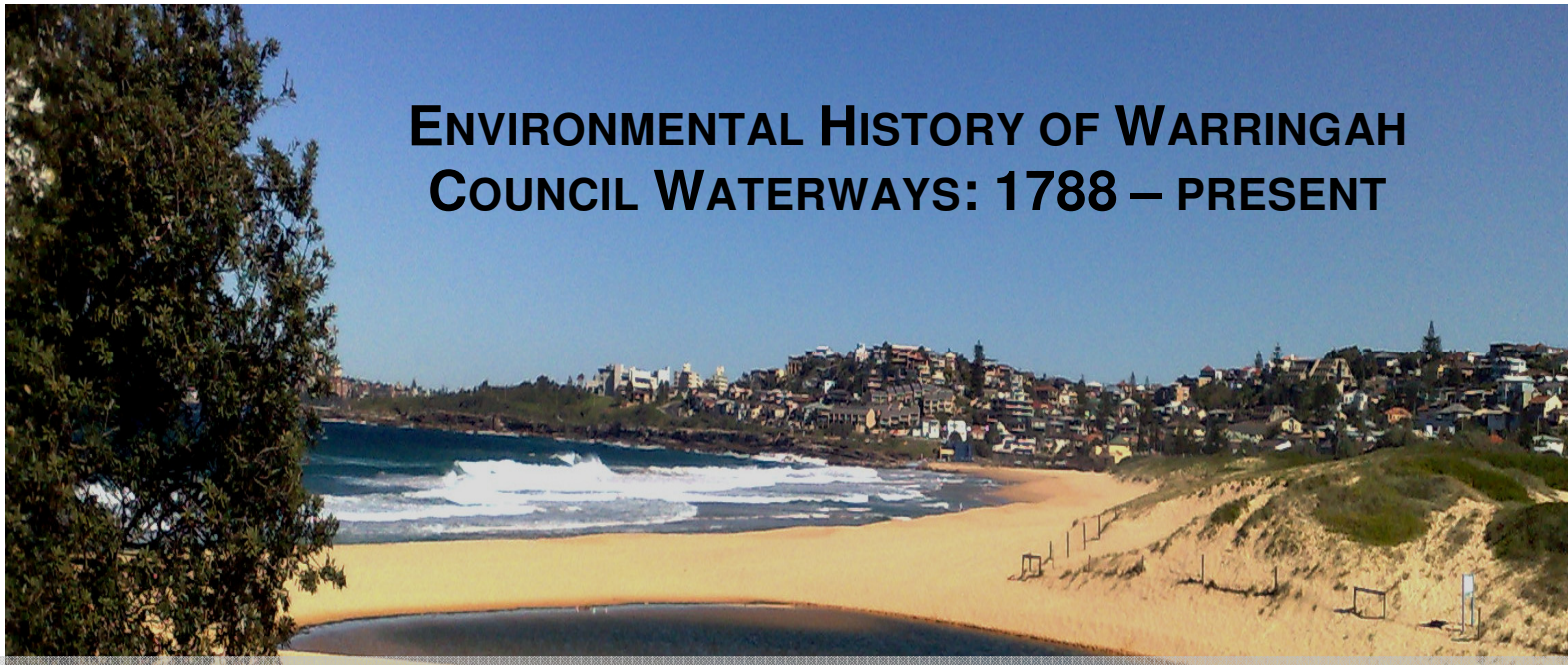
MACQUARIE UNIVERSITY



ENVIRONMENTAL HISTORY OF WARRINGAH COUNCIL WATERWAYS: 1788 – PRESENT

Prepared for:

Warringah Council Natural Environment Unit

Report Date: 15 June 2010

Macquarie University Graduate School of Environment

GSE 844 Environmental Management Practice Report

Authors	Reviewed/Approved
Sally Reynolds	Wendy Goldstein
Purvi Vyas	Tony Morrison
Prachi Grover	Greg Walkerden

Executive Summary

Warringah waterways include four major lagoons and creeks that feed the lagoons. The lagoons are Curl Curl Lagoon, Dee Why Lagoon, Manly Lagoon and Narrabeen Lagoon. Among all four Lagoons Narrabeen is the largest lagoon. In 1788 when European Settlers arrived the lagoons were in its pristine condition. The lagoons were surrounded by native vegetation and the lagoons were rich in fauna. In 1800s there were sparse settlers present within the different catchments.

In the early 1900's when transportation facilities improved more people had easier access to these catchment and thus population started to steadily grow. During this time the lagoons were popular for fishing, prawning, swimming, canoeing, and boating. The foreshores of the lagoons were popular picnic or camping spots. The water quality was good in all the lagoons before the 1900's. The lagoons were rich in biodiversity at that time. These suburbs were a popular destination for holidays and recreational activities.

From the 1940s to 1960s the land was used as market gardens. Still during this time these suburbs were popular holiday destinations but because of improvement in transportation people started developing permanent dwellings at these places. Market gardens peaked in 1950s and declined in 1960s. This land use practice marked the beginning of the degradation of the land. Sedimentation gradually increased. In 1960s and 1970s major development took place. Development continued at the cost of reclamation of the wetlands. During this time sedimentation took place at an accelerated rate. There were no planning instruments to address sedimentation. Septic tanks were used till 1970s within the catchment, so during heavy rainfalls the overflow of the septic tanks would get washed in to the lagoon. This caused eutrophication of the lagoon and added faecal coliform in to the water making it unfit for recreational purpose. Rubbish was dumped within the catchment which had impact on the water quality (because of leachate which goes into the water). During this time dredging was another concern which changed the bathymetry of the lagoons. In the case of Narrabeen dredging has created deep holes up to 4-6 metres at some places[1]. These holes are anoxic and do not support fauna or flora hence reduce the biodiversity of the lagoons[2]. Dredging also causes turbulence within the water which has an impact on sea grass beds and disturbs the whole ecosystem[3]. In late 1900s the entrance of the lagoons was periodically opened by the council which improved water quality because of increased tidal

[1] State Pollution Control Commission 1978, Environmental investigation of Narrabeen, Dee Why and Curl Curl Lagoon

[2] The Ecology Lab report 2007, Narrabeen Lagoon dredge hole investigation

[3] Erftemeijer P. Robin R. 2006, Environmental impacts of dredging on seagrasses: A review, Marine Pollution Bulletin, Vol 52, pp 1553-1572

flushing. The other reason for opening the entrance of the lagoons was to avoid flooding of properties, since development had been allowed very near to the lagoons and in the flood plains.

In late 1970s the catchments of the lagoons were sewered hence the effluents from septic tank overflow stopped going in to the lagoons. Installing sewer in the catchments as well as opening of the lagoons improved the water quality. Biodiversity declined during this time because of the deterioration of water quality, development, reclamation of wetlands, dredging, recreational use of the lagoons (for example speed boating).

Improvement in the water quality, a ban on certain recreational activities such as on water skiing and a lowering of the boat speed limit and revegetation led to a slight increase in fauna, such as black swans. However there is overall biodiversity loss as a result of reclaimed wetlands and clearing in the catchment, which is unlikely to be rehabilitated to that of an early period. In 1990s the sedimentation was still occurring in the lagoon as a result of changes in the catchment but was not as great as in the 1960-70s.

The lagoons are in better condition in 2010 than in 1960s and 1970s. Sedimentation is still an issue but the sedimentation rate has been reduced because of use of various planning instruments to control development within the catchment. The biodiversity of the lake has declined. Hardly anyone swims in the lagoons because of reduced water quality.

- Sedimentation started in 1940s and significantly accelerated between 1960s and 1970s when the development took place. This caused sedimentation in the lake.
- Dredging was carried out in all the lagoons at different time periods which altered the bathymetry of the lagoons, especially Narrabeen lagoon. Dredging was used to infill wetlands for development.
- Various dumping sites within the catchment of the lagoons also impacted the water quality
- Recreational activity changed over time. In early 1900s the lagoons were popular for fishing, swimming, boating, canoeing, sailing indicating that the water quality was good. But in 1960s and 1970s the decline in water quality and siltation reduced the range of recreational activities.
- The use of septic tanks led to euthrophication
- Development allowed within the sensitive areas (like flood plains) has resulted in the problem of flooding of properties.
- Entrance management improved tidal flushing as well as avoided flooding in low lying properties
- Biodiversity has declined over time because of the change in water quality, reclamation of wetlands, disturbances caused due to dredging, recreational use of lagoons (for example speed boating in the lagoon)
- The water quality has improved recently (as compared to what it was in 1960s and 1970s) because of entrance management, revegetation of the catchment, reduction of waste dumping in the and near the lagoons, and the use of planning instruments to control development.

Recommendations

As a result of the finding on human impacts on the lagoons a number of recommendations emerge for management:

- Engage the community in developing a common vision and goals for all the lagoons in a participatory process. This will clarify the management objectives and basis for planning how to balance for biodiversity, water quality, and depth, recreational use, amenity and protection of developments.
- Continue monitoring of the water quality and communicate findings to the public and address management issues.
- Monitor rubbish dumping sites/landfills and educate the community about catchment protection
- There are deep holes present in some parts of the lagoon. These holes are anoxic in nature and do not support “unique species”. These holes will take long time to naturally fill, or could be deliberately infilled to support more sea grass and fauna.
- Develop specific requirements for developments in the catchment to include water sensitive design. This will help in reduction of sediments going in to the lake.
- Consider restoring wetlands around the lake to help reduce sediments and nutrients going into the lagoon.
- Conducting a community education program to develop understanding that Narrabeen lagoon has not become shallow due to sedimentation. Although accelerated sedimentation took place in 1960’s and 1970’s now, because of regular openings of the lagoon from 1975, the lagoon is shallow because of a drop in water level.
- Provide information on the history of the lagoons on the Council website along with a list of FAQ’s to help the community understand the changes.
- Prior to undertaking dredging or entrance clearance council should provide information to the community

Contents

1.0 Introduction

Warringah Council Natural Environment Unit requested Macquarie University Graduate School of the Environment students to undertake a review of the catchment waterways and provide a report on the "Environmental history of Warringah's waterways: 1788 – present". The waterways include the main lagoons and creeks that drain into the lagoons.

Warringah is a local government area (LGA) situated in the Northern Beaches region of Sydney, Australia. Warringah overlaps with a number of suburbs from the Manly Council area to the south and the Pittwater Council area to the north. It includes a number of popular beaches for swimming and surfing such as Narrabeen, Collaroy and Dee Why.

Warringah LGA covers an area of 153 square kilometres, consisting of a mix of residential, crown land (including beaches and reserves), National Parks, business areas and light industrial areas. The waterways of the LGA consist of six catchments which include 14 km of coastline; four coastal lagoons and 50km of creeks and streams.

The aim of the report is to summarise the changes that have occurred to the major waterways through history and to link published literature, scientific research and photographs with the personal memories of local residents to obtain as accurate account as possible of the changes that have occurred to date.

1.1 Project rationale

Council has advised that local residents and community groups have concerns that the waterways are not "like they used to be". Council has been under pressure from community members to undertake dredging in the Narrabeen lagoon[4]. Council has replied through the Manly Daily that a full consultation and management plan is required before dredging can occur.

Council therefore requires a report that provides sufficient evidence of what the historical uses or physical characteristics of the waterways were to allow Council to have informed dialogue with the residents and groups. Therefore this report will provide a resource for Council to address issues of concern supported with historical and scientific evidence of the state of the waterways.

The waterway issues that Council has identified as community concerns are as follows:

- Geomorphology/physical changes (size, location, depth, clarity and vegetation);
- Water quantity;
- Water quality;
- Ecology; and

[4] *Brenton Cherry Manly Daily 11 Feb 10 @ 04:29pm*

http://manly-daily.whereilive.com.au/news/list/category/environment/

- Land management/land use.

To provide a background to assess the above issues and assist Council in understanding the condition of the waterways from the time of the first European settlement around1788 to the present the following aspects are to be researched: .

- Major changes to waterways that occurred post European settlement that had an adverse impact;
- The issues and problems that the community has identified today as important and determine if the historical use of the waterways has contributed to these problems;
- The changes in the use of waterways by the community over time and identify what improvements could be provided;
- An examination of land uses in the catchment to identify which developments have had the greatest impact.

1.2 Project objective

The objective of the project is to deliver a report that assesses the impacts and changes in the geomorphology, ecology, water quality and quantity of the Warringah waterways from first settlement using a triangulation technique to remove biases or weaknesses in the initial data.

1.3 The study area

Warringah LGA covers an area of 153 square kilometres[5], consisting of a mix of residential, crown land (including beaches and reserves), National Parks, business areas and light industrial areas. The population of the area is over 141,000[6] people.

The waterways of the LGA consist of six catchments which include 14 km of coastline; four coastal lagoons and 50km of creeks and streams.

The largest catchment is Narrabeen Lagoon, which is fed by South Creek, Middle Creek, Deep Creek and Mullet Creek.

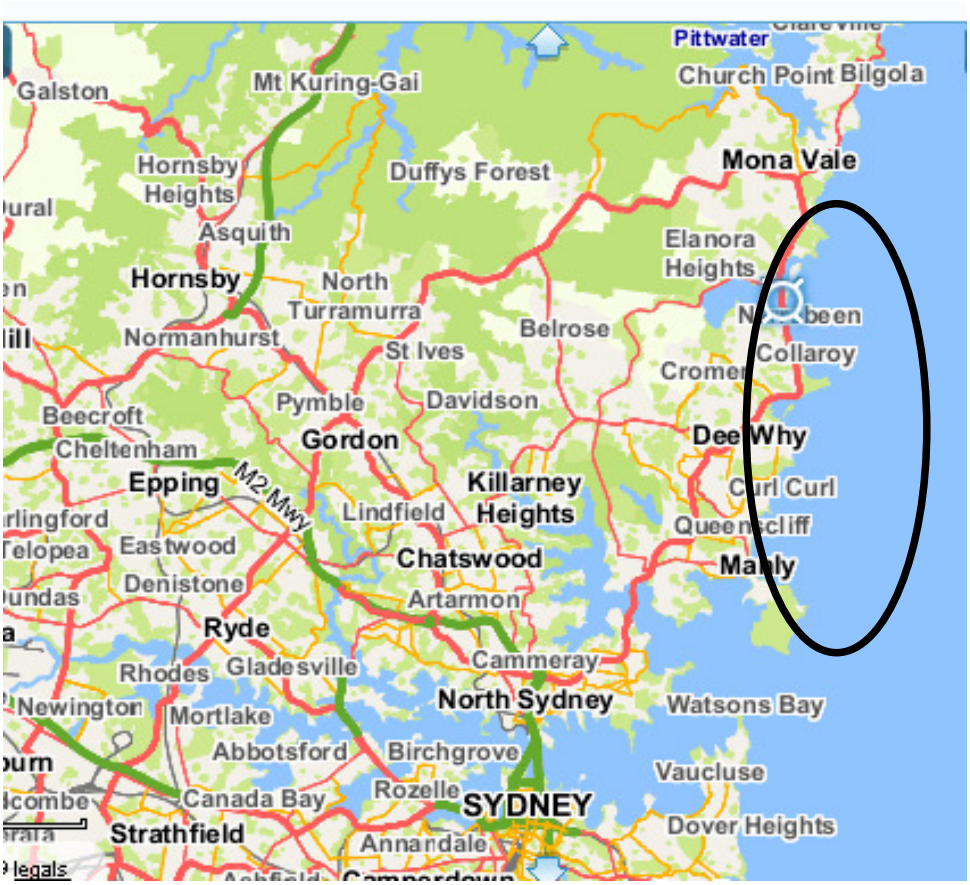
Dee Why, Curl Curl and Manly Lagoon are the other major water bodies within the LGA. Refer to Figure 1 and Figure 2 for details of the lagoon locations within the LGA[7].

Figure 1 Location of the study area (circled in black)

[5] Warringah council web http://www.warringah.nsw.gov.au/ (accessed 28/03/10)

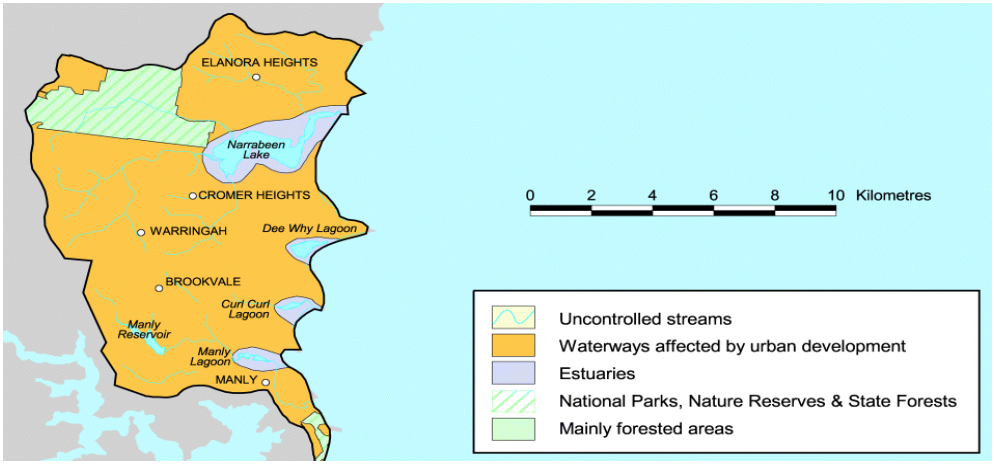
[6] Warringah council web http://www.warringah.nsw.gov.au/ (accessed 28/03/10)

[7] http://www.environment.nsw.gov.au/ieo/Gosford/maplg.htm (accessed 1/5/10)



Source: http://www.whereis.com/#session=MzY= accessed 1/5/10

Figure 2 Location of the four lagoons within the Warringah LGA



Source: http://www.environment.nsw.gov.au/ieo/Gosford/maplg.htm (accessed 1/5/10)

2.0 Project Context

Council has information on the LGA waterways, however, the information is not contained within one document, rather it is available in various forms such as scientific reports; historical documents; photographs; and maps. In addition, the available data for each waterway varies, for example, significant information on Narrabeen Lagoon is available however, reports and data for Manly Lagoon is limited.

The report will provide a resource that assimilates information for Council to use for reference when addressing issues from residents, businesses and other government departments relating to the LGA waterways. The information collated and analysed will focus on issues around dredging activities, varying lagoon water levels; water quality; land use and development; ecology; and geomorphology changes.

The report will provide an overview of the past and present condition of the waterways. and provide a timeline of the waterway changes with each event reviewed and verified using the triangulation method of cross referencing multiple sources with the aim of providing a useful resource that can be referenced quickly by Council when the community has enquiries.

2.1 Environmental management responsibilities

2.1.1 Legislation

Local Government has a range of functions, powers and responsibilities at its disposal to influence environmental management responsibilities - on both private and public land[8]. These include:

- *strategic planning* through land use zoning and statutory controls on all freehold land and locally managed public open space;
- *development control* of nearly all activities and works on freehold land and crown land (except national parks and state forests) through development consent powers;
- *enforcement powers* for development consent conditions, waste management and unauthorised land uses (eg. land clearing, drainage, and filling);
- *administrative responsibility* for state agency coordination through integrated planning, licensing and development concurrence;
- *stormwater management* and control; sewerage and drainage works, and flood control;
- pest, plant and animal *risk control measures*;
- influence over land clearance patterns through *incentive programs* (planning amendments, rate differentials, levies, rural fire management and developer contributions);

[8] Local Government and Shires Association of NSW http://www.lgsa.org.au/www/html/292-local-governments-role-in-nrm.asp

- *management of local open space* to restore remnant vegetation and recreate habitat; and
- primary advocate for and *coordinator of local community groups* and interests.

Councils are the planning authority for most developments, excluding those that are assessed by the NSW Minister for Planning and can therefore influence the developments that are approved. For example, Section 733 of the Local Government Act 1993, indicates Warringah Council should consider preparing a flood mitigation management plan for the lagoons in Warringah catchment. Council identifies flood affected areas and considers the costs and benefits before determining a course of action.

Responsibilities of councils include:

- Land use decision making;
- Designing and delivering infrastructure;
- Environment protection and management;
- Community engagement;
- Planning, construction, and management of specific coastal and water quality management infrastructure; and
- Management of public access to and use of foreshore[9].

The legislation relevant to the report includes the *Local Government Act 1993; Water Management Act 2000; Environmental Planning and Assessment Act 1979; Coastal Protection Act 1979 and Protection of the Environment Operations Act 1997..* A brief summary of the relevant sections of each Act is provided in Table 3.

Table 3 Summary of legislation applicable to environmental management

Legislation	Description
Local Government Act 1993[10]	
Section 7	• Provision of services and facilities; conduct activities appropriate to the current and future needs of local communities and of the wider public; improve and develop resources of the area.
Section 8	• Manage, develop, protect, restore, enhance, and conserve the environment of the area in a manner that is consistent with and promotes the principles of ecologically sustainable development. • Engage in long term strategic planning on behalf of the local community & facilitate involvement of members of public.
Section 36M	• Manage watercourses to protect biodiversity and ecological values including water quality and water flows. • Restore degraded watercourses; promote community education, and community access to and use of watercourses where possible.

[9] *Local Government Act 1993,* <http://www.austlii.edu.au /au/legis/nsw /consol_act/ lga1993 182/>

[10] *Local Government Act 1993,* <http://www.austlii.edu.au /au/legis/nsw /consol_act/ lga1993 182/>

Legislation	Description
Section 36N	• Maintain and protect the foreshore as a transition area between the aquatic and terrestrial environment; facilitate the ecologically sustainable use of the foreshore and mitigate impact on the foreshore by community use.
Section 733	• Coastal and flood management work where possible
Water Management Act 2000[11]	
Section 5	• water sources, floodplains and dependent ecosystem should be protected and restored and where possible land should not be degraded; the water quality of all water sources should be protected and, wherever possible, enhanced.
Environmental Planning and Assessment Act 1979 (EP&A Act)[12]	
	• Development applications other than "major projects" in NSW, local councils are the consent authority. • Council has the authority to approve or refuse developments, and impose conditions of consent. • EP&A Act prescribes mandatory matters that councils must consider when making a decision. These include impacts on the environment, social and economic impacts in the locality and the public interest. • Development applications are usually determined by reference to the relevant Local Environmental Plan and/or Development Control Plan, which contain zoning restrictions and development standards.
Coastal Protection Act 1979[13]	
Section 55B	• Requires council to prepare locally based coastline management plans incorporating emergency management plan
Protection of the Environment Operations Act 1997[14]	
POEO Act 1997	• The POEO Act enables the Government to set out explicit protection of the environment policies (PEPs) and adopt more innovative approaches to reducing pollution. PEPs are instruments for setting environmental standards, goals, protocols and guidelines. They provide both the framework for Government decisions that affect the environment, and are the means of adopting Australia-wide environment protection measures set by the National Environment Protection Council.

2.1.2 Strategic planning

Strategic plans are long-term visions for future land uses which can prevent unplanned gradual shifts by formalising the environmental values to be protected on a local government or wider scale[15].

Section 402 of the *Local Government Act 1993* states that each local government area should prepare a strategic plan that identifies the main priorities and aspirations for the future of the LGA which covers a period of at least 10 years from when the plan is endorsed. The strategic plan should include civic leadership, social,

[11] *Water Management Act 2000*, <http://www.austlii.edu.au/au/legis/nsw/consol_act/ wma2000166/>

[12] *Environmental Planning and Assessment Act 1979*,<http://www.austlii .edu.au/au /legis/nsw/consol_act/epaaa1979389/>

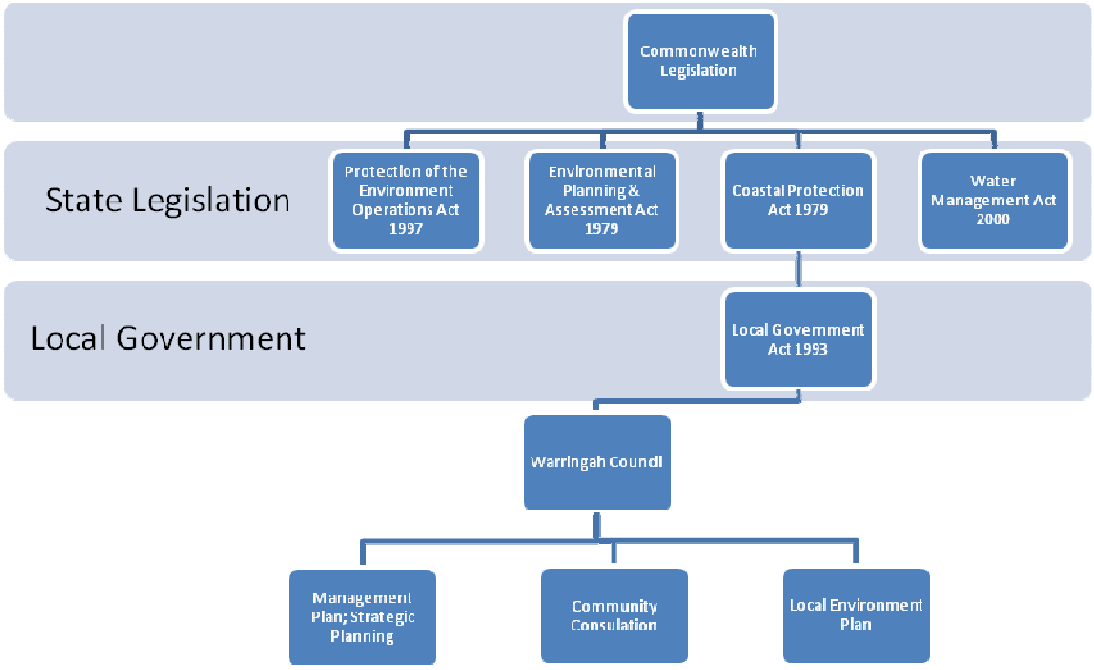
[13] *Coastal Protection Act 1979*, <http://www.austlii.edu.au/au/legis/nsw /consol_act/ cpa1979210/>

[14] Protection of the environment operations Act 1997 http://www.environment.nsw.gov.au/legislation/aboutpoeo.htm

[15] DEHWA www.environment.gov.au

environmental and economic issues in an integrated manner; it is developed having due regard to the state government's state plan and other relevant and regional plans of the state government[16]. Figure 4 provides details of how the various levels of government communicate and how the community is involved. The oral history report will provide guidance for Council when addressing community issues relating to changes in characteristics of the LGA waterways.

Figure 4 Levels of legislation and Council involvement



2.1.3 Environmental Education

Councils play an important environmental education role for the community. The aim of environmental education is to support projects or programmes that develop or widen the community's knowledge of, skills in, and commitment to protecting the environment and promoting sustainable behaviour. Warringah Council can provide support to community and volunteer groups that undertake revegetation works around the lagoon for environmental benefits and to improve the community understanding of the issues relating to the lagoon and catchment environment.

