Government), and the National Ocean Economics Program (NOEP, http://www.oceaneconomics.org/) maintained by the Monterey Institute of International Studies. The studies presented in this review are those which are of greatest relevance, through their examination of usage and the impacts of erosion and access restriction. The overview is restricted in the main part to the peer-reviewed literature, which excludes a number of applications. Phillip King and Vernon Leeworthy are particularly prolific publishers within the technical or grey literature (King, 2002, Leeworthy et al., 1990). This exclusion is primarily based upon the fact that these studies typically are not publicly available and are therefore of little use in policy analysis.

3.4.3.1 Single site models

The standard unit of measurement for TC valuations of beach recreation is the value of a beach day. Typically this is reported as the consumer surplus, though expenditure is also used in some government reports (Raybould and Lazarow, 2009). Figures presented hereafter are presented as published, and do not adjust for inflation or currency exchange rates. To adjust estimates for inflation assumes that preferences remain stable over time, with the only change in values due to change in monetary value. This assumption is highly dubious, based on previous work on temporal stability (Carson, et al., 1997). The year of the figures has been included where possible, i.e. reported in the original text referenced. If readers are comfortable to assume temporal stability, they are able to make their own adjustments for inflation and exchange rates. There is a strong focus in the valuation literature on comparison of welfare estimates with previous studies. This is a curious practice on theoretical grounds, as the motivation for the empirical study was presumably that the existing literature was not relevant to the question or policy under consideration. It perhaps results from the economists' need to reduce everything to a similar reference frame. Whilst the calculations involved are not particularly cumbersome, the assumptions driving the transformations are dubious at best. Dramatic changes such as increasing traffic congestion, improved fuel consumption, and non-uniform changes in income between the study sites and the policy site (in this case Sydney) render these calculations somewhat meaningless.

There are surprisingly few applications of TCM in a beach context, and where these models have been applied they are often valuing discrete aspects of the beach visit, such as the influence of water quality on health of the visitor (Freeman, 1995b, Smith and Desvousges, 1985, Sutherland, 1982), or simply using a beach-related dataset to explore intricate aspects of analysis or survey design (McConnell and Tseng, 1999). Pendleton identifies 29 applications of TC methodology in the coastal context (Pendleton et al., 2007), of which only 11 are valuing beaches, though the focus is only on the literature of the United States. There are also some glaring omissions from the list of prominent authors, so the basis of the literature review is unclear.

Moncur provides one of the earliest applications of TC methodology to the valuation of beach recreation on the Hawaiian island of Oahu. He specifically accounted for the presence of substitute sites in his analysis, which was based on the residential zip codes of respondents, but provides few details of the calculations performed (Moncur, 1975). His estimate for the value (consumer surplus) of a beach day at each of the 11 beach areas examined ranged between US$1.60 and US$6.25 per day in 1972 dollars.

Bell and Leeworthy examined long distance travellers to Florida in estimating the value of a beach day (Bell and Leeworthy, 1990). Their model incorporates the influence of both travel and onsite expenditures. Consumer surplus is estimated at US$33.91 per day in 1984 dollars, which (given the fact it was published two decades ago) remains one of the higher estimates in the published literature (Bell and Leeworthy, 1990). This is likely due to the distance from which visitors to Florida beaches were sourced. Mean travel distances were in excess of 900 miles, with both air and road travel considered. The use of Ordinary Least Squares (OLS) in estimation is also likely to have influenced estimates (Creel and Loomis, 1990).

The US Army Corps of Engineers (USACE) provides a generic value for a beach day, to be used in preliminary assessment of the costs and benefits of coastal protection works, particularly beach nourishment (Department of Defence, 2006). This figure is rarely updated, and is conservative in nature, in part because the primary objective of any beach nourishment project undertaken by USACE must be property protection. There are clear limits placed on the allowed percentage of total estimated project benefits which can be derived from recreation, and design criteria which must be satisfied in order for these values to be considered. Criteria include provision of parking spaces and access points (Whitehead et al., 2008).

King estimates the value of a beach day in Carpinteria County, California, as around US$23.38 during high season (2001 dollars). Interestingly, King estimates the value of a beach visit during low season at only US$3 per day (King, 2002). He does not provide substantive justification for the large discrepancy, except to say that these low season visits are more likely to be visits by local residents who are undertaking ‘low value’ activities such as walking. These visits therefore do not result in significant economic activity (King, 2002).

Bin et al. estimate the travel costs of both daytrip and overnight visitors to beaches in North Carolina, with mathematical corrections performed to correct for the biases associated with onsite sampling of beach users, namely oversampling of avid beach users (endogenous stratification) and non-sampling of non-users (truncation) (Bin et al., 2005). Estimates for daytrip visitors range from US$11-80 for different sites, which do not include onsite expenditure. Overnight visitors had CS estimates of between US$11 and US$40 per day, reflecting the fact that they had shorter travel distances (Bin et al., 2005) All figures are in 2003 USD.

Turning to the non-US international literature, Chen et al. estimated the value of a beach on Xiamen Island in China (Chen et al., 2004). Using a ZTCM approach, they estimate an annual aggregate value of US$53 million (1999 dollars). The authors use a proportional weighting of travel costs, based on responses gathered in the survey, to estimate the proportion of the costs of multipurpose trips that is attributable to the presence of the beach under study (Chen et al., 2004). I hold grave concerns with the use of such an approach, which forces respondents to compartmentalise in a way which I consider unnatural. The ability to recall intrinsic psychological aspects of the trip decision, and then allocate proportional weights to each motivator, is considered highly dubious.

There are few other international applications of single-site TC models in beach valuation, at least in the peer-reviewed literature published in the English language.
Nunes and van den Bergh estimated the lost value associated with a year-long closure of a beach resort at Zandvoort. They derive cumulative annual benefit estimates of €55 per person (2001 Euros) (Nunes and van den Bergh, 2004). Given the survey design, it is not possible to derive daily value estimates.

Blakemore estimated consumer surplus from visits to a Turkish beach resort area, deriving a figure of £12.75 per vacation (Blakemore and Williams, 2008). Surveys were conducted over a six year period, 1998-2004, though the year of the CS estimates is not given. This figure does not incorporate any consideration of the opportunity cost of time, and is considered very low. It is difficult for me to envision taking an extended vacation which would generate such a low level of CS, though this does not necessarily mean the figures are inaccurate, as it is common to find low CS estimates when high costs are involved, as most of the value is captured in the expenditure component. The value of a beach day is calculated by dividing this figure by the number of days spent at the beach during the vacation (average of 7.6 days) and multiplying by the "*mean value of beach enjoyment as a percentage of the total holiday experience*" which is 66%. This generates a value per beach day of £1.11 (Blakemore and Williams, 2008). Leaving aside for the moment the theoretical issues with determining a proportional 'value of enjoyment', division of the total CS figure by the number of days suggest that a similar adjustment has already been undertaken. It is assumed that the number of beach days (relative to vacation days spent in other activities) is likely to reflect the amount of utility generated by that activity, otherwise the respondent would have chosen to reallocate their vacation time and reduce their time spent at the beach.

3.4.3.2 Multiple site models

In the travel cost literature there is an increase in the move towards multiple site models rather than the traditional single site approach. This is driven primarily by recognition of the fact that the availability of substitutes can have a substantial influence on welfare estimates, and also a greater capacity to integrate information about the features or attributes of individual sites. Applications of attribute-based models in the coastal zone are increasingly frequent, as highlighted by Pendleton in his aforementioned review (Pendleton et al., 2007).

The Southern California Beach Valuation Project was one of the largest studies of beach usage, and employed diaries to document usage of 51 beaches across the Los Angeles and Orange Counties of southern California (Hanneman et al., 2005). The modelling estimated the value of a beach day at around US$11.17-$11.20[5], with slight variation depending on the weighting of sites by the number of visits they receive. This figure is lower than those found in previous technical studies for the value of a beach day in Callifornia (King, 2002), which is explained by the authors by the fact that the estimates are for the closure of a single site, where all other sites remain open (Hanneman et al., 2005).

Random utility models (RUMs) have been applied to the valuation of site attributes through examination of beach choices, and to the economic effect of changes in key attributes such as erosion at a single site. Parsons et al. examined the site choices among a choice set of 62 beaches on the coastline of New Jersey and Virginia (Parsons et al., 2000). The analysis accounts for the presence of favoured and familiar sites (Parsons et al., 2000), as previous work has demonstrated that inclusion of unfamiliar sites can produce vastly different parameter and welfare estimates (Hicks and Strand, 2000).

Lew and Larson estimated the value of a beach day in San Diego county using a RUM, arriving at estimates of between $21 and $23 (2001 USD)using a nested logit model which incorporated an option for respondents to choose not to visit a beach in the event of a site closure (Lew and Larson, 2008). Whilst the authors go to some pains to indicate a reasonable cooperation rate (see footnotes 19 and 20, p242), only 494 of 6119 attempted contacts provided fully completed surveys. The sample is also composed of highly avid beach users, with an average of almost 18 visits per 60 days, or more than two visits per week. There must be questions raised about the reliability of transferring these results to a broader population (Lew and Larson, 2008).

Importantly, Lew and Larson account for the contiguous nature of beaches used in the site choice model. They therefore estimate models which allow for aggregation of geographically indistinct sites into larger beach zones (Lew and Larson, 2008). This is an approach which deserves further work, as it is unlikely that beach site boundaries are defined similarly by

[5] Data was collected in 1999-2000 and the figures are assumed to be from 2000

visitors, coastal managers, and geomorphologists or coastal engineers. Failure to account for indistinct beach boundaries may result in biased estimates of the importance of individual sites, through 'fuzzy' site substitution. The process of aggregation in this study, however, did not have a statistically significant impact on parameter or welfare estimates (Lew and Larson, 2008).

Much of the multiple-site TCM theory is developed in the field of forest economics, where site characteristics are relatively easily sampled and quantified. This has led to the use of such models in valuing management interventions. TCM has been used to estimate the effect of fire on the demand for recreation and the resultant economic losses associated with reduced visitation (Starbuck et al., 2006, Hesseln, 2004). Incorporation of the economic implications of managing for different habitat types into benefit-cost analyses has informed the selection of forestry practices, and provides a supporting argument for the costs associated with fire suppression. This is a particularly useful field of research in considering management decisions in response to predicted climate change impacts.

Studies on the management of multiple-use forests, have attempted to identify the characteristics of natural environments that attract tourists or those engaged in recreation, in order to inform management decisions (Englin et al., 2005). A study on trail choices by backcountry hikers in Jasper National Park (Alberta, Canada) showed a preference for more mature forests, using travel costs as a means of assigning value to environmental characteristics (Englin et al., 2005).

Englin and Mendelsohn combined the hedonic and travel cost methods to determine the recreational value of altering site characteristics (Englin and Mendelsohn, 1991). This was done by determining the travel costs associated with travel to different trail heads, and integrating this with a detailed study of the environmental characteristics of the trails. This is a small scale consideration of substitute sites, within a larger site or region. The distinction between revealed and stated preference methods is somewhat blurred in this case, as assessing travel costs for sites with different levels of ‘quality’ is essentially an application of the choice modelling method (Bhat, 2003).

In my opinion, applying a RUM to the valuation of beach erosion impacts stretches the theoretical credibility of the model to the limit. In the case of Sydney, the primary cause of erosion is large waves which are generated by local storm systems (BOM, 2007). The intensity and location of the depression relative to the land, in terms of direction and distance, has strong influences on the orientation and magnitude of the waves which are experienced along the coast. Records of coastal erosion in Sydney indicate that beaches experience vastly different impacts from the same storm system (Foster et al., 1975, Watson et al., 2007). These are a function of exposure, the geomorphic nature of the beach, and the erosion and accretion history experienced by the particular beach (McLean and Thom, 1975, Harley et al., 2011). Each of these factors may be differently affected by SLR (McInnes et al., 2007), rendering meaningful estimates of site changes highly questionable at best.

3.4.3.3 Combined models

There is increasing use of combined revealed and stated preference models that seek to use the complimentary nature of the two approaches to better understand beach visitation drivers and values (Adamowicz et al., 1994, Andersson, 2007, Earnhart, 2001, Park et al., 2002). Whitehead is a particular proponent of the combined approach (Whitehead et al., 2010, Whitehead, 2005, Whitehead et al., 2008). Whilst the current study employed a joint survey instrument for the sake of convenience, no attempt to construct a pooled model was undertaken, due in large part to concerns about the quality of revealed preference visitation estimates. Without a good understanding of existing visitation patterns, and how these may change in the future, placing values on the trips is of less importance. Visitation estimates are discussed in greater detail in section 4.2.

3.5 Valuing willingness to pay – the contingent valuation method

Given that climate change projections fall beyond the scope of observed states for many beaches, and will involve both use and non-use aspects (see Table 2.1), there is a strong argument for the use of stated preference methods in the selection of policy and management responses. They are also the only methods that are available to answer a number of the key research questions:

- What activities do beach visitors undertake?
- What aspects of beaches are drivers of tourism and recreation demand?
- How would visitors respond to the absence of sand at the case-study locations?
- Are beach users willing to pay to prevent the loss of sand?

3.5.1 *Underlying theory and origins*

Stated preference models have a relatively long history of use in calculating the value of non-market goods. They were first proposed by Ciriacy-Wantrup in 1947 (Ciriacy-Wantrup, 1947). The first empirical application was by Robert Davis, as part of his doctoral research in the early 1960s (Davis, 1963). Contingent valuation developed because of a need for information to support policy decisions. This is particularly true when the dominant decision support tool employed is Cost Benefit Analysis (CBA).

Conceptually, this is the simplest of the models, although ensuring that the survey provides meaningful data requires careful survey design. Essentially, CVM involves survey respondents to determine the economic contribution that they would consider equivalent to a described environmental change. Respondents are presented with two situations, the status quo and the predicted or contingent. They are then asked to indicate how much they would be willing to pay (WTP) to ensure the positive change takes place or that the negative change does not. If those surveyed have a legal right to the existing resource, they are instead asked how much compensation they would require to offset a reduction in their rights/access to the resource (Willingness to Accept Compensations, WTA or WTAC).

This valuation question may be open-ended (e.g. How much would you pay?) or may represent a discrete choice or referendum model, where respondents are asked whether or not they would pay a random amount, generated from a focus group study (e.g. Would you pay $4?). An example scenario regarding the valuation of climate change adaptation activities on coasts (not that used in this study) would be:

> *"Climate change is predicted to result in coastal erosion and flooding. The only way to prevent this erosion is to pump sand onto the beaches to provide a buffer zone. The NSW government is seeking contributions from the public to be placed in a fund which can only be used for coastal protection, administered by the Department of Environment and Climate Change. What would you be willing to contribute to this fund to ensure that Sydney residents are able to continue to enjoy the beaches?"*

The final stage is to collect socio-demographic information about the respondents. This information is used to calibrate the data to the relevant population, to examine any trends or patterns that may influence the policy decision, and to perform tests of theoretical consistency (Australian Government, 1995).

From the responses generated in the survey, mean WTP can be calculated. This is multiplied by the relevant population to give an estimate of total WTP to prevent the negative change, or ensure the positive change takes place. It should be noted that the value elicited from the survey is not the value of the environment or environmental attribute as a whole. Rather, WTP represents determine the value associated with a small change in the attribute, as described in the survey (the marginal value).

A bid curve analysis is then performed, to validate responses against factors likely to influence the bids, such as age, household income and education level (Australian Government, 1995). There is also an increasing move towards the use of both revealed and stated preference methods for valuation of the same resources, which provides a further means of validating the results of contingent valuation studies (Brookshire et al., 1982, Adamowicz et al., 1994, Earnhart, 2001, Whitehead et al., 2010).

3.5.2 *Advantages and limitations of contingent valuation (CV)*

The key advantage of stated preference methods is in their flexibility. They can be adapted to measure the value of almost any good, hence they can be applied in valuation of almost any non-market goods. Another key benefit is that they can be used for valuing changes which are outside the scope of experience. They thus have particular application in the valuation of projected climate change projections, which may lie outside the historical records.

The other advantage of contingent valuation, and stated preference methods in general, is that they are able to value non-use values, whereas revealed preferences are dependent on some transaction taking place, and hence can value only direct and to a lesser extent non-use values. Not all societal preferences are captured in markets, either directly or indirectly, hence there is a role for stated preference methods (Krutilla, 1967). Even in the presence of surrogate markets from which environmental values can be derived using indirect valuation methods such as the hedonic pricing method (Rosen, 1974), changes in environmental quality may not be fully captured in the substitute market, so the change may be undervalued. Figure 2.1 illustrates the components of the value of a beach resource.

3.5.3 *Previous applications of CVM in beach valuation*

Direct estimates of value for beach recreation can be achieved through use of SP methods, through asking people about the tradeoffs they would make to maintain or enhance their recreational usage (Bell, 1986, McConnell, 1977, Silberman and Klock, 1988). It should be noted that this section specifically excludes review of the relatively extensive literature relating to the economic impact of coastal and lake water quality changes and management interventions (Freeman, 1995a, Le Goffe, 1995, Machado and Mourato, 2002, Rabinovici et al., 2004). This stance is justified by the definition of spatial extent and key research questions in Chapter 3. Influences on coastal water quality are typically related to catchment management issues, rather than those which can feasibly be addressed through coastal interventions.

3.5.3.1 Valuing beach width

Width is often used as a proxy measure for the quality of a beach, be it in beach quality assessments, (Phillips and House, 2009) or valuations employing stated preference (Silberman and Klock, 1988), revealed preference (Pompe and Rinehart, 1995) or combined approaches (Whitehead et al., 2010). Wider beaches are assumed to provide greater opportunities for recreation, and enhanced property protection from erosion (Pompe and Rinehart, 1994). The focus on beach width may stem from the coastal management framework under which the majority of beach valuation studies have been undertaken, namely the valuation restrictions imposed by the US Army Corps of Engineers (USACE) beach nourishment cost-sharing system (Whitehead et al., 2008). Under their cost-sharing structure, the USACE will fund 65% of project costs, with the remainder typically funded by local authorities. The primary objective is to provide property protection, although recreational benefits of the nourishment program can be used to justify up to fifty percent of project costs, on the proviso that access points and parking are sufficient, or their provision is included in the project. Whilst it would appear that this is an attempt to ensure that public funds are not expended to provide benefits that primarily accrue to a select group of beachfront residents (Bell, 1986), this has the somewhat perverse outcome that beaches can only be nourished if their use is intensified.

Preferences for wider beaches are borne out by surveys regarding preferences for beach characteristics. A sample of high school students in New Jersey consistently preferred wide beaches (Nordstrom and Mitteager, 2001). Importantly for management of these resources, the students also preferred those beaches with natural dune systems, despite the fact that dunes in the case-study area were often flattened in order to provide the wider beaches and promenades that were presumably assumed to be more important (Nordstrom and Mitteager, 2001). The preference for wide beaches appears to be consistent, having been supported by surveys in places as far reaching as Wales (Morgan, 1999) and Italy (Brandolini, 2006). The Welsh study found optimal beach width was between 50 and 200 yards at low tide, and between 20 and 50 yards at high tide. This presumably strikes a balance between recreational opportunities, the distance of travel from the car to the water, and congestion.

Landry et al. estimated the recreational benefits of nourishment on Tybee Island, Georgia, through a contingent choice survey of non-residents. Residents were excluded due to a concurrent hedonic analysis, with the assumption that all recreational amenities were measured in the hedonic model (Landry et al., 2003). This study showed that attributes of the project design influenced WTP for increased beach width, and also that WTP increased with increased beach width (Landry et al., 2003). Estimates of WTP for the wider beaches ranged from US$6.75-$9.92 (1996 USD) per household-day, and were influenced by the policy designed to achieve the objective. Nourishment and retreat were considered preferable to wider beaches in their analysis, reflecting divergent preferences in approach. It is difficult to understand how a number of the presented alternatives (for example increased beach width without nourishment) could reasonably be achieved, given that shoreline armouring typically results in beach scouring, hence the usefulness of the results may be questionable. A similar study by the same authors found comparable WTP for beach width on Jekyll Island (Georgia), with WTP values ranging from $6.06 to $7.71 (1998 USD) per household-day (Kriesel et al., 2004).

3.5.3.2 Valuing beach days

Since this study estimates WTP to prevent the loss of beach days, this is the unit of measurement most relevant for comparison. Unfortunately, it is also less commonly applied. Typically respondents are not asked directly their WTP for beach use, but this is derived through asking questions about WTP for prevention of beach closures (Huang et al., 2007) or for changes in beach attributes such as width. Whilst figures are reported in terms of the value of a beach day, these may not be the appropriate unit of measurement, as visitation may also change. Silberman and Klock found an increase from US$3.60 to $3.90 in mean WTP for a beach day following a beach nourishment project, but also found that the increase in visitation frequency had a larger impact on the economic assessment than the change in WTP (Silberman and Klock, 1988).

Falk et al. estimated the WTP for a beach day in Delaware, and found WTP before and after a hypothetical nourishment project of US$3.01 and $3.70 respectively, in 1993 dollars (Falk et al., 1994). Whitmarsh employs the Value of Enjoyment method to estimate the VOE of a beach visit as £8.63 (1995 pounds sterling, with the impacts of erosion estimated as causing a loss of £2.34 per day (Whitmarsh et al., 1999). This is compared to previous studies in the UK, which have a range of £7.37 (1990 data) to £9.48 (1996 data) per adult per day. The study also finds that the VOE for residents is higher than that of day-trippers, but less than that of overnight visitors (Whitmarsh et al., 1999).

Leeworthy et al. estimated WTP for access to four beaches in California, with estimates of Consumer Surplus of between US$1.72 and $8.04 per day (Leeworthy et al., 1990) Kline and Swallow conduncted onsite surveys on Gooseberry Is, Massachusetts, estimating different values for weekday and weekends or holidays. The value of a beach day for the two categories is $3.06 and $4.18 (1995 USD), respectively, derived from mainly local visitation. Smith et al. examine WTP for activities to remove marine debris, through showing respondents visitors of beaches at different levels of 'cleanliness', and find potential economic support for debris removal (Smith et al., 1997).

Dharmaratne and Braithwaite employ a travel cost method in estimating the value of beach recreation at west and south coast beaches of Barbados (Dharmaratne and Brathwaite, 1998). Their payment vehicle is somewhat unusual, in that it takes the form of a beach pass which is valid for the entire visit, regardless of duration. They present benefit estimates for a 7 day trip of US$620.36 for first-time visitors, with repeat visitors WTP slightly less (US$619.27). These figures (in 1994 USD) are particularly high compared to others in the relevant literature, even when divided by the number of days. The authors explain this discrepancy by virtue of the fact that the estimates are for all amenities on the island, rather than just the beaches.

3.5.3.3 Congestion

The importance of congestion in valuation of recreational sites has long been recognised. WTP to avoid congestion has been estimated by a number of authors (Bell, 1986, McConnell, 1977). McConnell used stated preferences for congestion to estimate the optimal spatial extent of beaches in Rhode Island (McConnell, 1977, McConnell and Duff, 1976). If demand exceeds the carrying capacity of the resource, the value placed upon a resource using this method will be too low, and hence supply of the resource will be insufficient (McConnell and Duff, 1976, Wetzel, 1977). The US Army Corps of Engineers requires a per-person area of $7m^2$ for planning purposes. Hence they intrinsically are including a measure of congestion in their design (McConnell, 1977).

Bell also investigated congestion, through comparing WTP values for congested and uncongested beaches in Florida. Using a telephone survey, respondents were asked their maximum WTP for a theoretical 'beach pass' required to fund erosion remediation activities. Using congestion measures (square foot per person) derived from external sources, Bell then derives a cost curve that relates the WTP to the degree of crowding at the beach (Bell, 1986). Whilst consideration is given to the differing features and facilities available at the beach, the results must still be treated with caution.

It is also important to note that for recreation management purposes the absolute number of visitors is often less important than the compatibility of resource users (Vail and Heldt, 2004). Canoeists were shown to be far more tolerant of other canoeists than of power boat users (Lucas, 1964). Managing for a range of recreation options is seen as desirable, but presents issues with relation to increased conflict between stakeholders (McIntyre, 1993). Congestion and conflict between users is a short term externality generated through excess recreation demand, whilst resource depletion is a long term externality (Vail and Hultkrantz, 2000). In the case of beaches, this equates to erosion.

3.5.3.4 Non-use values

Non-use estimates are rare in the environmental valuation literature. These estimates can by definition only come from the SP literature. Typically efforts to establish non-use values are through retrospective classification of stated preference responses based on follow-up qualitative questioning, or through theoretical models of contingent behaviour. Silberman et al. estimated existence value for beaches in New Jersey, through questions about the respondents' intention to visit the site after a proposed nourishment project (Silberman et al., 1992). They surveyed both those who used the site, and those who were unfamiliar with the site. They found that for those who intended to use the beach in the future, their 'existence' values were tainted by a recreational component, which implies a form of 'option value'. Beach users without any intention of visiting the named sites may be willing to pay for reduced congestion at their preferred site. The conclusion was that the only means of truly measuring existence value is to sample non-users with no intention to visit in the future (Silberman et al., 1992). To be highly pedantic, it could also be argued that even this measure could contain a bequest component, if the respondent thought that their children could potentially visit the site in the future.

Silberman and Klock employed similar methodology in an earlier study, though the use of vastly different bids in the WTP and existence components is likely to have influenced the estimates of existence value through starting-point bias, given that they are an order of magnitude greater than the WTP estimates (Silberman and Klock, 1988).

Shivlani et al. found that respondents had a higher willingness to pay for beach restoration when they had been informed about the importance of beaches for turtle nesting habitat (Shivlani et al., 2003). The WTP for beach width increased from \$1.69 to \$2.12 (1999 USD) per household-visit. Whether this is due to information provision or warm-glow influences is unclear.

3.5.4 *Alternative to Contingent Valuation - Choice modelling*

In response to the (perceived or actual) limitations of CV listed above, alternative stated preference methods have been developed which evolved from conjoint analysis techniques used in marketing (Boxall et al., 1996). These are Contingent Ranking and Choice Modelling

(CM), and have parallels with Random Utility and Hedonic Travel Cost models (Englin and Mendelsohn, 1991, Pendleton, 1999, Pendleton and Mendelsohn, 2000).

These methods are based on the idea that a resource can be described by a number of key attributes, and it is the levels of these attributes that determine the value of the resource. For example, an urban forest could be described by the age of the trees, the most common species, the presence of picnic facilities, and the presence of walking tracks (Englin et al., 2005). Respondents are presented with a series of choice sets representing varying levels in each of the attributes. Each choice set will include the status quo, and price can be incorporated as a further attribute of each option. From the choices it is possible to calculate the relative importance of attributes, and the monetary values attributed to each one. This can then be used to inform management options, by estimating the impact of each option on key attributes.

Bundles are provided without a price component in the Contingent Ranking method. These rankings can therefore provide useful information for management regarding public preferences, but are unable to provide the valuation required for CBA and is therefore not discussed further in this paper (New South Wales Government, 1997a).

3.5.5 *Theoretical basis*

In choice modelling, respondents are presented with a series of choices between bundles of environmental goods at different prices. The selections allow for an inferred calculation of the value of the different attributes (Hajkowicz and Okotai, 2006, Van Bueren and Bennett, 2004). In effect, referendum-style contingent valuations represent an application of the choice method, with a limitation of bundles to two choices. The respondent must choose between the status quo, with a price of $0, and the bundle of goods described by the proposed change, at the price presented (Boxall et al., 1996).

A version of this method is employed internally by tourists when choosing tourism destinations (Scarpa and Thiene, 2005), and is the basis of the RUM model discussed above (Pendleton and Mendelsohn, 2000). Consideration of a range of attributes is particularly true of longer, multiple-objective trips (Yeh et al., 2006). The decision to travel to Sydney, for example, may be influenced by the presence of friends or family, cultural or business activities, or the natural surroundings.

3.5.6 *Advantages and limitations of Choice Modelling*

This method can avoid the opposition to direct questions of willingness to pay, and provide a more detailed analysis of the attributes contributing to the overall value of the resource. It also removes the reward for strategic responses.

The generation of attribute-specific preference information heightens the usefulness of CM for policy support. It also increases the applicability in benefit transfer. This was empirically validated by Jiang et al., who used CM to estimate benefits for four sites in Rhode Island and Massachusetts. The values estimated at the two sites in Massachusetts were then compared to predicted benefits derived from transferring benefits from the Rhode Island sites. Benefit transfer estimates were shown to be between 70 and 90% of the value estimated by the direct method (Jiang et al., 2005). Whilst this still allows for an error of up to 30%, it compares very favourably with average figures for errors in benefit transfer, which range from 475% for function transfers to 577% for unit transfers (Rosenberger, 2005). Errors of this magnitude render meaningful transfer of benefit estimates impossible (Spash and Vatn, 2006). Conducting studies with a goal to generating transferable benefit estimates (Van Bueren and Bennett, 2004) is also questionable on theoretical grounds, as the rationale for the original valuation study is presumably that the existing benefit estimates available for the resource are not suitable or appropriate, given differences in the context or resource itself.

Where many attributes are used, it can require a large number of choice sets, which places a greater burden on the respondent. The results of the analysis are also sensitive to the attributes and attribute levels employed in the survey. There is increasing recognition of the fact that it is very difficult to characterise an environmental resource by a small number of descriptive attributes. This has resulted in a transition in management of protected areas from indicator-based approaches to adaptive management. It is also important to ensure that the attributes and the degree of variation in the choice sets accurately describe the environmental change to be valued (Boxall et al., 1996).

Nevertheless, the use of a restrictive definition of a beach, as detailed in section 3.1.2, means that it may be possible to accurately describe a beach with a limited number of characteristics. These could include: water quality, beach width, the availability of facilities such as parking or picnic tables, 'naturalness' of the beach system (presence of dunes, seawalls etc), and parking costs. This is identified as a potential future avenue of research, and is discussed further in the concluding chapter.

3.5.7 *Application to the current study*

My own view is that Choice Modelling is preferable to contingent valuation for policy applications, given the greater richness of attribute preferential data that is generated. The method also has greater potential for use in benefit transfer applications, and can be designed to provide non-monetary information which is of use in alternative appraisal approaches such as Multi Criteria Analysis.

Ultimately, the desire for transferability of the survey methodology placed limitations on the complexity of the survey instrument. The lack of previous applications in the coastal zone was of concern to some stakeholders, and was raised in review of grant reports to the funding body associated with this project. Choice modelling has greatest application in two stages of the Coastal Zone Management process of NSW, namely the selection of policy options and the prioritisation of those options. The site selection process undertaken in this study recognised a strong risk-management focus of the expert panel. The presence of pre-existing Coastline Management Plans was also a selection criteria used in the ranking of nominated case-study sites. As a result there was limited opportunity to provide direct input to the policy process in terms of selecting options.

It should also be noted that there is potential for coastal managers to be reluctant to employ valuation methods which explicitly outline coastal management alternatives under consideration if they are likely to generate strong responses from the community. It is rare in Australia that the broader community is directly involved in the selection of coastal policy options, although they may be represented on a Coastal Management Committee (or similar). Choice modelling is a potential future avenue of work, outlined in Chapter 7.

3.5.8 *Choice method applications*

Choice modelling (CM) has recently been used to estimate the economic impact of beach closures (Huang et al., 2007). This study also investigated the importance of negative influences such as erosion impacts outside the project area, and water quality influences. The results indicated that both the negative and positive effects of an erosion-prevention project should be included in the choice set to ensure valid results (Huang et al., 2007).

Failure to consider the availability of substitute sites may lead to an overestimate of the value of a single site. Conversely, failure to consider the potential for reduced utility due to an increase in visitation at substitutes sites may result in underestimation. Boxall et al. apply both CVM and CM to derive economic estimates of the impacts of forest management practices on moose hunting, and find significant differences. Examination showed that respondents were ignoring substitute sites in the CVM experiment, whilst they were specifically outlined in the CM component. Restriction of the CM to consideration of single sites produced comparable estimates(Boxall et al., 1996). Whilst in a vastly different field, this suggests that substitute sites are also likely to be of importance in determining WTP to prevent beach closures.

Two recent studies examine the response to water quality in the Carribean nation of Tobago (Beharry-Borg et al., 2009, Beharry-Borg and Scarpa, 2010). Water quality was specifically excluded from the scope of this study. Nevertheless these studies provide some important findings and suggest future avenues of work. The first study examined the choice of beaches within groups, first at the individual level and then at the group level (Beharry-Borg et al., 2009). The analysis explored the contribution of each individual's preferences to the group choice between beach destinations, which were described by different attribute levels relating to water quality and beach 'quality'. The beach quality attributes employed were the amount of plastic debris found on the beach and the level of coastal development. Two levels were used for the coastal development attribute, 25% and 75% developed, respectively. This classification is not defined further in the paper in terms of the type or height of development (Beharry-Borg et al., 2009).

In addition to the interesting finding that the woman's preferences contribute more to the joint decision of a couple, this paper also highlights the importance of the decision-making process in valuation estimates. Little attention has been paid in the contingent valuation literature to whether respondents are answering on behalf of themselves, or on behalf of their household or other group. This has particular relevance for methods based on random utility theory, which consider multiple sites and are likely to involve a more complicated decision-making process (Beharry-Borg et al., 2009).

The second application used latent class and mixed multinomial models to identify differences in preferences between snorkellers and non-snorkellers, and found there were significant differences in mean WTP for water quality improvements between the two groups (Beharry-Borg and Scarpa, 2010). This highlights the importance of effectively sampling all user groups for multiple-use resources such as beaches. This requirement, while recognised by many, presents numerous challenges for those wishing to value beach and nearshore recreation, as user groups may have vastly different patterns of usage (Nelsen et al., 2007).

Huybers and Bennett conducted a simple multinomial logit choice modelling experiment which explored the preferences of UK tourists for attributes of beach holiday destinations (Huybers and Bennett, 2000). Whilst the attributes employed do not directly relate to beaches, and are generalised to the extent that their usefulness must be questioned (see Table 1, p28. of the reference), the destinations chosen for comparison are all noted 'beach destinations'. One of the unusual and highly laudable aspects of this study is that potential tourists were surveyed before they made their destination choice, through a self-completed drop-off pick-up survey delivered to their residence in the UK (Huybers and Bennett, 2000).

3.6 Valuing protection and amenities – the hedonic pricing method (HPM)

As a response to RQ5, a hedonic approach is necessary. This method looks at the influence of environmental amenities on the values in a distributed market, typically the labour or residential markets. By establishing relationships between the amenities and market prices, the implicit value of the amenities can be inferred.

3.6.1 *Underlying theory and origins*

The hedonic pricing method takes its name from the Greek word for pleasure, implying that property purchasers act in a way to maximise their own utility (Edwards and Gable, 1991).

Edwards and Gable argue that the term 'hedonic' refers to psychological, rather than ethical hedonism, which results in utility-maximising rather than selfish action (ibid, p 39).

The method has its theoretical basis in composite good theory (Lancaster, 1966, Rosen, 1974), in that goods are typically made up of a number of component attributes, and that the total value of that good is a function of the values of the components. It is therefore possible to determine part-worths of the components. The method works by determining the relationship between variations in the amount of environmental attributes of interest and prices paid in an existing market, from which demand for the attributes may be inferred (Rosen, 1974). Citing the original text:

> *"The hedonic hypothesis [assumes] that goods are valued for their utility-bearing attributes or characteristics. Hedonic prices are defined as the implicit prices of attributes and are revealed to economic agents from observed prices of differentiated products and the specific amounts of characteristics associated with them. They constitute the empirical magnitudes explained by the model. Econometrically, implicit prices are estimated by the first step regression analysis (product price regressed on characteristics) in the construction of hedonic price indexes." (Rosen, 1974)*

The HPM is a surrogate market or indirect valuation method, as it involves calculating the effect of a non-market environmental characteristic through its impact upon the price of another product, which may be assessed through market means (Tribe, 2005). The two differentiated markets typically used in hedonic calculations are wages and property values (Palmquist, 1988). The application of HPM of interest to this study is in calculating the effect of environmental attributes, such as proximity to the ocean or a pleasant view, on property values in the housing market (Pearson et al., 2002, Lockwood and Tracy, 1995). The assumption in these analyses is that people are willing to pay more (referred to as the environmental price premium) for an increase in a desirable attribute, such as a view of a natural feature (Pearson et al., 2002), or reduce exposure to undesirable attributes such as noise pollution associated with a highway.

Property values are compared with property variables (size, frontage, land zoning), neighbourhood variables (location, access) and environmental variables (distance to ocean, air quality, aircraft noise), and regression analysis is used to determine the contribution of each attribute to the total price. Willingness to pay for the environmental characteristic can then be calculated. Location variables can include proximity to features (such as roads, parks or beaches), and more complex spatial variables such as the amount of green space in the surrounding area or the presence of views (Bastian et al., 2002, Geoghegan, 2002, Geoghegan et al., 1997).

A generic hedonic regression function is presented thus:

$$V = f(P, A, E) \qquad [3.6]$$

Where V represents house value, P represents property characteristics (area, frontage, zoning), A represents accessibility characteristics (road class) and E represents environmental characteristics (proximity to coast, proximity to shopping centre).

3.6.2 *Advantages and limitations of HPM*

A key advantage of the Hedonic Pricing Method is that it is able to capture use and amenity values of a natural resource that are enjoyed by the local residents, while employing a revealed preference valuation technique.

Bias against the use of stated preference models mean that the use of revealed preference methods is preferred by decision-makers (Adamowicz, 2004). The travel cost method (TCM) is the most commonly applied form of non-market valuation (NMV), but can present challenges in urban applications where variation in travel costs is insufficient for construction of a travel demand curve. The TCM was developed for valuation of national parks, where good entrance records are more likely to exist. In the case of urban parks and reserves with open access, these records are typically unreliable or non-existent. The challenges in non-market valuation presented by the lack of reliable visitation data are elaborated upon in Chapter 4. The HPM thus presents a method to value the use of the resource by local residents, which may be the information of greatest relevance to local decision-makers.

As it relies on actual behaviour in existing markets, this method is theoretically sound, and is in fact the underlying theory behind component valuation, which is the most common form of property valuation in many countries. Expert opinion (e.g. Land Valuer) is therefore available to identify the attributes likely to have the greatest influence on property prices (Pearson et al., 2002). The development of Geographic Information Systems has also made this approach much simpler through easy measurement of property attributes, distances to key features such as the coastline, and spatial measures of complexity of the surrounding area (Geoghegan et al., 1997, Bastian et al., 2002).

Unless there is sufficient variation in values and sufficient sample size, it will not be possible to identify reliably estimate attribute demand functions. It is also critical that the attributes selected are responsible for sufficient variation in marginal prices for results to be reliable (Ohsfeldt and Barton, 1985). Given the strong relationship between Sydney property prices and proximity to the ocean, even at the suburb level, this requirement would appear to be satisfied.

A further limitation of the hedonic model is that the environmental price premium identified in local hedonic studies does not capture the increased price of all land in the locality, only the marginal difference in the attributes. Thus the overall differences in regional land prices outlined in Table 2.2 are not considered, only the differences within the case study area. This may underestimate the value of the amenities under consideration.

There is also a challenge where environmental attributes of interest are correlated. In the case of Collaroy-Narrabeen, this leads to challenges in distinguishing the relative importance of the lake and the beach in determining local property values. The case-study location can be seen in Figure 3.2, and is further discussed in Chapter 6. Bin and Polansky discuss these challenges with regards to their valuation of proximity to both coastal wetlands and the open ocean (Bin and Polasky, 2003). Proximity to coastal wetlands is highly collinear with distance to the ocean, so it is difficult to disentangle these, and there is inherent bias in the parameter estimate for coastal wetland proximity. Their study also examined properties which are all relatively close to wetlands (within 1 mile on average), so the marginal changes due to proximity may be obscured (Bin and Polasky, 2003).

The HPM assumes that there are negligible transaction costs, which is rarely the case in the property market. In some market states, however, rapid increases in property values mean that the ease of selling property minimises the effect of transaction costs (Brookshire et al., 1982). Whether this is the case for purchases, however, is highly debatable. The influence of transaction costs can be overcome through the use of unimproved land values, which are routinely calculated in NSW for rating purposes and Land Tax assessments. There are no transaction costs associated with these valuations, as they are conducted by the State Government.

A further key assumption of the HPM is that people consider the environmental attributes in their purchase decisions, and that they are aware of and able to react to changes in the quantity of the good. This is examined further in Chapter 6, with reference to consideration of risk in property transactions.

3.6.3 *Previous applications of HPM in beach valuation*

The international literature relating to application of hedonic analysis in the coastal zone is quite extensive (Hamilton and Morgan, 2010, Parsons and Noailly, 2004, Pompe and Rinehart, 1995, Taylor and Smith, 2000), albeit limited in spatial extent (Pendleton et al., 2007). The following sections break this literature into categories, based on the coastal amenity that is the focus of the study. It is assumed that the beach amenity values identifiable in hedonic studies are derived from three main sources, pleasant views (Fraser and Spencer, 1998), access for recreation (Edwards and Gable, 1991) and property protection (Dorfman et al., 1996, Kriesel et al., 1993). More detailed analyses attempt to discern also the issues of beach quality.

Disentangling the sources of value is problematic, as environmental attributes in hedonic regressions are often highly collinear, which precludes identification of the relative contribution of individual attributes (Pendleton and Shonkwiler, 2001). This is particularly true in the case of coastal hedonic studies, where exposure of the property to coastal risks (erosion and inundation) and access are inversely linear in relationship. Thus valuation of beach quality (using width as a proxy) will involve implicit consideration of risk, and vice versa (Gopalakrishnan et al., 2009). Those properties with beachfront locations will also have the most complete viewsheds (Morgan and Hamilton, 2009), hence efforts to separate aesthetic and use values provide challenges in application. As a result, the classifications used in delineating the following sections are somewhat arbitrary, though they serve to illustrate the key applications.

3.6.3.1 Proximity to the coast – paying for access

Proximity to the coast is the most commonly used regressor of interest in coastal hedonic studies. Proximity is used as a proxy for the availability of beach and shoreline related services and amenities (Parsons, 1991, Brown and Pollakowski, 1977, Shabman and Bertelson, 1979, Edwards and Gable, 1991). Proximity to the coast has a large effect on property prices in most published studies, with rapid decay in property prices as distance from the ocean increases (Milon et al., 1984, Shabman and Bertelson, 1979, Earnhart, 2001). Milon et al. found a drop of 36% in property values when moving 500 feet (approximately 152.4 metres) from the Gulf of Mexico (Milon et al., 1984). Beach frontage is prized most greatly of all, as it provides uninterrupted views and unimpeded access. Beachfront locations are analogous to ski-in ski-out locations in mountain resorts. They provide the most exclusive and non-excludable beach access rights. Hence frontage is often incorporated into hedonic models. An innovative study on residential property rentals demonstrated that oceanfront properties were rented for up to 60% more than other similar properties in the same area (Taylor and Smith, 2000).

Bin and Polasky also estimated the relative value of ocean frontage (among other features) in residential property in North Carolina, and found that there were very large environmental premiums paid for this characteristic. These translated to a premium of US$182,000 (138% increase) for water frontage on mainland properties, and US$80,000 (33.8% increase) for oceanfront properties located on barrier islands. These compare to average property values for the two locations of US$132,000 and $237,000 respectively, with all figures in 2004 US dollars (Bin and Polasky, 2003).

Interestingly, this paper found that inland wetlands depressed local land values, whereas coastal wetlands resulted in an uplift of surrounding land values of mainland properties. Possible reasons for the negative amenity of inland wetlands (suggested by myself, not the original authors) may be the fact that these features may be associated with increased mosquito infestation and risk of flooding. There was no significant effect of the presence of coastal wetlands on barrier island properties, which may reflect the fact that these properties are already close to the ocean, which presumably duplicates the recreational amenities that the coastal wetlands would otherwise be providing (Bin and Polasky, 2003).

Those who live or stay closer to the beach have incurred additional sunken costs due to higher property prices in coastal locations (Parsons, 1991). In the case of recreational amenities, the property prices will include a discounted value or the expected benefits accruing from ownership of the property over the duration of ownership (Edwards and Gable, 1991). The willingness to pay this environmental premium stems from a desire to maximise the consumer surplus (CS) from their recreational activities, by co-locating with their recreational locations and minimising travel costs incurred per visit (Edwards and Gable, 1991). It follows that they most likely have stronger preferences for the amenities beaches provide than those who were unable or unwilling to purchase the property (Edwards and Gable, 1991).

Given sufficiently long time horizons, and reasonable personal discounting, recreation values can be estimated from property values in instances where travel cost surveys will display insufficient variation for effective analysis (Edwards and Gable, 1991). This allows for application in valuing beaches located close to residential areas, for which substantial visitation is generated from the local area, with minimal travel expenditures. It is possible to convert these capitalised streams into recreational values per year (t) using the following equation:

$$CS_t = PV * \frac{\left(1-(1+r)^{-T}\right)}{r} \qquad [6.1]$$

Where CS_t is consumer surplus in time period t, PV is the present value of the property, r is the discount rate, and T is the time horizon selected.

Based on this process, Edwards and Gable used household income and distance to the beach to estimate the demand for recreational amenities for households. They derive capitalised values of around US$20,100 per household (1980 USD). On first approach these figures seem high, although the author rightly points out that they represent WTP for coastal recreation opportunities over the entire length of property ownership (time periods of 50 and 25 years are used in the analyses presented in the paper). Given that travel cost and contingent valuation studies can cite daily usage values in the tens of dollars (as outlined in Chapters 5 and 6), this does not seem unreasonable, particularly given that coastal property owners presumably derive greater utility from beach recreation than a typical survey respondent. Whilst the analysis is by the authors' own admission simplistic and exploratory, it provides an interesting comparison with nourishment costs (Edwards and Gable, 1991).

3.6.3.2 Value of open space

Beaches and their adjacent reserves represent open or community space, which may be at a premium in urbanised locations. There is an extensive literature on the valuation of open space, which provides some guidance on the similarities and differences in the way that coastal open space is valued relative to other areas such as parks and forests (Anderson and West, 2006a, Bowman et al., 2009, Geoghegan, 2002). GIS technology has made the analysis of complex landscape functions possible (Geoghegan et al., 1997). For example, analysis of a measure of the degree of open space or density of housing in a given area around a property would be incredibly labour intensive without the spatial analysis capacity of GIS. This capacity has not yet been fully exploited in urban or environmental economics (Kong et al., 2007, Brasington and Hite, 2005).

Value of proximity to open space is not constant, but varies in line with other variables, and using average values may substantially under- or overestimate the true effect (Anderson and West, 2006). The value of open space was found by Anderson and West to be highest in areas with high crime, high income, high density, areas with large families, and areas in close proximity to the CBD. Many of these variables vary collinearly. It is unsurprising that residents of higher density inner suburbs place a greater premium on open space than those in outer suburbs, as this reflects decreasing marginal utility. Given standard urban geography theory, the price of land closer to the CBD is typically higher than in outer areas (McKenzie et al., 1967). Hence, for the open space, (which typically does not generate substantial income) to have remained it must have been considered highly important. This is the case even if the continued existence is preserved by legislation, rather than economic forces, but in this case the value is implicit rather than explicit.

3.6.3.3 Complex measures of proximity and access

All of the aforementioned studies use linear measures of coastal proximity (Rush and Bruggink, 2000), or dummy variables to account for location in a categorical manner (Parsons and Noailly, 2004). Simple measures of distance assume that the availability of these amenities is homogenous along the length of the beach, and that the limiting factor is accessibility. More recently, network-based distance measures have been used in place of Euclidean distances in identifying proximity value (Morgan and Hamilton, 2009).

Use of network analysis can imply a degree of accuracy that may not reflect the realities of beach usage. A true measure of network distance for urban beaches would require a cost-weighted network that incorporates travel density and time of travel. Travel times in Sydney can vary greatly by weekday and time of day, with significant traffic congestion and parking difficulty often experienced around popular beaches in peak periods. Consideration of different travel modes is also important, as those within a certain distance may travel by foot, whilst those residing at greater distance are likely to travel by another form of transport initially (private vehicle or public transport), and complete their journey on foot. The travel cost component of this study (Chapter 4) identified that the majority of non-resident drivers, who do not hold parking permits, choose to park outside the paid beach parking areas, hence their travel is not to the beach access point but to a nearby location, which is conditional upon availability. This is therefore the theoretically appropriate point to which network distances should be measured, although the location cannot be known in advance.

3.6.3.4 Beach width – paying for quality

Width is often used as a proxy for beach quality in the hedonic literature. Rinehart and Pompe are two authors who are responsible for much of the original research relating residential property values to the state of the beach (Pendleton et al., 2007). These authors investigated the effect of beach width on the property market in South Carolina, and found that for a 10% increase in width there was a corresponding house price increase of 2.6%. This effect diminished with increased distance from the coast (Rinehart and Pompe, 1994). This has key implications for future beach management decisions, particularly in relation to nourishment regimes and land tax revenues.

In a subsequent paper, the same authors used hedonic means to estimate the marginal benefit of an additional foot of beach width, which exhibits the expected decay with increasing distance from the coast (Pompe and Rinehart, 1995). What was somewhat unexpected was the difference in the way in which increased beach width affected developed and undeveloped properties. For beachfront properties, the benefit of an additional foot (increasing from 79 to 80 feet) was greater for undeveloped lots than for developed lots, with the marginal increase in lot values being US$754 and $558, respectively (in 1983 currency). The reverse effect was found on examination of properties which were located half a mile from the coastline (Pompe and Rinehart, 1995). The authors attempt to explain the difference through the fact that the sample area had not been affected by a hurricane recently, so current property owners may not place as much value in the added protection afforded by the change in beach width (p152, Pompe and Rinehart, 1995). An alternative hypothesis is that the change is too small to be perceived by the market, and that the reported variability is somewhat coincidental.

There are two conflicting but not mutually exclusive reasons for the difference in marginal WTP for beach width between undeveloped and developed lots. It is possible that the vacant beachfront land may be more highly valued in risky locations, as adaptive building practices can be employed to ensure longevity of use, whereas retrofitting existing housing stock may be expensive or impossible (Michael, 2007). Conversely, the increased cost of building may be a deterrent to the purchaser, whereas the owners of existing structures will have already made significant financial outlays and are willing to pay more to ensure the investment is protected.

Further work by Pompe used an interaction term encompassing distance from the beach and width to estimate WTP for beach width (Pompe and Rinehart, 1999). He estimated that an additional foot of width was worth approximately US$194 to developed property and US$310 to undeveloped properties, provided they were in oceanfront locations (1989 USD). For non-oceanfront properties with ocean views, the differential is reduced, with developed and undeveloped properties indicating WTP for an extra foot of beach width of approximately US$143 and $264, respectively. Properties without a view again display the reverse differential, with undeveloped properties WTP more than developed properties, at around

US$74 and $44, respectively, for an additional foot. The same explanations as detailed above can be employed to explain this differential, although concerns are raised again (including by the author) about the small sample sizes (Pompe and Rinehart, 1999). There must be limits to the conclusions that can be drawn from sample sizes for developed and undeveloped oceanfront properties of 5 and 9, respectively.

3.6.3.5 Dynamic inclusion of beach width

Typically, beach width is assumed to be a static variable, ignoring the fact that beach width on open coastlines may be highly variable at a range of temporal scales, from the tidal to the interdecadal (Short and Trembanis, 2004, Ranasinghe et al., 2004). Thus these studies can only ever provide a snapshot estimate of the value of beach width, based upon the current and historical beach conditions at the time the market data was captured (Gopalakrishnan et al., 2009). It must also be suggested that the degree of accuracy implied by the regression is unlikely to reflect the perceptive power of the property purchaser. With the possible exception of oceanfront property which is sold by onsite auction, it is unlikely that the purchaser has precise beach width information at the time of the transaction.

More recent applications have attempted to account for this variability, and to determine economically optimal nourishment frequency and volume (Yohe et al., 1995, Gopalakrishnan et al., 2009, Smith et al., 2009). Yohe et al. determined the optimal duration of protection through nourishment for communities in South Carolina, incorporating depreciation of the protected structures (Yohe et al., 1995). Smith et al. consider beach nourishment as a dynamic capital accumulation problem, including beach width, erosion rates and the benefits and costs of the proposed nourishment project (Smith et al., 2009). They consider the model as akin to determining optimal harvest (rotation) periods in forestry economics. Decisions about nourishment are often justified on the basis of hedonic studies identifying the importance of beach width in determining local property values. However, these nourishment projects in turn influence the strength of the underlying hedonic relationship. The findings of this study are on the whole, not earth-shattering, as they find that increased property values, erosion rates, WTP for beach width all result in an increase in optimal nourishment frequency, as do lower discount rates and costs of nourishment (Smith et al., 2009). These are all intuitive results, whereas the conflicting results generated through increases in costs of sand for nourishment and the rate of loss of sand post-nourishment suggests that the model requires further testing and calibration.

Gopalakrishnan et al. extend this work to integrate coastal geomorphology and beach nourishment schedules with hedonic estimates of WTP for beach width (Gopalakrishnan et al., 2009). This is the first study to explicitly account for the fact that there is a feedback between erosion rates, beach width and time between nourishment interventions. They construct a model such that the value of coastal property is a function of beach width, which is in turn a function of morphological factors (distance from the continental shelf and 'beach state' as estimated through the presence of beach scarps) and time in relation to nourishment and erosion cycles. They find that the estimate of WTP for beach width is around 3 times that found in typical hedonic studies where beach width is considered as a constant exogenous variable (Gopalakrishnan et al., 2009).

3.6.3.6 Coastal protection structures – paying for protection

Whilst beach nourishment provides a measure of property protection, it also increases recreational opportunities through widening beaches, and separation of these components is complex (Pendleton and Shonkwiler, 2001). There is also persistent debate about the effectiveness of beach nourishment for property protection, both on practical and economic grounds (Charlier and De Meyer, 1995, Hillyer et al., 1997). An alternative means of examining WTP for reduction in risk is therefore through examining the market influence of coastal protection structures, as these structures provide the protection services, but not the recreational opportunities (Kriesel et al., 1993). This has been undertaken by previous authors in relation to both residential property (Kriesel et al., 1993), and to holiday accommodation (Hamilton, 2007).

The market for protective services was investigated by Kriesel et al, in examination of property prices for lakefront property in the presence and absence of terminal erosion protection services (Kriesel et al., 1993). Kriesel et al. estimated the value of protective structures through an estimate of the number of years of erosion (at the current rate) until the property itself would be experiencing erosion, a factor they call GEOTIME (Kriesel et al., 1993). They then estimate WTP for structures which would provide an additional year of protection, and structures which would provide a further 20 years, arriving at values of US$34,540 and $48,710, respectively (Kriesel et al., 1993).

Hamilton examined the influence of coastline protection structures on the price of nearby accommodation, using district averages rather than individual apartments (Hamilton, 2007). It was predicted from this relationship that increasing the length of coastal dykes would result in a decrease in the prices of accommodation in the local area, with the reverse effect expected for an increase in open coast. This indicates that tourists have a preference for more natural coastlines. Further comparison of the costs of coastal management options and expected changes in accommodation revenue favoured the use of beach nourishment over dyke construction (Hamilton, 2007).

3.6.3.7 Consideration of risk in property purchases

Kask and Maani include a factor for self-protection expenses in the utility maximisation function of purchasers of property in areas where there is exposure to a hazard. The implicit assumption is that the properties closer to the hazard will be less expensive than those further from the hazard (Kask and Maani, 1992). This is contrary to the findings of most beach proximity valuation, which indicate a strong preference for beach frontage, almost irrespective of the risk associated with that location. There are two main sources of risk to properties located in the coastal zone, inundation and shoreline erosion (Aboudha and Woodroffe, 2006). It appears that these risk factors are not considered equally by property purchasers, however, with studies typically indicating depression of property prices located in areas which are subject to flooding or inundation. Properties located in areas exposed to wave action, however, are typically subject to price premiums (Bin and Kruse, 2006). This is presumably due to the overriding importance of amenities provided by open coastlines, which are not perfectly replicated by locations with protected water bodies.

Bin and Kruse examine the effects of hazard zones on real estate prices in Cataret County, North Carolina, and estimate that location of properties within a flood zone delineating the 1% Annual Exceedence Probability (AEP) sell for a discount of around 10% above properties that are otherwise similar but located outside the flood hazard zone (Bin and Kruse, 2006). Interestingly, this finding seems to have been cited as demonstrating the reverse effect in a subsequent paper prepared in part by the same authors (Bin et al., 2008). Donnelly also identified the depression of market values of property located on a floodplain (Donnelly, 1988).

Conversely, an earlier study by Bin and Kruse found properties on barrier islands located in a zone exposed to wave action contributes a price premium of 27%, indicating that the disamenity of risk is outweighed by the positive amenity due to proximity to coastal water. For mainland properties, the effect was even greater, accounting for a premium of 61% above otherwise similar property (Bin and Kruse, 2006).

3.6.3.8 Coastal views

Views are often mentioned in real estate advertisements, and are presumably considered by purchasers of coastal property. Numerous studies have demonstrated that residents are willing to pay more for a pleasant natural view (Gillard, 1981). Coastal or ocean views have been investigated by numerous authors (Fraser and Spencer, 1998, Rinehart and Pompe, 1999, Benson et al., 1998, Samarasinghe and Sharp, 2008). Samarasinghe and Sharp found that a wide ocean view contributed a premium of 44%, in analysis of coastal property prices in Auckland, and that this contribution was greater than views of non-water areas (Samarasinghe and Sharp, 2008). The scope of the view was also considered, with wide views more highly valued than narrow views. Benson et al. report similar findings, with high quality ocean views attracting a premium of 60%, and low quality views only an 8% premium. Views were also found to vary inversely with distance, such that a distant view is less valuable than a closer view, adjusting for quality (Benson et al., 1998).

When such large premiums are identified for coastal views, some concerns must be raised about the extent to which views can effectively be separated from non-aesthetic coastal amenities. Properties with views are typically located in close proximity to the coast. Consequently, care must be taken to ensure that other accessibility variables are not being captured in analysis of the value of coastal views. A number of authors have used Light Detection and Ranging (LIDAR) derived digital elevation models and three-dimensional viewscape analysis in GIS to more accurately estimate views, in an attempt to separate the 'view’ part-worth from the 'access’ value (Paterson and Boyle, 2002, Bin et al., 2008, Samarasinghe and Sharp, 2008).

The preoccupation in hedonic literature with the precise quantification of viewscapes is curious, and considered unnecessary. Whilst studies have estimated the economic importance of a 1 degree change in view angle (Bin et al., 2008, Hamilton and Morgan, 2010), it seems incredible that a property purchaser would employ the same degree of accuracy in assessing the view when considering their investment. It is likely that the views would be assessed on some form of categorical scale, such as was commonplace in previous studies (Pearson et al., 2002, Fraser and Spencer, 1998). Hence, whilst GIS software allows for precision, this degree of accuracy is not considered important in a policy context.

In the case of beachfront property, quantification of viewsheds in the manner detailed by previous studies (Bin et al., 2008, Hamilton and Morgan, 2010, Paterson and Boyle, 2002, Yu et al., 2007) may also fail to include important factors which influence the importance of that view, such as the ability to see breaking waves or the sandy beach (Price, 1995). Given the importance of North Narrabeen as a surfing location, the ability to see the surf break is likely to be a determinant of value for at least some of the population.

3.7 Non valuation method - Benefit Transfer

Given the time and expense associated with empirical benefit estimates, benefit transfer (BT) has been suggested as a means of more rapidly assessing the value of a site, particularly in cases where the decision-maker does not require highly accurate results. BT is a rapid assessment tool which can be used when time and resources are limited, or where an estimate of the order of magnitude of value of a resource is sufficient for decision-making.

This method draws on previous valuation studies for the same natural resource, and transfers the values calculated (or benefit function derived) in the previous study to the new site. The site at which the previous study has been completed is termed the ‘study site’. The site to be valued is termed the ‘policy site’ (Robinson, 2001). This may be through unit transfer, which is the direct transfer of benefit estimates on a per-unit basis, or benefit function transfer, in which the characteristics of the policy site are inputted into the benefit function from the study sites, and the benefit estimate is calculated (Downing and Teofilo Ozuna, 1996).

This method is the subject of much debate within the economic profession (Barton, 2002, Rosenberger, 2005). Of particularly relevance to the issue of beach valuation is the fact that the majority of beach valuation studies undertaken elsewhere in the world were completed at least ten years ago (Pendleton et al., 2007). This raises the issue of the temporal reliability of benefit estimates.

A key assumption made when using this method is that the resource and the relevant population are highly similar at both sites. This assumption is not always valid, and hence caution must be used when transferring values between sites, or adjustments must be made. Even where contextual adjustments are made in the benefit transfer process, the values derived may differ significantly from empirical studies using the same valuation instrument at nearby sites (Barton, 2002).

A significant problem for beach valuation benefit transfer is the fact that a majority of studies are not readily available, as they exist in the 'grey literature', having been completed as consultancy or government reports. This indicates that there is a strong unmet desire for economic valuation information from the policy side. It may also be symptomatic of an academic community that is somewhat disdainful of empirical environmental studies, given that they may not adhere to the strict theoretical guidelines for the tools applied, and may be seen more as part of a census-like cataloguing of environmental values (Hajkowicz, 2007, Nunes and Bergh, 2001). There may also be restrictions on publishing studies or results that are based on confidentiality clauses included in research contracts. This may result in challenges for publication of studies within the academic literature, which in the 'publish or perish' framework will result in lower citation indices and impacts on career advancement or status.

Notwithstanding the considerable theoretical issues associated with the use of BT, the potential savings in time and resources expended suggest that there is merit in a review of the Australian beach valuation literature. This is addressed in the next section.

3.8 Existing Australian beach valuation studies

Despite a critical and widely acknowledged need for value estimates for coastal resources, the Australian primary beach valuation literature is so small in extent that it is presented here in full to demonstrate the need for further empirical studies. I freely acknowledge that the unavailability of much of the 'grey' beach valuation literature means that this review is restricted in the most part to published papers and reports.

3.8.1 *Contingent valuation*

Pitt used the contingent valuation method to investigate community preferences for dune management to preserve native vegetation (Pitt, 1992a). The payment vehicle employed was an increase in rates per household. This work was updated in a later conference paper (Pitt, 1997). The use of bid ranges rather than point estimates and the translation of values derived from beachfront residents to the broader population introduce concerns such that the studies are not considered suitable for benefit transfer.

3.8.2 *Travel Cost*

Pitt applied a zonal travel cost model to estimate the economic impact of tourists to three beaches on the north coast of NSW (Pitt, 1992b). Resident beach users are not included in the analysis, presumably due to the challenge of determining travel costs. He does not incorporate travel time considerations, but does include expenditure on recreation equipment, which may indicate an overestimation as this equipment may be used elsewhere. The availability of substitute sites was not considered, hence the importance of the beaches valued is likely to be an overestimate (Pitt, 1992b).

Raybould and Mules (Raybould and Mules, 1999) examined historical tourism data to estimate a relationship between beach erosion events and visitation. In order to determine the economic impacts of beach erosion, they compared tourism revenue in periods immediately after known erosion events with the 'expected' revenue based on reference years with no significant erosion. This was then used in cost-benefit analysis of a proposed beached nourishment program to estimate the economic impact of these events, which required large scale beach nourishment and ongoing maintenance over a 25 year period. Whilst not a true travel cost model, this methodology has intrinsic appeal for the valuation of climate change and storm impacts on beaches. Previous studies have demonstrated strong linkages between the state of beaches and tourism revenue in coastal cities (Phillips and Jones, 2006).

The studies suggested that erosion events with recurrence frequencies of 5, 10, 25 and 50 years would result in 2%, 5.5%, 13% and 20% reductions in annual tourism revenue, respectively. The authors suggested that the proposed project would reduce the impact of these erosion events, and hence generate 'savings' in lost revenue. These savings were related to the costs of the proposed project, which resulted in a benefit-cost ratio of at least 17 to 1, using relatively conservative factors in the analysis (Raybould and Mules, 1999).

Raybould and Lazarow conducted a simple tourism expenditure analysis to estimate the social and economic importance of Gold Coast beaches, using mail-back surveys (Raybould and Lazarow, 2009). It is not a true travel cost approach, as there is no construction of a demand function, with expenditures simply multiplied by a broad estimate of visitation. No allowance is made for the opportunity cost of travel time, as it is assumed to be time spent in leisure and hence not subject to the same tradeoffs between travel time and cost that are typically reported in commuter studies.

Raybould and Lazarow encountered similar challenges to those found in this study when attempting to estimate the relevant population of beach visitors. This is despite the fortunate fact that the Gold Coast represents a discrete visitation area for national and international visitor surveys, and is relatively well studied. Given the limitations of the theoretical approach used in this study, it is not reported further, although it is noted that the results are widely cited and appear to be adequate for management purposes. Despite vocal argument to the contrary, it would appear that the degree of accuracy required for government decision-making does not always necessitate the most recent advances in theory, or strict adherence to principles of appraisal methods (Dobes and Bennett, 2009).

Blackwell employed a number of truncated negative binomial regression models in the valuation of recreation at Mooloolaba beach (see Figure 1.1) in Queensland (Blackwell, 2007. The models incorporated income, on-site and off-site expenditure in a number of different combinations. Blackwell included only the 'side trip' value, unless the trip to the beach was the 'central purpose'. Thus the estimates are conservative, and in line with the approach used in the current study. The estimate of average travel cost is AUD$14±3 (95% confidence) in 2007 dollars, which suggests higher use values than those found in the Australian literature for national parks and forests. Blackwell employs a wage rate of 40% for travel time calculations. Hence the estimates are scaled upwards from those employed in this study.

Two hundred and fifty groups were surveyed through systematic sampling, with every third group encountered as the interviewer traversed the beach asked to participate in the survey. Non response rates are very low, at 1.9%. Whilst formal response rates are not reported in the current study, they were similarly high. It would appear that there is a high degree of interest in the management of coastal resources. Some caveats must be applied to these response rates however, as they do not take into account the fact that many user groups may be neglected or under-sampled. For example, surfers, swimmers, joggers and cyclists are notoriously difficult to sample in beach intercept surveys.

It would appear that Blackwell has surveyed an avid, local sample, given the frequency of visitation of those surveyed (48±9 visits p.a.), although recall bias and prestige bias may also be explanations for high reported visitation frequency (Blackwell, 2007). It is often assumed in expenditure surveys that respondents have perfect recall over periods of up to 12 months. This is despite the fact that comparative analysis of responses via recall and diary methods has demonstrated statistical differences in reported expenses between the two approaches (Faulkner and Raybould, 1995).

Resident income is lower than that of visitors, as in the current study. This is likely to reflect the fact that those engaged in full time employment are unable to visit the site as frequently. Residents were found to visit the beach more frequently than visitors, which is expected based on the original premise of the model (Hotelling, 1949). Residents also visited substitute sites more often than visitors, who were more likely to have a favourite site. This may reflect a lack of familiarity with substitutes, or the fact that pure substitutes are not available. Studies on mountain climbers in Colorado have demonstrated that the lack of perfect substitutes can increase welfare estimates (Keske and Loomis, 2008).

Hundloe performed both TC and CVM studies to assess the impact of crown of thorns starfish (Hundloe et al., 1987) and coral bleaching on the Great Barrier Reef. Whilst considering a completely different resource type, and one that is of international significance and hence unlikely to be representative (King, 1995), the values used in this study are sometimes employed in the assessment of costs and benefits in Coastline Management Plans in NSW.

A recent study conducted at Jurien Bay in Western Australia (see Figure 1.1) examined the social preferences for coastal viewscapes, employing a double-bounded dichotomous choice model to estimate the welfare impacts of wind turbine placement in the dune environment, as opposed to a more landward location (McCartney, 2006). The impacts on the 'dune view', and that of the 'coast-ocean interface' were valued, with mean WTP for the two categories estimated at AUD$36.16 and $34.28 respectively. This suggested an economic argument for the preservation of coastal viewscapes.

3.8.3 *Hedonic pricing*

There are few Australian applications of the hedonic method in an environmental context, and even fewer related to beach or coastal amenities. When hedonic approaches have been applied, they have tended to focus on the presence or absence of coastal views, particularly views of the ocean. Whilst of theoretical interest, and relevance to property valuation and planning purposes, there is limited scope for the coastal manager to increase the availability of ocean views, as this is primarily determined by local relief and planning restrictions on building heights.

Viewscapes are preserved in the case-study area through the definition of Beach Precincts, which are subject to planning restrictions under the *Warringah Local Environment Plan 2000* (WLEP2000). Brookshire (Brookshire et al., 1982) also makes a valid point in the consideration of views in hedonic studies, in that scenic vistas may be unique, so how can they be valued if they are practically irreplaceable? Hence the studies which focus on ocean views have limited application in the policy response to climate change impacts, though they are discussed here in an attempt to provide a comprehensive assessment of coastal hedonic studies in Australia.

Mcleod looked at WTP for different residential properties in urban Perth (Western Australia, see Figure 1.1) particularly proximity to rivers, parks and highways (McLeod, 1984). Abelson examined the effect of various location and property attributes on the price of properties in Sydney. These included the presence of a good view and exposure to aircraft noise. Abelson makes an important clarification, in highlighting that land may be purchased for investment as well as consumptive purposes. Thus the price paid for the land may not be purely a function of the components of the property, but also be driven by some underlying assumption about the future sale value of the land, which is impossible to quantify except through broad trends in property prices by region (Abelson, 1979). This is likely to be of particular relevance to the Australian situation, where property ownership is an intrinsic component of the national psyche (Kemeny, 1977). It may also be particularly true of purchasers of beachfront property, where prestige is likely to be a factor.

Fraser and Spencer examined the effect of a coastal view on the value of lots in a new coastal development at Ocean Reef in Western Australia (Figure 1.1) (Fraser and Spencer, 1998). This paper introduced different classes of views, rather than a simple binary yes-no classification. The more detailed classification recognises the decreasing marginal utility of increases in the available view. There is decay in the value of an increase in the percentage of panorama and the permanency of the view. Permanency of view was given greater weight than degree of panorama in their weighting system, meaning that views which could not be built out were more highly valued by the analyst (Fraser and Spencer, 1998). This may not be consistent with the perception in the market, as recent housing patterns show a more frequent relocation cycle, so future potential loss of views may not be considered. The authors also considered whether the site was higher or lower than the road, and whether the site sloped upwards or downwards when moving from the front of the lot. As demonstrated by Pearson et al, not all of the suggested categories are theoretically possible, as a site cannot be above the road yet sloping downwards, and vice versa. (Pearson et al., 2002)

Fraser and Spencer consider both the value of a coastal view to individual properties, and also the aggregate of the view-related environmental price premiums across all sites, to give a total value of the ocean views for that region (Fraser and Spencer, 1998). This approach can be used to estimate the value of preservation of a desired visual feature, or prevention of an action that would preclude the existing view. An example may be in the decision about whether to allow a development on a ridge line, which would block the view of a large number of land owners. The authors also suggest their view-scoring system could be used in site planning for masterplanned communities and new developments, through maximising the aggregate number of points due to coastal views (Fraser and Spencer, 1998).

Following the classification system of Fraser and Spencer, Pearson et al. used a four point scale to classify ocean views (no view, poor partial, full partial, full unobstructed), and found that only a 'full unobstructed' view had a significant effect on house prices, partial views were not statistically significant (Pearson et al., 2002). Whilst the primary objective was valuation of Noosa National Park (see Figure 1.1 for location), proximity to the ocean was also a strong determinant of price. This effect was pronounced to 550m displacement from the coast, then ceased to be a significant influence (Pearson et al., 2002). The effect of an ocean view and proximity to the ocean were greater than views of or proximity to Noosa National Park, which was the primary focus of the study.

Pearson et al. also suggest that the environmental premium generated by urban parks offsets the loss of rates revenue from the setting aside of this land, and the increased management costs of the park itself. Whilst the assertion of Pearson et al. might be true in a theoretical sense, the environmental premium generated from parks may not flow to the same destination as the revenue from the displaced development. This assumption is of particular relevance to selection of coastal management alternatives that involve either restricting or removing coastal development, notable the 'Retreat' and 'Adapt' options.

Decisions to convert privately-owned residential areas, for which Councils have no legal or financial responsibility other than provision of services, to publicly owned assets such as parks, can result in both a loss of rates revenue and an increase in management costs through activities such as rubbish collection and lawn maintenance. Even if this loss of revenue is completely offset by increased rate revenue from a jump in the value of the surrounding properties, this increased revenue may not be realised until the next cycle of land valuation. In NSW, this may mean a delay of up to three years before rateable values increase, if indeed they do increase at all (NSW Department of Lands, 2004b).

Another implicit assumption is that Council rates are calculated in direct proportion to the value of the property, whereas there may be a fixed cost component. In NSW, rates are also 'pegged' by the Department of Local Government, limiting the extent to which they can be increased in a given year[6]. Reduction in the number of properties will thus reduce the overall rates base. Further discussion of the management challenges posed by rate pegging is included in Chapter 7.

[6] http://www.dlg.nsw.gov.au/dlg/dlghome/PublicTopicsIndex.asp?mi=0&ml=10&id=8#14

Burgan employed a hedonic study component in valuing the metropolitan beaches of Adelaide. This study showed that 30% of the value of beachfront property was attributable to beachfront access (through examining the coefficients on 'water views' and 'water views with beach access' in Model 4), and was used in the justification of the beach renourishment program (Burgan, 2003). Some concerns about multicollinearity must be raised, however, given that the regressors used in the preferred model (Model 4) include water views and no mention is made of how these are calculated or determined, the attribute estimates are likely to be collinear. This work updated a previous study involving the same author (Evans and Burgan, 1993), which in turn built on previous work in 1983 at the same location (Kinhill Stearns and Reidel and Byrne, 1983).

3.8.4 *Summary of potential for benefit transfer*

It can be seen that the Australian beach valuation literature is scant. Concerns must also be raised about the suitability of these studies for benefit transfer. It is also important to note that the usefulness of the functional benefit transfer approach to policy applications is often limited by the technical capacity of the end-users. This may result in point estimates being transferred, with a resultant loss of meaning. Reasons for concern are expanded through comparison of the context of the previous studies with that of urban Sydney beaches raises further issues.

3.8.4.1 Socioeconomic context differences

Sydney is the largest city in Australia, accounting for approximately one fifth of the total national population. It is the most densely populated city, with higher average incomes (ABS, 2009), and higher international visitation (Tourism NSW, 2008) than the other policy sites.

3.8.4.2 Biophysical context differences

The studies previously conducted have also been in areas which are subject to different biophysical influences. The Gold and Sunshine Coasts of south-east Queensland (see Figure 1.1) experience greatest erosion in summer and early autumn, which is the highest visitation period, as a result of the influence of tropical cyclones. Sydney is somewhat fortunate in that respect, as the greatest erosion typically occurs in the winter months, due to the influence of low pressure systems (ECLs) as described previously. In summer, whilst there are occasional larger swells from the NE (Short and Trenaman, 1992), wave conditions are typically benign, allowing for accretion of beaches.

3.8.4.3 Temporal stability

The only previous empirical valuation studies for the NSW coast were conducted in the early-to-mid 1990s (Pitt, 1992b, Pitt, 1992a, Pitt, 1997), which places them at more than fifteen years in age. Downing and Ozuna tested the reliability of transfers both temporally and spatially, and found that estimates were not comparable with direct estimates, even for the same sites in consecutive years (Downing and Teofilo Ozuna, 1996). Thus there must be serious reservations about the ability to use these values for benefit estimates in the current study.

Due to the concerns raised above, the Australian beach valuation literature is not considered adequate or appropriate for benefit transfer. Empirical studies are therefore suggested, employing the methods described in the previous sections. The focus thus now turns to application of the techniques.

3.9 Application of selected techniques

Having determined the appropriate valuation methods, this chapter now turns to the development and application of these models. This involves a number of steps, which are outlined below. The first of these is the design of surveys to address research questions RQ1-4.

3.10 Survey design process

This section describes the survey instrument which was developed, in order to value daytrip visitation and willingness to pay for prevention of erosion. The survey has two components, an Individual Travel Cost Method (ITCM) section, and a Dichotomous Choice Contingent Valuation (CV) component. The ITCM component asks people how they travel to the beach, how much time they spend onsite and in travel, and how much they spend on all onsite costs (including parking). Travel costs are then calculated based on travel mode. Ticket costs are included for public transport, engine size and running costs are included for private vehicles. The opportunity cost of time is calculated based on a proportion of the individual wage rate.

3.10.1 *Requirement for transferability*

Working with a regional organisation such as the SCCG, which represents a number of local Councils, it was important to design a survey process which could be easily applied to other sites. This requirement shaped the entire survey design process. The ultimate result is a survey which provides economic information that is in a form requested by the end-users of the data, but may not necessarily conform with the most recent advances in environmental valuation theory. I would argue that this strengthens, rather than weakens, the usefulness of the results.

3.10.2 *Selection of appropriate population*

For stated preference methods which require sampling the relevant population, considerable challenges in defining the extent and character population may be encountered. In situations where the site or resource is subject to restricted access, it may be possible to draw upon existing data sources to estimate the pool of potential respondents. In open-access cases, this can be substantially more difficult (Deacon and Kolstad, 2000). One approach is to use distance-decay models, implying that the likelihood of measurable welfare change is inversely proportional to distance from the feature of interest (Hanley et al., 2003).

3.10.3 *Relevant population*

The relevant population is often assumed to be dictated by jurisdictional boundaries, for example restricted to a sample from within a county or local government area. Whilst this is understandable from a management perspective, as the service obligations of managers typically extend only to their constituents, it may result in decisions that do not truly reflect the importance of a resource. Australian beaches are almost exclusively crown land reserves, which are managed by Local Governments as trustees. Hence the relevant population for sampling could be assumed to be the Australian population. This in turn neglects the substantial importance of Australian beaches for international tourism, and will likely result in an underestimation of true value. It also excludes the complexities of modelling involved in international tourism demand analysis, which would require a more detailed understanding of climate change impacts on Australian beaches (and those in competing beach tourism markets) than which currently exists.

In this thesis, only daytrip visitation (recreation as opposed to tourism) is valued, which is a deliberately conservative measure. The focus of the remainder of this chapter is therefore on defining the magnitude of beach visitation to the case-study sites. This excludes consideration of non-users of the resource, thereby restricting the definition of TEV. This restriction is justified on theoretical grounds.

Determining the relevant population for estimates of value for which no behavioural cues can be observed is a particular challenge. Theoretical concerns must be raised about the ability to determine a truly appropriate sampling design for estimation of non-use values. Johnson et al. suggest that non-use values cannot truly be estimated for those with no prior knowledge of the resource under consideration (Johnson et al., 2001). They suggest that geographical distance from the resource limits the extent to which a non-use value can reasonably be expected to exist. A contrasting view is held by King, who states that estimating the existence value of an internationally significant site requires aggregation across the entire global population (King, 1995).

My own views tend more towards those of Johnson et al., as surveys of non-users are likely to result in responses that tend towards more generic responses related either to a general preference for the good in question (e.g. a liking for pandas), or be attributable to warm-glow or yea-saying effects. Further analysis of previous attempts to estimate existence and other non-use values in the beach valuation literature is provided in Chapters 4 to 6). Given these theoretical concerns, and the considerable challenges in determining the appropriate population for aggregation, a survey of non-users was not attempted in this thesis, with surveys restricted to those who had direct contact with the resource. This then requires 'only' an estimate of the relevant population of beach users. This in itself proved challenging in the current study, and is examined further in Chapter 4.

Significant challenges were encountered in an attempt to use statistical techniques to select an appropriate sample and determine the required sample size, due to the absence of any good source of visitation data for beaches in Australia, as exists in some other locations (Raybould and Lazarow, 2009). Whilst it is possible to draw some conclusions about the order of magnitude of beach visitation in Sydney, this data is often influenced by the co-location of beaches within the urban footprint. Hence it is difficult to determine the motivation for travel when employing secondary sources of data such as parking records. Urban recreation resources are difficult to value for this very reason, as they may be visited before or after work and form only part of a longer multi-purpose trip (Hanson, 1980). This may be a significant reason why a large proportion of existing beach valuation studies have been conducted on beaches which have restricted access (e.g. Parsons et al., 2009).

3.10.4 *Surveying beach users*

Typically a survey sample will be drawn from a known population, using methods such as random or stratified-random sample selection (Dilman, 1978). In the case of beach visitation in Sydney, there is insufficient information on the existing patterns of usage to undertake this process. Even the number of visitors to beaches is unknown in most cases, notwithstanding estimates available from proxy sources such as parking records and public transport ticket sales. Hence it is almost impossible to design a sample selection process which accurately reflects beach visitation, as this would require detailed socioeconomic information on the current visitors.

In the absence of this information, a random-intercept model was employed (Blackwell, 2007), whereby all groups of beach visitors encountered whilst moving along the length of the beach were approached and asked to participate in the survey. In the case of a group, the person who had the most recent birthday was asked to participate. There are a number of other sources of bias in the use of this sample selection process. Some of these are inherent in the survey process and are common to all surveys, whilst others are specific to surveys of beach visitors.

Self selection poses a problem for all surveys, in that only those with sufficient interest in the survey topic will participate, regardless of the mode of administration (Whitehead, 1991). This is true even though beach visitors were not interviewed more than once over the survey period, and the online survey could only be completed once per computer IP address.

Frequent beach visitors and those who spend longer at the beach are more likely to be sampled by the random-intercept survey, simply by virtue of the fact that their chance of interception is increased. This has the potential to bias the results of the survey, as it can be expected that these frequent visitors will have a greater 'attachment' to the beach, and also a greater vested interest in the preservation of the beaches, as the same proportional damage (i.e. ten percent loss of beach days in the erosion scenario employed in this thesis) will represent a greater absolute loss of beach days (Ladenburg and Dubgaard, 2009). In the case of a valuation instrument which asks for contributions on a per-trip basis (e.g. through increased entrance fees), it can be expected that frequent visitors would have lower WTP (Shrestha et al., 2002a).

Conversely, those who spend the majority of their time in the water are less likely to be sampled, as they pass through the 'survey zone' rapidly. This means that some of the more avid beach user groups, namely surfers and ocean swimmers, are unlikely to be sampled in high numbers (Nelsen et al., 2007). This exclusion is complicated by the timing of beach visitation, as these user groups typically visit in the early morning and late afternoon. This can present logistical challenges for those conducting the surveys.

3.10.5 *Choice of survey administration mode*

The choice of survey administration mode is of great importance. The National Ocean and Atmospheric Administration (NOAA) panel recommended that only in-person interviews are able to generate reliable valuation estimates (Arrow et al., 1993). This assertion has also been made by a number of authors (Mitchell & Carson, 1989). Sources of bias through the presence of the interviewer have also been identified (Maguire, 2009). Alternatives using a combination of mailout and telephone methods have been suggested to keep costs low while maintaining reliability of responses. Adamowicz et al. used a telephone-mailout survey administration, although the dropout rates at each stage of the process meant that only 9% of the original sample called completed usable surveys (Adamowicz et al., 1994). Hanneman et al. used the reverse method, mailing out detailed information and calling recipients at a later date to undertake a more detailed phone interview (Hanneman et al., 1991).

More recently, the development of advanced internet survey capabilities has opened a new frontier in environmental valuation survey administration (Fleming and Bowden, 2009). The internet allows for completion of surveys in the respondents' home, at a convenient time. It is also possible to implement advanced survey methodologies (branching, anchoring of bid amounts to revealed preference information gathered from the respondent, visual cues, links to external sources of information etc.) which can aid in enhancing the reliability of results.

Initial tests indicate that responses from different survey administration modes are comparable, although further work is required in this field (Fleming and Bowden, 2009). A comparison of mail and personal surveys found greater differences in results between surveyors than between methods (Mannesto and Loomis, 1991). A recent study found that there were no significant differences between results of in-person and web-based surveys, which given the cost savings indicates a potential future avenue for large surveys able to incorporate non-users (Marta-Pedroso et al., 2007). It appears that while survey response rates may be much lower for online surveys, the responses do not differ significantly (Marta-Pedroso et al., 2007). This suggests substantial potential for online surveys, given their negligible deployment costs and ease of data compilation and analysis.

3.10.5.1 Mode chosen

Survey administration for this project was multimodal, incorporating online surveys accessible via the website of a project partner, and random-intercept personal interviews conducted with beach visitors at the three case-study sites. The online survey was promoted via email distribution of links in a 'snowball-sampling' procedure (Patton, 1990). The survey instruments for both modes were designed to be as similar as possible, to allow for examination of survey administration effects.

Mail surveys were not selected due to the extensive lag between administration and finalisation. It was also thought that a large number of visitors to at least one case-study site (Manly) were international tourists who visit the site only once. Determining the appropriate sampling procedure for sites with significant non-local visitation entails substantial challenges in determining the appropriate distribution of mailout surveys, hence application of a formal sampling system such as that proposed by Dilman is not possible (Dilman, 1978).

Personal interviews with beach users were conducted at the case-study sites over the summer of 2008-09. Surveys were conducted over the summer of 08-09, with survey completion details provided in Table 3.4.

Table 3.4 Onsite sampling details

Beach			Weekday (Proportion of total sample)			Month (Proportion of total at beach)					Survey location	
	Sample size	**Weekend (1=yes, 0=no)**	**Before work**	**Work hours**	**After work**	**Dec-08**	**Jan-09**	**Mar-09**	**Apr-09**	**May-09**	**On Sand**	**Crown Reserve**
Collaroy-Narrabeen	174	**0.32**	**0.01**	**0.67**	**0.01**	0.00	0.83	0.17	0.00	0.00	126	48
Manly Ocean Beach	148	0.33	0.01	0.66	0.00	0.22	0.10	0.38	0.30	0.00	71	77
Brooklyn	49	0.86	0.00	0.14	0.00	0.00	0.02	0.39	0.00	0.59	44	5
Dangar Island	46	1.00	0.00	0.00	0.00	0.00	0.00	0.41	0.00	0.59	42	4

A total of 417 personal interviews were completed at the three case-study sites. The numbers completed at Collaroy-Narrabeen, Manly and the combined Brooklyn-Dangar Island estuarine site were 174, 148 and 95 respectively. These interviews used Mobile Computer Assisted Personal Interviewing (MCAPI) techniques, which involved programming surveys to be conducted on a Palm Treo 750 ® smartphone. In-person interviews were conducted using Entryware Designer 6.2 (Techneos http://techneos.com/content/Entryware-64-specifications) on a Palm Treo 750 smartphone, running via Styletap® for Windows Mobiles in order to emulate the Palm OS®.

The use of handheld computers is relatively new in environmental economics, although it is gaining popularity in other forms of market research (Gravlee, 2002). There are a number of advantages to using handheld computers over traditional paper-based interviewing formats. These include the ability to program branches into the survey based on previous responses. This allows for respondents to be asked only questions of relevance, thus shortening the survey and improving completion rates.

For example, an initial question about the mode of travel used to visit the beach classifies respondents into the following groups: those who travelled in a private vehicle, those who did not use a powered vehicle (walked, cycled etc.) and those who used public transport. Those who travelled in a private vehicle were then asked about their vehicle type and parking costs. Public transport users were asked about the cost of their tickets. Human-powered beach visitors did not get asked either of these question groups, and all then continued with questions about time spent in travel and onsite.

An additional benefit of computer assisted surveys is in greatly reduced times for data compilation and entry into statistical analysis programs. Data was automatically compiled and saved during the survey process, and could be converted and exported in appropriate formats for analysis once the handheld was synchronised with a laptop computer. An additional, unforseen advantage was the ability to undertake surveys in weather which would otherwise be challenging, such as on windy beaches.

A further 130 survey responses were gathered through the use of an additional online survey component, designed to replicate as closely as possible the personal interviews. Online surveys were programmed and implemented using an academic license of EFS Survey ©[7] In the online survey, people were asked which of the case-study sites they had visited most recently. If they had not visited one of the beaches in the past twelve months, they were asked about their favourite beach. If they had not visited a Sydney beach in the past twelve months they were not included in the survey. This restriction was imposed as their recollection of the beach was likely to be diminished, which can influence the reliability of their responses. This is termed recall bias (Faulkner and Raybould, 1995).

Advances in internet survey software suggest a promising future direction for economic surveying, given the cost benefits of administration. However it is important to ensure that data quality is maintained and to assess whether responses are consistent between survey modes. Mixed-mode administration of the same survey instrument provides an opportunity to assess whether this is the case (Maguire, 2009, Marta-Pedroso et al., 2007). Online surveys also allow for greater inclusion of supportive multimedia such as graphics and audio. In the case of this survey, links were provided to maps of beaches in the Sydney region, to assist those who could not remember the name of the beach they had most recently visited.

3.11 Chapter conclusion

This chapter outlined the process of determining key coastal management issues for the Sydney region, using a panel of experts. Case-study sites were then selected to investigate these issues, and valuation tools were chosen to address the research questions that developed from the site selection criteria. This led to selection of valuation methods appropriate to answering these questions, and finally decisions about administration of the survey-based approaches. The next two chapters will discuss the design and results of these methods in greater detail.

[7] Enterprise Feedback Suite, version 6.0, Globalpark AG http://www.globalpark.com/128-0-EFS-Survey.htm .

4 Travel cost application

The proxy data identified in Chapter 2 suggests significant economic importance of beach tourism (Tourism NSW, 2008), and this activity is potentially affected by changes in site attributes such as beach closure through erosion (Parsons et al., 2009) or water quality issues (Rabinovici et al., 2004). It is therefore prudent to attempt to determine the magnitude and economic importance of beach recreation in Sydney. This chapter therefore reports on the application of the individual travel cost method (ITCM) at the case-study sites, designed to answer research question RQ1. The survey was administered via both onsite and online surveys, which allows for both between-beach and within-beach comparisons.

The chapter begins with discussion of the main factors which must be considered in application of the travel cost method (TCM). The chapter then gives special mention to the issue of determining estimates of beach visitation, examining the key data sources and their limitations, before outlining a possible remedy through the use of novel technologies.

Returning to the current application of ITCM, the next section outlines the methodology employed. This is followed by presentation of the observed results, which are summarised in categories relating to demographics, travel costs, trip characteristics and the rationale behind beach selection. Comparisons and contrasts are drawn between online and onsite samples in a test of the influence of survey administration mode. The results section concludes with discussion of the truncated negative binomial model employed to estimate a trip demand function for two of the case-study sites.

4.1 Theoretical considerations

4.1.1 *Variations on the Travel Cost Method*

A suite of valuation approaches belong to the TCM family, including more traditional TCMs (Chen et al., 2004), Travel Price Models which model travel costs as unobserved latent variables (Englin and Shonkwiler, 1995), and attribute-based discrete-choice models that incorporate site characteristics to explain visitor behaviour. These attribute-based models include the hedonic TCM (Brown and Mendelsohn, 1984, Englin and Mendelsohn, 1991) and random utility models (RUMs) (Parsons et al., 2000, Scarpa and Thiene, 2005). There is considerable debate about which is the more appropriate approach, although the distinction between the two approaches is somewhat unclear. Both have their origins in the same utility theory, and both produce similar results when consistent assumptions are applied (Pendleton, 1999, Pendleton and Mendelsohn, 2000). The common feature of all the models listed above is the use of travel related costs to estimate the lower bound of the value of a resource.

The original form of the TCM is the Zonal Travel Cost Model (ZTCM), which estimates the rate of visitation (typically in visits per 1000 population) from zones that represent similar travel costs incurred to visit the feature of interest (Hein et al., 2006, Navrud and Mungatana, 1994). This is then multiplied by the costs of visitation from that zone. The ZTCM has the advantage that it can be estimated primarily from secondary data, with relatively low resource demands (Hotelling, 1949). This method has high data needs, requires some simplifying assumptions such as constant income within a zone, and presents problems for aggregation of benefit estimates, which has led to criticism and reduced application in recent years (Moeltner, 2003).

The ZTCM has been primarily replaced in application by the Individual Travel Cost Method (ITCM) (Blackwell, 2007). This method involves determining individually specific estimates of travel costs through empirical surveys. These are typically administered to users, either onsite (Blackwell, 2007, Bin et al., 2005), through mailout methods (Raybould and Lazarow, 2009), or through internet surveys. The ITCM is a method which is most appropriate where there are high individual travel frequencies, as without variability in visitation rates it is not possible to determine the demand curve for visitation, and hence the value of the resource cannot be determined through integration (Bennett, 1996). ITCM typically provides lower CS estimates than ZTCM, as demonstrated by studies which compare the two approaches (Willis and Garrod, 1991).

4.1.1.1 Attribute based methods

The recreational opportunity spectrum is a concept which was developed in the field of protected area management in the late 1970s. This theory essentially states that the suite of potential activities that can be undertaken at a site are dictated by characteristics of the site itself, such as how developed the park is, and the sensitivity of the natural environment (Clark and Stankey, 1979). This provides early recognition of the importance of site features, which forms the backbone of attribute-based travel models such as the hedonic TCM (HTCM) and the Random Utility Models (RUM) (Pendleton and Mendelsohn, 2000).

Constructing a RUM requires knowledge of the suite of potential sites, and attributes of those sites that influence demand. Notwithstanding the challenges experienced in sourcing quantitative beach descriptive data in the site selection process, there are also challenges with determining the suite of alternative locations considered by international visitors. In the case of beaches which are primarily visited by local or regional visitors, this may be possible, as it is possible to determine average driving distance and thus derive a choice set of potential substitute beaches. In the case of internationally recognised beaches such as Bondi or Manly, this may not be possible, as the substitute sites may not even be in the same country.

Determining the appropriate sites for inclusion in the choice sets may require stated preference surveys, although defining even the source countries may present challenges in the absence of beach visitation information. Some clues about the sources of beach visitors may be found in the proxy data available in the International Visitor Survey (IVS) and National Visitor Survey (NVS) data, which periodically asks international and domestic visitors from key tourism market countries whether they visited Bondi or Manly beach (Battye and Suridge, 2002). This information is not available for other beaches. It was not considered feasible to address this concern in the current study, as this would require extensive surveying of potential international visitors to Australia (Huybers and Bennett, 2000). Random utility models were therefore not considered appropriate here, but present an opportunity for future work.

4.1.2 *Substitute sites*

The availability of substitute sites is likely to be important in determining the effectiveness of economic valuations of the environment (Shrestha et al., 2002b). This is particularly true in Sydney, where there are many alternative beaches in the event that one beach is significantly eroded or access is limited through other means. A recent paper found that the failure to consider the influence of congestion of substitute sites would result in a 50% underestimate of the value of the study site, as the loss of the study site would reduce the utility of visitation to the substitute sites (Timmins and Murdock, 2007). Substitution may occur in both spatial and temporal means, with beach users avoiding eroded beaches either through visiting an alternate site, or through delaying their travel until the original site returns to a suitable state.

Smith and Palmquist highlight the importance of temporal substitution in travel cost calculations (Smith and Palmquist, 1994). In response to known impacts at the site, visitors may choose to postpone their trip rather than cancel it. Impacts could be erosion (Parsons et al., 2009), water quality issues resulting from rainfall (Rabinovici et al., 2004), wild seas, or crowding (Jakus and Shaw, 1997). Failure to consider this form of substitution will lead to higher estimates of the consumer surplus loss from erosion incidents, although this assumes that the delayed visits represent perfect substitutes (Deacon and Kolstad, 2000). An example of temporal substitution can be found in my own beach visitation habits. My proximity to the coast and flexible work nature allow me to visit the beach during weekdays. I choose not to visit the urban Sydney beaches on weekends due to congestion and parking challenges.

4.1.3 *Multi-purpose trips*

Often trips are undertaken for more than one reason, and attempts to calculate the percentage of total travel costs associated with a particular activity are somewhat questionable. An attempt to determine the proportion of travel costs directly associated with flamingo viewing demonstrates the tenuous nature of these calculations (Navrud and Mungatana, 1994). In response to this weakness, a number of different methods have been developed which look at the process of site selection and the influence of site attributes.

A TCM study on the economic effect of setting aside land for recreation suggested that failure to incorporate stages in the decision making process will lead to an underestimation (Loomis, 1995). This study identified four stages: the decision to participate, the choice of sites, the choice of visit frequency, and the choice of trip duration. Use of nested logit (NL) estimations attempts to address the fact that choosing of recreational activities and sites is a complex process which is somewhat sequential (Provencher and Bishop, 1997).

4.1.4 *Opportunity cost of time*

Inclusion of the opportunity cost of time in valuation of recreation is a substantial source of debate. Travel cost assessments often do not include the opportunity costs of travel time, which can lead to undervaluation. One means to address this is to multiply travel time by a proportion of the respondent’s wage rate (Hesseln, 2004). This proportion is determined through substitution of the proportion of income at which workers will sacrifice income for reduced travel time, which is usually generated through looking at the opportunity cost of commuting to work. In ITCMs it is possible to include the individuals income or income range, without this information the average income for the area that was the source of the trip (suburb from which the trip originated) is used. The proportion itself is a matter of contention, with most authors using between 25% and 100% of the wage rate (Hanley et al., 2001b). A study by Smith et al. found that there was no support for using a proportion less than the full wage rate (Smith et al., 1983).

The assumption that travel time is a cost at all is also a matter of some debate, as some would argue that travel is part of the tourism or recreation experience (Englin and Shonkwiler, 1995). This can be either a negative component or a positive component, depending on the individual, the mode of travel and a range of other factors. In the case of a road-trip, travel can be the main motivation for travel, with the destination merely bracketing the experience (Larson and Lew, 2005).

The inclusion of the value of leisure time in travel cost calculations is a matter of some contention. One side of the argument is that this time must be valued at the opportunity cost, i.e. the next most valuable use of the time. If the value of the time spent in recreation is not at least equal to this opportunity cost, then the time would be better spent in the alternative pursuit. This assumes that people are able to vary their working hours freely, and that they will be paid for extra hours worked. These assumptions may not hold (Feather and Shaw, 1999).

There is also no means of estimating the appropriate calculation for those who are not employed, or have no income. This provided a challenge in the current study, due to the impacts of the Global Financial Crisis (GFC) in 2008, which meant that many who were reliant upon income from superannuation investments had a negative income. This would seem to imply that the value of their time is negative, which is not theoretically possible. It also provides challenges for tests of the validity of contingent valuation responses.

Surveys of beach users conducted onsite may also identify a substantial number of people who are on leave from full time employment. This leave may even be mandated, in which case there is no potential for the respondent to trade leisure time for further work. An example is in the closure of most Australian university campuses over the period between Christmas and New Year. This closure, which was originally introduced so that the universities could save on overtime and self-insurance costs, means that there is no potential for paid onsite work during this period. Respondents who are on leave may make completely different tradeoffs in terms of leisure time than those who are engaged in full time employment. Thus, the use of their wage rate in calculation of time costs may be inappropriate. In the case of Australia, annual leave may also be subject to a loading factor, typically in the order of 15-20%, hence calculations on average salary rate will again be inaccurate.

As an alternative to monetising the time component of the trip, travel time and onsite time can be introduced into the model separately to travel costs. This follows the work of McConnell and Strand, who incorporate time and budget components separately (McConnell and Strand, 1981). Bockstael et al. demonstrated that time and budget constraints cannot be combined (Bockstael et al., 1987). This has the effect of identifying the influence of travel time on visitation decisions, without conflating the time influence with that of travel costs, and is based upon the idea that the respondent has already made an internal tradeoff regarding time spent, using their own unobservable process of time valuation.

4.1.5 *Congestion*

Greater visitation can also cause indirect reductions in the utility of visitors, through increased crowding. The effect of congestion upon recreation demand has received considerable attention, given the economic implications of reduced visitor numbers resulting from poor experiences (Jakus and Shaw, 1997, McConnell and Duff, 1976, Wetzel, 1977, Davis and Tisdell, 1996). Given increased beach visitation with population increases in the coastal zone, it can be expected that congestion will be an issue of considerable concern for coastal managers in the future. There are, however, limited means by which congestion can be managed, hence the policy interest in the issue it typically restricted to management of conflict between different resource users. Congestion is discussed further in Chapter 5 in terms of the stated preference literature.

4.1.6 *Sample selection*

In designing a survey such as this one, sample selection is critical to the interpretation of the results, both for the travel cost component described in this chapter (Dobbs, 1993a), and for the contingent valuation component detailed in the next chapter (Whitehead et al., 1993). Considerable effort was therefore expended in attempting to determine the number and nature of beach visitors to the case-study locations. What this ultimately showed was that there is a severe lack of suitable information for this purpose. Further discussion of the need for estimates of beach visitation is provided in section 4.3, whilst efforts to determine these figures for the case-study locations are outlined in section 4.4.11.

4.2 Estimating beach usage

There are two main components to estimating the economic value of a natural resource via economic survey methods; determining an average value per the population of interest, and multiplying this value by the number of people in that population. The overwhelming focus of natural resource economics in recent years has been on improving the accuracy and theoretical basis of the individual welfare estimates, with relatively little attention paid to the source and accuracy of the population estimates. The result is that welfare estimates that are precise to multiple decimal places are multiplied by visitation estimates that may be grossly inaccurate (Deacon and Kolstad, 2000).

In the case of resources or areas with restricted access points and good records, determining the number of visitors is relatively straightforward. It is also possible to learn much about the visiting population through the use of visitor records and permit systems. Hence, if the focus is on determining the use value of the resource, much of the socioeconomic data is readily available. In the case of open access resources such as beaches, this is not the case. Rarely are good records available, even for approximate estimates of beach visitor numbers. Attempts to estimate non-use values encounter further theoretical issues. In the purest sense any estimate of existence values would require extensive surveying of people with no prior knowledge of the beach. Thus the potential population of interest knows no bounds (King, 1995). This issue is not discussed further in this paper, as the focus is on surveying of beach users.

4.2.1 *Need for visitation data*

The lack of information available about the economic importance of beach tourism in Australia is a severe impediment to effective management (New South Wales Government, 1997b). Making resource allocation decisions about managing beach tourism and recreation without this information is akin to attempting to insure a vehicle against theft without knowing the replacement value of the vehicle. Given the considerable uncertainties associated with both existing coastal hazards (Cowell and Zeng, 2003), and the potential future impacts of climate change on these resources (Tol, 2003, Cowell et al., 2006, Jones, 2000), it is also like not knowing where you parked the car.

Surveys on participation provide a stated measure of visitation frequency, from which total visitation can be inferred. The current study incorporated a visitation frequency question, which provides new information on beach visitation for the Sydney region.

Gaining an accurate understanding of the number of visitors to beaches is useful for planning resource allocation between beaches and between different council activities competing for funding, such as paid lifeguard services and beach cleaning activities at the Local Council level. An objective estimate of beach attendance can also result in greater recognition of the cultural and social importance of beaches, without the potential for inflated estimates designed to serve the purpose of politicians (Sturges, 1972).

