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Coastal Zone Management Plan for Gosford Lagoons

April 2015

DRAFT Coastal Zone Management Plan for Gosford Coastal Lagoons

Gosford City Council has prepared this document with financial assistance from the NSW Government through its Estuary Management Program. This document does not necessarily represent the opinions of the NSW Government or the Office of Environment and Heritage

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Synopsis: **The Gosford Lagoons Coastal Zone Management Plan provides a strategic framework and action plan for the future management of Wamberal Lagoon, Terrigal Lagoon, Avoca Lagoon and Cockrone Lagoon. It aims to redress current issues, and conserve existing values, using a range of implementation mechanisms, including on ground works, community engagement programs and planning instruments. The Plan includes an indicative costing, potential funding sources and identifies responsibilities for implementation and future monitoring**

REVISION/CHECKING HISTORY

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1	November 2013	PEH		MF	
2	June 2014	MF		MF	
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Foreword

There are a range of estuaries and coastal wetlands in the Gosford City Council LGA including Brisbane Water and its tributaries, Broken Bay and the Hawkesbury River estuary (including Mooney Mooney, Mullet and Patonga Creeks) and a number of important coastal lagoons including Wamberal, Terrigal, Avoca, Cockrone and the perched lagoon at Pearl Beach.

Over many decades Gosford City Council has worked with other government bodies, industry and community to appropriately manage activities in the coastal zone. Gosford City Councils emphasis for coastal management is on conservation, land use planning and rehabilitation. Partnerships between Council, government and the community will be necessary to ensure any conservation and rehabilitation work is undertaken and valued.

Council is working on a range of planning activities which aim to provide a balanced long-term management framework for the ecologically sustainable use of our coast and estuaries. These planning activities require a connected community that has the capacity to understand the role of government and the part we all play to ensure the long term protection of the coastal zone.

The primary purpose of coastal zone management planning is to describe proposed actions to be implemented by council, other public authorities and, potentially, by the private sector to address priority management issues in the coastal zone over a defined implementation period.

These issues include:

- Managing risks to public safety and built assets;
- Pressures on coastal ecosystems; and
- Community uses of the coastal zone.

Gosford's four coastal lagoon systems are a significant geographic feature of the Gosford region. These lagoon systems belong to a special class of estuary known as intermittently closing and opening lakes and lagoons (ICOLLs). An ICOLL can also be defined as a 'shallow coastal water body separated from the ocean by a barrier, connected at least intermittently to the ocean by one or more restricted inlets, and usually oriented shore parallel'.

Each lagoon is subject to a variety of pressures which may threaten existing economic, social and environmental values.

The Gosford coastal lagoon systems are a highly valued natural resource for both local residents and visitors alike. The systems support a network of significant ecological communities as well as a diverse range of recreational uses. However, past land-use changes and human activities, combined with a growing population, are placing increasing pressure on the natural values and ecological health of the lagoons.

Gosford City Council strives to preserve and enhance our coastal environments. This can only be achieved through community education about the importance of coastal environments, the potential impacts of human activity upon these environments and through good management.

This revised and improved Coastal Zone Management Plan compliments the development of Plans for the Lower Hawkesbury River Estuary (2009), Brisbane Water (2012) and Pearl Beach Lagoon

(2014). Additionally, Councils flood and beaches planning processes also consider issues which impact the use of our lagoons..

Council uses the latest scientific information, combined with community and stakeholder feedback, to develop plans which aim to:

- Protect, rehabilitate and improve the natural environment;
- Manage the coastal and estuarine environment in the public interest to ensure its health and vitality;
- Improve the recreational amenity of estuarine waters and foreshores;
- Recognise and accommodate natural processes and climate change; and
- Ensure ecologically sustainable development and use of resources.

There are also approximately 14 kilometres of beaches within the Gosford LGA, extending from Patonga in the south, to Forresters Beach in the north. Council has examined and assessed the coastal processes and hazards that impact this coastline. This includes beach erosion, shoreline recession, sand drift, coastal inundation, stormwater erosion, slope instability and climate change. Coastal processes are known to influence lagoons health and the interactions between the two systems are important to understand.

The updated Coastal Zone Management Plans will provide, amongst other things, a strategic policy framework for coordinated, integrated and ecologically sustainable development of sections of the coastline affected by the identified hazards, and the protection of fragile coastal environments into the future.

During the community engagement and management planning process the need for improved community understanding of Gosford's coastal and marine environments became clear. Many of the management issues raised during CZMP development will be addressed through strategic and specific education activities.

Residents living near coastal and marine environments need to understand the complexity of these systems and also develop their capacity to identify the importance of on ground rehabilitation projects and other aims associated with these key plans.

Executive Summary

Aim	The primary aim of the Gosford Lagoons Coastal Zone Management Plan (CZMP) is to improve environmental health of the four lagoons into the future
Purpose	The Coastal Zone Management Plan provides an Action Plan for undertaking works and other initiatives aimed at improving the overall health and condition of Wamberal, Terrigal, Avoca and Cockrone Lagoons To ensure consistency in planning, the overarching goals of the Gosford Coastal Lagoons Estuary Management Study and Plan are as follows: • To provide a strategic framework for the future management of Gosford's Coastal lagoons, now and into the future. • To improve community awareness and understanding of the lagoon systems through their involvement in the development and implementation of the Plan. • To be consistent with the NSW Estuaries Policy and the principles of Ecologically Sustainable Development. • To provide a framework for implementation such that all the objectives and desired goals set for the lagoons may be achieved.
Audience	The primary audience of the Coastal Zone Management Plan is Gosford City Council. Other stakeholders, including the general public, are also likely to take a keen interest in and contribute to future management of the lagoon.
Management Objectives-	• To improve water quality • To improve the condition of natural bushland and riparian vegetation • To improve water bird habitat • To protect threatened species • To protect aquatic and marine vegetation • To protect wetland fauna such as fish • To protect the educational value of Wamberal Lagoon • To protect the flood mitigation value of the entrance management policy • To protect the recreational swimming value (primary contact water quality) • To protect the tourism value • To protect indigenous cultural heritage • To protect the flood mitigation value of the entrance management policy

Context	This Coastal Zone Management Plan has been developed under the NSW Government's Estuary Management Program. It complies with the requirements of the NSW Estuary Policy 1992 and the NSW Coastal Policy 1997. It is consistent with the NSW Government's Guidelines for Preparation of Coastal Zone Management Plans (2013).
Relationship to other plans	The area covered by this CZMP is also subject to the requirements of the Local Environment Plan, Flood Management Plans and the Regional Biodiversity Strategy. Parallel to the implementation of this Plan, GCC will also be implementing CZMPs for Pearl Beach Lagoon and significant economies of scale may be achieved in implementing similar management actions across multiple localities. This Plan should be consulted during all future reviews of Environmental Planning Instruments and place-based Plans across the catchment area. The CZMP also covers areas subject to bushland reserves Plans of Management. The CZMP assists in meeting the guiding principles, aspirations and values identified in the Gosford 2025 Community strategic Plan. Due to interrelationship with flooding this CZMP will assist in informing implementation of Floodplain Risk Management Plans for each Lagoon.
Implementation responsibilities	For the majority of Management Actions, the responsibility for implementation rests with the relevant departments within Gosford City Council (GCC). In addition to GCC, the NSW Office of Environment and Heritage (Department of Premier & Cabinet), relevant catchment management bodies and the local community will continue to assist with the management and co-ordination of implementation of the Plan.
Program of works	Specific tasks have been identified to guide GCC and others with implementation. Implementation is recommended to commence immediately, with highest priority actions targeted first. It should be noted that implementation success is subject to funding availability and relies on project partnerships with government and community.
Costs and funding	There are a small number of Management Actions that will require significant new sources of funding. Many of the remaining Management Actions require in-kind involvement from existing staff and the community. Once certified, this Plan can be used as a lever for obtaining grant funding through the Federal and/or State Governments (e.g. Estuary Management Program).
Indicators for success	The ultimate success of the Gosford Coastal Lagoons CZMP will be gauged by how well the Objectives of the Plan have been met. Given that the Objectives are broad and measurable over a longer timescale, a series of Performance Measures have been incorporated into the Action Plan for each Management Action. Their purpose is to identify progress and short term successes in Plan implementation. These are also summarised in the Monitoring and Evaluation Chapter 5
Consultation	Consultation with the relevant Council departments, other stakeholders, and the community has underpinned the development of this Plan. The community will also have the opportunity to review the Plan during a public exhibition period.

Review and amendment provisions	This Plan has an indicative 10 year timeframe. Progress with implementation should be formally reviewed annually. Contingency measures should be activated if progress is slow. A complete review and amendment of the Plan should occur after 10 years, and should redress outstanding issues, new environmental management practices, new scientific data, and any emerging changed governance and administrative arrangements.

Table ES-1 Summary of High Priority Management Actions

Ref	Focus area	Action / Strategy	Timing	Capital Costs	Ongoing Costs
1	Research	Council continue to support research which improves understanding of lagoon catchments in order to develop improved management practices	Immediate / ongoing	Highly variable	Highly variable
2	Education, Compliance and Works	Encourage a reduction in catchment pollution through stormwater runoff	Immediate / ongoing	Within budget	Highly variable
3	Education	Work Staff Training Program	Within two years	Within Budget	Within Marine Coastal Education Program budget
4	Works	Incorporate climate change considerations into infrastructure asset management and planning processes	Within two years	Within budget	Within Budget
5	Environment	Continue to support volunteer based rehabilitation initiatives such as Bush Care	Immediate / ongoing	$5000/group/ year	$5000/group /year
6	Planning	Ensure new planning initiatives are consistent with this CZMP	Immediate / ongoing	Within Budget	Within Budget
7	Planning	Undertake a comprehensive review of the lagoon opening procedure and policy	Within 2 years	$54,000	-
8	Education	Develop and implement a comprehensive Coastal Lagoons Education Program	Immediate / ongoing	$40,000	$10,000
9	Compliance	Reduce Sewage contamination of lagoons	Immediate / ongoing	Within Budget	Within Budget
10	Planning	Ensure the present planning and development controls allow for sea level rise	Within 2 years	$30,000	Within Budget
11	Planning	Undertake Gosford Wetland Inventory and develop associated management strategy	Immediate / Ongoing	$30,000	Highly variable
12	Planning and works	Develop and Implement a holistic Foreshore Master Plan including consideration of access, water based recreation, commercial operators and enhancement of habitat values for Terrigal Lagoon (12a), Avoca Lagoon (12b) and Cockrone Lagoon (12c)	2-5 years	$10,000 / lagoon	Implementation costs depend on detail.
13	Environment	Investigate opportunities to remove contemporary sediments	2-5 years	$30,000	Highly Variable
14	Planning	Work with State Government to prepare an updated Plan of Management (POM) for Wamberal Lagoon Nature Reserve	2-5 years	Within Budget	Within Budget
15	Planning	Encourage inclusion of Stormwater Quality Improvement Devices (SQIDs) in private development activities	2-5 years	Integrated into development costs	
16	Planning and works	Identify sites where there is the potential for landward migration of lagoon vegetation and prioritise these for rehabilitation works	2-5 years	Planning within budget	$10,000 per year
17	Works	Undertake adequate and appropriate	Within 2	Within	Additional

Ref	Focus area	Action / Strategy	Timing	Capital Costs	Ongoing Costs
		maintenance of existing stormwater improvement devices to maintain their effectiveness, in particular GPTs.	years / ongoing	Budget	internal resources would increase efficiency - $50,000
18	Research	Investigate opportunities for harvesting macroalgae from Avoca Lagoon to assist in nutrient management	2-5 years	$25,000	
19	Environment	Minimise the potential for contaminated sites to leach into the lagoons	2-5 years	WITHIN BUDGET	
20	Environment	Investigate options to provide additional breeding habitats for Green and Golden Bell frogs adjacent to Avoca Lagoon	2-5 years	$10,000	-
21	Planning	Undertake a review of commercial (recreational) uses within the lagoon surrounds and determine appropriate intensities of these activities to avoid significant environmental and social impacts	2-5 years	$20,000	
22	Planning	Develop and implement monitoring and reporting programs for Gosford Coastal Lagoons	2-5 years	$20,000	

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1 Introduction

This document provides a suite of actions and related implementation details to be undertaken by Gosford City Council (GCC), other public authorities and the community to address priority management issues affecting Wamberal, Terrigal, Avoca and Cockrone Lagoons (the four lagoons) over the next 5-10 years.

As the CZMP will guide the investment of resources in the estuary, it needs to be based on the best possible information. To date, two key reports have been prepared and the information contained within them underpins this Coastal Zone Management Plan.

The first of these reports summarises and analyses the available scientific information and data related to the lagoons, the second reports on the strategic context, environmental and social values and external pressures impacting upon the lagoons. Full details of these two reports are given below

- Gosford Coastal Lagoons Estuary Processes Study (prepared by Cardno in 2010); and
- Coastal Zone Management Study For Gosford Lagoons (prepared by BMT WBM in 2012).

1.1 Why Develop a Coastal Zone Management Plan?

The coastal zone of NSW represents a priceless natural resource that is immensely valuable from an ecological, social and economic perspective. In addition to the open coast beaches and headlands, the NSW coastal zone contains over 130 estuaries that vary in size from small coastal creeks and lagoons to large lakes and rivers. Estuaries contain diverse ecosystems that form the foundation of the coastal food chain. They provide important habitats for a variety of marine and terrestrial plants and animals. These natural systems also provide important recreational and scenic centres for many coastal communities.

The four Gosford lagoons addressed in this plan from north to south are Wamberal, Terrigal, Avoca and Cockrone Lagoons. The lagoons are important components of the local landscape from a socio-economic perspective (like the iconic paddle boats in Terrigal Lagoon) as well as a natural perspective (including the various species of flora and fauna that depend upon them).

Under the *NSW Coastal Protection Act 1979*, a Coastal Zone Management Plan may be prepared to address risks to estuary health through management actions to maintain, improve or protect estuary values. Therefore, Gosford City Council (Council) with assistance from the NSW Office of Environment and Heritage (STATE GOVERNMENT) resolved to prepare the Gosford Coastal Lagoons Coastal Zone Management Plan (CZMP) to 'provide strategic direction and guidance on future actions within the lagoons and their catchments, to preserve, improve or maintain the community and environmental values of the lagoons'.

The CZMP shall be used to inform other strategic documents that aim to manage and rationalise human activities and development within the catchments. The CZMP will need to be considered when assessing new developments in accordance with Section 79C of the *Environmental Planning and Assessment Act, 1979*.

This CZMP aims to fulfil Council's requirement for applying the principles of Ecologically Sustainable Development (ESD) to the Gosford Coastal Lagoons and their catchments. This

CZMP will also provide an opportunity for future climate change to be considered in the strategic management and planning of the lagoons and surrounding sensitive coastal lands.

1.2 Area Covered by the Coastal Zone Management Plan

The planning process to which this study applies covers:

- Wamberal Lagoon;
- Terrigal Lagoon;
- Avoca Lagoon; and
- Cockrone Lagoon.

The lagoon catchments are also considered insofar as they influence environmental processes and estuary health. The four lagoons are illustrated in Figure 1-1. The Gosford Lagoons have an intermittent connection to the ocean (i.e. they are Intermittently Closed and Open Lakes or Lagoons [ICOLLs], refer Haines, 2008).

The Gosford coastal lagoons featured in this study have natural and acquired similarities and differences. Anthropogenic influences include the developed land within catchments, modification of foreshore areas, and artificial opening of lagoon entrances in order to mitigate flooding of low-lying foreshore areas when the entrances are closed to the ocean. These influences have placed different levels of 'pressure' upon the lagoons, with commensurate impact on their health and condition. ICOLLs naturally have a low tolerance to external pressures compared to other estuary types, so they need to be carefully managed and conserved in order to prevent significant environmental degradation.

1.2.1 Wamberal Lagoon

Wamberal Lagoon is the northernmost lagoon and is largely encompassed within the Wamberal Lagoon Nature Reserve. The extensive riparian vegetation around the lagoon provides a buffer from stormwater runoff and the two largest tributaries that enter the lagoon through Wamberal Park.

The trigger for artificial opening of the entrance (by Council) is when lagoon water levels reach 2.4 metres AHD. This trigger is typically reached three times a year with the entrance remaining open for an average of ten days at a time. The majority of the lagoon is shallow with a slightly deeper section close to the entrance (down to -1.5m AHD).

1.2.2 Terrigal Lagoon

Terrigal Lagoon is a popular recreation location for both locals and tourists, and as a result is subject to community pressure to provide healthy waters and adequate water depths, especially during the summer months.

The waterway area of the lagoon is relatively small and is shallow, with artificial entrance openings carried out primarily to mitigate flooding of residential properties. Historical dredging (with holes down to -3m AHD) occurred in the 1960's for the reclamation of foreshore areas for residential housing.

The trigger for artificial opening of the entrance (by Council) is when lagoon water levels reach 1.23 metres AHD. This trigger is typically reached 12 times a year with the entrance remaining open for an average of eight days at a time.

1.2.3 Avoca Lagoon

Avoca Lagoon is situated between the townships of North Avoca and Avoca. The lagoon has the largest variability in depths across all four Gosford lagoons. It also has the longest shoreline. Artificial entrance openings are triggered when water levels reach 2.09m AHD as a means to alleviate localised foreshore flooding. Openings occur on average 3 - 4 times per year.

Sand was dredged from Avoca Lagoon during the 1980's and continued until the commercial venture failed in the 1990's.

Considerable wetlands exist around the fringes of the lagoon and a large percentage of these are state recognised. The endangered Green and Golden Bell Frog inhabit Bareena wetland on the eastern edge of Avoca Lagoon. The wetland is artificial, formed in response to the laying of sewer pipes in the 1980s by a wall of earth and rock, which traps fresh water. The wall is semi permeable and saltwater also enters is response to lagoon entrance openings. Water levels within this wetland also respond rapidly to water level changes within the lagoon.

1.2.4 Cockrone Lagoon

Cockrone Lagoon is the smallest of the four lagoons, and the least impacted by urban development, with a catchment that is almost 70% forested. Cockrone Lagoon also has the highest of the artificial entrance opening trigger water levels, which is set at 2.53m AHD. Although the trigger level is quite high, the lagoon still experiences on average 2.4 openings per year.

The lowest bed elevation of Cockrone Lagoon is approximately -0.1 m AHD, which is means that this lagoon is relatively shallow at its normal water surface level, and likely promotes efficient wind driven mixing of waters within the lagoon. It is regarded though that the shallow nature of the lagoon also promotes algal growth due to effective light penetration through to the bed of the lagoon.

1.3 One Plan for Four Lagoons

There are a number of advantages to having a single Coastal Zone Management Plan that covers all four Gosford Coastal Lagoons, including:

- The similarities (values, threats) across the four lagoons require the same or similar management responses. That is, many of the management actions are applicable to all four lagoons, and indeed, are valuable actions to be implemented across the entire Gosford Local Government Area; and
- Application of actions across a broader area or the entire LGA scale provides greater efficiencies of scale, as well as being more attractive when seeking grant funding to implement works.

Aspects of the four lagoons (including values, threats etc.) that are different are specifically addressed by separate actions within this CZMP, ensuring the individuality of the lagoons is not

lost, but is being managed appropriately within a streamlined process that is easier for Council to manage.

1.4 Coastal Management Principles

The Guidelines for Preparing Coastal Zone Management Plans (DECCW, 2010) outline Minimum requirements for CZMPs. Each of these minimum requirements have been met through the development of this document.

One of the minimum requirements refers to principles that should be considered in evaluating potential coastal management actions and be reflected in draft CZMPs. As a quick reference guide, Table 1-1 outlines each of the relevant principles and how they have been addressed. Further details on the process undertaken in developing this CZMP can be found in the preceding Coastal Zone Management Study (BMT WBM, 2012).

