Clontarf / Bantry Bay

Data Compilation
&
Estuary Processes Study

FINAL REPORT

Part – I (Chapters 1 – 5)

August, 2007

Completed as part of the Clontarf / Bantry Bay Estuary Management Planning Process

The groups that oversee the planning process of the Clontarf/Bantry Bay Estuary Management Plan

Clontarf/Bantry Bay Estuary Management Working Group

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i EXECUTIVE SUMMARY

NSW has over 130 estuaries that vary in size from small coastal creeks and lagoons to large lakes and rivers. Collectively, they are immensely valuable from ecological, social and economic perspective. These estuaries contribute $400 M to the State's economy per annum (DNR 2006). The natural beauty of estuaries attracts many visitors and development, and as a result they are under constant pressure. To improve the management of these estuaries, the NSW Department of Environment & Climate Change (DECC) administers the Estuary Management Program. This program aims to provide a strategic approach to the sustainable management of estuaries and sets out a clearly defined process, culminating in the production and implementation of a comprehensive Estuary Management Plan.

Manly is known to people distinctively for its beaches and foreshore areas. For this reason, it is important that the waters and natural features around these beaches and foreshores are nurtured and protected. In line with efforts of NSW State Government, Manly Council has also embarked on planning and management of coastal and estuarine areas. The importance of coastal and estuarine management has been highlighted in all key policy, strategy, plan and management documents adopted by the Manly Council. Manly Lagoon Estuary Management Plan was adopted back in 1998. Manly Council has, since long, adopted a staged approach to cover the entire Manly foreshore. Coastal Zone Management Plans have been prepared, or are being prepared, for the following areas: Forty Baskets, Little Manly, Manly Cove, North Harbour, Cabbage Tree Bay and Manly Ocean Beach. The preparation of the Clontarf / Bantry Bay Estuary Management Plan will complete the coverage of the entire foreshore.

The Study

One of the key steps in the formulation of the Estuary Management Plan (EMP) is the preparation of an Estuary Processes Study, aimed at determining the baseline condition of the various estuarine processes (eg- physical, biological, chemical) and the interactions between these processes. This document aims to provide information on the baseline conditions in the Clontarf / Bantry Bay section of the Middle Harbour estuary.

To support the formulation of the EMP, the 'Clontarf / Bantry Bay Estuary Management Working Group' was established in May 2006 with representations from the Manly Council, community Precincts, Government organisations, Manly Council's Scientific Advisory Panel, neighbouring councils, community and Aboriginal community. An *Internal Staff Working Group* was also formed to support the development of the Clontarf / Bantry Bay Estuary Management Plan through expert contributions.

An extensive public consultation process and awareness campaign was undertaken through a variety of mechanisms including display panels, Manly Council's webpage, information through Precinct Newsletters, formal questionnaires and organized Field Days.

This study has been developed in-house with contribution from the 'Internal Working Group' under the guidance of the 'Clontarf / Bantry Bay Estuary Management Working Group'. The study report has gone through an extensive peer review including by state agencies.

Study Area

This study area relates to the northern portion of the Middle Harbour (part of the greater Port Jackson / Sydney Harbour) estuary and foreshore that corresponds with the Manly Local Government Area boundary. It covers an area of 350 hectares between Castle Rock and Bantry Bay and includes parts of Balgowlah Heights, Clontarf and Seaforth suburbs. The Spit Bridge, a landmark connecting northern beaches with Sydney, is located halfway along the foreshore of the study area. Population of the study area, according to 2001 census, is 5,873.

The entire study area is covered within the Sydney Harbour Foreshores and Waterways Area and excluded from the legally defined NSW coastal zone. The entire study area is also covered within the 'Sydney Metropolitan Catchment Area'.

The current land use remains predominantly residential development (65.5%), followed by road surfaces (22.0%) and open spaces and parks (10.2%). Pockets of bushland remain scattered throughout the area (which total 18.5 hectares in size), occurring mostly around the immediate estuary foreshore. Manly Scenic Walkway and Harbour to Hawkesbury Walking Tracks run through the study area. The estuary is used actively for walking, swimming, boating, sailing and passive recreation (eg- reading, meditation, picnicking). In addition, the estuary is also popular for kayaking, recreational fishing, sunbathing and walking dogs.

The study area is zoned under both the *Manly Local Environment Plan* 1988 and the *Sydney Regional Environmental Plan - Sydney Harbour Catchments 2005* or simply the Harbour REP. The Manly LEP establishes land use zones within the study area as zone 2 – Residential, 3 – Business Zone, 5 – Special Uses Zone, 6 - Open Space and Zone 8 – National Parks existing. The foreshores and waterways of the study area are located in five of the nine zones under Sydney Harbour REP: W1 (Maritime Waters), W2 (Environment Protection), W5 (Water Recreation), W6 (Scenic Waters – Active Use) and W8 (Scenic Waters – Passive Use).

The study area has a rich history, beginning with extensive Aboriginal occupation, which is evidenced through the many middens that are still present. The area was used extensively by the Aboriginals, known locally as the Gayemal clan of the Guringai tribe. The oldest Aboriginal site known in the Manly LGA is dated to about 4100 years before present. There are 22 recorded Aboriginal sites within the study area. Following European settlement in Sydney, the study area was slowly developed, until improved access made the area more desirable. In 1850 a punt began running from the Spit giving easier access to the north side. Access was further enhanced in 1924 with the opening of the first Spit Bridge. By the 1970s the area was already extensively developed.

Natural Environment – Physical Processes

The estuary within the study area exhibits semidiurnal tidal characteristics, with two high and two low tides each day. The area is not fed by any permanent creeks; however various water courses provide freshwater inflows during and after rain. In periods of wet weather, the estuary becomes stratified with the more buoyant fresh water sitting as a thin layer on the surface of the salt water.

Groundwater is an integral part of the “water cycle” and maintains the dynamics of estuarine and near-shore marine water bodies. The major aquifer class, in the study area, is consolidated porous rocks containing limited quantities of groundwater. However along the foreshores there occurs the aquifer termed ‘unconsolidated sediments’. This aquifer contains significant groundwater resources with a well defined water table that is responsive to recharge events, and even tidal influences in some cases.

Wind waves generated in Middle Harbour are generally less than 0.1m in height. Ocean swell waves penetrate lower Middle Harbour through the heads of Sydney Harbour, and undergo severe refraction and diffraction. The only place in the study area that is subject to waves from a consistent direction is the lower half (Castle Rock Beach to Sandy Bay), where ocean swell waves run along the shore. Sediment has been observed to move along the shore in the same direction, providing possible evidence of a longshore current.

Significant storm events affecting the Middle Harbour area are known to have occurred in April 1893, June 1923 and May-June 1974. The 1974 storm reported wall collapse near Middle Harbour Yacht Club and minor beach erosion at the Spit and Clontarf. The study area experienced waves and high winds from a recent storm on June 9-10, 2007 which resulted in a cruiser washing ashore at Clontarf but no serious erosion. The study area also experienced the impact of a tsunami on May 22, 1960 when a strip 100 yards by 60 yards wide was swept away from Clontarf Reserve Point Park.

From the Spit Bridge to the north western extremity of the study area, the foreshore is predominantly stable rock, with estuarine mud on the sea floor. This area is beyond the normal limit of ocean waves, and is reasonably deep, therefore creating a relatively stable sedimentary environment. However, the lower reaches, from Castle Rock Beach to the Spit Bridge, consists largely of unstable sandy shores, with a mixture of marine sand and estuarine mud on the sea floor. The estuary in this section consists of both a shallow sand bar and a deep channel. The marina at Clontarf lies directly in the path of the sand transport corridor between the tidal delta and Sandy Bay. However, the beach profile appears to have been modified from its natural state, due to the irregular shape of the shoreline between Clontarf Reserve and Sandy Bay. The large sand flat of Sandy Bay

transforms into a narrow beach with a steep drop-off on either side of Clontarf Marina, and then back into a sand flat to the south of the marina. There are many forces impacting on this part of the estuary, creating a complex system.

Natural Environment – Ecological Processes

The ecosystems within the study area are highly fragmented and have signs of the many pressures placed on them through development and high usage.

The marine environment within the study area has a diverse range of habitats. There are significant seagrass beds within the study area: the largest bed is adjacent to Castle Rock Beach and reasonably large meadows exist at Clontarf and Sandy Bay. Compared to the past, large losses of seagrass have been reported. There are several relatively deep holes within the mud basin section that provide habitat, with the deepest located upstream of the Spit Bridge. The mud basin provides habitat for various species, including invertebrates such as worms and molluscs. Over 570 species of fish have been recorded in greater Sydney Harbour, and it is likely that a large proportion of these are also present within the study area. The list includes 3 endangered, 5 vulnerable and 18 protected species.

The intertidal area within the study area has a range of habitats including rocky reefs and platforms, sandy beaches and mudflats, a few remaining mangroves and artificial habitat including seawalls, jetties and pontoons. The entire foreshore of the study area is protected as Intertidal Protected Area (IPA). Many types of algae (eg- red, green, brown) inhabit the intertidal zone, providing a food source for the many grazing invertebrates. Numerous types of invertebrates, such as worms, crabs and molluscs, can be found in the sediment. There is only one small pocket and few individual mangroves remaining within the study area. However, no salt marsh has been identified. A total of 62 species are known to be present in or directly adjacent to (and hence expected to also be in) the study area. The majority of these species are invertebrates. The Little Penguin is often sighted within the study area but no information is available on its nesting place. It feeds in the estuary during the day and nests on land during the night.

The terrestrial environment within the study area has seen the largest change. Bushland reserves occur in a total 18.5 hectares and are scattered throughout the study area. Six reserves have SEPP 19 status under EP&A Act, requiring preparation of management plans. Smaller patches of bushland on both public and private land do exist throughout, and in some places provide corridors between the reserves. There are seven specific vegetation communities present within these reserves. A total of 3 amphibian, 49 birds, 6 mammal and 13 reptile species have been recorded. Grey-headed Flying Fox (*Pteropus poliocephalus*) is the only threatened species recorded.

Human Interventions & Usage

Human activities have altered and modified the natural system of the study area. Foreshore development has been extensive. The first and major foreshore development in the study area happened with the construction of the Spit Bridge in 1924 (which was replaced by the existing bridge in 1958) and some other developments prior to this at the site: first punt operation in 1849, ferry operation in 1880 and tram services in 1900. Seawalls, both public and private, exist throughout the study area. Total length of seawalls is 2.4km, that approximately 46% of the foreshore length. Swimming baths/enclosures, Clontarf Marina and walkways including Manly Scenic Walkway are some other developments on the shore. Public access to foreshore is available at several points. There is no public pontoon/jetty in the study area but one to be constructed soon. There are sailing and yacht clubs providing boating facilities and contributing to estuary use through a number of events including racing, training etc. Manly Council is extracting 1.64 mega litres of groundwater at a depth of 6.1m for irrigation of Clontarf Reserve. Many private properties are also abstracting groundwater. Stormwater now flows through 16.0 km artificial drainage networks. The estuary is used actively for walking, swimming, boating & sailing and passive recreation (eg- reading, meditation, picnicking) with reasonable degree of use for kayaking, recreational fishing, sunbathing and walking dogs. Dogs are allowed on a leash in the Clontarf Reserve. These alterations have all impacted the natural environment.

There exist conflicts between different user groups and the impacts that competing users have on the environment. Examples of some of these conflicts identified include:

- Seawalls for protection of properties versus its damaging impact on natural ecosystem
- Groundwater abstraction and possible saline water intrusion in aquifer
- Beach raking for safety versus its impact on invertebrates
- Dog walking off leash and impact on shore birds
- Powered and sailing boats and their wake impacting on seawalls and beach erosion
- Access to mooring versus their impact on seagrass beds, ability to spread *caulerpa taxifolia*
- Powered boats and the safety aspects for swimmers and kayakers
- Ad hoc boat storage and its impact on amenity and habitat:
- Ad hoc access ways to foreshore for convenience versus destruction of habitat.

Processes & Impacts

With most parts of the Clontarf/Bantry Bay EMP study area being highly urbanised, there is significant pressure placed on water quality health. Despite the reported improvements in water quality recently, pollution is indeed still evident, particularly in times of rain when stormwater transports terrestrial pollutants into the estuary. Loads of pollutants in the estuary from the study area have been estimated at 2250 kg/year of total nitrogen; 260 kg/year of total phosphorus; 180 kg/year of copper, 230 kg/year of lead, 490 kg/year of zinc, and 128,000 kg/year of sediment. Four Gross Pollutant Traps (GPTs) are currently installed in the Clontarf / Bantry Bay Catchments. The Department of Primary Industries has placed a ban on all commercial fishing within Sydney Harbour including the study area, because of the presence of elevated levels of dioxins in fish and crustaceans. Of the three swimming pool/baths, Sangrado bath is the worst in terms of bacterial contamination. There are 5 known sewer overflow locations within the study area.

The study area is used extensively by a variety of vessels, particularly between Castle Rock Beach and Seaforth Bluff. This section of the waterway is the only access between greater Sydney Harbour and upper Middle Harbour, so all vessels wishing to travel between the two must pass through. Boat generated waves over time can cause foreshore erosion and weaken sea walls. They can impact on habitat. Boating can, in addition, impact on water quality via spills, anti-foul paints, littering from boats and from marinas where boats are washed and fixed etc. A No Wash Zone is in place between Clontarf Point and Seaforth Bluff. An 8 knot speed limit zone is also in place, between Clontarf Point and d'Albora Marina (Mosman side of Spit Bridge).

Erosion in the study area occurs along beaches, in front of stormwater outlets, along ad hoc access tracks, and where foreshore protection structures such as seawalls are collapsing. Beach erosion has been experienced at 4 sections of Clontarf Beach and Sandy Bay with varying degrees of severity, and fluctuations over time. Accelerated erosion occurs as a result of the concentration of stormwater flows through artificial drainage networks. The study area, specially the Clontarf Swimming area, also regularly experience siltation. The study area is susceptible to slope and cliff instability, with a large landslip having occurred at Seaforth Crescent in 1956.

An ecosystem health card has also been developed for the study area.

The study area will experience many of the impacts of climate change, with the low lying areas close to the foreshore likely to be subject to more of the impacts than the elevated areas. These impacts are likely to include: sea level rise; increases in extreme weather events; temperature increases; reductions in water availability; altered hydrology and increased flash flooding; and more frequent and more severe droughts (Hennessy et al, 2006).

Community Key Concerns

Concerns of the community were expressed through different means and at different occasions. More directly, a total of 120 survey forms were completed and returned throughout the consultation process. On marine based issues, water pollution, marine flora & fauna and conservation management issues, in broader perspectives, are of high concern of the community. Among land-based issues, pollution, storm water management, terrestrial flora & fauna, conservation management and foreshore walkway issues are of high concern. Climate change issue is also appeared to be of key concern.

Significance and Values of the Estuary

The Clontarf/Bantry Bay estuary is locally significant in its role as a habitat for native animals and plants, a provider of popular recreational resource for locals and visitors alike. The attraction of Clontarf/Bantry Bay is enhanced by its generally good water quality. Because of its scenic beauty and views, foreshores have already become highly sought after residential area. At present, 65% of the foreshore is under residential land use compared to 37% within Manly LGA. The Clontarf/Bantry Bay waterway has a very high economic value and is important to a range of stakeholders, ranging from local retailers to commercial tourism operators, real estate operators, boating services, marinas and support industries.

The study area is rich in Aboriginal cultural heritage giving it significance at the regional and state level. European cultural heritage is also an important feature of the study area with numerous heritage listed sites and buildings including public baths located along the shoreline, including Clontarf, Sangrado and Pickering Point. There exists several floras and fauna recorded as threatened, making the study area important.

The following values reflect attributes, activities and processes that are of importance to the community, and are the qualities on which the study area depends for its attractiveness, desirability, liveability and use.

- aesthetic values associated with a pleasant, appropriate and 'green' landscape character.
- physical values associated with estuary foreshore and processes. For example residents and visitors value being able to access and experience the foreshore and associated views.
- biophysical values associated with the protection and improvement of aquatic, inter-tidal and terrestrial environments. These include estuarine habitat, intertidal habitat, mixed rocky intertidal with sand, sandy beaches, sea grass beds, open forests, urban bush lands and reserves, mangrove forests and wetlands.
- cultural values associated with the area's indigenous and non-indigenous heritage and the identification of significant Aboriginal sites. The Aboriginal Heritage Office has recorded 22 Aboriginal sites within the study area.
- accessibility values associated with convenient access to all public areas. For example people value the ability for all people to access foreshores and enjoy the area.
- recreational values associated with an enjoyable environment for all users, visitors and local residents. For example people value being able to undertake various recreational activities in public places, both on land and on the estuary.
- Economic values associated with a number of economic activities.

Data Gaps & Further Studies Required

There exist various data gaps. These are related to sediment budget & movement, water quality, cliff & seawall stability, groundwater abstraction, loss of seagrass, little penguins and climate change issues. DECC will undertake photogrammetry of sandy shorelines (and possibly further hydro surveys) to better understand sediment processes.

ii ABBREVIATIONS

ANZECC	Australian and New Zealand Environment Conservation Council
AHO	Aboriginal Heritage Office
CBD	Central Business District
CSIRO	Australia's Commonwealth Scientific and Industrial Research Organisation
DCP	Development Control Plan
DDT	Dichlorodiphenyltrichloroethane
DEC	NSW Department of Environment and Conservation
DECC	NSW Department of Environment and Climate Change
DIPNR	The former NSW Department of Infrastructure Planning and Natural Resources
DNR	NSW Department of Natural Resources
DPI	NSW Department of Primary Industries
EIS	Environmental Impact Statement
EMA	Emergency Management Authority
EMP	Estuary Management Plan
EMS	Estuary Management Study
EPI	Environmental Planning Instrument (includes LEP, REP and SEPP)
EPS	Estuary Process Study
EPA	NSW Environment Protection Authority (DEC, recently changed to DECC)
ESD	Ecologically Sustainable Development
GIS	Geographic Information System
GSE	Graduate School of Environment, Macquarie University
IPA	Intertidal Protected Area
IPCC	Inter-Governmental Panel for Climate Change
LEP	Local Environmental Plan
LGA	Local Government Area
MSW	Manly Scenic Walkway
MSB	Maritime Services Board
NHT	National Heritage Trust
NRM	Natural Resources Management
NSW	New South Wales
RAN	Royal Australian Navy
REP	Regional Environmental Plan
SAP	Scientific Advisory Panel (of the Manly Council)
SCCG	Sydney Coastal Council Group
SEPP	State Environmental Planning Policy
SREP	Sydney Regional Environmental Plan
SREPP	Sydney Regional Environmental Planning Policy
UWS	University of Western Sydney
WPA	Wetlands Protection Area

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1. INTRODUCTION

1.1 ESTUARY MANAGEMENT IN NSW

NSW has over 130 estuaries that vary in size from small coastal creeks and lagoons to large lakes and rivers. The estuaries of NSW provide a priceless natural resource. Collectively, they are immensely valuable from an ecological, social and economic perspective. These estuaries contribute $400 million to the State's economy per annum (DNR 2006). Estuaries contain diverse ecosystems that form the foundation of the coastal food chain. They provide important habitats for a variety of marine and terrestrial plants and animals.

Estuaries have a special place in the lives of most Australians. In NSW, over 75% of the population live and work in towns and cities near estuaries. A high proportion of the State's commercial activity occurs near estuaries as they provide an important focus for industry, tourism and recreational activities. This high level of development pressure means that estuaries are subject to a range of direct and indirect impacts due to land use in the catchment, changes to hydrology and tidal processes and the direct use of the estuary waterway.

Pollutants that originate within a catchment eventually end up in an estuary affecting the water quality and estuarine ecosystem. Altered hydrology of estuaries may lead to increased sedimentation, altered freshwater flows and changes in tidal flushing. Estuaries have been used as dumping areas for solid wastes and sewage effluent discharges. They have been dredged, filled in, had their entrances trained with break-walls, and wetlands associated with them have often been destroyed. These changes can have profound impacts on estuarine and coastal ecosystems.

The State Government co-ordinates key strategic initiatives for the sustainable management and use of important natural resources. The Department of Climate Change (DECC, formerly DNR) provides financial and technical assistance to councils to help develop and implement sustainable estuary management plans through the Estuary Management Program. The Program was commenced in 1992 to assist local government to better manage estuaries through a strategic process outlined in the NSW Estuary Management Manual[1]. It targets a broad range of issues and engages local communities in the process. The program focuses on improving or maintaining the overall health and functionality of an estuary, and maintaining the integrity of the whole system - its chemical, physical, and biological properties, as well as its economic, recreational, and aesthetic values.

The Estuary Management Program encourages local communities to take responsibility for managing their own estuaries. An Estuary Management Committee is established by the local Council and is made up of members of the community - local residents, industry representatives, environmental interest groups and researchers as well as representatives from local government and state agencies responsible for managing the estuary's resources. These stakeholders work together to identify problems in the estuary, evaluate various management options, develop specific actions to address those problems, and create and implement a formal Estuary Management Plan to restore and protect the estuary.

The State Government provides significant annual funding to assist councils to prepare and implement the plans. The Department administers the Estuary Management Program, but program decisions and activities are carried out by the committees of local government.

1.2 COASTAL ZONE MANAGEMENT IN MANLY

Manly is known distinctively for its beaches and foreshore areas. For this reason it is vitally important that the waters and natural features around these beaches and foreshores are nurtured and protected. The majority of the Manly

1 A new Coastal Zone Management Manual is being prepared to combine and revise the existing Coastline and Estuary Management Manuals. The manual is being drafted in two volumes. Volume 1 deals with the generic process of developing coastal zone management plans and the inter-relationships with other land use and NRM plans and policies. Volume 2 provides the technical appendices to support the coastal zone management planning process and is being developed as an electronic, web-based document to enable regular updates of new information. During 2006 an initial draft of Volume 1 of the manual was circulated for agency comment. Comments are being incorporated in a revised draft which will be released for public comment (DNR 2006).

Local Government Area is bordered by water. Foreshore areas are under constant attack from natural elements such as wind and waves. Manly's coastal and harbour foreshores respond naturally to these processes, however human activities also contribute to modify them.

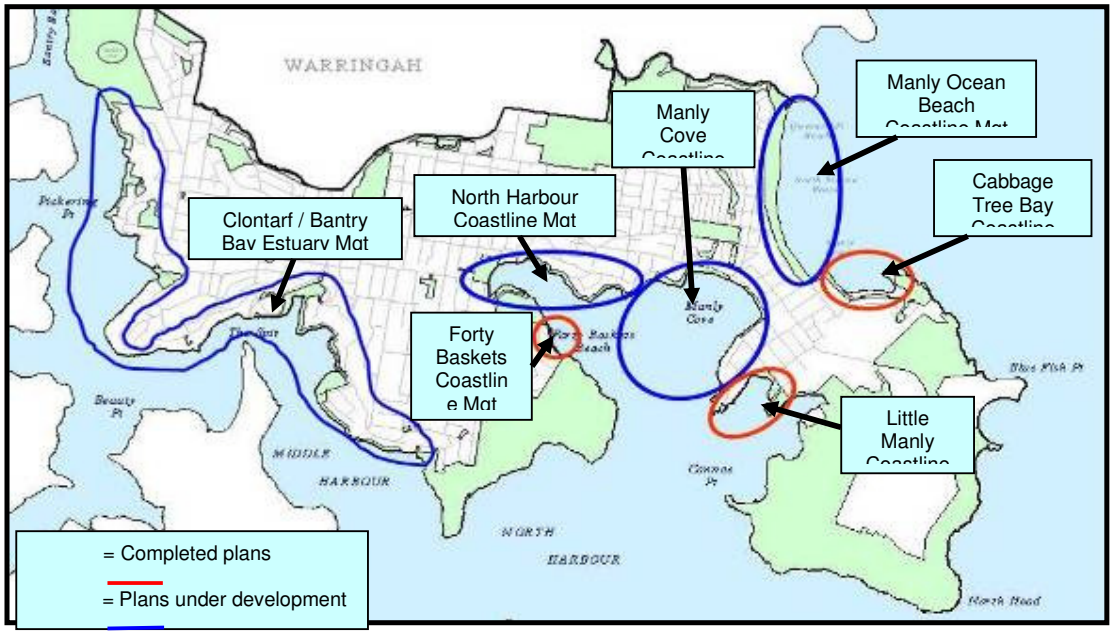
In line with efforts of NSW State Government, Manly Council has also embarked on planning and management of coastal and estuarine areas. The importance of coastal and estuarine management has been significantly highlighted in all key policy, vision & strategy documents adopted by Manly Council. One of the key theme areas of the Manly Sustainability Strategy (2006) is 'A Natural, Sustainable Manly'. The theme adopts the principle '*Recognise the intrinsic value of Manly's geodiversity, biodiversity and natural ecosystems, and protect and restore them*' and includes the 'Coastline and Estuary Management Program'.

Manly Lagoon Estuary Management Plan was adopted in 1998. Recently, Manly Council has adopted a staged approach to manage the entire Manly foreshore and has divided the foreshore into geographical sections sharing similar issues (Figure 1.2). Coastal Zone Management Plans have been prepared, or are being prepared, for the following areas:

- Forty Baskets
- Little Manly
- Manly Cove
- North Harbour
- Cabbage Tree Bay
- Manly Ocean Beach

The Clontarf / Bantry Bay Estuary Management Plan will complete the coverage of the entire foreshore.

Figure 1.2 – Coastline & Estuary Management Planning in the Manly LGA



Nb- areas specified above do not indicate management plan boundaries

1.3 THE CLONTARF / BANTRY BAY ESTUARY MANAGEMENT PLANNING PROCESS

As indicated in section 1.1, the NSW Government, through its 'Estuary Management Manual' (1992), provides a strategic process for the development of Estuary Management Plans in NSW, which is to be adapted by the local estuary management committee to suit local conditions. The Clontarf / Bantry Bay Estuary Management Working Group have identified the following tasks (Table 1.3) to guide the preparation of the Clontarf / Bantry Bay Estuary Management Plan.