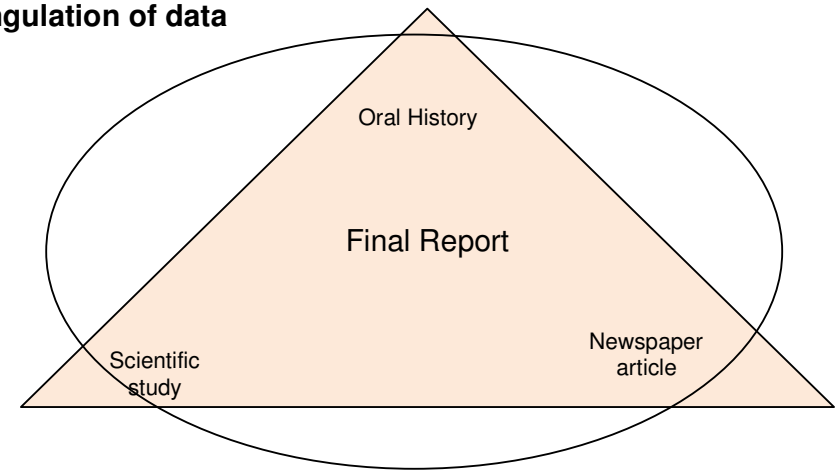
[16] DEHWA www.environment.gov.au

2.2 Method for the study

The approach for the project was to review data from various sources in order to assess the veracity of changes. Information in scientific reports; published reports and text (e.g. consultants reports, state of the environment report) will be compared with stories in newspapers; photographs and maps and cross referenced with local residents historical accounts of how they believe the waterways were and how they have changed over time.

This technique of assessing data is referred to as triangulation and is shown diagrammatically in Figure 3. Triangulating using multiple sources increases the reliability of an historical study's findings. When multiple sources confirm that a change has occurred, or is a reasonable inference, the likelihood of error decreases. It reduces bias and is less risky than single method, single-observer and single-theory studies.

Figure 3 Triangulation of data



We are informed that historical scientific information on the LGA is not well documented particularly for the period prior to the 1950's. However at times scientific data can be used from other similar coastal lagoon areas and existing scientific data was reviewed to substantiate historical assumptions and to rule out some hypotheses.

Historical texts, photographs and maps as well as reviews of vegetation maps and models were used to infer the change in ecology of the waterways and surrounding areas.

Warringah Council provided a list of residents that had lived in the area for a period of time and who would be interested in being interviewed for the project (refer to Appendix A). The interviews were conducted face to face using a set of questions (refer to Appendix B) and each interview was recorded on audio tape. A total of 7 residents were interviewed providing valuable insight as to what the natural environment was like from the 1930's and 1940's up to today.

Initially the issues that were identified during interviews with long term residents were tabulated and reference materials reviewed to determine the accuracy of the interviewee's accounts.

Newspaper reports provided information on the views of the community over time and the issues that have been raised relating to the waterways. As development and land use within the catchment has altered, community views on the impact have

been reported in the news. As newspapers are often influenced by various pressures, such as political parties or special interests, the information needs support from alternative sources. Therefore, other published reports and independent accounts of the changes are referenced to support the newspaper articles (refer to the Reference list for details). In addition the views of the interviewees are included in the comparison.

Cross referencing the sources using the triangulation method, will provide Council with a record of events supported from several sources and provide verified evidence for the environmental history of the waterways. Where not all information can be triangulated, Council will be at least aware of gaps in the knowledge and therefore the difficulty of making a definite assertion.

We interviewed six local residents out of which two referred to Narrabeen Lagoon, two for Curl Curl Lagoon, one for Manly Lagoon and one for Freshwater Creek after obtaining ethics clearance from Macquarie University. We conducted interviews in person and taped the interviews. In some cases further queries were made by phone. We did contact all the people on the list but were unable to interview a few people because of their lack of availability. We emailed our questionnaire to some on request though did not get reply from any one of them. The residents whom we interviewed were elderly long time residents of the area who were reflecting on events over a long period of time and represent a small section of the community. We were impressed with the commitment and work these residents have done to maintain a quality environment and suggest that these achievements should be publically acknowledged by the council.

Within the time constraint of this project we could not research and include information on other water ways present within the catchment.

Scientific documents included peer reviewed articles, scientific articles from journals, reports prepared by council/ by consultants for council and thesis. Historical documents included Newspaper archives of Manly Daily, and Sydney Morning Herald; some historical documents prepared by early European settlers which gave a description of the lagoons and its environment, pictures from Warringah Library Service and newspapers. We would like to thank all those who generously shared their resources.

We faced difficulty in fully triangulating our information to assure its validity as it was not possible every time to get all three sources for any event. Sometimes we found only two sources such as historical documents and pictures and confirmation from oral history but lacked scientific evidence. In other cases the information we found from historical documents contradicted the oral history. In some cases the oral history confirmed the occurrence of certain events but could not provide the specific year.

2.3 Environmental History Best Practice

2.3.1 Case Studies

Table 2: Summary of similar environmental history studies

Case Study	Type of study	Method Used	Relevance to Warringah Council
Rowes Bay, Townsville QLD[17]	Environmental history review from European settlement to current	Reviewed various sources including photographs, maps, newspapers	Similar method to be used, including the review of multiple sources to determine the history
Ross Creek, Townsville QLD[18]	Ross Creek Scoping Study	Review of historical documents, council reports and land use documents	The study examines plans for the future use of the creek area by rail authority, port authority, and council, takes in to consideration actions for future management
Ohio Watersheds, US[19]	Comparison of two adjacent catchments overtime. This study used combination of land use history, socioeconomic history, and natural science data to determine the changes.	Reviewed many sources including travellers' and settlers' accounts, emigrant guides, state archives, historical societies, interviewed local residents, newspapers, journal articles, periodicals, reports and maps on water & land uses, land surveys, census data, books, dissertation, theses, and scientific reports/journal articles	This study assessed land use history, socioeconomic history and natural science. Current environmental issues are the result of prior problems, actions, and consequences, just as future environmental issues can be a result of decision making today
Great Barrier Reef, QLD [20]	Environmental history of changes in coral reefs, islands and marine wildlife of the Great Barrier Reef. Includes the impact of European settlement and development of the adjacent coastal zone,	Various sources reviewed, including oral history review.	Great Barrier Reef Marine Park Authority report which is used to confirmed or refute anecdotal reports of decline in the coral reefs, islands and marine wildlife of Great Barrier Reef, to apply qualitative methods to the solution of an environmental problem,

[17] Mabin, 2002, Environmental History of Rowes Bay, Townsville City Council, < http://www. soe-townsville.org /data/from_SRI/history_rowes_bay.pdf>

[18] Browne W, Broome G, Faithful J, 1994, Ross Creek Scoping Study, Townsville City Council, < http://www.soe-townsville.org/inlandwaters.html>

[19] Hager I, 2004, The contribution of environmental history to the development of a model to aid watershed management: a comparative study of the Big Darby Creek and Deer Creek watersheds in Ohio, < http://drc.ohiolink.edu/handle/2374.OX/6703>

[20] Daley B, 2005, Changes in Great Barrier Reef since European settlement – implications for contemporary management, <http://eprints.jcu.edu.au/1312/>

Case Study	Type of study	Method Used	Relevance to Warringah Council
	especially the major land uses of the area.		
Introducing the Condamine and its oral history, QLD[21]	Oral history review of the Condamine River	Interviewed long term residents	Study reviewed government and economic influences in shaping the river for two centuries. By looking at the past cultural, social, economical, financial and environmental impacts on the river able to see how it has reached the state it is in today and hence giving us the opportunity to make thoughtful and calculative decisions for sustaining a healthy river for tomorrow.
The Ecology of Tuggerah Lakes. An Oral History[22]	Oral history	Interviewed long term residents to reconstruct the past and gather evidence on the changes to the lakes.	Study conducted to understand the ecological changes since European settlement. Hence it will provide a better understanding of ecological changes and will help in future management of the lake and catchment.

[21] Connors L, 2002, *Introducing the Condamine and its oral history.* In: Potter, Catherine and Moles, Sarah and Connors, Libby and Postle, Pam, (eds.) Conversations on the Condamine: an oral history from the Queensland Murray-Darling Basin. Envirobook, Annandale, NSW, Australia, pp. 13-28. ISBN 0 85881 189 8 http://eprints.usq.edu.au/5071/2/Connors_2002__Chapter_Notes.pdf

[22] Scott A, 1998, The Ecology of The Tuggerah Lakes. An Oral History, <http://www.clw.csiro.au/publications/technical98/tr40-98.pdf>

3.0 Environmental History Review of the four lagoons of Warringah Council

3.1 Introduction to coastal lagoons

The Warringah Shire lagoons discussed in this report are referred to as coastal lagoons retained by sand barriers from the sea. These lagoons are all "intermittently closing and opening lagoons" (ICOL). The estuaries that form part of the lagoon system are often sensitive to human intervention[23] as a result of recreational (swimming or boating) and/or urbanisation (sewerage, pollution).

The lagoons are used by the local population along with tourists for recreational use and the aesthetic values that they provide. The environmental benefits provided by the lagoons include biodiversity and biomass reservoirs, seafood, flood control for the surrounding area and shoreline protection[24].

When lagoons are closed to the sea all freshwater runoff from the surrounding catchment is captured which results in an increase in water level, and hence depth of the water body. The freshwater dilutes the salinity of the lagoon, however, if rainfall is low, evapotranspiration can result in water levels decreasing causing increased salinity of the lagoon[25]. As a result, the biodiversity of the lagoons needs to be able to tolerate a wide range of saline conditions.

The following sections discuss each of the lagoons from 1788, early European settlement, to the present day.

3.2 Curl Curl Lagoon

Curl Curl Lagoon is ~6 ha and elongated in shape. The area of the Curl Curl Catchment is 3.2 square kilometres (320 ha). The Curl Curl Lagoon was previously called Harbord Lagoon prior to the 1980's[26].

Greendale Creek is the predominant creek that drains into the lagoon and bisects the Curl Curl Catchment. Boyce (2006) reports that the size of the lagoon was "substantially" larger than it is today. The reduction in size of the lagoon is a consequence of the landfill/rubbish dump at the back of the lagoon where Greendale Creek enters the lagoon.

The water level of the lagoon is not constant; rather it varies due to the ICOL nature of the lagoon and also due to rainfall, evapotranspiration and tides which all create variation in the water level of the lagoon.

The lagoon bed is exposed on a regular basis when the lagoon is open[27]. The sand barrier (or berm) which acts as a barrier and prevents water flowing to the ocean is

---

[23] Haines P. E., Tomlinson R. B., Thom B. G. 2006 *Morphometric assessment of intermittently open/closed coastal lagoons in New South Wales, Australia.* Estuarine, Coastal and Shelf Science, 67 321-332.

[24] Danovaro R., Pusceddu A., 2007 *Biodiversity and ecosystem functioning in coastal lagoons: Does microbial diversity play any role?* Estuarine, Coastal and Shelf Science 75 4-12.

[25] Haines P. E., Tomlinson R. B., Thom B. G. 2006 *Morphometric assessment of intermittently open/closed coastal lagoons in New South Wales, Australia.* Estuarine, Coastal and Shelf Science, 67 321-332.

[26] Boyce J 2006 *Pictorial history Warringah* Kingsclear Books.

created by wave and wind action. In times of flood and heavy rainfall, this barrier is removed either by Council, residents or by overtopping opening the lagoon to the sea[28]. When this occurs the mud flats of the lagoon become exposed, revealing a lack of seagrass, but the presence of algae and also rubbish and odour[29]. The seagrass depletion was commented on during the interview refer to Clip 8 Resident A and Resident B

Table 3 provides a summary of the issues and a reference to the supporting sources for Curl Curl Lagoon.

[27] State Pollution Control Commission Environmental Investigation of Narrabeen, Dee Why and Harbord Lagoons 1978.

[28] Australian Water Technologies *Curl Curl Lagoon Ecological Monitoring Program* report for Warringah Council 2000.

[29] Australian Water Technologies *Curl Curl Lagoon Ecological Monitoring Program* report for Warringah Council 2000.

Table 3 Curl Curl Lagoon summary of issues and triangulation of data

Year	Issue	Oral History*	Scientific Data	Books/Maps/Media
1880s	Greendale creek area; many market gardens (Chinese)	Resident D	Boyce 2006	
Early 1900's	Water supply from the creek to the first houses prior to mains installation	Resident C		
1930's	Market gardens in the area	Resident D		
1930's	Bridge constructed across lagoon	Resident A and B		Figure 2
1940's	Sea grass beds prior to the tip being created, now depleted	Resident A and B	SPCC 1978, Danovaro 2007	
1940's	Removal of sand from the sand dunes during WWII	Resident D	Boyce 2006	
Post WWII	Dairy & Pigs bred in the catchment	Resident A and B		Figure 5
1943-2008	Size of the lagoon changed over time		Boyce 2006	Figure 2 & Figure 5
1951	Fish quantity reported that it was abundant	Resident A and B		Figure 9
1950-1970's	Land fill/rubbish dump consisting mostly of domestic rubbish, was dumped where Greendale Creek enters the lagoon	Resident A and B	SPCC 1978, AWT 2000	Boyce 2006
1960's	Dredging reported and sediment used to reclaim the low lying areas during the urbanisation of the area, including recreational areas (John Fisher & Weldon Parks)	?	Guerra et al 2009 SPCC 1978	
1980's	Sand dune creation			SLSA, 2010; Curl Curl Lagoon and Friends 2004
1978 & 1990	Decline in the bird population noted; in 1978 recoded 102 different species compared with 75 species in 1990	Resident A and B		Curl Curl Lagoon and Friends 2004
2001	Buffer zone created on either side of Greendale Creek and Curl Curl Lagoon to offer protection from pollution and filter run-off from the urbanisation surrounding the lagoon.	Resident A and B		Curl Curl Lagoon and Friends 2004
Overtime	Water quality monitored Dates 1978, 1994 - 2002	Resident A and B	AWT 2000, EC 2002, SOE 1993, SPCC 1978	

*Refer to Appendix A for Clip Identification

The information from Table 3 has been expanded and cross referenced in the following sections to justify and confirm or disprove the issues identified during the interviews with the local residents using the triangulation method.

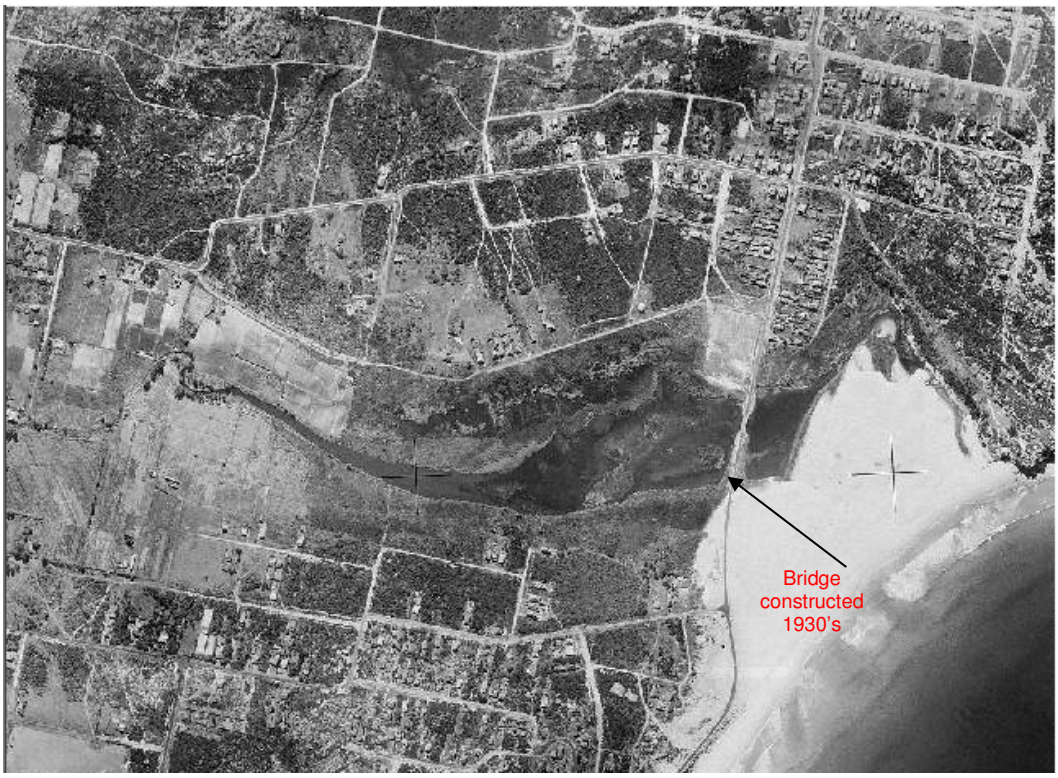
The images shown in Figures 4 to 9 reflect the changes to Curl Curl Lagoon between 1927 and 2008.

Figure 4 Curl Curl Lagoon 1927

Source: Warringah Library Service 2010

Figure 4 depicts the early holiday homes and early development of the area around the lagoon and beach. The Resident A, B and D's comment on the early settlements including market gardens and small farms such as pig and diary. These agricultural areas are likely to be shown in the photograph adjacent to the houses.

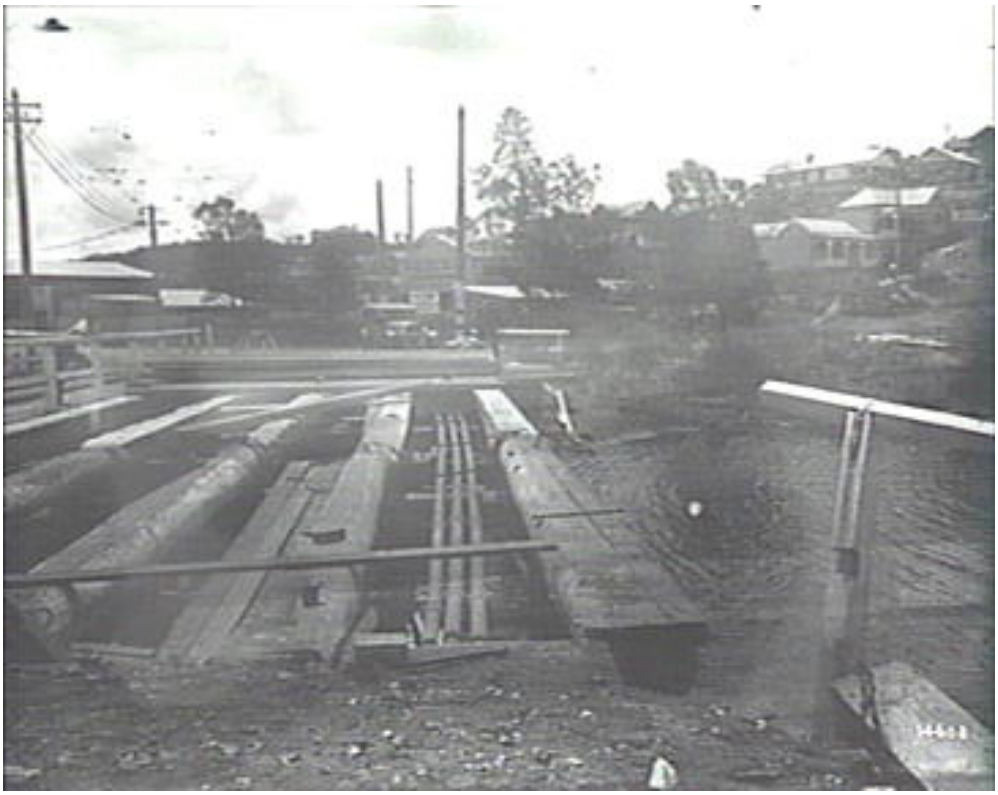
Figure 5 Curl Curl Lagoon 1943



Source: NSW Department of Lands 2010

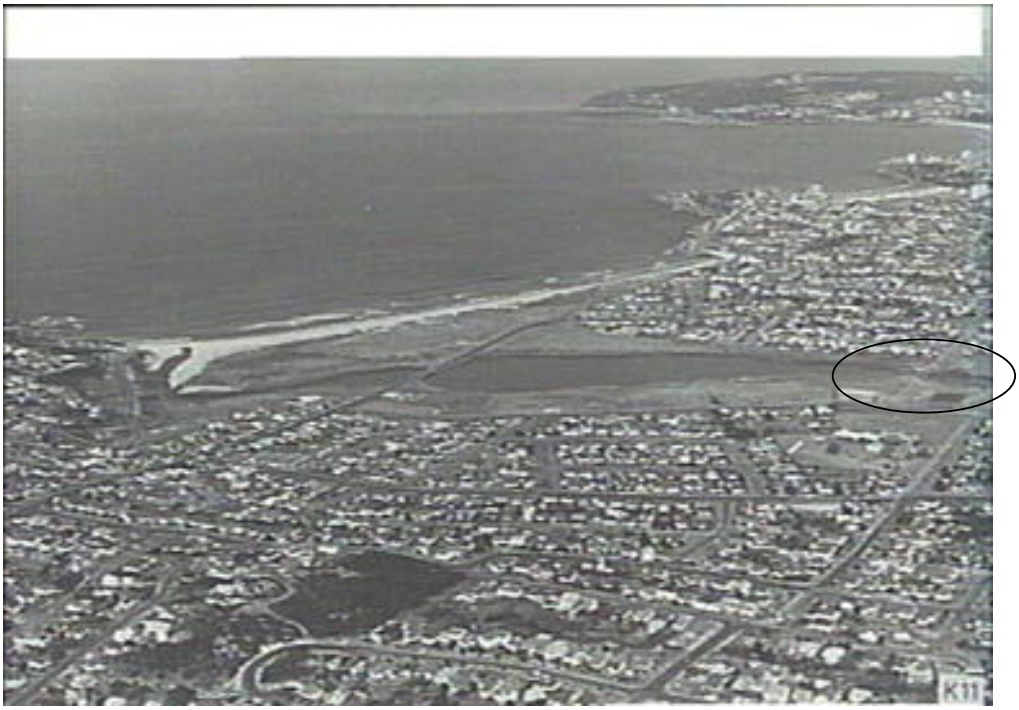
Figure 5 depicts the increase in development and infrastructure with the area adjacent to the lagoon appearing to have had the vegetation removed. During the early 1930's a bridge was built across the lagoon entrance to the sea. The construction of this bridge is shown in Figure 6.

Figure 6 Curl Curl bridge construction 1931



Source: Warringah Library Service 2010

Figure 7 Aerial view of Curl Curl 1970



Source: Warringah Library Service 2010

The development and infrastructure surrounding the lagoon has increased significantly as shown in Figure 7. The entrance can be seen to the left and appears not to be open to the sea. The size of the lagoon appears smaller to Figure 5 particularly where Greendale Creek enters the lagoon (circled). This area was used as a tip/landfill from 1950-1970[30].

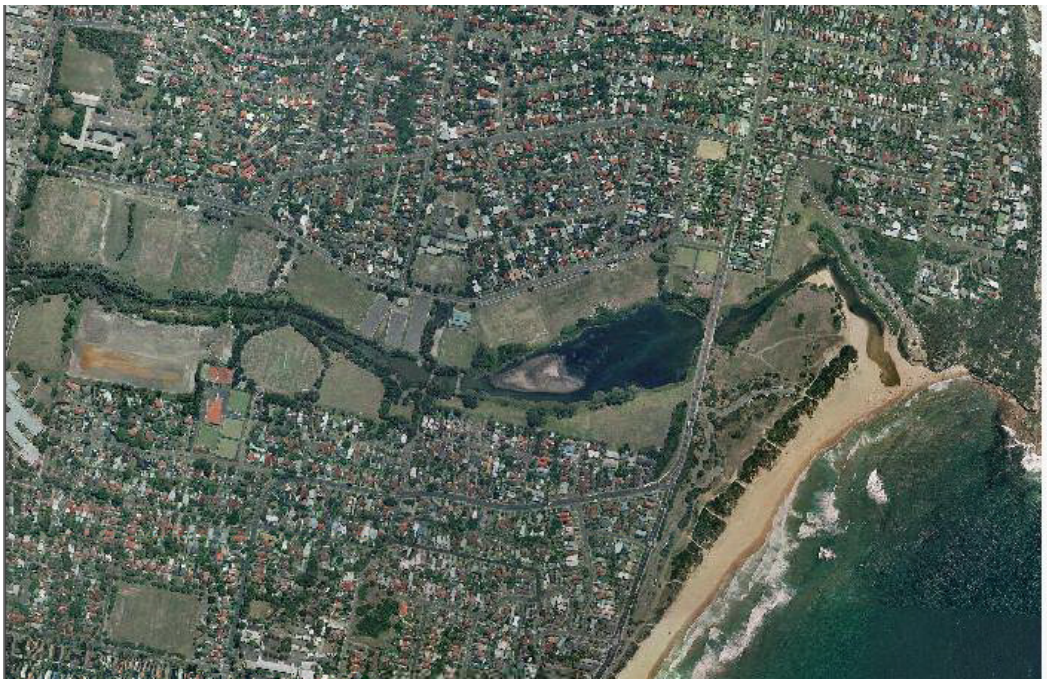
[30] Boyce J 2006 *Pictorial history Warringah* Kingsclear Books.

Figure 8 Aerial view of Curl Curl Lagoon entrance, ca. 1983

Source: Warringah Library Service 2010

The aerial photo in Figure 8 shows that the vegetation surrounding the lagoon appears minimal and excavation works are being undertaken at the top of the lagoon adjacent to Greendale Creek.

Figure 9 Aerial view of Curl Curl Lagoon 2008



Source: Department of Lands 2010

Figure 9 indicates that the entrance to the lagoon is open or recently closed. The vegetation along the creek and around the lagoon is greater and the buffer zone referred by Resident A and B is visible along the lagoon and Greendale Creek. This improvement in vegetation is a result of both a volunteer group "Curl Curl Lagoon and Friends revegetation group"[31] and by Warringah Council.

3.3 Impacts on the catchment

3.3.1 World War II

The Department of Defence used sand from the sand dunes to aid against attacks in WWII, refer to Figure 10, and constructed barbed wire barriers along Curl Curl beach[32]. The use of the sand for this activity depleted the northern dunes.

[31] Curl Curl Lagoon and Friends, Curl Curl Lagoon and Friends Inc 2004.

[32] Boyce J 2006 *Pictorial history Warringah* Kingsclear Books.

Figure 10 Sand dunes at Curl Curl, ca. 1928

Source: Warringah Library Service 2010

Figure 10 depicts an area of the sand dunes at Curl Curl that was used as a rifle range during pre WWII military training. This corresponds with Resident D and the use of the sand dunes for military training pre WWII and protection during the war time.

3.3.2 Market Gardens

Boyce (2004) reports Chinese market gardens existed from the late 1880's within the LGA. Evidence of market gardens and farms were common along the Greendale Creek which feeds into Curl Curl Lagoon[33]. The interview on Clip 2 refers to market gardens and farming during the 1930's. These details and the photographs in Figure 11 and Figure 12 confirm the recollections of the interviewee.

Figure 11 Len Riddle's pig farm at North Curl Curl, ca. 1922

Figure 12 North Curl Curl farm, ca. 1925

[33] State Pollution Control Commission Environmental Investigation of Narrabeen, Dee Why and Harbord Lagoons 1978.