Table 1-1 Consideration of Coastal Management Principles in the development of the Gosford Coastal Lagoons CZMP

	Coastal Management Principles	Addressed by Gosford Lagoons CZMP
Principle 1	Consider the objects of the *Coastal Protection Act 1979* and the goals, objectives and principles of the NSW Coastal Policy 1997	These have been considered throughout the document and in particular applied to the options assessment.
Principle 2	Optimise links between plans relating to the management of the coastal zone	By using a risk-based approach, existing controls within existing plans are reviewed and incorporated into the analysis of risk, and also used as starting point for developing risk treatments (i.e. management options).
Principle 3	Involve the community in decision-making and make coastal information publicly available.	Comprehensive community consultation has been undertaken throughout the development of this plan.
Principle 4	Base decisions on the best available information and reasonable practise; acknowledge the interrelationship between catchment, estuarine and coastal processes; adopt a continuous improvement management approach.	An investigation of the scientific aspects of the four lagoons was conducted. This was combined with community consultation and further investigations to identify the community values and human pressures upon the lagoons. The environmental and community values and threats to the lagoons are based upon these studies and information. The management intent has been based upon each estuaries values and the threat assessment has utilised this information. Both the degree of threat and values for the lagoons was used as the basis for preparing management actions.
Principle 5	The priority for public expenditure is public benefit; public expenditure should cost effectively achieve the best practical long-term outcomes	Cost benefit analysis for management options has recognised the public benefit as priority for management options

	Coastal Management Principles	Addressed by Gosford Lagoons CZMP
Principle 6	Adopt a risk management approach to managing risks to public safety and assets; adopt a risk management hierarchy involving avoiding risk where feasible and mitigation where risks cannot be reasonably avoided; adopt interim actions to manage high risks while long-term options are implemented	This plan has been prepared using the ISO 31000:2009 International Standard Risk Management Principles and Guidelines. The risk based approach is an internationally recognised framework for management because it incorporates the best available information and its uncertainty. The adopted Risk Management Framework intrinsically requires ongoing monitoring of risks and review and tailoring of risk treatments (management options).
Principle 7	Adopt an adaptive risk management approach if risks are expected to increase over time, or to accommodate uncertainty in risk predictions	The Risk Management approach is an internationally accepted standard that intrinsically incorporates both the known and possible frequency and consequence of a threat, thereby incorporating the uncertainty in the occurrence of risks / threats. The Coastal Zone Management Plan includes an ongoing monitoring and evaluation component, linked to an estuary health monitoring program.
Principle 8	Maintain the condition of high value coastal ecosystems; rehabilitate priority degraded coastal ecosystems	Ability of a management option to provide environmental protection or benefit has formed part of cost benefit analysis of options. Ecological values have been linked to future management intent to allow high value ecosystems to be prioritised for improvement while the objective for other areas is to maintain.
Principle 9	Maintain and improve safe public access to beaches and headlands consistent with the goals of the NSW Coastal Policy	The open coast and rocky headlands are not included in the study area. Public access to lagoon areas has been included.
Principle 10	Support recreational activities consistent with the goals of the NSW Coastal Policy	Recreational usage is an important component in determining the values of each lagoon. The management intent for each lagoon has considered the recreational values to a level that is appropriate with the community and environmental uses of the lagoon. This has facilitated the management of recreation activities in a manner that is consistent with the values of each lagoon in accordance with the NSW Coastal Policy.

Title:

Study Area for the four Gosford Coastal Lagoons

Figure: **1-1**

Rev: **A**

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0 0.75 1.5km

Approx. Scale

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Filepath : K:\N1997 Gosford Lagoons CZMS&P\MI\WOR\DRG_001_120503_ LocalityFig1-1.WOR

2 Consultation

The preparation of this document has necessarily involved extensive community and stakeholder consultation. This began in the early stages of the process with consultation undertaken during the preparation of the Gosford Coastal Lagoons Processes Study (Cardno, 2010) in the form of direct stakeholder correspondence, a public information session and periodic meetings with the committee

During the preparation of the Coastal Zone Management Study by BMT WBM, the following activities were undertaken:

- a series of four community workshops were held in June 2011 (one for each lagoon). The meetings were open invitation and were advertised through local newspapers and on local radio. Over the course of the two hour meetings, community representatives were asked to document values and threats for the relevant lagoon through a series of group activities. Management options that were suggested during this process were also documented for use in the preparation of the options for the CZMS;
- a one day workshop held on September 1st 2011 to analyse and evaluate the risks to lagoon health, with attendance from 23 representatives of Council, the CEMC and various state agencies. The workshop involved setting objectives for the CZMP and confirming the values identified for the lagoons. A threat assessment was then conducted (primarily for Avoca Lagoon as a case study), in which threats to the lagoons were confirmed by attendees, then analysed in terms of frequency and consequence, to prioritise the threats requiring management attention. Lastly, a group discussion was held to document the achievements of the previous Gosford Lagoons Management Plan and capture other existing controls;
- The values and management intent for all lagoons were discussed and assessed further at a second internal workshop attended by Gosford City Council and BMT WBM. This second workshop continued the methodology applied at the initial threat assessment workshop;
- Public exhibition of the Draft Management study from Dec 2012 to February 2013; and
- A series of three community meetings presenting the management options to the CEMC and community.
- Information was also made available online with 1206 site visits, 292 downloads of the Draft Study and 36 comments provided.
- A total of twenty (20) written submissions were received during the exhibition of the Draft Coastal Zone Management Study covering key issues including dog off leash access, lagoon opening procedure, community education, foreshore vegetation, commercial development activities, stormwater pollution/sedimentation access and sea level rise

2.1 Public Exhibition of this CZMP

Exhibition of the Draft Coastal Zone Management Plan (CZMP) for Gosford's Coastal Lagoons occurred 1 October – 14 November 2014. The Draft CZMP was made available for public review electronically on Councils webpage and via Councils 'Have Your Say' engagement platform.

The document was also made accessible in hard copy format at the Erina, Gosford, and Woy Woy Customer Service Centres during business hours (9.30am to 5pm) Monday to Friday during the exhibition period.

The Draft CZMP was presented at a public forum on Wednesday 5 November at the Terrigal SLSC to allow interested members of the community to learn more about the plan and to encourage comment. Approximately 33 people attended the event.

A total of 27 written submissions were received which referred to each lagoon with most submission received focussing on Wamberal Lagoon (see Figure 2-1).

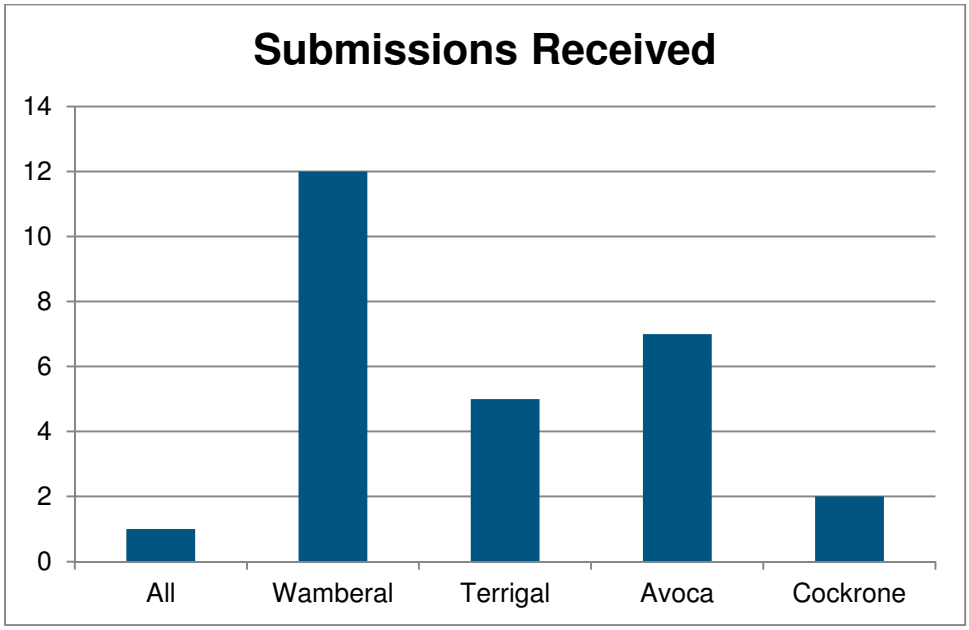


Figure 2-1 Number of Submissions Received Referring to Each Lagoon

Twelve key issues were raised in the submissions with sedimentation and development pressure being the most commonly raised refer to Figure 2-2.

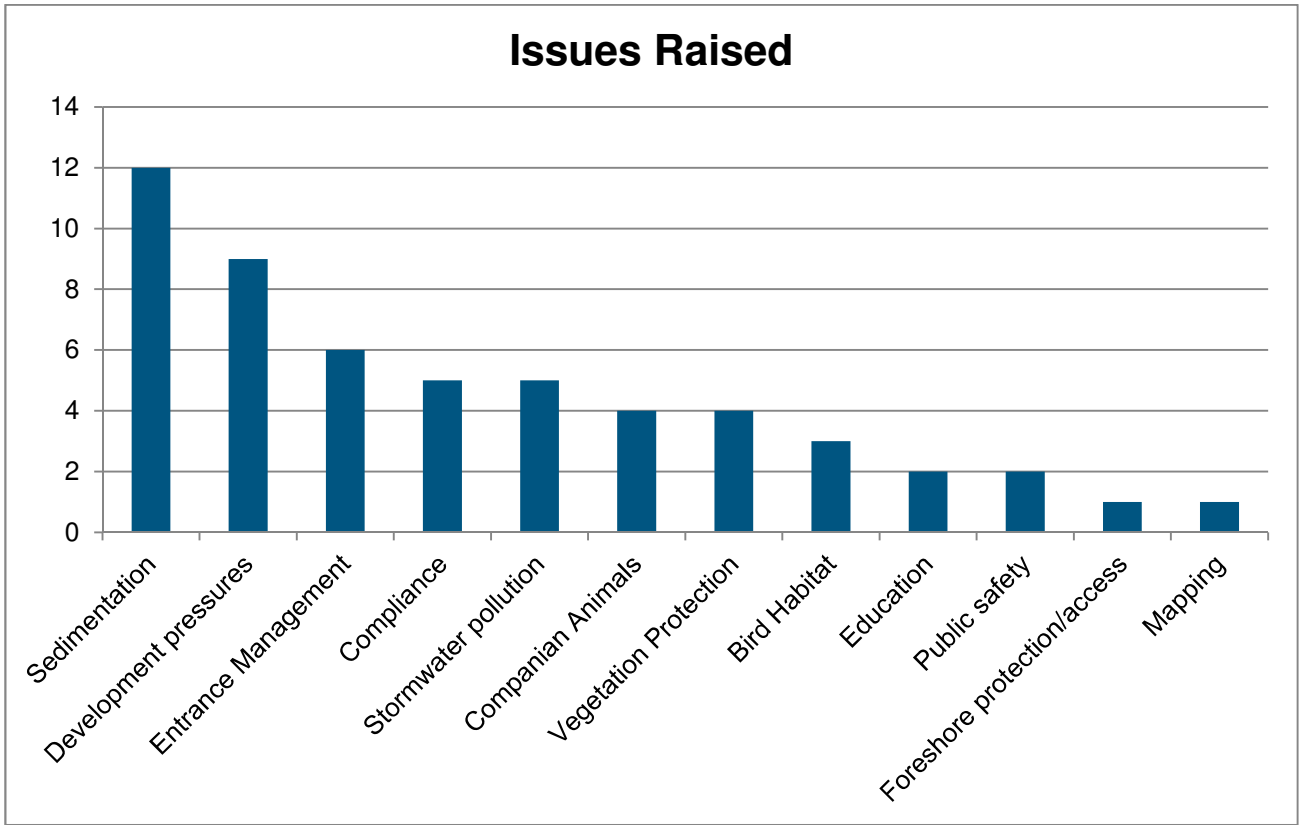


Figure 2-2 Issues Raised During the Exhibition Period

3 Objectives

To ensure consistency in planning, the overarching management goals of the Gosford Coastal Lagoons Estuary Management Study and Plan are as follows:

- To provide a strategic framework for the future management of Gosford's Coastal lagoons, now and into the future.
- To improve community awareness and understanding of the lagoon systems through their involvement in the development and implementation of the Plan.
- To be consistent with the NSW Estuaries Policy and the principles of Ecologically Sustainable Development.
- To provide a framework for implementation such that all the objectives and desired goals set for the lagoons may be achieved.

The objectives for the Coastal Zone Management Plan were developed in consultation with community and stakeholders. These Objectives are outlined below for each of the lagoons. For a description of how these were developed, please refer to the Coastal Zone Management Study (BMT WBM 2012).

- To improve water quality
- To improve the condition of natural bushland and riparian vegetation
- To improve water bird habitat
- To protect threatened species
- To protect aquatic and marine vegetation
- To protect wetland fauna such as fish
- To protect the educational value of Wamberal Lagoon
- To protect the flood mitigation value of the entrance management policy
- To protect the recreational swimming value (primary contact water quality)
- To protect the tourism value
- To protect indigenous cultural heritage
- To protect the flood mitigation value of the entrance management policy

4 Action Plan

The Coastal Zone Management Study identified large number of potential management options suitable for the Gosford Lagoons, as well as prioritising these options based on practicality and effectiveness. The 'Action Plan' for the Gosford Lagoons Coastal Zone Management Plan provides implementation details for the High Priority Actions only.

It is considered impractical to implement all options concurrently, and as such, only High Priority Actions are specified within the Action Plan. Notwithstanding, further details on the second pass options are provided in

Table 4-2, where relevant and available. The second pass options are those Options / Strategies that should be pursued once progressive and substantial completion of the High Priority has been achieved (potentially within about 5 years). It is expected that during the future reviews of this CZMP, these second pass options would be considered further (and revised or updated as necessary), and incorporated into amended versions of the Plan as appropriate.

As well as a description of the works involved, the implementation details for the High Priority Actions provided herein identify locations within the LGA, where relevant, for the various works. The details also cover any relevant linkages to existing initiatives, commencement timeframes, cost and resource requirements, and mechanisms for measuring the success of the option outcomes.

The Implementation Schedules also identify the 'focus area' of each action, indicating the department or section of the Councils that would nominally be given the responsibility for implementation. These focus areas are:

- Education
- Planning
- Works
- Compliance
- Research
- Monitoring

4.1 Consistency and Efficiency of Parallel Implementation with Other CZMPs

In addition to Wamberal, Terrigal, Avoca and Cockrone Lagoons, CZMPs will also be implemented for Pearl Beach Lagoon, Brisbane Water, the Lower Hawkesbury River and Gosford's Beaches. Benefit to each of these projects would be gained by economies of scale by drawing on similar actions and sharing the costs across the waterways. For example, individual lagoons as well as those CZMP areas identified above have similar recommendations regarding planning, compliance and education activities:

- Increased inspections and compliance of residential constructions;

- Development and implementation of updated Entrance Management Policies; and
- Updated Lagoon fact sheets.

Management issues relating to entrance management are also considered in flood and coastal processes planning activities and the various Plans aim to complement each other.

4.2 Potential Funding Sources

An important reason for preparing a Coastal Zone Management Plan is that it enhances the ability of Council to attract Government funding. By demonstrating that a considered and informed approach has been taken to designing actions, funding organisations can be confident that resources provided will be a good investment. This is particularly true for the NSW Government Estuary Management Grant Program, which is likely to be a key avenue for future funding. The Action Plan includes a range of grants and funding sources for each action. Some further information on potential grants is given in Table 4-1. This list of funding sources is not exhaustive and it will be important to track and identify emerging grants opportunistically during implementation.

Table 4-1 Examples of Potential Funding Sources

Grant Name / Further Information / key dates	Details
Estuary Management Grants Program Annual	The primary objective of the NSW Government's Estuary Management Program is to provide support to councils to improve the health of NSW estuaries and understand the potential risks from climate change.
The Gosford Protection of the Environment Trust	The Gosford Protection of the Environment Trust was set up by Gosford City Council to promote the protection and enhancement of the natural environment, in particular, the conservation of flora and fauna indigenous to the Local Government Area of Gosford City.
BiodiversityFUND Ongoing	The Biodiversity Fund will fund projects which best target the three themes: • biodiverse plantings • protecting and enhancing existing native vegetation • managing invasive species in a connected landscape
Caring for Our Country Ongoing	Target Area Grants will fund activities that will contribute to the achievement of the three strategic objectives of the Sustainable Environment stream of Caring for our Country: • maintenance of ecosystems services, including ecological and cultural values, now and into the future

Grant Name / Further Information / key dates	Details
	• protection of our conservation estate • enhanced capacity of Indigenous communities to conserve and protect natural resources
Community Action Grants	Community Action Grants are a small grants component of the Australian Government's Caring for Our Country initiative that aims to help local community groups take action to conserve and protect their natural environment. The grants are targeted towards established local community-based organisations that are successfully delivering projects to support sustainable farming and/or protect and enhance the natural environment. Each year, investment proposals are sought from environmental, Indigenous, Landcare, Coastcare and sustainable agriculture community groups for grants of between $5000 and $20 000 (GST exclusive) to take action to help protect and conserve Australia's natural resources and environment.
Habitat Action Grants	Habitat Action Grants are available to angling clubs, individuals, community groups, local councils and organisations interested in rehabilitating fish habitats in freshwater and saltwater areas throughout NSW. Habitat rehabilitation projects which may be funded include: • removal or modification of barriers to fish passage • rehabilitation of riparian lands (river banks, wetlands, mangrove forests, saltmarsh) • re-snagging waterways with timber structure • removal of exotic vegetation from waterways • bank stabilisation works • re-instatement of natural flow regimes program should be included.
Environmental restoration and rehabilitation Ongoing	The aim of the Restoration and Rehabilitation (R&R) program is to facilitate projects to prevent or reduce pollution, the waste stream or environmental degradation of any kind, run by community organisations and State and Local government organisations. Through these projects, we also aim to improve the capacity of communities and organisations to protect, restore and enhance the environment.
Ian Potter	The Ian Potter Foundation is a private Australian philanthropic foundation

Grant Name / Further Information / key dates	Details
Foundation always open	which makes grants for charitable purposes in Australia in areas including the environment
Coles Junior Landcare Grants Program Ongoing	Through the Junior Landcare Grants Program, any school or organisation that would like to involve their students in landcare projects, in conjunction with local landcare groups, can apply for grants to assist them with the cost of their projects
Open Gardens Australia Ongoing	Open Gardens Australia is a self-funding, not for profit organisation that promotes the knowledge and pleasure of gardens and gardening to all Australians. A demonstration site showing appropriate species and management approach (e.g. mowing) could be set up on private land beside a Lagoon. This could be used to educate other land owners and visitors about the lagoon, its significance and appropriate practices.

4.3 Implementation Tables for the High Priority Actions

1	Continue to support research	Relevant Lagoon/s	All
		Priority	Immediate / ongoing

Detailed description

Continue to contribute to research where it has the potential to increase the understanding of ICOLL function including entrance processes, ecology and nutrient dynamics. Projects funded should focus primarily on establishing cause and effect. Information obtained through this research will contribute to adaptive management. The challenge in using the adaptive management approach lies in finding the correct balance between gaining knowledge to improve management in the future and achieving the best short-term outcome based on current knowledge.

Research should be aimed at understanding the biological, chemical and physical functioning of the lagoons to aid estuary management toward the improvement of estuary health and meeting the objectives of this CZMP.

Council should encourage University Researchers to undertake studies on the ecology of lagoon fauna and to describe potential impacts caused by development in order to develop improved management practices for the fauna associated with the coastal lagoons. Priorities for research should be studies that will directly inform management of high priority values and threats.

Focus area	Research	**Values maintained / improved or protected**	Potential to contribute to all values depending on projects selected
Responsibility	GCC		
Supporting groups	Universities		
Links to other options	All	**Links to existing works**	Newcastle University research into macro algal blooms in Avoca Lagoon

Capital Costs	Ongoing Costs	Monitoring and performance indicators
$15,000 first year	$10,000 per year	Research outputs directly informing management

2	Encourage a reduction in catchment pollution through stormwater runoff	Relevant Lagoon/s	All
		Priority	Immediate / ongoing

Detailed description

Along with entrance condition, activities occurring within the catchments are a key driver of water quality within the lagoons. In particular stormwater inputs deliver the most significant pollutant loads to the lagoons.

This action will involve development of catchment based WSUD strategies for each of the lagoons.

The first steps in implementing this action will be:

- An audit of creek lines, stormwater easements and treatment devices within all lagoon catchments to determine maintenance and works requirements.
- Identify and map catchment pollutant sources;
- List opportunities for source based pollution reduction strategies;
- Liaise directly with landholders and operators to implement these;
- Council to enforce through compliance activities.

Specific locations that should be focussed on for each lagoon are:

Wamberal

- address bank scouring, sedimentation and stormwater pollution in Forrester's Creek
- address bank scouring, sedimentation and stormwater pollution From stormwater outlet/ creekline between Blue Bell Dr and Tall Timbers Rd
- consider dredging to remove sediment delta and re-establish channels to Forrester's Creek
- Focus treatment, community education and compliance on:
  - Design and construct appropriate sediment control measures in Forresters Creek catchment in line with WSUD principles
  - Forrester's Creek sub-catchment
  - residential areas between Pitt Road and Tall Timbers Road; and
  - Agricultural/semi rural land holders in the upper catchments.