Table 1.3 – Steps & Tasks for Developing the Clontarf / Bantry Bay Estuary Management Plan

Steps	Tasks	
Step 1 **Establish an Estuary Mgt Working Group**	1	Finalise format of Working Group
	2	Determine stakeholders
	3	Advertise for members (ensuring all relevant stakeholders are notified)
	4	Finalise members and have Working Group endorsed by Manly Council
	5	Start meeting with Working Group
	6	Establish an in-house council project team and meet on an as-needs basis
Step 2 **Assemble existing data**	1	Identify and formalise study area & boundaries
	2	Familiarisation of study area - undertake terrestrial and on-water ground truth with relevant stakeholders
	3	Community consultation - develop plan with Working Group and begin undertaking (eg- surveys, public events, letters to residents and stakeholders, media / adverts)
	4	Manly Council staff consultation - identify key relevant staff members, and hold focus groups to gather information
	5	Identify and liaise with one Manly Council Town Planner to assist with relevant planning issues
	6	Gather all existing data, reports, studies, maps - review, assess & document
	7	Assess data gaps that may need to be filled in later and / or instigate studies
Step 3 **Develop an Estuary Processes Study**	1	Determine baseline data - investigate biological & physical systems (using info collected in Step 2)
	2	Start preparing maps/figures/graphs of data
	3	Determine current uses & conflicts of use for study area
	4	Identify essential features of estuary
	5	Prepare the Estuary Processes Study document
	6	Comments & amendments to Estuary Processes Study
	7	Working Group endorsement of Estuary Processes Study
Step 4 **Carry out an Estuary Management Study**	1	Continue community consultation
	2	Develop management options & objectives (including outcomes from the Estuary Processes Study) and assess planning controls, works and other strategies to achieve objectives
Step 5 **Prepare a Draft Estuary Management Plan**	1	Consolidate Steps 2,3,4
	2	Prepare the draft document & offer mgt recommendations, actions, responsibilities & a schedule of costs and activities
Step 6 **Review Draft Estuary Management Plan**	1	Obtain endorsement from EM Working Group and State Govt agencies, and then provide a report to Manly Council to endorse draft document to go on public exhibition
	2	Provide copies of draft document to all stakeholders for comment and place on public exhibition
	3	Review and incorporate (where appropriate) all comments, and prepare final document
Step 7 **Adopt & implement Estuary Management Plan**	1	Provide a report to Manly Council to adopt final Estuary Management Plan
	2	Submit Estuary Management Plan to State Government Organisations for endorsement
	3	Seek funding for EMP implementation
	4	Begin implementation where possible
Step 8 **Monitor and Review**		Continue implementation of EMP - monitor & review as appropriate

1.4 ESTUARY MANAGEMENT WORKING GROUP

The first step in the planning process of the preparation of an EMP is the establishment of a committee to guide its development. As such, Manly Council resolved at its Planning & Strategy Committee meeting on 8 May 2006 to establish the Clontarf / Bantry Bay Estuary Management Committee, as a sub-committee of the existing Harbour Foreshores Committee. This committee has been renamed as the 'Clontarf / Bantry Bay Estuary Management Working Group', with aims and objectives, as follows:

- Provide a forum for discussion between Manly Council and the community on issues relevant to the development of the Clontarf / Bantry Bay Estuary Management Plan
- To conduct regular meetings and make recommendations to the Harbour Foreshores Committee and/or the General Manager on matters arising from the meetings.
- To guide & monitor the development of the Clontarf / Bantry Bay Estuary Management Plan

Council invited written Expressions of Interest from members of the Community with the appropriate aptitudes, motivation and skills to serve as Community Representatives on the Clontarf / Bantry Bay Estuary Management Working Group. The group, at present, has representations from the Manly Council, community precincts, Government organisations, Manly Council's Scientific Advisory Panel, neighbouring councils, local community and from the Aboriginal community. The status of the Working Group is advisory.

In order to support this Working Group and to obtain expert contribution to the process study, an *Internal Staff Working Group* was also formed.

The present membership of both these groups is presented in the inner cover page of this report.

1.5 PUBLIC CONSULTATION

A vital part in the estuary management planning process is community involvement and action. Hence, an extensive awareness campaign and consultation process is being undertaken in the development of the Clontarf / Bantry Bay Estuary Management Plan. Various mechanisms for consultation are summarized below.

Display Panels: A series of A3 Display Panels were created to assist in marketing the EMP development. They were designed and used for various events and displays. A4 laminated posters were displayed on the door of all the four Freebie Hop, Skip & Jump buses to reach as many people as possible.

Webpage: A webpage has been created on Manly Council's website (www.manly.nsw.gov.au) to allow easy access to information relevant to the plan.

Precinct Newsletters: Articles were regularly sent to the Precinct groups for inclusion in their monthly newsletter.

Survey: Two survey forms were produced to assist people in providing input into the development of the EMP – a comprehensive survey and a brief survey. The survey forms were distributed through various means, and were emailed or posted to people upon request. A total of 120 filled in survey forms were returned.

Field Days: Two community consultation field days were held within the study area –Clontarf Reserve (October 21, 2006) and Seaforth (November 12, 2006). The Seaforth field day was held as part of the Seaforth Centennial Event.

Detailed outcome from these community consultations is presented in Chapter 9 of this report. However, information from surveys has also been used in other chapters as found relevant.

1.6 DATA COMPILATION & ESTUARY PROCESSES STUDY

The second and third steps in the planning process of the preparation of an EMP are to assemble data and based on available data, develop an Estuary Processes Study. The purpose of an estuary processes study, according to Estuary Management Manual (NSW 1992), is to define the 'baseline' conditions of the various estuary processes, and the interaction between these processes so that actions in the next stage management study and plan are technically sound. In designing an estuary processes study, it is important that the interactions between physical, chemical and biological processes occurring in the estuary itself, and between estuarine, ocean and upstream catchment processes, be recognised at the outset, (eg the significance of ocean flushing and the action of surface run-off in delivering freshwater and its dissolved and suspended constituents, to the estuary).

The following items may be part of the overall processes/characteristics considered,

- **hydraulics:** tidal, freshwater, flushing, salinity, water quality and sediment behaviour etc
- **biology:** habitats, species, populations, endangered species etc
- **impacts:** impact of human activities on hydraulics and biology

This particular 'Estuary Processes Study' addresses processes evident in and impacting upon the study area both natural and human induced. Although in reality all of these processes are inherently linked, for the purposes of this study they have been divided into: Natural Environment – Physical Processes; Natural Environment – Ecological Processes; and Human Interventions & Modifications.

This study addresses how and why the various processes are occurring, and the likely impacts of each process (and interactions between processes). In this regard, all social, economic and environmental issues that affect the study area have been considered for inclusion throughout the Estuary Management Process. The broader Estuary Management Process is designed to incorporate the principles of Total Catchment Management, and also aims to include issues across the Triple Bottom Line.

The Estuary Management Study and Estuary Management Plan (as follow-up of this study and indicated in Table 1.3) will use the outcomes from this document to discuss a range of management options available to address key issues, and will adopt a set of agreed management actions.

This study has been developed in-house with contribution from the 'Internal Working Group' under the guidance of the 'Clontarf / Bantry Bay Estuary Management Working Group'. A detailed 'Stormwater Quality Desktop Study' was also internally done to support this process study and the report has been appended herewith.

Peer review

The study report has gone through an extensive peer review.

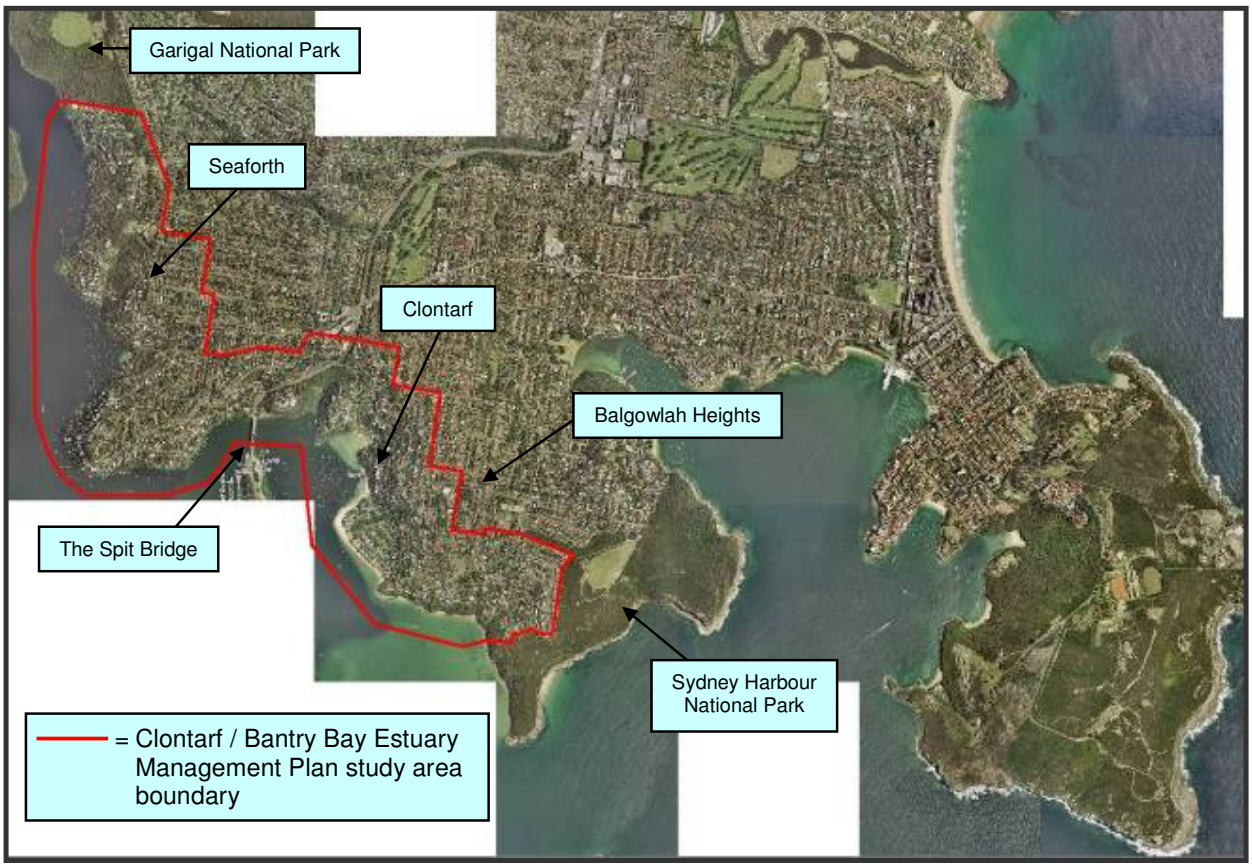
Members of the Internal Working Group have reviewed the preliminary draft. Daniel Wiecek and his colleagues at the DECC have also reviewed the preliminary draft and contributed written comments. A final draft was prepared accommodating comments and suggestions made by members of the Internal working Group and the DECC. The final draft was distributed to members of the 'Clontarf / Bantry Bay Estuary Management Working Group' for review, comments and contribution. Written contributions with additional information were received from the AHO (on Aboriginal heritage items), the NSW Maritime (on houseboat) and the DECC (overall review). The 'Clontarf / Bantry Bay Estuary Management Working Group', at its meeting on July 09 2007, endorsed the report pending incorporation of comments made by the Group. As per suggestion from the DECC and to align the report to Coastal Zone Management Manual (draft, approval pending), two chapters on 'Community Consultations & Key Concerns' and 'Significance and Values of the Estuary' have been added in this report. This Final Report accommodates all comments and suggestions received since. The Final Report has been posted on Council's website to further facilitate community contributions.

2. STUDY AREA

2.1 SITE DESCRIPTION

This study will address the northern portion of the Middle Harbour (part of the greater Port Jackson / Sydney Harbour) estuary and foreshore that corresponds with the Manly Local Government Area boundary. The boundaries of the study area (see Figure 2.1a below) are Sydney Harbour National Park at the south-eastern extremity and Garigal National Park at the north-western extremity. The study area boundary on the terrestrial side is the ridgeline, to ensure that the Plan adopts a total catchment management focus, which incorporates the relevant sub-catchments that drain to the foreshore. On the aquatic side the boundary extends to approximately the middle of the waterway. The Spit Bridge, a landmark connecting the northern beaches with Sydney, is located almost midpoint along the length of the foreshores of the study area.

Figure 2.1a – Aerial view of the Clontarf / Bantry Bay study area

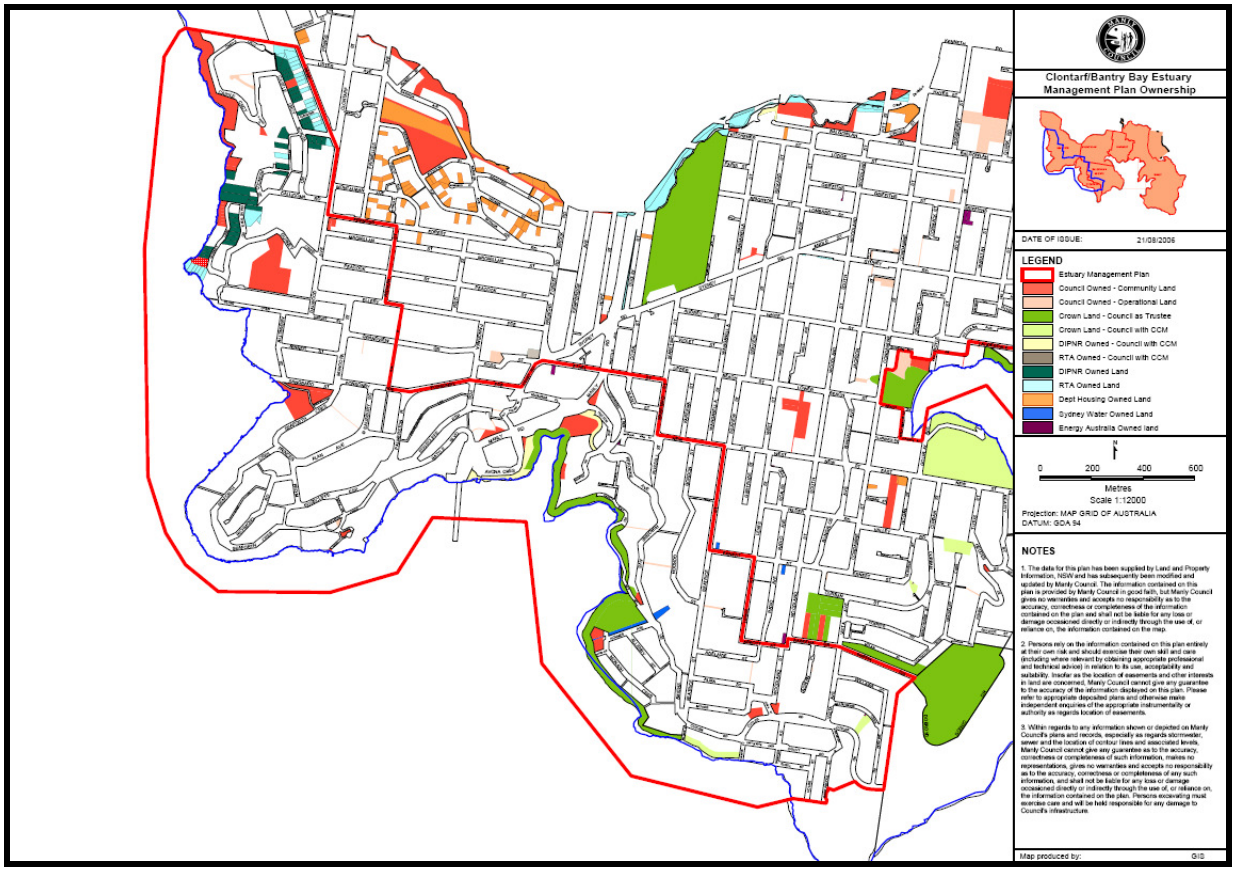


The study area covers an area of approximately 350 hectares, with a perimeter of approximately 11.5km, and takes in the suburbs of Balgowlah Heights, Clontarf and Seaforth, and also the local Precinct Community Forum areas of Balgowlah Heights, Clontarf and Seaforth. The entire study area is covered within the Sydney Harbour Foreshores and Waterways Area and is excluded from the legally defined NSW coastal zone. The entire study area is also covered within the Sydney Metropolitan Catchment Area. The catchment has an area of 1860 sq.km. and involves 39 LGAs including Manly.

Ownership of and management responsibilities for the land and seabed within the study area is shared by a number of government authorities and Manly Council. In general, land ownership of Clontarf/Bantry Bay EMP study area consists of private, Crown, Manly Council, Department of Environment & Climate Change, Sydney Water and Energy Australia owned and administered land, with Crown Land representing by far the major

public land holding (Figure 2.1b). NSW Maritime is responsible for the management of waterways and the Department of Lands is the land owner of the seabed.

Figure 2.1b – Land ownership within the Clontarf / Bantry Bay study area



Bathymetry of the aquatic side of the study area is presented in Figure 2.1c. The map has been acquired in January 2007 from the NSW Maritime.

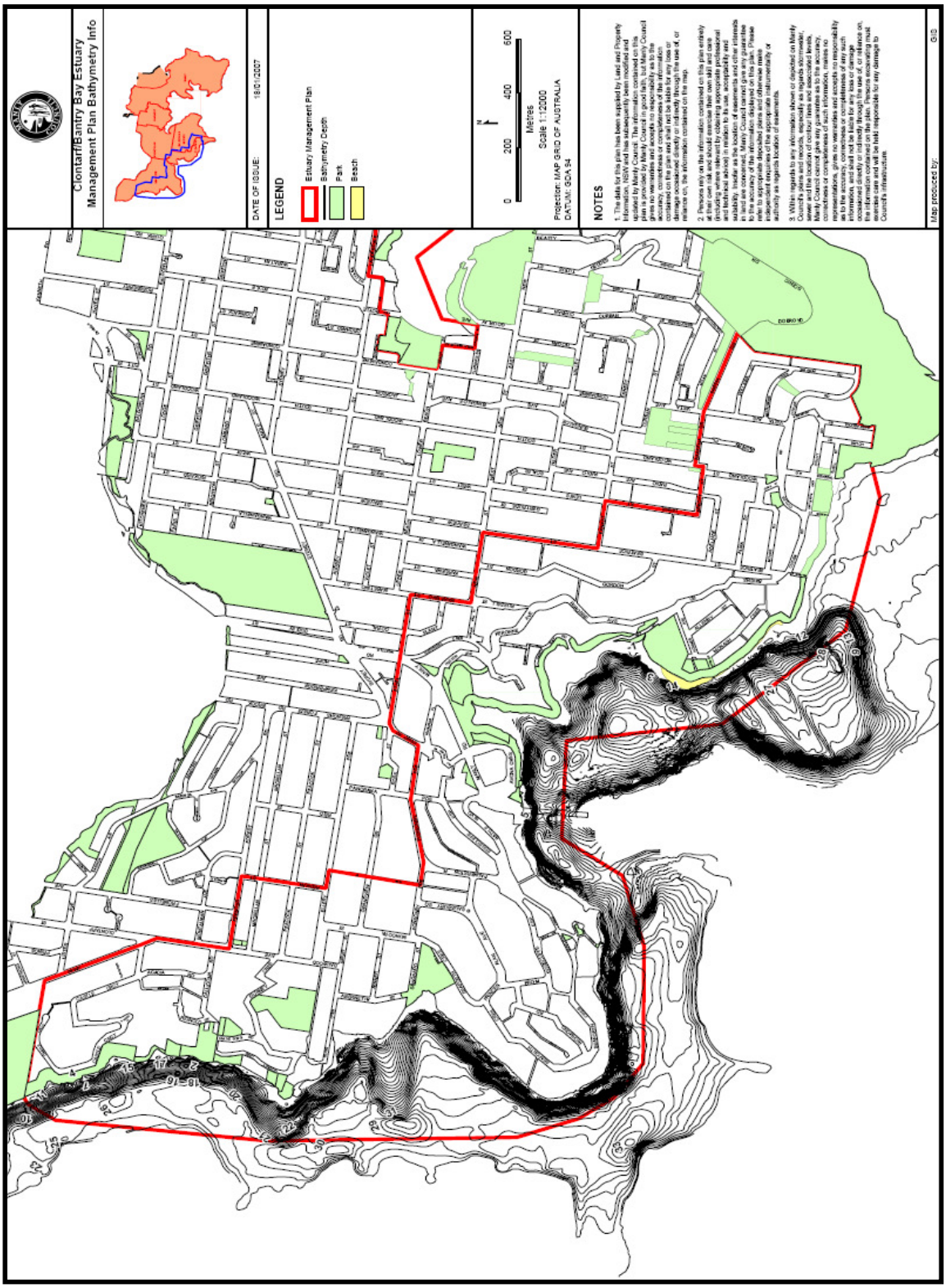


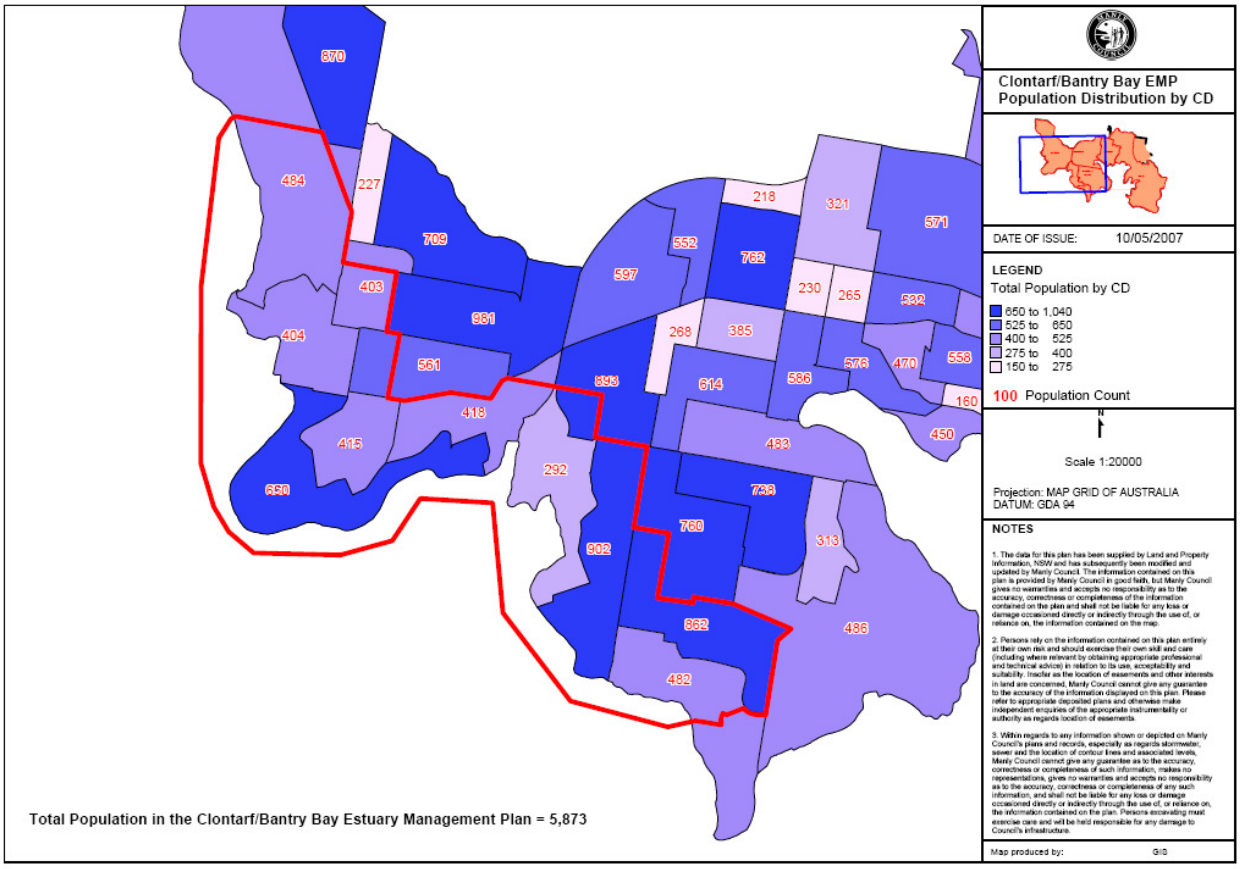
Figure 2.1c – Bathymetry of the Clontarf / Bantry Bay Estuary

2.2 DEMOGRAPHY

Population of the study area, according to 2001 census, is 5,873 (Fig 2.2). The study area consists of less populated suburbs in Manly LGA such as Balgowlah Heights, Clontarf and Seaforth. Although there occurred a census in August 2006, no suburb level data is yet available. However, according to Census 2006 report (ABS 2007), there were 37,110 persons usually resident in Manly LGA: 48.7% were males and 51.3% were females. Of the total, 17.5% were children aged between 0-14 years, and 24.8% were persons aged 55 years and over. The median age of persons was 37 years, compared with 37 years for persons in Australia. In the 2006 Census, there were 9,363 families in Manly LGA: 43.9% were couple families with children, 43.4% were couple families without children, 11.2% were one parent families and 1.6% were other families.

In Manly LGA, the median weekly individual income for persons aged 15 years and over who were usual residents was $790, compared with $466 in Australia. The median weekly household income was $1,705, compared with $1,027 in Australia.

Figure 2.2 – 2001 population distribution in the Clontarf/Bantry Bay study area.



An important feature of Manly LGA is that it receives approximately six million visitors annually, of which 75-88% are day visitors attracted to beaches, marine activities and the ferry ride (UWS 2005). These visitors mostly are focussed on the Corso and nearby beaches. The study area, being more natural and green, is destination of mostly nature lovers and family visitors. Fifty per cent of all visitors heading towards Manly and northern beaches arrive by cars crossing the 'Spit Bridge' in the study area and often make brief stopovers.

2.3 CLIMATE

The climate in the Middle Harbour area is dictated by its latitude and proximity to the ocean, and is generally temperate (Willing & Partners, 1999).