Source: Warringah Library Service 2010

Source: Warringah Library Service 2010

3.3.3 Recreation on the lagoon

The photograph in Figure 13 reflects the recreational activities, eg. swimming, boating, that occurred at Curl Curl Lagoon between the mid 1920's and early 1950's. The SPCC (1978) report suggested that the water quality was good prior to the tipping of rubbish in the lagoon that occurred in the 1950's. The source of the rubbish was generally domestic waste from the local area.

Figure 13 Les and Fred MacLean with Vic Evans on Curl Curl Lagoon, ca. 1928

Source: Warringah Library Service 2010

3.3.4 Ducks and wildlife on the lagoon

Duck and other wildlife populations were reported by the interviewee on Clip 8 to have declined in recent years. The Curl Curl Lagoon Friends (2004) also refer to the declining populations as a result of modifications to the environment and decrease in the amount of wetlands and vegetation. The image in Figure 15 depicts the lagoon surrounded with wetlands and abundant ducks swimming on the lagoon in 1930.

Figure 15 Curl Curl Lagoon 1930

Source: Warringah Library Service 2010

The area surrounding the lagoon is prone to flooding due to the low-lying state. Wetland vegetation surrounds the lagoon and includes rushes, reeds and low-growing shrubs[34].

3.3.5 Landfills along the lagoon shore

Landfills for domestic rubbish were created along the northern and southern shores during the 1950's[35] with the original vegetation mostly removed by 1961.

An ecological monitoring program was developed by Australian Water Technologies (AWT) in 2000 for Warringah Council to determine the impact of the contaminants on the natural environment. The report was to fulfil the NSW Government's Estuary Management Policy which required Council to sustainably manage the estuarine environment. The report AWT[36] provided suggests that the landfill is contributing leachate and nutrients to the lagoon and impacting on water quality and possibly biodiversity.

Environmental Consultants[37] undertook water quality monitoring for Warringah Council over a nine year period from 1994 to 2002. The results of the monitoring suggest that the water quality at the top of the catchment is clear and not contaminated and further down the catchment where Greendale Creek travels under Fisher Park Foot Bridge, the water quality declines and appears reddish brown in colour and is more turbid than in the upper reaches of the creek[38]. The results suggest the contaminants include nitrogen and phosphorus[39]. The visual changes to the water ways was commented on by the Resident A and B.

---

[34] State Pollution Control Commission Environmental Investigation of Narrabeen, Dee Why and Harbord Lagoons 1978.

[35] State Pollution Control Commission Environmental Investigation of Narrabeen, Dee Why and Harbord Lagoons 1978.

[36] Australian Water Technologies *Curl Curl Lagoon Ecological Monitoring Program* report for Warringah Council 2000.

[37] Laxton J, Laxton E, 1981, Environmental Impact Statement on the proposed management strategy, Laxton Environmental consultants.

[38] Laxton J, Laxton E, 1981, Environmental Impact Statement on the proposed management strategy, Laxton Environmental consultants.

[39] Laxton J, Laxton E, 1981, Environmental Impact Statement on the proposed management strategy, Laxton Environmental consultants.

3.3.6 Dredging, Entrance Opening and Closing

Dredging of the lagoon occurred in the 1960's to prevent flooding of the newly urbanised area[40] and to provide infilling material to reclaim the low lying areas. A review of hydrological survey's to compare the change in depth would be required to determine the significance of the dredging.

The streams that fed the lagoon were modified, with the banks of the creeks consolidated to cater for the increased urban development west of Harbord Road. John Fisher Park and Weldon park were created during the 1960s for recreational use by infilling the wetland areas[41], refer to the aerial photograph in Figure 4 which depicts sports fields and recreational areas.

The entrance to the lagoon is naturally opened following rainfall or is mechanically opened to assist in preventing flooding. However this has an impact on the lagoon environment. Residents interviewed reported an increased odour during times of opening (Resident A and B). Haines et al (2006) research cautions against mechanically or artificially opening lagoons as the environmental impacts can include "drying out and terrestrialisation of fringing wetlands, increased shoaling at the entrance and changes to macrophyte and benthos communities". The AWT (2000) report also concurs with the issues raised by Haines et al (2006) in relation to mechanically opening the lagoon, stating that "opening the lagoon 7 to 14 times a year does not cater for slower-developing, brackish-associated communities" which is the practice for Curl Curl lagoon. The result of opening the lagoon too frequently interrupts the ecological cycles typical of seagrasses, fish and birds[42].

3.3.7 Pollutants and Water Quality

The SPCC (1978) report states the water quality of Greendale Creek in the late 1970's contained high concentrations of detergents, organic matter and other pollutants that were a consequence of the rubbish that was dumped in the tip during the 1950-1960's. High levels of faecal coliform were reported along with ammonia and iron, the source of these contaminants is from the septic tank overflows that would occur prior to the connection of the sewer. An additional source of faecal coliforms is reported by EC (2002) from the many birds which feed on the exposed benthic invertebrates when the mud flats become exposed when the lagoon is open and draining to the sea, further having an impact on the water quality of the lagoon

The AWT (2000) report states that the water quality of the lagoon and Greendale Creek is not suitable for recreational use. This reflects the change in use of the lagoon from the 1920's (refer Figure 8) when the lagoon was used for boating and possibly swimming to the early 2000's when the lagoon is no longer suitable for such activities.

The AWT (2000) report states that odour and visible pollution become apparent when the lagoon is empty, reducing the aesthetic value of the lagoon. This was also commented on during the interview by Resident A and B.

---

[40] State Pollution Control Commission Environmental Investigation of Narrabeen, Dee Why and Harbord Lagoons 1978.

[41] State Pollution Control Commission Environmental Investigation of Narrabeen, Dee Why and Harbord Lagoons 1978.

[42] Australian Water Technologies *Curl Curl Lagoon Ecological Monitoring Program* report for Warringah Council 2000.

3.4 Dee Why Lagoon

Dee Why Catchment is 5.1 square kilometres (510ha) and the size of Dee Why Lagoon is ~30ha[43]. The lagoon is connected to the ocean at the north east section by an entrance channel. This channel is closed mostly except during heavy rainfall which removes the sand bar and opens the lagoon to the ocean. The sand bar is also mechanically removed to prevent flooding of the surrounding houses[44].

Vegetation surrounds the lagoon on the south western and north western areas and provides a screen or buffer from the residential developments. A creek, which originally flowed from the wetland area into Dee Why lagoon via Dee Why park, has been converted to a drainage channel to cater for increased runoff from the urbanised areas[45].

Table 4 provides a summary of the issues and a reference to the supporting sources for Dee Why Lagoon.

[43] State Pollution Control Commission Environmental Investigation of Narrabeen, Dee Why and Harbord Lagoons 1978.

[44] State Pollution Control Commission Environmental Investigation of Narrabeen, Dee Why and Harbord Lagoons 1978.

[45] State Pollution Control Commission Environmental Investigation of Narrabeen, Dee Why and Harbord Lagoons 1978.

Year	Issue	Oral History	Scientific Data	Books/maps/media
1810	Filled in wetland areas using dredging material	Resident A and B		
1920's	Holiday destination	Resident A and B		Boyce 2004
1924	Spit and Roseville bridges constructed			Boyce 2004
Pre WWII	Initially a poor area, mostly fibro houses	Resident A and B		
1940's	Dredging done for military purposes during WWII to prevent Japanese invasion and dunes built on foreshore	Resident D & Resident A and B	Guerra et al 2009	Boyce 2004
Post 1945	Market gardens developed by the immigrants from WWII (Yugoslavian)	Resident D & Resident A and B	SPCC 1978	
Post WWII	Immigration lead to development of the area	Resident A and B	SPCC 1788	
1940's – 1950's	Prawn fishing in the lagoon	Resident D	SPCC 1978	
1940's – 1950's	Lots of wildlife e.g. ducks, swans, kangaroos, many fish e.g. mullet, flathead, blackfish etc abundant	Resident A and B		Figure 17
1940's – 1950's	Water quality generally good	Resident D	SPCC 1978	
1940's – 1950's	Possible to canoe up the rivers, now prevented due to siltation/sedimentation	Resident D	SPCC 1978	
1950's – 1960's	Sewage waste dumped in Dee Why creek prior to sewage system integration.	Resident A and B	SPCC 1978	
1960's	Water quality degraded due to rubbish dumped near the creek entrance and seepage from septic tanks	Resident A and B	Danovaro et al 2007	SLSA 2010
1990's to current	Report exonerating Industry as not impacting on the water quality as does not generate waste for discharge	Resident D	SPCC 1978	
Current	Manually open lagoon entrance by surfers wanting to travel out to the ocean on boards – dig open entrance and float out to sea (enjoyment)	Resident D	Haines et al 2006	
Date unknown	Algal bloom (filamentous) strong odour from the stagnant water. No longer occur due to opening of lagoon	Resident D	Haines et al 2006	

Table 4 Dee Why Lagoon summary of issues and triangulation of data

The information provided in Table 4 has been expanded and cross referenced in the following sections to justify and confirm or negate the issues identified during the interviews with the local residents.

The images shown in Figures 16 to 19 reflect the changes to Dee Why Lagoon between 1927 and 2008.

Figure 16 Aerial view of Dee Why Lagoon 1943

Source: Department of Lands 2010

Figure 16 indicates that the sand bar is preventing drainage of the lagoon (circled). Development of the area is occurring, either as holiday houses or possibly a consequence of increased immigration at this time as discussed on Clip 2.

Figure 17 Aerial view of Dee Why Lagoon 1970

Source: Warringah Library Service 2010

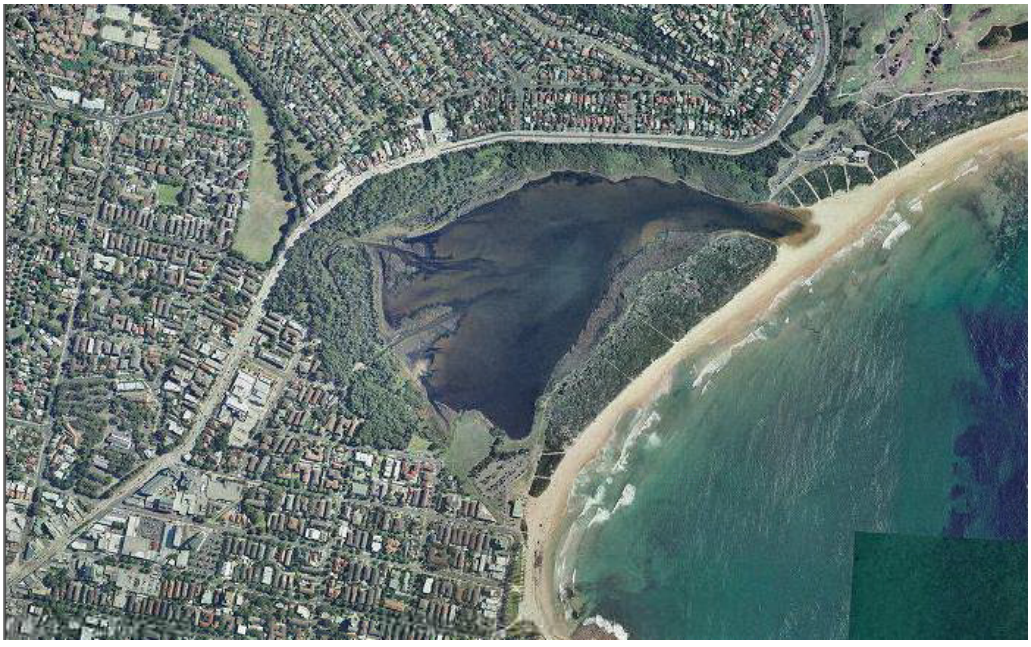
Figure 17, similar to Figure 16, indicates that the sand bar is preventing drainage of the lagoon (circled). Development of the area is significant with no evidence of the market gardens from the post war immigration. A vegetation buffer zone is present around the lagoon

Figure 18 Aerial view of Dee Why Lagoon 1990

Source: Warringah Library Service 2010

Figure 18 indicates that the sand bar is preventing drainage of the lagoon (circled) as is shown in the previous figures. The development appears to have slowed.

Figure 19 Aerial view of Dee Why Lagoon 2008



Source: Department of Lands 2010

Figure 19 suggests that the lagoon has remained the same shape and size between 1943 and 2008. The vegetation surrounding the lagoon has improved over this time period particularly along the sand dune that separates the lagoon from the beach.

3.4.1 World War II

During WWII, the military constructed sand barriers and installed barbed wire along Dee Why beach to prevent an attack from the Japanese as the area was considered a target[46]. The interview on clip 2 and Clip 6 discussed the Dee Why area as a training area for Defence personnel and that the military would dredge the lagoon as part of these exercises to construct the sand barriers along the beach front.

3.4.2 Recreation

During the 1920's Dee Why was a popular holiday destination rather than an urban area[47] with many weekend cottages and camping grounds established. Figure 20 suggests that the lagoon was used for recreational purposes and that these children are on a family summer holiday. The Residents A and B made comments on Dee Why as initially being a holiday destination prior to urban development which concurs with the report by Boyce (2004). The presence of only a few small houses in the background of Figure 20 also suggest this.

Prawn fishing was also highlighted as a popular activity in the 1940's -1950's by the Resident D. The SPCC (1978) report identifies the presence of prawn in the lagoon particularly if the entrance is closed creating an ideal environment for catching them as they aggregate near the entrance[48].

Figure 20 Swimming in the Dee Why Lagoon, 1926

Source: Warringah Library Service 2010

3.4.3 Wetland, seagrass and biodiversity

A wetland existed near Fisher Road North and South Creek Road until the 1970's when it was progressively filled, resulting in the removal of a natural trap for sediments and pollutants therefore increasing the sediment load[49]. Danovaro et al (2007) comments on the impact of anthropogenic activities on the ecosystems of coastal lagoons, indicating that the biodiversity, including the seagrass and wetland areas, are impacted by development causing a loss in the amount of biodiversity of the ecosystem over time. The Resident D mentioned that a decrease in birds and

[46] Boyce J 2006 *Pictorial history Warringah* Kingsclear Books.

[47] Boyce J 2006 *Pictorial history Warringah* Kingsclear Books.

[48] State Pollution Control Commission Environmental Investigation of Narrabeen, Dee Why and Harbord Lagoons 1978.

[49] State Pollution Control Commission Environmental Investigation of Narrabeen, Dee Why and Harbord Lagoons 1978.

wildlife has occurred over time. Figure 21 shows the lagoon in the 1920's with an abundance of birds.

If the lagoon is closed and not mechanically opened the seagrass beds grow quickly but die back when open and the water level is low. The SPCC (1978) reports that seagrass beds have declined in the past 20 years from 1958 to 1978.

Figure 21 Swans on Dee Why Lagoon, ca. 1920

Source: Warringah Library Service 2010

The SPCC (1978) report states that an increase in sedimentation occurred between 1965- 1976 in Dee Why Lagoon, with the most significant increase occurring at the mouth of the Dee Why main drain. During this time period, SPCC (1978) recorded data on faecal coliforms that indicate that the lagoon is not safe for recreational use unlike the image depicted of children swimming in the lagoon in the 1920's in Figure 20.

3.4.4 Urban development

In 1924, the Spit and Roseville bridges were completed improving access to the northern beaches[50]. This aided the development of the area and the transition from a holiday destination (Resident A and B) to a permanent residential area (Figure 19). Sand was often used from the dredging activities or surrounding sand dune for in-filling of wetlands surrounding the lagoon system. For example a car park was created in the mid 1970's from in-filling to allow for an increase in beach going visitors[51].

The industrial development that occurred in Dee Why was not generally pollution causing and therefore the impact on the lagoon water quality from chemical contaminants was limited[52]. A comment made by Resident D also made a similar observation.

A more significant impact from the urbanisation of the area was the septic discharges to the lagoon, particularly during high rainfall events. In the 1950's and 1960's sewage was reportedly pumped at the western end of the lagoon (Resident A and B) near Dee Why Drain. The sewer was connected to the majority of houses by

[50] Boyce J 2006 *Pictorial history Warringah* Kingsclear Books.

[51] Boyce J 2006 Pictorial history Warringah Kingsclear Books.

[52] Boyce J 2006 *Pictorial history Warringah* Kingsclear Books.

1978 and only minor sewage contamination of the lagoon occurs today which has assisted in improving the water quality of the lagoon.

3.5 Manly Lagoon

Table 5 Timeline – 1788

Year	Issue	Oral History	Scientific Data	Books/Maps/Newspapers/Pictures
Pre-European Settlement or Early European settlement	Good quality of water and high amounts of biodiversity in the lagoon.	Resident C	Manly Council, 2000	
1788	Governor Phillip-Discovery of Manly Lagoon surrounded by extensive wetlands	Resident C		McDonald & Henderson, 1975
1842	The first land grants in Manly area (see Map 2)			McInnes, 1985 (See Map 2)
1853	The first piece of land bought in the area of Manly (by Henry Gilbert Smith)			Manly Council's Heritage Committee, 2002; McDonald & Henderson, 1975
1854	Beginning of ferry service from Sydney to Manly – hence easier access			McInnes, 1985
1870	Manly became a municipality			McDonald & Henderson, 1975
1870's	The beginning of the first Chinese Market Gardens	Resident C		Metherell, 2006
Late 1870's	The Queenscliff foot bridge was built		Patterson Britton & Partners, 1995	McInnes, 1985; Sharpe, 1983; Meyer, 1880 (attach his page)
1881	Manly Council received a letter from a resident - requesting to keep the lagoon open			Champion G & Champion S, 2003

Year	Issue	Oral History	Scientific Data	Books/Maps/Newspapers/Pictures
1888	Population in Manly to Narrrabeen Lagoon reaches 2,000			Sharpe, 1983
Up to 1890	Tanks and wells provided water supply to the Manly area			McInnes, 1985
1892	The Manly Dam was built	Resident C		McInnes, 1985; McDonald, 1979; Warringah Council, 2010
After the dam was built	The lower Manly Lagoon flood plain did not flood that much – so people started building closer to the lagoon	Resident C		
1896	Manly's Population reaches 3,550			Sharpe, 1983
1899	Since the local community were complaining of flooding-the DPW suggested opening the lagoon			Champion G & Champion S, 2003
1900 onwards	A rubbish tip develops near Queenscliff Bridge – almost on the beach	Resident C		McInnes, 1985; Champion G & Champion S, 2003
1900 onwards	The quality of water in the Lagoon was very bad since there was an open tip next to the Lagoon and had all its runoff flow into it	Resident C		Champion G & Champion S, 2003
1900's	The electric tram service was extended to Mosman			Sharpe, 1983
1906	Manly's Population reaches 8,000			Sharpe, 1983

Year	Issue	Oral History	Scientific Data	Books/Maps/Newspapers/Pictures
1909	Manly Golf Course was established	Resident C		Champion G & Champion S, 2003
1909	Government decided that the Manly Lagoon needed to be properly drained because of its flooding issues and it also needed to be done for the future development and progress of Manly-tenders were called to carry out the work			Champion G & Champion S, 2003
1911	The Manly Lagoon was drained loosing fish and discovering a tiger shark as well			Champions G & Champions S, 2003
1912 onwards	Erection of the Garbage Destructor on the Manly Vale side of Manly Lagoon			Champions G & Champions S, 2003
1913	A butcher's farm was run near Brookvale Creek which affected the water quality in the Manly Lagoon (near Clearview Pl)			Champions G & Champions S, 2003
1910's-1930	Infilling of the lagoon with the help of Alderman A Keirle – who was the Mayor of Manly and also had a sand dredging business		Patterson Britton & Partners, 1995	McInnes, 1985; Attach Map
1920	Italian Market Gardens were present on the Brookvale edge			Read, 2000
1920's	The eastern section of the lagoon park was used as a tip		Patterson Britton & Partners, 1995	
1920's	The footbridge at Queenscliff was replaced with a road bridge			McInnes, 1985

Year	Issue	Oral History	Scientific Data	Books/Maps/Newspapers/Pictures
1923	Dredging of the Manly Lagoon – for the Manly golf course began		Patterson Britton & Partners, 1995	McInnes, 1985, Champions G & Champions S, 2003
1924	The steam punt was replaced by the spit bridge increasing access to the area by road			McInnes, 1985; Sharpe, 1983
1924	The Name 'Manly Lagoon' was now officially its identity – before 1924 it was called Curl Curl Lagoon	Resident C		Gordon, 2000
1927 onwards	Hinkler Park was made by dredged Material from Manly Lagoon	Resident C	Patterson Britton & Partners, 1995	McInnes, 1985, Champions G & Champions S, 2003
1930's	Keirle Park was completed (with dredged materials in filling the wetlands)			Champions G & Champions S, 2003
1930-1937	Low flow channels and pipes at the entrance of the lagoon were built to let the excess water flow (reduce the chances of flooding) out and to let sea water come in and help in flushing the lagoon		Patterson Britton & Partners, 1995	
1933	Warringah area's population – 16,054			Sue Rosen and Associates, 2004
1935	Infilling (with dredged material from the lagoon) for the 9 hole Warringah Golf course was completed			Champions G & Champions S, 2003
1937	Manly Creek (from Codamine St to the lagoon) was piped	Resident C		Champions G & Champions S, 2003

Year	Issue	Oral History	Scientific Data	Books/Maps/Newspapers/Pictures
1937ish	The southern side of Kentwell St was turned from marsh land into a park	Resident C		Champions G & Champions S, 2003
1937ish	Other low lying areas (marshland) was filled in by dredged material from the lagoon			Champions G & Champions S, 2003
1939	The tennis courts (were finished building) at the corner of Kentwell St and Pittwater road was filled in by dredging			Champions G & Champions S, 2003
1939 onwards	Warringah Golf Course extended itself to 18 holes			Champions G & Champions S, 2003
1939 onwards	Bowling green, cricket and football fields have been created in the southern section on the lagoon			Champions G & Champions S, 2003
1940's	Collingwood St, Cameron Ave, Eurobin Ave were now residential areas			Champions G & Champions S, 2003
1946-1952	The bridge across the lagoon was built (Pittwater Rd)		Patterson Britton & Partners, 1995	
1940's-1960's	Market gardens existed in the area of Warringah Golf Course, Passmore Reserve, Mackellar Girls High School		Patterson Britton & Partners, 1995	
1950's	The Brookvale area was zoned as Light Industrial Area			Sue Rosen and Associates, 2004
1954	The Garbage Destructor on the Manly Vale			Champions G & Champions S, 2003

Year	Issue	Oral History	Scientific Data	Books/Maps/Newspapers/Pictures
	side of Manly Lagoon was closed			
1956	Southern side of Hinkler Park is closed off by in-filling the area by dredged material (due to new bridge)		Patterson Britton & Partners, 1995	
1956	Closure of the southern side of the channel (next to Hinkler park) has significantly restricted the discharge of flood waters from the Burnt Bridge Creek catchment, particularly from the Manly Golf Course, thus exacerbating flooding in the lagoon upstream of Pittwater Rd		University of Western Sydney, 2003	
Before the Warringah Mall was built	The Warringah Mall was built on a swamp – and before it was built you could find turtles in it – hence high in biodiversity	Resident C		
After the Warringah Mall was made	Burnt Bridge Creek was piped or paved from Condamine St till the Manly golf course		Manly Council, 2000	McInnes, 1985
1963	The Warringah Shopping mall opened	Resident C		Sharpe, 1983
1961-1970	Infilling of western side of lagoon		Patterson Britton & Partners, 1995	
1961-1970	Further filling in of the remnant channel on the western side of Pittwater Road		Patterson Britton & Partners, 1995	

Year	Issue	Oral History	Scientific Data	Books/Maps/Newspapers/Pictures
1970's	Some people were taught to swim by Stuart Somerville in the lagoon	Resident C		
1975	Change of law for Dredging-stating that the council needs to get permission to dredge the bottom of the lagoon	Resident D		Coastal Environmental Centre, 2008
1980's	Manly Lagoon had huge fishing competitions – rich in biodiversity	Resident C		
1996	55 stormwater drains flow into the Manly Lagoon.		Manly Council, 2000	
1996	Manly Lagoon has 18 existing and 11 sealed sewage overflow points – which do effect the water quality in the lagoon (mostly during wet weather)	Resident C	Manly Council, 2000	
1999	Burnt Bridge Creek – condition is generally good in the upper catchment – poor in the middle catchment and very poor in the lower catchment		Manly Council, 2000	
1999	Since the extension of low flow pipes in 1999, this has allowed tidal circulation/exchange at the ocean end of the lagoon in dry season		University of Western Sydney, 2003	
2000	The lagoon entrance is managed (opening and closing of the lagoon) for flood reasons		Manly Council, 2000	
2000	The Lagoon is Perceived to be one of the most		Manly Council, 2000	Reizes, 1996

Year	Issue	Oral History	Scientific Data	Books/Maps/Newspapers/Pictures
	degraded coastal lagoons in NSW due to all the runoff, sediments and pollution that go into the lagoon. Also the over urbanization of the flood plain. As well as the light industrial area at the Brookvale Creek catchment.			
2000	Leaching of Chemicals and heavy metals found in water mainly due to the buried dumping areas which is close to the lagoon (however buried)		Manly Council, 2000	
2000	Quality of water in the Brookvale Creek is low due to the golf courses (which uses a lot of fertilizers and water from the creek) and the light industrial area on its banks	Resident C	Warringah Council, 2004	
2000	If the water quality in the lagoon is compared with what it was in the early 1900's, then the water quality in the year 2000 would be of better quality as compared to 100 years ago.			Gordon, 2000
2002	Water quality of the lagoon is poor		Healthy Rivers Commissions (2002)	
2002	There was a chemical spill (insecticide called Gusathion) by the Warringah Golf Course that killed 12,000 fish at the time	Resident C		Robinson, 2001

DPW-Department of Public Works

3.5.1 Introduction to Manly lagoon

Manly Lagoon is a small coastal lagoon situated at the boundary of Warringah and Manly Council in Sydney's Northern Beaches. It has a Catchment area of 18 square kilometers. Inflow includes Manly Creek, Burnt Bridge Creek and Brookvale Creek. It also receives inflow from a large number of stormwater drainages. Manly Lagoon is one of the most polluted waterways in NSW as it suffers from nutrient overload.[53,51]

The catchment is highly urbanized with about 60% of land use is considered as urban, while the remaining of the catchment is used as open spaces that include playing fields and two golf courses adjacent to the lagoon. Studies have identified quite a few sources of pollution flowing into the lagoon, which includes urban and storm water runoff, sewage overflows during high rainfall, dumping of industrial and trade waste – directly or indirectly. A study done in 1995[51] has also found high levels of faecal coliform in the water – which is caused due to the sewage overflows, the input from creeks and stormwater drainage systems. This impacts on the level of oxygen for the living fauna in the water and also increases the nutrients that are there in the lagoon. Large amounts of particulate matter are also transported into the lagoon during wet weather with studies showing a high level of heavy metals present in the sediments.[54]