Terrigal

2	Encourage a reduction in catchment pollution through stormwater runoff	Relevant Lagoon/s	All
		Priority	Immediate / ongoing

- Focus treatment, community education and compliance on the:
  - tributaries flowing to the north of Terrigal Lagoon (inc. north of the Central Coast Hwy);
  - Residential areas adjacent to Duffys and Hastings Roads

Avoca

- Focus treatment, community education and compliance on the:
  - catchments flowing to the north of Avoca Lagoon in the vicinity of Lake Shore Drive;
  - catchments flowing to the south of Avoca Lagoon in the vicinity of The Round Drive
  - catchments flowing to the west of Avoca Lagoon (including Saltwater Creek)
  - Potential pollutant inputs of extractive and other industries

Cockrone

- Focus treatment, community education and compliance on the:
  - Lakeside Drive Wetland
  - Catchment flowing to Casa Place stormwater outlet

Where appropriate, vegetated buffer zones should be created to reduce stormwater runoff through infiltration and therefore reduce pollutant. Appropriately selected species will also increase habitat value and protect banks.

Groundwater quality also needs to be protected and consideration should be given to preventing pollution of groundwater by the leaching of nutrients from within the lagoon catchments.

Sediment supply through stormwater runoff should be reduced through planning controls, compliance monitoring and the implementation of Water Sensitive Urban Design (WSUD) features.

Focus area	Education Compliance and works	Values maintained / improved or protected	Water Quality Aquatic / Marine Vegetation Primary Contact – Recreation Secondary Contact – Recreation
Responsibility	GCC		
Supporting groups	Catchment Management Body, Local Land Services		

2	**Encourage a reduction in catchment pollution through stormwater runoff**	**Relevant Lagoon/s**	All
		Priority	Immediate / ongoing

Links to other options	Works Staff Training Program (3)	**Links to existing works**	Councils erosion and sediment control Operational Procedure and development audit process

Capital Costs	**Ongoing Costs**	**Monitoring and performance indicators**
Implement through existing compliance and environmental education activities. However additional resources may be required (as identified in planning processes for Brisbane Water, and Pearl Beach Lagoon).	The costs for implementation of treatment measure are variable for both capital and ongoing maintenance. Maintenance of existing devices needs to be reviewed to encourage the best ecological outcome.	• Sources Identified • Landholders identified and approached • Sediment hotspots identified • Improvement in practices at 3 month or 6 month follow up. • include water quality improvements detected via monitoring and reporting

3	Works staff training program	Relevant Lagoon/s	All
		Priority	Within two years

Detailed description

Undertake an intensive engagement program for Council works to raise the profile of best practice erosion and sediment control, vegetation management and assist staff with new policies and procedures. The program will aim to:

- Establish current levels of knowledge for Council and contractor staff undertaking infrastructure works within the catchment
- Identify the areas where awareness can be improved
- Follow up with regular (possibly annual) audits and knowledge assessments to monitor success and to ascertain when further training and awareness may be required.

Focus area	Education	**Values maintained / improved or protected**	Water Quality Aquatic / Marine Vegetation Primary Contact – Recreation Secondary Contact – Recreation
Responsibility	GCC		
Supporting groups	GCC contractors		
Links to other actions	1, 2, 4, 5, 6, 7,8,9,10, 16,17, 20, 22	**Links to existing works**	This strategy is also being considered LGA wide to support Council Erosion and Sediment Control Policy

Capital Costs	Ongoing Costs	Monitoring and performance indicators
This can be achieved through existing resources as part of the development of the marine and coastal education program and internal IMS system.	Will be dependent on recurrent funding for the Marine and Coastal Education Program	• Reduction in the number of pollution incidents resulting from Council/contractor works • Audit work sites before

3	Works staff training program	Relevant Lagoon/s	All
		Priority	Within two years
		and after training administered	

4	Incorporate climate change considerations into infrastructure asset management and planning processes	Relevant Lagoon/s	All
		Priority	Within two years

Detailed description

Climate change is one of many aspects that need to be considered when planning how assets will be managed into the future. Where assets are being replaced, this strategy encourages asset planners to ensure design considers climate change projections in line with Councils endorsed (and particularly sea level rise). Sea level rise may also be the trigger for asset replacement in some instances.

Identify and document the risk, for all assets around the lagoons in Council's Asset Management Plan. Account for such coastal risks when prioritising asset maintenance and replacement Note that a rigorous assessment of sea level rise implications for the lagoons was not undertaken in the Estuary Processes Study.

This action will need to be implemented through an integrated climate adaptation approach that aligns with parallel planning processes (including the Gosford Beaches CZMP and Brisbane Water Flood Planning).

Focus area	Works	Values maintained / improved or protected	Flood mitigation / entrance management Aesthetic Beauty
Responsibility	GCC		
Supporting groups	Water Authority		
Links to other options	1, 3, 6, 7, 8, 9, 10, 11, 13, 14, 16, 20, 22	Links to existing works	Flood Management Program
Capital Costs		Ongoing Costs	Monitoring and

4	Incorporate climate change considerations into infrastructure asset management and planning processes	Relevant Lagoon/s	All
		Priority	Within two years

		performance indicators
Within existing budgets. .	Consideration of climate projections will assist in minimising costs in the long term should projections become apparent.	Sea level rise incorporated into infrastructure management and planning systems Constructed infrastructure compatible with projected sea level rise.

5	Continue to support volunteer based rehabilitation initiatives such as Bush Care	Relevant Lagoon/s	All
		Priority	Immediate / ongoing

Detailed description

Bush Care is an environmental volunteering program undertaking bush regeneration activities on Council managed land. Gosford City Council Bush Care assists community volunteers to undertake bush regeneration by providing them with training, tools, supervision and technical advice. This action would involve continuing to support the provision of these. It is also important that the work undertaken through this program is consistent with the intent of the CZMP. For example, volunteers should be aware of the possibility of uncovering Aboriginal items and have an understanding of what to do in this circumstance. Priority should be given to rehabilitation of vulnerable estuarine communities, particularly where migration in response to sea level rise is a possibility.

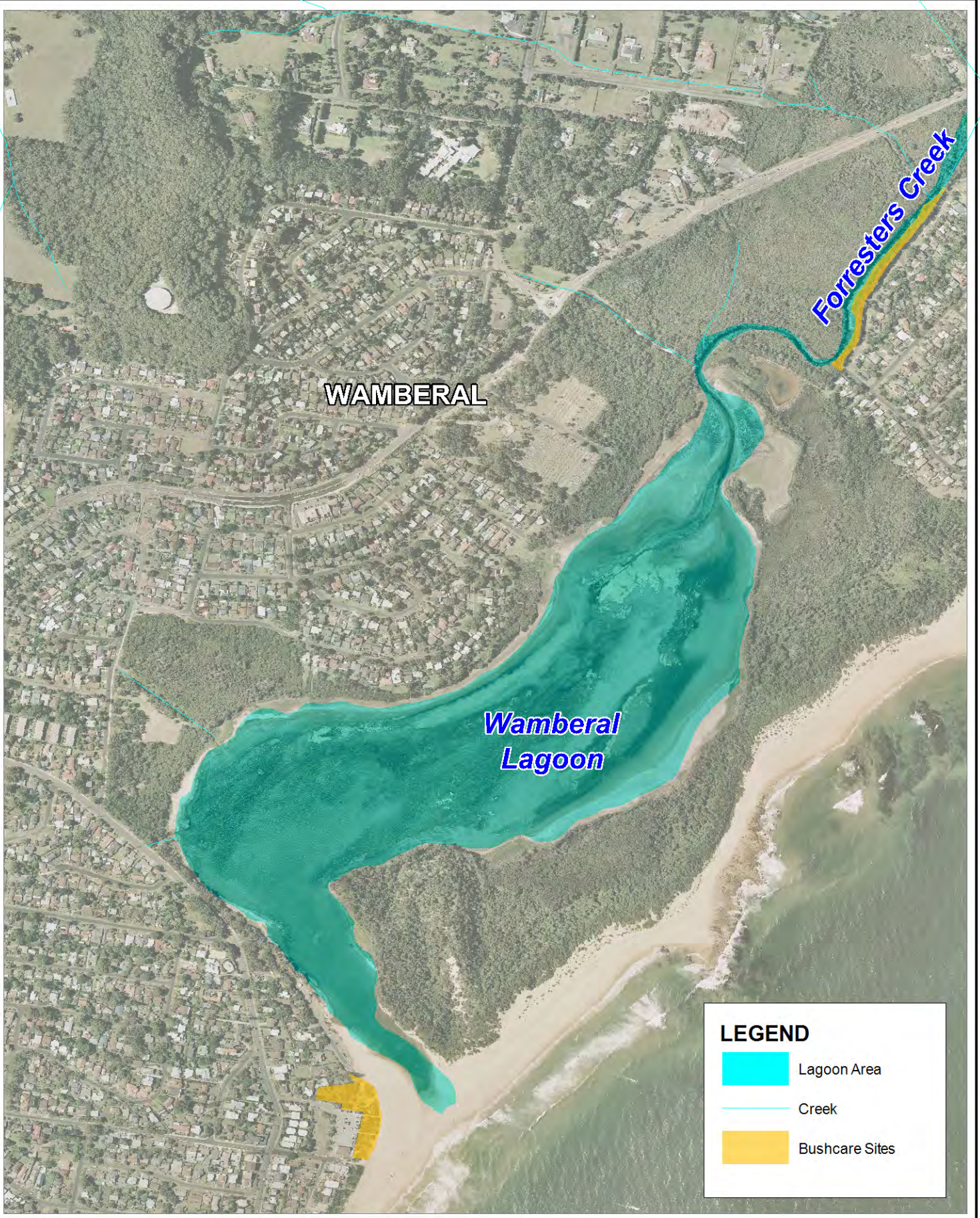
At present, the Council Bush Care program includes a series of educational seminars and workshops, and an end of year barbeque to thank all the volunteers for their contributions. Bush Care makes an important contribution to rehabilitation of bushland in and around the lagoons and their catchment. This has many benefits for the lagoons through improving the water quality of runoff entering the lagoons, improving aesthetics and providing habitat.

Existing Bush care sites are shown on Figure 4-1, Figure 4-2, Figure 4-3 and Figure 4-4.

Focus area	Environment	Values	Natural Bushland/ Riparian

5	**Continue to support volunteer based rehabilitation initiatives such as Bush Care**	**Relevant Lagoon/s**	All
		Priority	Immediate / ongoing
Responsibility	GCC	**maintained / improved or protected**	Vegetation, Presence of threatened species, Wetland Fauna, Aesthetic Beauty, Water Quality, Tourism
Supporting groups	Dependent upon volunteer contributions		
Links to other options	1, 2, 3, 4, 6, 7, 8, 11, 12, 13, 14, 16, 20, 22	**Links to existing works**	

Capital Costs	Ongoing Costs	Monitoring and performance indicators
Within existing budgets		Improved riparian vegetation distribution and condition



Title:

Wamberal Lagoon - Bushcare Sites

Figure: 4-1

Rev: A

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Approx. Scale

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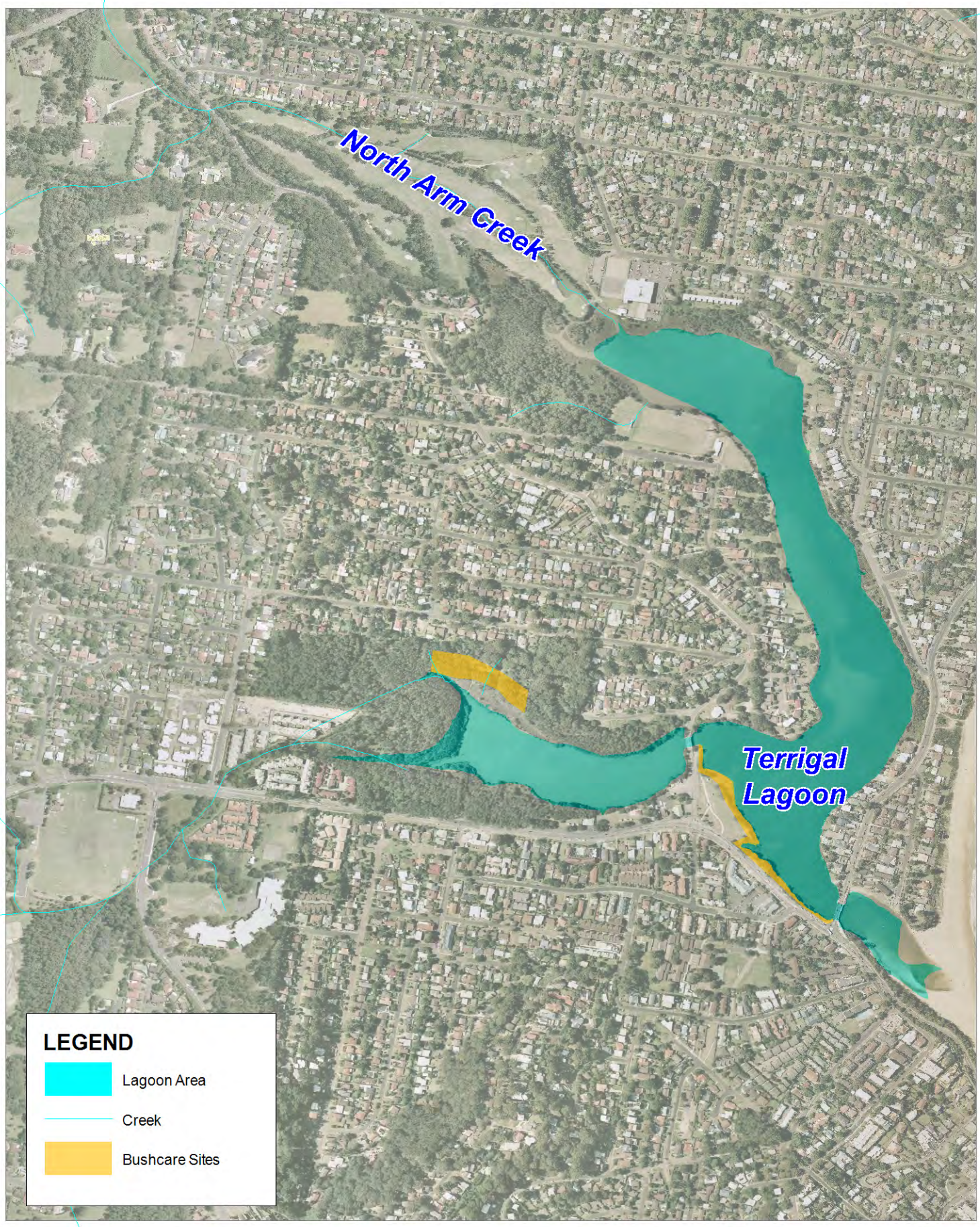

Title:

Terrigal Lagoon - Bushcare Sites

Figure: **4-2**

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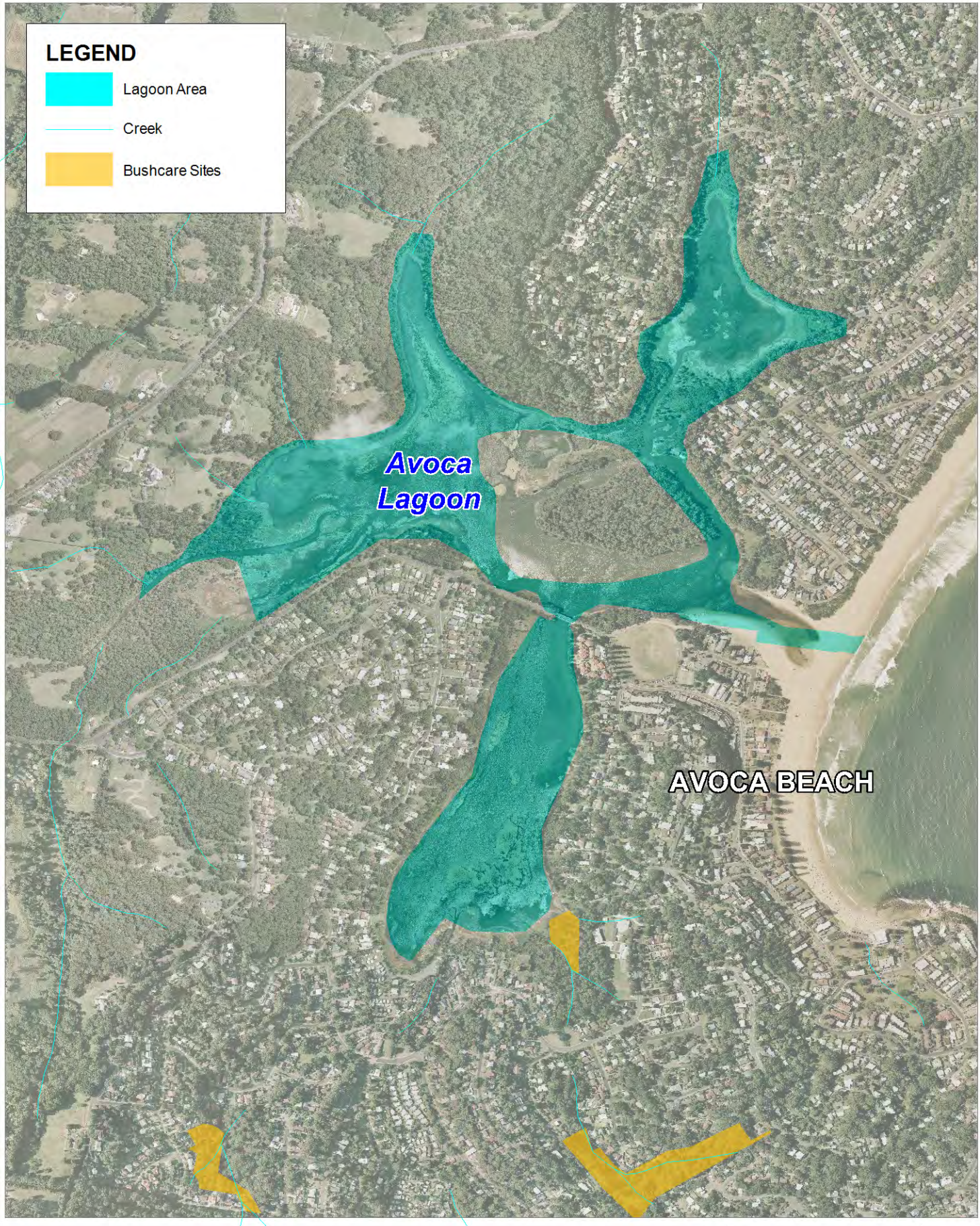

Title:

Avoca Lagoon - Bushcare Sites

Figure: 4-3

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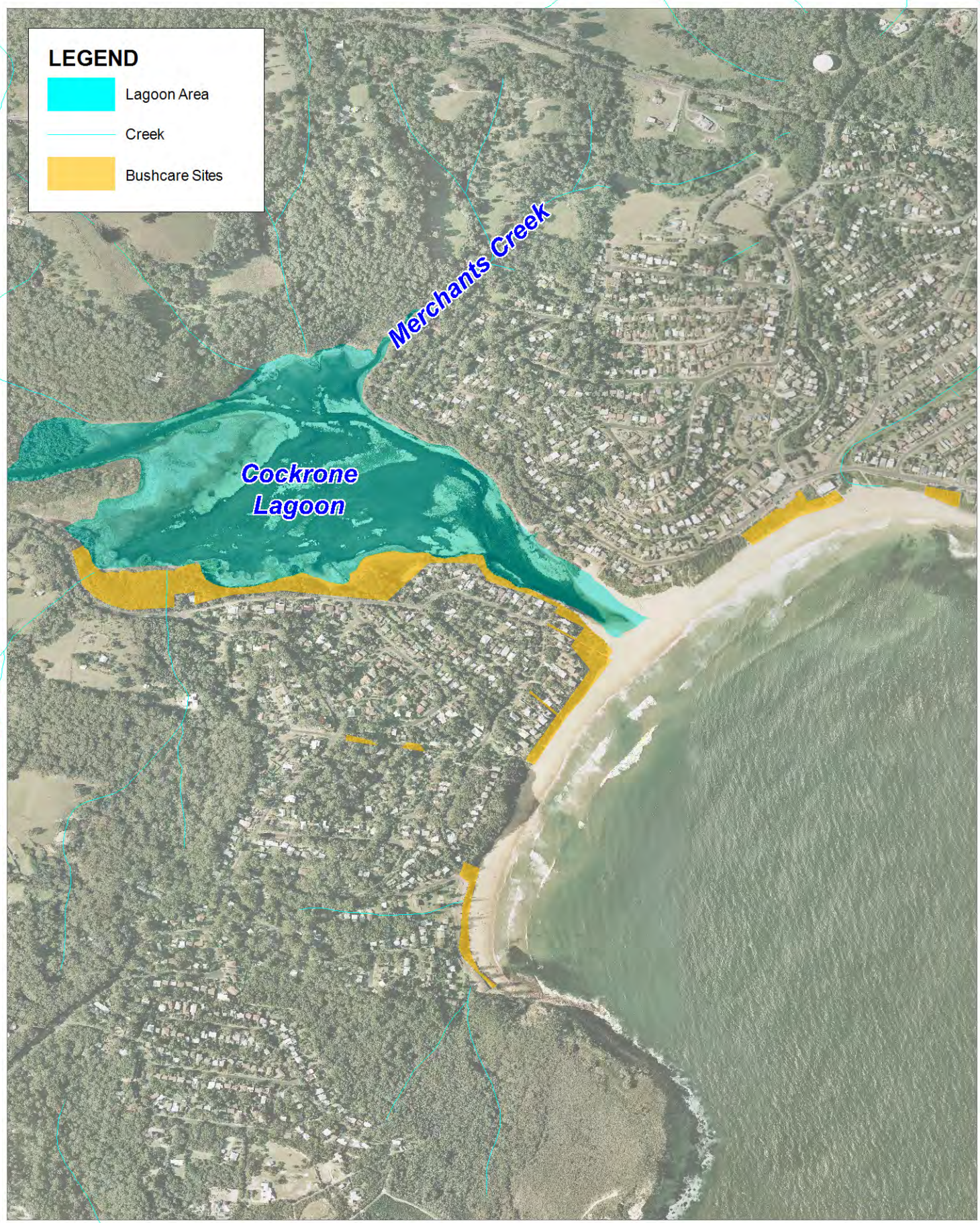

Title:

Cockrone Lagoon - Bushcare Sites

Figure: **4-4**

Rev: **A**

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6	Ensure new planning initiatives are consistent with this CZMP	Relevant Lagoons	All
		Priority	Immediate/ ongoing

Detailed description

Ensure consistency with the objectives of this CZMP when undertaking reviews of strategic planning initiatives. CZMP objectives should be considered when revising LEPs, DCPs, Plans of Management, Master planning and during the early stages of planning new infrastructure and asset management planning (e.g. designing new road networks, sewer networks etc.). These objectives should also advise Council Policy review to ensure every opportunity to achieve good management outcomes and to set a clear direction for future adaptation for the lagoons is taken.