Table 2.3 summarises the key climate data for the study area showing mean monthly figures. Temperature and evaporation data was originally sourced from Riverview Observatory, which lies on the Sydney CBD side of the greater Sydney Harbour estuary system. Rainfall data has been obtained from the Bureau of Meteorology's Manly Dam rainfall station, between 1907 and 2002. The mean rainfall figures were calculated using a total of 58 years from within this period, as years with incomplete data were not included in the calculations.

Table 2.3 - Mean Monthly Rainfall, Evaporation & Temperature

Month	Mean Daily Minimum Temperature (°C), 1909 to 1997, Riverview Observatory [1]	Mean Daily Maximum Temperature (°C), 1909 to 1997, Riverview Observatory [1]	Mean Total Monthly Rainfall (mm) 1907 to 2002, Manly Dam [2]	Mean Total Monthly Evaporation (mm), 1993 to 1999, Riverview Observatory [1]
January	17.3	26.3	111.4	157.9
February	17.5	26.3	112.2	122.3
March	15.9	25.1	121.9	136.8
April	12.7	22.6	139.6	102.2
May	9.7	19.5	124.2	79.8
June	7.5	17.0	101.4	64.7
July	6.2	16.6	103.7	73.9
August	6.9	18.2	72.4	103.6
September	9.0	20.5	70.1	115.9
October	11.8	22.6	70.8	152.5
November	13.9	24.2	86.1	160.6
December	16.1	25.6	87.3	180.0
Total	N/A	N/A	**1201.1**	**1450.2**

Source: [1] = Willing & Partners, 1999; [2] = Bureau of Meteorology

2.4 GEOLOGY & SOILS

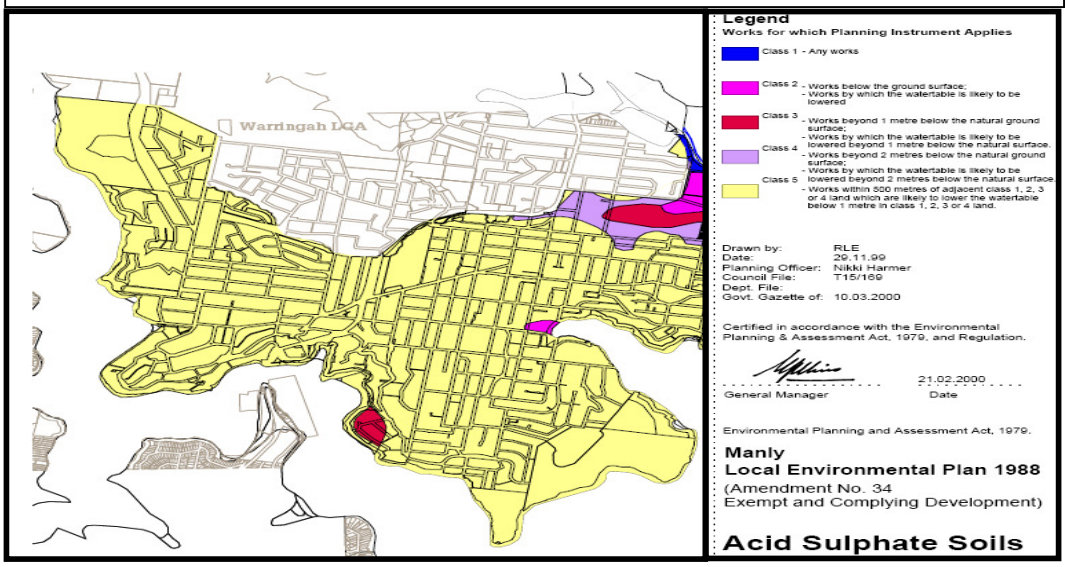
The geology of the area is dominated by Hawkesbury sandstone, which overlies the Newport Formation of the Narrabeen group. A shale sequence marks the top of the Newport formation. The Hawkesbury sandstone is characterised by medium to coarse quartz sandstone, while the Newport formation is characterised by imbedded laminite, shale and quartz to lithic-quartz sandstone (Manly Council, 2006).

The soils of the area are derived predominantly from the Hawkesbury sandstone, and are generally shallow and highly erodable, with low fertility. There are small pockets of different soil types scattered throughout the study area, such as the Woy Woy group, which is found at Clontarf. Urban development has the ability to significantly increase the nutrient level in these soils, which in turn alters the flora that is able to survive. This is evident in and around various watercourses within the study area, where nutrient rich runoff has altered the fertility of the soil and encouraged the growth of exotic plant species (Willing & Partners, 1999).

Potential acid sulphate soil sites have been identified within the study area by Manly Council (Figure 2.4), and are located at Clontarf Reserve and surrounds. Willing & Partners (1999) also suggest that acid sulphate soils could potentially exist in the heads of any bays and at any creek mouths, such as Fisher Bay and Powder Hulk Bay (although these are not indicated on the map). Acid sulphate soils occur when soils containing naturally occurring iron sulphide are dried and exposed to the air, usually as a result of human activity. In air, iron sulphides are oxidised and sulphuric acid is produced (DNR, 2006). This sulphuric acid has the potential to

leach into the surrounding environment, where it can affect the health of waterways, groundwater, aquatic and terrestrial plants and animals, and also causes damage to engineering structures (Willing & Partners, 1999).

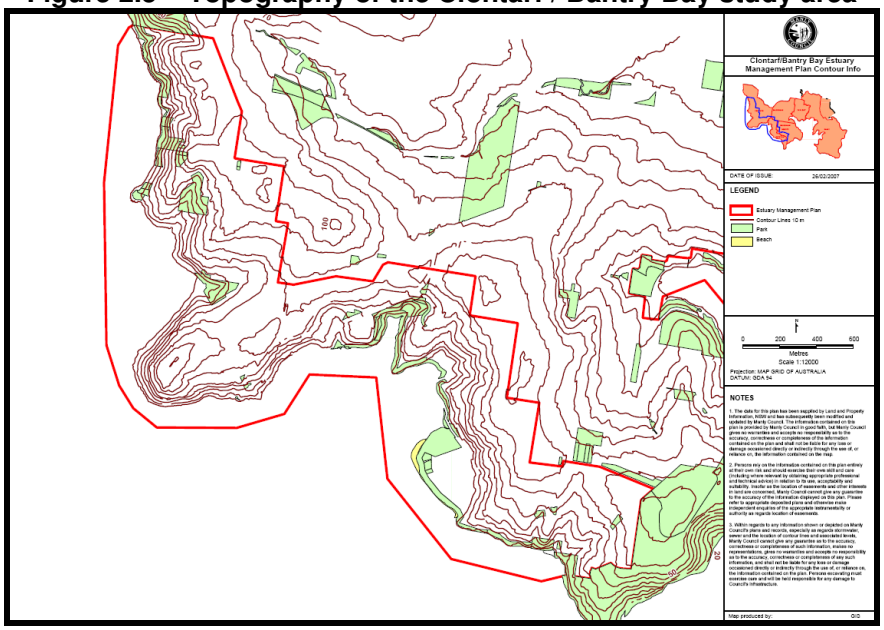
Figure 2.4 – Potential Acid Sulphate Soils within the Clontarf / Bantry Bay Study Area



2.5 TOPOGRAPHY

The study area is dominated by drowned river valleys with a ridge-line that closely follows the entire shoreline, and rises at an altitude of 100m at Seaforth above Pickering Point (Figure 2.5). This results in a generally very steep escarpment that drops rapidly to the foreshore through the various bays, valleys and headlands (Manly Council, 2006). This steep terrain has implications for stormwater management, public access to foreshores, erosion, and the potential for land slip.

Figure 2.5 – Topography of the Clontarf / Bantry Bay study area



2.6 PRESENT LAND USES & ZONES

The current land use within the study area is shown in Table 2.6. Land use is predominantly residential development (65.5%) compared to only 37.2% within Manly LGA. This is followed by road surfaces (22.0%) and open spaces and parks (10.2%). Along much of the foreshore, to the west and north of the Spit Bridge, development comes right down to the waters edge, with public access mostly limited to the beaches within each embayment. To the east and south of the Spit Bridge the immediate foreshore is predominantly bushland, beaches and headlands with extensive public access, largely due to the Manly Scenic Walkway.

Pockets of bushland remain scattered throughout the area (which total 18.49 hectares in size), occurring mostly around the immediate estuary foreshore, with the National Parks at each extremity of the study area (Garigal at the north-west and Sydney Harbour at the south-east) providing more extensive expanses of bushland, smaller patches of bushland on both public and private land do exist throughout, and in some places provide corridors between the reserves (Further information under section 4.3.1).

Table 2.6 - Land-use breakdown in the six Clontarf / Bantry Bay Catchments in Manly Council

Catchment Name	Area (sq m)	Land use Breakdown (%)			
		Residential	Open Space^	Roads	Other*
Gurney Crescent	319,923	62.4	15.1	18.4	4.2
Bligh Crescent	179,511	55.3	13.2	17.9	13.6
Sangrado Street	428,540	75.6	4.3	20.1	0.0
The Spit	474,719	62.4	10.5	26.1	1.0
Clontarf	610,506	65.2	10.6	22.5	1.7
Castle Rock Reserve	292,324	65.9	10.3	23.8	0.0
Study Area	**2,305,524**	**65.5**	**10.2**	**22.0**	**2.3**
Manly LGA		**37.2**	**30.9**	**14.6**	**17.3**

^ includes both open spaces and national parks; * includes commercial, special use property and unzoned

Zoning

The study area is zoned under both the *Manly Local Environment Plan* 1988 (Manly LEP) and the *Sydney Regional Environmental Plan - Sydney Harbour Catchments 2005* or simply the Harbour REP. The Harbour REP does not affect any existing land-based zoning under any other environmental planning instruments, such as councils' local environmental plans. The comprehensive waterways zones have been specifically tailored to suit the differing environmental characteristics and land uses of the Harbour.

The Manly LEP establishes land use zones within the Manly LGA. Land within the study area is zoned as 2 – Residential, 3 – Business Zone, 5 – Special Uses Zone, 6 - Open Space (including areas to be acquired) and Zone 8 – National Parks existing (including parks to be acquired) , as shown in Figure 2.6a.

The foreshores and waterways of the study area are located in five of the nine zones under Sydney Harbour REP: W1 (Maritime Waters), W2 (Environment Protection), W5 (Water Recreation), W6 (Scenic Waters – Active Use) and W8 (Scenic Waters – Passive Use), as shown in Figure 2.6b.

Figure 2.6a – Land zoning within the Clontarf / Bantry Bay study area

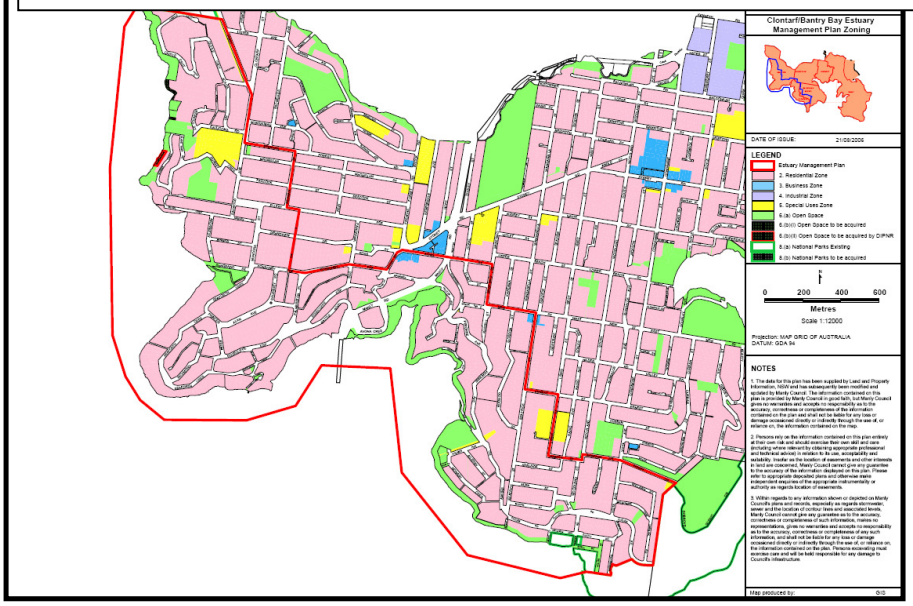
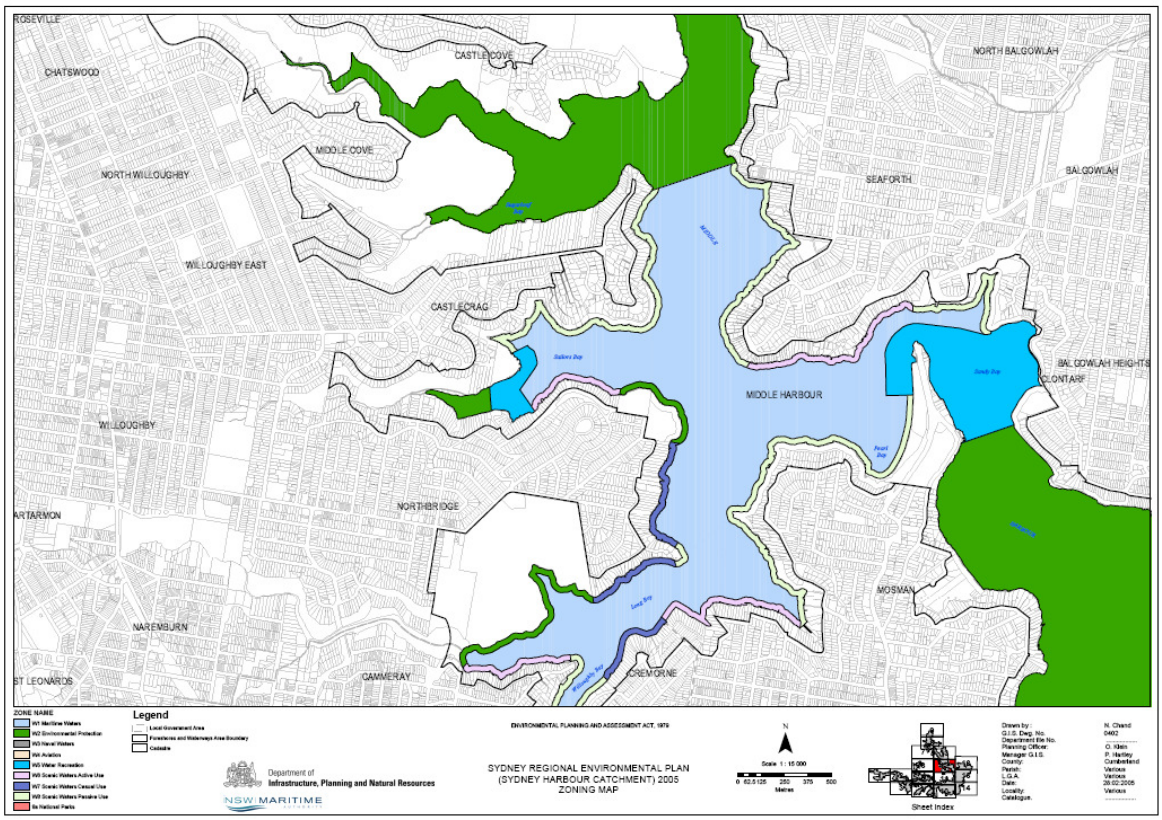


Figure 2.6b – Zoning map of Sydney Harbour showing the Clontarf / Bantry Bay study area



2.7 HISTORY OF LAND USES

2.7.1 Aboriginal Occupation

For thousands of years prior to the arrival of Europeans, the vast area of land stretching between what is now known as Newcastle through to the southern-most part of present day Sydney was home to the Guringai people. Living primarily along the foreshores of the harbour, they fished and hunted in the waters and hinterlands of the area, and harvested food from the surrounding bush. Self-sufficient and harmonious, the Guringai had no need to travel far from their lands, since the resources about them were so abundant, and trade with other tribal groups was well established. Moving throughout their country in accordance with the seasons, the Guringai spent only 4-5 hours per day working to ensure their survival. With such a large amount of leisure time available, they developed a rich and complex ritual life - language, customs, spirituality and the law - the heart of which was connection to the land (AHO 2007).

The entire Clontarf / Bantry Bay study area was used extensively by the Aboriginals, known locally as the Gayemal clan of the Guringai tribe, who spent much of their time on the foreshores of Sydney Harbour (Aboriginal Heritage Office, 2007). Estuaries have been important locations for Aboriginal land use. The Guringai people lived a self-sufficient and harmonious life, and had a rich and complex culture that included trade with other tribes, and a large amount of leisure time (Aboriginal Heritage Office, 2007). The estuaries, in general, contain areas of cultural importance to Indigenous people (NSW Fisheries, 2001). Fishing is an important part of Aboriginal culture. Indigenous fishing is undertaken using a variety of methods and equipment, including hand gathering, lines, rods and reels, nets, traps and spears. Indigenous fishing targets a range of species of fish, shellfish, crabs and worms that are used for food, medicine or bait. Target species include (but are not limited to) mullet, flathead, whiting, tailor, bream, blackfish, mud crab, oysters, pipis, prawns, beach worms and river worms. Beach worming and shellfish gathering are recognised as an important part of the Aboriginal fisheries.

The Clontarf / Bantry Bay study area provided shelter in all weather conditions in the various bays and valleys, with the extensive sandstone outcrops providing an abundance of overhangs and caves. There was also an abundance of food resources and fresh water, as evidenced by the many and extensive middens that can be found throughout. In excess of 1500 Aboriginal middens have been recorded along the coast, primarily as open sites (Sullivan 1988). Many middens are situated in rock shelters, reflective of relative abundance of cavernous overhangs to the shoreline. Middens are observed to be of varying size and length. Mounded middens are also found on the south coast. Estuarine shell fish species comprise approximately 50% of the shell in middens along the coast. Oyster is the dominant shell fish throughout the deposit. Most midden sites are within 200 meters of a water supply.

Many midden sites have been destroyed by European land uses, with substantial destruction in the early years of colonisation when middens were exploited as a source of lime (NSW Fisheries 2001). Human burials have been reported from midden sites right along the coast and are highly significant to the Aboriginal community.

2.7.2 European Arrival

The arrival of Lieutenant James Cook to (what is now) Sydney in 1770 marked the decline of the traditional way of life for local Aboriginal people. Lieutenant Cook declared that the land was uninhabited and should be named New South Wales, to be the property of Britain's King George III. Captain Arthur Phillip then arrived in January of 1788 with orders to establish a penal colony, and take control of the land for settlement. The first European land ownership was granted only four days after this arrival, when a group of men began clearing land to gain access to fresh water. By 26 January 1788 the first fleet had landed in Sydney Harbour and begun inhabiting the surrounding land.

The arrival of the Europeans resulted in numerous armed conflicts with the Guringai people contributing to the demise of the local population. Along with the conflict, the Guringai people also began to suffer from a shortage of food as the much larger white population depleted fish and kangaroo stocks through unsustainable netting and hunting, cleared the land and polluted the water.

Exotic diseases from Europe were introduced with the invasion, for which the isolated Aboriginal people had no immunity. Over half the Aboriginal population of the Sydney basin died from small pox in less than one year. The remaining population was displaced from the land as the Europeans cleared it for farming and settlement. These brought to an end of traditional lifestyles of Aboriginal population in this area. Aboriginal people continue to live in the area, although very little traditional knowledge has survived.

2.7.3 European Settlement

After European settlement began in 1788 the study area slowly became populated, with several regionally important farms established. In 1850 a punt began running from the Spit giving easier access to the north side, and promoting an increase in population. Later trams ran from North Sydney to the Spit, where the passengers alighted and crossed the narrow stretch of water on the punt. Areas such as Clontarf became popular destinations for day trips by boat, and people would arrive from throughout Sydney to enjoy the Harbour front venue. From the early 1860s, Clontarf was the location of Pleasure Gardens, operated by Isaac Moore, a Sydney publican, and his family. An advertisement which appeared in the *Sydney Morning Herald* on 30 December 1863 described the venue:

"Clontarf Pleasure Grounds, Middle Harbour, formerly known as Brady's Flat – parties wishing to engage the above grounds for New Year's Day will receive information at Mr. Moore's, Custom House Hotel, Argyle-street. The above grounds are the oldest, largest, and most shady pleasure grounds in the harbour."

The venue attracted large crowds on holidays. The Catholic Young Men's Societies held an excursion to Clontarf on Anniversary Day, 26 January 1864, when a band was engaged, and arrangements made for dancing. There was also an Irish piper and fiddler. Up to two thousand people attended. By 1866, the Pleasure Grounds were well established as a destination for excursions on public holidays. By 1911 there was a connecting tram on the north side to continue to Balgowlah and beyond. Access was further enhanced in 1924 with the opening of the first Spit Bridge, and more significant development began to take place throughout the area as a result (Balgowlah Online, 2006).

This increased access of the early 20th century, particularly the construction of the Spit Bridge in 1924, resulted in a large increase in development (McIntosh, 1988). The more rural land uses made way for broad residential and infrastructure development (see Figure 2.7.3a & 2.7.3b and also Appendix C), with minor commercial and industrial development in small isolated pockets. Small pockets of state government owned land in Seaforth were released for residential development. With an increased population and greater infrastructure, the area began to experience increased local activities. Sandy Bay began operating as a boat repair location from shortly after European settlement. This was followed by the arrival of a shipwright in the 1930's, who lived behind the Bay and fixed boats on the shore. A slipway was then built on the current Clontarf Marina site prior to the war with a boatshed added to the slipway in 1945 when a formal licence was obtained from the Waterways Authority.

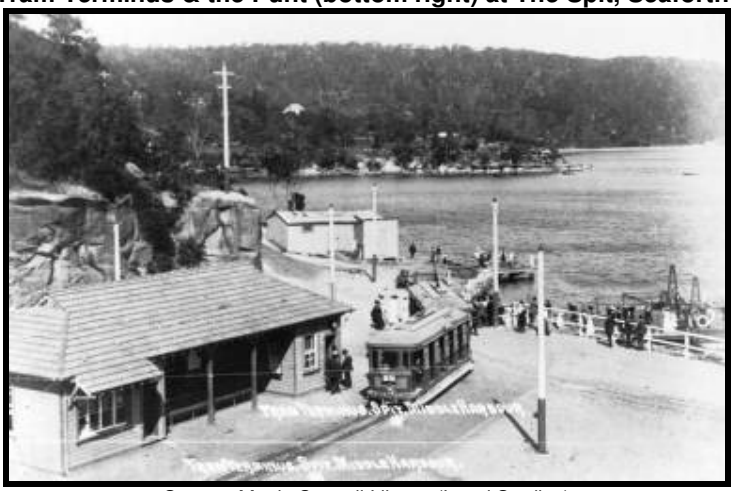
During the Depression in the 1930s, Clontarf reserve and other areas between the marina and Clontarf Point were filled with a tent city containing 200-300 people living out the tough times. They got posts from the bush and covered them in hessian, covered with whitewash, lime and fat to make them weatherproof. During WWII, beachfront land at Clontarf was cheap, and at £100 pounds a block, "you couldn't even give it away".

Seaforth Moth Sailing Club then opened in 1952, and boating activity steadily grew into a popular local activity (McAteer, 2006). A small sand boat ramp was also later opened at Clontarf Reserve adjacent to the sewage siphon, although it was only suitable for small craft. The original Spit Bridge was then replaced by the current structure in 1958, which incorporated the lift section to allow tall boats to pass between upper and lower Middle Harbour. As access improved over the years, the entire foreshore became popular for leisure and recreational activities such as fishing, picnicking and walking. This residential and infrastructure development boom took place until the 1970's, and the scale of development has not changed greatly since. The Manly Scenic Walkway opened in 1988, providing a foreshore walking track between Manly CBD and the Spit Bridge, and steadily become a major attraction for locals and visitors alike.

Figure 2.7.3a – Manly to Spit Punt, c1908

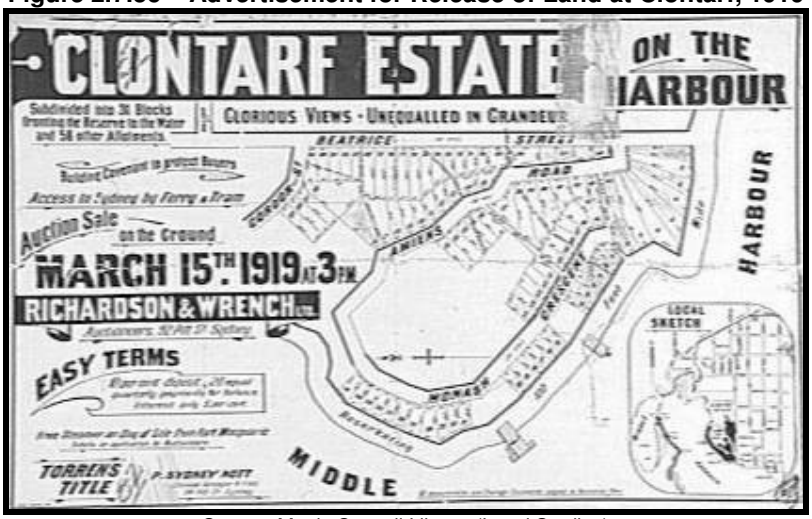
Source: Manly Council Library (Local Studies)

Figure 2.7.3b – Tram Terminus & the Punt (bottom right) at The Spit, Seaforth (year unknown)



Source: Manly Council Library (Local Studies)

Figure 2.7.3c – Advertisement for Release of Land at Clontarf, 1919



Source: Manly Council Library (Local Studies)

Figure 2.7.3d – Sailing at Clontarf, 1940's

Source: Manly Council Library (Local Studies)

2.8 HERITAGE SITES / ITEMS

An item / site with historical, scientific, cultural, social, archaeological, architectural, natural or aesthetic history and importance have a heritage value. These are, very often, specified in an inventory of heritage items made by different authorities and for different purposes. These can have global to local significance.

The NSW *Heritage Act 1977* provides for heritage management by government agencies. Section 170 of the Heritage Act outlines the special obligations of government agencies.