Having a good understanding of the numbers of people who visit the beach is also a key component in the design of any emergency or evacuation plan. This is particularly true in the case of sudden and potentially catastrophic events such as tsunami. Currently, the community understanding and emergency response to tsunamis in Australia leaves a little to be desired (Bird and Dominey-Howes, 2008, Dominey-Howes and Goff, 2010). Emergency Action Plans are mandatory inclusions in Coastline Management Plans in the Coastal Zone Management process administered by the NSW Department of Environment and Climate Change, and hence accurate attendance numbers are key information inputs into this process (New South Wales Government, 1997b).

Understanding how many people travel to different beaches on different days, and the mode of transport they use, can also be used in traffic planning, scheduling of public transport services, and the development of more suitable parking fee systems. For example, people who visit early in the morning when visitation is low could have a reduced parking fee, as most parking fees are designed to limit congestion in peak times and provide for equitable access to public resources.

Understanding the way beaches are currently used, and how these patterns change in response to variables such as weather, can also allow for some projections about future visitation. Beach visitation and usage is presumed to be a function of the state of the beach (Deacon and Kolstad, 2000). Given this assumption, there are two projected behavioural responses to a loss of beach width. The first is that the same number of people continues to visit, but experience congestion and a reduced utility for their beach visit. McConnell investigates the relationship between congestion and WTP for beach nourishment, and estimates the optimum beach width, from which beach nourishment regimes could be estimated (McConnell, 1977). The second alternative is that fewer people visit, and experience the same level of utility, resulting in an overall reduction in the 'value' of the natural resource.

The potential for climate change impacts on beach visitation is broad, as visit frequency and quality can be influenced by a range of external factors. If, for example, it is shown that beach attendance is greatest when the maximum daily temperature is above 25°C, but drops off sharply when temperatures reach 35°C, this can be compared to climate projections to make some more informed projections about how beach visitation will change in the future. The same can be said of changes to wave intensity and orientation, rainfall patterns and beach width, although the degree to which the information required to perform these estimations is available is highly variable between beaches.

Partial loss of sand from a beach may restrict the use of that beach for certain activities. A local example was seen recently at Manly, where the permanent beach volleyball courts had to be relocated due to severe storm erosion. Partial or temporary loss of sand has not previously been explicitly valued. It has always been assumed that beaches will be either open or closed. Even more subtle impacts, such as slight changes in water colour or quality (Smith and Davies-Colley, 1992, Pendleton et al., 2001) or sand dune formation (Nordstrom and

Mitteager, 2001), have the potential to greatly influence the amount of enjoyment that a beach visitor gains from their trip, and their willingness to pay for beach nourishment projects (Shivlani et al., 2003).

Clearly, the complete absence of sand will have a marked impact on the ways in which a beach may be used. This is unlikely to be a total loss of value as a recreational resource, however. A study on bathing and beach attendance in Southern California found that fewer than half of the visitors to a beach actually enter the water, and hence the impacts of loss of sand on direct usage may not be as severe as expected (Dwight et al., 2007). It should be noted that enjoyment of a beach does not necessarily require direct contact with the sand or water, as there are many ways in which a natural resource can be valued by society.

4.2.2 *Estimating beach visitation*

Determining even the relevant population of beach users can be problematic, if there is insufficient information on beach visitation. In the case of Sydney beaches, there is little reliable information on even the magnitude of visitation, let alone information on source locations, demographics or travel modes which could be used to design a random or stratified sample (Dilman, 1978). This presents problems not only for sample design, but also for determining the total value of a beach resource, as there is no well defined population across which to aggregate benefit estimates.

Despite the many potential uses of accurate beach attendance figures, this information is often lacking for many public resources such as beaches. There are a number of reasons why this is the case. Beaches have a number of characteristics which make them particularly difficult to sample. Chief among these is the fact that the majority of beaches have a number of access points. Thus any monitoring system would have to be deployed at a number of locations, which adds to the complexity and costs of visitor counts. It is also difficult to clearly define the spatial area which should be considered. Should the definition of a beach include the adjacent parkland, even if this parkland is located behind a terminal coastal protection structure such as a seawall?

Direct estimates of beach visitation can be sourced from lifeguard estimates, dedicated surveys, or from aerial photography. The main source of visitor estimates for most beaches in

Australia is through lifeguard estimates. This thesis makes the distinction between lifeguards and lifesavers. Lifeguards are professionals employed by the local council. Lifesavers are typically volunteers who patrol beaches on weekends and public holidays. There are a number of reasons why this is problematic. Firstly, lifesaving services have a defined working day, typically from around 7:30am to 4:30pm. This means that lifesaver estimates systematically under sample those user groups which visit outside these times. Surfers and those who jog or walk along the beach before work are obvious omissions from these estimates (Nelsen et al., 2007). In many jurisdictions, the Council-employed lifeguards are only in attendance for the peak swimming period, which is defined in Sydney as the start of October to the end of April. Outside these dates much of the Australian coastline is not surveyed for visitation in any meaningful manner.

Lifeguard and lifesaver estimates also become less accurate during peak visitation periods, as it is during these times that they are most busy performing rescues and directing swimmers and board riders to safer areas. This is not a criticism of lifesavers, merely recognition of the fact that their most important duties do not include providing accurate estimates of visitor numbers, and these estimates will always be given less priority. This can be seen in the missing data records that are typical of beach attendance data (Lew and Larson, 2005b). Even where lifesaver records are complete, the accuracy of the estimates has been questioned. Deacon and Kolstad found that beach attendance estimates of lifeguards were up to five times higher than the 'true' attendance figures (Deacon and Kolstad, 2000).

Assuming that the area can be clearly defined, it remains very difficult to accurately estimate the number of objects (people) within that space. Research in the fields of visual perception and psychology has shown that density and the available space can have a large influence on estimates of numerousness (Granberg and Aboud, 1969). Hence, if the same group of 100 people visit a small beach and a large beach, and all arrange themselves identically at both beaches, attendance estimates will be greater at the smaller beach (Granberg and Aboud, 1969).

Some novel methods have been proposed for estimating crowd numbers using secondary information, including counting the amount of rubbish left behind when the crowd has dissipated (Sturges, 1972). Obviously, this could merely indicate the proportion of people who used the bins provided. An alternative method involves estimating the density of people at the location, and multiplying this by the available space. This is known as the Jacobs Crowd Formula (Sturges, 1972), after a researcher at the University of California, who based the "personal-space" formula on the density of students observed at protest rallies held on campus, in a plaza of known dimensions and with conveniently patterned tiles dividing crowds into manageable portions. His estimates are that people generally avoid excessive crowding, and require between four and 9.5 square feet in a typical rally situation (0.4-0.9m^2) (Sturges, 1972).

Clearly, people on a beach are not normally packed as tightly as those participating in a protest march or rally, even during peak periods and special events. McConnell (McConnell, 1977) lists state guidelines for the optimum beach area per person, which varied from around 25 to 75 square feet per person (approx 2.3-6m^2). Estimates within McConnell's paper places the optimum level between around 8 and 1500 square feet per person (McConnell, 1977), with substantial variation between beaches. Given such a large variability in spatial distribution the Jacobs Crowd Formula cannot be relied upon to provide accurate estimates of beach attendance.

A potential source of visitor estimates is through the use of still photography. Photographs can be taken from a range of sites, including elevated lifeguard towers, patrol aircraft, and adjacent buildings. By taking a number of photographs throughout the day, or performing onsite validation, it may be possible to determine the daily patterns of visitation, to ensure that photographs are taken at the times of highest visitation. If it is possible to take a recording or image of the beach, and have this analysed at a later time, this will result in the most accurate estimate of beach attendance. This is a time intensive exercise, and is limited in application to relatively small beaches.

Direct observations which employ photographic tools are also reliant upon the ability to clearly distinguish beach visitors. A balance must be struck between field of view (FOV) and clarity of the images produced. This tends to restrict image collection to periods with good optical contrast, meaning that samples are often collected in the middle of the day. Aerial photography is also limited to periods of good weather (Blackweir and Beckley, 2004, Houghton, 1989).

Direct observations can only provide a snapshot of visitation at the time the survey is undertaken. This is true both of count estimates conducted by field observation, and those remote sensing methods which employ actual snapshots. In order to convert this to a more robust estimate of visitation, it is necessary to have some understanding of the duration of beach visits, and to make appropriate adjustments to the snapshot values (Deacon and Kolstad, 2000). Understanding trip duration requires surveys of beach visitors, with trip durations likely to be biased upwards by endogenous stratification (Martínez-Espiñeira and Amoako-Tuffour, 2008). Deacon and Kolstad detail in the appendix to their article a method for converting spot counts and trip duration responses to arrive at an estimate of cumulative beach attendance, based upon the sampling rate of the trip duration surveys (Deacon and Kolstad, 2000). It is interesting to note that this paper is authored by witnesses for defendants in the American Trader oil spill case, as it is unfortunately incidences of environmental damage that have led to much of the work in quantifying beach attendance.

The timing of the survey is also highly important. If the period between observations is long, there is a reduced likelihood of capturing beach visitors who visit outside or between the sampled times. This has the potential to not only influence the magnitude of visitation estimates, but also to introduce sampling bias through the timing of different coastal activities. Surfers are known to frequent the beach early in the morning (Nelsen et al., 2007), whereas other user groups may be more likely to visit in the middle of the day.

In Western Australia, digital images taken from Shark patrol aircraft were manually inspected in order to determine visitation levels at metropolitan beaches in Perth (Blackweir and Beckley, 2004). This study provides a rare example of a time series of photographs, to allow for examination of patterns of visitation as discussed before. Normally the costs associated with the use of this approach are prohibitive, and hence they are of limited use to most Local Councils.

4.2.3 *Public transport fare and expenditure information*

For Manly beach, the location of bus and ferry terminals in the immediate vicinity provides options for estimating visitation by users of public transport. This requires a measure of trips which terminate or begin at relevant stations, which is easily derived for ferry trips as there are no intermediate stations. Similar information is not available for bus travel. Sydney Ferries data lists Manly Ferry patronage at 5,972,873 for the year ended June 2010 (Sydney Ferries, 2011). The number of beach visitors is estimated by subtracting the proportion of commuters from the overall ticket numbers. Sydney Ferries estimates that 45% of their patrons are commuters, with 51% of trips taken for leisure purposes (Sydney Ferries, 2010). Whilst the ratios are likely to vary between the different routes, this provides a rough estimate of 3.05 million leisure trips on the Manly Ferry per year. Based on previous surveys, approximately half of visitors to Manly travel by ferry (UWS, 2004). This suggests that Manly beach visitation accounts for 6 million visits per year. Results of the current study found a lower proportion (33%) of visitors travelled by ferry, which suggest that visitation could be as high as 9 million visits per annum, although serious reservations must be held about the use of such simplistic arithmetic in a matter which has the potential to drastically alter aggregate welfare estimates. Further attention is given to estimates of visitation to Manly in section 4.3.10.

For Brooklyn, the location of the Hawkesbury train station permits a similar exploration. Unfortunately, Hawkesbury station is an unmanned station without ticket validation machines, hence there is no data available regarding the number of passengers boarding or alighting. For Dangar Island, usage data from the Hawkesbury ferry provides a potential source of visitation estimates, although a proportion of respondents travel by private vessel. The ferry is operated by a private commercial entity who was attempting to sell the business during the preparation of this thesis, so they declined to provide any patronage information.

Each of these potential sources of information are also employed by commuters, so some adjustment must be made to account for non-beach trips. Manly Council applies this method to estimate tourist visits, through transformation of Sydney Ferries ticket information. This survey confirmed the findings of previous work, identifying the high proportion of visitors to Manly beach who travel by ferry (UWS, 2004).

4.2.4 *Parking records*

It is also possible to estimate beach attendance from parking records. This can be in the form of parking fee receipts, estimates of vehicle numbers, and number of traffic infringement notices issued at each location (Lew and Larson, 2005b). This is easiest when beaches are located in a remote location, where it is relatively easy to monitor the number of visitors. An example from the Sydney region is that of Garie beach in Royal National Park. This beach has a single access road, so it would be possible to count all vehicles that visit the beach per day. This can then be multiplied by the average number of persons per vehicle, estimated either through observation or onsite surveys.

On first approach, parking records appear to be a good source of visitation data. In urban areas, however, it is difficult to determine the proportion of parking in beach precincts which is due to beach visitation, and that which may be driven by beach-complementary activities such as visiting local restaurants or attributable to non-beach activities such as local employment (Hanson, 1980).

Parking structures in the Manly area employ numberplate recognition to limit the abuse of free timed parking, hence there is some potential to link this information with vehicle registration databases to provide a good estimate of the origin of beach visitors. The use of this data was restricted for a number of reasons. Firstly, the vehicle registration information is restricted to law enforcement and government agencies. Secondly, the vehicle recognition systems do not store information for extended periods, but are used to ensure that vehicles do not shuttle between different parking structures to 'renew' their two hour free parking limit. Hence the data is not available for construction of a beach visitation model. Location of the parking structures adjacent to the commercial centre at the Manly Corso also introduces the challenges in delineation described in the previous paragraph.

Street level parking is restricted at all case-study locations, hence records of fines or vehicle observations could also be used. There are a number of distortions in existence, however, which mean that this data is not useful. Chief among these is the fact that few visitors pay for parking, hence there is no record of their visit. Free parking is available for a period of two hours at Manly, and for four hours at Brooklyn. There are no vehicles on Dangar Island.

At Collaroy-Narrabeen paid parking is in place, although the availability of residential permits means that few spaces are occupied by paying visitors. The widespread allocation of free parking permits has typically been based upon political, rather than economic grounds. For example, Warringah Council estimates that it distributes approximately 140,000 residential parking permits annually, whilst there are only around 2000 beach parking spaces in the entire LGA (Warringah Council, 2010b). With Manly and Dangar Island, the majority of visitors either take public transport (UWS, 2004), are holders of an annual resident permit, or park outside the permit zone, and hence these passengers do not pay for parking. In order for their visit to be recorded, standalone surveys or assessments would be required.

4.3 Methodology

4.3.1 *Sampling considerations*

With no pre-existing information about the source locations of beach visitors at the case-study beaches, determining the relevant population of beach users was not possible, and survey sampling relied upon intercept samples. Given the high proportion of international visitors and repeat visitors, an individual travel cost model was chosen. A mixed-mode survey instrument was employed, which was deployed both onsite and via email invitations to an online survey. Intercept sampling was employed in the onsite survey, with the surveyor approaching each individual or group. Within each group, the person with the most recent birthday was asked to complete the interview. This provides a simple means of randomising the sample, and reduces the potential for bias associated with self-selection of the most outspoken within a group (Latham, 1991). Only those over the age of eighteen were surveyed, as interviewing minors would have required adult supervision.

4.3.1.1 Sample bias through exclusion of non-users

This survey was administered only to beach users. Whilst the trip demand curve is estimated with correction for truncation of the sample, these results are assumed to apply only to beach users, with no assumptions drawn about the relevance of responses to the broader population. Estimates of beach visitation (explored further in section 4.3.14) are taken as the 'representative population' in calculation of aggregate recreational use value of the case-study beaches.

Further sample restriction is also evident for practical reasons. Responses could not be gathered from those who were cycling or jogging. They could also not be gathered from those engaged in aquatic pursuits. Whilst studies in southern California have demonstrated that fewer than half beach users may enter the water (Dwight et al., 2007), these users may have greater expenditure. Studies on surfers conducted in Australia, California and Spain have shown that surfers typically drive further and spend more in order to visit favourite beach locations (Nelsen et al., 2007).

4.3.2 *Travel distance*

The advent of trip planning technology provides a simple means of assessing the travel time and distance for individuals. For calculations performed in this thesis I employed the trip planner on the VisitNSW website[8]. This planner calculates the route which takes the shortest time, rather than the shortest distance. Given the driving distances are typically short, any extra distance driven is likely to be minimal. Travel distances were estimated from the central point of each suburb. A greater degree of accuracy could be achieved by using the exact street address of each respondent; however these were not collected due to a desire to preserve anonymity of respondents. The end point used to calculate driving distances was the closest street location to the point on the beach at which they were interviewed. In the case of Dangar Island, Brooklyn was used as a proxy for driving directions, as there are no vehicles on the island.

Trip planning websites often include measures of congestion delays, and may choose different routes based on the time of trip. This is also a potential response of beach visitors with knowledge of alternative routes, hence driving distances may vary. Although the time of interview was recorded, congestion allowances were not included in the analysis due to complexity. It is also likely that traffic and trip timing will vary between trips.

4.3.3 *Travel time and ticket costs*

In the majority of cases, the travel time and ticket prices included in the cost calculations are those reported by the respondent. This is true even when they are demonstrably inaccurate, as it is the perceived time and expense that is the determinant of the trip function (Randall,

[8] http://www.visitnsw.com/NSW_Maps_and_driving_directions_P3449.aspx

1994). In the event that respondents did not know their expenses, calculations were performed to populate the response. This practice results in a greatly improved number of usable responses, and tests have demonstrated that the approach is reasonable, based on benefit estimates generated (Bowker et al., 1996).

When travel employed public transport, the trip planner on the NSW Government Transport Info website[9] was used to calculate travel times from their suburb of origin. It was assumed that the respondent would use the travel mode (or combination of modes) corresponding with the shortest travel time, unless their answers indicated otherwise. Ticket costs were calculated by estimating the least cost adult fare from the origin suburb to the interview location. For train journeys, this employed the fare calculator tool on the CityRail website[10].

4.3.4 *Off site expenditure and multipurpose travel*

Due to the complexities of separating the beach 'component' from a multiple-purpose trip, expenditures associated with accommodation were excluded. The only travel costs included in this estimation are those associated with the daytrip. The use of capital equipment in recreation, such as surfcraft and swimwear, is also not included, as estimating the marginal costs is problematic. The exception in this study is in estimates of travel costs that include standing or depreciation costs of the vehicle used, although these are presented only in generic terms and do not take into consideration the variation in vehicle value.

4.3.5 *Income*

Use of income figures in analysis was severely hindered by privacy concerns identified in pre-testing, which led to the income question employing broad income ranges as response categories, rather than an open-ended question format. The use of ranges presents challenges in calculating accurate hourly incomes for use in travel time cost calculations, as the midpoint is typically employed (e.g. Blackwell, 2007) which reduces the usefulness of income as an

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[9] http://www.131500.com.au/newjourney.asp

[10] http://www.cityrail.info/tickets/fare_calculator.htm;jsessionid=830D34EF4BDEB3BC3653A14BB580C802

explanatory variable for WTP responses. The corollary is higher response rates. There is high variability in income, due to the presence of a significant number of respondents with zero (taxable) income. These are primarily students and retirees. It should be noted that this survey was conducted in part during the height Global Financial Crisis, at a time when the vast majority of stocks experienced major declines in value. This meant that a large number of self-funded retiree respondents had either uncertain or negative income. In these cases, no attempt to input estimated incomes was made, as this has the potential to bias the interpretation. There was also a substantial component of respondents (65 of 516, or 12.6% of the combined sample) who were unwilling to answer the demographic component of the survey. Whilst a perfectly justifiable response, this leaves the analyst without data to assess the influence of theoretically important factors (such as income and employment status) on the trip demand function. In instances where there was no income information provided, the sample average for the appropriate case-study site was employed.

Salaries in different currencies were converted to annual salaries in Australian dollars using the salary converter at http://www.xe.com/ucc/full/ with rates as at 30 June 2010, and rounded to the nearest thousand dollars. For weekly salaries, they were multiplied by 52 weeks, monthly salaries were multiplied by 12. Whilst exchange rates have changed over the course of this project, the use of broad income ranges and midpoints means that the converted incomes are likely to fall within the same range.

Hourly rates for the opportunity cost of time were calculated using National Employment Standards, which prescribe the standard working hours in Australia, and are derived from the *Fair Work Act 2009*. Although surveys have shown that typical working hours for full time employment are greater, the standard working week is 38 hours, for 48 weeks per year. It is typical to have 4 weeks of paid annual leave, which may be subject to leave loading. It is assumed for the purposes of calculations that there is no leave loading, and pay is at the normal rate, hence the salary is consistent across all weeks. Estimates of annual salary are therefore divided by 52.

4.3.6 *Travel time costs*

In the case of Manly and Dangar Island in particular, the trip to the site may be an enjoyable experience in itself, as they both can involve travel by ferry across picturesque water bodies (Brown et al., 2010). As such, these journeys may actually contribute utility, and the use of a negative wage rate may overstate the travel time component. Nevertheless, the range of other conservative adjustments employed in the analysis lead me to believe that the true economic impact is likely to be substantially higher, with these estimates representing a conservative lower bound.

4.3.7 *Duration*

Previous studies have shown that the time taken to complete a survey can be an indicator of the comprehension of the instrument by the respondent, and have an effect on the responses gathered (Hess et al., 2008).

The timestamp recorded is the time that the survey record was created, i.e. the time that the survey was completed. The elapsed time recorded by the software used in the online surveys (Techneos Entryware 6.1) is the difference between the creation of the record and the timestamp of the previous record. This creates strange figures when there is a large gap between consecutive records. In effect, this is a measure of survey frequency. It is possible that this information could provide some insight into the response rate, or the efficiency of individual surveyors, however this was not inspected.

Extensive pretesting indicated that the survey was typically completed in less than 15 minutes. Elapsed times were therefore cleaned to remove those where the survey took more than 50 minutes, as this typically corresponds to the surveyor taking a break, or failing to close the survey between surveying days or sessions.

4.3.8 *Driving costs*

Costs of running a car were estimated using the figures provided by the Royal Automobile Club of Queensland (RACQ), with the most popular car in each class used in calculations (RACQ, 2010). If the vehicle was classified as ‘Unknown’, small car was used as a proxy, unless the make and model were provided to allow for more accurate classification. The author was unable to find evidence of running costs for a standard motorbike, hence the lowest running costs for a light car were used as a proxy. This may be an overestimate. Figures used in calculations are presented in Table 4.1 (RACQ, 2010).

Table 4.1 Cost estimates used in driving cost calculations. Source: RACQ (2010)

Vehicle category and example vehicle in each class used in calculations	Running Costs ($AUD Cents/km)	Running Cost including depreciation ($AUD Cents/km)
Motorbike (Light as a proxy)	12.48	43.73
Hyundai Getz		
Small car (less than 1600cc)	15.22	55.87
Hyundai i30		
Medium (4 Cyl, 1601-2600cc)	17.32	73.13
Toyota Camry		
Large (6 Cyl, over 2601cc)	19.59	83.55
Holden Commodore		

Although the standing costs of vehicle ownership can be attributed to a broad range of activities, not just to beach visitation, the use of full running costs is justified through experiments where respondents are asked to estimate their travel costs. In these cases, respondents typically estimate a range far exceeding the running costs alone, and more in line with depreciation costs (Willis and Garrod, 1991). It is the expected rather than actual costs which determine visitation frequency, despite the fact that these anticipated costs are not observable (Randall, 1994).

4.3.9 *Parking costs*

The majority of respondents either held parking permits, stayed less than the permitted time, or parked outside the paid parking area. Parking costs included in the analysis were derived from the respondents own estimates, even where they may differ from the verifiable parking costs for parking in the study area at which they were interviewed. No correction is made to estimate a pro-rata parking fee for holders of residential parking permits, as costs of these permits are incorporated into the residential rates system and hence determining marginal components is not possible.

4.3.10 *Visitation equation estimation*

Previous sections have outlined calculations associated with expenditure and imputed costs associated with beach visitation and recreation. Given that those surveyed have chosen to outlay the time and resources described, it can be assumed that the monetary equivalent of the utility they gain from their beach visit is greater in magnitude. The difference between the total value they derive from the trip and the outlay necessary to make the visit is termed consumer surplus, and is unobserved but estimable through construction of a demand curve for visitation (Hanley et al., 2001b). This demand curve is approximated using the visitation frequency as the (discrete) dependent variable, and demographic and trip cost components as explanatory variables.

The selection of sampling procedure has the potential to introduce a number of potential biases in TCM, which should be addressed in analysis to ensure predictions are accurate. Key among these sources of bias are those of truncation and endogenous stratification. Endogenous stratification refers to the fact that those visitors who visit the site most frequently are more likely to be intercepted by onsite surveys. Truncation refers to the fact that visitation frequency will be artificially constrained to positive integers, as the respondents must have made at least one trip in order to be intercepted at the site. TCM are often estimated through onsite sampling, due to the convenience of rapidly accessing a group which is known to interact with the resource. There is inherent bias of the sample through sampling of only site visitors, either onsite or though initial screening questions in alternative survey formats, means that some form of statistical model that accounts for this is required. Another key consideration is that the number of trips taken is rarely estimated as a continuous variable, but is reported as falling into a category or group (Dobbs, 1993b). Count data models are therefore required for analysis. OLS forms are not the most efficient estimators for count models, as they imply a continuous dependent variable, and are therefore not appropriate for analysis of onsite samples (Shaw, 1988). Maximum likelihood estimators (MLE) should therefore be employed. Models commonly applied include truncated negative binomial (TNB), truncated poisson, and zero-inflated poisson (ZIP) models (Grogger and Carson, 1991, Haab and McConnell, 1996).

Poisson distributions assume that mean and variance are equal, and are rarely applicable to count data due to the likely presence of overdispersion (Grogger and Carson, 1991). Overdispersion refers to the fact that the majority of visitors will take only a few trips, whilst avid visitors may visit very frequently. This has the effect of skewing the visitation frequency distribution to the right. Simple regression-based tests for overdispersion are described by Cameron and Trivedi (Cameron and Trivedi, 1990).

Zero-inflated Poisson (ZIP) models account for overdispersion through allowing increased number of observations at zero (Haab, 2003). Augmented poisson models are also proposed by Haab and McConnell to account for excess zeroes (Haab and McConnell, 1996). Given the censoring of this sample through onsite surveys, this degree of complexity is not required.

The most common means of analysis for single-site ITCM data is the truncated negative binomial regression (Blackwell, 2007). This model has the advantage that it replicates the Poisson if overdispersion is not present (Martínez-Espiñeira and Amoako-Tuffour, 2008).

A truncated negative binomial model was estimated in Limdep, following the approach of McKean (McKean et al., 2003) with visits per summer swimming season as the dependent variable. Demographic and trip characteristic variables were investigated for significance in determining frequency of visitation. Results are presented in section 4.5.

4.3.10.1 Selection of independent variables

Previous sections have discussed the components of the travel cost variable, particularly the inclusion of the opportunity cost of travel time, and the appropriate wage rate at which it should be calculated. Tables 4.2 and 4.3 show the variability with which cost components and substitution costs are incorporated into TC studies in the peer-reviewed public literature. The welfare estimates show considerable sensitivity to the different cost specifications, as they change the slope of the (estimated) demand curve. This was the rationale for the testing of multiple models with differing cost components in the current study.

Table 4.2 Exemplar cost and substitution components included in beach recreation demand studies

		Cost components			Site and substitution components		
Primary Author	**Year**	**Travel costs**	**Travel time cost**	**Onsite costs**	**Substitute sites**	**Site quality**	**Substitute activities**
Bell	1990	US$0.08*mile or standard airfare, adjusted for % of trip which is 'non-beach'	N	Y	N	Categorical factors for: congestion, parking availability	# of Non-beach days
King	2002	US$0.49*mile for driving+ airfare function for air travel	33% of household income	N	N		
Bin	2005	0.35c * mile	Test alternatives from 25% to 100% of household income, constant driving speed assumed	N	Y - for 2 alternatives.	Dummy variables for beach at which survey was conducted	Dummy for multipurpose trips
Chen	2004	Zonal model - cost calculations unclear	1/3 wage rate (unclear if household or personal)	Y - 1/3 wage rate	N	N	Pro-rata adjustment for time spent at beach relative to 5 other key attractions
Nunes	2004	Train ticket costs, car fuel costs only (parking costs included separately), no costs for bicycle and foot visitors	Variable time cost based on travel mode and income. Dummy for full-day visits	N	N	Site specific dummy, sunny weather dummy, Weekend visit dummy	N

Table 4.3 Exemplar cost and substitution components included in beach recreation demand studies (continued)

		Cost components			Site and substitution components		
Primary Author	**Year**	**Travel costs**	**Travel time cost**	**Onsite costs**	**Substitute sites**	**Site quality**	**Substitute activities**
Nunes	2004	Train ticket costs, car fuel costs only (parking costs included separately), no costs for bicycle and foot visitors	Variable time cost based on travel mode and income. Dummy for full-day visits	N	N	Site specific dummy, sunny weather dummy, Weekend visit dummy	N
Blakemore	2008	Total trip costs including flights, lodging and meals	N	Y - meals included in travel costs	N	Beach rating score	% contribution of beach activities to enjoyment
Hannemman	2004	Travel costs calculated based on engine size and driving distance	0, 1/3 and 100% of wage rate	Y	Site choice nested Logit model -53 sites	Named sites, imputed quality	N
Parsons	2000	Vehicle running costs	100% of wage rate	N	Site choice model - 62 sites	Beach length, development, surfing status, beach width (wide and narrow), access, boardwalk, amusements, suburb and park variables	N
Lew	2008	Vehicle running costs	Stochastic measure based on employment status and wage rate	N	Site choice model - 31 beaches in total, 16 in aggregated choice set	Variables representing lifeguard and parking status, length	N

The basis for selecting the non-monetary variables which are assumed to influence visitation is also poorly informed by the published literature. Table 4.4 demonstrates the variability in non-cost parameters typically included in travel cost models. It is clear that the published literature is not representing a consistent basis for model construction, rather one that is perhaps guided more by the views of individual authors and maximisation of model explanatory power.

Table 4.4 Demographic variables employed in beach recreation demand models

		Demographic components							
Primary Author	**Year**	**Income**	**Age**	**Gender**	**Resident status**	**Race**	**Education**	**Tastes**	**Comments**
Bell	1990	H	Y	N	Overnight visitors only	Y	N	N	Beach days is the dependent variable, rather than trips
King	2002	H - in time costs only	N	N	N	N	N		
Bin	2005	H. High Income dummy	Y	Y	Tourists only, separated into daytrippers and overnight visitors	Dummy - nonwhite	2 dummy variables for tertiary and postgraduate study	Dummy representing membership of env. Or conservation group	Average driving distance of 419 miles.
Chen	2004	Dummy for 'median or higher' income	N	N	Y - Zone 1 = local residents	N	Y - dummy for post-secondary study	N	Average group size of 17.5 persons
Nunes	2004	H	Y	Y	N	N	Dummy for economics major	In-a-relationship' dummy	Estimate of annual benefits rather than day-usage CS.
Blakemore	2008	H	Y	Y	Combined	Y	N		Social class' variable - not defined
Hannemman	2004	H	N	Y	N - very few overnight visits	Y (categorical)	Y	N	
Parsons	2000	H-in time costs only	N	N	N	N	N		Previous visits used to calibrate 'familiar' sites
Lew	2008	H-in time costs only	Y	Y	N	N	Y	N	Non-parsimonious model

Selection of appropriate regressors in the current study was therefore based in part upon three guiding principles: theoretical support, consistency with the literature (where possible), and the key points of interest for the project partners. These research partners are particularly interested in questions such as the influence of tourism marketing and residential status on visitation, given the economic repercussions for local businesses identified elsewhere (King, 2002). Turning to the results of previous studies also provides some direction on model development.

Numerous authors have explored the influence of non-monetary factors in determining both recreation demand and willingness to pay. It is typical to include a range of demographic variables, including age, education status and gender (Parsons, 2003). Income is almost always included in demand models as a test of theoretical consistency, with the assumption that increased ability to pay will result in reduced price sensitivity both in terms of travel costs and entrance fees. This is offset somewhat by the fact that the opportunity cost of travel time for high earners is greater than for the unemployed. There is some disagreement within the non-market valuation literature about whether income should be incorporated on a household or personal basis. The utility theory framework upon which welfare economics is built focusses on maximisation of individual utility, and hence the individual measure is more appropriate. Quiggin suggests that household WTP is more appropriate, though notes that this depends on the financial roles and relationships within the household (Quiggin, 1998).

Rigorous testing has previously identified differences in WTP based on the income elicitation question, with questions relating to individual income resulting in higher benefit estimates. These differences, however, were not significant at the 5% level (Lindhjem and Navrud, 2009). In this study, personal income was selected as it was found to be more easily estimated by respondents during pretesting. Whilst further analysis would be required to identify reasons for this difference, it may result from the high proportion of respondents who were travelling in a non-familial group, e.g. with friends. All previous studies on the matter appear to have assumed that travel occurs only within related family groups with shared understanding of family finances, which may not be an appropriate assumption.

The current study initially included income as a factor in the traditional fashion, although broad ranges meant that these responses are categorical rather than discrete. Income was insignificant when included in ‘continuous’ form. The use of broad income categories, as described in section 4.4.4, is likely clouding the issue here. It should also be noted that whilst included in the original screening models, income is often found to be statistically insignificant in coastal travel cost models. This is typically assumed to be because beach recreation costs are relatively minor.

Additional dummy variables were tested including: “no job”, “high income” and “low income”. The first of these categories includes those who were students, retirees, or unemployed at the time of completing the survey. These respondents would have greater opportunities to visit the beach than those in employment, though they may be expected to be more sensitive to price increases. The continuous measure of income is replaced in final models with two categories, HighInc and LowInc, representing those with annual incomes greater than AUD$85,000 and less than AUD$25,000, respectively (2008 dollars). Those in the low income category are expected to have reduced capacity to visit, and also increased price sensitivity. Those in the high income category are expected to have reduced price sensitivity but fewer visitation opportunities (Emmert, 1999).

Age and Gender are incorporated in the typical manner, as continuous and binary variables, respectively. Age has been shown to influence outdoor water-based recreation demand in previous studies (McKean, Johnson, & Taylor, 2003). Previous studies have also identified gender as a statistically significant determinants of WTP (Swallow et al., 1994). Education is presented by two dummy variables, NoHighSc and Universi, which represent those who have not completed secondary education and those who have completed some form of post-secondary qualification, respectively.

Employment status is represented by the category NoJob, which refers to those who were unemployed, retired or students at the time of completing the survey. It is theorised that in the urban setting time is more important than travel costs in determining visitation opportunities. These respondents will have greater opportunities to visit the beach than those in full time employment, hence it is expected that their visitation will be higher. Previous studies have shown that available (discretionary) time is a significant factor in determining recreation demand (McKean, et al., 2003). Experience with beach closure (Beach_cl) is used as a proxy for familiarity with the good under consideration.

Resident or tourist status is expected to be a factor in determining visitation frequency and also WTP for beach preservation, especially given the long lead time before the described damage in climate-change erosion scenarios. Previous studies (Bell & Leeworthy, 1990; Blackwell, 2007) have conducted split-sample analysis on the two groups, based on the assumption (typically proven to be true) that their preferences differ substantially.

Bowker and Leeworthy (1998) explored the influence of ethnicity on recreation demand, finding substantial differences in price elasticity and consumer surplus estimates between White and Hispanic sub-samples. The ethnicity of onsite survey respondents in the current study was classified on a continent basis, with the underlying assumption being that those who are Australian citizens will have a higher visitation frequency and subsequently WTP values.

4.3.10.2 Construction of seasonal visitation estimates

The survey instruments asked respondents how many times they had visited the beach in the previous month, rather than per season or per annum as is more typical in the literature. The original intention was to convert these to annual figures based on the visitation model constructed from objectively sourced beach usage data and weather characteristics, which would have been a novel addition to the field (see section 4.4.10). Unfortunately, this was ultimately not possible given data limitations. In order to generate more comparable results, these reported monthly figures were converted to seasonal figures using proxy data sources. Given the lack of visitation data for the winter months, even proxy sources, it was not feasible to reliably estimate annual visits. Seasonal data has been used previously in the literature by Parsons et al. (G.R. Parsons, Kang, Leggett, & Boyle, 2009).

This scaling process first necessitated definition of resident status. In the current study, residential status is incorporated via a dummy variable. This variable was constructed from responses, as residential status was not specifically assessed by the surveys. This omission stemmed from a number of theoretical and political challenges. Pretesting found that the response rate was substantially impacted by questions about resident status. Project partners were also reluctant to have direct questions relating to resident status incorporated into the survey, due to political backlash relating to climate change levies that were proposed by partner councils while the survey was being administered.

Residential status was estimated retrospectively, using the following assumptions. Residents were defined as:

- holders of parking permits;or
- those who walk but do not stay overnight;or
- those with travel times of less than 20 minutes

Those who stayed overnight were excluded from the resident category. It is assumed that these are tourists staying at the beach in question. There were two respondents with particularly long trip durations, 60 and 180 nights. It is assumed for analysis purposes that these people are residents. Other people who reported staying in the region overnight are given the number of nights as their annual trip frequency.

For residents, their monthly reported visitation is converted to an annual figure by a scaling process based on council lifeguard observation data at Manly Beach. Table 2.1 shows the monthly visitation estimates for the summer season of 2007-08, the period over which the survey sampling was conducted. It can be seen that there is a peak in visitation corresponding with the months of December and January, with lower visitation estimates for the other months. The ratio of visits between months is used to provide 'filled' estimates of visitation for the other summer months.

For example, a person who was surveyed in April and stated that they visited the beach twice in the previous month is assumed to have visited the beach in January for a total of 2*(1.0/0.5) times, or 4 visits. The maximum 'filled' figure is limited to the number of days in the month. The same procedure is used for the other months, to derive a total estimated number of visits for the summer period. This is then used as the dependent variable in the TNB analyses.

Table 4.5 Council lifeguard estimates for Manly Beach Summer 2007-08

Month	Beach users (Lifeguard estimates)	# of reports	Standardised monthly beach users	Proportion of summer total	Relative proportion of peak visits (Proportion of January visitation)
October	262000	30	270733	0.14	0.8
November	220500	30	227850	0.12	0.6
December	345000	31	345000	0.18	1.0
January	353500	31	353500	0.19	1.0
February	213500	29	228224	0.12	0.6
March	303500	31	303500	0.16	0.9
April	146500	28	162196	0.09	0.5
Total	1844500		1891004		

n.b. May visitation estimates are assumed to be half that of April.

4.4 Results and analysis

Responses gathered in the onsite sample at the four case-study sites are presented in this section. Beach-by-beach comparisons between samples from the various case-study beaches are not undertaken for all results. It is my view that these comparisons are not of great theoretical value, as the decision to undertake separate studies in each location presumably stems from the fact that the context differs between sites. The main value of these comparisons is therefore to assess whether the individual studies were justified, or whether a more rapid means of assessment based on benefit transfer could have provided appropriate welfare estimates. In this study, overall screening of differences between beaches is conducted via Kruskal-Wallis Analysis of Variance by Ranks, which is the non-parametric equivalent of the ANOVA F-test (Wooldridge, 2006). Chi-squared analysis identifies the same factors as significantly different, with minor differences in test-statistics.

Beach-wise comparisons are made only between the online and onsite samples of Manly and Collaroy-Narrabeen, and the samples from Brooklyn and Dangar Island. The former set of comparisons allows for tests of the effect of survey administration mode, while the latter tests the assumption that these sites draw from a similar pool of beach visitors and can be treated as a combined site. These analyses are undertaken with the Mann-Whitney U test, the non-parametric equivalent of the student’s t-test (Wooldridge, 2006).

The absence of pre-existing information about beach visitors also provides challenges in terms of the analysis of the results. It is difficult to know how representative a sample is of the broader beach-going population, without first knowing the demographic makeup of the population of interest. Hence the results presented in the subsequent section are presented in the absence of reference figures.

4.4.1.1 Demographics

Table 4.4 presents the summary statistics for demographics of the sampled populations at the case-study locations. Discussion is restricted to those factors where there is a significant difference between the case-study sites. The majority of factors presented should be self-explanatory in nature. “No Job” is a binary attribute indicating that the respondent was either on leave, a student, retired, or unemployed. It is hypothesised that these respondents will have greater free time so they will be able to visit the beach more frequently. Whilst income constraints may impact upon this visitation, the fact that they have been intercepted at the beach means that these restrictions are not insurmountable.

Responses to the nationality question were coded by continent. The proportion of Australian citizens ranged between 39% at Manly and 74% at Dangar. In the case of Australian residents, distinction was made between those holding only Australian citizenship, and those who held dual citizenship, indicating that they were born overseas. Brooklyn and Dangar Island samples are highly dominated by Australians and naturalised dual citizens, with these categories accounting for 80% and 86% of the total samples, respectively. Manly has the lowest proportion represented in these two categories, with 44% of the total sample. The remaining sample is primarily composed of those from the UK (23%) and mainland Europe (14%). Once again, this is likely to have been strongly influenced by the requirement that the survey be completed in English. Tour groups frequently visit Manly beach, with tours conducted in numerous Asian languages. Whilst a number of tour groups were approached about distributing the survey, none expressed interest in participation.

Table 4.6 Demographics comparison between beaches

	Beach												Kruskal-wallis (df=3)	
	Collaroy-Narrabeen			Manly			Brooklyn			Dangar				
	N	Mean	Std. Deviation	N	Mean	Std. Deviation	N	Mean	Std. Deviation	N	Mean	Std. Deviation	Chi-square	Asymp. Sig.
Gender (male=1)	173	0.57	0.50	148	0.51	0.50	47	0.45	0.50	46	0.37	0.49	6.579	.087
Age (years)	169	39.62	15.16	146	39.13	14.82	46	44.20	13.10	43	46.49	11.98	16.127	**.001**
Hourly wage rate	158	23.51	19.30	133	22.65	20.69	42	27.56	20.53	40	29.42	21.13	4.781	.189
Income (AUD$ p.a.)	158	46462.03	38142.86	133	44751.88	40880.86	42	54464.29	40558.36	40	58125.00	41751.52	4.781	.189
University	172	0.39	0.49	147	0.56	0.50	46	0.48	0.51	44	0.73	0.45	19.471	**.000**
No High School	172	0.08	0.27	147	0.07	0.26	46	0.11	0.31	44	0.11	0.32	1.010	.799
No Job	172	0.22	0.41	147	0.28	0.45	46	0.28	0.46	44	0.32	0.47	2.965	.397
Aussie	173	0.51	0.50	148	0.39	0.49	48	0.73	0.45	46	0.74	0.44	28.021	**.000**
UK	173	0.13	0.34	148	0.23	0.42	48	0.04	0.20	46	0.11	0.31	12.433	**.006**
Naturalised	173	0.06	0.23	148	0.05	0.21	48	0.04	0.20	46	0.11	0.31	2.709	.439
Europe	173	0.16	0.36	148	0.14	0.34	48	0.06	0.24	46	0.00	0.00	10.167	**.017**
Nth Am	173	0.03	0.18	148	0.10	0.30	48	0.00	0.00	46	0.00	0.00	13.824	**.003**
NZ	173	0.02	0.15	148	0.04	0.20	48	0.06	0.24	46	0.00	0.00	3.814	.282
Sth Am	173	0.03	0.17	148	0.02	0.14	48	0.00	0.00	46	0.00	0.00	2.697	.441
Asia	173	0.01	0.11	148	0.03	0.16	48	0.02	0.14	46	0.02	0.15	1.033	.793
Nation Other	173	0.02	0.15	148	0.01	0.08	48	0.00	0.00	46	0.00	0.00	3.269	.352

The sampled visitors at Dangar Island were the most highly educated on average, with almost three-quarters of the sample having undertaken some form of university education. Across the whole sample, around 60% of respondents hold some form of tertiary qualification (Figure 4.6). This may be biased through selection of respondents able to complete the survey in English, which for tourists may indicate post-secondary study.

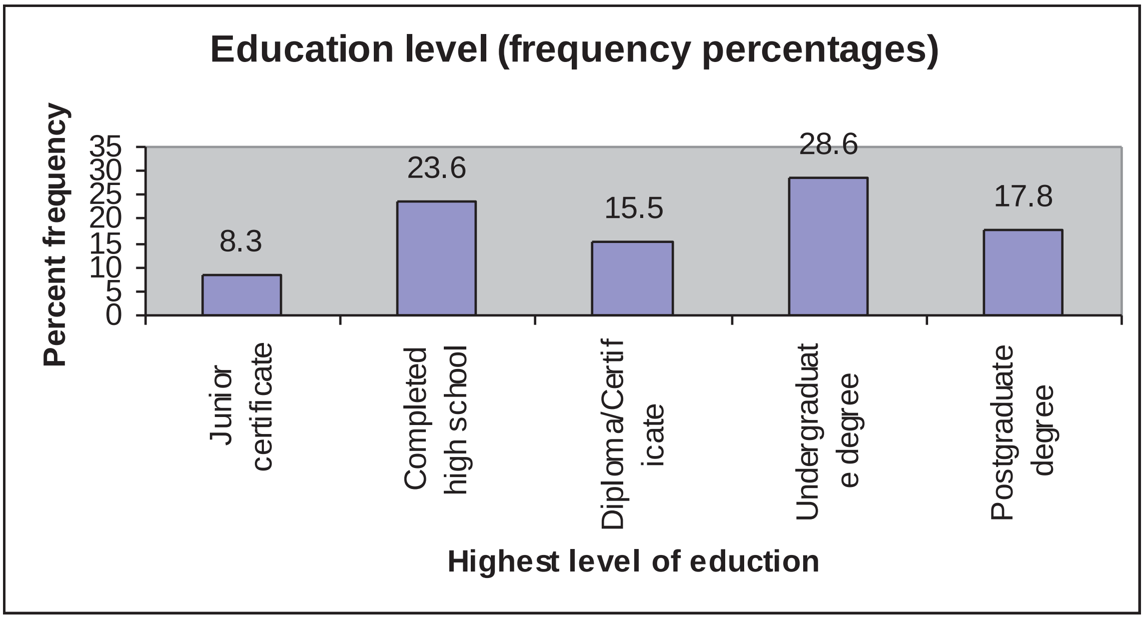

Figure 4.1 Education level of Sydney beach visitors

The samples from Brooklyn and Dangar were slightly older on average than the Manly and Collaroy-Narrabeen sample. Given the long timeframe before onset of the climate change impacts described in this study (damage scenario is described in Chapter 5), it is hypothesised that this will result in a lower overall WTP for beach erosion protection. Conversely, older respondents may give greater consideration to the impacts upon their children and grandchildren. There was a significant difference in the age class breakdown by beaches. The sample from Collaroy-Narrabeen had a higher proportion of younger visitors, the sample from Dangar was weighted slightly towards the elder classes, whilst the Manly and Brooklyn samples were relatively balanced across the classes (Figure 4.2).

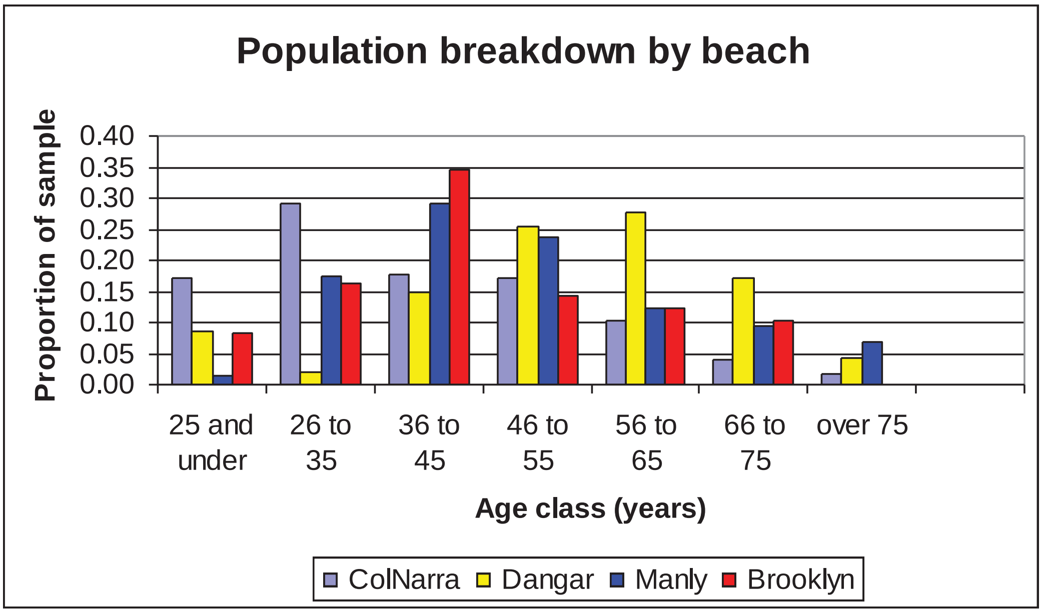

Figure 4.2 Age class breakdown by beach, onsite sample only

Approximately half the sample was employed full time, or on leave from full time employment (Figure 4.3). Previous studies of beach visitors give little detail on the employment status of their samples, despite the fact that this has the potential to influence both visitation frequency and financial status or ability to pay.

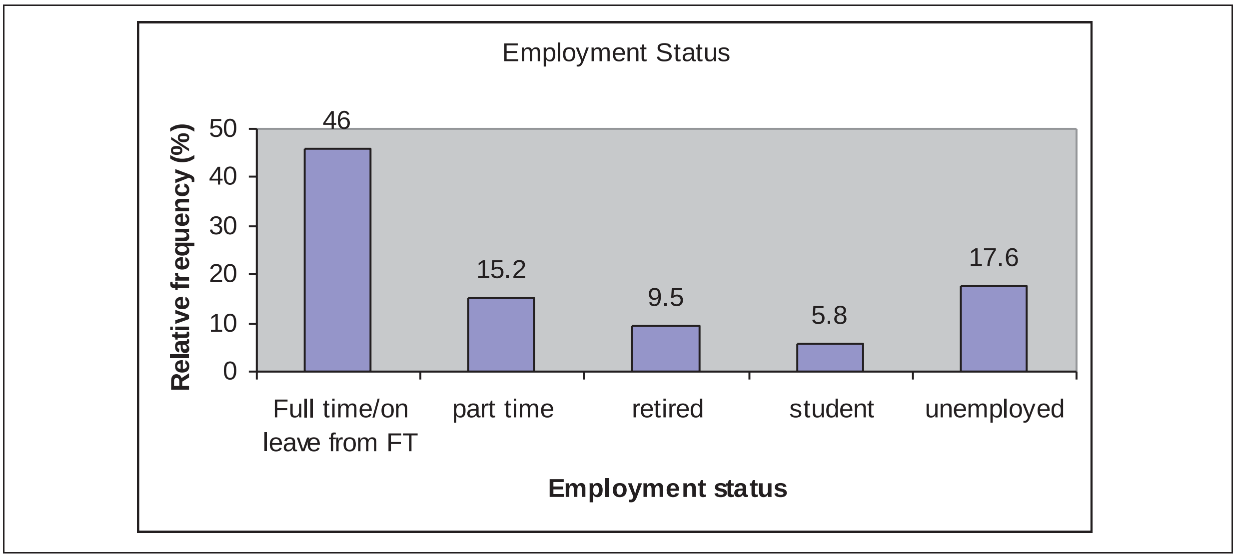

Figure 4.3 Employment status of beach visitors

An exception can be found in the work of Nelsen et al., who use such information to dispel stereotypes about surfers in California, demonstrating that the average member of a sample of surfers at Trestles Beach is both more wealthy and better educated than the average beachgoer (Nelsen et al., 2007).

4.4.1.2 Trip Characteristics

Table 4.7 presents a summary related to the choice of travel mode (Car, Human, Ferry, BusTrain). Table 4.8 presents further information on the time spent in travel (TT1way) and onsite (TimOnsit), and the number of people in the group (GrpTotal), and visitation frequency (Visit Freq). Each of the sites is serviced by different modes of transport. Dangar Island is accessed by ferry or private boat. Brooklyn is located near the Hawkesbury River train station, and may also be accessed by ferry or car. Manly is a transport hub, with bus and ferry terminals. Collaroy-Narrabeen is the most poorly serviced site by public transport. There are bus stops along the length of Ocean St and Pittwater Rd, although these are not thought to be major transport providers for beach visitors.

Table 4.7 Travel Mode by beach

Beach	Car	Ferry	Human	Bus or Train
Collaroy-Narrabeen	0.61	NA	0.34	0.04
Manly	0.29	0.33	0.36	0.02
Brooklyn	0.84	0.00	0.04	0.11
Dangar	0.12	0.44	0.44	NA
Total Sample	0.47	0.17	0.33	0.04

Brooklyn is relatively remote, and is visited primarily by car. Dangar is even more remote, in that it requires ferry or boat travel from Brooklyn. The responses indicating use of car for travel to Dangar Island represent a misspecification, as there are no vehicles on the island, although in the absence of data to inform the correct reclassification these responses are not adjusted. Almost half of the sample on Dangar Island report travelling by foot, indicating a highly local sample. Given that there are approximately 200 residential lots on the island, and a proportion of these are used for holiday rentals, the sample size represents a substantial component of the total population.

Table 4.8 Trip characteristics by beach

	Beach								Kruskal-wallis (df=3)	
	Collaroy-Narrabeen (n=174)		Manly (n=148)		Brooklyn (n=48)		Dangar (n=45)			
	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	Chi-square	Asymp. Sig.
Group Total	2.63	4.73	2.69	5.10	3.31	1.52	2.98	1.88	29.81	**0.00**
Car	0.61	0.49	0.29	0.46	0.84	0.37	0.12	0.32	78.76	**0.00**
Human	0.34	0.48	0.36	0.48	0.04	0.21	0.44	0.50	19.75	**0.00**
Ferry	0.00	0.00	0.33	0.47	0.00	0.00	0.44	0.50	90.72	**0.00**
Bus or Train	0.04	0.19	0.02	0.14	0.11	0.32	0.00	0.00	9.98	**0.02**
TT1way (minutes)	28.06	33.36	55.08	57.86	86.13	50.90	102.42	97.93	56.78	**0.00**
TTless20	0.59	0.49	0.36	0.48	0.12	0.33	0.37	0.49	39.40	**0.00**
Time Onsite (minutes)	126.19	80.12	160.97	88.94	145.33	75.40	95.58	93.10	29.49	**0.00**
Duration (seconds)	826.91	488.58	700.93	376.16	596.17	348.07	846.49	621.63	16.90	**0.00**
Visit Freq (#/ month)	12.98	11.15	10.14	9.99	4.13	5.93	9.82	11.35	53.64	**0.00**

Approximately a third of visitors to both Manly and Collaroy-Narrabeen travel by human power, which indicates a highly local sample of visitors has been sampled.[11] This is common with onsite surveys (Blackwell, 2007), and is a source of bias that must at least be considered, if not addressed (Bin et al., 2005, Martínez-Espiñeira and Amoako-Tuffour, 2008). In the case of Collaroy-Narrabeen, the remainder of the sample is primarily made up of drivers of private vehicles. Travel to Manly is split almost evenly between the three dominant modes.

Ferry travel to Manly is considered to be part of the beach visit experience for many visitors, as it allows a scenic trip on Sydney Harbour (Brown et al., 2010). It is also the most direct means of access to Manly via Circular Quay, which is serviced by direct public transport services from major accommodation centres in the CBD and Bondi (NSW Transportinfo, http://131500.com.au)

Bus travel was poorly represented in the sample. For Manly this is somewhat unexpected, as there is a major transport hub located at Manly. This may indicate that the bus is not a preferred mode of transport for beach recreation. This could potentially be due to the challenges of transporting beach recreation equipment on a bus. It also indicates that the use of ticket records is not likely to generate useful estimates of beach visitation.

The survey questions asked the respondents to name the most recent travel mode, in the event that they had taken more than one mode, i.e. driven to the ferry stop then taken the ferry. As such, it both under-reports the use of multiple modes of transport, and likely underestimates the true value of the trip, as it only considers the final side trip. It is likely that a substantial proportion of visitors who came to Manly by ferry had travelled to the departure point (Circular Quay) by bus.

The vast majority of visitors to all sites were daytrip visitors, which was the intended sample. All visitors to Dangar Island were daytrip visitors or residents on the island. Thus no tourists were surveyed. Given that beachfront accommodation is available at Bradley's Beach, this is likely to represent a biased sample. Mean trip duration is biased upwards for Manly and Collaroy-Narrabeen by the presence of outliers. These outliers indicated trip durations of 180

[11] This stratification is addressed through use of the Truncated Negative Binomial distribution in estimation of visitation equations.

and 60 nights, respectively. It is likely that these respondents are temporary residents on working holiday visas. The seasonal influx of visitors to beachside locations in Sydney is substantial, and can cause conflict with resident populations (Allon et al., 2008). This study excludes the economic importance of these visitors, despite the fact that the presence of beaches is likely to be a substantial motivation for selecting Sydney. Hence the estimates can be considered highly conservative.

Of the 515 respondents in the pooled sample, 158 (30.6%) travelled to the beach under their own power. This suggests a very localised sample has been surveyed. This is further validated by examination of the travel time and visitation frequencies. The sample consists of highly avid beach visitors, as evidenced by the relative visitation frequency shown in Figure 4.4.

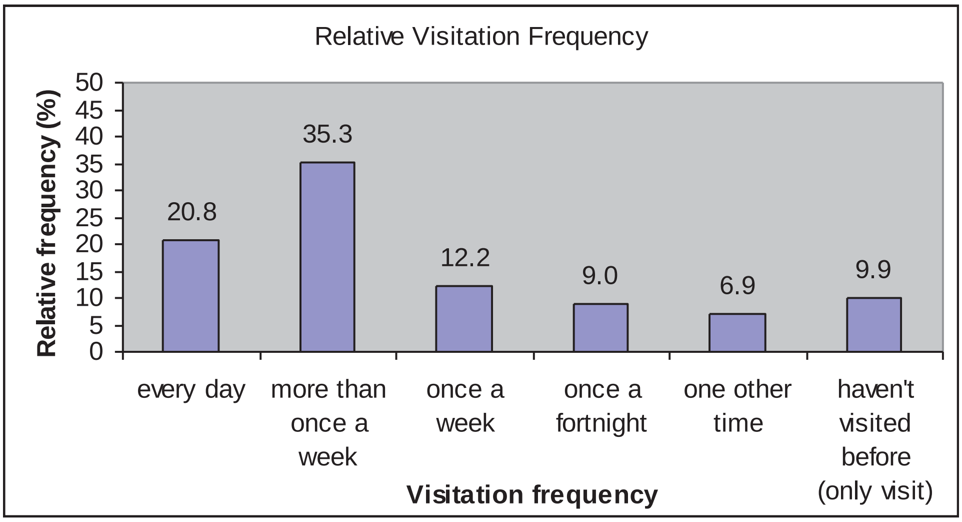

Figure 4.4 Trip characteristics by beach

This is most apparent for Manly and Collaroy-Narrabeen, where almost 70% of respondents visited the site at least once per week in the previous month. Visitation frequency by beach is shown in Figure 4.5. This result is somewhat surprising for Manly, given the high degree of international visitation. It is likely to be an artefact of the sampling regime, as only those who were able to complete the survey in English were included in the sample.

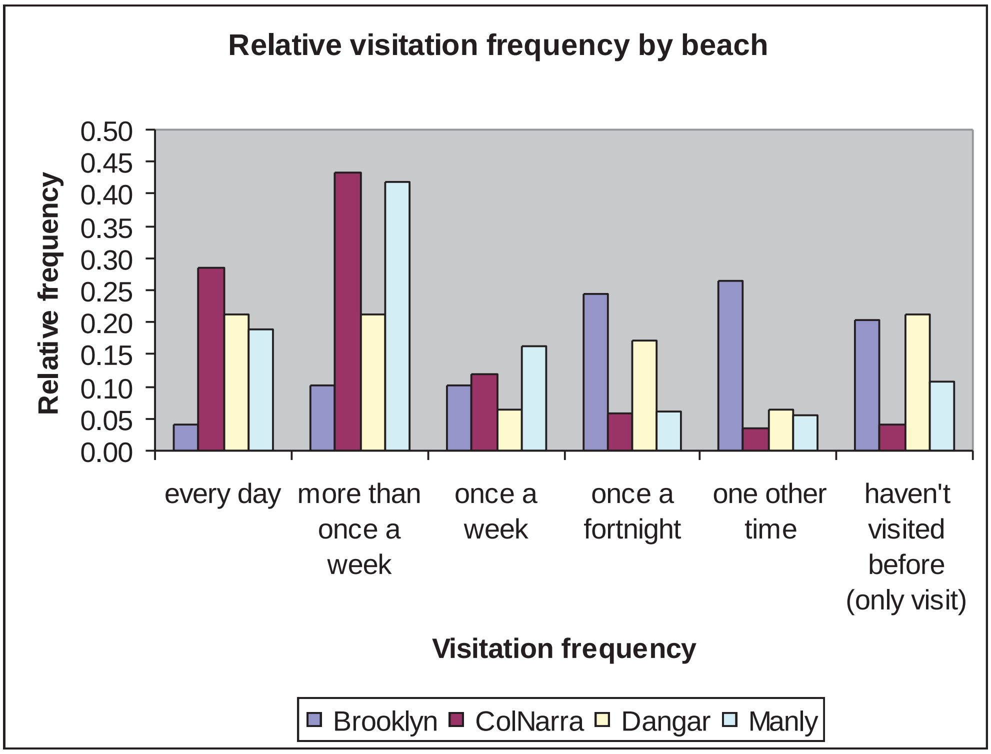

Figure 4.5 Visitation frequency by beach

The origin of the sampled population of beach visitors was widely spread over the Sydney and greater region, with 122 suburbs represented. As a reference, there are around 750 suburbs in the Greater Sydney region. Average travel time for the entire sample was 23 minutes for the return trip. Average one-way travel distance for those who drove was 11.2 kms, following exclusion of outriders. Almost 44% of the sample (226 of 515) is taken from visitors with one-way travel time of less than 20 minutes.

The same pattern can be seen in travel times, as shown in Figure 4.6. This figure shows a large number of respondents with very short travel times, indicating they are likely to live in the local area and be avid beach users.

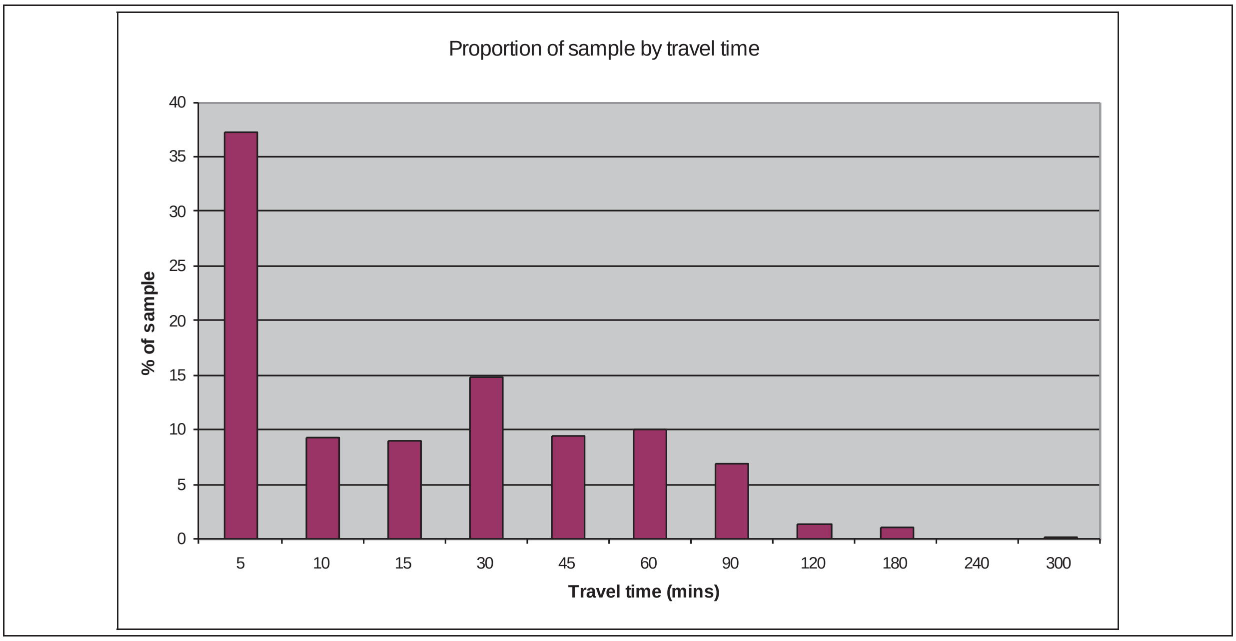

Figure 4.6 Proportion of respondents to personal interviews by travel time

Distance travelled is significantly different between sites, with visitors to Dangar and Brooklyn travelling much further on average (Figure 4.7). This is in line with the site being regionally important, and the lack of available substitutes.

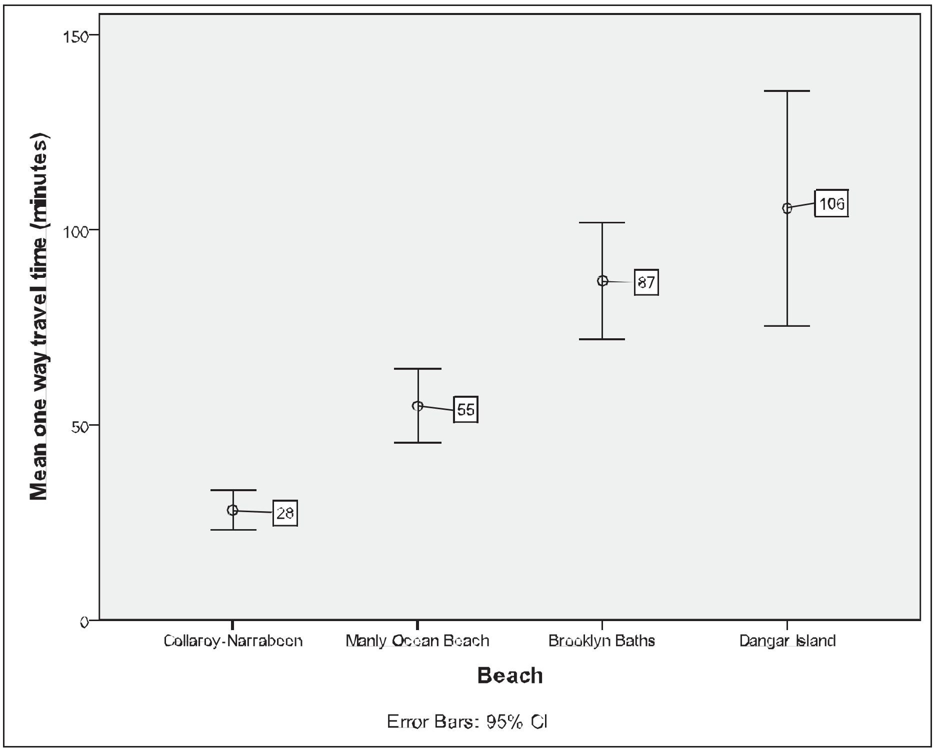

Figure 4.7 Mean travel time by beach

4.4.1.3 Travel Cost

A number of travel cost variables are calculated, to test for sensitivity to specification differences. Results are presented in Table 4.9. The most basic of these is Travel Costs (TC), which is the sum of driving, parking and ticket costs, where appropriate. Costs of travel are zero for those who travelled via human power. TDep is the costs of travel, with driving costs incorporating the vehicle depreciation costs. These figures are not used in construction of the demand curve for beach visitation, as it is assumed that the vehicle is used primarily for other purposes and the contribution of the trip is minor to the overall depreciation of the vehicle. They are presented purely to demonstrate the substantial differences in travel cost estimates that arise from different specifications. Onsite is the total expenditure per group while visiting the beach, in dollars. OnsitePP is the expenditure divided by the number of visitors, including all adults and children. OnTC is the sum of OnsitePP and TC. OnTDep follows the same pattern as OnTC, with the exception that depreciation costs are again included for comparative purposes. TTC is the opportunity cost of travel time, which is estimated by the hourly wage rate multiplied by the number of hours for roundtrip travel (TT1way*2/60). It should be noted that the trip demand functions presented later in this chapter use a fraction of the wage rate (25%) in calculation of travel times. The figures presented in Table 4.7 are therefore 4 times those used in the regressions. TCTTC is the cost of travel plus the opportunity cost of travel time. TCTTCOn is the previous measure, with the addition of onsite expenditure per person.

Significant differences were found between beaches for all measures of travel cost. Travel costs are greatest at Brooklyn and least at Collaroy-Narrabeen, which aligns with the visitation frequency and local sample. Manly, Collaroy-Narrabeen and Dangar all have significant numbers (approximately one third) of local visitors (walkers) with no travel expenses, which has a downward influence on mean travel expenses. Marked differences were observed in the travel time cost components, which reflects the presence of a small number of interviewees who travelled long distances. Brooklyn is regionally important, with visitors travelling long distances, typically by car. Outliers for travel to Brooklyn and Manly skewed this data heavily to the right; they have been removed as they were clearly not day trip visitors, given that they involved one-way travel of more than 300 kilometres. Onsite expenditure did not differ significantly between groups.

4.4.1.4 Beach Choice

Given the differing nature of the case-study beaches, it is anticipated that the motivation for visiting each location will vary. This reflects the desire of the SCCG Beach Management Working Group to select beaches that differ in character and visitation patterns. Table 4.10 presents the summary of motivations for site selection by beach, which have been derived from onsite coding of the qualitative responses by the survey administrator. ‘Close or Easy’ indicates that the respondent chose the beach because it was the easiest to visit or closest to their home. ‘Features’ indicated that there was some aspect of the beach that was the source of the appeal. This may have included the swimming or beach conditions typically present at the beach, or it may refer to the presence of subsidiary features such as adjacent parkland or nearby shopping facilities. ‘Favourite’ indicates that the respondent had previously visited the beach and found it to be a pleasant experience. ‘Tourism’ indicated that the visitor had not previously visited the beach, but had received favourable recommendations from a source such as a newspaper article, a tourist guide book or the opinion of a friend or relative.

Visitors to Collaroy-Narrabeen were most likely to state the features of the beach were important in their beach selection. This reflects the fact that the beach is a highly important surfing site, with features that are not replicated by other nearby beaches. For the ocean sites, the fact that the beach was close or easy to get to was the most commonly cited reason for selection. This is in line with trip duration and travel mode statistics presented in the previous section, highlighting the local nature of the sample. For the estuarine sites, recommendations were the most important in determining visitation choices.

Table 4.9 Travel Costs parameters by beach

	Beach													
	Collaroy-Narrabeen			Manly			Brooklyn			Dangar			Kruskal-wallis (df=3)	
TC	160	2.90	4.643	145	6.31	6.922	45	14.72	8.645	43	7.49	8.094	65.264	**.000**
Tdep	160	11.00	17.612	145	10.59	16.766	45	60.80	39.141	43	16.00	31.640	73.321	**.000**
Onsite	160	9.84	16.828	145	11.87	17.847	45	18.07	20.226	43	16.28	22.993	6.038	.110
OnsitePP	160	4.25	7.338	145	5.62	8.007	45	5.60	7.430	43	5.52	8.785	3.294	.349
OnTC	160	7.29	9.781	145	12.27	11.108	45	20.95	12.765	43	13.17	14.012	51.179	**.000**
OnTdep	160	15.06	20.781	145	11.42	18.285	45	64.45	40.179	43	16.62	33.804	65.149	**.000**
TTC	160	23.03	40.095	145	34.46	62.134	45	68.94	76.354	43	99.66	137.945	22.415	**.000**
TCTTC	160	25.93	42.735	145	40.78	64.685	45	83.66	79.243	43	107.15	142.605	46.536	**.000**
TCTTCOn	160	30.32	45.285	145	46.73	64.522	45	89.88	84.052	43	112.84	146.451	45.574	**.000**

Table 4.10 Reason for beach choice

	Beach													
Motivation	Collaroy-Narrabeen			Manly			Brooklyn			Dangar			Kruskal-wallis (df=3)	
	N	Mean	Std. Deviation	N	Mean	Std. Deviation	N	Mean	Std. Deviation	N	Mean	Std. Deviation	Chi-square	Asymp. Sig.
Close or Easy	174	0.40	0.49	148	0.30	0.46	48	0.15	0.36	46	0.22	0.42	14.52	**.002**
Favourite	174	0.07	0.26	148	0.12	0.33	48	0.10	0.31	46	0.04	0.21	3.57	.312
Features	174	0.25	0.43	148	0.10	0.30	49	0.00	0.00	46	0.02	0.15	31.38	**.000**
Tourism	174	0.07	0.25	148	0.26	0.44	48	0.21	0.41	46	0.30	0.47	25.68	**.000**

4.4.2 *Test of sample mode effects*

The current study employed both online and in-person surveys (survey instruments are presented in Appendices 5 and 6, respectively), allowing for comparison of the effects of the differing modes (although sample sizes limit these tests). There are some limitations on the potential for testing of survey mode effects, due to a number of factors. Whilst the onsite survey was designed to supplement the onsite survey, a number of minor differences significantly affect the reliability and usefulness of the results for comparative purposes. The first limit placed on the online sample is one of sample self-selection. The online survey was not promoted extensively, meaning that respondents were mainly sourced passively via visitors to the homepage of the organisation hosting the survey. The usability of the online data was therefore limited by low response and completion rates. As such, it could be expected that these respondents have a greater interest in coastal management matters, and hence stronger preferences for preservation of beaches, representing a form of response (rather than non-response) bias (Pearl and Fairley, 1985). This assumption is investigated in terms of the influence on responses to the various survey components in the relevant sections.

Having satisfied the self-selection challenge, there are further sample selection hurdles that limit sample sizes. Three screening questions were employed at the start of the online survey. These initially seek the participants consent to participate in the survey, confirm the respondent is over 18, and that they have visited a Sydney beach in the previous 12 months. Failure to comply with any of these conditions will results in the respondent being excluded from further participation. This is also the case for nonsense responses, such as a birth year of 6786.

The online sample was not restricted to the case-study locations. Of the 153 completed responses, 33 (21.6%) had most recently visited Collaroy-Narrabeen whilst 66 (43.1%) had most recently visited Manly. Only two responses were received from visitors to Dangar Island (1.3%), with none from Brooklyn Baths. Results for the online survey are included from those respondents who selected Collaroy-Narrabeen or Manly. The latter two groups are excluded from analysis, as are the responses from visitors to non case-study beaches. Of the non-case-study beaches listed by respondents, the most frequently visited was Coogee beach, with 10 respondents. This is likely to be a sampling artefact, as this is the closest beach to the

University of NSW, and an internal postgraduate student mailing list was used as one means of promotion for the online survey instrument.

This section therefore presents the results of comparisons between onsite and online samples for Manly and Collaroy-Narrabeen. Given the resource advantages associated with use of online surveys, they present a promising alternative for survey-based non-market valuation methods. There is still little evidence, however, on the way in which samples differ between modes (Maguire, 2009, Marta-Pedroso et al., 2007). All variables have the same names and descriptions as previously, although some comparisons are not possible due to differences in survey design.

4.4.2.1 Demographics

Differences in socioeconomic characteristics were significant for almost all factors in the Manly samples (Table 4.11). On average, respondents to the online sample were more likely to be female (64% versus 49%, $p<0.05$), higher income earners (approximately $59,000 p.a. versus almost $45,000 p.a.), substantially more likely to have completed university education (85% versus 56%), and far less likely to be without a job (15% versus 28%). These differences are consistent with those reported in previous studies which seek to compare web surveys with alternative methods. Marta-Pedroso et al. found that respondents to a web survey were more highly educated and had higher incomes than onsite samples for the same contingent valuation survey instrument (Marta-Pedroso et al., 2007). Interestingly, Maguire et al. find that respondents to telephone surveys were typically less educated and lower earners than respondents to mail surveys. In person survey respondents were more highly educated and earnt more again than those who completed the mail survey (Maguire, 2009). Neither study identifies differences in gender such as those identified in this analysis.

The same differences in demographic attributes were not found in the Collaroy-Narrabeen samples (Table 4.12). The only difference that was statistically significant ($p<0.001$) was that relating to university education, with online respondents more than twice as likely (82% versus 39%) to have completed tertiary studies. This may suggest a more homogenous sample, or may be an artefact of the smaller sample size and higher standard deviation relative to the Manly sample.

Table 4.11 Demographic characteristics: Manly online and onsite samples

	Manly Onsite			Manly Online			Mann-Whitney U	Asymp. Sig. (2-tailed)
	N	Mean	Std. Deviation	N	Mean	Std. Deviation		
Gender (male=1)	148	0.51	0.50	58	0.34	0.48	3597.0	**0.04**
Age (years)	146	39.13	14.82	63	39.83	12.54	4390.5	0.60
Hourly wage rate	133	22.65	20.69	50	30.49	16.55	2416.5	**0.00**
Income (AUD$ p.a.)	133	44751.88	40880.86	51	59068.63	33455.05	2530.5	**0.01**
University	147	0.56	0.50	60	0.85	0.36	3121.5	**0.00**
No High School	147	0.07	0.26	61	0.08	0.28	4451.5	0.86
No Job	147	0.28	0.45	62	0.15	0.36	3947.5	**0.04**

Table 4.12 Demographic characteristics: Collaroy-Narrabeen online and onsite samples

	Collaroy-Narrabeen Onsite			Collaroy-Narrabeen Online			Mann-Whitney U	Asymp. Sig. (2-tailed)
	N	Mean	Std. Deviation	N	Mean	Std. Deviation		
Gender (male=1)	173	0.57	0.50	31	0.48	0.51	2460.0	0.40
Age (years)	169	39.62	15.16	35	39.09	13.46	2932.0	0.94
Hourly wage rate	158	23.51	19.30	25	28.59	17.53	1618.0	0.14
Income (AUD$ p.a.)	158	46462.03	38142.86	27	52314.81	36531.90	1902.0	0.36
University	172	0.39	0.49	34	0.82	0.39	1655.0	**0.00**
No High School	172	0.08	0.27	35	0.03	0.17	2851.0	0.27
No Job	172	0.22	0.41	35	0.29	0.46	2797.5	0.36

Nationality information was not collected in the online survey. The initial screening questions restricted respondents to those who had visited a Sydney beach in the past 12 months. Hence the participation of international respondents was severely limited. All respondents who completed the survey were Australian residents except for one respondent, with only 8 (of the 99 respondents included in the analysis).

4.4.2.2 Trip Characteristics

It can be seen from Figure 4.8 that there was a significant difference in visitation frequency between the differing survey modes. This figure employs the results from all sample sites. The Manly samples displayed significant differences in visitation frequency, and also in the time taken to complete the survey (Table 4.13). There was almost no difference in travel mode between the online and onsite samples, indicating that the figures are robust for extrapolation. There was no significant difference in the one-way travel time, or in the proportion of those who had a travel time less than 20 minutes (TTless20). This indicates that the online sample is also sampling a relatively local sample, which is likely a result of self-selection bias.

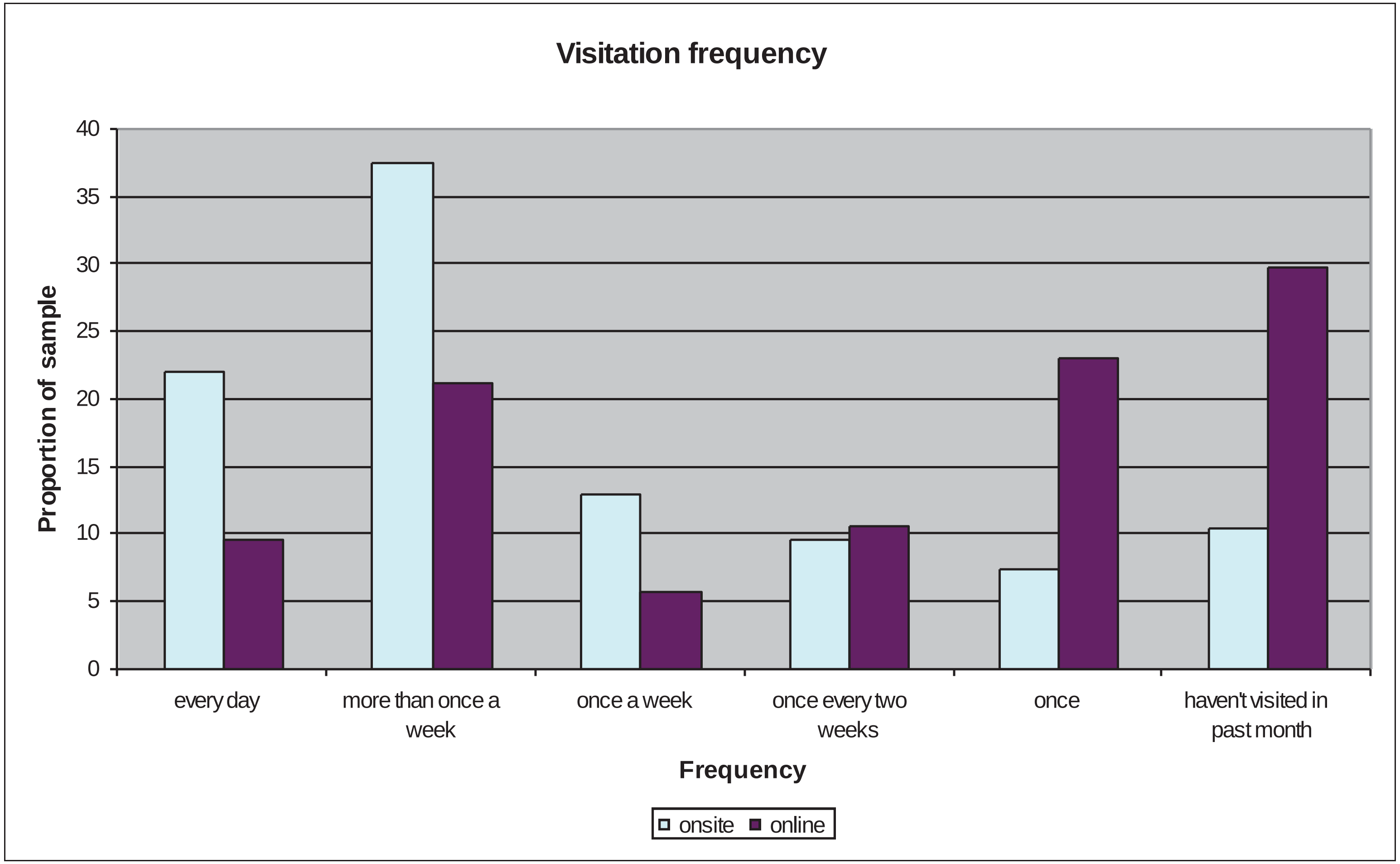

Figure 4.8 Visitation frequency by survey mode (All beaches)

Table 4.13 Trip Characteristics for online and onsite samples, Manly beach

	Manly Onsite (n=148)		Manly Online (n=63)		Mann-Whitney U	Asymp. Sig. (2-tailed)
	Mean	Std. Deviation	Mean	Std. Deviation		
Group Total	2.69	5.10	2.51	1.32	3884.0	0.07
Car	0.29	0.46	0.30	0.46	4513.0	0.86
Human	0.36	0.48	0.35	0.48	4524.5	0.90
Ferry	0.33	0.47	0.33	0.48	4557.0	0.97
Bus or Train	0.02	0.14	0.02	0.13	4545.5	0.82
TT1way (minutes)	55.08	57.86	43.11	44.01	4081.0	0.38
TTless20	0.36	0.48	0.48	0.50	4143.0	0.13
Time Onsite (minutes)	160.97	88.94	148.52	83.50	4101.5	0.40
Duration (seconds)	700.93	376.16	728.02	603.10	3833.5	**0.04**
Visit Filled (#/ month)	10.14	9.99	5.23	9.44	2094.0	**0.00**
No visits in previous month	0.00	0.00	0.39	0.49	2793.0	**0.00**

Substantial differences were also found in terms of visitation frequency for the Collaroy-Narrabeen samples (Table 4.14). Those sampled online had a mean visitation frequency of 4.35 visits per month, whereas those intercepted at the beach visited the beach an average of 12.98 times per month. This highlights the challenges with extrapolation from onsite convenience samples, which will over sample those with high avidity (Martínez-Espiñeira and Amoako-Tuffour, 2008).

Table 4.14 Trip characteristics for onsite and online samples, Collaroy-Narrabeen.

	Collaroy-Narrabeen Onsite (n=174)		Collaroy-Narrabeen Online		Mann-Whitney U	Asymp. Sig. (2-tailed)
	Mean	Std. Deviation	Mean	Std. Deviation		
Group Total	2.63	4.73	2.31	1.57	2679.0	.672
Car	0.61	0.49	0.71	0.46	2515.0	.260
Human	0.34	0.48	0.23	0.43	2477.5	.188
Bus or Train	0.04	0.19	0.06	0.24	2745.0	.597
TT1way (minutes)	28.06	33.36	30.00	29.58	2518.5	.348
TTless20	0.59	0.49	0.51	0.51	2826.0	.433
Time Onsite (minutes)	126.19	80.12	125.14	91.89	2708.5	.758
Duration (seconds)	826.91	488.58	778.49	460.59	2774.5	.436
Visit Filled (#/ month)	12.98	11.15	4.35	7.16	1147.5	**.000**
No visits in previous month	0.02	0.15	0.15	0.36	2576.5	**.001**

4.4.2.3 Travel Cost

No significant differences were found in the travel cost parameters for the online and onsite samples from Collaroy-Narrabeen (Table 4.15). This may be because of the relatively low-profile nature of the beach, meaning that both visitation and interest in the survey topic are derived mainly from the local resident population. The low travel costs for both samples (AUD$2.90 and AUD$3.37 for onsite and online samples, respectively) support this assumption. For Manly (Table 4.16) the only parameters which were significantly different were those that incorporated the onsite cost component. This difference arises from the greater expenditure of the respondents to the onsite survey, which most likely is derived itself from the fact that these are more likely to be non-local visitors.

Table 4.15 Travel cost parameters: Collaroy-Narrabeen onsite and online samples

	Collaroy-Narrabeen Onsite (n=160)		Collaroy-Narrabeen Online (n=35)		Mann-Whitney U	Asymp. Sig. (2-tailed)
	Mean	Std. Deviation	Mean	Std. Deviation		
TC	2.90	4.643	3.37	4.251	2416.00	.194
Tdep	11.00	17.612	12.55	15.766	2428.00	.209
Onsite	9.84	16.828	11.71	18.902	2691.50	.689
OnsitePP	4.25	7.338	4.78	9.838	2660.00	.606
OnTC	7.29	9.781	8.15	12.654	2701.50	.743
OnTdep	15.06	20.781	17.33	20.717	2512.50	.339
TTC	21.18	38.948	15.88	25.169	2933.50	.729
TCTTC	23.85	41.576	19.25	27.397	2655.50	.232
TCTTCOn	27.88	44.195	24.03	31.404	2770.00	.399

Table 4.16 Travel cost parameters: Manly onsite and online samples

	Manly Onsite (n=145)		Manly Online (n=63)			
	Mean	Std. Deviation	Mean	Std. Deviation	Mann-Whitney U	Asymp. Sig. (2-tailed)
TC	6.31	6.92	6.37	7.54	4308.00	0.50
Tdep	10.59	16.77	11.12	21.69	4375.00	0.62
Onsite	11.87	17.85	22.14	19.59	3103.5	**0.00**
OnsitePP	5.62	8.01	9.99	9.94	3176.5	**0.00**
OnTC	12.27	11.11	16.36	13.73	3764.00	**0.04**
OnTdep	11.42	18.29	21.11	24.07	2903.00	**0.00**
TTC	33.77	61.69	31.75	48.06	4201.50	0.25
TCTTC	39.95	64.28	38.12	50.93	4368.50	0.47
TCTTCOn	45.79	64.20	48.10	52.58	4194.50	0.25

4.4.2.4 Beach Choice

Unfortunately due to a programming oversight it was not possible to compare the motivations for beach selection between the onsite and online samples. The onsite samples were restricted to coding for the most important reason, with a single response recorded. The online sample was not restricted in such a manner; hence responses are not mutually exclusive.

4.4.3 *Testing assumptions in site selection*

The previous section identifies differences between case-study sites across all locations, but it does not identify the source of those differences. Beach-by-beach comparisons are not undertaken, as they are considered somewhat pointless except in the calibration of benefit transfer. Given that Brooklyn and Dangar Island were selected as a combined site, it is prudent to test whether the beaches are in fact visited by similar populations. All variables have the same names and descriptions as in the overall comparison.

4.4.3.1 Demographics

Comparison of the demographic characteristics of the two samples does not give rise to any grave concerns about differences between the two samples, as shown in Table 4.17.

Table 4.17 Comparison of Brooklyn and Dangar Island samples - demographics

	Brooklyn (n=49)		**Dangar Island (n=46)**		**Mann-Whitney U**	**Asymp. Sig. (2-tailed)**
	Mean	Std. Deviation	Mean	Std. Deviation		
Gender (male=1)	0.45	0.50	0.37	0.49	997.5	0.45
Age (years)	44.20	13.10	46.49	11.98	876.5	0.36
Hourly wage rate	27.56	20.53	29.42	21.13	806.5	0.75
Income (AUD$ p.a.)	54464.29	40558.36	58125.00	41751.52	806.5	0.75
University	0.48	0.51	0.73	0.45	760.0	**0.02**
No High School	0.11	0.31	0.11	0.32	1007.0	0.94
No Job	0.28	0.46	0.32	0.47	976.0	0.71
Aussie	0.73	0.45	0.74	0.44	1093.0	0.91
UK	0.04	0.20	0.11	0.31	1030.0	0.22
Naturalised	0.04	0.20	0.11	0.31	1030.0	0.22
Europe	0.06	0.24	0.00	0.00	1035.0	0.09
NZ	0.06	0.24	0.00	0.00	1035.0	0.09
Asia	0.02	0.14	0.02	0.15	1103.0	0.98

The only difference significant at the $p<0.05$ level is that relating to university level education. The sample on Dangar Island is substantially more highly educated, with almost three-quarters (73%) of the sample holding a university qualification, compared to less than half (48%) of the sampled population at Brooklyn.

4.4.3.2 Trip Characteristics

Differences in trip characteristics are to be expected, given the variable accessibility characteristics of the two sites. This is indeed observed, as shown in Table 4.18. There is a marked difference in the number of visitors that travelled by human power, with 44% of the Dangar Island sample falling into this category versus only 4% of the Brooklyn sample.

Table 4.18 Trip characteristics comparison – Brooklyn and Dangar Island

	Brooklyn (n=49)		Dangar Island (n=46)		Mann-Whitney U	Asymp. Sig. (2-tailed)
	Mean	Std. Deviation	Mean	Std. Deviation		
Group Total	3.31	1.52	2.98	1.88	806.0	0.17
Car	0.84	0.37	NA	NA		
Human	0.04	0.21	0.44	0.50	583.0	**0.00**
Ferry	0.00	0.00	0.44	0.50	540.0	**0.00**
Bus or Train	0.11	0.32	NA	NA		
TT1way (minutes)	86.13	50.90	102.42	97.93	949.5	0.88
TTless20	0.12	0.33	0.37	0.49	848.5	**0.01**
Time Onsite (minutes)	145.33	75.40	95.58	93.10	569.5	**0.00**
Duration (seconds)	596.17	348.07	846.49	621.63	760.0	**0.01**
Visit Filled (#/ month)	4.13	5.93	9.82	11.35	727.5	**0.02**
Weekend	0.86	0.35	1.00	0.00	966.0	**0.01**

This suggests that the Dangar sample is largely drawn from the permanent residents of Dangar Island, whereas the Brooklyn sample is drawn to a greater extent from vehicular visitors to the site. More than three quarters of the Brooklyn sample (84%) travelled by car, which supports this assumption. The differences in the proportion of respondents with one-way travel times of less than 20 minutes provides further evidence, with 37% of the Brooklyn sample in this category, compared to only 12% of the Dangar sample. Visitation frequency in the Dangar sample is also more than double that of the Brooklyn sample. This is likely to reflect the local resident population's own visitation patterns.

4.4.3.3 Travel Cost

Substantial differences are found in travel costs, due to the increased use of the car and increased driving costs in the Brooklyn sample (Table 4.19). Onsite expenditure does not differ markedly between the two samples, and neither does the opportunity cost of leisure time.

Table 4.19 Travel cost comparisons for beach visitors to Brooklyn and Dangar Is sites

	Brooklyn (n=49)		Dangar Island (n=46)		Mann-Whitney U	Asymp. Sig. (2-tailed)
	Mean	Std. Deviation	Mean	Std. Deviation		
TC	14.72	8.64	7.49	8.09	466.0	**0.00**
Tdep	60.80	39.14	16.00	31.64	288.0	**0.00**
Onsite	18.07	20.23	16.28	22.99	861.5	0.34
OnsitePP	5.60	7.43	5.52	8.79	877.5	0.42
OnTC	20.95	12.76	13.17	14.01	621.5	**0.00**
OnTdep	64.45	40.18	16.62	33.80	328.5	**0.00**
TTC	63.31	75.55	93.17	135.57	1100.5	0.84
TCTTC	76.83	79.32	100.16	140.34	1000.0	0.34
TCTTCOn	82.55	84.23	105.48	144.26	1004.0	0.36

4.4.3.4 Beach Choice

No significant differences were found in the reason for selection of the sites (Table 4.20). The most frequent reason for visitation was due to the recommendation of a friend or a promotional piece in a newspaper.

Table 4.20 Beach choice reasoning – Brooklyn and Dangar Island

	Brooklyn (n=49)		**Dangar Island (n=46)**		**Mann-Whitney U**	**Asymp. Sig. (2-tailed)**
	Mean	Std. Deviation	Mean	Std. Deviation		
ClosesEasy	0.15	0.36	0.22	0.42	1025.0	0.37
Favourite	0.10	0.31	0.04	0.21	1037.0	0.27
Tourism	0.21	0.41	0.30	0.47	998.0	0.29
Features	0.00	0.00	0.02	0.15	1102.5	0.30

4.4.3.5 Summary of differences

Given substantial differences identified in the trip characteristics between the Brooklyn and Dangar Island samples, the wisdom of selecting the two sites as a combined location is questionable. It is not possible to treat these as a combined site in estimation of a trip demand curve, as differences in critical explanatory variables mean that the sites are subject to different patterns of visitation. The result of this is that it is not possible to proceed with this step for the two sites in question, as the split samples are too small in size for robust estimation.

4.4.4 *Visitation equation estimation results*

This section presents the model results of the use of truncated negative binomial models to derive trip demand functions for the onsite samples from Collaroy-Narrabeen and Manly. Models are not estimated for other datasets due to small sample sizes, which precluded the identification of robust relationships.

A number of models were estimated, to test sensitivity to specification of the cost parameter. Model 1 included only expenses incurred in making the trip (TC), Model 2 included depreciation for those who drove vehicles (TDep). These specifications are common in the published literature. Model 3 included onsite expenditure, but did not include depreciation (OnTC), Model 4 included the cost of travel time (using 25% of the wage rate) but not onsite expenditure (TCTTC), and Model 5 includes all aspects of the trip (TCTTCOn). Inclusion of onsite and offsite expenditures in estimation of TC models has a strong influence on estimates of CS, but has received little research attention (English and Bowker, 1996). Results for Collaroy-Narrabeen and Manly are presented in Table 4.21 and 4.22, respectively.

Overdispersion is present in the data, as evidenced by the dispersion coefficient, which is significantly different from zero for the majority of models, meaning that the Poisson distribution is not appropriate (Haab, 2003). Explanatory power is good for all models. For negative binomial models there is no theoretical equivalent to the r-squared measure in Ordinary Least Squares (OLS) regression. McFadden's pseudo R-squared or rho-squared (ρ^2) is a measure which relates the log-likelihoods of the base model (employing only the constant) and the model incorporating all variables.

This parameter is calculated using the following formula:

$$\rho^2 = 1 - \frac{LL_1}{LL_0} \qquad \textbf{\textit{[4.1]}}$$

Where LL_1 is the log-likelihood of the model under consideration, and LL_0 is the log-likelihood of the base model. This returns a value between 0 and 1, with higher values preferred. Given the structure of the statistic, values of greater than 0.5 are difficult to attain

(McFadden, 1979). McFadden suggests (1979, p309) that ρ^2 values of between 0.2 and 0.4 represent an excellent fit (McFadden, 1979).

The demographic parameters that were significant in the Collaroy-Narrabeen models were residential status (all but Model 5), age (all but Model 4), having high income (Models 4 and 5, which incorporate travel time), having university education (Models 2 and 3) and being an Australian citizen (Models 3-5). Also significant were the variables that indicate that the survey took place on a weekend (Models 3-5), that they chose the beach based on the presence of certain features (model 5 only) or because of recommendations either from a friend or via promotional material (Tourism, all models).

The weekend variable had a negative influence on reported visitation, indicating that those intercepted on the weekend had a lower frequency of attendance. Given time constraints, there are likely to be a large proportion of respondents who are unable to visit the beach during the week, and hence only visit on weekends. The influence on visitation of the ‘Features’ parameter was positive, which means that the beach is favoured for some attribute of the beach that separates it from other potential substitutes. This is most likely the presence of a high-quality surf break at the northern end of the beach, although respondents also mentioned that the unbroken length of sand was an attractive feature.

University education and Australian citizenship have unexpected signs, both lowering the frequency of visitation. Downward influence is also associated with increased age, though this is expected. Increased visitation is associated with being a local resident though this is to some extent a result of the scaling process necessary to derive seasonal visitation estimates from monthly responses. High income and beach recommendations are significant factors in increasing visitation.

The Manly results are broadly similar, though the models which incorporate onsite expenditure (Models 3 and 5) result in positive and statistically insignificant travel cost parameters. This is likely due to the presence of a high proportion of day trippers who incur high onsite expenditures and thus alter the slope of the demand curve. Whether or not the respondent was an Australian citizen (AusNat=1) was significant at the $p<0.10$ level for all models. Residential status again has the expected effect on visitation frequency. Increased age results in increased frequency of visitation at Manly, which may be due to the fact that it is a preferred location for sheltered swimming. Australian citizenship again shows the surprising downward influence on visitation. Gender is also significant, with males likely to visit more frequently than females in Models 2-5.

Table 4.21 Results of the TNB Models for Collaroy-Narrabeen

Collaroy-Narrabeen	Model 1(n=159)			Model 2 (n=159)			Model 3 (n=159)			Model 4 (n=159)			Model 5 (n=159)		
	β	t-ratio	Prob.	β	t-ratio	Prob.	β	t-ratio	Prob.	β	t-ratio	Prob.	β	t-ratio	Prob.
Constant	2.01	6.57	0.00	1.95	6.25	0.00	1.69	4.77	0.00	1.67	5.77	0.00	1.79	6.12	0.00
WEEKEND	-0.18	-0.76	0.45	-0.21	-0.87	0.38	-0.60	-2.43	**0.02**	-0.53	-2.37	**0.02**	-0.56	-2.38	**0.02**
RESIDENT	3.59	11.98	**0.00**	3.70	12.12	**0.00**	4.49	13.35	**0.00**	4.06	13.32	**0.00**	0.22	1.28	0.20
FEATURES	0.20	1.00	0.32	0.20	0.96	0.34	0.29	1.50	0.13	0.18	0.98	0.33	1.63	4.44	**0.00**
TOURISM	0.78	1.96	**0.05**	0.75	1.99	**0.05**	1.70	4.55	**0.00**	1.37	3.63	**0.00**	4.25	13.78	**0.00**
MALE	0.09	0.41	0.68	0.09	0.40	0.69	-0.24	-1.06	0.29	-0.13	-0.61	0.55	-0.20	-0.96	0.34
AGE	-0.02	-2.24	**0.03**	-0.02	-2.31	**0.02**	-0.02	-2.67	**0.01**	-0.01	-1.52	0.13	-0.02	-2.41	**0.02**
HIGHINC	0.31	1.06	0.29	0.32	1.08	0.28	0.35	1.11	0.27	0.76	2.26	**0.02**	0.54	1.94	**0.05**
LOWINC	0.01	0.03	0.98	0.02	0.07	0.94	0.29	1.23	0.22	0.05	0.23	0.82	0.18	0.86	0.39
NOJOB	0.14	0.58	0.56	0.16	0.66	0.51	-0.21	-0.95	0.34	-0.19	-0.96	0.34	-0.25	-1.26	0.21
UNIVERSI	-0.31	-1.51	0.13	-0.35	-1.66	**0.10**	-0.43	-1.78	**0.08**	-0.37	-1.72	0.09	-0.45	-2.03	0.04
AUSNAT	-0.29	-1.24	0.22	-0.30	-1.31	0.19	-0.51	-2.03	**0.04**	-0.59	-2.68	**0.01**	-0.54	-2.57	**0.01**
Travel cost parameter	Travel Costs only (TC)			Travel costs with depreciation (Tdep)			TC and onsite expenditure (OnTC)			Travel costs and travel time costs (TC TTC)			TC TTC and onsite expenditure (TC TTC On)		
	-0.37	-4.87	0.00	-0.09	-4.80	0.00	-0.05	-2.67	0.01	-0.10	-3.97	0.00	-0.05	-3.15	0.00
Dispersion parameter	0.79	4.43	0.00	0.81	4.40	0.00	0.94	4.36	0.00	0.84	4.69	0.00	0.87	4.59	0.00
Log Likelihood	-614.85			-617.81			-633.87			-682.06			-685.22		
Chi-squared (1,159)	4137.11			4134.89			4118.40			4565.42			4561.11		
McFadden's pseudo r-squared	0.77			0.77			0.76			0.77			0.77		

Table 4.22 Results of the TNB models for Manly beach

Manly Ocean Beach	Model 1 (n=145)			Model 2 (n=145)			Model 3 (n=145)			Model 4 (n=145)			Model 5 (n=145)		
	β	t-ratio	Prob.	β	t-ratio	Prob.	β	t-ratio	Prob.	β	t-ratio	Prob.	β	t-ratio	Prob.
Constant	0.59	1.24	0.21	0.64	1.51	0.13	-0.20	-0.41	0.69	0.78	1.70	0.09	0.09	0.18	0.86
WEEKEND	0.21	0.87	0.38	0.27	1.19	0.24	0.02	0.07	0.94	0.18	0.77	0.44	0.08	0.32	0.75
RESIDENT	3.69	10.95	**0.00**	3.49	10.29	**0.00**	4.34	12.05	**0.00**	3.22	10.00	**0.00**	4.00	11.37	**0.00**
FEATURES	0.31	1.10	0.27	0.39	1.27	0.20	0.10	0.32	0.75	0.29	1.05	0.29	0.17	0.54	0.59
TOURISM	0.37	1.35	0.18	0.32	1.17	0.24	0.01	0.02	0.99	0.33	1.31	0.19	0.04	0.16	0.88
MALE	0.31	1.28	0.20	0.37	1.76	**0.08**	0.53	2.48	**0.01**	0.40	1.98	**0.05**	0.54	2.59	**0.01**
AGE	0.02	2.78	**0.01**	0.02	2.69	**0.01**	0.01	2.04	**0.04**	0.01	2.30	**0.02**	0.02	2.31	**0.02**
HIGHINC	-0.23	-0.63	0.53	-0.30	-0.82	0.41	-0.32	-0.84	0.40	-0.13	-0.36	0.72	-0.29	-0.79	0.43
LOWINC	-0.17	-0.71	0.48	-0.21	-0.88	0.38	-0.11	-0.45	0.66	-0.46	-1.73	**0.08**	-0.15	-0.54	0.59
NOJOB	0.27	1.16	0.25	0.18	0.78	0.43	0.27	1.12	0.26	0.40	1.84	**0.07**	0.35	1.47	0.14
UNIVERSI	0.09	0.38	0.70	0.00	-0.01	0.99	-0.05	-0.21	0.84	0.07	0.32	0.75	-0.06	-0.29	0.77
AUSNAT	-0.42	-1.34	0.18	-0.03	-0.10	0.92	-0.58	-1.72	**0.09**	-0.33	-1.10	0.27	-0.54	-1.66	**0.10**
Travel cost parameter	**Travel Costs only (TC)**			**Travel costs with depreciation (Tdep)**			**Travel costs and onsite expenditure (OnTC)**			**Travel costs and travel time costs (TC TTC)**			**Travel costs, travel time costs and onsite expenditure (TC TTC On)**		
	-0.11	-4.79	0.00	-0.09	-4.53	0.00	0.01	0.70	0.49	-0.06	-5.42	0.00	-0.01	-0.76	0.45
Dispersion parameter	0.86	4.05	0.00	0.80	4.60	0.00	1.05	0.26	4.02	0.78	4.33	0.00	1.01	4.15	0.00
Log Likelihood		-504.17			-498.49			-492.50			-490.74			-503.08	
Chi-squared (1,145)		2247.91			2286.98			1513.05			1333.46			1573.49	
McFadden's pseudo r-squared		0.69			0.70			0.61			0.58			0.61	

The negative binomial function is a variation on the logarithmic form, so the per-trip consumer surplus estimates can be estimated as the negative inverse of the travel cost parameter estimate (Englin & Shonkwiler, 1995; Yen & Adamowicz, 1993). Consumer surplus estimates from the TNB models are derived by taking the negative inverse of the coefficient estimate for the travel cost parameter, as per Creel and Loomis (1990). Results of this calculation are presented for all models in Table 4.23. Confidence intervals are estimated in LIMDEP via the Delta method (Greene, 1993).