3.5.2 Governor Phillips encounter with the Manly Lagoon in 1788

Governor Phillip decided to explore Manly shortly after the settlement was established in Sydney. In April 1788 while we was on an expedition northward from Manly he landed at the Manly Lagoon.[55]

This is how he described it –

"… a large lake, which we examined…it is surrounded by a bog and large Marsh, in which we were frequently up to the middle; here we saw a black Swan, it was larger than the common Sawn and when it rose, after being fired at the wings appeared to be edged with white, there is some red on the bill, and it a very noble bird." [56]

Governor Phillip and his group appeared to have found the large swampy area around the mouth of Burnt Bridge Creek, which has since been drained and made into a golf course. [53]

---

[53] Reizes J, 1996, Greening Golf Courses to Avoid Algal Blues, Soil and Water – Management for Urban Development;

[54] Patterson Britton & Partners, 1995, Manly Lagoon Estuary Management Study, Manly and Warringah Councils

[55] Sue Rosen and Associates, 2004, Study of Heritage Significance of a Group of RTA Controlled Bridges & Ferries, Accessed on 15th April 2010, http://www.rta.nsw.gov.au/cgi-bin/index.cgi?action=heritage.show&id=4305016

[56] Champion G & Champion S, 2006, Finding the Right Tract: Governor Phillip's Inland Exploration from Manly towards Middle Harbour and Westward: 15th to 18th April, 1788

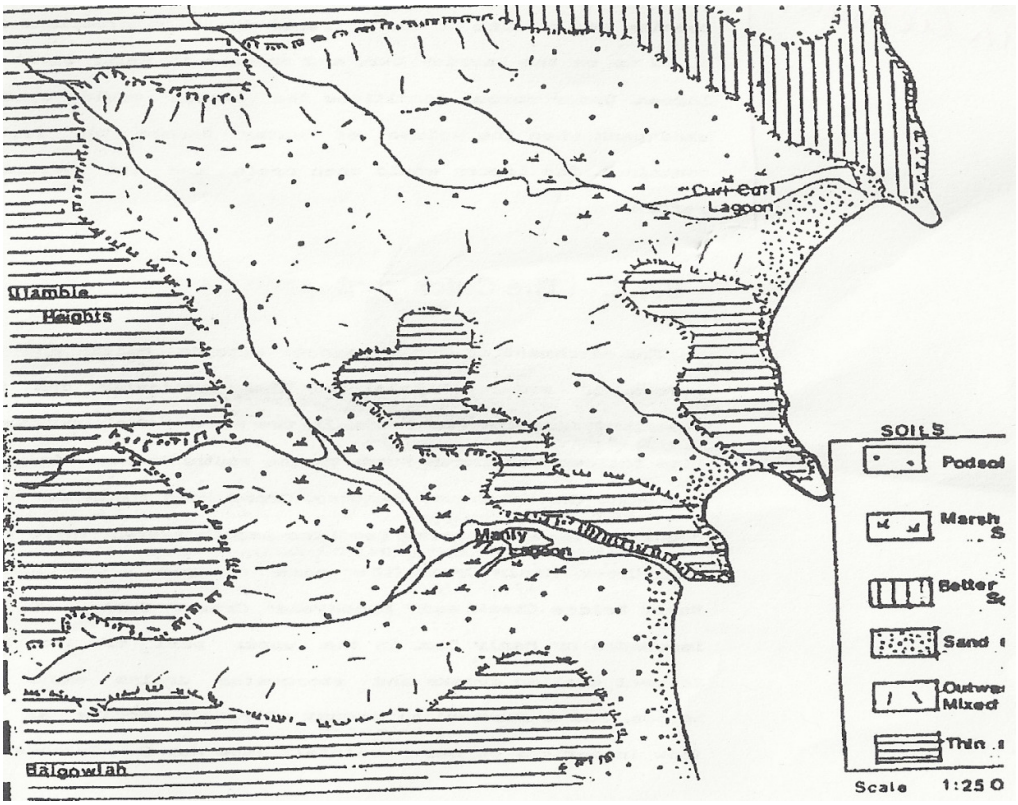


Figure 22 – Manly Lagoon and the extent of marsh around the lagoon (Source – McInnes, 1985)

The map above indicates the size of the Manly Lagoon at the time of the first settlements, extended well inland. There were marshes or wetlands surrounding Manly Lagoon. The Lagoon was home to schooling fishes, whiting bream and turtles, which would enter the swamp and bred in the lagoon.[57] Governor Phillip also described the swamps as dense and difficult to penetrate[58]. One can only assume the biodiversity in the lagoon was very rich in 1788.

3.5.3 Slowly Development in the area grew

In 1842 the First Land Grants were released and in 1853 Henry Gilbert Smith bought the first piece of land in the Manly area. In 1854 a ferry service began between Sydney and Manly and in 1870 the Queenscliff foot-bridge was built improving access to the area. This was commenced the development around the Manly Lagoon.

[57] Foley D, 2001, Repossession of our Spirit, Traditional Owners of the Northern Sydney; Resident 10

[58] Champion G & Champion S, 2006, Finding the Right Tract: Governor Phillip's Inland Exploration from Manly towards Middle Harbour and Westward: 15th to 18th April, 1788

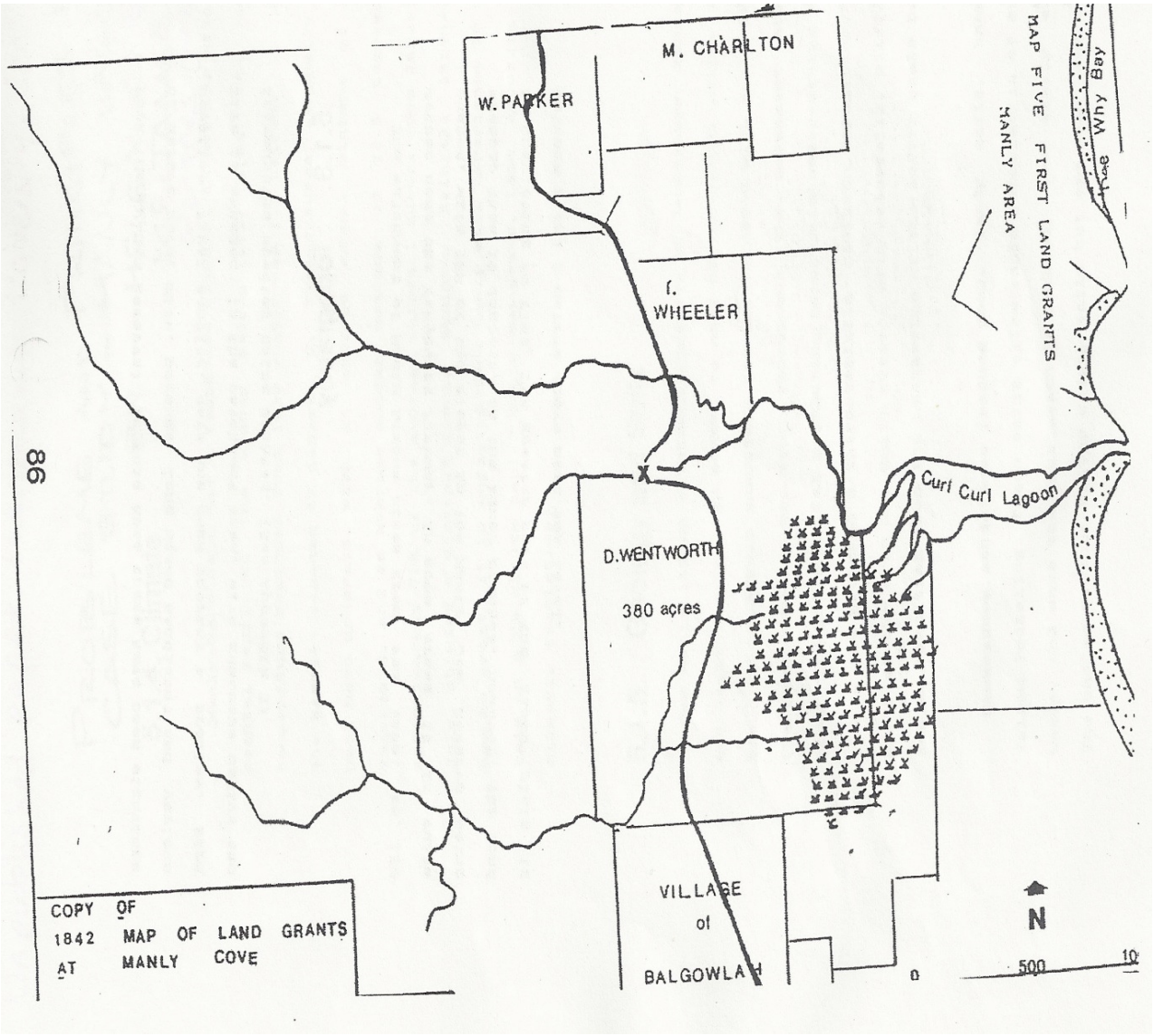


Figure 23 –First land grants around Manly Lagoon. Note Manly Lagoon was called Curl Curl Lagoon in 1842 (Source – McInnes, 1985)

Map 2 is from 1842. One can see how the lagoon's shape is very different to what we see today. The Mouth of the Burnt Bridge Creek is so much bigger here. Also one can see the large swampy area at the mouth of the Creek. Today the creek runs under Condamine Street, then under Balgowlah shopping centre and finally under the Manly golf course[59]. The swamp (the hatched area) in the Map has been drained and made into the Manly Golf course.

[59] McInnes H C, 1985, Problems and Principles in Estuarine Management Case Study – Manly Lagoon, Unpublished paper, Macquarie University, Centre for Environmental and Urban Studies, Sydney

3.5.4 The beginning of the Chinese Market Gardens – 1870's

In 1871 a Chinese gardener was listed in Manly. The Market Gardens began in the area around the Burnt Bridge Creek and Condamine Street. There were Chinese gardens near to where the Warringah and Manly golf club are today. The Chinese Market Gardens seemed to have developed on unwanted swampy lands much of which was later converted into recreational or industrial or commercial places. For example – Warringah Mall, Brookvale Industrial Estate, Mackellar Girls' High School and Warringah Golf course. [60]

1890 parish map showing the 1880s estate names *LPI NSW (Courtesy Mitchell Library)*

Figure 24 – Showing Manly Lagoon (then called Curl Curl Lagoon) in 1880 with increasing road development

This Map above shows the estate names in the 1880's. One can see that development has slowly begun in the area. However the lagoon's water body still remains quite large and the Burnt Bridge Creek remains free to flow in its natural bed. This Map is before the Manly Dam was built. It is important to notice also that there is no island (Hinkler Park would have come into existence between 1925-1929) in the middle of the lagoon.

3.5.5 Keeping the Lagoon open

It was 1881 when the first (recorded) request was made to keep the mouth of the Manly Lagoon open in order to prevent the low lying houses (in the flood plain) to be

[60] Metherell T, 2006, Faster: Manly in the 1920s, Chapter 10: Manly's Chinese Gardens, Accessed on 15th may 2010, http://www.manly.nsw.gov.au/IgnitionSuite/uploads/docs/10%20Manlys%20Chinese%20Gardens.pdf

flooded.[61] The Council replied that the lagoon area was out of the Council's boundary line.

By 1899 the residents around the Manly Lagoon area had for a long time tried to solve their flood problems through approaches to the local council. Finally the residents appealed to the State Government. The local people and the council received a reply from the Department of Public Works suggesting to make a small cut through the sand bar when the lagoon water rises – so that the lagoon is opened before it can make any damage.[58]

In the 1900's there was a tip next to the Queenscliff Bridge. This was a huge problem for the residents in the area. When it rained the water flowed into the lagoon making it stink and affecting the vegetation and fauna in the lagoon. A newspaper commented, "…it is stagnant muck of swamp and dirty water and the juice of the dump is not by any means the only nastiness that drains into it. It is a great mosquito nursery." [62, 58]

3.5.6 Golf Courses

The Manly Golf Course was established in 1909. At the turn of the century – a large portion of the Many Golf Course was still marsh and inaccessible. The marshy area was described as low lying- only a few feet above sea level. Also it was covered with vegetation – and in times of storm or rain this part became the extension of the lagoon (its flood plain).[59]

The grounds men who were employed to drain and reclaim this land described it as follows :

"The present fourth fairway was a big swamp. With bushes ten and twenty feet high. There were tree stumps everywhere and many dead stinking cattle"[59]

Even after the reclamation of land and draining out the marshes – the golf course suffered from frequent flooding. In 1923, Alderman A Keirle provided his dredge at no charge to the Manly Golf Club. This was when a large amount of area in the lagoon was dredged and the marshes were filled up. It was hoped that by dredging the lagoon and rising the level of land around the lagoon – the water would escape quickly and easily.[59]

---

[61] Champion G & Champion S, 2003, Some Early History of Curl Curl Lagoon (now know as Manly Lagoon), Accessed on 15th May 2010, http://www.manly.nsw.gov.au/IgnitionSuite/uploads/docs/Curl%20Curl%20Lagoon%20-%20early%20history.pdf

[62] McInnes H C, 1985, Problems and Principles in Estuarine Management Case Study – Manly Lagoon, Unpublished paper, Macquarie University, Centre for Environmental and Urban Studies, Sydney;

3.5.7 Dredging and in-filling the marshes of the lagoon

Much of the reclamation of wetlands surrounding the Manly Lagoon was mainly due to Alderman A Keirle who was the Mayor of Manly in 1915 to 1923 and 1926 to 1928. He owned a sand dredging business. The areas filled or reclaimed include – Warringah Golf Course, Manly Golf Course, Lagoon Park, Hinkler Park, and Keirle Park.[60]

Hinkler Park was originally an island made in the lagoon (between 1915-1930). However the southern side of the lagoon near the island was filled in when the Pittwater Road Bridge was made. The bridge only spanned the northern portion of the lagoon.[60]

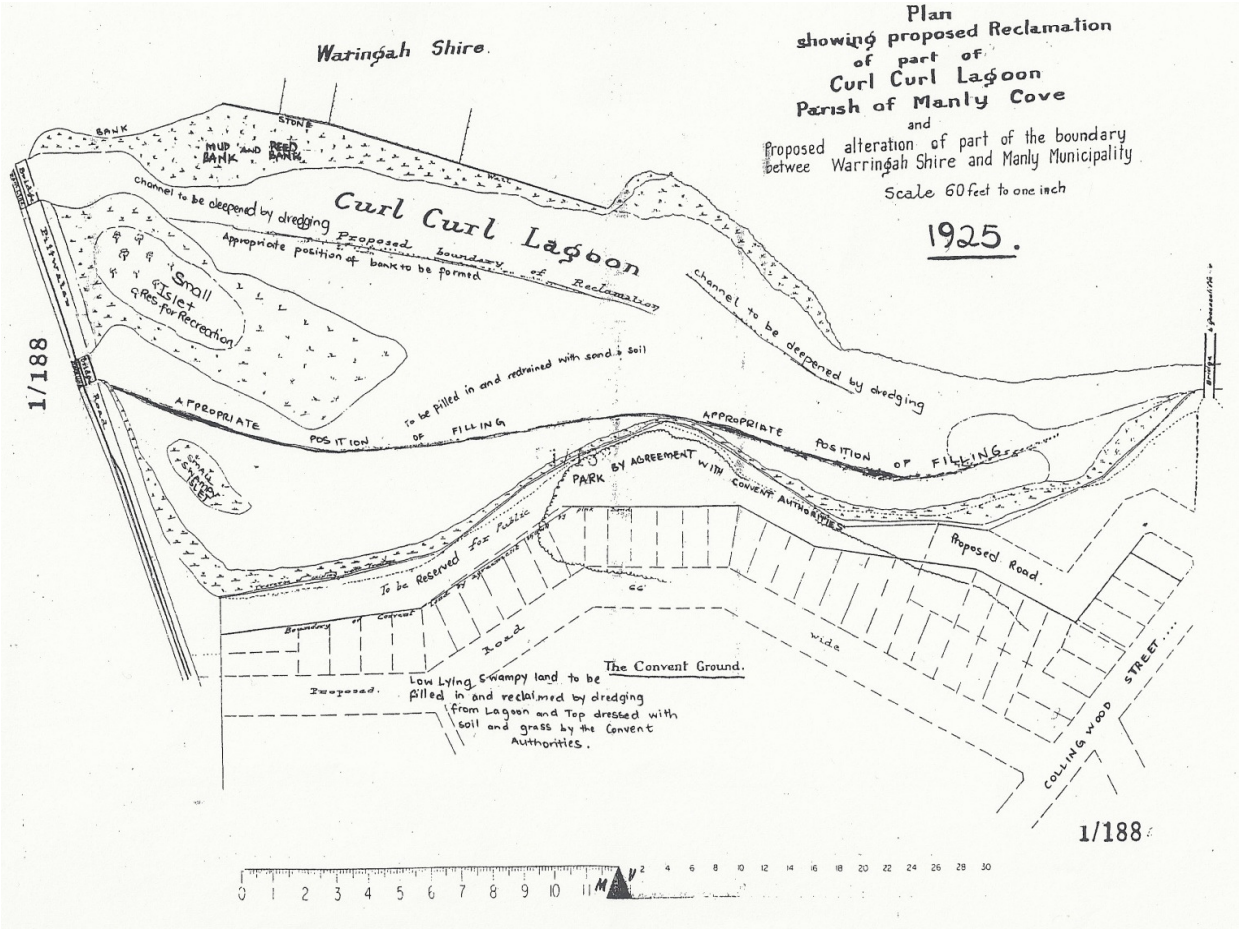


Figure 25 – Map of Manly Lagoon in 1925 showing the planned island to be created from dredging the lagoon (Source – Manly Environmental Centre)

The Map above is from 1925 and it shows the plans of dredging the lagoon and filling up the banks or the flood plain. The island in the middle of the lagoon was created from dredging. The proposed recreational site is shown for reclamation which today is the Hinkler Park.

[60] Patterson Britton & Partners, 1995, Manly Lagoon Estuary Management Study, Manly and Warringah Councils

3.5.8 Developments from 1930 to 1970

In the report written in 1995[61], it is found that the mouth of Burnt Bridge Creek was getting high levels of sedimentation since the early 1900's. It accelerated from 1930 onwards. It is believed that this would be due to development around the lagoon as well as due to the loss of native vegetation holding the soil in its place. A paper written in 1985[62] describes the quality of soil present in the Manly Lagoon. It also discusses the features of the soil. Since it is made from Hawkesbury sandstone and shales, this soil allows rapid movement of water through its pores however once the vegetation is removed then this soil is easily eroded. Hence it can be concluded that when the reclamation of wetlands began in the 1910's to the 1930's – sedimentation began since there was a loss in the native vegetation holding the soil together.

Figure 28

Source: Google Earth 2010

By 1937 there was a new waterway constructed by dredging.[61]

By 1937 the southern part of the lagoon started to be encroached and built upon.[61]

By 1940's the vegetation upstream of Burnt Bridge Creek had been cleared and later used as a dumping ground (1951). After which it shifted a bit up north along the lagoon.[61]

By 1970's the old tip point was covered up as TS Condamine was built over it.[61]

[61] Patterson Britton & Partners, 1995, Manly Lagoon Estuary Management Study, Manly and Warringah Councils

[62] McInnes H C, 1985, Problems and Principles in Estuarine Management Case Study – Manly Lagoon, Unpublished paper, Macquarie University, Centre for Environmental and Urban Studies, Sydney

Figure 29

Source: Google Earth 2010

Market Gardens were around the Manly Creek from 1940's to 1960's. They existed in varying degrees in the area of Warringah Golf Course, Passmore Reserve and Mackella Girls High School during this period. Before TS Condamine was built it was a tipping point (before 1970's), however before it was a tipping point it was part of the Market Gardens (1940's-1960's).[63]

Source: Google Earth 2010

In 1951, the new Pittwater road is under construction on the northern side of Hinkler Park.[63]

By 1956 the southern side of the Hinkler's Park is dredged and filled in.[63]

By 1951, the residents in the Riverview Parade are growing continuously.[63]

[63] Patterson Britton & Partners, 1995, Manly Lagoon Estuary Management Study, Manly and Warringah Councils

Figure 30

Source: Google Earth 2010

In 1956, the bowling greens is under construction.[64]

By 1956, Brookvale Creek is wider downstream of Kentwell Road.[64]

By 1961, the Warringah mall (site is beyond this map's coverage) is about to open. It was built on the swamp, which was drained out to build the mall. The swamp was very rich in biodiversity.[64]

There were known to be turtles in that swamp before the mall was built.[65]

3.5.9 Manly Lagoon Entrance Dredging

It is now known that the lagoon's fringing wetlands where reclaimed for rubbish dumps and are now playing fields.[64] This has resulted in the tidal exchange of water from the sea being reduced, and more importantly the flood storage volume has been reduced as well. This reduced flood storage volume combined with the permanent tidal exchange through the low flow pipes has resulted in the loss of flushing the lagoon efficiently. [66]

As per the study done in 2007[66] a clear pattern of improvement in tidal response cannot be seen in Manly Lagoon. At Manly Lagoon tidal flushing benefits are not apparent, as the low flow pipes are a major control on tidal response and limit the variation as a result of disturbances such as dredging and storm waves.

3.5.10 Biodiversity

As mentioned earlier, Governor Phillip had seen black swans on the lagoon in 1788. He described them to be much bigger than a normal swan. Also a botanical excursion to the Manly Lagoon in June 1889 described in a paper written in 2003[67] talks about the biodiversity in the area. 'Shells were scattered along the beach, revealing some fine specimens of marine life. Numerous shark eggs were also found

[64] Patterson Britton & Partners, 1995, Manly Lagoon Estuary Management Study, Manly and Warringah Councils

[65] Resident C = Clips 10 - 18

[66] Wiecek D and Floyd J, 2007, Does Dredging in ICOLL Entrance Improve Tidal Flushing? , Department of Environment and Climate Change, Sydney, NSW, Accessed on 1st May, 2010, http://www.coastalconference.com/2007/papers2007/Danny%20Wiecek.pdf

[67] Campion G Champion S, 2003, Some Early History of Curl Curl Lagoon (now known as Manly Lagoon), Accessed on 15th May 2010, http://www.manly.nsw.gov.au/IgnitionSuite/uploads/docs/Curl%20Curl%20Lagoon%20-%20early%20history.pdf

during this excursion. The botanists then described the wetlands around the lagoon as rough and exceedingly dense and it also included wild flowers.'[68]

In the year 1912, when the lagoon was being drained a large number of fish were noticed to rush out with the current and, to the surprise of the onlookers, a shark, measuring nearly 4ft made an appearance.[68] In 1960's when the Warringah Mall was built on a wetland they had to drain it out, before which there were turtles in this swamp.[69]

It can be seen that the lagoon was rich in biodiversity till 1960's, however they infilling and draining of the lagoon has caused it to loose the different species that used it as their homes and breeding grounds.

3.5.11 Water Quality

A study conducted by in 2002[70], concluded that the water quality of the lagoon was generally poor for primary contact. In particular it was evident that Burnt Bridge Creek suffered from the greatest amount of faecal coliform contamination.

As per an investigation held in 1985[71] the major sources of pollution into the lagoon were as follows –

- Urban and stormwater runoff which brings in nutrients, debris, decaying organic matter on the bed of the lagoon
- Earthworks (mainly in relation to the siltation problems)
- Sewage overflows during storms and high rainfall
- The reduced circulation of water when the lagoon mouth is closed & the quality of tidal water entering the lagoon when it is open
- Miscellaneous sources such as possible illegal or accidental discharges of trade and industrial waste.

3.5.12 Urban development

Urban development around Manly Lagoon Started in the 1870's after the Queenscliff Bridge was built. It was slow initially – only as holiday homes. After which it had the market gardens and then a few tipping points which overlapped with more and more people moving into the flood plain of the lagoon.

The increase in urban development has increased the sediment load into the lagoon.[72,73] Impervious surfaces and reduced vegetation cover has resulted in

---

[68] Campion G Champion S, 2003, Some Early History of Curl Curl Lagoon (now known as Manly Lagoon), Accessed on 15th May 2010, http://www.manly.nsw.gov.au/IgnitionSuite/uploads/docs/Curl%20Curl%20Lagoon%20-%20early%20history.pdf

[69] Resident C = Clips 10 - 18

[70] Boothman S, Mansfield J, Weston L, 2002, Sources of Faecal Coliform Pollution with the Manly Lagoon Catchment. In UTS Freshwater Ecology Report 2002, Department of Environmental Sciences, University of Technology, Sydney

[71] Cheng's(1985) paper in - Patterson Britton & Partners, 1995, Manly Lagoon Estuary Management Study, Manly and Warringah Councils

[72] Patterson Britton & Partners, 1995, Manly Lagoon Estuary Management Study, Manly and Warringah Councils

increase in runoff, increase in the flow velocity causing the erosion of creek banks and lagoon margins.[73]

3.5.13 Recreation

The lagoon and the floodplain provides a range of areas for active recreation – playing fields, golf courses, picnic areas and playgrounds. The current uses of the lagoon and its foreshores include fishing, walking and biking as well. Previously it was used for swimming and boating. [73]

The developments of these open spaces have contributed to pollution (litter and fertilizers) runoff into the lagoon. Concerns have been raised about grass clippings (carried by wind and open pipes into the lagoon) and the use of woodchips (easily washed away). The golf courses also have a high usage and extraction of water, which further affects the amount of oxygen present in the water.[73]

All these different recreational activities have an adversely impact on terrestrial and aquatic ecosystems. [73]

Around 40years ago some people were taught to swim by Stuart Somerville in the Manly Lagoon. They used to swim from Passmore Reserve to Riverview Parade[74]. In recent times the water based recreational activities have been reduced due to the decline in water quality in the lagoon.[75]

[73] University of Western Sydney, 2003, Manly Lagoon and Catchment Integrated Catchment Management Strategy and Evaluation Volume 2 Report, Integrated Catchment and Environmental Management Research Group

[74] Resident C = Clips 10 - 18

[75] Patterson Britton & Partners, 1995, Manly Lagoon Estuary Management Study, Manly and Warringah Councils

3.6 Narrabeen Lagoon

3.6.1 Introduction

Narrabeen Lagoon is the largest catchment among all four lagoons (Manly, Dee Why and Curl Curl). The area of lagoon is 207 hectare[63] and the catchment area of the lagoon is 5500 hectares[64]. The three parts of the lagoon include:

- western and central basin, comprising the largest part of the lagoon;
- eastern channel which connects the basins to the sea; and
- narrow entrance channel that connects the eastern channel to the sea.