In relation to conservation of local heritage, Manly Council is also committed:

(i) to promote the Manly Council area's environmental heritage and celebrate its diverse environment, including architecture, Aboriginal archaeology, industrial archaeology and landscape;
(ii) to set a good example with the Manly Council area's heritage and guide, encourage and educate others to further the appropriate conservation of the heritage items they own or administer; and
(iii) to continue an active program of public information and participation in heritage and conservation matters; and

2.8.1 Aboriginal Heritage

Aboriginal places and objects are an important part of the rich heritage of Manly and are of great significance to Aboriginal communities, providing links to culture, environment and knowledge. The oldest Aboriginal site known in the Manly LGA is dated to about 4100 years before present. Estuaries have high Aboriginal heritage sensitivity. European development has had a great impact on Aboriginal heritage in these areas. It is important to look after and protect these special places for future generations. Estuarine and foreshore areas are generally considered to have very high potential for Aboriginal sites. Sites can be found immediately above the tidal zone, on slopes above foreshore areas, and on ridge tops.

Manly Council, jointly with 6 councils, has established the Aboriginal Heritage Office (AHO) in a progressive move to protect Aboriginal Heritage in these areas. The office has prepared 3 volumes Aboriginal Site Management Report for Manly Council (2006). Part of the work of the Aboriginal Heritage office is to monitor these Aboriginal sites on a day to day basis.

The AHO has recorded 22 Aboriginal sites within the study area (personal communication, AHO). This includes the following types (there can be more than one feature at one site):

11 Shelters with midden
5 open middens
5 Rock Engravings

1 Shelter with Art
1 Burial
1 Shelter with potential archaeological deposit
1 set of grinding grooves

Within the study area, middens are located in Castle Circuit, Pickering Point, and Sangrado and in Fisher Bay:

- Castle Circuit midden is in very fragile condition. Any management/upgrading will be difficult without disturbing the site.
- Pickering Point midden is a large one. Excavations have been done at some points. Management of this site may be easier by directing paths etc. away from sensitive areas.
- Sangrado midden is located among stored dinghies to the south of the pool.
- Fisher Bay midden is badly eroded and located in the middle of Manly Scenic Walkway.

Figure 2.8.1 – Foreshore Aboriginal Midden within the Clontarf / Bantry Bay Study Area

However, due to potential sensitivities in mapping specific sites and locations of Aboriginal significance, maps and detailed descriptions have not been included in this report. It is likely that further sites will be present in areas that have not been surveyed or where they are not visible at the surface.

Aboriginal sites are vulnerable to many of the same processes that affect other estuary assets, such as wave action (natural and from boat traffic), development and earthworks, pedestrian traffic, graffiti and so on.

2.8.2 Built Heritage (European)

A list of architectural and archaeological items existing in the study area, built during European settlement period, as listed in different documents, is presented in Table 2.8.2.

The Middle Harbour Siphon is a rare item of considerable cultural heritage significance. The siphon is a key component of the Northern Suburbs Ocean Outfall Sewer (NSOOS), the third major sewerage system to be built to service Sydney's growing wastewater needs. It was built between 1922 and 1925 and provides an excellent example of the skills of engineers of the time in constructing major public works. It is also possibly the best example in the state of an inverted siphon on such a scale.

Table 2.8.2 - Items of the architectural and archaeological items in the Clontarf/Bantry Bay study area

ITEM	ADDRESS
Listed under the NSW Heritage Act	
Middle Harbour Siphon NSOOS	Monash Crescent (East Side), Clontarf
Listed under Sydney Regional Environmental Plan	
The Spit Bridge	Spit Road, Seaforth
Listed under Manly Local Environmental Plan	
Dalwood Home - principal building	21 Dalwood Avenue Seaforth
Stone outbuilding to Dalwood home	21 Dalwood Avenue, Seaforth
House	16 Edgecliffe Esplanade, Seaforth
House	18 Edgecliffe Esplanade, Seaforth
Residential flat buildings	12 and 14 Ethel Street, Balgowlah
House	14 Palmerston Place, Seaforth
House	"Stone House" Lot 2, Rignold St, Seaforth
Alan Avenue, Seaforth	
Middle Harbour Submarine	Clontarf Reserve, adjacent to Syphon Holmes Avenue, Clontarf
The Spit, Seaforth	Seaforth
Reserved track for trams	From Whittle Avenue to The Spit Bridge, Seaforth
Former Bridge	The Spit, Seaforth
Vehicular ferry ramp	The Spit Bridge, Seaforth
Tram terminus and wharf for tram punt	The Spit Bridge, Seaforth
Monument	The Spit Bridge, Seaforth

Source: Schedule 4 of Manly LEP 1988 (updated September 2006) *(Refer Clause 7)*

At present, Manly Council is reviewing its LEP to include additional items in the heritage list, being identified through Manly's Sustainable Heritage Conservation Plan.

2.8.3 Natural Heritage

Landscape items, as listed in Manly LEP, is declared as heritage items and is presented in Table 2.8.3.

Table 2.8.3 – Landscape items, as environmental heritage, in the Clontarf/Bantry Bay study area

ITEM	ADDRESS
Landscape Items	
Panorama Parade	(from Edgecliffe Esplanade to Ponsonby Parade), Seaforth
Clontarf Park	Clontarf, Middle Harbour
Norfolk Island Pine Commemorative tree *(Araucaria heterophylla)*	Clontarf Park, Middle Harbour
2 Trees *(Ficus rubiginosa* and *Pinus radiata)*	Lot B, D.P. 393053, off, Battle Boulevard, Seaforth
2 Monterey Pine Trees *(Pinus radiata)*	2 Link mead Avenue, Clontarf, lot Y, D.P. 415123
Fisher Bay	Fisher Bay between Spit Bridge, Seaforth, and Sandy Bay Road, Clontarf
Remnant natural bushland and baths	Powder Hulk Bay in vicinity of Sangrado Street, Seaforth

Source: Schedule 4 of Manly LEP 1988 (updated September 2006) *(Refer Clause 7)*

3. NATURAL ENVIRONMENT – PHYSICAL PROCESSES

3.1 GENERAL

The estuary within the study area is known as Middle Harbour, part of the larger Sydney Harbour (also known as Port Jackson) estuary system. The entire Middle Harbour estuary system is a 12 kilometre long drowned river valley, with a number of side bays and coves on both sides of the system, occupying an area of 560ha (Willing & Partners, 1999). Table 3.1a details some of the key characteristics that are generic for the Middle Harbour estuary system, and Table 3.1b details some of the key characteristics that are specific to the Clontarf / Bantry Bay study area.

Table 3.1a – Key Characteristics of the Middle Harbour Estuary System

Characteristic	Detail
Longitude	151.283ºE
Latitude	33.828ºS
Estuary Classification (Port Jackson)	Tide Dominated (OzEstuaries, 2006) Tide Dominated (Drowned River Valley) (Roy et .al., 2001)
Interim Biogeographic Region	Sydney Basin
Interim Marine & Coastal Region	Hawkesbury Shelf
Estuary Length	12 kilometres (Willing & Partners, 1999)
Entrance Width (of Middle Harbour estuary)	720 metres (Manly Council GIS)
Mean Maximum Wave Height at Clontarf Beach	<0.5 m
Mean Wave Period	6.96 seconds
Maximum Wave Period	13.50 seconds
Tidal Range (Sydney Harbour)	1.82 metres (Lawson and Treloar, 2003)
Tidal Classification	Micro tidal
Tidal Period	Semi Diurnal

Source: OzEstuaries, 2006 (unless stated otherwise)

Table 3.1b – Key Characteristics of the Clontarf / Bantry Bay Study Area

Characteristic	Detail
Area	349 hectares (Manly Council GIS)
Estuary Length	5.2 kilometres (Manly Council GIS)
Perimeter	11.5 kilometres
Intertidal Flats Area	Approximately 2.4 hectares (Manly Council GIS)
Salt marsh / Salt flat Area	0 (NSW Government Department of Planning, 2005)
Mangrove Area	Approximately 0.05 hectares (Manly Council GIS)
Seagrass Area	1.8 hectares (West et. al. 1985)
Maximum Depth	33 metres (Willing & Partners, 1999)

Source: OzEstuaries, 2006 (unless stated otherwise)

3.2 TIDAL CHARACTERISTICS

The study area exhibits semidiurnal tidal characteristics. A semidiurnal tide is defined by Manly Hydraulics Laboratory (2006) to be:

"Having a period or cycle of approximately one-half of a tidal day……with two high waters and two low waters each tidal day."

This regular tidal exchange has significant benefits for the flushing of the estuary, and the pollutants that enter the system. The flushing times for the various parts of the study area are estimated to be approximately:

- Less than one day up to Castle Rock Beach
- 1 to 5 days from Castle Rock Beach to Seaforth Bluff
- 5 to 10 days from Seaforth Bluff to Bantry Bay

(Willing & Partners, 1999)

Hence, pollutants in the lower reaches of the study area estuary have little time to settle and accumulate in the ecosystem. Pollutants that enter the upper reaches of the estuary are often carried into the system during rain events, and the stratification that takes place during rain means that these pollutants are rapidly transported by the freshwater 'layer' to the lower reach of the estuary, where flushing times are quicker (see 3.3 below).

3.3 FRESHWATER INFLOWS

The study area is not fed by any permanent creeks, however various water courses provide freshwater inflows during and after rain, and the many other catchments throughout Middle Harbour provide significant freshwater flows into the system.

In periods of wet weather the estuary becomes stratified, with the more buoyant fresh water sitting as a thin layer on the surface of the salt water. During a heavy rainfall event in 1992 a surface layer of freshwater approximately one metre thick was measured at the head of the estuary, becoming gradually thinner downstream, until it reached the Spit Bridge where there was no distinct layer between fresh and salt water. This stratification process aids in the rapid transportation of pollutants from their upstream source to the lower parts of the estuary, where tidal flushing is more regular and further aids in dispersal of the pollutants (Willing & Partners, 1999)

Following wet weather, the stratification process is followed by a period of mixing, while the waterway reverts back to its dry weather state of vertically homogenous salinity. This mixing period can take as little as one day, or up to ten days for a large rainfall event (Willing & Partners, 1999)

3.4 GROUNDWATER

Groundwater is an integral part of the "water cycle" (or "hydrologic cycle") and maintains the dynamics of estuarine and near-shore marine water bodies, contributing inflows of fresh water to otherwise saline environments.

In New South Wales the volume of groundwater is estimated to be 5 billion mega litres (ML), more than 200 times the storage capacity of all water supply dams in the state. Approximately 200,000 people in 130 communities in NSW rely on groundwater for their drinking supply (NSW EPA 1995). Broadly, the beneficial use of groundwater defined within the *NSW State Groundwater Quality Protection Policy* (NSW Government 1998) is: ecosystem protection, recreation and aesthetics, raw water for drinking water supply, agricultural water and industrial water.

In general, three different generic aquifer classes are recognized based on the predominant mode of groundwater occurrence: consolidated porous rocks; unconsolidated sediments and variably fractured rocks (SCCG 2006).

The major aquifer class, in the study area, is consolidated porous rocks with occurrence of unconsolidated sediments along the foreshores only.

The **porous rock aquifers** contain limited quantities of groundwater because of the manner in which the water bearing zones formed (SCCG 2006). Generally, the sandstones are fine- to medium-grained and cemented, making the bulk of the rock mass relatively impermeable. Groundwater occurs within sub-horizontal porous layers (coarser sands and gravels in which the cementing agents have been dissolved) at various depth intervals throughout the rock mass (primary porosity). In addition, fissuring due to movement of the rock mass after it had formed generated a secondary porosity comprising fractures and joints. Porous rock aquifers have

not strictly developed the type characteristics of a confined aquifer. The sandstone itself often forms both the confining layers (cemented fine-grained intervals) and the aquifer (water bearing zones of coarse-grained and fractured rock).

The **unconsolidated sediments - coastal sand bed aquifer** contain significant groundwater resources because they have a subsurface characterized by sandy material that is highly permeable and porous (SCCG 2006). These deposits form the characteristics of the type unconfined aquifer, with a well defined water table that is responsive to recharge events, and even tidal influences in some cases. Coastal sand bed aquifers are readily recharged by direct rainfall infiltration. These aquifers generally have a relatively shallow water table, often less than a few metres below the natural ground surface level in low-lying areas. Because the groundwater in these aquifers is close to the ground surface, they are very vulnerable to contamination, particularly in urban environments. They also have a substantial ecosystem support function for Groundwater Dependent Ecosystems (GDEs), such as wetlands, swamps, estuarine habitats and coastal terrestrial vegetation.

In smaller localized areas, alluvial aquifer also occurs. They are comprised of clayey and silty materials with low inherent permeability often yield poor quality groundwater and therefore do not generally incorporate a substantial resource.

3.5 WAVE CLIMATE

3.5.1 Wind Waves

Information on wind waves is mainly limited to the lower half of the study area (east of the Spit Bridge). Assumptions are made about wind wave conditions in the upper half of the study area.

Wind waves in Middle Harbour are generally small. The relatively narrow and winding nature of the estuary means that the fetch at any given location is limited, and hence the potential for wind-generated waves is limited. Wind waves generated in Middle Harbour are rarely greater than 0.5m in height, and are generally less than 0.1m in height (Kennedy, 2002).

Low tide sand terraces are a common feature of wide estuaries which have an energetic wind regime. Sandy Bay and Fisher Bay are the only two locations in the study area that have a low tide terrace, and they have the largest fetch (to the south) for any of the bays in the lower half of the study area (Kennedy, 2002). Wind-waves in the lower half of the study area, hence, are greatest in southerly wind conditions, and maximum waves heights exceeding 0.5m can be experienced in Sandy and Fisher Bays (GSE, 1990). It can also be assumed that northerly wind conditions would produce waves of similar magnitude, although these would be experienced on the shores of the Mosman side of the lower Middle Harbour estuary (i.e. - not in the study area).

In the upper half of the study area (above the Spit Bridge) the largest fetch is in a north-south direction, with the distance from Seaforth Bluff to Pickering Point and beyond similar to the largest fetch in the lower half of the study area (as described above). It can hence be assumed that wind generated waves in this stretch, in southerly or northerly wind conditions, would reach similar maximum wave heights to that experienced in Sandy and Fisher Bays. However, these waves would not impact directly on any of the bays in this half of the study area due to the protection provided from the headlands at Seaforth Bluff and Pickering Point. The fetch from Powder Hulk Bay to the south west is reasonably large, and a south-west wind would likely result in some wind-generated waves, although not to the extent of that described above.

3.5.2 Ocean Swell Waves

Ocean swell waves penetrate lower Middle Harbour after entering through the heads of Sydney Harbour, and undergoing severe refraction and diffraction, although swell heights are reduced substantially following this process. Storm wave heights are also limited by the tidal delta at the entrance to Middle Harbour (see 3.8.1), which causes waves higher than approximately 2.5m to break and lose energy before entering Middle Harbour. Ocean waves from the east incur the least resistance, and affect Middle Harbour the most (GSE, 1990).

With all of the above impediments, waves of up to 0.5m are possible in Middle Harbour during ocean storms. Ocean waves during storms are greatest at the south-east end of Clontarf beach, diminishing rapidly along Clontarf Beach towards Sandy Bay (GSE, 1990). Figure 3.5.2 shows waves at the south-east end of Clontarf Beach during storms in February and June 2007.

Figure 3.5.2 – Wave Activity at Clontarf Beach

12 February 2007

08 June 2007

3.6 WAVE INDUCED CURRENTS

The two most common types of wave induced currents are longshore currents and rip currents (Patterson, Britton & Partners, 2004).

Longshore currents can occur where waves break and move in a direction parallel to the shoreline. These currents can result in the transport of sediment along the shoreline (Patterson, Britton & Partners, 2004). The only place in the study area that is subject to waves from a consistent direction is the lower half (Castle Rock Beach to Sandy Bay), where ocean swell waves enter Middle Harbour and run along the shore. Sediment has also been observed to move along the shore in this area, in the same direction, providing evidence that a longshore current exists (GSE, 1990).

Rip currents flow in a seaward direction from the shore, and are the result of the return movement of water which is piled up on the shore by incoming waves and wind. Rips are generally strong currents that result from significant wave action, and are therefore not common in the study area. The lower half of the study area that is subject to ocean swell waves would possibly experience some rip current action in times of large storms, although it would likely be limited to the period of the storm (Patterson, Britton & Partners, 2004).

3.7 STORMS, TSUNAMI & ELEVATED WATER LEVELS

The water level in Middle Harbour is subject to short term elevations beyond the normal tidal fluctuations, due to storm surges (Harris & O'Brien, 1998). Storm surges elevate water level through a combination of wind setup and barometric setup. Wind setup is when an onshore wind causes water to 'pile up' in coastal areas. Barometric setup is a localised rise in water level due to a reduction in atmospheric pressure. Storm waves can further elevate these storm surge water levels when waves cause temporary increases above the still water level (Patterson, Britton & Partners, 2004).

Water level in greater Sydney Harbour is elevated by 0.48cm for every metre/second of wind speed blowing from 162° and by 0.74cm for every hectopascal decrease of atmospheric pressure (Harris & O'Brien, 1998).

Tidal measurements since 1897 from Fort Denison, Port Jackson, indicate that water level in greater Sydney Harbour can be raised by up to 0.7m during storm surges (Bryant, 1980). When combined with high tides (particularly spring high tides) and large storm waves, these elevated water levels have the potential to greatly exacerbate problems such as beach erosion and shoreline recession (see section 6.1.1).

A Macquarie University researcher, Dale Dominey-Howes, has reported (2007) 37 tsunamis in NSW in the past 150 years. Waves reached maximum of 1.7 metres above sea level. Other research suggests a few huge tsunamis hit NSW between 6000 and 10,000 years ago, flooding the coast up to 30 kilometres inland. Historically, there is evidence that three major tsunami events occurred within the last three thousand years, the last event about 500BP (Australian Heritage Office 2007).

A tsunami with a maximum 1.7 metre run-up was recorded (at Eden, Queensland) on May 22, 1960. This has affected the study area as evident from the following description (EMA Disaster Database)

The huge tide tore from their moorings about 30 launches and small craft and two barges at The Spit. Barges were swirled in among drifting launches, overturning several of them and damaging others. One of the barges smashed into the Spit Bridge. A strip 100 yards by 60 yards wide was swept away from Clontarf Reserve Point Park, exposing a high tension submarine cable.

Figure 3.7 – Tsunami Induced Erosion at Clontarf Reserve (24/05/1960)

Photo courtesy: Tony Gonninen

As recent as on April 01, 2007, the tsunami alert for NSW was issued at 10.29am saying waves may impact the Sydney region after 11.30am. Sydney Ferries suspended its Manly and eastern suburbs services from 10.30am as a precautionary measure. A sea level rise of just 10 centimetres was recorded along the NSW coast (Braithwaite 2007).

Only limited information is available on the history of storms affecting the Middle Harbour area. However, several brief written accounts and one research paper about significant storms have been identified, which provide evidence that the predicted severe storm and wave events (as per above and section 4.4.3) can indeed be experienced in Middle Harbour.

An unpublished monograph titled *North Shore to Manly* (2006), talks of a storm in Middle Harbour in 1893:

"The swaying of the punt cable also proved to be a problem in rough weather, so much so that during a storm in April 1893 vehicles were unable to land on the Manly side. Alderman Farmer complained of the great inconvenience caused to him personally. Following this incident Mr Barling, Under-Secretary for Public Works, wrote on 22 June 1893 that better arrangements would be made to enable vehicles to cross the Spit and secure their safe landing from the steam punt during rough weather."

This monograph talks of storm activity so great that it penetrated far enough up the estuary to inhibit the operation of the Spit to Manly punt. As noted above (section 4.4.3) storm waves are at a maximum at the south-east of Clontarf Beach, and diminish rapidly to the north. Therefore wave activity great enough to affect the operation of the punt at The Spit would likely have meant extremely large wave activity, and most likely erosion, in the higher intensity zone near the south eastern end of Clontarf Beach (GSE, 1990).

An article by Captain C W T Henderson in *The Manly Daily* (date indecipherable, probably c1970) on the storms of 26 June 1923, states:

"Huge ocean rollers broke heavily on the rocks below North Head and pounded hard against Middle Head and Dobroyd Point. A continuous line of broken surf stretched across the four cables-length shallow bar which lies between Grotto Point and the Balmoral Shore opposite... Such tremendous seas as were seen had seldom been witnessed. The Burra Bra ferry was subjected to a severe buffeting off the Heads."

The above article provides evidence that waves large enough to break on the tidal delta are possible in Middle Harbour. As indicated above (section 3.4.2), it is likely that these waves were greater than 2.5m in height when they entered Middle Harbour, and that waves of up to 0.5m were experienced in the lower reaches of the study area (GSE, 1990).

The *Daily Telegraph* on 27 May 1974 (page 2) reports on the severe storm of that year:
"Seven yachts and small boats were washed up near the RAN base at Balmoral in Middle Harbour, where a boatshed and wharf were destroyed."

The storm was described as an extreme event, with offshore wave heights greater than 6 metres (Patterson, Britton & Partners, 2004). The RAN base discussed is near the entrance to Middle Harbour, so any storm it experienced would certainly be experienced in the lower reaches of the study area.

Foster et al. 1975 reported widespread damage along the entire Sydney coast by two severe storms in 1974, in close proximity of each other – 25/26 May 1974, and 19 June 1974. The paper reported wall collapse near Middle Harbour Yacht Club and minor beach erosion at the Spit and Clontarf.

June 9-10, 2007 storm

An intense low pressure system wreaked havoc on the Central Coast, Hunter Valley and Sydney over the June long weekend. This was described as the worst storm to hit NSW since 1998 by the Bureau of Meteorology. Gale-force winds lashed New South Wales' coastline, causing ocean swells as high as 18 meters

The study area experienced waves, high winds and significant siltation. Many trees were down. Seaforth residents experienced power cut after a tree fell on power lines. A cruiser washed ashore at Clontarf.

Source: Manly Daily, June 12, 2007

3.8 SEDIMENT BUDGET & MOVEMENT

Sedimentary processes are extremely complex, with many different factors influencing the sediment budget and movement for any given system. Only limited information is currently available about sedimentary processes within the study area, and the major information source (GSE, 1990) is relatively old. However, the limited information was sufficient to provide a partial understanding of the processes within the study area. As noted in section 7.3, the Department of Environment & Climate Change (DECC) have agreed to undertake

photogrammetry and if required, additional hydro survey of the study area which will contribute to a better understanding of sedimentary process.

3.8.1 Overview of Sediment Budget & Movement

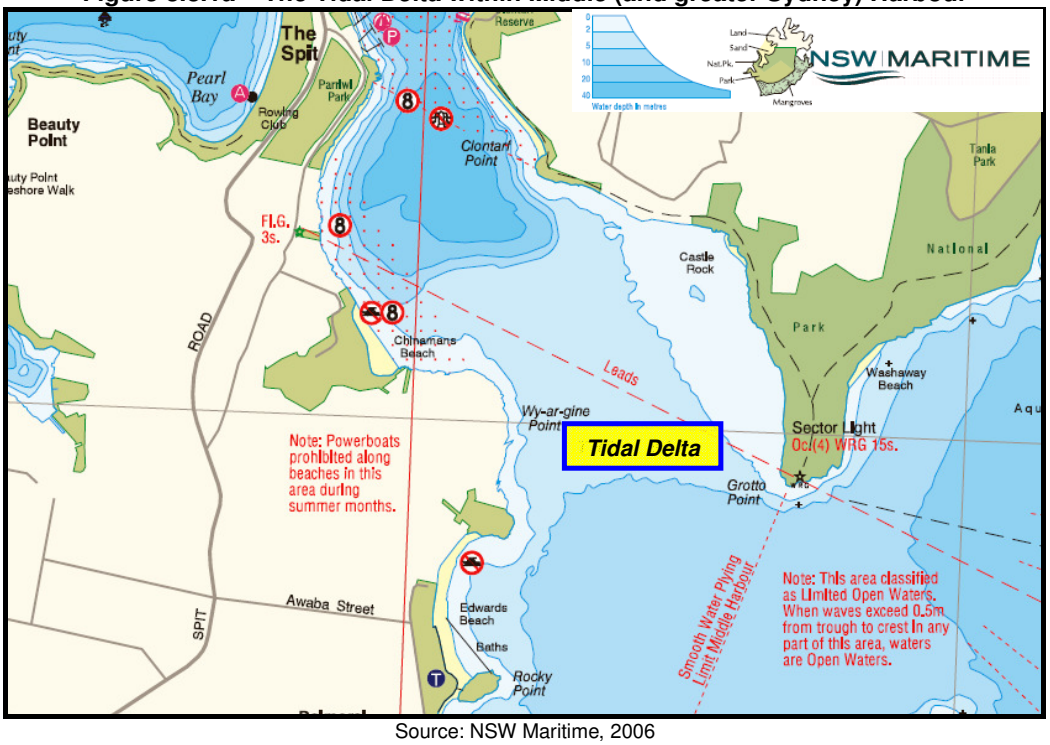
From the Spit Bridge to the north western extremity of the study area, the foreshore is predominantly stable rock, with estuarine mud on the sea floor. This area is beyond the normal limit of ocean waves, and is reasonably deep, therefore creating a relatively stable sedimentary environment. However, the lower reaches of the study area, from Castle Rock Beach to the Spit Bridge, consists largely of unstable sandy shores, with a mixture of marine sand and estuarine mud on the sea floor. The estuary in this section consists of both a shallow sand bar and a deep channel, and is influenced by ocean waves, which, when combined with human pressures, creates a dynamic and ever-changing estuary system.

The current situation in the lower reaches of the study area was originally created when marine sand was transported by ocean waves through Sydney Heads and into Middle Harbour at the end of the last ice age, as sea levels rose, creating a tidal delta. The front of this delta is currently located approximately between Clontarf Point and Wyargine Point (Mosman LGA), and it extends back into Sydney Harbour proper (See Figure 3.7.1). The tidal delta is slowly extending northwards, infilling the mud basin beyond, as ocean waves transport sand upstream of the delta front (GSE, 1990).