It can be seen that the CS estimates for Collaroy-Narrabeen are lower than those for Manly, which reflects the local visitation patterns already described. Of those interviewed at Collaroy-Narrabeen, 59% (94 of 159) would be classified as being local residents, by virtue of their having travelled for less than 20 minutes to reach the beach. At Manly, only 36% of interviewees (52 of 145) were local residents by the same classification. Previous studies have highlighted differences between local and visitor populations (Blackwell, 2007), and it is likely that similar patterns exist in the surveyed population. People place a higher value on recreation areas which are nearby in studies on WTP for recreation, although this is a non-linear relationship (Tyrvainen and Vaananen, 1998). Given the desire to explore the effect of different travel cost parameters on consumer surplus estimates, it was not considered appropriate to split the sample on the basis of travel times, as these figures are also used in the calculation of the opportunity cost of travel time.

There is general agreement in magnitude for Model 2, presumably due to the increased travel costs of those who drive to Collaroy-Narrabeen (when depreciation is included) are broadly comparable to the costs of ferry travel to Manly. The CS estimates for Model 4 are most closely aligned to the form that is reported in most studies of this kind, and are broadly in the range of published estimates of the recreational value of a beach day.

Table 4.23 Consumer surplus estimates by model and beach

Beach	Model 1		Model 2		Model 3		Model 4		Model 5	
	Consumer Surplus estimate	Standard error	Consumer Surplus estimate	Standard error	Consumer Surplus estimate	Standard error	Consumer Surplus estimate	Standard error	Consumer Surplus estimate	Standard error
Collaroy-Narrabeen	2.72	0.56	11.28	2.35	20.04	7.51	10.28	2.59	20.63	6.55
Manly Ocean Beach	9.20	1.92	11.50	2.54	NA	NA	16.18	2.98	NA	NA

4.5 Conclusions and implications

This section briefly explores the broader implications of the findings of the travel cost component of the study. Further examination of the management implications is reserved for the concluding chapter, where these benefits are compared with costs of coastal management alternatives in a rudimentary benefit-cost analysis.

4.5.1 *Extrapolation to broader populations*

Given sufficient information about the broader population, it is possible to adjust welfare estimates such that they can also be aggregated across non-users. It was not possible to make such adjustments in the current study, as the relevant 'host' population was not known for many respondents. International respondents were identified only on the basis of their country of origin; hence national averages would be the only possible source of data for calibration.

The surveys were applied only to those who had visited the beach, and hence the results of this survey are assumed to apply only to beach visitors, with no attempt to extrapolate to a broader population that is likely to contain many non-users. Given the challenges in determining even the relevant number of beach users with any degree of confidence, it is felt that further extrapolation would be based on wholly untested assumptions.

There is no reliable source of visitation estimates for beach visitation in Australia and as such, proxy data must be used. This data is of dubious quality, and estimates vary wildly. The Sweeney Sports Report 2007-08 identified that around 2 million Australians go surfing each year (Sweeney Research, 2008). This result is based on interviews conducted with 1000 residents of capital cities, and extrapolated to the national level via calibration with census data (Sweeney Research, 2008). In stark contrast, Surf Life Saving Australia estimates annual beach visitation as somewhere in the vicinity of either 55 (SLSA, 2009) or 80 (SLSA, 2005) million visits per year. Whilst it is clear that not all visitors engage in surfing whilst at the beach, the difference in estimates is vast.

Somewhat ironically, one of the best sources of information regarding beach usage is for those who travel from outside the local area. The NVS identifies patterns of visitation and expenditure for daytrip and overnight domestic visitors (BTR, 2002), whilst the IVS provides similar summaries for international tourists (Battye and Suridge, 2002). These surveys ask respondents if they visited the beach, and provide some measure of the scope of beach visitation in Sydney. The NVS suggests that approximately 8% of daytrip domestic visitors to Sydney visit the beach, with seasonal variation of around half of a percentage point (Tourism NSW, 2008). Domestic overnight visitors are more likely to visit the beach, with 21% making at least one beach trip during their stay in Sydney (BTR, 2000). International visitors to Sydney are most likely to visit the beach, with around 66% making at least one trip (Tourism NSW, 2005). Current annual visitation figures for the three groups are 17.4 million, 6.8 million and 2.6 million, respectively (Tourism NSW, 2010). This results in estimated figures of 1.39 million, 0.14 million and 1.72 million beach trips, respectively, for a total of 3.25 million beach visits in the Sydney region. As the estimated visitation for Bondi beach is in the order of 1 million annual visits (Battye and Suridge, 2002), it can be expected that the other beaches receive substantially fewer non-resident visitors. This excludes any measure of visitation by residents. Unfortunately, the surveys do not ask about specific beaches, except at infrequent intervals where questions are included in the IVS regarding visitation to key beach tourism destinations such as Bondi and Manly (Battye and Suridge, 2002).

Given these data deficiencies, it is not possible to estimate aggregate values with any degree of confidence.

4.5.2 *Towards aggregate values – visitation estimates*

Given the lack of available proxy information to estimate visitation to the case-study sites, a novel approach was attempted, using analysis of footage from surf cameras. The rise in popularity of surf cameras, and their placement in optimal locations, suggests potential for future use in generation of beach visitation estimates. This is particularly true where access is restricted, where the procedure would be akin to examination of parking records. It may also have other benefits. There are potential legal and ethical issues arising from the remote photography of people on beaches (Coleman, 1987), which must be dealt with by researchers hoping to employ this approach. Use of existing cameras can avoid this challenge, as under current law there is a 'reasonable expectation' that people will be photographed or videoed whilst in a public place (Burton, 2006).

This section introduces a novel method which attempted to utilise object-recognition software and imagery from existing surf cameras to provide objectively verifiable beach visitation estimates. This data was then to be used in development of a predictive model of beach attendance, with a view to the use of the results in developing climate change adaptation strategies for beach environments. Whilst the experience was an exercise in frustration, and ultimately unsuccessful, the attempt is described in further detail. Beach visitation estimates are compared using a range of data sources, including professional and volunteer lifeguard estimates. The focus is on the case-study site Manly beach, as this location has multiple sources of visitation data.

4.5.3 *Surf camera imagery*

Beach visitor counts were purchased from CoastalCOMS (http://www.coastalcoms.com), which is the commercialisation arm of the Coastalwatch surf imagery company. Coastalwatch Pty Ltd has deployed a series of robotic surf cameras at popular locations around Australia. The camera deployed at North Steyne (part of the case study site at Manly, see Figure 3.3) beach is shown in Figure 4.9.

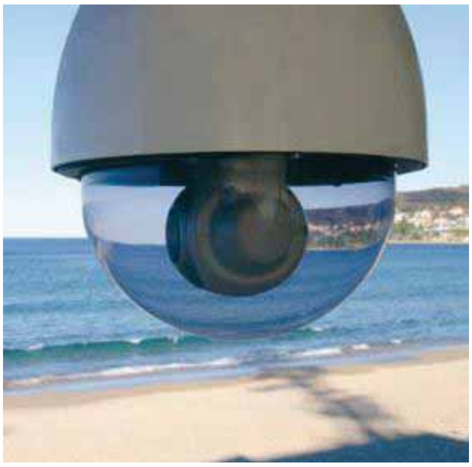

Figure 4.9 Coastalwatch camera viewpoint at North Steyne (Manly beach, Sydney. Source: http://www.sony.com.au/objects/pdf/SCANIssue2_2004.pdf

These cameras display real-time surf and beach conditions to lifesavers, and via the internet to other stakeholders. The placement of these cameras has been designed to allow lifesavers to monitor the most highly used regions of the beaches they monitor, and hence they have already been placed in the optimum position for estimating beach attendance.

The cameras are programmed to capture digital images every hour, which are cached in a storage facility. The storage of these images provides a valuable resource, and one which can be manually analysed to determine the number of people present in each image. This is, however, a time-intensive, tedious and expensive exercise. In conjunction with researchers at Griffith University, Coastalwatch has therefore developed a computer program termed CoastalCOMS which is able to process the captured images, and determine whether an object on the beach is a person or non-person. An example image is shown in Figure 4.10.

Figure 4.10 Image from Coastalwatch camera showing objects classified by CoastalCOMS as people (Williams et al., 2007)

Captured images are converted to a grayscale image. Contrast between the light coloured sand and darker objects is used to identify boundary conditions, thereby identifying objects which should be classified. These objects are then run through a physical recognition system using a trained neural-classifier. This is performed for the entire field of view, giving a visitor count for the given time (Green et al., 2006). Figure 4.11 outlines a graphical representation of this process.

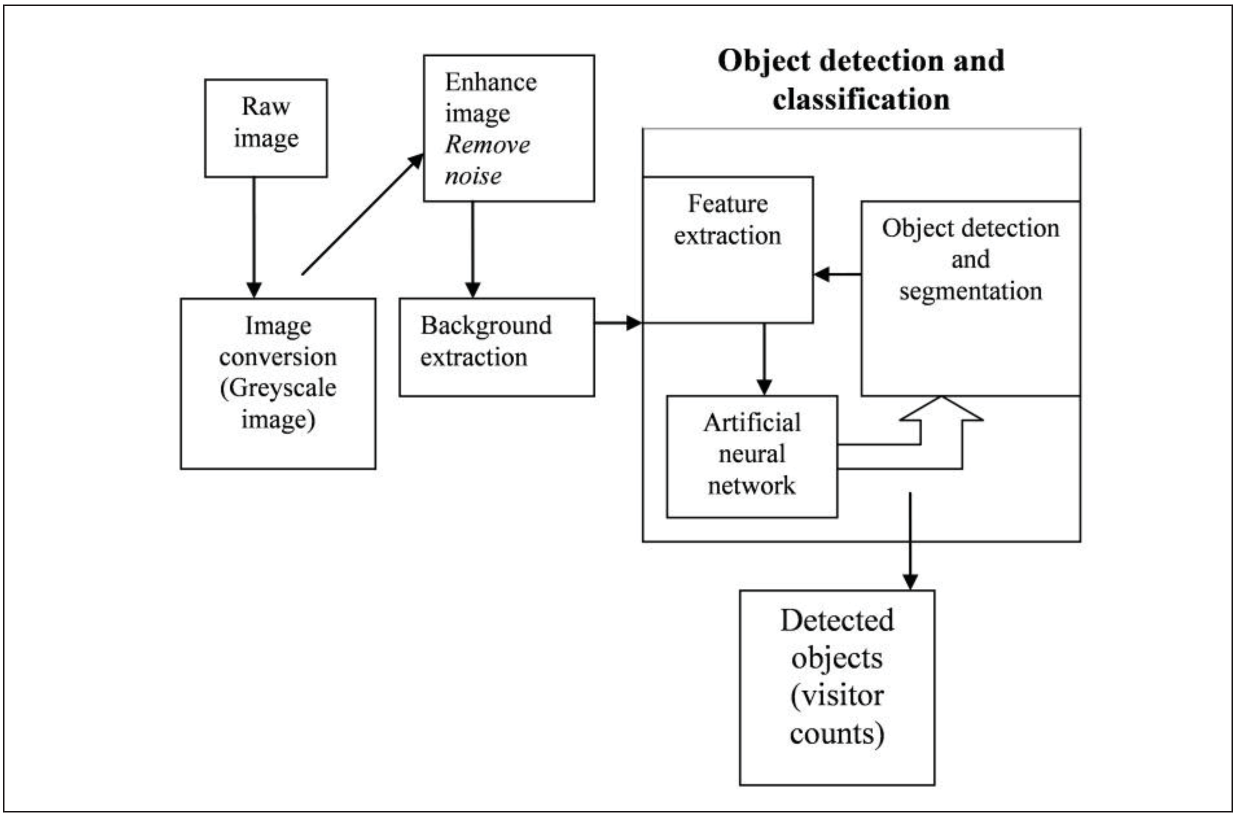

Figure 4.11 The CoastalCOMS visitor count methodology. Edited after Green et al. 2006

The outputs of this process are provided as raw data counts. Visitor counts resulting from analysis of camera images taken at at 9am, 12 noon and 3pm at North Steyne (see Figure 3.3) were purchased. The period of interest is the official swimming period of Summer 2007-2008 (October 1 2007 – Apr 30 2008), to allow for validation with other data sources.

Data from CoastalCOMS was insufficient for estimation of a model of beach visitation, and even of little use in estimating beach visitation figures. A summary of the overall results is presented in Table 4.24. The full dataset, for the CoastalCOMS data as well as other sources of visitation data discussed below, are not reproduced in full due to commercial licensing restrictions, but are available upon request.

Table 4.24 Monthly cumulative visitation at Manly beach, estimated from analysis of surf camera imagery.

Month	Total visitors	# of counts	Average/count
October	669	78	8.58
November	477	78	6.12
December	351	82	4.28
January	588	68	8.65
February	482	58	8.31
March	712	63	11.30
April	623	52	11.98
Total	**3902**	**479**	**8.15**

There were extended periods where no estimates were possible using the image analysis data, which included the crucial Christmas-New Year period. There were 479 reports in total, split approximately equally between the 9am, midday and 3pm images. Visitor counts were uniformly very low, with a maximum count of 72 'person-objects'. Total person-objects counted for the entire period was 3902, which equates to an average of 8.15 persons per image capture. The average onsite time reported in the onsite interviews conducted at Manly beach is 2 hours 40 minutes (see Table 4.7). Approximately 50% of people surveyed in stay less than 3 hours, so they will not be captured by the surf camera imagery twice, even if they remain in or return to the same location. Deacon proposes a complex methodology for estimating visitation from point estimates (Deacon and Kolstad, 2000). This is not considered necessary here, given that it is an exploratory analysis. It is assumed for simplicity that the estimates represent discrete counts, and no attempt is made to adjust these figures to more accurately estimate total beach visitation.

This conflicts strongly with the advice of the professional lifeguards at Manly, who estimate the carrying capacity of the beach during busy periods to be in the vicinity of 25 thousand people per day[12]. There was no explanation forthcoming from the data providers as to the reasons for this large discrepancy, so I was forced to draw my own conclusions, and these are presented in the following paragraphs.

[12] David Boardman, Chief Lifeguard Services Manly Council, personal communication.

The ability of the CoastalCOMS computer system to accurately classify objects as person and non-person is a key factor in the precision of the visitor counts. Storage of the original images allows for manual quality assurance procedures to be carried out. By using Bureau of Meteorology databases, a simple analysis of the effectiveness of the camera under different weather conditions can also be performed, and checked against manual counts and classifications. Unfortunately access to the original imagery for quality control was not provided by CoastalCOMS due to concerns about commercial sensitivities. Thus it was not possible to assess the effectiveness of the image recognition system.

There are also temporal limitations to the use of surf camera imagery in this manner. Given that the process undertaken by the computer program requires converting images to grayscale, it is most effective when there is greater contrast between the light-coloured beach and the darker coloured object. Thus it is most effective when there is bright sunlight, in the middle of the day. This will mean that user groups which access the beach outside these times (surfers, fisherman, walkers) will be under-represented in the beach visitation estimates. Accurately sampling these groups and determining what proportion of visitors are not being included in the surf camera images would require further independent study.

Spatial limitations of surf cameras must also be considered. The field of view of the camera is restricted, and will not capture the entire beach area. For this reason, the visitor counts from within the field of view should be considered as significant underestimates of total beach visitation. The approximate extent of the possible field of view is shown in Figure 4.12. The image has been rotated for ease of visualisation. North is to the left of the image as shown. The busiest section of the beach is towards the southern end, to the right of the image.

Figure 4.12 Field-of-view of the surf camera used in beach visitor counts

The camera will, however, be trained on the area of the beach between the flags which identify the safest swimming locations based on the prevailing surf and swell conditions. This is likely to capture a reasonable (as yet unmeasured) proportion of the total visitors to the beach. Again, those user groups which voluntarily avoid (or are instructed to avoid) the flagged area will be under-represented. All of the concerns raised above suggest that whilst objective measurement of beach visitation is a desired input to coastal management and valuation, it is subject to significant technical challenges. It must therefore be concluded that the limitations of the technology are currently too great for use in the intended application, although they suggest opportunities for future research.

Given the shortcomings of the data sourced from the surf camera footage, alternative sources of data were sought in an attempt to gain a better understanding of beach visitation patterns.

4.5.4 *Surf Life Saving Australia estimates*

Surf Life Saving Australia (SLSA) is a volunteer organisation which provides lifesaver services. They operate only on weekends and public holidays, during the summer swimming season, and augment the efforts of the professional lifeguards. Data was sourced for the same period as the CoastalComs data, at the three patrol locations of Manly, North Steyne and Queenscliff (see Figure 3.3). Estimates are provided for "on beach", "in water" and "craft", referring to the use of surfcraft such as surfboards or paddleskis. Only the beach estimates were examined in this analysis.

Estimates of visitation did not align in any way with the CoastalCOMS data. SLSA estimates for North Steyne, which is the site of the CoastalCOMS camera (Figure 4.12), are that the beach received 179,064 visitors in the same summer period in which only 3902 visitors were identified in the surf camera imagery. The southern end of the beach is the most highly visited, with Manly accounting for 465,029 visits over the summer period. Queenscliff contributes a further 211,784, for a total of 855,877 visits for the full site over the summer period. The precision of this estimate is a cause for some concern.

SLSA estimates varied substantially, due primarily to the presence of multiple different observers. Whilst strong correlations between individual observers and the reported figures were identified, these cannot be reported for privacy reasons. The fact that SLSA estimates are performed by volunteers, who may not have a good understanding of the pattern of visitation over extended periods, is likely to influence the unreliability of these estimates. A number of wildly unlikely estimates were recorded, such as a visitation figure of 873 people. It does not appear possible to achieve that degree of accuracy in such a large crowd, hence it suggests that the person taking attendance is not taking the exercise seriously, and the visitor estimates should therefore be accorded a similar degree of respect. There were also a substantial number of attendance estimates where a zero value was recorded, despite an a priori assumption that attendance would be non-zero, such as on public holidays. SLSA representatives were unable to provide guidance on whether these zero values were true zero values, or represented the lack of a recorded figure for the given time period (personal communication, Matthew Thompson, Coastal Safety Services Manager, SLSA).

4.5.5 *Manly Council professional lifeguard estimates*

Having determined that neither surf camera imagery nor lifesaver estimates were of use in estimating visitation numbers, I then turned to the records of the Manly council lifeguards. Council lifeguards are permanent employees, who work full time in patrolling the beach. They are therefore likely to be the best judges of crowd numbers. Data was sourced for the same period as the CoastalCOMS data, October 2007- April 2008, to allow for comparison between data sources.

Council lifeguards do not estimate total crowd numbers, in part because of the challenges addressed above in providing accurate figures. Instead they use an ordinal scale, with 5 representing the maximum number of beach visitors the beach can reasonably hold. Through discussions with the head lifeguard (David Boardman, pers. comm.), this scale was translated to an approximate figure for beach users. Reservations must be held about the accuracy of this approach. The estimate for total beach visitation over the summer period was 1,229,500 for North Steyne. Manly hosted 1,849,500 beach visitors, whilst Queenscliff contributed a further 1,040,100, for a total figure of 4,119,100 for the full stretch of Manly Ocean Beach.

There were also discrepancies in the way that surf height was recorded, with some lifeguards recording wave height in feet and some reporting in metric. In the surfing community, wave height estimates in feet are vastly different from subjective measurements. A wave which is reported as 6 foot may be as much as 2 ½ times the height of a person standing on the wave (Butt et al., 2002), with even greater variation in areas that regularly experience large surf, such as the Hawaiian islands. Whilst estimation of wave height is a subjective and contentious issue (Caldwell, 2005), this provides further challenges in any attempt to construct beach visitation models that incorporate wave or surf variables. In the case of this study, measurements were assumed to be technically accurate, and metric wave height estimates were converted into feet. For example, a wave reported as 1m in height was converted to 3 feet for analytical purposes.

4.5.6 *Summary of beach visitation estimates from the available sources*

There was substantial disparity in the cumulative estimates of beach visitation over the 2007-2008 summer period, as derived from the various methods. Figures from SLSA estimates are approximately 45 times those derived from the surf camera imagery. The council lifeguard estimates represent a further fivefold increase. The disparity in estimates is displayed graphically in Figure 4.13, which shows the cumulative daily visitation estimate from the multiple sources. Readers should note that the y-axis employs a logarithmic scale, indicating that there are orders of magnitude difference between the CoastalComs estimates and those of the lifesavers and council lifeguards.

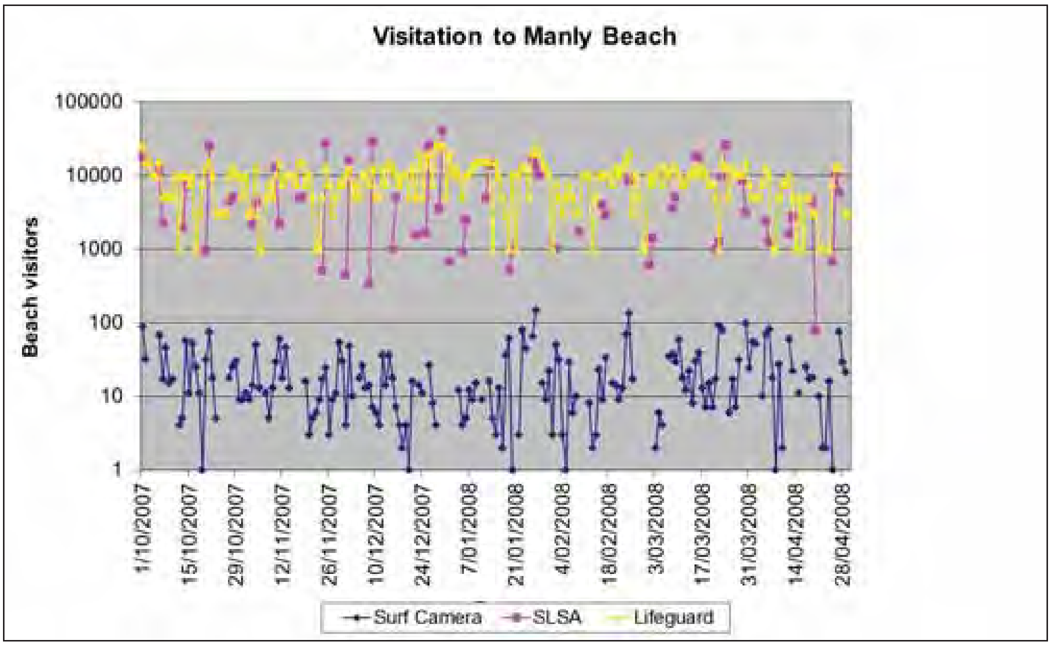

Figure 4.13 Daily beach visits to Manly beach, multiple sources.

As can be seen, the estimates do not lend themselves to consistent estimates of aggregate economic value. This is shown in Table 4.25, which shows the mean estimates of visitation for the summer period of 2007-2008.

Table 4.25 Manly beach visitation estimates Summer 07-08

Method employed	Beach visitors (estimated)
Surf camera analysis :	3902 (limited FOV)
SLSA estimates :	855877
Council lifeguard :	4.1 million (on sand)

The situation is even worse for the other case-study sites. The only available source of information for Collaroy-Narrabeen is SLSA data, which suggest total visitation for summer 2007-2008 of 293,090 persons. There are numerous data gaps, and no figures were recorded for South Narrabeen, hence this is likely to be an underestimate. No visitation figures of any kind are available for the other case-study sites.

It was also not considered a worthwhile exercise to pursue the development of a predictive beach visitation model, as even a perfect model would be merely replicating highly imperfect data. It is hence not considered worthwhile for predictive purposes. The only contingent visitation data available is therefore the stated visitation frequency data collected in the current study.

4.5.7 *Substitute sites*

Substitute sites were not explicitly considered in the project description or analysis. Consequently, those who have travelled past possible substitutes may value the site more highly than those who visit only their closest site. This is a simplistic assumption in the case of beaches, as the imputed value may fluctuate from day to day based on weather and ocean conditions.

Contingent behaviour questions about the response to the loss of sand (see section 5.4.11.1) also suggest that substitute sites may not be as important in determining the response to beach closure as sometimes suggested in the literature. When asked what they would do if they travelled to the beach to find that there was no sand, but the beach was otherwise open for swimming, few respondents indicated that they would travel to another beach Table 5.20). Nevertheless, the economic importance for recreation of the site at which surveys were conducted is likely to have been overstated by the lack of information about costs of substitution.

4.5.8 *Travel cost models – perfect explanation of imperfect recollection?*

Applications of TCM are becoming increasingly complex, in a quest to obtain precise estimates of consumer surplus and aggregate value for the resources in question. There are an endless array of refinements proposed in order to more accurately incorporate the opportunity cost of time (Feather and Shaw, 1999, Hynes et al., 2009, Lew and Larson, 2005a, Smith et al., 1983), to better allow for the truncation and overdispersion biases introduced by onsite-sampling (Bateman et al., 1995, Martínez-Espiñeira and Amoako-Tuffour, 2008, Shaw, 1988), and to the selection of models to better approximate the trip count data collected in application of TCM (von Haefen and Phaneuf, 2003, Shrestha et al., 2002b, Hellerstein, 1991, Creel and Loomis, 1990). All of these efforts concentrate on either the statistical model employed in analysis, or the explanatory variables incorporated into these models. Little attention is paid to the independent variable which the models attempt to explain, the visitation frequency.

This visitation frequency is typically in the form of a number of visits over a defined period, whether it is a season (Parsons et al., 2009) or a year (Blackwell, 2007). It is derived directly from the responses of those surveyed, and is therefore subject to a number of potential sources of variability, including the ability to accurately recall the number of visits (Faulkner and Raybould, 1995) and over-reporting or prestige bias (MacDonald and Dillman, 1968, Malvestuto, 1996). These issues have received little attention in the TCM literature, which suggest an assumption of accuracy.

4.5.8.1 Recall and temporal bias

It is often assumed in expenditure surveys that respondents have perfect recall over periods of up to 12 months. This is despite the fact that comparative analysis of responses via recall and diary methods has demonstrated statistical differences in reported expenses between the two approaches (Faulkner and Raybould, 1995). Due to concerns about recall bias, respondents in the current study were only asked about their beach visits in the previous month. Given that the majority of surveys were undertaken during the 'official swimming season' (October 1st to April 30th, the period when council lifeguards are employed), this is likely to represent an upwardly biased estimate of visitation frequency.

There is also potential for 'prestige bias', where self-reporting respondents overestimate their participation in activities which confer status. This has been reported for hunting (MacDonald and Dillman, 1968) and fishing (Malvestuto, 1996) activities, and is assumed (by the candidate) to also apply to the skill-based beach activities of surfing and board or ski paddling. Whilst no objective verification of this effect was possible, it is my view that this could explain the relatively high proportion of sampled respondents who indicated that they visited the beach on a daily basis.

The biases engendered by stated preference methods may be substantial. Gaterall et al. formed predictions of site visits resulting from water quality improvements using two different models, one a gravity model and one derived from a marketing study. Their analysis showed a more than fivefold difference in visitation estimates (Gaterell et al., 1999). Differences of this magnitude render small variations in welfare estimates relatively meaningless when aggregating benefits (Hanley et al., 2003). Hence, establishing relevant populations should be a key focus of survey-based valuation methods. This is not often the case, however. Given the importance of defining the relevant population for sampling design, and for aggregation of benefits, this deficit requires attention. Potential sources of beach visitation data for the current study are therefore reviewed in the following sections.

4.6 Chapter conclusion

This chapter has presented the results of the travel cost component of the surveys administered to users of the beach both onsite and online. Whilst the absence of visitation information presents challenges in both sampling and aggregation of welfare estimates, the point estimates derived from the trip demand function are broadly consistent with those found in the published literature. Using the best available proxy data for visitation estimates, the aggregate values that could be derived demonstrate the importance of daytrip beach recreation to the local and regional economies. The absence of any visitation estimate for two of the sites, as well as the smaller sample sizes, precludes the derivation of similar estimates for all sites. The next chapter turns to consideration of how these values may be impacted by beach closure due to erosion, and exploration of the willingness to pay for erosion prevention.

5 Contingent valuation application

This chapter describes the contingent valuation exercise undertaken, which seeks to estimate the willingness of beach visitors to pay for measures to prevent loss of beach days through erosion. It employs a novel survey design, with screening questions to identify protest responses, and a ‘single bound with open-ended follow-up’ format to identify anchoring and starting-point bias.

The chapter begins with a justification of the need for stated preference methods, and a review of theoretical considerations. It then turns to a brief overview of previous beach valuation studies, which are reviewed through the lens of a coastal scientist. This identifies a number of theoretical challenges to the effective valuation of beach use and coastal management activities. The chapter then defines the survey design employed in the current study, which attempts to address some of these theoretical challenges, and strikes a balance between transferability and precision. The results are then presented and discussed.

5.1 Need for stated preference approach

There is both a practical and a legal requirement for the use of stated preference models in estimation of environmental values. These both stem from the prevalent use of Cost Benefit Analysis (CBA) in planning and decision making in the environmental arena, as discussed in Chapter 1. CBA has increased in popularity in part because governments have recognised that they require more information on societal preferences to inform the decision-making process (Hanneman, 1994). Given the entrenched nature of benefit-cost analysis in public policy decision-making, pricing of environmental goods is essential for sound policy in the environmental arena (Hanneman, 1994). The proper application of CBA requires valuation of all costs and benefits associated with policy choices, something which cannot be achieved purely through the use of revealed preference methods such as TCM and HPM. These methods require some form of contact with the resource, or the presence of a financial transaction, which is absent in non-users.

Environmental valuation studies conducted only on resource users will, unless carefully designed, only determine the expenditure and consumer surplus associated with on-site activities. Even where surveys are accurately designed, there is a tendency for non-use values such as bequest values to be disregarded or underestimated (White and Lovett, 1999). This does not capture all of the private or social benefits or costs of recreation (Schreyer and Driver, 1989, Kearney, 2002). This is likely to result in a significant underestimation of the social benefits accruing from setting aside area for recreation (Navrud and Mungatana, 1994). Non-market commodities, such as social benefits from recreation, can be more economically significant than the profits generated through commercial resource use (Lockwood et al., 1992). Contingent valuation studies are able to capture both indirect use (generally outdoor recreation) and non-use values that revealed preference models cannot, and thus they can provide important input to any estimate of the Total Economic Value of a resource. Ciriacy-Wantrup (Ciriacy-Wantrup, 1947) recognised that in the absence of market prices, assessing societal preferences through personal interviews is a more relevant way of 'valuing' the utility generated from the presence of a resource.

Hence, there is both a legal and theoretical argument for the use of CV in consideration of environmental policy decisions. Attention now turns to the technical aspects of application.

5.2 Technical considerations

There are a number of potential weaknesses of contingent valuation which must be considered in the survey design. Key points of debate centre on the hypothetical nature of the method, and the provision of information. Other potential sources of error include strategic or protest bidding, the choice of payment vehicle, and the choice of open-ended or referendum format. Arrow et al. provide a detailed series of guidelines for the design and use of contingent valuations (Arrow et al., 1993). These guidelines are derived from the findings of a panel of economic experts convened to consider the use of CV in legal decisions, arising from the Exxon Valdez oil spill. The panel ultimately gave qualified support for the use of CV, with a number of recommendations for improving the reliability and theoretical validity of applications of the method (Arrow et al., 1993).

A number of potential sources of bias in contingent valuation studies are discussed below. These issues have been discussed widely in the valuation literature, and many valuation studies preface their results with a lengthy justification based on microeconomic theory. Given the legislative requirements for total economic valuation imposed by regulatory requirements for CBA, and the inability of revealed preference methods to capture non-use values, this degree of justification for the use of stated preference methods is considered unnecessary. Nevertheless, key technical aspects relevant to application of CVM are discussed below.

5.2.1 *Hypothetical nature*

Much of the debate about the use of contingent valuation hinges on the fact that it relies upon the stated responses of respondents in response to creation of a hypothetical market (Carlsson, 2001, Sinden, 1988). Because of the hypothetical nature of the contingent valuation question, many have questioned whether the responses represent real WTP or a strategic response designed to achieve the desired policy outcome, a case of strategic bias. One of the most commonly cited examples is that of protest responses, whereby respondents answer negatively to WTP questions even when they may have a positive true WTP (Halstead et al., 1992). Typically protest responses are assumed to be linked to a desire to avoid the potential of actual payments through implementation of the proposed policy, but may also be linked to aspects of the survey design and reflect attitudes towards the management agency, payment vehicle or the good under consideration (Jorgensen and Syme, 2000, Jorgensen et al., 1999). The assumption that strategic benefit can only benefit from strategic behaviour through provision of false responses is also dubious:

> *"Economists have traditionally asserted that respondents in surveys about public goods have no incentive to answer questions about their preferences carefully or honestly. Hence, there is no reason to believe that subjective responses reliably reflect respondents' behavior in actual choice contexts. As a result, the profession has enforced something of a prohibition on the collection of subjective data". (Manski, 2000)*

This tends to ignore the fact that there are also assumptions employed in revealed preference methods, and discredits the ability of the respondent to provide useful feedback in a CV context. Citing Hanneman:

> *"In the debate on contingent valuation, critics have shown a tendency to employ simplistic dichotomies. Surveys of attitudes are fallible and subject to the vagaries of context and interpretation; surveys of behavior are unerring. In the market place, people are well informed, deliberate, and rational. Outside it, they are ignorant, confused, and illogical."(Hanneman, 1994)*

Considerable efforts have been expended in attempting to validate (or otherwise) the results of hypothetical experiments with those where people are asked to make actual payments for the same good. Nevertheless, the results of these tests are not entirely unambiguous, but provide evidence to support both sides fo the argument. Income effects in CV surveys are lower than when people are asked to make actual payments, indicating that they are not considering the payments in the same light (Schläpfer, 2008). Conversely, Sinden investigated the differences between hypothetical and actual willingness to pay for soil conservation and tree protection measures. In a series of seventeen experiments, the two measures of WTP did not differ statistically in any case (Sinden, 1988). Carson et al. make the valid point that CV studies typically require a time investment of at least ten minutes, with resultant point estimates in the order of US$20-$250 dollars. These are considered, by the authors, to be comparable to the amount of time that would be dedicated to purchasing decisions of a similar magnitude (Carson et al., 2001). Thus there does not appear to be an objectively justifiable basis for exclusion of stated preference methods on the basis of their hypothetical nature.

Convergent validity can also be tested by comparison of values derived from revealed and stated preference methods for the same environmental good. Typically, these comparisons show that revealed and stated preferences are comparative, at least when valuing the same good (Knetsch and Davis, 1966). The use of a combined approach is becoming increasingly popular, in part as a means of limiting the criticism of stated preference approaches. Where these tests have been performed, values are generally relatively close (Kling, 1998, Carson et al., 1996). Interestingly, benefit estimates from two stated preference methods may be less likely to be comparable.

Boxall et al. found that estimates from contingent valuation were 20 times greater for the same good than estimates from a choice method approach, although he explains the difference in terms of compliance bias (c.f. social persuasion, discussed below) (Boxall et al., 1996).

5.2.2 *Bid format*

Concerns about the ability of respondents to form stable preferences for public goods and the potential for strategic bias, has led to a transition away from the open ended (OE) format. These have been replaces with questions offering a random amount with a yes-no answer (referendum model). These are termed Dichotomous Choice (DC) questionnaires, and were first proposed by Davis (Davis, 1963). The increased use of DC question formats was a guideline identified as essential by a group of prominent economists who considered the use of WTP estimates as legal evidence (Arrow et al., 1993). Dichotomous choice (DC) questionnaires are more reliable as they do not deal in such abstract valuation terms; therefore the conceptual burden is limited. These are also termed referendum models, as they are assumed to be similar to a tax voting exercise. There is also no strategic benefit in underestimating WTP (Arrow et al., 1993). Under the DC design, the respondents are considering a self-imposed tax at the rate offered, with the result of the tax being the environmental change that is described. It should be noted that this suggestion was developed by economists with experience in taxation referendums, as is commonplace in California. These tax voting exercises are not well known in other countries, hence their theoretical basis has been questioned (Spash, 2000).

DC surveys can take a number of forms. The original format suggested is the single bounded (SBDC) or referendum format. The Double Bounded Dichotomous Choice (DBDC) format was proposed by Hanemann et al. (1991) as a means of gaining statistical efficiency. This gain is through placing bounds on the distribution of 'true WTP', which is assumed to fall in the categories shown in Table 5.1.

Table 5.1 Responses and implied bounds on true WTP from DBDC surveys

Response to DBDC questions (initial-follow up)	Assumed bounds on true WTP	
	Lower	Upper Bound
Yes-Yes	Follow up bid	Disposable income
Yes-No	Initial Bid	Follow up bid
No-Yes	Follow up bid	Initial bid
No-No	0	Follow up bid

If anchoring is not present, the statistical gains from the DBCV result in greater precision of parameter estimates (Hanneman et al., 1991). Use of a DBDC design also provides a measure of insurance against selection of inappropriate bid values. The higher second bid insures against too low an initial bid, whilst the lower second bid insures against too high an initial bid. These 'insurance bids' are realised in the event of positive and negative responses to the initial bid, respectively (Hanemann and Kanninen, 1999).

Whilst no-no responses and yes-yes responses do not place absolute bounds on the WTP estimate, they truncate it in a way which makes estimation and precision easier. This follow-up question is typically a further binary choice, but may be open ended (OE). There may be further DC questions, which give rise to a multiple bounded dichotomous choice design or MBDC (Bateman et al., 2001). Split sample tests for scope effects on the OE follow up questions in health economics failed to identify sensitivity, which was put forward as proof that the dichotomous choice with open ended follow up (DC+OE) approach is invalid (Kartman et al., 1997). An alternative conclusion is that preferences for the good in question are relatively inelastic, and anchoring from the first bid obscures any differences.

DBDC questions are not without problems, however. Estimates of WTP using DBDC methods show significant evidence of anchoring, where the second bid does not vary as greatly as expected from the initial bid (Green et al., 1998). Studies have demonstrated that these MBDC approaches have the potential to derive more precise bid estimates, but come at the expense of substantial anchoring issues, and may suffer from theoretical issues (Bateman et al., 2001, Whitehead, 2002). The downward bias is much greater for open-ended follow-up questions than for closed questions (DeShazo, 2002).

In the case of policy applications, selection of bid formats and analysis methods which provide conservative estimates may be desirable, to provide a measure of insurance. There may also be an incentive for respondents to undertake a form of free-riding, where they are essentially gambling that a low bid will result in improvement of the proposed program (Farmer and Lipscomb, 2008). In the case of environmental advocacy, the reverse may be true, as large welfare estimates may be desired.

5.2.2.1 Selecting bid amounts

There are a number of highly technical approaches to estimating the selection of appropriate bid amounts. In some instances these methods would require more work than the implementation of the WTP survey itself. They also tend to require some previous knowledge or assumptions about the existing distribution of 'true' WTP (Cooper, 1993, Alberini, 1995, Dalmau-Matarrodona, 2001, Kanninen, 1993). In this survey, as in many others, initial bid amounts were selected on the basis of pretesting both with a convenience sample and in initial field testing. Follow-up bids were open ended, hence the distribution of these bids is determined by the user (though presumably conditioned by the initial bid).

Schläpfer argues, amongst many other things relating to CV studies, that generating meaningful responses from dichotomous choice CV experiments require that the bid amounts are similar to the actual amounts likely to be encountered if the policy is enacted, as this reduces the incentives for strategic bidding (Schläpfer, 2008). He suggests that a means to achieve this is through the use of relative (percentage) changes rather than absolute amounts. He goes further to suggest that respondents should be able to choose to align their responses with those of a larger (hopefully better informed and well intentioned) organisation with known political orientation (Schläpfer, 2008). These approaches are unfortunately only applicable where there is an existing charge for the service or access in question, and are restricted to certain payment vehicles. Given my own experience with politically active interest groups, I am also not filled with confidence that these groups can more accurately represent my underlying preferences than I am able to do myself, however irrational my responses may appear.

5.2.3 *Payment vehicle*

Choice of payment vehicle and starting bid has significant potential to influence the WTP (Silberman and Klock, 1988, Morrison et al., 2000). Selection of an appropriate payment vehicle was a substantial challenge in survey design. Open access resources such as Australian beaches provide a number of theoretical obstacles in the selection of payment vehicles, as it is neither legally possible or practical to institute entrance fees for a beach. In most countries, the right to recreate on public or privately owned land is not a legally defined right, rather an assumed privilege (Kearney, 2002). In Sweden the right to recreate on privately owned land is not explicitly defined, but an extension of common law, and is known as “everyman’s right”: allemansrätten (Rider et al., 1988). The issues associated with management of “the commons” have been discussed extensively elsewhere (Arnason, 1996, Vail and Hultkrantz, 2000, Curry, 2001). Much of the land available for outdoor recreation in Australia is publicly owned, with a history of open access (Batt, 2000). Thus access to land for recreation is a non-excludable right, and in this situation a fee cannot be collected for use (Randall, 1987). This contrasts with many studies overseas, where the valued beaches are often located within a managed recreation area with paid parking and restricted access (Parsons et al., 2009). Under these conditions, changes in parking fees may be a more appropriate payment vehicle.

Site-specific measures such as site access fees do play a role in limiting the demand for particular sites, particularly when there are comparable substitutes nearby (Kerkvliet and Nowell, 2000). Anglers in Yellowstone National Park were shown to be much more sensitive to site specific increases such as entrance fees than to (more substantial) increases in non site-specific measures such as an increase in annual fishing licence fees (Kerkvliet and Nowell, 2000). The price elasticity of demand of an activity is proportional to the percentage of available income that is required to undertake that activity (Navrud and Mungatana, 1994, Walsh, 1986). Hence activities which are more expensive are more easily managed through introduction of a user fee. This means that user fees are more effective at managing activities with higher environmental impacts, or in areas which are difficult to access. It is also proportional to the uniqueness and quality of the recreational experience (Walsh, 1986). In situations where visitor fees are the basis of management budgets, changes in visitor numbers such as those predicted after fire by contingent demand studies (Starbuck et al., 2006) will result in insufficient funding for management (LaPage, 1996).

5.2.3.1 Access and parking fees

The most common payment vehicle employed in the beach valuation literature is an increase in access or beach parking fees (Landry et al., 2003, Oh et al., 2008). This may be either through direct questions about parking permit fee increases, or through asking how much respondents would be WTP for an increase in beach width, with parking and access to be ensured as part of the project. This is in part a result of the fact that most beach valuation studies have been undertaken in the United States, where the USACE guidelines dictate the requirements for nourishment projects (Whitehead et al., 2008).

Under Australian legislation, it is illegal to charge a beach access fee. It is also an option which would likely garner strong psychological responses. An example can be seen in the recent 'animated' response to the proposed move by Warringah Council to remove the free residential parking permit scheme (Cherry, 2010). This may increase the proportion of protest votes and render contingent valuation studies inaccurate. Beach parking fees are a proxy for access, although they suffer from a number of distortions. In urban locations, a large proportion of beach visitation may be derived from local residents. These residents may not travel by private vehicle, hence they are not affected by parking fees. Almost a third of the sample in this study did not pay for their travel in any means, as they travel to the beach under their own power (see Table 4.6).

Free parking is available in some form at most Sydney beaches. This may be restricted to local residents through a permit parking scheme, or may be limited through time limitations. Parking fees are applicable only to those who travel in a private vehicle, do not have a parking permit, and choose to park within the paid parking zone. This excludes a large number of beach visitors, as evidenced by the patterns of visitation identified in the previous chapter. Only 4% of the beach visitors surveyed paid for parking, hence the use of this payment vehicle would not have been equally received by those who pay for parking, and those who utilise free parking. There was also a difference in the parking fees in place at the case-study sites, meaning that any nominal change in fees would represent a different proportional increase.

5.2.3.2 Increase in property rates

Rates were not considered a suitable payment vehicle, as a large proportion of residents in all case-study sites were in rental properties (33.1% Manly LGA, 44.7% Manly suburb, 25.3% Warringah LGA, 38.8% Narrabeen suburb, 20.5% Collaroy, 21.1% Dangar Island, 21.6% Brooklyn) and therefore do not pay rates (ABS, 2006a). Rates increases or levies, though suggested by some authors as the most appropriate payment vehicle, are not applicable to visitors. In addition, two of the case-study sites are adjacent to LGA boundaries (Manly and Warringah), meaning that even the closest residents may not reside in the same LGA, and more than half of visitors to the Manly LGA are non-residents of the LGA. This is termed coverage bias, in a review by Morrison et al. of payment vehicle selection effects and biases (Morrison et al., 2000). This paper cites previous unpublished work of one of the co-authors, Russel Blamey, which stated that selection of appropriate payment vehicles for CV studies in Australia is a substantial challenge (Morrison et al., 2000).

Timing of the purchase is important, particularly for durable items. This was noticeable in the qualitative survey responses, as the survey spanned the onset of the global financial crisis. Many respondents, particularly retirees, stated that they were unsure about their financial future and had to cut back on non-essential spending. They typically also had negative income, which makes theoretical consistency tests of income-dependency particularly troublesome.

5.2.3.3 Tourism tax

Tourism or bed taxes are applied in many locations in the United States, particularly coastal regions of Florida and California (Blakemore and Williams, 2008). They have been proposed and employed as a payment vehicle for visitors in studies elsewhere (Blakemore and Williams, 2008, Pagiola, 2001). The challenge in application for valuing metropolitan beaches in an international city such as Sydney is that the beach visit/s may be only a small component of the trip to Sydney, and may even be a small component of the day's outing. Tourists may spend many weeks in Sydney and only visit the beach once, which means that they would be considering more than just the loss of their beach experience, which may represent a small component of their overall trip.

Attempting to derive the component of the trip motivated by the presence of healthy beaches is both a logistic and theoretical challenge that would place a large conceptual burden on the respondent. An example of this approach is found in the attempt to determine the proportion of a safari trip by international tourists to Africa that is attributable to the presence of flamingos (Navrud and Mungatana, 1994). The contingent valuation component of this study asks people to outline their personal travel costs, and subsequently their Willingness to Accept Compensation (WTAC) for the absence of flamingos, and their maximum WTP to ensure the presence of flamingos.

5.2.4 *Information provision and survey testing*

One of the most critical aspects of CV design is the amount, nature and potential bias of the information supplied to the respondent (Shapansky et al., 2008). This information must ensure the respondent understands what they are being asked to value, without unduly changing the value they place on the resource being valued. People cannot express robust preferences for unfamiliar goods without a survey design which provides sufficient informational prompts to allow the respondent to generate a consistent 'response' to the good being valued (Schläpfer, 2008). Effective and objective communication of future states is a key component of the CVM.

In addition to being clearly understood, the information upon which contingent states are based must also be accurate (Arrow et al., 1993). If it is discovered post-valuation that the assumptions used in the generation of contingent state scenarios are inaccurate, there is limited potential to predict the effect of this inaccuracy on the results. This has particular relevance for the valuation of impacts related to climate change, which are associated with varying levels of confidence (IPCC, 2007c). This is hampered by scientific uncertainty on the absolute magnitude and timing of sea-level rises. Whilst means to address variability in timing and magnitude have been developed in coastal risk assessments (Cowell and Zeng, 2003), integrating this uncertainty into CV experiments remains a challenge in application (Tol, 2003).

Photographical representations of contingent states are gaining increasing popularity in contingent valuation to address the issue of subjectivity in contingent state descriptions. Use of visual aids, such as the image in Figure 5.1, can assist in communication of these states, although it also has the potential to induce scepticism or strong emotional responses.

Figure 5.1 Computer generated image showing potential extent of sea-level rise at Collaroy-Narrabeen in 2050, as displayed in newspaper article (Frew, 2006)

Whilst sufficient information is required to elicit preferences, the choice of information and the way in which it is presented will influence the responses received. This subjectivity can be addressed through an assessment of the complexity and logic of the proposed survey, which may be incorporated into the survey or done separately (Tyrvainen and Vaananen, 1998, Loomis et al., 2000). It should also be noted that respondents will have varying degrees of inherent familiarity with the good in question, which have the potential to influence both their processing of the scenario and ultimately their WTP (Johnson et al., 2001). Familiarity with a good is an aspect which has received some attention in the travel cost literature (Hicks and Strand, 2000, Parsons et al., 2000), but relatively little in the SP context.

The information provided also has the potential to influence the WTP of the survey respondents, so that they may no longer be representative of the stakeholder group they are purported to represent. This difference can be exploited, by taking a selection of the community and providing them with as much information as possible. This is the Citizens Jury approach (Robinson, 2001), which was developed in response to the differing responses generated when people respond with different levels of information, and when taking on different roles (consumer and citizen) (Blamey et al., 2000). The role which respondents are asked to play can be of significant importance. In examining preferences for forest management, van Rensburg et al. found that different preferences are generated by WTP studies when people are asked to indicate personal preferences, and when they are asked to indicate the views of "…society as a whole, keeping in mind the interests of future generations" (van Rensburg et al., 2002).

There was a significant difference between the preferences of forest managers and preferences indicated by respondents when acting as individuals. Managers were more likely to prefer ecosystem functions, whilst individuals were more likely to prefer visual amenity (van Rensburg et al., 2002). This could be symptomatic of differences in information, as it would be expected (and hoped) that forest managers are better informed about environmental issues than visitors. Societal and manager preferences were more comparable, which indicates that the difference due to perception of role is valid, as it would be hoped that forest managers attempt to represent the preferences of society. Given this assumption, the expenditure of time and money required to gather and communicate the expert evidence required for a citizens jury approach (Blamey et al., 2000) seems unnecessary, as this effort effectively turns citizens into de-facto managers.

5.2.5 *Stressor or agent of change*

It is not only the type and magnitude of change that is important in determining the response of those surveyed, but also the means in which the change is brought about. Diamond et al. argue that the cause of damage should not be important, only the end result (Diamond et al., 1993). This view is not considered consistent with programs attempting to value climate change impacts, as this is a highly volatile and contentious issue. This was the theoretical basis for inclusion of a question testing whether the respondent believed the erosion scenario, as described in section 5.6

It is also not true of programs which seek to identify preferences for different coastal protection options, as these too are the subject of much heated debate amongst coastal residents. For this reason, the survey in the current study was designed to minimise the effects of preferences for or against different alternatives, by not naming the mechanism by which beach erosion would be prevented.

5.2.6 *Warm glow and 'yea saying'*

In situations where respondents have no experience of the good being traded, or a negligible WTP, they may still indicate a positive WTP due to the moral satisfaction thy derive from the response, or due to social persuasion. This is termed the 'warm glow' effect (Kahneman and Knetsch, 1992). Kahnemann and Knetch (Kahneman and Knetsch) highlight the fact that WTP for a series of causes can be directly related to the predicted level of moral satisfaction from support for the respective causes. The purchase of this satisfaction could be considered a component of the existence value of the resource.

Warm glow effect is a term used to describe the psychological benefit of contributing to a cause through a voluntary donation (Nunes and Schokkaert, 2003). Whether this is an appropriate term to describe the reasons for yea-saying in contingent valuation surveys is questionable, as agreeing to pay a non-zero sum essentially amounts to the respondent imposing a tax on themselves. There should be no reason for them to agree to this action if they do not anticipate that the welfare benefits will outweigh the costs of the tax, in exactly the same way that a person considering a visit to a natural resource should not undertake the trip if they expect the costs to be greater than the utility they expect to derive from the trip.

Responding to a survey imposes a conceptual burden on the respondent, which is rarely compensated. They may resort to an answering strategy of 'satisficing', i.e. providing an answer that will be accepted and allow the respondent to move on, rather than expending the effort required to process the question, consider their internal preference structure and communicate their response (Hanley et al., 2001a).

5.2.7 *Scope effects*

Scope effects describe the idea that people provide similar answers for WTP for proposed programs of vastly different scale (Carson, 1997, Kartman et al., 1997, Smith and Osborne, 1996). This is also termed an embedding effect. For an example relevant to this study, this would be consistent with the concept that respondents would be willing to pay roughly the same amount to preserve the single beach where they were interviewed (as per the design of the survey), or to preserve all 38 ocean beaches in the Sydney region. Whilst tests of scope were not specifically included in the current study, qualitative responses were analysed for responses indicating that the scope of the project influenced the responses to the WTP questions. Results are presented in section 5.4.6.

5.3 Methodology

This section describes both the content of the CV component of the survey instruments, and also the process by which they were developed. Given the considerable uncertainties associated with projected climate change impacts on Sydney beaches (Cowell et al., 2006), this was a lengthy and detailed component of the survey design procedure.

5.3.1 *Survey design process*

Despite the importance of survey design in determining the accuracy and usefulness of benefit estimates, it is often given scant attention in the published literature. This section outlines aspects of the survey design process, which was a participatory collaboration between the research team, the Sydney Coastal Councils Group (SCCG) and the case-study councils, with further input from a panel of coastal management experts.

5.3.2 *Damage scenario – realism vs practicality*

In order to determine WTP to avoid the impacts of beach erosion, it is first necessary to describe the intended impacts in the absence of the project under consideration. The erosion scenario is perhaps the most important aspect of the design of surveys to estimate the economic value of a coastal management program, as it is in response to this scenario that all other components are framed. Determining the appropriate erosion scenario was a monumentally challenging component of the survey design process. There remains considerable uncertainty about the potential future state of beaches, given the influence of numerous factors such as storm frequency and intensity, concurrent rainfall and tidal conditions (Cowell et al., 2006, Cowell and Zeng, 2003). This is complicated further by the uncertainties associated with climate change impacts. This ultimately results in an inability of coastal experts to agree on a likely future state of beaches at the local level. Whilst this is an unavoidable and highly appropriate outcome, it provides challenges for both decision makers and also those seeking to value projects designed to modify that future state.

Use of recession scenarios suggested by either application of the Bruun rule or a more complex method assumes the absence of terminal structures which would limit erosion. In the case of Collaroy-Narrabeen and Manly (Cowell et al., 2006), this assumption is invalid. As noted in Chapter 2, there exist detailed estimates of the shoreline recession for two of the case-study sites. The original damage scenario used these estimates in presenting the contingent state to respondents. A problem that was encountered early in the design process is that damage estimates in their normal form (metres of shoreline recession, sometimes accompanied with a likelihood of occurrence) are not easily understood by lay people without the provision of substantial background information. Even project partners with substantial coastal management experience struggled to visualise what a shoreline recession of "X metres" would mean in terms of the beach, and how it would affect their usage of the site. An additional challenge for the use of detailed shoreline recession estimates are that they are rarely performed using the same methodology at different sites at the same time. Differences in estimate timing mean that the time horizon varies between beaches, or if a common time horizon is used (meaning shorter prediction intervals) and identical damage estimates are reached, this can mean that more intense damage is being valued.

Permanency of erosion (or placed material) is also assumed in most valuations of beach erosion or replenishment. Whilst this is certainly a likely outcome in the medium term (2100 onwards), permanent loss of sand may not be observed by the time horizon used in this survey. Storms are likely to result in periodic loss of sand, with partial or complete recovery over periods of months to years (Short and Wright, 1981).

The availability of substitute sites is likely to be important in determining the effectiveness of economic valuations of the environment (Boxall et al., 1996, Shrestha et al., 2002b). The results of choice experiments and WTP assessments are similar when only one destination is considered. In the presence of beach recovery and differential impacts of erosion, temporal (Smith and Palmquist, 1994) or spatial (Loomis and Keske, 2009) substitution of recreational sites may be possible, though this is rarely addressed in SP studies. Thus it is the intermittent yet total loss of sand that is of greatest interest for managers of Sydney's coastal beaches. This complicates the choice of erosion scenario further, as outlined in the next section.

5.3.2.1 Desire for transferability

It was very challenging to design a survey that is transferrable to different sites, as each site is characterised by different biophysical and socioeconomic contexts, and will be subject to different climate change impacts. This was true both in terms of their spatial extent, and also the time horizon at which critical thresholds or tipping-points will be reached. Ideally, the specification of future states for use in valuation would be informed by site-specific shoreline translation modelling. For example, differences in the design (and presence) of seawalls will result in different shoreline recession patterns (Cowell et al., 2006). Hence a balance must be reached between technical accuracy for individual sites and a measure which is comparable between sites.

5.3.2.2 Erosion impact scenario employed

A measure of erosion damage which is consistent between sites allows for greater comparison, while one which is specific to each site will give greater accuracy for that site. The ultimate solution was to value beach loss in terms of the impact on beach use. This was described as a ten percent reduction in the number of days with exposed sand present at high tide.

(Survey instructions)

> *I have asked you some questions about how you currently use the beach and what you like about this beach.*
>
> *I'm now going to describe a hypothetical future scenario for the beach, which you should consider in answering the following questions:*

(Erosion scenario description)

> *All Sydney councils are considering the future management of their natural resources, and the potential impacts of climate change. One of the most certain of these for coastal areas is a rise in sea-levels. Higher sea-levels are likely to result in the gradual but permanent loss of sand from [@Beach] .*
>
> *In the shorter term, sea-level rise is likely to result in the more frequent loss of sand from the beach due to normal storm activity.By the year 2050, this could lead to a situation where 10% of the times you visited [@Beach] , there was no dry sand present at high tide.*

The symbol [@Beach] indicates a wildcard used in survey programming to allow transferability. This wildcard records the name of the beach entered in the earlier section of the survey and propagates the beach name throughout the remainder of the survey whenever the wildcard identifier occurs. Thus the survey respondent is only asked about the beach where the survey was conducted. In the case of the online surveys, the case-study beach they visited most recently is used as the wildcard, or their favourite beach if they have not visited a case-study beach in the previous 12 months.

Importantly, it was a fixed percentage reduction in the presence of sand at high tide, in terms of the number of times each respondent visited. Thus, the relative damage is preserved, but the objective amount of erosion is different for each respondent. More simply, a person who visits ten times per year is essentially valuing the absence of sand on one of these days, whilst the person who visits every day is valuing absence of sand for around 5 weeks of the year. This is akin to the practice of pivot designs recently applied in the Choice Modelling literature (Rose et al., 2008), although it has not (to the author's knowledge) been applied in DC valuation.

This contrasts with the normal practice in the valuation literature of using a fixed amount of damage. In the case of recreation, this means that the benefit estimates and responses are not derived from a consistent interpretation by the user. For frequent users, a loss of 1 beach day may represent a loss of 1/300th of their recreation visits, whereas for infrequent visitors such as those on long distance beach holidays, a loss of 1 beach day may represent half of the annual number of beach visits. In effect, the use of a consistent figure imposes inconsistent scope. It could be expected, therefore, that the response to a WTP question that seeks to estimate WTP to prevent that loss will result in different responses. There are two opposing potential responses. It may be that the more avid beach visitor will consider the change to be insignificant, and provide a low or zero WTP response. Alternatively, daily visitation to a beach may be a central component of the respondent's lifestyle and help to determine their self image, in which case loss of a single day may represent a gross insult to their recreation patterns. Evidence of the importance of daily visitation can be seen in the presence of year-round swimming clubs in Sydney. The most famous of these is the Bondi Icebergs (http://icebergs.com.au/), who swim in the unheated ocean pool at the southern end of Bondi beach every day of the year. Similar clubs exist at Bronte (Splashers), Clovelly (Eskimos), Coogee (Penguins), Maroubra (Seals) and Cronulla (Polar Bears) (http://www.nswoceanbaths.info/topics/t004.htm).

5.3.2.1 Timing of damage

The online survey incorporated a split-sample design, whereby the timing of the described erosion scenario was varied. Respondents were randomly allocated to one of three groups, which was told that the erosion described (resulting in a 10% chance of beach closure) would occur either in 2020, 2050 or 2100. It was theorised that the more proximal impacts would be considered more important, with resultant increases in the strength of the preference response. This may not necessarily have led to a greater WTP value, however, as it may have led to a greater proportion of respondents rejecting the erosion scenario.

5.3.3 *Erosion prevention project description*

This survey does not include an explicit description of the project, but deliberately refers only to a fund that could only be used to prevent erosion as described in the erosion scenario. This approach was taken for a number of reasons. Chief among these is that there was no defined beach erosion prevention project for any of the case-study sites. The feasibility of undertaking any project designed to maintain beach access is also limited by practical and and legal restrictions. Whilst nourishment is a preferred option in many Coastline Management Plans in NSW, there are very limited examples of beach nourishment in an Australian context. Two notable exceptions relevant to the Sydney region are the nourishment of Bate Bay beaches with sand dredged from Port Hacking, and replenishment of Collaroy-Narrabeen with sand removed from the mouth of Narrabeen Lagoon. The former is undertaken in part for navigational purposes, whilst the latter is undertaken primarily to reduce the risk of flooding of properties adjacent to the lagoon.

The primary reason for this is the lack of available sources of sand. A recent report by AECOM identified suitable sources of offshore sand for beach nourishment, and demonstrated that the project would have positive economic impacts (AECOM, 2010). At the time of writing, the NSW Government maintains an unwritten policy of not allowing offshore dredging (AECOM, 2010). Whilst this stance developed in response to commercial proposals to source offshore sand for construction purposes, it nevertheless restricts the consideration of nourishment to the hypothetical.

There is also a challenge in describing future states to those with different knowledge of the current status of the resource. A number of respondents indicated daily visitation over a number of years, and hence they would be expected to have formed an internal picture of the 'status quo' beach. Their ability to accept the future state presented may be limited by experiential anchoring. One-time visitors will not be anchored to the same extent.

5.3.1 *Bid format employed*

This survey employs a single referendum question (hereafter SB), with a follow up open-ended question about maximum WTP (herafter referred to as the OE response), and a number of open-ended qualitative questions to identify reasoning and motivations driving responses. This approach is variously termed; 'binary with follow-up' or BWFU (Onwujekwe, 2004) or 'anchored – open ended' or AOE (de Faria et al., 2007). Whilst not particularly common in application, it has been shown through Monte-Carlo simulation to improve statistical efficiency, even in the presence of strategic behaviour (de Faria et al., 2007). This model was initially employed due to challenges in programming automatic bid values for the follow-up response. It also allows for multiple examinations of WTP, through estimation of models which look only at the first bid, only at the second bid (with assumption of no anchoring), and combined models which use both bid responses (Boyle et al., 1996).

5.3.1 *Double Bound Discrete Choice (DBDC)*

With the survey design employed in this study, it is possible to construct artificial double-bound bids, and use bivariate probit analysis to analyse the results as if a DBDC design was used. The bounds of the unasked second referendum question in the DB model are constructed through the development of artificial bid values. Upper bid values are calculated as twice the initial bid amount, and lower bid values are calculated as half the initial bid amount. The OE response is then compared to this value to determine if a positive response would have been received. This follows the approach of Greiner and Rolfe (2003).

The bounds generated using this process are defined in Table 5.2. In the case of Yes-Yes bids, the OE response is preferred to a positive infinity measure. In the case of No-No bids with a positive OE value, this is preferred to the artificially constructed follow up bid (Bf).

Table 5.2 WTP bounds employed in DBDC analysis

Response sequence to constructed DBDC format	**Bounds implied by responses**	
	Lower bound	Upper bound
Yes-Yes	Bf	OE
Yes-No	Bi	Bf
No-Yes	Bf	Bi
No-No	0	OE or Bf if OE is 0

5.3.2 *Open ended responses*

It is also possible to analyse the OE responses as if the OE question was asked in the absence of the DC questions. This approach has been undertaken by a number of authors (Greiner and Rolfe, 2003), although this practice must be questioned, given the strong anchoring evidence identified in previous studies on MDBC survey formats (Whitehead, 2002).

5.3.3 *Payment vehicle*

The choice of payment vehicle can significantly alter the responses received. Nevertheless, there is no theoretically preferred payment vehicle for stated preference beach valuation studies. An equitable distribution of fees for all users would require some combination of payment systems (Black et al., 1990). This would likely entail a property-based fee for residents (Parsons and Noailly, 2004) and overnight visitors, and some form of access fee for daytrip visitors (Kriesel et al., 2004). Whilst a number of studies have suggested appropriate forms for one or the other approach, there is no ideal solution that encompasses both. Varying payment vehicles are identified in the relevant published literature, as demonstrated by Table 5.3.

Table 5.3 Payment vehicles employed in beach valuation WTP studies

Primary Author	Year	Payment vehicle
Landry	**2003**	Parking fees
Silberman	**1998**	Admission pass
Kriesel	**2004**	Parking fees
McConnell	**1977**	Additional WTP for visit - vehicle unclear
Shivlani	**2003**	Parking fees
Hanley	**2003**	Combined TC/CV approach - # of intended trips with better water quality
Togridou	**2006**	NP access fees
Lindsay	**1992**	beach management fund donation
Kline	**1998**	access fee

Given the mixed visitation of the case-study sites, and the desire for transferability to other locations, we sought to employ a payment vehicle which was appropriate to a range of locations. Options considered included different payment vehicle models for different user groups. Hence an examination of alternatives was undertaken. Examples of the options explored were: rates increases or special levies for local residents, a 'tourism occupancy' tax for tourists staying in the same Local Government Area, and parking fee increases for those who travel by private vehicle. Comments on each, and the payment vehicle ultimately selected, are included in the following sections.

5.3.3.1 Voluntary donation

The payment vehicle specified in the surveys is in the form of a voluntary donation to a beach management fund, restricted to use only at the beach in question, and administered by an unspecified State government agency. This is despite concerns about the suitability of this payment method, as expounded by Hanneman:

> *"…soliciting an intention to make a' charitable donation is a poor test of contingent valuation, because it invites less commitment than soliciting an intention to vote for higher taxes" (Hanneman, 1994)*

Nevertheless, this was the valuation method chosen for a number of reasons. Firstly, beaches in Sydney are typically visited by a large number of international and domestic tourists. There was no logical taxation payment vehicle for these respondents that was comparable to responses from local residents.

As a result, the decision was made to use a more generic measure, in the form of a donation to a hypothetical beach fund:

(Payment vehicle description)

> *Suppose for a moment that there was a dedicated [@Beach] Beach Management Fund, which could only be used to prevent the erosion described.*
>
> *This fund would be administered by a state government agency, and could only be used at [@Beach]. It would be subject to independent annual audit, to ensure that the funds were being spent appropriately.*

5.3.4 *Management agency*

During the design stages, the decision was made to avoid agency bias against the local councils (due in part to the proposed introduction of a 'climate change levy' by Manly Council) by having the fund administered by a State Government Agency. Interestingly, the public sentiment towards the NSW State Government changed markedly during the course of the study. By the end of the study, the NSW Government was being widely criticised for poor financial management, and fewer local respondents were willing to contribute to a fund that would be administered at state level. This was noticeable in the comments collected in the qualitative 'debriefing' questions, which are available in Appendices 4 and 5, and are discussed in terms of their influence on WTP in the results section of this chapter. The beach management fund was also restricted to activities at a single beach, to identify any spatial differences between the case-study sites.

5.3.4.1 Plausibility screening question

Given the uncertainties about the timing and extent of climate-change induced erosion, and the history of coastal management debate at the case-study site Collaroy-Narrabeen, it was considered prudent to include a question which explicitly asked whether the respondent believed the erosion scenario was likely to occur. Binary responses to this question, named REJECTSC which indicates rejection of the proposed future state, are analysed to identify the effect the scenario description has on the resultant WTP responses. The plausibility question acts as a screening process, identifying 'scenario rejection'. This is an important distinction, as respondents who reject the scenario may in fact have a positive WTP. Groothius and Whitehead (2009) examine scenario rejection through the use of a provision-point survey structure. They find that failure to believe the premise of the question is likely to result in biased WTP estimates, as it will result in negative responses which may not reflect true underlying preferences (Groothius and Whitehead, 2009).

5.3.1 *Protest screening*

Typically, the responses to a contingent valuation (CV) survey indicate a large number of zero bids, and a smaller number of high positive bids (Strazzera et al., 2003). The use of a direct screening question to identify 'in-principle' willingness to pay (WTP) identify protest votes results in greater accuracy than attempting ex-post to explain the varying motivations behind the high proportion of zero bids to CV questions. This was the reason for the insertion of the following question:

> *"In principle, would you be willing to make a once-off donation to such a fund, if it existed?*
>
> *Remember that this is only one of a number of potential environmental projects, that there are a number of other beaches which may not be equally affected, and consider your available budget."*

The "In principle…" question was used as a screening process to identify protest voters, who were not asked the valuation questions. Negative responses were coded as PROTEST, and these respondents were not asked to indicate a WTP value. They were asked open-ended follow up open-ended question that explored their reasoning. This is referred to as a 'payment principle' question (Ragkos et al., 2006). This approach is rarely applied in stated preference questionnaires, though it was first proposed in 1979 by Bishop and Heberlein (Bishop and Heberlein, 1979). It has the potential to improve the precision of benefit estimates when a large proportion of protest bids are expected (Jacobsen and Thorsen, 2010), as was the case in this study. The use of a payment principle question has the effect of censoring the data, which can significantly influence WTP estimates in the upward direction, through removal of low or zero bids. It has the advantage, however, of identifying protest responses, and provides information useful in modification of the proposed project, which is useful for management purposes (Kontogianni et al., 2001).

Whilst it has the additional benefit of producing more precise estimates, it also means that these estimates cannot be aggregated across the entire population. Hence models are often presented both with and without censoring. In the case of uncensored data, protest bidders are assigned a hypothetical bid value (in this case a value of $1), and coded as providing a negative response, as per Powe and Bateman (Powe and Bateman, 2003). This may artificially assign non-zero values to true zero bids, hence biasing WTP upwards.

Inclusion of protest votes (zero bids for WTP, regardless of the amount offered) has the potential to substantially influence measures of average WTP (Nahuelhual-Muñoz et al., 2004), hence identification of the reasons for negative responses is important. This was aided in the current survey by an open-ended follow up question:

> *"What is the main reason for your answer to the previous question?"*

5.3.2 *Coding of qualitative responses*

The CV survey questions were structured in such a way that reasons for WTP responses can be deduced from the previous questions, and also from the follow-up qualitative responses. Qualitative responses to the follow-up questions regarding responses to plausibility and WTP questions were coded for analysis, using a simple classification system. Responses to these questions can be used to better understand the motivation for WTP and to attribute use and non-use values where possible, but also to aid in the design of any future beach management funding scheme. An examination of the coding employed to identify the true nature of responses is provided below:

RECUSE indicates responses which indicated recreational use of the beach as the primary motivation for the WTP response.

PAYVEH refers to a problem with the proposed payment vehicle. The majority of these responses indicated that taxes, rates and associated levies were the preferred income sources. Some responses declared that the use of a once-off payment would be unlikely to be effective, with an annual payment preferred.

PRIORITY indicates that the prevention of erosion was considered a low priority for the respondent, with alternative projects such as marine species conservation considered more important.

INSTITUTION indicates a preference for management at alternative levels of government, either Local or Federal. Negative WTP responses coded in this manner represent a general distrust of the State government, or concerns about the administration and oversight of the fund.

PROJECT indicates that the respondent either required further information on the proposed erosion prevention activities in order to make their determination, or that they did not believe the prevention of erosion was feasible.

ECON indicates citing of economic reasons for the WTP response. In most instances this indicated that those on low incomes did not feel that they could afford the amount offered. In instances with WTP, it indicates mention of economic incentives for preservation, such as ownership of local property or businesses.

SUBST indicates mention of other beaches, or mention of the fact that they were not a resident of the area and would be unlikely to benefit from the proposed project. Respondents were explicitly reminded of the possible availability of substitute beaches, following the guidelines of the NOAA panel (Arrow et al., 1993).

GLOW indicates either a response which specifically makes mention of a general disposition towards environmental projects, or one that indicates a positive WTP that appears to conflict with previous responses. People who indicate that they either do not believe the scenario, or are unsure of its plausibility, but have a positive WTP value, are likely exhibiting a 'warm glow' response, as logic would dictate that you would not donate to a project that seeks to offset a risk you do not believe will occur. This may indicate a general disposition towards environmental or coastal management projects. It may also indicate that they whilst they do not believe the details of the scenario, they believe that some future damage may occur, and are donating towards the prevention of 'that' amount of damage. This could arguably be termed a scenario rejection issue.

BEQUEST indicated explicit mention of future generations in the reason for WTP values.

Whilst the design of the survey in this study does not allow for tests of scope effects directly, qualitative responses were recorded that indicate that respondents were carefully considering the scope of the proposed project. A substantial proportion (26 of 417, or 6.2% of the online sample) of respondents who said that they would not be WTP the bid amount for the proposed project, but would be willing to contribute to a fund with a broader scope (i.e. contributing to erosion prevention at all Sydney beaches, or a national beach management fund). A number of respondents noted in their qualitative responses that they did not wish to contribute to a fund that was so narrowly directed, but they would be willing to support a fund that was aimed at beach protection over either a larger spatial scale, or with a more holistic beach management framework, including catchment management. Reasons for this included that it was not their favourite or local beach, and that they considered other beaches to be more vulnerable or important for preservation. These were coded as 'SCALE' responses and incorporated into analyses.

5.4 Results and analysis

This section presents the results of the CV component of the survey instrument. Results were pooled across beaches, with dummy variables incorporated to identify differences between case-study locations. Demographic information was collected from all respondents, including those who did not answer the WTP questions, in order to test for sample selection bias. The summary of the socioeconomic characteristics of the overall sample was examined in detail in the previous chapter, and is not presented again. Demographic differences between groups of respondents for the key questions are presented in the relevant sections.

Ideally, this information would be used to calibrate the responses to the known distributions in the broader population. There are two challenges to this process in the current study. The first is that there is no information available about beach visitation for the case-study sites, in terms of either the origin of visitors or their socioeconomic characteristics. The second is the high proportion of international visitation recorded at a number of the case-study sites. Calibration of these responses to a true population distribution would requite information about the socioeconomic characteristics of all visitors from the source location. Again, this information is not available. As such, responses are assumed to only apply to beach visitors, with aggregate estimates restricted in the same manner.

Responses to three key questions are discussed in this chapter, and include belief in the erosion scenario, 'in-principle' support for the beach management fund, and responses to the SBDC question. A conceptual map of responses to the three key questions is presented in Figure 5.2. Due to the structure of the survey, the decisions that determine WTP responses are sequential in nature. The respondent first decides whether or not they believe the erosion scenario as described. They then decide whether to support the management fund and erosion prevention project to prevent the erosion scenario from occurring. They then decide whether to support the fund at the amount requested in the SBDC question. This design leads to a series of 'nested' analyses, which are explored in turn below.

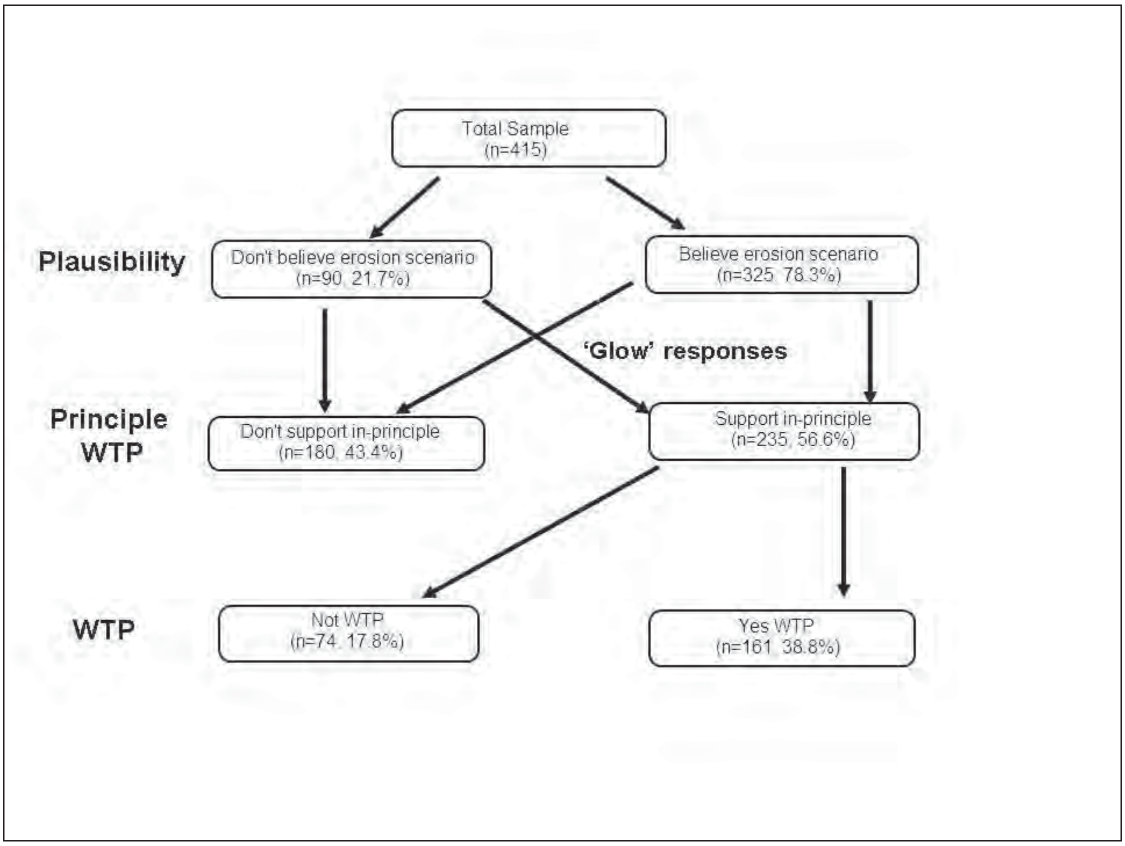

Figure 5.2 Response to key WTP questions, overview and frequencies

A summary of the responses to the three key questions, and exploration of further responses of interest, is presented in Table 5.4. Table 5.5 summarises the response and attributes of the referendum WTP question, which is asked only of those who indicated in-principle support for the program as described. These results are discussed throughout the following sections. This is followed by presentation of the results of probit analysis conducted to further explore the reasons behind WTP responses.

5.4.1 *Results of the plausibility question*

Belief in the erosion scenario was strong, with only 16% of the sample rejecting the scenario outright (Table 5.4). Overall, more than three quarters of the sample (78.3%) believed that the erosion scenario was likely to occur, with the balance of the respondents indicating they were unsure as to whether the scenario would occur. For the sake of simplicity, unsure responses were reclassified as rejection responses.

This level of belief is approximately consistent with the level of belief in climate change found in a recent survey of Australian households by Newspoll, which found that 71% of those surveyed gave a positive response when asked the question:

> *"Do you personally believe or not believe that climate change is currently occurring?" (Newspoll, 2010)*

This contrasts with the results of a poll conducted by Essential Media, which found that only 45% of people thought that climate change was both occurring, and caused by human actions (Essential Media, 2010).

Examination of the question wording shows that there is a difference that is likely to explain the apparent difference in responses.

> *"Do you agree that there is fairly conclusive evidence that climate change is happening and caused by human activity or do you believe that the evidence is still not in and we may just be witnessing a normal fluctuation in the Earth's climate which happens from time to time?"*

The difference in wording in polls of this nature is analagous to the issues surrounding information provision in CV studies, as the nature of the question will influence the outcomes.

Table 5.4 Plausibility, protest responses, and overall WTP

Beach	Collaroy-Narrabeen (n=174)		Manly (n=148)		Brooklyn (n=49)		Dangar Island (n=46)		Kruskall Wallis (df=3)	
Factor		Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Asymp. Sig.
RejectScen	0.16	0.37	0.25	0.43	0.29	0.46	0.24	0.43	5.93	0.11
Protest	0.36	0.48	0.46	0.50	0.65	0.48	0.39	0.49	15.42	0.00
WTP (total)	0.43	0.50	0.34	0.48	0.27	0.45	0.49	0.51	7.22	0.07

Table 5.5 Responses to SBDC WTP question

Beach	Collaroy-Narrabeen (n=112)		Manly (n=80)		Brooklyn (n=17)		Dangar Island (n=27)		Kruskall Wallis (df=3)	
Factor									Chi-square	Asymp. Sig.
Amt1	128.04	187.30	113.56	174.55	101.56	158.93	101.85	171.53	0.36	0.95
WTP bid	0.67	0.47	0.64	0.48	0.81	0.40	0.81	0.40	4.26	0.24
OE max WTP	108.63	211.58	142.18	572.61	107.50	240.08	108.33	202.74	5.67	0.13
Anchored OE Bid	0.27	0.44	0.21	0.41	0.50	0.52	0.26	0.45	1.25	0.74

5.4.1.1 Demographics and plausibility responses

Mann-Whitney tests were employed to test for statistical differences between those who believed the erosion scenario and those who rejected it as implausible. Those factors which were identified as significantly different between the two samples are presented in Table 5.6.

Table 5.6 Significant differences between those who believed and rejected the erosion scenario

Mean	Believe scenario	Reject Scenario	Mann-Whitney U	Asymp. Sig. (2-tailed)
Coll	0.45	0.31	12605.00	0.02
RecUse	0.44	0.31	12695.00	0.02
Bequest	0.08	0.00	13410.00	0.00
Glow	0.08	0.38	10315.00	0.00
Male	0.48	0.62	12450.00	0.02
Age	39.42	45.33	10915.50	0.00
NoHighSchool	0.07	0.15	13253.00	0.02
NoJob	0.24	0.33	13072.00	0.08
NZ	0.02	0.07	13757.50	0.03
Beach_closure	0.61	0.46	12974.50	0.06

Respondents from Collaroy-Narrabeen were less likely to reject the erosion scenario. This is likely to stem from the greater level of experience with coastal erosion, as outlined in section 2.3.1, due to the localised sample and history of erosion at the site. Those with greater familiarity with the natural cycles of beach erosion, rotation and accretion (Harley et al., 2011, Ranasinghe et al., 2004) may be more willing to accept the potential that future states will be greatly different from the current status of the beach. Adamowicz et al. demonstrated that the 'perceived' level of damage, rather than the objectively described, can be more effective in explaining WTP responses (Adamowicz, Swait, Boxall, Louviere, & Williams, 1997). For this reason, a categorical variable representing prior experience with beach closure (Beach_cl) was incorporated into the model. Familiarity with the good in question is often cited as a potential influence on the reliability and magnitude of welfare estimates from CV studies (Desvousges and Gable, 1993).

It should be noted that the survey structure in the current study was such that the plausibility question was before any mention of the project or payment mechanisms, hence the responses are 'untainted' measures of the degree of belief in the scenario. These untainted responses, however, may already have been influenced by compliance bias or yea-saying. As the interviewer introduced themselves as conducting research on behalf of the University of NSW, which hosts a well-regarded climate change research centre, there may be a higher level of acceptance of the stated scenario than would be received if the interview was conducted by representatives of the local council.

5.4.2 *Sensitivity to timing of erosion impact*

The online survey instrument randomly allocated respondents to three separate groups which were told that the erosion would occur either in 2020, 2050 or 2100. This permits some exploration of the way in which the timing of the damages influences willingness to pay to prevent that erosion. The limited number of respondents in the 2020, 2050 and 2100 sub-groups of the online sample (19, 19 and 16, respectively) who indicated a positive in-principle WTP at each time horizon (2020, 2050, 2100) means that probit analysis and split-sample comparisons of demographics and response characteristics were not undertaken. Whilst sample sizes preclude the rigorous exploration of the influence of timing on the plausibility and WTP responses, some initial comparisons can be made. These are presented in Table 5.7, although few conclusions can be drawn from the results and they must be considered exploratory in nature.

Table 5.7 Effect of damage scenario timing on plausibility and WTP responses

	Damage timing						Kruskal Wallis Test (df=2)	
	2020 (n=34)		2050 (n=33)		2100 (n=28)			
Responses	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	Chi-square	Asymp. Sig.
RejectSc	0.06	0.24	0.00	0.00	0.04	0.19	1.96	0.38
Principle WTP	0.32	0.47	0.33	0.48	0.29	0.46	0.17	0.92
Amt1	51.91	118.04	113.94	187.70	41.79	97.35	2.12	0.35
WTP1	0.44	0.50	0.24	0.44	0.21	0.42	4.62	0.10
OE WTP	120.95	230.37	61.05	111.04	68.33	68.47	1.72	0.42
Anchored OE bid	0.41	0.50	0.39	0.50	0.46	0.51	0.32	0.85

Belief in the scenario appears to peak at 2050, with lower levels at 2020 and 2100. This may well be an appropriate pattern, as 10% closure of the beach by 2020 would indicate a more substantial degree of damage than is likely, whilst predictions of any nature become less reliable at greater time horizons. The only investigated parameter that is signficant at the p=0.1 level is the proportion of respondents who are WTP the bid amount, having indicated in-principle support. This is greater for those who were asked to contribute to a fund to prevent erosion occuring in 2020, and diminishes as the erosion scenario is further into the future. This suggests discounting of future potential damage.

5.4.2.1 Sampling bias through age restriction

For ethical reasons, it was not possible to interview persons under the age of eighteen. As such, the average age of the sample is likely to have been biased upwards. This is a problem common to many surveys, but it may have a greater influence on the results of surveys relating to climate change impacts, and hence it is worthy of further discussion.

The erosion scenario employed in the personal interviews describes damages occurring in the year 2050. The average age of those who completed this survey was 40.5 years across all sites. As such, in 2050 the average age of respondents to this survey will be approximately 81 years. Given the life expectancy of those born in 1965-67 (1968 was the average birth year of those who completed the survey) was 67.63 for males and 74.15 for females (ABS, 2008), it is unlikely that many of the respondents would witness the projected impacts firsthand. They therefore may consider that prevention of this damage is of less personal concern. Conversely, those who are most likely to be actively using the beach, young children, are not included in the survey. Whilst it is challenging to include young children in complex surveys of this nature due to cognitive (Borgers et al., 2000) and ethical concerns (Morrow and Richards, 1996), this is a serious theoretical challenge which should be considered in all surveys of climate change related attitudes, and consideration of planning and management responses which employ this information in a CBA framework. Previous research has suggested that those with children will have different WTP responses to those without (Dupont, 2004). Tests of the influence of children on WTP responses and particularly on the likelihood of bequest responses cannot be undertaken in the current survey, as a design oversight meant that the respondents were asked how many children they had travelled with, not the number of children they had, whether or not they travelled together.

It is also likely that the active use of the beach by the survey respondents will decline over the intervening time, due to decreased mobility. It can be presumed, therefore, that their RecUse of the beach resource will also decline. This decline may or may not be replaced by an increased personal preference for passive use (i.e. aesthetic appreciation of the beach landscape) or non-use values, such as a willingness to ensure that the beaches are preserved for future generations, including their own offspring.

5.4.3 *Results of the protest screening question*

Protest responses are identified explicitly, through examination of the preliminary payment principle question. Negative responses are classified as protest votes, with the open-ended qualitative response analysed to determine the reason for the protest vote. There were a high proportion of protest responses, with 180 of the 417 total responses[13] answering in the negative to the 'payment principle' question (Figure 5.2). In a study addressing similar concepts to the current analysis, Goodman et al. found that only 24% of respondents did not support increasing taxes to support coastal conservation programs (Goodman et al., 1998). The relatively high rate of protest responses in the current study are likely due to the inclusion of climate change in the description of the damage scenario, and the high proportion of visitors. The rate is not inconsistent, however, with other surveys which include such screening questions. In estimating WTP for preservation of the Naples Museum, Santagata and Signorelli found a protest rate of 48%, with genuine indifference to the good under consideration the most common reason identified through follow-up questions (Santagata and Signorello, 2000).

The protest rate varies substantially between sites, with Brooklyn respondents least likely to be willing to pay anything, and ColNarra residents most likely to be willing to pay (Table 5.4). It is interesting to note the difference between Brooklyn and Dangar respondents. This may be because Dangar respondents were more likely to be residents, whereas Brooklyn respondents had typically travelled quite some distance. It could also reflect the fact that Brooklyn Baths represent an artificial bathing environment, with sand providing only a small proportion of the amenities afforded by the enclosure itself and the adjacent park and picnic facilities.

5.4.3.1 Demographics and the protest response

Given the high protest rate, statistical comparisons are undertaken to identify differences between the two subsample populations, with results presented in Table 5.9. Many differences

[13] n.b. slight variation in sample sizes reported throughout the chapter is due to full-case analysis and missing data for some variables

were found in the demographics and qualitative responses of the two groups, with only those that were significant at the 10% level included in Table 5.8.

Those who protested against the payment-principle were more likely to be male, be without a fulltime job, and to not have finished high school. They were likely to be slightly older and have higher incomes than those who supported the project. The location of the survey was a key influence on protest responses. Collaroy-Narrabeen respondents were more likely to be supportive of the project, whilst Brooklyn respondents were less likely to support the project. They were also twice as likely to reject the plausibility of the erosion scenario. Respondents who rejected the scenario are likely to account for the variability in responses from Brooklyn, Collaroy-Narrabeen, and among those who were coded as providing GLOW responses.

Experience with beach closure is not significant in determining protest responses. This is a curious result, as it suggests that familiarity does not influence belief in the erosion scenario. Conversely, it may be that those with greatest experience of beach closure recognise that erosion of the beach is part of the natural dynamism of coastal systems, and are thus not willing to contribute to projects to control such variability.

Table 5.8 Statistically significant differences between protester and non-protester populations

	Mean of sub-sample		Mann-Whitney U	Asymp. Sig. (2-tailed)
	Accept payment-principle	Protest		
Coll	0.48	0.34	18355.0	0.01
Brook	0.07	0.18	18830.0	0.00
OthBch	0.21	0.14	19584.5	0.07
RejectScen	0.15	0.30	18045.0	0.00
PrincSupport	1.00	0.00	0.0	0.00
Male	0.47	0.57	18764.5	0.04
Age	38.55	43.51	16162.0	0.00
NoHighSchool	0.06	0.11	19821.0	0.08
Visit Freq	11.41	9.42	17324.5	0.00
NoJob	0.21	0.31	18635.0	0.02
IncomeCode	42922.37	55230.52	14142.0	0.01
SthAm	0.03	0.01	20433.5	0.08
RecUse	0.73	0.01	5877.5	0.00
PayVeh	0.07	0.21	18242.5	0.00
Priority	0.01	0.11	18980.0	0.00
Scale	0.01	0.13	18717.5	0.00
Institution	0.03	0.09	19692.5	0.00
Bequest	0.11	0.01	18927.5	0.00
Glow	0.26	0.00	15660.0	0.00
Subst	0.02	0.36	13872.5	0.00
ClosesEasy	0.36	0.26	19037.0	0.04

A number of qualitative response categories were related to the protest responses. Figure 5.3 shows the relative frequency with which each coded qualitative response was received, with the sample split into those who gave in-principle support for the project, and those who did not (protesters). It is important to note that the relative frequency figures do not add to unity, as respondents often cited more than one reason and the most important reason could not be determined during coding.

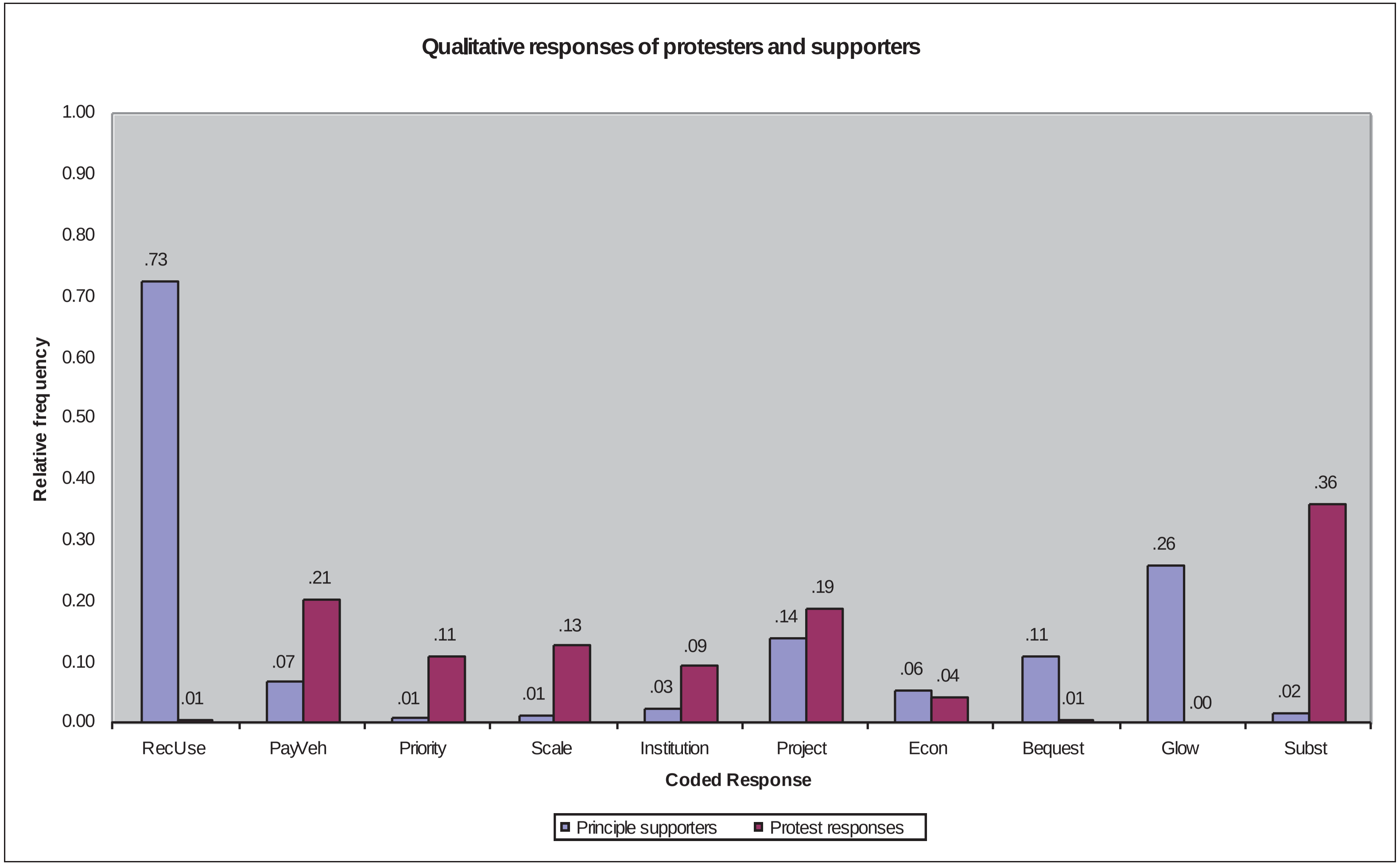

Figure 5.3 Qualitative responses of protesters and supporter

Almost three quarters of the respondents who supported the project (73%) cited recreational use (RecUse) as the primary motivation for their response. This compares to only 1% of those who protested. The most commonly cited reason for not wanting to contribute to the program was the fact that the site was not the preferred or most frequently visited location for the respondent. This was coded as Subst, indicating that the respondent was considering alternative sites. This is essentially a mirror of the of RecUse response, as the respondent is stating that they would not reap the recreational benefits of preserving the beach. The reverse pattern of frequency is found, with 36% of protest responders coded as citing a Subst response, versus only 2% of those who supported the project.

Other common reasons for not wishing to support the project are disagreement with the payment vehicle (coded PayVeh, 21% of respondents), a desire for further information about the intended project or lack of belief that the project could achieve the desired objective (coded Project, 19% of respondents), concern about the local nature of the project (coded SCALE, 13%), and a general feeling that the project was a low priority (Priority, 11%). The latter group represents those who may truly have zero values for WTP, as opposed to rejecting some aspect of the survey instrument. Some practitioners would suggest that these zero values be included in the sample, although this was not undertaken in the current study. From the perspective of my own theoretical interests and views, learning the reason for stating a zero value is as important as the classification of responses. This information can be used in the design of both future valuation exercises, and also in the development of management funds in the ‘real world’. An unintentional test of the hypothetical nature of this contingent valuation exercise is discussed further in section 5.4.9.

Interpretation of the reasons for those who indicated in-principle support for the project is somewhat complicated, as the responses analysed include those who subsequently provided a negative response to the WTP question. Hence it appears in the figure that there are a number of people (7%) who supported the project, and stated that concern about the payment vehicle was a major motivation for their response, which is an illogical combination.

5.4.4 *Results of the WTP question*

Those respondents who indicated a positive response to the in-principle WTP question were then asked whether they would be WTP a given amount, in a SBDC bid format. This section provides a summary of the responses to the SBDC question, where respondents are asked whether they would pay a reference amount. Bid values ranged from $5 to $500, and were randomly assigned. There was no significant difference between sites in the distribution of bid amounts, the total proportion of people WTP the bid amount, the OE maximum WTP amount, or the proportion of respondents who displayed perfect anchoring (Table 5.5). Preliminary analysis showed that the response to the WTP questions was primarily driven by the bid amount (Figure 5.4), and hence demographic comparison of the two groups is not undertaken. Results of probit analysis of responses are presented in Section 5.4.6.

5.4.5 *Tests of survey mode effects*

Failure to adequately allow for the statistical impacts of the split-sample approach also meant that there were small numbers of responses at each site which were subject to the same erosion scenario timing (erosion occurring in 2050) as that employed in the onsite instrument. Hence opportunities for comparison of estimates between the two models are limited, and are not explored further.

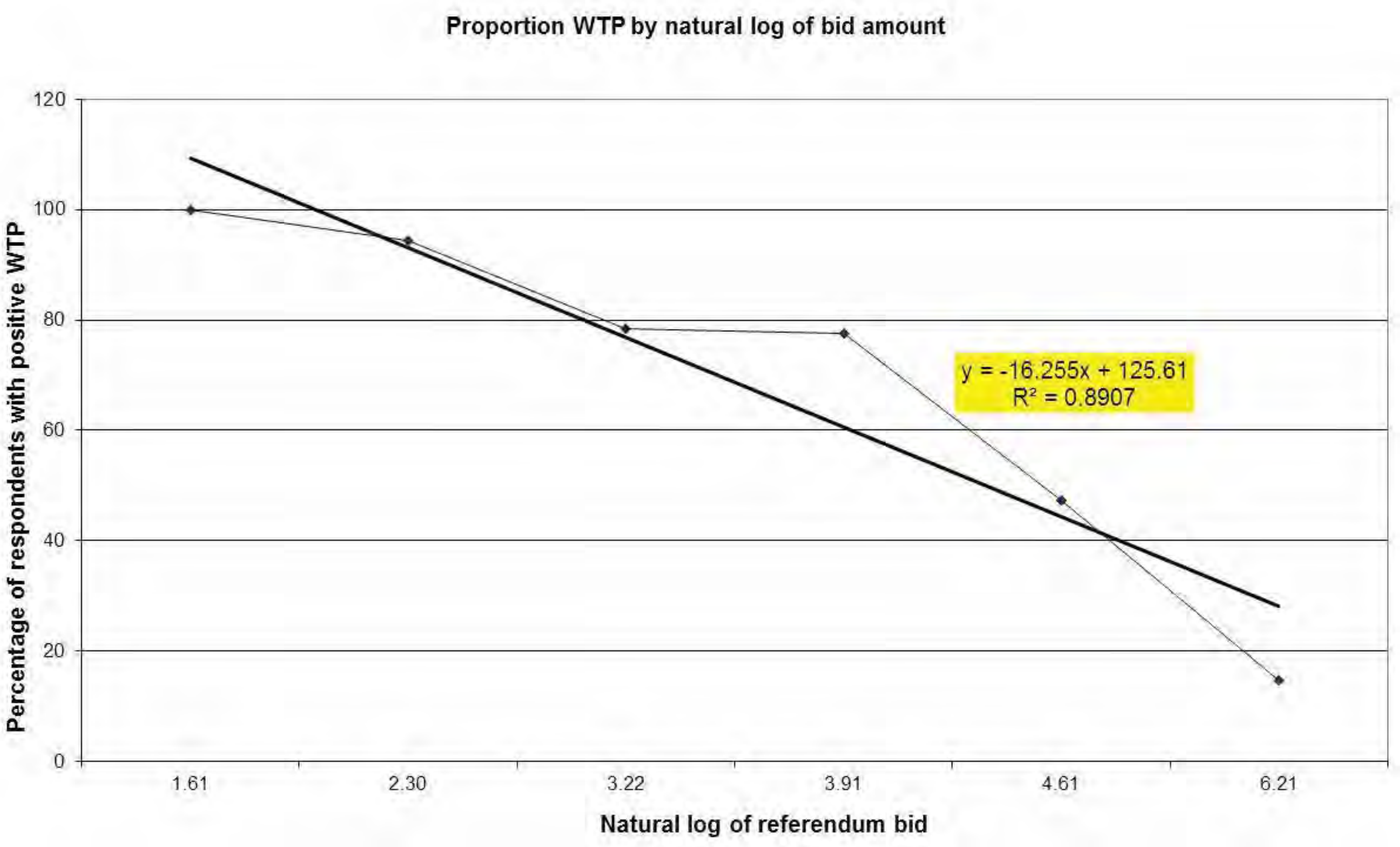

Figure 5.4 Effect of bid amount on willingness to pay response

5.4.6 *Probit analysis of the key research questions*

Whilst the previous sections have outlined the demographic differences between groups on the basis of their response to the research questions, this does not imply causality. Probit analysis is a means of assessing the likelihood of a postive response to a question, and provides more information on the influence of demographic factors on WTP responses.