Focus area	Planning	**Values maintained / improved or protected**	Potential to contribute to all of the values
Responsibility	GCC		
Supporting groups	Department of Planning		
Links to other options	All	**Links to existing works**	

Capital Costs	Ongoing Costs	Monitoring and performance indicators
Within existing budgets	Within existing budgets	Plans consistent with CZMP

7	**Undertake a comprehensive review of the lagoon opening procedure and policy**	**Relevant Lagoon/s**	All
		Priority	Within two years

Detailed description

One of the key human influences on lagoon processes is the timing of lagoon openings, with the entrance berm actively managed for flood mitigation purposes. Artificial management of lagoon entrances has had a significant impact on lagoon hydraulics, with flow on effects for water quality, sediment transport and ecological processes. The let out (or breakout) levels in the entrance management policy are determined primarily by the desire to prevent inundation of surrounding property.

While the entrance management policy identifies other issues of concern (e.g. odours after breakout, water quality and the exposure of habitat for the Green and Golden Bell Frogs at Avoca) in relation to lagoon water levels, the implementation of the policy focuses on Council's obligations to mitigate risk to life and property from flooding.

In moving forward it is recommended that the desired environmental values be articulated and options for adjusting the entrance management practices towards facilitating the desired ecological values while meeting the flood mitigation imperatives be assessed.

The interaction of beach berm height, flooding of properties and the potential of the lagoon to develop from marine, oscillating to mature brackish ecology is a critical consideration. The need to understand this interaction is important to appreciate the following strategies.

Some of the aspects that might be considered include:

- Location of the opening channel, in particular considering dune vegetation, access and coastal processes;
- Variable opening levels to stimulate ecology through mimicking (within limits) natural variability;
- Minimising the length of time the lagoons are drained by carefully selecting the tidal cycle and rainfall event to ensure the lagoon's berm quickly closes and thus minimising the loss of wet areas fringing the lagoons and the time required for them to reinstate previous water levels.
- Changes to the requirement for berm height maintenance at some lagoons;
- Upgrade of vulnerable assets and implementation of flood mitigation measures to help raise opening triggers;
- Consideration of beach user safety following mechanical opening;
- Maintaining pedestrian access at lagoon entrances (particularly Avoca and Terrigal);

7	Undertake a comprehensive review of the lagoon opening procedure and policy	Relevant Lagoon/s	All
		Priority	Within two years

- Assessing the existing and future impacts of flooding through review of the Floodplain Risk Management Study and Plans for individual lagoons;
- Regularly check the berm level and when necessary create an overflow path on the lagoon's beach berm;
- Machinery will be used to create passive overtopping control. Where practical machinery will assist in active opening;
- Active management of the beach berm level will occur on all four coastal lagoons;
- Council investigate the practicability and desirability of mechanically assisting the closure of the lagoon where the lagoon has been open for more than one week; and
- Lagoon breakout policies need to reflect integrated management of flooding, water quality and the lagoon ecology and should preferably attempt to ensure adequate tidal flushing to occur during lagoon breakout procedures before lagoon closure to enable movement of fish and marine estuarine fauna.

The review of Lagoon opening Policies and procedures should be extended to cover Pearl Beach Lagoon.

Focus area	Planning	Values maintained / improved or protected	Potential to impact on each of the values
Responsibility	GCC		
Supporting groups	State Government		
Links to other options	1, 2, 3, 4, 6, 8, 9, 10, 12, 14, 16, 18, 20, 21, 22, 23	Links to existing works	Lagoons Entrance Management Policy and Procedure

Capital Costs	Ongoing Costs	Monitoring and performance indicators
Allow $40,000	Within existing budgets	Entrance management plan Completion of entrance management review

7	**Undertake a comprehensive review of the lagoon opening procedure and policy**	**Relevant Lagoon/s**	All
		Priority	Within two years
		Community acceptance and fewer complaints Ecological improvement	

8	Develop and implement a comprehensive Coastal Lagoons Education program	Relevant Lagoon/s	All
		Priority	Immediate / Ongoing

Detailed description

In further establishing Councils coastal and marine education program a range of educational materials which assist in enhancing understanding and appreciation of the Lagoons and their catchments should be developed. Education should focus upon identified values including information on habitat values, the importance of the lagoons in the local landscape and ways residents can contribute to their protection and management.

Information must also assist to manage threats such as current mowing extents, appropriate species selection for gardening, mindful domestic pet ownership and promoting provision of woody debris and other suitable materials which provide habitat. Particular emphasis should be given to providing information to private landholders directly adjacent to the lagoons.

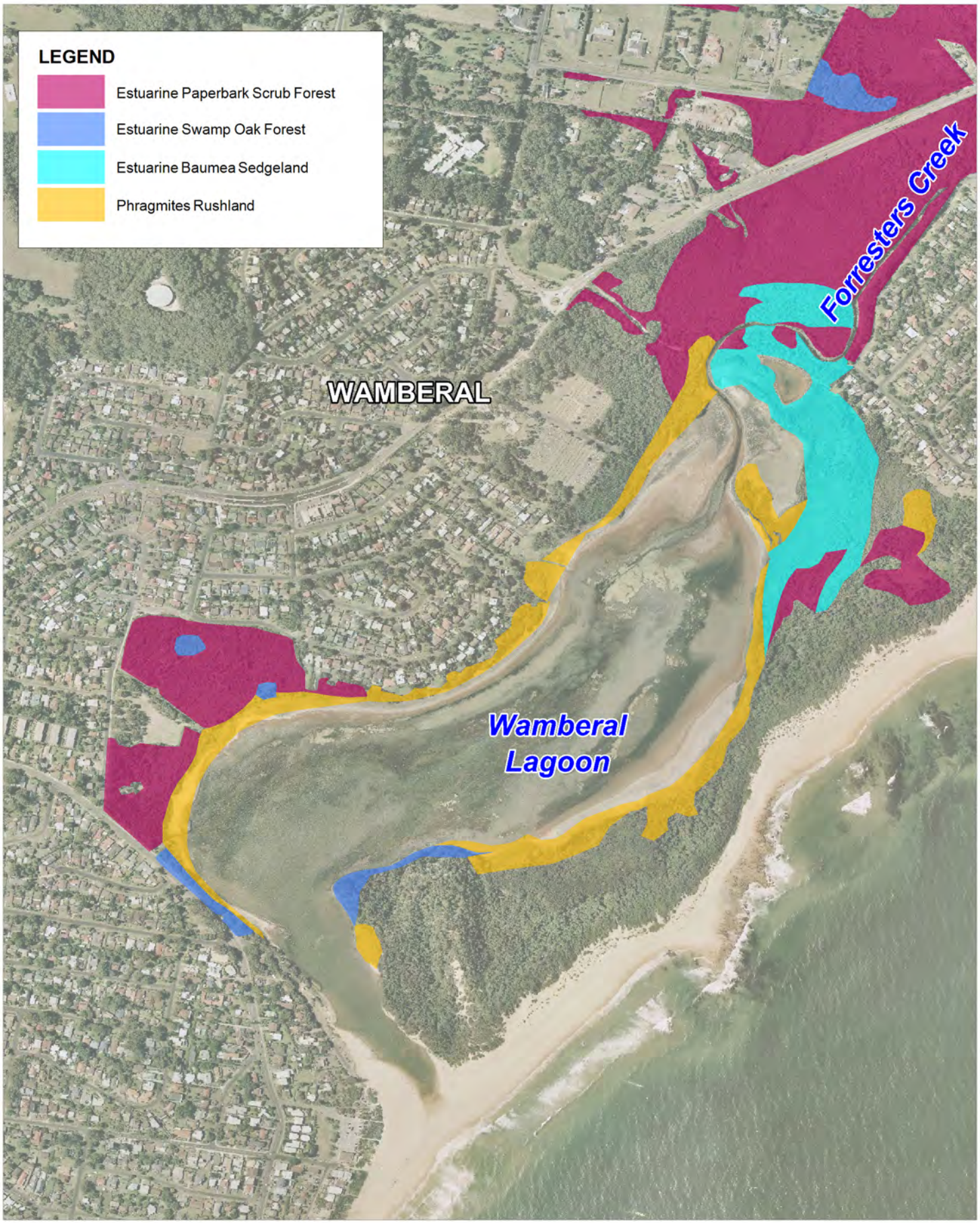
- Educational resources may include factsheets, web information, smartphone applications, improved interpretive signage and information sessions. Community awareness and education will include:
- Council initiated active education program in all schools within the respective catchments.
- Council prepare and issue a series of information pamphlets on desirable practices within the catchment.
- Council erect information signs within the catchments on undertaking desirable practices within the catchments. On all information signs Council include a contact point within Council where further information can be obtained.
- Council assist in the formation and operation of lagoon care groups for each lagoon.
- Council liaise with the NSW Government to obtain funding assistance to implement public awareness campaigns aimed at nutrient reduction, management of riparian and wetland vegetation and nutrient control structure design.
- Provide targeted information to private landholders that have key habitat and vegetation communities on their properties - letting them know specifically what is on their property, describing its conservation significance and describing actions that should or should not be taken. Available Key Habitat Mapping is shown in Figure 4-5, Figure 4-6, Figure 4-7 and Figure 4-8. The Wetland Management Strategy could update this mapping and increase the accuracy.

Focus area	Education	Values	Potential to impact on all values

8	**Develop and implement a comprehensive Coastal Lagoons Education program**	**Relevant Lagoon/s**	All
		Priority	Immediate / Ongoing

Responsibility	GCC	**maintained / improved or protected**	
Supporting groups	Bush Care, Local Land Services		
Links to other options	All	**Links to existing works**	Develop factsheet and educational material as part of large coast and estuary education program under development

Capital Costs	Ongoing Costs	Monitoring and performance indicators
$40,000	$10,000 per year	Changes in behaviour, e.g. portion of mowed areas around the lagoons edge Proportion of appropriate native species utilised in new plantings



Title:

Wamberal Lagoon - Key Habitat Communities

Figure: **4-6**

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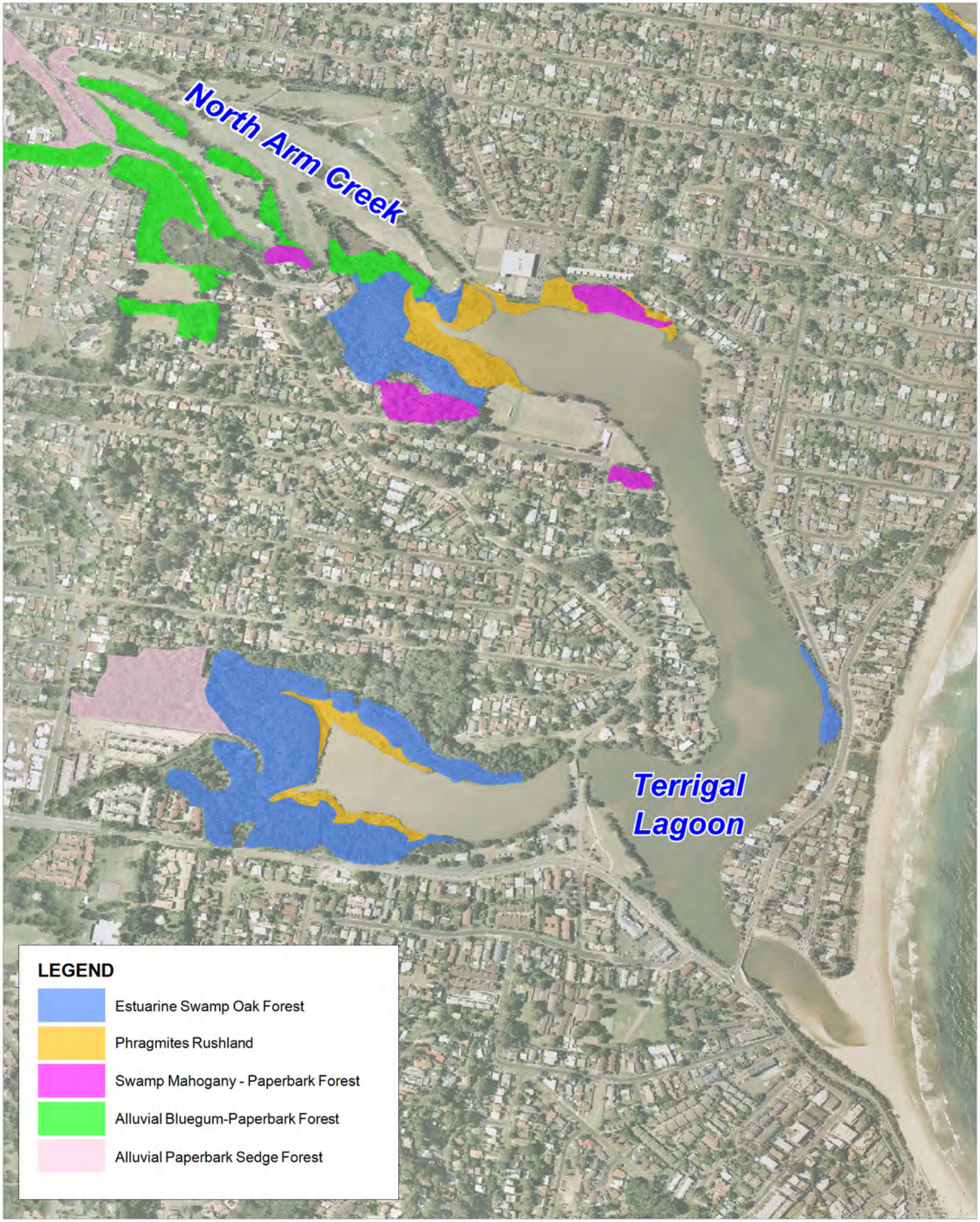

Title:

Terrigal Lagoon - Key Habitat Communities

Figure: 4-7

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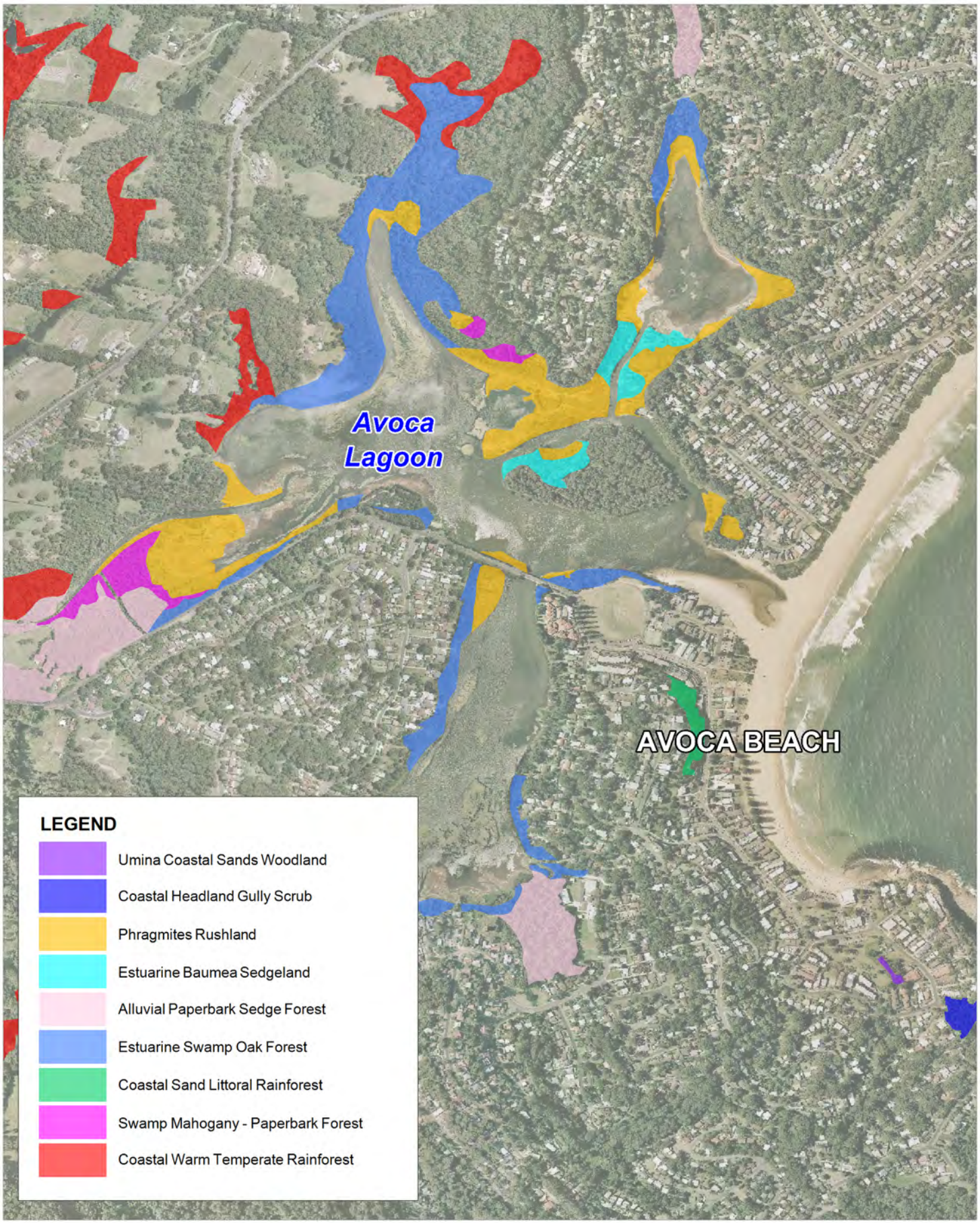

Title:

Avoca Lagoon - Key Habitat Communities

Figure: 4-8

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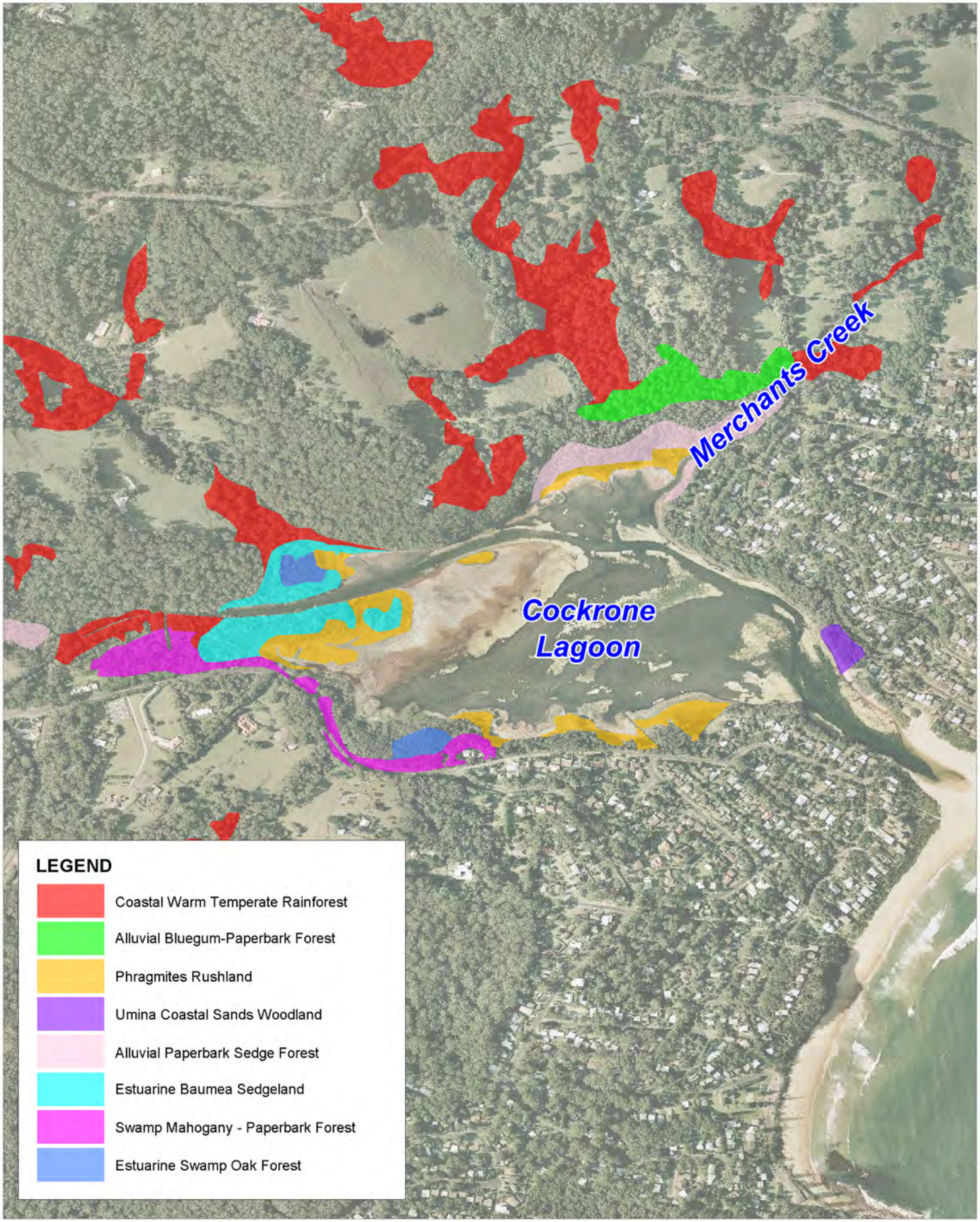

Title:

Cockrone Lagoon - Key Habitat Communities

Figure: **4-9**

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9	Reduce Sewage contamination of lagoons	Relevant Lagoon/s	All
		Priority	Immediate / ongoing

Detailed description

A number of recreational swimming locations across the coastal lagoons are tested for a range of parameters, including faecal contamination, through Councils water quality monitoring program.

Results for the coastal lagoons, particularly Terrigal, have exhibited 'poor" and 'very poor' microbial water quality results. This highlights that the lagoons are highly susceptible to faecal pollution and microbial water quality may often be unsuitable for swimming.

Potential sources of faecal contamination in the catchment area include, but are not limited to, sewage overflows and associated stormwater pollution, infiltration from on-site sewage management (OSSM) systems, wildlife, domestic animals and livestock. This option should draw on research undertaken locally (in Wyong LGA) and other areas regarding sources of faecal contamination.

It is therefore important that Council work to reduce potential sewage contamination of the lagoons, by identifying sources and implementing management response through works, compliance and education activities.

Recommended responses include:

- Implement an ongoing and improved inspection program for OSSM systems in order to reduce or eliminate potential wet weather discharges into the lagoon;
- Implement an ongoing and improved inspection program for the reticulated sewerage system to assist in identifying pollution sources and improve local water quality within the catchment;
- Implement an ongoing and improved maintenance/upgrade of the reticulated sewerage system aimed at reducing or eliminating instances of potential wet weather discharges;
- Continue Councils routine water quality monitoring program including regular reporting of water quality to the community;
- Investigate additional water quality monitoring options such as microbial source tracking to better determine sources of faecal contamination in the catchment (i.e. human, animal or bird;
- Ensure appropriate swimming advisory signage is provided across key locations on lagoon foreshores; and
- Improve riparian vegetation around the lagoons and their tributaries.

9	Reduce Sewage contamination of lagoons	Relevant Lagoon/s	All
		Priority	Immediate / ongoing

Gosford City Council is listed as a Water Supply Authority in the Water Management Act 2000 and is responsible for the transport, treatment and disposal of sewage. In order to accurately identify sewage contamination events and to reduce impacts to the environment, it is essential that suspected pollution is reported immediately.

The community is encouraged to report observed issues with public and private sewers impacting on water quality to Council using the number (02) 4325 8222 (24-hours a day, 7-days a week).

Focus area	Compliance	**Values maintained / improved or protected**	Water Quality (and to some extent, each of the values)
Responsibility	GCC		
Supporting groups			
Links to other options	1, 2, 3,4 6, 7, 8, 13, 18, 20, 21, 22	**Links to existing works**	Upgrade of the Coastal Carrier System (CCS)

Capital Costs	Ongoing Costs	Monitoring and performance indicators
Resources provided by Council	Within Budget	Events identified and corrective action taken

10	**Ensure that present planning and development controls allow for sea level rise**	**Relevant Lagoon/s**	All
		Priority	Within 2 years

Detailed description

Accommodation of sea level rise will become increasingly important for lagoon management. A good no regrets strategy is to ensure that present planning and development controls allow for sea level rise and if possible a gradual increase in lagoon opening levels by progressively increasing minimum floor heights together with raising ground levels and infrastructure and implementing other appropriate flood management actions.

As a comprehensive assessment of sea level rise implications for the lagoon has not been undertaken, floor heights should be informed by the flood planning process.

Houses, land and infrastructure surrounding Terrigal Lagoon will be particularly susceptible.

Focus area	Planning	**Values maintained / improved or protected**	Potential to impact on each of the values as it will influence the entrance management policy
Responsibility	GCC		
Supporting groups			
Links to other options	1, 4, 6, 7,8	**Links to existing works**	Flood Management Program

Capital Costs	Ongoing Costs	Monitoring and performance indicators
Within existing budget	Within existing budget	Floor heights consistent with sea level rise projections

11	Undertake Gosford Wetland Inventory and develop associated management strategy	Relevant Lagoon/s	All
		Priority	Immediate / ongoing

Detailed description

The Gosford Wetland Strategy is to be prepared Council and amongst other things will involve a comprehensive inventory of wetland parcels within the Gosford Local Government Area. The project will identify and assess all wetland parcels in public and private ownership and prioritise these wetlands for management and rehabilitation. The resulting prioritisation will be used to inform resourcing for wetland rehabilitation, education and compliance activities, commercial licence applications, recreation and asset planning.

This planning process will link to and inform wider natural asset management planning activities being undertaken for the Local Government Area.

Focus area	Planning	**Values maintained / improved or protected**	Natural bushland and riparian vegetation, presence of threatened species, supports species at critical life stage, wetland fauna, aesthetic beauty, tourism
Responsibility	GCC		
Supporting groups			
Links to other options	This action provides key information for other options including 5,6,7,8	**Links to existing works**	Council is in the process of preparing the Wetland Strategy

Capital Costs	Ongoing Costs	Monitoring and performance indicators
Allow $30,000	Highly variable	Strategy complete and used within standard Council operations

12a	Develop and implement a holistic Foreshore Master Plan for Terrigal Lagoon	Relevant Lagoons	Terrigal
		Priority	2-5 years

Detailed description

Prepare a holistic foreshore landscape masterplan to guide rehabilitation of key habitats and encourage appropriate recreational access across the Terrigal Lagoon foreshores. The Masterplan will focus upon:

Access – uncontrolled access is currently an issue for various foreshore locations across the Terrigal Lagoon foreshore (i.e. Lake View Road). The masterplanning process will enable appropriate management of access issues while encouraging safe and accessible recreational activities. The process will aim to:

- promote key entry points to enhance the visitor experience;
- propose appropriate path networks (i.e. low key crush sandstone);
- ensure accessible parking to support recreational access;
- passive water recreation access points (to support kayaking, stand up paddle boarding, model boating, fishing etc);
- enhance protection of valuable habitat;
- address encroachment issues;
- enhance pedestrian and cycleway network in consideration of the Gosford Bike Strategy;
- establish viewing points which are non-obtrusive and avoid impacting upon private property;
- Undertake ownership mapping for key foreshore areas to enable accurate assessment of open space linkages;
- Capitalise on any opportunities to acquire privately owned land and bring them into public ownership to improve and enhance public access and ecological values; and
- All development adjoining the lagoon foreshore should be designed to have a minimal visual impact on the lagoon.

Amenity – the masterplan will look to enhance the visitor experience while encouraging appreciation and learnings of the surrounding environment. Amenity provisions will be designed to ensure the visual appeal of the lagoon foreshore is promoted and maintained through recognition of community values in regard to recreation, heritage, education and visual character. Amenity improvements may extend to:

- improved and accessible seating, tables, BBQ and toilet facilities
- provision of recreational corralling areas to minimise impacts of recreational activity

12a	Develop and implement a holistic Foreshore Master Plan for Terrigal Lagoon	Relevant Lagoons	Terrigal
		Priority	2-5 years

- provision of appropriate interpretive/educational/compliance signage at entry and interest points
- improved and accessible children's play equipment; and
- appropriate waste management facilities.

Vegetation Enhancement Plan – is to be developed based upon vegetation mapping and aim to enhance endangered ecological communities and habitat values. This component of the Masterplan will identify required weed management, revegetation plantings and opportunities for bush regeneration. Vegetation along and within drainage lines should be conserved and the focus should include:

- protection of fringing wetland and lagoon vegetation to provide adequate breeding and safe roosting areas for birds.
- the requirements of the complete suite of species ranging from migratory waders to endemic water birds
- Encourage the planting of appropriate species to enhance connectivity, green corridors and succession of desired adult trees.

The plans should balance social and economic needs whilst ensuring that natural shoreline habitats and their ecological function are not impacted. These plans will need to address habitat conservation and ecosystem services in the face of potential climate change.

Preparation should include mapping of unauthorised encroachment to public land and inappropriate mowing of foreshore areas. The plan should include bank erosion works in areas currently experiencing foreshore erosion and instability and areas likely to be vulnerable in the future. This option links with wider bushland management activities and the Coastal Open Space System (COSS) corridors project..

Focus area	Planning, Works and Education	Values maintained / improved or protected	Primary contact – recreation, secondary contact- recreation, Tourism, Wetland Fauna
Responsibility	GCC		
Supporting groups	Bushcare groups		
Links to other options	1, 2, 5, 6, 7, 8, 9, 13, 14, 15, 16, 17, 20, 21, 22	Links to existing works	

12a	Develop and implement a holistic Foreshore Master Plan for Terrigal Lagoon	Relevant Lagoons	Terrigal
		Priority	2-5 years

Capital Costs	Ongoing Costs	Monitoring and performance indicators
Prepared within budget	Implementation $50,000	Foreshore Masterplan developed in liaison with the community Funding acquired for implementation Progressive implementation achieved

12b	Develop and implement a holistic Foreshore Master Plan for Avoca Lagoon	Relevant Lagoon/s	Avoca
		Priority	2-5 years

Detailed description

Prepare a holistic foreshore landscape masterplan to guide rehabilitation of key habitats and encourage appropriate recreational access across the Avoca Lagoon foreshores. The Masterplan will focus upon:

Access – The masterplanning process will enable appropriate management of access issues while encouraging safe and accessible recreational activities. The process will aim to:

- promote key entry points to enhance the visitor experience;
- propose appropriate path networks (i.e. low key crush sandstone);
- ensure accessible parking to support recreational access;
- passive water recreation access points (to support kayaking, stand up paddle boarding, model boating, fishing etc);
- enhance protection of valuable habitat and minimise human impact on wading / migratory bird species;
- address encroachment issues; and
- establish viewing points which are non-obtrusive and avoid impacting upon private property.
- capitalise on any opportunities to acquire privately owned land and bring them into public ownership to improve and enhance public access and ecological values

Amenity – the masterplan will look to enhance the visitor experience while encouraging appreciation and learnings of the surrounding environment. Amenity provisions will be designed to ensure the visual appeal of the lagoon foreshore is promoted and maintained through recognition of community values in regard to recreation, heritage, education and visual character. Amenity improvements may extend to:

- improved and accessible seating, tables, BBQ and toilet facilities
- provision of recreational corralling areas to minimise impacts of recreational activity
- provision of appropriate interpretive/educational/compliance signage at entry and interest points
- improved and accessible children's play equipment; and
- appropriate waste management facilities.

Vegetation Enhancement Plan – is to be developed based upon vegetation mapping and aims to

12b	Develop and implement a holistic Foreshore Master Plan for Avoca Lagoon	Relevant Lagoon/s	Avoca
		Priority	2-5 years

enhance endangered ecological communities and habitat values. This component of the Masterplan will identify required weed management, revegetation plantings and opportunities for bush regeneration. Vegetation along and within drainage lines should be conserved and the focus should include:

- protection of fringing wetland and lagoon vegetation to provide adequate breeding and safe roosting areas for birds.
- the requirements of the complete suite of species ranging from migratory waders to endemic water birds
- Encourage the planting of appropriate species to enhance connectivity, green corridors and succession of desired adult trees.

Preparation should include mapping of unauthorised encroachment to public land and inappropriate mowing of foreshore areas. The plan should include bank erosion works in areas currently experiencing foreshore erosion and instability and areas likely to be vulnerable in the future.

The plans should balance social and economic needs whilst ensuring that natural shoreline habitats and their ecological function are not impacted. These plans will need to address habitat conservation and ecosystem services in the face of potential climate change. This option links with wider bushland management activities and the Coastal Open Space System (COSS) corridors project.

Focus area	Planning, Works and Education	Values maintained / improved or protected	Natural Bushland / riparian vegetation, presence of threatened species, supports species at critical life stage, wetland fauna, secondary contact - recreation
Responsibility	GCC		
Supporting groups	Bushcare groups		
Links to other options	1, 2, 5, 6, 7, 8, 9, 13, 14, 15, 16, 17, 20, 21, 22	Links to existing works	

Capital Coats	Ongoing Costs	Monitoring and performance indicators
Prepared within budget	Implementation up to $50,000	Foreshore Management Plan developed in liaison with community

12b	**Develop and implement a holistic Foreshore Master Plan for Avoca Lagoon**	**Relevant Lagoon/s**	Avoca
		Priority	2-5 years
		Funding acquired for implementation Progressive implementation achieved	

Title:

Avoca Lagoon - Foreshore Master Plan

Figure: **4-5**

Rev: **A**

N

0 125 250m

Approx. Scale

BMT WBM

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Filepath : K:\N1997 Gosford Lagoons CZMS&P\MI\WOR\DRG_003_Avoca_ForeshoreManagementPlan.WOR

12c	Develop and implement a holistic Foreshore Master Plan for Cockrone Lagoon	Relevant Lagoon/s	Cockrone
		Priority	2-5 years

Detailed description

Prepare a holistic foreshore landscape masterplan to guide rehabilitation of key habitats and encourage appropriate recreational access across the Cockrone Lagoon foreshores. The Foreshore Masterplan should protect the tranquil and aesthetically pleasing 'naturalness' of the lagoon. The Masterplan will focus upon:

Access – The masterplanning process will enable appropriate management of access issues while encouraging safe and accessible recreational activities. The process will aim to:

- promote key entry points to enhance the visitor experience;
- propose appropriate path networks (i.e. low key crush sandstone);
- ensure accessible parking to support recreational access;
- passive water recreation access points (to support kayaking, stand up paddle boarding, model boating, fishing etc);
- enhance protection of valuable habitat and minimise human impact on wading / migratory bird species
- address encroachment issues; and
- establish viewing points which are non-obtrusive and avoid impacting upon private property.
- Capitalise on any opportunities to acquire privately owned land and bring them into public ownership to improve and enhance public access and ecological values

Amenity – the masterplan will look to enhance the visitor experience while encouraging appreciation and learnings of the surrounding environment. Amenity provisions will be designed to ensure the visual appeal of the lagoon foreshore is promoted and maintained through recognition of community values in regard to recreation, heritage, education and visual character. Amenity improvements may extend to:

- improved and accessible seating, tables, BBQ and toilet facilities
- provision of recreational corralling areas to minimise impacts of recreational activity
- provision of appropriate interpretive/educational/compliance signage at entry and interest points
- improved and accessible children's play equipment; and
- appropriate waste management facilities.

<table>
<tr><td rowspan="2">12c</td><td rowspan="2">Develop and implement a holistic Foreshore Master Plan for Cockrone Lagoon</td><td>Relevant Lagoon/s</td><td>Cockrone</td></tr>
<tr><td>Priority</td><td>2-5 years</td></tr>
<tr><td colspan="4">Vegetation Enhancement Plan – is to be developed based upon vegetation mapping and aims to enhance endangered ecological communities and habitat values. This component of the Masterplan will identify required weed management, revegetation plantings and opportunities for bush regeneration. Vegetation along and within drainage lines should be conserved and the focus should include:
• protection of fringing wetland and lagoon vegetation to provide adequate breeding and safe roosting areas for birds.
• the requirements of the complete suite of species ranging from migratory waders to endemic water birds
• Encourage the planting of appropriate species to enhance connectivity, green corridors and succession of desired adult trees.
Preparation should include mapping of unauthorised encroachment to public land and inappropriate mowing of foreshore areas. The plan should include bank erosion works in areas currently experiencing foreshore erosion and instability and areas likely to be vulnerable in the future.
The plans should balance social and economic needs whilst ensuring that natural shoreline habitats and their ecological function are not impacted. These plans will need to address habitat conservation and ecosystem services in the face of potential climate change. This option links with wider bushland management activities and the Coastal Open Space System (COSS) corridors project.</td></tr>
<tr><td>Focus area</td><td>Planning, Works and education</td><td rowspan="3">Values maintained / improved or protected</td><td rowspan="3">Natural Bushland/ riparian vegetation, Presence of threatened species, Wetland fauna (migratory and resident waterbirds)</td></tr>
<tr><td>Responsibility</td><td>GCC</td></tr>
<tr><td>Supporting groups</td><td>Bushcare groups</td></tr>
<tr><td>Links to other options</td><td>1, 2, 5, 6, 7, 8, 9, 13, 14, 15, 16, 17, 20, 21, 22</td><td>Links to existing works</td><td></td></tr>
<tr><td colspan="2">Capital Costs</td><td>Ongoing Costs</td><td>Monitoring and performance indicators</td></tr>
<tr><td colspan="2">Prepared within budget</td><td>Implementation up to $50,000</td><td>Foreshore Management Plan</td></tr>
</table>

12c	Develop and implement a holistic Foreshore Master Plan for Cockrone Lagoon	Relevant Lagoon/s	Cockrone
		Priority	2-5 years
		developed in liaison with community Funding acquired for implementation Progressive implementation achieved	

12d	Develop and implement a holistic Foreshore Master Plan for Wamberal southern foreshore	Relevant Lagoon/s	Wamberal
		Priority	2-5 years

Detailed description

Southern Foreshore - Council owned portion of shoreline

Focus area	Planning, Works and education	**Values maintained / improved or protected**	Natural Bushland/ riparian vegetation, Presence of threatened species, Wetland fauna (migratory and resident waterbirds)
Responsibility	GCC		
Supporting groups	Bushcare groups		
Links to other options	1, 2, 5, 6, 7, 8, 9, 13, 14, 15, 16, 17, 20, 21, 22	**Links to existing works**	

Capital Costs	Ongoing Costs	Monitoring and performance indicators
Prepared within budget	Implementation up to $30,000	Foreshore Management Plan developed in liaison with community Funding acquired for implementation Progressive implementation achieved

13	Investigate removal of contemporary sediments from the mouths of creeks entering the lagoons	Relevant Lagoon/s	All
		Priority	2-5 years

Detailed description

Each of the lagoons are in a stage of natural infilling, in geological terms, however the rates of infilling have been accelerated by catchment development. The net result of enhanced sedimentation rates is an increase in the maturity of coastal waterways, and a decrease in their overall lifespans. Lagoons such has Wamberal and Terrigal have a high sediment trapping efficiency and are susceptible to increases in the magnitude of sediment loads carried by rivers and creeks. Over the course of implementing this CZMP, if increased sedimentation is observed around the inflowing creeks and streams, particularly in the upper reaches, the feasibility of removing sediments should be investigated and if it is considered feasible and to have a net benefit, alluvial sediment fans should be removed by Council. Impacts to be considered include:

- Smothering of habitats where sediment is deposited more rapidly than tolerated by benthic invertebrates or microalgae.
- Turbidity levels and the amount of sediment-bound nutrients (e.g. Total P, Total N & Total Organic Carbon), trace elements (e.g. Fe, Zn, Pb) and other toxicants entering the lagoons in association with increased rates of sedimentation.
- Increased organic matter to be degraded by anoxic processes with flow on impacts for denitrification.
- Potential for increased flushing following sediment removal
- Impacts of sediment removal and disposal

Focus area	Environment and Works	**Values maintained / improved or protected**	Water Quality Recreational Swimming
Responsibility	GCC		
Supporting groups			
Links to other options	2, 3, 12, 15 ,16, 17	**Links to existing works**	Asset management and maintenance

13	Investigate removal of contemporary sediments from the mouths of creeks entering the lagoons	Relevant Lagoon/s	All
		Priority	2-5 years

Capital Costs	Ongoing Costs	Monitoring and performance indicators
$40, 000		•

14	Work with State Government to prepare an updated Plan of Management (POM) for Wamberal Lagoon Nature Reserve	Relevant Lagoons	Wamberal
		Priority	2-5 years

Detailed description

The National Parks and Wildlife Act 1974, requires that a PoM be prepared for each nature reserve. PoM's contain information on the natural environments, Aboriginal heritage and recreational opportunities in a park or reserve A plan of management is a legal document that outlines how the area will be managed in the years ahead.