The creeks which drain into the catchment are:

- Deep Creek which drains into the northern section;
- Middle Creek which drains in to the western part;
- South Creek which drains in to the western part; and
- Mullet Creek and Nareen Creek drain Warriewood Valley and north eastern part of the catchment.[1]

[64] Gilbert A. 1984, Narrabeen Lagoon: A case study in coastal lagoon management

Table 6 Timeline – 1788

Year	Issue	Oral History	Scientific paper/report	Historical documents/newspapers
1818	First Land grants in the "Narrabeen Lagoon" catchment area	Resident E Clip 3	Gilbert 1984	Matthew Flinders, John Hunter, James Cook, Arthur Philip, Myers aboriginal work for swan
1822	Road named Jenkin's road linked Manly and Sydney		Gilbert 1984	
1830	Land grants in Warriewood Valley		Pittwater Council 1996	
1832	Western part of the catchment surveyed, three creeks flowing in to western basin		Gilbert 1984	
1880s	Settlements were isolated, Narrabeen bridge constructed, increase in population		Gilbert 1984	RTA, 2009
1881-1887	Subdivision estates and sale of estates; construction of south creek road		Gilbert 1984	
1888	Post Office for Narrabeen		Gilbert 1984	
1889	Narrabeen School at Ramsay Estate,		Gilbert 1984	
1904	Lake is shallow, sand banks appear in it at several places and bar at mouth is very flat, near the mouth 3 feet of water in the deepest places where once the depth was			Sydney Morning Herald, 14 January 1904, 'A ruined fishery'

Year	Issue	Oral History	Scientific paper/report	Historical documents/newspapers
	about 6 or 8 feet			
1910	Armature fishermen cleared a channel with the shovels, fishermen ready with nets to secure fishes			Sydney Morning Herald, 19 March 1910, Angling
1911	NSW Public Works declared low lying areas where Gondola road, Rickard road, Nareen Parade as unfit for building		SPCC 1978	Manly Daily, 8 July 1983, 'Light planes once landed on lagoon'
	Dredging by council as lagoon was shallow	Resident D		Manly Daily, 13 September 1988, 'Why Lagoon silts up'
1913	Electric tramway connected Narrabeen to Manly led to population increase		Gilbert 1984	RTA 2009
1924-1927	Siltation, closed sea entrance, drought led lagoon to dry up, entrance was wider,		Gilbert 1984	Manly Daily, 8 July 1983, 'Light Planes once landed on lagoon'
	Repairing bridge above Narrabeen lagoon			RTA, 2009
1928	Light plane land on sand flats of lagoon as lagoon was closed between 1922-1928 to build bridge	Resident D		Manly Daily, 15 April 1985, 'In the roaring twenties and no bikini in sight' Manly Daily, 8 July 1983, 'Light Planes once landed on lagoon'
1930	Replacement of bridge over Narrabeen lagoon			RTA, 2009

Year	Issue	Oral History	Scientific paper/report	Historical documents/newspapers
	Fishing in the deep holes left by the sand dredge men, lake remains open to the ocean			Sydney Morning Herald, 4 January 1930, 'Good fishing: Narrabeen and Pittwater'
1944	Holiday makers dug the channels to let the sea in to the lake, which has become stagnant and evil smelling owing to sustained drought, very little water reached the lakes			Sydney Morning Herald, 30 December 1944, 'Attempt to fill Narrabeen Lake'
1939	Trams replaced by buses		Gilbert 1984	
1940-1960s	Yugoslavians and Italians and introduced practice of market gardens Gradual increase in settlement	Resident D	Gilbert 1984 SPCC 1978	Manly Daily, 11 February 1984, 'Time is getting on for the old man'
1960s & 1970s	Significant increase in development Introduction of Clear Water Act which restricted dredging	Resident D Resident E	SPCC 1978 Gilbert 1984 Johnston et al 1986 Laxton et al 1981 Dunston J 1990	Manly Daily, 5 July 1979, 'Auction of ASL Valley assets' Manly Daily, 9 July 1979, 'Shire lagoon sand plan deserves support'
1968	Commercial company dredging in the area of Wimbledon island	Resident D	Laxton et al 1981	Manly Daily, 15 October 1988, 'Salty tales of the good old days'
1974	Kimbriki tip came in to operation		SPCC 1978	Manly Daily, 22 September 79, 'Tipping the big bucket'

Year	Issue	Oral History	Scientific paper/report	Historical documents/newspapers
	Lot of illegal dumping during this period	Resident E		Flake et al 1996
1975	Some parts of the catchment got sewered		Laxton et al 1981 SPCC 1978	Manly Daily, 8 July 1988, 'In depth facts on lagoon'
1977	Sea plane facilities proposed Government rules out proposal Trail bikes causing problem in the catchment, Elanora district heights unsewered, water not suitable for swimming, residential septic brings in ecoli, water level down, silt has built up, presence of privet, lantana in the catchment of creeks		Laxton et al 1981 Gilbert 1984	Manly Daily, 18 August 1977 Sydney Morning Herald, 13 August 1977
1978	Closed for swimming, Warriewood shopping complex being constructed, sand blocks runoff, difficulty in water skiing because of siltation		Laxton J, Laxton E, 1981 SPCC 1978	Manly Daily, 28 June 1978, 'Report of inquire in to lagoon released' Manly Daily, 1 November 78, 'Shopping complex underway'
1979	Swimming, fishing, skiing, canoeing, sailing are recreational activities	Resident D	Laxton et al 1981	Manly Daily, 10 April 1979, ' Caution advised over extracting sand' Manly Daily, 3 April 1979, 'Skiers fight lagoon ban'

Year	Issue	Oral History	Scientific paper/report	Historical documents/newspapers
	Decline in ribbon weed particularly in upper section of lake, muddy ooze, water not so clear			Manly Daily, 19 April 1979, 'Anglers view on lagoon dredging' Manly Daily, 24 April 1979, 'Dredging will be harmful'
	Commercial dredging near Wimbledon avenue helped cut down silt			Manly Daily,22 May 1979, 'Lagoon gradually disappearing'
	Water quality not good for fishing and swimming			Manly Daily, 30 June 1979, 'Preserving our marine life"
	Council opened lagoon to improve the ventilation, sand replenished Collaroy			Manly Daily, 9 July 1979, 'Shire Lagoon Sand plan deserves support'
	Clean up of lagoon led to increase in bird life			Manly Daily, 7 July 1979, 'Lagoon bird heaven'
	Dredged upstream from ocean street bridge to protect properties in low lying area			Manly Daily, 20 November 1982
1980	Warriewood shopping complex officially opened	Resident D		Manly Daily, 15 April 1980, 'Shopping complex officially opened'
	Council started removal of pollutants (development of leachate) from Kimbriki tips		Laxton J, Laxton E, 1981	Manly Daily, 1980, 'Pollutants pumped from the tip'

Year	Issue	Oral History	Scientific paper/report	Historical documents/newspapers
	Alpha chemicals charged for discharging chemicals in Kimbriki tip – the company had licence for discharging waste but breached its condition and failed to advise the depot authority about the nature of waste	Resident E	Gilbert 1984	Manly Daily, 22 August 1980, 'Dumped mercury on the tip' Sydney Morning Herald, 26 August 1980, 'Birds home to roost'
	Water skiing banned by council Black swans present in western basin	Resident D	Bishop 2007	Sydney Morning Herald, 26 August 1980, 'Birds home to roost'
1981	Paddle boats, wind surfers, canoes, paddle boards, sailing boats recreational activities popular			Manly Daily, 29 August 1981, 'Paddle power this summer'
1982	State government rezoned Warriewood valley as industrial area and council received number of development application,		Laxton et al 1981 Gilbert 1984	Manly Daily, 22 May 1984, 'Minister silent over urgent valley decision'
1983	Pilot sand dredging program	Resident D	Laxton et al 1981	Manly Daily, 8 July 1983, 'Light Planes once landed on lagoon'

Year	Issue	Oral History	Scientific paper/report	Historical documents/newspapers
	Algal bloom (Slimy green weed) due to pollution (brown colour associated with sewerage outfall) from north head of lagoon Infection caused swimmers itch (algae Trichodesmium), sea wall being built, storm caused flooding	Resident E	Gilbert 1984	Manly Daily, 7 January 1983, 'Bird's eye view shows creeping water menace
	Opening entrance to prevent flooding of the properties			Manly Daily, 19 February 1983, 'Sand creeps as council waits to see'
1984	Plant for disposing of waste from septic tanks at Warriewood valley shut down because of complaint from residents of stink		Laxton et al 1981	Manly Daily, 31 October 1984, 'Plant shut up after stink over stench'
1985	Siltation is so serious that the main channel at the mouth has changed from the eastern to western side, new land has begun to appear on the eastern foreshore			Sydney Morning Herald, 2 May 1985
1986	Warringah shire released 40 hectares of land for business and industrial use in Warriewood valley			Manly Daily, 12 March 1986, 'Way clear at last for valley industry'
1987	Council opened the entrance to protect low lying properties from flooding		Laxton J, Laxton E, 1981 Gilbert 1984	Manly Daily, 12 September 1987, 'Clearing on time'

Year	Issue	Oral History	Scientific paper/report	Historical documents/newspapers
1988	Planning minister released 52 ha of non urban land at Terry Hill biggest in the history of Warringah			Manly Daily, 3 February 1988, 'Business park is ready for green light'
1989	Lagoon rezoned by planning minister so that council can dredge it , to ensure recreational use of water ways, several residential sites released at Beacon Hills,	Resident D		Manly Daily, 21 March 1989, Way is cleared for dredging of lagoon by Marj Belessis
1990	Mullet creek polluted and smells, bird life vanished, presence of Warriewood square, red hill development got cleared			Manly Daily 30-6-90 Wetland features are not preserved by Les Forno Manly Daily 29 November 1990 Residents lost two year battle Marj Belessis
1991	Garigal National Park gazetted	Resident D		Sydney Morning Herald 6 April 1991 New National Park has black and white history
1992	Council opened the entrance in response to the risk of residential flooding	Resident D Resident E	Gilbert 1984 Laxton J et al 1981	Manly Daily 27 November 1992 Lagoon flowing again
1993	Fish died in the lagoon – due to heat wave or pollution, contamination in sample from Narrabeen lagoon 50 percent higher than recommended level			Manly Daily 12 February 1993 Fish die in heat wave temperature by peter Alexander
	Excavation of sand from the mouth of lagoon as part of Warringahs management strategy			Manly Daily 27 March 1993 Dirty verdict on lagoons

Year	Issue	Oral History	Scientific paper/report	Historical documents/newspapers
1994	Pittwater Council owner of Warriewood wetland, bushfire in red hill, oxford falls, lake shallow			Manly Daily 31 March 1994 Council gets wetland Manly Daily 9 May 1994 Morning glory helps control lake pollution Manly Dailly 22 July 1994 Narrabeen lake too shallow
1995	Algal blooms in Mullet creek, Sydney water confirmed it near the mouth of the creek			Manly Daily 30 August 1995 'Alert as students find algal bloom by Lorna Knowles'
	Council opened the lagoon to avoid flooding		Cameron et al 2007Wiecek et al 2007	
1999	Council opened the lagoon to avoid flooding		Cameron et al 2007 Wiecek et al 2007	
2002	Council opened the lagoon to avoid flooding		Cameron et al 2007 Wiecek et al 2007	
2006	Council opened the lagoon to avoid flooding		Cameron et al 2007, Wiecek et al 2007	

3.6.2 1700s time period

In 1770, Captain Cook mentioned in his book "some broken land that appeared to form a bay" [65]. In 1788, Governor Philip described Narrabeen lagoon as a large lake surrounded by a bog and marsh land, taking three days to walk around the lagoon[66]. "The lagoon had large seagrass meadows and extensive fringes of wetland, reeds and sheoaks. Early accounts show that the lagoon was deeper than today, with clear water, a sandy bed, and abundant birds, fish and prawns able to support commercial fishing. The northern lagoon shore and ancient trees were reported to be full of roosting birds at night – egrets, cormorants, pelicans, thousands of birds…Narrabeen sand spit had thick groves of lillypilly and tall figs."[67]

3.6.3 World War II (1939 to 1945)

During World War II concrete pyramids were placed across the mouth of the lagoon and barbed wires installed across them in order to stop Japanese invasion in 1942. During heavy rainfall the logs would be washed along with the water in the creeks and creating a dam within the creeks. This caused flooding up to Waterloo road as mentioned by Resident E.[68]

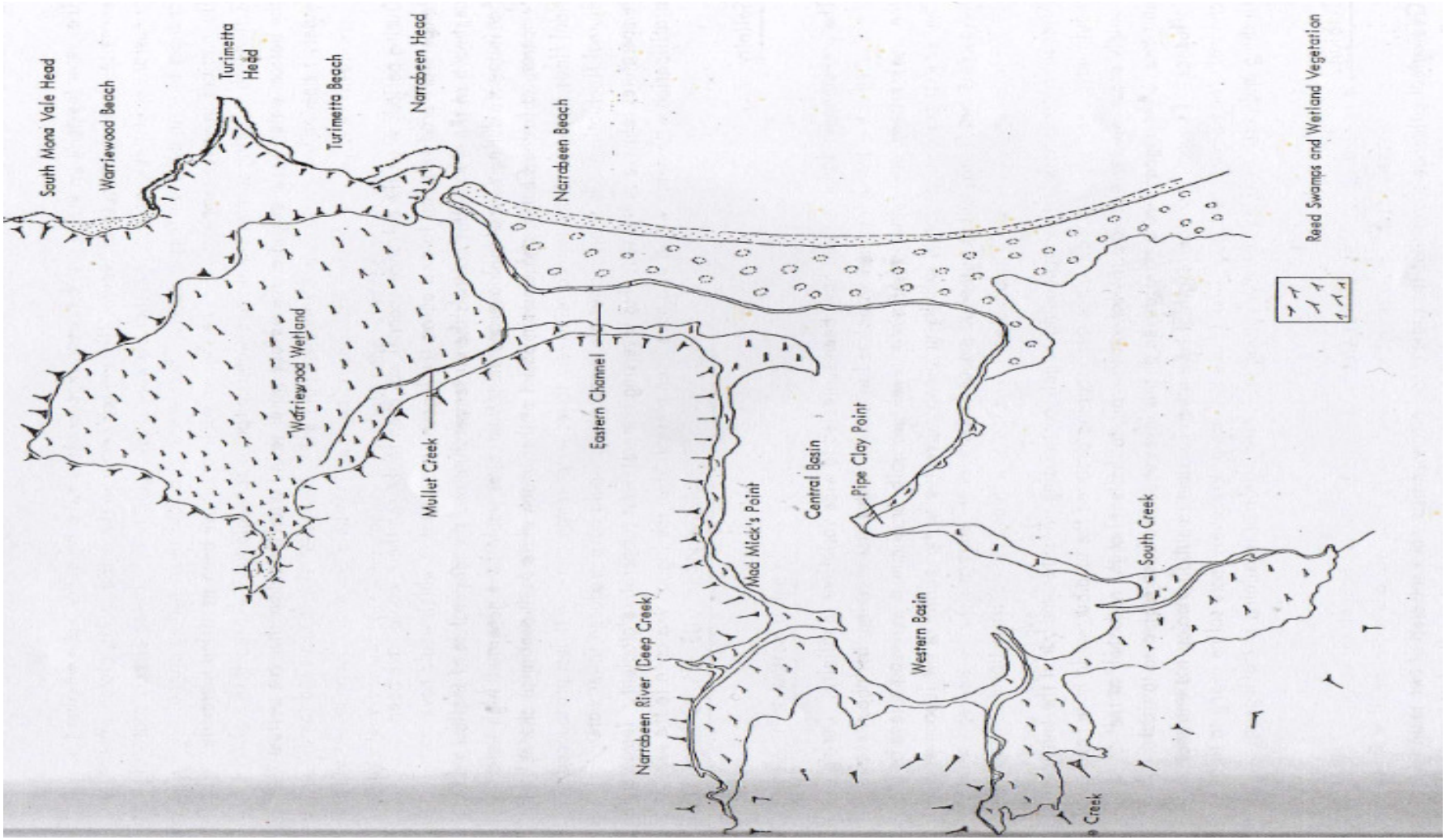
[65] Coastal Environment Centre, 2008, Environmental History of Narrabeen Lagoon

[66] Coastal Environment Centre, 2008, Environmental History of Narrabeen Lagoon

[67] Coastal Environment Centre, 2008, Environmental History of Narrabeen Lagoon

[68] Resident E – Clip 3

Figure 31: Distribution of reed swamps around the perimeter of the Pre European Narrabeen Lagoon



Source: Laxton 1981

Figure 32 Anti Aircraft Guns North Narrabeen 1938

(Source: Warringah Library Service, 2010)

Figure 33 Flooding, Narrabeen 1942

Source: Warringah Library Service, 2010

3.6.4 Market Gardens

Interviewee E mentioned that market gardens and dairy's existed from 1830s [69]. In 1920s Yugoslavians and Italians started colonizing the area. They also introduced the practice of market gardens and referred to the area as the glass city because 3,500 glass houses were present in the catchment.[70]

In the 1950s agriculture was practiced within four areas of the catchment including Warriewood, Mona Vale, Ingleside, South Creek and Oxford falls. The products of farms and market gardens were fruits, glasshouse tomatoes, citrus, vegetables, flowers and livestock.[71] Market gardens declined during the 1960s particularly following a significant hail storm that damaged the glass houses in 1963[72]. "The decline of market gardens was because of the degradation of farm lands and glass houses".[73] In addition the community wanted the land surrounding Irrawong Reserve to be rezoned from rural area to urban area and further residential development took place.

Figure 34 Glass houses and Crop field at Garden Street 1960s

[69] Resident E – Clip 3

[70] Pittwater Council 1996, Irrawong Reserve plan of management

[71] State Pollution Control Commission, 1978, Environmental investigation of Narrabeen, Dee Why and Harbord Lagoon

[72] Manly Daily, 11 February 1984, 'Time is getting on for the old man'

[73] Pittwater council 1996, Irrawong Reserve plan of management

Source: Warringah Library Service, 2010

Figure 35: Glass houses at Macpherson Street 1960s

(Source: Warringah Library Service, 2010)

3.6.5 Recreation

Recreational activities including fishing, sailing, canoeing, swimming, water skiing, kayaking, wind surfing, camping on the foreshores of the lagoon, trail bikes (in the catchment of the Deep Creek) and horse riding were popular at various times since European settlement.

The use of Narrabeen lagoon for recreational activities has changed over time. Early 1900's lagoon was popular for fishing and prawning. In 1913 there were holiday cottages present near the lagoon and bunglows by the water edge.[74] Introduction of trams led to increased recreational use of the lagoon. Sometimes due to overfishing restrictions were imposed on fishing for declared interval of time in early 1900's.[75] There are reports of fishing in deep holes left by sand dredge men in 1930 (black bream and flat head being caught from the deep holes).[76] During drought period (1924 -1928), the lagoon bed was dry and was

[74] Sydney Morning Herald, 1 February 1913, 'Prawning at Narrabeen'

[75] Sydney Morning Herald, 29 April 1912, 'Closure of Narrabeen for fishing'

[76] Sydney Morning Herald, 4 January 1930, 'Good Fishing – Narrabeen and Pittwater'

used for motor bikes as well as for biplanes/light planes landing[77]. Sailing was popular and the sailing club was constructed forty seven years ago[78]. The sports academy was built in late 1940's and early 1950's.[79] Construction of Academy of Sports complex caused extensive disturbance of the southern floodplain.[80]

Before 1975 the entrance was not mechanically opened and so the water level was higher. The water quality was poor between the 1960s to 1970s because of effluent from septic tanks that would overflow during high rainfall event into the lagoon. This restricted recreational activities because of the presence of some microorganisms like fecal coliforms and infection caused by algal blooms resulting in the water becoming inappropriate for recreational activities[81]. Interviewee B concurs with the decline in water quality, mentioning that "Algal blooms caused infections like swimmers itch or impetigo".[82]

[77] Manly Daily, 8 July 1983, ' Light planes once landed on Narrabeen Lagoon; Gordon A. 2006, Narrabeen Lagoon Restoration Project – concept; Coastal Environment Centre, 2008, Environmental history of Narrabeen Lagoon

[78] State Pollution Control Commission 1978, Environmental investigation of Narrabeen, Dee Why and Harbord Lagoons

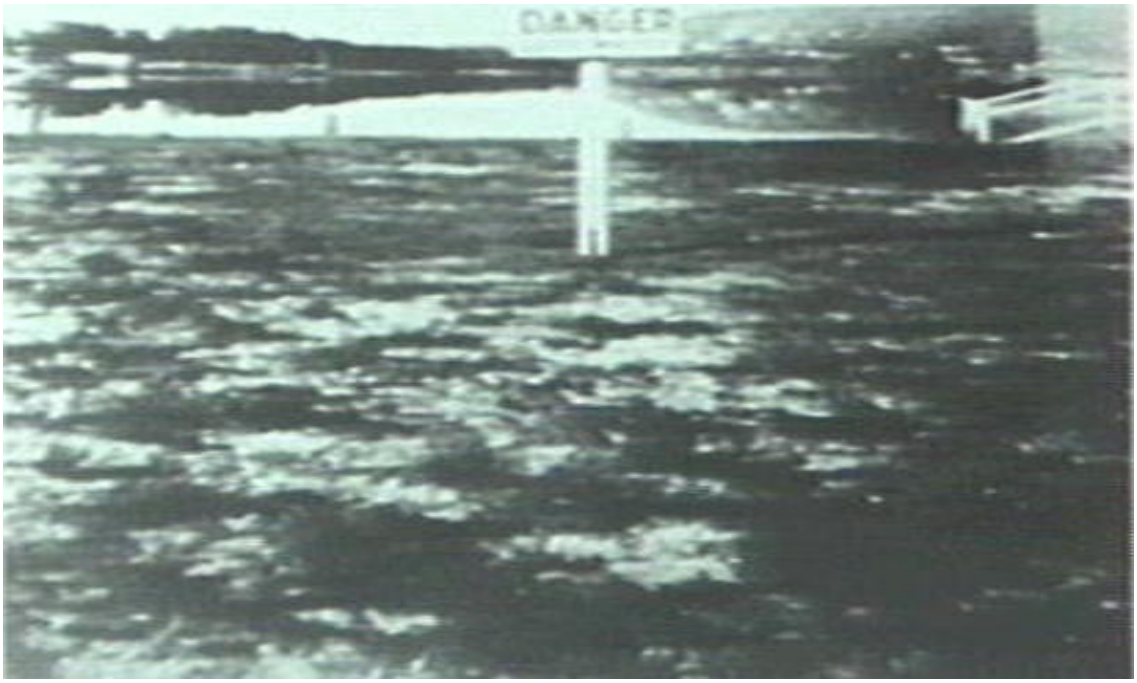
[79] Flack K. Erskine W. 1996, Development of the Middle Creek delta plain, Narrabeen Lagoon, NSW, Australian Geographer, Vol 27, No 2, pp 235-248

[80] Flack K. Erskine W. 1996, Development of the Middle Creek delta plain, Narrabeen Lagoon, NSW, Australian Geographer, Vol 27, No 2, pp 235-248

[81] Gilbert A. 1984, Narrabeen Lagoon – A case study in Coastal Lagoon management

[82] Manly Daily, 7 January 1983, 'Bird's eye view shows creeping water menace'; Resident D and E – Clip 1, 2 and 3

Figure 36 Drought affected Narrabeen Lagoon ca 1924



Source: Warringah Library Service, 2010

Interviewee A mentioned that in the 1950s it was possible to canoe through the creek entering from the mouth of the creek but after that there were formation of deltas which made it difficult[83]. Swimming was still popular during 1978 as per the SPCC report however the council closed the lagoon for swimming in 1978 on the advice from Health Commission[84].

Interviewee B mentioned that "now no one goes swimming" and the impacts of trail biking has severely degraded the environment[85] In 1980 water skiing was banned because it had an adverse impact on lagoon. The speed limit for speed boating has been restricted to eight knots in an attempt to reduce the impact on seagrass beds[86].The entrance of the lagoon has been mechanically opened from 1975 in order to protect the property from flooding, and to improve the water quality. Hence the water level remains less than it was before 1975.

[83] Resident D – Clip 1 and 2

[84] State Pollution Control Commission, 1978, Environmental investigation of Narrabeen, Dee Why and Harbord Lagoons

[85] State Pollution Control Commission, 1978, Environmental investigation of Narrabeen, Dee Why and Harbord Lagoons

[86] Bishop M. 2007, Displacement of epifauna from sea grass blades by boat wake, Journal of Experimental Biology and Ecology, vol 354, no 1, pp 111-118

Recreation on Narrabeen Lagoon

Figure 37 George Brook with a catch of fish Narrabeen ca 1900

Figure 38 Anniversary Day, Narrabeen lakes 1931

Figure 39 Kayaking, Narrabeen Lagoon 1980

Figure 40 Sailing on Narrabeen Lagoon 1988

Source: Warringah Library Service, 2010

3.6.6 Biodiversity

The first time Narrabeen lagoon was encountered by Europeans it was described as a lagoon surrounded by bogs and marsh. It had large seagrass meadows, reeds and sheoaks. The lagoon was deeper, clear water, sandy bed and abundant birds, fish and prawns. The wild life included black swans, ibis, water hens, pelicans, ducks, blue pigeons and teal. Kangaroos could be seen and the

area was bush land. Biodiversity was high during this period. Fishes present in water were bream, whiting, flathead, blackfish, mullet and eels[87].

The habitat for birds is the seagrass beds and the bush near the lagoon. For feeding they depend on the sea grass beds. Some of the waterfowl like ibis, egrets, and spoonbills are affected by water level because they cannot feed in deep waters. These birds were affected by human activity. Black swans are sensitive to human activity particularly the power boat activity[88]. This was evidenced by the population increase in 1980 once water skiing was banned[89]. Prior to 1980 the swan population was rare, some arriving in autumn. But after the ban on power boat activity a permanent population has been established.

During survey carried out at different times 1981, 2000 and 2007 revealed that biodiversity of fish has declined[90]. Deep holes created within the dredging are anoxic and does not support much life or biodiversity[91]. In 1991, some parts of the Deep Creek and its catchment have been declared as National Park which helped to preserve vegetation within the catchment.

Seagrass beds play important role in the ecosystem. They are nurseries for juvenile fishes. It acts as source of food for water fowls as well as fishes because of presence of benthic organisms on it. In early 1900's people considered it as useless waste getting in to their way for recreation. In 1934 Mr. Stone who proposed dredging mentioned that "the dredging proposed to be carried out by his company would be through areas which at low tides are filthy morasses of decaying sea weed, especially the part between the two bridges."[92]

[87] Gilbert A. 1978, Narrabeen Lagoon – a case study in coastal lagoon management

[88] Bishop M. 2007, Displacement of epifauna from sea grass blades by boat wake, Journal of Experimental Marine Biology and Ecology, vol 345, no 1, pp 111-118

[89] Sydney Morning Herald, 26 August 1980,'Birds home to roost'

[90] The Ecology Lab 2007, Narrabeen Lagoon dredge hole investigation

[91] Resident D – Clip 3

[92] Sydney Morning Herald, 17th December 1934

Figure 41 Black swans on Narrabeen Lagoon 1900

Source: Warringah Library Service

Seagrass species present in the lagoon are Zostera, Ruppia, and Halophila. Ruppia[93] was not observed in 1984. As mentioned by Resident D, the seagrasses have increased now compared to the early days. Seagrass expanded between 1939 and 1965, which was determined by using aerial photographs.