5.4.6.1 Selection of model attributes and *a priori* assumptions

It is theorised that personal characteristics of the respondent are the key determinants of whether a person is likely to believe the erosion scenario as described. These will include demographic variables such as age, nationality, education level and prior experience with beach closures. Examination of the published CV literature again identifies considerable inconsistency in the inclusion of demographic variables (Table 5.9). The demographic variables employed in the employed in the CV analysis were therefore chosen to be the same as those employed in the travel cost (TC) chapter, with the exception of timing variables. The variables for the timing of the survey were not statistically significant in determining WTP responses, and are dropped from the model for the sake of parsimony.

The decisions about whether or not to support the beach management fund (the PrincSup response) are less clear-cut in their theoretical basis. Whilst it can be expected that those who reject the erosion scenario (RejectSc=1) will not be willing to pay any amount towards the fund, the motivations for responses from those who do believe the scenario (RejectSc=0) may be influenced by a suite of factors. These include the demographic and experiential factors described above, which influence both ability to pay (income), but also consideration of future use. The latter factor is a product of their personal future use (linked to age, given the long lead time) and the future use of others. These dual influences on future use considerations are examined through the coding of qualitative responses, and are represented by the factors RecUse and Bequest, respectively.

Also of importance are the respondents' likely behavioural response to the beach erosion (the subjective importance of the damage) and the design of the payment vehicle and project description. If the person's utility from the beach visit is not linked directly to the presence of sand (NoSand) they will not be likely to support the fund. They are also unlikely to support the fund if they would respond by going to another beach (OthBch=1), or if the beach at which they were surveyed is not their preferred beach (Subst=1), given that the fund is restricted to erosion prevention activities at that beach alone.

Having made the decisions to give in-principle support to the management fund as described (PrincSup=1), it is expected that the main driver of responses to the SBDC question is the amount requested. Making mention of an actual amount may seek to ensure that the respondent gives the question more careful consideration, bringing the aforementioned issues of ability to pay and future use into play.

Table 5.9 Demographic variables included in studies of WTP for beach use and amenities

		Demographic components						
Primary Author	**Year**	**Income**	**Age**	**Gender**	**Resident status**	**Race**	**Education**	**Tastes**
Landry	**2003**	H	Y	Y	Y-'local' dummy (residents on island excluded due to concurrent HPM study	N	Y	Support for env. Protection, support for Government
Silberman	**1998**	H	Y	Y	N	N	N	
Kriesel	**2004**	H	Y	N	Y		Y	Pro-green, Pro-government attitudes
McConnell	**1977**	H	N	N	N	N	N	N
Shivlani	**2003**	N	N	N	N	N	N	Nature or birdwatching
Hanley	**2003**	N	N	N	N	N	N	Variable to denote swimming
Togridou	**2006**	Y	Y	Y	Y	Y	Y	Environmental disposition
Lindsay	**1992**	Y	N	N	Y	N	Familiarity with beach wall laws	Attitude to development, seawalls
Kline	**1998**	N	N	Y	N	N	N	Activity variables

5.4.6.2 Probit analysis of plausibility response

Binary probit analysis was undertaken with RejectSc as the dependent variable, and is presented in Table 5.10. The single bound probit takes the form:

$$\Pr(Y = 1 | X) = \Phi(X'\beta) \qquad \textbf{[5.1]}$$

Where Pr is probability (in this case of a response value of 1, given the regressors X), Φ is the cumulative distribution function of the standard normal distribution, X' is a vector of the regressors assumed to influence the outcome, and β are coefficients associated with those regressors. Parameter coefficients are derived via maximum likelihood estimation (Greene, 1993).

Coefficients of probit models are not as easily interpreted as those in linear models, as they relate to the cumulative normal distribution function. They therefore relate to changes in Z scores, which are familiar to those with statistical backgrounds. Given the absence of continuous variables in the final model, the constant represents the Z score that applies to a person with a score of zero for all dummy variables. From the standard normal distribution, the cumulative probabilities to the left of the Z score give the likelihood associated with the score (Greene, 1993).

It is easier to interpret the marginal effects or elasticities, which internalise this calculation. The marginal effects of the dummy variables are estimated as the difference between the probability when the variable takes the value zero, P(0), and when it takes the value one, P(1), calculated at the means of all other variables. Prediction probability tables are another means of interpreting the success of a model in explaining binary outcomes (McFadden, 1979), and these are presented in the following sections where appropriate.

Table 5.10 Probit analysis of plausibility responses (n=412)

Variable	Coefficient	b/St.Er.	P[|Z|>z]	Mean of X
Constant	-1.05	-3.22	0.00	
BEACH_CL	-0.31	-1.90	**0.06**	0.57
NOCLOS	0.47	0.93	0.35	0.02
WEEKEND	-0.12	-0.68	0.50	0.46
COLNARRA	-0.33	-1.89	**0.06**	0.42
BROOKLYN	0.15	0.56	0.58	0.11
DANGAR	0.10	0.34	0.74	0.11
RESIDENT	-0.26	-1.14	0.25	0.49
SUMRNDVI	0.00	1.60	0.11	46.46
FEATURES	0.21	0.93	0.35	0.14
TOURISM	0.13	0.61	0.54	0.17
MALE	0.25	1.59	0.11	0.51
AGE	0.01	2.43	**0.02**	39.57
HIGHINC	0.06	0.25	0.80	0.20
LOWINC	0.05	0.26	0.79	0.40
NOJOB	0.09	0.51	0.61	0.25
UNIVERSI	-0.20	-1.24	0.21	0.49
AUSNAT	-0.15	-0.85	0.40	0.57
Log Likelihood		-197.40		
Chi Squared (17,412)		32.59		
Prob [ChiSqd > value]		0.01		
McFadden Pseudo Rsquared		0.08		

The response variable under analysis is that of RejectSc or rejection of the erosion scenario. Hence, a positive response indicates that the respondent does not believe the scenario will occur as described. Summary and diagnostic statistics have the same interpretation as in the previous chapter. The probit results roughly correspond to those identified in the split-sample analysis. Those factors which significantly influence the likelihood of belief in the scenario are prior experience with beach closure, increased age, and being interviewed at Collaroy-Narrabeen. These are all experience-based influences, given the erosion history of the region.

Climate change, despite increased scientific certainty, remains a somewhat contentious issue. Predicting with any degree of certainty the local-scale impacts on beaches is a challenging task. Both the magnitude and the timing of the damage are likely to be strong influences on the level of belief. These allow for two tests of scope effects. The influence of the timing of the described erosion impacts on survey responses is presented in section 5.4.2. Unfortunately; sample size constraints preclude a more detailed analysis of this scope effect.The influence of the magnitude of the damage can be examined through incorporation of the number of visits as an endogenous variable (SumRndVi). Given that the erosion scenario was described as a relative loss of beach days (10% chance of no sand at high tide), the differing levels of visitation represent different absolute numbers of ‘sand-free’ days. The parameter estimate for this variable is not (quite) significant at the p=0.10 level, and hence these responses fail the test of theoretical consistency.

Elasticities of the parameters which significantly influence belief in the erosion scenario are calculated for the model, and presented in Table 5.11. These represent the change in probability of a positive response given a one unit change in the independent variable.

Table 5.11 Elasticities of the variables included in the probit model for plausibility

Variable	Partial derivative	Standard Error	b/St.Er.	P[|Z|>z]	Elasticicy
Constant	-0.38	0.13	-3.01	0.00	
BEACH_CL	-0.09	0.05	-1.88	0.06	**-0.26**
NOCLOS	0.15	0.18	0.83	0.41	0.02
WEEKEND	-0.03	0.05	-0.68	0.50	-0.08
COLNARRA	-0.09	0.05	-1.94	0.05	**-0.19**
BROOKLYN	0.04	0.08	0.53	0.59	0.03
DANGAR	0.03	0.08	0.33	0.74	0.02
RESIDENT	-0.07	0.06	-1.15	0.25	**-0.18**
SUMRNDVI	0.00	0.00	1.60	0.11	**0.17**
FEATURES	0.06	0.07	0.89	0.38	0.04
TOURISM	0.04	0.06	0.59	0.55	0.03
MALE	0.07	0.04	1.59	0.11	**0.18**
AGE	0.00	0.00	2.44	0.01	**0.68**
HIGHINC	0.02	0.06	0.25	0.80	0.02
LOWINC	0.01	0.05	0.26	0.79	0.03
NOJOB	0.03	0.05	0.50	0.62	0.03
UNIVERSI	-0.05	0.04	-1.25	0.21	-0.14
AUSNAT	-0.04	0.05	-0.84	0.40	-0.12

The greatest influence on the likelihood of disbelieving the scenario is increased age. The other key positive influences on the likelihood of rejecting the erosion scenario are gender (with males significantly more likely to reject) and estimated visitation frequency. This perhaps relates to the absence of prior experience with erosion, given that the east coast of Australia has been in a relatively benign climatic situation since the storms of the 1970s. These people may also have first-hand observations of the ability of beaches to recover after storm events, and hence do not believe the magnitude of the erosion described will transpire.

Climate change impacts lie outside the scope of experience of most beach visitors, and it is expected that long-term and heavy beach users will be more heavily anchored to their prior experience. Interestingly, prior experience with beach closure appears to contradict this suggestion, as it is a strong negative influence on the likelihood of disbelief. Residential status and coming from Collaroy-Narrabeen are also negative influences,. Given the erosion history of the site, this result gives further support to the idea that prior experience with beach erosion will dictate the level of belief in future erosion scenarios.

As can be seen from Table 5.12, the model over-predicts the likelihood of a negative response. The model suggests that around 97% of the sample (400 of 412) will believe the scenario, whereas the actual rate of belief was 78.6%.

Table 5.12 Predicted and actual responses to the erosion scenario plausibility question

Willingness to Pay	Predicted Values				Actual Values	
	0		1			
	Count	**Percent**	**Count**	**Percent**	**Count**	**Percent**
0	319	77.4	5	1.2	324	78.6
1	81	19.7	7	1.7	88	21.4
Total	400	**97.1**	**12**	**2.9**	**N=412**	**100**

Further analysis shows that the greatest source of error is in predicting those who will reject the scenario, meaning that their RejectSC=1 value is predicted as a Rejectsc=0 (Table 5.13). Only 7 of the 88 positive responses were predicted correctly.

Table 5.13 Sources of prediction error in explaining rejection of the erosion scenario

Prediction Failure	Percent
False pos. for true neg. = actual 0s predicted as 1s	1.54
False neg. for true pos. = actual 1s predicted as 0s	92.05
False pos. for predicted pos. = predicted 1s actual 0s	41.67
False neg. for predicted neg. = predicted 0s actual 1s	20.25
False predictions = actual 1s and 0s incorrectly predicted	20.87

Determining the reasons for rejection of erosion scenarios, and climate change projections in general, is a challenge for estimation of WTP for prevention of these impacts. Further exploration of this failure is not undertaken as it is beyond the scope of the current study. Nevertheless, generating a greater understanding of public perception of potential climate change impacts and the resultant attitudes towards alternative coastal management options is likely to be influential in selection of policy and protection responses. Previous work has suggested that belief in climate change can be driven by a number of factors, including perception of risk (O'Connor et al., 1999) and underlying belief structures and values (Stern et al., 1995).

5.4.6.3 Probit analysis of protest responses

In order to avoid spurious conclusions, probit analysis was again undertaken to identify the factors which contribute to the likelihood of the protest response. Beach variables were also incorporated to identify any differences between sites, but were not significant and are dropped from the final model. Coded qualitative responses are also explored, relying upon the respondents own answers rather than the assumptions of the analyst. This would appear to be a simpler way of accessing such information about motivations. Results are presented in Table 5.14, with the likelihood of a protest response the dependant variable. Explanatory power is very good for a model of this nature, with a pseudo r-squared of 0.65.

Table 5.14 Probit regression results for the Payment-Principle question

Variable	Coefficient	b/St.Er.	P[|Z|>z	Mean of X
Constant	0.58	1.05	0.29	
REJECTSC	0.62	2.22	**0.03**	0.21
BEACH_CL	-0.09	-0.34	0.74	0.57
NOCLOS	-0.93	-1.42	0.16	0.02
STAYSAD	-0.38	-1.03	0.30	0.32
OTHBCH	-0.60	-1.48	0.14	0.18
CARESAND	-0.51	-1.38	0.17	0.36
SUMRNDVI	0.00	1.12	0.26	46.46
FEATURES	-0.12	-0.38	0.71	0.14
TOURISM	-0.11	-0.37	0.71	0.17
SCALE	0.82	2.00	**0.05**	0.06
SUBST	1.44	4.03	**0.00**	0.17
PAYVEH	0.56	1.82	**0.07**	0.12
INSTITUT	0.71	1.75	**0.08**	0.06
BEQUEST	-1.92	-2.86	**0.00**	0.07
RECUSE	-3.36	-6.43	**0.00**	0.42
PROJECT	-0.22	-0.84	0.40	0.16
ECON	-0.73	-1.75	**0.08**	0.05
WEEKEND	0.12	0.53	0.59	0.46
RESIDENT	-0.28	-0.89	0.38	0.49
MALE	0.28	1.16	0.25	0.51
AGE	0.01	0.92	0.36	39.57
HIGHINC	0.65	1.88	**0.06**	0.20
LOWINC	-0.15	-0.57	0.57	0.40
NOJOB	-0.19	-0.69	0.49	0.25
UNIVERSI	-0.37	-1.56	0.12	0.49
AUSNAT	-0.19	-0.73	0.47	0.57
Log Likelihood		-97.94		
Chi Squared (26,412)		367.09		
Prob [ChiSqd > value]		0.00		
McFadden Pseudo Rsquared		0.65		

Examination of the elasticities with respect to the parameters (Table 5.15) shows some unusual behaviour, however. There is a large elasticity with respect to the respondent stating that there beach usage would not be affected by the lack of dry sand (CareSand=1), though this has a downward influence on the likelihood of a protest response, which is the opposite of the expected relationship. This may be because the respondents are more interested in activities that are either in the adjacent coastal reserve, benefiting from coastal amenities without direct contact with the sand, or they may be involved in aquatic activities which would not be directly affected by sand loss.

The large elasticity of age on the likelihood of protest responses is somewhat inexplicable, although some potential reasoning is explored in section 5.4.2.1. It should also be noted that whilst the elasticity is large, the magnitude of the effect is not, and it is not statistically significant in determining protest responses.

Table 5.15 Elasticities of variables included in the Payment-Principle probit model

Variable	Partial derivative	Standard Error	b/St.Er.	P[|Z|>z	Elasticity
Constant	0.12	0.09	1.44	0.15	
REJECTSC	0.20	0.10	1.99	0.05	0.21
BEACH_CL	-0.02	0.07	-0.34	0.74	-0.07
NOCLOS	-0.17	0.07	-2.31	0.02	-0.02
STAYSAD	-0.10	0.09	-1.08	0.28	-0.16
OTHBCH	-0.14	0.08	-1.73	0.08	-0.12
CARESAND	-0.13	0.09	-1.44	0.15	**-0.24**
SUMRNDVI	0.00	0.00	1.13	0.26	0.16
FEATURES	-0.03	0.08	-0.39	0.70	-0.02
TOURISM	-0.03	0.08	-0.38	0.71	-0.03
SCALE	0.29	0.16	1.76	0.08	0.09
SUBST	0.50	0.13	3.87	0.00	**0.42**
PAYVEH	0.18	0.11	1.61	0.11	0.11
INSTITUT	0.24	0.16	1.58	0.11	0.07
BEQUEST	-0.23	0.07	-3.58	0.00	-0.08
RECUSE	-0.71	0.04	-16.84	0.00	**-1.49**
PROJECT	-0.06	0.06	-0.89	0.38	-0.05
ECON	-0.15	0.06	-2.30	0.02	-0.04
WEEKEND	0.03	0.06	0.53	0.59	0.08
RESIDENT	-0.08	0.09	-0.88	0.38	-0.19
MALE	0.08	0.07	1.15	0.25	0.20
AGE	0.00	0.00	0.91	0.36	**0.37**
HIGHINC	0.21	0.12	1.67	0.09	0.21
LOWINC	-0.04	0.07	-0.58	0.56	-0.08
NOJOB	-0.05	0.07	-0.72	0.47	-0.07
UNIVERSI	-0.10	0.07	-1.57	0.12	**-0.26**
AUSNAT	-0.05	0.07	-0.73	0.46	-0.15

Rejection of the erosion scenario significantly increased protest responses, which is to be expected. It would make little sense to pay to avoid damage that you do not believe will occur. The strongest determinants of Protest responses are found in the coded qualitative responses. The majority of coded qualitative variables examined increase the likelihood of a protest response, and are statistically significant. Those who cited children or grandchildren as a motivation for their responses (BEQUEST) were also more likely to be WTP to contribute to the fund as described. The strongest (non-demographic) factor in determining negative responses is the availability of substitute sites. Around half the respondents were non-residents, and stated that whilst they had a general disposition towards beach management, they would not contribute to a fund restricted to erosion prevention activities at the location where the survey was conducted.

Those who cite recreational use of the beach as their primary motivation for contribution (RECUSE) are significantly less likely to protest against contributing to a beach management fund. Interestingly, estimated visitation (SumRndVi) does not influence protest responses, suggesting that the scope of damage is not important in determining likelihood of being WTP. There are very strong elasticities with respect to intended future recreational use of the site (RecUse=1), and consideration of substitute sites (Subst=1), which is typical of studies on recreational resources. These two factors have an even greater influence on the probability of a protest response than whether or not the respondent considered the erosion scenario to be plausible.

This point is evidenced more emphatically by the fact that there were a number of respondents (36, equal to 8.7% of the total sample and identified as GLOW respondents in the descriptive statistics examined previously) who were willing to provide in-principle support for the program, despite the fact that they did not believe that the erosion scenario would come to pass. Similar behaviour has also been noted in a study of WTP for wilderness designation in Utah (Keith and Fawson, 1996). In that instance, respondents who indicated that they were 'neutral' in attitude towards wilderness designation were found to have positive WTP values. In some instances, the WTP of the groups without strong underlying preferences was higher than those who were 'positive' in attitude towards wilderness designation, and was always significantly different from zero (Keith and Fawson, 1996). Whilst seemingly illogical, there are a number of possible explanations for this behaviour.

The first possible explanation lies in the sources of potential bias that are assumed to afflict SP experiments of this nature. Either yea-saying or the warm-glow effect could explain a higher likelihood of a positive response to the payment principle question. In the former case, the respondent may seek to provide an answer that they assume the surveyor is seeking. This is also termed compliance bias (Mitchell and Carson, 1989). In the latter, they may be positively disposed towards coastal management in general, and not be considering the detail of the program described in the survey (Nunes and Schokkaert, 2003). This suggests that the responses to SP questions are not related to the true underlying preferences, which would conform with criticism of the CV method (Carlsson, 2001). An alternative explanation can be found in the uncertainty associated with projected climate change impacts. The precautionary principle mandates that action be taken in the absence of scientific certainty (Brundtland, 1987), and may be the decision-making process being employed by respondents. Given that the financial outlays described by the bid amounts in this survey are relatively minor with respect to income of the surveyed population, the tax imposed may be being considered as a small 'wager' against the potential future impacts. Ledoux and Turner (2002) provide greater exploration of the use of precautionary approaches in coastal management since the Rio Summit of 1992, such as the adoption of safe minimum standards (SMS), although they note that costing of benefits is still relevant for such decisions.

5.4.6.4 Probit analysis of WTP responses

Probit analysis was again employed to identify the greatest influences on WTP responses. Having made the decisions to give in-principle support to the management fund as described (PrincSup=1), it is expected that the main driver of responses to the SBDC question is the amount requested. Making mention of an actual amount may seek to ensure that the respondent gives the question more careful consideration, bringing the aforementioned issues of ability to pay and future use into play. The bid amount is incorporated in logarithmic form, based on goodness of fit.

This analysis is restricted to those respondents who indicated that they provided in-principle support for the project as described. Responses to the payment-principle question represent a protest rate of 43.2%, which limits the sample size for analysis substantially (n=235 rather than 415 for the total sample), as these responses are removed from the sample for probit analysis of WTP for the prescribed project. Regardless of the motivation for the response, these are assumed to be valid responses. Table 5.16 presents the results of this analysis. Explanatory power is very good despite the reduced sample size, with a Pseudo R-squared value of 0.51.

Table 5.16 Results of the Referendum WTP probit regression

Variable	Coefficient	b/St.Er.	P[|Z|>z]	Mean of X
Constant	3.13	4.88	0.00	
LNAMT1	-0.80	-7.36	**0.00**	3.64
REJECTSC	-1.22	-3.34	**0.00**	0.15
SUMRNDVI	0.01	2.03	**0.04**	51.94
CARESAND	0.47	1.72	**0.09**	0.35
BEQUEST	0.84	1.67	**0.10**	0.11
SUBST	0.48	0.59	0.55	0.02
RECUSE	0.23	0.85	0.39	0.73
RESIDENT	0.32	0.94	0.35	0.56
FEATURES	-0.83	-2.63	**0.01**	0.16
MALE	-0.24	-0.91	0.36	0.46
AGE	0.01	0.72	0.47	37.56
HIGHINC	1.15	2.34	**0.02**	0.15
LOWINC	-0.46	-1.62	0.11	0.42
NOJOB	-0.28	-0.84	0.40	0.21
UNIVERSI	-0.21	-0.84	0.40	0.49
AUSNAT	0.26	0.95	0.34	0.58
Log Likelihood		-71.34		
Chi Squared (16,235)		150.11		
Prob [ChiSqd > value]		0.00		
McFadden Pseudo Rsquared		0.51		

Negative influences on the probability of a positive WTP response are increases in the amount of the bid (LnAMT1), lack of belief in the erosion scenario (REJECTSC=1), being male, mentioning site-specific features, having low income or being out of employment, and having completed university education. All of these are consistent with theoretical assumptions, with the exception of the university education parameter and the site-specific features parameter, the latter of which is statistically significant. Also inconsistent with economic theory is the parameter representing those expressing the opinion that the lack of sand would not affect their beach visit (the somewhat poorly named CARESAND). All other variables have a positive influence on WTP likelihood, with statistically significant influences attributed to having high income, mentioning bequest motivations for WTP (Bequest=1), and the estimated number of trips taken in the summer season (SumRndVi). The latter result demonstrates sensitivity to scope, given the erosion scenario is described as a proportional loss of beach days. This result suggests theoretical consistency. Marginal effects are again calculated, and are presented in Table 5.17.

Table 5.17 Marginal effects for prediction of Willingness to Pay

Variable	Partial derivative	Standard Error	b/St.Er.	P[|Z|>z	Elasticity
Constant	0.84	0.16	5.20	0.00	
LNAMT1	-0.21	0.03	-7.22	**0.00**	-0.96
REJECTSC	-0.42	0.13	-3.17	**0.00**	-0.08
SUMRNDVI	0.00	0.00	2.04	**0.04**	0.10
CARESAND	0.12	0.06	1.84	**0.07**	0.05
BEQUEST	0.16	0.06	2.59	**0.01**	0.02
SUBST	0.10	0.13	0.79	0.43	0.00
RECUSE	0.07	0.08	0.82	0.41	0.06
RESIDENT	0.09	0.09	0.93	0.35	0.06
FEATURES	-0.27	0.11	-2.38	**0.02**	-0.05
MALE	-0.07	0.07	-0.89	0.37	-0.04
AGE	0.00	0.00	0.72	0.47	0.08
HIGHINC	0.21	0.06	3.73	**0.00**	0.04
LOWINC	-0.13	0.08	-1.60	0.11	-0.07
NOJOB	-0.08	0.10	-0.79	0.43	-0.02
UNIVERSI	-0.06	0.07	-0.84	0.40	-0.04
AUSNAT	0.07	0.08	0.92	0.36	0.05

Having indicated a positive WTP, or at least potential support for paying for such a program, the main influence on whether the respondents accept the referendum amount offered is the (natural log of the) bid value itself. This effect is much greater than the influence of any other parameter, indicating that those who are willing to provide in-principle support are most highly influenced by the amount requested. This indicates that any attempts to raise funds should be highly sensitive to the amount requested. The responses generally display the assumed relationship, with a reduction in the proportion of respondents who are willing to pay as the amount requested increases. Figure 5.4 presents the results of the referendum willingness to pay (WTP) questions, where respondents were presented with a randomly selected bid amount (5,10,25,50,100,500), and asked whether they would be willing to pay that amount as a once-off donation to the beach management fund described in the survey. These results are presented for the respondents who indicated that they were 'in-principle' willing to contribute to a fund as described in the survey.

The factors with the next most significant influences on the likelihood of a positive WTP response are responses indicating that the interviewee did not believe the erosion scenario (RejectSc=1) and that representing the number of trips (SumRndVi).

Again, these are consistent with a rational respondent, as in the former case it is logical to not pay to prevent something occurring if you do not believe it is likely to in the first place, and the latter indicates sensitivity to the scope of the damage described.

Consideration of substitutes sites is known to result in a depression of WTP estimates (Loomis and Keske, 2009), though in this instance the factor is not significant. This is likely due to the survey question wording, which reminded the respondent of the availability of substitute sites in asking their In-Principle WTP. Having committed to the program, which restricts donations to use at the single site, they have already indicated that substitute sites are not influencing their decision.

The influence of CareSand is counter-intuitive, but may be explained through consideration of the TEV of beaches. If the respondent does not consider that the availability of dry sand is an important attribute in determining their usage of the beach, then the damage scenario does not affect their utility, and the logical response is to not contribute to the erosion management fund. This would suggest that non-use values are driving these responses.

The model slightly over predicts the likelihood that the respondent will accept the bid amount. It predicts that 71.1% of those who have already indicated in-principle support will go on to provide positive response to the SBDC question, when in fact this figure is 68.5% (Table 5.18).

Table 5.18 Predicted and actual responses to the SBDC question

Willingness to Pay	Predicted Values				Actual Values	
	0		1			
	Count	**Percent**	**Count**	**Percent**	**Count**	**Percent**
0	56	23.8	18	7.7	74	31.5
1	12	5.1	149	63.4	161	68.5
Total	**68**	**28.9**	**167**	**71.1**	**235**	**100**

5.4.6.5 Analysis of follow-up responses

Perfect anchoring was identified as instances where the response to the OE question about maximum WTP was equal to the amount offered in the initial DC question. Evidence for anchoring was strong at all sites, with more than 25% of all responses equivalent to the initial bid at all sites (Table 5.5), indicating that the responses to the follow-up question are not reliable (Green et al., 1998).

The anchoring effect was greatest for Brooklyn, where 50% of respondents provided a perfectly anchored maximum WTP response. This finding is consistent with many previous studies examining DBDC responses (Green et al., 1998, O‘Conor et al., 1999) and even SB responses (Boyle et al., 1997). Given such a high degree of anchoring, further analysis of OE bids was not undertaken, as they are not thought to be indicative of a well thought out response, rather an artefact of yea-saying or the 'warm glow' effect. Analysis to prove the existence and extent of anchoring (Boyle et al., 1997, Green et al., 1998, O‘Conor et al., 1999) is not considered necessary on theoretical grounds. It seems highly unlikely that, from a universe of possible preference values, the respondent was randomly assigned the bid value that perfectly aligned with their true underlying preference. Whilst this limits the scope for tests of the influence of analysis on welfare estimates, it is my view that understanding the motivation for responses is a more important goal than statistical comparisons.

Bivariate probit analysis of the DBDC responses, though attempted, was unable to achieve substantial explanation of the follow-up bids, and is not reported. This may be because the bids were not truly received, but constructed from OE responses. It may also be because of the influence of anchoring, which is identified as a major source of bias in MBDC surveys (Whitehead, 2002).

The bid format employed was chosen in part on the basis that it provided a balance between statistical efficiency and realism (de Faria et al., 2007). Ultimately, it was not possible to undertake a number of the intended analyses, as tests indicated that the responses to the follow-up questions were suffering from substantial starting-point bias (Herriges and Shogren, 1996, Silverman and Klock, 1989). This suggests evidence for the contention that it is only ever possible to obtain a single untainted responses regarding WTP, and MDBC surveys are not efficient in the presence of these biases (Whitehead, 2002).

5.4.7 *Estimates of consumer surplus*

The expected value of the natural logarithm of WTP is given by the ratio of the grand constant term to the coefficient on the bid level variable. The grand constant term is derived by the sum of the constant and the products of the coefficients and means of the non-bid parameters. The exponential of this figure gives the median WTP, as per equation 5.2. Median WTP values are estimated from the univariate probit coefficients by the following formula, as per Hanneman (1984).

$$MedianWTP = e^{-\left(\frac{\beta_0 + X'\beta_2}{\beta_1}\right)} \qquad \textbf{[5.2]}$$

This calculation produces a median consumer surplus estimate of $116.27 for the sample (in 2008 dollars), restricted to those who indicated in-principle support. Confidence intervals are estimated via the Delta Method, employing the Wald procedure in Limdep (Greene, 1993), deriving a 95% interval value of AUD$69.63 (p=0.095). Comparison with similar studies is challenging, given that there are a myriad of scenario and analysis differences between studies, although these measures appear to be on the higher end of the spectrum. This is true even when WTP values are scaled by the proportion of the sample that had no in-principle support for the suggested program (i.e multiplied by 56.6%), giving a median WTP value of AUD$65.8 (±39.41). No corrections were made in the survey design for hypothetical bias, and the figures may therefore be considered to be excessively high. There is no similar fund or scheme which could be used for a test of plausibility, though section 5.4.9 outlines an unintentional test of WTP for climate change action that suggests hypothetical bias may be substantial.

Aggregate estimates of WTP for beach erosion prevention are plagued by the same challenges highlighted in the previous chapter, and are not explored further.

5.4.8 *Comparison of WTP benefit estimates with estimates from Travel Cost application*

It is common in the non-market valuation literature to employ joint TC-CV valuation instruments in order to compare the results of the two processes. This is done largely to test the theoretical validity of the CV welfare estimates. The theoretical validity of the process itself must be questioned, however, in that they are typically valuing fundamentally different things. In the case of the current study, for example, the CS estimates from the TC study represent the utility a typical respondent gains from a single beach visit. The results of the CV component, in contrast, are the estimated average utility a respondent would receive from a project designed to prevent a 10% loss of beach days in the year 2050. Why these two figures should be related to each other is beyond the comprehension of the author. Nevertheless, in the interest of consistency with the literature, the standard test is undertaken (Table 5.19).

The basic assumption is that the CV values should be higher than those of the TC study, as the CV is designed to provide a more holistic valuation, whereas the TC study values only use components of TEV. The CV study is a pooled sample of all respondents from the case study locations, and is not divided by beaches.

Table 5.19 Comparison of CS estimates from CV and TC components

Beach	TC Model 1	TC Model 2	TC Model 3	TC Model 4	TC Model 5	CV
Collaroy-Narrabeen	2.72±0.56	11.28±2.35	20.04±7.51	10.28±2.59	20.63±6.55	116.27±69.63
Manly Ocean Beach	9.20±1.92	11.50±2.54	NA	16.18±2.98	NA	

It can be seen that the CV estimates of CS pass this theoretical hurdle. Further comparison is not undertaken.

5.4.9 *Test of hypothetical nature of support*

It should also be noted that this was framed as a voluntary donation to a hypothetical fund. Those surveyed may respond differently to a proposal for a mandatory tax. Despite the fact that the estimates passed the theoretical test of validity, a real-world test indicates that the responses may not be reliable estimators of future behaviour.

A practical experiment regarding 'actual' WTP for climate change adaptation activities was unintentionally undertaken at one of the case-study sites, when Manly Council announced an intention to introduce a 4.4% climate change levy on ratepayers. This proposal was presented as a non-binding poll question at Council elections in September 2008, and was defeated approximately 2 to 1 following substantial public outcry[14].

This was despite pre-polling suggesting that the levy would receive substantial support, although the payment vehicle and 'bid value' were different, so results must be considered in that light[15]. The levy was subsequently replaced in 2009 with the establishment of a Voluntary Climate Change Fund[16]. Donations to this fund are confidential and were not available at the time of writing, although they are understood to be relatively small in number. Whilst this would appear to invalidate the current study, at least in terms of local resident responses, it should be noted that one of the intended uses of the fund is to strengthen or establish seawallls. This would ultimately lead to the loss of sand through scouring impacts, with the resultant loss of amenity and recreational opportunities (Jonathon et al., 2001). Hence responses can therefore be considered as responses to a diametrically opposed project to the scenario presented in the current study, and rejection of the proposed levy may even suggest support for a project to prevent erosion.

Nevertheless, critics of the CV method would suggest that this is evidence that the hypothetical responses are insufficiently certain to form the basis of large investments in offsetting the projected future impacts of climate change. An alternative method of valuing these impacts on coastal tourism is presented in the next section.

[14] http://www.pastvtr.elections.nsw.gov.au/LGE2008/result.Manly.poll.html

[15] http://property.manlydaily.com.au/default.aspx?iid=9569&startpage=page0000016

[16] http://www.manly.nsw.gov.au/Voluntary-Contribution-to-Climate-Change-Fund.html

5.4.10 *Contingent travel cost*

Given the challenges associated with generating precise contingent states under climate change scenarios (Tol, 2003), and persistent concerns about the ability of survey respondents to adequately express their preferences (Spash, 2000), an alternative method is to explore contingent behaviour under a range of future climate scenarios, and integrate this with existing revealed preference data on expenditure and consumer surplus. This is sometimes termed the contingent behaviour travel cost method (Loomis, 2002), and has been employed by a number of authors in the terrestrial environment.

Richardson and Loomis considered the importance of site characteristics in determining demand, and how this would influence recreational demand when site characteristics change. They used contingent visitation surveys to determine the effect of climate change on recreation demand, by estimating the effect of climate changes upon environmental features, and then asking people how this would affect their recreational decisions. Economic impacts were then calculated from a travel cost survey (Richardson and Loomis, 2004). This study predicted an increase in the number and duration of trips under the new climate change scenarios, although the decision to visit the park was often made more than two months in advance, with weather playing little role in the choice to visit (Richardson and Loomis, 2004). Whilst the scientific basis for the contingent states may be questionable, this approach has more application to recreation management, as it makes use of existing visitor information, and provides direction to managers regarding site alteration preferences.

Silberman and Klock also found increases in visitation frequency following beach nourishment. The effect was greater than that on WTP for a beach visit, indicating that determining visitation in a more accurate manner may be more important in determining the economic benefits of nourishment projects than estimating benefits on a per-trip basis (Silberman and Klock, 1988). This suggests potential for use of such a contingent behaviour-travel cost model in the beach valuation context.

5.4.11 *Beach closure experience*

It is theorised that experience with beach closure will be the greatest influence on behaviour in the event of future closures. Table 5.20 presents the results of the question regarding experience with beach closure, and a coded summary of how the interviewee would respond in the event that they came to the beach to find the beach was closed. The codes employed are explained in the next section. Just under half of respondents across all sites had experience with beach closure. Experience with beach closures was significantly different between sites, which is expected due to the differing history of erosion issues. Collaroy-Narrabeen had a higher proportion of respondents with experience of beach closures, while Brooklyn had a lower proportion. Manly and Dangar samples did not depart significantly from the mean.

The relatively high proportion of respondents with experience of beach closure at the estuarine sites, Brooklyn and Dangar, likely indicate experience at a different location, as these sites do not experience the same degree of erosion as exposed ocean beaches.

Table 5.20 Experience with and response to beach closure

	Beach								Kruskal-wallis (df=3)	
Beach	Collaroy-Narrabeen (n=173)		Manly (n=148)		Brooklyn (n=49)		Dangar (n=46)			
Factor	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Chi-square	Asymp. Sig.
Beach_closure	0.66	0.47	0.55	0.57	0.43	0.50	0.48	0.51	11.95	**0.01**
CareSand	0.29	0.45	0.38	0.49	0.61	0.49	0.30	0.47	18.09	**0.00**
StaySad	0.29	0.45	0.32	0.47	0.31	0.47	0.39	0.49	1.80	0.62
NoClos	0.03	0.18	0.01	0.08	0.02	0.14	0.00	0.00	4.31	0.23
OthBch	0.28	0.45	0.16	0.37	0.00	0.00	0.02	0.15	31.58	**0.00**

5.4.11.1 Response to beach closure

Respondents were asked what they would do if they visited the beach to find that there was no sand, but the beach was otherwise open for swimming. This clarification was to ensure that respondents were not considering other factors typically associated with beach closures, such as rough seas and coastal water quality issues. It should be explicitly noted that this was framed as a single closure, whereas climate change impacts have the potential to result in permanent closure of some locations. The duration of closure is a key factor which is often neglected in CV studies, despite recognition in the travel cost literature of the importance of temporal substitution (Smith and Palmquist, 1994).

Responses were classified into those that would remain at the beach, but with a lower level of utility (StaySad), those whose utility would not be affected by the absence of sand (CareSand), those who would go to an alternative beach (OthBeach), and those that did not believe that it would happen (NoClos). Brooklyn respondents indicated reduced sensitivity to the loss of sand, with 61% of respondents stating that the presence of sand was not important to them, and closure would not affect their visit. This contrasts with Collaroy-Narrabeen, where only 29% of respondents indicated lack of sensitivity to beach conditions.

Significantly, there were no respondents in the online survey who indicated that they would return home. This would suggest that beach recreation is not easily substitutable with other activities. A number of reasons can be suggested for the lack of importance of substitute sites. The first is that the beach visitor was not aware of the erosion of the beach before undertaking the trip. Hence they have already invested time and resources in visiting their chosen location, and are reluctant or unable to make further investments to visit a substitute site. Frequent local visitors will be more aware of current beach conditions, hence they are unlikely to visit eroded beaches or beach sections, if the presence of sand is important in their selection of sites. They may then seek out substitute sites. Blackwell noted that local residents were more likely to visit a number of different beach sites, whereas visitors from more distant locations were more likely to visit a single beach (Blackwell, 2007).

Those who did indicate that they would travel to another beach often did not know which beach they would attend. This may because they are unable to comprehend a loss of sand at their chosen site, or a lack of knowledge of alternative beach locations. Responses gathered in this project indicate that whilst there are many beaches in the Sydney region, alternative sites act as imperfect substitutes. In the case of the estuarine sites, Brooklyn and Dangar Island, the nearest beach requires substantial travel by either vehicle or boat. In the case of Manly, integrating a beach visit with a ferry trip is considered by many tourists to be an irreplaceable experience (Brown et al., 2010). In the case of Collaroy-Narrabeen, a number of respondents highlighted that the long unbroken stretch of sand played a part in their site selection, as it provided the opportunity for an extended beach walk. The relatively low intensity of use in certain sections of the beach also afforded more opportunities for pursuits such as shore-based angling. This beach is substantially longer than nearby beaches (Short, 2007), and hence there may not be pure substitutes.

5.4.11.2 Beach Closure experience and response – online and onsite samples

Given the differences in visitation frequency identified between the online and onsite samples in the previous chapter, it can be expected that there will be both differences in the level of experience with beach closures due to erosion, and also in the behavioural responses to these closures. Table 5.21 presents the results of this comparison for Manly beach. It can be seen that there are significant differences in the level of experience with beach closure, with 76% of online respondents having seen this occur, compared to 55% of the onsite sample ($p<0.01$). This reflects the higher proportion of visitors in the onsite sample, who are less frequent visitors and have a lower chance of visiting the beach on a day when the beach is closed. An alternative explanation is suggested by the mode of distribution of invitations to participate in the online survey. This promotion was largely through the use of mailing lists of the SCCG, hence it can be assumed that the respondents are drawn from a subset of the broader population who are both interested in the coast, and potentially involved in the management of beach or coastal environments. As such, it would be expected that they display a higher level of awareness of beach closures.

There were also significant differences in the way in which the two groups would respond to beach closures. Onsite respondents were highly unlikely to leave the beach upon finding that it was closed, except to go to another beach, whereas a small but significant proportion of the online sample stated that they would go elsewhere. Importantly, almost 70% of both samples for Manly indicated that they either did not care about the presence of sand at the beach (38% and 32% of the onsite and online samples, respectively), or that they would be disappointed by the lack of sand but would remain at the beach (32% and 37% of samples, respectively).

Table 5.21 Experience with beach closure – onsite and online samples for Manly beach

	Manly Onsite (n=148)		Manly Online (n=63)		Mann-Whitney U	Asymp. Sig. (2-tailed)
	Mean	Std. Deviation	Mean	Std. Deviation		
Beach_closure	0.55	0.57	0.76	0.43	3615.00	**0.00**
NoClos	0.01	0.08	0.02	0.13	4619.50	0.53
CareSand	0.38	0.49	0.32	0.47	4378.00	0.40
StaySad	0.32	0.47	0.37	0.49	4440.50	0.50
OthBch	0.16	0.37	0.14	0.35	4572.00	0.72
GoAway	0.00	0.00	0.08	0.27	4292.00	**0.00**
OtherLeave	0.00	0.00	0.03	0.18	4514.00	**0.03**

Table 5.22 presents the results of similar investigations for the Collaroy-Narrabeen responses collected in the two different modes. As with the Manly sample, more than half of respondents in both forms of the Collaroy-Narrabeen survey indicated that they would be either unaffected by the loss of sand (Care Sand), or experience a reduced level of utility from the visit (Stay Sad), but remain at the beach. Cumulative totals are 58% and 55% for the two samples, respectively. This suggests that the sand is a more integral component of the beach experience for visitors to Collaroy-Narrabeen than for those that visit Manly.

Table 5.22 Experience with beach closure: Collaroy-Narrabeen onsite and online samples

	Collaroy-Narrabeen Onsite (n =174)		Collaroy-Narrabeen Online (n =35)		Mann-Whitney U	Asymp. Sig. (2-tailed)
	Mean	Std. Deviation	Mean	Std. Deviation		
Beach_closure	0.66	0.47	0.80	0.41	2621.5	0.11
NoClos	0.03	0.18	0.06	0.24	2959.5	0.53
CareSand	0.29	0.45	0.29	0.46	3017.5	0.97
StaySad	0.29	0.45	0.26	0.44	2931.0	0.70
OthBch	0.28	0.45	0.20	0.41	2775.5	0.31
GoAway	0.00	0.00	0.03	0.17	2941.0	**0.03**
OtherLeave	0.00	0.00	0.17	0.38	2523.0	**0.00**

5.4.11.3 Explaining the lack of importance of sand for beach visitors

Finding that more than half of the beach visitors would still derive some utility from a beach that is closed due to erosion indicates that the presence of sand at the beach is not necessarily the most important factor in determining visitation. Studies in southern California have found that only 45% of beach visitors have contact with water (Dwight et al., 2007), and I would suggest that a similar proportion of sampled visitors actually have physical contact with the sand (even if only passing across it in order to access the water). A potential avenue of future research related to the current study is to attempt to determine the proportion of beach visitors for which the presence of sand is integral to their recreation or tourism experience. Some insights can be drawn from the online sample, which asked respondents where they spent the majority of their time whilst at the beach. The results of this analysis are shown in Table 5.23, and demonstrate that there are likely to be substantial differences in the way in which visitors to different beaches respond to the loss of sand from those locations.

Table 5.23 Main activity location during beach visit.

	Collaroy-Narrabeen Online sample (n=36)		Manly Online sample (n=63)		Mann-Whitney U	Asymp. Sig. (2-tailed)
	Mean	Std. Deviation	Mean	Std. Deviation		
In water	.53	.506	.22	.419	787.500	**.002**
On sand	.19	.401	.17	.383	1111.500	.806
In park	.00	.000	.10	.296	1026.000	.057
Walking path	.19	.401	.46	.502	832.500	**.008**
Other activity	.08	.280	.05	.215	1093.500	.476

As can be seen, the proportion of those who spend the majority of their time in the water is much higher at Collaroy-Narrabeen than at Manly, 53% as opposed to 22%, and this difference is significant at the $p<0.05$ level. This reflects the fact that Collaroy-Narrabeen is known as a surfing location. The proportion of those who use the walking path or spend their time in the adjacent park are also both significant at the $p<0.10$ level, with the former being significant at the $p<0.01$ level.

This finding is somewhat misleading, however, as Collaroy-Narrabeen does not have a walking path, and the adjacent parkland does not have the same visual amenity as that of Manly, due to the presence of high frontal dunes. It is also one of the few locations in Sydney wehere private property boundaries are within the active beach system. This means that there is not the same public reserve for passive recreation, joggin or walking as is typical of most beaches. What is interesting to note is that less than 20% of both samples indicate that they spend the majority of their time on the sand. Whilst understanding the patterns of beach usage is likely to be of great importance in determining the response to erosion and closure of these locations, the behavioural response to a loss of sand does not appear to have been studied in great detail. Rather, the assumption is simply that a given amount of erosion would result in a commensurate loss of tourism revenue, when this may in fact not be the case. This presents an opportunity for further research, which will be examined in Chapter 7.

5.5 Chapter conclusion

Whilst efforts should undoubtedly be made to minimise theoretical and practical errors in survey design, and to improve the precision of benefit estimates, the relentless pursuit of the 'perfect estimate' is probably unjustified on a number of grounds. Precise estimates of benefits can only be achieved through detailed specification of the status quo and the program. Both aspects provide challenges in beach valuation, where the environment is dynamic in character and spatial extent, and the projected costs and effectiveness of coastal management interventions may not be realised (or measurable) for many years.

Attempting to predict the impacts of climate change at the global level is challenging. Down-scaling of these impacts to regional models presents further theoretical difficulties. Deriving precise estimates of the local effects of these changes is, to paraphrase Winston Churchill's comments on Soviet Union policy, like attempting to decipher a riddle, wrapped in a mystery, inside an enigma. To then try and integrate these estimated changes with the dynamism of the coastal environment results in a cascade of uncertainties that does not lend itself to precision. This is true both in terms of the magnitude of projected impacts, and also the timing with which they will occur. Given the importance of discounting in economic evaluation, variability in timing has serious implications for assessments of Net Present Value.

Selection of a necessarily deterministic contingent state for use in CV surveys therefore means that the results of the survey will be useful if, and only if, the actual future state is substantially similar to that described. Coupled with the numerous potential sources of error in application of these surveys, the suitability of CV for valuation of climate change impacts must be questioned. There is also a substantial challenge in determining the relevant population of interest in beach valuation CV studies, with resultant impacts on the aggregate benefits.

Median WTP is AUD$116.27± 69.63, or approximately $66 when adjusted for the proportion of those who would not be willing to pay anything. This is higher than values reported in the literature, although the difference most likely stems from the difference in bid format. Respondents were asked their WTP as a once-off voluntary donation to a hypothetical management fund. The damage was also described as occurring at a defined point in the future, in the year 2050 for onsite samples (as reported here) and in 2020, 2050 or 2100 for the online sample. The more common payment vehicle in the literature is a visit-specific measure such as an increase in bed tax, entrance fee or property rates. Previous work has shown that site-specific cost increases are likely to affect visitation responses (Kerkvliet & Nowell, 2000).

Despite substantial efforts in survey design, guided by end-users, this survey may have done little more than to 'take the preference temperature' of the beach-going public with regards to the effects of beach erosion. Perhaps the most important finding to come from this exercise is that approximately half of beach visitors would be willing, in principle, to contribute to beach management funds designed to prevent beach erosion. Hence there is scope to investigate funding measures in further detail, using the analysis of qualitative responses as a starting point for more detailed workshops to guide fund and project design.

6 Hedonic Pricing Application

This chapter outlines the application of hedonic analysis to estimate the willingness to pay (WTP) for environmental amenities provided by Collaroy-Narrabeen beach in the Sydney region. This beach is subject to substantial coastal management challenges, due to the location of residential structures within the active beach zone, and allows for examination of a number of coastal risk factors.

The chapter begins with a brief discussion of the technical considerations in applying the hedonic approach to coastal valuation. This is followed by a review of the application of the method in valuation of coastal amenities. The review begins with an overview of hedonic applications in the coastal zone. This is restricted to international applications, given the Australian applications of the hedonic pricing method (HPM) were addressed in Chapter 3. Description of the applied methodology follows, then a summary of the results of the analysis and conclusions. The chapter concludes with some brief discussion of the potential reasons for the observed patterns of distribution of coastal property values. Discussion of the potential management implications and responses is reserved for the following chapter.

6.1 Technical considerations

The origins and underlying theory of the HPM have previously been introduced in Chapter 3, hence this section focuses on the practical application of the model to coastal valuation. It addresses in turn the key considerations that must be attended to in order to ensure reliable and policy-relevant results.

6.1.1 *Data requirements*

To perform a hedonic analysis, a large number of samples (house sales figures, property valuations for rating purposes etc.) are required in order to ensure statistical reliability of the results. Ideally, these would be market valuations, as they give a true estimate of WTP. In the case of beachside properties, this may present challenges, as these properties appear to be more tightly held than other properties, and thus there are fewer available market transactions (Kriesel and Lichtkoppler, 1989). Section 6.6.1 outlines attempts to employ market transaction data in the current study. The lack of centralised data on market transactions in some countries, including Australia, can also hinder the use of market data in hedonic applications (Pearson et al., 2002). We return to this issue in section 6.6.

One means of addressing data requirements is to undertake repeat sales analysis (Palmquist, 1982). If corrections are made for those properties that have undergone substantial modification, then it can be assumed that the remaining sample represents properties for which the property attributes remain constant. To quote the author:

> *"It appears that the explanatory power of the hedonic regression is not significantly reduced by assuming the coefficients are constant over time. This implies that when the price-relative is formed, it is reasonable to allow the characteristics functions to cancel out." (Palmquist, 1982, p345)*

This method thus provides a means of assessing the effect of changes in environmental attributes, through looking at the changes in prices paid for the same property (Palmquist, 1982). Some corrections must be made for broader changes in the property market, such as rising and falling markets.

This requirement for large data sets is also accounted for by the use of unimproved land values, as these are calculated on July 1st every year for all properties in NSW (NSW Department of Lands, 2004b). The land valuation process in NSW lends itself to time-series investigations of this nature, as land is valued annually for rating and land-tax purposes. As such, there is potential to examine the impacts of (past and proposed) coastal land-use policy changes on the value of coastal property in Sydney (NSW Department of Lands, 2004b). This approach is likely to be of particular relevance in assessing the impact of coastal erosion and other climate change impacts on coastal property markets. There is already evidence in Australia that concerns about shoreline recession is influencing property prices in some of the more threatened areas (Grigg and Allen, 2010, Johnstone, 2010). Unimproved land values are typically more readily available, although this data is often held by Government agencies and may be difficult or costly to access.

There is the potential for criticism of the hedonic method when applied to land values in this fashion, due to the fact that these values are not true market values, but an estimate of the market value of a parcel of land with the described attributes (Pearson et al., 2002). In this study, attempts were made to confirm the identified relationships through the use of market data, though this served mainly to highlight the lack of readily available market data (see section 6.6). This means that the environmental price premiums are theoretical, given that it is not possible to purchase vacant land with the attributes described. Hence the implicit prices estimated through hedonic analysis represent "probable Willingness to Pay" for these attributes, if this was indeed possible (Pearson et al., 2002).

6.1.2 *Attribute specification*

The selection of attributes in HPM studies is critical. Failure to include relevant attributes may result in over-estimation of the relative importance of those attributes included in the model. Again turning to the published literature, we can take little guidance from previous studies, which employ different units of measurement and attributes (Tables 6.1 and 6.2), dependent upon data availability and the particular topic under investigation.

It is important to not only include the correct attributes, but to ensure that they are represented in the correct units of measurement. Quantitative measures of distance to ocean or lake frontage may imply a degree of accuracy of perception that is not found in the purchaser, who merely cares whether the property (for example) has direct frontage or not. Hence categorical variables may be more appropriate (Smith and Palmquist, 1994), and this is the approach employed in the current study.

There are, however, challenges in the selection of these categories, as inclusion of subjective levels introduces contention. There is no guarantee that these levels are perceived in the same way by property purchasers. If these variables are not significant, it may be due to incorrect classification, rather than true non-relevance. The attributes employed in the models of the current study are therefore restricted to those which are unambiguous, and of greatest policy relevance. These attributes are described in section 6.3.

Table 6.1 Attribute and function specification for beach HPM studies

Primary Author	**Year**	**Data source**	**Functional form**	**Proximity measure (c=continuous Euclidean)**	**Views measure**	**Beach state measure**	**Property attributes**	**Location attributes**
Fraser	**1998**	Sales data	Linear, Log-linear	C	Categorical	NA	Area, views, shape, gradient, frontage	Corner block, road type, culdesac. Walking distance to highway, parks, schools, shopping centres
Pearson	**2002**	Unimproved land value	Liner, kinked linear, hyperbolic - all related to log of price	C	Categorical, views of park, beach, hinterland	NA	Gradient, aspect, views, area, frontage, zoning	Corner block, culdesac, road type
Kriesel	**1993**	Sales data	Log-log	C -(log transformed)	N	Years until eroded - 'Geotime'	fireplace, aircon, building area, plot area, garage,stone façade,age, rooms on 1st floor, bathrooms	includes income of local area
Pompe	**1999**	Sales data	Log-log	C	Binary	beach width	age, square feet, detached, rooms, bathrooms.	On creek

Table 6.2 Attribute and function specification for beach HPM studies (continued)

Primary Author	Year	Data source	Functional form	Proximity measure (C= continuous Euclidean)	Views measure	Beach state measure	Property attributes	Location attributes
Gopalakrishnan	**2009**	Sales data	Semi-log, Log-log (two stage, with endogenous beach width)	C	NA	beach width, dunes, shells	bedrooms, baths, condo, multistorey,age,building area	Distance to beach, locality
Hamilton	**2007**	Advertised room rates by coastal district	Log-linear	NA	NA	NA	Hotel and B&B dummies	Shoreline status in district: open, dyke and cliff lengths and proportions. Beach, moorland, waterbody,heathland areas. North Sea dummy. Population of district
Parsons	**2004**	Sales data	Linear, log-linear	Zonal	NA	NA	Area (living), bathrooms, fireplace, garage, age	Suburb dummies
Rinehart	**1994**	Sales data, before and after Hurrican Hugo	Log-linear	C, interaction with width, oceanfront dummy	Binary for ocean and inlet views	Beach width	age, building area, fireplace,dock	distance to local town centre
Samarasinghe	**2008**	Sales data	semi-log	C	Categorical, ocean and other views	NA	age,land area, building area,garage,deck,roof condition,gradient	income, Citizenship of area (% European), distance to CBD, distance to parks
Bin	**2003**	Sales data	Semi-log	C-. Dummies for 1st and 2nd row from ocean	NA	NA	bathrooms, fireplace, quality, building area, land perimeter	Income, education, female employment ratio, location in township, size and dist. to closest inland and coastal wetland

6.1.3 *Functional form*

There is no theoretical basis for the selection of a preferred functional form for the hedonic regression equation (Rosen, 1974). Hence, a number of functional forms are typically tested, with statistical tests used to select the most appropriate (Cassel and Mendelsohn, 1985, Halvorsen and Pollakowski, 1981). Popular functional forms include: linear, log-linear (with a logarithm of Price as the dependent variable), exponential and parabolic (Cassel and Mendelsohn, 1985). There are two main approaches to selecting the appropriate form. The first is to examine the effect of different functional forms on the primary independent variable of interest. The second is a more structured assessment such as Box-Cox transformation (Box and Cox, 1964).

In the first approach, linear regression is used first as a screening process to identify the relative importance of the regressors (Wertheim et al., 1992). The typical method employed is to find the dominant independent variable, and to sequentially add variables whilst examining the functional fit. This assumes a linear relationship between independent and dependent variables, which is not suggested *a priori* by economic theory. Taking the square root of the value variable is one approach to ensure normality and equivalent variances of the error terms (Neter et al., 1989). In the second approach, a Box-Cox transformation is used to identify the correct form based on functional fit, with selection performed between linear, log-linear and double-log model forms. Importantly, this does not necessarily result in better predictive power of the value of different characteristics (Kong et al., 2007).

Simple linear functions perform well compared to other functions, as tested by Monte Carlo analysis (Cropper et al., 1988). Linear regression of house/property price on attributes, however, assumes that the marginal utility of attributes remain constant over the range found in the data. For example, the utility gained from having a fifth bathroom is equal to the utility from having the first bathroom. This is unlikely to be the case in practice.

Each of these models is interpreted differently. A linear-log model allows for changes in marginal utility. Including the log of an independent variable implies that there is diminishing marginal utility, taking the exponential implies that there is increasing marginal utility (Milon et al., 1984). Log transformation of the distance variables therefore typically results in a better functional fit than strictly linear measures (Mahan et al., 2000). With a log-linear model, the parameter estimates for the attributes represent their percentage contribution to the overall value. With a log-log model, the parameter estimates represent the elasticities, i.e. the percentage increase in total value resulting from a 1% increase in the attribute level, assuming that the parameter estimates are marginal in nature. With all combinations including logarithmic functions, categorical variables taking the value of zero are not transformed due to mathematical constraints (Bastian et al., 2002).

6.2 Hedonic application in the current study

6.2.1 *Study area*

The case-study for the hedonic model is Collaroy-Narrabeen (Figure 2.2), as described in Chapter 3 and in more detail in Appendix 2. This area is bounded to the south by increased elevation, to the west and north by Narrabeen Lagoon, and to the east by the Pacific Ocean. An overview of the area is provided in Figure 6.1. Details relevant to the hedonic analysis such as property boundaries and the location of hazard zones are presented in later figures. The area is one of the few locations in the Sydney catchment where absolute beachfront property is available. It is subject to the impacts of coastal erosion from the seaward direction, and also flooding from the landward side, hence it provides an interesting case-study area.

The majority of properties included in the analysis are located on the Narrabeen peninsula, a tongue of land extending in a north-south orientation. The peninsular is bounded on the seaward side by the Pacific Ocean and on the 'landward' side by Narrabeen Lagoon. Limiting a study to a small area reduces the burden of determining attribute levels for all neighbourhood variables thought to be of interest (Abelson, 1979). The simple geography, similar in nature to a barrier island as is common on the north-east coast of the United States, allows for some simplification of the spatial analysis, and for greater comparability with previous studies.

Figure 6.1 Aerial view of case-study area: Collaroy-Narrabeen beach, Sydney, NSW, Australia. (Source: Nearmap)

The other case-study locations were excluded from consideration on theoretical and practical grounds. Manly is a highly developed area with a predominance of apartment buildings in the area immediately adjacent to the beach. Application of hedonic analysis to apartments is a complex process, given the potential for unseen variables such as the quality of fixtures to substantially influence the apartment sale price (Toda et al., 1998). In NSW, it is also hampered by the land valuation process (NSW Department of Lands, 2004b). Apartments are allocated a proportion of the land value, on a per-unit basis, which may not reflect the true market value of the individual apartments. In a beachfront residential apartment building, for example, the apartments with ocean views may be expected to be substantially more valuable than those on the landward side of the building, though this will not be reflected in the unimproved land values which are employed in the current study. There is also a wide promenade, coastal park reserve and road separating the residential properties from the beachfront at Manly beach (Figure 3.3), hence the ability to examine willingness to purchase beachfront property is limited.

Brooklyn data was excluded from the analysis as there was insufficient variability in proximity or exposure variables. The 'beach' at Brooklyn baths is also a highly modified bathing enclosure, so transferability of the results gathered from this site is limited. Dangar Island was chosen as a case-study location in part because of the differing shoreline frontage types present, which present an opportunity to examine WTP for different shorelines. This was ultimately not possible, due to the small sample size and the mass valuation process employed in land valuation in NSW (NSW Department of Lands, 2004b). All properties on Dangar Island are members of the same 'component', hence they are assumed to vary in a proportional manner from year to year. Hence, land values are artificially restricted, rendering hedonic analysis theoretically untenable. (There are 11 components within the Collaroy-Narrabeen sample.)

6.2.2 *Data sources*

This study employed the use of unimproved land values, as estimated by the NSW Department of Lands for rating and land tax purposes. Land in NSW is valued annually for rating and land-tax purposes (NSW Department of Lands, 2004a). Spatially-referenced data on unimproved land values were provided in GIS format by the Valuer General's Office for the Collaroy-Narrabeen area. In total, this represented 3151 land parcels. These were restricted to land valuations performed in the financial year starting 1st July 2008.

The original data supplied by the Department of Lands extended northward into the Pittwater LGA, on the northern side of Narrabeen Lagoon. These properties were excluded from the final analysis for a number of reasons. Property owners in Pittwater do not receive the same residential parking permits as Warringah residents. Hence, their beach access conditions differ. Properties in Pittwater also have different accessibility features to those properties selected for analysis, due to their location near Wakehurst Parkway, an important arterial road on the west of Narrabeen Lagoon which represents the main alternative to Pittwater Road as a route to the Sydney CBD, and takes a large proportion of commuter traffic from the more northerly suburbs. Inclusion of these properties would require greater consideration of commuting time as a determinant of property value, which would require information that was not available, including a traffic-weighted road network raster layer to be used in cost-distance calculations.

Consideration of potential coastal management options is also complicated through inclusion of properties in multiple jurisdictions. Whilst management of Narrabeen Lagoon for the control of flooding is undertaken as a joint partnership between Warringah and Pittwater councils, management of Collaroy-Narrabeen beach is the exclusive responsibility of Warringah Council. Whilst Pittwater residents who use the beach would undoubtedly benefit from projects designed to preserve the sand, they are not likely to be asked to contribute in a financial manner to ensure these projects are undertaken. Thus these properties were not included in the analysis.

Properties on Collaroy Plateau (see Figure 6.1) were also included in the original dataset, in order to consider properties which had views of the ocean but relatively poor access due to local relief. These properties were ultimately excluded from analysis, due to the absence of essential building height data necessary to construct an accurate viewshed. This topic is covered more extensively in section 6.4.5.

Analysis was therefore restricted to properties in the suburbs of Collaroy and Narrabeen. Ground-truthing was undertaken with site visits and analysis of aerial photography, to exclude incorrectly categorised property parcels from the analysis of Collaroy-Narrabeen data. This resulted in 1192 land parcels being included in the analysis. Only single-residence dwellings were included in the modelling, as characteristics of multiple-residence properties complicate the process of determining the environmental price premium for individual properties (Pearson et al., 2002).

6.2.3 *Hedonic analysis*

Contour data, cadastral parcels and aerial photography was provided by Warringah and Pittwater councils. Warringah council also provided information on the legally-defined shoreline, coastal hazard zone boundaries, road networks, and council reserve areas. Topographic information was also provided in the form of 2m contours, with height given in reference to the Australian Height Datum (AHD).

All spatial analysis was performed using ArcGIS 9.2. Euclidean distances to the beach and lake reserves, and land parcel geometry were estimated in ArcMap, using the Spatial Analyst extension. An elevation grid was interpolated from the contour data, using the Topo to Raster tool in the 3D Analyst extension. Zonal statistics were then estimated using Spatial Analyst extention, to calculate the minimum, maximum and mean elevation for each land parcel. This information was used to estimate vulnerability to inundation, and is described in section 6.4.4.1. The attribute table of the spatial analyses was exported and analysed by NLogit 4.0, a statistical analysis program based on the architecture of Limdep 9.0 (Greene, 2007).

The advent of GIS software enables rapid analysis of spatial variables (Samonte-Tan et al., 2007). These previously required laborious calculations, particularly for complex landscapes and irregularly shaped land parcels (Geoghegan et al., 1997). Spatial attributes included in hedonic studies typically include distance to environmental attributes of interest (Rush and Bruggink, 2000) and the area of the land parcel (Fraser and Spencer, 1998). Other factors may include the value or usage of the surrounding land parcels (Wertheim et al., 1992). In this study, measures of proximity are combined with binary factors to further describe the location of beachfront properties along the beach. Distribution along the beach length indicates different exposure to erosion and proposed management actions. Further detail is provided in the description of Models 3 and 4 in section 6.5.

6.3 Attribute selection

A large number of model attributes were screened for their influence on house prices. Regressors were selected based upon the advice of staff from the Valuer General's office, discussions with coastal experts within Warringah Council, and through an extensive search of the international hedonic beach valuation literature. Only the attributes which were statistically relevant and of policy interest are included in the following sections, and these are listed in Tables 6.3 and 6.4. Not all of these attributes are included in the final models, but are provided for completeness.

6.3.1 *Coastal proximity and accessibility attributes*

Coastal proximity has a strong influence on property price in the published studies (Rush and Bruggink, 2000). It is assumed that increased distance is a negative influence on property price. This effect can be seen graphically in Figure 6.2. Distance was originally incorporated as a log-transformed attribute (LNDistBch) in all models, due to assumptions about the non-linear importance of distance (Samarasinghe and Sharp, 2008). In the instance of the Narrabeen peninsular, distance from the ocean varies inversely with distance from the lake. Hence it is not possible to include both factors in the analysis. Casual observations, and also findings of previous studies suggest a non-linear proximity relationship (Bin et al., 2008). Distance had the expected significant negative influence on property prices, indicating a preference for proximity to the beach.

When categorical variables indicating location within a block from the beach (Block1) or more than 500m from the beach (BchDrive) are included, the continuous measure of proximity is no longer statistically significant, indicating a rapid decay in the value of proximity. The dichotomous classifications are preferred in the final model on the basis of model fit.

- **Block1** is a dummy variable, indicating that the property is within 1 block of the beach.
- **LnDistBch** is the natural log of the mean Euclidean distance of the property from the beach sand, measured from the central point of the property. As the primary variable of interest in this study is coastal proximity, distance from the lake is excluded. The natural logarithm of value and distance from the beach are used in examination of the semi-log model.
- **Access** is a binary variable indicating that the property is located adjacent to a formal beach access path. These are located at the eastern end of all roads leading to the beach.
- **Bchdrive** is a binary variable indicating that the property is located more than 500m from the beach. Five hundred metres is taken as a representative walking distance. The majority of properties in the sample are within 500m of the beach, with the exception of the southern and western extents of the study site. Hence this variable may be representing other unknown neighbourhood attributes.

Figure 6.2 Spatial representation of land values in Collaroy-Narrabeen

Use of network-analysis to account for ease of access was not considered relevant in the current study, as public access to the beach is a right preserved in legislation and policy (NSW Government, 1990, NSW Government, 1997), and access points are provided at frequent intervals along the beach length. The grid-like road network, regular access points (at the eastern extent of all lateral roads), and narrow peninsula also mean that there is limited variability between Euclidean and network measures of coastal proximity. Given the urban location of Collaroy-Narrabeen, location adjacent to an access point can also be considered a potential negative influence on property value, as considerable parking congestion is experienced in peak usage periods. Other potential negative aspects of location near an access point include noise and litter associated with use of those facilities. Disamenity associated with location near public parks has previously been noted in Australian hedonic studies (Pearson et al., 2002).

6.3.2 *Property attributes*

Property attributes are substantially simplified by the use of land values, rather than property values. The following attributes were investigated:

- **Area** is the spatial extent of the land parcel in square meters.
- **Elev** is the mean elevation of the property, as extracted from the interpolated topographical grid. The unit of measurement is metres above AHD.
- **Steep** is a binary variable indicating that there is more than 10m change in elevation across the property. It is assumed to be a negative, due to difficult access and increased costs of construction. Conversely, steep blocks may confer views, and hence a premium could be expected. The attribute was not statistically significant in any of the models, hence no conclusions can be drawn about the true relationship.

6.3.3 *Non-coastal location attributes*

In addition to the property and proximity variables, a number of other variables were included to take into account factors assumed to influence property prices. In this study, the primary sources of open space are the lake and the beach.

- **MainRoad** is a dummy variable indicating the property is on a major road, which is defined as Pittwater Rd (marked in yellow on Figure 6.1) or Ocean St (marked in red on Figure 6.1).
- **Culdesac** is a binary variable indicating that the property is located on a road which terminates. (It was not a significant determinant of land value).

- **Park** is a dummy variable representing direct access to a park or open space area. It was also insignificant.
- **WtrFront** is a dummy variable representing lake frontage.
- **Lake1** takes the same form as Block1, indicating the property is within 1 block of the lake.
- **Collaroy** is a neighbourhood variable designed to pick up any differences between properties in the two suburbs included in the case-study area.

6.3.4 *Risk attributes*

It was my intention to include property protective services in the hedonic application, through consideration of both beach width and the presence of protective terminal structures. There is an extensive history of analysis of beach width for the study site, including the longest beach transect record in the southern hemisphere (Short and Trembanis, 2004). This was recently updated using Real Time Kinetic GPS (RTK-GPS) and ARGUS image derived profile data (Harley et al., 2011), and represents one of the most highly studied beach systems in the world. This data notwithstanding, beach width was not incorporated into the current study for a variety of reasons, outlined below.

What the extensive beach width data records serve to demonstrate is that the beach width varies substantially on hourly, daily, monthly, annual and decadal scales, and incorporation of a static measure of beach width is unlikely to accurately represent the perceptions of the property purchaser at the time the transaction occurs. Whilst the unimproved land values employed in this analysis are estimated from true market transactions, they are normalised to a common date (1st June 2008). This does not reflect the fact that the state of the beach is likely to have varied substantially over the course of the preceding 12 months, and individual beachfront property transactions may have varied in parallel.

Secondly, beachfront property in the study area is highly valuable and may represent the majority of a landowner's net worth. Unless financial circumstances are extenuating, beachfront property is not typically sold at times when the beach is eroded. An exception to this rule of thumb is that of Belongil beach, where the financial crisis led to the forced sale of a number of beach properties in an area which is highly eroded. Due to the small number of properties in the area, and the substantial discounting due to the poor financial climate at the time, this has resulted in a drop of property values in the order of 50%, as evidenced by the updated unimproved land values released by the Valuer General in 2010 (Grigg and Allen, 2010, Johnstone, 2010). Belongil beach is located in the Byron Shire Council area, and is the only location on the NSW coast which is subject to an adopted policy of planned retreat. As such, the reduction in property values may also reflect buyer uncertainty about future climate change impacts on the properties, as the science around SLR has improved markedly in the period between land valuation cycles (IPCC, 2007b).

Given the challenges in quantifying protective services provided by the beach itself, (and theoretical concerns about the extent to which these influence housing market transactions), I then sought to assess the presence or absence of terminal protection structures on the value of beachfront properties in a manner similar to that of Kriesel et al. (1993), as the degree of shoreline armouring varies along the Collaroy-Narrabeen stretch. Unfortunately two challenges prevented the effective consideration of this variability in an econometric sense.

The first is that the protective structures are typically buried under sand dunes, and exposed only in times of significant storm erosion. Hence hedonic theory (and psychology as detailed above) would suggest that they are not being considered by property purchasers, except possibly as a positive protective amenity in the event they are discovered in land title searches. The second reason is that further investigations undertaken by Patterson Britton (unpublished) in updating the Collaroy-Narrabeen hazard lines found that some form of coastal protection is present for almost all properties. Fewer than 10 beachfront residential properties are unprotected, although the degree of protection afforded by the structures is unknown. The majority of protective armouring has been constructed in an ad-hoc manner in response to previous storm erosion events, and the exact nature of the material employed at each location is not known to any degree of accuracy. Hence, more general measures of erosion risk have been employed, through increasingly more detailed specifications of coastal hazard zones, derived from the CNCMP (Appendix 2). These are outlined in description of the models in section 6.4.

6.3.4.1 Flooding risk

Inundation likelihood (INUND) for lakefront properties is estimated as a simple function of elevation, which is the average elevation of the property as interpolated from topographic information using the Spatial Analyst extension of ArcMap. If a lakefront property has a mean elevation of less than 3.2m, it is assumed to be subject to some form of inundation. This value is derived from the maximum inundation depth associated with an 0.01 AEP flood event and a tide height of 2.1m, which is composed of tide, storm surge and wave set up. It is the maximum inundation depth (for the 100 year event) employed in modelling by AECOM in examining alternative management strategies for the entrance of Narrabeen Lagoon (AECOM, 2009), and hence represents a conservative measure. The flood levels are in turn derived from a flood study conducted for Narrabeen Lagoon by the NSW Public Works Department in 1990 (PWD, 1990). Whilst this information is somewhat aged, it remains the most current publicly available data.

Inundation is not estimated for non-lakefront properties for two reasons. Oceanfront properties are typically raised above the stillwater sea-level by virtue of their location on substantial dune systems, and are not subject to the same level of inundation threat. They are exposed to inundation only when also exposed to erosion, and the desire to separate these risks in analysis leads to their separation. Properties which are not lakefront, but subject to flooding risk are also excluded, as they may not have the same level of exposure, in practice, as the quantitative measure of elevation would indicate. The entrance to Narrabeen Lagoon is intensively managed in times of heavy rainfall or storm surge leading to flooding threats, with artificial opening employed to lower lagoon levels once the water level in the lake exceeds the bank limits.

Ultimately, vulnerability to inundation was interacting with the term defining waterfront access, and was not contributing to explanation of land value variation. It was therefore excluded from final models.

6.3.5 *Aesthetic considerations – valuing views*

Although it is likely to be a statistically significant determinant of beachside property prices, the presence or absence of coastal views is not explicitly incorporated into the analysis due to technical constraints. A true measure of viewshed from each property was not possible, due to the absence of multiple-return LIDAR as employed by in previous studies (Yu et al., 2007, Bin et al., 2008, Hamilton and Morgan, 2010). Whilst topographic information was provided by Warringah Council in the form of countours, and elevation was interpolated using the

Topo to Raster tool of the Spatial Analyst extension of ArcMap, this is generated from the final-return of the LIDAR and therefore does not take into consideration the presence of visual obstacles such as vegetation or buildings. Without building footprint and elevation data, calculation of the viewshed would therefore generate results subject to significant measurement error, although this 'bare-earth' approach has been applied previously (Paterson and Boyle, 2002).

The study area is relatively flat and fully developed (no vacant lots), so view varies in line with distance from the ocean. Given the relatively low relief of the majority of the study site, views are likely to display similar decay characteristics as those found in the work of Bin et al., with unobstructed views primarily accruing to beachfront properties (Bin et al., 2008). It is not possible to separate the contribution of views and access. The presence of views is also an attribute used in the estimation of unimproved land value in NSW (NSW Department of Lands, 2004a), although precise details on the way in which it is incorporated were not available. Hence any attempt to include views, if not consistent with the 'uplift factor' applied in the land valuation process, may result in spurious results. Attempts to obtain the results of the view-related classification system from contracted land valuers via the Valuer General were unsuccessful.

Location within the coastal hazard zone 'Wave Impact' (BCHRISK) is assumed to be a positive factor, given the beachfront access and unobstructed views this location entails. The same is true of the other coastal hazard zones 'Slope Adjustment' and 'Reduced Foundation Capacity'. The exception to this assumption is where the property is located within a hazard zone, but is not in a beachfront location.

There are 38 properties which are located within the first block from the beach, but not subject to inclusion in a beach hazard zone. Six of these properties are beachfront properties, and they can be located in the south-eastern corner of the study area, located above cliffs at Collaroy. These properties are expected to be the most valuable properties in the study area, as they provide essentially the same access amenities, but are not subject to the same coastal hazards, due to the presence of underlying bedrock. These properties are assumed to have the highest value, and indeed this can be seen in Figure 6.3.

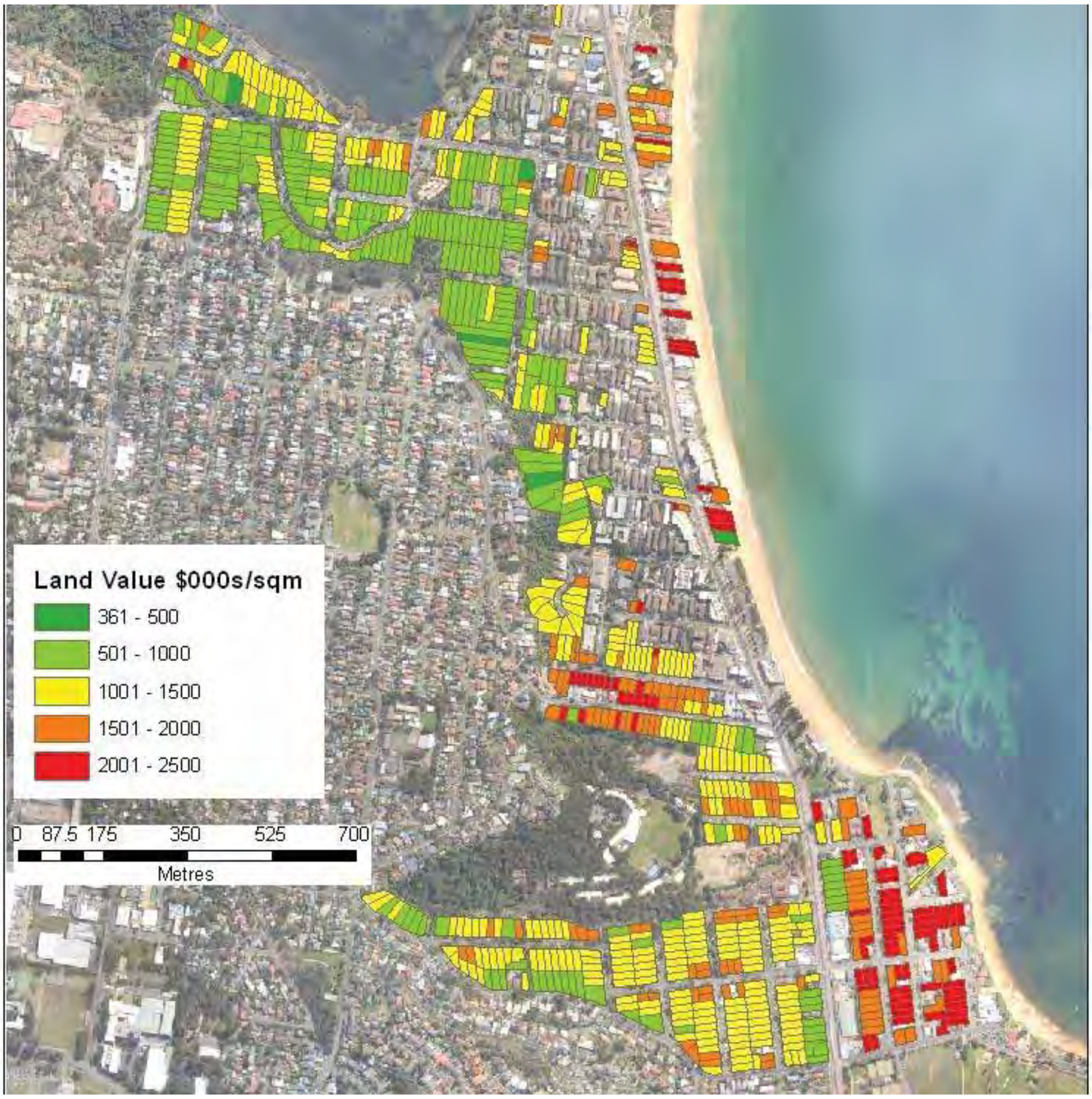

Figure 6.3 Land values of properties in the southern half of the study location, showing higher estimates for clifftop properties in the south-eastern quadrant

6.3.6 *Functional form*

Linear, log-linear and double-log specifications were investigated. The linear and log-linear models performed better in terms of goodness of fit, hence they are the models presented here. The inclusion of attributes in the final model is based on comparison of the correlation matrix and the use of both goodness of fit (r-squared) and the Akaike Information Criterion (AIC), which is a model selection criterion giving greater weight to parsimonious models. Box-Cox transformation is not undertaken, as the majority of independent variables are binary and cannot be transformed due to the presence of zero values (Wooldridge, 2006). Cropper et al. have demonstrated that omitted variable bias and use of proxies rather than continuous variables lead to the simpler linear and semilog forms performing more efficiently than more advanced transformations (Cropper et al., 1988).

6.4 Results and analysis

Results are presented for four models, which represent increasing levels of spatial detail in investigating the influence of beach proximity and erosion risk. Model 1 estimates the price premium for beachfront property. In Model 2, the influence of risk information on beachfront property prices is examined. Model 3 examines variability in beachfront land values along the length of the beach, something which has not been addressed previously in the literature. Model 4 expands upon Model 3 by incorporating risk information into the longitudinal analysis. The linear relationship is retained for assessment of sensitivity to functional form, and for easy assessment of marginal effects, as per Loomis (Loomis, 2004). In the linear model, the dependent variable is the land value in thousands of dollars (2008 AUD). Presentation of the models in this fashion allows for further exploration of the key factors of proximity and risk in explaining coastal land values. Descriptions of the attributes employed in each model are included in presentation of the results.

6.4.1 *Descriptive statistics and results of a priori assumption tests*

Continuous variables are summarised in Table 6.3 and show a high average value of land in the case-study area. VAL is the value of the property, as estimated by the Valuer General's Office in 2008. VALSQM divides this figure by the area of the land parcel in square metres (AREA). DISTL and DISTBCH represent the Euclidean distance to the lake and beach, respectively. Average property value is approximately AUD$972,000 dollars, with an average price per square metre of around AUD$1500. The total unimproved value of land included in the sample is over AUD$1.1 trillion (in 2008 dollars), reflecting the high cost of land in Sydney. Given that developed property in Narrabeen is typically 75% more expensive than undeveloped land (AECOM, 2010), this represents a residential property value of more than $2 trillion dollars. Beachfront properties (n=96) account for a cumulative value of $191.301 million (or an average of $1.993 million per property), and properties located within the first block of the beach (n=45) account for $54.826 million (average of $1.218 million per property) with the same adjustments for developed property applicable.

Table 6.3 Descriptive statistics – continuous and transformed variables

Variable	Mean	Std.Dev.	Minimum	Maximum
VAL	972392	440325	339000	4010000
VALSQM	1551.53	684.16	361.00	4911.00
DISTL	868.47	766.14	11.01	2217.29
DISTBCH	395.76	261.54	10.79	1080.95
AREA	676.92	262.54	139.36	2562.35
ELEV	17.45	14.73	0.00	67.22

Descriptive statistics of categorical variables included in the final regression are presented in Table 6.4. (Note that not all variables are incorporated in the final model but they are presented here for completeness). There are 96 beachfront properties, with all but 6 of these located within at least one of the coastal hazard zones. Approximately half of beachfront properties (42 of 96) are not included in the zone of Slope Adjustment. Of the 51 lakefront properties, only 12 are not below the design flood height used in the analysis.

Table 6.4 Descriptive statistics – dummy variables

Variable	Mean	Occurences
BCHFRONT	0.08	96
WTRFRONT	0.04	51
INUND	0.03	39
MAINRD	0.15	179
COLLAROY	0.49	589
ACCESS	0.05	57
CULDESAC	0.03	31
BLOCK1	0.04	45
LAKE1	0.14	172
BCHDRIVE	0.30	352
EASEMENT	0.04	47
STEEP	0.13	150
BCHPREC1	0.02	18
BCHPREC5	0.03	39
BCHPREC3	0.04	46
BCHSAFE	0.04	42
BCHRISK	0.04	49

The majority of these factors have already been described. Those which are highlighted are explained in the model descriptions in sections 6.5.3-6.5.6. Initial explorations included all listed regressors to test *a priori* assumptions. Location on a main road was the most powerful disamenity. Negative influences on property prices are also estimated for the continuous variables of increased elevation and greater distance from the beach, and for the categorical variables representing steep blocks, and location on an access road. Elevation is incorporated in the final models, as are categorical measures of distance. Other factors were insignificant in explaining variation in land values.

All coefficients have the expected signs except for Access and Elevation. Location adjacent to a formal access point is a negative amenity. This may indicate that exclusive access is a driver among purchasers of beachfront property, and may also reflect parking issues as highlighted previously. Increased elevation has a negative influence on land values. At first approach this appears counterintuitive, as properties closer to sea-level are exposed to greater risk of erosion and inundation. Further examination suggests two explanations for this observed relationship. Firstly, increased elevation is correlated with distance from the beach, which is a negative influence on property prices. Secondly, the mean elevation for the sample is approximately 17.5m AHD, whereas the most favoured properties are located below approximately 8m AHD. Hence increased elevation indicates reduced likelihood of location in a beach or lakeside location.

6.4.2 *Statistical tests*

A number of diagnostic tests are common in hedonic model estimation. These include tests of correlation, heteroskedasticity, and multicollinearity. This analysis does not contain time-series data, as all land values are estimated in the same year, so temporal correlation is not observed nor testable. Spatial correlation is possible, however, and is regularly observed in hedonic models, even where all neighbourhood variables are statistically insignificant (Dubin, 1992). The reality is that spatial correlation is expected in models based on component or mass valuation processes, as is the case in this study (NSW Department of Lands, 2004a). Under the mass valuation process employed in many countries (including Australia), the change in value from year to year is estimated in detail for a number of properties. This relative change is then applied to a group of properties assumed to be similar, a component. Typically, a component is a spatial cluster of properties, and hence the land values, spatial attributes, and unobserved residual factors will all tend to vary in similar ways.

Whilst the analysis was conducted in a GIS platform, the spatial attributes included in the final model do not include any continuous variables other than area. Hence the neighbourhood characteristics are described only by the inclusion of the suburb level binary classification, Collaroy. The use of categorical measures of distance removes the potential for detailed examination of spatial autocorrelation in a manner that is common in hedonic studies employing more detailed spatial measures (Anselin and Hudak, 1992, Bin et al., 2008). Prior to analysis, records were sorted by a unique object identifier for each land parcel. These identifiers are spatially allocated by the Department of Lands, so they were first distributed randomly. Durbin-Watson tests of autocorrelation within the residuals were conducted, and statistics presented in summary of results for each model indicate no autocorrelation is present (Wooldridge, 2006).

Heteroskedasticity may also be an issue in hedonic models. White's robust covariance matrix (White, 1980) is calculated via the REGRESS procedure in Limdep (Greene, 2007), which does not require knowledge of the type of heteroskedasticity, and also provides the Breusch-Pagan test statistic, which is shown in the results tables presented hereafter.

Multicollinearity is a challenge for hedonic models, given the inherent spatial linkages between attributes of interest such as coastal proximity and erosion risk. Given high correlation between explanatory variables, it is difficult to separate the contribution of each attribute to the model (Pendleton and Shonkwiler, 2001). Perfect collinearity is observed in the hazard zone classifications, due to their spatial relationship. For example, all properties included in the zone of Wave Impact are necessarily included in the zones of Slope Adjustment and Reduced Foundation capacity. Hence the final model represents only those attributes of greatest policy interest, with other attributes displaying high correlation removed from the specification. The correlation matrices of included attributes are presented in Appendix 7, for both the overall and spatially-explicit models where beachfront properties are broken down into precincts.

6.4.3 *Model 1 –valuing beachfront property*

Model 1 is the most basic of the models, in which beachfront location of a property is represented by a binary variable. Other regressors have already been explained in section 6.4. Results are presented in Table 6.5. All parameters are significant at the p= 0.001 level. Further parameters are excluded from analysis due to collinearity issues, despite potentially statistically significant influence on land values. The t-ratios provided are the ratio of the parameter estimate to the standard error of the estimate. Attempts to determine the contribution of individual attributes is complicated by the number of dummy variables. Each property will be described by a combination of these variables, hence determining an average reference property is challenging. For a property which takes the mean value for the continuous variables (elevation and area), and zero for all binary variables, the land value is estimated by the intercept.

Table 6.5 Regression results for Model 1

Regressors (common)	Coefficient	Standard Error	t-ratio	Implicit price premium
Intercept	582716.22	24079.47	24.20	
Area	441.96	42.00	10.52	0.08
Elevation	-4127.58	639.72	-6.45	-0.71
MainRd	-236239.28	26398.20	-8.95	-40.54
Collaroy	193340.62	16410.05	11.78	33.18
Wtrfront	384210.30	28092.50	13.68	65.93
BchDrive	-85159.62	16242.70	-5.24	-14.61
Block1	433883.34	38674.63	11.22	74.46
Beach Regressors				
BchFront	1173880.00	57770.46	20.32	201.45
Adjusted r-squared	0.67			
Durbin-Watson statistic	2.12			
Breusch-Pagan LM Statistic	1060.11			
Model Test (8, 1181)	303.01			

Explanatory power is good, particularly given the simplifying assumptions and data limitations, with an adjusted r-squared value of 0.67. The null hypothesis of heteroskedasticity cannot be rejected, given the Breusch-Pagan test statistics. Hence the robust standard errors are used, adjusted as per White (White, 1980). Property variables are limited in explanatory power, suggesting that location is more important than the size or elevation of the property.

It can be clearly seen that the dominant factor in the regression is the binary factor for beach frontage (BchFront in Table 6.5). Beachfront property is a desirable good, despite the risks associated with the location of beachfront property in the active beach zone. An average property, given the same assumptions as for the reference property but with BchFront taking the value of 1, will be worth approximately $1.75 million. This represents a premium of around 201%. Properties which are located within one block of the beach, but are not beachfront properties, are also subject to a significant price premium, in the order of 75%.

Waterfront (lakefront) property is also a desirable good, despite the risks associated with flooding. The implicit price for lake frontage is less than that for beachfront property, although it still represents a premium of around 66%. The intensive management of the Narrabeen Lagoon entrance reduces flood risk substantially, hence it is assumed that purchasers of lakefront property are operating under the assumption that this management will continue in their favour. Given the negative parameter estimate for elevation, and the fact that beachfront and waterfront properties are all below the mean elevation, there will be an additional premium associated with these properties.

The neighbourhood variable included to account for differences between the two suburbs included in the analysis is significant, with Collaroy properties relatively more valuable than otherwise similar properties in Narrabeen. Reasons for this difference are unclear, however variation could be explained in part by the reduced exposure of the most valuable properties (located on the beachfront) to erosion. Large swells are almost exclusively from a southerly direction, meaning that properties in Collaroy are afforded protection by Long Reef headland to the south (Short and Trenaman, 1992). Given the narrowing of the peninsular to the north, there are also a higher proportion of properties located on main roads, which has a strong downward pressure on prices as shown by the coefficient on MainRoad in Table 6.5. Location near the commercial centre of Narrabeen may also be an influence.

6.4.4 *Model 2- Examining risk to beachfront property*

Location on the beachfront provides both access to coastal amenities, but also exposure to coastal hazards. In the case-study areas, this is of particular relevance, as this beach is periodically exposed to highly erosive storm swells. There is a strong history of erosion in this location (as detailed in Appendix 2), and it is assumed that purchasers are aware of the inherent risks. Nevertheless, the value of the most threatened properties does not appear to reflect this risk. This is not a unique finding (Bin and Polasky, 2003), but reflects strong preference for coastal amenities that outweigh risk information.

As a result, Warringah Council developed coastal hazard lines, which reflect the degree of risk posed to zones near the beach (WLEP2000). Inclusion of the property within a coastal hazard zone is listed on the section 149 certificate linked to the property title at the time of transaction.

Coastal hazard lines are available for the case-study area, and are separated into zones of Wave Impact, Slope Adjustment, and Reduced Foundation Capacity. An example image showing the location of these lines is found in Figure 6.4, and description of their basis is found in Appendix 2. These lines are linked to the likely location of the shoreline at a given time horizon and under a given storm scenario, and are taken from the *Warringah Local Environment Plan 2000* (WLEP 2000), which is in turn based on the CNCMP (Appendix 2).

The location of these lines is based upon a deterministic approach, rather than a more advanced stochastic measure, hence it is not a perfect approximation of coastal erosion risk. Given changes in the state of climate change science since the CNCMP hazard studies were undertaken (in the late 1980s), erosion rates were not incorporated into the current study. The coastal hazard study is currently being reviewed by Patterson Britton, hence a more comprehensive incorporation of erosion threats into the hedonic analysis is a potential avenue of future work. Nevertheless, it is likely that these hazards zones would be the primary source of erosion risk information employed by purchasers of beachside property, as location within one of these zones is listed as a note on the property title under section 149 of the *Environmental Planning and Assessment Act 1979*. The location of the lines can be seen in Figure 6.4.

Inclusion within one or more of these zones is not included directly as an attribute in the analysis as the zones are highly collinear with other regressors of interest (e.g. **beachfront** and **Distbch**). They are instead used in construction of variables which account for erosion risk in a more complex manner.

Influencing market behaviour through disclosure of risk information is a potential means of managing exposure of coastal councils to litigation, and to reduce the financial constraints on such management responses such as voluntary purchase programs (NSW Government, 1990). Model 2 therefore progresses from the simpler model through classification of the beachfront properties into those that are likely to be exposed to wave action, and those that are relatively protected from erosion:

- **BchRisk** is a variable generated through interacting risk and location for beachfront properties. It is given a value of 1 if the property is located on the beachfront, and in the zone of Wave Impact.
- **BchSafe** is constructed in the same fashion, but indicates properties which are not contained in the zone of Slope Adjustment. Whilst the property may still be subject to building restrictions based on reduced foundation capacity, the lower level of exposure is assumed to be a positive influence on property value.

Results are presented in Table 6.6. Explanatory power is improved in this model, with an adjusted r-squared of 0.73. Common regressors retain similar importance between the two models, so discussion is restricted to the beach-related parameters.

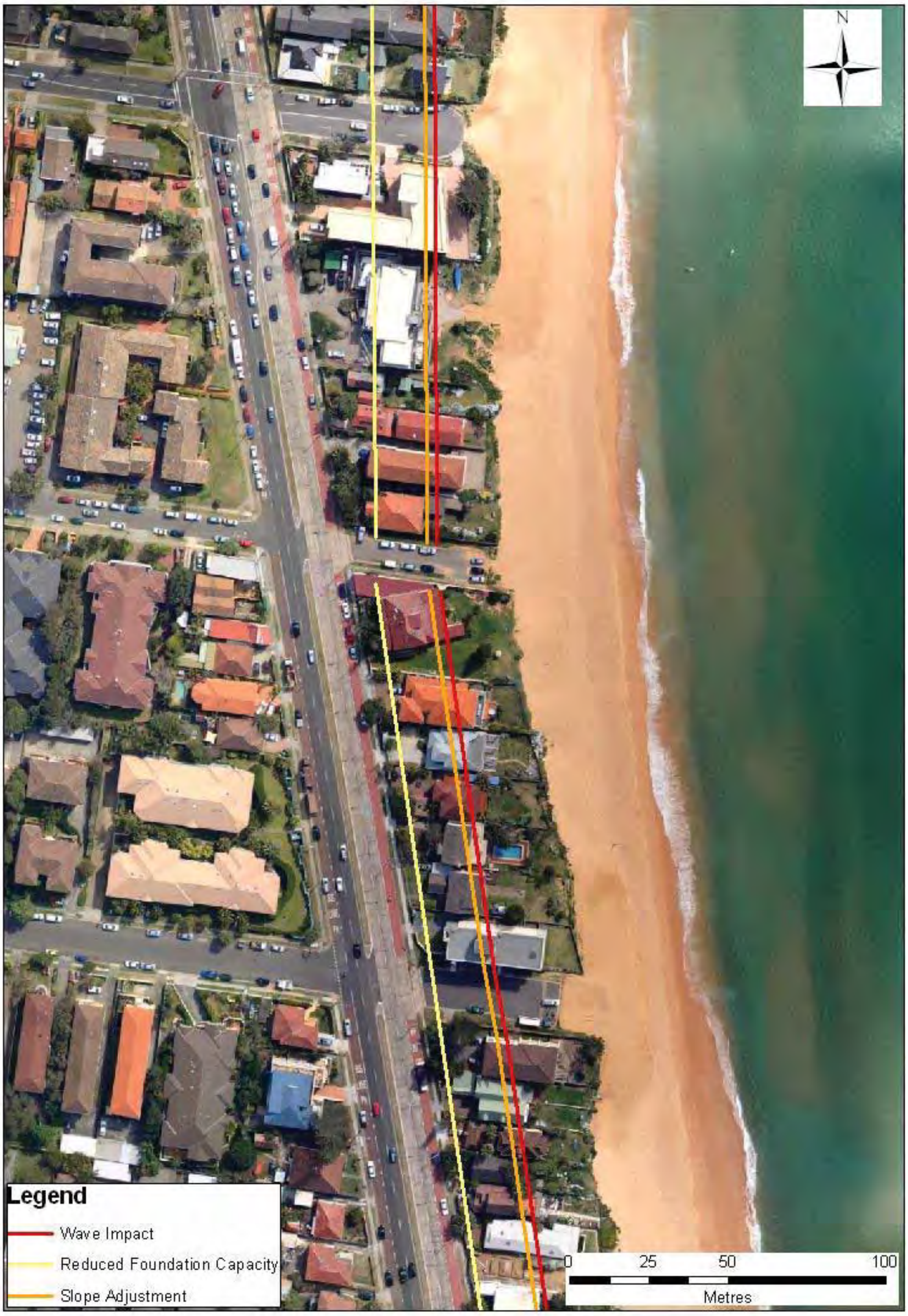

Figure 6.4 Hazard zones in Precinct 3, Collaroy Narrabeen beach. Source: Aerial photo from Nearmap, Hazard lines from Warringah Council.

Table 6.6 Regression results for Model 2

Regressors (common)	Coefficient	Standard error	t-ratio	Implicit price premium (%)
Intercept	582040.82	21992.55	26.47	
Area	427.05	37.90	11.27	0.07
Elevation	-4082.65	602.98	-6.77	-0.70
MainRd	-188006.31	20394.43	-9.22	-32.30
Collaroy	203836.65	14829.21	13.75	35.02
Wtrfront	396426.56	27290.19	14.53	68.11
BchDrive	-86676.20	14769.53	-5.87	-14.89
Block1	421080.42	38351.77	10.98	72.35
Beach Regressors				
BchSafe	1569230.00	63686.21	24.64	269.61
BchRisk	821122.85	60356.41	13.61	141.08
Adjusted r-squared	0.73			
Durbin-Watson statistic	2.04			
Breusch-Pagan LM Statistic	605.22			
Model Test (9, 1180)	351.67			

It can be seen from the coefficients in the linear model that beachfront property is worth much more if located in a 'safe' location with respect to the effects of coastal erosion. The difference in the implicit price premium suggests that safe beachfront property is worth around $750,000 more than property which is at risk of erosion. Nevertheless, the attraction for coastal property remains strong, with premiums for 'at risk' beachfront property still in the order of 141% relative to the average property. This suggests that while disclosure of risk information has a definite effect on coastal property prices in the case-study area, the desire for beach amenities can outweigh the consideration of risk. Further explanation of risky behaviour is attempted in section 6.6, and potential management responses are explored in Chapter 7.

6.4.5 *Model 3 - Management influence on beachfront property prices*

Five coastal management precincts (Appendix 2, pg 7) were identified in the *Collaroy Narrabeen Coastline Management Plan 1997 (CNCMP)*, and these are included in Models 3 and 4 as dummy variables. Warringah Council is currently updating the CNCMP, which is now two decades old, although the revised document is not publicly available at the time of preparation of this chapter. Hence the hazard zones and management are somewhat outdated and conclusions are drawn from the results with this caveat. It should also be noted that

Warringah Council failed to adopt the proposed development of a seawall in Precinct 3, due to substantial public opposition orchestrated by the Surfrider foundation (Figure 6.5).

Figure 6.5 "Line in the Sand" demonstration at Collaroy-Narrabeen, November 2002. Source: Sydney Morning Herald.

No properties included in the land value data provided for analysis were located in precincts 2 or 4; hence these are dropped from the model. Analysis is restricted to properties in Precincts 1, 3 and 5, represented by the attributes BchPrec1, BchPrec3 and BchPrec5, respectively. These precincts are subject to different coastal erosion patterns and management regimes, and hence represent different levels of risk and development. Their location is shown on Figure 6.3, and management considerations are detailed in Appendix 2.

BchPrec1 is located at the southern end of the beach. Properties in this precinct are not subject to the same erosion risks as those in other precincts, as they are primarily located on solid bedrock. As such, all but one of the 19 properties in this region are located outside the zone of Wave Impact. BchPrec3 is located in the central portion of the beach. This region of the beach is periodically subject to substantial erosion, as shown in Figure 6.6. All of the 42 beachfront properties in this precinct are potentially exposed to wave action. BchPrec5 is located at the northern end of the beach, in an area with a relatively extensive dune system. Hence, only 11 of the 36 beachfront properties in this location are subject to substantial erosion risk. This suggests potential for further classification, which is undertaken in Model 4.

Figure 6.6 Beach erosion in Precinct 3 following a large storm, June 2007. Source: Coastalwatch.

Table 6.7 presents the results of the analysis incorporating beach precincts. It can be seen that there is substantial variation in the implicit price premiums for beachfront property, with properties in the north (Precinct 5) and south (Precinct 1) of the beach subject to premiums around twice that of the beachfront properties in the centre of the beach (Precinct 3).

Table 6.7 Regression results for Model 3

Regressors (common)	Coefficient	Standard error	t-ratio	Implicit price premium (%)
Intercept	582580.84	21893.305	26.61	
Area	414.19	38.068934	10.88	0.07
Elevation	-4089.12	592.62609	-6.90	-0.70
MainRd	-169484.37	19753.423	-8.58	-29.09
Collaroy	213089.78	14056.054	15.16	36.58
Wtrfront	405816.82	27217.761	14.91	69.66
BchDrive	-82459.79	14672.56	-5.62	-14.15
Block1	417435.71	38226.713	10.92	71.65
Beach Regressors				
BchPrec1	1543510.00	132946.6	11.61	264.94
BchPrec3	717960.01	62485.641	11.49	123.24
BchPrec5	1433090.00	63579.858	22.54	245.99
Adjusted r-squared	0.73			
Model Test (10,1179)	315.92			
Durbin-Watson statistic	2.03			
Breusch-Pagan LM Statistic	670.06			

The parameter estimate for BchPrec1 is greater than that for BchPrec5. Whether this is because cliff-top properties have better viewscapes than those properties located behind dune systems, or because of differing risk profiles is unclear. (This was further investigated in Model 4). An alternative hypothesis lies in the location of specific coastal features. North Narrabeen is an iconic surfing location, so the *a priori* assumption is that beachfront properties to the northern end of the beach will be more valuable than other beachfront properties. This was indeed shown in Model 3.