Castle Rock Beach lies in the middle of the tidal delta, so is not currently influenced by its progression or otherwise. Its proximity to the heads and open ocean mean that irregular storm waves are responsible for the sediment movement that shapes the beach, with storm conditions eroding the sandy beach, and calm conditions replacing it (Kennedy, 2002).

The beaches and tidal flats between Castle Rock Beach and The Spit were initially created when sediments were transported to the foreshore from the surrounding catchments. The tidal flats (i.e. - Fisher Bay and Sandy Bay) were then extended over time by the action of locally generated wind waves pushing sediments into the respective bays (GSE, 1990).

Figure 3.8.1a – The Tidal Delta within Middle (and greater Sydney) Harbour



Source: NSW Maritime, 2006

Once the beaches and tidal flats reached sufficient size, they provided a corridor to allow the tidal delta to begin supplying sand along the shore of Clontarf Beach and into Sandy Bay, again due to the influence of ocean waves. This corridor accelerated the growth of the associated beaches and the Sandy Bay tidal flat, until they reached the present situation. The supply of delta sand continues along Clontarf Beach and into Sandy Bay and continues to slowly modify the local conditions. Expected outcomes (as per 1990 conditions) from this continual supply of delta sand are:

- northward advance of the north-facing beach at Clontarf Park
- further growth of the Sandy Bay tidal flats out into the mud basin
- eventual bypassing of marine sand into Fisher Bay, once the growth of Sandy Bay links the transport corridor (GSE, 1990)

Human development of the area has interfered with these natural processes, and several issues have resulted. These are covered in section 6.1 of this document.

Clontarf Marina

The marina at Clontarf lies directly in the path of the sand transport corridor between the tidal delta and Sandy Bay. However, the beach profile appears to have been modified from its natural state, due to the irregular shape of the shoreline between Clontarf Reserve and Sandy Bay. The large sand flat of Sandy Bay transforms into a narrow beach with a steep drop-off on either side of Clontarf Marina, and then back into a sand flat to the south of the marina (see Figures 3.8.1b & 3.8.1c).

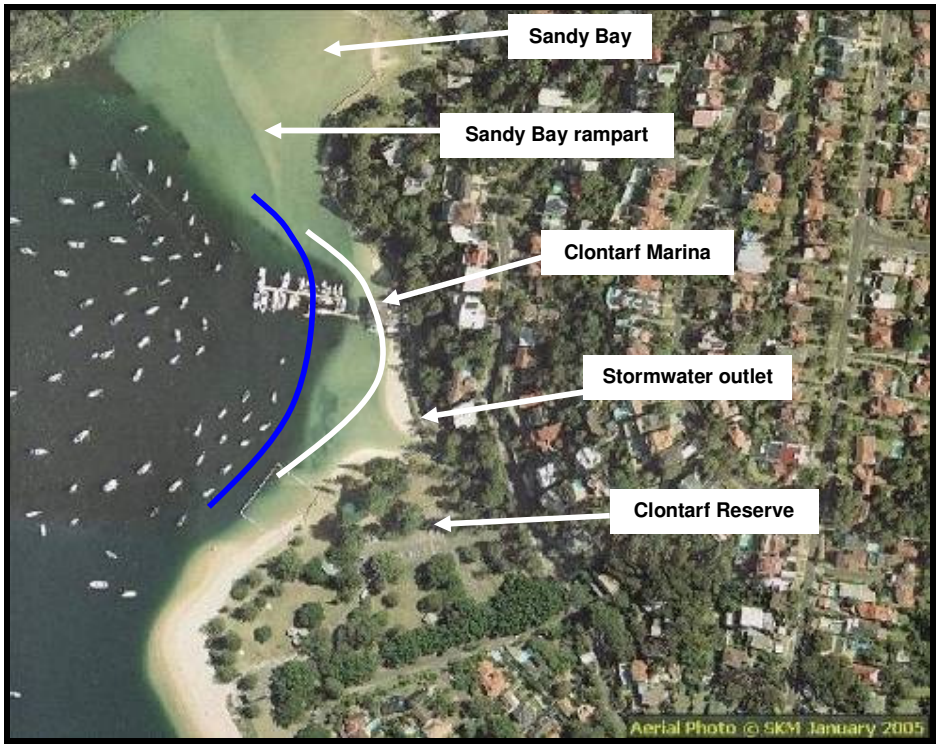
There are many forces impacting on this part of the estuary, creating a complex system. Along with the sand transport corridor, there is a large stormwater outlet that discharges immediately to the east of Clontarf Marina (see Figure 3.8.1b). Many boats move in and out of the bay to access the marina and moorings, with their associated propeller wash and wake contributing to sediment transport. The overall result of all of these forces cannot be confirmed with the limited information available (see section 6.3).

One possible scenario is that dredging occurs at the marina to maintain sufficiently deep access for boats to their berths, and the natural beach profile would be a continuos sand flat between Clontarf Reserve and Sandy Bay – indicated by the blue line in Figure 3.8.1b. In the past Clontarf Marina undertook 'propeller wash maintenance operations' to maintain navigable depth around the marina. This was done by securing a boat at the bow, and using the wash from the propeller at the rear to flush sand away. It is noted that this was done in the direction of the natural sand transport corridor. However, a small spit-like bar on the seaward boundary of the Sandy Bay sand flat indicates the line of transport of sand into Sandy Bay. This appears to support the scenario that the beach profile may naturally follow the blue line, and that the spit would normally extend parallel to the shore to Clontarf Beach (GSE, 1990). In this scenario, artificial displacement (eg- propeller wash operations, dredging, or through the constant movement of boats) of sand would appear to be the only reason for the deep hole that exists on each side of the marina.

Another possible scenario is that the stormwater outlet next to Clontarf Reserve has created an unnatural sand flat, as beach sand is eroded by the action of flowing stormwater and then deposited further into the estuary. In this instance, a natural beach profile similar to that indicated by the white line may be more accurate. The Graduate School of the Environment (1990) suggests that the beach profile indicated by the white line in Figure 3.8.1b *may* be the natural profile in the absence of the stormwater outlet; however, this partially contradicts the scenario deduced according to the existence of the spit-like bar.

It is possible that the situation around the marina is in fact a mixture of the above two scenarios. The results of the surveys to be undertaken by DECC and a comprehensive sediment process study will be required before conclusions can be drawn.

Figure 3.8.1b – The Beach Profile Surrounding Clontarf Marina



Source: Manly Council, 2007

Figure 3.8.1c – Boats Berthed in the Steep Beach Drop-off Surrounding Clontarf Marina

3.8.2 Aeolian (Wind) Sand Movement

Aeolian sand movement is described as the erosion, transport, and deposition of sand by wind (OzEstuaries, 2006). It can be a significant problem where human development has encroached into a beach / dune system that naturally migrates seaward and landward depending on prevailing conditions.

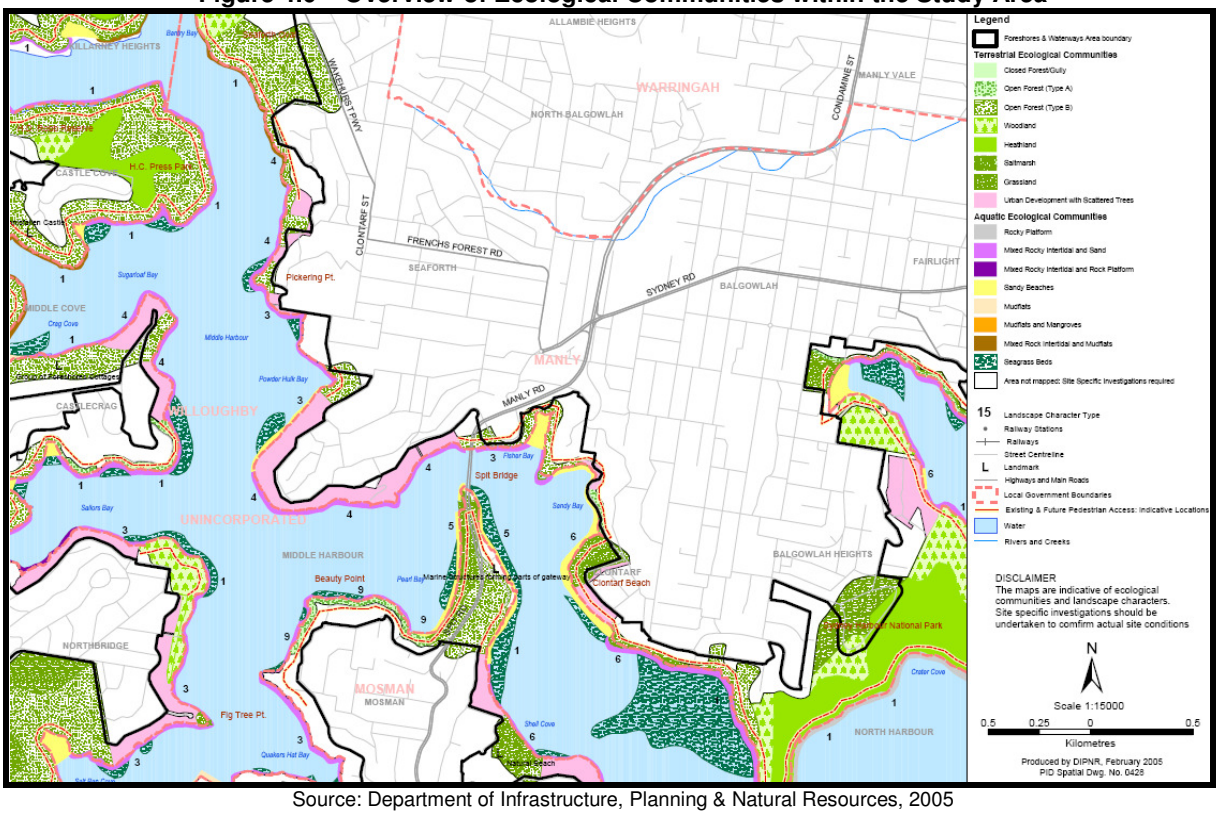
As described above, the study area to the west and north of the Spit Bridge is relatively stable, with only small isolated sandy beaches in several of the bays. All of these bays are surrounded by relatively steep catchments immediately behind, so the potential for aeolian sand movement becoming a problem is negligible.

The study area to the east and south of the Spit Bridge has much greater potential for aeolian sand movement to become an issue, due to the more extensive sandy beaches and sand spits, and generally flatter landscape. However, it does not appear to have become an issue to date - development right up to the foreshore has stabilised sandy areas that would otherwise be subject to the impacts of wind. Clontarf Reserve is located on a large sand spit (GSE, 1990), however landscaping and development has largely stabilised the sand between MHWM and the grassed reserve. Similarly in Sandy Bay, the construction of a seawall has limited any opportunity for aeolian sand movement at this section.

4. NATURAL ENVIRONMENT – ECOLOGICAL PROCESSES

The ecosystems within the study area are highly fragmented and likely to only represent a selection of the ecosystem/habitat types that would have been present prior to development of the area. The different habitat types have signs of the many pressures placed on them through development and high usage. Figure 4.0 (below) provides an overview of the ecological communities present within the study area, while the following sections look at each component in more detail.

Figure 4.0 – Overview of Ecological Communities within the Study Area



Source: Department of Infrastructure, Planning & Natural Resources, 2005

4.1 MARINE ECOLOGY

4.1.1 Habitat & Flora

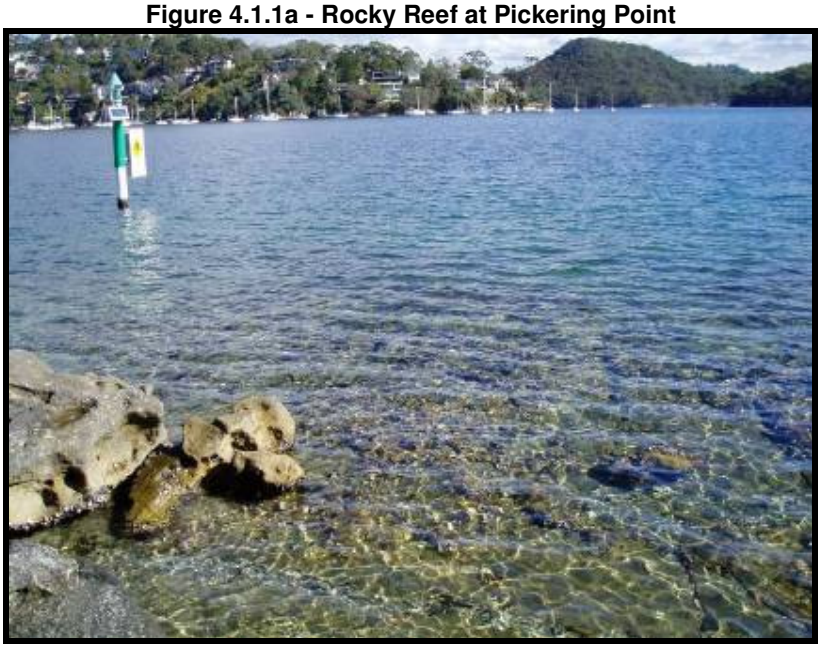
The marine environment within the study area has a diverse range of habitats. These are in relatively reasonable condition compared to other areas of Sydney harbour, despite the highly modified nature of the estuary and the intensity of its usage.

There is an abundance of rocky shores and reefs (Figure 4.1.1a) throughout the study area, mostly adjacent to the headlands of the various bays. The reefs provide valuable shelter, such as caves and crevices, and also a food supply, for various marine species. Crustaceans and invertebrates live on the rocks, and fishes that feed on them live in the surrounds. These rocky areas also contain patches of kelp beds, which provide vertical underwater structure and much valuable habitat and also a source of food for certain marine species. Kelp is a form of macro-algae, with anchors to hold it onto the rocks rather than a formal root system.

There are still significant seagrass beds within the study area (see Figure 4.1.1b below and Table B4 in the appendix). Seagrass is a flowering plant that provides food and shelter that is critical to the survival to a wide

range of aquatic biota. Under the Fisheries Management Act, 1994, all seagrass is protected, and must not be damaged or collected (DPI, 2007).

Figure 4.1.1a - Rocky Reef at Pickering Point



The largest seagrass bed is found adjacent to Castle Rock Beach, where the tidal delta (see section 3.7.1) provides a large shallow sandy bottom, with sufficient light penetration suitable for seagrass growth. Clontarf and Sandy Bay also have reasonably large meadows of seagrass. Seagrass is also found in various isolated patches around the shallow foreshores of the upper half of the study area, although not to the same abundance as in the lower reaches.

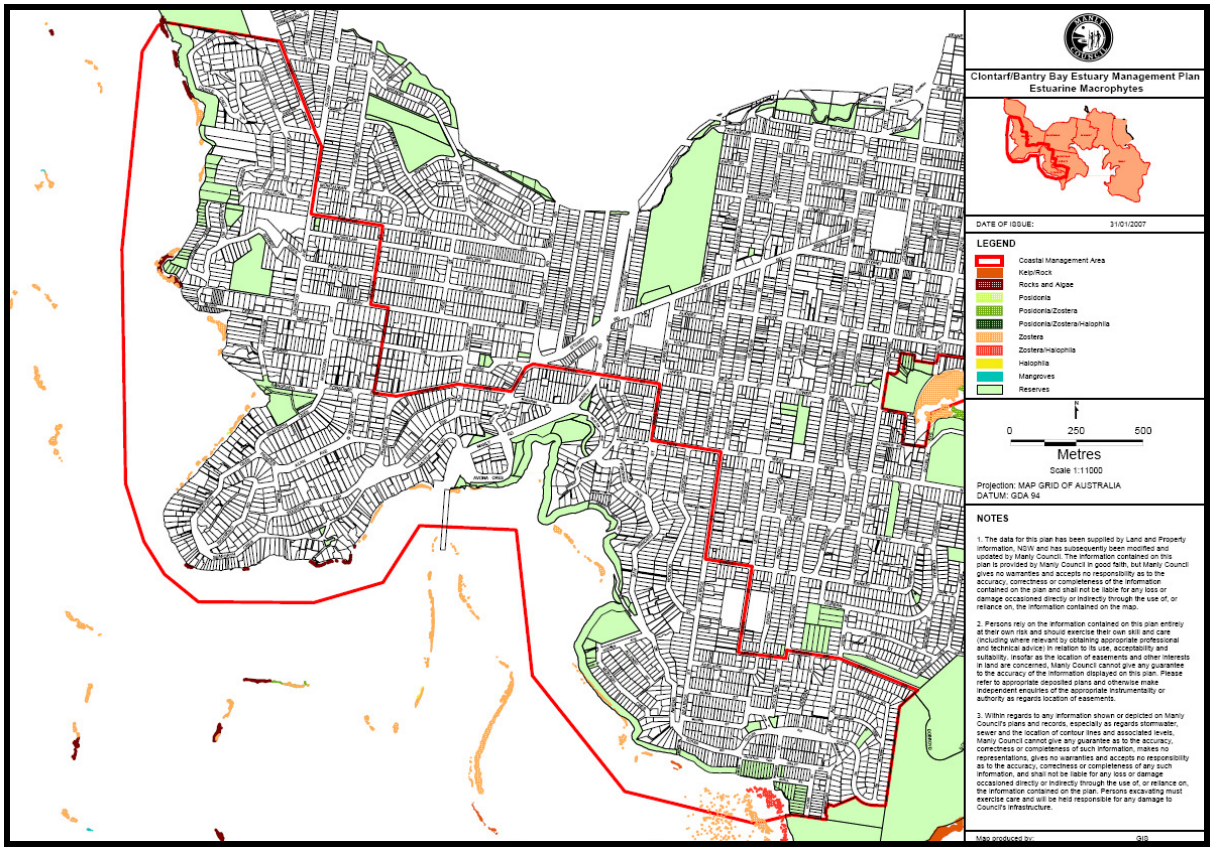
Anecdotal evidence, received through the community consultation undertaken for the Clontarf / Bantry Bay Estuary Management Plan, suggests that Clontarf and Castle Rock have experienced large losses in seagrass. West et al (2004) confirms this and states that large losses of seagrass have occurred inside Middle Harbour adjacent to Grotto Point (the tidal delta) and also at Clontarf. A 1981 Seagrass Map of Port Jackson produced for the Sydney Metropolitan Catchment Management Authority of the time provides further evidence, and indicates a significant stand of seagrass in Sandy Bay, much larger than that indicated by DPI in the current seagrass map (see Figure 4.1.1b).

Interestingly, there is no Posidonia seagrass within the study area identified in the map provided by NSW DPI, whereas it is evident in other areas of Sydney Harbour. Posidonia does not readily re-colonise once it has been lost, so if it was previously present within the study area (likely, since it is present in other areas of the Harbour) and has been lost, it is not likely to return (DPI, 2007).

There are several relatively deep holes within the mud basin section of the study area (see section 3.8.1) that provide habitat, with the deepest located upstream of the Spit Bridge. Species that prefer reduced levels of light, or wish to hide from either predators or prey, can be found in these holes. The mud basin itself also provides habitat for various species, including invertebrates such as worms and molluscs. Conversely, the tidal delta (see section 3.8.1) provides a shallow sandy sea floor habitat. Similar to the exposed sand flats and beaches, different layers in the sediment provide different habitat environments, with variations in levels of oxygen, organic matter, bacteria and moisture (Edgar, 2001).

Foreshore structures such as jetties, sea walls and marinas alter the balance of important natural inter-tidal habitat and while these structures do provide habitat for some species, they are a poor replacement. These structures offer shelter and a suitable substrate for the growth of some marine organisms that require hard

Figure 4.1.1b –Seagrass within Middle Harbour



Source: NSW Department of Primary Industries, 2007

substrates for attachment (eg- oysters, mussels), similar to natural structure hard substrate habitats such as rocky reefs. Seawalls, Clontarf Marina, swimming enclosures, the Spit Bridge pylons and the many private foreshore structures all provide selective habitat, evidenced by the extensive marine growth that is visible on them at low tide (Figure 4.1.1c). For example, threatened seahorses have been found in the mesh of swimming enclosures. Research on seawalls in Sydney Harbour illustrates that seawalls provide very little intertidal area compared to natural shorelines, as seawalls are vertical and typically provide an intertidal area of 2m in height, as apposed to more horizontal natural shores that can have intertidal areas of 10's of metres in width. In addition, many seawall surfaces are smooth, and do not provide diverse microhabitats such as crevices and pools that are important for a number of species. For example, several species of sea anemones, whelks and starfish, are not found on seawalls (Chapman & Bulleri 2003, Bulleri et al 2005, Moreira 2006). In an aquatic fauna surveys undertaken at Clontarf Marina, 62 different fish species were recorded around the marina (see Appendix B) with a total of 22 fish species recorded in the sandy habitat adjacent to the marina (The Ecology Lab, 2002). The fish assemblages present around marina structures are, however, different from communities that utilise sand habitats. There is evidence that sandy bottom habitats will have different fish assemblages (and less diversity) to seagrass beds (Gray et al. 1996; West & King 1996).

To protect the existing range of habitat available in Middle Harbour, the NSW State Government, under its Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005, has zoned large parts of the study area as Environmental Protection (see Figure 4.1.1d below). The aim of this zoning is to "provide for the protection, rehabilitation and long term management of the natural and cultural values of the waterways and adjoining foreshores (NSW Department of Infrastructure, Planning & Natural Resources, 2005).

Figure 4.1.1c – Marine Growth on the Clontarf Swimming Enclosure

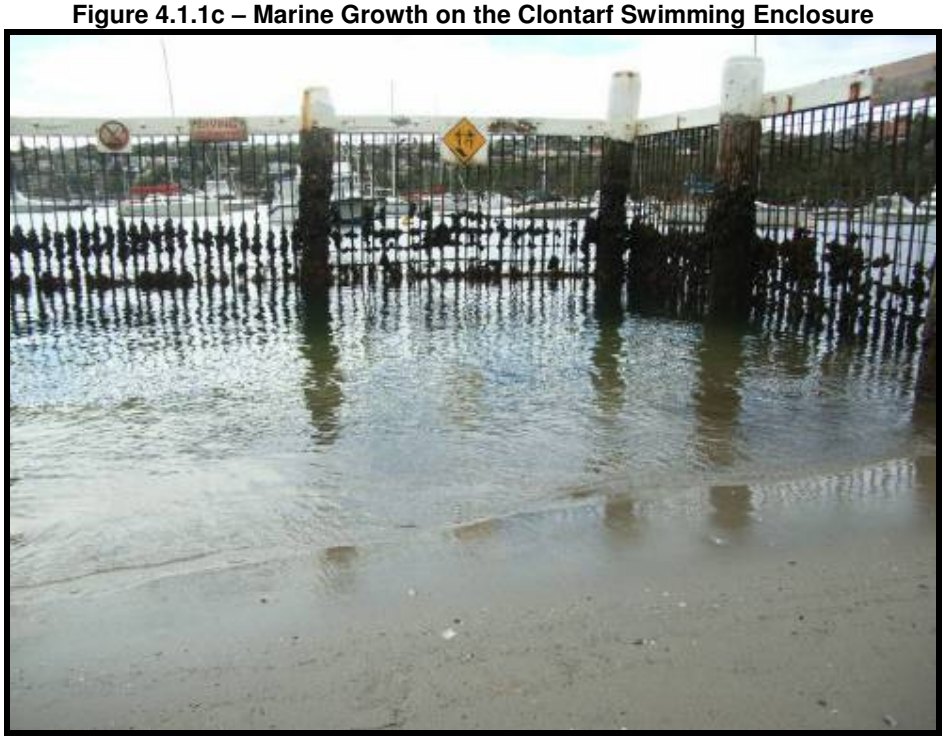
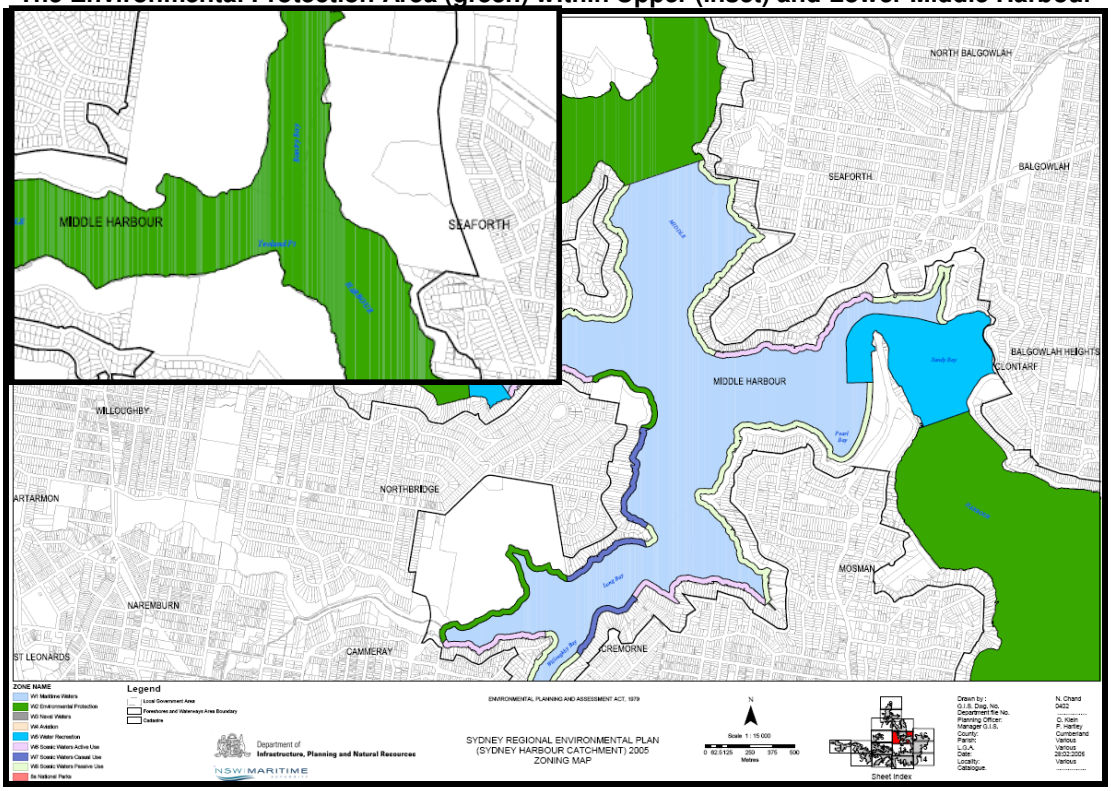


Figure 4.1.1d
The Environmental Protection Area (green) within Upper (inset) and Lower Middle Harbour



Source: Department of Infrastructure, Planning & Natural Resources, 2005

4.1.2 Fauna

The aquatic environment within the study area is home to an extremely diverse range of fauna despite the intensity of its usage. Over 570 species of fish have been recorded in greater Sydney Harbour, and it is likely that a large proportion of these are also present within the study area (Australia Museum, 2007). The diversity is most likely due to the broad range of habitat that is available.