It declined from 1965 till 1977 and after that in 1978 there was an expansion of the seagrass beds[94] (refer figures 42-47).The reason for the expansion and decline is not known because of absence of historical data on the physical environment.

Figure 43 Sea grass beds 1956 was obscured by clouds as mentioned in the report by State Pollution Control Commission in 1978.

[93] Resident D – clip 1 and 2

[94] Resident D – clip 1 and 2

Figure 42 Sea grass beds 1951

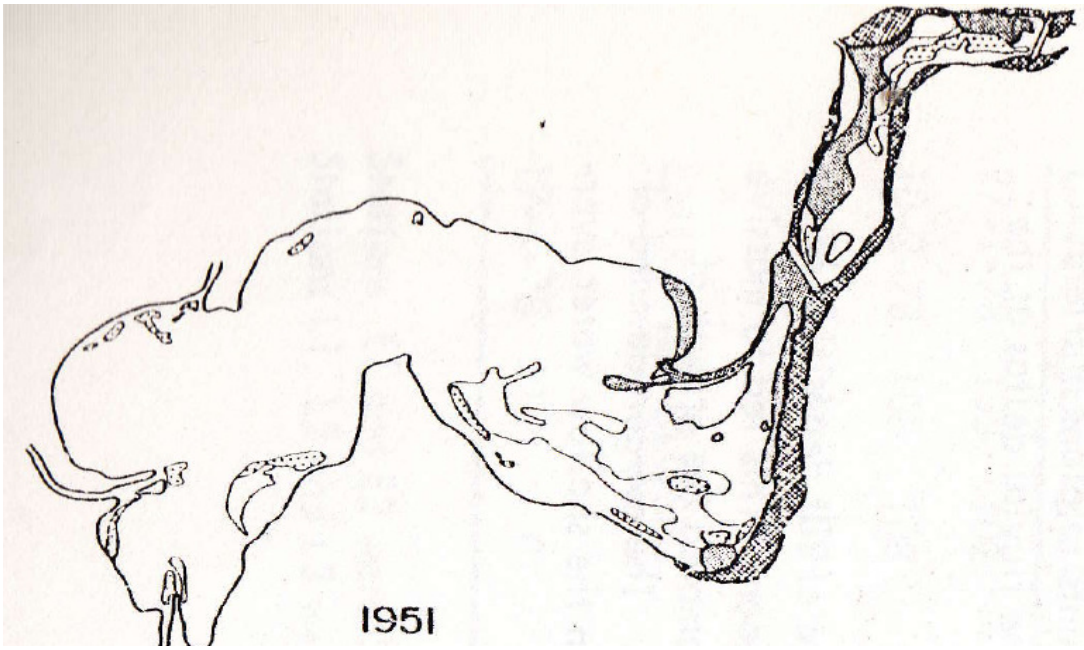
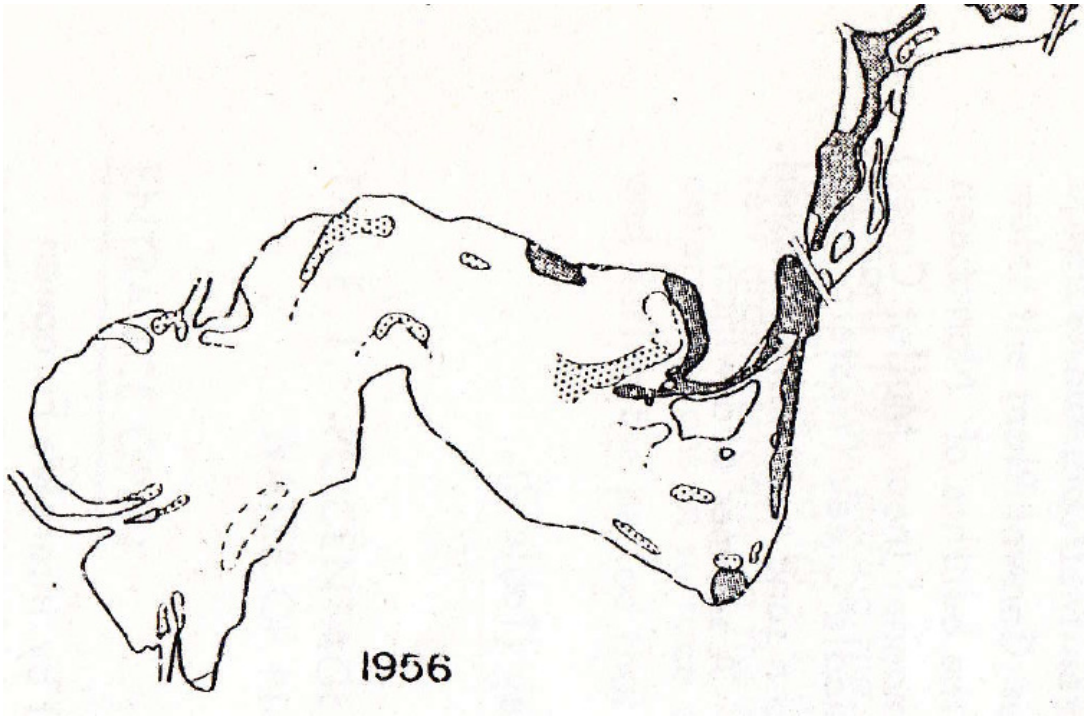


Figure 43 Sea grass beds 1956



Source: SPCC 1978

Figure 44 Sea grass beds 1961

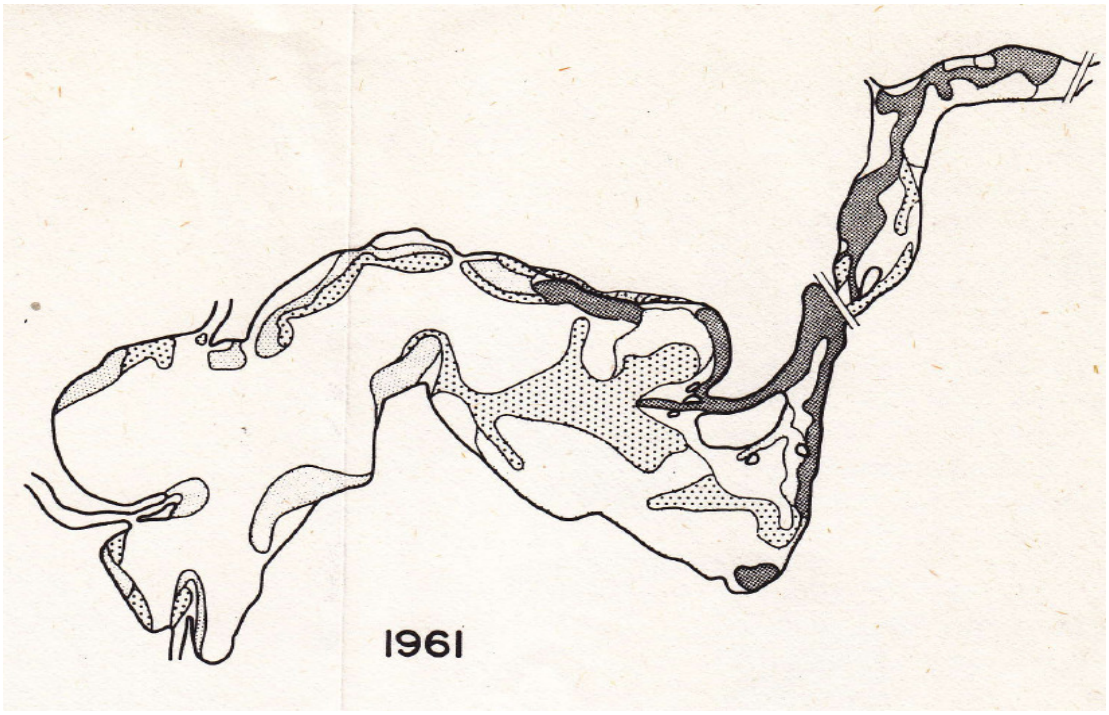
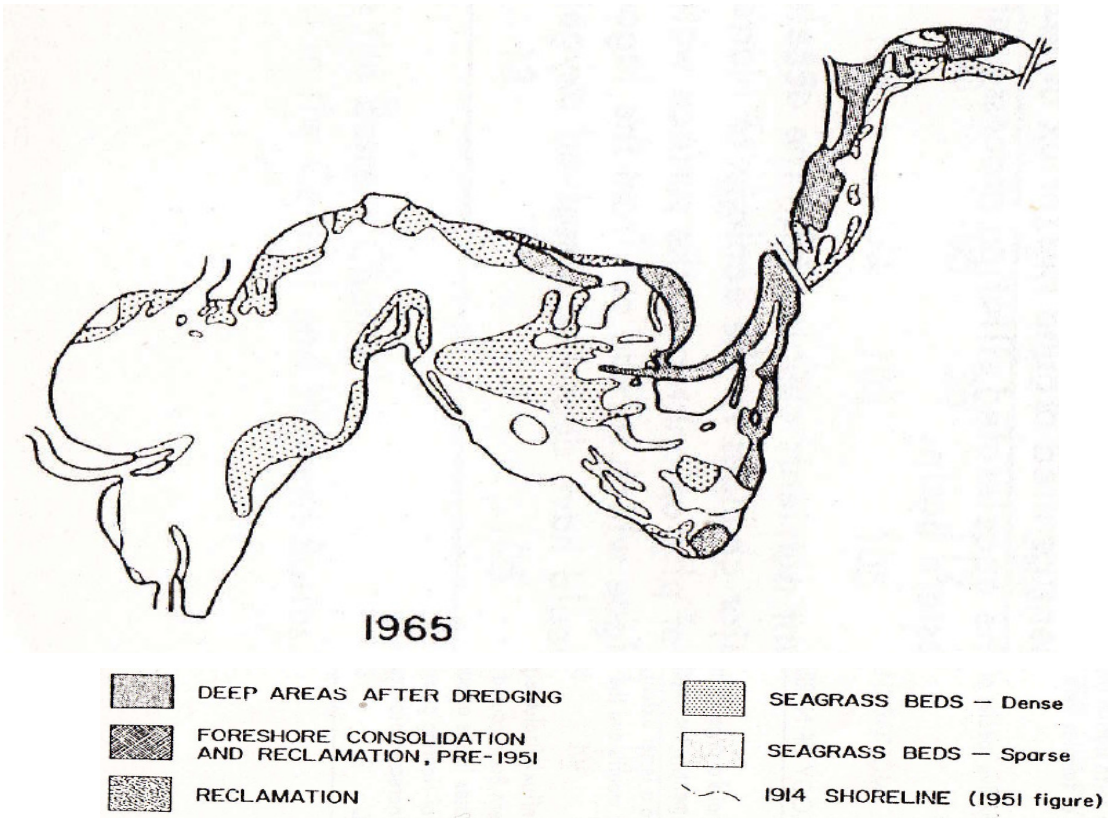


Figure 45 Sea grass beds 1965



Source: SPCC 1978

Figure 46 Sea grass beds 1970

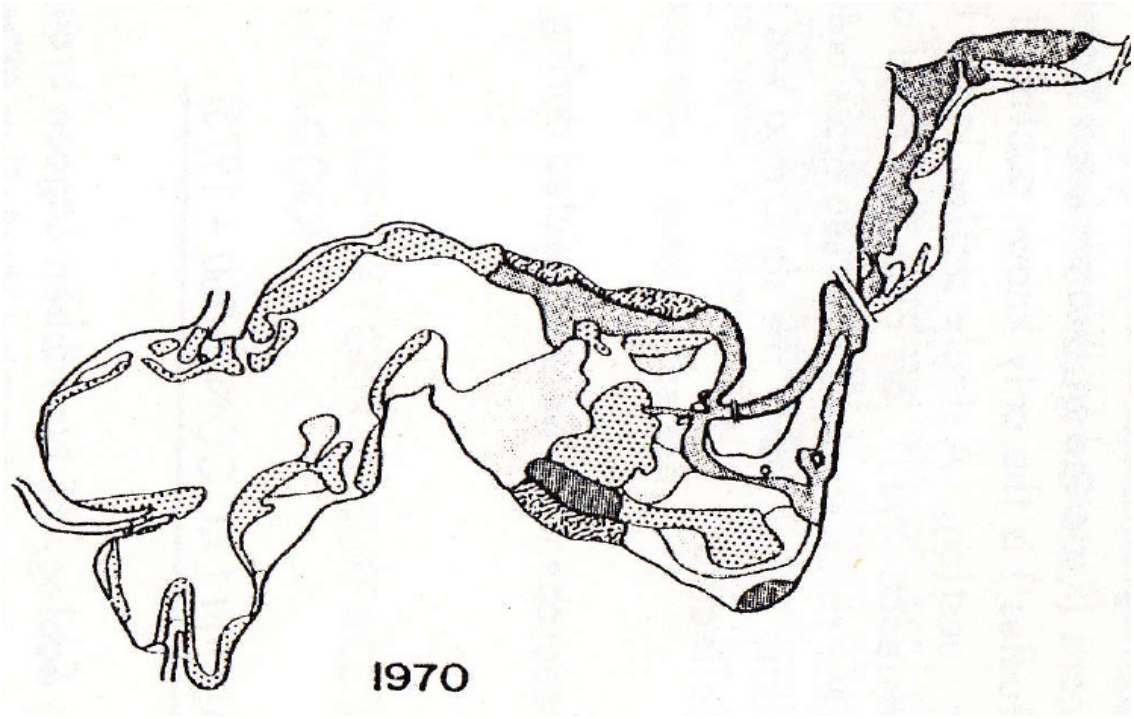
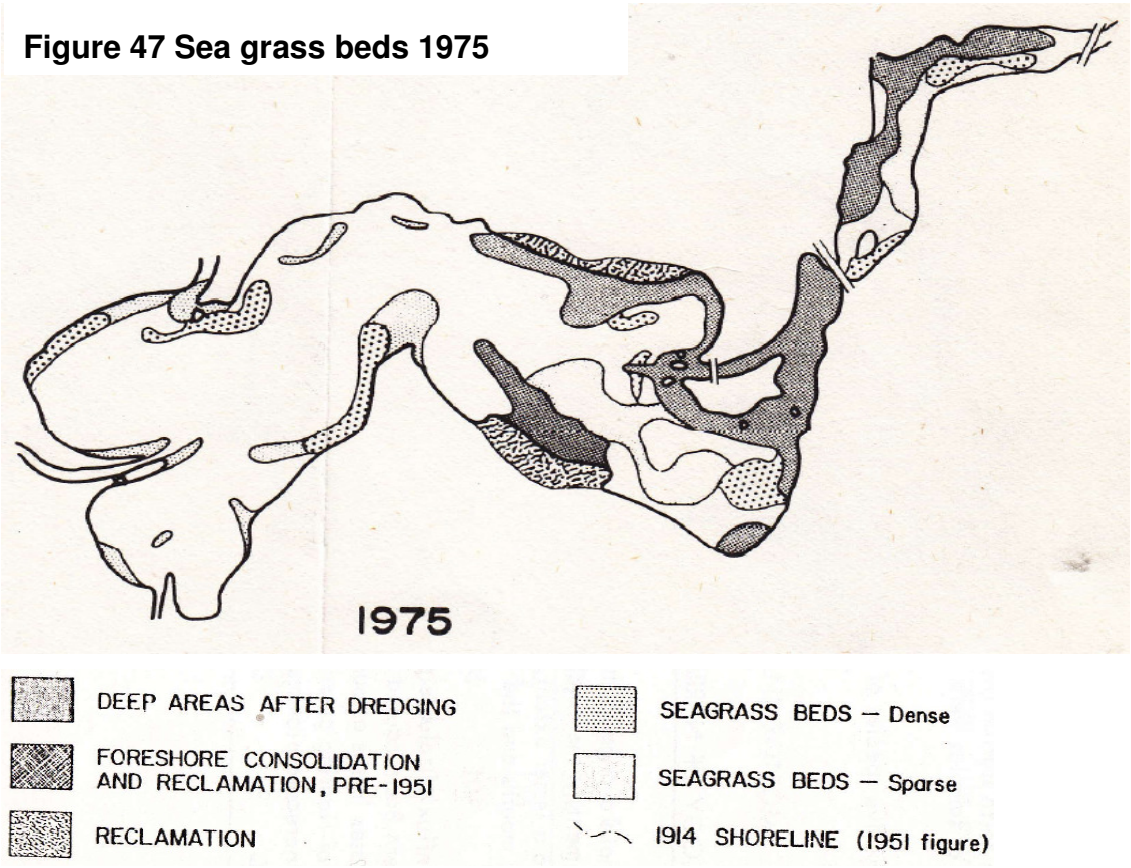
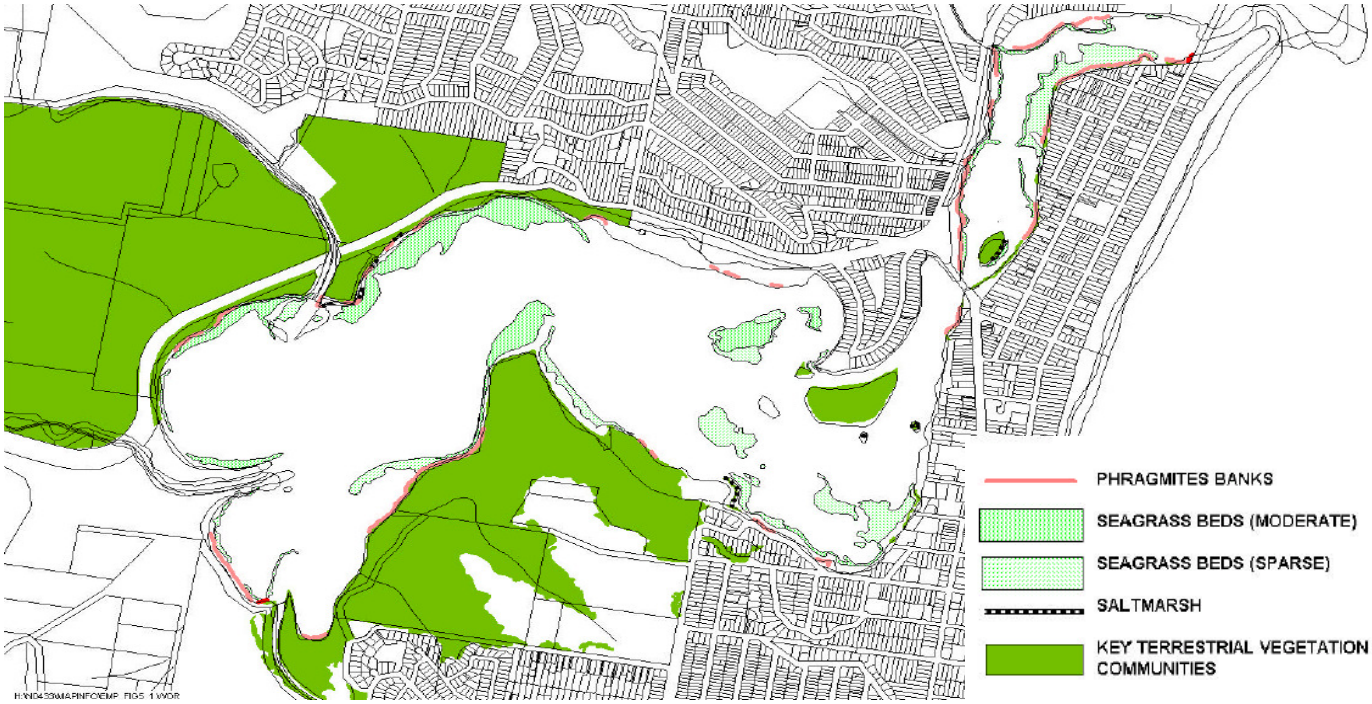


Figure 47 Sea grass beds 1975



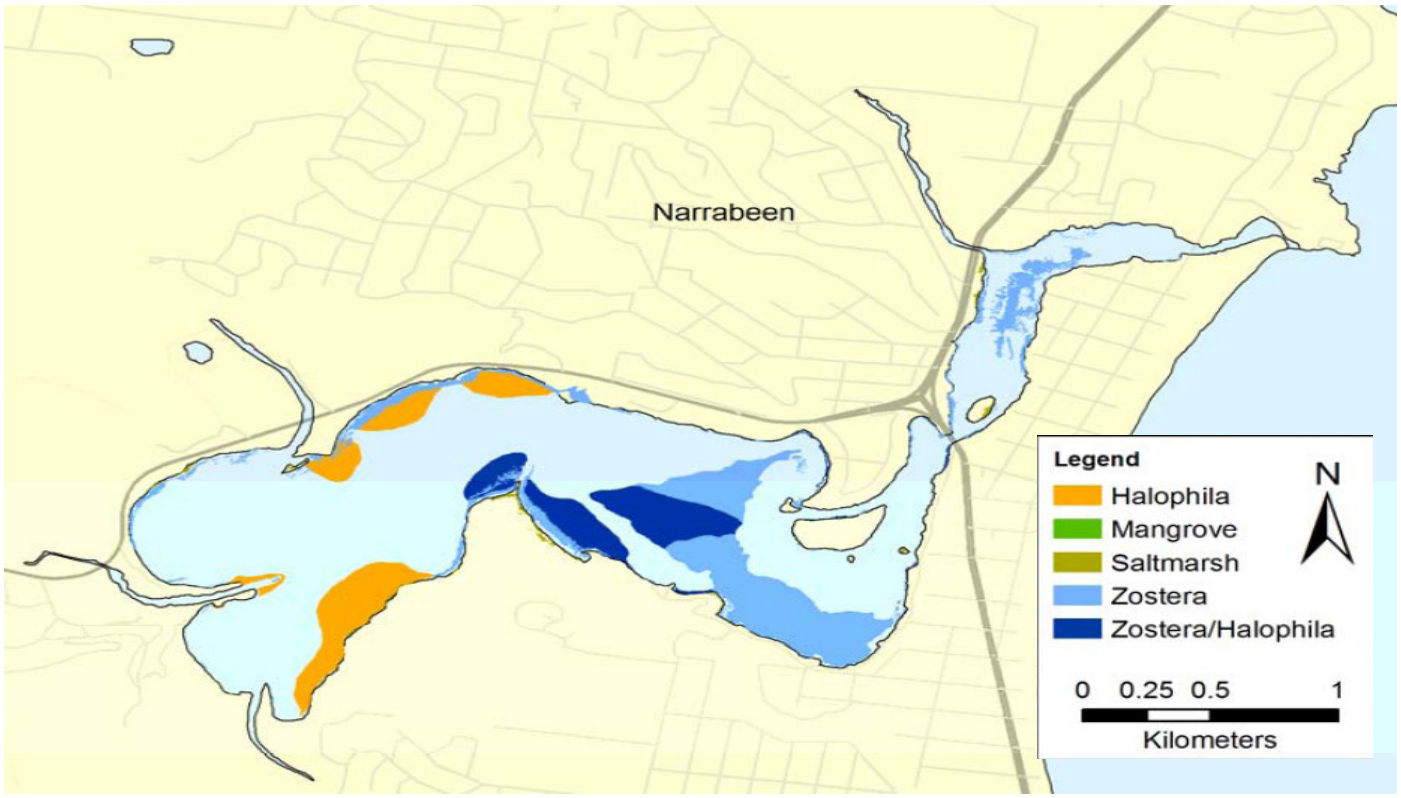
Source: SPCC 1978

Figure 48 Sea grass beds 2002



Source: WBM 2002

Figure 49 Sea grass beds 2008-2009



Source: Creese et al, 2009

Comparing the above two figures 48 and 49 for seagrass beds, it can be seen that the beds have expanded. It indicates that the beds are recovering and reasons could be a result of any of the following[95]:

- Less disturbance[96] (as no dredging is carried out in the lagoon)
- Increased tidal flushing,
- Reduction in turbidity or siltation; and/or
- The parts where dredging has been done before are recovering, providing suitable condition for the growth of sea grasses[97].

Study conducted by on Zostera in 1980 confirmed that rapid degeneration of Zostera beds during heavy rainfall in 1973. The changes were more evident in water shallower than 0.6 metre.[98] Heavy rainfall was responsible for decline of Zostera between January and March in 1979 but such heavy rainfall have not occurred in the subsequent years hence such severe decline was not observed.[99]

3.6.7 Dredging and Entrance clearance

Dredging in Narrabeen lagoon took place between 1911-1985[100]. Dredging mostly occurred in the eastern basin of the lagoon and also the western basin which had sand present on the deltas which was of commercial value[101].

Various reasons for dredging (in the central basin as well as eastern channel) were siltation which was making the lagoon shallow; preventing properties from flooding; and complaints from community members with regard to recreational use of the lagoon.

Council started dredging in 1910/1911[102]. The extraction was done for commercial purposes; to fill areas for development; and to reduce the impact of flooding[103].

---

[95] West R, 1983, The sea grasses of New South Wales estuaries and embayments

[96] Erftemeijer P. Robin R, 2006, Environmental impacts of dredging on seagrasses: A review, Marine Pollution Bulletin, Vol 52, pp 1553-1572

[97] The Ecology Lab 2007, Narrabeen Lagoon dredge hole investigation

[98] Harris et al in Gilbert A. 1984, Narrabeen Lagoon – a case study in coastal lagoon management

[99] Harris et al in Gilbert A. 1984, Narrabeen Lagoon – a case study in coastal lagoon management

[100] WBM 2002, Narrabeen Lagoon Esturay Management Plan, Resident D – clip 1 and 2

[101] Gilbert A 1984, Narrabeen Lagoon – a case study in coastal lagoon management, Interviewee A – clip 1 and 2

[102] Resident D – clip 1 and 2; Gordon A. 2006, Narrabeen Lagoon restoration project – concept; Manly Daily 21 March 1989, Way is cleared for the dredging of the lagoon

From 1934 to 1945 Edward Giles Stone operated a cement factory called “Never Been Beaten Lime and Cement works’ which dredged shell grit from the lagoon.[104] Commercial extraction was done by Warringah Council and Glynmar Sand Supplies Pty Ltd in parts near Wimbledon Avenue[105].

The area near Wimbledon Avenue has been dredged to a depth of about 6 meters[106]. Central basin has a 2 to 6 meters hole while the eastern basin has 2 to 4 meters holes[107].

As per the SPCC report (1978) from 1911 to 1978 about 15% of the lagoon has been dredged[108]. Dredging impacted sea grass beds by making the water turbid and creating anoxic holes[109]. Dredging has altered the bathymetry near Wimbledon Avenue[110]. In 1970s the Clean Waters Act was introduced which restricted dredging.