As evidenced in the description of the beach precincts included above, and in the CNCMP included as Appendix 2, these zones are subject to different levels of erosion risk. All but one of the properties in Precinct 1 would be classified as BchSafe in the classification employed in Model 2, whilst all properties in Precinct 3 would be classified as BchRisk. Hence, the premiums associated with these zones are very close to those estimated for those categories in Model 2. The price premium for Precinct 1 is 265% compared to 269% for BchSafe in Model 2, whilst the premium for Precinct 3 is 123% compared to 141% in the previous model.

Precinct 5 properties display more variability, hence there is potential to explore the discounting of beachfront property due to risk avoidance in more detail. This is the basis of Model 4.

6.4.6 *Model 4 – risk aversion within precincts*

The final model investigates the potential for spatial preference along the length of the beach, controlling for risk of erosion. Thus the beachfront Precinct 5 properties are divided into those which are in the zone of Wave Impact (WIPre5) and those which are outside this zone (SafePre5). This allows for exploration of the interaction between location and risk attributes, with the assumption that whilst the desire for beach frontage can outweigh consideration of exposure to coastal hazards, avoidance of these hazards is still desirable. It is therefore hypothesised that the properties which are in SafePre5 will be considered more valuable than those which are in WIPre5. This is indeed the case, with an average price differential of around $362,000. This equates to a discount of the risk premium (relative to the average property, represented by the intercept) of around 62% for beachfront properties located within this zone (Table 6.8).

Table 6.8 Regression results for model 4

Regressors (common)	Coefficient	Standard error	t-ratio	Implicit price premium (%)
Intercept	584143.01	21986.28	26.57	
Area	413.66	38.18	10.84	0.07
Elevation	-4103.76	593.20	-6.92	-0.70
MainRd	-175016.15	20034.34	-8.74	-29.96
Collaroy	212716.31	14044.56	15.15	36.42
Wtrfront	404714.43	27233.28	14.86	69.28
BchDrive	-82965.52	14679.87	-5.65	-14.20
Block1	418418.51	38184.73	10.96	71.63
Beach Regressors				
BchPrec1	1543000.00	132990.21	11.60	264.15
BchPrec3	721958.40	62500.75	11.55	123.59
WIPrec5	1184670.00	53800.76	8.19	202.80
SafePre5	1547240.00	144649.97	28.76	264.87
Adjusted r-squared	0.73			
Model Test (11,1178)	293.36			
Durbin-Watson statistic	2.04			
Breusch-Pagan LM Statistic	707.36			

Small sample sizes and the component valuation system reduce the statistical power of this relationship such that it is not significant $F(5, 23) = 1.73$, $p = 0.17$. The relative size of the implicit price premiums for all the zones suggests that there is a hierarchy of preferences among purchasers of coastal property in the case-study area. Waterfront property, and that located within a block of the ocean beach are considered much more valuable than a representative property, with premiums of around 70% in both cases. Beachfront property which is at risk of erosion is more valuable again, though there is substantial variability in the premium for beachfront property along the length of the beach. Properties located in the more frequently eroded BchPrec3 demand a premium of 124% relative to average properties, whilst those properties located at the northern end of the beach demand premiums of around 203%. This may be due to a desire to be located close to the surf break at North Narrabeen. The greatest premium is payable for those properties which have ocean frontage, but are not subject to the same degree of risk. These properties are to be found in BchPrec1 and SafePre5, and demand premiums in the order of 264%, relative to an average property in the area. This hierarchy suggests some potential management options, which are discussed in the next chapter.

6.5 Discussion

6.5.1 *Market validation*

Attempts were made to validate the results of this analysis through examination of market transactions for the same area. The absence of centralised data on housing market transactions in Australia makes this problematic, as it is reliant upon the efforts of local real estate agents and auctioneers, and also the purchasers and sellers of the property being willing to provide the sales data (Beer and O'Dwyer, 2000).

Property transaction details for the 24 month period to November 2009 were purchased from Australian Property Monitors for the postcodes 2097 and 2101 (Collaroy and Narrabeen, respectively). This represented over 1600 records. Upon removal of data representing apartments and those for which price of property data was missing, however, this sample size reduced to 437 records. Matching these against the sample of unimproved land values identified only 147 matches with full data availability. Of these, only five properties were beachfront properties. Due to the small sample size, further analysis was not pursued. Whilst previous studies have attempted to draw conclusions from such sample sizes (Pompe and Rinehart, 1999), I do not consider this to be an appropriate practice.

This highlights the challenges with application of hedonic studies in Australia, and also supports the hypothesis that beachfront property in the Sydney market is very tightly held. This is consistent with studies elsewhere, which indicate that waterfront properties are not subject to the same degree of resale as other similar properties (Kriesel and Lichtkoppler, 1989). Significant erosion was experienced in June 2007 (Watson et al., 2007); hence property transactions for beachfront property may have been limited due to depressed beachfront property markets. Whilst the global financial crisis (GFC) also appears as a potential explanation, the property valuations employed in the current analysis were all completed prior to the onset of the GFC.

In reality, the unimproved land values in developed areas (where vacant land is rare) are estimated from market transactions. Professional valuers make allowances for the building characteristics, accessibility and key amenities in performing their assessment (NSW Department of Lands, 2004b). Pearson et al. provide an overview of the process of determining unimproved values for developed land (in Queensland), and a brief summary of the case law that supports the use of this method in valuation (Pearson et al., 2002).

Thus, property variables have been implicitly included in the model, although the inclusion was based upon professional experience, rather than the assumptions and analysis of the econometrician. The use of unimproved land values removes a degree of complexity from the model, as it does not require inclusion of property variables which describe the built structure. This results in greater accuracy, as these factors do not influence the estimation of the price premium attributable to the environmental amenity (Pearson et al., 2002). It also means, however, that it is not possible to estimate the willingness to pay (WTP) of buyers in the housing market for changes in the levels of the environmental attributes, it is only possible to estimate the likely WTP, in the event that the properties in the area were all undeveloped land parcels.

6.5.2 *Explaining risky behaviour*

The assumption in hedonic analysis of market transactions is that the consumers and producers have complete information about all features of the property. In the case of exposure to natural hazards such as coastal erosion and inundation, this assumption may be violated (Kask and Maani, 1992). This is particularly relevant in the case of projected climate change impacts, where various impacts are associated with differing levels of confidence and precision (IPCC, 2007b). It is possible that purchasers are not fully aware of their exposure to risks through purchasing in threatened locations. As a result, their subjective probabilities (perceived risk) are highly different from objective probabilities (actual risk). These differences are related to the quality and quantity of available information (Kask and Maani, 1992). Those seeking further information on the risks may not be able to assimilate the information in a way which affects their purchasing behaviour.

An explanation for 'risky purchases' in the case-study area may also be found in the history of coastal erosion on the NSW coast. There has been a relatively benign period of coastal activity since the 1970s, which is linked to the El Niño-La Niña cycle (Ranasinghe et al., 2004). This means that the majority of properties in the area have been sold and purchased in a time with little history of severe erosion. Research in the area of health risks of known likelihood has shown that the ability of a person to successfully process risk is related to: the time since the last impact, personal impacts on the respondent, anchoring effects, and the quality of the individual's recall (Lichtenstein et al., 1978). It may also be the case that there is 'invisible risk', which is risk that is difficult to understand or process, and hence is not properly considered (Yamashita, 2009). Kriesel and Lichtkoppler theorise that a property must be 'visibly' at risk at the time of the transaction before it affects the value (Kriesel and Lichtkoppler, 1989).

Other research has shown that if the likelihood of an event is below some threshold value (e.g. 1 in a million), then the perceived probability drops to zero (Kunreuther et al., 1978). Investigations in the field of cognitive dissonance have also suggested that people discount information on risks that are contrary to their entrenched preferences and prior experience (Bradshaw and Borchers, 2009). Thus, if provided with information that their house is subject to a threat of erosion, despite their historical knowledge of the area being relatively safe from that risk, they may place less credibility in this new information. This is not an irrational choice, rather reliance on alternative information which they believe to be the truth (Akerlof and Dickens, 1982). Whilst a number of authors have attempted to separate risk and proximity or exposure in hedonic studies (Bin et al., 2008, Daniel et al., 2009, Donnelly, 1988, Hallstrom and Smith, 2005), this remains an area for future research. Further opportunities for extension of this application are discussed in the next section.

6.6 Opportunities for future work

There are a number of avenues for expansion of this study. The first of these is time series analysis, through the use of a similar methodology to the repeat-sales analysis of Parsons (Parsons, 1992). The annual land valuation process in NSW (NSW Department of Lands, 2004b) provides significant potential to examine the impacts of (past and proposed) coastal land-use policy changes on the value of coastal property in Sydney (Palmquist, 1982, Parsons, 1992). The current study provides a baseline against which these changes can be assessed.

An additional area for expansion can be found in consideration of coastal visual amenities. Whilst the importance of ocean views in determining coastal property prices has been a substantial focus of the literature, there has not previously been an examination of the importance of views of the beach itself. This is curious, given that the view of the ocean is not something which can be influenced by management intervention, except through building restrictions, whereas the presence or absence of views of the sand may be directly influenced by the choice of erosion management response. With the use of GIS technology, it is possible to estimate the economic impact of both widening and narrowing of the beach through hedonic means. This would require estimating the future extent of the beach in terms of elevation and seaward extent. The cumulative value of a narrower beach due to shoreline recession would be assumed *a priori* to be smaller, as fewer properties will be able to see the strip of sand. Conversely, a wider beach through large-scale nourishment activities may increase the number of properties with a beach view, and could result in an increase in value of the properties with newly acquired visual amenity. This is a future avenue of research to be undertaken once more complete elevation data is available.

6.7 Chapter summary

This chapter demonstrated a relatively simple hedonic analysis of coastal property at one of the case-study locations, Collaroy-Narrabeen. Results indicate that beachfront properties are subject to a substantial environmental price premium. The strength of this relationship is explained in terms of the exclusivity of beachfront property in the Sydney region, and failure to adequately consider potential risks for a range of technical and psychological reasons. The costs associated with management choices in response to loss of beaches will be examined further in the next chapter, as well as opportunities for management intervention in the reduction of risk to coastal property.

7 Conclusions and management implications

Having established in previous chapters that there are substantial economic benefits and income streams derived from the beaches at each of the case study locations, this chapter now turns to discussion of how this information can influence selection of coastal management options and effective policy responses to the projected climate change impacts on these locations.

7.1 Summary of research findings

This section presents a summary of the thesis. It first examines the primary research questions and objectives, and provides a brief response to each item. This naturally flows to an assessment of the limitations of the current study, which in turn frames the areas for future research.

In examining the research findings, it is useful to first restate the research questions outlined in section 1.5. These questions were:

- What is the existing economic importance of daytrip visitation and recreation at the case-study beaches? (Individual Travel Cost Method - ITCM)
- What aspects of beaches are drivers of tourism and recreation demand? (ITCM/Contingent Valuation Method - CVM)
- How will visitors respond to the absence of sand at the case-study locations? (Contingent behaviour)
- Are beach users willing to pay to prevent the loss of sand? (CVM)
- What is the affect of beach amenities on the local property market, and how are these influenced by erosion risk information and coastal planning zones? (Hedonic Pricing Method - HPM)

7.1.1 *Value of daytrip recreation and tourism*

Expenditure estimates for the four case study sites show a range of travel costs from $2.90 at Collaroy-Narrabeen to $14.72 at Brooklyn. Manly and Dangar Island samples had average travel costs of $6.31 and $7.49, respectively. Differences between samples were statistically significant. A highly localised population was sampled, indicating that survey administration should be carefully considered in future beach valuation studies. Online samples for Collaroy-Narrabeen and Manly had average travel costs of $3.37 and $6.37, respectively. Differences between the onsite and online samples were not statistically different. Onsite expenditure per person did not differ significantly between case-study locations, and was in the range of $4.25 (Collaroy-Narrabeen) to $5.62 (Manly).

Whilst demographic characteristics of the sampled populations at Brooklyn and Dangar Island did not differ substantially, significant differences were found in both the travel mode and travel cost parameters. This indicates that there may be substantial differences in patterns of visitation and expenditure even in adjacent beach locations, particularly when they differ in terms of transport options and accessibility characteristics. Whilst originally selected as a combined site, differences in travel patterns meant that they could not be incorporated into a pooled model for estimation of a trip demand function, and hence estimates of consumer surplus were not possible.

Consumer surplus estimates were derived for the other case study sites, with estimates varying based on the included cost components. Estimates of the consumer surplus related to a beach visit are in the order of AUD$2.72 to $20.63 per person per day, depending on the site visited, model assumptions and inclusions.

Attempts to determine beach visitation were unsuccessful, highlighting the lack of essential information for coastal management in the current day. This is only likely to be more critical in determining the responses to future climate change impacts on coastal resources. The best available estimates indicate that total beach visitation in the Sydney region is in excess of 5 million visits per year, and may be as high as 10 million. In the absence of reliable visitation estimates, it is not possible to determine an aggregate value of beach recreation that can be treated with much confidence.

7.1.2 *Factors influencing beach choice*

Given the highly localised samples collected in the onsite survey, it is unsurprising that easy access is highly cited as a motivation for beach visitation. Recommendations about a site were also responsible for a large proportion of visitation at Manly, Brooklyn and Dangar Island, accounting for more than 20% of all visits. This suggests that any negative impacts and experiences have the potential to greatly affect future visitation, through word-of-mouth. The importance of individual site features, such as a walking path or good swimming conditions, was lower than expected. This suggests that, at least for some of the case-study sites, the beach itself may be an ancillary component of the recreational day trip. There may also be a more muted than expected response to changes in these attributes in response to climate change.

7.1.3 *Response to loss of sand*

The contingent behaviour question incorporated into this study provides important information regarding the response of beach visitors to the temporary loss of sand at the case-study beaches. This information can be used to estimate the likely economic impact of beach closures through integration with travel cost information. Responses gathered in this study provide for some degree of optimism with regards to the potential impacts of climate-related beach erosion, as a relatively large proportion of respondents indicated that they may not necessarily be adversely affected by the absence of sand. Analysis of responses from the online survey suggest that only a subsample of beach visitors actually engage in physical contact with either the sand or the water. In the case of Collaroy-Narrabeen, 19% of respondents spent the majority of their time on the sand, with 53% spending the majority of their time in the water. For Manly beach, a similar proportion of respondents (17%) spend their time mainly on the sand, with far fewer (22%) engaging in water-based activities. These differences reflect the different character of the case-study beaches, and are likely to result in different behavioural responses to the loss of sand. It should be noted that the sampling procedure introduced a bias against the users who spend the majority of time in the water, due to logistical challenges.

It should be noted that these responses are likely to vary with both the severity and duration of beach erosion events (Smith and Palmquist, 1994), and that under climate change projections there may be a total and permanent loss of sand at some beaches. It is expected that responses to permanent shoreline recession would differ greatly to those for temporary events. Behavioural responses to beach erosion can also be used to explain responses to contingent valuation responses, which is an area of research that is worthy of future efforts.

7.1.4 *Willingness to pay for erosion prevention*

Whilst belief in the erosion scenario was high, equating to around three-quarters (78.3%) of the total sampled population, this did not translate directly into a positive WTP for beach erosion protection. Protest responses accounted for approximately half of the total sample, with statistically significant differences between the case-study sites. Protest rates ranged from 36% at Collaroy-Narrabeen to 65% at Brooklyn. At Manly and Dangar Island the protest rates were 46% and 39%, respectively.

Analysis of qualitative follow-up responses provides some explanation of the motivations underlying WTP. The most common reason cited for not being WTP was consideration of substitute sites, with 36% of those who provided a negative response to the principle payment question citing this as their primary reason. This indicates that any future survey that builds upon the work in this thesis must incorporate more explicit consideration of the availability of substitute sites. Recreational use of the beach was the most commonly cited (73% of those who indicated in-principle support for the project) reason for being willing to contribute to the erosion management project. This would suggest that funding options for beach management are likely to be supported primarily by users of the resource.

The median WTP for erosion protection was AUD$116.27± 69.63 per person as a once-off donation, among those who indicated in-principle support for the erosion prevention project. Responses indicated significant sensitivity to the amount requested, with all respondents WTP small bid values ($5), and comparatively few WTP large amounts ($100-$500).

7.1.5 *Price premiums for beachfront property*

The hedonic analyses conducted for the Collaroy-Narrabeen case-study site demonstrated that there were substantial premiums paid for beachfront property. In the simplest model, beachfront properties were worth approximately 200% more than the average property in the sample area. A number of more complex models were employed to investigate the influence of coastal erosion information

There was substantial variability in beachfront values along the length of the beach, with properties in the centre of the beach worth approximately 40% less than those at the northern and southern ends. It appears that this is related to coastal erosion risk. In the most complex model, it appears that coastal erosion risk information has a negative influence on this price premium. Beachfront properties which were included in the zone of Wave Impact, with notations included on the property title, were subject to a discount of 40%, relative to properties in the same locality without the same level of erosion exposure. This suggests opportunities for management via risk disclosure, as outlined in section 7.3.

7.2 Comparison with previous Australian studies

This section compares the findings of the current study to previous beach valuation estimates from studies conducted in Australia. Comparison with estimates available in the international literature is undertaken only where there is no alternative, as it remains my opinion that the different socioeconomic and biophysical contexts render these evaluations problematic.

There are few Australian studies that provide suitable estimates for comparison, which was a major motivation for the current study. The findings of this study represent an important baseline against which future studies can be assessed, and provide timely information in selection of coastal management options for the NSW coast. Nevertheless, some contrasts can be drawn.

7.2.1 *Travel cost findings*

In the case of the TC results, the most similar study is that of Blackwell, who explored visitation at Mooloolaba beach with a negative binomial travel cost model (Blackwell, 2007). Comparison between the two studies is complicated by different definitions of travel cost components. Blackwell estimates consumer surplus for four travel cost parameters, of which only three are statistically significant. Blackwell reports estimates from a model which incorporated the costs of travel time into the TC parameter (TTSCTIM), but includes the costs of depreciation in these calculations. A similar model was not estimated in the current study, due to concerns about determining the marginal cost of use of vehicles for beach visitation.

The TC specification which most closely aligns with a specification in the current model is TTSCMIN, which includes only the fuel costs of those who drove to the site. This is most closely aligned to Model 1 in the current study, although in the current study the estimates are derived from a pooled sample of visitors employing a range of transport modes. Blackwell estimated consumer surplus for this model of $12.99 per person-visit for the entire sample, with further distinction by residents and visitors, with figures of $2.39 and $11.86 for these two groups, respectively (Blackwell, 2007). Standard errors and confidence intervals are not reported. Taking the resident and visitor estimates, and adjusting for inflation via the consumer price index (http://www.rba.gov.au/calculator/annualDecimal.html) for the period between the surveys conducted by Blackwell and those in the current study (1999-2000 and 2008-2009, respectively), gives figures of $3.26 and $16.20. Figures in the current study ranged between $2.72 (±0.56) for Collaroy-Narrabeen and $9.20 (±1.92) for Manly beach, with residents and tourists jointly estimated in a pooled sample. There is general agreement between the two studies, with the figures for Collaroy-Narrabeen aligning closely with the resident sample, befitting the high proportion of local residents surveyed.

For the other sites, demand functions were not estimated, and hence the best comparison is with other studies which examine expenditure rather than consumer surplus. Raybould and Lazarow estimated average expenditure of Gold Coast beach visitors in two studies, separating respondents into local residents and tourists (Raybould and Lazarow, 2009). Expenditure of residents was in the range of $0.50-$2.30 per beach day per person (2008 AUD). Average travel costs for Brooklyn and Dangar Island are $14.72 and $7.49, respectively, with no differentiation between local residents and visitors from further afield. This is more in line with the estimates derived by Raybould and Lazarow for tourists, which were in the range of $15-$45 per beach visit (2008 AUD). Travel distances and time are lower than those found in the current study, which explains the lower expenditure in the resident sample. The resident sample is highly localised, with around half of all respondents living within 5km of a beach, although census data suggested that this under-represented the local population.

7.2.2 *Contingent valuation findings*

In terms of the CV analysis, there are no good studies for comparison, as any results are strongly influenced by the selection of erosion scenario and payment vehicle. The use of a percentage damage scenario rather than an absolute loss of beach days, whilst more realistic from a coastal geomorphology perspective, further diminishes potential for comparison.

7.2.3 *Hedonic pricing application*

The limited number of coastal hedonic applications in Australia precludes substantial comparison. The premiums for oceanfront property estimated in this study are substantially higher than those estimated by Burgan, who examined coastal property in Adelaide (Burgan, 2003). This study estimated premiums in the order of 30% for beach frontage. Having visited the case-study sites examined in Burgan, I would suggest that the majority of properties included in Burgan's analysis are not truly beachfront properties, but are separated from the ocean in most instances by substantial seawalls and public roads. Hence they may be in fact representing implicit prices for proximity and visual amenities, rather than frontage as stated.

Studies overseas have shown that ocean frontage may increase the value of a representative house by values closer to those found in this study. Bin and Polasky estimated premiums for ocean frontage of around 138%, which are at least comparable in order of magnitude (Bin and Polasky, 2003). The small number of property transactions, and the exclusivity of the beachfront property market in Sydney, may provide some explanation about the relative contribution of direct beach access, which is higher in this study than in other similar studies in Australia.

7.3 Management implications and opportunities

In addition to the derivation of value estimates, this thesis also sought to explore a number of questions in relation to the management implications of the valuation findings. Whilst not the primary focus of the current study, consideration of the management context is critical in determining both how the valuation work should be undertaken, and also how the findings can best be integrated into the policy and management frameworks. To this end, additional questions that form the basis of this chapter were:

- What can be said about the impact of climate change on the values previously identified?
- How will these values be affected by management interventions or coastal policy changes?; and
- What are the implications for current and future coastal management, with a focus on the Sydney region?

This section does not attempt to answer these questions directly, as to some extent the uncertainty associated with climate change precludes clear analysis. It instead provides some consideration of key coastal management responses to the climate change impacts that were considered of greatest relevance in the current study. These were the influences of inundation and shoreline recession through erosion events and sea-level rises.

The extent to which management can respond to inundation threats is somewhat limited, and will become more so as inundation frequency, depth and duration increase in line with SLR (Adger et al., 2005). As such, the focus of this section is on the potential responses to shoreline recession. As discussed in previous chapters, there are two main classes of response to shoreline recession, those related to retreat and those related to protection or modification of the property to alleviate the impacts. This section examines the potential costs associated with the retreat and nourishment options.

7.3.1 *Aggregate value limitations*

Efforts to estimate aggregate values for the economic value of beach recreation and the WTP for beach erosion protection are stymied by the absence of visitation figures. Whilst considerable effort was certainly expended in attempting to obtain defensible visitation estimates, the extent to which this was successful varied substantially by case study site. No estimates whatsoever are available for either Brooklyn or Dangar Island, precluding the estimation of aggregate values for these sites, even when talking purely about expenditure analysis. Only one visitation estimate (surf lifesaver estimates) is available for Collaroy-Narrabeen, with considerable data gaps at key locations along the length of the beach.

Thus the only potential estimation of an aggregation value which would withstand much scrutiny would be at the case study location Manly Ocean Beach. This could be based on a systematic methodology that allows for uncertainties, for example via a Monte-Carlo simulation approach. Given the lack of reliable cost estimates outlined above, this remains one of the potential avenues of future research, but is outside the scope of the current study. In the absence of cost estimates for the key management responses of retreat and beach nourishment, proxy data must be used.

7.3.2 *Cost of retreat*

Ultimately, coastal management problems arise when development or hard structures restrict the ability of the natural beach system to respond to change. In the absence of coastal development, there would be no need for management interventions. Even in the presence of development, there is an argument for relocation of threatened assets, rather than enhanced protection (Pilkey and Dixon, 1998).

If no action is taken, and recession is allowed to continue, then the impacts can be estimated by examining the value of property which would be lost to the ocean. Parsons and Powell estimated the cost of retreat for Delaware, using hedonic analysis to determine the cost of land and structures under threat from coastal retreat over a 50 year time period. They conclude that nourishment is an economically feasibly alternative, given the constraints selected (Parsons and Powell, 2001). There is a fundamental flaw in the exclusion of amenity values, however. The authors assume that these values should be excluded, as they merely 'roll' backwards onto the properties which are now on the beachfront (Parsons and Powell, 2001). This in turn assumes that there is no structural boundary, either natural or artificial, that would restrict this movement. In the majority of policy applications, there is likely to be a terminal barrier in the form of a road, if nothing else. This will serve to restrict landward movement, and cause erosion of the sand from in front of the structure, thereby removing the source of the majority of beach amenities.

Hennecke et al. integrated a GIS-based recession model with a register of land values to estimate the cost of erosion at Collaroy-Narrabeen (Hennecke et al., 2004). There are a number of calculations used which weaken the usefulness of results. One is the development of a ratio between sale price (market value) and land value, using the entire local government area (LGA) due to a lack of sales data in the study area. This is, in effect, the reverse process that was applied by the Valuer General in determining the land value, although there is no guarantee that the same outcome will be achieved. The authors also assume a linear relationship between the percentage area of individual lots lost to recession and the resultant impact on property value. This is unlikely to be the case in practice, as there may be a point where recession renders a proportion of the land uninhabitable, hence the value drops markedly.

Perhaps most importantly, whilst an uplift factor is applied to estimate the future value of land in 50 years, and property improvements are depreciated over the same timeframe, there does not appear to be any discounting of losses incurred in the future. Incorporation of discounting (at 7%) changes the figures substantially, with the projected losses in 50 years time resulting from a 50 year storm and 50 years of SLR equating to around $8.3 million (1998 AUD$), as opposed to the $245 million cited in Table 6 of the paper (Hennecke et al., 2004).

In the case of the current study, the total value of property located within the first block from the ocean is approximately $245 million (2008 dollars), with $191 million of this figure attributable to beachfront property. Of this beachfront property, around $88 million worth of property is located within the zone of wave impact, and can therefore be considered at serious risk of erosion. It is important to note that this represents only the land value. Advice provided by local real estate agents is that the built structures result in an uplift of 75% above the rateable land value (AECOM, 2010). Thus it is estimated that around $154 million in property is likely to be subject to the effects of erosion. Without knowing the exact timing and magnitude of erosion events, it is not possible to perform an effective cost-benefit of a retreat policy. The magnitude of these figures suggests that retreat may not be the most cost-effective response to shoreline recession, however, which leads us to consideration of alternatives. Whilst these could take a number of forms, the results generated in the travel cost component of the current study suggest that these should be restricted to those options which preserve the presence of sand on beaches, rather than simply provide property protection services. The next section therefore considers the costs associated with beach nourishment.

7.3.3 *Costs of beach nourishment*

Given the severity of impacts projected for ocean beaches in particular, this discussion must consider whether or not these beaches should be preserved through management intervention. Whilst there are a number of means to achieving the preservation of sand on beaches, including construction of artificial reefs and breakwaters, financial and practical concerns limit likely options to those which endeavour to increase the sand buffer through nourishment. Under the NSW Coastal Management process, there is a requirement to ensure that access is maintained or enhanced. There is also a preference for approaches which are adaptable, and do not enhance the risks of coastal hazards (NSW Government, 1990). Under conditions of erosion, this would suggest the need for beach nourishment on some scale. The focus of this section is therefore to explore, in necessarily generic terms, whether there is economic justification for beach nourishment at each of the case-study locations.

The first issue is to ascertain estimates of the cost of nourishing the case-study sites, for use in a back-of-envelope CBA of these actions. This presents challenges, given that there are no currently accessible sources of sand for such activities. There are also no known nourishment projects suggested for the case study beaches (AECOM, 2010). The comparison of costs and benefits undertaken in this concluding chapter is reliant upon cost estimates derived from the SCCG Offshore Sands project, a scoping study conducted on behalf of the Sydney Coastal Councils Group, which investigates the feasibility of using offshore sand deposits for beach nourishment (AECOM, 2010). The full report is available at the SCCG website[17]. The executive summary of the report, estimation of nourishment costs for Collaroy-Narrabeen and Manly, and economic appraisal component of the study are provided in Appendix 8. These estimates involve a number of assumptions, such as returning beaches to a pre-development profile, which would not be typical in projects proposed by local Councils due to cost constraints. Their usefulness in a formal CBA is thus questionable, and such a rigorous analysis is not undertaken. The use of offshore sands for nourishment is also not currently supported by the NSW Government, which is the major source of funding for such activities. Hence a formal CBA would be of theoretical interest only, and would serve to duplicate the SCCG Offshore Sands report. Whilst there remain a number of legal and political obstacles to the implementation of such a project, the report nevertheless provides a recent estimate of costs for the two ocean beach case-study sites. The report also provides a desktop study of benefits associated with the project which is not discussed further, except to say that the benefit estimates in the current study are substantially higher, and thus strengthen the case for nourishment.

The report estimates the costs of dredging and nourishment for Collaroy-Narrabeen and Manly, assuming a SLR or 10cm per decade. Nourishment is proposed to occur in a series of campaigns at 10 year intervals, with the initial campaign to include sufficient sand volumes to return beaches to the extent that was likely in 1870, and subsequent campaigns to maintain this volume of sand (AECOM, 2010). Cost estimates are provided in Table 7.1. In the case of Collaroy-Narrabeen, allowance has been made for sand losses into Narrabeen Lagoon, and these are included in the total figures.

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[17] http://www.sydneycoastalcouncils.com.au/node/53

Table 7.1 Nourishment cost estimates for case-study beaches.

Location	Campaign 1 Nourishment cost estimate ($AUD)	Subsequent campaign cost estimates ($AUD)
Manly	15,611,122	6,202,986
Collaroy-Narrabeen	28,096,025	11,163,787
Narrabeen Lagoon	3,433,061	1,364,447
Total for Narrabeen	**31,529,086**	**12,528,234**

Comparison with benefit estimates from the current study is complicated by the lack of information necessary to estimate aggregate values. Some assumptions must therefore be made about visitation figures. Assuming the SLSA figures for visitation at Manly and Collaroy-Narrabeen are reliable estimates, and employing the consumer surplus estimates derived in Chapter 4 of the current study, aggregate estimates can be derived. Whilst the estimates of visitation are questionable, they are likely to be underestimates, and hence are conservative. The same approach is taken with welfare estimates, which use consumer surplus figures derived from the model which only incorporates direct travel expenditure. Figures employed are presented in Table 7.2.

Table 7.2 Estimates of aggregate value for case study ocean beaches

Beach	Visitation estimate (SLSA estimates), beach visits per annum	Consumer surplus (Model 4 – TC and TTC at 25% wage rate) AUD$ per visit	Annual recreational value (AUD$ p.a.)
Manly	855,877	16.18	13,848,089.86
Collaroy-Narrabeen	293, 090	10.28	3,012,965.20

Using these figures, the economic case for nourishment is strong. Assuming that the welfare estimates remain stable over a decade, and discounting at a rate of 7% as per the guidelines from the NSW Treasury (New South Wales Government, 1997a), the net present value (NPV) figures for Collaroy-Narrabeen and Manly are $22.6 million and $104.1 million, respectively. This would suggest support for the project, although it should be noted that this assumption is only valid in an all-or-nothing situation, where all benefits of beach recreation would be lost without the management expenditure.

These figures are based on the highly simplistic assumption that all visits will cease in the event that the beach is lost. The responses to the contingent behaviour questions incorporated into this study show that this is unlikely to be the case. When these behavioural responses are integrated with information about the travel and spending patterns of beach visitors (such as those generated in the current study), it can be used to provide information about the likely economic implications of lost tourism- and recreation-derived revenue, if beach visitation was to decrease. Consequently, this could be used to inform decisions about coastal management alternatives with different levels of impact on beach environments. Both the online and onsite surveys employed in this project also asked respondents what they would do if they ventured to the beach to find there was no sand (see section 5.4.11.1. The results of this question are presented in Table 5.20-5.22, and show that the proportion of people who state that they would not be adversely affected by the loss of sand from the beaches ranges from 29% at Collaroy-Narrabeen to 61% at Brooklyn.

It should be noted that these responses are to a short-term closure of the beach, whereas the long-term impact of climate change will be total and permanent loss of the beach. Taking the assumption that behavioural responses will be consistent, something which has been proven to be false by previous studies (G.R. Parsons, et al., 2009), the benefit estimates for Manly and Collaroy-Narrabeen are scaled by the relevant proportions (0.16 and 0.28, respectively, the proportion who stated that they would go elsewhere, hence the benefits are assumed lost to the LGA). The resultant potential annual benefit loss estimates due to total erosion of beaches for Manly and Collaroy-Narrabeen are downscaled to $2,215,694 and $843,630, respectively. It should be noted that these figures represent only the use value of the beaches for daytrip recreation. There is a potential argument for addition of the values derived in the hedonic pricing and contingent valuation studies to these figures, in order to arrive at a more complete estimate of the benefits provided by these beaches. This addition has not been undertaken, as there are a number of theoretical obstacles. The first of these is that the CVM estimates are, at least hypothetically, holistic estimates that include use values. It is not possible to separate the relative contribution of use and non-use values, and hence double-counting cannot be avoided. In the case of the values derived in the hedonic pricing study, these are derived from unimproved land valuations data rather than market sales. Hence, the relative importance of beach proximity and risk may not be identical when considering building age and other factors. The addition is therefore not undertaken.

Cost figures are also dependent on the sand volumes and assumptions included in the cost calculations (see Appendix 8 for details of calculations), hence they can provide estimates for comparison only in the event that a nourishment program would adhere to these specifications. Unit costs are very high compared to the international literature (Muñoz-Perez et al., 2001), and also to similar exploratory studies in Australia (Patterson Britton and Partners, 2006). The unit costs include substantial allowances for environmental studies and the like (detailed in Appendix 8). Revision of these figures to more consistent figures from the nourishment literature would strengthen the argument for the nourishment campaigns.

It would therefore appear that the economic case for nourishment is supported by the recreational use values of the case-study locations alone. A number of caveats must be placed upon these comparisons. Whilst these figures are substantial, particularly when compared to available management budgets, this does not mean that it is possible to draw the conclusion that the proposed nourishment project is justified, without project-specific cost and benefit estimates. This would require a more rigorous cost-benefit analysis including all value streams, including the substantial non-use and housing amenity values identified elsewhere in the thesis.

7.3.4 *Comments on economic feasibility of beach erosion prevention activities*

Given the absence of defined coastal management options at the case-study locations, comments on the selection of alternatives must necessarily remain broad. As such, this section provides a ‘non-technical’ assessment of the feasibility of erosion prevention through beach nourishment at the case-study locations.

Dunn et al. find that beach nourishment can satisfy a CBA assessment only in densely populated and highly visited locations. In other areas, alternative means of management such as managed retreat must be the primary focus, with nourishment only incorporated as a component of the coastal management strategy (Dunn et al., 2000). It would appear that the results of this study support their suggestions.

Recreational expenditure supports the economic argument for beach nourishment at Manly beach, which is the most highly visited of the case study locations. At Collaroy-Narrabeen there is support for nourishment through looking at the influence of beach frontage and erosion hazard on the local property market. At the other case-study sites, the situation is less clear. Brooklyn receives beach visitors from a large ‘catchment area’, given the lack of available beach substitutes. Whilst estimates of visitation are difficult to establish, the relatively minor expense associated with maintaining a sandy beach within the bathing enclosure would appear justified on economic terms, given the high per-capita expenditure on travel costs and onsite expenditure.

Dangar Island presents a more clouded picture, given the highly local nature of the visitation. This suggests that the recreational value of the location is unlikely to support the expense associated with maintaining the status of the beach. It also suggests that the beach represents a strong attraction for purchasers of coastal property in the area. Purchasers of beachfront land parcels are therefore likely to have incorporated some form of capitalisation of future recreational opportunities in determining their ultimate WTP for the properties. It should therefore be possible to estimate the recreational value of these properties as per Edwards and Gable (Edwards and Gable, 1991). This was not undertaken in the current study due to limitations of the available non-market land value information available, but remains as a potential area of future work.

There are also practical considerations regarding the potential for nourishment of Bradley’s beach. There is a substantial seagrass bed located offshore from Dangar Island, which could be adversely impacted by any nourishment project undertaken at the site[18]. As the site is located within the Hawkesbury Estuary and not subject to the same degree of wave exposure as the other locations, it is likely to suffer more greatly from the effects of inundation rather than shoreline recession. Given the very low relief of the beachfront properties, of which some are around one metre above Highest Astronomical Tide (HAT) there is a limit to the extent that nourishment could prevent climate change impacts. The relatively small number of

[18] http://www.seagrasswatch.org/latest_news/Dangar_Is_Workshop.pdf

beachfront properties suggests the potential for enacting either managed retreat or voluntary repurchase policies.

As outlined in Chapter 2, coastal management options in developed urban areas are restricted by feasibility. They are also restricted by economic reality. All options considered in Coastal Zone Management Plans in the Sydney region, and detailed above, carry price tags in the multiple millions of dollars. Those options which are designed to preserve the existence and nature of the beach, thus preserving the economic streams and relationships identified in the current study, are likely to be the most expensive of all. It is important, therefore, to examine the existing sources of coastal management funding in NSW, and to perform some assessment of their adequacy.

7.3.5 *Funding limitations*

The primary sources of coastal management funding in NSW are internal revenue from the relevant local Council, and grant funding from the NSW State Government (NSW Government, 1990). There is no national coastal body providing funding for management or dredging programs, such as the role undertaken by the US Army Corps of Engineers (USACE), and private funding options have not yet been employed, despite recent suggestions for coastal protection service charges, detailed in section 7.3.7.

There is no national coastal management agency in Australia, and federal funding for coastal management actions is restricted to individual grants under complementary programs. Thus the costs of any coastal management activities are borne primarily by local councils, with potential for assistance from the relevant State governments.

Council revenue is derived primarily from rates revenue. As an example, Warringah Council received approximately $77 million in rates and service charges in the 2009-2010 financial year, which represented 57% of total income (Warringah Council, 2010a). This income stream is essentially fixed, as the ability of councils to increase revenue is limited in NSW by the practice of rate pegging, which is a State Government system which limits the amount of revenue which can be collected through rates[19]. The allowed percentage increase in total income generated from rates is prescribed each year by the Department of Local Government, with calculations made with regard to the Consumer Price Index.

The NSW coastline management program is the primary source of additional funding for coastal management activities in NSW (NSW Government, 1990). An examination of the funding of the program and an assessment of adequacy is therefore justified. In the 2009-10 NSW State Budget, $19.1 million was announced for the Department of Environment, Climate Change :

"…to support local councils undertaking estuary, coastal and flood plain management activities, with a new focus on preparing for sea-level rise"[20].

Of this amount, only $820,320 was allocated to the Coastal Management Program, with a focus on the preparation of coastal hazard assessments[21]. It seems clear that this is unlikely to result in adoption of either of the coastal management options outlined in the previous sections, even for a single beach.

It is also important to note that not all funding offers are taken up by local councils. The funding is allocated as retrospective reimbursement of 50% of funds expended by the council. Thus the council must be able to either allocate the full amount from internal revenue, or to access alternative funds, which may entail further administration or interest costs. Funds may also be used over a number of years, depending on the process for which they are allocated. Hence, actual budget expenditure may vary on an annual basis.

7.3.1 *Potential sources of funding*

As can be seen from the previous section, there is a lack of available funding under existing programs to implement either retreat or nourishment options. As such, it is likely that coastal management options will be restricted to those which are lowest in terms of capital

[19] http://www.dlg.nsw.gov.au/dlg/dlghome/PublicTopicsIndex.asp?mi=0&ml=10&id=8#9
[20] http://www.treasury.nsw.gov.au/__data/assets/pdf_file/0016/17611/bp3_03dprem.pdf
21 http://www.environment.nsw.gov.au/coasts/coastalmgmtgrants2010to11.htm

expenditure, namely the construction of seawalls. Having looked at the existing sources of funding for coastal management in Sydney, and found them to be inadequate for the types of projects that would be required in order to ensure the persistence of beaches in Sydney, this section discusses potential alternative sources of funding for both existing and future management costs, and also means of funding retreat options. The options discussed here are presented as hypothetical possibilities, without a full assessment of the broader economic implications or the legal and practical obstacles to their implementation.

7.3.2 *Implementation of a coastal tourism bed tax*

Tourism bed taxes were introduced in NSW in 1998, but repealed in 2001 with the introduction of the national Goods and Services Tax (GST) (Row and Duhs, 2001). Tourism taxes are commonplace in other areas where significant beach-related tourism occurs, such as California and Florida (King, 2008). These taxes are applied as a surplus charge on accommodation costs, and are typically in the order of 2-10% (Mak, 1988). These taxes are placed in a fund to be used for coastal management activities (King, 2002).

Proximity to the shoreline, and to key features such as more natural beachfront, have been demonstrated through hedonic analysis to be drivers of accommodation prices (Hamilton, 2007, Smith and Palmquist, 1994). Under erosion conditions, these will also be the areas which require greatest management attention. Hence the use of relative percentages, rather than fixed price measures, ensures that the taxes are distributed with spatial equitability. Higher priced accommodation is also selected by those with higher incomes and as such, the proportional tax is socially equitable in distribution (Weston, 1983). Whilst land use planning measures may be required to ensure that beach access is not restricted to those who can afford more luxurious accommodation, this presents a potential source of income for beach management activities in Sydney. An examination of the potential income stream follows, with sensitivity analysis to the tax rate and to visitation impacts.

Whilst there is potential for site-specific tourism taxes to influence local demand for recreation (Kerkvliet and Nowell, 2000), the enhanced management of these resources with the generated revenue can provide substantial economic gains. It is estimated that the beach nourishment program in Florida, in part funded by tourism tax receipts, is responsible for increases in tourism revenue that far outweigh the costs of the projects (Murley et al., 2003)

7.3.3 *Beach parking permits*

Whilst there is substantial opposition to paid beach parking permits in Sydney, the reality is that they are neither a limiting factor in beach usage, nor a realistic source of funds for the management of beach resources. In fact, analysis of the onsite surveys found that only 4% of visitors would be counted if parking records were used as the source of visitation, as shown in Figure 7.1.

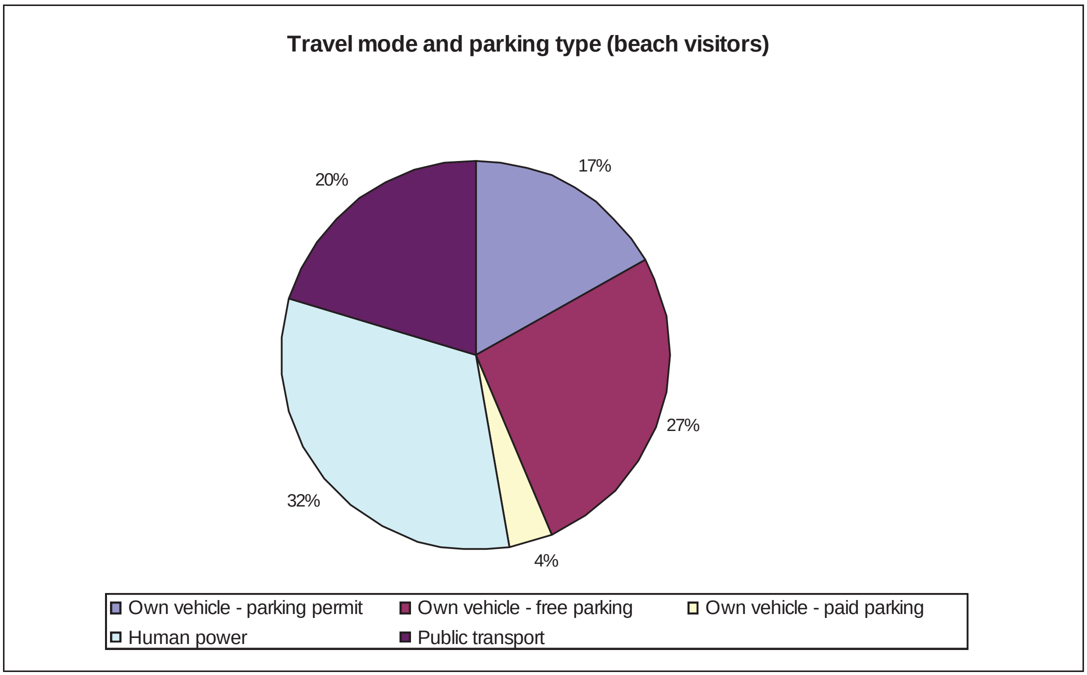

Figure 7.1 Travel mode and parking permit usage. Pooled onsite sample from all beaches.

7.3.4 *Re-allocation of existing tourism tax revenue*

Conceptually, it would be simplest to have the majority of tourism taxes redistributed to the LGA in which the activity occurs. This does not necessarily reflect the true costs of management, particularly in response to erosion impacts. Highly visited beaches may be relatively resilient to the impacts of visitors, through site hardening or increased visitor capacity. Examples can be found at the highly visited Sydney beaches of Bondi, Manly (Figure 2.7) and Coogee. Each of these beaches has a developed promenade area with adjacent coastal parkland. Evidence collected in this study suggests that these areas are the site of greater visitation than the sand and water of the beach itself.

The revenue collected through the GST passes to the federal government, which then reallocates the money back to the States and Territories based on a formula which is essentially dictated by relevant population. Importantly, the relevant population that is used is the resident population. This may disadvantage those areas where the majority of the economic activity takes place, as a large proportion of activity may be the result of interstate or international visitation.

An alternative is proposed here, whereby the allocation of GST would be based on a measure of visitation, divided by the resident population. This would provide additional funding to areas which receive substantial seasonal influxes of beach tourists, but are unable to generate sufficient management revenues through existing rates revenue streams. Obviously, it would also necessitate a more accurate estimate of visitation for coastal localities, although this information would satisfy multiple objectives.

7.3.5 *Risk-based allocation of land tax and property rates*

The hedonic pricing analysis conducted as part of this study indicated that there is a very strong property premium for beachfront property, mediated to some extent by risk information. This finding is consistent with previous international studies, which demonstrate that the most at-risk properties are often subject to the highest premiums (Bin and Polasky, 2003). Rates revenue from these properties, though fixed through rate pegging, is a substantial source of revenue.

Land tax is another stream of income, which flows not to the local council but to the State government. Owners of investment properties and those used to generate income are required to pay land tax, if those properties which have a rateable land value in excess of a threshold. In 2008 the land tax threshold was $359,000, with the payable amount equal to 1.6% of the property value plus a nominal fee of $100[22]. There are few single-residence properties in beachside Sydney suburbs which have a lower value than the threshold. Of the 97 beachfront properties examined in the hedonic pricing application in the current study, the lowest value is $393,000 in 2008 dollars. Of the entire sample, only around 100 properties are below the land-tax threshold. This therefore represents a substantial stream of revenue, at least for those properties which are used for rental purposes.

[22] http://www.osr.nsw.gov.au/taxes/land/

Properties which are at the greatest risk may entail increased management costs. This may be in actual expenditure on risk reduction activities, or through time and monetary expenditure on legal cases relating to disagreements about how the coastal margin should be managed (Fraser, 2010). Whilst these properties are subject to a greater rates liability through their enhanced costs, there is further potential for the NSW Government to reallocate some proportion of land tax to local councils which are tasked with managing highly variable localities for the enjoyment of the broader beach-going population. This would allow for some more proactive management actions, such as those of nourishment or retreat outlined above. The exact structure or means of redistribution is beyond the extent of my expertise, although some lessons can be drawn from the existing literature relating to property value capture taxes.

7.3.6 *Property value capture tax*

The high importance of beachfront locations, proximity to the beach, and location within a block of the beach indicates that coastal management interventions have the potential to greatly influence the local property market. This should be considered by the relevant agencies when considering policy changes, in terms of the potential influence on local rates revenue and land tax.

It also indicates that there may be potential for a value-capture property tax system, such as that suggested for Delaware properties by Parsons and Noailly (Parsons and Noailly, 2004). This study estimated that ocean frontage increased the value of a representative property by 42%, as opposed to a property which is within 500 feet of the shoreline (Parsons and Noailly, 2004). The study also defines a series of zones of increasing distance from the coast (Table 2, p 56), and estimates the contribution of shoreline proximity to the value of the property, relative to an otherwise identical property in the most distant zone (Parsons and Noailly, 2004).

This finding was used to suggest the possible structure of a tax on local property that more accurately reflected the costs and benefits associated with beach nourishment works. The authors suggest that their tax structure is equitable, because the costs of the nourishment project are levied upon the local residents who are assumed to benefit most from the project. Contributions are balanced against the hedonically estimated benefit they derive from both proximity to the beach and an interaction term which incorporates beach width and proximity, to allow for changes in quality (Parsons and Noailly, 2004). Pompe and Rinehart provide additional research on the structure of a beach protection service charge (Pompe and Rinehart, 1999).

Whilst intuitively appealing, the practicalities of estimating such a tax index are problematic, and require some simplifying assumptions. One such assumption, which is highlighted by the authors, is that the property tax is estimated without consideration of the benefits that accrue to non-resident users. Thus the entire cost of the project is borne by the residents of the nearby properties. In essence, this approach shifts the nourishment expense from the public to the private sector.

7.3.7 *Practical application of a coastal property protection service charge*

During the course of preparation of this thesis, the NSW Government enacted a bill entitled *'Coastal Protection and Other Legislation Bill 2010'*. This legislation introduces the potential for a *'Coastal protection service charge'* to be levied upon the owners of all properties which benefit from coastal protection works. In the event that the property owners contribute the entire cost of the structure, then the levy must be imposed by the relevant Council. If there is a shared contribution, involving both landowners and one or more tiers of government, then imposing the levy is optional.

This bill was passed on October 21st 2010, although it does not come into force until the technical guidelines which support application of the bill have been finalised. This charge has a strong theoretical basis, and is a step towards a user-pays system of coastal management funding. The guideline relating to the Coastal Protection Services Charge is in draft form at the time or writing. Nevertheless, it appears clear that the means of determining the CPSC is on a pro-rata basis, in direct proportion to the percentage that the property owner contributed to the costs of construction[23].

Whilst the technical guidelines associated with this bill outline four different alternatives for temporary or emergency coastal protection works (ECPW), the practical limitations on their

[23] http://www.environment.nsw.gov.au/coasts/coastalerosionmgmt.htm

use suggest that nourishment is not likely to be employed. Thus the bill is explicitly supporting the focus on property protection over beach preservation.

7.3.8 *A proposal for a better property protection charge*

The focus of both the examples cited above is on valuing the property protection services afforded to beachfront and adjacent properties. Given that this may represent only a small proportion of the benefits a beach provides, and that the benefits accrue mainly to a very small proportion of the beach going population, this focus is considered to narrow. The following paragraphs suggest an amendment to ensure that coastal management decisions incorporate consideration of the potential negative impacts of protective structures on the beach environment.

In the field of health economics there is a concept known as Quality Adjusted Life Years (QALYs), which is used to prioritise medical interventions in the case of limited resources (Drummond et al., 1997). This is a form of Cost Utility Analysis, which can be adapted for application in environmental fields (Hajkowicz et al., 2008). Conservation output protection years (COPYs) was a measure developed to evaluate the conservation outcomes of threatened species management options in New Zealand (Cullen et al., 2001).

Here I suggest a similar potential application for the assessment of coastal protection options, namely ‘Closure-Likelihood Adjusted Property Protection Years', or CLAPPYs. Whilst the available data did not permit consideration of such an index, it is an avenue that will be explored in future work. This measure would take a form as per Equation 7.1:

$$Z_{ij} = \frac{TP_i}{TP_b} \times \frac{BW_i}{BW_{av}} \times \frac{1}{TC_i} \qquad \textbf{\textit{[7.1]}}$$

Thus, the score (Z) for each alternative (i) given the assumed climate and weather parameters (j) is a product of three factors:

- the Total Protection Years delivered by the project (TP_i), divided by the Total Protection Years currently available as a baseline (TP_b);
- the minimum average beach width provided by the project (BWi) at the end of the project period, divided by the average beach width without the project (BWav); and
- the reciprocal of the total discounted cost of the project, including any maintenance or periodic expenditure.

Whilst previous work has investigated both the influence of beach width on coastal property values (Pompe and Rinehart, 1995), and willingness to pay for coastal protection services (Kriesel et al., 1993), there has not been an attempt to value these factors in an integrated manner. Incorporating both protection and beach width addresses in part the differing strengths of the various protection options. Whilst there is an increasing move in coastal management policy towards 'soft' approaches such as beach nourishment or dune rehabilitation, there is also recognition of the fact that these approaches may be more costly than the traditional 'hard' measure such as the construction of seawalls, groynes and breakwaters. Hard terminal structures often result in a loss of the sub-aerial beach however, so consideration must be given to the status of the beach in selecting protection options if maintaining beach access and availability is a consideration.

7.3.9 *Opportunity for management through risk disclosure*

It is clear that the coastal property market does not reflect the erosion risk to the beachfront properties, except where that information is specifically included on property titles. This results in higher than optimal land values, which in turn restrict the management options available to the local land managers. An example can be seen in the limitations of the Voluntary Repurchase program suggested by the NSW Coastline Management Manual (NSW Government, 1990). Whilst Warringah Council has purchased two threatened properties under a scheme funded by developer contributions under s.94 of the *Environmental Planning and Assessment Act 1979*, the capacity to purchase further properties has been significantly eroded (pun intended) through rapid increases in property prices and a lack of further development contributions.

The HPM component of this study identified that risk information included on property titles appears to have a substantial influence on the premiums attributable to location on the beachfront. Many of the issues associated with adaptation to climate change can be linked to the presence of highly valuable private and public infrastructure in the threatened locations. Without this development the coastline can be allowed to respond to SLR and erosion in a natural manner (Pilkey and Dixon, 1998). Hence, there is an opportunity to address this issue through manipulation of the coastal property market, via the provision of more detailed risk information to landowners and potential purchasers (Yamashita, 2009).

Consideration must be given to full disclosure of risks on a property-by-property basis, in order to ensure that purchasers of beachfront property are truly aware of the risks. This assessment should incorporate the most current and accurate modelling of shoreline erosion and inundation, rather than simply applying ‘rule-of-thumb’ approximations via the Bruun rule and ‘bathtub’ inundation mapping (Cowell et al., 2006, Cowell and Zeng, 2003). The NSW Department of Planning recognised the need for more detailed information on property titles relating to coastal hazards. This indicates a move towards a more risk-aware coastal property market, which I consider to be a necessary transition, although the notifications regarding inundation and erosion remain based upon the simplistic Bruun-rule approach (NSW Department of Planning, 2011).

To this point, the NSW Government and Local Councils have been reluctant to release detailed information relating to coastal vulnerability, presumably due to concerns about the impact on the relevant property markets in risky locations. Risk disclosure may result in adjustments in property value such as those recently seen at Belongil Spit in the Byron Shire, both in terms of assessed values as provided by the Valuer General (Grigg and Allen, 2010), and market results from auctions (Johnstone, 2010). These both reflect reductions of around 50% since the previous 'transaction' dates, which were three years previous. Belongil represents a unique case study for management of coastal NSW, and factors such as the impacts of the global financial crisis may have been more important than any risk-related changes (Grigg and Allen, 2010).

This fear would appear to be unfounded, at least for the case study site Collaroy-Narrabeen, as the most at-risk sites maintain a healthy property premium. Previous studies have also indicated that the Sydney property market is relatively immune to economic impacts of risk disclosure. In Sydney, flooding does not have a lasting effect on land value, as evidenced by a review conducted by Yeo (Yeo, 2003). Whilst short-term impacts due to flooding can be substantial (up to 60% reduction in land value), property prices typically recover within a few years. Inclusion of properties on flood maps was also shown to have relatively small impacts (around 4% depression in Toongabbie) on the value of property, relative to properties outside the 100 year flood line (Yeo, 2003). This was despite the claims of some local journalists and politicians, who predicted permanent and catastrophic collapses in land value due to inclusion of properties within flood-prone designations (Handmer, 1985). Given the strength of preferences for beaches demonstrated in the current study, it is likely that the economic impact of inaction will greatly dwarf the economic impact of any losses due to risk disclosure.

There may also be no market response, as landowners appear to be operating under the assumption that their properties will be protected by government *ad infinitum* (Dowling, 2009). Pompe suggests that assumptions about future management actions can explain inelastic responses to beach width in hedonic regressions (Pompe and Rinehart, 1999). This view was given greater credence by the recent passing of the *Coastal Protection and Other Legislation Amendment Bill 2010*, which allows owners of beachfront property to protect their land using temporary structures in the event of coastal erosion[24]. Whilst a number of safeguards are incorporated to limit the application of these temporary structures, they are likely to have impacts on the beach and its potential for use by non-residents. This reflects a higher priority associated with protection of private property than it does on the preservation of public access, despite this being an object of the original piece of legislation (s3. (d)).

7.3.9.1 Funding retreat through insurance

An amendment to the US National Flood Insurance Program (NFIP) in 1987 allowed for the use of funds totalling up to 40% of the insured value of the property towards relocation. This ultimately means that the exposure of the insurer is reduced (Daniel, 2001). Whilst this

[24] http://www.environment.nsw.gov.au/coasts/coastalerosionmgmt.htm

amendment was ultimately repealed in favour of alternative measures, it provides a potential insight into the role of the insurance sector in the response to coastal threats.

There is currently no similar government subsidised insurance program in Australia, so insurance companies can simply fail to offer insurance to those properties for which the risk is considered too great. There may, however, be an opportunity for proactive insurers to investigate similar schemes, such as funding the raising of floor heights within a location prone to flooding. This may even go so far as to allow the insurance industry to have input into coastal policies where they can see decisions being made which substantially increase their exposure to natural hazards and the impacts of climate change. This could ultimately result in an increased revenue base for the insurance industry, through continued issuance of policies to those in areas which would otherwise entail substantial risk. Whilst I am loathe to suggest that coastal policy should be dictated by commercial enterprise, greater integration of the insurance industry and government agencies may result in the identification of novel approaches which are able to offset risk while allowing continued use of coastal lands.

7.4 Integrating beach valuation with coastal management – persistent challenges

Whilst the provision of suitable coastal resource values is an important step towards the selection of appropriate management responses to projected climate change impacts, it is not the panacea to cure all ills. This section poses some persistent theoretical and practical challenges for integration of coastal management and non-market valuation of beaches and related coastal systems. A number of these are insurmountable, as they relate to underlying patterns in the beach system, or psychological aspects of perception that are poorly understood. Some potential solutions to other challenges are then presented.

7.4.1 *Understanding, managing, and valuing variable commodities*

The greatest limitation identified in this study is that there is a fundamental lack of technical knowledge of the beaches of Sydney. This deficiency extends from basic information about the extent and variability of beaches in a physical sense, to understanding the nature and magnitude of beach visitation. Given the high economic importance of beaches identified in this study, there should be a high priority based on all areas of research that can contribute to coastal management. The relevant fields extend across the physical, social, legal and business disciplines.

It is clear that there remains a substantial knowledge gap surrounding the structure and function of beaches in the Sydney region (Hebert and Taplin, 2006). This is a hindrance to the daily management of these resources, and also in understanding how they will respond to the various aspects of climate change under current projections (Walsh et al., 2004). It also substantially increases the complexities with assessing management options (Tribbia and Moser, 2008). In any economic appraisal, it is necessary to define the baseline situation, i.e. the “Do-Nothing” or “Status Quo” alternative. Costs and benefits of a project or impact are then referenced to this baseline in order to determine the relative efficiency of the proposal. There are two key steps to this determination; the estimate of coastal changes, and an estimate of the resultant change in economic streams currently supported by the beach system. This provides substantial challenges, as the coastal systems are not constant. As such, determining the magnitude of the change is difficult.

7.4.1.1 Logistical challenges

Whilst highly satisfying, this project was also highly challenging from a theoretical and logistical perspective. Complications and limitations were experienced in gaining access to what information was available. Integrated Coastal Zone Management (ICZM) requires collaborative efforts across a range of disciplines, and whilst a worthy objective, provides challenges for those subject to the time and resource constraints of academic research. This is only likely to become more complicated in light of the increasing desire by research and commercial organisations to control intellectual property arising from collaborative research. If the objectives of ICZM are to be truly achievable, this is an issue which must be addressed in each individual project.

7.4.2 *Disjoint between costs and benefits*

Costs of mitigation or adaptation are often in a per-unit measure, such as a dollar value per cubic metre of sand placed upon the beach, or per metre of seawall length. Hence, a true Cost-Benefit Analysis would require the benefits of the project to be valued in the same units. This is a challenge, as the current state of the beach is not a fixed commodity.

Beaches in high energy wave environments display considerable temporal variation in width. Citing Aboudha and Woodroffe:

> *"The coast is rarely in a steady state, but changes over time in response to forcing – from daily (e.g. tides and precipitation river flow), seasonal (e.g. climatic patterns), annual (e.g. fisheries yield), and decadal (e.g. ENSO) to millennial scales (e.g. sea-level)."(Aboudha and Woodroffe, 2006)*

Even where the extent of a beach remains relatively constant, there may be substantial variation in the subjective value of a beach visit. For example, a beach in the Sydney metropolitan area may one day be covered in kelp, the next highly eroded due to a large storm swell, the next covered in bluebottle jellyfish due to a NE wind. If a beach is covered in kelp and the water is full of jellyfish, it is likely that the utility a beach visitor derives from their trip will be less than they may have experienced on a sunny day with a beach free of wrack, small waves and warm water. Smith et al. provide some exploration of these issues, in assessing the response of beachgoers to marine debris (Smith et al., 1997).

This presents a number of challenges, due both to the inherently variable nature of beaches themselves, and also because of the inadequacy of the valuation tools. Values from travel cost studies are typically consumer surplus estimates of the value of a beach day. These are then integrated with estimates of visitation to provide an aggregate estimate of beach value, which may then be disaggregated to measures of value per unit length or area. The potential sources of error in these calculations are large and numerous. Units of value from contingent valuation studies vary considerably, as they depend to a large extent on the payment vehicle employed in the study. They are also dependent on the scenario and project description, and hence their transferability is limited.

Hedonic studies provide the most directly translatable estimates of beach value, although they are not without their own limitations. Attempts to disentangle the amenities associated with beach access, property protection and visual amenity continue without a clear solution in sight.

Given the extent of erosion possible under climate change projections, it is also possible that some beaches will be lost completely. Loss of beaches is a non-marginal change, and hence the valuation of this change is problematic for welfare economics.

7.4.3 *Perception and communication challenges*

The qualitative responses highlight that there are a number of areas which are outside the scope of influence of the coastal manager. Key among these is belief in the erosion scenario, which forms the context for the CV exercise. The capacity of local managers to influence this rate of belief may be limited. It appears that this level of belief closely mirrors that of surveys related to more general belief in climate change (Newspoll, 2010, Essential Media, 2010). Hence, whilst education and extension can play a key role in communication of likely erosion scenarios, this is likely to be processed by the audience through their own lens of climate change belief and understanding.

Designing a contingent valuation scenario that is both easily interpreted and scientifically plausible is a major challenge in estimating the impacts of climate change on the use value of beaches. Estimating the impacts on non-use values is even more difficult, and may not ultimately be possible. The technical challenges in communicating future states of the beach are also considerable, as the range of processes involved in determining the state of the beach at any one time means that there is likely to be a persistent level of uncertainty in any projections. This does not necessarily diminish with increased technical understanding of the systems, as evidenced by my own research in the current study. I would place myself within the category of those who reject the erosion scenario as stated, not because I do not believe that there will be some degree of climate-related influence on shoreline dynamics, but because I do not believe that it is possible to predict a single future state with any degree of certainty. It is difficult to see how such a challenge can be effectively overcome.

Even understanding and communicating the current status of the beach is challenging. Beach amenities are interpreted differently by coastal engineers and the general coastal public (Frampton, 2010). Coastal engineers discuss such concepts as closure depth (Schwartz, 2005), whereas beach visitors are typically interested only in the visible sand (Marin et al., 2009). Wave dominated beaches vary between dissipative and reflective states in response to the current and historic wave climate. In response to large waves, a greater proportion of the sand budget in a littoral cell is shifted offshore in the form of transverse bars (Wright and Short, 1983). This beach is actually more effective at preventing further erosion, but it is perceived to be a diminished resource.

7.4.3.1 Valuing non-use values of recreation and leisure

The term utility is used in a recreation or leisure context to describe all benefits from the experience, which may include self-actualisation, a sense of belonging to a group, and improved cardiovascular fitness (Csikszentmihalyi and Kleiber, 1991). Recreation demand is a product of expected utility, which can be influenced by an enormous range of factors (Provencher and Bishop, 1997). Quantification of the non-marketable benefits of recreation is difficult, as these are intrinsic factors produced through interaction of the recreation experience and personal values (Hamilton-Smith, 1994). Greater integration of the fields of economics and psychology has the potential to improve understanding of motivations and behaviour (Spash, 2000), but it is likely that classification and monetisation will remain clouded in uncertainty and assumption.

7.4.3.2 Congestion through management

A potential drawback from the use of expenditure based travel cost methods, particularly in decisions about whether user fees could justify the designation of protected areas, is that there is an economic incentive to maintain or increase the existing level of visitation. This can result in direct environmental degradation, such as compaction of informal walking tracks, or reduced utility through congestion (McConnell, 1977, McConnell and Duff, 1976).

Using expenditure based methods to determine the economic value of resources also has the potential to favour those sites with higher travel costs. Whilst this suggests greater importance of the sites, and is an underlying principle of the method proposed by Hotelling, it could favour inefficient travel modes or prioritise management expenditure on those sites which are visited by tourists rather than locals. Given recognition of the greenhouse gas emissions of international air travel (Olsthoorn, 2001), this is undesirable from an ecological perspective. The use of expenditure as a means of allocation of resources among different user groups also brings with it issues of intragenerational equity through favouring resource uses with greater expenditure, as raised in relation to management of fisheries (Edwards, 1991, McPhee and Hundloe, 2004).

7.4.3.3 Congestion through changes in recreation and development

The "sea change" phenomenon in Australia has seen dramatic increases in the property values of coastal suburbs in recent years (Pittock, 2003). Some proportion of this value can be attributed to an increased desire for proximity to the coast. This would imply that the subjective value of the coast has changed over this period. Whilst certainly not the only driver, it can be assumed that at least part of this change can be allocated to an increase in the desire for access to beaches. This is consistent with studies of patterns of recreation, which show an increased desire for unstructured outdoor recreation. This is matched by increased spending on the required materials to participate in these activities (ABS, 2006b). Household expenditure surveys in NSW indicate between 1999 and 2004 average weekly expenditure on recreation rose from 9.4% to 12.8% of total spending. This represents a 34.2% growth in recreation spending over the period (ABS, 2006b). As socioeconomic changes result in an increased demand for outdoor recreation experiences, congestion of beaches is also likely to become a greater issue.

7.5 Opportunities for future research

Given the fact that this study was designed primarily to provide baseline estimates of the values associated with the case-study beaches, and is to some extent exploratory in nature, there were inevitably areas where improvements can be made. This section provides some details on proposed and potential future research efforts to expand upon and improve the work detailed in this thesis. It attempts to address some of the key limitations and challenges outline in previous sections, to the extent that this is possible.

7.5.1 *Estimating beach visitation and usage patterns*

The need for a more detailed understanding of beach visitation has been a recurrent theme in this thesis, and is not detailed further. This is in no small part due to the fact that surmounting the challenges in adequately estimating beach visitation is a theoretical challenge with no clear solution. An important first step towards this goal however, would be surveys of participation and visitation in a similar manner to those undertaken in the Sweeney Sports survey process (Sweeney Research, 2008).

7.5.2 *Understanding behavioural responses to changes in beach state*

Development of a dynamic baseline requires inclusion of relevant socio-economic trends in determining the future state. In the case of determining the economic value of beaches this may include projections of beach-related tourism demand. Unfortunately, there is insufficient existent information to identify the linkages between the state of beaches and revenue generate from beach-related tourism to generate current baseline states, let alone to make projections about the likely future baseline. High level estimation of the costs of climate change impacts on the coast can be performed using models such as FUND and FARM (Darwin and Tol, 2001). These models suffer from a number of deficits, however, meaning that the use of their outputs for local scale estimates is inappropriate (Aboudha and Woodroffe, 2006).

A key problem is that there is rarely a post-ante assessment of the change in tourism as a result of either a storm event or a nourishment program. It is unfortunate that these assessments are primarily conducted as damage assessments related to litigation, as per the American Trader oil spill, which spurred increased interest in contingent valuation and beach visitation (Arrow et al., 1993, Chapman et al., 1998). Raybould and Mules estimated a relationship between beach state and regional tourism visitation and revenue for the Gold Coast, as a means of estimating the projected benefits of a nourishment and protection project (Raybould and Mules, 1999).

Further work suggested here would involve the use of the contingent travel cost method, which is described in Chapter 5. This would involve choice modelling exercises administered in two separate applications. The first would be to survey visitors who have not yet made a decision regarding their tourism destination, to see how their choices would be influenced by changes in beach state. This would follow a similar approach to Huybers and Bennett (2000). The complexities of this application are not insignificant, as it would require detailing the likely impacts of climate change on beaches in multiple international locations. Nevertheless, it is a worthwhile goal. The second application would build upon the contingent behaviour questions outlined in Chapter 5 of the current study. This would seek to gain a more detailed understanding of the behavioural responses to different beach states, both upon arrival at the affected beach, and also when beach state information is available in advance in the same manner as water quality information currently provided under the Beachwatch program[25].

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[25] http://www.environment.nsw.gov.au/beachApp/default.aspx

7.5.3 *Valuing risk prevention*

Erosion of beaches can lead to exposure of underlying bedrock, seawalls and other hazardous material (Figure 7.2). These can pose a hazard to beach users and those in the water, and can lead to closure of the beach due to safety concerns (D.Smith, 2009). One means of placing an economic value on the non-marketable benefits of enhancing or maintaining beach amenities is therefore by through examining the health-related costs associated with injuries causing permanent disability.

Figure 7.2 Exposed rocks on Manly beach following storm erosion.

Whilst this is a theoretically sound means of estimating the value of mobility and wellbeing, it requires placing a value on human life, which in my opinion is ethically questionable. Nevertheless, this has been used to value the services of lifeguards in Australia (Allen Consulting Group, 2005), and may be an increasing area of focus in the future. Suffice to say that if the climate change projections for Australia eventuate, (particularly the high winds, heavy rainfall and damaging surf associated with an increased frequency and intensity of large east coast-lows), there will be greater potential for injury or loss of life. Whether this will be reflected in reduced visitation or utility at the most seriously affected locations remains to be seen. Whilst I do not hold clear views on how this work would best be attempted, valuing risk reduction is likely to be a key decision-making criteria for some coastal managers.

7.5.4 *Impact of coastal protection features on value*

A recent article examined the influence of coastline protection structures on the price of nearby accommodation in northern Germany, using district averages rather than individual apartments (Hamilton, 2007). It was predicted from this relationship that increasing the length of coastal dykes would result in decreases in the prices of accommodation in the local area, with the reverse effect expected for an increase in open coast. This indicates that tourists have a preference for more natural coastlines. Further comparison of the costs of coastal management options and expected changes in accommodation revenue favoured the use of beach nourishment over dyke construction (Hamilton, 2007).

I would argue that revealed preference information is not necessarily the best means of identifying the influence of coastal protection features on property or accommodation markets. These structures are likely to be selected on the basis of underlying differences in geomorphology and development. Hence, the areas differ in more than just the coastal protection options. Stated preference surveys which identify the likely influence of coastal protection options on both prospective residential property purchasers and prospective overnight visitors are likely to be more effective. These would employ visual aids, and seek responses in a contingent visitation or 'contingent purchase' context.

7.5.5 *Impact of risk disclosure on property market*

Given the recent release of property risk information on a national scale via the National Coastal Risk Assessment reports (Australian Government, 2009), there is potential for a long term study to analyse the effect of these releases on the property markets in affected coastal areas. This would employ the information generated in the HPM component of the current study as a baseline against which both property prices and environmental premiums could be tracked. Of particular interest is the effect of the release of new hazard lines for Collaroy-Narrabeen as a result of the unpublished study by Patterson Britton, on behalf of Warringah Council. The influence of the CPOLA and technical guidelines relating to emergency coastal protection works[26] will also be of keen interest. A similar approach was employed by

[26] http://www.environment.nsw.gov.au/coasts/coastalerosionmgmt.htm

Parsons, in examining the effect of land use restrictions on properties adjacent to Chesapeake Bay in Maryland (Parsons, 1992).

Alternatively, the effect of different could be explored through the use of choice modelling, where the likelihood of beach closure and risk of property damage are incorporated into coastal housing choices. Preliminary surveys of coastal homeowner attitudes toward the use of a retreat scheme were conducted by researchers from the Commonwealth Science and Industrial Research Organisation (CSIRO)[27].

7.5.6 *Exploration of private funding for beach erosion prevention*

Further work could explore the potential for private funding of beach management activities. Given the lack of alternative funding sources, it is likely that private funding will have an increasingly important role in the future of the Australian coastline. This may be through enforced user-pays measures, but could also build upon the contingent valuation (CV) findings of this study to explore voluntary contributions.

From the responses that were gathered in the CV component of this study, it is possible to consider a hypothetical coastal management funding instrument that would generate the greatest potential contributions. It is likely that such a fund would be administered by a standalone agency or organisation, able to be used at a beach of the contributor's choice, and provide full details of the project to be employed at each location. Choice modelling could again be employed to identify the influence of contribution amounts, frequency of payments, managing agencies and project outlines on the overall WTP patterns.

7.6 Overall conclusions and comments

It is with great relief but also a touch of remorse that this thesis concludes. There are a number of areas of research where the study was unable to achieve the initial objectives. This, however, provides opportunities for future research efforts, as outline above. This section therefore makes only some general comments on the research findings, and provides a call-to-arms for further investment and efforts in non-market coastal valuation.

[27] http://www.nccarf.edu.au/conference2010/wp-content/uploads/Russell-Gorddard.pdf

7.6.1 *Comments on research findings*

This study has identified that Sydney beaches have substantial economic importance, generating extensive market and non-market values. Whilst the exact timing, nature and magnitude of climate change impacts on these resources is to some extent uncertain, it is highly likely that there will be negative consequences for the economy at the local, regional and higher levels.

The findings of the travel cost, contingent valuation and hedonic analyses presented in this chapter serve to highlight the scope of economic impact that is possible. They suggest that more detailed, project-specific economic analysis of coastal management responses to climate change and erosion impacts is justified. The results of the contingent behaviour section of the survey suggest that the response to beach erosion will not be clear-cut, and that further response is needed to establish the economic impacts of changes in visitation and usage. The use of soft approaches such as beach nourishment can preserve the beach-associated values, whilst also providing flexibility in responding to uncertain climate change impacts.

While there is a clear role for economics to play in coastal management, and indeed an unfulfilled legislative requirement in some cases, it is important to recognise that environmental economics is not a golden bullet, and in itself is reliant upon good inputs. Greater integration with the physical and social sciences, particularly psychology, are necessary to improve the effectiveness of coastal economics in policy and decision making.

Decisions about the future of the coast in vulnerable locations are complex and can involve highly-charged emotions. A balance must be struck between the desire to minimise impacts on owners of coastal property and infrastructure, and the potentially conflicting desire to preserve public beaches for use by residents and visitors alike. The current balance, in my opinion, is too highly weighted towards the former priority. This thesis has demonstrated the magnitude of values and income streams that are related to the presence of beaches in the region, highlighting that there is both an economic and a cultural argument for their continued preservation.

7.6.2 *Reviving non-market valuation*

A significant obstacle to the effective management of the coastal zone is the lack of integration between economic and environmental objectives (New South Wales Government, 1997b). In the case of the Australian coastal zone, this extends to a lack of policy support for stated preference studies, which are likely to be critical in informing the response to climate change projections. There are few cases where stated preference studies have had a major influence on policy in Australia. There is no legislated support for their use, as is the case in the US following the Exxon Valdez case (Arrow et al., 1993). This may be due to concerns about the theoretical basis of the method, although it is perhaps more likely to be due to the fact that studies are rarely designed with specific policy outcomes in mind (Adamowicz, 2004). The result of this policy reluctance is that resources are likely to be undervalued.

Adamowicz examines the trends in publication of articles containing terms of relevance to environmental valuation techniques, and finds a marked increase in the number of papers since the early 1990s (Adamowicz, 2004). Application of environmental valuation is not applied as often as expected in a policy context. It is particularly rare to find an example of an application where passive uses have been valued.

> *"Although there have been many CVM and other environmental valuation studies undertaken, the number which have significantly influenced decisions has been small. The majority of studies has been of an academic nature and has not been intended to influence decisions. There appears to be a considerable level of skepticism among decisionmakers and the community at large about the validity of 'putting a price on the environment' and the results of such studies are treated accordingly" (Government of South Australia, 1999) p6*

Adamowicz suggest that values are not always required, and goes on to state (footnote 14) that environmental offsets may be a simpler way of compensating for environmental damages (Adamowicz, 2004). This seems a bold suggestion, given that environmental valuation evolved in part because of the challenges of determining equivalency in benefit cost analysis involving impacts on environmental resources. It is difficult to see how this challenge could be surmounted in the case of comparisons between different ecosystems.

Adamowicz also identifies differences in the application of valuation methods in the academic and policy sectors. The review finds that stated preference methods are commonly applied in the academic literature, as are hedonic applications. The most commonly employed method in policy applications is Benefit Transfer (Adamowicz, 2004). Given the concerns about this method (Downing and Teofilo Ozuna, 1996), and the paucity of suitable studies for beach value benefit transfer outlined in Chapter 2, this is a cause for some concern.

There is a critical need for greater focus on non-market valuation in Australia. Given the economic importance of the coast identified both in the current study and in patterns of visitation and residential concentration, this should be a prime area of focus for the future. I would like to take this final opportunity to commend the project partners and stakeholders for proposing and supporting the current study, and looks forward to a long profession in the field. The first steps will be to address some of the research opportunities outlined within this chapter.

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Appendices for thesis:

Estimation of the economic importance of beaches in Sydney, Australia, and implications for management

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Submitted in fulfilment of the requirements of the award of the degree Doctorate of Philosophy

March, 2012

Appendix 1 – Manly Ocean Beach Coastline Management Plan (extract)

MANLY COUNCIL

Manly Ocean Beach
Coastline Management Plan

Support Document

Issue No. 4
March 2008

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consulting engineers

EXECUTIVE SUMMARY

GENERAL

A Coastline Management Plan (CMP) has been prepared for Manly Ocean Beach to identify issues relevant to future management of the coastline and to identify appropriate management options for each issue. The development of a CMP is identified in Council's Manly Management Plan (2007-2010) and the Manly Sustainability Strategy 2006.

KEY ISSUES AND MANAGEMENT OBJECTIVES

Management objectives for Manly Ocean Beach were established through assessment of the values and significance of the beach and identification of key issues for management. The key issues and management objectives are set out in the table below.

Key Issue	Management Objectives
Beach Erosion and Shoreline Recession	• to manage the beach erosion and shoreline recession hazards now and into the future in a manner that: - maintains or improves beach amenity - ensures an acceptable risk of damage to beachfront assets; and • to take into account the potential for future climate change to affect the magnitude of coastline hazards.
Water Quality	• to ensure water quality meets the community's expectations and provides water quality suitable for swimming and fishing.
Access	• to improve and control access for pedestrians, cyclists and service vehicles, minimising conflicts and negative impacts; and • to improve access for people with disabilities.
Recreational Activities	• to provide for the continuing, enjoyable and sustainable use of Manly Ocean Beach for a range of recreation and tourism activities, minimising the impact of these activities on the environment by responding to the area's carrying capacity and patterns of use; and • to recognise the place of Manly Ocean Beach as an iconic tourism and recreation attraction.
Safety	• to minimise the risks to human safety from the use of and access to the coastline.
Aquatic Ecology	• to ensure activities at Manly Ocean Beach are carried out in a manner that maintains or improves the ecological condition of aquatic habitats.
Aboriginal Heritage	• to maintain and protect the indigenous heritage values of Manly Ocean Beach.

Cont'd

Key Issue	Management Objectives
Historic Heritage	• to manage and protect the tangible historic heritage assets of Manly Ocean Beach and its immediate surrounds; and • to acknowledge the place of Manly Ocean Beach in the Australian identity and popular beach culture.
Aesthetics	• to maintain the iconic or symbolic key visual elements of the beachscape of Manly Ocean Beach – notably the Norfolk Island Pines, promenade, long wide arc of largely uninterrupted sandy beach, and major vistas; and, • to reduce the adverse impacts of features that detract from the visual quality of Manly Ocean Beach, and to enhance the area's aesthetic appeal.

MANAGEMENT OPTIONS AND RECOMMENDATIONS

The focus was on identification of realistic management options to address the key issues. Options that were unlikely to satisfy the management objectives of the CMP were quickly dismissed. Issues were grouped under 'study area wide' issues and 'specific area' issues, as noted below:

Study Area Wide Issues	Specific Area Issues
• beach erosion • shoreline recession • coastal inundation • climate change • recreation and competing beach user groups • waste management and beach raking practices • aquatic ecology • water quality • conservation items of heritage significance • aesthetics	• Manly Lagoon entrance • stormwater outlets

The management options recommended in the CMP to address a number of the key issues are summarised below:

Key Issue	Recommended Management Option
• beach erosion	• implementation of an Emergency Action Plan (EAP) to deal with the erosion hazard when it occurs and where it occurs along the beach (the EAP is included in a stand-alone report); • investigation of structural measures to stabilise the toe of the seawall and allow removal of rock aprons, particularly south of the Corso.
• shoreline recession	• beach nourishment, ideally involving use of an offshore source of sand, combined with ongoing implementation of the EAP.
• inundation	• monitoring of sea level rise, measuring of wave runup levels at times of storms and undertaking repairs to any overtopping as and when required. Consider raising coping levels, or create coping, should the risk of overtopping become unacceptable.
• climate change	• monitoring of sea level rise and other climate change factors; • beach nourishment to address shoreline recession due to sea level rise; • investigation of groundwater behaviour.
• recreation	• numerous strategies, including supporting and enhancing the existing informal/self-regulating dispersal of differing uses and visitor groups along the beach and foreshore.
• water quality	• numerous strategies, including initiatives and measures to manage the quantity and quality of stormwater flows to the beach, such as rainwater tanks, detention and infiltration systems, and gross pollutant traps.
• aesthetics	• numerous strategies, including maintenance and enhancement of key visual elements of Manly Ocean Beach, specifically the Norfolk Island Pines, promenade and the long wide area of largely uninterrupted sandy beach.
• Manly Lagoon entrance	• continuation of current management regimes in regard to kelp removal from the low flow pipes, operation of the flood outlet channel and sediment removal near Queenscliff Bridge.
• stormwater outlets	• a number of strategies including stormwater volume reduction measures in the catchment, investigation of diversion and shortening options, and detailed hydraulic analysis including consideration of sea level rise.

ACTION PLAN

A specific Action Plan has been developed for the key issues which identifies recommendations/strategies, priorities, responsibilities for implementation, and funding opportunities.

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1.1 INTRODUCTION TO COASTLINE MANAGEMENT IN MANLY

The Manly Ocean Beach Coastline Management Plan (CMP) has been developed in response to legislative requirements and community issues in accordance with current best practice for the management of coastal and estuary foreshores. The development of Coastline Management Plans is also identified in Council's Manly Management Plan 2007-2010 and Sustainability Strategy 2006.

This CMP is intended to be a strategic plan for the study area with a long-term time frame of 10-20 years (with appropriate revisions). Implementation of the CMP will involve considerable expenditure and therefore implementation must have regard to resource availability and to other priorities of Council and the other agencies identified in the Action Plan.

The CMP was developed to identify issues relevant to management of the coastline and to identify appropriate management options for each issue identified.

While Council does not have management responsibility or jurisdiction for a number of the issues considered in this CMP, Council sought to liaise with relevant state government agencies, responsible for each of those issues during the CMP development. Please note that this CMP may not reflect the thoughts, ideas and perspective of those government agencies, however, Council will be seeking endorsement of the CMP and a commitment to its implementation.

1.2 STUDY AREA

The study area lies between Manly Lagoon entrance and Manly Surf Life Saving Club (SLSC) extending both seaward and landward from the shoreline (refer **Figure 1.1**). The study area is dominated by Manly Ocean Beach, the adjoining parklands and promenade immediately behind the beach. The beach is separated from adjacent development by a constructed seawall along its full extent. The parks and reserves behind the beach have been largely modified from the natural landscape and are characterised by landscaping, a public pedestrian pathway, cycleway, surf pavilions and amenities, public shelters, picnic tables and play equipment.

Land and aquatic areas outside the immediate study area boundaries, which impact on the biophysical or social environment within the study area, have also been considered in the development of the CMP in order to establish holistic management strategies.

A description of the area's values and what the community would like the area to look like and be like in the future is detailed in **Section 1.8**.

FIGURE 1.1

Patterson Britton & Partners Pty Ltd

STUDY AREA

1.3 DEVELOPMENT OF THE MANLY COASTLINE MANAGEMENT PLAN

1.3.1 General

The NSW Coastline Management Manual (1990) and the NSW Hazard Policy (1988) were introduced to provide a management system for local councils to make balanced, merit based decisions. They set out the Government's requirements and provide information for coastal processes, hazards and hazard management measures. The management system uses an integrated planning approach that incorporates the management of coastline hazards with social, economic, aesthetic, recreational and ecological factors.

The steps involved in formulating a CMP are summarised in **Figure 1.2** and include:

- establishing a coastline management committee. The Manly Coastline Management Committee has been formed under the stewardship of Manly Council and includes representatives of relevant government departments, environmental groups and the local community;

- identifying the type, nature and significance of the various coastal processes and hazards that affect the area of interest. A Coastline Hazard Definition Study for Manly Ocean Beach was undertaken by Patterson Britton & Partners (*2003*) on behalf of Manly Council;

- undertaking a coastline management study including the identification of management options with regards to social, economic, aesthetic, recreational and ecological issues;

- preparing a CMP that consists of the best combination of options for dealing with the various social, economic, aesthetic, recreational, ecological and hazard issues and problems; and,

- developing an Action Plan to implement the management options.

1.3.2 Committees

As noted above, the NSW Coastline Management Manual (1990) identifies the establishment of a Coastline Management Committee as the initial stage in the preparation of a CMP.

The Manly Coastline Management Committee, under the stewardship of Manly Council, has overseen the formulation of the CMP for Manly Ocean Beach. The Committee includes Council Officers and representatives of relevant government departments, environmental groups, key stakeholders and the local community. The relevant government departments include:

- State Emergency Services (SES);
- Department of Environment and Climate Change (DECC);
- NSW Maritime; and,
- Department of Primary Industries (DPI).

The Manly Coastline Management Committee is being guided by the NSW Government's *Coastal Protection Act* (incorporating the *Coastal Protection Amendment Act 2002*), Coastline Hazard Policy 1988, Coastline Management Manual 1990, NSW Coastal Policy 1997, Sydney Regional Coastal Management Strategy 1998 and State Environmental Planning Policy No 71 – Coastal Protection. The Coastline Management Manual documents the Government's Coastline Hazard Policy and outlines a structured management process leading to the adoption and implementation of a CMP.

The Committee has met at strategic milestones throughout the development of the CMP and provided information as requested by the project manager.

1.3.3 Community Consultation

The program of stakeholder and community consultation undertaken for the study has involved the following key tasks:

- consultation with key Council officers;
- consultation with the Manly Ocean Beach Coastline Management Committee;
- identification and development of a mailing list of key stakeholders;
- consultation with Manly's Precinct Committees;
- a Precinct Forum Evening;
- a Community Information Day; and,
- internal and external stakeholder meetings.

The key community consultation activities were advertised in the Manly Daily and Precinct newsletters.

1.3.4 Development of Coastline Management Study

A Manly Ocean Beach Coastline Management Study was undertaken to identify issues and set objectives to be addressed by the CMP. The study also provides a general review of the relevant planning systems and management frameworks relevant to the study area, which have been considered when developing management options for inclusion in the CMP.

A range of studies were carried out including aesthetic and ecological factors, recreational amenity, social and economic studies, and risk and hazard assessment as input into the Coastline Management Study.

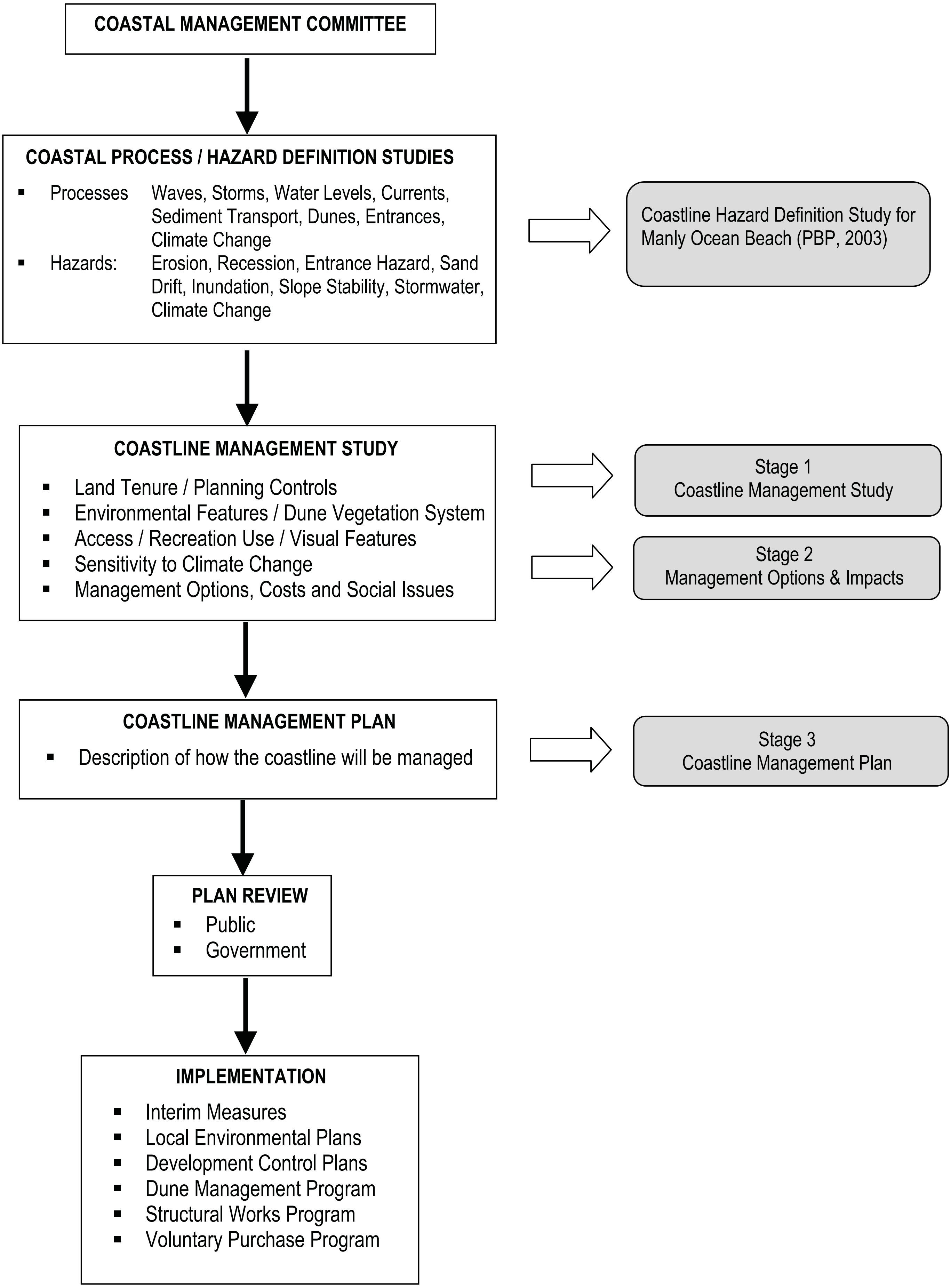
1.3.5 Approval from Department of Lands

The study area includes community land owned by the NSW Department of Lands, which is leased to Council. The CMP will be forwarded to the Department of Lands for comment prior to public exhibition, and the Department of Lands endorsement of the final Plan will be sought prior to implementation of the CMP.

1.3.6 Plan Exhibition

The draft Manly Ocean Beach CMP was placed on public exhibition for comment for a period of four weeks between 3 September 2007 and 1 October 2007.

FIGURE 1.2



Reference: Coastline Management Manual (NSW Government, 1990)

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ELEMENTS OF THE COASTLINE MANAGEMENT SYSTEM

The draft Manly Ocean Beach CMP and EAP were placed on public exhibition at the following locations:

- Manly Environment Centre;
- Manly Library;
- Manly Council's Web-page; and
- Manly Council Offices.

Exhibition of the plans was advertised in the Manly Daily, on Council's Web-page and via the Community Precincts.

1.3.7 Adoption of the Plan

Following the public exhibition period, Council considered those submissions received. Following subsequent amendments of the CMP, Council adopted the CMP on 11 February 2008.

1.4 PLAN OBJECTIVES

The overall objective of the CMP is to develop a strategy to guide the sustainable management of the area now and in the future. Management objectives have been identified through the assessment of the values and significance of Manly Ocean Beach and the identification of key issues for the management of Manly Ocean Beach.

The CMP is being developed to meet the objectives of the *Coastal Protection Act 1979*, NSW Coastline Hazard Policy 1988 and the NSW Coastal Policy 1997. The objectives of the CMP have also been developed having regard to the objectives of the following acts and management plans to ensure consistency between existing and future management objectives for Manly Ocean Beach:

- *Crown Lands Act 1989*;
- *Local Government Act 1993*;
- *Environmental Planning and Assessment Act 1979*;
- Manly Council Plan of Management for Community Lands; and
- Plan of Management for Manly Ocean Beach.

The management objectives for Manly Ocean Beach are set out below.

Beach Erosion and Shoreline Recession

- to manage the beach erosion and shoreline recession hazards now and into the future in a manner that:
  - maintains or improves beach amenity
  - ensures an acceptable risk of damage to beachfront assets
- to take into account the potential for future climate change to affect the magnitude of coastline hazards

Water Quality
- to ensure water quality meets the community's expectations and provides water quality suitable for swimming and fishing.

Access
- to improve and control access for pedestrians, cyclists and service vehicles, minimising conflicts and negative impacts; and
- to improve access for people with disabilities.

Recreational Activities
- to provide for the continuing, enjoyable and sustainable use of Manly Ocean Beach for a range of recreation and tourism activities, minimising the impact of these activities on the environment by responding to the area's carrying capacity and patterns of use; and,
- to recognise the place of Manly Ocean Beach as an iconic tourism and recreation attraction.

Safety
- to minimise the risks to human safety from the use of and access to the coastline

Aquatic ecology
- to ensure activities at Manly Ocean Beach are carried out in a manner that maintains or improves the ecological condition of aquatic habitats.

Aboriginal Heritage
- to maintain and protect the indigenous heritage values of Manly Ocean Beach.

Historic Heritage
- to manage and protect the tangible historic heritage assets of Manly Ocean Beach and its immediate surrounds; and
- to acknowledge the place of Manly Ocean Beach in the Australian identity and popular beach culture.

Aesthetics
- to maintain the iconic or symbolic key visual elements of the beachscape of Manly Ocean Beach – notably the Norfolk Island Pines, promenade, long wide arc of largely uninterrupted sandy beach, and major vistas; and,
- to reduce the adverse impacts of features that detract from the visual quality of Manly Ocean Beach, and to enhance the area's aesthetic appeal

1.5 PLANNING FRAMEWORK

The planning framework for Manly's coastline has been described in a separate document (refer **Appendix A**). The document describes the planning framework in which the CMP was prepared and in which it will be implemented.

For example, the overall introduction outlines requirements for community land management under the *Local Government Act 1993*. It also identifies the process for coastal management as detailed in the State Government's Coastline Management Manual.

The document also outlines the management responsibilities of a variety of government agencies.

1.6 HOW TO USE THIS PLAN

The Manly Ocean Beach CMP consists of two parts, the **Support Document** and the **Action Plan**. The Support Document provides the framework for preparing the management recommendations, which are outlined in the Action Plan.

1.7 COUNCIL'S MANAGEMENT PLAN & BUDGET

The CMP has a direct relationship with Manly Councils Management Plan (2007-2010) through the performance targets and management recommendations (strategies) identified. The management recommendations identified to achieve the agreed performance targets shall be integrated into Council's Management Plan so that appropriate monetary and staff resources shall be allocated to achieve this Plan's performance targets.

1.8 VALUES

In making decisions about the future use and management of Manly Ocean Beach, it was important to gain an appreciation of the multiple values of the area and what the community would like the area to look like and be like in the future. As part of the community consultation for the study, and to facilitate stakeholder and community input and comment for the first stage of the study, a Community Information Day was held on Sunday 28th August 2005. A Community Comment Form was prepared and distributed to people who attended the information day with additional copies distributed to key stakeholders

The values of Manly Ocean Beach as a whole and its special individual features listed in **Table 1.1** were identified by the community and key stakeholders.

The following values and significance of Manly Ocean Beach were identified from:

- literature reviews undertaken for specialist studies for the Manly Ocean Beach Coastline Management Study;
- discussions held with relevant Council and State Agency officers; and,
- local knowledge.

<u>Coastal Ecology</u>
- key habitats include: dry upper beach; swash zone; surf zone; and near shore zone in deeper water
- four main groups of biota include: infauna and epifauna; plankton; fish; and birds
- no marine vegetation and no threatened or protected species, populations or ecological communities occur in habitats on Manly Ocean Beach
- some listed threatened or protected species may occur in adjacent habitats, particularly Cabbage Tree Bay Aquatic Reserve

Table 1.1 Summary of values from Community Comment Form

VALUES	Number of responses
Natural Values	
Clean beach and water	11
Green grass and trees	4
The visual / natural aspects – location, views, beauty	4
Ocean environment	1
A naturally beautiful place that should be protected	1
Ability to watch dolphins catching a wave	1
Lots of sand, no rocks	1
Protection of aquatic life	1
Large beach	1
The beach is the reason I live in Manly	1
Social or Community Values	
Open space	4
Unique character	3
Relaxed family fun and family atmosphere	3
Esplanade walk along seawall and other walkways	3
Our backyard and a place of serenity and peace	2
Place to relax away from work	2
Iconic beach with great surf and associated surf scene, which is great to come to.	2
A place to walk, swim, have a picnic	2
Cost-free access and space	2
Well maintained beach front including children's play equipment, grassed areas, clean benches and picnic tables.	1
The beach and the cove / all the activities associated with the beach and the cove.	1
The community coming together around the beach and the cove – at a yacht club, surf club, café on the Steyne, bar on the wharf etc.	1
Retention of historical heritage while being modern for locals and visitors	1
A place of concentration and celebration of life due to the combination of people and nature together in a central place.	1
A well preserved swimming/surfing beach	1
A place where people can enjoy themselves	1
Everything about Manly Ocean Beach – it is an important part of my life	1
Protection for all future users so they can also enjoy the benefits	1
Safe waters and beach	1
Easily accessible to enter water	1
Showers	1
Ability to watch people enjoying the sand, the surf, cafes, the promenade and bike track.	1
Free volleyball courts	1
Electric nature of the place	1
Cycleways	1
Variety of people	1
Bushland track above The Bower / Shelly Beach	1
Seaside enclave surrounded by water, beaches, wildlife and nature, combined with café and beach culture.	1
Economic Values	
Surf lifesaving clubs – ability to participate in these clubs and also their valuable function.	4
Good mix of cafes, bars, restaurants open day and night, attracting visitors and locals.	1

Indigenous Heritage

- Manly Ocean Beach is part of the lands traditionally occupied by the Gayamaygal Aboriginal Clan
- the area would have in the past contained an abundant assemblage of the evidence of thousands of years of occupation and use by Aboriginal people
- the district would also be expected to have had a rich layering of cultural and spiritual values or traditions
- no recorded sites remain today within the study area although this does not preclude the occurrence of unrecorded Aboriginal sites within the study area

Historic Heritage

- "Manly Beach and Surrounds" was listed on the Register of the National Estate in 1999 and recognises the Beach's cultural associations for surfing as well as beach recreation and scenery
- the entire beach front reserve along Manly Ocean Beach – Merrett Park and The Steyne – is listed by the Manly Local Environmental Plan (LEP) as a significant landscape feature
- also listed in the LEP are:
  - Queenscliff Surf Life Saving Club
  - North Steyne Surf Life Saving Club; and
  - public shelters

Aesthetics

- the wide sandy beach - the stage for much of the beach culture and events
- the surf zone - which is in constant motion and provides a highly variable setting for the range of active surf pursuits, from relaxed to highly challenging activities
- the rows of Norfolk Island Pines – presenting a very strong green element between the open space of the beach and the highly urban environment to the west
- the seawall and promenade – despite the varied built form and height of the seawall, they unify the beach from north to south while separating the promenade from the sand and surf
- the fringing parklands of formalised and landscaped open spaces

Recreation – Surf Zone

- more popular uses - surfing, body/boogie boarding, body surfing, swimming, paddling and water play, surf life saving and nipper activities, surf schools and surf competitions
- board riders cluster at varying location along the surf zone according to wave quality
- scuba diving and snorkeling occurs especially at southern end near Cabbage Tree Bay Aquatic Reserve
- swimmer and paddlers use entire beach with higher concentrations in patrolled sections

Recreation – Sandy Beach

- more popular uses - surf life saving and nipper activities, surf schools, surf competitions, sunbathing, socialising, sand play, jogging, walking, beach volley ball
- beach goers tend to congregate in front of the three surf life saving clubs
- the southern section is typically more heavily used as The Corso has the effect of funnelling visitors
- beach volley ball courts create a pinch point leaving a comparatively small strip of sand

- overall the beach makes a transition from a busy, vibrant, strongly tourist area in the south to a quieter local beach in the north at Queenscliff

<u>Recreation – Promenade and fringing Parklands</u>

- more popular uses – sightseeing and tour groups, walking, jogging, socialising, picnicking, sitting, relaxing, reading, bicycling, roller-blading, skateboarding
- the more hardened and developed southern section receives the highest level of tourism and visitor use
- the southern section is also well patronised at night
- to the north the promenade and parklands become increasingly less developed and formalised and widen considerable north of North Steyne SLSC
- Norfolk Pines, SLSC and visitor facilities located along the promenade

1.9 IMPLEMENTATION, REVIEW & EVALUATION

1.9.1 Implementation

Implementation of the Manly Ocean Beach CMP is identified in the Manly Sustainability Strategy (2006) and is included in Council's Manly Management Plan (2007-2010).