Appendix B1 details a species list that was prepared by The Ecology Lab (2002), who undertook an aquatic habitat survey for Clontarf Marina (within the study area). The survey was repeated five times over a six year period (1996 – 2002), and recorded species sighted at two different locations – under the Clontarf Marina structure, and in the sandy habitat adjacent to the marina. The list cannot be considered as a definitive list of all species present in these locations, as it was only undertaken on five individual occasions. It does, however, provide a good overview of the species that can be expected in two of the habitat types within the study area and greater Middle Harbour. . Other habitat types not sampled that are very important to fish and other faunal communities include seagrass beds.

Appendix B2 details a species list that was prepared by the Australian Museum (2007) on the fishes found within Sydney Harbour. The list is much larger than the above-mentioned list, and details species for which the Australian Museum Fish Collection holds a specimen from Sydney Harbour. Although Sydney Harbour incorporates much more than just the study area, it is likely that many fishes from throughout the Harbour may at some stage be present within the study area. Hence, it has been included as a likely species list for the study area. However, similar to the above-mentioned species list, it cannot be considered as a definitive list of all fish species within Sydney Harbour, but it likely includes the majority of species that live or at some stage swim into the study area and Harbour. It is worth mentioning here that (unlike many terrestrial species) there are no barriers to recruitment from other areas. Fish abundance will be determined by available habitat.

Appendix B3 details other fauna species (not just fishes) that have been recorded within the study area or Sydney Harbour. It is again assumed that species recorded in other parts of Sydney Harbour are also likely to have at some stage visited the study area if their preferred habitat type is represented here.

The species present within the study area changes throughout the year. Many species will be present throughout the year; however some species will only be present seasonally. Whales, for example, will only be present at the start of winter when they pass Sydney on their way north to warmer waters, and at the start of summer, when they return south. Many of the pelagic species are also seasonal, with fish such as Kingfish preferring the warmer months, and fish such as Silver Trevally preferring the cooler months.

Of interest is the number of sharks that frequent Middle Harbour. Craig Mcgill (2006), a fishing guide with 30 years experience in fishing Middle Harbour, describes it as the “shark fatality capital of Australia”. Craig notes that six shark fatalities have occurred in Middle Harbour, with four upstream of Sugarloaf Bay and two in the shallows near Balmoral. A three metre bull shark was netted by fishermen at Grotto Point (near the south-eastern end of the study area) in 1999 in only two meters of water. More recently, in January and February 2007, there have been numerous anecdotal reports of large sharks in Middle Harbour, including a 13 foot Tiger Shark just off Clontarf Beach, within the study area (Sydney Fish Finder, 2007).

Threatened Species that have been recorded in the above-mentioned species lists are named below.

Endangered Species:

- Green sawfish *(Pristis zijsron)*
- Grey nurse shark *(Carcharias taurus)*
- Dugong (*Dugong dugon)*

Vulnerable Species:

- Great White Shark (*Carcharodon carcharias)*
- Black Cod *(Epinephelus daemelii)*
- Australian Fur Seal (*Arctocephalus pusillus doriferus)*
- Sperm Whale (*Physeter macrocephalus)*
- Humpback Whale (*Megaptera novaeangliae)*

Protected Species:

- Seahorse (*Hippocampus* sp)
- Big belly Seahorse (*Hippocampus abdominalis)*
- White's Seahorse (*Hippocampus whitei)*
- Crested Pipefish (*Histiogamphelus briggsii)*
- Girdled Pipefish (*Festucalex cinctus)*
- Hairy Pipefish (*Urocampus carinirostris)*
- Javelin Pipefish (*Lissocampus runa)*
- Mother-of-Pearl Pipefish (*Lissocampus runa)*
- Ornate Ghost pipefish (*Solenostomus paradoxus)*
- Red Pipefish (*Notiocampus ruber)*
- Robust Ghost Pipefish (*Solenostomus cyanopterus)*
- Sawtooth Pipefish (*Maroubra perserrata)*
- Spiny Pipe horse (*Solegnathus spinosissimus)*
- Spotted Pipefish (*Stigmatopora argus)*
- Stick Pipefish (*Trachyrhamphus bicoarctatus)*
- Tiger Pipefish (*Filicampus tigris)*
- Upside Down Pipefish (*Heraldia nocturna)*
- Wide-body Pipefish (*Stigmatopora nigra)*

4.2 INTERTIDAL ECOLOGY

This refers to:

1. the area between the mean high water and mean low water marks, and
2. flora and fauna that occurs in both the marine and terrestrial environment

4.2.1 Habitat & Flora

The intertidal area within the study area has a range of habitats, which play a vital role in the overall ecosystem. The entire foreshore of the study area is protected as Intertidal Protected Area (IPA) under the Fisheries Management Act, 1994. IPA's are created to protect selected rocky habitats and intertidal species, and aim to:

- protect intertidal community biodiversity and structure;
- provide biological reservoirs of breeding stock so exploited areas nearby can be recolonised or sustained; and
- help ensure harvesting of intertidal invertebrates is undertaken at sustainable levels.

The IPA extends from the mean high water mark to 10 metres seaward from the mean low water mark, and collecting seashore animals is strictly prohibited in this area (Department of Primary Industries, 2007).

The rocky habitat mentioned in section 4.1.1 (above) extends in parts of the study area into the terrestrial zone, creating an intertidal zone in between. This rocky intertidal zone is an exceptionally harsh environment, with organisms having to tolerate long periods of drying under the full summer sun, large changes in salinity levels as rock pools full of salt water dry up or are flushed with rainwater, and perhaps even frosts in winter (Edgar, 2001).

The rocky outcrops and headlands are predominantly sandstone and shale, with a mixture of flat shelves and boulders. Despite the harsh environment, the weathered sandstone, with its many cracks and crevices, along with the boulders and flat surfaces, provides significant habitat for many intertidal species. Many types of algae (eg- red, green, brown) also inhabit the intertidal zone, providing a food source for the many grazing invertebrates (GHD, 2003). These algae generally differ from those in the marine zone, as they are never submerged to any great depth, and hence do not grow as tall. Encrusting algae that form dense mat-like layers over the surface of rocks are very common (Edgar, 2001).

The sand flats in areas such as Sandy Bay and Fisher Bay provide extensive areas of habitat, with the steeper sandy beaches providing smaller areas of similar habitat. The many layers of sediments within sandy flats and beaches, and the resulting changes in amounts of organic material, moisture, oxygen levels and bacteria,

provide a range of habitat in what often appears to be a barren environment. Numerous types of invertebrates, such as worms, crabs and molluscs, can be found in the sediment. Some are surviving through filtering food from their surrounds and others through predation. Washed up seaweed and seagrass are extremely important on sand flats and beaches, with many invertebrates at the base of the food chain dependant on it as a source of food for survival (Edgar, 2001).

There is only one small pocket and few individual mangroves remaining within the study area. They are located at:

- Fisher Bay – one individual tree
- Powderhulk Bay – a small pocket near the swimming enclosure (Figure 4.2.1a below)
- Pickering Point – several individual trees scattered along the point (Figure 4.2.1b below)

Mangroves are extremely important to intertidal ecosystems, as they provide habitat, shelter and a source of food (Lynch & Burchmore, 2006). They also provide a buffer between the terrestrial environment and the estuary, and can filter runoff before it reaches the waterway. In the early years of settlement, untreated sewage (containing both human and industrial waste) was discharged directly onto the foreshore, and mangrove-filled bays were used as unregulated land-fill sites (i.e. - dumping of chemicals and other pollutants) so the land could be reclaimed (Birch and Taylor, 2004).

Figure 4.2.1a – Mangroves at Powder Hulk Bay

Figure 4.2.1b – Lone Mangrove at Pickering Point

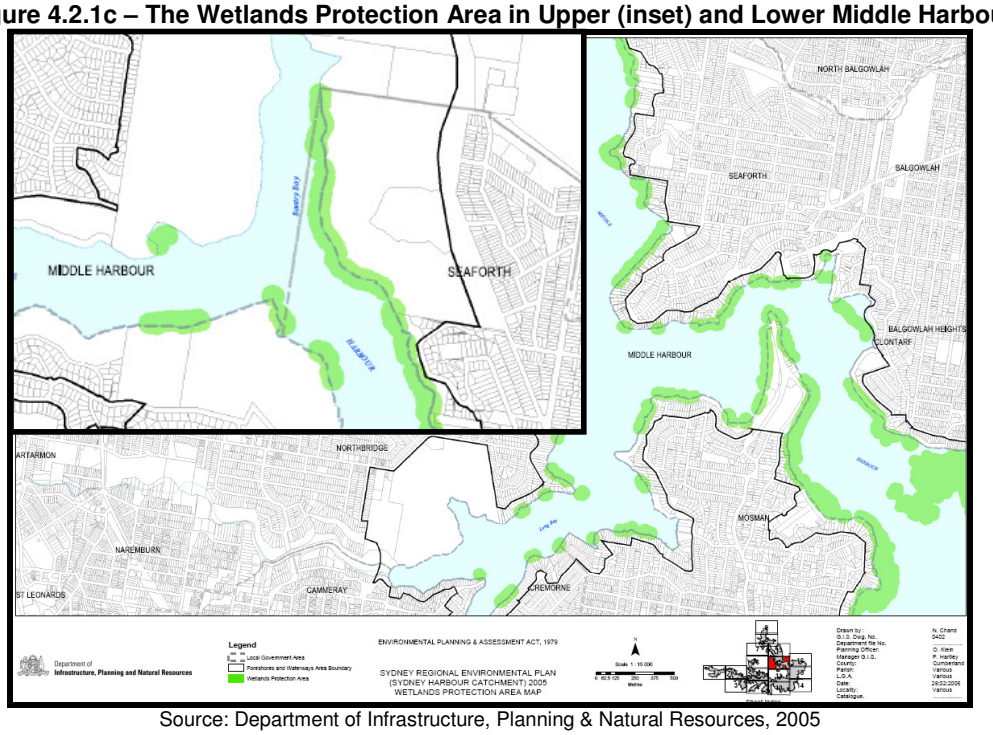
Salt marsh is often found adjacent to mangroves. However, no salt marsh has been identified within the study area (West et al, 2004).

Although the extent of wetland habitat (mangroves and salt marsh) in the study area is limited, large areas have been designated as a Wetlands Protection Area (WPA) by the NSW State Government (see Figure 4.2.1c below). This area is designed to allow for future growth, as well as preserving and protecting the existing populations (NSW Department of Infrastructure, Planning & Natural Resources, 2005).

4.2.2 Fauna

Information on flora within the intertidal zone of the study area is extremely limited, although information about fauna in the general Middle Harbour intertidal zone provides some detail. Table B6 in the Appendix lists species that are known to be present in or directly adjacent to (and hence expected to also be in) the study area. The majority of these species are invertebrates. There are also likely to be many species that live in the sediments of the beaches and sand flats (see section 4.2.1) that are not represented within the list. The majority of these species are also invertebrates, ranging from those visible to the naked eye, to microscopic species. Although they are not represented in the species list, they are extremely important to the ecology of the intertidal zone (Edgar, 2001).

Figure 4.2.1c – The Wetlands Protection Area in Upper (inset) and Lower Middle Harbour



Source: Department of Infrastructure, Planning & Natural Resources, 2005

The Little Penguin is included in this list, as it feeds in the estuary during the day and nests on land during the night. It is unknown whether the Little Penguins that are regularly sighted throughout the study area (as per community consultation for the EMP) are from the Endangered North Head Population, or whether they are separate and nesting somewhere in Middle Harbour (see section 6.5 and Figure 5.6b).

Figure 4.2.2 – Intertidal Fauna at Castle Rock Beach

The fauna in the intertidal zone plays an extremely important role in the greater ecosystem. Invertebrates on the rocks feed on the surrounding algae, ensuring it does not overcolonise, while they provide a food source for many marine fishes at high tide. Invertebrates within the sand on beaches and flats clean the sand by filtering it

for food, and again themselves provide a food source for marine fishes at high tide. Both of these groups of invertebrates also provide a vital source of food for terrestrial fauna, such as wader birds.

4.3 TERRESTRIAL ECOLOGY

4.3.1 Habitat & Flora – Urban Bushlands

Pockets of bushland remain scattered throughout the area, occurring mostly around the immediate estuary foreshore, with the National Parks at each extremity of the study area (Garigal at the north-west and Sydney Harbour at the south-east) providing more extensive expanses of bushland habitat. Skelton et al. (2004) classified and named all of the formal bushland reserves in Manly in a report, titled *Flora and Fauna: Manly Councils Bushland Reserves* and for simplicity these names have been adopted for the relevant reserves within the Clontarf / Bantry Bay study area (see Figure 4.3.1a).

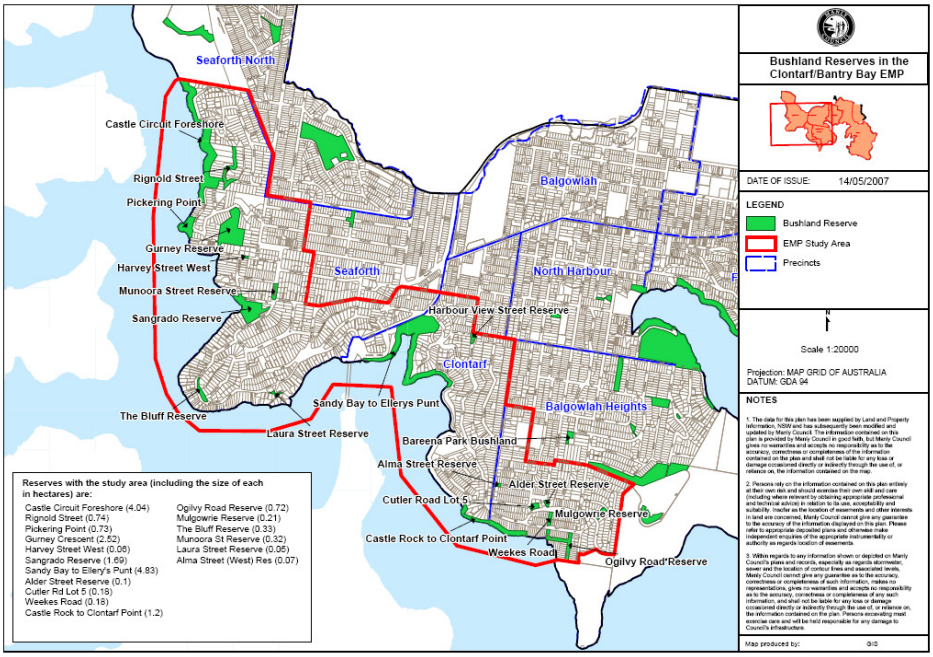
Manly's bushland is a valuable resource, providing residents and visitors with:

- areas for recreational use
- a better urban environment in which to live
- habitat for native birds and animals
- preservation of native flora
- an educational resource

Bushland reserves occur in a total 18.49 hectares and are scattered throughout the study area. Smaller patches of bushland on both public and private land do exist throughout, and in some places provide corridors between the reserves. Skelton et al (2004) noted important corridors between the Castle Circuit Foreshore and Pickering Point reserves, and also the Castle Rock to Clontarf Point and Weekes Road reserves. These corridors are extremely important habitat features, and allow for fauna to move throughout the study area and maintain populations.

According to Skelton et al (2004), there are extensive shelter resources available for fauna within the reserves. These include: tree-hollows and stags; canopy foliage; groundcover vegetation; leaf litter; logs; woody debris; rock outcrops; dense shrubs and thicket; cliff lines and sandstone rock features; creek lines; and seeps.

Figure 4.3.1a – Bushland Reserves in the Clontarf / Bantry Bay Study Area



Source: Skelton et al, 2004 and Chris Kraus (personal communication)

Skelton et al (2004) indicates that there are seven specific vegetation communities present within the study area reserves, which can be grouped into two broad types of vegetation communities. The communities described are largely based on a classification system developed by Benson and Howell (1994), but were modified slightly by Skelton et al (2004) to suit local conditions in Manly. The vegetation communities contain an array of different species, and range from open scrub, to denser rainforest. This range of communities offers a range of habitat, which provides suitable conditions for many different species of fauna. They are detailed in Table 4.3.1.

Table 4.3.1 - Vegetation Communities within the Clontarf / Bantry Bay Study Area

Subcategory Description	Broad Vegetation Community
Coastal Banksia - Eucalypt Woodland	Sydney Sandstone Gully Forest
Open forest/woodland: Eucalyptus piperita - Angophora costata - Corymbia gummifera	Sydney Sandstone Gully Forest
Closed Forest: Ceratopetalum apetalum - Tristaniopsis laurina	Sydney Sandstone Gully Forest
Littoral Rainforest	Sydney Sandstone Gully Forest
Creek line Rainforest	Sydney Sandstone Gully Forest
Woodland/Low woodland: Corymbia gummifera - Eucalyptus haemastoma	Sydney Sandstone Ridgetop Woodland
Open-scrub: Banksia ericifolia - Hakea teretifolia	Sydney Sandstone Ridgetop Woodland

Source: Skelton et al, 2004

A combined native flora species list for all of the reserves and communities in the study area is presented in Appendix B (Table B10). Table B11 then describes the exotic flora species found within the study area, although these are discussed in more detail in section 5.8.3 (below). More detailed information on the vegetation communities and the flora species specific to each reserve within the study area can be found in the Skelton et al report.

There are a number of State Environmental Planning Policies (SEPPs) which operate under the EP&A Act, of which SEPP No. 19 - Bushland in Urban Areas is relevant here. The general aim of this policy is to protect and preserve bushland within the Greater Sydney area. It requires that bushland not be disturbed without the consent of Council. The SEPP also provides for the preparation of management plans for SEPP 19 Bushlands. This Policy is integrated into Council's Development Application process. The following six reserves within the study area have the State Environmental Planning Policy No.19 (SEPP 19) status:

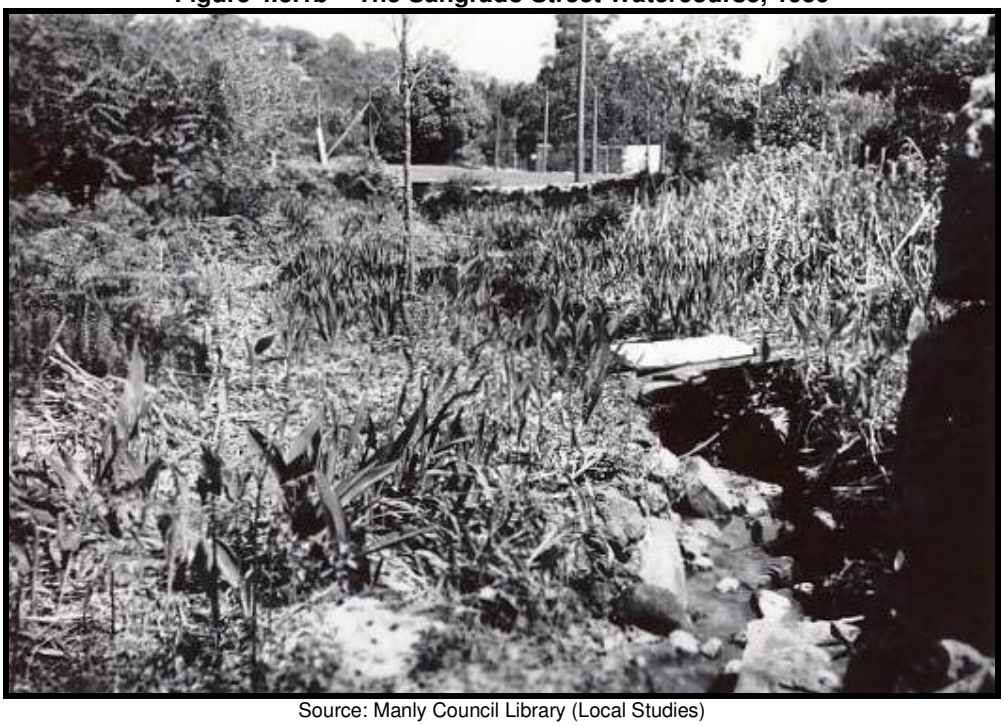
- Castle Circuit Foreshore (4.04 ha)
- Pickering Point – partly (0.73ha)
- Gurney Reserve (2.52 ha)
- Sangrado Reserve (1.69 ha)
- Castle Rock to Clontarf Point (1.20 ha)
- Ogilvy Road Reserve (2.47 ha)

Skelton et.al. (2004) classified additional five reserves within the study area that meets the definition of SEPP 19 status and recommended formalisation of their approval. These are Weekes Road (0.18ha), Alder Street Reserve (0.10ha), Cutler Road Lot5 (0.18 ha), part of Sandy Bay to Ellerys Punt (4.83ha) and Rignold Street (0.74 ha).

The study area only has minimal freshwater aquatic habitat due to the interference of humans. Permanent watercourses would likely have been located in most of the valleys within the study area, with rainwater and groundwater seepage providing an almost constant supply of water flowing towards Middle Harbour. However, with urban development the catchments have become hardened, and rainwater is quickly and efficiently channelled by the stormwater drainage network to the foreshore. Therefore, there is only minimal ongoing supply of water to the watercourses, and they can become dry in periods of no rain (Skelton et al, 2004). Figures 4.3.1b and 4.3.1c (below) show the Sangrado Street watercourse in 1959, with much less development than currently, and what appears to be a steady flow of water. The watercourse now fluctuates between steady flows in times of rain, to barely a trickle in dry periods. It contains a man-made weir near the bottom of the valley (see Figure 4.3.1d below), which results in a small near-permanent body of water – it is not known when

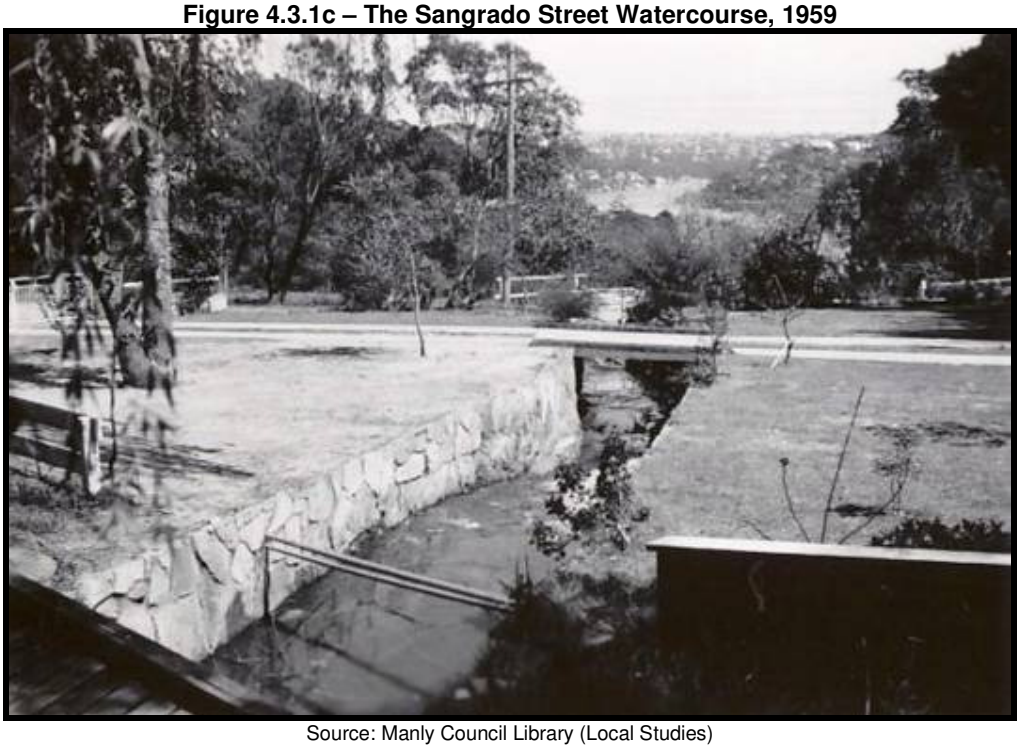
the weir was erected, although it is likely a remnant from the house that was located in Sangrado Reserve until the 1970's (McAteer, 2006).

Figure 4.3.1b – The Sangrado Street Watercourse, 1959



Source: Manly Council Library (Local Studies)

Figure 4.3.1c – The Sangrado Street Watercourse, 1959



Source: Manly Council Library (Local Studies)

Figure 4.3.1d – The Bottom of the Sangrado Street Watercourse with Weir in Background, 2007

The fluctuating watercourses throughout the study area would now provide limited habitat for relevant species, in comparison to before the area was developed, due to the direct disturbance of areas, encroachment into the riparian zones and the highly variable supply of water.

4.3.2 Fauna

There is still a significant amount of native terrestrial fauna within the study area, despite the many evident pressures, such as encroachment, high usage of bushland areas, and presence of introduced species. Skelton et al (2004) recorded:

- 3 amphibian species
- 49 bird species
- 6 mammal species
- 13 reptile species

See Table B8 in Appendix B for the full species list of fauna recorded within the study area.

There has also been one threatened species recorded in the study area, the Grey-headed Flying Fox (*Pteropus poliocephalus*). The Grey-headed flying fox is listed as Vulnerable on Schedule 2 of the NSW Threatened Species Conservation Act, 1995, and Endangered on the Commonwealth Environmental Protection and Biodiversity Conservation Act, 1999.