Figure 50 Never been beaten lime and cement works 1941

[103] Gordon A. 2006, Narrabeen Lagoon restoration project – concept; Interviewee A – clip 1 and 2

[104] Warringah Heritage Inventory 2008

[105] State Pollution Control Commission 1978, Environmental investigation of Narrabeen, Dee Why, and Harbord Lagoons

[106] WBM 2002, Narrabeen Lagoon Estuary Management Plan; Gordon A. Narrabeen Lagoon restoration project – concept;

[107] The Ecology Lab, Narrabeen Lagoon dredge hole investigation

[108] State Pollution Control Commission 1978, Environmental investigation of Narrabeen, Dee Why, and Harbord Lagoons

[109] The Ecology Lab Report 2007, Narrabeen dredge hole investigation

[110] Gilbert A. 1984, Narrabeen Lagoon- a case study in coastal lagoon management

(Source: Warringah Heritage Inventory 2008)

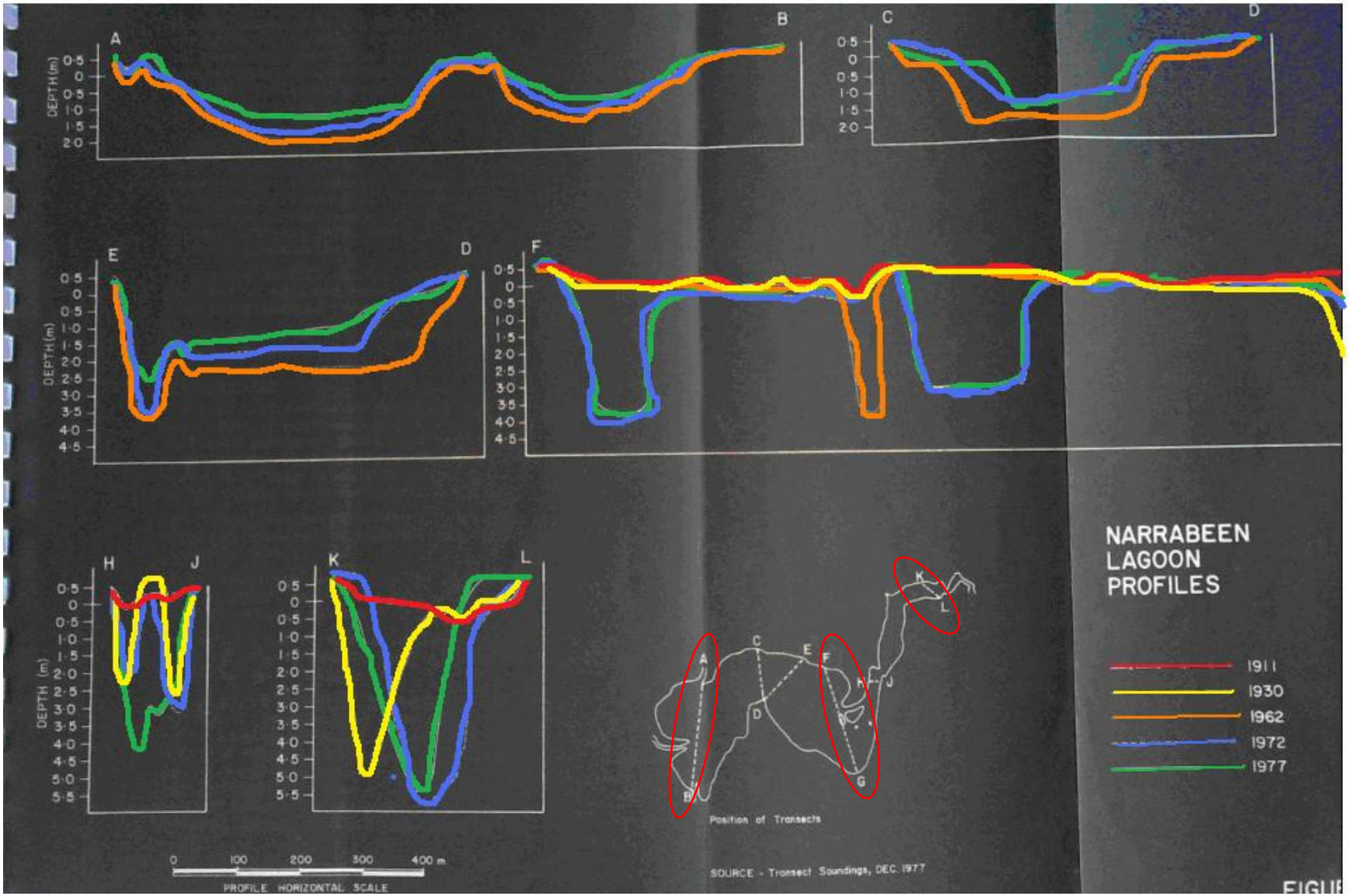
Figure 51 shows transects of various positions of the Narrabeen Lagoon (transects AB, CD, ED, FD, HJ, and KL) considered for different years (1911, 1930, 1962, 1972, and1977).

Among all the given transects if we consider transect AB which is in the western basin, where three creeks (Deep Creek, Middle Creek and South Creek) drain one can clearly see that siltation took place over time (especially near the mouth of the creeks it is evident).

Now consider transect FG (which is near Wimbledon Avenue) where commercial dredging took place deep holes can be see in the given figure. In 1911, 1930 and 1962 it appears shallow but in 1972 and 1977 deep holes are evident in the figure.

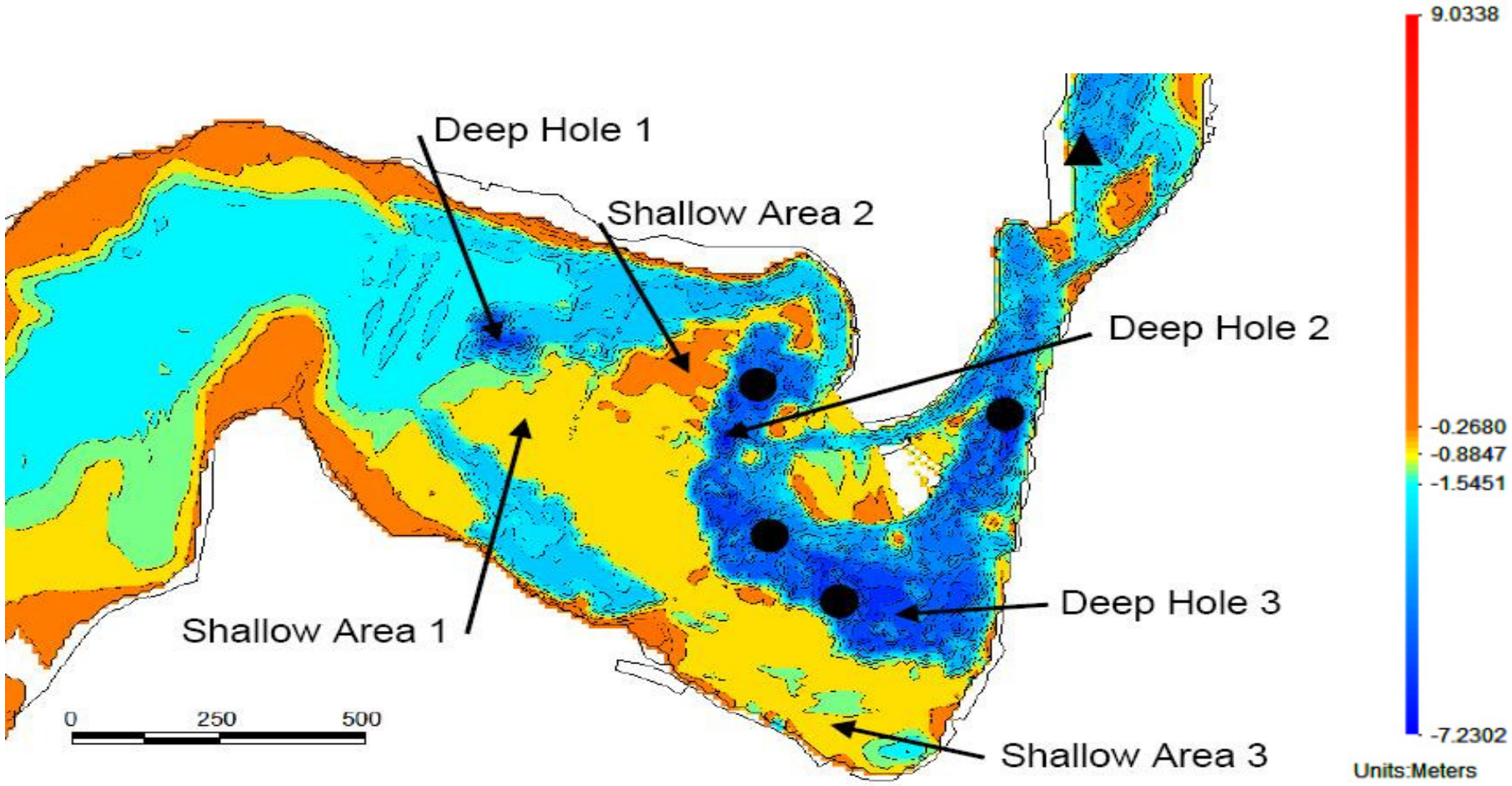
If we consider transect KL holes have been created due to dredging or may be due to the maintenance operations carried out by the council to keep the entrance of the lagoon open. In figure 42 deep holes can be seen which are anoxic in nature.

Figure 51 Transects from the Narrabeen Lagoon



Source: DEC in SPCC 1978 (modified)

Figure 52 Depth of Narrabeen Lagoon



Source: The Ecology Lab 2007

Table 7 Entrance Clearance

Year	Sediment removed (m^3)	Reason for opening	Reference
1910	-	Amateur fishermen cleared a channel with shovels and ready to secure fishes with nets	Sydney Morning Herald, 19 March 1910, Angling
1944	-	Holiday makers dug the channel in order to improve ventilation	Sydney Morning Herald, 30 December 1944, 'Attempt to fill Narrabeen Lake'
1946	-	Residents opened the entrance mechanically to avoid flooding	Gledhill in Gilbert 1984
1975	150,000	To avoid flooding	Cameron et al 2007
1979	37,500	To improve ventilation of the lagoon	Manly Daily 9-7-79
		To avoid flooding	Cameron et al 2007, Manly Daily 15-1-83
1982/1983	60,000	To avoid flooding, improve water quality	Cameron et al 2007, Manly Daily 15-1-83
1986	-	Clearing mouth after properties got flooded because of storm	Manly Daily 14-8-86
1987	40,000	To avoid flooding before storm	Manly Daily 12-9-87, Cameron et al 2007
1990	30,000	To avoid flooding	Cameron et al 2007
1992/1993	56,000	To avoid flooding	Cameron et al 2007
1995	27,500	To avoid flooding	Cameron et al 2007, Wiecek et al 2007
1999	70,000	To avoid flooding	Cameron et al 2007, Wiecek et al 2007
2002	40,000	To avoid flooding	Cameron et al 2007, Wiecek et al 2007
2006	45,000	To avoid flooding	Cameron et al 2007, Wiecek et al 2007

Council has been maintaining the entrance of the lagoon from 1975. At present the water level is 0.4meters[111] above the average sea level. The entrance is mechanically opened if the water level reaches between1.3 meters and 1.4 meters above that level. Council is maintaining the water level in order to avoid the flooding of the properties in low lying areas.

In the report prepared by SPCC in 1978, it is mentioned that Warringah council opened the entrance if the water level reached approximately 1.5 meters above Standard Datum (that is if it rises 1 meter above 0.5 meters).

The lagoon was occasionally flooded during heavy seas and storm surge which raised water level 1.5 to 1.8 meters above Standard Datum[112]. After 1974 storm surge, Birdwood park was built to avoid flooding by storm surge. Gledhill (1946) [113] mentioned that residents would open the entrance of the lagoon mechanically if it flooded their property. In 1910 amateur fishermen dug channel with the help of shovels and were ready to secure in their nets[114]. While in 1944 holiday makers dug channel in order to improve ventilation or to allow tidal flushing but very little sea water entered the lagoon[115].

Table 8 Flood Events

Historical Floods	Main Flooding Mechanism
May 1889	Rainfall runoff
January 1911	Rainfall runoff
July 1931	Elevated ocean level and rainfall runoff
March 1942	Elevated ocean levels and rainfall runoff
June 1956	Elevated ocean levels
March 1958	Rainfall runoff
1961	Rainfall runoff
May 1974	Elevated ocean levels
1975	Rainfall runoff
1986	Elevated ocean levels and rainfall runoff

[111] Warringah Council 2010

[112] State Pollution Control Commission 1978, Environmental investigation of Narrabeen, Dee Why, and Harbord Lagoons

[113] Gilbert A. 1984, Narrabeen Lagoon – A case study in coastal lagoon management

[114] Sydney Morning Herald, 19 March 1910, Angling

[115] Sydney Morning Herald, 30 December 1944, 'Attempt to fill Narrabeen Lake'

Source: AECOM 2010

Table 7 provides details of historical flood events and reason for flooding. Two events match in Table 6 and Table 7. The entrance was opened in 1975 and 1976 to avoid flooding of low lying areas in the catchment.

Figure 53 Council clearing the entrance of the lagoon 1982

Source: Warringah Library Service, 2010

3.6.8 Urban Development

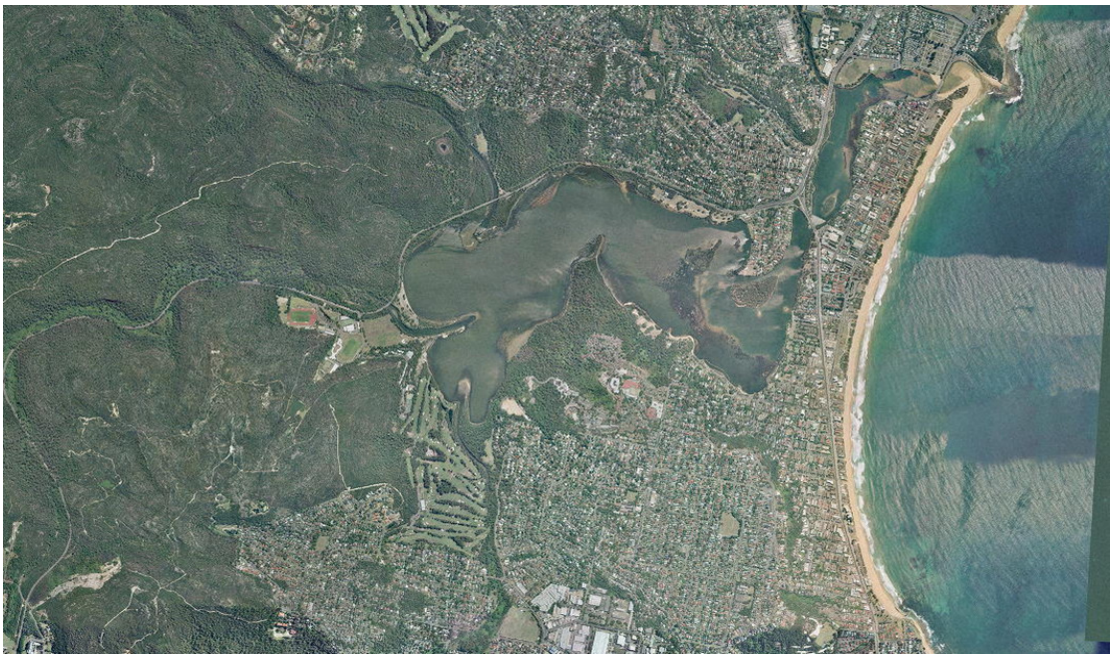
Figure 54 is an aerial photograph of the lagoon and its catchment in 1943 and Figure 55 is the lagoon and its catchment in 2009/2010. Near the western basin one can see that the area or part of the catchment has not changed much (apart from the presence of sports academy near the Middle Creek) as the catchment of the Deep creek and the Middle Creek are within the National park.

The part near the mouth of the lagoon North Narrabeen and Warriewood Valley are present, southern side where Collaroy Plateau, Wheeler heights, Cromer are present – these parts are significantly developed. Most of them are residential developments.

Figure 54 Narrabeen Lagoon and catchment 1943

Source: Land Department NSW, 2010

Figure 55 Narrabeen Lagoon and catchment



Source: Land Department NSW, 2010

In 1818, after surveying the land, first lands were granted. In 1822 Jenkin's road connected Manly and Sydney. Settlements were isolated during 1880s and between 1881 and 1887, South creek road was built[116]. The Narrabeen Bridge was built

[116] Gilbert A. 1984, Narrabeen Lagoon – a case study in coastal management

during 1880s. In 1911 low lying areas near the lagoon were declared as unsuitable for development because presence of wetland, chance of getting floods, soil erosion[117]. In 1913 the electric tram connected Manly and Narrabeen. Hence the improved means of transportation and the roads built to link this suburb increased the population. Thus, development started within this catchment.

Figure 56: Bryson's Fish and Chips Shop at the Corner of Pittwater Road Street c 1940

Source: Warringah Library Service, 2010

[117] State Pollution Control Commission 1978, Environmental investigation of Narrabeen, Dee Why, and Harbord Lagoons

Figure 57 Electric Tram c 1930

‘

Source: Warringah Library Service, 2010

The Soil Conservation Service identified that the “bulk of the lagoon catchment are not recommended for urban development because of steep slope gradient, soil erodibility, and the consequent hazard of severe siltation, that surface disturbance for urban development would generate”[118]. Some parts of Warriewood Valley were considered suitable for development because it was less steep than other parts in that catchment.

In map below (Figure 61) we can see that the residential development has been developed all around the lagoon apart from the upper end (near western basin which is National Park). In late 1940s and early 1950s Academy of Sports was constructed on the southern floodplains of the Middle Creek due to which extensive backswamps were reclaimed.[119] Aerial photo examination of 1951 and 1994 photographs (Figure 58 and 59) of the Middle Creek confirmed the width near the mouth of the creek has increased over time due to erosion.[120] The location of the scour channel dissecting the crest of the river mouth bar has also changed from northern side in 1951 to the

[118] State Pollution Control Commission 1978, Environmental Investigation of Narrabeen, Dee Why, and Harbord Lagoon

[119] Flack K. Erskine W. 1996, Development of the Middle Creek delta plain, Narrabeen Lagoon, NSW, Australian Geographer, Vol 27, No 2, pp 235-248

[120] Flack K. Erskine W. 1996, Development of the Middle Creek delta plain, Narrabeen Lagoon, NSW, Australian Geographer, Vol 27, No 2, pp 235-248

south eastern side in 1994.[121] The channel has also migrated slightly further upstream on the delta plain near the curve.[122] "Average width at five photogrammetric cross sections increased by approximately 33 per cent between 1951 and 1994".[123] In 1996 silt jetty erosion was active as reported by Flack and Erskine (1996). 1960s and 1970s saw the real estate boom and development started within this catchment. Suburbs developed within the catchment of the lagoon were Elanora Heights, North Narrabeen, Frenches Forest, Ingleside, Terrey Hills, Belrose Beacon Hill and Cromer; and erosion hazard (within these suburbs) was minor to moderate[124]. In 1982-1986, council rezoned the Warriewood valley in to light industrial area[125]. After rezoning about in 1990s onwards, suburbs like Belrose, Oxford Falls, Red Hill, Cromer Heights, Collaroy Plateau and rest of the Warriewood Valley developed[126]. Soil disturbance and erosion were caused during the development of these suburbs between 1960s and 1970s. This also led to accelerated and increased run off. The wetlands which were around the lagoon got filled gradually and were extended by reclamation. Between 1913 and 1951 there was sequential reduction in the lagoon area from foreshore consolidation in the eastern channel and after 1951 reclamation along the north and south shores of the eastern basin[127]

Some part of the wetland in Warriewood Valley has been filled up to develop Warriewood shopping complex in 1980[128]. "Fox's swamp (the remnants of which are known as the Narrabeen Parade wetland) and Wimbledon Avenue were filled with dredged material. The creek which drained Fox's Swamp once entered the lagoon south of Pittwater Road Bridge; this has been redirected and the wetland now drains via culvert under Pittwater Road bridge and Mullet Creek". [129] Kimbriki tip came in to operation in 1974[130] and another depot was present on Mona Vale Road[131]. Illegal

[121] Flack K. Erskine W. 1996, Development of the Middle Creek delta plain, Narrabeen Lagoon, NSW, Australian Geographer, Vol 27, No 2, pp 235-248

[122] Flack K. Erskine W. 1996, Development of the Middle Creek delta plain, Narrabeen Lagoon, NSW, Australian Geographer, Vol 27, No 2, pp 235-248

[123] Flack K. Erskine W. 1996, Development of the Middle Creek delta plain, Narrabeen Lagoon, NSW, Australian Geographer, Vol 27, No 2, pp 235-248

[124] State Pollution Control Commission 1978, Environmental investigation of Narrabeen, Dee Why and Harbord Lagoons

[125] Manly Daily, 12 March 1986, 'Way clear at last for valley industry'

[126] State Pollution Control Commission, Environmental investigation of Narrabeen, Dee Why, and Harbord Lagoon

[127] State Pollution Control Commission, Environmental investigation of Narrabeen, Dee Why, and Harbord Lagoon

[128] Manly Daily, 15 April 1980, 'Shopping complex officially opened

[129] Gilbert A. 1984, Narrabeen Lagoon – a case study in coastal lagoon management

[130] Curby P. Macleod V. 2003, Good Riddance – A history of waste management in Manly, Mosman, Pittwater and Warringah

dumping was problem at this time[132]. Other waste disposal facility operated by the Council were depots at Cromer (putrescible waste) and at North Narrabeen (non-putrescible waste) but were closed in 1978[133]. It is present within the catchment of Deep creek. The leachate was formed from this tip[134]. Resident E said that St Mathew's farm was used as dumping site.

[131] State Pollution Control Commission 1978, Environmental investigation of Narrabeen, Dee Why, and Harbord Lagoons

[132] Resident E – Clip 3; State Pollution Control Commission 1978, Environmental investigation of Narrabeen, Dee Why and Harbord Lagoons

[133] State Pollution Control Commission 1978, Environmental investigation of Narrabeen, Dee Why and Harbord Lagoons

[134] Gilbert A. 1984, Narrabeen Lagoon – A case study in coastal lagoon management

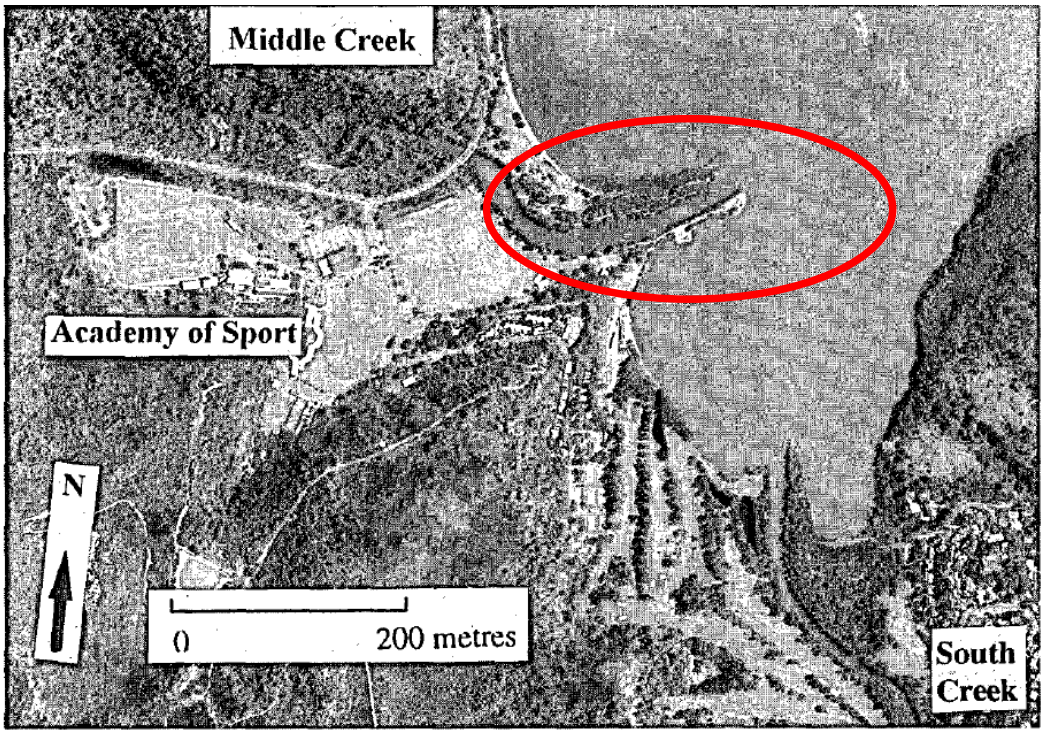


Figure 58: Aerial Photograph of the Middle Creek delta plain 1994

Source: Flack et al 1996

PLATE 2. 1994 vertical air photograph of the Middle Creek delta plain. (Crown copyright—aerial photography supplied by the Sydney Map Shop, 23–33 Bridge Street, Sydney, 2000.)

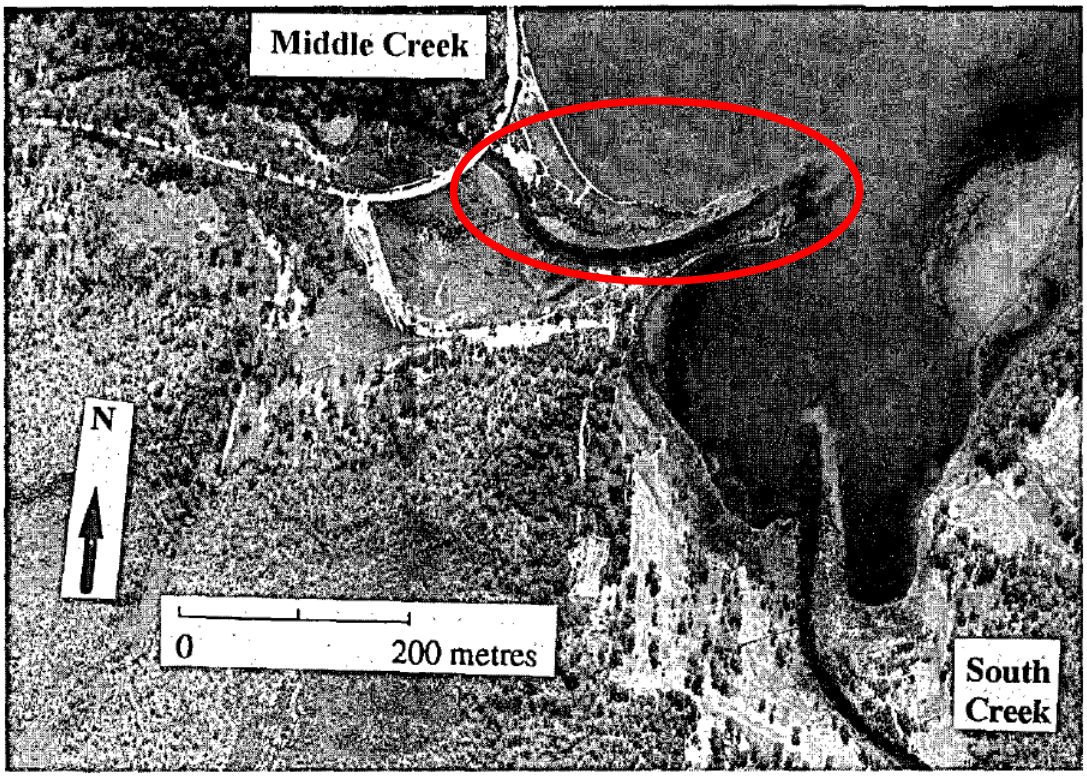


Figure 59: Aerial Photograph of the Creek delta plain 1

Source: Flack et al

PLATE 1. 1951 vertical air photograph of the Middle Creek delta plain. (Crown copyright—aerial photography supplied by the Sydney Map Shop, 23–33 Bridge Street, Sydney, 2000.)