Whilst Council is not responsible for all areas and issues identified in the CMP, implementation of the recommendations contained in the Plan will rely heavily on an integrated approach by the relevant key stakeholders agencies, which nave been involved in the development of the Plan.

Manly Council will be seeking the endorsement of all responsible agencies to adopt and implement this plan.

Implementation will be assisted by the Manly Coastline Management Committee, under the stewardship of Manly Council.

Funding sources for implementation of the Plan are listed below in **Section 1.9.3** and detailed in Council's "Coastline Management Plans: Introduction and Planning Framework document".

1.9.2 Review

The Manly Ocean Beach Coastline Management Plan Support Document is to be reviewed every five (5) years and updated on an as needs basis.

The Manly Ocean Beach Coastline Management Plan Action Plan is to be reviewed every two (2) years, or as required, to ensure that the Plans' strategies and priorities are kept up-to-date.

1.9.3 Funding Sources

There are a number of possible options for funding of management recommendations (strategies) identified by this Plan. These include but are not limited to:

- Council's Environment Levy (subject to a budget bid process);
- Council's General Revenue Budget (subject to a budget bid process);
- State Government's Coastal Management Program (50% subsidy funding subject to a submission process);
- State Government's Estuary Management program (50% subsidy funding subject to a submission process);
- State Government's Floodplain Management program (50% subsidy funding subject to a submission process;
- Department of Lands - Public Reserve Management Fund (Council must be appointed as Trust Manager to be eligible); and
- Natural Heritage Trust.

1.9.4 Evaluation

Evaluation of the effectiveness of recommendations identified in the Action Plan should be undertaken to determine whether the vision (to be established), the Plan's objectives performance targets and values have been achieved.

In order to evaluate the CMP, in particular the effectiveness of the Action Plan's management recommendations in achieving the Plan's objectives, it is essential that specific and measurable performance targets and indicators be established from the start. Therefore the initial implementation of the Plan shall involve the establishment of a set of indicators (performance measures), which can be used in the evaluations of the CMP. The indicators should be:

- simple;
- measurable;
- achievable;
- reliable; and
- timely.

Evaluation is to be undertaken every 2 years and a full review every 5 years.

2 LAND OWNERSHIP, ZONING AND CATEGORISATION

2.1 LAND OWNERSHIP

Land ownership details for the study area, provided by Manly Council's Land and Property GIS Officer are shown on **Figure 2.1**.

As indicated by **Figure 2.1,** there is a mix of land tenure within the study area including:

- Manly Council – Community Land;
- Crown Land – Park; and
- Crown Land - Public Reserve.

2.2 LAND CATEGORISATION

Under the NSW *Local Government Act 1993* (LG Act) a Council must classify Public Land as either 'community' or 'operational' land. Operational land has no special restrictions other than those that may apply to any piece of land. However, the use of community land must be in accordance with an adopted Plan of Management.

Manly Council has adopted an overarching Plan of Management for Community Lands (1996) and has also adopted a Plan of Management for Manly Ocean Beach (2002), which addresses the legislative requirements for the management of Community Land and, in accordance with the Coastal Policy 1997, also includes the management of Crown Land within the foreshore study area in order to streamline the management of public open space along Manly Ocean Beach.

It is understood that it is Council's intention that the CMP and the adopted Plan of Management for Manly Ocean Beach (2002) will remain as separate documents, together co-governing the future management of the study area. The CMP has therefore been developed so as to support the values, objectives and actions identified in the adopted Plan of Management.

2.2.1 Crown Land

The *Crown Lands Act 1989* (CL Act) governs the planning, management and use of Crown lands for a range of public purposes. Crown Land must be used and managed in accordance with the following principles, as established by the CL Act:

- that environmental protection principles be observed in relation to the managed and administration of Crown Land;
- that the natural resources of Crown Land (including water, soil, flora, fauna and scenic quality) be conserved wherever possible;
- that public use and enjoyment of appropriate Crown Land be encouraged;
- that, where appropriate, multiple use if Crown Land be encouraged;

FIGURE 2.1

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LAND OWNERSHIP

- that, where appropriate, Crown Land should be used and managed in such a way that both the land and its resources are sustained in perpetuity; and
- that Crown Land be occupied, used, sold, leased, licenced or otherwise dealt with in the best interests of the State consistent with the above principles.

The Coastal Crown Lands Policy 1991 also applies to the study area. The CMP is to be consistent with the following objectives

- conserve and maintain the intrinsic environmental and cultural qualities of coastal Crown Land;
- retain all coastal Crown Lands of an environmentally sensitive nature and/or required for public purpose, in public ownership;
- optimise public access and use of coastal Crown Lands;
- provide Crown Lands, as appropriate, for recreation, tourism, residential and commercial coastal development with due regard to the nature and consequences of coastal processes;
- encourage the rehabilitation of degraded coastal lands; and
- continue to acquire significant coastal lands for future public use.

2.2.2 Community Land

The Plan of Management for Manly Ocean Beach is required under the LG Act to further categorise Community Land. **Table 2.1** summarises the categorisation of public open space land within the study area as established by the Plan of Management.

Any leases, licences and other estates relating to community land must be expressly authorised by the Plan of Management (PoM) for that land, which is required to specify any purposes for which a lease, licence or other estate may be granted. The Plan of Management for Manly Ocean Beach (2002) has expressly authorised the granting of leases, licences and other estates for uses permissible pursuant to the Manly LEP 1988 noting that the land is zoned 6(a) open space. In order to determine whether a use is permissible reference should be made to the objectives of the 6(a) open space zone and also the development table in clause 10 of the Manly LEP, as summarised in **Table 2.2**. Under the LG Act no lease, licence or other estate may exceed a period of 21 years.

The Plan of Management also authorises the granting of a lease, licence or other estate on community land that has been categorised within the study area so long as the use is compatible with the core objectives for that land category (refer to **Table 2.1**). The PoM, more specifically, provides for the lease of the Visitor Information Centre for its commercial use as a ‘refreshment room’ in addition to other uses compatible with the core objectives for the land category.

2.2.3 Operational Land

No areas of Public – Operational Land under Manly Council’s Ownership are located within the study area.

Table 2.1 Categorisation of Community Land

Area	Category	Core Objectives[1]
The Ocean Beach (including all land from Lagoon Park east of North Steyne to the natural rocky point adjacent to the Manly SLSC)	Cultural Significance	To retain and enhance the cultural significance of the area (namely its Aboriginal aesthetic, archaeological, historical, technical or research or social significance) for past, present or future generations by the active use of conservation methods. Those conservation methods may include any or all of the following methods:- • The continuous protective care and maintenance of the physical material of the land or the context and setting of the area of cultural significance; • The restoration of land, that is, the returning of the existing physical material of the land to a known earlier state by removing accretions or by reassembling existing components without the introduction of new material; • The reconstruction of the land, that is, the returning of the land as nearly as possible to a known earlier state; • The adaptive reuse of the land, that is, the enhancement or reinforcement of the cultural significance of the land by the introduction of sympathetic alterations or additions to allow compatible uses (that is, uses that involve no changes to the cultural significance of the physical material of the area, or uses that involve changes that require a minimum impact); and • The preservation of the land, that is, the maintenance of the physical material of the land in its existing state and the retardation of deterioration of the land.
Three Surf Pavilions and the Former Visitor Information Centre	General Community Use	To promote, encourage and provide for the use of the land, and to provide facilities on the land, to meet the current and future needs of the local community and of the wider public: • In relation to public recreation and the physical, cultural, social and intellectual welfare or development of individual members of the public; and • In relation to purposes for which a lease, licence or other estate may be granted in respect of the land (other than the provision of public utilities and works associated with or ancillary to public utilities).
The beach between mean high water mark and the seawall	Natural Area - Foreshore	• To conserve bio-diversity and maintain eco-system function in respect of the land, or the feature or habitat in respect of which the land is categorised as a natural area; • To maintain the land, or that feature or habitat, in its natural state and setting; • To provide for community use of land access to the land in such a manner as will minimise and mitigate any disturbance caused by human intrusion; • To assist in and facilitate the implementation of any provisions restructuring the use and management of the land that are set out in a recovery plan or threat abatement plan prepared under the Threatened Species Conservation Act 1995 or the Fisheries Management Act 1994. • To maintain the foreshore as a transition area between the aquatic and the terrestrial environment, and to protect and enhance all functions associated with the foreshores' role as a transition area; and • To facilitate the ecologically sustainable use of the foreshore, and to mitigate impact on the foreshore by community use.
All remaining areas within the study area	Park	• To encourage, promote and facilitate recreational, cultural, social and educational pastimes and activities; • To provide for passive recreational activities or pastimes and for the casual playing of games; and • To improve the land in such a way as to promote and facilitate its use to achieve the other core objectives for its management.

[1] These Core Objectives are applied by the *Local Government Act 1993* and can not be changed unless the land is re-categorised.

Table 2.2 Current Leases, Licences and Other Estates – Manly Ocean Beach Open Space Lands

Land	Lease /Licence /Other Estate	Lease Details
Reserve (South Steyne) 5120-3000 Community Land	Leased to Manly Surf Life Saving Club	Lease of Manly Surf Pavilion (ie: South Steyne) from 14 February 2005 to 13 February 2025
Reserve (South Steyne) 4156-3000 Community Land	Leased to Manly Surf Life Saving Club	Lease of Manly Surf Pavilion (ie: South Steyne) from 14 February 2005 to 13 February 2025
Reserve (Ashburner Street) 2801/728431 Crown Reserve	Leased to Manly Surf Life Saving Club	Lease of Manly Surf Pavilion (ie: South Steyne) from 14 February 2005 to 13 February 2025
North Steyne Reserve 7183/1074329 Community Land	Lease to North Steyne Surf Life Saving Club	Lease of North Steyne Surf Pavilion from 17 March 1999 to 17 March 2009
Merrett Park 7098/1077174 Crown Park	Lease to Queenscliff Surf Life Saving Club	Lease of Queenscliff Surf Pavilion from 17 March 1999 to 17 March 2009
North Steyne Reserve	Lease to Excell Bistro Pty Ltd for the operation of the Manly Ocean Beach House	Lease of the former Visitor Information Centre for a period of 10 years, expiring in December 2011.
Manly Ocean Beach	Beach Licence	Licence for the Use of the Beach Volleyball Courts from October 2005 to October 2009
Manly Ocean Beach	Beach Licence	Licence for the Use of Manly Ocean Beach to operate the Learn to Surf Program from October 2005 to October 2009
Manly Ocean Beach	Beach Licence	Licence for the Use of Manly Ocean Beach to operate the Surf Education Awareness Program from October 2005 to October 2009
Manly Ocean Beach	Beach Licence	Licence for the Use of Manly Ocean Beach to operate a Beach Equipment Hire venture from October 2005 to October 2009
North Steyne Reserve	Beach Licence	Licence for the Use of North Steyne Reserve to operate a Beach Lockers Hire venture from October 2005 to October 2009

2.3 LEASES, LICENCES & OTHER ESTATES

Existing leases, licences and other estates within the study area are listed in **Table 2.2.**

2.4 EVENTS

In addition to Leases and Licences, Council approves beach events. Council's Events Approval Policy allows in the order of 40 events per annum, and no more than one major event each month. These numbers have been reduced in the recent past to maintain residential amenity and reduce the impact on non-structured beach users. Council's Events Approval Policy does not permit commercial signage or products promotion.

2.5 LAND ZONING

The *Manly Local Environmental Plan 1988* (Manly LEP) is the main statutory control over local development within the Manly Local Government Area. The Plan applies to all land within the Municipality of Manly. The boundary of the LEP extends 1 km seaward of Manly Ocean Beach.

The Manly LEP provides broad controls for environmental planning. It is supported by more detailed planning provisions identified in Council's Development Control Plans (DCPs).

The LEP also identifies Items of Environmental Heritage, Environmentally Sensitive Areas, Foreshore Scenic Protection Ares and acid Sulfate Soils.

The Manly LEP establishes land use zones and requires general restrictions on development within each of those zones. Land within the study area is zoned by the Manly LEP as 6(a) open space as shown on **Figure 2.2**. Land adjacent to the study area is primarily zoned residential with some areas around The Corso zoned business or special use.

2.5.1 Zone 6(a) Open Space

The objectives of the 6(a) zone are as follows:

a) to ensure there is provision of adequate open space areas to meet the needs of all residents and provide opportunities to enhance the total environmental quality of the Municipality;
b) to encourage a diversity of recreation activities suitable for youths and adults;
c) to identify, protect and conserve land which is environmentally sensitive, visually exposed to the waters of Middle Harbour, North Harbour and the Pacific Ocean and of natural or aesthetic significance at the water's edge;
d) to facilitate access to open areas, particularly along the foreshore, to achieve desired environmental, social and recreation benefits;
e) to conserve the landscape, particularly at the foreshore and visually exposed locations, while allowing recreational use of those areas; and,
f) to identify areas which:
    i. in the case of areas shown unhatched on the map are now used for open space purposes, and
    ii. in the case of land shown hatched on the map are proposed for open space purposes.

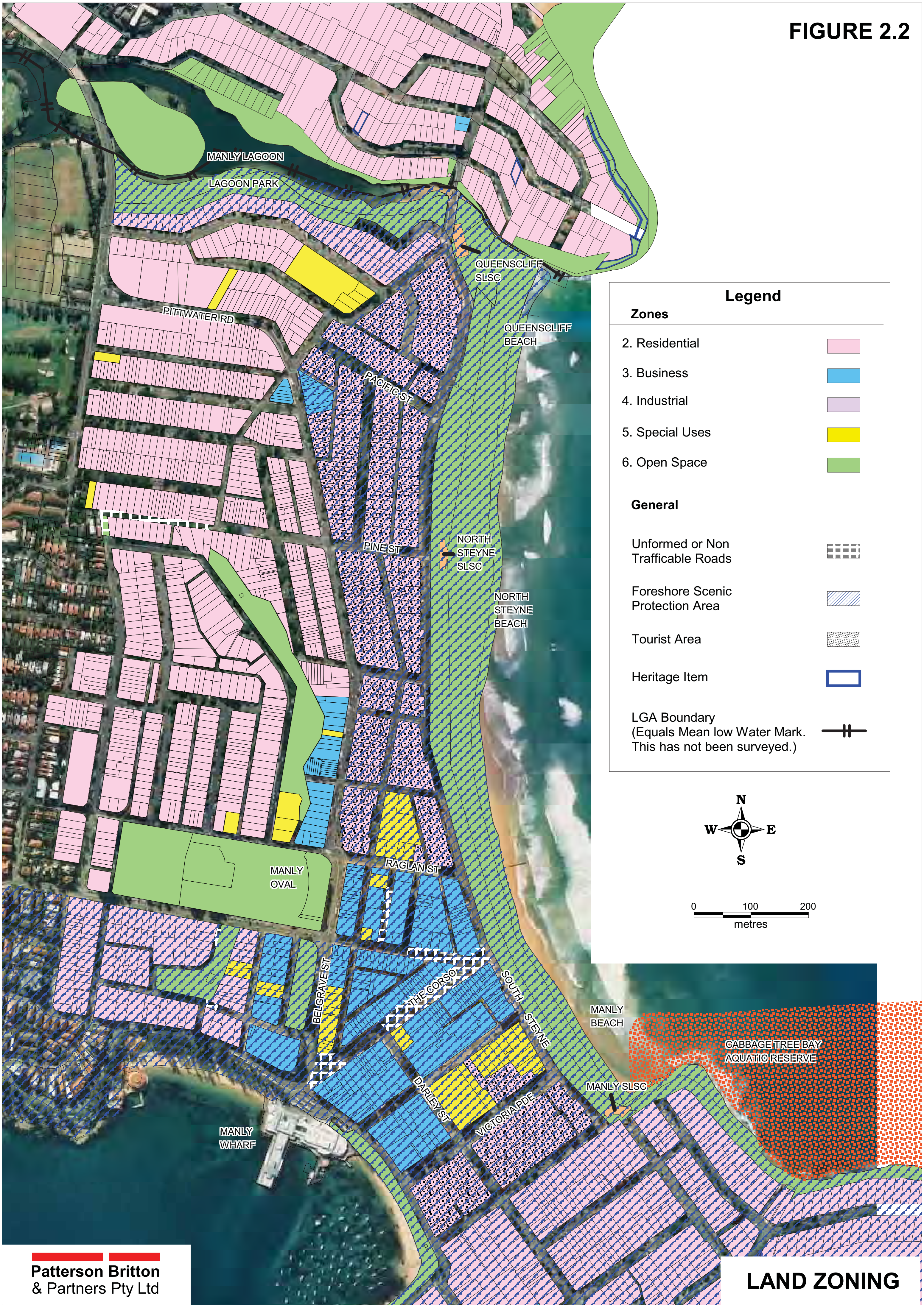
Within this zone works for the purposes of landscaping, gardening or bushfire hazard reduction are permitted without development consent.

Refer to the LEP for uses requiring development consent, prohibited uses, exempt development and complying development.

2.5.2 Heritage Provisions

Manly LEP 1988 identifies the following list of items of heritage significance within the study area:

FIGURE 2.2



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LAND ZONING

- North Steyne Surf Club
- Queenscliff Surf Club
- Public shelters at South Steyne
- North and South Steyne Beach Reserves (Merrett Park and The Steyne)
- The Ocean Foreshore

2.5.3 Environmentally Sensitive Areas

Manly's LEP (1988) (Amendment 34. Exempt and Complying Development) identifies Environmentally Sensitive Areas. These areas are parts of the Manly LGA where development or works are required to be sensitive to actual or potential environmental conditions. Development is not complying development if it is carried out within an environmentally sensitive area. The whole of the study area falls within an environmentally sensitive area.

2.5.4 Foreshore Scenic Protection Area

A Foreshore Scenic Protection Area has been established by the Manly LEP. As identified in **Figure 2.2,** all of the land within the CMP study area forms part of the Manly Foreshore Scenic Protection Area.

The Manly LEP states that a Consent Authority shall not grant consent unless it is satisfied that proposed development requiring consent will not have a detrimental effect on the amenity of the Foreshore Scenic Protection Area.

2.5.5 Development for Certain Additional Purposes

The Manly LEP refers to land listed in Schedule 5 of the LEP, with regard to specific development. Land being 93–95 North Steyne is identified in Schedule 5.

Nothing in the Manly LEP prevents the carrying out of development on that land for the following purposes:

- the hire and sale of goods associated with recreational activities on the Manly Ocean Beach and beach front reserve in shops on the ground floor of the building situated on the land;
- subject to any specified conditions of consent.

2.5.6 Acid Sulphate Soils

The Manly LEP refers to development on land identified on Acid Sulfate Soils (ASS). Map 5 of the Manly LEP identifies ASS by various Classes. The study area is identified on Map 5 as Class 4 or Class 5 land. Unless otherwise indicated by Council, consent is required for the carrying out of works[2] described in **Table 2.3** on land of each relevant class.

[2] Works are defined by the Manly LEP as
(a) any disturbance of more than one [1] tonne of soil (such as occurs in carrying out construction and maintenance of drains, extractive industries, dredging, the construction of artificial waterbodies [including canals, dams and detention basins] or foundations, or flood mitigation works), or
(b) any other works that are likely to lower the watertable regardless of how much soil they disturb.

Table 2.3 Acid Sulfate Soils Classifications

Class of Land	Works
4	Works beyond 2 metres below natural ground surface; works by which the water table is likely to be lowered beyond 2 metres below natural ground surface.
5	Works within 500 metres of adjacent Class 1, 2, 3 or 4 land which are likely to lower the watertable below 1 metre AHD on adjacent Class 1, 2, 3 or 4 land.

3 ISSUES AND MANAGEMENT OPTIONS

3.1 GENERAL

Key issues for the management of Manly Ocean Beach were identified as part of the Manly Ocean Beach Coastline Management Study through:

- consultation with the community and key stakeholders;
- literature reviews undertaken for specialist studies;
- discussions held with relevant Council and State Agency officers; and,
- local knowledge of the study team.

An overview of the key issues identified is provided below. A more detailed description of each issue can be found in Section 7 of the Manly Ocean Beach Coastline Management Study.

An assessment of management options to address the identified key issues was also undertaken as part of the Manly Ocean Beach Coastline Management Study. Identification of management options was based on:

- consultation with groups of internal (Manly Council) and external stakeholders:
- a review of management options included in the Coastline Management Manual (NSW Government, 1990); and,
- the experience of the study team.

In the identification of management options there was a focus on realistic management options. Those options that were unlikely to meet the objectives of the CMP set out in **Section 1.4** were quickly dismissed.

The detailed assessment of options and identification of a preferred option(s) for each issue can be found in Section 9 of the Manly Ocean Beach Coastline Management Study. The preferred management options have been discussed briefly below and presented in the Coastline Management Plan: Action Plan.

3.2 STUDY AREA WIDE ISSUES & MANAGEMENT OPTIONS

3.2.1 Beach Erosion

Beach erosion has in the past and will continue in the future to threaten foreshore assets, since the volume of sand available on the beach is not sufficient to accommodate sand losses in severe storms. The level of threat into the future will be exacerbated due to predicted shoreline recession (refer **Section 3.2.2**).

The detailed assessment of management options for beach erosion undertaken for the Manly Ocean Beach Coastline Management Study included consideration of the following options[3]:

- Option A - implementation of an Emergency Action Plan (EAP) to deal with the erosion hazard when it occurs and where it occurs along the beach.
- Option B - structural works to ensure the integrity of the seawall in the design erosion event such that implementation of an EAP is not required.
- Option C - nourishment of the beach such that there is always an adequate volume of sand on the beach to accommodate the design erosion event and thus prevent damage to the seawall.

An EAP has been prepared for Manly Ocean Beach and includes, among other things, emergency protection measures that might be implemented to mitigate erosion damage. The EAP is contained in a stand-alone report and incorporates Council's 'Draft Emergency Response to Rock Exposure Action Plan'.

The detailed assessment of management options for beach erosion undertaken for the Manly Ocean Beach Coastline Management Study indicated that the preferred management option for beach erosion, on mainly economic grounds, is implementation of the EAP to deal with the erosion hazard when it occurs and where it occurs along the beach (Option A).

The Coastline Management Study also noted that investigation of structural measures to stabilise the toe of the seawall and allow removal of the rock aprons along the beach should be pursued due to the amenity and safety benefits that could be achieved. The greatest benefit of such work is likely to be derived in the section of beach between about the former Tourist Office and the stairs at Victoria Parade, due to the high recreational usage in this area, generally narrower beach width and lower beach level, and past consequences of rock exposures.

3.2.2 Shoreline Recession

Shoreline recession as a result of Greenhouse sea level rise is a concern for Manly Ocean Beach and would result in ongoing loss of beach width over time with consequent loss of beach amenity, greater erosion threat to foreshore assets, and adverse economic effects.

The detailed assessment of management options for shoreline recession undertaken for the Manly Ocean Beach Coastline Management Study included consideration of the following options:

[3] Note that a 'Do Nothing' option is not realistic for Manly Ocean Beach; it is not the historical practice of Council having regard to the social, environmental, heritage and economic consequences of erosion. The 'Do Nothing' option was rejected by the Coastline Management Committee at its meeting on 23 August 2006.

- Option A - upgrading of the seawall to accommodate the design erosion event and the greater erosion threat over time as the beach narrows due to shoreline recession.

- Option B - beach nourishment combined with ongoing implementation of the EAP.

- Option C - beach nourishment combined with seawall upgrading

Assessment of the options was undertaken against a number of parameters comprising:

- recreational values including beach safety;
- aesthetic values;
- cultural heritage values;
- aquatic ecology;
- benefit / cost ratio.

The assessment indicated that the preferred management option for shoreline recession comprises beach nourishment combined with ongoing implementation of the EAP (Option B).

3.2.3 Coastal Inundation Hazard

Existing wave runup levels in severe storms overtop the crest of the seawall and in the past have lead to some damage to coping and parapet walls along the seawall. Widespread or prolonged flooding due to wave runup is not a significant issue since overtopping occurs as a 'pulse' with each wave uprush and the astronomical tide component of the elevated ocean water level ensures that water levels (and runup levels) drop within hours.

The risk of overtopping and damage to existing coping and parapet walls will increase over time due to the predicted Greenhouse sea level rise. However, the appropriate course of action over the next 5-10 years is considered to be one of monitoring of sea level rise and measurement of runup levels at times of storms (as data is generally limited) and undertaking repairs to any damage as and when required.

There is scope to raise coping levels, or create coping, in particular areas at a future time should the risk of overtopping (risk = likelihood x consequences) be considered unacceptable. Raising of the promenade level is not considered necessary, nor desirable, for the foreseeable future.

3.2.4 Climate Change

During the course of the stakeholder consultation an issue was raised regarding the potential impact on flooding and groundwater levels within the adjacent residential and commercial areas as a result of Greenhouse sea level rise, particularly given the number of existing basements in these areas and the likelihood of additional basements in the future associated with redevelopment of properties.

Flooding due to oceanic inundation is not considered to be a concern for the foreseeable future. However, this situation should continue to be monitored and sea level rise should be considered during detailed hydraulic analysis for stormwater upgrading.

Groundwater levels can be expected to rise behind the beach in response to a rise in mean sea level. The attenuation of this rise with distance from the beach and the implications for basements is difficult to assess without more investigation. Investigations are a recommended management option.

3.2.5 Recreation and Competing Beach User Groups

Issues relating to recreational use of the study area identified in the Manly Ocean Beach Coastline Management Study include the following:

- the local community has demonstrated a past reluctance to accept significant or sudden changes to the beach's use, management or appearance, with a preference for incremental change or evolution clearly shown;

- visitor safety is a central management issue in challenging environments such as surfing beaches, especially when large numbers of inexperienced users may be present. Maintaining adequate signage, visitor information and a comprehensive lifeguard/volunteer lifesaving service at key points along the beach will be a critical continuing visitor safety requirement;

- the two large stormwater pipes that cut the lower beach and intrude into the surf zone are a serious potential hazard to swimmers and surfers in their vicinity, especially under rough or difficult conditions;

- sand quality and coverage is a critical determinant of visitor satisfaction on Manly Beach. Substantial long-term reductions in sand area, or sand quality, would seriously adversely impacts visitors' enjoyment of the area;

- visitor use of Manly Beach, and especially the location of different users groups and crowding, has to-date been largely successfully self-regulating. However any serious reduction in sand coverage/quality or usable beach area, or a major sustained increase in visitor numbers or alterations to usage patterns, may exacerbate crowding or increase user conflicts. This would especially be the case on the southern end of the beach, which is already crowded during peak use periods;

- the landscaped promenade area opposite the seaward end of The Corso is a very high use zone. The limited capacity of this comparatively narrow area may become a crowding and visitor management issue in the mid term;

- to ensure equitable access and enjoyment of the beach Council will need to continue to be vigilant in balancing special event, commercial and organised usage of the beach with maintaining public accessibility, use and quality beach settings;

- to avoid over-commercialisation, crowding, the disruption of other users, and diminishing visitors' experience of Manly Ocean Beach Council will need to continue to be vigilant in managing commercial use and commercial tourism operators within the study area;

- Manly Ocean Beach has a reputation as a significant surfing beach, as well as a long association with surfing and the surf lifesaving movement. The continued quality of the area's surf breaks, and the sandbanks that significantly influence this, should be considered in any management of sand volumes and movement along the beach;

- visitor use is not evenly spread along the beach. Additional capacity, both on the sand and in the surf, can be found in the North Steyne to Queenscliff section of the beach. The present more informal, relaxed and less tourism-oriented character of this end of the beach should be preserved;

- access to the beach zone for people with disabilities or mobility challenges is only fair at present, and could be improved as part of any additional works;

- high usage levels will require that Council continue to invest in the routine high quality maintenance and periodic refurbishment of the landscape works and visitor facilities across the study area in order to maintain current amenity and enjoyment levels. Further development and hardening of the now less formal parts of the beachfront should only be undertaken as a planned process, rather than incremental or maintenance-driven development;

- visitors' use and enjoyment of the beach will need to be balanced with the amenity of local residents/neighbours in the area's future development and management.

A number of management strategies have been identified to address the issues listed above, these include:

- maintain adequate signage, visitor information and other educational efforts, as well as a comprehensive lifeguard/volunteer lifesaving service at key points along Manly Ocean Beach to ensure the safety of visitors and beach users;

- investigate options for expanding the promenade and formal landscape area opposite and south of the seaward end of The Corso, to increase the capacity of this comparatively narrow and at times crowded high use area;

- improve physical access to the beach zone for people with disabilities or mobility challenges;

- support and enhance the existing informal/self-regulating dispersal of differing uses and visitor groups along the beach and foreshore, largely through indirect design and management measures (such as the location of beach access points, special activity areas, picnic facilities, and so on);

- continue the licencing process and special management arrangements for major events, commercial and organised usage of the beach and foreshore areas. Regularly review the approval processes and frequency/occupation levels for such commercial or organised beach uses to ensure equitable visitor access and enjoyment of Manly Ocean Beach and avoid over-commercialisation, crowding, or reduction in the area's visitor appeal;

- ensure that Manly Beach's key surf breaks and reputation as a "quality surf spot" are considered in the identification of any beach management actions impacting the surf zone and are not unduly compromised;

- continue to invest in the routine high quality maintenance and periodic refurbishment of the landscape works and visitor facilities along Manly Ocean Beach, in keeping with the proposed unifying Landscape Masterplan and avoiding incremental or maintenance-driven development/hardening of less formal beachfront areas;

- continue to balance park use and visitor enjoyment of the beachfront with the amenity of local residents/neighbours.

3.2.6 Waste Management and Beach Raking Practices

As is the case for many urban beaches, Council maintains the aesthetics, amenity, utility and safety of Manly Ocean Beach through regular cleaning. A mechanical rake / sieve operates 7 days per week, cleaning Council's eight accessible beaches. The BeachTech 2000 rake / sieve rakes the surface sand and can sift sand in the upper 200 mm layer (although sifting depends on conditions and the time available).

Raking collects litter and debris (e.g. wrack, bottles, cans and cigarette butts) while sieving gives a more thorough clean. A 'grooming' device across the rear of the machine, gives a 'combed' finish to the sand. Due to the need to complete this work during times of least use, (i.e. early morning) there are occasions when wrack or litter may be deposited on beaches after the daily cleaning.

Issues identified in the Manly Ocean Beach Coastline Management Study regarding beach raking include:

- regular removal of wrack may adversely impact on faunal diversity and sand loss - faunal diversity - wrack is an essential component to a thriving and diverse sandy beach ecosystem, as it acts as a direct food source and shelter for many species living above the sand and provides nutrients to fauna living in the sand. Hence, its regular, wholesale removal through beach cleaning is a removal of an important component of the beach;

- regular removal of wrack may result in sand loss - accumulations of wrack can buffer wave action and help to keep sediment stable (Fairweather and Henry 2003). Raking and sifting can break the hard pan of the beach subsurface, making it more susceptible to wind erosion. Hence, at the extreme, the result of wrack removal may enhance sediment (sand) loss; and,

- litter on the beach – the effectiveness and need for more frequent raking.

A management option involving the development of appropriate ecological indicators would assist in determining the ecological significance of the removal of wrack due to beach raking at Manly Ocean Beach (refer **Section 3.2.7**).

The current waste management approach, involving initiatives such as Council's litter avoidance strategy and waste minimisation policy, is considered appropriate.

3.2.7 Aquatic Ecology

The ecological issues associated with Manly Ocean Beach are related to the potential interaction of socio-cultural systems and natural systems. Potential impacts to natural systems of Manly Ocean Beach are important as they can affect sensitive nearby environments and biota, and effect different user groups of the beach.

Aquatic ecology issues identified in the Manly Ocean Beach Coastline Management Study include:

- beach raking - may have the adverse side effects of removing wrack, which contains beach organisms or their food. Raking may also potentially compact areas of the beach or enhance sediment loss;

- trampling by recreational users - may compact areas of the beach. Barros' (2001) findings of fewer ghost crab burrows on beaches in urban areas may indicate such an effect;

- beach nourishment – results in impacts on organisms caused by changes in habitat. In addition, nourished sand may move out of the nourished area to neighbouring habitats or to somewhat deeper water, potentially affecting benthic communities offshore (Verhagen 1996). An impact of particular concern would be the potential for leakage of sand from a nourished beach to reef habitats in Cabbage Tree Bay Aquatic Reserve;

- water quality - although recent Beachwatch data for Manly Ocean beach indicates that water quality is good during dry weather, Manly Ocean Beach is exposed to some stormwater discharges. Any impacts to natural systems of Manly Ocean Beach could potentially affect biota in adjacent habitats. Cabbage Tree Bay Aquatic Reserve would be sensitive to degradation of natural systems at Manly Ocean Beach, particularly changes to water quality or parts of the food webs that support species in the reserve;

- lack of local information - virtually no published information specific to the beach is available. More information on components of the natural systems of Manly Ocean Beach will enable better management.

Management strategies identified to address the issues listed above include:

- commission ecological studies to learn more about the aquatic ecology of Manly Ocean Beach.

- establish ecological indicators to monitor the condition of beach habitats.

Aquatic ecology issues were also considered in the assessment of management options for waste management, shoreline recession, water quality and the stormwater pipes.

3.2.8 Water Quality

Dry weather water quality at Manly Ocean Beach has been shown to be good. However, the key water quality issue for Manly Ocean Beach is water quality following rainfall events. Bacterial densities for Manly Ocean Beach generally increase with increasing rainfall. Faecal coliform and enterococci levels often exceeded the median guideline limit after significant rainfall of more than 5 to 20 mm in the previous 24 hours (DEC, 2004). The main sources of pollutants are from:

- stormwater pipes; and
- Manly Lagoon.

Manly Lagoon is subject to a range of management initiatives contained within the Manly Lagoon Estuary Management Plan (1998). Many of these management initiatives have been implemented or are proposed by Council.

Recently, the SEA (Stormwater Environment Awareness) Change program was commenced around Manly Council's catchments. This program was developed through mutli-organisational partnerships with funding provided from the Stormwater Trust. The program aims to restore Manly Lagoon and other waterways, both ecologically and in a recreational capacity, by systematically targeting pollution "hotspot" catchments.

The Sea Change program has also led to the recent development and adoption of an Integrated Catchment Management Strategy. The Manly Lagoon Integrated Catchment Management Strategy (2004) was prepared to provide a co-ordinated approach to managing the Manly Lagoon catchment within both Warringah and Manly Councils. The strategy includes a 5 year action matrix and targets. Listed actions include further improvement in the quality of water entering the Lagoon through improving sewerage infrastructure, urban runoff and creeks; the removal of contaminated sediment in the Lagoon; and the maintenance and enhancement of waterway features, flows and tidal interchange.

Initiatives under the Manly Estuary Management Plan, the Sea Change Program and the Manly Lagoon Integrated Catchment Management Strategy that improve the water quality of Manly Lagoon are endorsed as they will assist in meeting the objectives of the Manly Ocean Beach CMP.

Exposed stormwater pipes extend across the sand and into the ocean at Pine Street near North Steyne SLSC and at Raglan Street. In addition, stormwater enters the beach at three other locations along the seawall. Gross pollutant devices are secured to the end of some pipes to prevent rubbish polluting the beach. However, stormwater from the pipes on Manly Beach can be polluted and adversely affect the water quality at the beach after heavy rain.

Manly Council has undertaken numerous initiatives/measures to improve stormwater that flows to Manly Ocean Beach. In addition, Manly Council is proposing a range of initiatives in the catchments such as rainwater tanks, detention storage and infiltration which would have the effect of reducing stormwater flows from the catchments to Manly Ocean Beach. Proposed measures Manly Council is considering include:

- targeted rainwater tank subsidies in key catchments on Manly Flats;
- Ivanhoe Park detention and infiltration system;
- Pine Street end of pipe storage and aquifer injection;
- Kangaroo Lane stormwater detention and on-use; and
- feasibility assessment of removing or shortening stormwater pipes.

Measures implemented and proposed by Council that improve the quality of stormwater flowing to Manly Ocean Beach are endorsed as they will assist in meeting the objectives of the Manly Ocean Beach CMP.

Sydney Water made a submission to Manly Council following public exhibition of the draft CMP and advised that:

- Sydney Water is supportive of Council's catchment based initiatives to improve stormwater quality and reduce stormwater flows through the Raglan Street outfall, and is prepared to explore these initiatives with Council;

- Sydney Water agreed that options to remove or divert the Raglan Street outfall require peak storm flows through the outfall to be reduced.

Section 3.3 notes issues and management options associated with the Manly Lagoon entrance and the stormwater pipes. Water quality issues along Manly Ocean Beach will be addressed by the adoption of the identified management options for the Manly Lagoon entrance and the stormwater pipes.

3.2.9 Conservation Items of Heritage Significance

Although there would have been abundant evidence of Aboriginal occupation and land use of Manly Ocean Beach, almost all have been destroyed or hidden by urban development and land uses. No recorded sites today remain within the study area.

Issues relating to Aboriginal heritage identified in the Manly Ocean Beach Coastline Management Study include the following:

- a range of Aboriginal sites were previously known in the Manly Ocean Beach area, and as yet unknown or unrecorded sites may still be found along the oceanfront and elsewhere within the study area. The possibility of unknown/unrecorded Aboriginal sites warrants consideration in the development assessment process;

- tangible Aboriginal heritage objects and sites are protected by legislation. Any objects and sites within the study area that may be located, including sites uncovered during development or management works, will require appropriate protection and management;

- the Manly area's Aboriginal history, heritage, sites and contemporary associations/significance are all of potential interpretive interest to residents and visitors.

A number of management strategies have been identified to address the issues listed above, these include:

- establish and maintain a co-operative working relationship with the Metropolitan Local Aboriginal Land Council, and other Aboriginal people or groups as required, regarding the identification, appropriate management, and culturally appropriate presentation of Aboriginal heritage sites/values - both tangible and intangible - along Manly Ocean Beach;

- require Aboriginal heritage investigations to be carried out as part of the development planning and approval process for any major proposals located in the vicinity of previously known or suspected Aboriginal heritage sites along Manly Ocean Beach;

- incorporate "awareness, identification and response" provisions regarding unknown/unrecorded Aboriginal cultural sites in development/building approvals for major excavations works along Manly Ocean Beach;

- establish protocols for managing any unknown/unrecorded Aboriginal heritage sites that may be located during development/construction works along Manly Ocean Beach;

- incorporate information regarding the Manly area's Aboriginal history, heritage, sites and contemporary associations/significance in future interpretation measures - both on and off site - for Manly Ocean Beach;

- investigate the dual-naming of Manly Ocean Beach and the wider public use and recognition of the area's traditional Aboriginal name.

Issues relating to historic heritage identified in the Manly Ocean Beach Coastline Management Study include the following.

- Manly Ocean Beach is listed on the Register of the National Estate as an iconic location for surfing, beach culture and recreation that is inextricably associated with the imagery of the "bronzed Aussie" as well as having a long history as an urban ocean-side resort. The place of Manly Beach in the Australian identity and popular culture, as well as its tangible heritage sites and assets, requires sensitive and sympathetic treatment to maintain these cultural associations and values;

- several identified sites of historic heritage significance occur within or adjacent to the study area. These sites are of different levels of significance and are afforded varying degrees of legislative protection. The impact of any proposed works on the heritage values of these places must in all cases be identified and fully considered in the planning and development process;

- Manly Ocean Beach has a long association with surfing and surf lifesaving. The beach and surf zone as a quality "surf spot" should be maintained.

Management strategies identified to address the issues listed above include:

- acknowledge and actively maintain the iconic "bronzed Aussie", surf culture and seaside recreation values of Manly Ocean Beach in all aspects of the area's future planning and management in ways that ensure the protection but evolution of these values and cultural associations;

- continue to manage Manly Ocean Beach consistent with its listing on the Register of the National Estate, recognising its nationally significant built and cultural heritage values in all aspects of the area's future planning and management;

- ensure appropriate recognition, consideration and protection of sites identified, and listed, as having historic heritage significance along Manly Ocean Beach and its curtilage in the development planning and approval process;

- ensure that Manly Beach's key surf breaks and reputation as a "quality surf spot" are considered in the identification of any beach management actions impacting the surf zone and not unduly compromised.

3.2.10 Aesthetics

Issues relating to beach aesthetics identified in the Manly Ocean Beach Coastline Management Study include the following.

- Manly Ocean Beach is renowned for its Norfolk Island Pines and long wide arc of sandy beach. These trees are of great importance due to their symbolic nature, contribution to the beachscape, vulnerability (relative to the sandy beach) and the effort and resources invested in them to date.

- the current landscape features a gradual transformation of the beachfront from a more formalised (paved) promenade and landscape in the south to a less formal (green) open parkland in the north. It is important that these areas retain their intended role and characters- rather than being progressively formalised or altered under the influence of maintenance convenience and unplanned change.

- the local community has expressed a strong reluctance to endorse any rapid or significant change in the presentation of the Manly beachscape.

- the northern end of Manly Ocean Beach is bounded by Queenscliff headland, which falls within Warringah Council LGA. Development and change of this area's visual character strongly impacts upon the visual quality of Manly Ocean Beach.

- while visitors may desire trees along the beach front for shade and aesthetic reasons, local residents may find these trees obstruct their views. Without careful planning and management conflict may arise.

Management strategies identified to address the issues listed above include:

- maintain and enhance the key visual elements of Manly Ocean Beach - specifically the Norfolk Island Pines, promenade, and long wide arc of largely uninterrupted sandy beach;

- prepare a Tree Management Plan or Tree Conservation Plan to guide future management of the Norfolk Island Pines;

- prepare and implement a revised landscape masterplan for Manly Ocean Beach based on Council's previous landscape plan prepared in 1995 to guide the character and presentation, visitor use and enjoyment, and maintenance of the area;

- maintain a process of incremental change or evolution in the presentation and aesthetics of Manly Ocean Beach, avoiding major significant alteration to the area's appearance;

- ensure appropriate recognition, consideration and protection of the visual qualities of Manly Ocean Beach in the development planning and approval process for major proposals likely to adversely impact the area's appearance and the experiences of users;

- liaise with Warringah Council regarding co-operative planning and development assessment/approvals across the south-side of Queenscliff Headland, to minimise the potential adverse impacts of development in this area on the visual quality of Manly Ocean Beach;

- continue to balance park use and visitor enjoyment of the beachfront with local residents' desire for amenity and views in all future planning and management of the landscape of Manly Ocean Beach.

3.3 SPECIFIC AREA ISSUES

3.3.1 Manly Lagoon Entrance

<u>Low Flow Pipes</u>
Following large southerly swells, kelp often gets washed into the low flow pipes and channel. This inhibits tidal exchange between the ocean and Manly Lagoon. If the kelp

remains in the channel for an extended period of time, the kelp starts to putrefy and becomes odorous which results in considerable community complaints.

The current management regime to deal with kelp is as follows:

- the Manly Council beach rake driver notifies relevant staff if there is a noticeable buildup of kelp on the beach and around the entrance to the low flow pipes;
- based on this advice a decision may be taken to lift the stainless grate at the landward end of the original low flow pipes (downstream end of the low flow open channel) in an effort to have the kelp to disperse naturally[4];
- if it becomes necessary to mechanically remove the kelp, Manly Council seeks the approval of the Department of Primary Industries (Fisheries) to do so. Following approval, mechanical removal is undertaken using a backhoe and the kelp is stockpiled adjacent to the channel on the sand for about two days to allow dewatering. The kelp is then loaded into trucks by Warringah Council and disposed of to landfill.

The current management regime for dealing with kelp is considered the best approach in the circumstances. Removal of the stainless steel grates at the landward and seaward ends of the low flow pipes to reduce the risk of clogging is not advisable due to safety concerns for swimmers and boardriders. Over time as greater knowledge of the circumstances surrounding the introduction of kelp is developed and the success of the current management regime is reviewed, current practices can be revised if considered necessary.

<u>Flood Outlet Channel</u>
A flood outlet channel for Manly Lagoon is located at the northern end of Queenscliff Beach and is regularly maintained by Manly Council (on behalf of both Manly & Warringah Councils) for flood mitigation purposes. The current maintenance procedure for the flood outlet channel is in accordance with the method outlined in the Manly Lagoon Flood and Estuary Management Plans.

The channel is maintained as a precautionary measure to allow Council to act quickly in the event of heavy rainfall to prevent damage due to flooding of Manly Lagoon. The response time required to open the lagoon to prevent flood damage can be quite short, in the order of 1-2 hrs. It takes the dozer about 40 minutes to open the sand headwall at the end of the channel.

The existence of the flood outlet channel across the beach is of some concern to the community due to impacts on beach amenity and the potential for water quality problems if the channel is excavated too deep and intercepts the water table leading to stagnation and collection of litter.

From time to time Manly Council receives complaints from the community in regard to the impact of the maintained flood outlet channel on beach amenity. While it would be

[4] Council officers have also advised that loose rocks at the bottom of the low flow pipes were recently removed to allow better movement of the kelp and assist with the mechanical removal of the kelp.

inappropriate for Council not to maintain the channel due to the flooding risk, a number of management practices should continue to be employed to minimise impact on beach amenity and impact on coastal and lagoon processes. These are outlined below:

- the flood outlet channel should be located as close as practicable to the low flow channel to provide as large a useable berm area as possible for the public south of the channel, whilst having regard to:
  - the level of bedrock, which may constrain excavation depths;
  - the risk that sand stockpiled north of the excavation may slip or be blown into the low flow channel and thereby contribute to blockage of the low flow channel;

- the flood outlet channel should not be excavated so deep that it intercepts the groundwater table on the beach as this can create shallow stagnant pools of water within the berm area which also can be a trap for litter. Consequently, it can lead to health concerns and detracts from the aesthetics of the beach;

- some sand from the excavation of the flood outlet channel should be pushed towards the seawall in front of the Queenscliff SLSC to create a berm and reduce the risk of undermining of the seawall in flood flows.

Sediment Removal near Queenscliff Bridge

Every three years or so Manly Council undertake removal of marine sand from the entrance area of Manly Lagoon, just upstream of Queenscliff Bridge, that enters the lagoon from the adjacent beach as a result of wave, tide and wind processes. The purpose of the sediment removal is to improve tidal exchange between the lagoon and the ocean, remove restrictions to fish passage, avoid continued migration of sand upstream that could impact on aquatic vegetation and provide recreation benefits.

The method of removal involves a bulldozer pushing sand to the southern edge of the lagoon. Here it is temporarily stockpiled for several weeks to allow “bleaching” and testing prior to its removal by truck and placement on Manly Ocean Beach in eroded areas.

The current approach to management of the marine sand that enters Manly Lagoon, as described above, is considered the most appropriate. Any clean marine sand that is removed from the entrance area should continue to be placed on Manly Ocean Beach so that it is retained in the local coastal system. Practices that have the potential to cause accelerated infilling of the lagoon, such as the method of stockpiling of sand excavated for the flood outlet channel, should continue to be monitored and revised where required.

3.3.2 Stormwater Outlets

Stormwater outlets are located along the beach. Issues relating to the stormwater outlets include water quality, beach erosion, safety and visual impacts.

The major stormwater outlets along Manly Ocean Beach are listed below.

- opposite Raglan Street, two 600 mm dia pipes pass under the seawall to an ocean outfall – an overflow is provided in the form of two grated apertures in the face of the seawall. It is evident that the overflow structures can become filled with sand up to the beach level;

- opposite Steinton Street, a concrete box culvert 525mm high by 1050mm, fitted with a steel end piece (which includes a detachable net for capturing gross pollutants), that discharges at a distance of approximately 6m from the seawall. The invert level of the box culvert is generally at or above the typical sand level at the beach. The scour action of the stormwater flows tends to sustain a depression or swale in the beach profile. Council has a practice of grooming the beach profile so that the detachable net is situated on the sand surface and does not become buried in the sand. Recently, floats were attached to the net to reduce the risk of it becoming buried.

- immediately to the north of North Steyne SLSC opposite Pine Street, a pipe approximately 600 mm in diameter passes under the seawall and extends across the beach into the surf zone. A surcharge outlet is located near the seawall and shows some risk of blockage with sand; and,

- opposite Pacific Street, a pipe approximately 300 mm in diameter protrudes at the wall with its invert approximately 2.6 m below promenade level. Rock has been placed near the outlet to reduce the impact of beach scour at times of stormwater discharge. These rocks are arranged haphazardly on the beach and detract from the beach amenity when exposed.

Following a detailed review of available background information undertaken for the Manly Ocean Beach Coastline Management Study and discussion with Manly Council officers, a short list of options for management of the stormwater outlets along the beach were identified and were referred to as Options A, B, C and D (refer below). It was viewed that all options would benefit from a reduction of stormwater volumes entering the drainage networks in the first place from the catchment, and that such works should be carried out in conjunction with the preferred option.

Major stormwater peak flow reductions into drainage networks could be accomplished through targeted rainwater tank subsidies to residents in surrounding catchments; and stormwater detention, harvesting, re-use, and/or aquifer injection schemes by Council. Such schemes have already achieved major local peak flow reductions from Manly CBD buildings (Corso amphitheatre storage and irrigation) and at North Steyne (stormwater harvesting, storage under beachfront reserve , and irrigation).

The four options can be briefly described as follows:

- Option A - diversion of all stormwater to a single outlet at Queenscliff Headland, a distance of approximately 1000m from the southern-most outlet at Raglan Street
- Option B - termination of all outlets at the seawall (noting that the Pacific Street and Steinton Street outlets already terminate at or near the seawall)
- Option C - termination of those outlets that cross the beach (Pine Street and Raglan Street) higher up the beach ie. a shortening of these two outlets,

together with installation of warning signage at these outlets to alert beach users to the safety hazard. Pacific Street and Steinton Street outlets remain at the back of the beach

- Option D - retention of the existing configuration of all the outlets, with installation of warning signage at the Pine Street and Raglan Street outlets

On the basis of a detailed assessment of the short listed management options undertaken for the Manly Ocean Beach Coastline Management Study, the preferred approach to management of stormwater outlets on Manly Ocean Beach is considered to be as follows:

Pine Street and Raglan Street Outlets

- install warning signage in the immediate term (this has now been completed);
- investigate the risk of blockage of the overflow structure at Pine Street outlet in the short term;
- implement stormwater volume reduction measures in the catchment;
- when upgrading of the stormwater systems in the catchments is considered:
  - undertake a detailed hydraulic analysis of the stormwater systems with particular consideration of ocean tailwater level, consider the implications of sea level rise,
  - prepare designs and carry out an environmental assessment for Option B and for Options C and D,
  - in the case of Options C and D, critically review the ARI flow to be delivered across the beach,
  - in the case of Options C and D, retain the warning signage.

Pacific Street Outlet

- formalise existing rock scour protection in the short term;
- implement stormwater volume reduction measures in the catchment;
- when upgrading of the stormwater system is considered:
  - undertake a detailed hydraulic analysis of the stormwater system with particular consideration of ocean tailwater level, consider the implications of sea level rise,
  - maintain the outlet as a back-beach discharge,
  - critically review the ARI flow to be conveyed to the beach,
  - re-examine scour provisions in front of the seawall since an upgraded outlet would take more flow in the rarer events.

Steinton Street Outlet

- implement stormwater volume reduction measures in the catchment;
- when upgrading of the stormwater system is considered:
  - undertake a detailed hydraulic analysis of the stormwater system with particular consideration of ocean tailwater level, consider the implications of sea level rise,

- maintain the outlet as a back-beach discharge,
- critically review the ARI flow to be conveyed to the beach,
- re-examine scour provisions in front of the seawall since an upgraded outlet would take more flow in the rarer events.

Sydney Water made a submission to Manly Council following public exhibition of the draft CMP and advised that:

- Sydney Water agree that implementing Water Sensitive Urban Design in the catchment and reducing stormwater flows discharging to the beach is a priority and critical to water quality and options for the stormwater outfalls;

- Sydney Water would offer its assistance to Council in exploring and investigating the four options for stormwater management, in respect of the Raglan Street outfall.

4 ADMINISTRATIVE MANAGEMENT

In order to successfully implement the recommendations of the CMP it will be necessary to record the level of agreement amongst the various stakeholders to the recommendations made and their commitment to implementing the Action Plan. Various stakeholders should be requested to review the recommendations that fall within their delegations and record their agreement to the implementation. Similarly, concerns regarding the recommendations should be indicated and negotiated with Council.

To ensure Council's commitment to the implementation of this CMP it is recommended that the implementation of the CMP be integrated into Council's Corporate Plan and that the Manly Ocean Beach Coastline Management Committee be responsible for steering the implementation of the CMP.

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Appendix 2 – Collaroy-Narrabeen Coastline Management Plan (extract)

COLLAROY NARRABEEN

COASTLINE MANAGEMENT PLAN

A Coastline Hazards Policy - Plan of Management

Warringah Council

Warringah Council

COLLAROY NARRABEEN COASTLINE MANAGEMENT PLAN

A Coastline Hazards Policy - Plan of Management

Prepared by
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August 1997

Acknowledgments

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EXECUTIVE SUMMARY

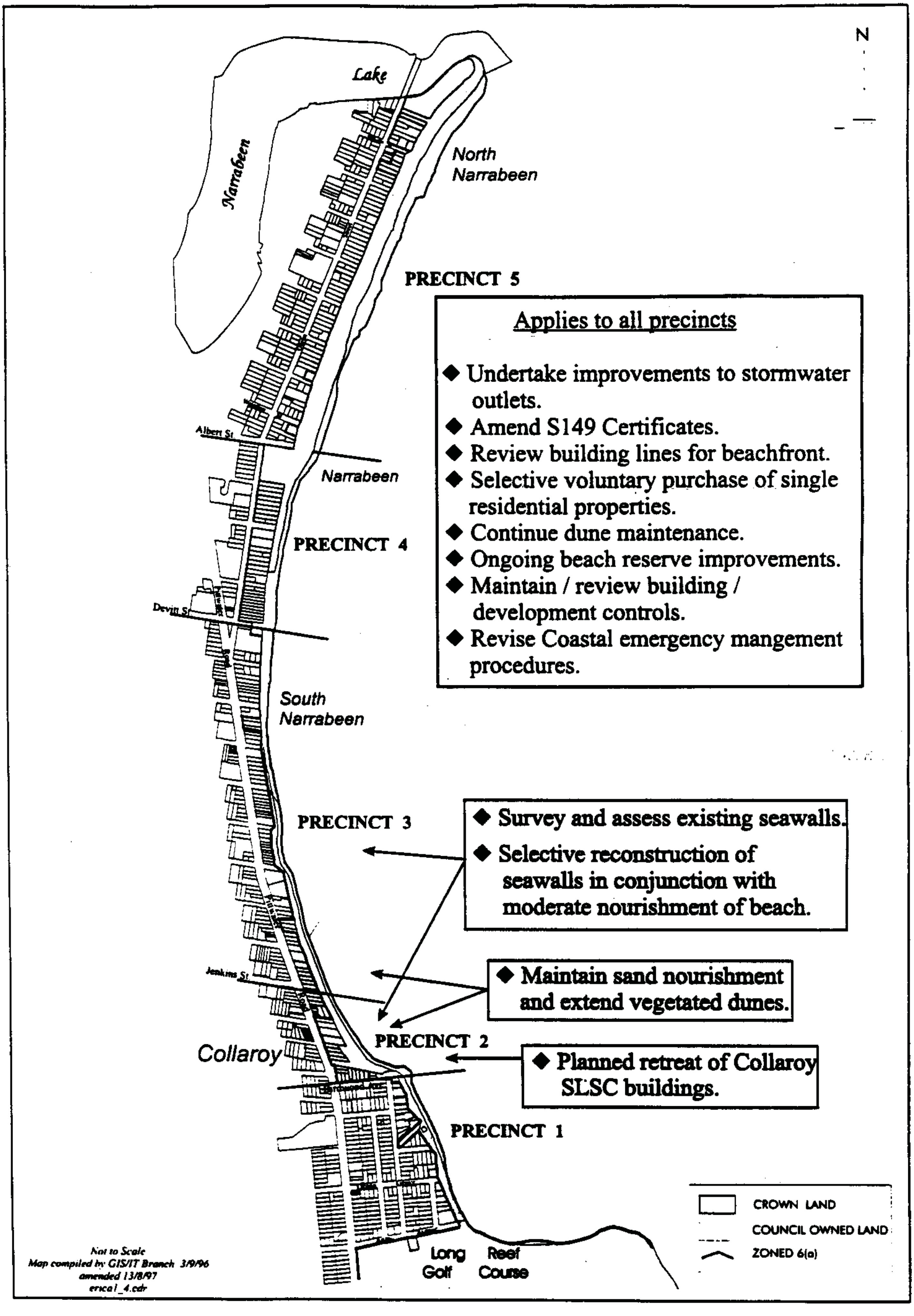
Collaroy and Narrabeen Beaches have experienced a long history of storm damage and coastal erosion, with the beaches ranked nationally as the third area most at risk from coastal processes. Hazards affecting these beaches include, beach and stormwater erosion, climate change and coastal inundation. This Coastline Management Plan addresses coastal hazards impacting on the beach. It has been prepared in accordance with the State Government's Coastline Hazards Policy, administered by the Department of Land and Water Conservation.

Preparation of the plan involved an extended and extensive community consultation process, in which coastal hazards and appropriate management responses were debated. A consensus-based Coastline Management Plan was pursued by Council but not achieved, with strong differences of opinion emerging between the community, the Warringah Coastal Management Committee (responsible for advising Council on coastal areas), and the Council. The Coastal Management Committee, in a majority vote, recommended <u>not</u> to include "reconstruction of seawalls" in the final Management Plan. Notwithstanding the differences of opinion, Council has given careful attention and consideration to all comments and issues raised, enabling an improved level of understanding to be developed by all parties.

To address objectives of the State Government's Coastline Management Manual and specific objectives proposed by the Warringah Coastal Management Committee, the Plan proposes the following four broad coastal management strategies and thirteen (13) associated actions. These actions are further illustrated in **Figure 1** (next page).

Strategy	Actions
A. **Undertake protective works**	1. Survey and assess existing seawalls. 2. Selective reconstruction of existing seawalls and minor construction to infill gaps in existing walls. 3. Undertake moderate nourishment of beach in association with reconstruction of seawalls. 4. Improvements to stormwater outlets along beachfront.
B. **Implement environmental planning measures**	5. Amend Section 149 Certificates. 6. Selective voluntary purchase/open space acquisition of single residential properties. 7. Planned retreat of Collaroy Surfclub buildings.
C. **Implement development control conditions**	8. Maintain/review building and development controls for beachfront. 9. Revise coastal emergency management procedure for Collaroy/Narrabeen Beach. 10. Review building lines for beachfront.
D. **Undertake Dune Management**	11. Maintain moderate sand nourishment and extend dune reconstruction and revegetation. 12. Continue current dune maintenance. 13. Improve beach amenity through ongoing beach reserve improvements and maintenance works.

FIGURE 1. Summary of Coastline Management Actions.



1.0 INTRODUCTION

Collaroy/Narrabeen Beach, one of Sydney's recreational beaches, is located 16 km north of Sydney's Central Business District within 'A' Ward of the Warringah Local Government Area (**Figure 2**). Collaroy Beach is bounded by a minor headland and Fishermans Beach to the south. Narrabeen Beach is bounded to the north by North Narrabeen rock pool, Narrabeen Headland and Turimetta Beach. The beach is approximately 3.6 km in length from Collaroy rock pool to the entrance of Narrabeen Lagoon. Wetherill Street forms the map boundary between the beaches of Collaroy and Narrabeen.

The Collaroy/Narrabeen beach embayment is characterised by having the most intense and highly capitalised shoreline development in Warringah. Development along the beach reserves is further characterised as the third area most at risk nationally from coastal processes, ranking behind only Queensland's Gold Coast and Adelaide's City beaches.

1.1 Purpose of this Plan

The principal purpose of this Coastline Management Plan is to provide a sound basis for management of coastline hazards affecting Collaroy/Narrabeen Beach, adjacent reserves and residential areas.

This Plan is based on information contained in numerous technical reports and studies, information provided through community debate and discussion of the issues; and a range of formal and informal presentations and submissions to the Coastal Management Committee and Council.

1.2 Responsibility for Implementation

The Collaroy/Narrabeen Coastline Management Plan will be implemented by Warringah Council through the Warringah Coastal Management Committee. The Committee comprises State Government representatives, a variety of community and resident representatives, Councillors and Council staff.

1.3 Beach Characteristics

The beach is often perceived as the sandy area between the waterline and the vegetated dunes. This sandy area is only part of the complete active beach system affected by coastal processes. The complete system extends seawards to water depths of around 20-30 metres (some 2km offshore) and landward to the back beach dune system or sand barrier. It is necessary to examine the complete active beach system when considering coastal processes of the beach system (**Figure 3**).

The state of the beach at any particular time depends on complex interactions between the sand and coastal processes.

1.4 Study Area

This ***Collaroy/Narrabeen Coastline Management Plan*** applies to the area bounded by Birdwood Avenue in the south, Pittwater Road/Ocean Street to the west, to the northern embankment of Narrabeen Lagoon entrance and seaward to the extent of the 20 - 25 metre depth contour offshore from the embayment (see **Figure 2**).

Separate policies guide the management of Narrabeen Lagoon and Narrabeen Lagoon entrance, namely the *NSW Estuary Management Policy, 1992* (NSW 1992) and the *Management Policy for Narrabeen Lagoon Entrance, 1996* (WC 1996). These and other policies influencing the coastal zone are further described in Section 3.2.3.

1.5 Land Tenure and Zoning

In land tenure terms, Collaroy/Narrabeen Beach is a Crown Reserve (No. 79606) owned by the Crown. The Reserve is some 202,300 square metres in area, reserved for the purposes of public recreation. Warringah Council has been appointed Trustee of this Reserve, under Section 95 of the Crown Lands Act 1989 by Government Gazette of 27/6/97. The Reserve is zoned 6(a) Open Space in accordance with Warringah Council's Local Environmental Plan 1980 and its community land category is 'Natural area/Foreshore' in accordance with the Local Government Act 1993.

1.6 Objectives of this Plan

The range of coastal management objectives relevant to this Plan are provided in Section 3.0. The specific objectives of the Collaroy/Narrabeen Coastline Management Plan are provided below.

Collaroy/Narrabeen Beach Coastline Management Objectives

I. To preserve and protect the beach as a national asset for public recreation and amenity;

II. To ensure that building and development along Collaroy and Narrabeen Beaches has regard to the current and future hazards of wave impact and coastal erosion;

III. To be consistent with the aims and objectives of the NSW Government's Coastline Hazards Policy and Coastline Management Manual; and

IV. Be within the reasonable and practical financial capacity of Council to implement, with financially equitable impacts across the Warringah community.

1.7 Structure of this Document

This Plan is essentially structured on guidelines provided in the State Government's *Coastline Management Manual, 1990* (NSW 1990). ***Section 2*** provides background information, outlining a history of coastal storms and Local and State Government coastal management actions. ***Section 3*** provides the policy and planning context, detailing both Warringah Council's and the State Government's coastal management and planning frameworks.

Section 4 deals with community consultation, providing information on Council's management philosophy, as well as the consultation process and public comments received. ***Section 5*** explains the coastline management issues, providing information on coastal processes and coastal hazards, with ***Section 6*** detailing the proposed management strategies and actions. The implementation schedule is provided in ***Section 7***.

2.0 BACKGROUND

2.1 History of Coastal Erosion and Storm Damage

A detailed history of the nature and extent of storm damage along Collaroy/Narrabeen Beach, from 1880 to 1986, is provided in the Public Works Department's *Collaroy/Narrabeen Beaches - Coastal Process Hazard Definition Study, December 1987,* (PWD 1987). A summary of this information is provided below.

The first European settlement of the area dates from the early 1800s, although it was not until the 1880s that a bridge was built over Narrabeen Lagoon. In 1906 land at the north end of Narrabeen Beach was subdivided and auctioned. By 1925-1930, Fishermans Beach and Collaroy beachfront were almost fully developed with developments including houses, Arlington Hall (then a theatre and now the Collaroy Beach Services Club) and surf club buildings. At this time though, only half the lots north of Goodwin Street had been developed.

By 1941 the Collaroy/Narrabeen beachfront had been virtually fully developed, with the exception of the strip between Devitt and Albert Streets which has remained largely undeveloped to the present day. In May 1944, a storm washed away outbuildings at Collaroy and homes were undermined. In June 1945, Collaroy Beach was severely eroded with two houses being "lost to the sea" and approximately six to seven others suffering substantial damage. Seven houses were subsequently demolished. The strip of beachfront between the Collaroy Beach Services Club and Jenkins Street was resumed in 1946 and is now a carpark and public reserve.

Further development and redevelopment occurred in the 1950s and 1960s with the high rise home unit blocks of Flight Deck, Shipmates and Marquesas being constructed in the 1960s. During this period, severe beach erosion occurred in August and September 1967, with Collaroy Beach again most affected. Houses were damaged and a house and Flight Deck undermined by erosion. More severe damage was only prevented by the emergency dumping of thousands of tonnes of fill and rock and the construction of sea walls.

Severe beach erosion again occurred in 1974, with the area from Clarke to Devitt Street near the centre of the embayment suffering the worst attack. Several houses and the foundations of the more seaward of the two Marquesas home unit blocks were threatened, resulting in further emergency dumping of large volumes of fill and rock. These works were undertaken by Council and residents.

Less severe storms subsequently occurred in 1978 and 1986, with the past decade having been a time of unusually few storms.

2.2 History of Government Actions

From the 1960s onwards, Warringah Council and the State Government have actively addressed the issues of coastal erosion, wave attack and the threat to properties along Collaroy/Narrabeen Beach. A detailed chronological account of the investigations and action taken are provided in **Appendix A**, with a summary of key actions provided below.

2.2.1 Warringah Shire Council 1985 - 1990

In 1985 Warringah Shire Council, in conjunction with the Public Works Department of NSW, prepared a *Coastal Management Strategy for Warringah Shire* (WSC 1985). This work identified Collaroy/Narrabeen Beach as the most at risk from coastal processes. This is due to the shoreline containing the most intense and highly capitalised beach development in Warringah, with over 120 single residential or dual occupancy dwellings, 293 residential units (including a number of major multistorey home unit developments) and public and commercial buildings. Much of this development is currently under threat from severe storm erosion, a situation which is expected to deteriorate into the future due to Greenhouse induced climatic changes and predicted rises in sea level.

In view of the substantial risk to development along Collaroy/Narrabeen Beach, Warringah Council undertook a number of studies (listed below) during the period 1987 to 1989. These reports were publicly exhibited, with comments sought on a preferred option.

- *Collaroy/Narrabeen Beaches Coastal Process Hazard Definition Study,* prepared for Council by the Public Works Department (PWD 1987);
- *Collaroy/Narrabeen/Fishermans Beach Coastal Management Strategy - Phase One: Hazard Definition,* prepared for Council by Nielsen Lord Associates (NLA 1988);
- *Collaroy/Narrabeen/Fishermans Beach Coastal Management Strategy - Management Options and Appendices*, prepared for Council by Nielsen Lord Associates and Travers Morgan Pty Ltd (NLA 1989).

Following a period of exhibition and public consultation, the preferred option was determined by the community to be *massive beach nourishment*, in combination with stormwater outlet improvements. On 17 July 1990, this option was formally adopted by Council.

2.2.2 NSW State Government 1988 - 1990

In parallel with these actions, in 1988 the NSW Government adopted its 'Coastline Hazards Policy', with the objective to "reduce the impact of coastal hazards on individual owners and occupiers of coastal lands, thus reducing public and private losses and to ensure that future development is compatible with the hazards" (NSW 1990: 2).

In September 1990, the NSW Government released its *Coastline Management Manual* (NSW 1990) detailing the management system advocated in its Coastline Hazards Policy (**Figure 4**). The Manual was available to assist local councils in developing balanced Coastline Management Plans and to assist their understanding of the nature of coastline hazards and the options available for management.

2.2.3 Warringah Council 1991 - 1997

Following adoption of massive beach nourishment as the preferred management option in July 1990, Warringah undertook a period of work in accordance with the State Government's Policy. This work sought to enable finalisation and implementation of a Coastline Management Plan for Collaroy/Narrabeen/ Fishermans Beach.

Council identified a number of further investigations which would be required. These were to be undertaken in three parts, with Parts A and B undertaken concurrently, and Part C dependent on the outcome of A and B, as follows:

- Part A - investigation of massive beach nourishment and stormwater improvements;
- Part B - investigation into suitable sand sources for nourishment;
- Part C - preparation of an Environmental Impact Statement (EIS) for sand extraction.

Pending completion of these studies and finalisation of the Coastline Management Plan for Collaroy/Narrabeen Beach, Council developed a set of *revised Interim Building and Development Guidelines for Collaroy Narrabeen Fishermans Beach, August 1991* (WSC 1991). Objectives of these Guidelines included:

* *"to enable assessment of building and development applications prior to finalisation of the management plan;*
* *to afford protection to proposed building and development along Collaroy/Narrabeen Fishermans Beach; and*
* *to maintain the recreational and aesthetic values of Collaroy/Narrabeen/Fishermans Beach."*

The Guidelines were based on the report - *Criteria for the Siting and Design of Foundations for Residential Development, February 1991,* (GEO 1991) prepared for Council by Geomarine Pty Ltd and Coffey Partners International Pty Ltd. This report provides a series of Hazard Maps for Collaroy, Narrabeen and Fishermans Beach, delineating hazard zones along each map, namely: the Wave Impact Zone, the Zone of Slope Adjustment and the Reduced Foundation Zone (see **Appendix B**). The maps do not take account of longer term predicted changes due to Greenhouse, such as sea level rise and long term beach recession.

The 1991 Interim Guidelines have been used to assess and determine building and development applications for properties along Collaroy/Narrabeen Beach. These Guidelines are now generally reflected in the *Collaroy/Narrabeen Coastline Management Plan - Development Guidelines for Collaroy/Narrabeen Beach policy,* attached as **Appendix B**.

Completion of *the Collaroy/Narrabeen Beach Nourishment Investigations, July 1993* (PB 1993) estimated that massive beach nourishment for the whole of Collaroy/Narrabeen Beach would cost $28.9 million and required construction of a groyne at the entrance to Narrabeen Lagoon. Following a public meeting and consideration of the issue by the reconvened[1] Warringah Coastal Management Committee, Council resolved at their meeting of 29 March 1994, to review its decision supporting massive beach nourishment as the preferred long term management option.

Following recommendations of the Warringah Coastal Management Committee, Council subsequently resolved to prepare a Coastline Management Plan for Collaroy/Narrabeen Beach, incorporating a low key approach for long term management, including a combination of the following:

* *"a review of development and building controls (prevention of redevelopment and new development but allowing maintenance and additions);*
* *survey of existing seawalls, allow upgrading or minimum construction to a standard design;*
* *ongoing beach maintenance (incorporating minimal, continual beach nourishment);*
* *continued dune stabilisation;*
* *selective voluntary purchase of Class 1 and Class 2 dwellings consistent with the Valuer General's estimations. (These benefits to the public of voluntary purchasing should be recognised by Council);*
* *a review of Council's Emergency Management Plan, (which should include a clause to the effect that no material other than sand is to be placed on the beach in an emergency situation); and*
* *funding options, including State Government contributions, to be explored in respect of voluntary purchase and included as part of the Management Plan."*

[1] This Committee was set up in August 1993 under the NSW Government's Coastline Hazards Policy. Details of the Committee are contained in Appendix C to this report.

Lengthy community consultation and debate followed, with the above resolution presented to the community for discussion and comment in Council's *Green Paper - Issues for Discussion: Preparation of the Collaroy/Narrabeen Beach Draft Coastline Management Plan, August 1995* (WC 1995). This was further modified in the *draft Collaroy/Narrabeen Beach Coastline Management Plan, September 1996* (WC 1996).

The final period of community involvement was concluded in May 1997 with community presentations to Council's meeting of 27th May 1997 and Council resolving at their meeting of 24 June:

a) *"That a Management Plan for the Collaroy/Narrabeen Beach be finalised. Such Plan should address the nine objectives required by the NSW Government's Coastline Management Manual and also address the two objectives specific to the Collaroy/ Narrabeen Coastline with the aim of:*
    * *Preserving and protecting the beach as a national asset or public recreation and amenity;*
    * *Ensuring building and development along the Collaroy and Narrabeen Beach has regard for the current and future hazards of wave impact and coastal erosion.*

b) *That the Management Plan contain strategies to address the following matters:*
    * *Voluntary purchase of single residential/dual occupancy properties;*
    * *The upgrading and/or maintenance of the existing sand-covered seawall;*
    * *Minor beach nourishment and maintenance thereof;*
    * *Dune stabilisation and beach maintenance;*
    * *Controls on building and development;*
    * *Stormwater outlets;*
    * *Emergency management procedures;*
    * *Any other relevant matters.*

e) *That the finalised Management Plan be placed before Council for endorsement in August 1997.*

f) *That the Management Plan be reviewed within 5 years of adoption."*

3.0 POLICY AND MANAGEMENT CONTEXT

The policy driving preparation of Coastline Management Plans is the NSW Government's Coastline Hazards Policy. This is described below and detailed in the State's *Coastline Management Manual, 1990* (NSW 1990). The management context for preparation of this Plan involves the management framework detailed in the *Coastline Management Manual,* in addition to Warringah Council's Basis for Management for its coastline. The basis for management is described in Section 3.2, comprising the 'Values' for the coastline and 'Guiding Principles' for managing coastal open space, as articulated by the Warringah Community.

3.1 NSW Coastline Hazards Policy

The primary objective of the NSW Coastline Hazard Policy is to reduce the impact of coastal hazards on individual owners and occupiers and to reduce private and public losses resulting from natural coastal forces. It is the policy of the NSW Government that:

* *"the impact of coastal forces on existing developed areas shall be reduced by works and measures and by the purchase of property on a voluntary basis, where appropriate;*

* *the potential for coastal damage in respect of any proposed coastline development shall be contained by the application of effective planning and development controls by local councils; and*

* *a merit approach to all development and building decisions which takes account of social, economic and ecological as well as oceanic process considerations, shall be followed by local councils and developers."* (NSW 1990: A-1)

In formulating this Policy, the NSW Government had regard to:

* *"the coastline of NSW being a priceless asset at local, state and national levels which should be managed with care and protected; and*

* *coastal land being a valuable resource, the development of which should not be unnecessarily restricted because of undue concern over hazards"* (NSW 1990:5).

Implementation of the State Government's Policy includes provision for:

* *"Management of the coastal zone is, primarily the responsibility of local government, in accordance with its normal responsibilities for local planning and development control. This responsibility to be discharged through the preparation and implementation of Coastline Plans of Management; and*

* *The State Government providing, through its Coastline Management Program, financial assistance for:*
⇒ *the development and implementation of management measures and works, to reduce potential damage from oceanic processes in existing developed areas;*
⇒ *construction of works for the conservation and improvement of beaches and public reserves; and the provision of specialist technical advice on coastal hazards resulting from oceanic processes"* (NSW 1990:A-2).

3.1.1 NSW Coastline Management Framework

The Coastline Management Program is administered by the Department of Land and Water Conservation. The objectives of the program are to protect the environmental wellbeing of the coastline, to improve public recreational amenities along the coast and to protect public and private infrastructure from coastal hazards where this can be done in a manner which does not impair the environmental and amenity values of the coast.

The State's *Coastline Management Manual, 1990* (NSW 1990) sets out the steps involved and issues to be considered in formulating a coastline management plan. These steps are summarised in **Figure 4** and set out below.

1. Establish a coastline management committee.

2. Identify the type, nature and significance of the various coastal processes and hazards that affect the area of interest.

3. Undertake a coastline management study to identify:
⇒ land tenure and existing planning controls, and the adequacy of existing planning controls;
⇒ environmental features and the condition of dune vegetation;
⇒ access, recreational use patterns and visual and aesthetic features; and
⇒ sensitivity of the site to climate change.

4. Identify management options as part of the management study, having regard to social, economic, aesthetic, recreational and ecological issues in the coastal zone; and the potential impact of any assessed climate change on coastal hazards.

5. Prepare a coastline management plan consisting of the best combination of options for dealing with the various social, economic, aesthetic, recreational, ecological and hazard issues and problems.

6. Develop a strategy to implement the plan.

The development and implementation of a coastline management plan is the responsibility of local councils with the assistance of relevant government agencies.

3.2 Warringah's Management Plan Framework

The Collaroy/Narrabeen Coastline Management Plan forms one component of a comprehensive planning framework for Warringah's Coastline, shown in **Figure 5**. The basis for management within this planning framework aims to reflect a "values" based approach, where the community and those responsible for management have jointly defined the values and guiding principles relevant to management of the coastline. To determine these "values" and "management principles", an extensive community consultation program was undertaken, through a range of meetings with community, Council staff and user groups. Initially, focus groups were held, with public notice, invitations and organisations encouraged to participate. Special interest groups were also contacted and people interviewed individually.

The community consultation process identified and prioritised important and valued qualities of the coastline, and documented key issues to be addressed in managing the coastline. From this process, the Values and Guiding Principles which form the Basis of Management for Warringah's coastline were formulated. This Basis for Management and Planning Framework underpins all plans of management for Warringah's coastal areas including this Coastline Management Plan for Collaroy Narrabeen Beach.

3.2.1 The Values of Warringah's Coastline

The community of Warringah identified the following six values for Warringah's coastline (in no particular order):

- **Natural environment value:** The diverse physical environment, particularly its geographic features, the quality of the marine and inter-tidal environment, rock platforms and headlands, and the standard of adjoining bushland and estuarine areas is of significant value.

- **Aesthetic value:** The aesthetic value of the coastline, comprises the uniqueness and variety of the beaches and headlands, the peaceful nature, expansive views, special features such as pelicans, rock platforms and public art, and the smells and sounds of the coast, are highly valued.

- **Recreation value:** Warringah's beaches and coastline are highly valued for the range of active and passive recreation opportunities available, in a diversity of settings.

- **Access and Availability:** The local community appreciates the availability of beaches and surrounding open space free of charge, and the opportunity to easily access the related recreational, cultural and natural resources. Council will manage these areas in a stewardship role for all people.

- **Water Safety value:** The community recognises and appreciates the high standard of beach and water safety provided by Warringah Council and the Surf Life Saving movement. The availability of these services underpins an enjoyable experience at the beach.

- **Cultural value:** The beaches and coastline are valued for their cultural and historical significance, and contribution to the quality of life, sense of place and community identity in Warringah.

3.2.2 Guiding Principles Relating to Coastal Open Space.

The following guiding principles for managing Warringah's coastal open space, place the above community values into a policy context. These are consistent with Council's corporate objectives and adopted principles for community land and Crown land.

- Warringah's coastal open space will be managed to conserve and enhance its environment including the diversity and flora and fauna and its habitats.

- Warringah's coastline will be managed in an ecologically sustainable manner to ensure that present use of the coast does not compromise future use of the area.

- Warringah's coastal open space system will remain available to the entire community, in recognition of its inherent value as publicly owned space. Access to most areas for informal recreation purposes will be provided, and enhanced where necessary.

- The structured use of coastal open space and facilities will be managed to minimise impacts on other users and the local environment, and to optimise cultural and recreational opportunities.

- The design, location and provision of facilities and developments will be managed to minimise the impact on the coast's natural environment and aesthetic qualities. Environmental protection will be integrated into the development approval process.

- Commercial developments will not be encouraged. Where identified, only those of a low key nature which are ancillary to public recreation and have broad community benefits and will be considered.

- The cultural and heritage qualities of the coastal open space will be protected and restored; significant areas and items will be promoted and managed sensitively. Council will recognise the importance of beach culture to the local community as part of a diverse and innovative management approach.

- Council will ensure that a beach and water safety service is provided on Warringah's beaches throughout the summer swimming season.

- The social and economic value of well managed open space that satisfies visitors needs and complements and supports local businesses will be recognised.

3.2.3 Other Relevant Policies

The following are other policies and procedures that currently influence or impact on the coastal zone in the vicinity of Collaroy/Narrabeen beach:

- Management of Narrabeen Lagoon entrance is guided by the *Management Policy for Narrabeen Lagoon Entrance, November 1996* (WC 1996) developed, reviewed and implemented through the Narrabeen Lagoon Joint Estuary/Floodplain Management Committee. This Policy has been adopted by both Warringah and Pittwater Councils.

- All building and development along Collaroy Narrabeen and Fishermans Beaches is currently guided by the *Interim Building and Development Guidelines for Collaroy/Narrabeen Fishermans Beach, August 1991* (WSC 1991) including the series of maps A8634 sheets 1-3.

- Management of Narrabeen Lagoon estuary is guided by the *NSW Estuary Management Policy, 1992* (NSW 1992). This Policy is implemented through the Narrabeen Lagoon Joint Estuary/Floodplain Management Committee.

3.3 Coastline Management Objectives

The objectives for this Plan originate from the Warringah Coastal Management Committee, the NSW Government's Coastline Hazards Policy and the NSW Government's Coastline Management Manual.

The ***Warringah Coastal Management Committee*** recommended two specific objectives for a Collaroy/Narrabeen Beach Coastline Management Plan, which were subsequently adopted by Council. The objectives are that the Plan should:

1. *"Aim for the preservation and protection of the beach as a national asset for public recreation and amenity"; and*

2. *"Aim to ensure that building and development along Collaroy and Narrabeen Beaches has regard to the current and future hazards of wave impact and coastal erosion."*

The primary objective of the NSW Governments ***Coastline Hazards Policy*** is to "reduce the impact of coastal hazards on individual owners and occupiers, and to reduce private and public losses resulting from natural coastal forces." (NSW 1990:A-1)

The State Government's ***Coastline Management Manual*** also provides objectives for Coastline Management Plans, such that Plans should ensure that:

* *"all reasonable measures are taken to avoid hazards and potential damage to existing properties and recreational amenity at risk;*

* *future development, works and activities in the coastal zone do not cause any significant or unacceptable growth in hazard or damage potential by adverse interaction with coastal processes;*
* *the long term protection and use of the coastline is provided for, as required by the NSW Coast: Government Policy;*

* *land subject to coastline hazards is identified and managed in a manner compatible with the type, nature and damage potential of these hazards;*
* *guidance is given to developers concerning issues and factors they should address when proposing development;*

* *hazardous lands are managed to maximise the social, economic, aesthetic, recreational and ecological benefits to both individuals and the community, as well as taking into account hazard considerations, and rights of private landowners;*

* *information on the nature of existing and possible future hazards is made available to the public;*

* *due regard is paid to community safety, health and welfare; and*

* *appropriate warning systems and contingency plans are available to minimise personal risk and to facilitate post-event recovery."* (NSW 1990:7)

In accordance with the objectives detailed in this Section, the specific objectives of the ***Collaroy/Narrabeen Coastline Management Plan*** are as follows:

Collaroy/Narrabeen Beach Coastline Management Objectives
I. Preserve and protect the beach as a national asset for public recreation and amenity;   **II. Ensure that building and development along Collaroy and Narrabeen Beaches has regard to the current and future hazards of wave impact and coastal erosion;**   **III. Be consistent with the aims and objectives of the NSW Government's Coastline Hazards Policy and Coastline Management Manual; and**   **IV. Be within the reasonable and practical financial capacity of Council to implement with financially equitable impacts across the Warringah community.**

4.0 COMMUNITY CONSULTATION

The NSW coastline is a priceless community asset and is acknowledged as such by the State Government. The whole community has a legitimate interest in the management of the coastline, whether or not they are directly affected by coastline hazards and whether or not they live nearby or visit to enjoy the recreational amenity it offers.

Proposals for coastline management are required to involve community consultation, participation and comment, allowing the community access to information. The ultimate responsibility for making a final determination based on the issues and submissions however, remains with the local Council, in this case Warringah Council, as the responsible authority.

4.1 Decision Making Basis

In the hope of achieving a consensus-based Plan, Warringah Council embarked on an ambitious program of consultation and participation which began in the late 1980s. Coastal hazards and appropriate management responses were debated openly and in depth. This resulted in strong differences of opinion emerging between the various stakeholders in the community, among members of the Warringah Coastal Management Committee, and between these groups and the Council. A consensus-based Coastline Management Plan was not achieved.

The results of the consultation process were that the Warringah Coastal Management Committee, in a majority vote, recommended not to include "reconstruction of seawalls" in the final Management Plan. This proposal was supported by a "Say No to Seawalls" petition with some 4254 signatures and through a number of questionnaires and submissions to Council.

Notwithstanding the differences of opinion, in the process of developing this management plan Council has given careful attention and consideration to all comments and issues raised during the consultation process. This Plan is based on:
- information contained in a range of technical reports and studies;
- information provided through community debate and discussion of the issues; and
- formal and informal presentations and submissions to the Coastal Management Committee and Council by a variety of people.

Although consensus was not achieved, the benefits of the consultation process were:
- community concerns and issues were discussed from an early stage in the planning process;
- local knowledge contributed to the available scientific knowledge;
- the community and Council staff improved their knowledge of coastal processes and Collaroy/Narrabeen Beach, resulting in more informed decision making.

4.2 Background

Council endeavoured at the outset to achieve a management philosophy based on a consensus of community opinion. This resulted in open debate at numerous forums over the last ten years, on issues such as storm erosion and appropriate coastline management responses. Examples of consultations undertaken are:

1. Meetings of Warringah's Coastal Management Steering Committee, a joint committee of Council and State Government technical advisers, set up in 1988 under the Chairmanship of Cr Mark Hummerston.

2. Public meetings such as the three (3) held in 1989 to discuss the options for beach management detailed in the *Narrabeen/Collaroy/Fishermans Beach Coastal Management Strategy, Management Options* (NLA 1989) or the public meeting held in September 1993, where it was resolved to "not consider the construction of a groyne at North Narrabeen as part of the Narrabeen/Collaroy Fishermans Beach Management Plan".

3. Public exhibition and comment periods, with submissions invited on numerous Council reports such as: *Narrabeen/Collaroy/Fishermans Beach Coastal Management Strategy, Phase One Hazard Definition* (NLA 1989), the *Collaroy Narrabeen Beach Nourishment Investigations Report, July 1993* (PB 1993), the *Green Paper - Issues for Discussion: Preparation of the Collaroy/Narrabeen Beach Draft Coastline Management Plan, August 1995* (WC 1995) and the *draft Collaroy/Narrabeen Coastline Management Plan, September 1996* (WC 1996).

4. Meetings of Warringah's Coastal Management Committee, a joint consultative committee, convened in August 1993 under the State Government's Coastline Hazards Policy, chaired by Cr Tom Webster or Cr John Caputo. The Committee comprises State Government representatives, a variety of community and resident representatives, Councillors and council staff.

5. The Coastal Information Night, organised in November 1995, to discuss Council's *Green Paper - Issues for Discussion: Preparation of the Collaroy/Narrabeen Beach Draft Coastline Management Plan, 1995* (WC 1995).

4.3 Management Plan Consultation Process

The period of consultation for the Collaroy/Narrabeen Coastline Management Plan extended from August 1995 - with exhibition of Council's *Green Paper - Issues for Discussion: Preparation of the Collaroy/Narrabeen Beach Draft Coastline Management Plan, August 1995* (WC 1995) - to May 1997, with resident presentations to Council's meeting of 27 May 1997.

The consultation and participation process included:

- advertising the Green Paper and draft Management Plan in local newspapers and inviting comments and submissions from all people;
- a Coastal Information Night, in November 1995, to discuss Council's Green Paper;
- an informative display on the draft Management Plan: one set up in Council's Civic Centre or Library and the other a roving display, set up in a variety of local businesses in Collaroy and Narrabeen; and
- advertisement of the exhibition period for the draft Management Plan in Warringah's Coastal News newsletter, sent to over 150 key stakeholders and environment groups, calling for comment on the proposals.

4.3.1 Section 149 Certificates

As part of the consultative process, and to fulfil Council's legal obligations to notify property owners about matters affecting the land, Council resolved to place a notification on particular properties in accordance with provisions set out in Section 149 of the Environmental Planning and Assessment Act 1979.

In accordance with the Act, Council resolved that for all properties along Collaroy, Narrabeen and Fishermans Beach (marked on Council's *Plan A8634* sheets 1 through 3), having any part of the property within the Zones of: Wave Impact, Slope Adjustment, or Reduced Foundation Capacity, that the following question to the prescribed matter, be answered in the affirmative,

> *"(k) Whether or not the council has by resolution adopted a policy to restrict the development of the land by reason of the likelihood of land slip, bushfire, flooding, tidal inundation, subsidence or any other risk."*

Furthermore, Council resolved that the following additional information on "other relevant matters" affecting the land be included for all Certificates issued above,

> *"This land is subject to Council's resolution of 20th August 1991. Assessment of building and development applications will be made by reference to the Interim Building and Development Guidelines. A copy of the resolution and the Guidelines may be obtained from Council at the cost of the applicant."*

Currently, there are some 413 individual properties notified in this way.

Advice on S149 Certificates will, in the future, refer to the *Collaroy/Narrabeen Coastline Management Plan - Development Guidelines for Collaroy/Narrabeen Beach policy 1997,* attached as **Appendix B.**

4.4 Public Comment

Numerous concerns and comments were raised during the period from August 1995 to May 1997. In addition to the 108 individual letters and submissions received during this period, Council received 368 reply paid questionnaires and a petition on "Say No to Seawalls" with 4254 signatures. In addition, a majority vote of the Warringah Coastal Management Committee resolved against the inclusion of seawalls in the final management plan.

Key concerns and comments raised by the community during this period are listed below (in no particular order).

- New buildings should be restricted to existing foundations, with additions and redevelopment constrained.
- Support review of Building/Development Guidelines based on 50 year impact line.
- The 50 year impact line is only a theory.
- Can I claim compensation from Council if the 50 year line does not occur?
- How did Council and Public Works identify this beach as "most at risk"?
- Who indemnifies Council if the 50 year line is reached and Pittwater Road is undermined?
- Difficult to understand that in 50 years >75% of my property will be gone.
- Preparation of a Coastline Management Plan for Collaroy/Narrabeen is supported.
- What about the 'do-nothing' option?
- Council is not competent to determine these coastal matters.
- Strict building controls should remain in place until the Management Plan is finalised.
- Say no to seawalls.
- Seawall upgrading or construction should be done at owners' expense.
- Upgrading of seawalls plus beach nourishment is supported.
- Upgrading of seawalls supported only if there is no voluntary purchase programme.
- Concern expressed at powers of State Emergency Services (SES) to override Council.
- The SES would <u>not</u> limit dumping to sand only, during an emergency.
- Use of public funds for public property only, with private funds for private property.
- Public funding should not be pursued to protect private property.
- Beach stabilisation for the entire beach length is supported.
- Notifications on Section 149 Certificates should be changed as it devalues properties.
- Sea level rise due to "Greenhouse" not a proven fact.
- Don't believe in 'Greenhouse'.
- Is Collaroy/Narrabeen Beach in long term recession?
- Phrases used in the Green Paper are biased against beachfront owners with terms such as 'beach recession' and Greenhouse sea level rise, being presented as facts.
- Voluntary purchase strategy should consider loss of rate revenue to Council.
- What will the strategy be for dealing with the 'high rise'?
- Beach is <u>not</u> in long term recession only "oscillation". Current erosion oscillation will deteriorate with impact of climate change.
- Long term plan should not protect properties but maintain beach for future generations.

- Objective of the management plan should be the preservation/protection of the beach.
- Number of beachfront residents compared to beach users is very small.
- All users of the beach should have an equal say in the future of their asset.
- What is the major interest along the beach? private property or public recreation?
- Storm damage and risk to private property should not be shared by whole community.
- Collaroy/Narrabeen is a public asset and should be maintained as such.
- Existing open space land along beachfront is poorly maintained.
- Observations of the beach are that it has not changed over time.
- Observations suggests that beach is cyclical, not in a state of degradation.
- All past evidence indicates that building on active beach zone will lead to disaster.
- Gradual deterioration of the shoreline has been observed over the past 40 years.
- Human efforts to change major natural systems are expensive and inadequate.
- Development along Collaroy/Narrabeen is responsible for beach erosion.
- Solutions through construction of offshore reefs should be considered.
- Further development should not be permitted.
- Owners should be prepared to pay the costs to protect their homes.
- Valuation of properties is too low.
- Treatment of homes along beach is inconsistent with treatment of bushfire risk homes.
- Removal of impediments at lagoon mouth will assist in sand availability to the beach.
- Public land will also require beach protection.
- Council should not take action against nature, it can lead to enormous costs to rectify the damage.
- Problems along Collaroy/Narrabeen are due to past Council works and mis-management of Narrabeen Lagoon entrance.

5.0 COASTLINE MANAGEMENT ISSUES

When considering the coastal processes of the beach system it is necessary to examine the complete active beach system (as illustrated in **Figure 3**) extending landward to the back beach dune system and seaward to water depths of around 20-30 metres (some 2km offshore).

5.1 Beach Characteristics

Collaroy/Narrabeen beach is backed by dunes which vary in height from 5m AHD[2] at Collaroy to around 10m AHD at North Narrabeen Beach. In the area offshore, there are sandy areas out to the limit of the active beach system, at depths of approximately 20 to 25m, with bedrock outcrops in depths ranging from 2 m at Collaroy, to 6-8m at North Narrabeen, out to 20 to 35 metres (**Figure 6**).

The state of the beach at any particular time depends on complex interactions between the sand and coastal processes. The dynamic nature of beaches is often witnessed during storms, when waves and elevated water levels act to remove the sand from the beach and transport it by a combination of currents beyond the breaker zone. Here it is deposited in deeper water as sand bars. As the offshore sand bars build up during storms, the waves break further offshore causing wave energy to be dissipated in the surf zone, reducing further beach erosion. Severe storms may remove the beach berm and attack the frontal dune, forming a steep erosion escarpment. This erosion process usually takes place over a period of hours to a few days.

After the storms, less energetic ocean swells gradually move sand from the offshore bars back onto the beach, where onshore winds blow it back onto the frontal dune. This beach rebuilding phase typically takes from a few hours to a few days to reach a width suitable for walking along the beach, and may months to years to reinstate the full beach berm, presuming no further severe storms occur.

During storms the ocean also rises to a level above that of normal tides due to the action of waves, onshore winds and a lowering of barometric pressure. Large waves combined with this 'storm tide' can overtop the dunes reaching areas behind the dunes.

[2] m AHD = Metres expressed in Australian Height Datum. This is a relative level of measurement, where zero on this scale corresponds approximately to mean sea level, with so many metres above or below this zero point.

5.2 Coastal Processes

Coastal lands are exposed to coastal processes of atmosphere, ocean and coastal rivers. Waves, increased water levels and winds associated with storms, together with coastal currents and rivers flowing into coastal waters, reshape beaches and shift beach sands - offshore, onshore and alongshore. In order to better manage coastline hazards, it is necessary to understand the various processes that cause them.

Coastal processes relevant to Collaroy/Narrabeen beach are summarised below from the State Government's *Coastline Management Manual, September 1990*, (NSW 1990). Specific terms are defined in the Glossary to this Plan.

- **Storms** - major meteorological disturbances, characterised by strong winds, raging seas and possibly heavy rain. An intense storm close to the coast can severely erode the shoreline and damage coastal developments.

- **Elevated Water Levels** - Coastal water levels are influenced by a variety of factors, which at times interact to significantly elevate water levels above normal tide level. Storms which develop low atmospheric pressure, strong onshore winds and large waves are the most common cause of elevated water levels.

- **Waves** - are one of the dominant factors shaping a coastline. They are largely responsible for beach erosion, longshore drift and elevated water levels. Waves transport energy from remote areas of the ocean to the coastline.

- **Currents** - occur within the deep ocean, over the continental shelf and within the offshore and nearshore zones. Currents may be limited to the surface or to the seabed or may extend over the full depth of water. Types of currents include: ocean; rip and longshore.

- **Waterborne Sediment Transport** - is a natural process where beaches continually adjust to the ever-changing nearshore wave and water level conditions. Sand is transported onshore, offshore and alongshore by the action of waves and currents. Factors affecting this process include: particle size; storms and swell waves.

- **Dune Vegetation** - Vegetation is the key factor in dune stability and the vulnerability of dune vegetation makes the dunes sensitive to impacts. Dune vegetation may be degraded or damaged through natural or artificial processes.

- **Windborne Sediment Transport** - Apart from the indirect effects of generating waves and causing wind setup of nearshore water levels, wind can transport sand off the beach and promote coastal erosion in the form of windbourne sediment transport.

- **Rainfall and Runoff** - Severe storms are often accompanied by extended periods of heavy rainfall. Rainfall and associated runoff have a number of effects on coastal processes, such as increases in groundwater levels, flooding of coastal rivers, and stormwater flow onto beaches.

- **Coastal Entrances** - Lagoon and river entrances affect nearby coastal areas. Entrances are subject to tides, waves, currents, sediment movement and flooding. The interaction of these factors causes lagoon entrances to migrate along the coastline, to shoal, to close up or re-open.

- **Climate Change** - "Greenhouse Effect" describes a warming of the earth due to accumulation of certain gases in the atmosphere. The current consensus of scientific opinion is that such changes could result in a global warming over the next 30 to 50 years. Such a warming could lead to changes in climate, weather and sea levels, in turn causing significant changes to coastal processes such as increased severity and frequency of storms, resulting in increased wave heights.

- **Human Activities** - in the coastal zone are many and varied and can significantly affect coastal processes. Hazards or "problems" in the coastal zone are largely perceived in terms of the interference of coastal processes with human activities.

Coastal processes do <u>not</u> operate in isolation, but interact with each other, often in complex ways. Interactions between coastal processes acting on an area, result in large fluctuations in the beach state over relatively short periods of time, particularly during storms. Coastal processes also have different time and length scales. Some processes such as tides, apply uniformly throughout a study area, whilst others such as waves, show large variations between different parts of the coastline.

The current understanding of coastal processes on Collaroy/Narrabeen Beach is based on investigations carried out by the Public Works Department for Warringah Shire Council in the *Collaroy/Narrabeen Beaches Coastal Process Hazard Definition Study, December 1987* (PWD 1987). Coastal processes are further discussed in the *Collaroy/Narrabeen/Fishermans Beach Coastal Management Strategy - Phase One Hazard Definition* (NLA 1988) and in the *Collaroy/ Narrabeen Beach Nourishment Investigations, July 1993* (PB 1993).

5.3 Coastline Hazards

Coastal processes give rise to a variety of coastline hazards that can damage or destroy coastal developments and coastline amenity. An understanding of coastline hazards and their impacts is essential if the coastline is to be better managed. Hazards are generally perceived in terms of their impact on human uses and coastal amenity.

Coastal hazards are described in detail in the *Coastline Management Manual, September 1990* (*Appendix C*) (NSW 1990) and include:

⇒ Beach Erosion
⇒ Shoreline Recession
⇒ Coastal Entrance Behaviour
⇒ Sand Drift
⇒ Coastal Inundation

⇒ Slope and Cliff Instability
⇒ Stormwater Erosion
⇒ Climate Change

Table 1 shows the principal processes that contribute to different coastal hazards. Because of their interrelated nature, various processes contribute to the same hazard, with processes of climate change and human activity contributing to all hazards.

Table 1 - Principal Processes Causing Coastline Hazards

Coastal Processes	Coastline Hazards						
	Beach Erosion	Shoreline Recession	Entrance Behaviour	Sand drift	Coastal Inundation	Cliff Instability	Storm water Erosion
Storms	✓	✓	✓		✓		✓
Elevated water levels	✓	✓	✓		✓		✓
Waves	✓	✓	✓		✓		
Currents	✓	✓	✓				
Waterborne sediment transport	✓	✓	✓				
Vegetation degradation	✓	✓		✓			
Windborne sediment transport				✓			
Rainfall and runoff					✓	✓	✓
Coastal entrances	✓		✓				✓
Climate change	✓	✓	✓	✓	✓	✓	✓
Human activities	✓	✓	✓	✓	✓	✓	✓

Source: *Coastline Management Manual, September 1990*, (NSW 1990: C-33)

5.4 Coastal Process Design Parameters

Hazard definition studies such as the *Collaroy/Narrabeen Beaches Coastal Process Hazard Definition Study, 1987* (PWD 1987) identify the most important coastal processes and their associated hazards. These hazards and their effects are then quantified as Coastal Process Design Parameters. Design parameters are used in defining and assessing coastal management strategies.

For the purposes of defining coastal hazards and coastal process design parameters, Collaroy/ Narrabeen Beach is divided into four precincts (2 to 5)[3] where common hazards may apply. The precincts are described below and shown in **Figure 7**.

⇒ Precinct 2 - Collaroy Beach, south of Jenkins Street
⇒ Precinct 3 - Collaroy and Narrabeen Beach, Jenkins Street to Devitt Street
⇒ Precinct 4 - Narrabeen Beach, Devitt Street to Albert Street
⇒ Precinct 5 - Narrabeen Beach, Albert Street to Birdwood Park

Some design parameters are "general" and relevant to the beach as a whole, such as 'offshore wave climate', 'sea level rise' and 'sediment loss due to natural processes'. Other design parameters such as 'design storm erosion demand' and 'inundation level' are specific to each precinct.

The key coastal processes/hazards (in normal type) and their related *coastal process design parameters* (in italics) affecting Collaroy/Narrabeen are described below and summarised in **Table 2**.

- **Waves/*Offshore Wave Climate*** - the Collaroy/Narrabeen embayment is exposed to a high energy wave climate. An offshore significant wave height of 10m has been adopted for design purposes, based on historical records.

- **Elevated Water Levels/*Wave Setup at the Shoreline*** - Wave setup is the increase in water level within the surf zone, caused by the breaking action of waves. Based on a 10.0 metre significant wave height, it is estimated at between 1.3 and 1.6 metres for design purposes.

- **Climate Change (sea level rise)/*Shoreline Recession*** - a sea level rise of 0.22m by the year 2050 is adopted for this Plan, based on scenarios in the 1996 IPCC Climate Change Report. For a sea level rise of say 1 metre, a corresponding landward movement of the beach system (shoreline recession) of 50m has been adopted.