The PoM for Wamberal Lagoon Nature Reserve (1990) is considered to be out of date. The Wamberal Lagoon Nature Reserve PoM applies the following general objectives relating to the management of nature reserves in New South Wales:

- the protection and preservation of scenic and natural features;
- the maintenance of natural processes as far as is possible;
- the conservation of wildlife;
- the preservation of Aboriginal sites and historic features; and
- the encouragement of scientific and educational enquiry into environmental features and processes.

In addition to those general objectives the following specific objectives apply to Wamberal Lagoon Nature Reserve:

- to protect the natural condition of those parts of Wamberal Lagoon and sandspit within the nature reserve for the primary purpose of promoting low impact environmental education use;
- to promote appropriate land use planning and management amongst neighbours of the nature reserve and other land use authorities which will afford the highest practicable protection for the natural condition of Wamberal Lagoon; and
- to permit limited opportunities for low impact recreational use of the lagoon and beach units of the nature reserve.

An updated PoM consistent with this CZMP would contribute to integrated and appropriate management across agencies. It would also contribute to appropriate resource allocation. Two key pressures that are not considered in the current POM are sea level rise and its potential impact on estuarine vegetation and also the entrance management policy and procedures.

This action involves Council working with OEH on a revised POM for Wamberal Lagoon to complement the CZMP.

Focus area	Planning	Values	Riparian vegetation

<table>
<tr><td rowspan="2">14</td><td colspan="2" rowspan="2">Work with State Government to prepare an updated Plan of Management (POM) for Wamberal Lagoon Nature Reserve</td><td>Relevant Lagoons</td><td>Wamberal</td></tr>
<tr><td>Priority</td><td>2-5 years</td></tr>
<tr><td>Responsibility</td><td>State Government</td><td rowspan="2">maintained / improved or protected</td><td colspan="2" rowspan="2">Waterbird habitat
Educational resource</td></tr>
<tr><td>Supporting groups</td><td>GCC</td></tr>
<tr><td>Links to other options</td><td>1, 2, 4,5,6,7,8, 11, 12(d), 13, 15, 16, 17, 21, 22</td><td>Links to existing works</td><td colspan="2"></td></tr>
<tr><td colspan="2">Capital Costs</td><td colspan="2">Ongoing Costs</td><td>Monitoring and performance indicators</td></tr>
<tr><td colspan="2">To be undertaken by OEH (NPWS) with input from council staff</td><td colspan="2"></td><td>New POM that is consistent with CZMP.</td></tr>
</table>

15	Encourage inclusion of Stormwater Quality Improvement Devices (SQIDs) in private development activities	Relevant Lagoon/s	All
		Priority	Within 2-5 years

Detailed description

Stormwater quality improvement devices (SQIDs) cover a range of physical devices or components of a stormwater network used to improve stormwater quality. This action includes Council encouraging the inclusion of SQIDs in new developments through development planning. Education and compliance initiatives need to be undertaken in relation to sediment controls. Appropriate maintenance regimes are also critical in ensuring management objectives are met. and undertaking regular compliance and education initiatives in relation to sediment controls

Focus area	Planning	**Values maintained / improved or protected**	Water Quality Wetland Fauna Recreational Swimming
Responsibility	GCC		
Supporting groups			
Links to other options	1, 2, 3, 6, 8, 12,14, 17, 22	**Links to existing works**	Asset management and maintenance

Capital Costs	Ongoing costs	Monitoring and performance indicators
Integrated into development costs	Maintenance by Council into the future	SQIDs incorporated in new developments

16	**Identify sites where there is the potential for landward migration of lagoon vegetation and prioritise these for rehabilitation works**	**Relevant Lagoon/s**	All
		Priority	

Detailed description

Changes in the hydraulic regime for coastal lagoons are expected into the future due to projected sea level rise. As a result of the changes to saltwater intrusion, tidal range and average water levels within wetland areas the distribution and type of fringing wetlands is expected to change.

Mapping undertaken as part of Councils wetland inventory project has been undertaken to assist in identifying, describing and prioritising all wetland parcels within Gosford LGA. In order to actively facilitate landward migration of vegetation communities it is important to identify wetland vegetation fringing the lagoon that would not be restricted through development. The level of accuracy and value of the mapping would be improved through sea level rise modelling to show areas likely to be permanently inundated.

Following the identification of suitable areas Council could implement active planting activities which encourage establishment of endemic vegetation communities. The introduction of "No-mow zones" may also encourage natural regeneration. This action will integrate with master planning and other bushland management actions.

Focus area	Planning and Works	**Values maintained / improved or protected**	Riparian vegetation, Waterbird Habitat, Educational Resource
Responsibility	GCC		
Supporting groups	Bushcare		
Links to other options	1, 2, 3, 5, 6 7, 8 11, 12, 13, 14, 22	**Links to existing works**	Bushcare and maintenance

Capital Costs	Ongoing Costs	Monitoring and performance indicators
Planning within existing budgets	Active planting and vegetation maintenance, allow $10,000 per year	Suitable foreshore locations identified for rehabilitation, plantings undertaken

17	Undertake adequate and appropriate maintenance of existing stormwater improvement devices to maintain their effectiveness, in particular GPT's	Relevant Lagoon/s	ALL
		Priority	

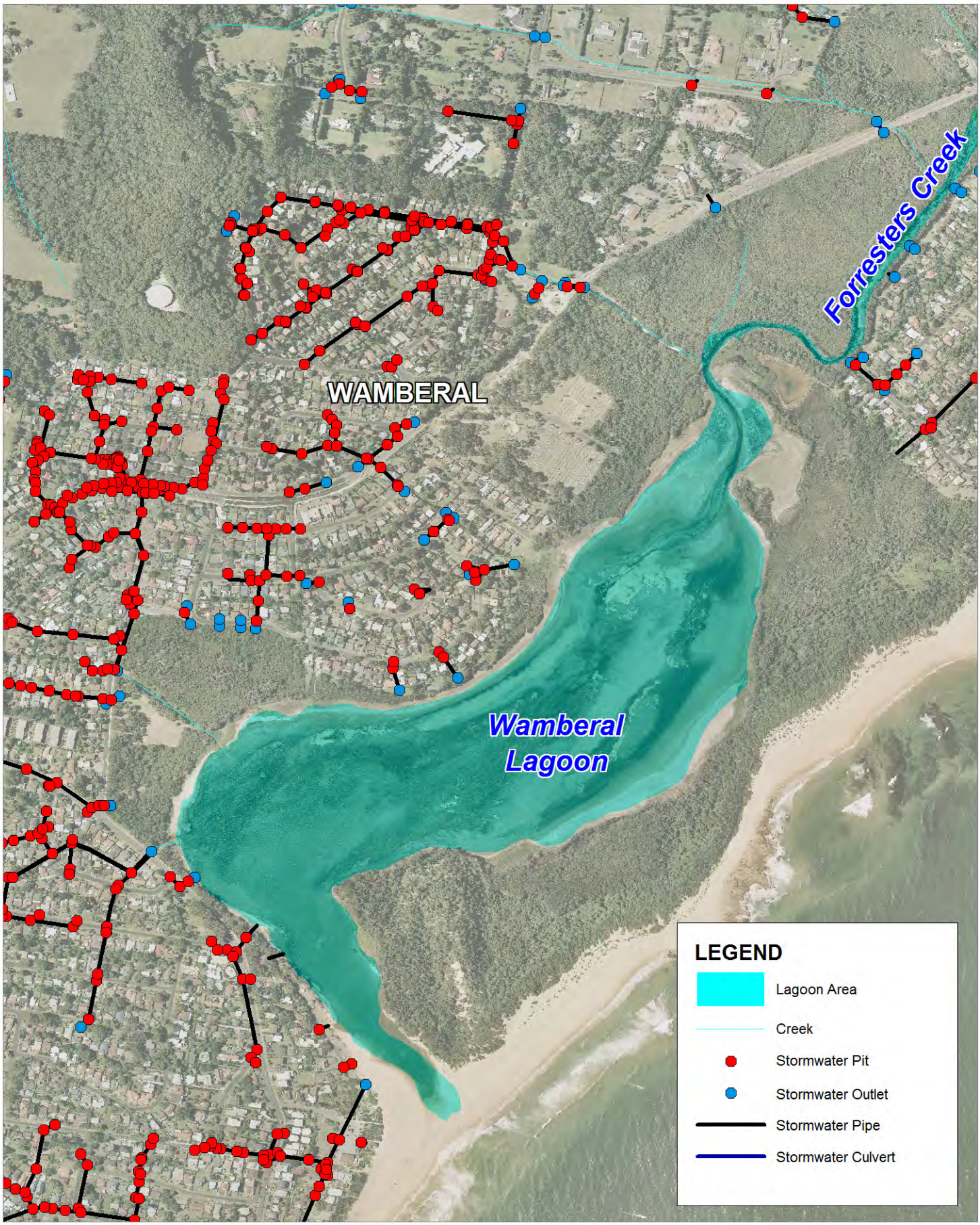
Detailed description

A common failing of stormwater treatment devices is inadequate maintenance. For example, gross pollutants stored in a wet holding area without turnover will experience organic material decomposition, with depleted oxygen levels creating severe reducing conditions. Under these conditions, collected pollutants can be transformed from a relatively innocuous state to highly bio-available forms that are then released to downstream waters with any through flow.

This action involves the identification of existing stormwater treatment devices (assets) and an assessment/review of existing maintenance regimes. This would involve routine and event based monitoring of devices to establish if they are being cleaned out often enough and are able to function properly during large storm events. Regular inspection of openings of existing culverts or land drains that feed into the water should be undertaken to ensure they remain unblocked from any obstructions. Undertake adequate and appropriate maintenance of existing treatment devices to maintain their effectiveness, in particular GPTs, nutrient filters and other stormwater quality improvement devices.

Focus area	All Lagoons	Values maintained / improved or protected	
Responsibility	GCC		
Supporting groups			
Links to other options	1, 2,3, 6, 8, 12, 15, 21, 22	Links to existing works	Councils erosion and sediment control Operational Procedure and development audit process Maintenance and asset management processes

Capital Costs	Ongoing Costs	Monitoring and performance indicators
This activity is currently undertaken by Council staff.	Additional internal resources would increase efficiency allow $50,000	Identification of stormwater treatment assets, assessment of current maintenance regime, identification of revised maintenance program



Title:

Wamberal Lagoon - Drainage Infrastructure

Figure: 4-10

Rev: A

N

0 200 400m

Approx. Scale

BMT WBM

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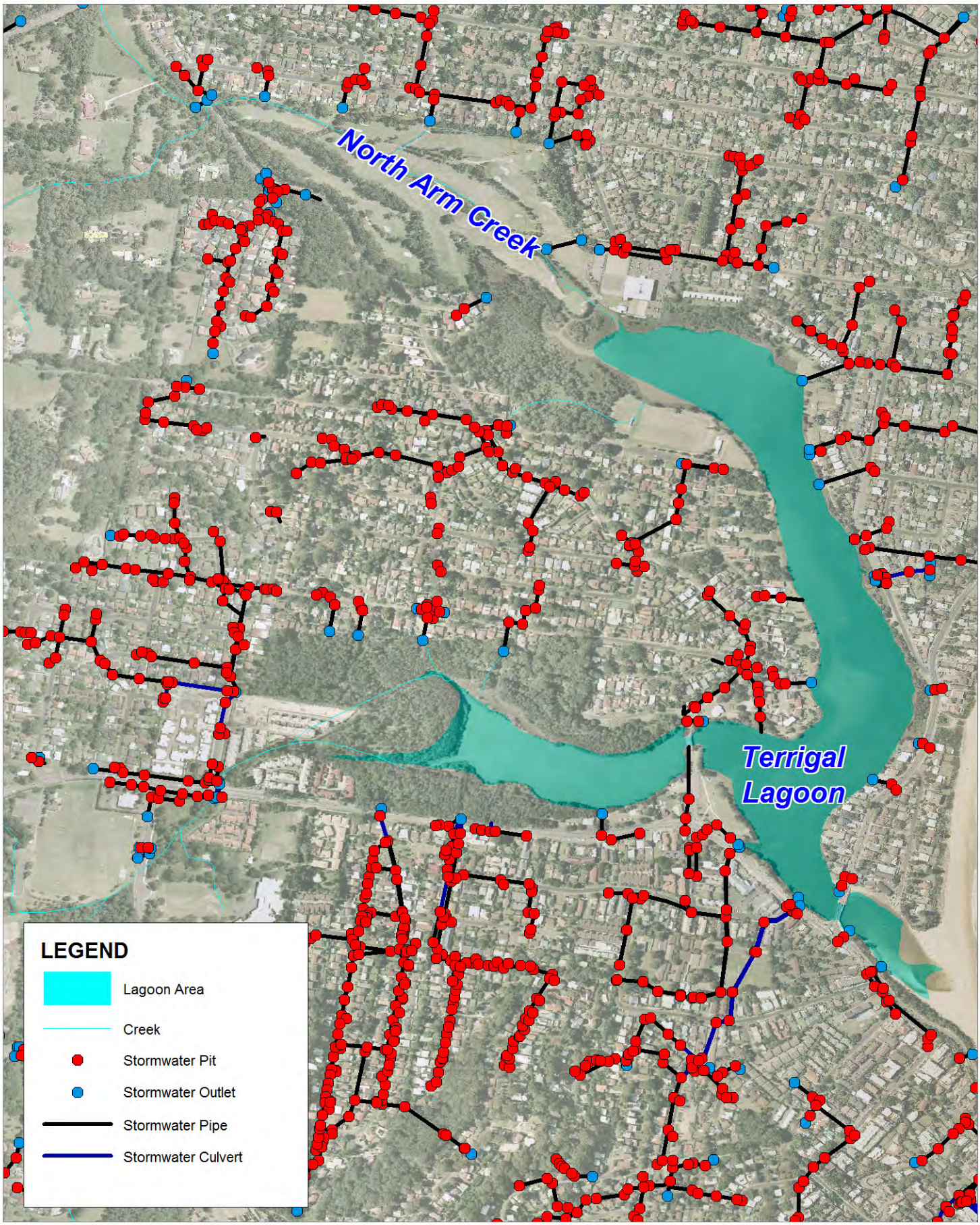
Filepath : K:\N1997 Gosford Lagoons CZMS&P\MI\WOR\DRG_005_Wamberal_Drainage.WOR



Title:

Terrigal Lagoon - Drainage Infrastructure

Figure: 4-11

Rev: A

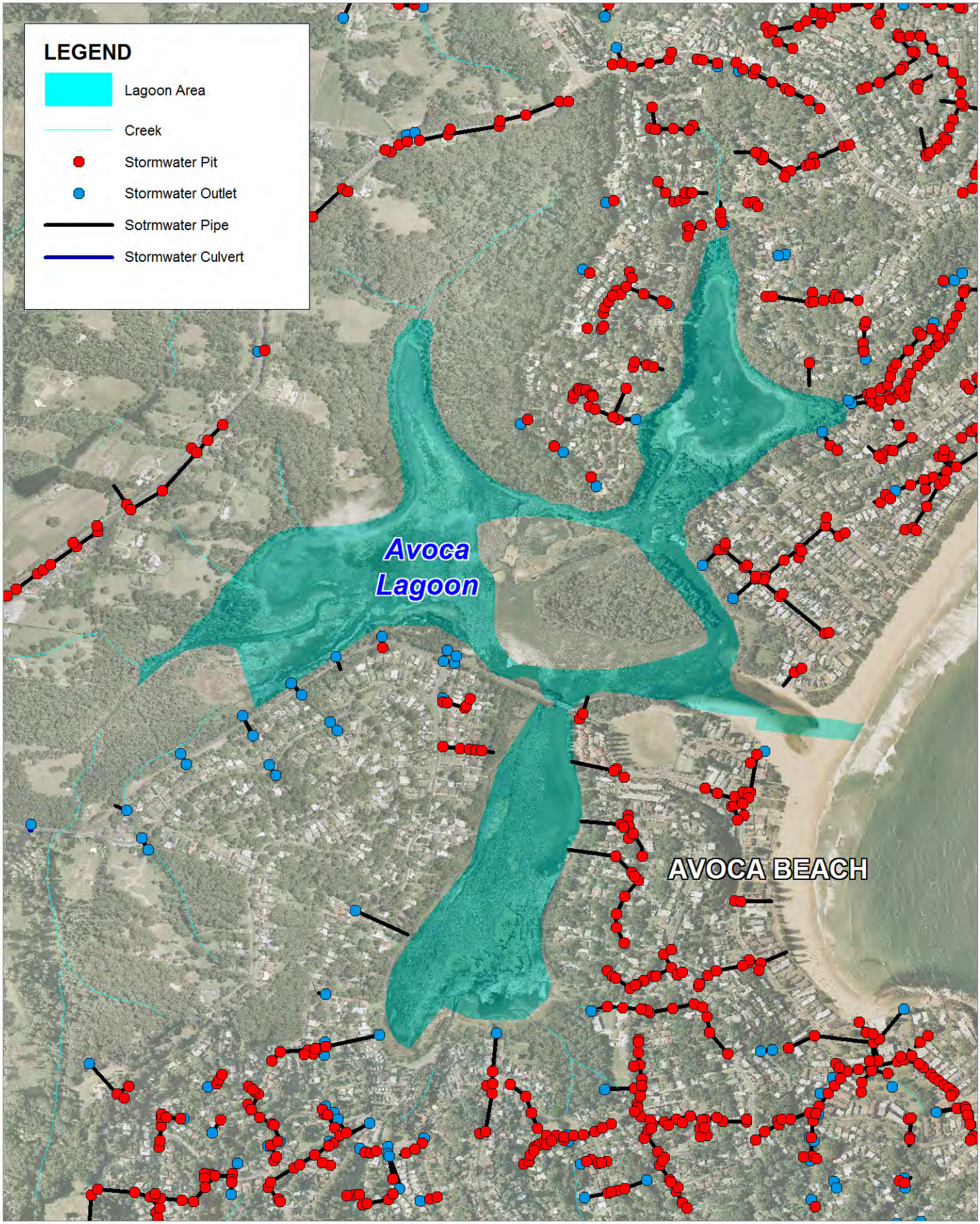
N

0 200 400m

Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : K:\N1997 Gosford Lagoons CZMS&P\MI\WOR\DRG_004_Terrigal_Drainage.WOR



Title:

Avoca Lagoon - Drainage Infrastructure

Figure: 4-12

Rev: A

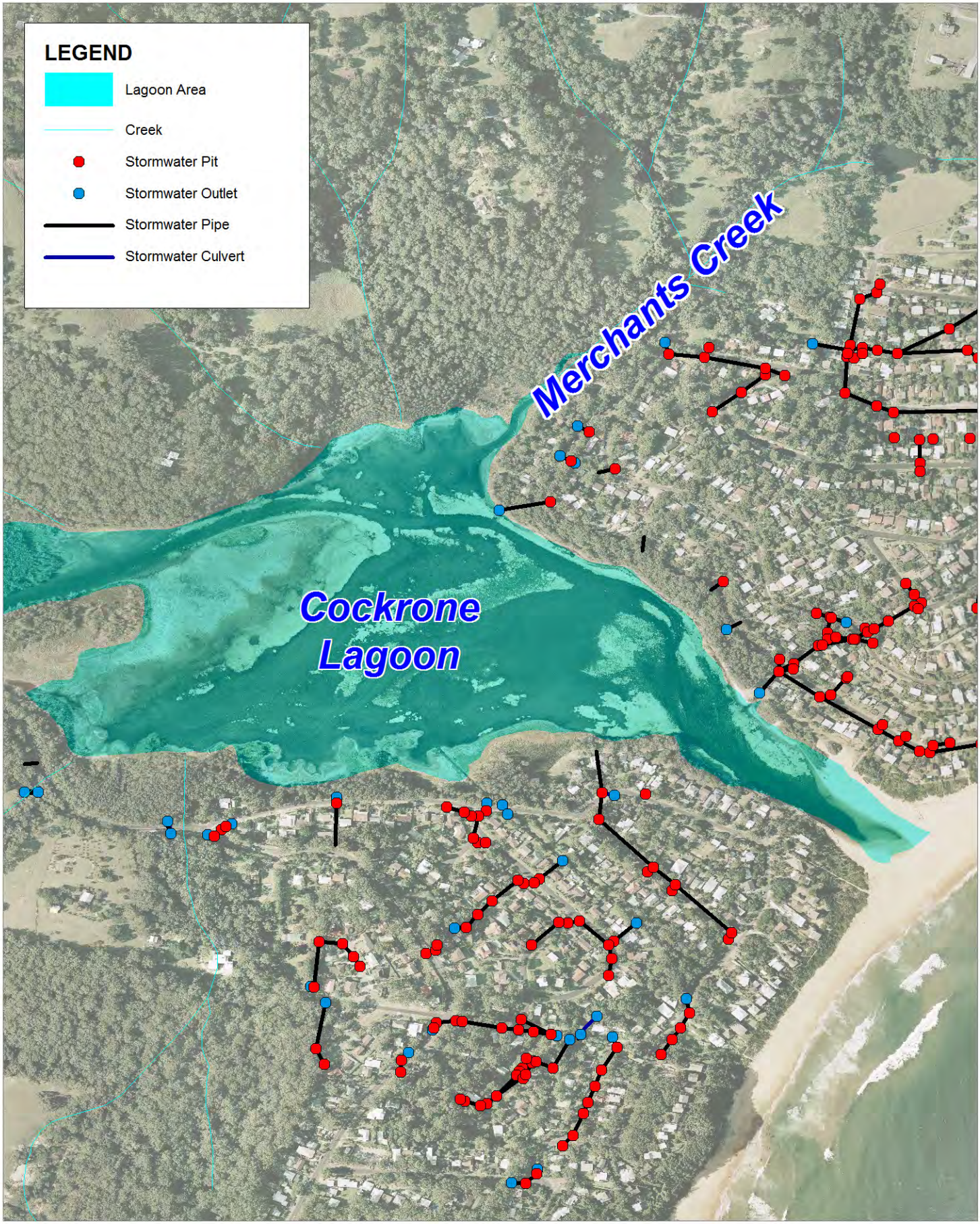
N

0 250 500m

Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : K:\N1997 Gosford Lagoons CZMS&P\MI\WOR\DRG_003_Avoca_Drainage.WOR



Title:

Cockrone Lagoon - Drainage Infrastructure

Figure: 4-13

Rev: A

N

0 125 250m

Approx. Scale

BMT WBM
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Filepath : K:\N1997 Gosford Lagoons CZMS&P\MI\WOR\DRG_002_Cockrone_Drainage.WOR

18	Investigate opportunities for harvesting algae from Avoca Lagoon to assist in nutrient management	Relevant Lagoon/s	Avoca
		Priority	2-5 years

Detailed description

This option should be informed by current research funded by Council into factors influencing algal growth in the lagoon and flow on influences to the Lake's nutrient budget.

The decision to harvest algae to mitigate undesirable impacts of algal blooms such as disruption to recreational activities and periods of anoxia following mass die off and increased biological oxygen demand needs to be considered against the benefits of algal growth for the Lagoon such as:

- Structure for colonisation and provision of habitat
- A food source for water birds (particularly swans)
- Spawning grounds shelter and refuge from predators for juvenile fish species and benthic invertebrates.

Algal harvesting has been undertaken in Tuggerah Lake and Lake Illawarra. Like Avoca lagoon, Lake Illawarra experience blooms with the most problematic species being *Chaetomorpha linum*.

The current methods for harvesting algae elsewhere involve a floating harvester in water deeper than 0.5 metres and front end loaders for shallower areas. Lagoon opening regimes may also influence algal growth and should be considered in future management of algal growth.

Priority in removal of algal mats should be placed along those public use foreshore areas where extensive build up exceeds 20 metres in width from the water's edge prior to the onset of peak seasonal holiday periods, in order to minimise any impacts on the amenity of the lagoon. Council develop a policy that considers removal and disposal procedures. Damage to the lagoon bed should be minimised.

Focus area	Research	**Values maintained / improved or protected**	Water quality, Primary contact-recreation, Secondary contact-recreation
Responsibility	GCC		
Supporting groups	University Research		
Links to other options	1,2, 6, 7,8,9, 12 (a), 15,17, 20, 21, 22	**Links to existing works**	Research Programs

18	Investigate opportunities for harvesting algae from Avoca Lagoon to assist in nutrient management	Relevant Lagoon/s	Avoca
		Priority	2-5 years

Capital Costs	Ongoing Costs	Monitoring and performance indicators
Allow $25,000 for environmental assessment and single event harvesting activity		Briefing paper on options and costs

19	Minimise the potential for contaminated sites to leach into the lagoons	Relevant Lagoon/s	All
		Priority	

Detailed description

Contaminated sites are potentially an indirect source of pollution to the lagoons. This may be via stormwater runoff or through leaching into groundwater flows. Potential and actual contaminated sites are mapped by council. The Estuary Processes Study (Cardno 2010) lists the known sites at the time it was published, however this list will need to be updated based on the Contaminated Land register maintained by State Government (Environment Protection Authority) and Councils mapping register.

Corrective Actions can be developed and implemented on a case by case basis and in conjunction with the NSW Government to minimise the impacts on the lagoons.

Focus area		**Values maintained / improved or protected**	Water Quality
Responsibility	GCC		
Supporting groups			
Links to other options	1,2,3,4,6, 8, 13, 15, 17, 22	**Links to existing works**	

Capital Costs	Ongoing Costs	Monitoring and performance indicators
Investigations can be undertaken to identify sites within existing budgets.		Updated risk assessment of contaminated lands within catchments

20	**Investigate opportunities to enhance breeding habitat sites for green and golden bell frogs adjacent to Avoca Lagoon**	**Relevant Lagoons**	Avoca
		Priority	2-5 years

Detailed description

This option is consistent with the recommendations of the Green and Golden Bell Frog POM prepared for Gosford LGA. This will also link with the POM being prepared for Bareena Reserve.

A long term goal of the Green and Golden Bell Frog POM is the creation of significant additional breeding habitat adjacent to the existing Bareena Wetland. Alternative freshwater breeding habitat may provide some buffering to the impacts of lost tadpoles due to entrance opening. Another option is the provision of a small nearby pond fed through the stormwater network. This action also should include investigation of the potential for a control structure to allow manipulation of water levels in Bareena wetland during Green and Golden Bell frog breeding times

GGBF has been identified on Lakeshore Drive on the western side of the lagoon in good numbers (December 2013).

A careful and adaptive approach will need to be taken due to the complex requirements of the Green and Golden Bellfrog. Generally the requirement is for a water body that is shallow (i.e. <1m deep), still or moving slowly (e.g. ponds), unshaded and free of fish, has an area of open water (ie., free of floating and/or emergent vegetation), and contains water that has low salinity (i.e. <8 ppt) and is warm (i.e. >200C) during the spring/summer breeding season. In addition, this species breeds opportunistically and responds to certain types of habitat disturbance that trigger movement and breeding. This disturbance, which may include changes in water depth, salinity or amounts of aquatic vegetation, can be naturally or artificially induced.

Focus area	Environment	**Values maintained / improved or protected**	Supports species at a critical life stage, wetland fauna
Responsibility	GCC		
Supporting groups	State Government (NPWS)		
Links to other options	1, 2, 3, 5, 6, 7, 8, 9, 11, 12, 13, 15, 16, 17, 18, 21, 22	**Links to existing works**	POM Green and Golden Bell Frog

Capital Costs	**Ongoing Costs**	**Monitoring and**

20	Investigate opportunities to enhance breeding habitat sites for green and golden bell frogs adjacent to Avoca Lagoon	Relevant Lagoons	Avoca
		Priority	2-5 years

		performance indicators
Investigations up to $10,000. Implementation costs up to $15,000	Expected to be minimal Program	Additional breeding habitat constructed and utilised

21	Undertake a review of commercial recreational activities within the lagoon catchments	Relevant Lagoon/s	All Lagoons
		Priority	2-5 years

Detailed description

Tourism is a significant industry in the area. A variety of commercial activities occur in and around the lagoons. Each of these activities interacts with the social, environmental and ecological values of the lagoons. This action involves undertaking an audit of each of the commercial activities and determining appropriate intensities of these activities to avoid significant environmental and social impacts. This review would also recognise the benefits associated with these activities.

Key information to be sought through the review includes:

- Identification of the contribution of the lagoons to the local economy
- Assessment of the short and long term impacts of different commercial activities to the lagoon values
- Restrict any water use including recreational activities that may directly destroy or impact on existing seagrass beds
- Recommendations for guidelines for future commercial operations in and around the lagoons that are consistent with the intent of this CZMP.

It is particularly important that the review takes into account the different value priorities for each of the lagoons as determined through this process. While social and economic values have been prioritised for Terrigal Lagoon, ecological values are most important for Wamberal Lagoon.

Focus area	Planning	**Values maintained / improved or protected**	Potential to impact upon all values
Responsibility	GCC		
Supporting groups			
Links to other options	1, 2, 3, 6, 7, 8, 9, 12, 13, 14, 17, 18, 19, 20, 22	**Links to existing works**	

21	Undertake a review of commercial recreational activities within the lagoon catchments	Relevant Lagoon/s	All Lagoons
		Priority	2-5 years

Capital Costs	Ongoing Costs	Monitoring and performance indicators
$20,000		Review undertaken Outcomes considered in assessment of new commercial activities

22	**Develop and implement monitoring and reporting programs for Gosford Coastal Lagoons**	**Relevant Lagoon/s**	All Lagoons
		Priority	2-5 years

Detailed description

The adopted estuary health monitoring program should be based on key indicators that are monitored at the State level under the MER Program. This includes monitoring of:

- Turbidity;
- Other supporting physico-chemical indicators such as salinity, dissolved oxygen, pH, and temperature;
- Estuarine Macrophytes (seagrasses, saltmarsh, mangroves) distribution change;
- Macroalgae blooms; and
- Riparian vegetation distribution and condition.

Please refer to Section 5 for more details.

Focus area	Planning	**Values maintained / improved or protected**	Potential to impact upon all values
Responsibility	GCC		
Supporting groups			
Links to other options	All	**Links to existing works**	

Capital Costs	Ongoing Costs	Monitoring and performance indicators
$20,000	Within Budgets	Monitoring undertaken Reporting undertaken Management approach adapted to monitoring results

Table 4-2 Second Level Options to be considered after the High Priority Actions are implemented

Second Level Option	*Details/comments*
Undertake bird and fauna surveys across lagoons to assess conservation value and inform future management	Surveys align with COSS/Bushland Reserve fauna survey and COSS corridors project
Support implementation of the Central Coast Environment Network (CEN) Rehabilitation Plans	Detail can be found in individual CEN Plans

4.4 Actions Carried forward from Lagoons Coastal Management Plan 1995

Whilst a majority of the management actions contained within the Gosford Coastal Lagoons Management Plan (1995) have been implemented a number require further consideration for implementation in this CZMP. Priority for implementation of these actions can only be determined through site inspection and assessment of site characteristics and condition.

Due to the specific nature of these actions many will be considered as part of the masterplanning processes for each lagoon.

The banning of motorised vehicles on all Lagoons should continue to be enforced.

4.4.1 Carry over management options for Wamberal Lagoon

- Nutrient filter and scour restoration on drain near Tumbi Road Roundabout within Nature Reserve.
- Nutrient filter on drain at end of Tall Timbers Road.
- Design and construct appropriate sediment control measures in Forresters Creek catchment in line with WSUD principles.
- Sediment traps and nutrient filter is required at Remembrance Drive.
- Ocean View Drive - redesign of drainage outlets is required to provide nutrient and pollution management.
- Sediment removal and ongoing maintenance at end of Loxton Avenue. Sediment control at cemetery.
- Nutrient filter on drain at end of Winston Street.

4.4.2 Carry over management actions for Terrigal Lagoon

- Nutrient filters on creek and drains running off Duffys Road.
- Review capacities of drains to minimise flooding within the Bundara Avenue - Lumeah Avenue area.
- Sediment trap or sediment removal from the drain running off Terrigal Drive between Willoughby Road and Ocean View Drive.
- Nutrient filters on drains running off Terrigal Drive at top end of the western arm of the lagoon and manage the wetland off Bellbird Avenue as a nutrient and sediment filter.

- Manage existing remnants of native vegetation located at the end of Karalta Road, Terrigal Drive/Mittara Road and off Charles Kay Drive within the catchment to protect these remnants in order to assist with water quality management.
- Council investigate the deepening of the lagoon to improve the aesthetic appearance by trimming the bed to remove deep pockets which can accumulate undesirable sediment concentrations.

4.4.3 Carry over management actions for Avoca Lagoon

- Provide nutrient filter/sediment trap and retain existing vegetation at top end of Surf Rider Avenue.
- Nutrient filters at end of southern area of lagoon.
- Manage vegetation areas to protect emergent vegetation/nutrient filters within the Saltwater Creek areas off the western arm.
- Protect existing native vegetation and assist re-vegetation of Palmgrove at North Avoca and provide a vegetated foreshore in public reserve.
- Council investigate rehabilitation of the dredging site and the dredged area of the lagoon to eliminate deep pockets and provide support to Bareena Island by bed trimming of the lagoon. Areas of bed trimming may improve the aesthetic appearance of these sections of the lagoon.

4.4.4 Carry over management actions for Cockrone Lagoon

- Investigate provision of nutrient/sediment filter on Merchants Creek.
- Manage vegetation at Cockrone Creek to provide nutrient filter.
- Check the performance of the nutrient filter off Lakeside Drive.
- Manage vegetation along Cockrone Creek and The Scenic Drive to maintain nutrient retention and incorporating the use of local communities to assist in weed control and revegetation works.

4.5 Excluded Options

A number of management actions were identified through community consultations which were assessed as not being feasible for implementation. These have been listed below along with the reasoning behind exclusion from the implementation plan.

Table 4-3 Excluded Options

Excluded Option	Reason for exclusion
Ensure compliance for dogs being off leash in unsuitable areas	This issue is being dealt with separately through Councils Dogs in Open Spaces Strategy and associated policies
Do not allow any further development within lagoon catchments	It would not be possible to have this option adopted by Council
Remove mats of algae along the public use foreshore areas prior to the onset of peak season	Wrack serves as a food source and habitat for a range of aquatic organisms

Excluded Option	Reason for exclusion
Use of a submersible pump set at a level of one metre to keep Terrigal Lagoon at a consistent level	This option is not considered to be environmentally, socially or economically (maintenance) viable when costs and benefits are considered..
Reduce the opening level to 1 metre	The lagoon would not empty as it would be susceptible to ocean inundation. The present adopted let out level of 1.23m AHD is only 0.15m higher than the Highest Astronomical Tide.
Dredge the lagoon to give greater depth and allow greater storage	Dredging is expensive and has significant environmental impacts. Dredging the lagoon would not reduce flooding issues due to existing groundwater levels.
Construct control structures in Terrigal Lagoon to allow a permanently open entrance	This would be prohibitively expensive and would change the ecological character of the lagoon.
Remove or reduce barriers to natural movement of water	These need to be considered on an individual basis with reference to modified values. For example the Green and Golden Bellfrog breeding habitat is maintained through an artificial bund.

4.6 Issues referred to other documents / processes

A number of management options were raised during the community consultation sessions that are best addressed through alternate planning processes. These have been listed in Table 4-4 below.

Table 4-4 Issues referred to other processes

Issue	Referred to
Need to raise the kerb and guttering of Lake View Road Terrigal between no's 16-20 from the corner of Minell Close to prevent flooding	This should be considered through the flood program. Options may include tidal flaps. Sea level rise and groundwater influences will need to be considered.
Ensure compliance for dogs being off leash in unsuitable areas	This issue is being dealt with separately through Councils Dogs in Open Spaces Strategy and associated policies
Upgrade North Avoca SPS at Tramway Road	Work undertaken through Coastal Carrier sewerage asset upgrade

5 Monitoring and Evaluation

5.1 Monitoring

Ongoing monitoring is an important component of the CZMP and a requirement of the Guidelines for preparing Coastal Zone Management Plans.

5.1.1 Identifying the status of estuary health

As stated in the CZMP Guidelines (OEH, 2013), the assessment of the health of estuaries should be evaluated against applicable 'estuary health' targets, for example, the NSW Government's Water Quality and River Flow Objectives (DEC, 2006). In reality, all estuaries and especially coastal lagoons, are highly dynamic systems with complex and varied ecosystems. Conditions that define a "healthy" status can therefore vary greatly between ecosystems, or even between locations within an ecosystem. Estuaries are an ecotone between salt and fresh water environments. Given the potential variability of chemical, biological and hydrodynamic conditions within estuaries, applying a single definition or scale for estuary health can be problematic as well as misleading.

Complicating any measure of estuary health is the availability of data to assess health status. Our understanding of these complex systems is generally poor, although improving. Indeed Golley (1993) stated that "ecosystems are not only more complex than we think, they are more complex than we can think". In addition to the availability of data, or lack thereof, it is possible that historical data are now unreliable (due to inaccuracies in measurement techniques or laboratory analysis), or indeed focused on parameters that are now considered unsuitable as indicators of estuary health.

A good example of the difficulty in defining a "healthy" estuary is the recent work by Scanes *et al.* (2011) assessing data collected from lagoons and estuaries in the Nadgee Nature Reserve, including Nadgee Lake, which have had virtually no impact by humans. These estuaries represent an opportunity to study a predominantly closed ICOLL in its complete natural state. The work in the Nadgee wilderness area confirmed earlier work by Scanes *et al*. (2007) that there does not appear to be a relationship between the magnitude of catchment disturbance and ambient nutrient concentrations in estuarine waters. That is, elevated nutrient concentrations still occur in these lakes that have not been impacted by catchment development. The results indicate that some or all of the existing preconceptions about the chemical and algal dynamics of infrequently opened coastal lagoons may need to be re-examined.

The CZMP Guidelines suggest an initial assessment of estuary health be undertaken based on existing information, which may include the National Land and Water Resources Audit (2008) and the State of the Catchments Reports (OEH, 2010). Bearing in mind the complications in assessing estuary health status, the outcomes of these two broad scale (NSW-wide) assessments of estuary health that have included the Gosford Coastal Lagoons are presented in the following sections.

Unfortunately, neither of these assessments give results that are considered to be reflective of the actual status of estuary health for the four Gosford Coastal Lagoons. The reports in fact illustrate the difficulties in applying measures of health to ecosystems as diverse as the estuaries of NSW, and particularly in assessing ICOLLs with a standard set of parameters and thresholds that cover all estuaries.

It is recommended that, instead of focussing upon the outcomes of these reports that may or may not reflect the true status of health in Gosford's Lagoons (and further, may not reflect the values associated with these systems to the community as well as the environment), a program of monitoring to reflect the key parameters of interest to defining changes in environmental and / or community values be developed.