5. HUMAN INTERVENTIONS & USAGE

This section looks at the extent of urban development of the study area including human activities and usage of the estuary. These have gradually changed the natural processes within the area. These alterations have impacted the natural environment, and often with consequences to both humans and the environment.

5.1 FORESHORE DEVELOPMENT

Development of the foreshore has been extensive in the study area. Some of these are described below:

5.1.1 The Spit Bridge

The first and major foreshore development in the study area happened with the construction of the Spit Bridge in 1924 and replaced by the existing bridge in 1958 and some other developments prior to this at the site: first punt operation in 1849, ferry operation in 1880 and tram services in 1900. The bridge is located across the Middle harbour linking all three suburbs of Seaforth, Balgowlah and Clontarf in the study area and northern beaches with the suburb of Mosman and Sydney. Clontarf Reserve and Sandy Bay Beach, located 600m east of the bridge, are popular recreational destinations for families and picnickers. A boat refuelling area is located in the vicinity of the Clontarf Reserve. A small bay (Fisher Bay) is located approximately 300m to the east of the bridge. The Spit provides the base for range boating and marine related recreation activities. The foreshore in this area is also used for recreational fishing. The bridge is heritage listed by the Manly Council.

The Government announced in 2002 a proposal to widen the Spit Bridge by providing an additional two lanes for the movement of traffic with widening of existing approaches to the bridge. A Statement of Environmental Effects/Review of Environmental Factors was also prepared (GHD 2003) indicating mitigatory measures to address a number of negative environmental consequences considering already altered foreshore development. The plan has now been axed (Manly Daily, May 2, 2007).

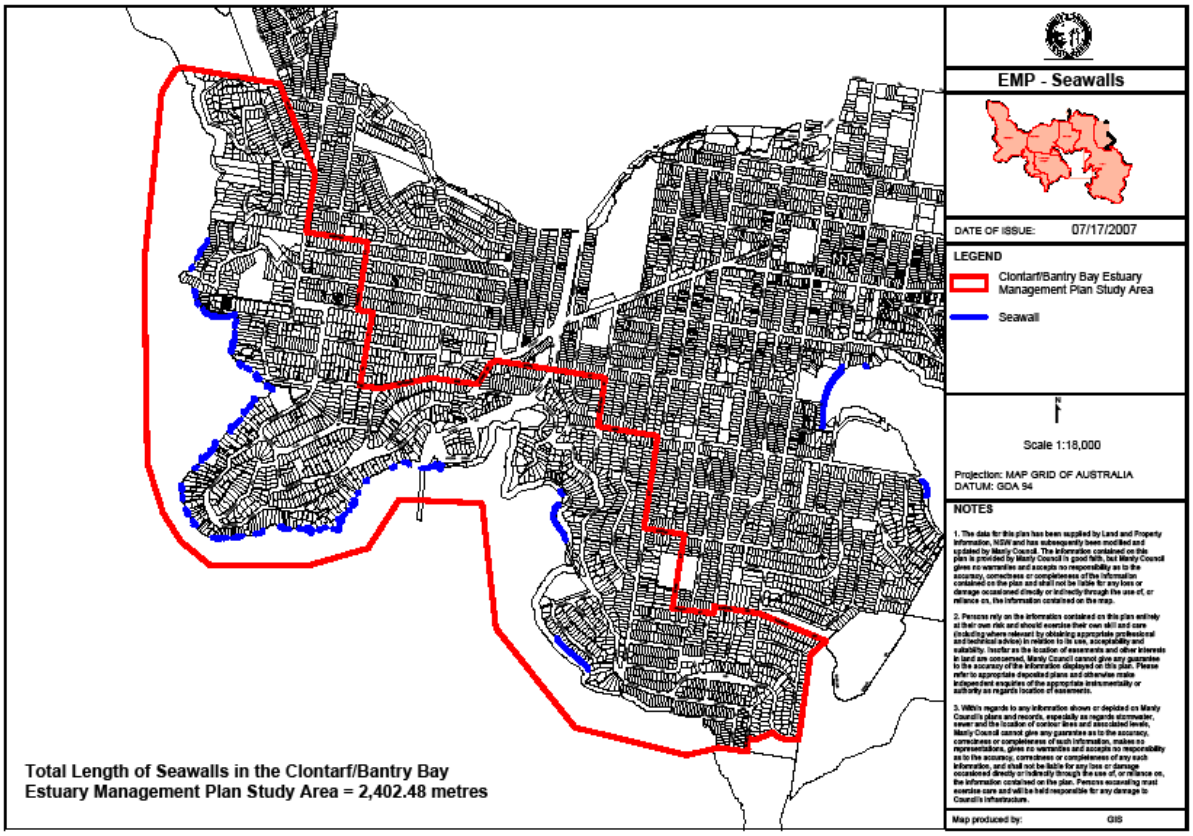
5.1.2 Seawalls

Seawalls, both public and private, exist throughout the study area. They are now common features of landscape in shallow coastal waters of urbanised areas. In some areas, they have replaced considerable portions of natural habitats, such as natural rocky shores or beaches. In Sydney Harbour, approximately 50% of the shore is composed of retaining seawalls or other built habitats (Chapman & Bulleri 2003). Similarly, within the study area, total length of seawalls is 2.4km (Figure 5.1.2c), that approximately 46% of the foreshore length.

Figure 5.1.2a: Different types of seawall in beachfront residences

Figure 5.1.2b: Cracked seawall on Clontarf beach

Figure 5.1.2c – Seawall locations within the study area



Seawalls are designed to protect properties against storm waves and surge, rather than against long term estuary processes, so it is important that they are sufficiently stable to protect against the severe storm conditions that can be experienced in Middle Harbour (Piorewicz, 2007). In this regard, seawall stability upstream of the Spit Bridge is less critical than below, as ocean swell waves do not penetrate beyond the Spit Bridge (see section 3.4.2). Seawalls upstream of The Spit need only be capable of protecting against small locally generated wind waves, boat generated waves, and storm surge (which can still be considerable and cause undermining and degradation of seawalls), but not storm waves (see sections 3.4 & 5.6).

Anecdotal reports suggest that the seawalls within the study area have adequately protected foreshore properties below the Spit from storm waves in recent years. Erosion has taken place at the base of the walls in times of higher wave activity and large stormwater flows (see section 6.1), although there have been no obvious signs that the integrity of the walls have been compromised. However, the study area has not seen a large storm for many years. Storms like those experienced in 1974 (see section 4.6) have not been experienced since, and it is unknown how the seawalls would stand up to a storm of that magnitude.

5.1.3 Moorings & Marinas

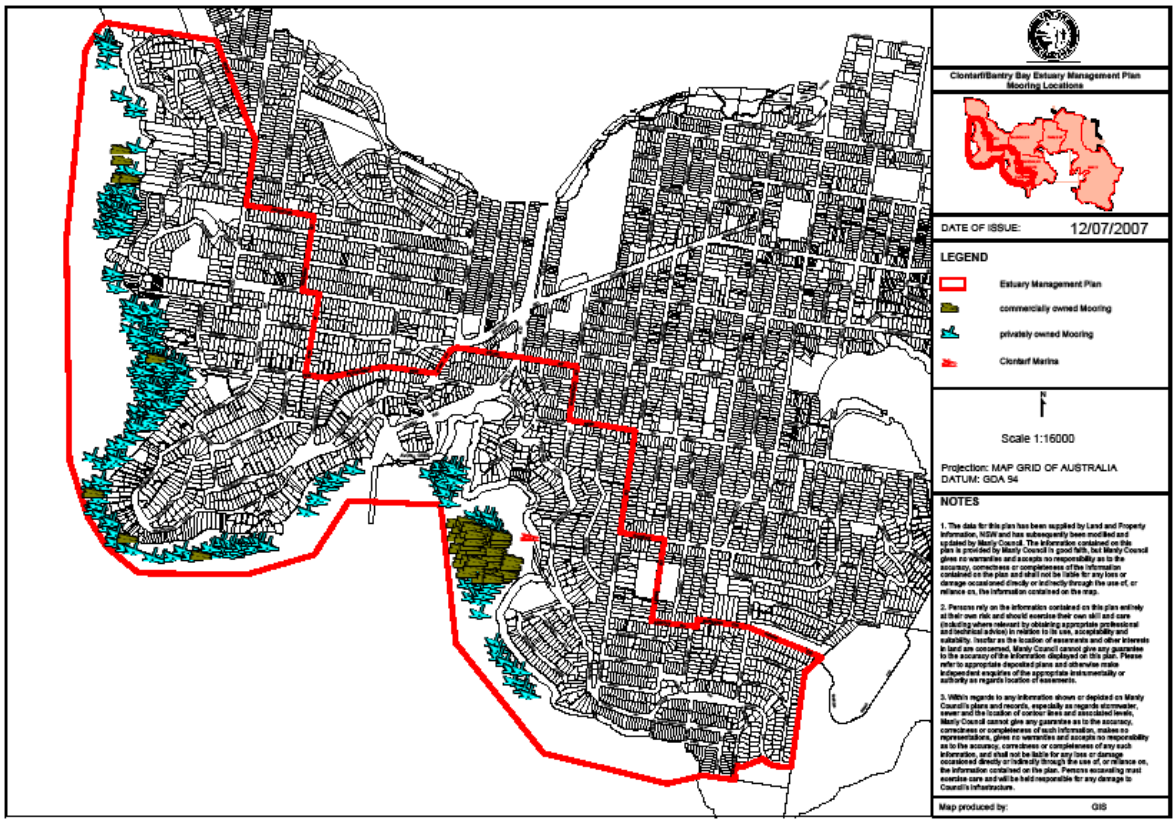
Boat storage facilities within study area consist predominantly of private swing moorings and commercial marinas. The study area is popular and has a number of mooring locations, offering convenient locations in relatively calm and secure conditions (Table 5.1.3 and Figure 5.1.3). Moored boats are usually accessed by dinghies that are stored all along the shores.

Table 5.1.3 – Number of private and commercial moorings in the Clontarf / Bantry Bay Study area
(As on July 01, 2006)

Mooring area	Commercial		Private	
	Licenses	Sites	Licenses	Sites
Clontarf	1	1	7	7
Fisher Bay	0	0	18	18
Pickering Point	1	2	31	31
Powder Hulk Bay	0	0	94	94
Seaforth	2	2	45	45

Most of the moorings in Clontarf / Bantry Bay estuary are swing moorings, with chains dragging across the seafloor damaging the seagrass beds within their range. Swing moorings have resulted in bare patches within the seagrass beds.

Figure 5.1.3 – Mooring locations within the study area



In 2004 NSW Maritime and the NSW Department of Planning prepared a Boat Storage Policy for Sydney Harbour. The policy aims to provide a more strategic and certain approach to regulating boat storage facilities on the harbour and outlines the NSW Government's policy for achieving a balance between promoting a prosperous working harbour, maintaining a healthy waterway and promoting recreational uses of the foreshores and waterways.

Clontarf Marina

Clontarf Marina is a popular spot for yachtsmen. One of Clontarf's best-known identities was yachtsman Ben Lexcen who had premises adjoining the marina. He was the designer of the winged keel of *Australia II*, which

won the America's Cup. Clontarf Marina has 59 moorings and 18 floating births and is one of 39 marinas in Sydney Harbour. Marina follows effective environmental management procedures to ensure they do not have a detrimental effect on sensitive aquatic eco-systems.

Work on boats at the marina is carried out on their slipway. Plastic drop sheets are used on the beach below the slipway. These sheets offer an inexpensive solution to a common problem associated with marinas. No spraying of paint is permitted on the slipway or at the births. Waste oil is removed by an oil recycling company. The refuelling depot is equipped with oil absorbent booms and mats to contain a spill if one was ever to occur. Emergency clean up kits are always in evidence for spills on land.

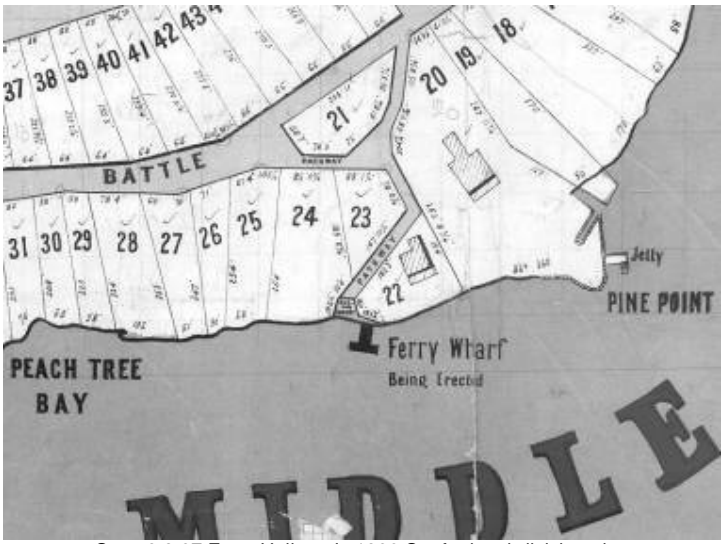
To provide the Marina and other interested parties with information on the impacts of marinas on the environment, the management has volunteered their location as a test site for the monitoring of marine flora and fauna. Once a year, scientists from the Ecology Laboratory test for species health and diversity compared to a similar location within the harbour.

5.1.4 Pontoons & Jetties

Pontoons and jetties within the study area are generally for private use and are located along foreshores between the Spit Bridge and the Pickering Point. The pontoons and jetties are used for a variety of purposes including boat mooring and access. There are no public pontoon/jetties. However, there is a proposal to install a jetty access and public floating pontoon at Powder Hulk Bay, beside Sangrado Pool, to provide recreational boating access to the Harbour for boat owners, nearby residents and the general public. There are a significant number of boat moorings in Powder Hulk Bay which will benefit from this new access. Manly Council has already received a grant from the NSW Maritime to construct this pontoon. Although the tentative time of construction is yet to decided, detailed designs of the pontoon has already been made.

Besides, there is remnant of a 1906 wharf located off Laura Street, Seaforth. The wharf site is not heritage listed. As the record goes, *"In 1906 Henry Halloran envisaged a ferry service to the city from a wharf at the bottom of stairs that go down from Seaforth Crescent alongside Laura Street. It is shown on the 1906 Seaforth subdivision plan as "under construction" (Figure 5.1.4a). "It will not take Seaforth long to have a fleet of regular ferry steamers equal to Manly's", stated Halloran's publicity."* The ferry did not eventuate.

Figure 5.1.4a: Laura Street Ferry Wharf as shown in 1906 Seaforth Subdivision Plan



Scan 9.8.07 From Halloran's 1906 Seaforth subdivision plan

Laura Street Wharf site is still used by boat users (Figures 5.1.4 b and c). Laura Street Wharf is used by mooring licensees for Seaforth to store their dinghies, as there is no other public access (personal communication, Anita Robinson, NSW Maritime).

Figure 5.1.4b. Aerial View of Laura Street Wharf (2007)

Figure 5.1.4c. Remnants of Laura Street Wharf (08/08/2007)

5.1.5 Sailing & Yacht Clubs

These clubs provide boating facilities and contribute to estuary use through a number of events including racing, training etc. Clubs located on both shores share the estuary.

Seaforth Moth Club incorporated within Northbridge Sailing Club
Founded in 1951-52. On January 1, 2000, the club merged with the Northbridge Sailing Club. This is a vibrant club with a reputation for design and innovations. There is rigging spaces for about eight boats on the front deck and up to 15 in the back. Extensive junior program, club is accredited AYF training school. Sunday racing in Northbridge Juniors, NS14's, 29ers, Lasers, Tasars, Moths, and MG's on courses in Middle Harbour from Sugarloaf Point to the Spit.

Middle Harbour Heron Sailing Club
Sunday racing in Herons on courses in Hunters Bay, North Harbour, and the Sound (sails from beach at Clontarf Reserve).

Middle Harbour Amateur Sailing Club
This is a small club that races Lasers on Sundays on courses in Middle Harbour and the Sound.

Middle Harbour 16ft Skiff Sailing Club
Races in 16ft skiffs on Saturdays & Sundays, plus Twilights, over four different courses in North Harbour and Middle Harbour.

Middle Harbour Yacht Club
Founded in 1939 on the site of the old Spit Baths. Registered club with extensive hire facilities for dining, functions, and meetings. Saturday racing year round, Wednesday Twilights, on courses in Middle Harbour and the Sound. Races in keelboats (inshore and offshore), 505's, F11's, and MJ's.

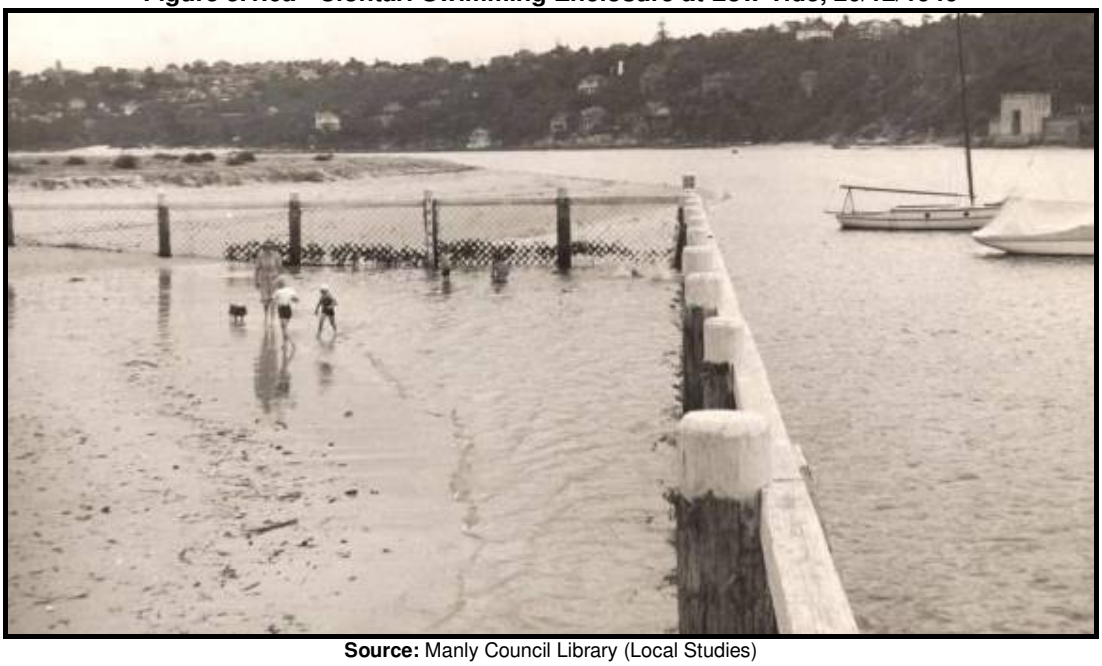
On water club activities**:** Keelboat racing Saturday, Wednesday, and Thursday evenings in the daylight saving period. Centreboard racing Sundays. Cruising calendar. Training Programs: junior, intermediate, senior and adult. Offshore Activities: Sydney to Mooloolaba Yacht Race; Ord Minnett SORC.

5.1.6 Swimming Enclosures & Baths

There are three swimming enclosures/baths in the study area. Each of these swimming enclosures is heritage listed and therefore, subject to limitations on future modifications.

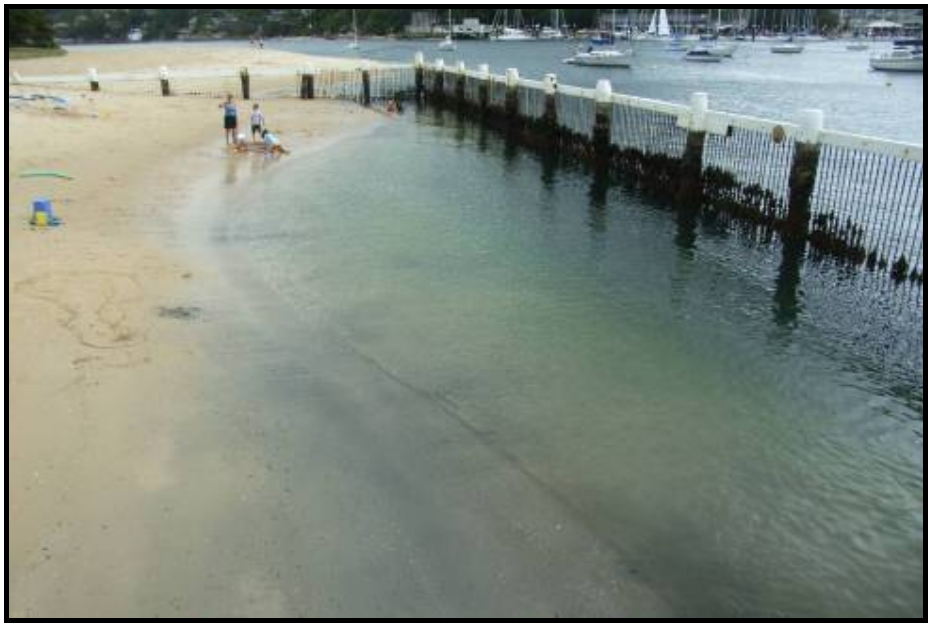
Clontarf Swimming Enclosure: The swimming enclosure at Clontarf Beach is used regularly by the thousands of locals and tourists who visit the Beach every year. However, at low tide there is so little water in the pool that it is virtually unusable (Figures 5.1.6a & 5.1.6b).

Figure 5.1.6a - Clontarf Swimming Enclosure at Low Tide, 20/12/1949



Source: Manly Council Library (Local Studies)

Figure 5.1.6b – Clontarf Swimming Enclosure at Low Tide, 03/01/2007



The pool lies directly in the path of the sand transport corridor between the tidal delta and Sandy Bay (see section 5.1.3), and disrupting this natural flow of sand may have undesirable consequences further down the corridor. Further, as the supply of sand is continuous, the enclosure simply fills back up, and the dredging would need to be done regularly to maintain depths. Dredging has been undertaken in the enclosure in the past, and sand returned to the pool in a month (GSE, 1990).

Gurney Crescent Baths: The bath is a 20-metre-square netted swimming enclosure backed by a bush reserve and is located on Pickering Point. Seasonal compliance for faecal coliforms has ranged from 80% to 100% over the last five years. Levels of enterococci compliance have been more variable, ranging from 52% to 100%.

Sangrado Baths: The bath is a 25-metre by 20-metre netted swimming enclosure in Powder Hulk Bay and backed by a bush reserve. Stormwater drains discharge to Powder Hulk Bay and water quality is affected by bacterial contamination from sewage overflows in the catchment of Middle Harbour. This bath has recently collapsed (August 2007) and awaiting decision of its fate.

The Baths at Gurney Crescent and Sangrado are in more suitable environment than the one at Clontarf but have different problems. These Baths do not experience the sediment migration.

However, all these swimming enclosures are subject to significant marine growth, particularly oysters. The oysters cover not only the enclosures themselves, but also the steps leading into the pools, and the floor of the pools. This has made these pools also virtually unusable, due to the dangers associated with the extremely sharp oysters. Periodic removal of oysters would likely be a relatively simple and effective process, although approval from DPI would be necessary due to the area being part of the Intertidal Protected Area (see section 4.2.1 above).

5.1.7 House Boat

Houseboats throughout NSW are required, under the Protection of the Environment Operations Act 1997, to install holding tanks to prevent the discharge of raw sewage. NSW Maritime officers can issue on-the-spot fines for polluting water. In addition, certain areas are declared as "no-discharge" zones for treated sewage.

The Act is complemented by a range of new measures to better manage sewage pollution from vessels. Houseboats should dispose rubbish ashore. Houseboat users should wipe cooking utensils and plates clean with a paper towel before washing up. They need to use low or non-

phosphate soaps in sinks and showers.

There is only one houseboat within the study area and is located in Fisher Bay. The houseboat, aka "The Ark" has been at the present location since about 1934 when issued with a mooring licence by the then Sydney Harbour Trust Commissioners (predecessor of the Maritime Services Board). The houseboat was then put under a lease by the then Maritime Services Board (MSB) which commenced in 1991. The lease is currently on an annual holdover (personal communication, Anita Robinson, NSW Maritime, July 2007).

There is a telephone and water connection from the shore to the houseboat in the lease agreement. The houseboat uses solar power and also has a petrol pump to generate electricity. There is rainwater collection facility on the boat for general use.

As per lease agreement, there is no requirement as to a holding tank but requires:

Clause 15 (Lessee Not to Pollute Waterways) provides that *the Lessee shall not permit, suffer or allow any timber, iron, oil, refuse or other material to be thrown or discharged or to fall or flow into waters of the Port of Sydney from the Premises or from any vessel which may be berthed or moored thereat".*

Clause 16 (Lessee to Take Preventative Measure to Avoid Pollution) also provides that *the Lessee shall take all such precautions as may in the opinion of the MSB be necessary effectually to prevent timber and oil, refuse or other materials from falling into or otherwise reaching the waters of the Port of Sydney from the Premises.*

However, the Lessee maintains a holding tank for sewage discharge that is emptied into an inflatable bag and taken to the pump out facility at D'alboras at the Spit. At present, there is no cause for concern for any pollution.

5.1.8 Walkways & Walking Track

As presented in section 5.4, walking has been indicated as the most preferred usage of the study area. There are two walking trails within the study area: a popularly known, Manly Scenic Walkway and Harbour to Hawkesbury Walking Track. These are used extensively by both visitors and residents.

Figure 5.1.8 – Uses & Attractions along Walkways in the Study area

Manly Scenic Walkway (MSW): This walkway was opened in 1988 and is jointly managed by the Manly Council and the National Parks and Wildlife Service of the DECC. It is almost 10 km long starting from Manly and reaching up to the Spit Bridge with approximately 5 km within the study area. There are numerous entrance points to allow shorter walks. All flora, fauna, Aboriginal sites, rock formations and historic structures are protected on the walk. Of the 23 points of interest (MSW Brochure), the following seven points are within the study area.