- **Sediment Loss (due to natural processes)/*Shoreline Recession*** - long term beach/shoreline recession also occurs when the beach is losing more sand than it is gaining. This results in a landward movement of the whole beach system with time. It is estimated that a loss of 2,000 cubic metres per year from the sub-aerial profile, ie. The beach profile above mean sea level. This is equivalent to a shoreline recession rate of 0.1 metres/per year. For design purposes, it is conservatively estimated that total

[3] The precinct numbering starts at Precinct 2, as earlier studies covered the full Collaroy/Narrabeen embayment, with Fishermans Beach included and classified as Precinct 1.

losses from Collaroy/Narrabeen, ie. from the sub-aerial and subaqueous parts of the beach profile, are about 10,000m^3/yr (recession rate of 0.2 m/yr).

- **Beach Erosion/*Design Storm Erosion Demand*** - This is the volume of sand which can be eroded from the beach berm and dunes during a severe storm or series of storms. The design values established for Collaroy/Narrabeen Beach are in the range of 200 to 250 cubic metres per metre of beach.

- **Beach Erosion/*Beach Scour Level*** - This is the base level of sand erosion on the beach berm during a severe storm, expressed in metres relative to AHD. Based on assessments of nearshore wave heights and dune stability, a design level of -1 metres AHD has been adopted for all precincts.

- **Coastal Inundation/*Maximum Inshore Wave Height*** - This is the maximum wave height in metres which can occur for a given inshore depth and offshore significant wave height of 10.0 metres. For a seabed level of -1m AHD, the design maximum inshore wave height would be 3 metres.

- **Coastal Inundation/*Inundation Level*** - This is the maximum level (in metres AHD) to which wave runup and therefore inundation would occur on a natural sand dune for the design offshore significant wave height of 10.0 metres. Values for inundation along Collaroy/Narrabeen Beach are in the range of 7 to 9 metres AHD.

- **Stormwater Discharge** - There are 7 primary stormwater outfalls located along the beach (**Figure 8**). The sum of the pipe flow rates and estimated overflow rates onto the beach are given for each precinct in **Table 2**. Discharges are in cubic metres per second and estimated for a rainfall event expected once every year, and for an event expected to occur once every 20 years.

Table 2 - Coastal Process Design Parameters for each Precinct.

Design Parameters	Precinct			
	P2	P3	P4	P5
Shoreline wave setup (m AHD)	1.3	1.4	1.5	1.6
Shoreline recession (from sediment transport) (m/yr)	0.2	0.2	0.2	0.2
Design Storm Erosion Demand (m^3 per linear metre of beach)	200	250	250	250
Beach Scour Level (m AHD)	-1.0	-1.0	-1.0	-1.0
Inundation Level (m AHD)	7	8	9	9
Stormwater Discharge (m^3/sec)				
1 yr storm return period (approx)	4	4	0.2	0.3
20 yr storm return period (approx)	9	10	0.4	0.5

Source: *Coastal Management Strategy Phase One Hazard Definition, 1988* (NLA 1988:x) *and Collaroy Narrabeen Beach Nourishment Investigations, 1993,* (PB 1993:17).

6.0 COASTAL MANAGEMENT STRATEGIES

Having identified the type, nature and significance of coastline hazards impacting on Collaroy/Narrabeen, all feasible planning and management options to address the above hazards are identified below. These are then discussed and assessed with recommended management strategies and actions selected.

6.1 Hazard Management Options

In accordance with the State's *Coastline Management Manual, 1990* (NSW 1990) there are essentially four strategies for managing coastline hazards with a number of associated hazard management options. These are discussed in detail in the Manual and listed below in **Table 3**.

Table 3 - Hazard Management Strategies and Options.

Strategies	Hazard Management Options
Protective Works/Structural Controls - (to protect against coastal hazards)	Seawalls Training Walls Groynes Beach Nourishment Offshore Breakwaters Artificial Headlands Dredging
Environmental Planning Measures - (to ensure development is not unnecessarily sited in hazardous locations)	Buffer Zones Restrictive Zoning Planned Retreat of Buildings Voluntary Purchase
Development Control Plans/Conditions - (to ensure that developments and potential developments are compatible with the known hazard/risk)	Building Setback Building Types Dune Protection Flood Mitigation Foundation Design Emergency Access Relocatable Buildings Planned Retreat
Dune Management - (to protect against the hazards)	Dune Management Planning Community Involvement Dune Reconstruction Dune Revegetation Dune Protection Dune Maintenance

Source: *Coastline Management Manual, 1990* (PWD 1990:23)

The hazard management strategies and options presented in **Table 3** were then assessed having regard to a range of issues such as, the social, economic, aesthetic, recreational, ecological and other issues associated with land use along the coastline. Various management studies were undertaken to assess the range of feasible management options, having regard to these and other issues.

These studies and issues they addressed are detailed in **Table 4**.

Table 4 - Coastline Management Studies

Study	Management Issues Addressed
Coastal Management Strategy Phase Two: Management Options and Appendices, 1989 (NLA 1989)	Ownership of land Social issues Economic issues Ecological issues Recreational amenity Extent of study area
Criteria for the Siting and Design of Foundations for Residential Development, 1991 (WSC 1991)	Planning under uncertainty Climate change Social issues Economic issues Planning/building controls
Collaroy/Narrabeen Beach Nourishment Investigations, 1993 (PB 1993)	Ownership of land Extent of study area Aesthetic factors Ecological factors Recreational amenity Social issues Economic issues Land tenure
Green Paper - Issues for Discussion in Preparation of the Collaroy/Narrabeen Coastline Management Plan, August 1995 (WC 1995)	Recreational amenity Economic issues Land tenure Planning controls

The selection of specific hazard management strategies and actions for this Coastline Management Plan, has taken into account the following considerations:

1) implications of the State Government's Coastline Hazards Policy;

2) fulfilling the range of objectives listed in Section 3.3, particularly the three core objectives for this Management Plan;

3) the type and nature of the coastline hazards impacting on Collaroy/Narrabeen;

4) aesthetic, recreational and ecological values and issues;

5) social factors, including the community issues raised and the needs and desires of the community, expressed through the consultation on this Plan;

6) long term considerations of climate change;

7) economic factors, including expected costs and benefits to public and private sectors, beachfront owners and the community in general; and

8) findings of the technical studies and reports prepared for Collaroy/Narrabeen Beach.

6.2 Proposed Management Strategies and Actions

Taking into account the eight considerations listed above and all four strategies, twelve (12) associated actions are proposed to manage coastline hazards for Collaroy/Narrabeen Beach. These are listed below in **Table 5** and described in detail in Section 6.3.

The actions are not listed in order but have regard to the four essential strategies, provided in Table 3, from the *NSW Coastline Management Manual* (NSW 1990), with actions prioritised in **Sections 6.3** and **7.0**. Table 5 also indicates the precinct where the action will be implemented and the coastline management objectives to which the action contributes.

Table 5. - Coastal Management Strategies and Actions.

Strategy	Actions	Applies to Precinct	Relevant Objective
A. **Undertake protective works and structural controls**	1. Survey and assess existing seawalls. 2. Selective reconstruction of existing seawalls and minor construction to infill gaps in existing walls. 3. Undertake moderate nourishment of beach in association with reconstruction, of seawalls. 4. Undertake improvements to stormwater outlets along beachfront.	2 & 3 2 & 3 2 & 3 All	II, III II, III, IV I, III I, III
B. **Implement environmental planning measures**	5. Amend Section 149 Certificates. 6. Selective voluntary purchase/open space acquisition of single residential properties.[4] 7. Planned retreat of Collaroy Surfclub buildings.	All All 2	I, III, IV II, III II, III
C. **Implement development control conditions**	8. Maintain/review building and development controls for beachfront. 9. Revise coastal emergency management procedure for Collaroy/Narrabeen Beach. 10. Review building lines for beachfront.	All All All	II, III I, II, III II, III
D. **Undertake Dune Management**	11. Maintain moderate sand nourishment and extend dune reconstruction and revegetation. 12. Continue current dune maintenance. 13. Improve beach amenity through ongoing beach reserve improvements and maintenance works.	2 & 3 All All	I, III I, III I, III

[4] "Single residential" includes dual occupancy dwellings

6.3 Detailed Description of Management Actions

A description of each management action, including the major steps for implementation, estimated cost and completion target date is provided below.

STRATEGY A Undertake Protective Works and Structural Controls

Action A-1.	**Survey and assess existing seawalls**
Description	To determine in detail, the alignment, design, condition and integrity of existing seawalls.
Implementation Steps	i. Prepare a brief to survey alignment; assess toe level, suitability and size of amour units, and filtration performance; ii. Prepare preliminary design/alignment and costing estimate for seawall; iii. Presentation of results of (i) and (ii) to Coastal Management Committee and to Council for approval.
Additional Information	As described in Section 2.1 - the history of coastal erosion and storm damage has led to dumping of rock and construction of sea walls along approximately 1000 metres of beach in Precincts 2 and 3 (**Figure 8**).
Outcomes and issues	• Results of the survey will influence ***Actions A-2.***, • ***C-8.***, ***C-9.*** and ***C-10.;*** • Consideration be given to public access and safety issues; and • Alignment of the seawall be optimised to satisfy both engineering objectives and to minimise alienation of public open space.
Estimated Cost	$50,000 for preparation of brief and survey/assessment.
Funding Sources	Council's Environmental & Stormwater Special Rate (50%), NSW Coastline Management Policy (50%)
Priority	High
Target Completion	1997/98
Responsibility	Warringah Council
References	*Collaroy/Narrabeen Beach Nourishment Investigations, 1993.*

Action A-2.	Selective reconstruction of existing seawalls and minor construction to infill gaps in existing walls
Description	To reconstruct and replace existing seawalls along the length of Precincts 2 and 3 and undertake minor construction to infill gaps in existing seawalls.
Implementation Steps	i. Finalise ***Action A-1.***, prior to commencement; ii. Identify easements and refine costing for seawall; iii. Obtain landowners agreement to easements for construction/maintenance along length of wall; iv. Obtain agreement from affected beachfront owners to imposition of Special Rate, levied over say 20 years, to raise 50% of the total cost & maintenance of the wall fronting their particular property; v. Complete an environmental impact statement (EIS) for the work and obtain all necessary approvals; vi. Complete detailed design and tender documentation; vii. Call tenders; viii.Supervise construction works.
Additional Information	· Alignment of the seawall be optimised to satisfy both engineering objectives and to minimise alienation of public open space. · Results of survey and assessment (**Action A-1**.) should be used to determine extent of involvement of individual owners in this action.
Outcomes and Issues	Additional issues to be addressed include: · maintaining maximum beach use for recreational purposes during construction; · re-use of existing unconsolidated rock and rubble where possible, during selective reconstruction work. Foreign objects eg. Steel, concrete, would be removed or selectively buried so as not to become exposed; · normal hardship allowanced apply for Special Rate; · consideration be given to staging construction; · consideration be given to public access and safety issues; and · consideration be given to having a variable seawall design and alignment, based on existing property boundaries and public allotments.

Action A-2.	**Selective reconstruction of existing seawalls and minor construction to infill gaps in existing walls (Continued)**
Estimated Cost	• $10,000 for securing easement & Special Rate • $40,000 for EIS and obtaining approvals (this would be combined with $80,000 for the EIS in Action A-3., • $60,000 for detailed design and tender documentation • $10.9 million (maximum)[5] for reconstruction works • $10,000/yr for maintenance of seawall[6], maintenance costs for stormwater outlets and dune stabilisation are contained in ***Actions A-4. and D-11***.
Funding Sources	Warringah Council & NSW Coastal Hazards for EIS and design works. New Special Rate on beachfront owners (50%) and State Government's Coastline Management Programme (50%) for reconstruction works.
Priority	High to Medium
Target Completion	2001/02 for Implementation Steps (i to vi)
Responsibility	Warringah Council, beachfront owners
References	*Collaroy/Narrabeen Beach Nourishment Investigations*, .

[5] This figure assumes all existing walls need upgrading, this may be conservative. This figure also includes cost of dune stabilisation and stormwater modifications, detailed in Action A-4. And D-11.
[6] Estimate only, maintenance costs involves re-establishing rocks that move due to wave action or slumping of sand material.

Action A-3.	**Undertake moderate nourishment of beach in association with reconstruction of seawalls**
Description	To undertake minor beach nourishment to restore beach amenity to an acceptable level.
Implementation Steps	i. Implement in conjunction with **Action A-2**; ii. Complete environmental impact statement for extraction and placement of initial <u>and</u> maintenance sand volumes; iii. Obtain all necessary approvals for the work; iv. Undertake detailed design and documentation; v. Maintenance of nourishment sand and re-nourishment (maintenance steps are detailed in ***Action D-11***; vi. Call tenders; vii. Supervise works.
Additional Information	The source of nourishment sand (marine/land/estuary) will significantly affect the cost of this action.
Outcomes and issues	Success of this action depends in part on ongoing implementation of **Action D-11.**
Estimated Cost	• $80,000 for EIS and obtaining approvals • $40,000 for detailed design and documentation • $4.7 to>15 M for nourishment, depending on sand source
Funding Sources	Council's Environmental & Stormwater Special Rate (50%), NSW Coastline Management Policy (50%).
Priority	High to Medium
Target Completion	2001/02 for Implementation Steps (i to v)
Responsibility	Warringah Council, NSW Government (for approvals)
References	*Collaroy/Narrabeen Beach Nourishment Investigations, 1993.*

Action A-4.	**Undertake quality and quantity improvements to stormwater outlets along beachfront**
Description	To improve water quality and reduce effects of quantity of discharge onto the beach from six[7] of the existing seven (7) stormwater outlets.
Implementation Steps	i. Undertake, where possible, in conjunction with **Actions A-1.** and **A-2**; ii. Prepare detailed design, cost estimates and tender documentation for works proposed for each outlet; iii. Undertake necessary environmental assessments and obtain approvals; iv. Call tenders; v. Supervise construction works.
Additional Information	The design may include stormwater rationalisation, drainage reconstruction and/or treatment of stormwater.
Outcomes and issues	Accurate costings to be determined following detailed investigation of each outlet.
Estimated Cost	• $5,000 and $25,000 for detailed designs of high priority outlets (Goodwin St and Ramsay St respectively). Similar costs are anticipated for the remaining outlets. • $250,000 for upgrading all outlets. Costs <u>included</u> in $10.9M for reconstruction/upgrading of seawall, **Action A-2.**, • $20,000/year for maintenance of all outlets.
Funding Sources	Council's Environmental & Stormwater Special Rate (50%), NSW Coastline Management Policy (50%)
Priority	Medium (Ramsay St and Goodwin St outfalls have highest priority of outfalls)
Target Completion	2000/01 for completion of detailed costings/design and reconstruction of high priority outlets.
Responsibility	Warringah Council
References	*Collaroy/Narrabeen Beach Nourishment Investigations, 1993* and **Figure 8** - *Stormwater Outfalls on Collaroy/ Narrabeen Beach.*

[7] No modifications to the existing Collaroy Street outfall would be necessary.

STRATEGY B Implement Environmental Planning Measures

Action B-5.	Amend Section 149 Certificates
Description	Amend the wording of S 149 notifications of affected properties, to reflect the objectives and intent of this Plan, following its adoption.
Implementation Steps	i. Identify wording of new notification to reflect this Plan and the Development Guidelines for Collaroy/Narrabeen Beach, attached as Appendix B; ii. Following adoption of new wording by Council. amend all current notifications; iii. Inform owners of changes to notifications.
Additional Information	• Information on current notifications can be found in Section 4.2.1 of this document. • Appendix B to this Plan.
Estimated Cost	$5,000 for staff costs and legal advice
Funding Sources	Warringah Council's Operating Budget
Priority	High
Target Date	October 1997.
Responsibility	Warringah Council
References	Council's resolution of August 20th 1991.

Action B-6.	Selective voluntary purchase/open space acquisition of single residential properties
Description	To selectively purchase beachfront properties, to improve beach access, increase the amount of open space and provide additional areas of beach reserve.
Implementation Steps	i) Council is to use the following criteria to guide voluntary purchase of single dwellings (in priority order): ⇒ the property is within Precinct 3; ⇒ the purchase of the property would make a significant contribution to the current recreational open space holdings; ⇒ purchase of the property would make a significant contribution to improving beach access; ⇒ a history of ongoing storm damage and beach erosion indicates an increased risk to a property. ii. Prepare a Section 94 Plan for Acquisition of Open Space in the Collaroy/Narrabeen area; iii. Ensure any additional allotment obtained as open space are addressed through **Action D-13.**
Additional Information	· Flat and multi-unit developments currently occupy 33% of the beach frontage of Precinct 3. · Selective voluntary purchase does <u>not</u> automatically give Council the right to purchase a property. Property owners wishing to sell their property could place it in the open market, in which Council may participate. Should Council decide <u>not</u> to purchase the property, that would <u>not</u> prevent its sale to another purchaser.
Outcomes and issues	Multi-flat/unit blocks will not be considered for purchase.
Estimated Cost	Up to $1 million/per year
Funding Sources	Warringah Council, S94 Plan (to be prepared), NSW Coastline Management Policy
Priority	High
Target Completion	Aim for purchase of one property each year.
Responsibility	Warringah Council
References	*Local Government Act 1993*

Action B-7.	Planned retreat of Collaroy Surfclub buildings
Description	Plan the retreat of Collaroy Surf Club, including re-siting of existing Club and changing facilities away from active beach zone.
Implementation Steps	i. To be considered by Council whenever replacement, extensions or renovations to the Club are being proposed.
Additional Information	This action applies only to Collaroy Surf Life Saving Club. Other Surf Clubs, namely, South Narrabeen, Narrabeen and North Narrabeen have already been relocated or are sited behind the Wave Impact Zone.
Outcomes and issues	In considering re-location of Surfclub buildings attention should be given to the existing seawall protection in front of the Club, which is in the form of a substantial sheet pile wall. Information from **Action A-1.** should be included in determination of this Action.
Estimated Cost	To be determined.
Funding Sources	Warringah Council, NSW Coastline Management Policy
Priority	Low
Target Completion	Before 2018
Responsibility	Warringah Council, Surf Life Saving Association
References	*Warringah Shire Coastal Management Strategy, 1985, and Collaroy/Narrabeen Beach Nourishment Investigations, 1993:51* – for information on the seawall.

STRATEGY C Implement Development Control Conditions

Action C-8.	**Maintain/review building and development controls for beachfront**
Description	To assess development applications for Precincts 1, 2, 3 and 4 through application of Council's *Development Guidelines for Collaroy/Narrabeen Beach,* (see Appendix B)
Implementation Steps	i. Undertake a review of the Guidelines following completion of **Action A-2**; ii. Revise the Development Guidelines at regular intervals following adoption of this Coastline Management Plan; iii. Review the Hazard Lines (on which the Development Guidelines are based) at regular intervals or as information becomes available, iv. Undertake future reviews following completion of major works detailed in this Plan, such as **Action A-2**.
Additional Information	*Collaroy/Narrabeen Development Guidelines 1997*, attached as Appendix B, and Council's Maps A1 8634 sheets 1-3.
Outcomes and issues	Review of Guidelines may alter nature of approvals for building and development applications issued for Precincts 2 and 3.
Estimated Cost	$3,000 of staff time for each review.
Funding Sources	Warringah Council's Operating Budget
Priority	High to Medium
Target Completion	1998/99 to implement reviewed Guidelines for Precincts 2 and 3
Responsibility	Warringah Council
References	*Development Guidelines for Collaroy/ Beach,* attached as Appendix B.

Action C-9.	**Revise coastal emergency management procedure for Collaroy/Narrabeen Beach**
Description	To review the coastal emergency management plan to deal effectively with emergency situations for Collaroy/Narrabeen.
Implementation Steps	i. Continue to apply the *Warringah Shire Council - Coastal Emergency Plan, February 1991,* until the document has been reviewed; ii. Familiarise relevant Council and SES officers on existing Emergency Plan, as a high priority step; iii. Review the document in conjunction with the SES; iv. Re-train relevant Council and SES officer on the revised Emergency Plan.
Outcomes and issues	The current and revised plan will have implications for both private and public actions taken during coastal storm emergencies.
Estimated Cost	$10,000 for familiarisation and re-training of relevant officers (staff costs) $10,000 for review and implementation of document
Funding Sources	Warringah Council, NSW Coastline Management Policy
Priority	High
Target Completion	1997/98 (for steps i to iii) training and review, 1998/99 (for step iv) implementation of revised plan.
Responsibility	Warringah Council, SES, LEMC
References	*Warringah Shire Council - Coastal Emergency Plan, February 1991*

Action C-10.	Review building lines for beachfront
Description	To review existing building lines for Collaroy/Narrabeen beachfront having regard to information in this Plan.
Implementation Steps	i. Review current building lines in conjunction with **Action C-8**; ii. Inform affected owners of any changes.
Additional Information	Following coastal storms in 1967 and 1974, building lines were established along Collaroy Beach. A 15 metre building line was established north of Goodwin Street and a 23 metre building line was established south of Goodwin Street to Jenkins Street. These building lines were adopted to minimise property damage through erosion, based on the then current state of knowledge.
Outcomes and issues	The review may alter the information required for Building Applications and may change the nature of building approvals issued for Collaroy/Narrabeen.
Estimated Cost	$3,000
Funding Sources	Warringah Council's Operating Budget
Priority	Medium
Target Completion	1998/99
Responsibility	Warringah Council
References	Warringah Local Environmental Plan

STRATEGY D Undertake Dune Management

Action D-11.	Maintain moderate sand nourishment and extend dune reconstruction and revegetation
Description	Implement an ongoing program to manage and maintain the nourished beach in the vicinity of Precincts 2 and 3 and maintain beach amenity into the future.
Implementation Steps	i. Prepare and implement a maintenance programme, following completion of *A-3.;* ii. Prepare and implement a Council Procedure for 'Beach Scraping', to re-work sand on beach; iii. Continue works to replace excavated beach sand from entrance of Narrabeen Lagoon onto Precincts 2 and 3, in accordance with *Management Policy for Narrabeen Lagoon Entrance, November 1996;* iv. Re-nourish beach with sand from an external source, on a periodic basis, approximately once every ten (10) years; v. Set up a financial reserve for managing annual contributions for periodic replenishment; vi. Undertake a programme to extend dune reconstruction and revegetation on areas of nourished sand.
Estimated Cost	• $35,000/yr for implementation of maintenance program • $5,000 for preparation of maintenance programme and beach scraping procedure (staff costs) • $200,000 every 3 years for clearance of Narrabeen Entrance (partially funded by Pittwater Council and the NSW Flood Mitigation Programme) • $70,000/yr for re-nourishment of sand • $20,000/yr for maintenance of new dunes established.
Funding Sources	Council's Environmental & Stormwater Special Rate (50%), NSW Coastline Management Policy (50%)
Priority	Medium to Low
Target Completion	Steps i and ii by completion of **Action A-3.**
Responsibility	Warringah Council
References	*Collaroy/Narrabeen Beach Nourishment Investigations, 1993* and NSW *Coastline Management Manual 1990.*

Action D-12.	Continue current dune maintenance
Description	Continue the current programme of dune management to maintain and enhance existing vegetated dunes.
Implementation Steps	i. Continue current dune maintenance program; ii. Document the program in a "Dune Maintenance Procedure", to address: upgrading and maintenance of dune stabilisation vegetation; extending areas of vegetated/stabilised dunes where possible; provision and maintenance of fences and access tracks; and establishing secondary/tertiary dune vegetation where possible; iii. Establish a "Dune Maintenance Agreement" with all Surf Clubs, for areas of stabilised dunes in the vicinity of Clubs; iv. Establish/encourage a DuneCare Group for Collaroy and Narrabeen Beaches in conjunction with the Sydney Northern Beaches Catchment Management Committee.
Estimated Cost	• $5,000 for preparation of procedure (staff costs) • $30,000/yr for implementation of procedure.
Funding Sources	Council's Environmental & Stormwater Special Rate (50%) NSW Coastline Management Policy (50%)
Priority	Medium
Target Completion	1998/99 for steps i, ii and iii.
Responsibility	Warringah Council, Surf Life Saving Association
References	*Coastal Management Strategy 1985*

Action D-13.	**Improve beach amenity through ongoing beach reserve improvements and maintenance works**
Description	To maintain and enhance the recreational amenity of existing and proposed areas of beach reserve, through an ongoing programme of beach reserve improvements and maintenance works.
Implementation Steps	i. In all Precincts, design and implement works to upgrade areas of park with landscape plantings, shade trees and picnic/barbecue facilities; ii. Formalise and landscape existing carparks; iii. Establish continuous public park/recreation area from Devitt Street to Furlough Park; iv. Undertake maintenance of stormwater outlets; v. Continue maintenance work that ensure recreational amenity for beach and surf users.
Additional Information	Detailed works to cover the implementation steps would be incorporated in Council's Reserves Improvement Program.
Estimated Cost	$20,000 per year
Funding Sources	Council's Environmental & Stormwater Special Rate (50%) NSW Coastline Management Policy (50%)
Priority	Medium
Target Completion	Ongoing
Responsibility	Warringah Council
References	*Coastal Management Strategy 1985*, previous Annual *Reserve Improvement Programmes*

7.0 IMPLEMENTATION SCHEDULE

The following implementation schedule is provided for actions listed in Section 6.0

No.	Action and Implementation Steps	Priority	Complete
B-6. i	Purchase single dwellings/acquire open space	HIGH	Ongoing
D-12. i	Continue current dune maintenance	HIGH	Ongoing
C-9. i	Apply Coastal Emergency Plan	HIGH	Ongoing
A-1. i	Prepare brief	HIGH	Sept 1997[8]
B-5. i, ii and iii	Amend Section 149 Notifications	HIGH	Oct 1997
C-9. ii	Familiarisation of Council/SES officers	HIGH	Nov 1997
B-6. ii	Prepare Section 94 Plan	HIGH	Dec 1997
D-11. ii	Prepare/implement beach scraping policy	HIGH	May 1998
C-9. iii and iv	Review Coastal Emergency Plan and re-train Council/SES officers	HIGH	June 1998
D-12. ii	Prepare dune maintenance procedure	HIGH	June 1998
A-1. ii	Preliminary design/costing/alignment	HIGH	July 1998
C-8. i	Review Development Guidelines	HIGH	Sept 1998
A-1. iii	Presentation of survey/preliminary costing	HIGH	Oct 1998
A-2. ii	Identify easements/refine costing for seawall	HIGH	Oct 1998
D-12 iii	Establish dune maintenance agreement	HIGH	Dec 1998
A-2. iii	Obtain agreement to easements Precincts 2/3	HIGH	1999/00
A-2. iv	Obtain agreement to Special Rate for owners	HIGH	1999/00

[8] Funding for implementation steps listed for 1997/98 have been allocated in Council's Environmental and Stormwater Special Rate program for 1997/98 or can be covered through Council's normal operating budget for 1997/98.

No.	Action and Implementation Steps (cont')	Priority	Complete
A-4. ii and iii	Prepare detailed designs and tenders and undertake environmental assessment	Medium	Ongoing
D-11. iii	Continue replacement of entrance sand	Medium	Ongoing
D-13. iv	Maintain stormwater outlets	Medium	Ongoing
C-10. i and ii	Review building lines/inform owners	Medium	1998/99
D-13. i	Upgrade parks	Medium	1999/00
D-13. ii	Formalise/landscape carparks	Medium	1999/00
C-8. iii	Review Hazard Lines	Medium	1999/00
A-2. v	Complete EIS and obtain approvals	Medium	2001/02
A-3. ii	Complete EIS for initial/maintenance sand	Medium	2001/02
A-3. iii	Obtain necessary approvals	Medium	2001/02
A-2. vi	Complete detailed design and tender	Medium	2002/03
A-3. Iv	Detailed design for nourishment	Medium	2002/03
A-4. iii and iv	Call tenders/construct stormwater outlets	Medium	2002/03
C-8 ii	Revise Development Guidelines	Medium	2002/03
C-8. iv	Future reviews of planning controls	Low	All low priority actions to be completed after 2002/03
D-12 iv	Establish DuneCare Group	Low	
D-11. i	Maintenance program for nourishment	Low	
D-11. vi	Extend dune vegetation into nourished area	Low	
D-13. iii	Establish park (Devitt St to Furlough Park)	Low	
D-11. v	Set up Financial Reserve	Low	
D-11. iv	Replenish nourishment sand	Low	
A-2 vii	Call tenders for seawall works	Low	
A-2 viii	Supervise seawall works	Low	
B-7. i	Consider planned retreat of Collaroy SLSC	Low	Ongoing

7.0 REFERENCES

The following reference reports were used to prepare this Plan and are available from Warringah Council or Council's Library at Dee Why.

GEO 1991, *Criteria for the Siting and Design of Foundations for Residential Development, February 1991,* Geomarine Pty Ltd and Coffey Partners International Pty Ltd, Report No. 69021 R02, Sydney, (for Warringah Shire Council)

NLA 1988, *Narrabeen/Collaroy/Fishermans Beach Coastal Management Strategy - Phase One Hazard Definition, April 1988,* Report of the Coastal Management Steering Committee, prepared by Nielsen Lord Associates, Report No. 87020.01.003, Sydney, (for Warringah Shire Council)

NLA 1988, *Narrabeen/Collaroy/Fishermans Beach Coastal Management Strategy - Management Options, December 1988,* Report of the Coastal Management Steering Committee, prepared by Nielsen Lord Associates and Travers Morgan Pty Ltd, Report No. 88013.01.001, Sydney, (for Warringah Shire Council)

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NSW 1990, *Coastline Management Manual, September 1990,* New South Wales Government, 1990, ISBN 0730575063

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PB 1993, *Collaroy/Narrabeen Beach Nourishment Investigations, July 1993,* Patterson Britton & Partners Pty Ltd, Sydney, (for Warringah Council)

PWD 1987, *Collaroy/Narrabeen Beaches - Coastal Process Hazard Definition Study, December 1987,* Public Works Department Report No. 87040, 1987 (for Warringah Shire Council)

WC 1991, *Revised Interim Building and Development Guidelines for Collaroy/Narrabeen/ Fishermans Beach, August 1991, Maps A8634 Sheets 1-3,* Warringah Shire Council, 1991, Sydney

WC 1995, *Green Paper - Issues for Discussion: Preparation of the Collaroy/Narrabeen Beach Draft Coastline Management Plan, August 1995,* Warringah Council 1995, Sydney

WC 1996, *Draft Collaroy/Narrabeen Beach Coastline Management Plan, September 1996,* Warringah Council 1996, Sydney

WC 1996, *Management Policy for Narrabeen Lagoon Entrance, November 1996*, Warringah Council 1996, Sydney

WSC 1985, *Coastal Management Strategy*, Warringah Shire Council, 1985, Sydney

WSC 1991, *Coastal Emergency Plan*, Warringah Shire Council, 1991, Sydney

8.0 GLOSSARY

Accreted Beach The profile (cross section) of a sandy beach that develops in the 'calm' periods between major storm events. During such periods waves move sand from offshore bars back onto the beach to rebuild the beach berm.

AHD (Australian Height Datum) A relative level of measurement, where zero on this scale corresponds approximately to mean (average) sea level.

Artificial Headland Built structures connected to the shoreline to provide coastal protection or to restrict longshore drift of sand.

Back Beach Dune See Dunes - 'hinddune'

Beach Berm That area of shoreline lying between the end of the waves and the dune system.

Beach Erosion The movement of sand offshore during storms.

Beach Nourishment The supply of sand by mechanical means, to supplement existing sand on a beach or to build up an eroded beach.

Beach Scour Level The base level of sand erosion on a beach during a severe s storm, expressed in metres relative to AHD, average scour levels are around 0 to -1 metres AHD.

Beach Scraping A process to mechanically push beach sand from below high tide level to the back of the beach.

Building Line A building line is a line fixed by Council, between which and any public place or public reserve a building may not be erected.

Cliff Instability Can be due to gradual weathering of the cliff or undercutting by waves, loading on cliff tops and changed groundwater conditions, leading to relatively infrequent but sudden collapse of large portions of the cliff face.

Coastline Hazards Detrimental impacts of coastal processes on the use, capability and amenity of the coastline. Hazards include:
* Beach erosion
* Shoreline recession
* Sand drift
* Coastal inundation
* Cliff instability
* Stormwater erosion

Coastal Inundation This is the maximum level to which wave run-up would occur on a natural sand due, taking into account the offshore significant wave height, barometric pressure and onshore winds.

Coastal Processes These are the actions of the ocean, atmosphere and rivers which influence or impact on coastal land. Processes do not operate in isolation but interact in complex ways, examples of coastal processes include:

* Storms
* Water levels
* Waves
* Currents
* Rainfall
* Climate change

Currents Currents flowing parallel to the shore are "longshore" currents. Currents can also flow onto the shoreline "onshore" and away from the shoreline "offshore".

Design Storm The coast can experience a design storm event at any time. A coastline hazard is typically expressed in terms of the likely impact of a design storm event. A design storm is specified in terms of its probability, eg. The 5% storm event has a 5% chance of occurring in any year, with on average five such storms expected to occur over a period of 100 years.

EIS (Environmental Impact Statement) A report of anticipated impacts or effects on the environment and measures proposed to mitigate or lessen these impacts. An EIS typically includes an economic appraisal of the social, financial and ecological costs of the proposed project.

Erosion Demand The amount of sand which can be eroded from the beach berm and sand dunes during a severe storm or series of storms.

Frontal Dune Also called 'incipient' dune, see Sand Dunes.

Greenhouse Effect A term used to describe the likely global warming predicted to accompany the increasing levels of carbon dioxide and other "greenhouse" gases in the atmosphere.

Groyne Low walls built perpendicular to a shoreline to trap longshore sand. Typically, sand buildup on the updrift side of a groyne is offset by erosion on the downdrift side.

Inshore Wave Height The maximum wave height in metres which can occur for a given inshore depth and offshore significant wave height.

Nearshore Zone This is coastal waters between the offshore bars and 60 metre depth contour. Waves in the nearshore zone are unbroken, but their behaviour is influenced by the presence of the seabed.

Offshore Bar A submerged sandbar formed offshore by processes of beach erosion. Typically, swell waves break on the offshore bar.

Planned Retreat The planned relocation of buildings and/or structures from areas of coastal hazards.

Sand Drift The movement of sand by wind.

Sand Dunes Mounds or hills of sand lying landward of the beach berm. Sand dunes are usually classified as:
'incipient' (frontal dune) - The most seaward and immature dune of the system, characterised by grasses.
'foredune' - Large mature dune, lying between the incipient and hinddune area.
'hinddune' (back beach dune) - Sand dune located at the back of the beach, often characterised by mature vegetation.
During storm conditions, incipient and foredunes may be severely eroded by waves. During the intervals between storms, dune are rebuilt by wave and wind effects. Dune vegetation is essential to prevent sand drift and associated problems.

Section 149 Certificate A certificate issued under S149 of the *Environmental Planning and Assessment Act 1979*, for a particular property, enclosing a variety of information about that land, such as policies affecting that land.

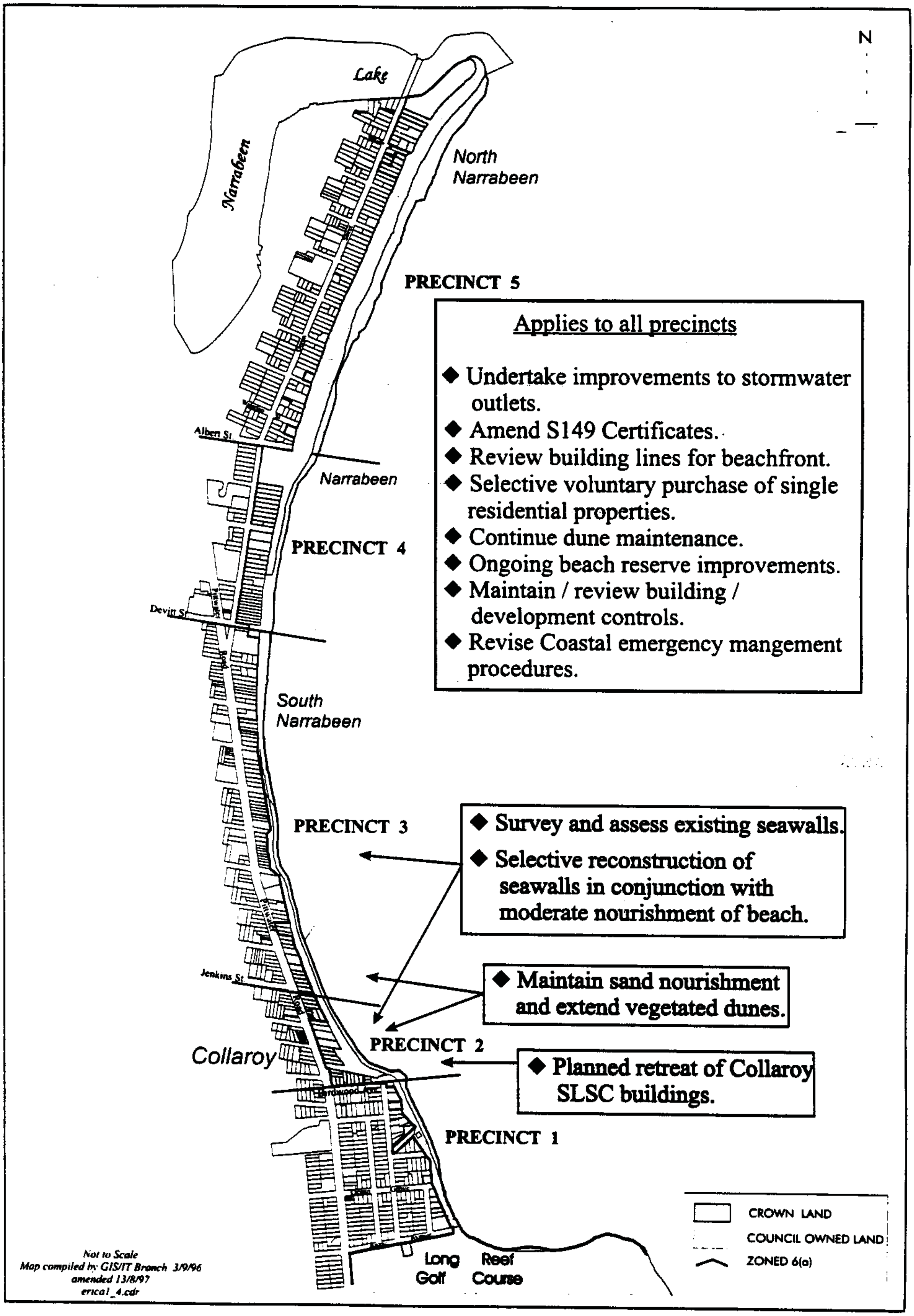
Section 94 Plans A Plan prepared under section 94 of the *Environmental Planning and Assessment Act 1979*, enabling Council to levy contributions towards the cost of providing or improving amenities and services, to meet increased demands created by development.

Shoreline Recession A net long term landward movement of the shoreline caused by a loss in the 'sediment budget'. The sediment budget is an accounting of the rate of sediment supply from all sources and the rate of sediment loss from an area of coastline.

Significant Wave Height	The average height of the highest one third of waves recorded in a given monitoring period.
Special Rate	This is a "special rate" in accordance with S495 (2) of the Local Government Act 1993, towards meeting the cost of any works, services, facilities or activities, where the rateable land will benefit from those works and services.
Stormwater Rationalisation	The reduction or relocation of stormwater outlets to improve the overall aesthetics of an area.
Tides	The regular rise and fall of sea level in response to the gravitational attraction of the sun, moon and planets. Tides along the NSW coastline are 'semi-diurnal' in nature, ie. They have a period of about 12.5 hours.
Tsunami	Long period ocean waves generated by geological and tectonic disturbances below the sea. Incorrectly referred to as "tidal waves", tsunami travel at speeds of to 800 km/hour in the open ocean, where they are of low height. However tsunami can rise to a height of 10m or more through the shoaling process as they approach land.
Wave runup	The vertical distance above mean water level reached by the uprush of water from waves across a beach (or up a structure).
Wave setup	The increase in water level within the surf zone, above mean still water level, caused by the breaking action of waves.
Wind setup	The increase in mean sea level caused by the "pilling up" of water on the coastline by the wind.

10.0 FIGURES .... Page

FIGURE 1. Summary of Coastline Management Actions.



Appendix 3 – Site selection survey instrument

Appendix 3: SCCG Beach Valuation Project
Site selection criteria ranking survey

Please rank the following site characteristics in terms of their importance for selecting case study sites for valuation.
(Place a 1 next to the most important criteria, 2 next to the second most important....until all criteria have been ranked).
Please do not assign part scores (e.g. 2.5, 3.2) or assign equal rankings to multiple attributes.

Site attribute	Importance Rank
Coastal Hazard Definition Study has been completed for the site	
site is an iconic tourism destination (significant domestic and international tourism)	
site is a significant regional surfing destination	
vulnerability to inundation/direct impacts of sea level rise	
vulnerability to coastal processes	
presence of private infrastructure in coastal hazard zone (at the time the hazard definition study was completed)	
presence of public infrastructure in coastal hazard zone (at the time the hazard definition study was completed)	

If there is a criterion which has not been included on the list which you feel strongly should be considered, please list the site attribute below.

Comments: ____
____
____
____
____
____

Thank you for your time and consideration.
All responses will be kept confidential.

Please return via email to david.anning@student.unsw.edu.au

Appendix 4 – Sensitivity testing results for site selection process

Appendix 4: Sensitivity testing results for site selection process

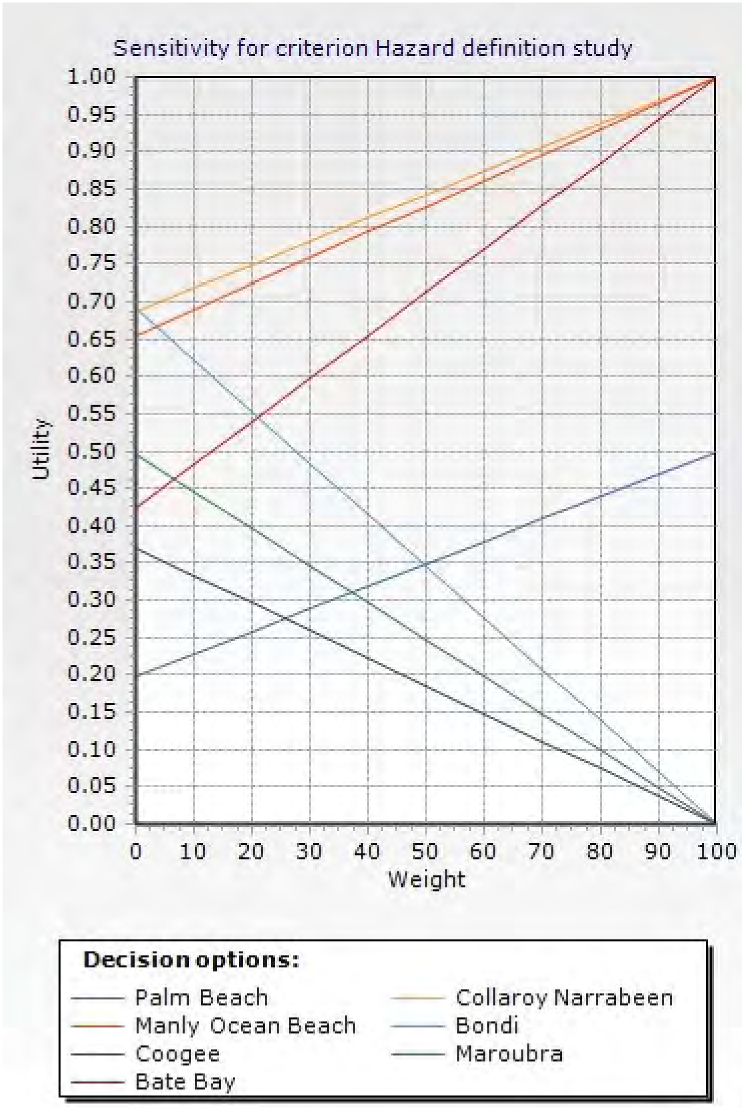


Figure A4.1 Sensitivity to weighting for Criteria 1: Hazard definition study completed. Graph generated via MCAT

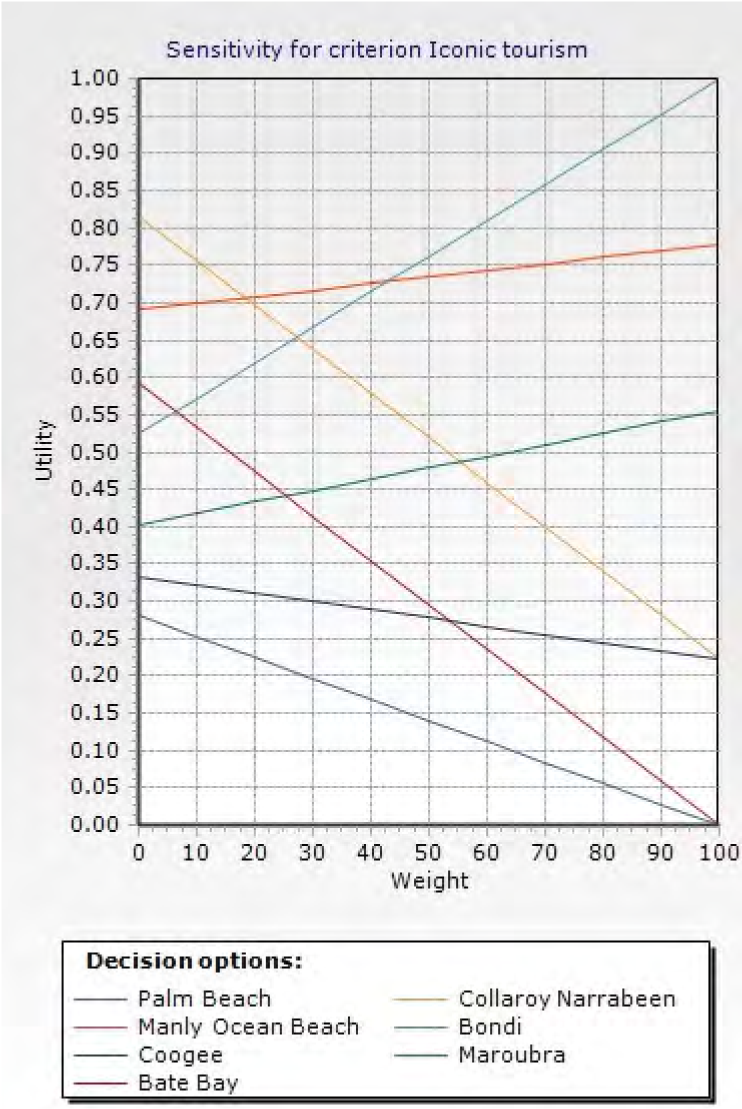


Figure A4.2 Sensitivity to weighting for Criteria 2: Iconic tourism destination. Graph generated via MCAT

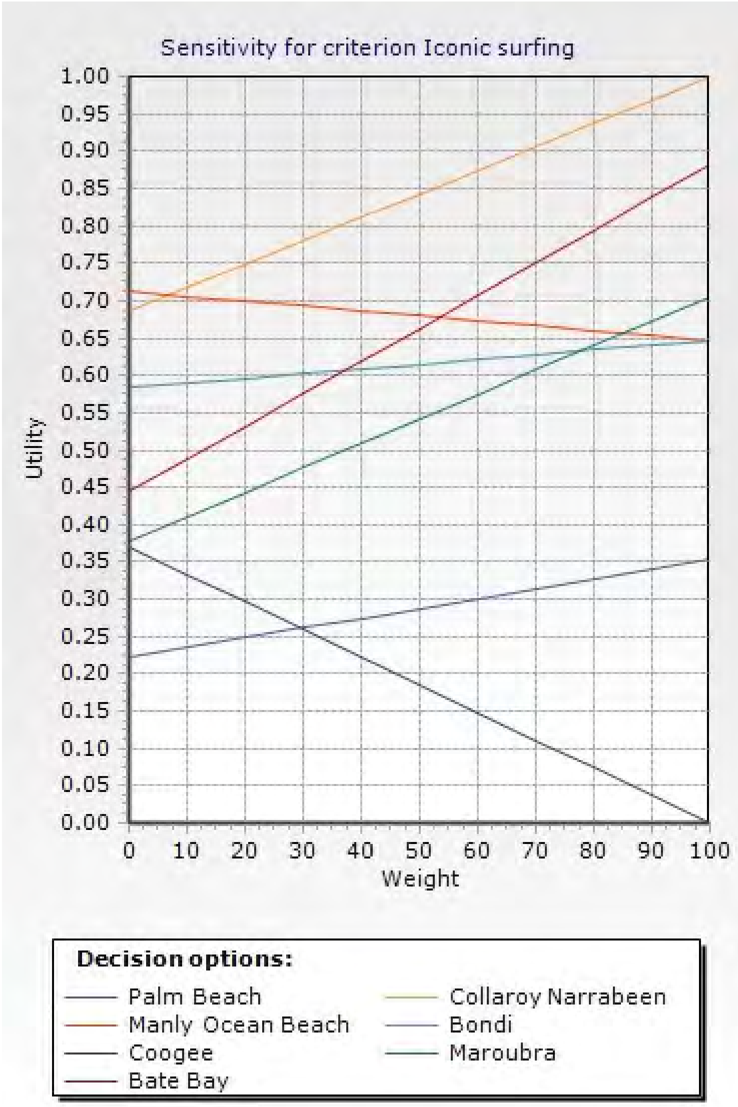


Figure A4.3 Sensitivity to weighting for Criteria 3: Iconic surfing destination. Graph generated via MCAT

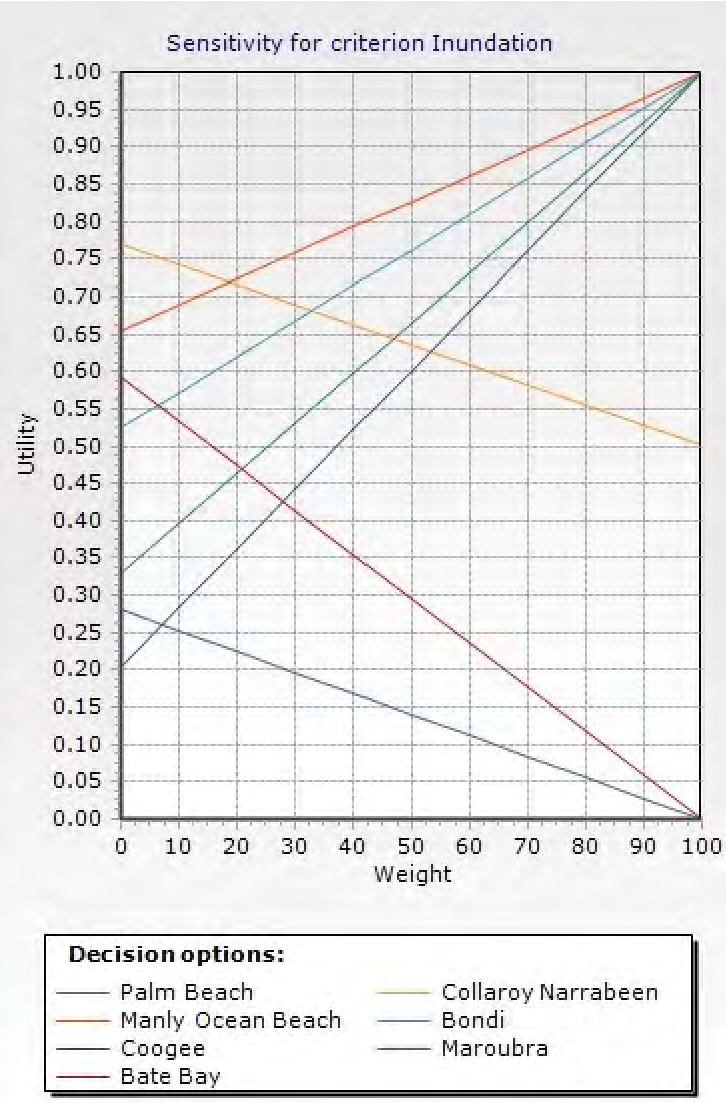


Figure A4.4 Sensitivity to weighting for Criteria 4: Vulnerability to inundation. Graph generated via MCAT

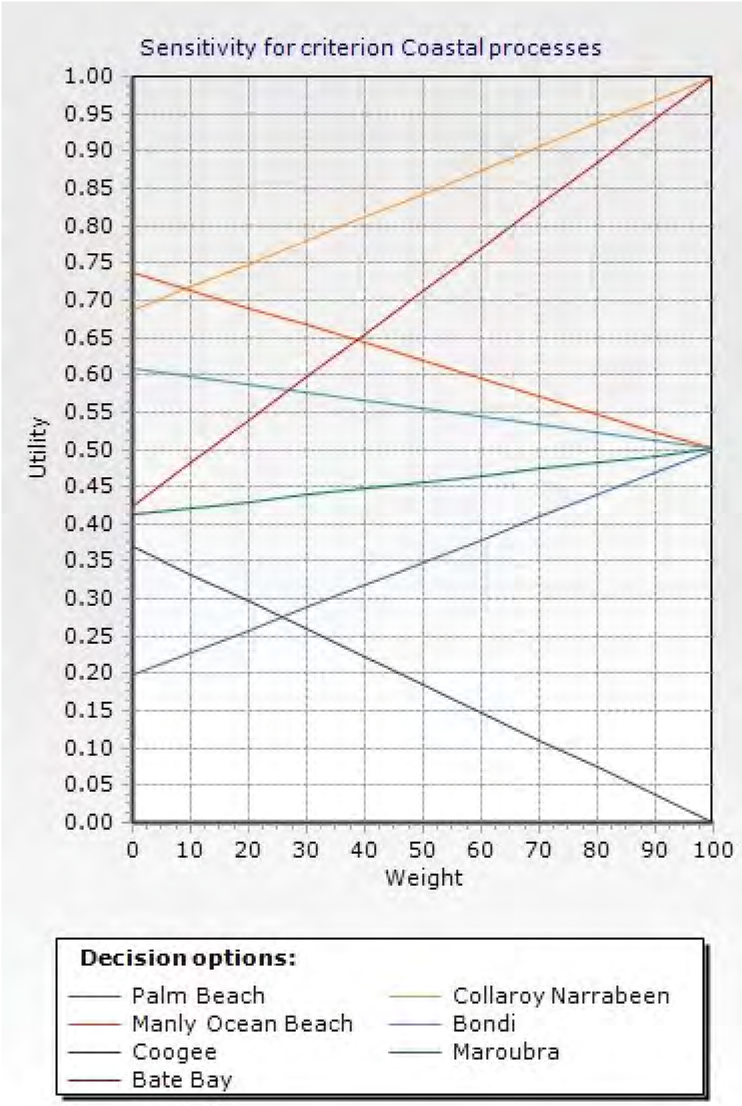


Figure A4.5 Sensitivity to weighting for Criteria 5: Vulnerability to coastal processes. Graph generated via MCAT

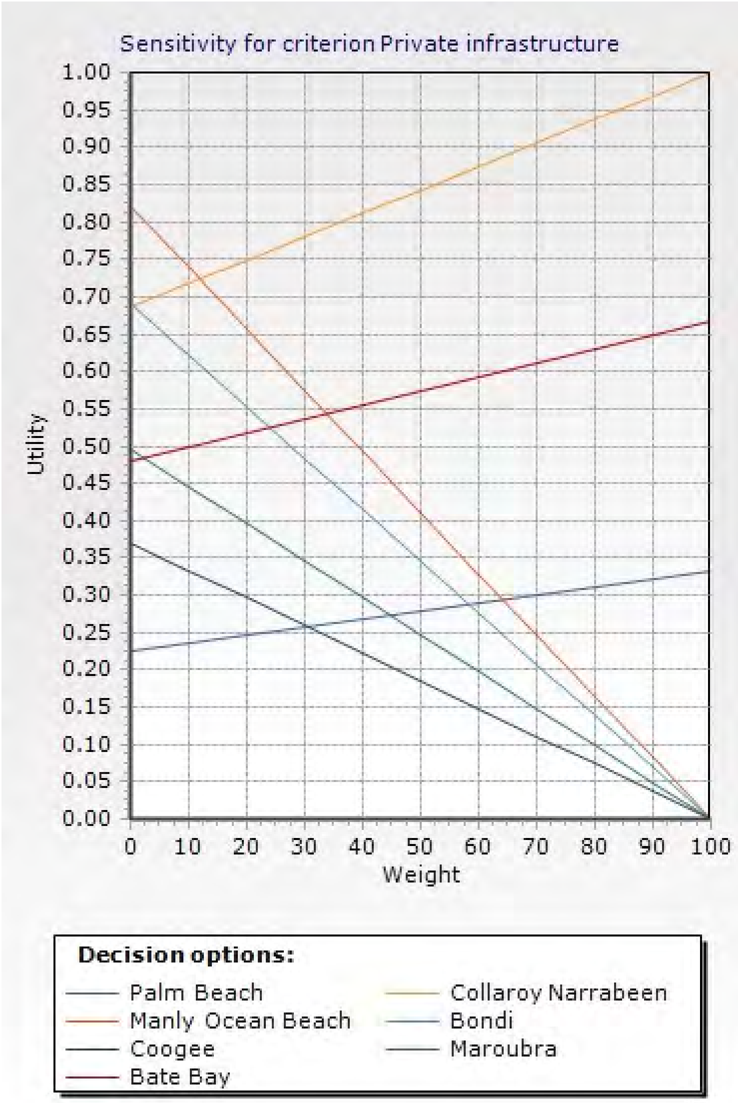


Figure A4.6 Sensitivity to weighting for Criteria 6: Exposure of private infrastructure. Graph generated via MCAT

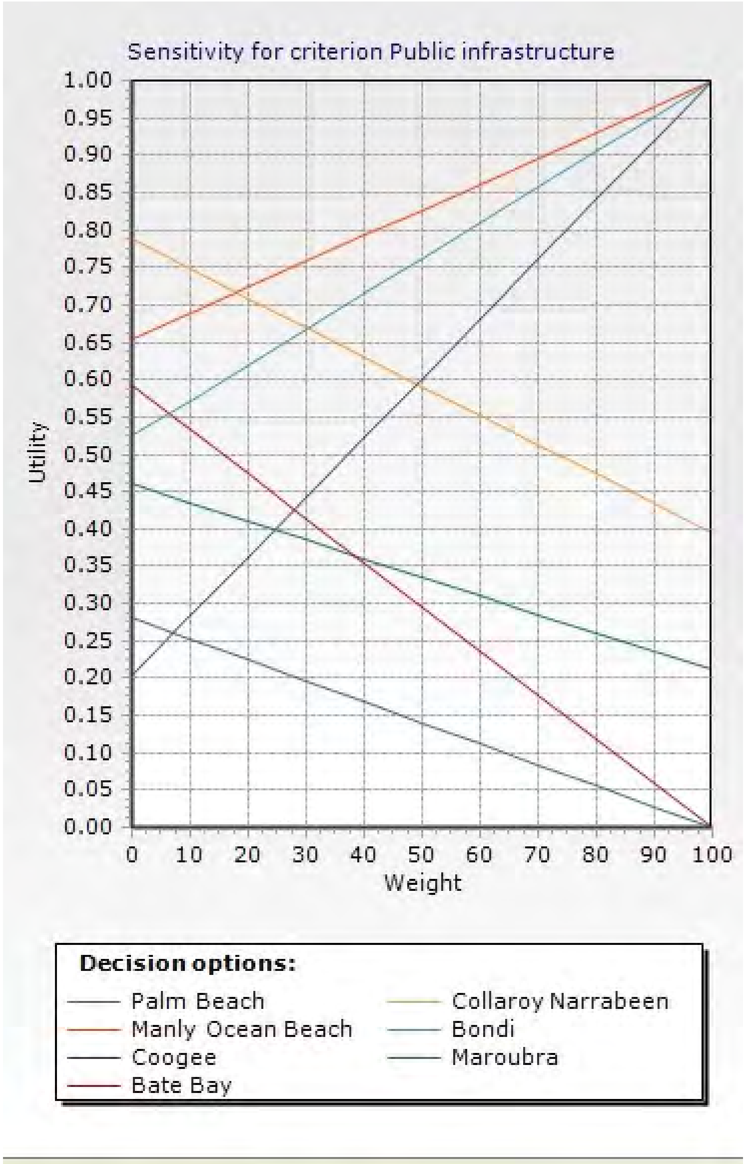


Figure A4.7 Sensitivity to weighting for Criteria 7: Exposure of public infrastructure. Graph generated via MCAT

Appendix 5 – Online survey instrument: Sydney Beaches Valuation Project

Display options

Info: Here you can change the display options. If you select a language which doesn't have own text elements, the text elements of the default language will be displayed.

Edit display options:	☑ Show filters ☐ Show pretest comments ☐ Show to-dos ☑ Show triggers ☑ Show plausibility checks ☑ Disable randomization
Language	English (Standard)

Save settings

Information on survey Sydney Beach Valuation

Survey no.	87968
Author	David Anning
Staffer	
Start	2008-08-07 00:00:00
End	2010-07-28 00:00:00

Questionnaire

1 [Page ID: 504828] [L]

Introduction

trigger:

Logout trigger - no consent - refuse consent - Condition: if(v_367 = 2) - Position of execution: "After submitting page, after filter"

Sydney Beaches Valuation Project

Thank you for your interest in the Sydney Beaches Valuation Project. The Sydney Coastal Councils Group and project partners The University of New South Wales hope to learn about the way people currently use beaches in Sydney, and how beaches can be managed best in the future in response to predicted climate change impacts.

You can assist in this study by completing the following survey

The survey takes around 10 minutes to complete, and participation is purely voluntary. If you choose to participate, your answers will be used to inform the future management of Sydney beaches.

If you agree to participate, you will be asked questions about which beaches you have recently visited, how and why you chose to travel to those particular beaches, and some questions about your response to projected beach changes under climate change scenarios. No personally identifiable information will be collected. You will be asked some demographic questions to enable us to make sure that survey respondents effectively represent beach visitors, although you can choose not to answer this section of the survey.

This survey has been approved by the University of New South Wales Higher Research Ethics Committee.
Any complaints regarding the content of the survey may be directed to the Ethics Secretariat, The University of New South Wales, SYDNEY 2052 AUSTRALIA (phone 9385 4234, fax 9385 6648, email ethics.sec@unsw.edu.au). Any complaint you make will be investigated promptly and you will be informed out the outcome.

All results of the survey will be made available via the Sydney Coastal Councils Group website:
http://sydneycoastalcouncils.com.au/

Clicking on "Yes, take me to the survey" will indicate that you have consented to participate in the survey, after reading the above information. Do you wish to continue?

- ○ Yes, take me to the survey
- ○ No, I do not wish to continue

2 [Page ID: 626722] [L]

Age verification

Thank you for agreeing to assist with this project

We understand that your time is valuable. In order to ensure the survey is as easy to complete as possible, the next few questions will be used to determine the best set of questions to ask you, so that you are not asked unnecessary questions.

The survey typically takes around 10 minutes to complete. You can track your progress by looking at the progress bar in the top right-hand corner of the screen.

Please consider your answers and answer as accurately as possible. If you are unsure of your answer select the closest estimate, unless directed otherwise.

In what year were you born?

3 [Filter ID: 626728]

Filter: if not over 18

v_314 (yrbirth) Year of birth	In what year were you born? - Year of birth (From page 2: Age verification)	greater	1989

3.1 [Page ID: 626730] [L]

thanks too young

Thank you for your interest in the Sydney Beaches Valuation Project
Unfortunately, ethical guidelines prevent us from surveying those under 18 years of age.

Stay tuned to the Sydney Coastal Councils webpage to see the results of this project as they are released.
http://sydneycoastalcouncils.com.au/

Close window

4 [Page ID: 626527] [L]

New location questions

Where do you normally live?
Select the most appropriate response

- Sydney
- Australia (other than Sydney)
- Country other than Australia

Please enter the postal or zip code of your normal home location.
If unknown or not applicable, please leave blank

Have you ever visited a beach in Sydney?

- Yes
- No
- Unsure

5 [Filter ID: 626530]

Filter: Haven't visited Sydney Beaches

v_465 (sydbeach) visited beaches in sydney	Have you ever visited a beach in Sydney? - visited beaches in sydney (From page 4: New location questions)	unequal	1

5.1 [Page ID: 626772] [L]

Thanks not suitable

Thank you for your interest in the Sydney Beaches Valuation Project

This survey is specifically interested in the economic valuation of Sydney beaches, and requires that people have experience with at least one Sydney beach.

We are currently working to develop surveys that are appropriate for all people with an interest in the current and future management of beaches.

Come back to the Sydney Coastal Councils webpage to see when the new surveys are up and running, and to see the results of this project as they are released.
http://sydneycoastalcouncils.com.au/

Close window

6 [Page ID: 627079] [L]

Case study site visitation

Which of the following beaches have you visited most recently?
Manly Ocean Beach includes Queenscliff, South and North Steyne

- Manly Ocean Beach
- Collaroy-Narrabeen Beach
- Brooklyn Baths
- Dangar Island Beach
- Haven't visited any of those beaches in the last 12 months
- Don't know/unsure

7 [Filter ID: 628722]

Filter: if haven't visited case study beach

	v_465 (sydbeach) visited beaches in sydney	Have you ever visited a beach in Sydney? - visited beaches in sydney (From page 4: New location questions)	equal	1
and	v_375 (notvis12) Haven't visited any of those beaches in ...	Which of the following beaches have you visited most recently? - Haven't visited any of those beaches in the last 12 months (From page 6: Case study site visitation)	equal	1
or	v_374 (dunnovis) Don't know/unsure	Which of the following beaches have you visited most recently? - Don't know/unsure (From page 6: Case study site visitation)	equal	1

7.1 [Page ID: 628720] [L]

Other beaches

Which Sydney beach do you visit most often?
Please enter only the beach name.
If you do not remember the name of the beach you visit, please refer to the following links to see a map:
Sydney Ocean Beaches
Sydney Harbour Beaches
Botany Bay Beaches
Pittwater Estuary Beaches

- I normally visit

8 [Page ID: 504833] [L]

Party size and travel mode

When you were last in Sydney, where did you stay?
Please select the accommodation type which best describes where you left from last time you visited #l_5#

- own home
- with friends or family
- paid accommodation (hostel/hotel/camping ground)

How many other people travelled with you last time you visited #l_5#?
Please select the number of adults and children who travelled with you last time you visited #l_5#. Do not include yourself, or anyone who travelled independently from you

	0 travelled by myself	1	2	3	4	5	more than 5 others
Adults (18 years and over)	○	○	○	○	○	○	○
Children (17 years and under)	○	○	○	○	○	○	○

How did you travel to #l_5# on your last visit?
If you used more than one form of transport in your trip, please select the last one you used before you arrived at #l_5#. If you were on an organised tour, but used public transport, please select the mode of public transport you used last

- own vehicle
- Walking, jogging, skateboarding, cycling, paddling
- Bus (not chartered or operated by a tour company)
- Train
- Ferry or water taxi
- Organised tour with separate transport (e.g. charter bus)
- private boat

Including all people in your travel group, how much do you estimate you would you have spent on food and drinks while at #l_5# ?
Please select the closest amount in Australian dollar

did not purchase any food or drink	2 $AUD	5 $AUD	10 $AUD	15 $AUD	20 $AUD	30 $AUD	40 $AUD	50 $AUD	more than 50 $AUD
○	○	○	○	○	○	○	○	○	○

9 [Filter ID: 507809]

Filter: if paid accomodation

v_67 (typeacco) Accommodation type	When you were last in Sydney, where did you stay? - Accommodation type (From page 8: Party size and travel mode)	equal 3

9.1 [Page ID: 504831] [L]

accommodation not home

How many nights did you spend in the Sydney area?

- 0
- 1
- 2
- 3-5
- 6-7
- 8-10
- 11-14
- 15+

What was the average cost of your accommodation per person, per night?
Select the closest dollar amount

25 $AUD per night	50 $AUD per night	75 $AUD per night	100 $AUD per night	125 $AUD per night	150 $AUD per night	175 $AUD per night	200 $AUD per night	more than 200 $AUD per night
○	○	○	○	○	○	○	○	○

What is the name of the suburb or hotel you left from to visit #l_5#?

10 [Filter ID: 506153]

Filter: if own vehicle

v_65 (travmode) Travel mode	How did you travel to #l_5# on your last visit? - Travel mode (From page 8: Party size and travel mode)	equal 14

10.1 [Page ID: 506156] [L]

Own vehicle travel costs

What is the size of the engine in your vehicle?
Please enter the size of the engine in the vehicle you used last time you travelled to #l_5#. If you do not know, please enter the make, model and year.

- scooter/motorcycle
- up to 1.6L (small car)
- 1.61-2.6L (medium car)
- 2.61L+ (large car)
- Truck
- unknown (please enter make and model)

How much did you pay for parking?
Please estimate you parking costs for the most recent beach visit. Select the closest dollar amount.

Parked in free parking area	Annual/resident parking permit	2 $AUD	4 $AUD	6 $AUD	8 $AUD	10 $AUD	12 $AUD	14 $AUD	greater than 14 $AUD
○	○	○	○	○	○	○	○	○	○

11 [Filter ID: 629370]

Filter: if private boat

v_65 (travmode) Travel mode	How did you travel to #l_5# on your last visit? - Travel mode (From page 8: Party size and travel mode)	equal	21

11.1 [Page ID: 629371] [L]

private boat costs

Please estimate your total trip costs for the beach visit, including fuel costs and mooring fees if applicable
Enter the closest dollar amount

$AUD

12 [Filter ID: 506158]

Filter: if public transport

v_65 (travmode) Travel mode	How did you travel to #l_5# on your last visit? - Travel mode (From page 8: Party size and travel mode)	greater	14

12.1 [Page ID: 506159] [L]

public transport mode

What was the round-trip cost of all tickets YOU personally paid for to visit #l_5#? If you purchased tickets for more than one person, please include the cost of all tickets. If you travelled with others who bought their own tickets, do not include their ticket costs.
Please enter the closest dollar amount, or select the description that best describes your travel choice

- multitrip ticket (please enter type and colour if known)
- Unsure/didn't pay
- Return ferry from Circular Quay
- Train from Central Station
- Bus from Central Station
- Up to 2 $AUD
- 2-5 $AUD
- 5-7.5 $AUD
- 7.5-10 $AUD
- 10-15 $AUD
- greater than 15 $AUD

13 [Page ID: 506163] [L]

travel time

How long did it take you to travel to the beach, including parking and walking times?
Select the closest amount of time.

less than 5 mins | 10 mins | 15 mins | 20 mins | 30 mins | 40 mins | 50 mins | 1 hour | 90 mins | 2 hours | greater than 2 hours | can't remember

What is the total amount of time you spent at the beach? Include time you spent in adjacent parkland or on the esplanade.
Select the closest amount of time

30 mins	1 hour	90 mins	2 hours	3 hours	4 hours	5 hours	greater than 5 hours	can't remember

Why did you choose to visit #l_5#?
Please check all that apply

- Closest
- easiest to get to
- easy to find parking
- best appearance
- less crowded
- adjacent parkland
- good swimming or surfing conditions
- nearby shopping
- nearby food outlets (cafe/restaurants)
- good beach conditions (protected from wind, available shade etc)
- Recommendation of a friend or family member
- Visited the beach before
- Tourism or marketing material
- other

When you visit the beach, how do you spend the majority of your time?
Please select the most appropriate answer.

- In the water (surfing, swimming etc.)
- On the sand (sunbaking, walking etc.)
- In the parkland nearby
- Walking along the paths next to the beach
- other

Occasionally beaches are closed for safety reasons, because large waves have removed sand from the beach. Have you experienced this before?

- yes, at #l_5#
- yes, but not at #l_5#
- no
- unsure

If you had travelled to #l_5# to find that the beach was open for swimming, but there was no dry exposed sand, what would you do?
Please select the most appropriate response

- I would go to another beach (please specify if known)
- It wouldn't affect my trip, the sand is not important to me
- I would stay, but I would be disappointed
- I would go somewhere else, but not to another beach
- other

- I don't believe that will happen
- Return home

14.1 [Page ID: 626526] [L]

10 percent CV 2020

We have asked you some questions about how you currently use the beach and what is important to you.
We will now describe a hypothetical future scenario for #l_5#, which you should consider in answering the following questions.

All Sydney councils are considering the future management of their natural resources, and the potential impacts of climate change. One of the most certain of these for coastal areas is a rise in sea levels. Higher sea levels are likely to result in the gradual but permanent loss of sand from **#l_5#**

In the shorter term, sea level rise is likely to result in the more frequent loss of sand from **#l_5#** due to normal storm activity.

By the year 2020 , this could lead to a situation where

10 percent

of the times you visited **#l_5#**, there would be no dry sand present at high tide.

14.2 [Page ID: 512118] [L]

10 percent CV 2050

We have asked you some questions about how you currently use the beach and what is important to you.
We will now describe a hypothetical future scenario for #l_5#, which you should consider in answering the following questions.

All Sydney councils are considering the future management of their natural resources, and the potential impacts of climate change. One of the most certain of these for coastal areas is a rise in sea levels. Higher sea levels are likely to result in the gradual but permanent loss of sand from **#l_5#**

In the shorter term, sea level rise is likely to result in the more frequent loss of sand from **#l_5#** due to normal storm activity.

By the year 2050 , this could lead to a situation where

10 percent

of the times you visited **#l_5#**, there would be no dry sand present at high tide.

14.3 [Page ID: 626525] [L]

10 percent CV 2100

We have asked you some questions about how you currently use the beach and what is important to you.
We will now describe a hypothetical future scenario for #l_5#, which you should consider in answering the following questions.

All Sydney councils are considering the future management of their natural resources, and the potential impacts of climate change. One of the most certain of these for coastal areas is a rise in sea levels. Higher sea levels are likely to result in the gradual but permanent loss of sand from **#l_5#**

In the shorter term, sea level rise is likely to result in the more frequent loss of sand from **#l_5#** due to normal storm activity.

By the year 2100 , this could lead to a situation where

10 percent

of the times you visited **#l_5#**, there would be no dry sand present at high tide.

15 [Page ID: 507528] [L]

plausibility

Do you believe the amount of erosion described in the previous scenario will occur?

- [ ] yes
- [ ] no
- [ ] unsure
- [ ] don't wish to answer

What is the main reason for your answer to the previous question?

16 [Page ID: 512143] [L]

WTP at all

Suppose for a moment that there was a dedicated #l_5# Management Fund, which could only be used for activities to prevent the erosion described.

This fund would be administered by a state government agency, and could only be used at #l_5#.
It would be subject to independent annual audit, to ensure that the funds were being spent appropriately.

In principle, would you be willing to make a donation to such a fund, if it existed?
Remember that this is only one of a number of potential environmental projects, and consider your available budget, and that there are a number of other beaches in the Sydney region which may not be equally affected.

- [ ] yes
- [ ] no

- unsure
- decline to answer

What is the main reason for your answer to the previous question?

17 [Filter ID: 512222]

v_288 (notwtp) no	**Filter: if WTP = yes** Suppose for a moment that there was a dedicated **#l_5# Management Fund**, which could only be used for activities to prevent the erosion described. This fund would be administered by a state government agency, and could only be used at #l_5#. It would be subject to independent annual audit, to ensure that the funds were being spent appropriately. In principle, would you be willing to make a donation to such a fund, if it existed? - no (From page 16: WTP at all)	unequal 1

17.1.1 [Page ID: 512056] [L]

referendum wtp 5 dollars

Imagine that #l_5# management fund described has now been established.

If you were contacted by someone seeking donations to the fund, would you be willing to make a once-off contribution of

5 Australian dollars

to this fund?

Consider your available budget, the fact that this is only one potential environmental cause, and the possibility that other beaches in Sydney may not be equally affected.

- yes
- no
- unsure
- decline to answer
- probably, need more information

17.1.2 [Page ID: 512054] [L]

referendum 10 dollars

Imagine that #l_5# management fund described has now been established.

If you were contacted by someone seeking donations to the fund, would you be willing to make a once-off contribution of

10 Australian dollars

to this fund?

Consider your available budget, the fact that this is only one potential environmental cause, and the possibility that other beaches in Sydney may not be equally affected.

- yes
- no
- unsure
- decline to answer
- probably, need more information

17.1.3 [Page ID: 512050] [L]

referendum wtp 25 dollars

Imagine that #l_5# management fund described has now been established.

If you were contacted by someone seeking donations to the fund, would you be willing to make a once-off contribution of

25 Australian dollars

to this fund?

Consider your available budget, the fact that this is only one potential environmental cause, and the possibility that other beaches in Sydney may not be equally affected.

- yes
- no
- unsure
- decline to answer
- probably, need more information

17.1.4 [Page ID: 512051] [L]

referendum wtp 50 dollars

Imagine that #l_5# management fund described has now been established.

If you were contacted by someone seeking donations to the fund, would you be willing to make a once-off contribution of

50 Australian dollars

to this fund?

Consider your available budget, the fact that this is only one potential environmental cause, and the possibility that other beaches in Sydney may not be equally affected.

- yes
- no
- unsure
- decline to answer
- probably, need more information

17.1.5 [Page ID: 512052] [L]

referendum wtp 100 dollars

Imagine that #l_5# management fund described has now been established.

If you were contacted by someone seeking donations to the fund, would you be willing to make a once-off contribution of

100 Australian dollars

to this fund?

Consider your available budget, the fact that this is only one potential environmental cause, and the possibility that other beaches in Sydney may not be equally affected.

- yes
- no
- unsure
- decline to answer
- probably, need more information

17.1.6 [Page ID: 626524] [L]

referendum wtp 500 dollars

Imagine that #l_5# management fund described has now been established.

If you were contacted by someone seeking donations to the fund, would you be willing to make a once-off contribution of

500 Australian dollars

to this fund?

Consider your available budget, the fact that this is only one potential environmental cause, and the possibility that other beaches in Sydney may not be equally affected.

- yes
- no
- unsure
- decline to answer
- probably, need more information

17.2 [Page ID: 512233] [L]

maximum wtp

What is the maximum amount that you would be willing to contribute as a once-off donation to #l_5# fund described?
Please enter the amount in dollars
[ ] dollars

18 [Filter ID: 629373]

Filter: avoid double other beach

	v_375 (notvis12) Haven't visited any of those beaches in ...	Which of the following beaches have you visited most recently? - Haven't visited any of those beaches in the last 12 months (From page 6: Case study site visitation)	equal 0
and	v_374 (dunnovis) Don't know/unsure	Which of the following beaches have you visited most recently? - Don't know/unsure (From page 6: Case study site visitation)	equal 0

18.1 [Page ID: 629372] [L]

other beach if answered case study site

Which Sydney beach do you visit most often?
Please enter only the beach name

- I normally visit [ ]

19 [Page ID: 507536] [L]

Validation questions

We are now going to ask some demographic questions to ensure that the participants in this survey effectively represent all beach visitors.

This information is completely anonymous, and will not be able to be linked back to you in any way. You may choose to skip any questions which you do not wish to answer, without giving a reason.

Do you wish to continue?

- yes
- no

20 [Filter ID: 507541]

v_237 (agreedem) Demographic permission	**Filter: Agree validation** We are now going to ask some demographic questions to ensure that the participants in this survey effectively represent all beach visitors. This information is completely anonymous, and will not be able to be linked back to you in any way. You may choose to skip any questions which you do not wish to answer, without giving a reason. **Do you wish to continue?** **- Demographic permission (From page 19: Validation questions)**	equal 1

20.1 [Page ID: 507542] [L]

demographic questions

Gender

- Female
- Male
- Decline to answer

What is the highest level of education you have completed?

- Junior certificate
- Completed high school
- Diploma or certificate (including trade qualifications)
- Undergraduate degree
- Postgraduate degree
- decline to answer

How often have you visited #l_5# in the past month?

- every day
- more than once a week
- once a week
- once every two weeks
- once
- haven't visited in past month

Are you currently employed?
Please select category that best describes your employment status

- full-time employment
- part-time employment
- full time student
- part time student
- on paid leave
- on unpaid leave
- unemployed
- decline to answer

Please select the income bracket which contains your personal income in a typical week
Do not include income of other household members.

- No income/negative
- 1-499 per week (25 thousand p.a.)
- 500-999 (25 -50 thousand p.a.)
- 1000-1499 (50 -75 thousand p.a.)
- 1500-1999 (75-100 thousand p.a.)
- 2000+ (more than 100 thousand p.a.)
- decline to answer

21 [Page ID: 507650] [L]

concluding comments

Do you have any additional comments related to climate change issues?

Do you have any additional comments in relation to coastal management issues?

22 [Page ID: 504812] [L]

Final page

Thank you for taking the time to complete this survey.

Your responses will be used to inform coastal management decisions in the response to climate change impacts on Sydney beaches.
Results and updates will be available on the Sydney Coastal Councils Group website:
http:www.sydneycoastalcouncils.com.au

For further information on the project, or if you experience technical problems with the survey, please contact the Project Coordinator, Dave Anning, by clicking the link below

Send Mail

Close Window

Appendix 6 – Onsite survey instrument: Sydney Beaches Valuation Project

Onsite costs 27 Jan 08

Beach

1 Location where survey was completed (select one)
[Beach]

- ☐ 1 Collaroy-Narrabeen
- ☐ 4 Manly Ocean Beach
- ☐ 5 Brooklyn Baths
- ☐ 6 Dangar Island - Bradley's Beach

Narrabeen Cross St

2 Enter nearest cross st, surf club or access pt
[Cross_St_or_Access1]

- ☐ 1 NN carpark - Pittwater side
- ☐ 2 NN - Lagoon/Caravan park
- ☐ 13 Narrabeen Surf Club
- ☐ 20 South Narrabeen Surf Club
- ☐ 28 Collaroy Surf Club
- ☐ 34 Long Reef Golf Club

Manly Cross St

3 Enter nearest cross st, surf club or access pt
[Manly_Cross_St]

- ☐ 3 Queenscliff Surf Club
- ☐ 6 North Steyne Surf Club
- ☐ 11 Corso
- ☐ 14 Manly Surf Club
- ☐ 15 Shelly beach - walkway
- ☐ 2 Lagoon

Locality

4 Where was the survey conducted?
[Locality]

- ☐ 2 Sand
- ☐ 3 Crown reserve - not sand
- ☐ 8 Other: includes shops

Introduction

5 My name is .... and I am a research student from the University of New South Wales

(SHOW ID CARD)

In this survey I will ask you some questions about how you travelled to the beach today, why you chose to come to this particular beach, and some questions about the future management of the beach.

The survey typically takes between 5 and 10 minutes to complete, and all responses are completely anonymous. This survey has the approval of the University of NSW Higher Research Ethics Committee.

Do you wish to participate in the survey?

[Introduction]

☐1 Yes

☐2 No

Suburb

6 What is the suburb you left from to come to the beach today? If you do not know the suburb, what is the hotel name?

[Suburb]

____

____

Trip origin

7 Did you spend last night in paid accommodation?

[Trip_origin]

☐1 Yes

☐2 No

Nights accomodation

8 How many nights do you expect to stay in the [@Beach] area?

[Nights_accomodation]

Answer: ______________________

Group size

9 How many people travelled with you today?

[Group_size]

Answer: ______________________

daily expenses

10 Including all people in your group, how much do you think you will have spent on food and drinks while visiting [@Beach]?

[onsitecosts]

- ☐ 1 did not purchase any food or drinks
- ☐ 2 AUD $2
- ☐ 3 AUD $5
- ☐ 4 AUD $10
- ☐ 5 AUD $15
- ☐ 6 AUD $20
- ☐ 7 AUD $30
- ☐ 8 AUD $40
- ☐ 9 AUD $50
- ☐ 10 More than 50 dollars

Travel mode

11 How did you travel to [@Beach] today?

[Travel_mode]

- ☐ 1 own vehicle
- ☐ 4 human powered
- ☐ 5 bus
- ☐ 6 ferry
- ☐ 7 train
- ☐ 3 tour

Engine size

12 What size is the vehicle you travelled in today?

[Engine_size]

- ☐ 1 motorbike/scooter
- ☐ 2 up to 1600cc (small car)
- ☐ 3 1601-2600cc (4 cylinder)
- ☐ 4 more than 2601cc (6 cylinder)
- ☐ 5 unknown

Parking permit

13 Do you hold a parking permit for this area?

[Parking_permit]

- ☐ 1 Yes
- ☐ 2 No

Parking costs

14 How much do you expect to pay for parking today?

[Parking_costs]

- ☐ 1 free parking
- ☐ 4 2 dollars
- ☐ 5 4 dollars
- ☐ 6 6 dollars
- ☐ 7 8 dollars
- ☐ 8 10 dollars
- ☐ 9 12 dollars
- ☐ 10 14 dollars
- ☐ 11 greater than 14 dollars

Ticket Cost

15 What was the round trip cost of all tickets you purchased to visit [@Beach] today?

[Ticket_Cost]

- ☐ 1 Unsure
- ☐ 11 12.60 ferry return
- ☐ 3 up to 2 dollars
- ☐ 4 2-5 dollars
- ☐ 5 5-7.5 dollars
- ☐ 6 7.5-10 dollars
- ☐ 7 10-15 dollars
- ☐ 10 greater than 15 dollars

Travel time

16 How long did it take you to travel to [@Beach] beach today, in minutes?

[Travel_time]

Answer: ______________________________

Onsite time

17 What is the total amount of time you intend to spend at [@Beach] today?

[Onsite_time]

- ☐ 1 30 mins
- ☐ 2 1 hrs
- ☐ 3 90 mins
- ☐ 4 2 hrs
- ☐ 5 3hrs
- ☐ 6 4-5 hrs
- ☐ 7 5 hrs

Beach Choice

18 Why did you choose [@Beach] today?

[Beach_Choice]

- ☐ 1 closest to my point of origin
- ☐ 12 tourism/recommendation
- ☐ 13 previous experience/habit
- ☐ 2 easiest to get to
- ☐ 5 swimming or surfing conditions
- ☐ 3 easy to find parking
- ☐ 6 best appearance
- ☐ 7 nearby parks/playgrounds
- ☐ 8 availability of shade
- ☐ 9 nearby retail shopping
- ☐ 10 nearby food outlets
- ☐ 11 other ______________________

Beach closure

19 Occasionally beaches are closed for safety reasons, because large waves have removed sand from the beach. Have you experienced this before?

[Beach_closure]

- ☐ 1 yes
- ☐ 2 no
- ☐ 3 unsure

Closure response

20 If you had travelled to [@Beach] today to find that the beach was open for swiming, but that there was no dry exposed sand, what would you have done?

[Closure_response]

- ☐ 1 wouldn't affect trip - sand not important
- ☐ 2 stay with lower enjoyment
- ☐ 3 don't think it will happen
- ☐ 4 go somewhere else (not beach)
- ☐ 5 go to another beach

Different beach

21 Which beach would you go to?

[Different_beach]

____

____

Contingent scenario

22 I have asked you some questions about how you currently use the beach and what you like about this beach.
I'm now going to describe a hypothetical future scenario for the beach, which you should consider in answering the following questions.

CVM scenario

23 All Sydney councils are considering the future management of their natural resources, and the potential impacts of climate change. One of the most certain of these for coastal areas is a rise in sea levels. Higher sea levels are likely to result in the gradual but permanent loss of sand from [@Beach] .

percent damage

24 In the shorter term, sea level rise is likely to result in the more frequent loss of sand from the beach due to normal storm activity.

By the year 2050, this could lead to a situation where
10%
of the times you visited [@Beach] , there was no dry sand present at high tide.

Plausibility

25 Do you believe the amount of erosion described in the previous scenario will occur?
[Plausibility]

- ☐ 1 yes
- ☐ 2 no
- ☐ 7 unsure
- ☐ 4 decline to answer
- ☐ 5 comments ______________________

Fund description

26 Suppose for a moment that there was a dedicated [@Beach] Beach Management Fund, which could only be used to prevent the erosion described.
This fund would be administered by a state government agency, and could only be used at [@Beach]. It would be subject to independent annual audit, to ensure that the funds were being spent appropriately.

Principle WTP

27 In principle, would you be willing to make a once-off donation to such a fund, if it existed?
Remember that this is only one of a number of potential environmental projects, that there are a number of other beaches which may not be equally affected, and consider your available budget.
[Principle_WTP]

- ☐ 1 yes
- ☐ 2 no
- ☐ 3 unsure
- ☐ 5 decline to answer

Reason for WTP

28 What is the main reason for your answer to the previous question?
[Reason_for_WTP]

____

____

Dummy variable

29 Dummy variable for wtp selection. Enter value between 1 and 6, must be one larger than value for previous record.
[dummy]

Answer: ______________________

WTP 5 dollars

30 Imagine that the [@Beach] management fund has now been established.
If you were approached by someone seeking donations to the fund, would you be willing to make a once-off donation of
5 dollars
to the fund?
[WTP_5_dollars]

- ☐ 1 yes
- ☐ 2 no
- ☐ 3 unsure
- ☐ 4 comments ______________
- ☐ 5 decline to answer ______________

WTP 10 dollars

31 Imagine that the [@Beach] management fund has now been established.
If you were approached by someone seeking donations to the fund, would you be willing to make a once-off donation of
10 dollars
to the fund?
[WTP_10_dollars]

- ☐ 1 yes
- ☐ 2 no
- ☐ 3 unsure
- ☐ 4 comments ____________________
- ☐ 5 decline to answer ____________________

WTP 25 dollars

32 Imagine that the [@Beach] management fund has now been established.
If you were approached by someone seeking donations to the fund, would you be willing to make a once-off donation of
25 dollars
to the fund?
[WTP_25_dollars]

- ☐ 1 yes
- ☐ 2 no
- ☐ 3 unsure
- ☐ 4 comments ____________________
- ☐ 5 decline to answer ____________________

WTP 50 dollars

33 Imagine that the [@Beach] management fund has now been established.
If you were approached by someone seeking donations to the fund, would you be willing to make a once-off donation of
50 dollars
to the fund?
[WTP_50_dollars]

- ☐ 1 yes
- ☐ 2 no
- ☐ 3 unsure
- ☐ 4 comments ____________________
- ☐ 5 decline to answer ____________________

WTP 100

34 Imagine that the [@Beach] management fund has now been established.
If you were approached by someone seeking donations to the fund, would you be willing to make a once-off donation of
100 dollars
to the fund?
[WTP_100]

- ☐ 1 yes
- ☐ 2 no
- ☐ 3 unsure
- ☐ 4 comments ____________________
- ☐ 5 decline to answer ____________________

WTP 500 dollars

35 Imagine that the [@Beach] management fund has now been established.
If you were approached by someone seeking donations to the fund, would you be willing to make a once-off donation of
500 dollars
to the fund?
[WTP_500_dollars]

- ☐ 1 yes
- ☐ 2 no
- ☐ 3 unsure
- ☐ 4 comments ____________________
- ☐ 5 decline to answer ____________________

Max WTP

36 What is the maximum amount that you would be willing to donate to the [@Beach] Management Fund as a single once-off donation?
[Max_WTP]

Answer: ________________________________

Validation permission

37 I would now like to ask you some demographic questions to make sure that the participants in this survey effectively represent all beach visitors.
This information is completely anonymous, and you may choose to skip any questions you do not wish to answer, without providing a reason.
Do you wish to continue?
[Validation_permissio]

- ☐ 1 Yes
- ☐ 2 No

Gender

38 (DO NOT ASK!!!!)
enter the gender of the respondent
[Gender]

- ☐ 1 male
- ☐ 2 female

Nationality

39 What is your nationality? If you have dual citizenship, where were you born?
[Nationality]

- ☐ 1 Australian
- ☐ 2 New Zealand
- ☐ 3 England
- ☐ 4 Ireland
- ☐ 10 France
- ☐ 11 Spain
- ☐ 5 USA
- ☐ 6 Canada
- ☐ 7 China
- ☐ 8 Japan
- ☐ 9 other ______________________

age

40 In what year were you born?
[age]

Answer: ____________________________________

Education

41 What is the highest level of education you have completed?
Please listen to the list and choose the most appropriate
[Education]

- ☐ 1 Junior certificate
- ☐ 2 Completed high school
- ☐ 3 Diploma/Certificate
- ☐ 4 Undergraduate degree
- ☐ 5 Postgraduate degree
- ☐ 6 Decline to answer

Visitation

42 In the past month, how often have you visited a beach?

[Visitation]

- ☐ 1 haven't visited before (only visit)
- ☐ 6 every day
- ☐ 5 more than once a week
- ☐ 4 once a week
- ☐ 2 once a fortnight
- ☐ 3 one other time
- ☐ 7 unsure

Employment

43 What is your current employment situation?

[Employment]

- ☐ 1 full time employment
- ☐ 2 part time employment
- ☐ 3 student
- ☐ 4 paid leave
- ☐ 5 unpaid leave
- ☐ 6 unemployed
- ☐ 7 decline to answer
- ☐ 8 retired

Income

44 Please listen to the following income ranges and tell me when I read out a range which includes your personal weekly income, before tax.
A reminder that you may choose not to answer this question.

[Income]

- ☐ 1 no income - negative
- ☐ 8 unsure
- ☐ 7 decline to answer
- ☐ 9 currency other than dollars ____
- ☐ 2 1-499 per week (25k p.a.) ____
- ☐ 3 500-999 per week (25-50k p.a.) ____
- ☐ 4 1000-1499 per week (50-75k p.a.) ____
- ☐ 5 1500-1999 a week (75-100k p.a.) ____
- ☐ 6 above 2000 a week (over 100k p.a.) ____

Survey comments

45 Do you have any comments on the design or content of this survey?

[Survey_comments]

ICM comments

46 Do you have any comments on climate change or coastal management in general?

[ICM_comments]

Appendix 7 – correlation matrices for hedonic models

Appendix 7 – Covariance matrices for models presented in Chapter 6 – Hedonic Pricing Method

(Highest correlation in each table is highlighted in yellow)

Table A7.1 Covariance matrix – Model 1

	ELEV	BCHFRONT	AREA	WTRFRONT	MAINRD	COLLAROY	BLOCK1	BCHDRIVE
ELEV	1	-0.20	0.30	-0.22	-0.26	0.25	-0.12	0.35
BCHFRONT	-0.20	1	0.11	-0.06	0.44	-0.02	-0.06	-0.16
AREA	0.30	0.11	1	0.08	-0.02	-0.03	-0.09	0.11
WTRFRONT	-0.22	-0.06	0.08	1	-0.09	-0.21	-0.04	-0.13
MAINRD	-0.26	0.44	-0.02	-0.09	1	-0.14	0.11	-0.24
COLLAROY	0.25	-0.02	-0.03	-0.21	-0.14	1	-0.04	0.02
BLOCK1	-0.12	-0.06	-0.09	-0.04	0.11	-0.04	1	-0.13
BCHDRIVE	0.35	-0.16	0.11	-0.13	-0.24	0.02	-0.13	1

Table A7.2 Covariance Matrix – Model 2

	ELEV	BCHSAFE	BCHRISK	AREA	WTRFRONT	MAINRD	COLLAROY	BLOCK1	BCHDRIVE
ELEV	1	-0.11	-0.16	0.30	-0.22	-0.26	0.25	-0.12	0.35
BCHSAFE	-0.11	1	-0.04	0.12	-0.04	0.18	-0.02	-0.04	-0.06
BCHRISK	-0.16	-0.04	1	0.05	-0.05	0.41	0.00	-0.04	-0.14
AREA	0.30	0.12	0.05	1	0.08	-0.02	-0.03	-0.09	0.11
WTRFRONT	-0.22	-0.04	-0.05	0.08	1	-0.09	-0.21	-0.04	-0.13
MAINRD	-0.26	0.18	0.41	-0.02	-0.09	1	-0.14	0.11	-0.24
COLLAROY	0.25	-0.02	0.00	-0.03	-0.21	-0.14	1	-0.04	0.02
BLOCK1	-0.12	-0.04	-0.04	-0.09	-0.04	0.11	-0.04	1	-0.13
BCHDRIVE	0.35	-0.06	-0.14	0.11	-0.13	-0.24	0.02	-0.13	1

Table A7.3 Covariance Matrix for Model 3

	ELEV	BCHP REC1	BCH PREC3	BCH PREC5	AREA	WTR FRONT	MAINRD	COLLARO Y	BLOCK1	BCH DRIVE
ELEV	1	-0.08	-0.15	-0.08	0.30	-0.22	-0.26	0.25	-0.12	0.35
BCHPREC1	-0.08	1	-0.02	-0.02	0.06	-0.03	-0.05	0.13	-0.02	0.00
BCHPREC3	-0.15	-0.02	1	-0.03	0.01	-0.04	0.39	0.05	-0.04	-0.12
BCHPREC5	-0.08	-0.02	-0.03	1	0.13	-0.04	0.31	-0.17	-0.04	-0.11
AREA	0.30	0.06	0.01	0.13	1	0.08	-0.02	-0.03	-0.09	0.11
WTRFRON T	-0.22	-0.03	-0.04	-0.04	0.08	1	-0.09	-0.21	-0.04	-0.13
MAINRD	-0.26	-0.05	0.39	0.31	-0.02	-0.09	1	-0.14	0.11	-0.24
COLLAROY	0.25	0.13	0.05	-0.17	-0.03	-0.21	-0.14	1	-0.04	0.02
BLOCK1	-0.12	-0.02	-0.04	-0.04	-0.09	-0.04	0.11	-0.04	1	-0.13
BCHDRIVE	0.35	0.00	-0.12	-0.11	0.11	-0.13	-0.24	0.02	-0.13	1

Table A7.4 Covariance matrix for Model 4

	ELEV	BCH PREC1	BCH PREC3	SAFE PRE5	WI PREC5	AREA	WTR FRONT	MAINRD	COLLAROY	BLOCK1	BCH DRIVE
ELEV	1	-0.08	-0.15	-0.07	-0.05	0.30	-0.22	-0.26	0.25	-0.12	0.35
BCH PREC1	-0.08	1	-0.02	-0.02	-0.01	0.06	-0.03	-0.05	0.13	-0.02	0.00
BCH PREC3	-0.15	-0.02	1	-0.03	-0.02	0.01	-0.04	0.39	0.05	-0.04	-0.12
SAFE PRE5	-0.07	-0.02	-0.03	1	-0.01	0.11	-0.03	0.28	-0.15	-0.03	-0.09
WI PREC5	-0.05	-0.01	-0.02	-0.01	1	0.07	-0.02	0.13	-0.10	-0.02	-0.06
AREA	0.30	0.06	0.01	0.11	0.07	1	0.08	-0.02	-0.03	-0.09	0.11
WTR FRONT	-0.22	-0.03	-0.04	-0.03	-0.02	0.08	1	-0.09	-0.21	-0.04	-0.13
MAINRD	-0.26	-0.05	0.39	0.28	0.13	-0.02	-0.09	1	-0.14	0.11	-0.24
COLLAROY	0.25	0.13	0.05	-0.15	-0.10	-0.03	-0.21	-0.14	1	-0.04	0.02
BLOCK1	-0.12	-0.02	-0.04	-0.03	-0.02	-0.09	-0.04	0.11	-0.04	1	-0.13
BCHDRIVE	0.35	0.00	-0.12	-0.09	-0.06	0.11	-0.13	-0.24	0.02	-0.13	1

Appendix 8 – AECOM nourishment report (extract)

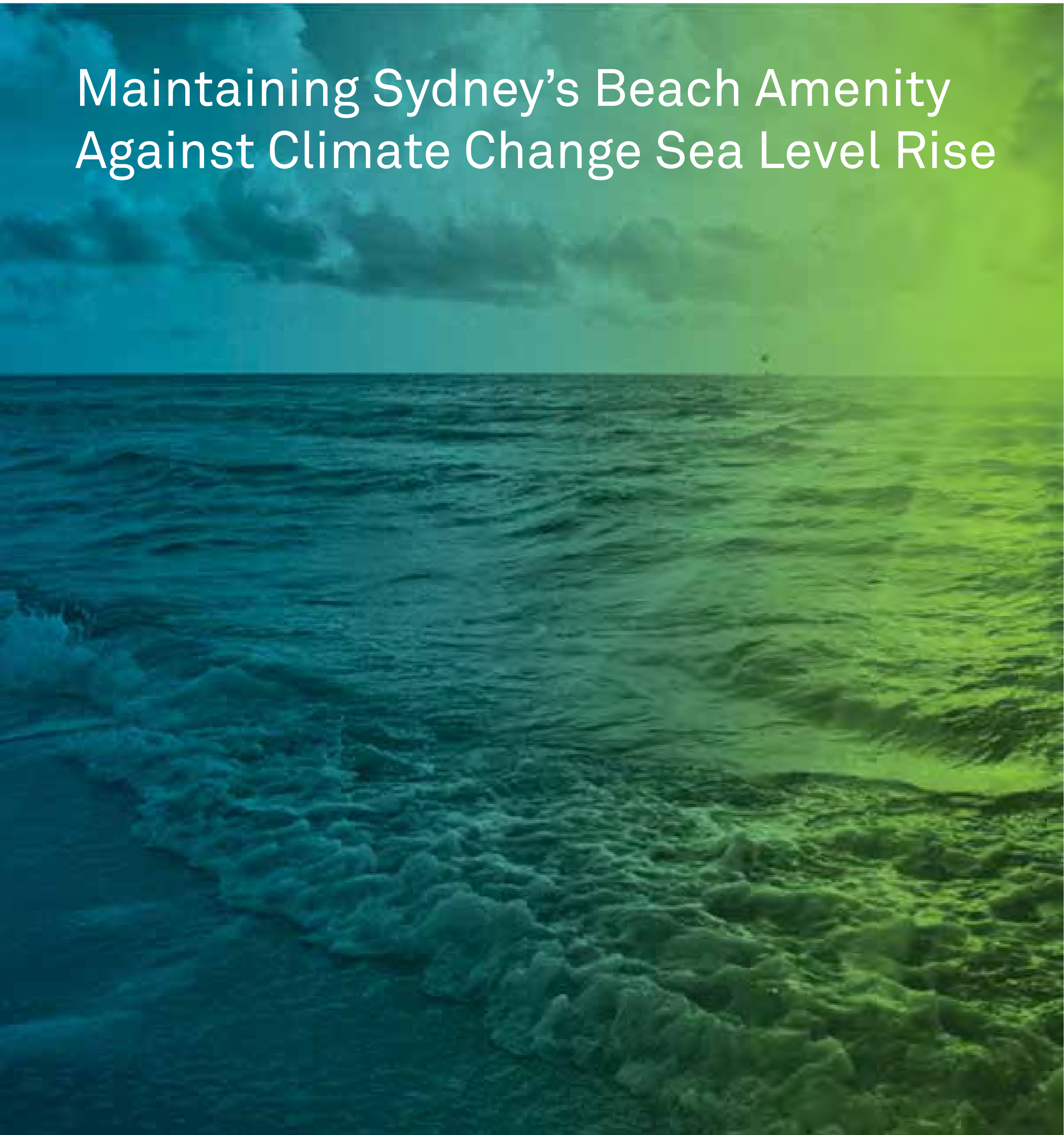
Prepared for
Sydney Coastal
Councils Group Inc.