5.1.2 The National Land and Water Resources Audit (NLWRA, 2008)

The National Land and Water Resources Audit (the NLWRA Audit) was funded by the Australian Government through the Natural Heritage Trust. It was set up in 1997 to improve land, water and vegetation management by providing better information to resource managers. The Audit ended on 30 June 2008. The audit included an estuary assessment, which collated information on 979 estuaries and was undertaken to:

- assess the condition of Australian estuaries;
- develop a process-based understanding of estuaries and their diversity across Australia; and
- contribute to an information base that can underpin and inform estuarine management.

The classification scheme used in the audit considered:

- dominant processes (based on estuary type and size);
- catchment characteristics such as land use and hydrology;
- tidal regime;
- condition of the floodplain;
- estuary use;
- pests and weeds; and
- estuarine ecology.

The assessment adopted a pressure, state, response approach.

From the NLWRA Audit, Terrigal Lagoon and Avoca Lagoon are considered to have 'modified conditions', while Wamberal Lagoon and Cockrone Lagoon are considered to have 'extensively modified' conditions. Without detailed appraisal of the Audit methods and associated data, it is not possible to rationalise how these categories were assigned to the Gosford Coastal Lagoons.

5.1.3 Gosford Coastal Lagoons Estuary Processes Study

This section summates the findings of the estuary processes study in regard to estuary health. For more comprehensive discussion please refer back to the Estuary Processes Study (Cardno 2010) or the Coastal Zone Management Study (BMT WBM 2013).

Cardno (2010) describes catchment characteristics and lagoon processes separately. The summary given in BMT WBM 2013 outlines the natural processes (geology and topography; hydrodynamics, sediments, water quality, ecology), making note of the influences of the catchment and entrance to each of these aspects together. Likewise, the summary of external pressures described may occur from the catchment influences (e.g. land use) or entrance conditions (e.g. artificial openings).

5.1.3.1 Measured Water Quality

Council undertakes a range of water quality monitoring programs. The available water quality data for the lagoons indicates that it is generally of a high enough standard to support ecological function and recreational activities. There is the potential to improve water quality into the future.

Cardno (2010) noted that the measured water quality values represent a limited range of conditions in the lagoons (e.g. samples rarely captured breakout events or open entrance conditions), and so there is potential for greater variability in water quality in the lagoons than reported.

The water quality data for the lagoons is generally compliant with the ANZECC Guidelines. Exceptions include turbidity for Terrigal Lagoon which is often above the guideline value. DO concentrations are usually above 5 mg /L in all lagoons, which is typically accepted as sufficient to support aquatic species such as fish.

Cockrone lagoon was the only one of the four to frequently show pH values above the guidelines. Although the limited data available for Nadgee Lake in Scanes (et al 2008) also shows slightly basic conditions so it is possibly a natural condition rather than an indicator of poor estuary health.

For Nitrogen, the measured concentrations of Ammonia, NOx and TN in all the lagoons generally exceeded ANZECC (2000) guidelines, which suggests susceptibility to algal blooms. Measured concentrations of total phosphorous (TP) are generally within the guideline values, suggesting that phosphorous may be the limiting factor for algal growth.

Cardno (2010) stated that the available data on nutrient concentrations is not sufficient to make meaningful conclusions about water quality processes in the context of nutrient dynamics and algal bloom dynamics. Based upon the limited data on nutrients, Cardno (2010) observed that nutrients in Avoca and Cockrone lagoons tended to increase in concentration with time since entrance closure; for Terrigal Lagoon, nitrogen and phosphorus species generally tended to decrease in concentration with increased time since entrance closure; and nutrient parameters for Wamberal Lagoon tended to be variable.

Both Avoca and Cockrone lagoons are prone to blooms of macro algae. The persistence of these blooms suggests nutrient loads in the water column and/or the sediments are sufficient for their sustained existence.

5.1.3.2 Water Quality for recreational users

Measured data from the lagoons indicates that faecal coliform counts have on occasion exceeded the NHMRC Guidelines for managing risk in recreational waters (2008). While this can represent bacteria from sewer overflows, animal faeces are also a source of faecal coliforms and may be influencing the sample results.

Enterococci have been monitored since 2010 through the beachwatch partnership program. From October to April each year council monitors and reports on the recreational water quality of the lagoons based on 1 site per lagoon, close to the entrance area. Enterococci counts have recorded some exceedences above the ANZECC (2000) guidelines for primary and secondary contact recreation. Enterococci have a higher tolerance to saline waters than faecal coliforms and would therefore be a more reliable risk indicator at those times when lagoon waters are brackish or more saline.

5.1.3.3 Fringing wetlands and riparian habitat

The extensive areas of wetland that exist in the Gosford Lagoons (except Terrigal) are considered to be in excellent condition. Vegetation surveys reviewed by Cardno (2010) identified the following types of fringing wetland communities around the lagoons:

- Alluvial Paperbark Sedge Forest;
- Coastal Sand Swamp Forest;
- Estuarine Paperbark Scrub Forest;
- Estuarine Swamp Oak Forest;
- Swamp Mahogany – Paperbark Forest;
- *Phragmites* Rushland; and
- *Baumea* Sedgeland.

Wetlands play important roles in providing breeding areas for fish and habitat for migratory birds and other waders and for trapping nutrients that would otherwise flow into the lagoons.

Saltmarsh and mangroves are largely absent from the four Gosford Coastal Lagoons, and this is likely to be their natural state rather than anthropogenic (i.e. due to human influences). Haines (2008) reports that mangroves in ICOLLS are rare, found in small numbers only and in systems that are mostly open. The vegetation mapping for Gosford (East Coast Flora Surveys 2009) does not identify the mangrove forest occurring in the western section of Terrigal Lagoon, however this is of a significant size and further investigation and mapping should be undertaken.

Likewise, riparian vegetation, while not strictly within the lagoons, is very important to the habitat within the lagoons. Riparian vegetation stabilises the banks of creeks and controls sediment supply thereby directly affecting water quality. It is also important as a habitat for native animals and for providing wildlife corridors (Cardno, 2010).

5.1.3.4 Seagrass coverage

Coverage of seagrass within the lagoons is naturally quite variable due to entrance breakout processes, where deeper areas are suddenly reduced in depth or even exposed following a breakout. The number of breakouts may vary from year to year in line with the variability of rainfall, and so, this will necessarily impact upon estuarine vegetation such as seagrasses. Variations in coverage are therefore not considered to be indicators of declining estuary health for these lagoons.

5.1.3.5 Macroalgae

Investigations in the Nadgee wilderness area (Scanes *et al*., 2007) suggest there is not necessarily a relationship between the magnitude of catchment disturbance and ambient nutrient concentrations in ICOLLs. This is somewhat similar to the Gosford Lagoons, where Terrigal Lagoon has a more disturbed catchment, but it is the least disturbed catchments of Avoca and Cockrone that exhibit macroalgae blooms. To what extent the macroalgae blooms have been modified (i.e. increased or decreased) by changes to catchment land use is unknown.

The macroalgae *E. intestinalis* and *C lignum* have relatively low salinity tolerances, and where these macroalgal species are present in the lagoon at the time of a breakout, they will suffer die-back due to both the increase in salinity and drop in water levels, as the lagoon volumes typically decrease by 50%. In Cockrone Lagoon, the die off of macroalgae following a sustained period of entrance closure and subsequent opening has been associated with oxygen depletion and fish kills (Cardno, 2010), as also occurs in Nadgee..

Macroalgae blooms are not considered a useful indicator of estuary health for the lagoons at this time.

5.1.3.6 Bird life

The Gosford Coastal Lagoons support a wide variety of bird life, particularly migratory birds that utilise the lagoons for food and shelter. Birds are an important part of the overall biodiversity of estuaries and lagoons and may also be valued for their functional role in ecological processes such as nutrient cycling, seed dispersal and population regulation (including both predation and herbivory) (Cardno, 2010). The study area is on the route of the East Asian-Australasian Flyway which is used by shorebirds to move between Australia / New Zealand, East Asia and the Arctic region of the northern hemisphere.

A search of the Birds Australia database conducted by Cardno (2010) on 7/12/2009 found records for 207 bird species in the general study area, including:

- 15 species protected under the *Threatened Species Conservation Act 1995*;
- 65 species listed marine species under the *Environment Protection and Biodiversity Conservation Act 1999*;
- 17 species protected under Japan-Australia Migratory Bird Agreement (JAMBA);
- 17 species protected under China-Australia Migratory Bird Agreement (CAMBA); and
- 12 species protected under Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).

The maintenance of water quality and habitat extents greatly assists in supporting the resident and migratory birdlife who utilise the lagoons. For example, the periodic exposure of areas of mudflats, as occurs after entrance breakouts, provides important foraging opportunities for a number of bird species (Cardno, 2010).

5.1.3.7 Aquatic fauna

There is a Green and Golden Bell Frog resident population of about 100 adults, in North Avoca in Bareena Wetland.

There is a wide diversity of fish species that inhabit coastal lagoons. Resident species may spend their entire lives in the lagoon. Marine estuarine dependent species will need to utilise the estuaries at some point over their life cycle, for example, as juveniles and during part of their adult stages, then as adults migrating out to sea to spawn. Haines (2008) reports that ICOLLs tend to exhibit lower fish species diversity when compared to permanently open estuaries. This is particularly evident following extended periods of closure.

Sampling undertaken by Newcastle University in 2009 and cited by Cardno (2010) found that Terrigal Lagoon had the greatest diversity of fish (23 species), followed by Avoca (15 species), Wamberal (13 species) and Cockrone (12 species) (Cardno, 2010). Again, the diversity appears to be correlated to opening frequency, with the more frequently open the lagoon, the greater the fish diversity. Species counts for these systems are not considered to be a good indicator of estuary health.

In terms of abundance of fish, an opposite correlation between opening frequency and abundance was observed (Cardno, 2010). Comparing the lagoons, Wamberal had the highest abundance of fish and Terrigal the lowest (Edwards and Gladstone, 2009), likely due to the low habitat diversity of this lagoon. While there were substantial changes in the abundance and diversity of larval and juvenile fish in all the lagoons over time, there was no evidence that these changes were associated with lagoon openings. It was generally found that both the diversity and abundance of fish in Wamberal, Avoca and Cockrone Lagoons (which opened at approximately the same time) decreased after entrance openings.

Few prawns or other crustaceans were recorded in the surveys by NSW Fisheries between 1986 and 2008, as cited by Cardno (2010).

Shellfish are relatively rare in the Gosford Lagoons with pipis (*Donax deltoides*) being most abundant at Avoca, but only one sample with a single individual was found at Wamberal and none in the other lagoons. Shellfish inhabiting hard substrata, such as rock or mangrove roots and trunks, are rare as these habitats are not well represented in the lagoons (Cardno, 2010).

Since the completion of the EPS, McCormack (2010) has published information regarding aquatic surveys undertaken for Avoca and Cockrone lagoons in late August and early September 2010, while Terrigal and Wamberal lagoons were surveyed in May and June 2010 (during flood conditions). Biological surveys were undertaken as part of both the broad Australian Crayfish Project and the Australian Aquatic Biological Survey and a targeted sub-project on Gosford LGA.

Within the Terrigal lagoon catchment aquatic biodiversity & population densities were rated as low. Very few native fish and no freshwater snails or shellfish were found.

Some of the largest freshwater snails ever collected by ACP & AABS were found within the Wamberal Lagoon catchment. A new native species of Gramastacus crayfish was discovered as well as an invasive Cherax freshwater crayfish species was found to be proliferating within the lagoon.

For the Avoca Lagoon Catchment McCormick (2010) reported finding that the aquatic biodiversity and population densities of freshwater shrimp and snails were good. Relatively good numbers of native fish were also reported. While freshwater cray fish were not found, anecdotal indications of their presence warrant further investigations.

Within the Cockrone Lagoon Catchment, numbers of native fish and overall aquatic biodiversity and population densities were low compared to the other lagoons. This is not considered an indicator of estuary health, just a reflection of a different lagoon type with a different opening regime.

5.1.3.8 Fish Kills

While disturbing for the public, Fish Kills may be a natural phenomena and are not necessarily an indication of poor estuary health.

Fish kills have been observed in Cockrone Lagoon on several occasions. Investigations of two events suggest that the fish kills occurred due to a rapid decrease in dissolved oxygen that results when blooms of macroalgae decompose immediately following a lagoon breakout.

Council staff have also advised that fish kills occur in Wamberal Lagoon following breakout.

Water levels decrease significantly after a break out event and large expanses of the lagoon (if not the entire waterbody) drain to dry. The result is rapidly declining and persistent low dissolved oxygen levels following the death of significant amounts of algae along the previously unexposed shoreline. Decomposition of this organic matter consumes most of the oxygen from the water. In addition, the low water levels also limit the availability of refugia for fish, further contributing to the fish kill as they cannot escape the low oxygen water. It should be noted that fish kills are not observed after every breakout event, nor after every macro algae bloom.

5.1.3.9 Macrobenthic Invertebrates

Diversity and abundances of macrobenthic invertebrates were greatest in the central mud basin of the lagoons and least in the beach berm regions. This is likely due to lower rates of disturbance in the deeper parts of the lagoons. Of particular interest was the finding that when comparing assemblages before lagoon breakout to when the lagoon has re-established, there were no significant difference in assemblage structure in any of the lagoons. These results indicate that the effects of artificial opening are short-lived and that the benthos recovers rapidly in the entrance barrier (Gladstone *et al*., 2006).

5.1.4 Collection of Baseline Data to Inform Performance Review

A key focus for the monitoring program is to collect data now that can be used along the implementation time line to assess the performance of the plan in the future. Most environmental processes involve intra seasonal variability and require long term data on natural processes and patterns before the effects of individual management actions could begin to be assessed. There are, however some indicators that could be collected now to build baseline knowledge. The collection of this information now provides the opportunity for community involvement, and will assist in informing an adaptive management approach. These include:

- Proportion of foreshore that is mowed to within 1 metre, 2 metres and 3 metres of the bank.
- Quadrant based present or absent assessment of understorey recruitment in riparian and wetland areas
- Proportion of foreshore that is vegetated by natural species
- Documentation of all lagoon entrance opening events including details such as location of channel at opening, (surveys of channel, available wave direction and size, preceding and predicted rain), opening at different levels, impacts on dunes etc.).
- Foreshore condition in terms of vegetation cover and bank erosion

- Snapshot audit of construction sites within the catchment
- monitoring of WSUD devices following events and on a regular basis

Care will be needed to make sure data collection and categorisation techniques are clearly outlined to allow sampling to be repeated in the future.

5.1.5 Adaptive Management Considerations

Monitoring needs to be strategic with results directly advising maintenance and education activities. Some examples of where this can apply are:

- Monitoring of WSUD devices with results influencing Councils maintenance program;
- Monitoring of foreshore management on private lands with results influencing education strategies;
- Water quality monitoring for public health indicators influencing recreation planning
- Continuing documentation of implementation including challenges (funding, logistics, community concerns etc.) achievements and failures to inform adaptive management

5.1.6 Indicators for Monitoring

The adopted estuary health monitoring program should be based on key indicators that are monitored at the State level under the MER Program. This includes monitoring of:

- Turbidity;
- Other supporting physico-chemical indicators such as salinity, dissolved oxygen, pH, and temperature;
- Estuarine Macrophytes (seagrasses, saltmarsh, mangroves) distribution change;
- Macroalgae blooms; and
- Riparian vegetation distribution and condition.

Some other potential indicators by

5.1.7 Sampling Period and Effort

Sampling period and effort will in part be limited by available resources, however it is recommended that at a minimum the following occurs:

- One off assessments of estuarine macrophyte distribution and condition every 5 to 10 years to identify change in extent and condition over time.
- One off assessments of riparian vegetation distribution and condition every 5 to 10 years to identify change in extent and condition over time.
- Sampling sites should be as for existing water quality sites. Regular and event based sampling of physio chemical parameters. In particular event based sampling should be undertaken to help understand the biological and biogeochemical response that occurs immediately following rainfall.

- The methodology for assessing change in macrophyte distribution over time will follow the State of the Catchment Reports methodology.

5.2 Evaluation

Evaluation of the available information should be undertaken by Council, at least every two years. A more thorough review should be undertaken (preferably independently) every 5 years. Considerations of the evaluations may focus on pressing issues.

In most circumstances, the key focus will be on continuous improvement, however this will need to be considered in light of the naturally variability of the Australian climate and the impacts of drought and flood cycles on the selected indicators.

Special care needs to be taken when simplifying estuary monitoring data in to a report card type approach due to the complexity and natural variability experienced within ICOLLs. In particular, recent work undertaken by Skenes et al regarding atypical estuaries (refer to Scanes, et al 2014).

5.3 Reporting of Estuary and Catchment Health

Evaluation of the data is important for determining whether any priorities of the plan need to be amended or specific actions need to be taken. Evaluation should be an ongoing process.

All monitoring activities would be reported on, including:

- Beachwatch
- Routine Council water quality monitoring
- Macrophyte distribution and abundance
- Riparian vegetation
- WSUD devices (function and performance)
- Lagoon entrance management (official and, where reported, unofficial opening)

Reporting of the data is important for highlighting to key stakeholders and the community in general how the health of each of the Lagoons is changing over time and compares to other estuaries. Reporting should be in the form of yearly report cards on estuary health / water quality.

These sites are monitored weekly for enterococci - a group of bacteria which indicates if water is polluted by stormwater or sewage surcharge - to determine if any area is not suitable for swimming. Results of Beachwatch monitoring are updated weekly on the council and Beachwatch websites, providing up to date information for residents and visitors on water quality and whether to avoid swimming at certain locations and/or times.

5.3.1 State of the Catchment Reports

The NSW Natural Resources Commission has set 13 state-wide targets for natural resource management. The target for estuaries is: “By 2015 there is an improvement in the condition of estuaries and coastal lake ecosystems”. Outcomes of the NSW Natural Resources Monitoring and Evaluation Reporting Strategy (MER) were used to compile the 2010 State of the Catchments (SOC) Reports for each catchment management authority region in NSW. Protocols for the

assessment of the condition of estuaries and coastal lakes to derive outcomes for the 2010 SOC Reports is documented in Roper *et al.* (2011).

Wamberal, Terrigal, Avoca and Cockrone Lagoon are all included in the SOC Report (noting the Gosford Coastal Lagoons fall within the Hunter Central Rivers Catchment Management Authority region).

The SOC report uses two indices for estuaries, being estuary condition and pressure. Each indicator has been scored relative to a reference or least impaired condition. A number of methods have been employed to develop scoring classes on a five-colour scale of 'very good', 'good', 'fair', 'poor' and 'very poor' to represent the extent of deviation from the reference condition.

The indicators of estuary condition used in the SOC Reports were:

- eutrophication: chlorophyll a, macroalgae and turbidity (microalgae may also be included in the future);
- habitat distribution: change in seagrass, mangrove and saltmarsh (macrophytes) extent;
- fish assemblages: species diversity and composition, species abundance, nursery function and trophic integrity (food web).

The key pressure indicators for the pressure index in the SOC Report (STATE GOVERNMENT, 2010) provided a broad scale listing of the pressures on the Gosford Coastal Lagoons.

The indicators selected, paucity of data and comparison to large permanently open estuaries are problematic for small ICOLLs and the results are again not considered reflective of the actual conditions of the Gosford Coastal Lagoons. Thus, for the Hunter Central Rivers SOC report Cockrone Lagoon is the only estuary rated as 'poor'. Yet within the Gosford basin, Cockrone Lagoon would be amongst the most pristine systems as it has the least catchment disturbance. For the pressure index, the results for the four Gosford Coastal Lagoons are a category of moderate pressure for Wamberal, Avoca and Cockrone Lagoons and High pressure for the Terrigal Lagoon. Terrigal Lagoon is agreed to be under high pressure, although it is arguable that the remaining three lagoons would be considered under only moderate pressure.

5.3.2 Use of report cards

NSW Government is encouraging a report card approach, at the time of CZMP preparation. Gosford Council in partnership with the Central Coast Environment Network is undertaking a project developing a report card methodology that incorporates the unique aspects of the coastal lagoons.

Report cards can be a useful tool for communicating with te public about changes in eatuary indicators. Care will need to be taken however, to ensure confidence in data analysis, so that results communicated represent cause and effect changes rather than short term fluctuations in response to weather and other natural variations.

5.4 Plan Review

It is recommended that this Implementation Action Plan be reviewed annually, to determine progress with individual actions and strategies, while a broader audit and update be conducted every 5 years. The annual review should focus on funding, resources and barriers to

implementation of the individual actions and strategies, whereas the 5 year audit should target re-evaluation of values, processes and threats to determine progress with overall aims and objectives.

From the 5 year audit, changes can be made to the Plan to ensure the document remains current, and relevant to the community uses and understanding of lagoon processes. A full review of the Plan should occur by 2025.

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