- Castle Rock Beach: This is a popular little harbour beach on the boundary of the National Park. Access is via steps from Ogilvy Road.
- Duke of Edinburgh Reserve: It has dense healthy woodland vegetation. Sandstone formations include a wave shaped rock and overhanging ledge above a strata of eroded shale.
- Clontarf Beach: Site of an early Sydney picnic ground and dance hall. The ground was previously served by a ferry from Sydney.
- Sandy Bay: Large sand flat exposed at low tide. The sound of crabs scuttling and digging may be heard.
- Aboriginal Shell Midden: This protected archaeological site contains layers of shells and food refuse
- Fisher Bay: Sub-tropical rainforest vegetation can be seen at the head of the bay and along the creek that runs into the bay
- Ellery's Punt Reserve: Site of a punt connecting Manly to the Spit for foot, horse, tram and vehicular traffic and originally commenced in the 1850s. The tram service ceased in 1939. The Walkway follows the old tram route for 200 meters towards Fisher Bay.

Harbour to Hawkesbury Track: The total track is almost 47 km and permits walkers experience of scenic bushlands, harbours and waterways. The walking track was officially opened by the Mayor on the 6th of April 2006 at Seaforth Oval.The track within the study area is 4.5 km long and the section is called 'the Spit to Seaforth Oval'. The walk uses staircases and regular roads.

Both these walking tracks are part of the 'Trunk Walking Routes of the Harbour and North Shore'.

Some discussion has occurred in relation to the opportunity to extend the Manly Scenic Walkway to include the 'Spit to Seaforth Oval' section located within the Manly LGA. However, a number of limitations exist for this concept.

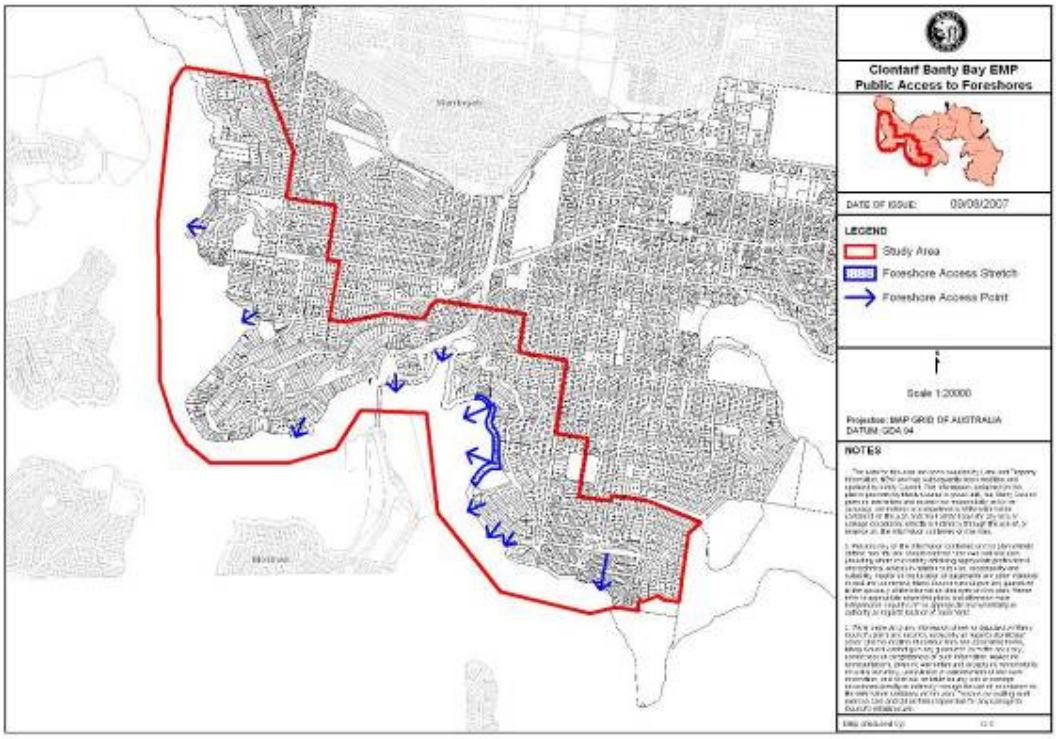
5.1.9 Access to Foreshores

As highly developed residential area, public access to foreshores is important. The desire to walk along the foreshore is long held and loudly voiced. It is essential that public access be provided as far as possible to the complete foreshore of study area and that the design of this public access varies in response to local circumstances including, but certainly not limited to, the provision of a sequence of variable public open spaces (such as green areas, paved areas, squares, boardwalks and viewing points). Whilst the walk along the foreshore may be diverted away from the water's edge for reasons of safety, it is essential that the walk be continuous and accessible to all people at all times.

The following public access points to foreshores have been identified (Figure 5.1.9).

- Steps via Ogilvy Road or Cutler Road, Clontarf along Weekes Road Reserve; access to Castle Rock beach. Access is also from MSW.
- Two points along Monash Crescent, also from Amiens Road; access to Clontarf beach. On MSW.
- Access from end of Holmes Road via Wharf Road and all along Sandy Bay Road; access to Clontarf beach, Clontarf pool and Sandy Bay. On MSW
- Stairs from Manly Road Car Park (near Spit Bridge) or steps from Avona Crescent; access to shores of Ellery's Punt Reserve and Fisher Bay. On MSW.
- Access from dead end of Laura Street
- Steps from Sangrado Road; access to Sangrado Bath
- Steps from Gurney Crescent; access to Pickering Point Bath.

Figure 5.1.9– Public Access Points to Foreshores in the Study area



5.1.10 Dog Exercise Area

Dog exercising is a popular activity for many members of the community. There are a number of leash-free areas along the foreshores that are frequented by the public and their companion animals.

Dogs are allowed on a leash in the Clontarf Reserve under the effective control of a competent person between the hours of 10am and 6pm (eastern standard time) and 10am and 8pm eastern summer time) on weekends, school holidays and public holidays. Alternative dog routes are marked on the Manly Scenic Walkway.

Dogs are allowed off the leash in most of Council's reserves. One must still ensure that the dog is under control, doesn't annoy or attack anybody or animals. The dog must be 10 metres away from children's play areas, BBQ's and picnic areas.

Dogs are not permitted on any beaches or in swimming enclosures. However, dogs are seen both on and off the leash on Sandy Bay beach. There is desire by dog owners to declare Sandy Bay even unleashed dog swimming area.

A radical dog rights group has launched a law breaking civil disobedience campaign to highlight the need for more areas for dog. They recently had a peaceful mass assembly at Manly (SMH July 01, 2007).

5.2 GROUNDWATER ABSTRACTION

Groundwater close to the surface is localised throughout the Middle Harbour catchment, due to the presence of rock at shallow depth in most areas (Willing & Partners, 1999). In the study area groundwater is most accessible on the sandy flats at the base of each catchment, where the aquifer is close to the surface, and has the greatest head due to the pressure from flowing down the steep catchments surrounding Middle Harbour.

With recent droughts, groundwater has become an attractive and viable alternate water source for irrigation of public and private land. However, groundwater is not an endless resource, and care needs to be taken to ensure that extraction rates are sustainable. Groundwater can also be heavily influenced by development. Above ground development can harden the catchment and limit the infiltration (supply) of water into an aquifer, and development underground can alter groundwater flow patterns. Modified groundwater systems can have a significant effect on local hydrology and environments, with potential impacts on soil moisture and the ability to support vegetation communities (Willing & Partners, 1999).

Licenses are issued by the Department of Water & Energy (DWE) to ensure the sustainable use of groundwater, and that the cumulative extraction of all of the bores and developments in a given aquifer does not exceed the recharge rates of that aquifer.

5.2.1 Manly Council Bore

Manly Council is extracting groundwater for irrigation of Clontarf Reserve, with a licensed bore located near the southern end of the Reserve. There are two spear points in close proximity that collect groundwater at a depth of 6.1m. Extracted water is stored in a 45,000L tank (see Figure 5.2.1 below), which is attached to an automated irrigation system that services Clontarf Reserve.

Figure 5.2.1 – Groundwater Storage Tank at Clontarf Reserve

Irrigation is undertaken through 70 sprinkler heads around the reserve, which each distribute 15 litres per minute, and are used for three 10 minute runs per week. Total groundwater consumption at Clontarf Reserve is therefore:

70 sprinkler heads x 15L per head per minute x 3 runs per head per week x 10 minutes per run
= **31,500 litres per week**

This equates to approximately 1.64 mega litres of groundwater abstraction per year. Details on the recharge rates of the aquifer at Clontarf are unknown.

The quality of the groundwater is tested regularly to ensure that it meets ANZECC guidelines for irrigation, and it has always been within guidelines. As an added safety precaution, irrigation is undertaken at night when the Reserve is not (generally) in use, to ensure minimal human contact with the groundwater in case of any quality problems.

5.2.2 Residential Bores

Many properties along the immediate beachfront at Clontarf display signs indicating that they are extracting groundwater for residential irrigation purposes. Due to the close proximity of these bores to the Manly Council bore, it is assumed that they are both accessing water from the same aquifer. As noted above, to access groundwater in NSW it is necessary to first obtain a licence or approval from the Department of Water & Energy (DWE) before any drilling or bore construction takes place. DWE was contacted to determine if the above-mentioned properties had the appropriate licence, and it was found that 6 out of the 17 properties did not (per comms with Wayne Connors, NSW Department of Water & Energy). Domestic properties with a groundwater licence are afforded 1 mega litre per annum.

There are likely to be other properties within the study area that use groundwater for irrigation, although not likely in a concentrated group such as Clontarf Beach. All unlicensed bores are of concern, but of greatest concern is areas with numerous unlicensed bores (together with licensed bores) all extracting from one aquifer, which could potentially be exceeding the recharge rate of that aquifer.

Groundwater abstraction, from bores so close to the estuary, can lead to seawater intruding into the freshwater aquifer. This could render the use of the groundwater unsuitable if contaminated by higher salinity. Further research needs to be undertaken on these issues (see section 8.4).

5.3 STORMWATER DRAINAGE NETWORK

Stormwater within the study area flows through artificial drainage networks. The hard artificial surfaces that stormwater travels over and through in urban environments greatly increases its velocity. These high velocity concentrated flows are then directed and released into bushland, watercourses or the foreshore. Often the end of the pipe is surrounded by soft surface material such as soil or sand, which is easily eroded by the large volumes of high velocity rainwater during a storm.

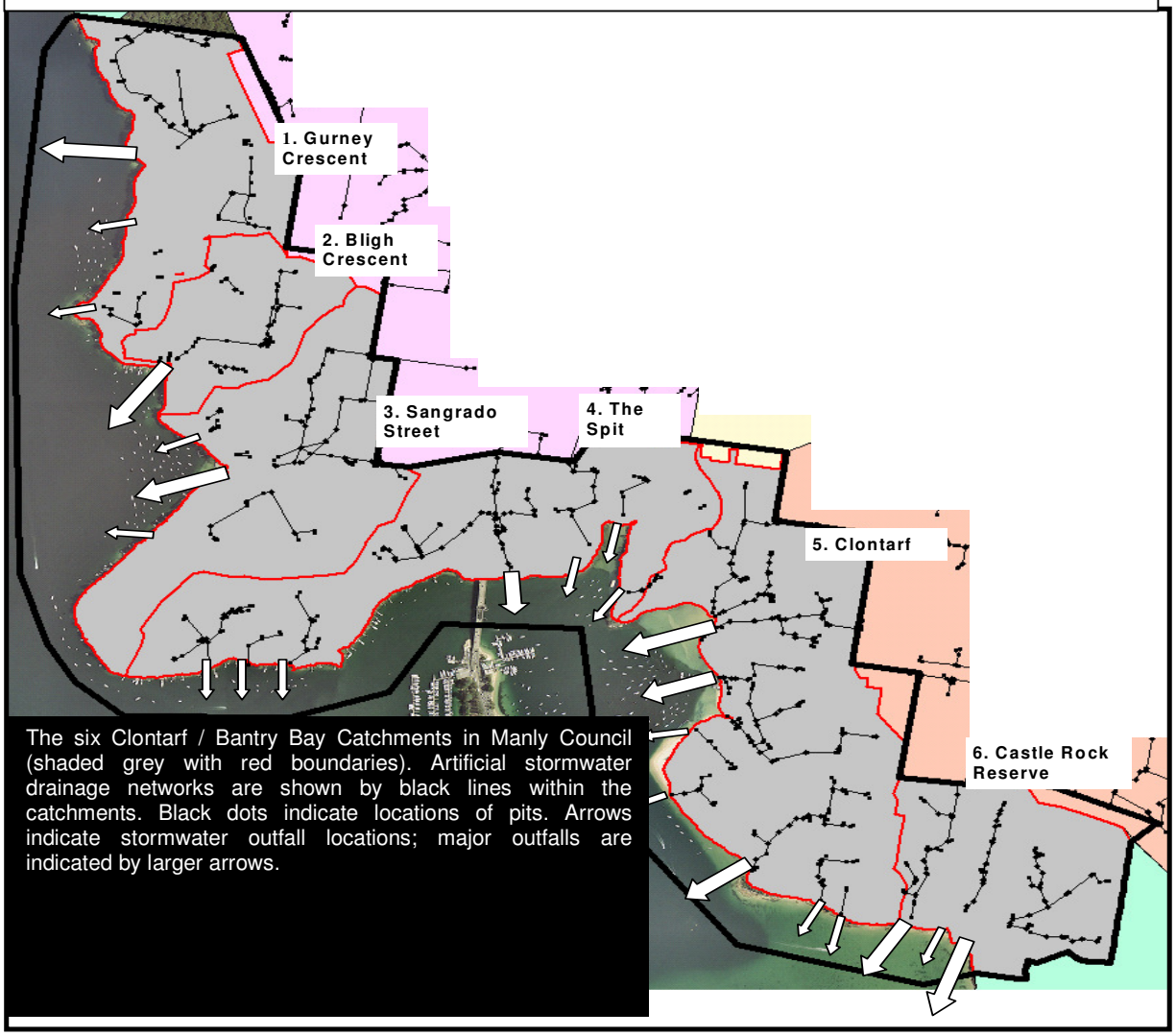
There are six stormwater catchments in the study area: Gurney Crescent; Bligh Crescent; Sangrado Street; The Spit; Clontarf and Castle Rock Reserve. Some characteristics of these catchments are presented in Table 5.3.

Table 5.3 – Stormwater catchments in the six Clontarf / Bantry Bay Catchments in Manly Council

Catchment Name	Area (ha)	Artificial drainage network length (km)	Number of Outfalls	
			Major	Minor
Gurney Crescent	31.99	2.09	1	2
Bligh Crescent	17.95	0.99	1	0
Sangrado Street	42.85	2.35	1	2
The Spit	47.47	3.71	1	6
Clontarf	61.05	4.90	3	2
Castle Rock Reserve	29.23	1.99	2	1
Total	**230.55**	**16.03**	**9**	**13**

In the study area, the relatively narrow and steep catchment means that nearly all of the major stormwater pipes extend right to Middle Harbour, and discharge either onto the foreshore or directly into the water (see Figure 5.3). Some of the pipes direct flows over rock, which provides a stable surface.

Figure 5.3 – The Clontarf / Bantry Bay Catchments and Artificial Drainage Network



The six Clontarf / Bantry Bay Catchments in Manly Council (shaded grey with red boundaries). Artificial stormwater drainage networks are shown by black lines within the catchments. Black dots indicate locations of pits. Arrows indicate stormwater outfall locations; major outfalls are indicated by larger arrows.

5.4 ESTUARY USAGE

The public spaces and waterway within the study area are used extensively for various types of passive and active recreation, with the more easily accessible areas in the lower half of the study area being the most popular. Boating (power and sail), kayaking, rowing, walking, swimming, picnicking, and fishing are all popular activities that are regularly undertaken. Commercial fishing used to be arguably the largest commercial activity undertaken in the study area, however was banned throughout all of Sydney Harbour on 10 February 2006, and this ban remains in effect until 9 February 2011, unless sooner amended or revoked (NSW Department of Primary Industries, 2006). The ban was based on the existence of dioxins found in Sydney Harbour fish, due to contaminated sediments at various locations within the Harbour (see section 6.3).

In order to assess community perception of estuary usage, a survey was conducted, as mentioned in section 1.5. Responses to the questionnaire identified from 120 filled in forms show a diverse range of uses, values and provided confirmation of activities and issues of importance within the study area. The most common estuary usage types of respondents (to the questionnaire) are shown in Figure 5.4a.

These usage statistics indicate that the estuary is used actively with higher uses being walking, swimming, boating & sailing and passive recreation (eg- reading, meditation, picnicking). In addition, the estuary appears to be reasonably used by respondents for kayaking, recreational fishing, sunbathing and walking dogs.

These usage results are consistent with observations made during site visits.

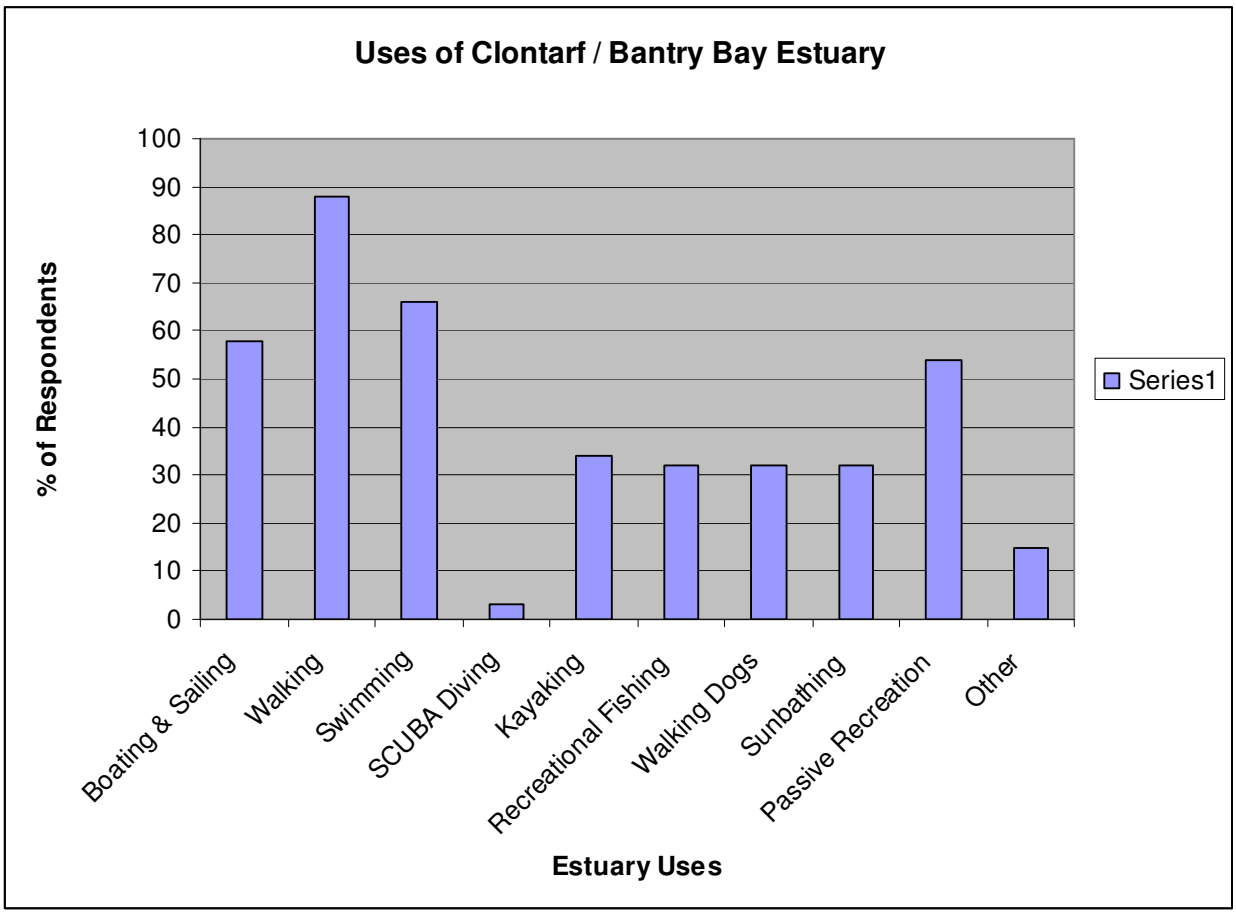


Figure 5.4 Estuary usage

5.5 USAGE AND USER CONFLICTS

There exist conflicts between different usage, user groups and the impacts that competing usage, user groups have on the environment. Different usages have already been described in relevant sections. In this section, only the conflicts are highlighted. Possible compromises, where possible, have also been discussed.

- Natural foreshores versus seawalls and its damaging impact on natural ecosystem

  Seawalls are constructed sufficiently strong and stable to protect against the storm conditions that are experienced in Middle Harbour (Piorewicz, 2007). 46% of the total natural foreshores within the study area have been relaced with seawall. Researches on seawalls in Sydney Harbour show that seawalls have very little intertidal area (because they are vertical) and the surfaces are often smooth, providing few different sorts of microhabitats. Though, seawalls provide habitat for some

species, they are a poor replacement. Several species of sea anemones, whelks and starfish, are not found on seawalls (Chapman & Bulleri 2003, Bulleri et al 2005, Moreira 2006).

- Groundwater abstraction and possible contamination of aquifer

  With recent droughts, groundwater has become an attractive and viable alternate water source for irrigation of public and private land. Many properties along the immediate beachfront at Clontarf are extracting groundwater for residential irrigation purposes. Due to the close proximity of these bores to the Manly Council bore, it is assumed that they are accessing water from the same aquifer. Excessive groundwater abstraction, from bores so close to the estuary, can lead to seawater intruding into the freshwater aquifer.

- Beach raking for safety versus its impact on invertebrates

  Beach raking is currently carried out daily on Clontarf beach. This captures gross pollutants not prevented by street sweeping or other pollutant reduction measures. This activity is also known to be detrimental to the ecology of the intertidal area. As mentioned in section 4.2.1, marine debris such as seagrass wrack (not rubbish) washed up on the shore provides an important source of food and habitat for a diverse range of invertebrate species, which are an important part of the intertidal food chain. Raking of the beach removes this habitat and food source.

- Dog walking off leash and impact on shore birds

  Dog exercising is a popular activity for many members of the community. There are a number of leash-free areas along the foreshores that are frequented by the public and their companion animals. Uncontrolled dogs can be a major source of disturbance to shorebirds. A number of studies (Lafferty 2001, Thomas et al. 2003) have shown that free roaming unleashed dogs negatively affect foraging times and effort for shorebirds. Unleashed dogs are known to prey on shorebird chicks and adults.

- Powered boats and their wake impacting on seawalls and beach erosion

  The upper half of the study area beyond Seaforth Bluff (and the boating restrictions) is used extensively by all types of vessels, and is regularly used by boats towing people (water-skiing, wake-boarding etc). For wake-boarding in particular, there is a desire by participants to have the largest wake possible, enhancing the potential for significant boat generated waves. There has been a recent trend towards ownership of increasingly larger motor cruisers in all of Sydney's waterways, which effectively means that larger boat generated waves will be experienced as a result. Boat generated waves over time can cause foreshore erosion and weaken sea walls. They can impact on habitat. Boating can, in addition, impact on water quality via spills, anti-foul paints, littering from boats and from marinas where boats are washed and fixed etc.

- Access to mooring versus their impact on seagrass beds, ability to spread *caulerpa taxifolia*

  Boating is an extremely popular recreational activity within the study area, but unfortunately it can have detrimental impacts on the marine environment. Anchors, moorings, propellers and hulls can all damage the seafloor and associated seagrass. Moorings are fixed in place with a heavy anchor weight with a chain, rope and buoy attached. The chain drags along the bottom with the current in a circular motion around the anchor, and has the effect of scouring the sea floor. If the mooring is located in a seagrass bed, the scouring will damage or destroy the seagrass within the limit of the chain. Similarly, anchored boats can have impact on seagrass to that of moorings, with a comparable setup of anchor and chain. They differ in that anchors are not permanent, and can therefore damage a larger area over time, as anchors can be placed over a different patch of the same seagrass bed every time a boat stops. Further, anchors work by embedding themselves in the seabed, and when they are raised they can completely remove seagrass by the roots. Due to this high risk of damaging seagrass, the Fisheries Management Act, 1994 prohibits all anchoring within seagrass beds (DPI, 2007).

- Powered boats and the safety aspects for swimmers and kayakers

  Safety is a concern in this area because of the large amount of traffic using the waterway (personal communication with Nick Richards of NSW Maritime, 2006) including swimmers and kayakers. All boats travelling between upper and lower Middle Harbour must pass through this zone, and there

are also numerous marina berths and moorings on each side of the channel, along with several other recreational activities that use the waterway. A No Wash Zone is in place between Clontarf Point and Seaforth Bluff. No Wash Zones are designated "where the wash from a vessel is likely to cause damage to the foreshore or vessels, or injury or annoyance to people" (NSW Maritime, 2007). An 8 knot speed limit zone is also in place, between Clontarf Point and d'Albora Marina (Mosman side of Spit Bridge). Speed limit zones are designated purely for safety reasons.

- Ad hoc boat storage and its impact on amenity and habitat:
  This is an issue at several locations in the study area (e.g. Sangrado, Castle Circuit, Gurney Crescent, Sandy Bay). In the absence of storage facilities, a number of boats are squashing foreshore vegetation and chains are used around trees to lock them up leading to ringbarking. At places, Aboriginal midden sites have been affected.

- Ad hoc access ways to foreshore for convenience versus destruction of habitat.
  Informal pathways have an impact on the bushland within the study area. Pathways have been illegally made to create access to areas such as beaches, formal walking tracks (eg- Manly Scenic Walkway) and recreation areas, with many originating from private properties. These tracks are often not well constructed, and exacerbate problems such as erosion, compaction of soil, and weed dispersal. As many of the tracks are also on Council land, they pose a liability risk to Council. Some of the existing ad hoc pathways (e.g. Gurney Crescent) are the only way to the foreshore and are very difficult to traverse.

All of these are presented in a processes interaction matrix (Table 7.0).