18 February 2010

AECOM

Beach Sand Nourishment Scoping Study

Maintaining Sydney's Beach Amenity Against Climate Change Sea Level Rise



Beach Sand Nourishment Scoping Study

Maintaining Sydney's Beach Amenity Against Climate Change Sea Level Rise

Prepared for

Sydney Coastal Councils Group Inc.

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Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
A	06/10/2009	Draft	Peter Fountain Industry Director - Maritime	
B	09/12/2009	Final Draft	Peter Fountain Industry Director - Maritime	
C	18/02/2010	Final	Peter Fountain Industry Director - Maritime	

Table of Contents

Executive Summary

Executive Summary

Shoreline erosion issues are not unique to Sydney or the NSW coastline and it has long been held that beach nourishment is, in many cases, the best long-term management strategy. If sufficient sand deposits are available for nourishment works, hazards associated with storm events and sea-level rise can be alleviated. The primary purpose of this scoping study was to develop the outline of a sand nourishment programme utilising suitable offshore sand deposits for amenity enhancement and to ameliorate increased hazard risk from sea-level rise. A key environmental driver for the study was the projected climate change sea-level rise. Generally, sea-level rise causes beach erosion and recession which could result in permanent loss of beach amenity. The scoping study identified potential benefits and impacts of a nourishment programme associated with physical, environmental, social and economic issues. It also drew comparisons with the “do nothing” approach.

While the study scoped a nourishment programme for the whole of Sydney that is closely aligned to nourishment of all NSW ocean beaches, it case studied three (3) Sydney beaches in more detail. The nominated beaches were Collaroy-Narrabeen, Manly and Bate Bay.

The environmental, economic and social evaluations of the nourishment campaign demonstrated substantial positive benefits associated with the project. Some potential adverse ecological impacts may be caused by the nourishment programme with the smothering of aqueous benthic communities. These are likely to be less severe than the ecological impacts associated with a “do nothing” approach and the subsequent loss of the inter-tidal beach, resulting in a total loss of the beach ecosystem. Environmental monitoring programmes would need to be developed to measure and, if required, respond to ecological impacts.

Nourishment campaigns are scheduled at intervals of approximately 10 years, with the first nourishment campaign estimated to cost $300M at a unit rate of approximately $25/m^3 of sand. The second and subsequent nourishment campaigns are estimated to cost $120M at a unit rate of $30/m^3 of sand.

Beach Nourishment – Past and Present Climate Change Sea-Level Rise Considerations

The volume of sand required on the beaches to maintain the existing amenity in response to climate change sea-level rise is dependent on the amount of sea-level rise, with the economic assessment next dependent upon the rate of sea-level rise. In this study an upper-bound estimate of sea-level rise of 0.1m/10yrs has been adopted. From a cost/benefit perspective and nourishment campaign frequency approach this is the most conservative assessment. Adopting a lower rate of sea-level rise will result in a more favourable cost/benefit outcome.

The volume of sand required to accommodate sea-level rise is small compared with that required to protect existing infrastructure along Sydney’s foreshore. For example, at Manly Beach the volume of native sand required to accommodate a 0.1m sea-level rise is approximately 170,000m^3, but the volume of native sand required to protect the sea wall against storm damage is 2Mm^3 (WRL 2003). The main objective of the sand nourishment campaign is to maintain beach amenity in response to sea-level rise and not specifically to address present risk to infrastructure.

Sea level has risen and beaches have been eroding for decades. Between 1870 and 2004 the mean global sea level has risen by almost 0.2m. The approach for the first 10-year sand nourishment campaign would be to accommodate both a past sea-level rise of 0.2m and a future sea-level rise of 0.1m. This would reinstate and maintain beach amenity and provide some storm protection buffer.

Subsequent sand nourishment campaigns are scheduled to occur at sea-level rise increments of 0.1m (i.e. each 10 years). The entire campaign considers a 50 year planning period from a cost/benefit perspective, although sea-level rise will extend beyond this planning period.

Offshore Sand Sources and Availability

Potential offshore sand sources have been identified at Providential Head, Cape Banks, the Central Coast and offshore of the rocky cliffs at Bondi and Malabar. Cape Banks sand reserves are the most compatible with the native sand gradings on the beaches. The Providential Head, Cape Banks and Central Coast sand bodies are subject to exploration licenses and mining lease applications. No license or lease arrangements exist for the Bondi and Malabar offshore sand bodies.

There is currently a prohibition on offshore minerals extraction due to the effect of the *Offshore Minerals Act 1999 (NSW)*. It would require an amendment to Schedule 2 of the Offshore Minerals Act 1999 and the introduction of companion regulations to enable a mining licence to be issued over an area of sand within the State Government

3Nm limit to enable sand to be recovered for beach nourishment purposes. Changes of this nature would require considerable discussions with Government at the highest levels.

Sand Nourishment Volumes

Based on a 0.3m sea-level rise increment, $9Mm^3$ of native sand would be required to maintain the recreational amenity of all of Sydney's ocean beaches. This is equivalent to an average native sand volume of $300m^3$/m length of beach. Ideally, nourishment sands should have a similar size grading, shell content and colour to the native sands. Using the most suitable identified sand borrow source at Cape Banks (slightly smaller grain size), $12Mm^3$ of borrow sand would be required. This is equivalent to an average borrow sand volume of $400m^3$/m length of beach. Subsequent nourishment campaigns (each 10 years) would require $3Mm^3$ of native sand or $4Mm^3$ of borrow sand that is of similar characteristics to Cape Banks sand.

All costs quoted in this study are determined using Cape Banks as the borrow source. It is noted that the estimated volume of available sand at Cape Banks is approximately $10Mm^3$ (based on a sand extraction depth of 5m) although reserves may be considerably greater. This will be close to being sufficient for the first nourishment campaign, but alternative borrow material will need to be sourced for subsequent nourishment campaigns.

The extraction and delivery of $12Mm^3$ of sand is likely to extend over a duration of 12 to 18 months.

Sand Extraction

Based on the high wave energy operating environment and the sand extraction water depth limitations of the dredging plant, the Trailer Suction Hopper Dredge is the most suitable dredging equipment for this project. Many sand extraction projects around the world utilise this equipment, particularly if the sand placement area is some distance away from the extraction area. The Trailer Suction Hopper Dredge skimming technique is considered to be more environmentally friendly than other techniques, such as a Cutter Suction Dredge, because plume generation is minimised.

Physical Impacts

Within specified constraints it was considered that it would be possible to undertake any extraction configuration within extraction areas without any measureable impact on the shorelines. Without these constraints extraction of sand offshore may affect the coastline in the following ways:

- If too close to the shore it may create a depression such that beach sediment is transported offshore (known as drawdown) into the extracted area.
- An offshore bank may protect the coastline, scattering or absorbing some of the wave energy, and the removal of such a barrier may result in beach erosion.
- The locally increased depths may alter the angle of incidence of waves and distribution of wave energy approaching the adjacent beaches, thereby resulting in erosion and accretion.
- The removal of offshore sediment may deprive the coast of a natural source of sediment.

The coastal engineering criteria established for the design of the proposed extraction configurations, in conjunction with criteria from other specialised studies, led to the following generalised constraints:

- The near-shore depth limit for extraction off the rocky cliffed coast be the 25m isobath.
- The alongshore extent of extraction to the 25m isobath be beyond 1.5km of the end of a beach.
- The inshore limit of extraction directly off beaches be the 35m isobath.
- Extraction depth be limited to 5m below the natural surface.
- Allowance be made for initial batter slopes around the extraction configurations to develop to 1:20.
- Adequate buffers be left around shipwrecks and reefs.

Ecological Impacts

The following categories of potential ecological impacts associated with the sand extraction were identified:

- Effects on benthic macrofauna and demersal fish due to the removal of sand from the seabed.
- Effects on marine habitats, primary producers, benthic organisms, nektonic organisms, marine mammals and seabirds resulting from the release of fines with the excess water.

- Effects on the marine environment due to operation of, or accidents involving, the extraction vessel.
- Conflicts with users of other marine resources.

The impacts on benthic invertebrates would be significant, but highly localised and short-term, persisting until recolonisation occurred. Longer-term or wider scale impacts are not expected. Mobile species, such as whales, fish and prawns, and large bivalves may be able to avoid the dredger extraction head by swimming away or burrowing, respectively. Some of the organisms extracted would be released back into the sea with the excess dredging water, however, not all would survive, because of the change in water pressure, abrasion against the sand, impact with the screens, deposition into unsuitable habitat or consumption by predators such as fish. Other organisms would be relocated to the nourishment zone with the sand. The removal of organisms would change the structure of benthic assemblages, affect their ability to recover from natural disturbances, resulting in a net loss of benthic productivity.

Sand Placement

From an engineering and economic perspective, beach nourishment utilising offshore placement (profile nourishment) is the simplest, natural and most cost effective solution. Environmental impacts are likely to be kept to a minimum using this method, with the volumes of nourishment sand placed offshore being of the same order of magnitude as the storm demand (sand moved offshore) for a severe storm. An offshore nourishment programme would not require closure of the beach and, therefore, most social and business activities would continue without disruption.

Two options were considered feasible, both with similar cost structures. The preferred placement methods are:

Method 1

A Trailer Suction Hopper Dredge would be used to extract the sand from the designated offshore sand body and then sail under its own power to the nourishment site. The Trailer Suction Hopper Dredge has a large draft (>10m) and the sand would be transferred via pipeline to a spreader pontoon at the deposition site (-5m AHD to -10m AHD) and then placed on the seabed.

Method 2

The second method involves double handling of the extracted sand. A Trailer Suction Hopper Dredge would be used to extract the sand from the designated offshore sand body and then sail under its own power to offshore of the nourishment site. The sand would be discharged to the seabed in approximately 20m water depth (temporary storage site). A smaller Trailer Suction Hopper Dredge would load the sand from the temporary storage site and then sail close to the shoreline and place the sand within the nourishment zone (-5m AHD to -10m AHD).

Ecological Impacts

It is likely that the largest ecological effects of nourishment will occur in the near-shore environment where the spoil would be deposited. Given that inter-tidal species a) live within the sand, b) can probably survive some degree of burial and c) are adapted to sediment disturbance by waves, any nourishment effects on the inter-tidal biota are likely to be negligible if sand gradually accretes to the beach face via wave action.

Social Considerations

Compared with international case studies there are relatively few examples of near-shore and offshore exploration and mining within Australia. Following the release of a map indicating Australia has a wealth of offshore minerals, CSIRO has undertaken limited research on the social acceptance of seafloor exploration and mining for commercial purposes. However, little to no research has been conducted to investigate the social acceptance of sand extraction for beach nourishment purposes in the Australian context.

As part of this study a review of media and literature was undertaken and a targeted stakeholder workshop convened to gain an understanding of the social acceptance of sand extraction and beach nourishment within NSW. Based on the media review, the public appear to be generally aware of the effects of climate change and the impact this will have on the coastlines, including sea-level rise. Although there appears to be a distinct lack of factual information available about sand extraction and beach nourishment it is felt that the public would be more accepting of sand extraction for beach nourishment purposes than for commercial reasons. This acceptance will only be achieved through implementation of a carefully planned Consultation and Communication Strategy.

Cost - Benefit

For each of the three case studies, a nourishment programme is economically viable. The main economic benefits of the beach nourishment programme to be valued are associated with the avoidance of flow-on effects from loss of beach amenity to beach visitors, local residents and businesses and government revenues. In the case of Collaroy-Narrabeen this also includes the potential loss of property. Much of the information required for the economic assessment is being collected in the Sydney Beaches Valuation Project being conducted at the UNSW for the SCCG (http://www.sydneycoastalcouncils.com.au/documents/sydneybeachvaluationproject.pdf).

Pending the completion of the UNSW study, AECOM has undertaken a high-level benefit valuation using data from secondary sources on key parameters of expenditure including coastal goods and services, and on indicators of other attributes of beach amenity where the market does not provide a satisfactory measure of economic value.

Case Study – Collaroy-Narrabeen Beach

For Collaroy-Narrabeen Beach the cost-benefit analysis demonstrated that the proposed beach nourishment programme is economically viable – it produced a net present value of $42M, a benefit-cost ratio of 1.6 and an economic internal rate of return of 12%. The high economic rate of return for Collaroy-Narrabeen Beach is due to the intensely developed shoreline. The value of the benefit-cost ratio indicates that, on the basis of the quantified benefits, the programme is expected to provide medium value for money.

The main quantified benefits are the avoided loss of:

- Residential property values attributable to beach amenity (45% of total quantified benefits).
- Value of residential properties located within hazard lines (38%).
- Expenditure by beach visitors (8%).
- Rates revenue from residential property values within walking distance of the beach as a result of lower property values (4%).

The sensitivity analysis showed that the economic viability is reasonably robust. However, the programme is not economically viable in the most extreme sensitivity test (where project benefits are reduced by 30% and project costs are increased by 30%).

Adopting a lower discount rate (4% instead of 7%), as is increasingly the overseas practice in economic appraisal of social and environmental projects with long-term benefits, increases the benefit-cost from 1.6 to 2.2.

The economic results are also sensitive to the shape of the relationship between beach width and the loss of economic value from the flow-on effects of reduced beach amenity. Use of an exponential rather than a linear relationship increases the benefit-cost ratio from 1.6 to 2.5.

Case Study – Manly Beach

The cost-benefit analysis undertaken for Manly Beach also demonstrated that the proposed beach nourishment programme is economically viable – it produced a net present value of $48M, a benefit-cost ratio of 2.4 and an economic internal rate of return of 20%. The high economic rate of return for Manly Beach is due to its iconic status and importance to regional tourism. The value of the benefit-cost ratio indicates that, on the basis of the quantified benefits, the programme is expected to provide high value for money.

The main quantified benefits are the avoided loss of:

- Residential property values attributable to beach amenity (49% of total quantified benefits).
- Expenditure by beach visitors (23%).
- Rates revenue from businesses in the Manly Business District as a result of lower property values (13%).
- Non-traded value (consumer surplus) associated with beach visits (9%).

The sensitivity analysis confirmed the robustness of the economic results, with the programme being economically viable in all sensitivity tests undertaken. Adopting the lower discount rate of 4% increases the benefit-cost ratio from 2.4 to 3.3.

Case Study – Bate Bay

For Bate Bay the cost-benefit analysis demonstrated that the proposed beach nourishment programme is economically viable – it produced a net present value of $13M, a benefit-cost ratio of 1.2 and an economic internal rate of return of 8%. However, the value of the benefit-cost ratio indicates that, on the basis of the quantified benefits, the programme is expected to provide low value for money. The whole of Bate Bay may not require nourishment because a considerable extent of the shoreline contains a natural dune system. Therefore a smaller sand nourishment volume for Bate Bay will generate a higher economic return.

The main quantified benefits are the avoided loss of:

- Residential property values attributable to beach amenity (73% of total quantified benefits).
- Expenditure by beach visitors (13%).
- Rates revenue from residential property values within walking distance of the beach as a result of lower property values (5%).
- Non-traded value (consumer surplus) associated with beach visits (5%).

The sensitivity analysis showed that the economic viability is not robust, with the programme not being viable in most of the sensitivity tests. However, adopting the lower discount rate of 4% increases the benefit-cost from 1.2 to 1.6.

The economic results are also sensitive to the shape of the relationship between beach width and the loss of economic value from the flow-on effects of reduced beach amenity. Use of an exponential rather than a linear relationship increases the benefit-cost ratio from 1.2 to 1.8.

Business Case Outline

As a result of the positive cost-benefit assessment and the favourable environmental and social outcomes, the preparation of the Strategic Gateway Review will be the first gate in the establishment of a business case to NSW Treasury to seek funding to progress the programme. The NSW Gateway System is a process applied by the NSW Treasury to examine a project at critical stages of its lifecycle. There are six defined gates at which reviews are undertaken.

The first gate is the Strategic Gateway Review, which requires the presentation of a preliminary business case to:

- Support the strategic assessment of the need for the proposed intervention and its priority and timing.
- Identify any realistic options for the intervention.
- Outline the high-level costs and benefits, risks and sustainability issues relevant to each option.
- Identify any relevant technical standards or legislative requirements associated with the proposal and the options.
- Outline the governance arrangements (key elements, milestones and risks) planned to take the intervention proposal through to the next stage of the Gateway System, the final business case.

Way Forward

The NSW Government has adopted a position prohibiting the commercial extraction of offshore marine sands. It is the intent of the SCCG that this study will provide a rational basis to inform both the member councils and the NSW Government of the pros and cons of utilising offshore marine sand sources to facilitate immediate and longer term demands for nourishment purposes in the Greater Metropolitan Region.

The preparation of the Strategic Gateway Review is the first step in the establishment of a business case to the NSW Treasury to seek funding to progress the programme.

Chapter 7

Nourishment Costs

7.0 Nourishment Costs

Costs for the nourishment programme have been estimated to facilitate the cost-benefit assessment of the project. Costs are based on an economy of scale approach. It is envisaged that all of Sydney's oceans beaches will initially be nourished over a single specified period of time, and subsequently at trigger values (intervals) of approximately every 10 years.

The first nourishment campaign is based on the extraction and placement of 12Mm^3 of Cape Banks or similar sand. Subsequent nourishment campaigns are based on the extraction and placement of 4Mm^3 of sand that is of equivalent suitability to the Cape Banks sand deposits and is of similar sailing distance to all beaches.

Estimated costs have been developed following discussions with several dredging contractors. While the costs are order of magnitude estimates, the cost-benefit assessments for each of the three case study beaches include a sensitivity analysis based on a 30% increase in project cost estimates.

Costs for the first nourishment campaign are contained in Table 7.1 and costs for subsequent nourishment campaigns are contained in Table 7.2. All costs are based on present day values. Costs for the first nourishment campaign are estimated at \$25/m^3 of sand and costs for subsequent nourishment campaigns are estimated at \$30/m^3 of sand.

A sand nourishment volume has been included for the Narrabeen Lagoon flood tide delta. While, nourishment of Narrabeen Lagoon entrance is not an objective of the campaign, additional sand would migrate to the flood tide delta as sea level rises. This sand would originate from Collaroy-Narrabeen Beach and therefore, an allowance has been made for this coastal process. The migration of sand to the entrance in response to sea-level rise would not alter the present lagoon entrance maintenance regime.

Within each of the nourishment campaigns, a fee has been allocated for a royalty payment to the leaseholder for extraction of the sand. This may or may not be required, but will be subject to further investigation and negotiation. Project fees extend well beyond the time period required to nourish all of the beaches. Fees would be incurred throughout the duration between subsequent nourishment campaigns. For example, fees have also been allocated to undertake annual hydrographic surveys of all nourished beaches, continuous environmental monitoring and ongoing project management.

Within the first nourishment campaign additional fees have also been allocated to geotechnical considerations, the establishment of environmental monitoring programmes, the environmental approval processes and social workshops. As such, additional project management fees have also been allocated to the first nourishment campaign.

Chapter Summary

The first nourishment campaign is based on the extraction and placement of 12Mm^3 of Cape Banks or similar sand. Subsequent nourishment campaigns are based on the extraction and placement of 4Mm^3 of sand that is of equivalent suitability to the Cape Banks sand deposits. The first nourishment campaign is estimated to cost \$300M at a unit rate of approximately \$25/m^3 of sand. The second and subsequent nourishment campaigns are estimated to cost \$120M at a unit rate of \$30/m^3 of sand.

Assumptions and explanatory notes addressing the fee breakdown in Tables 7.1 and 7.2 are as follows.

Direct Dredging and Nourishment Costs

Mobilisation and demobilisation cost - A THSD and associated equipment with the capacity to undertake a nourishment campaign of this magnitude will need to be engaged from an overseas location. The first nourishment campaign also includes initial set-up costs and site establishment that will not need to be budgeted for in the subsequent nourishment campaigns.

Operating unit cost – This is the unit rate to extract the sand, transport it to the beach and profile nourish. The unit rate of \$15/m^3 is much higher than estimates for campaigns such as Byron Bay with unit rates estimated by PBP (2006) of \$2.80 to \$5.80 depending on the adopted methodology. The unit rate of \$15/m^3 considers down time due to weather and maintenance, the large sailing distances between the borrow source and nourishment site, and the sand placement methodologies (i.e. the potential double handling).

Royalties – The current leaseholders of potential sand sources have invested in the exploration of the lease areas. A fee has been allocated for the payment of sand from the present leaseholders.

Environmental management – The dredging contractor will have environmental monitoring and compliance requirements that will need to be met for the nourishment campaign. The cost has been based on other dredging programmes and is estimated at 5% of the total operating cost.

Associated Project Costs

Pre and post construction survey – Prior to the commencement of a nourishment campaign the sand extraction zone and all beaches would need to be hydro-surveyed. Surveys would also be required at the completion of the nourishment of each of the beaches and the extraction zone.

Yearly post construction monitoring survey – Annual post construction surveys of each of the beaches is required to monitor the performance of the nourishment programme.

Beach sediment sampling and analysis – A more detailed understanding of the sediment characteristics at each of the beach sites is required. At present, beach sediment data is very limited. Beach sediment characteristics are critical in estimated required beach volumes.

Geotechnical investigation (Sand source coring) – Volumes and compatibility of sand sources requires further investigation. Borrow sand compatibility is critical in estimating required beach volumes. Cape Banks has been identified as the most suitable sand body for the first nourishment campaign. In subsequent nourishment campaigns, alternate sand bodies may be required. Funding has been allocated to investigate other sand bodies for the subsequent nourishment campaigns.

Environmental studies – Mapping of existing benthic and mobile flora and fauna in both the subaerial and sub-aqueous environment for Sydney's beaches would be required prior to the commencement of a nourishment campaign.

EIS and EMP – Ecological and environmental monitoring programmes will need to be established to meet statutory, scientific and community requirements. These programmes would be ongoing.

Social workshops – Workshops would need to be scheduled for each of the beaches to be nourished to inform and educate the community on the nourishment campaign. A budget has been allocated for the first nourishment campaign only.

Programme management – Management of the dredging consultant, community liaison, reporting and performance monitoring have been budgeted within the project management budget. In the first 10 years, 3 people have been allocated on a full-time basis. In subsequent campaigns this has been reduced to 2 full-time workers.

Design and tender documentation – A budget of 8% of the "associated project costs" has been allocated to engineering design and contractual components of the nourishment campaign

Table 7.1 First beach nourishment campaign (10 years)

	Type	Total	Cost Breakdown	
Direct Dredging and Nourishment Costs	Total Volume of Nourishment Sand	12,000,000 m^3		
	Mobilisation and demobilisation cost	$15,000,000		
	Operating unit cost	$15.00/$m^3$		
	Total operating cost	$180,000,000		
	Royalties	$24,000,000	$2 / m^3	
	Environmental management	$9,000,000	5% x operating cost	
	Total dredging and nourishment cost	***$228,000,000***		
	Unit cost for dredging and nourishment	$19.00/$m^3$		
Associated Project Costs	Pre and post construction survey	$5,000,000	2 surveys	
	Yearly post construction monitoring survey	$10,000,000	10 surveys	
	Beach sediment sampling and analysis	$250,000	500 samples x $500	
	Geotechnical investigation (Sand source coring)	$5,000,000		
	Environmental studies	$10,000,000	31 beaches + 1 lagoon	
	Social workshops (31 beaches)	$792,000	2 person x 20 hours x $200/hour x 31 beaches x 3 workshops + 6 contingency workshops	
	EIS for sand source area	$500,000	1 sand source area	
	EIS and EMP for beaches	$15,000,000	31 beaches + 1 lagoon	
	Programme Management	$11,700,000	3 person x 37.5 hours/week x $200/hour x 52 x 10 years	
	Subtotal	***$58,242,000***		
	Design and tender documentation	$4,659,360	8% x subtotal	
	Contingency	$8,736,300	15% x subtotal	
	Total associated project costs	***$71,637,660***		
Average Sand Volume Unit Rate		**$24.97/$m^3$**		
Total Project Cost		**$299,637,660**		
		Beach Length / Area	**Volume (m^3)**	**Cost**
Case Study Areas	Collaroy/Narrabeen	2813m	1,125,200	$28,096,025
	Narrabeen Lagoon	458,295m^2	137,489	$3,433,061
	Manly	1563m	625,200	$15,611,122
	Cronulla	3788m	1,515,200	$37,834,249
	Totals		**3,403,089**	**$84,974,456**

Table 7.2 Second and subsequent beach nourishment campaigns (10 years)

	Type	Total	Cost Breakdown	
Dredging and Nourishment Costs	Total Volume of Nourishment Sand	4,000,000 m^3		
	Mobilisation and demobilisation cost	$10,000,000		
	Operating unit cost	$15.00/$m^3$		
	Total operating cost	$60,000,000		
	Royalties	$8,000,000	$2 / m^3	
	Environmental management	$1,500,000	5% x operating cost	
	Total dredging and nourishment cost	$79,500,000		
	Unit cost for dredging and nourishment	$19.88 / m^3		
Associated Project Costs	Post construction survey	$2,500,000	1 survey	
	Yearly post construction monitoring survey	$10,000,000	10 surveys	
	Beach sediment sampling and analysis	$250,000	500 samples x $500	
	Geotechnical investigation (Sand source coring)	$7,500,000	New sand source area	
	EIS for sand source area	$500,000	1 sand source area	
	EIS and EMP for beaches	$5,000,000	31 beaches + 1 lagoon	
	Programme Management	$7,800,000	2 person x 37.5 hours/week x $200/hour x 52 x 10 years	
	Subtotal	$33,550,000		
	Design and tender documentation	$2,684,000	8% x subtotal	
	Contingency	$3,355,000	10% x subtotal	
	Total associated project costs	$39,589,000		
Average Sand Volume Unit Rate		**$29.77/$m^3$**		
Total Project Cost		**$119,089,000**		
		Beach Length / Area	**Volume (m^3)**	**Cost**
Case Study Areas	Collaroy/Narrabeen	2813 m	374,973	$11,163,787
	Narrabeen Lagoon	458295 m^2	45,830	$1,364,447
	Manly	1563 m	208,348	$6,202,986
	Cronulla	3788 m	504,940	$15,033,212
	Totals		1,134,091	$33,764,432

Chapter 8

Case Study 1: Collaroy-Narrabeen Beach

8.0 Case Study 1: Collaroy-Narrabeen Beach

This chapter considers the social and economic implications of a sand nourishment campaign for Collaroy-Narrabeen Beach.

Chapter Summary

Collaroy-Narrabeen Beach is an intensely developed residential precinct, is popular with the surfing community and has restricted beach amenity and access following storms. For the "do-nothing" scenario properties along Collaroy-Narrabeen Beach will become more susceptible to storm hazards as beach amenity width reduces.

The placement of 1.3Mm^3 (or 400m^3/m length of beach plus 140,000m^3 for the Narrabeen Lagoon tidal delta) of sand from the Cape Banks borrow site would improve beach amenity by extending the mean beach width. This would also provide some additional buffer for storm erosion demand.

The cost-benefit analysis demonstrated that the proposed beach nourishment programme is economically viable – it produced a net present value of $42M, a benefit-cost ratio of 1.6 and an economic internal rate of return of 12%. The high economic rate of return for Collaroy-Narrabeen Beach is due to the intensely developed shoreline.

Collaroy-Narrabeen Beach is located 20km north of the Sydney CBD. It is the second longest beach in Sydney with a shoreline length of 3.6km and extends from Narrabeen Head to the Collaroy baths. The southern section of the beach is called Collaroy and the northern section is known as Narrabeen. Narrabeen Lagoon is a prominent environmental and recreational feature located at the northern end of the beach.

The area was first settled by Europeans in the early 19th century (Figure 8.1). The Sydney tram line was extended to Narrabeen in 1913 and the area quickly became a popular destination for camping and other activities. Throughout the 20th century the shoreline along the beach was extensively developed and today Collaroy-Narrabeen beach is the most intensely developed and highly capitalised shoreline in NSW (Hennecke *et al*. 2004). The beach is serviced by four surf lifesaving clubs; North Narrabeen, Narrabeen, South Narrabeen and Collaroy. Professional lifeguards from Warringah patrol the beach, as well as volunteer surf life savers on the weekends during the swimming season.

Figure 8.1 Collaroy Beach 1907 (National Library of Australia) and August 2009 (WRL Coastal Imaging Camera)

Although not as popular among tourists as Manly Ocean Beach to the south, Narrabeen holds its own place in the Australian psyche. The Narrabeen section of the beach is one of the most popular and consistent surf breaks in Sydney and has produced more world champion surfers than any other area in Australia. During the 1960's and 1970's Narrabeen was at the forefront of surf culture and surfboard design. Simon Anderson, from Narrabeen, is widely known for having invented the "three fin thrusters" which has become the most popular fin arrangement of all time, with millions of versions of the original design developed and sold around the world. The beach is also popular for swimming and fishing.

Collaroy-Narrabeen Beach has a long history of storm erosion (Figure 1.2). Major storms in 1945, 1967 and 1974 caused erosion to dunes and damage to property. As the most at risk and highly capitalised shoreline in NSW, a suite of coastal process studies, hazard definition, management studies and emergency plans have been developed. It is one of the most intensively studied beaches in Australia. Extensive data sets have been acquired by the University of New South Wales Water Research Laboratory (WRL) and University of Sydney Coastal

Studies Unit (CSU). The CSU has undertaken monthly beach profiles at selected locations since 1976. More recently WRL has installed and operated ARGUS cameras from the roof of a high rise apartment block on the beach face. These data sets provide an indicator of beach response to storm events and longer term beach behaviour to dominant wave directions.

The Collaroy-Narrabeen Coastline Management Plan was adopted by Council in 1997 (Warringah Council 1997). The plan identified management strategies for dealing with coastal erosion along the beach. Management strategies included: 1) protective works; 2) environmental planning; 3) development control and conditions, and; 4) dune management. The protective works included an upgrade of ad-hoc seawalls constructed in front of approximately 55 properties. The proposed seawall upgrade was met by very strong community opposition (Figure 8.2).

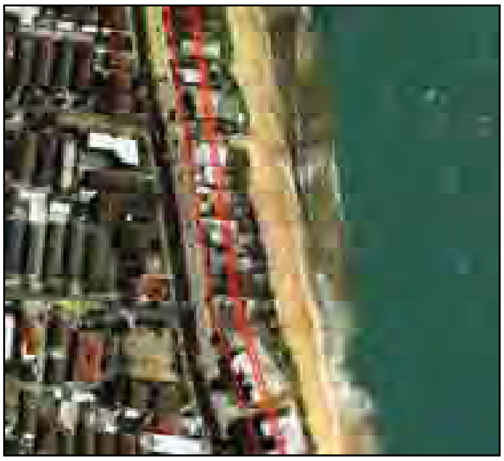

Figure 8.2 Collaroy-Narrabeen Beach 1991 Hazard Lines and Beach Users Protesting Against the Proposed Seawall

Collaroy-Narrabeen Beach has been selected as one of the three case study beaches because it is an intensely developed residential precinct, it is popularity with the surfing community and access is routinely restricted following storms.

8.1 Physical

The beach is composed of fine to medium quartz sand with around 30% carbonate (shell) content. Harley (2009) reports a grain size D_{50} of 0.3mm for Collaroy–Narrabeen Beach. Patterson Britton and Partners (1993) reports a grain size D_{50} of 0.34mm for Collaroy–Narrabeen Beach. The wave climate at Collaroy-Narrabeen is generally from the northeast through to southeast with an average H_S of 1.6m and T_P of 10s (Short & Trenaman 1992). It has a mean spring tide range of 1.3m (Short *et al*. 2000).

The entrance to Narrabeen Lagoon features a large flood tide delta consisting of sand transported from Collaroy-Narrabeen Beach. This sand is removed on a regular basis (every 3 to 4 years) to alleviate rainfall-runoff flooding of properties adjacent to the lagoon and to maintain tidal flushing within the lagoon. Typically 40,000m^3 to 45,000m^3 of sand has been removed during each of the last three clearance operations in 1999, 2002 and 2006 (Cameron *et al*. 2007). The removed sand was used to replenish Collaroy-Narrabeen Beach.

There are nine primary stormwater outlets along Collaroy-Narrabeen Beach, the majority of which discharge at the back of the beach. These are located at:

- Collaroy Rock Baths.
- Collaroy Street (outlet in the surf zone).
- Frazer Street.
- Ramsay Street.
- Goodwin Street.
- Albert Street.
- Octavia Street.
- Tourmaline Street.

- Malcolm Street.

The stormwater outlets cause localised scour during rainfall runoff events.

Collaroy-Narrabeen Beach is essentially a closed sediment system bounded to the south by an extensive underwater bed-rock ridge extending seaward from Long Reef and bounded to the north by Turimetta Headland (Figure 8.3).

Figure 8.3 Collaroy-Narrabeen Beach

NSW Public Works Department (PWD 1987) undertook photogrammetric analysis for the period 1941 to 1986 and estimated a historical long-term recession of Collaroy-Narrabeen Beach of 0.1±0.1m/yr. Nielsen Lord Associates (1990) adopted a net sediment loss of 1.5m^3/m/yr for hazard mapping along Collaroy-Narrabeen Beach which is equivalent to the PWD (1987) upper bound rate of 0.2m/yr. The historical long-term recession estimate of 0.1m/yr between 1941 and 1986 is close to what could be expected due to climate change sea-level rise over the same period.

Dr Andrew Short from the University of Sydney commenced regular (approximately monthly) cross-shore surveys in April 1976 at 5 transects along Narrabeen-Collaroy Beach. Dr Short continued his transect surveys until July 2005 when Mitch Harley of UNSW (PhD student) continued regular surveys using a GPS unit mounted on a quad bike. Harley’s work enabled full survey coverage of the beach above 0m AHD. These data sets (up to August 2008) have been plotted by Peter Horton of Worley Parsons (pers. comm. September 2009) as statistical beach widths and are reproduced in Figure 8.4.

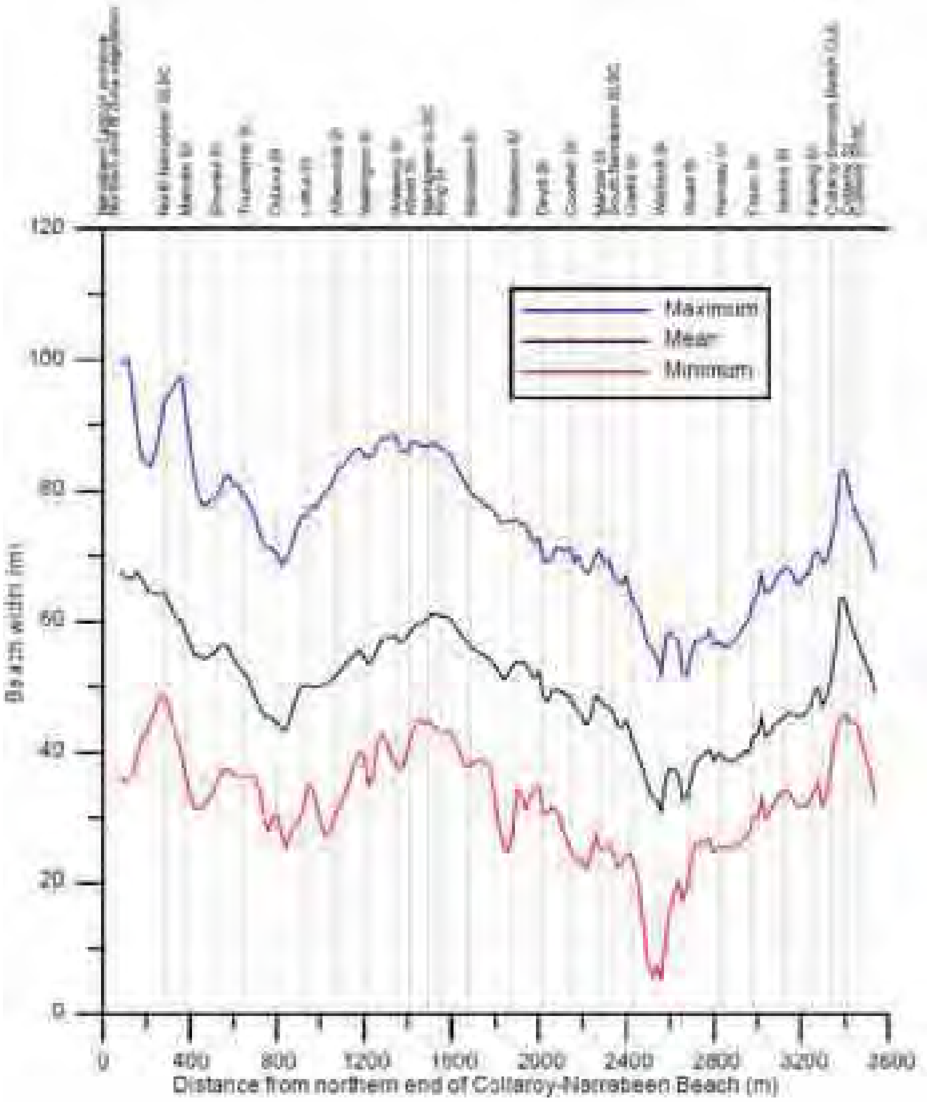

Figure 8.4 Collaroy-Narrabeen Beach Width July 2005-August 2008 (Source: Peter Horton, Worley Parsons)

The average beach width for Collaroy-Narrabeen Beach was approximately 50m during the period July 2005 to August 2008, although spatially along the full extent of the beach the average width varied from 30m to 70m (Figure 8.4). The narrowest beach section was around Wetherill St, where minimum widths of less than 10m were surveyed.

8.1.1 Do Nothing Scenario

The average beach width for Collaroy-Narrabeen Beach was approximately 50m during the period July 2005 to August 2008, although spatially along the full extent of the beach the average width varies and is only 30m at Wetherill St (Figure 8.4). Assuming that the dune face would not be permitted to migrate landwards, and using an upper-bound estimate of a 0.1m rise in sea level every 10 years, the beach width will theoretically reduce a further 5m every 10 years. Therefore, in 50 years the average beach width is predicted to reach half its present extent and there will be a total loss of beach amenity near Wetherill St.

The average beach volume above 0m AHD in 30 years would be comparable to the minimum beach width recorded over the period July 2005 to August 2008 (Figure 8.4). The risk to private property and mapping of hazard lines has been extensively documented in Nielsen Lord Associates (1990). The findings of their report is presently being updated by Worley Parsons using more recently published climate change sea-level rise estimates. Properties along Collaroy-Narrabeen Beach will become more susceptible to storm hazards as beach width reduces.

8.1.2 Nourishment Requirements

The volume of native sand required to accommodate past sea-level rise (0.2m), as well as that projected to occur over the next 10 year period (0.1m) is $1Mm^3$. The placement of $1Mm^3$ would improve beach amenity by extending the mean beach width from 50m to approximately 65m. This is equivalent to $1.3Mm^3$ (or $400m^3$/m length of beach plus $140,000m^3$ for Narrabeen Lagoon tidal delta) of sand from the Cape Banks borrow site. This would also provide some additional buffer for storm erosion demand. A sand nourishment volume has been included for the Narrabeen Lagoon flood tide delta. While, nourishment of Narrabeen Lagoon entrance is not an objective of the campaign, additional sand would migrate to the flood tide delta as sea level rises. This sand would originate from Collaroy-Narrabeen Beach and therefore, an allowance has been made for this coastal process. The migration of sand to the entrance in response to sea-level rise would not alter the present lagoon entrance maintenance regime.

Subsequent nourishment campaigns are scheduled at sea-level rise increments of 0.1m (i.e. each 10 years). This is equivalent to approximately $130m^3$/m length of beach of sand from the Cape Banks borrow site.

8.2 Environmental

There are no published studies of the inter-tidal and subaqueous biotic assemblages at Collaroy-Narrabeen Beach. However, Collaroy-Narrabeen Beach is known to contain a number of aquatic habitats, including inter-tidal rock platforms, subaqueous rocky reefs, sandy beaches and subaqueous soft sediments.

The biota of Sydney's ocean beaches and Collaroy-Narrabeen Beach comprise the following components:

a) Vascular plants (and associated invertebrates) occupying dunes above high water.
b) Air-breathing species on the upper beach including crustacean and insect assemblages inhabiting seaweed wrack and ghost crabs.
c) Shore birds.
d) The assemblages living under the inter-tidal sand.

A general description of the biota assemblages for Sydney's beaches is provided in Appendix F.

8.2.1 Do Nothing Scenario

A substantial length of Collaroy-Narrabeen Beach is backed by seawalls. These seawalls are ad-hoc structures, are not certified and are unlikely to be fully protective in the long-term. Sea-level rise will cause the beach to migrate landwards which is likely to result in the failure of many of these seawall structures. In such cases, the beach ecosystems would probably remain intact (albeit littered with seawall debris) with urban infrastructure being progressively impacted. In other cases, where the seawall structures remain intact, the beach width would reduce until no inter-tidal beach remains, resulting in a deterioration of the beach ecosystem.

8.2.2 Nourishment Impacts

The generic inter-tidal and subaqueous ecological impacts of a nourishment campaign for all of Sydney's beaches are described in Section 6.3 and Appendix F of this report. Of particular concern at Collaroy-Narrabeen Beach is the potential smothering of the subaqueous rocky reefs and their associated flora and fauna. Nourishment could potentially result in the permanent loss of subaqueous rocky reef habitat. The presence or extent of seagrass beds and kelp fields is presently unknown.

Monitoring of these key ecological issues will need to be considered as part of a proposed nourishment campaign.

8.3 Social

Community Priorities

The Warringah community and their Local Government representatives have a high level of interest in preserving their natural environment. Warringah's vision for the future as presented in 'Living Warringah 2005' (Warringah Council 2005) states: 'A vibrant community, improving our quality of life by living and working in balance with our special bush and beach environment'.

The community's key priority areas for the future include:

- Living Spaces – A relaxing, enjoyable and safe environment with ease of access to shops and facilities.
- Living Environment – Providing a legacy to future generations through conservation of the local environment.

- Living Community – A sense of community belonging that encourages community participation and involvement by residents.
- Living Enterprise – A range of businesses and services that provide job opportunities and encourage visitors to the area without compromising the environment.

Media Review

The Collaroy-Narrabeen Beach is widely cited in the media as one of the most vulnerable to coastal erosion in Australia. Mitigation measures addressed in the media have included building seawalls, buying back properties and sourcing sand from other locations. In 2002 the community voiced strong opposition to the proposal of a sea wall and the other options have been deemed expensive by Warringah Council. General support has been shown for the sourcing of offshore sand for the purpose of nourishing Collaroy-Narrabeen Beach.

8.3.1 Do Nothing Scenario

If no action to mitigate the effects of sea-level rise and beach erosion is taken at Collaroy-Narrabeen potential impacts will include, but not be limited to, the following:

- Loss of sandy beach amenity and impeded access for beach users.
- Loss or damage to Surf Life Saving Clubs (South Narrabeen, Narrabeen, North Narrabeen, Collaroy).
- Loss or damage to recreational facilities within Collaroy Park.
- Loss of local revenue from ‘learn to surf’ schools, and professional surfing tournaments.
- Loss or damage to residential property to the east of Pittwater Road and Ocean Street.

The social implications associated with the do-nothing scenario are immense and predominantly negative.

8.3.2 Nourishment

If a beach nourishment programme is commenced to mitigate the effects of sea-level rise and beach erosion Collaroy-Narrabeen beach will remain unchanged and beach users will be able to enjoy the benefits of the sandy beach and coastal area into the future.

Social implications are predominantly positive and beneficial for beach users. Depending on the funding mechanism for the nourishment programme, some people may not be accepting of the costs associated with the nourishment programme, particularly if they are not beach users.

8.4 Economic

The technique of cost-benefit analysis has been used to evaluate the net economic benefit of investment in a beach nourishment programme to mitigate the loss of beach amenity from reduced beach width as a result of future sea-level rise associated with climate change. The loss of beach amenity has the potential to cause economic costs, and it is the avoidance of these costs which is the economic benefit of the programme. In the case of Collaroy-Narrabeen this assessment also includes the potential loss of property.

The cost-benefit analysis involved a comparison of the expected situation with the programme against the expected situation without the programme, the latter being referred to as the base case. The investment case is evaluated on an incremental basis from the base case.

The evaluation involves assessing whether the economic benefits of implementing a beach nourishment programme exceed the economic costs of providing the programme. The evaluation is conducted over a 50-year period, because of the long-term nature of sea-level rise associated with climate change. In conducting a cost-benefit analysis at a strategic level, it is standard practice to omit:

a) Expenditures which are common to the base case and the investment case. For instance, any expenditures on lagoon entrance clearance, dune vegetation, seawalls and other protection works, etc. do not need to be included if they are common to the base case and the investment case.

b) Minor capital or operating expenditures on beach management in the base case. This is because of the order of accuracy of the cost estimates for the investment case.

This means that the estimated capital and operating costs of the investment case represent the incremental costs to be used in the cost-benefit analysis. The methodology for valuing the economic benefits of the beach nourishment programme is described in Appendix H. The parameter values used in the cost-benefit analysis are outlined below.

8.4.1 Costs

The relevant capital and recurrent costs for the Collaroy-Narrabeen Beach nourishment programme are given in Table 8.1.

Table 8.1 Beach Nourishment Programme Cost Estimates [a] – Collaroy-Narrabeen Beach

	1st 10-year Campaign	Following 10-year Campaigns
Capital	**Unit Costs ($/m^3)**	**Unit Costs ($/m^3)**
Dredging & nourishment	19.00	19.88
Other	3.75	4.64
Total	22.75	24.52
Recurrent	**Unit Costs ($/m^3)**	**Unit Costs ($/m^3)**
Monitoring	1.02	3.00
Management	1.20	2.30
Total	2.22	5.30
Sand Volume (m^3)	1,262,689	420,803
	Total Costs ($'000)	**Total Costs ($'000)**
Capital	28,726	10,318
Recurrent	2,803	2,230

Note:

a) Derived from Tables 7.1 & 7.2 by separating out recurrent costs from the engineering cost estimates.

8.4.2 Benefits

The quantified benefits of the Collaroy-Narrabeen beach nourishment programme are summarised in Table 8.2. The detailed calculations are presented in Appendix H. Total benefits shown allow for the application of an uplift factor to gross value added (GVA), which would provide some allowance for the value of non-traded attributes associated with beach amenity (these attributes include consumer surplus, which is the value of the beach to people over and above that indicated by expenditure). The sensitivity of the economic results to the uplift factor is assessed in Section 8.4.4.

Table 8.2 Beach Nourishment Programme Quantified Benefits – Collaroy-Narrabeen Beach

Year ending June [b]	Avoided Loss [a]						Total
	GVA [c]	Non-traded Value [d]	Rate Revenue Residential[e]	Rate Revenue Business[f]	Residential Property Value [g]	Tax Revenue [h]	
2012	343	137	199	16	3,777	72	4,544
2022	686	274	397	33	7,553	144	9,087
2032	1,029	412	596	49	11,330	216	13,631
2042	1,372	549	794	66	15,106	288	18,175
2052	1,715	686	993	82	18,883	360	22,719

Notes:

a) Assumes beach width is an indicator of beach amenity and a linear relationship applies between the loss of beach width and the loss of economic value from flow-on effects. Based on existing average beach width of 50 metres and beach width receding five metres every ten years.

b) First full year following each beach nourishment.

c) GVA is gross value added and measures the total market value of output less net taxes (such as GST and excise duties). GVA per business is sourced from Tourism Research Australia (2009), Table 12; it has been adjusted for output that is not related to beach visits. The contribution of beach-related activities by type of business is:

- 33% for cafes, restaurants & take-aways;
- 33% for clubs, pubs, taverns & bars;
- 70% for accommodation;
- 33% for retail (the number of retail businesses excludes those primarily serving local residents, e.g. homewares);

- 10% for galleries, museums, etc; and
- 100% for businesses providing on-beach activities.

Updated to 2009/10 by change in household final consumption expenditure from December Quarter 2006.

d/ Non-traded attributes of beach amenity valued at 40% of GVA (average of ratios reported in other studies – refer Appendix H).

e/ Based on information provided by Warringah Council for properties within hazard lines; assumes that these properties do not exist in the base case. Also, allows for properties within easy walking distance (500m) of beach with property value differential of 40% between the base case and the investment case.

f/ Businesses located in Collaroy and Narrabeen shopping centres and along Ocean Street; includes special purpose rate for Manly Business Centre Improvements. Adjusted for rates attributable to beach amenity – refer Appendix H.

g/ Reflects the impacts of beach amenity on residential property values, assuming that property value is an indicator of willingness to pay for beach amenity. Assumes that properties within hazard lines do not exist in the base case.

h/ Average tax rate on tourism industry products is 21% - sourced from Tourism Research Australia (2008), page 8. This compares to the overall industry average of 9-10%.

The following data/information needs to be verified during project development from the results of the Sydney Beaches Valuation Project being conducted for the SCCG by Dave Anning at UNSW or from additional specific-purpose surveys:

- Percentage of day visitors and overnight visitors attracted to Collaroy-Narrabeen by the beach.
- Number of beach visits and average expenditure per beach visit by visitors and residents.
- Consumer surplus (‘willingness to pay’) associated with a beach visit.
- Number of retail outlets primarily serving Collaroy-Narrabeen residents.
- Property value attributable to beach amenity.

8.4.3 Cost-Benefit Analysis Results

The cost-benefit analysis was undertaken over a 50-year period, using a real discount rate of 7% (alternative discount rates were used in the sensitivity analysis). All costs and benefits were expressed in 2009 prices, and 2009/10 was adopted as the discount year. Appendix H contains the parameter values and the detailed cost and benefit streams on which the cost-benefit analysis was based. The results of the cost-benefit analysis are summarised in Table 8.3.

Table 8.3 Economic Evaluation Results – Collaroy-Narrabeen Beach

	Incremental to 'without beach nourishment' case ($'000 in 2009 prices)
Total cost [a)]	$187,240
Present value [b)]	
Dredging & nourishment costs	36,460
Management & monitoring costs	34,803
Total costs	***71,263***
Avoided loss of:	
Gross value added	8,502
Non-traded value	3,401
Rates revenue	
Residential	4,922
Business	409
Residential property value	93,630
Tax revenue	1,785
Total benefits	***112,649***
Net present value	**$41,695**
Benefit-cost ratio	**1.6**
Economic internal rate of return	**12%**

Notes:

a) Calculated from cost estimates in Table 8.2.
b) Discounted to 2009 /10 at 7% real discount rate.

Table 8.3 shows that the sand nourishment programme is economically viable, with a net present value of $42M, a benefit-cost ratio of 1.6 and an economic internal rate of return of 12%. The value of the benefit-cost ratio indicates that, on the basis of the quantified benefits, the programme is expected to provide medium value for money. Generally, a project requires a benefit-cost ratio in excess of 1.5 in order to be considered as providing medium value for money.

The main quantified benefits are the avoided loss of:

- Residential property values attributable to beach amenity (45% of total quantified benefits).
- Value of residential properties located within hazard lines (38%).
- Expenditure by beach visitors (8%).
- Rates revenue from residential property values within walking distance of the beach as a result of lower property values (4%).

8.4.4 Sensitivity Analysis

The following sensitivity tests were undertaken to assess the robustness of the economic results:

- Alternative real discount rates of 4% and 10%.
- Uplift factor of 1.1 applied to GVA (1.4 in the main analysis).
- Exponential relationship between beach width and beach amenity (linear relationship in the main analysis).
- 30% increase in project cost estimates.
- 30% decrease in project benefits.

The results of the analysis are shown in Table 8.4.

Table 8.4 Sensitivity Analysis Results – Collaroy-Narrabeen Beach

	Incremental to 'without beach nourishment' case
Main Evaluation [a)]	
Net present value	**$41.7M**
Benefit-cost ratio	**1.6**
Economic internal rate of return	**12%**
Real discount rate of 4%	
Net present value	$117.9M
Benefit-cost ratio	2.2
Economic internal rate of return	12%
Real discount rate of 10%	
Net present value	$11.2M
Benefit-cost ratio	1.2
Economic internal rate of return	12%
Uplift factor of 1.1 applied to GVA	
Net present value	$39.1M
Benefit-cost ratio	1.5
Economic internal rate of return	12%
Exponential relationship between beach width and beach amenity	
Net present value	$108.8M
Benefit-cost ratio	2.5
Economic internal rate of return	21%
30% increase in project cost estimates	
Net present value	$20.4M
Benefit-cost ratio	1.2
Economic internal rate of return	9%
30% decrease in project benefits	
Net present value	$7.9M
Benefit-cost ratio	1.1
Economic internal rate of return	8%
30% increase in project cost estimates and 30% decrease in project benefits	
Net present value	-$13.4M
Benefit-cost ratio	0.9
Economic internal rate of return	6%

Note:

a) From Table 8.3.

Table 8.4 shows that the economic viability of the sand nourishment programme is reasonably robust. However, in the most extreme sensitivity test (where project benefits are reduced by 30% and project costs are increased by 30%), the programme is not economically viable. The sensitivity analysis showed that the economic results are particularly sensitive to the shape of the relationship between beach width and the loss of economic value from flow-on effects of reduced beach amenity. Use of an exponential rather than a linear relationship increases the benefit-cost ratio from 1.6 to 2.5. A combination of the exponential relationship and the most extreme sensitivity test results in a benefit-cost ratio of 1.4.

One of the sensitivity tests involves a lower real discount rate of 4%. A lower discount rate is increasingly being adopted in other countries for the economic appraisal of social and environmental projects with long-term benefits. A real discount rate of 4% rather than 7% increases the benefit-cost ratio from 1.6 to 2.2.

8.4.5 Summary of Economic Viability

The main cost-benefit analysis showed that the sand nourishment programme is economically viable and is expected to provide medium value for money. The sensitivity analysis showed that the economic viability is reasonably robust. However, the programme is not economically viable in the most extreme sensitivity test (where project benefits are reduced by 30% and project costs are increased by 30%).

Adopting a lower discount rate, as is increasingly the overseas practice in economic appraisal of social and environmental projects with long-term benefits, increases the benefit-cost from 1.6 to 2.2.

The economic results are also sensitive to the shape of the relationship between beach width and the loss of economic value from the flow-on effects of reduced beach amenity. Use of an exponential rather than a linear relationship increases the benefit-cost ratio from 1.6 to 2.5.

Chapter 9

Case Study 2: Manly Ocean Beach

9.0 Case Study 2: Manly Ocean Beach

This chapter considers the social and economic implications of a sand nourishment campaign for Manly Ocean Beach.

Chapter Summary

Manly Ocean Beach has an iconic status, a prominent social standing and a significant cultural heritage. It has limited ability to respond to climate change sea-level rise due to the presence of the seawall and associated lack of back beach barrier dunes. Many local businesses rely on the existence of the beach and loss of beach amenity would have a devastating impact on economic turnover. Loss of the beach amenity and promenade would also impact significantly upon the sub-aerial and inter-tidal coastal environment.

The placement of 625,000m^3 (or 400m^3/m length of beach) of sand from the Cape Banks borrow site will improve beach amenity by extending the mean beach width. This will also provide some additional buffer against storm erosion and additional protection of the vulnerable seawall.

The cost-benefit analysis demonstrates that the proposed beach nourishment programme is economically viable – it produced a net present value of $48M, a benefit-cost ratio of 2.4 and an economic internal rate of return of 20%. The high economic rate of return for Manly Beach is a result of its iconic status and importance to regional tourism.

Manly Ocean Beach is one of Australia's most iconic and popular beaches. The beach is located 16km north east of the Sydney CBD and extends from Manly Surf Club at the southern corner to Queenscliff Headland in the north. The beach is 1.5km long and is referred to as Manly/South Steyne at the southern end, North Steyne along the mid sector and Queenscliff at the most northern extent. The beach is backed by a seawall of varying design and age, with a promenade and foreshore reserve along its entirety.

Figure 9.1 Manly Beach 1895 and present

Manly was first settled by Europeans in the early 1800's. Originally the area was accessed by ferry and paddle steamer via Sydney Harbour. By the late 19th and 20th century the area was one of early Australia's most popular seaside resorts. The renowned Norfolk Pines that line the shoreline were planted between 1860 and 1890. It was illegal to swim in the water at Manly until 1902 when a local man defied the law and bathed in daylight hours, paving the way for ocean swimming in Australia (Short 1993). Seventeen people drowned in 1903, leading to the creation of a number of ad-hoc volunteer surf lifesaving clubs, some of the earliest in Australia. Today, three surf lifesaving clubs operate on the beach; Manly, North Steyne and Queenscliff. The beach is also patrolled by professional lifeguards employed by Manly Council.

The Manly region receives 5 to 8M visitors each year (Manly Council website 2009). The area is used for numerous recreational and social activities in the water, on the beach and on the adjoining promenade. The southern end of the beach has a walking mall with many shops, restaurants and bars. The beach is well serviced by public transport and the Manly Ferry Terminal is within walking distance. The area is also of significant importance to the surfing community and plans are underway to have the beach dedicated as a National Surfing Reserve (Farmer & Short 2007). Residents and tourists flock to Manly to learn to surf and to buy surf related products at the many stores in the area.

During large or frequent storm events Manly Ocean Beach is subject to loss of amenity and damage to assets as there are insufficient volumes of sand to accommodate the storm erosion demand (PBP 2008b). In 1913, storm waves lashed the foreshore and destroyed beach facilities that had been constructed. Large storms also hit the beach in 1943 and 1950, damaging the seawall and threatening North Steyne SLSC (Figure 1.1). The largest storm events on record occurred in 1967 and 1974, causing extensive damage to the seawall. More recent storms in 1999, 2001 and 2007 have also damaged the seawall.

Rock protection has been added to the toe of the seawall along much of the beach as part of stabilisation works. Exposure of this rock protection during storm events leads to amenity and safety issues in the period prior to natural beach recovery and reburial of the rock armour (PBP 2008b).

Manly Ocean Beach has been selected as one of the three case study beaches because of its iconic status, its social and cultural heritage, and its limited ability to respond to climate change sea-level rise due to the presence of the seawall and associated lack of back-beach barrier dunes. Many local businesses rely on the existence of the beach and loss of beach amenity would have a devastating impact on their economic turnover. Loss of beach amenity and the promenade would also impact significantly on the sub-aerial and inter-tidal coastal environment.

9.1 Physical

Manly Ocean Beach is bounded by Queenscliff Headland to the north and Blue Fish Point and North Head to the south. The embayment is essentially a closed sediment system with extensive rocky reefs offshore of Blue Fish Point, indicating no significant littoral sand supply from the south. The relatively shallow depths at Queenscliff Headland may permit minor transport of sand to Freshwater Beach during large storm events.

The beach has a typical slope of 1 in 50 and consists of fine to medium grained golden sand to a depth of approximately 14m LAT (Figure 9.2). At depths greater than 14m the sand is classified as fine grained and fawn coloured. Details of actual grain size are not available, but could be expected to fall in the range 0.30mm to 0.35mm.

Figure 9.2 Manly Beach

Manly Lagoon entrance is situated at the northern extremity of Queenscliff Beach. Several large stormwater pipes also cross the beach and are clearly visible (Figure 9.3). In addition, several stormwater drains terminate at the back of the beach and create localised erosion zones following rainfall.

Photogrammetric analysis of historical aerial photography between 1930 and 2002 indicates that the volume of sand above 0m AHD has, in the longer term, remained relatively stable (PBP 2008a). This provides some support to the notion that the embayment is a closed sediment system.

A coastline hazard definition study has been published for Manly Ocean Beach (PBP 2003). More recently a Coastline Management Study (PBP 2008a) and a Coastline Management Plan (PBP 2008b) have been completed for Manly Ocean Beach. Historical surveys of the beach have indicated that the short term cross-shore sand transport due to storm events is generally higher at the northern end of the beach. The southern end of the beach is afforded some protection from southerly storms by Blue Fish Point. PBP (2008a) recommended design volumes for storm demand along the subaerial beach for the 100yr ARI of between 100 and 180m^3/m. Based on the more accreted beach conditions from the photogrammetric survey data, available subaerial beach volumes range from 55 to 125m^3/m (PBP 2008a). During eroded conditions in July 1974 and May 1976 the volume of sand remaining on the beach above 0m AHD was less than 30m^3/m. PBP (2008a) recommend nourishment of 300m^3/m (subaerial and sub-aqueous) or a total volume of 500,000m^3 to ‘guarantee’ protection of the Manly Seawall. This volume appears to be based on a depth of closure of approximately 10m.

Figure 9.3 Stormwater pipes on Manly Beach 2009 (Courtesy Manly Council)

In this report the adopted depth of closure is approximately 22m. WRL (2003) also adopted a similar closure depth to that used in this scoping study. This results in substantially higher estimated nourishment volumes to protect the seawall than those estimated by PBP (2008a) and is discussed further in Section 9.1.2.

9.1.1 Do Nothing Scenario

The average beach width (between South Steyne and the Queenscliff boatshed) determined from photogrammetry is approximately 50 m (WRL 2003). Based solely on a 200mm sea-level rise between 1870 and the present, the theoretical width of Manly Ocean Beach, using the “Bruun Rule”, would have reduced by approximately 10m during this period.

Using an upper-bound estimate for sea-level rise of 0.1m every 10 years, the beach width will theoretically reduce a further 5m every 10 years. Therefore, in 50 years the average beach width will be half its present extent. The average beach volume above 0m AHD by 2050 would be comparable to the most eroded condition recorded (e.g. Figure 1.1) over the period 1930 to 2001 (WRL 2003). Consequently, the threat of major damage to the existing seawall is very high.

9.1.2 Nourishment Requirements

The volume of native sand required to accommodate past sea-level rise (0.2m), and that for the next 10 year period (0.1m) is 520,000m^3. The placement of 520,000m^3 would improve beach amenity by extending the mean beach width from 50m to approximately 65m. This is equivalent to 625,000m^3 (or 400m^3/m length of beach) of sand from the Cape Banks borrow site. This would also provide some additional buffer against storm erosion and some additional protection of the vulnerable seawall. This volume will not ‘guarantee’ protection of the seawall as reported by PBP (2008a).

WRL (2003) estimated that Manly Ocean Beach width would need to be increased by 57m (to 107m) to provide adequate protection of the existing seawall based on present sea level elevation. This would require approximately 2Mm^3 of native sand. This can probably be considered an upper-bound volume because it includes sufficient sand to prevent exposure of the rocks near the toe of the seawall.

Subsequent nourishment campaigns are scheduled at sea-level rise increments of 0.1m (i.e. each 10 years). This is equivalent to approximately 130m^3/m length of beach of sand from the Cape Banks borrow site.

9.2 Environmental

There are no published studies of the inter-tidal and subaqueous biotic assemblages at Manly Beach. However, Manly Beach is known to contain a number of aquatic habitats, including inter-tidal rock platforms, subaqueous rocky reefs, sandy beaches and subaqueous soft sediments. The region also includes Cabbage Tree Bay Aquatic Reserve that provides protection and sanctuary for the weedy sea dragon, elegant wrasse, black rock cod and the blue groper.

The biota of Sydney's ocean beaches and Manly Beach comprise the following components:

a) Vascular plants (and associated invertebrates) occupying dunes above high water.
b) Air-breathing species on the upper beach including crustacean and insect assemblages inhabiting seaweed wrack and ghost crabs.
c) Shore birds.
d) The assemblages living under the inter-tidal sand.

A general description of the biota assemblages for Sydney's beaches is provided in Appendix F.

9.2.1 Do Nothing Scenario

At beaches with seawalls (Manly Beach), sea-level rise and erosion will reduce the width of the beach until no inter-tidal beach remains, resulting in a total loss of the beach ecosystem.

9.2.2 Nourishment Impacts

The generic inter-tidal and subaqueous ecological impacts of a nourishment campaign for all of Sydney's beaches are described in Section 6.3 and Appendix F of this report. Of particular concern at Manly Beach and Cabbage Tree Bay Aquatic Reserve is the potential smothering of the subaqueous rocky reefs and their associated flora and fauna. Nourishment could potentially result in the permanent loss of subaqueous rocky reef habitat. The presence or extent of seagrass beds and kelp fields is presently unknown.

Monitoring of these key ecological issues will need to be considered as part of a proposed nourishment campaign.

9.3 Social

Community Priorities

The Manly community and their Local Government representatives have a high level of interest in the built and natural environment. Manly's vision for the future as presented in the 'Surfing the Future – A Vision for the Manly Local Government Area for 2025' (Manly Council 2006) states: 'A thriving community where residents and visitors enjoy a clean, safe and unique natural environment enhanced by heritage and lifestyle.'

Manly's coastal location defines the character of the area. The iconic beach and associated surf culture attracts visitors, tourists and residents to the area. Protection of the natural environment and culture is strongly linked to a sense of identity and quality of life for local residents. Mitigating the negative impacts of sea-level rise, coastal erosion and shoreline retreat resulting from increases in the frequency and intensity of coastal storms and floods, therefore, is an important priority.

The Manly Ocean Beach Coastline Management Plan, Support Document (PBP 2004) identifies features associated with Manly Ocean Beach that are deemed valuable by the community.

Key areas of value include:

- *Costal Ecology* – The community place value on maintaining the range of habitats, flora and fauna associated with the beach environment.
- *Heritage* – The Manly Beach area encompasses a range of indigenous and non-indigenous heritage areas and issues. The recognition of the beach as a historically iconic area and its cultural associations with

surfing, beach recreation and scenery provide a foundation for the identity of the local community and suburbs.

- *Aesthetics* – The iconic beach and local amenity attract visitors, tourists and residents to the area. The beach provides a stage for beach culture and events.
- *Recreation* – The beach provides a number of areas for recreational use in the form of the surf zone (surfing, body boarding, body surfing, swimming, water play, surf lifesaving and nipper activities, surf schools, and surf competitions), sandy beach (surf life saving and nipper activities, surf schools, surf competitions, sunbathing, socialising, sand play, jogging, walking, beach volleyball) and surrounding promenade and parklands (sightseeing and tour groups, walking, jogging, socialising, picnicking, relaxing, bicycling, skateboarding).
- *Social and Economic Benefits* – Manly beach provides a focus for Manly as a tourist destination. The high volumes on visitors to the area provide a wide ranging customer base which benefits local businesses. The beach culture has also seen the associated development of recreational clubs and groups providing a range of activities and services to residents of the area.

Media Review

Manly Beach is often cited in the media as one vulnerable to sand erosion. Media commentary to date has focused on the impacts of sand erosion on the amenity of the area and the emergency plans put in place by Manly Council to combat sand erosion. Media reports of future options for nourishment of Manly Beach have been within general discussions of Australia wide beach nourishment options.

9.3.1 Do Nothing Scenario

If no action to mitigate the effects of sea-level rise and beach erosion is taken at Manly Ocean Beach potential impacts will include:

- Loss or damage to Manly Surf Life Saving Club, North Steyne Surf Life Saving Club and Queenscliff Surf Life Saving Club.
- Loss or damage to recreational facilities including the promenade and associated car parking.
- Loss of heritage sites including the Norfolk Island Pines.
- Loss of sandy beach amenity and impeded access for beach users.
- Loss of local revenue from ‘learn to surf’ schools, and professional surfing tournaments.

The social implications associated with the do-nothing scenario are immense and predominantly negative.

9.3.2 Nourishment

If a beach nourishment programme is commenced to mitigate the effects of sea-level rise and beach erosion Manly Ocean Beach will remain unchanged and beach users will be able to enjoy the benefits of the sandy beach and coastal area into the future.

Social implications are predominantly positive and beneficial for beach users. Depending on the funding mechanism for the nourishment programme, some people may not be accepting of the costs associated with the nourishment programme, particularly if they are not beach users.

9.4 Economic

The technique of cost-benefit analysis has been used to evaluate the net economic benefit of investment in a beach nourishment programme to mitigate the loss of beach amenity from reduced beach width as a result of future sea-level rise associated with climate change. The loss of beach amenity has the potential to cause economic costs, and it is the avoidance of these costs which is the economic benefit of the programme.

The cost-benefit analysis involved a comparison of the expected situation with the programme against the expected situation without the programme, the latter being referred as the base case. The investment case is evaluated on an incremental basis from the base case.

The evaluation is to assess whether the economic benefits of implementing a beach nourishment programme exceed the economic costs of providing the programme. The evaluation is conducted over a 50-year period, because of the long-term nature of sea-level rise associated with climate change. In conducting a cost-benefit analysis at a strategic level, it is standard practice to omit:

a) Expenditures which are common to the base case and the investment case. For instance, any expenditures on lagoon entrance clearance, dune vegetation, seawalls and other protection works, etc. do not need to be included if they are common to the base case and the investment case.

b) Minor capital or operating expenditures on beach management in the base case. This is because of the order of accuracy of the cost estimates for the investment case.

This means that the estimated capital and operating costs of the investment case represent the incremental costs to be used in the cost-benefit analysis. The methodology for valuing the economic benefits of the beach nourishment programme is described in Appendix H. The parameter values used in the cost-benefit analysis are outlined below.

9.4.1 Costs

The relevant capital and recurrent costs for the Manly beach nourishment programme are given in Table 9.1.

Table 9.1 Beach Nourishment Programme Cost Estimates [a] – Manly Ocean Beach

	1st 10-year Campaign	Following 10-year Campaigns
Capital	**Unit Costs ($/m^3)**	**Unit Costs ($/m^3)**
Dredging & nourishment	19.00	19.88
Other	3.75	4.64
Total	22.75	24.52
Recurrent	**Unit Costs ($/m^3)**	**Unit Costs ($/m^3)**
Monitoring	1.02	3.00
Management	1.20	2.30
Total	2.22	5.30
Sand Volume (m^3)	625,200	208,348
	Total Costs ($'000)	**Total Costs ($'000)**
Capital	14,223	5,109
Recurrent	1,388	1,104

Note:

a) Derived from Tables 7.1 & 7.2 by separating out recurrent costs from the engineering cost estimates.

9.4.2 Benefits

The quantified benefits of the Manly beach nourishment programme are summarised in Table 9.2. The detailed calculations are presented in Appendix H. Total benefits shown allow for the application of an uplift factor to gross value added (GVA), which would provide for some allowance for the value of non-traded attributes associated with beach amenity (these attributes include consumer surplus, which is the value of the beach to people over and above that indicated by expenditure). The sensitivity of the economic results to the uplift factor is assessed in Section 9.4.4.

Table 9.2 Beach Nourishment Programme Quantified Benefits – Manly Ocean Beach

Year ending June [b]	Avoided Loss [a]						Total
	GVA [c]	Non-traded Value [d]	Rate Revenue		Residential Property Value[g]	Tax Revenue[h]	
			Residential[e]	Business[f]			
2012	760	304	65	438	1,627	160	3,354
2022	1,520	608	130	875	3,255	319	6,708
2032	2,280	912	195	1,313	4,882	479	10,061
2042	3,040	1,216	260	1,751	6,509	638	13,415
2052	3,800	1,520	325	2,189	8,136	798	16,769

Notes:

a) Assumes beach width is an indicator of beach amenity and a linear relationship applies between the loss of beach width and the loss of economic value from flow-on effects. Based on existing average beach width of 50 metres and beach width receding five metres every ten years.

b) First full year following each beach nourishment.

c) GVA is gross value added and measures the total market value of output less net taxes (such as GST and excise duties). GVA per business is sourced from Tourism Research Australia (2009), Table 12; it has been adjusted for output that is not related to beach visits. The contribution of beach-related activities by type of business is:

- **33% for cafes, restaurants & take-aways;**
- **33% for clubs, pubs, taverns & bars;**
- **70% for accommodation;**
- **33% for retail (the number of retail businesses excludes those primarily serving local residents, e.g. homewares);**
- **10% for galleries, museums, etc; and**
- **100% for businesses providing on-beach activities.**

Updated to 2009/10 by change in household final consumption expenditure from December Quarter 2006.

d) Non-traded attributes of beach amenity valued at 40% of GVA (average of ratios reported in other studies – refer Appendix H).

e) Based on average rate revenue per occupied private dwelling of $824; 500 occupied private dwellings affected (those along North Steyne); and property value differential of 30% between the base case and the investment case. Also, allows for properties within easy walking distance (500m) of beach.

f) Businesses located in Manly Business District; includes special purpose rate for Manly Business Centre Improvements. Adjusted for rates attributable to beach amenity – refer Appendix H.

g) Reflects the impacts of beach amenity on residential property values, assuming that property value is an indicator of willingness to pay for beach amenity.

h) Average tax rate on tourism industry products is 21% - sourced from Tourism Research Australia (2008), page 8. This compares to the overall industry average of 9-10%.

The following data/information needs to be verified during project development from the results of the Sydney Beaches Valuation Project being conducted for the SCCG by Dave Anning at UNSW or from additional specific-purpose surveys:

- Percentage of day visitors and overnight visitors attracted to Manly by the ocean beach.
- Number of beach visits and average expenditure per beach visit by visitors and residents.
- Consumer surplus (‘willingness to pay’) associated with a beach visit.
- Number of retail outlets primarily serving Manly residents.
- Property value attributable to beach amenity.

9.4.3 Cost-Benefit Analysis Results

The cost-benefit analysis was undertaken over a 50-year period, using a real discount rate of 7% (alternative discount rates were used in the sensitivity analysis). All costs and benefits were expressed in 2009 prices, and 2009/10 was adopted as the discount year. Appendix H contains the parameter values and the detailed cost and benefit streams on which the cost-benefit analysis was based. The results of the cost-benefit analysis are summarised in Table 9.3.

Table 9.3 Economic Evaluation Results – Manly Ocean Beach

	Incremental to 'without beach nourishment' case ($'000 in 2009 prices)
Total cost [a)]	$91,967
Present value [b)]	
Dredging & nourishment costs	17,733
Management & monitoring costs	17,232
Total costs	**34,965**
Avoided loss of:	
Gross value added	18,843
Non-traded value	7,537
Rates revenue	
Residential	1,614
Business	10,852
Residential property value	40,344
Tax revenue	3,957
Total benefits	83,148
Net present value	**$48,183**
Benefit-cost ratio	**2.4**
Economic internal rate of return	**20%**

Notes:

a) Calculated from cost estimates in Table 9.1.

b) Discounted to 2009 /10 at 7% real discount rate.

Table 9.3 shows that the sand nourishment programme is economically viable, with a net present value of $48M, a benefit-cost ratio of 2.4 and an economic internal rate of return of 20%. The value of the benefit-cost ratio indicates that, on the basis of the quantified benefits, the programme is expected to provide high value for money. Generally, a project requires a benefit-cost ratio in excess of 2.0 in order to be considered as providing high value for money.

The main quantified benefits are the avoided loss of:

- Residential property values attributable to beach amenity (49% of total quantified benefits).
- Expenditure by beach visitors (23%).
- Rates revenue from businesses in the Manly Business District as a result of lower property values (13%).
- Non-traded value (consumer surplus) associated with beach visits (9%).

9.4.4 Sensitivity Analysis

The following sensitivity tests were undertaken to assess the robustness of the economic results:

- Alternative real discount rates of 4% and 10%.
- Uplift factor of 1.1 applied to GVA (1.4 in the main analysis).
- Exponential relationship between beach width and beach amenity (linear relationship in the main analysis).
- 30% increase in project cost estimates.
- 30% decrease in project benefits.

The results of the analysis are shown in Table 9.4.

Table 9.4 Sensitivity Analysis Results – Manly Ocean Beach

	Incremental to 'without beach nourishment' case
Main Evaluation [a)]	
Net present value	$48.2M
Benefit-cost ratio	2.4
Economic internal rate of return	20%
Real discount rate of 4%	
Net present value	$110.7M
Benefit-cost ratio	3.3
Economic internal rate of return	20%
Real discount rate of 10%	
Net present value	$22.4M
Benefit-cost ratio	1.8
Economic internal rate of return	20%
Uplift factor of 1.1 applied to GVA	
Net present value	$42.5M
Benefit-cost ratio	2.2
Economic internal rate of return	18%
Exponential relationship between beach width and beach amenity	
Net present value	$97.7M
Benefit-cost ratio	3.8
Economic internal rate of return	34%
30% increase in project cost estimates	
Net present value	$37.6M
Benefit-cost ratio	1.8
Economic internal rate of return	14%
30% decrease in project benefits	
Net present value	$23.2M
Benefit-cost ratio	1.7
Economic internal rate of return	13%
30% increase in project cost estimates and 30% decrease in project benefits	
Net present value	$12.7M
Benefit-cost ratio	1.3
Economic internal rate of return	10%

Note:

a) From Table 9.3.

Table 9.4 shows that the economic viability of the sand nourishment programme is robust. The programme remains economically viable in all of the sensitivity tests undertaken. The sensitivity analysis shows that the economic results are more sensitive to variations in benefits than costs.

One of the sensitivity tests involves a lower real discount rate of 4%. A lower discount rate is increasingly being adopted in other countries for the economic appraisal of social and environmental projects with long-term benefits. A real discount rate of 4% rather than 7% increases the benefit-cost ratio from 2.4 to 3.3.

9.4.5 Summary of Economic Viability

The main cost-benefit analysis showed that the sand nourishment programme is economically viable and is expected to provide high value for money. The sensitivity analysis confirmed the robustness of this result, with all of the sensitivity tests showing an economically viable programme. Adopting a lower discount rate, as is increasingly the overseas practice in economic appraisal of social and environmental projects with long-term benefits, increases the benefit-cost ratio from 2.4 to 3.3.

AECOM

Appendix H

Economic Evaluation

Appendix H Economic Evaluation

The main economic benefits of the beach nourishment program to be valued are associated with the flow-on effects from loss of beach amenity. Much of the information required is being collected in the on-going Sydney Beaches Valuation Project being conducted by Dave Anning at UNSW for the SCCG. The Project will produce an estimate of the Total Economic Value of two of the Scoping Study beaches (Manly and Narrabeen/Collaroy).

Total Economic Value (TEV)

In cost-benefit analysis and welfare economics, TEV is conventionally estimated on a 'willingness-to-pay' (WTP) basis. It comprises an expenditure component based on market prices of traded goods and services and a non-market based component where the market does not provide a satisfactory measure of economic value. For the latter component, values of non-traded attributes need to be derived using surrogate or proxy measures of WTP indicators, the approach being used in the UNSW study.

Non-traded attributes include:

- Consumer surplus – the value of the beach to people over and above that indicated by the expenditure component of TEV;
- Indirect use value – the value which the beach provides as protection of foreshore assets from storms; and non-use value – the value people hold for the beach's actual existence even though they may never use it.

Scoping Study Approach

Pending the completion of the UNSW study toward the end of 2009 and the valuation of the non-traded components of TEV for Sydney beaches, AECOM will undertake high-level benefit valuation using data from secondary sources on key parameters of the expenditure component of TEV. These parameters determine the change in expenditure on coastal goods and services and the change in government revenues as a result of flow-on effects following the loss of beach amenity.

Fiscal impacts need to be part of the assessment of 'value for money' of a public investment as affordability to government will often be a critical factor in deciding whether an investment program is realistic and practical. The inclusion of fiscal impacts along with impacts on economic efficiency and wider economic impacts is consistent with the latest developments in project appraisal.

At this stage, the avoided loss of the non-market component of TEV can only be approximated. This is because, pending the results of the specific valuations that are being undertaken in the UNSW study:

- For beach use, the value of WTP for beach amenity would need to be based on transferring benefits from studies of other coastal areas to the Sydney context – we believe this approach is limited because of the individual nature and characteristics of specific beaches;[1]

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[1] It is only under certain conditions that benefits transfer provides a credible basis for valuation. Factors influencing these conditions include:

- Purpose of original value estimates
- Consumer groups considered
- Location of original study site
- Good or service valued
- Type of environmental impact
- Reference and target levels (existing quality and quality outcome sought)
- Reliability of source data
- Market structure
- Demographic and socio-economic characteristics of the population
- General attitudes, perceptions, or levels of knowledge of the population

- For price differentials of properties in close proximity to beaches, information is not available on what is driving the willingness to pay a price premium – it could be the beach, the water views, the open space or a combination of these.[2]

Benefits Measurement

The following benefits of the beach nourishment investment program will be valued in the Scoping Study:

- Avoided loss of the expenditure component of TEV
  - The current level of expenditure will be estimated by combining Tourism Research Australia estimates of Gross Value Added (GVA) per tourism business and information on the number of potentially affected business properties;
  - The percentage of this expenditure which is beach-related is assumed for each type of tourism business, based on the factors shown below:

Cafes, restaurants & take-aways Clubs, pubs, taverns & bars Retail	• resident: visitor ratio • ratio of visitor average daily expenditure to resident average daily expenditure • % of visitors attracted by the beach
Accommodation	• % of visitors attracted by the beach
Galleries, museums, etc	• weak association with beach amenity
Other entertainment services	• only on-beach activities included

  - The annual loss of expenditure over the evaluation period will be derived from the rate of beach width reduction in the base case;
  - Inclusion of this benefit assumes that beach-related expenditure is not diverted to other coastal locations where beach width reduction is less severe.[3]
  - Uplift factor for the non-traded component of TEV
  - An uplift factor will be applied to the expenditure component of TEV to provide some allowance for the value of non-traded attributes;
  - A possible range for the uplift factor will be derived from relevant Australian studies where non-traded attributes have been valued;
  - The range of values will enable assessment of the sensitivity of the economic results to this factor.
- Avoided loss of Council rate revenue
  - This will be estimated by assuming that:

1) There will be a differential of about 30% between rate revenue from residential properties with direct beach access:
   - This property price differential is based on analysis of property values[4] in Adelaide reported in Burgan (2003)5;
   - This will be assumed to apply to rateable land value
   - The annual loss of rate revenue will align with the rate of beach width reduction in the base case
2) There will be a differential of about 40% between rate revenue from residential properties within easy walking distance of a beach

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[2] For this component, we have drawn on the property willingness-to-pay relativities reported in Burgan (2003).
[3] This benefit will be overestimated to the extent that expenditure is diverted to other beaches.
[4] For properties having water views with direct access to the beach and those having water views only. The relativity is derived using the coefficients of the dummy variables in Model 4 which is the preferred model using the 2003 data (refer Page 16).
[5] In the case of Collaroy/Narrabeen (because this is where the potential impact on residential property values is most significant), the differential has been checked for reasonableness with local real estate agents.

  - This property price differential is based on analysis of property values[6] in Adelaide reported in Burgan (2003)[4]
  - This will be assumed to apply to rateable land value
  - The annual loss of rate revenue will align with the rate of beach width reduction in the base case

3) Rate revenue from properties within easy walking distance assumed to be over 3 times that of properties with direct beach access - from Burgan (2003);
4) Rate revenue from potentially affected business properties will reduce at the same rate as the reduction in the expenditure component of TEV.

- A WTP factor to reflect the impacts of beach amenity on residential property values
  - This assumes that property value is an indicator of WTP for beach amenity;
  - This will be approximated by annualising the property value impacts derived from the application of a ratio of residential property value to rate revenue to the avoided loss of residential rate revenue (the ratio assumes that property value is typically 75% higher than land (site) value);
  - The annualisation factor is calculated using 7% interest rate over 50 years.
- Avoided loss of tax revenue
  - This will be estimated by applying the average tax on tourism industry products to the reduction in the expenditure component of TEV (when expenditure is measured in terms of GVA it excludes taxes on products);
  - Taxes in the tourism industry are significantly higher than the national average – in 2006-07, 21% for the tourism industry compared to the national average of 9-10%.

In summary, the benefits of the beach nourishment program will be measured as:

Benefits = (Avoided loss of expenditure component of TEV)

x Uplift factor for non-traded component of TEV

+ Avoided loss of Council rate revenue

+ (Avoided loss of Council residential rates revenue)

x Property value factor x Annualisation factor

+ Avoided loss of tax revenue

Parameter Values

The parameter values used in the three case study cost-benefit analyses are set out in the following table.

[6] For properties within easy walking distance of a beach (defined as within 500 metres) and those not within this distance. The relativity is derived using the coefficients of the dummy variables in Model 4 which is the preferred model using the 2003 data (refer Page 16).

PARAMETER VALUES				
	Unit	Manly	Collaroy-Narrabeen	Cronulla
Discount rate	%	**7.0%**		
With Sand Nourishment				
Unit Costs - 1st Campaign				
Capital				
Dredging & nourishment	$/m^3	19.00		
Other	$/m^3	3.75		
Total	$/m^3	22.75		
Recurrent	$/m^3			
Monitoring	$/m^3	1.02		
Management	$/m^3	1.20		
Total	$/m^3	2.22		
Sand Volume	m^3	625,200	1,262,689	1,515,200
Total Costs - 1st Campaign				
Capital	$'000	14,223	28,726	34,471
Recurrent	$'000	1,388	2,803	3,364
Unit Costs - 2nd & subsequent Campaigns				
Capital				
Dredging & nourishment	$/m^3	19.88		
Other	$/m^3	4.64		
Total	$/m^3	24.52		
Recurrent	$/m^3			
Monitoring	$/m^3	3.00		
Management	$/m^3	2.30		
Total	$/m^3	5.30		
Sand Volume	m^3	208,348	420,803	504,940
Total Costs - 2nd & subsequent Campaigns				
Capital	$'000	5,109	10,318	12,381
Recurrent	$'000	1,104	2,230	2,676
Benefits				
GVA	$'000	7,601	3,344	4,965
Uprate factor [a/]		1.4	1.4	1.4
Residential rates revenue	$'000	651	1,330	1,862
Property value factor [b/]		347	264	216
Annualisation factor [c/]		0.072	0.072	0.072
Residential property value [d/]	$'000	16,273	25,301	28,900
Business rates revenue	$'000	4,377	153	887
Tax revenue	$'000	1,596	702	1,043
Base Case [e/]				
Year 1-10		0.9	0.9	0.9
Year 11-20		0.8	0.8	0.8
Year 21-30		0.7	0.7	0.7
Year 31-40		0.6	0.6	0.6
Year 41-50		0.5	0.5	0.5

Notes:

a/ Derived using the travel cost method as indicator of the consumer surplus associated with a beach visit. Average of values from relevant studies:

(i) Lower and upper value of 1.10 and 1.45 - based on expenditure per beach visit of $5.09 (excl parking and public transport) [Table 9] and travel cost per beach visit of $0.50 (lower) and $2.30 (upper) [Table 18], from Raybould (2009).

(ii) 1.62 for residents and 1.72 for visitors - based on on-site expenditure of $3.85 by residents and $16.53 by visitors [Table 3, calculated as TTSCALL-TTSCTIM] and travel cost per beach visit of $2.39 for residents and $11.86 for visitors [Table 6], from Blackwell (2007).

b/ Residential rates revenue = land value x residential rate. Therefore, ratio of residential property value to rates revenue can be approximated as:

(Land value x 1.75 x 1/Residential rate)

assuming property value is typically 75% higher than land (site) value.

c/ Calculated using 7% interest rate over 50 years.

d/ Assumes property value is an indicator of willingness to pay for beach amenity.

e/ Proportion of 2009/10 beach amenity benefits.

Collaroy-Narrabeen Case Study

VALUE OF BEACH-RELATED EXPENDITURE AND ASSOCIATED TAX REVENUE: COLLAROY-NARRABEEN

	GVA per business [a/] ($'000)	No. of businesses	Total GVA ($'000)	Beach-related % of Base [b/]	Beach-related GVA ($'000)
2006/07					
Cafes, restaurants & take-aways	58	28	1,624	59%	965
Clubs, pubs, taverns & bars	105	3	315	59%	187
Accommodation	306	6	1,836	90%	1,652
Retail [c/]	21	10	210	59%	125
Galleries, museums, etc	24	0	0	10%	0
Other entertainment services	19	6	114	100%	114
Beach-related expenditure					3,043
Tax revenue [d/]					639
2009/10 [e/]					
Beach-related expenditure					3,429
Tax revenue					720

Notes:

a/ From Tourism Research Australia, *Tourism Businesses in Australia June 2004 to June 2007,* March 2009, Table 12.

b/ Assumed percentage contribution of beach-related activities to economic base. Assumptions based on:

Cafes, restaurants & take-aways	) 2:1 resident:visitor ratio, visitor average daily expenditure
Clubs, pubs, taverns & bars	) twice that of residents, with 90% of visitors attracted by the
Retail	) beach
Accommodation	90% of overnight visitors attracted by beach
Galleries, museums, etc	weak association with beach amenity
Other entertainment services	only on-beach activities included

c/ Excludes retail outlets that primarily serve local residents (eg. homewares).

d/ From Tourism Research Australia, *Tourism's contribution to the Australian economy 1997-98 to 2006-07, October 2008*, page 8. Average tax rate in tourism sector is: 21%

e/ Updated by change in household final consumption expenditure from Dec Qtr 2006 to June Qtr 2009 1.127

VALUE OF RATES REVENUE: COLLAROY-NARRABEEN	
Affected area	**Value**
Residential	
Direct Beach Access	
Units	
No. of occupied private dwellings	392
Average rates revenue per occupied private dwelling [a/]	$923
Rates revenue	$361,816
Houses	
No. of occupied private dwellings	96
Average rates revenue per occupied private dwelling [b/]	$5,000
Rates revenue	$480,000
Total	$841,816
Value differential [c/]	100%
Loss of rates revenue	$841,816
Walking Distance	
Ratio of impact on property values [d/]	3.2
Rates revenue [e/]	2,693,811
Value differential [f/]	40%
Loss of rates revenue	$1,077,524
Total Loss of Residential Rates Revenue	**$1,919,340**
Business	
No. of businesses	53
Average rates revenue per business property [g/]	$3,113
Rates revenue	**$164,989**

Notes:

a/ Assumes the minimum rate for occupied private dwellings.

b/ Based on average land value for a selection of beachfront properties.

c/ These properties will not exist in the base case.

d/ From Burgan (2003).

e/ Assumes same housing mix as for properties with direct beach access (20% houses, 80% units/ flats/apartments)

f/ Based on premium in Adelaide property values of being within easy walking distance of a beach (defined as 0.5 km) - from Burgan (2003).

g/ Based on average rates revenue for properties within hazard lines.

COST-BENEFIT ANALYSIS: COLLAROY-NARRABEEN ($'000 in 2009 prices)

	Costs		Benefits [a/]							Net
Year ending June	Dredging & Nourish	Mgmnt & Monitor	GVA	Non-traded Value	Rates Revenue Resid'tl	Rates Revenue Business	Resid'tl WTP	Tax Revenue	Total	Net Economic Benefits
2010	0	0	0		0	0	0	0	0	0
2011	28,726	2,803	257	103	149	12	2,832	54	3,408	-28,122
2012	0	2,803	343	137	199	16	3,777	72	4,544	1,741
2013	0	2,803	343	137	199	16	3,777	72	4,544	1,741
2014	0	2,803	343	137	199	16	3,777	72	4,544	1,741
2015	0	2,803	343	137	199	16	3,777	72	4,544	1,741
2016	0	2,803	343	137	199	16	3,777	72	4,544	1,741
2017	0	2,803	343	137	199	16	3,777	72	4,544	1,741
2018	0	2,803	343	137	199	16	3,777	72	4,544	1,741
2019	0	2,803	343	137	199	16	3,777	72	4,544	1,741
2020	0	2,803	343	137	199	16	3,777	72	4,544	1,741
2021	10,318	2,230	514	206	298	25	5,665	108	6,816	-5,733
2022		2,230	686	274	397	33	7,553	144	9,087	6,857
2023	0	2,230	686	274	397	33	7,553	144	9,087	6,857
2024	0	2,230	686	274	397	33	7,553	144	9,087	6,857
2025	0	2,230	686	274	397	33	7,553	144	9,087	6,857
2026	0	2,230	686	274	397	33	7,553	144	9,087	6,857
2027	0	2,230	686	274	397	33	7,553	144	9,087	6,857
2028	0	2,230	686	274	397	33	7,553	144	9,087	6,857
2029	0	2,230	686	274	397	33	7,553	144	9,087	6,857
2030	0	2,230	686	274	397	33	7,553	144	9,087	6,857
2031	10,318	2,230	772	309	447	37	8,497	162	10,223	-2,325
2032	0	2,230	1,029	412	596	49	11,330	216	13,631	11,401
2033	0	2,230	1,029	412	596	49	11,330	216	13,631	11,401
2034	0	2,230	1,029	412	596	49	11,330	216	13,631	11,401
2035	0	2,230	1,029	412	596	49	11,330	216	13,631	11,401
2036	0	2,230	1,029	412	596	49	11,330	216	13,631	11,401
2037	0	2,230	1,029	412	596	49	11,330	216	13,631	11,401
2038	0	2,230	1,029	412	596	49	11,330	216	13,631	11,401
2039	0	2,230	1,029	412	596	49	11,330	216	13,631	11,401
2040	0	2,230	1,029	412	596	49	11,330	216	13,631	11,401
2041	10,318	2,230	1,029	412	596	49	11,330	216	13,631	1,083
2042	0	2,230	1,372	549	794	66	15,106	288	18,175	15,945
2043	0	2,230	1,372	549	794	66	15,106	288	18,175	15,945
2044	0	2,230	1,372	549	794	66	15,106	288	18,175	15,945
2045	0	2,230	1,372	549	794	66	15,106	288	18,175	15,945
2046	0	2,230	1,372	549	794	66	15,106	288	18,175	15,945
2047	0	2,230	1,372	549	794	66	15,106	288	18,175	15,945
2048	0	2,230	1,372	549	794	66	15,106	288	18,175	15,945
2049	0	2,230	1,372	549	794	66	15,106	288	18,175	15,945
2050	0	2,230	1,372	549	794	66	15,106	288	18,175	15,945
2051	10,318	2,230	1,286	514	745	62	14,162	270	17,039	4,491
2052	0	2,230	1,715	686	993	82	18,883	360	22,719	20,488
2053	0	2,230	1,715	686	993	82	18,883	360	22,719	20,488
2054	0	2,230	1,715	686	993	82	18,883	360	22,719	20,488
2055	0	2,230	1,715	686	993	82	18,883	360	22,719	20,488
2056	0	2,230	1,715	686	993	82	18,883	360	22,719	20,488
2057	0	2,230	1,715	686	993	82	18,883	360	22,719	20,488
2058	0	2,230	1,715	686	993	82	18,883	360	22,719	20,488
2059	0	2,230	1,715	686	993	82	18,883	360	22,719	20,488
2060	0	2,230	1,715	686	993	82	18,883	360	22,719	20,488

PV at 7.0%	36,460	34,803	8,502	3,401	4,922	409	93,630	1,785	112,649	41,695
Notes:										
a/ Assumes benefits accrue for only 9 months of first year of each campaign.									**NPV ($m)**	**41.7**
									BCR	**1.6**
									EIRR	**12%**

Manly Ocean Beach Case Study

VALUE OF BEACH-RELATED EXPENDITURE AND ASSOCIATED TAX REVENUE: MANLY

	GVA per business [a/] ($'000)	No. of businesses	Total GVA ($'000)	Beach-related % of Base [b/]	Beach-related GVA ($'000)
2006/07					
Cafes, restaurants & take-aways	58	100	5,800	33%	1,914
Clubs, pubs, taverns & bars	105	10	1,050	33%	347
Accommodation	306	18	5,508	70%	3,856
Retail [c/]	21	80	1,680	33%	554
Galleries, museums, etc	24	7	168	10%	17
Other entertainment services	19	3	57	100%	57
Beach-related expenditure					6,744
Tax revenue [d/]					1,416
2009/10 [e/]					
Beach-related expenditure					7,601
Tax revenue					1,596

Notes:

a/ From Tourism Research Australia, *Tourism Businesses in Australia June 2004 to June 2007*, March 2009, Table 12.

b/ Assumed percentage contribution of beach-related activities to economic base. Assumptions based on:

Cafes, restaurants & take-aways	) 2:1 resident:visitor ratio, visitor average daily expenditure
Clubs, pubs, taverns & bars	) twice that of residents, with 50% of visitors attracted by the
Retail	) beach
Accommodation	70% of overnight visitors attracted by beach
Galleries, museums, etc	weak association with beach amenity
Other entertainment services	only on-beach activities included

c/ Excludes retail outlets that primarily serve local residents (eg. homewares).

d/ From Tourism Research Australia, *Tourism's contribution to the Australian economy 1997-98 to 2006-07, October 2008*, page 8. Average tax rate in tourism sector is: 21%

e/ Updated by change in household final consumption expenditure from Dec Qtr 2006 to June Qtr 2009 1.127

VALUE OF RATES REVENUE: MANLY

Affected area	Value
Residential	
Direct Beach Access	
No. of occupied private dwellings fronting North Steyne	500
Average rates revenue per occupied private dwelling [a/]	$824
Total rates revenue	$412,000
Value differential [b/]	30%
Loss of rates revenue	**$123,600**
Walking Distance	
Ratio of impact on property values [c/]	3.2
Rates revenue [d/]	1,318,400
Value differential [e/]	40%
Loss of rates revenue	$527,360
Total Loss of Residential Rates Revenue	**$650,960**
Business	
Manly Business District [f/]	$4,377,000
Attributable to beach amenity [g/]	50%
Loss of Business Rates Revenue	**$2,188,500**

Notes:

a/ Estimate from Manly Council.

b/ Based on difference in Adelaide property values between having water views with direct access to a beach and having water views only - from Burgan (2003).

c/ From Burgan (2003).

d/ Assumes same housing mix as for properties with direct beach access (1% houses, 99% units/ flats/apartments)

e/ Based on premium in Adelaide property values of being within easy walking distance of a beach (defined as 0.5 km) - from Burgan (2003).

f/ Includes special purpose rate for Manly Business Centre Improvements.

g/ Based on percentage of GVA of businesses that is beach-related (from preceding table).

COST-BENEFIT ANALYSIS: MANLY ($'000 in 2009 prices)

Year ending June	Costs: Dredging & Nourish	Costs: Mgmnt & Monitor	Benefits [a/]: GVA	Non-traded Value	Rates Revenue: Resid'tl	Rates Revenue: Business	Resid'tl P'ty Value	Tax Revenue	Total	Net Economic Benefits
2010	0	0	0	0	0	0	0	0	0	0
2011	14,223	1,388	570	228	49	328	1,220	120	2,515	-13,096
2012	0	1,388	760	304	65	438	1,627	160	3,354	1,966
2013	0	1,388	760	304	65	438	1,627	160	3,354	1,966
2014	0	1,388	760	304	65	438	1,627	160	3,354	1,966
2015	0	1,388	760	304	65	438	1,627	160	3,354	1,966
2016	0	1,388	760	304	65	438	1,627	160	3,354	1,966
2017	0	1,388	760	304	65	438	1,627	160	3,354	1,966
2018	0	1,388	760	304	65	438	1,627	160	3,354	1,966
2019	0	1,388	760	304	65	438	1,627	160	3,354	1,966
2020	0	1,388	760	304	65	438	1,627	160	3,354	1,966
2021	4,924	1,104	1,140	456	98	657	2,441	239	5,031	-997
2022	0	1,104	1,520	608	130	875	3,255	319	6,708	5,603
2023	0	1,104	1,520	608	130	875	3,255	319	6,708	5,603
2024	0	1,104	1,520	608	130	875	3,255	319	6,708	5,603
2025	0	1,104	1,520	608	130	875	3,255	319	6,708	5,603
2026	0	1,104	1,520	608	130	875	3,255	319	6,708	5,603
2027	0	1,104	1,520	608	130	875	3,255	319	6,708	5,603
2028	0	1,104	1,520	608	130	875	3,255	319	6,708	5,603
2029	0	1,104	1,520	608	130	875	3,255	319	6,708	5,603
2030	0	1,104	1,520	608	130	875	3,255	319	6,708	5,603
2031	4,924	1,104	1,710	684	146	985	3,661	359	7,546	1,518
2032	0	1,104	2,280	912	195	1,313	4,882	479	10,061	8,957
2033	0	1,104	2,280	912	195	1,313	4,882	479	10,061	8,957
2034	0	1,104	2,280	912	195	1,313	4,882	479	10,061	8,957
2035	0	1,104	2,280	912	195	1,313	4,882	479	10,061	8,957
2036	0	1,104	2,280	912	195	1,313	4,882	479	10,061	8,957
2037	0	1,104	2,280	912	195	1,313	4,882	479	10,061	8,957
2038	0	1,104	2,280	912	195	1,313	4,882	479	10,061	8,957
2039	0	1,104	2,280	912	195	1,313	4,882	479	10,061	8,957
2040	0	1,104	2,280	912	195	1,313	4,882	479	10,061	8,957
2041	4,924	1,104	2,280	912	195	1,313	4,882	479	10,061	4,033
2042	0	1,104	3,040	1,216	260	1,751	6,509	638	13,415	12,311
2043	0	1,104	3,040	1,216	260	1,751	6,509	638	13,415	12,311
2044	0	1,104	3,040	1,216	260	1,751	6,509	638	13,415	12,311
2045	0	1,104	3,040	1,216	260	1,751	6,509	638	13,415	12,311
2046	0	1,104	3,040	1,216	260	1,751	6,509	638	13,415	12,311
2047	0	1,104	3,040	1,216	260	1,751	6,509	638	13,415	12,311
2048	0	1,104	3,040	1,216	260	1,751	6,509	638	13,415	12,311
2049	0	1,104	3,040	1,216	260	1,751	6,509	638	13,415	12,311
2050	0	1,104	3,040	1,216	260	1,751	6,509	638	13,415	12,311
2051	4,924	1,104	2,850	1,140	244	1,641	6,102	599	12,577	6,549
2052	0	1,104	3,800	1,520	325	2,189	8,136	798	16,769	15,665
2053	0	1,104	3,800	1,520	325	2,189	8,136	798	16,769	15,665
2054	0	1,104	3,800	1,520	325	2,189	8,136	798	16,769	15,665
2055	0	1,104	3,800	1,520	325	2,189	8,136	798	16,769	15,665
2056	0	1,104	3,800	1,520	325	2,189	8,136	798	16,769	15,665
2057	0	1,104	3,800	1,520	325	2,189	8,136	798	16,769	15,665
2058	0	1,104	3,800	1,520	325	2,189	8,136	798	16,769	15,665
2059	0	1,104	3,800	1,520	325	2,189	8,136	798	16,769	15,665
2060	0	1,104	3,800	1,520	325	2,189	8,136	798	16,769	15,665

PV at 7.0%	17,733	17,232	18,843	7,537	1,614	10,852	40,344	3,957	83,148	48,183
Notes:										
a/ Assumes benefits accrue for only 9 months of first year of each campaign.									**NPV ($m)**	**48.2**
									BCR	**2.4**
									EIRR	**20%**