There was no sewage during this time so people used septic tanks or pump out systems[135]. The fish and chip shops present during that time used to pump out the sewerage water directly in to the lagoon[136]. During heavy rainfall the sewage effluent would go in the lagoon along with runoff and enrich the lagoon with nutrients. Nutrient enrichment leads to algal bloom. This had impact on water quality of the Creeks. About after 1975 in Narrabeen reticulated sewerage system got installed. In Elanora heights the reticulated sewage system got installed in 1978/1979. So before sewerage got installed, there were problems of increased nutrients, fecal coliform, and algal bloom[137]. Wetlands play important role for maintaining water quality of lagoon by trapping sediments as well as nutrients from the catchment[37] but by this time most of the wetlands were reclaimed. Deltas formed at the mouth of the creeks and have grown (observation by Gilbert in 1984) and no dredging has taken place within this region. Study conducted by Pittwater council on Mullet Creek in 1998 mentioned that sediment transport is active but stable[138] One of the interviewee told that they could canoe in the middle creek in 1950s but they cannot do that now because of siltation[139]. Vegetation has been cleared within the catchment for the development that has increased siltation[37]. The clarity of water has reduced overtime[140].

[135] Gilbert A. 1984, Narrabeen Lagoon – a case study in coastal lagoon management; Resident D – clip 1 and 2; Resident E – clip 3

[136] Resident E

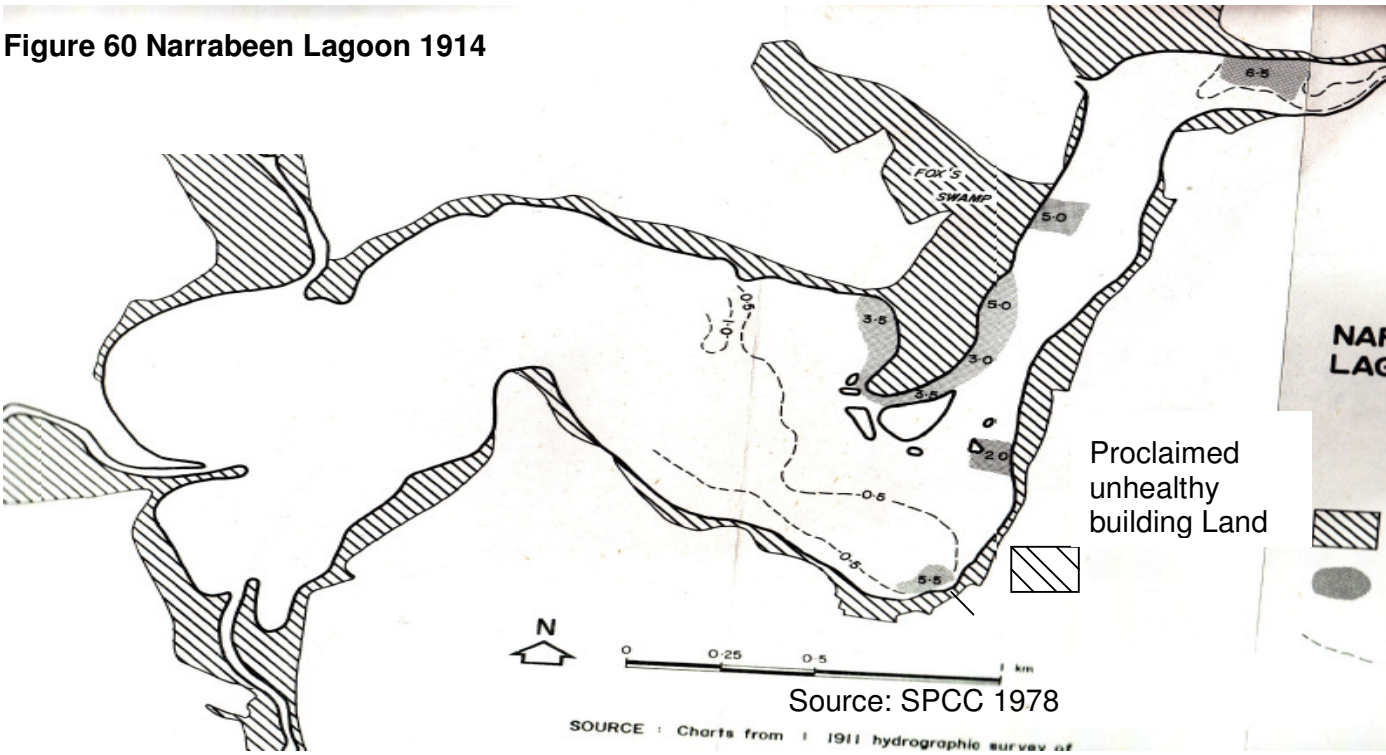
[137] State Pollution Control Commission 1978, Environmental investigation of Narrabeen, Dee Why and Harbord Lagoon

[138] NSW Department of Public Works and Services- Manly Hydraulics Laboratory, 1998, Warriewood Wetland – Draft Management Plan

[139] Resident D – Clip 1 and 2

[140] Resident E – Clip 3

Figure 60 Narrabeen Lagoon 1914



Source: SPCC 1978

Figure 61: Narrabeen Lagoon showing reclaimed parts

Source: Google Maps 2010

3.6.9 Water Quality

The water from all the four creeks South Creek, Middle Creek, Deep Creek and Mullet Creek drained in to the lagoon. Pre European map shows that the lagoon was surrounded by reed swamps and wetland vegetation. The catchment was completely covered by vegetation. The catchment is made up of Hawkesbury Sandstone hence it is prone to erosion. Warriewood Valley (to the eastern side of the lagoon) is less steep while topography of the rest of the catchment around lagoon is steep[141]. But before 1788 as the catchment was vegetated the erosion would have been less and whatever small amount of sediments came during rainfall or along with the creek flow would have been trapped by the wetlands. In EIA report[142] it is mentioned that the Western Basin contained large deposits from estuarine mud and clay while Eastern Channel and Central Basin bed were composed of 'marine tidal delta sand. Hence the water had wide range of transparencies. Nutrient load would have been low and whatever nutrients came would have been trapped by sediments or wetlands[143].

After lands were rezoned in around 1906 in Warriewood Valley, farms and market gardens were established in this part. As mentioned by Resident E[144] some market gardens as well as a dairy existed in 1830s. But after World War II most from 1940s to 1960s market garden existed and were at its peak during 1950s. These market gardens and farms enriched the upper stretches of the Middle Creek.

As settlement started slowly within the catchment vegetation would have been cleared. Then they started filling wetlands for development purpose. The market gardens declined due to degradation of farmlands and glass houses. Sedimentation would have been increased during this time.

From 1960s to 1970s extensive development took place in the catchment. This led to increased sedimentation rates in the lagoon and during this period 260 000 cubic meters of the sediments was received[145]. Even during this period the suburbs used septic tanks which added nutrients to the lagoon after heavy rain as mentioned by in Resident D and E[146]. This caused the problem of algal blooms which made water unfit for recreational purposes. As stated by Resident E that in south creek during early 1940s the water was very clear. But as infilling of St Mathews's farm with rubbish led to deterioration of water quality in South Creek[147]. Interviewee B also reported that algal blooms were observed during the period 1960s and 1970s. Increased nutrient levels and turbidity were observed in all four creeks during 1970s. In 1970s leachate from Kimbriki tip used to flow in to the Deep Creek. The depot site was not vegetated hence heavy rain would disturb the eroded soil and would add

[141] Johnston D. Gerstle B. 1986, The urbanization of the Narrabeen Catchment – a case study

[142] Laxton J. Laxton H. 1981, Environmental Impact Assessment Narrabeen Lagoon

[143] Johnston D. Gerstle B. 1986, The urbanization of the Narrabeen Catchment – a case study

[144] Resident D – Clip 1and 2; Resident E – Clip 3

[145] Johnston D. Gerstle B. 1986, The urbanization of the Narrabeen Catchment – a case study

[146] Resident D and E

more sediments in to the creek/lagoon[148]. In 1983 algal bloom as well as oil spill deteriorated the water of the lagoon.

After 1970s, the development continued but as some development control instruments were introduced as well as sediment control methods were used, that would have reduced the rate of sedimentation. After 1978 reticulated sewage system was installed in the catchment which reduced nutrient enrichment of the lagoon as well as, the council managed the entrance of the lagoon at intervals when required (to improve the water quality and avoid flooding of low lying areas). Resident D mentioned that "the water quality of Narabeen lagoon is better than Curl Curl, Dee Why and Manly lagoon"[149]. Resident E mentioned that, "now the water quality of the lagoon has improved"[150]. Narrabeen Lagoon is considered as healthy modified lagoon by Healthy Rivers Commission[151].

[147] State Pollution Control Commission 1978, Environmental investigation of Narrabeen, Dee Why, and Harbord Lagoon

[148] State Pollution Control Commission 1978, Environmental investigation of Narrabeen, Dee Why and Harbord Lagoon

[149] Resident D – Clip 1 and 2

[150] Resident E – Clip 3

[151] Healthy Rivers Commission, 2002, Coastal Lake inquire

4.0 Conclusion

This review found that all four lagoons had similar changes over the past 200 years. In 1788 they all had large wetland areas which where rich in flora and fauna. However due to most of the land being developed on in the 1950's to 1970's the wetlands have drastically reduced or have disappeared in some cases.

- The water quality in the lagoons was good before the European settlers. By the 1870's the wetlands had Market Gardens slowly developing on them and by the 1900's there were few open rubbish dumping areas on the wetlands.[152] This was when the water quality started deteriorating within the lagoons. By the 1960's-70's the development was high and the issue of 'septic tanks' overflows as well as illegal dumping of industrial waste (in some lagoons) started coming up, hence the water quality during this time was at its lowest. However after the 1990's the water quality was gradually improving due to entrance management by the authorities and the catchments were sewered in late 1970s.
- Dredging within all four lagoons happened at different times over the years. They have affected the bathymetry of the lagoon especially in Narrabeen Lagoon. Due to dredging, some of the lagoons have deep holes within them, which are anoxic, and do not support any flora or fauna[153]. Dredging also impacted sea grass beds[154].
- The sedimentation within the lagoons started in 1870's when the Market Gardens slowly developed on the wetlands of the different lagoons. It peaked in the 1960's – 1970's as this was when development in the area was high[155]. Currently sedimentation is low, as development has slowed down quite a lot as compared to the 1970's. Change in the shape for some of the lagoons can be observed for example refer Figure 18 and 19 of Dee Why lagoon due to sedimentation.
- The entrance management of the lagoon was started at different times for all the four different lagoons. It was done mainly to reduce flooding of houses that were built close to the lagoon or in the flood plain and to improve ventilation in the lagoons. In the last 100 years development has taken place close to the

[152] Campion G Champion S, 2003, Some Early History of Curl Curl Lagoon (now known as Manly Lagoon), Accessed on 15th May 2010, http://www.manly.nsw.gov.au/IgnitionSuite/uploads/docs/Curl%20Curl%20Lagoon%20-%20early%20history.pdf

[153] The Ecology Lab 2007, Investigation of dredge hole, Narrabeen

[154] Erftemeijer P. Robin R. 2006, Environmental impacts of dredging on seagrasses: A review, Marine Pollution Bulletin, Vol 52, pp 1553-1572

[155] Johnston D. Gerstle B. 1986, The urbanization of Narrabeen catchment – a case study

lagoons and within its flood plain and thus it is important for the Council to manage the entrance of the lagoon to ensure the houses built on the flood plain aren't flooded.

- Recreational activity changed over time. In early 1900s the lagoons were popular for fishing, swimming, boating, canoeing, sailing indicating that the water quality was good. But in 1960s and 1970s the decline in water quality and siltation reduced the range of recreational activities.

- Biodiversity has declined over time because of change in water quality, reclamation of the wetlands, disturbance caused due to dredging, recreational use of lagoons (for example speed boating in the lagoon).

4.0 Recommendations

- Engage the community in developing a common vision and goals for all the lagoons in a participatory process. This will clarify the management objectives and basis for planning how to balance for biodiversity, water quality, and depth, recreational use, amenity and protection of developments.

- Continue monitoring of the water quality and communicate findings to the public and address management issues.

- Monitor rubbish dumping sites/landfills and educate the community about catchment protection
- Bush fire was reported in 1994 in Garigal National Park[156]. There are chances that the nutrients get washed along with the creek and enrich the lagoon. Hence it can cause eutrophication. Better fire management plan should be prepared for bush fire.
- There are deep holes present in some parts of the lagoon. These holes are anoxic in nature and do not support unique species[157] [158]. These holes will take long time to naturally fill, or could be deliberately infilled to support more sea grass and fauna.
- Develop specific requirements for developments in the catchment to include water sensitive design. This will help in reduction of sediments going in to the lake.

[156] Kubiak P. 2009, Fire response of bushland plants after the January 1994 wildfires in northern Sydney, Cunninghamia: a journal of plant ecology for eastern Australia, vol 11, no 1, 132-164

[157] The Ecology Lab 2007, Narrabeen Lagoon dredge hole investigation

[158] Resident D

- Consider restoring wetlands around the lake to help reduce sediments and nutrients going into the lagoon. .
- Entrance clearance should be continued because of the development which council has allowed very close to the lagoon.
- Conducting a community education program to develop understanding that Narrabeen lagoon has not become shallow due to sedimentation. Although accelerated sedimentation took place in 1960's and 1970's now, because of regular openings of the lagoon from 1975, the lagoon is shallow because of a drop in water level.
- Provide information on the history of the lagoons on the Council website along with a list of FAQ's to help the community understand the changes.
- Prior to undertaking dredging or entrance clearance provide the community with information on the requirement for the activity
- Develop an education program for the golf courses operators to encourage sustainable management practice

5.0 References

AECOM 2010, Coastal Inundation at Narrabeen Lagoon – Optimizing Adaptation Investment,<http://www.climatechange.gov.au/~/media/coastal-flooding-narrabeen-lagoon.ashx>

Bishop M. 2007, Displacement of epifauna from sea grass blades by boat wake, Journal of Experimental Marine Biology and Ecology, vol 354, no 1, pp 111-118.

Boothman S, Mansfield J, Weston L, 2002, Sources of Faecal Coliform Pollution with the Manly Lagoon Catchment. In UTS Freshwater Ecology Report 2002, Department of Environmental Sciences, University of Technology, Sydney

Boyce J 2006 Pictorial history Warringah Kingsclear Books.

Cameron W. Morris D. Collier L. Mackenzie T. 2007, Management and monitoring of an ICOLL entrance clearance, < http://www.gse.mq.edu. au/docs/gse811/ CoastalConferen cePaper2007.pdf>

Champion G & Champion S, 2003, Some Early History of Curl Curl Lagoon (now know as Manly Lagoon), Accessed on 15th May 2010, http://www.manly.nsw.gov.au/IgnitionSuite/uploads/docs/Curl%20Curl%20Lagoon%20-%20early%20history.pdf

Champion G & Champion S, 2006, Finding the Right Tract: Governor Phillip's Inland Exploration from Manly towards Middle Harbour and Westward: 15th to 18th April, 1788

Cheng D, 1985, Environmental Investigations of Manly Lagoon, Prepared for Warringah Shire and Manly Municipal Councils

Coastal Environmental Centre, 2008, Environmental history of Narrabeen Lagoon

Creese R, Glasby T, West G, Gallen C, 2009, Mapping the habitats of NSW estuaries, < http://www.dpi.nsw.gov.au/__data/assets/pdf_file/ 0004/306625/AE_2009_Output-1575_Creese-et-al_Habitat-Mapping-Final-Report-113_REPORT.pdf>

Danovaro R., Pusceddu A., 2007 Biodiversity and ecosystem functioning in coastal lagoons: Does microbial diversity play any role? Estuarine, Coastal and Shelf Science 75 4-12.

Dunstan D. 1990, Some early environmental problems and guidelines in New South Wales estuaries, Wetlands (Australia), vol 9, no 1, pp 1-6

Flack K. Erskine W, 1996, Development of the middle creek delta plain, Narrabeen Lagoon, NSW, Australian Geographer, vol 27, no 2, 1996

Foley D, 2001, Repossession of our Spirit, Traditional Owners of the Northern Sydney

Francis Meyer, 1880, "Beautiful Manly" (Attached in Appendix)

Gilbert A. 1984, Narrabeen Lagoon: A case study in coastal lagoon management

Gordo A. 2006, Narrabeen Lagoon Restoration Project – Concept, < http://www. arringahnsw.gov.au/nvironment/documents/narrabeen%20restoration%20concept%20paper1.pdf>

Healthy Rivers Commisions, 2002, Coastal Lakes, Independent Enquirey into Coastal Lakes – Final Report

Haines P. E., Tomlinson R. B., Thom B. G. 2006 Morphometric assessment of intermittently open/closed coastal lagoons in New South Wales, Australia. Estuarine, Coastal and Shelf Science, 67 321-332.

Johnston D. Gerstle B, 1986, The urbanization of the Narrabeen Lagoon Catchment - a case study, Journal of soil conservation, vol 42, no 1, pp 18

Gilbert A. 1984, Narrabeen Lagoon: A case study in coastal lagoon management

Gordon G, 2000, Harbord – Queenscliff and South Curl Curl 1788 – 2000, Deblaere's Imagesetting Service Pty Ltd

Guerra R., Pasteris A., Ponti M., 2009 Impacts of maintenance channel dredging in a northern Adriatic coastal lagoon. I: Effects on sediment properties, contamination and toxicity. Estuarine, Coastal and Shelf Science 85 134-142.

Laxton J, Laxton E, 1981, Environmental Impact Statement on the proposed management strategy, Laxton Environmental consultants.

Manly Council, 2000, State of the Environment Report 1999-2000

Manly Council's Heritage Committee,2002, Awalking-tour guide to Heritage Plaques in Manly, Accessed on 15th May 2010, http://www.manly.nsw.gov.au/IgnitionSuite/uploads/docs/Heritage2.pdf

Manly Daily, 8 July 1983, 'Light planes once landed on lagoon'

Manly Daily, 13 September 1988, 'Why Lagoon silts up'

Manly Daily, 15 April 1985, 'In the roaring twenties and no bikini in sight'

Manly Daily, 11 February 1984, 'Time is getting on for the old man'

Manly Daily, 5 July 1979, 'Auction of ASL Valley assets'

Manly Daily, 9 July 1979, 'Shire lagoon sand plan deserves support'

Manly Daily, 15 October 1988, 'Salty tales of the good old days'

Manly Daily, 22 September 79, 'Tipping the big bucket'

Manly Daily, 8 July 1988, 'In depth facts on lagoon'

Manly Daily, 18 August 1977

Manly Daily, 28 June 1978, 'Report of inquire in to lagoon released'

Manly Daily, 1 November 78, 'Shopping complex underway'

Manly Daily, 10 April 1979, 'Caution advised over extracting sand'

Manly Daily, 3 April 1979, 'Skiers fight lagoon ban'

Manly Daily, 19 April 1979, 'Anglers view on lagoon dredging'

Manly Daily, 24 April 1979, 'Dredging will be harmful'

Manly Daily, 30 June 1979, 'Preserving our marine life"

Manly Daily, 7 July 1979, 'Lagoon bird heaven'

Manly Daily, 15 April 1980, 'Shopping complex officially opened'

Manly Daily, 1980, 'Pollutants pumped from the tip'

Manly Daily, 22 August 1980, 'Dumped mercury on the tip'

Manly Daily, 29 August 1981, 'Paddle power this summer'

Manly Daily, 22 May 1984, 'Minister silent over urgent valley decision'

Manly Daily, 31 October 1984, 'Plant shut up after stink over stench'

Manly Daily, 12 March 1986, 'Way clear at last for valley industry'

Manly Daily, 12 September 1987, 'Clearing on time'

Manly Daily, 3 February 1988, 'Business park is ready for green light'

Manly Daily, 21-3-89, Way is cleared for dredging of lagoon by Marj Belessis

Manly Daily 30-6-90 Wetland features are not preserved by Les Forno

Manly Daily 29-11-90 Residents lost two year battle marj belessis

Manly Daily 27-11-92 Lagoon flowing again

Manly Daily 12-02-93 Fish die in heat wave temperature by peter Alexander

Manly Daily 27-3-93 Dirty verdict on lagoons

Manly Daily 31-3-94 Council gets wetland

Manly Daily 9-5-94 Morning glory helps control lake pollution

Manly Daily 22-7-94 Narrabeen lake too shallow

Manly Daily 30-8-95 Alert as students find algal bloom by Lorna Knowles

McDonald C E, 1979, Manly – Warringal Stories of the Peninsula, Murry Child & Company

McDonald C E, Henderson C W T, 1975, The Manly-Warringah Story, Paul Hamlyn Pty Ltd

McInnes H C, 1985, Problems and Principles in Estuarine Management Case Study – Manly Lagoon, Unpublished paper, Macquarie University, Centre for Environmental and Urban Studies, Sydney

Metherell T, 2006, Faster: Manly in the 1920s, Chapter 10: Manly's Chinese Gardens, Accessed on 15th may 2010, http://www.manly.nsw.gov.au/IgnitionSuite/uploads/docs/10%20Manlys%20Chinese%20Gardens.pdf

Muir T, 2001, The Warringah Verdict – An accident waiting to happen, Turfgrass management, Accessed on 15th May 2010, www.agcsa.com.au/static/atm_articles/html/5_6d.html

NSW Department of Lands 2010 https://six.lands.nsw.gov.au/wps/portal/!ut/p/c5/04_SB8K8xLLM9MSSzPy8xBz9CP0os3gPI0tH07AwQwML1yBXA6MADzNzN1dLQwMDI_1I_ShzhLy7uZ8hUN7S1NnJ0NzYwMBEPzInNT0xuVK_IDtUEQC7lEjm/?reset=true#7_H29A5VV10G7N102P95CB173004 accessed 21/5/2010.

Patterson Britton & Partners, 1995, Manly Lagoon Estuary Management Study, Manly and Warringah Councils

Pittwater Council 1996, Irrawong Reserve Plan of Management, < http://www.pittwater.nsw.gov.au/__data/assets/pdf_file/0020/6563/Irrawong_POM.pdf>

Read P, 2000, Belonging: Australians, place and aboriginal ownership, Cambridge University Press

Reizes J, 1996, Greening Golf Courses to Avoid Algal Blues, Soil and Water – Management for Urban Development

Robinson B, 2001, The Warringah Verdict, Accessed on 15th April 2010, www.agcsa.com.au/static/atm_articles/html/5_6d.html

RTA, 2009, Narrabeen Lake Bridge, viewed 23 May 2010, < http://www.rta.nsw .gov.au/cgi-bin/index.cgi?action=heritage.show&id=4305004>

Sue Rosen and Associates, 2004, Study of Heritage Significance of a Group of RTA Controlled Bridges & Ferries, Accessed on 15th April 2010, http://www.rta.nsw.gov.au/cgi-

bin/index.cgi?action=heritage.show&id=4305016

Sharpe A, 1983, Pictorial Memories – Manly to Palm Beach, Kingsclear Books.

SLSA 2010 http://www.slsa.com.au/default.aspx?s=beachprofile&beachid=nsw315B accessed 26/5/2010.

Sydney Morning Herald 6-4-91 New National Park has black and white history

Sydney Morning Herald, 2 May 1985

Sydney Morning Herald, 26 August 1980, 'Birds home to roost'

Sydney Morning Herald, 13 August 1977

Sydney Morning Herald, 14 January 1904, 'A ruined fishery'

Sydney Morning Herald, 19 March 1910, Angling

Sydney Morning Herald, 4 January 1930, 'Good fishing: Narrabeen and Pittwater'

Sydney Morning Herald, 30 December 1944, 'Attempt to fill Narrabeen Lake'

The Ecology Lab 2007, Narrabeen Lagoon dredge hole investigation, < http://www.arringah.nsw.gov.au/community/documents/ConsolidatedNarrabeenLagoonDredgeHolesFinal28_5_07.pdf>

Warringah Council, 2004, Creek Management Study, MWH Australia Pty Ltd

Warringah Council, 2010, Manly Dam, Accessed on 15th May 2010, http://www.warringah.nsw.gov.au/community/History1.aspx

Warringah library service 2010 http://www2.photosau.com/warringah/scripts/home.asp accessed 26/5/2010.

Warringah Council, 2004, Creek Management Study, MWH Australia Pty Ltd

Wiecek D and Floyd J, 2007, Does Dredging in ICOLL Entrance Improve Tidal Flushing? , Department of Environment and Climate Change, Sydney, NSW, Accessed on 1st May, 2010, http://www.coastalconference.com/2007/papers2007/Danny%20Wiecek.pdf

Warringah Heritage Inventory, 2008, < http://www.warringah.nsw.gov.au/community/documents/UpdatedInventorySep08.pdf>

WBM 2002, Narrabeen Lagoon Estuary Management Plan

West R, 1983, The seagrasses of New South Wales estuaries and embayments, < http://ojs.library.unsw.edu.au/index.php/wetlands/article/view/214/239>

Wiecek D. Floyd J, 2007, Does dredging in ICOLL entrances improve tidal flushing? < http://www.coastalconference.com/2007/papers2007/Danny%20Wiecek.pdf>

University of Western Sydney, 2003, Manly Lagoon and Catchment Integrated Catchment Management Strategy and Evaluation Volume 2 Report, Integrated Catchment and Environmental Management Research Group

Appendix A Interview List

Clip 1 – Resident D (Narrabeen, Dee Why, Curl Curl)

Clip 2 – Resident D (Narrabeen, Dee Why, Curl Curl)

Clip 3 – Resident E (Narrabeen)

Clip 4 – Resident A and B (Curl Curl)

Clip 5 – Resident A and B (Curl Curl)

Clip 6 – Resident F (Freshwater)

Clip 7 – Resident C (Manly)

Appendix B Interview Questions

Interview questions:

1. Can you recall any significant physical changes to the waterways?

.....

.....

.....

.....

2. What do you remember about the lagoons in the surrounding area?

.....

.....

.....

.....

3. Have the lagoon entrances changed, including the frequency of the opening/closing?

.....

.....

.....

.....

4. Do you remember the lagoons being larger than they are today?

.....

.....

.....

.....

5. Do the lagoons/creeks seem to contain the same quantity of water?

.....

.....

.....

.....

6. Do you think the water quality has changed (cleaner/dirty/rubbish etc)?

.....

.....

.....

.....

7. Do you recall any algal blooms on the lakes/lagoons? If so, how long did they last.

.....

.....

.....

.....

8. What were the uses of the waterways, ie fishing, prawning, swimming?

.....

.....

.....

.....

.....

9. Has development played a role in the changes to the waterways?

.....

.....

.....

.....

10. Have the wetland areas changed.

.....

.....

.....

.....